In the early 1860s British colonial interests commissioned three young Swedish metallurgists to plan and lead the construction of two ironworks in India, one in the foothills of the Himalayas, the other in the Narmada Valley. In their Indian setting, both ironworks were pioneering enterprises, based on the most modern European ironmaking technology. Neither ironworks ever saw full and continuous production and the Swedish engineers returned to Sweden. In spite of their lack of success, or maybe because of it, the history of the ironworks and the ironmasters remaining narrative, is of wide relevance, not only in explaining the workings and effects of adaptation, but also as a description of the complex trends influencing a transfer of technology.

Landscapes of Technology Transfer is a wide-ranging empirical study. From a local and individuated perspective it traces lines of connection across boundaries of time and geography. The historical landscapes of technology transfer are described in their cultural, social, economic, and political dimensions and the remains of the ironworks and their local landscapes in present-day India are used as a central source for writing their histories. The book is illustrated with more than 170 photographs and drawings, both nineteenth-century and modern.

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Landscapes of Technology Transfer is a doctoral dissertation.

Jan af Geijerstam

Landscapes of Technology Transfer

Swedish Ironmakers in India

1860–1864
LANDSCAPES
OF TECHNOLOGY
TRANSFER
Landscapes of Technology Transfer
Swedish Ironmakers in India 1860–1864

Jan af Geijerstam
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Foreword

This thesis is the product of research conducted in the discipline of Industrial Heritage Studies at the Department of History of Science and Technology of the Royal Institute of Technology (KTH) in Stockholm. An intellectual fellowship manifested in informal and formal discussions has been an essential constituent of the setting and my work has been completed with the support of close friends and colleagues in the Department. I hope I have been, and will be able, to repay at least a part of the generosity I have experienced.

In the course of my work, I have exchanged views and information with scholars and friends, and with scholars who have become friends, all over the world. Even a brief word, a short conversation or an exchange of letters has often left a lasting impression - the ongoing, everyday support received from others even more so. In different ways, they have all been of great importance.

At times I have felt it would be both a necessity and a pleasure to name each and every one of these helpful friends, but finally, rather than risk omitting some – and embarrassing others in a context they might not fully endorse – I have decided to contend myself with thanking them all collectively. Yet there are some I would like to mention individually.

It was Professor Marie Nisser who invited me to conduct a study at the Royal Institute of Technology and she has been my tutor and close ally throughout this work. Under her guidance I was generously received and introduced to a happy atmosphere of constructive criticism and encouragement at the Department of History of Science and Technology, with first Professor Svante Lindqvist and since 1999 Professor Arne Kaijser as its heads. Special thanks are also due to Dr. Per Hilding, Department of Economic History, University of Stockholm, who has been my co-tutor and to Dr. Göran Rydén and Dr. Chris Evans who were my opponents at a final seminar.

Peter Nyblom has been my companion for more than fifteen years. We first met in the midst of the Swedish steel crisis in the early 1980s and in 1987 we travelled from Peter’s former place of work at No. 2 Steel Mill in Fagersta to Bhoruka Steel in Bangalore and Tisco in Jamshedpur. All along he has been an untiring and generous supporter and through his many photographs he is also an important co-author of this book. He and many
other friends have also helped me to remain in touch with present-day realities in Fagersta, Norberg and other communities in Bergslagen.

* 

Many new friends in India have helped me in the most personal and generous manner. An important part of my work has consisted of discussions and co-operation with distinguished Indian historians in history, economic history and the history of science. They have not only shared their knowledge with me and given me constructive critics, but also given invaluable practical support. Across the world close ties of scholarly interaction and friendship have been established. Among Indian colleagues, I would like especially to mention Professor Deepak Kumar and his family and Professor Nasir Tyabji, both at the Jawaharlal Nehru University in New Delhi.

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* 

Ottonie Nyberg helped me to interpret Mitander’s diary and interpret his handwriting, Geetali Jonson to arrange travels and to interpret letters in Hindi, Yngve Axelsson at the library of Jernkontoret to answer each and any question on the history and technique of ironmaking and Per-Olov Bjällhag at the National Museum of Science and Technology in Stockholm who has given me the most generous support concerning the archives of Julius Ramsay and Gustaf Wittenström.

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* 

Closest, enduring the daily and seemingly never-ending preoccupation with this work, are of course the members of my family, Kri, Karin and Peder.

* 

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* *

And finally, I would like to thank and commemorate Harry Pettersson, blast-furnace worker and trade unionist, for his ever humanitarian, joyful, generous and inspiring energy. Harry lived in the small and today dormant iron-making community of Högfors in central Sweden and he passed away before this work was even begun.

With his stories and his songs about his work, neighbours, social life and politics Harry bridged the gap between deep engagement in and respect for the everyday life of the community in Högfors and a profound sense of affinity and solidarity in a the wider world. His spirit has accompanied me throughout the project and still does. During our conversations beside the ruins of the blast furnaces in Högfors, or at his home in Broarna nearby, he expanded the horizons from the seemingly insignificant facts of daily life to the greater questions of human existence.

Stockholm, April 2004

Jan af Geijerstam
Preface

Iron is not only the most common single element in the earth we tread, it is also present in almost every part of the society we ourselves have built. The sickle with which we cut our wheat, the bridges carrying us across valleys and turbulent rivers, the guns that shed the blood of our brothers and sisters, the rails that bring us together, the very nuts and bolts of industrial society... all are made of iron.

* The Swedish steel industry was once at the very core of Swedish industrial pride. *Svenskt stål biter* (Swedish steel bites) was a slogan known to every schoolchild. The strong, forceful cutting edge of the steel industry was a self-evident part of the Swedish identity, a safe and reliable component of Swedish welfare society.

In the late 1970s and the 1980s something happened. The industry was subjected to profound restructuring and the words “steel” and “crisis” became a familiar collocation in the news. Over a period of ten years a tidal wave of closures rolled over the people of ironmaking communities of central Sweden.

The small steelmaking town of Fagersta, was one of the hardest-hit. In 1985 No. 2 mill in Fagersta was one of the few special steel mills of Sweden. The input was scrap, and the end product was highly specified slabs of special steel. The mill was modern and considered very efficient. The employees kept setting new productivity records.

Nevertheless overcapacity and rationalisation continued to cast a shadow over the works. After protracted discussions and negotiations involving both the leading steel companies and the State, it was decided that one of Sweden’s three special steel mills would have to close. Finally, the choice fell on Fagersta. The decision met with indignant protests from the workers and from a shocked and bewildered local community. Children from the schools in Fagersta assembled outside the local headquarters of the company, carrying placards bearing desperate: “Think of my Dad!”, “Save us!”. One of them was addressed directly to the strong man in the board of the company, Jan Stenbeck. “Stenbeck, make a drive for Fagersta’s staying alive”, it said.

None of the protests had any effect. No. 2 mill closed in the summer of 1985.
During these years, following global events such as the worldwide oil crisis, community after community suffered the blows of closure and dismissals, and the hard realities of the international steel market were cited as the unavoidable cause. Of the 50,000 employees in Swedish steelworks in the mid-1970s some 30,000 lost their jobs in only twenty years.3

In this sombre story one recurring feature caught my attention. Redundant steel mill equipment was often dismantled in Sweden and re-exported for reuse in the countries of Asia, Latin America or Africa. As late as the early 1970s, the optimistic years of expansion, Monex Svenska AB, a Swedish subsidiary of a German company, had worked exclusively on the import of new steelmaking equipment to Sweden.4 During the following period of decline, the flow reversed completely and for a period the sole business of the company was the re-export of decommissioned steelmaking equipment.5 This seemingly irrational sequence of events provoked questions.

How could these costly investments so soon become useless? Why this difficulty in planning investment and working for more than limited periods, resulting in economic crisis for local communities and human disaster for individual employees and their families? What could justify this waste of capital and human knowledge and experience, and what could be done to counter it? And, why there and not here?

*
Peter Nyblom was one of the workers at the steel mill in Fagersta. When he lost his job, after fifteen years at the mill, he turned to professional photography. Together we began to explore the causes and consequences of the Swedish steel crisis and we decided to follow a path leading out from Sweden into the new landscape of steelmaking in a world seldom seen and seldom discussed in Sweden.

In 1987 we traced a steel furnace from the Nyby Steel Works in Torshälla to a small Indian steel mill in Bangalore, Karnataka, Southern India – Bhoruka Steel. We followed its route and our resulting journey to India was, in more senses than the geographical, a visit to another part of our world. But even if it was far away, it was a part of the world with close links to ours.
In three parts, it told three different stories. First of the iron mill in the little village of Högfors in Central Sweden, closed in 1953; secondly of the fifteen years of the rise and fall of No. 2 mill in Fagersta; and finally of the life of Bhoruka Steel. In this triangle of three case studies, we tried to find the unifying themes across time and space. We used the lives of the people in each place as the fundamental starting point of our stories and we called the book *Mitt i världen, mitt i tiden* (In the Middle of the World, in the Middle of Time), denoting our basic conception of the uniqueness and importance of the life of every man and woman, the uncompromising relevance of keeping this view of the world in mind or even in focus, as well as telling the bigger stories of which we all are a part.6

I do not know if we found any answers in our work on *Mitt i världen, mitt i tiden*, but our knowledge broadened – and new questions arose.

In both India and Sweden ironmaking is deeply rooted in a long tradition. In spite of this, there is an enormous difference in the histories of their iron and steel industries.

Sweden is a small country in the far north and its economy is highly dependent on external markets. In spite of this, its iron and steel industry has shown continuing technological development and rising output, passing through periods of crisis and restructuring. There is a thread of tradition and change, through slumps and new starts, often highly influenced by import of technology from abroad. And even through the crisis in the early 1980s, steel production in Sweden rose.

India is one of the world’s biggest countries. Its iron and steel industry achieved only a limited output before India’s independence in 1947. Historians talk of the deindustrialisation of its iron production during the colonial era. Since then, thanks to sustained and strenuous sacrifices, it has grown to a considerable size. India’s crude steel production had reached 27.3 million tons by 2001 and India ranked as the eighth largest steel-producing country in the world. Sweden ranked as number 26, producing 5.5 million tons.7

Measured on a per capita basis, however, the difference between the two countries is remarkable. India’s steel production is but a fraction of Sweden’s. In 2001 India’s population was 1,033 million, Sweden’s 8.9 million.8 At this time India’s production of crude steel represented approximately 26 kg, Sweden’s 618 kg per inhabitant.

A general, fundamental question was how these differences developed and how they were cemented in the tough structures of development and underdevelopment? I felt compelled to dig into history and in doing so I met three Swedish metallurgists at work in India during the 1860s. I discovered material that illuminated history in stories of individual human interest. This stimulated me to probe further.
The journey to Bhoruka Steel was a move across the globe, but it was also a journey in time. The web connecting ironmaking in Sweden and India had a history. In an extensive account of the economic geology of iron ore, iron and steel in India, the Director of the Geological Survey of India, M. P. Krishnan, wrote of a Swedish metallurgist who worked in India. It was not more than a couple of sentences, but it gave history a shadow of a human face.

Iron ores occur at Barwai and a few other places forming the matrix of a breccia in the Bijawar formations. In 1866, the Secretary of State for India made arrangements to depute Col. Keating to Sweden to obtain practical experience as to the method of smelting these ores. A Swedish Metallurgist called Mitander was brought out to India to set up smelting works. 1,000 tons of good ore was raised from Nandia and Mitanderpur, containing 50 percent or more iron. Firebricks were produced locally. A blast furnace, charcoal ovens, rolling mill and casting house was constructed. However, when operations were about to commence, Government decided to incur no more expenditure. The works were put up for sale in 1863. The total expenditure incurred was £25,000. But, though the works were offered

*Bhoruka steel. Workers bending reinforcement bars at Bhoruka Steel in Bangalore, before loading them onto lorries. Photo: Peter Nyblom, 1987.*
for anything over £400, there was no buyer. Mr. Mitander returned to Europe greatly disappointed and without producing any iron.

These few sentences aroused my curiosity.

During the years that followed, I continued my work as a freelance journalist. Parallel to many other assignments I began to follow the track of Mitander and slowly uncovered additional information. The story of two other Swedish metallurgists emerged, contemporary with Mitander: Julius Ramsay and Gustaf Wittenström. Both were employed in India in the early 1860s to build an iron-producing plant in the northern part of the subcontinent.

I also found part of Nils (Wilhelm) Mitander’s diary of his Indian journey in a Swedish archive. Suddenly the past became very vivid. I opened the cover and I read how Mitander saw the first contours of India from the railing of the steamship Orissa, in the early morning mist of 26 October 1862. Mitander wrote: “How can I ever describe my feelings this morning when I first saw this land, old India, where I am to work for four years, the Almighty willing.” With increasing fascination I read Mitander’s notes on the sometimes lonely building of the Burwai Iron Works and of a new future in India and his utter disappointment when it became clear that he would be forced to abandon all his hopes and all that he had achieved, just as described by Krishnan.

I also found the report to Jernkontoret (today the Swedish Steel Producers’ Association) from Julius Ramsay, where in lyrical terms he described the scenic beauty of his place of work in a valley of the lower Himalayas. I found a big collection of his letters to friends in Sweden, describing the ups and downs of his daily life together with his Swedish colleague Wittenström, whom he brought out to help him.

Slowly a hitherto unknown history emerged and this became the subject of my research. I have tried to find out how the histories of the ironworks at which the Swedes worked could shed light on my more general question of the reason for the huge differences in iron production between Sweden and India.

This thesis is intended to constitute a wide-ranging empirical study of two projects of technology transfer, their background and setting, all in the context of one basic question:

Why did the Kumaon and Burwai Iron Works never reach the stage of full and continuous production?

I have focused on India and used the stories of the Kumaon and Burwai Iron Works and the experiences of Nils Mitander, Julius Ramsay and Gustaf Wittenström as tools in a search for answers of wider relevance. I attempt to retrace the ties across time and geographical boundaries. I tell the histories of Ramsay’s and Wittenström’s Kumaon Iron Works in present day Uttarakhand and of Mitander’s Burwai Iron Works in Madhya Pradesh. Hopefully these case studies will help us to depict the background to the world of today.
Questions Raised
and Investigative Method

On Power and the Dynamics
of Development

In the early 1860s three Swedes, Nils Wilhelm Mitander, Julius Ramsay and Gustaf Wittenström, were engaged by the British to build and run ironworks in India. These works, the Burwai Iron Works in the case of Mitander and the Kumaon Iron Works in the case of Ramsay and Wittenström were both to be based on the most modern European technology. The projects were pioneering. The ambitions were high and stakes big – but after only a few years the projects were closed and the Swedes returned home.

This thesis features a detailed study of the Kumaon and Burwai Iron Works, from their first conception to their final closure. The investigation is basically empirical and a fundamental question is: Why were the works never brought into full and continuous production?

It is also intended to put this investigation into a more general framework of the dynamics of economic development and technology transfer.

How can the late development of India’s iron and steel industry be explained? What could be the explanatory significance of the histories of the Kumaon and Burwai Iron Works? What are the important factors in a successful technology transfer?

This introductory chapter discusses the theories and methods used in my research. A special emphasis is laid on the physical environment and its role in our search for knowledge of the past.

Theoretical Framework
and Key Concepts

Efforts to explain inequalities and the unevenness of economic development in the world have been dominated by two, often competing, theories. On one hand “underdevelopment” has been explained by internal factors, such as a lack of the necessary preconditions for industrialisation, implying the importance of religious-cultural traits in the society concerned. Alternatively the main explanation has been said to lie in external factors, such as colonialism, which have inhibited or arrested economic development.
These conceptions of the roots of underdevelopment have been closely tied to discussions on future roads towards sustainable and dynamic development, in most cases understood as economic growth. This has been an important arena of debate among economists, at least since the 1950s and 1960s when two important positions in this debate were formed by what came to be called the modernising school and the dependistas. Followers of the modernising school argued that the future of underdeveloped nations is, or rather should be, an extrapolation and repetition of the history of the already industrialised nations. The latter were proposed as ideals and – based on the specific experiences of European industrialisation – the causes of underdevelopment were attributed to the lack of certain requisite factors of production such as capital to finance a “take-off” or certain values and institutions. It was alleged that the causes of underdevelopment were basically to be found within countries. They had lagged behind, but if they trod the same road as the industrialised countries once took, development would ensue.

The modernising school was criticised on two main counts. The first was its circumscribed concept of growth. The main line of the modernising school developed in the tradition of positivism, where factors that could be expressed in figures were of prime importance. Often economic growth was equated with a growing national product. This limited the view, and overshadowed questions of equality and democracy. Development should instead, argued the critics, be understood as an improvement in physical and cultural welfare and security for the great majority of the population.

The second target of criticism was the inability to see the world as an interdependent system, where some were winners and others losers. The dependency school, with its base in Latin America, argued instead that the main emphasis should be on external factors, such as colonialism, which had inhibited or arrested economic development. Central concepts were “centre-periphery” and “metropolis-satellite”, and these dichotomies were postulated to pinpoint an interdependence on unequal terms that had led to an uneven development. There had been a reciprocal connection between development in the industrialised countries of Europe and North America and the development of underdevelopment in the poor countries of Latin America, Africa and Asia.

Studies of the economic history of India, which is of primary importance to this present study, show affinities with the above-referred discussion of underdevelopment in general. They can be said to take one of two general positions: imperial apology, which argues for the benefits of colonial rule, or nationalist criticism, which stresses factors that modified or impeded possible positive effects of colonialism. I will return to these two lines of reasoning in Chapter 1.
Technology Transfer and Development

Technology is the use of machinery, tools and other physical artefacts to meet human wishes and needs. This clearly spells out that technology is always defined in a human context. Man uses the artefacts and man defines their purposes. Therefore, no technology can be understood in isolation from social and cultural circumstances.

This being so, iron and steel technology is defined not only as the hard technical components used by man to produce iron and steel, like the blast furnace, the Bessemer converter or the Lancashire forge, the physical artefacts here designated as technique. It is also the total physical layout into which these physical artefacts are put, the layout of the workshops and even the placing of the works and the underlying infrastructure in the landscape. In this tangible set-up of a production unit men and women are at work putting a body of knowledge and experience into practice. All these components, and the way work is organised within a societal frame of customs, rules and laws, together form a technological or socio-technical system. A technological system consists of parts forming an integrated totality and comprises, beside the artefacts, also actors and organisations, institutions and institutional legislation or sets of rules. These components are functionally interrelated and form a body, which could be described as an organic whole with a high degree of self-generated momentum. This whole notion of technology as both socially constructed and society-shaping also has fundamental implications for any study of technology, be it contemporary or historical. The totality of and complexity of the socio-technical system must be the object of study. Without such a wide-ranging study the actual making of iron becomes a technical abstraction.

Technology Transfer

Throughout history technological solutions have moved across the world, sometimes changing the direction and pace of transformation of societies. Technology transfer and diffusion are an essential part of economic development. Focusing on Scandinavia, as one example, its history has been characterised by high levels of technology import, and technology transfer has been “in key respects the core of the industrialisation process”. In our time of intensified globalisation the importance of this transfer of technology has rather grown, and in foreign aid programmes it is also widely recognised as a major means of generating economic growth in poorer countries.

Over time there are similarities – and differences – in technology transfer, most of them relating to its socio-cultural content and its close connection to prevailing structures of power and subordination. Such a comparison also pinpoints fundamental characteristics of a technology transfer that serve to place its analysis in a context of theories of development and underdevelopment.
Transfer and diffusion are two closely related concepts used to describe the movement of technologies, sometimes even used as synonyms. It is however useful to make a distinction between them. Technology transfer is the geographical relocation of a technology to a setting where it was not established before. Here it should also be stressed that the immaterial component of technologies also means that men transfer technology simply by passing on knowledge, without carrying a single piece of machinery.

Diffusion on the other hand is here seen as the spreading of knowledge via old or newly created linkages and possibly to new uses, in the new setting to which a technology has been transferred. Diffusion is a central part of the continuous and self-contained process of development, which may follow a successful transfer of technology. This is especially true of complex technologies, which can be dispersed as a whole, but also in parts. An engine embodies a bolt – which of course can be and is put to other uses. It also embodies the knowledge of the use of airtight pipes, possibly being transformed or transferred, or spreading or diffusing to other applications. A characteristic of transfer is also that it is more easily defined in time and space and more easily identified as an act of will than the vaguer and more continuous process of diffusion.

Finally, a distinction should be made between technology transfer as a course of action and as an accomplished result, between the process of technology transfer and a technology transferred. The Kumaon and Burwai Iron Works clearly represent processes of transfer of a machinery and mode of production to be introduced in Barwah and Dechauri. But to what extent did these processes ever become cases of completed technology transfers?

Changes and Constancies

There are many opportunities to learn from history, but in the search for analogies between our time and the stories of the Kumaon and Burwai Iron Works similarities – and differences – in the setting in which technology transfer has taken place should be kept in mind.

When the waves of the first industrial revolution swept over Europe the core of the prevailing technologies was mechanical engineering. During the second industrial revolution the dominant features and the dynamic centre of new development instead became mass production, with new materials and new sources of energy. And with the move into our times, in what has been called a third industrial revolution into the age of information, digital and genetic technologies have come to the fore. This long process of shifts in the technological frontiers has taken place alongside a transformation of the nature of the human skills needed in production and acting as catalysts in development, from craft skills to broad scientific, mathematical and theoretical knowledge, based on formal education.

Alongside these shifts in the character of production spanning extended periods of time, fundamental changes have taken place in the realm of eco-
nomic organisation of industrial enterprises. These changes have been both responses to and prerequisites for the changes in technology. Mass production of cars and integrated iron-and-steel production exemplify an interrelation between increasing scale of production and long-term investments, and over time we have seen the emergence and growing importance of the limited companies and later of the multinational or transnational corporations which superseded the formerly so important family firms. In addition there has been a fundamental change in communications, facilitating fast contacts in global networks.

This description of differences between the mid-nineteenth century and today could be made longer, but there are also fundamental similarities and constants in the essence of technology transfer. A number of general concepts remain relevant and useful in studies of technology transfer, whether they concern the early twenty-first century or the middle of the nineteenth. Besides the social character of technology, concepts such as agents and social carriers of technology, projects, systems and power can usefully be used in both cases. Using these, the conclusions arrived at in this study can be raised to a more general level.

In spite of the intangibility of the techniques, it is also highly relevant to whether there are not a number of problems in the mid-nineteenth century technology transfer at the Kumaon and Burwai Iron Works that are familiar to people dealing with technology transfer today. Without defining or categorising them, David Jeremy lists such problems, some of a more practical, day-to-day character and some more general: “inappropriate technologies, bottlenecks, secretiveness, dependency on key managers and technical staff, choices between organisational structures, clashes of values, state-imposed inhibitions, legal contests, struggles with climate and weather.”

Social carriers of technology have been defined as central actors in every transfer of technology. The carrier need not be an individual, but is defined by Edquist and Edqvist as a social entity with a number of characteristics. The carrier has an interest in introducing the technology and is organised in a way that makes decision-making possible. The carrier has sufficient social, economic and political power to introduce the technology, is acquainted with it and has access to it. Lastly it possesses or is able to acquire the skill to manage the technology. This concept is closely related to the concept of system builder, as described by Thomas P. Hughes. The system builder is the purposeful entrepreneur working for a vision where parts will form a whole and one of the primary characteristics of system builder “is the ability to construct unity from diversity, centralization in the face of pluralism and coherence from chaos.” Furthermore, instead of focusing on individual
artefacts, system builders “direct their attention to the interfaces, the inter-
connections, among system components. Further, system builders often
preside over the establishment of systems that involve both physical artifacts
and organizations.” In a very concrete way the Swedish engineers were car-
rriers of technology, but the question is whether they ever became social car-
rriers of technology in the sense of Edquist and Edqvist and to what extent
they became system builders.

The concept of a social carrier of technology offers a way to describe and
understand a process of technology transfer, but its viability depends on the
way the setting is defined. Focusing on a local level, the realm of choice and
power might seem large, but when the analysis is widened possibilities of
choice and unilateral action are gradually narrowed. The freedom of move-
ment might seem apparent and obvious until it is considered how the frames
of action are decided. Players at a local level then appear as only pawns in a
game. The concept of a carrier of technology is thus closely related to the
concept of power, here defined as the ability to act or cause actions unilater-
ally and independently.

Here we again return to the discussion of power and subordination as
raised in the previous discussion of (under)development. An overall hy-
pothesis of this thesis is that the power relationship, that of supremacy and
subordination, was ultimately the decisive element determining the outcome
of the projects. This should be possible to discern at the central level of deci-
sion-making, but it is also necessary to examine how this relationship of power
was manifested and expressed in the processes and histories of the Kumaon
and Burwai Iron Works on the micro level. How was power manifested when
it was decided to explore and map India and its resources, or when the tech-
nology for the ironworks was chosen? Can it be seen in the physical layout of
the works, in Barwah and Dechauri? How is the power structure of colonial-
ism expressed and manifested in the structures and chronologies of the
Kumaon and Burwai Iron Works?

TECHNOLOGICAL TRANSFER
– FROM PROJECTS TO DEVELOPMENT

The concept “technological project” is of great importance in the analysis of
transfers of technologies, especially when the size and complexities of the
technology attain such dimensions as at Kumaon and Burwai. To describe
the process of technology transfer the degree of integration of these projects
into the society to which the technology was transferred can be described
using a hierarchy of concepts, technological projects, development projects
and technological systems.

The technological project consist in its inception of self-contained entities
and its boundaries in time, in geography and in society are quite distinct,
bound together by a certain technology. Its life-line is at first closely con-
connected to the sender, with concrete means of transport forming links with its home environment.

Such enterprises can operate for decades as alien enclaves, linked to distant suppliers and customers with little or no local articulation. Modern transportation permits the geographical relocation of technologies with little cultural diffusion or linkages with the local economy. In the worst cases they may provide a substitute rather than an incentive for local development.21

There is thus a potential dynamic element in a technological project. Influences can diffuse across the borders of the project and initiate wider processes of technical, economic and societal change. Even new forms of industrial, scientific and legal organisations emerge. In such cases technological projects become development projects with a greater autonomy. This is often the stated goal of a transfer of technology. The intention is to initiate a wide and lasting process of development and the effects are meant to transcend the boundaries of the project.

The study also closes in on what might be the most important process leading to technology-induced societal change: the diffusion of technology through innovations imported from abroad.

A third level of socio-technological entity is the aforementioned technological systems that are both socially constructed and society-shaping, and thus, by definition, closely linked to the society of which they are a part.

With such a broad analytical framework and its connections with issues of development, the meeting point of technique and the social setting in which it is to function becomes crucial. It can be argued that a technique embodies certain characteristics and thus the choice of which technology to transfer becomes an important part of the process.22 But transferred technologies can also become subject to adaptation to local conditions as they “frequently require considerable modification before they can function successfully in a new environment. This process of modification often involves a high order of skill and ability, which is typically underestimated or ignored.”23 David J. Jeremy has noted that “[d]ifferences in language, customs, values, religious beliefs have been and remain of the greatest importance in limiting or liberating possibilities for the adoption and modification of imported, new technologies” and that the adaptability of a technique to local conditions is essential, if it is to work. This knowledge has been rephrased in almost normative terms in the concept of appropriate technology. 24 A starting point is that “a project that does not fit, educationally and organizationally, into the environment, will be an economic failure and a cause of disruption” and that an appropriate technology should create development designed to improve the quality of life of the people, to maximise the use of renewable resources and to create work places where the people live. To achieve this the solutions chosen should employ local skills, local material resources and local financial
resources, be compatible with local culture and practices and satisfy local wishes and needs.  
This leads to three connected questions: What was the inherent social content of the technique carried to Barwah and Dechauri? How was it adopted and adapted? Was it appropriate?

Investigative Methods

Small and local facets of daily life are most often expressions of fundamental questions of societal development. Every man or woman is in the middle of time, with a past and future. Every human being is in the middle of the world, a focus of individual life, but also inseparably part of a bigger whole. This might be a view of our existence, but it is also an intrinsic part of research. It is a key to understanding the bigger totalities, to studying history.

Factor Analysis and Composite Holism

During an early phase of my doctoral studies I attended a course on the French Annales school. These studies both supported my own conception of the purpose of studying the past and influenced my general understanding of what writing history can be. The historians of the Annales school, with Lucien Febvre, Marc Bloch and Fernand Braudel as the prime movers in the early phases, were the single most important force in the development of what has sometimes been called “new history”. Its leading ideas were: to replace the traditional narration of events with a problem-oriented analytical history; to put the history of the whole range of human activities in the place of a mainly political account; to try to integrate the agendas of other disciplines, e.g. geography, sociology, psychology, economics, linguistics, social anthropology etc., into the study of history; and to heed “the desire, when one confronts a problem, to go systematically beyond its limits”. The Annales also put new words to the conception of time in history naming first the almost timeless history of the relationship between man and his environment, second the slowly, but continuously moving, history of economic, social, and political structures and finally, the fast-moving history of events.

In a similar tradition, although more confined in scope and focusing on a local level, technology transfer has been studied by separating and analysing different factors influencing the transfer, such as technical, geographical, economic, social and cultural circumstances. Such analyses occur in many general studies of industrial development and growth, as different forms of factor endowment analysis. Even if we turn back to British India in the nineteenth century, similar examples are easy to find. Such a nationalist critic as the Bengali lawyer Mahadev Govind Ranade discussed colonial policies in the 1890s, but he took account of natural and economic resources as well as
of the access to technology, geographical factors and the supply of managerial knowledge.³¹

Taking a step closer to Kumaon, William Sowerby, one of the most important players at the Kumaon Iron Works in the 1850s, noted that there were many “circumstances and elements necessary besides an abundance of raw materials for the successful establishment of ironworks” and he listed the three principal elements: labour, capital, and a market for the products.³² He also discussed the importance of culture and tradition in iron technology, noting the “numerous methods prevailing in the various countries of Europe, each having its own peculiar merits”. These various modes depended “on the materials, the facilities, the labourers, and their old and long established customs and prejudices”.³³

The analysis of the Kumaon and Burwai Iron Works aims to be multidimensional in several respects, spanning different levels of time and space in terms of interconnections and dependence. The approach can be termed composite holism, pointing to a method that considers a number of different factors in order to form a complex whole, moves from the micro to the macro scale, sees the history of events in a setting of slowly changing environmental circumstances, and uses an empirical factor analysis.

**INDUSTRIAL HERITAGE RESEARCH – FIELD STUDIES AND RECONSTRUCTION**

This study has been carried out within the academic field of Industrial heritage research. This discipline is intended to shed light on the social, economic and ideological forces behind industrial growth. Methodologically the physical setting and the layout and set-up of industries are seen as providing important sources of knowledge. Industrial heritage research is based on systematic field studies, but a wide variety of other sources are also used, including the archival material normally forming the basis for more traditional historical research. The aim is to find material that can be used to understand or even reconstruct physical representations no longer available for direct study. An emphasis is often placed on material such as drawings, pictures and photographs.³⁴ The discipline is related to industrial archaeology in Great Britain or United States but in contrast to this mostly more object-oriented tradition industrial heritage studies has a wider approach.³⁵

Industrial heritage research is also closely linked with preservation of the physical memories of industrial society – an undertaking that has gained momentum as an increasingly urgent task during the last thirty years, especially in Europe and North America. In 1978 the International Committee for the Conservation of the Industrial Heritage, Ticcih, was founded in Sweden as an international body promoting the preservation, conservation, investigation, documentation, research and interpretation of this historical heritage.³⁶ In Sweden, interest in the industrial heritage has also grown
dramatically in recent decades. A number of new organisations have been launched and the preservation of the industrial heritage has been made an area of priority for The National Heritage Board by the Swedish government. This growing interest makes more urgent the need for an all-encompassing interpretation of the sites.77

On the international scene, there is a strong geographical imbalance in industrial heritage studies and preservation. The focus is on the industrial histories of Western Europe and North America, and participants from these regions singularly dominate international bodies for co-operation and scientific exchange. This is worthy a note, since essential parts of the joint industrial heritage of the world are to be found in Africa, Asia and Latin America. A list of links across the world in the history of industry would be almost infinite. The colonial and industrial history of Asia, Africa and Latin America is an integrated and inseparable part of the history of industrialism in Europe and North America, and vice versa.37 An aim of this thesis is to analyse cross-border relationships.

In studies taking a comparative, international perspective it becomes more evident and articulates knowledge otherwise passed over. The move across geographical borders, implies an approach to an unknown setting that reveals characteristics unnoticed by an everyday observer.

The study of physical remains of times gone by and of the environment into which they are placed, is vital in the historian’s search for knowledge of the past.39 It sets the scene in a tangible way and it helps us to understand continuity and change. It is also often a daily and continuous reminder of our past, as well as of the relationship between man and his environment. In historical research, the physical environment as it stands and its tangible contents are vital complements, correlates and correctives to other sources.

Physical objects, artefacts, are, like a technology, social constructions, and it can be argued that they manifest social relations. Technology has been called “hardened history, the embodiment of social relationships in the past”.40 The immaterial component of technologies means that technique also carries a meaning. The design and structures of technological systems are the physical embodiment of values and social structures and are thus possible to use as guides to the past. Similarly it is possible to approach the totality of a historical landscape of industry. The stones and structures, the traces of human life have a language, and if we learn to understand it they speak to us in and convey meanings.

At the same time the character of a technology is always redefined, according to the historical context of which it forms a part. The social construction of a technology is especially apparent in cases of technology transfer, as the uses and workings of all parts of the technology must be redefined in a new geographical, cultural, economic and social setting. In each specific situation, this technology is inseparably linked to the actors and social organisations building and operating the artefacts. This, the social and human content in a technology, makes it intangible and devoid of permanence.41
METHODOLOGIES AND SOURCES

An imperative of the industrial heritage studies method is to visit the site, to see people move, to feel the climate, to experience the geography, the difference in altitude and the distances. The field study is a necessary aid in any interpretation. It gives a temporality to any photograph of an industrial site. Without a visit to Barwah and Dechauri it would never be possible to make a reconstruction or to feel any confidence in an analysis of the difficulties and possibilities encountered by the Swedes. Physical remains give us the opportunity to verify facts given in other sources or to express doubt. Without this experience of visits to the sites any description of the Kumaon and Burwai Iron Works would lose much of its reliability.

For most archaeologists the use of field studies and excavations is a necessity due to the lack of detailed archival sources, and there are well-tried methods and techniques for mapping history. In the case of industrial heritage studies there is often a wealth of archival sources, sometimes giving exact details, but often lacking a necessary context. Artefacts and physical settings are also in these cases sources of history, but as parallels to archival, written sources. They are sources of verification of information and conclusions, adding new insights and new questions. As a by-product the methods and sources used in industrial heritage research are often reflected in the method of presentation of the result of research, thereby increasing their educational value.

Field Studies

As already mentioned, field studies can be used as a foundation of a construction or reconstruction of an industry and of an industrial production landscape. In the cases of the Kumaon and Burwai Iron Works two general questions can be posed regarding this material: Are there, or were there, physical representations of circumstances of importance to the outcome of the projects? How can such representations help to provide an answer to the central question of why the projects never resulted in full and continuous production?

More specifically, a number of further questions can be put, for example: What was the layout of buildings and production of the Kumaon and Burwai Iron Works in reality? Were the plans carried out as described in the written sources? Is the social structure of the employees at the works in any way manifested in the landscape? Is the engineering culture brought in from Sweden, or Britain manifested in the historical landscapes? What observations can be made on the character of the forest resources, the ores, topography, and climate? Is it possible to trace the difficulties experienced regarding climate and topography?

The remains of both the Kumaon and Burwai Iron Works have been subjected to on-site analyses during visits to Barwah in 1997 and 2003 and to
Kumaon in 1997 and 2000. At Kumaon the field trips have involved surface
surveying, at Dechauri, Kaladhungi, Khurpa Tal and Ramgarh in the vicinity
of Nainital. At Barwah, three field studies have been carried out. In 1997 I
visited Barwah, measured the site of the ironworks and visited mining sites
with the principal of the Governments boys’ higher secondary school located
at the site of the Burwai Iron Works and other local guides. Three years later,
in May 2000, Jayashree Bhatnagar made an independent field study. In 2003
I made a return visit to the site in order to check some of my earlier observa-
tions.

At Barwah, large sections of the central part of the ironworks are still stand-
ing, partly in ruins. The equipment has been removed, but the furnace shaft
itself is preserved. At Dechauri, almost no part of the works is still intact, but
there are numerous remains, either as traces in the ground or as parts of later
buildings. Without actual archaeological excavation this permits measure-
ment and other kinds of physical examination.

Just as ordinary archival sources need an active use of source criticism, the
interpretation of the historical landscape of an industry necessitates an
awareness of circumstances that can lead to faulty conclusions. As evident in
the case of the Kumaon Iron Works important parts of buildings or other
structures might have been obliterated by cultivation or replaced by new
buildings as at Dechauri. In the physical remains there are normally no hidden
agendas in the way there are in documents, but there may also be messages
in the physical structures beyond the immediately apparent. A big industrial
edifice is not only a utility but also a manifestation of power. In order to
interpret such messages a careful analysis has to be made, placing the inter-
pretation in a correct historical setting. The way a temporary visitor interprets
a site in India is not the way it was experienced by an Indian labourer in the
1860s. Important changes might also have occurred in the landscape of the
sites to be studied. The photographs of Gustaf Wittenström show a landscape
denuded of both forests and cultivation at Dechauri and Kaladhungi, land-
scapes today lushly green of trees and fields. The region around Barwah has
suffered serious deforestation during the last decades, and it is questionable
if the present-day sense of forests consisting mainly of small and struggling
trees is really representative of the forests as they were.  

**Situated Knowledge and Oral Traditions**

Local people are important in any field survey. They have a situational knowl-
edge and often a lifelong experience of the areas in question. They know the
normalities and the deviations in the landscape. In some cases they can even
contribute narratives based on local, often oral traditions.

Only some few interviews have been held with elderly people at the sites,
however. In 2000 I spoke to two men in Kaladhungi on the making of iron
in the area. Although well over one hundred years had passed since the
ironworks were active, they still had vivid stories to tell of how iron was
made in the blast furnaces. At Dechauri Mr. Pramod Kumar Tripathi, the present farmer-owner of the ironworks area, was of invaluable help. The same applies to the principal of the Govt. Boys’ Higher Secondary School in Barwah, S. R. Charuey, and an old woman at Barwah, who told a story of a holy man, Baba Chimney, whose will had been an important cause of the failure of Mitander’s try to make iron at the site, or the married couple working in the field at Nandia, near Barwah who asked me and my companions if we were interested in resuming mining at the site.

Jayashree Bhatnagar, teacher and leader at a school for adivasi (tribal) children in the Badwani district of Madhya Pradesh, conducted an independent investigation at the Burwai Iron Works in 2001. This included short interviews in connection with visits to the sites.23

The importance of competent interpreters during field studies cannot be exaggerated. Graduate students of the University of Kumaon aided us in Kaladhungi, but albeit generous and efficient in guiding us in the local community, it was found that opportunities of obtaining more detailed information in our interviews were lost due to language problems. It has later become apparent, following a translation of the recordings made at the site, that information was lost in our conversations across and lines of enquiry were left unexplored.

### Drawings, Plans, Photographs

For the reconstruction of the ironworks there are contemporary descriptions in different kinds of archival sources: the diary of Nils Mitander; the letters of Julius Ramsay; and official reports, assessments and evaluations made by the Swedes, by their British superiors or by other British civil servants. Besides the written material there are also contemporary plans of the layout of the works and even some detailed blueprints of individual buildings. Pictures, both photographs, drawings and paintings belong to this category of archival material.

### Incomplete archival sources

The archival sources are scattered and incomplete. Isolated references to limited parts of the works supplement a few overviews of a more extensive character. In the case of the Kumaon Iron Works, there are references to plans of the layout, but these drawings seem to have been lost.24 The most extensive and comprehensive descriptions of these works were compiled when the works were due to be sold, but they do not give any detailed information on the layout as a whole.25 In the case of the Burwai Iron Works the situation is slightly better since a plan has survived.26 Other differences concern written archival sources with a comprehensive official material on the Burwai Iron Works during the time of Mitander, giving details of daily work, while this role is filled at Kumaon by Ramsay’s letters.
Analogies and Prototypes

Yet another approach to an understanding of the physical organisation of the works is to study the predominant technology in contemporary Sweden or England. This may provide a clue to which technical solutions the Swedes chose, to be verified or refuted. As references, I use basic metallurgical textbooks used in Sweden in the middle or the latter part of the nineteenth century. Johan Carl Garney, *Handledning uti svenska masmästeriet* [A Guide to Swedish Ironmaking] (1791, 1816) is a classic description of ironmaking technology at the beginning of the end of the eighteenth century. Martin Nisser, *Anteckningar in jernets metallurgi, till de lägre bergskolornas tjänst* [Notes for Use in the Junior Colleges of Mining] (1876) is reasonably contemporary with the ironworks in India and was a standard textbook on ironmaking. Hjalmar Braune’s *Om utvecklingen av den svenska masugnen* [On the Development of the Swedish Blast Furnace] (1904) gives a general view of prevailing technologies during different periods. He described technical development as especially rapid in the middle of the nineteenth century and even considered the modern blast furnace to have been born in 1859. E: G:son Odelstierna, *Jernets metallurgi* [On the Metallurgy of Iron] (1913) is not contemporary, but contains historical parts and considers older technologies. Its size (720 pages) is enough to give guidance on different details of plant used for making charcoal iron. Another work of special importance is John Percy’s *Metallurgy: The Art of Extracting Metals from Their Ores, and Adapting Them to Various Purposes of Manufacture* (1864). It was very contemporary and in part the result of a joint project in which one of the most important figures in the present study, Andreas Grill, participated. Another contributor was Christer Sandberg, Consulting and Inspecting Engineer in Britain for the Swedish State Railways.

Also of importance are experiences from previous jobs and plants brought by the Swedes to India. According to Mitander’s own notes the blast furnace and ironworks of Silverhyttan, in the ironmaking district of Karlskoga in central Sweden, was even used as a direct model for the works at Barwah. In spite of several archival searches almost no material on the physical appearance of Silverhyttan has been found. Complementary field trips and archival studies in Sweden have also been made to the home districts of the three Swedes, in the southern part of Värmeland, Närke and the western part of Östergötland, all in the iron-making district Bergslagen. During these trips I made a special visit to the site of Silverhyttan Ironworks in 2002. The works were closed in 1872; in the early twenty-first century only foundations of the charcoal sheds and the water channel remain intact. At Dahl in southern Finland, from where Wittenström came directly to India, charcoal ovens still remain and for the ironworks at Sten, drawings for the new works were made by Mitander and published in 1863 in Percy’s *Metallurgy* as an example of a typical Swedish charcoal blast furnace. These examples have especially direct relevance for the study of the Burwai Iron Works since they are either referred
to as models or were sites at which Mitander worked during the years immediately before his travel to India.

ARCHIVAL SOURCES

This present study has offered the possibility of using archival material of widely differing origin and character, from India, Great Britain and Sweden. Crossing borders has not only cast new light on historic issues, but also created important opportunities for comparative studies. This illustrates an opportunity that might too often be forgotten in academia, if compartmentalised by walls of specialisation and differences in language – and when material is fetched from only one country or one cultural sphere.²²

As will be seen below, the material available in the two cases differ widely in extent and character. This asymmetry might be regarded as a drawback, since it preclude a comparative study, but at the same time the two cases complement each other when the archival material contrasts in origin and character. Combining and comparing the two cases and their differences strengthens the totality of the analysis.

A primary material of great importance is kept in the official archives. The Board of Directors of the British East India Company and, from 1858, the Government of India in Calcutta were, like the Home Government in London, well-informed regarding the Kumaon and Burwai Iron Works, at least as long as the works were in government hands. This is evidenced by the rich primary material of official papers, often comprising long and intensive discussions, as frequent as the modes of transport of the day could allow. Many of the official records were printed in order to allow for a common frame of reference at different points in the British Empire. Today these volumes are available in different archives; here they have been studied at the National Archives in New Delhi or at the Oriental and India Office Collections of the British Library, London (OIOC). In general the OIOC seem to contain a richer wealth of material, including a unique set of documents not copied into the printed records. London was the final destination of many reports and London was where major decisions were made. Much of the primary material in the National Archives of India was not transferred when the archives were moved to Delhi with the transfer of the Government and all government offices from Calcutta in 1912. In comparison with the newly built and technically well equipped British Library in London and its well kept and meticulously registered archives, even the National Archives in New Delhi, still suffers from insufficient resources. Besides the often recurring note of “NT”, meaning “not transferred” on returned order slips when the documents are found missing, another not uncommon note when volumes are not delivered to the researcher is “brittle”. An unsuitable climate in the archives in combination with inferior paper combine to create a file that falls to pieces if not handled with extreme care or conserved.²³

Handwritten letter from Mitander.
The letters from the Swedes while in India. In Stockholm there is a large collection of letters from the Swedish engineers while they were in India. The most important collection is from Julius Ramsay to his friends in Sweden, but this is one of the letters sent from Nils Mitander to Ramsay while they both were in India. It brings the tidings of the death of Mitander’s father, and was written on 6 January 1863 on a black-edged paper. “Heartfelt thanks for the sympathetic words in your letter that arrived with the mail yesterday – I have certainly suffered a grievous blow and I had thought I would be stronger than I have now found myself to be …”. Ramsay’s papers, E1:1.07.
Another body of primary material is kept in Sweden, and is a direct result of the work of the three Swedes. These sources available in Sweden differ both in importance and character in the two cases studied. This is in part due to differences in the personalities and the way Mitander and Ramsay recorded their lives. In part it is a result of the character of the two projects, the Burwai Iron Works being a government concern, the Kumaon Iron Works, at least in the years covered here, being run by a private company.

On the Burwai Iron Works, there is quite a substantial collection of official documents referring to the works, reports both from the men involved at the site and from external observers. The works was a concern of official bodies, and thus subject to scrutiny. These documents should nevertheless be read with some caution, since they may of course have been influenced by the particular position of the writer.

Nils Mitander’s diary, mentioned above, is preserved in the Kinship Centre (Emigrantregistret), in Karlstad, Sweden, *Dagbok under resan till Indien. Och sedermera fortsättning under vistelsen derstädes* [Diary of My Journey to India. And Later Continuation during My Stay There]. Mitander made daily entries in this diary, mostly short notes, on events as they occurred. The notes vary in extent. Some are long and describe feelings and episodes in detail. During some periods he made only short summaries, covering several days. The diary is incomplete, covering the first half of his sojourn in India. It starts with his departure from Gothenburg on 21 September 1860 and ends on 20 November 1862, before the blow that eventually became one endpoint of the Burwai Iron Works. The diary of Mitander is personal and does not bear any trace of being explicitly intended for any particular reader. But, it must be added that there seems to be certain prudence with regard to details of a very personal character in the diary too. Mitander’s diary adds many everyday details that are absent from the material on the Kumaon Iron Works. Apart from the diary, the archival material left by Mitander is surprisingly sparse. According to notes in his diary, Mitander was a very frequent correspondent, but only occasional and sporadic letters and other material written by him have been found, in spite of exhaustive searches.4

In contrast to the Burwai Iron Works the official documentation of the Kumaon Iron Works from this period is quite sparse and there are only isolated documents from the company. As an aid, however, there are, as in the case of Burwai, official reports etc. from the period before and after the private era, the latter often giving a summary of events. In this case, archival collections in Sweden have been as important as the official records. Among the records kept in Sweden are the personal archives of Julius Ramsay and Gustaf Wittenström, including Ramsay’s handwritten report to the Swedish Ironmasters’ Association, collections of letters to and from friends and
business contacts in Sweden and England, drawings and other primary material.

Julius Ramsay was clearly a fluent and industrious correspondent and many of his letters have been preserved. The most important are found in a series written at regular intervals of about a fortnight, to his friends in Örebro and Nora. Before he left he had organised a group of friends as the Örebro Ostindiska Company [Örebro East India Company] or later Örebro ostindiska correspondent-compani [Örebro East India Correspondence Company]. The addressees were to share the contents of each letter and since the collection seems to consist only of originals, Ramsay must have collected his letters after arrival home. There are also a number of other letters, from and to Ramsay, saved from his time in India.

Another important source is the account of his work in India that Julius Ramsay submitted to Jernkontoret (Berättelse om under-tecknads vistelse i Ostindien och verksamhet derstädes under åren 1861–1863 [Report on the Undersigned’s Stay in the East Indies and Work There during the Years 1861–1863]), which seems broadly to be based on his collected letters. Concerning this source there are two reasons for caution. First, it was written more than a year after his arrival back home in Sweden, in Örebro in December 1864; second it was submitted to a body representing the most influential possible employers and Ramsay was most interested in obtaining new employment. Ramsay would hardly strive to be self-critical in such a document. The report has the same very typical personal stamp of Ramsay as his letters, self-confident and descriptive, although his letters do not have the underlying motive of the official report. This should give the letters a higher value as direct observation. They are intended for recipients who have to be informed of many things that are too well known to the writer of a diary to bother to repeat.

A collection by photographs of Gustaf Wittenström form an invaluable source of the history of the Kumaon Iron Works, and they are also a remarkable document of the time. On his way to India, Wittenström bought a camera in London. It is not known what kind of camera it was or even if he previously knew how to take pictures, but his purchase resulted in a number of photographs that today form unique testimony to the state of affairs in the winter of 1862/63 at Dechauri.

When Gustaf Wittenström left to return to Sweden, Julius Ramsay bought his camera, and he also took a number of photographs, although he deplored their quality:

It is astonishing to find how many amateurs here are practising photography. Most men know something about it and in a party of 8 or 10 you may be sure to find at least one amateur photographer. It is indeed a great amusement and I have a good mind to take it up again after returning home.

Of special interest are also the autobiographical notes of Gustaf Wittenström, Lefnadsbeskrivning av år 1893 [Autobiography for the Year 1893]. All this is pre-
Served in the Archives of the National Museum of Science and Technology in Stockholm.

Silences in the Sources

Different points of source criticism, briefly mentioned above, mainly concern how the writer’s societal position and conception of and relation to the recipient of his writings might have influenced his standpoint and selection of facts. A point of special importance to heed in a colonial setting is the imbalances in the totality of materials, ranging from the body of physical remains open to the industrial archaeologist to the mass of archival material. Historical research on India’s colonial past is dominated by questions either posed from a clearly British point of reference or otherwise depending heavily on sources of European origin. The whole complex of preferential right of interpretation embodied in and created by the course of history itself contributes to write the history of those in power, in this case the British and mostly men in the prime of their life. Indians, the lower classes, women, the young and the elderly, belong to the groups that almost never have a voice in the sources.

The gender and class perspectives of source material are not solely a colonial problem. The class bias of historical sources is often obvious in European historical research. But the unequal balance of power in a colonial setting and linguistic barriers may make a change of perspective more difficult in writing on Indian history.

The British, and in this case also the Swedes, wrote, administered, and thus left the decisive footprints in the archives, strongly influencing our view of the past. The character of the primary sources and the many practical problems that make them hard to access can all too easily define the scope of analysis. The British anthropologist Bernard P. Cohn has criticised this dependence by historians on material “generated by white conquerors”. In 1978, Eduard Said summarised his assessment of Western studies of the people of the world in his monumental “Orientalism”. This is a crushing critique of the agenda of studying objects, “the others”, the “Orientals”.

Subaltern studies, a school of historical writing originating in India in the early 1980s, has generated research which seeks to shift precedence in the interpretation of history from the state or elite to an analysis from below, a subaltern study. In this sense subaltern studies come close to the Marxist historians, but the genre also developed in opposition to what was considered to be the economic determinism of orthodox Marxism. A similar organised effort to base research on the writing of history from below emerged at the same time in Sweden. Since the 1970s a small group of historians, Arkivet för folkets historia [Archive of the History of the People] has been studying the history of the people, under the motto of “the people are the driving force in history”.
Even if research is intended to transcend boundaries of culture, class and gender, it easily becomes trapped in a perspective with a Eurocentric, upper-class, male, bias. Thus the stories of the Kumaon and Burwai Iron Works contain important elements of “the privileging or foregrounding involved in writing the traditional historical narrative. These narratives were generally constructed around a few Western and typically male figures; everyone else served as background.”

Even the basic question in this research is in itself defined by British interest, that is to say Eurocentric: Why did a European technique, brought in by the British, fail to work?

But the primary material is also in itself fragmentary and incomplete. Any social group other than the Europeans is usually missing from the primary material. In the sources the Indians are anonymous and silent, and there is no information on where they came from, or who they were – and never more than a part of a sentence on their terms of employment. As Ian Kerr noted with resignation in his work on the construction of the Indian railways: “Nineteenth-century construction workers will always be mute: people spoken of, who left no first-hand accounts of their own.” But this is, in part, an exaggeration. Historical research can help to give a voice to seemingly mute witnesses, sometimes through the medium of other actors on the stage of history. Points of conflict and contradiction, which are described by the Europeans and reflected in the sources, give a first opportunity of constructing a perspective “from below”, since by their very existence they demonstrate the presence of opposing interests.

It is with a deep feeling of dissatisfaction and imperfection that I have become aware of my own Eurocentric perspective. By acknowledging bias in the questions and bias in the sources, I wish at least to share a fundamental critical awareness of the problem with the readers of this thesis. The ironworks projects did not take place in a vacuum, but have to be studied in a complex context of geography and nature, of socio-political relations and culture. A one-sided, singular and Eurocentric view of history would misrepresent the facts of history and regenerates a structure of one-sided dominion.

On Language, Place Names and Units of Measurement

This thesis has been written in English, which readers may already have realised is not my mother tongue. To rectify the most obvious shortcomings the text has been checked by Bernard Vowles, although to a tight time limit. The author has also translated the quotes from Swedish. Most sources in Sweden are in Swedish, and quotations used have been translated by the present author. The translation of the many personal comments of Mitander, Ramsay and Wittenström has caused particular difficulty, since such contemporary texts “give a flavour of that particular and peculiar language that reveals so much of the actors’ own fundamental beliefs through style, inflection and
content.” All translations have however been checked against the Swedish originals by Bernard Vowles.

In some cases explanations of Anglo-Indian expressions have been collected from Hobson-Jobson, *The Anglo-Indian Dictionary*, in which cases the spelling in this dictionary has been used.24

There was no standard practice in the transliteration of local place names in the nineteenth century. Dechauri could be spelled “Dechourie”, “Dech-Chowrie”, “Dechowree”, “Dechourke”, “Dechowrie” etc. Barwah could, as is evident from the very name of the ironmaking company, be spelled “Burwai”, and the spelling “Burwy” was also used. Another very important geographical feature that appears in different spellings is the Narmada River, often spelled “Nerbudda” or “Narbada”. Usually such shifts do not cause any serious problems, but in some cases uncertainties emerge. The interpretation of handwritten sources is rendered more difficult and certain place names have not been given a positive identification. This was the case when sites of mines and charcoal burning sites were to be placed geographically. Some names might also have been used for only a limited time. The spelling of place names used in this paper is that currently used in official Indian maps: Barwah, Choral (River), Dechauri, Kaladhungi, Khurpa Tal, Nainital, Narmada (River), Ramgarh, Ramganga (River) etc. Some relatively recent changes concerning some of the largest cities of India illustrate a similar problem. In this book Bombay (Mumbai), Madras (Chennai) and Calcutta (Kolkata) are used, consistent with the usage of the time described. When sources are quoted, the original spelling in the primary source is used, but the official spelling is given in brackets. In some cases the Himalayan Gazetteer has been used in order to arrive at a uniform spelling. This is the case with Bhabar, the lower, often wooded, stretch of the lowest hills bordering the plains.44 Kumaon as used in this thesis denotes the province of British Kumaon. Together with the province of Garhwal to the west this region is today Uttarakhand.

In the case of Barwah there is no self-evident geographical location in a region or province, stable throughout history, as there is in the case of Kumaon. This will be explained in more detail later, but I have chosen to say that Barwah is a part of Nimar.

Individuals in official papers are normally only noted by their initials (W. Sowerby, H. Drummond etc.). When known, their names have been written in full (William Sowerby, Henry Drummond etc.).

As a uniform denomination of the British long ton (1,016 kg) and the metric tonne (1,000 kg) the word ton has been used. In no case the difference between the long and the metric ton is of any significance for the arguments and in most cases the numbers in themselves carry a much bigger uncertainty. With some few exceptions, abbreviations and acronyms are only used in the footnotes.
Principal Aim
and Questions at Issue.
An Analysis
from the Local to the Global

As outlined in the Preface, I started the journey of which this thesis is a part, from the tangible manifestations of power and work at the local level of the Steel Mill in Fagersta, Sweden. From there I raised the perspective and crossed boundaries in two directions, geographically to India, backwards in time following the traces of three Swedish metallurgists and reaching the historical landscapes of two ironworks in Barwah and Dechauri.

For this thesis I have also tried to continue this journey in time and between continents, but now with the Kumaon and Burwai Iron Works as empirical focal points and possibly also finding connections between these histories and our times.

The first question concerns continuity, change and the relevance of the historical study, whether the Kumaon and Burwai Iron Works were isolated episodes and unimportant exceptions and whether they have anything to tell us about our life and future in today’s world.

What is the significance of the history of the Kumaon and Burwai Iron Works and the experiences of the Swedish metallurgists Mitander, Ramsay and Wittenström for our understanding of the development and present situation of the iron and steel industry, especially in India?

The next task is to establish what really happened, to describe the general outline of the histories of the two works and to explain their fate and why the Swedes had to return to Sweden before their task was accomplished. This is the basis of my second question.

How were the Kumaon and Burwai Iron Works planned, built, used and abandoned? Why were the works never brought into full and continuous production?
Thirdly, it is my aim to use the local historical landscapes in Barwah and Dechauri as a source for writing the histories of the ironworks and to see if it is possible to distinguish manifestations of the big and international questions in the tangibility of the local setting. I try to move between the global level and an empirical study on the micro level. My conviction is that a study of historical processes gives us a unique opportunity to see small parts in bigger patterns, over time and spatially, and accordingly my third question was formed.

To what extent is it possible to read the histories of the ironworks and their fates in the tangible local settings of Barwah and Dechauri of today? How are the big questions on a macro level reflected in the historical landscapes of the Kumaon and Burwai Iron Works?

The Layout of the Thesis.
A Move in Time and Space

This thesis deals with events, situations and developments and the connections between them over a long period of time and in three different countries. The focus is on the Kumaon and Burwai Iron Works, but this history of the micro level is related to a holistic and macro level analysis, conceptually and geographically. A chronological line is drawn and to give it substance the physical evidence from a very confined spatial setting is examined. The thesis is divided into four major parts and eleven chapters.

Part I, Colonial Context and Histories of Iron, is an introductory part, placing the two case studies of this thesis in a wider context. It consists of two chapters. In Chapter 1 the study is placed in the context of the British Empire and in Chapter 2 the history of iron is described.

In Part II, The Stage and the Key Players, the thesis moves to the history of events at the Kumaon and Burwai Iron Works. The section comprises three chapters, presenting the chronology of the ironworks and identifying the key players. There is a focus on three decades in the middle of the nineteenth century, 1850–1880. The prehistory of the ironworks (Chapter 3), the recruitment of the Swedes (Chapter 4), their work in India and the late history of the works (Chapter 5) are examined in detail.

Part III, Technology Carried, is the major empirical part of the thesis and uses landscapes, structures and artefacts to analyse the process of technology transfer. It focuses on the local, micro level and comprises three chapters on the historical landscape of an iron industry, mapping the two sites using field studies and the methods of industrial heritage research (Chapter 6); and identifying the technology transferred (Chapter 7). In the last chapter of this part, details are given of the production that actually did take place (Chapter 8).

Part IV, Bonded Projects in a Global System, is the final part and here the analysis shifts to the natural resources (Chapter 9) and the social structure of
the works (Chapter 10). These two chapters put the industries into a wider physical landscape, extending to the relationship between technology, man and the almost timeless history of his environment.

The focus also moves to the economical and political sphere, and – in a geographical sense – widens to include the whole Indian subcontinent and the colonial system (Chapter 11). The analysis is raised to a macro level and the works are discussed in economic terms in relation to the markets. It also refers back to the socio-political and technological circumstances outlined in the introductory first part.

The thesis ends with a chapter of summary and conclusions.

Finally, four appendices are presented that give the conversion factors for different units of measurement used (Appendix 1); Julius Ramsay’s estimate of the number of employees at the future the Kumaon Iron Works (Appendix 2); a list of shareholders of the Kumaon Iron Works (Appendix 3); and a list of blast furnaces in nineteenth-century India (Appendix 4).
PART I

The Colonial Context and Histories of Iron

An introductory part placing the study of the Kumaon and Burwai Iron Works in a wider context
CHAPTER 1

An Imperial Context

Starting with explorers and traders in the late fifteenth century, Europe gradually increased its power and influence over the Indian subcontinent. From the mid-eighteenth century onwards, two hundred years of British rule left indelible marks on India’s history.

In order to place the histories of the Kumaon and Burwai Iron Works into a social, political and economic context this chapter sets out to give a brief summary of the history of colonial dominance over India.

Contemporary observers in the middle of the nineteenth century portrayed the owners and other representatives of the growing British factories – the millocracy – as the most important lobby group and driving force behind English colonial expansion and rule. This description has long been widely accepted, but lately new interpretations of the social context of Empire have questioned the exclusive emphasis on the industrialists. A more complex picture has been painted, of financial and trade interests joining forces with the old landed aristocracy and forming what has been called gentlemanly capitalism. This chapter also gives a short account of these new analyses and of theories concerning the driving forces behind British imperialism. What were the basic motives and what expression did they find in Indian policy?

The chapter ends with a brief outline of the two districts in which the Kumaon and Burwai Iron Works were situated. What were the basic geographical, social and political characteristics of Nimar and Kumaon?

The British colonial government was not only the sovereign power on the Indian subcontinent, but also the direct initiator of both the Kumaon and Burwai Iron Works projects. The decisions to invest in the ironworks were essentially anchored in a British context. It is therefore important to set the histories of the works against a background of the forces and motives behind British empire-building.
India – Brief Account of a Long History

The mountain range of the high Himalayas is a barrier between India and the rest of Asia, and throughout a long history successive groups of people have circumvented it by moving into the land from the north-west, heading for the fertile river valleys. Along this route, there is also an ancient history of links between India and Europe, long before the arrival of the first European ships and the advent of the late colonial era.

The road to the north-west was a trading route to Europe, just as the Indian Ocean was a link with East Africa. The armies of Alexander the Great marched this way when they occupied the Indus Valley. It became a meeting point of Indian and Greek culture. Spices, silk, cotton, opium and indigo were important trading commodities.

For Europe the east-west trade with Asia was a major source of wealth, and when Arab merchants and, later, Venetians established a monopoly of the import of goods from the East to Europe, this led Portugal to search for a trade route across the sea. And thus, in 1498, as the leader of a small fleet of four ships, and after rounding the Cape of Good Hope, Vasco da Gama reached Calicut in the far south. This was to become the start of a new era, increasing European trade, intrusion, occupation and subordination, trade, investments and construction.¹

Command of the high seas was the key to power and within a century the Dutch and the British, among others, challenged Portuguese supremacy. During the following centuries a number of European trading ports were established along the coast of India, by Britain, the Netherlands, Denmark, France and Portugal.

The English East India Company was incorporated by a royal charter in 1600 and entrusted with a monopoly of British trade with East and South-east Asia and India. In India the Company became involved in politics and acted as an agent of British imperialism from the early eighteenth to the mid-nineteenth century.

When the Europeans arrived and during the following centuries large parts of India were divided into a number of smaller states under local or regional Indian rule, in co-operation or competition. In 1526 the two centuries of Mughal rule began over a loosely assembled empire encompassing most of Northern and Central India. But by the eighteenth century the days of this rule were numbered.

Throughout the seventeenth century the East India Company slowly expanded its operations, using three important settlements as its base: Madras (1640), Bombay (1661) and Calcutta (1696). From these trading posts British supremacy gradually grew and these centres of trade and power became the capitals of three presidencies that remained the chief administrative divisions of India under British rule until the late nineteenth century.
With trade and traders as the driving force, together with individual servants of the Company in pursuit of private fortunes, the frontier of British power continued to advance across the Indian subcontinent.

By means of a combination of military power and opportunism, and taking the opportunities to exploit differences and strife between Indian rulers and deepening conflicts between contending European interests, the British moved from the position of trading partners to that of territorial power. The East India Company had a well-trained mercenary army and Indian rulers were given British military protection in return for payment in cash or land. These, at first sight, bilateral agreements were soon transformed into formal subjugation. The Indian rulers were already too weak to live up to the harsh conditions of the treaties they had signed. In the 1750s the British East India Company became a major territorial power in Eastern and Southern India. Its affairs were administered by a court of 24 directors, elected annually by the shareholders, who in this way could exert a direct influence on policies in India.

After the Battle of Waterloo in 1815 Britain ruled the seas. Side by side, the Royal Navy and the powerful British Merchant Marine became the controllers of world trade. Naval and economic power reinforced each other. The “workshop of the world” dressed the world in Lancashire clothing and Sheffield became a symbol of excellence in iron and steel. Adam Smith, professor of political economy at the University of Glasgow, became the prophet of the new era and his most important work, *An Inquiry into the Nature and Causes of the Wealth of Nations* (1776), became a bible for generations of colonial officials and statesmen. Free competition and trade, without monopolies and state intervention, would bring the greatest wealth to the greatest number. And according to David Ricardo’s theories of competitive advantage (*The Principles of Political Economy and Taxation*, London 1817) the greatest joint benefit would ensue if a division of work based on natural endowments could be established.

The East India Company had earned much of its profit from the trade in high-value luxury goods, but when this trade began to shrink around 1800 Company profits dwindled. Industrialisation stimulated bulk shipments of cheap manufactures and raw materials that could not bear the heavy overheads of the East India Company. The cost of protecting conquered territory and of military and civil charges soared and the need to balance expenditure and income grew to be a dominant theme of British policy in India. Government began to object to the one-sided exercise of power by a small wealthy elite. Under the India Act of 1784 a ministerial Board of Control was set up to oversee the Company’s administration of its Indian empire and a Governor-General, to be placed in India as the representative of the British Government, was appointed. The foundations of a civil administration were laid as supervision from London was increased. The problem of how to secure enough revenue for the administrative and military overheads of British rule governed the gradual shift of power and privileges away from the East India Company.
and from 1834 onwards it was mainly a managing agency for the British Government of India.2

THE GREAT REBELLION OF 1857–8

The imperial policies created a social structure of massive contradictions, from which a momentous internal conflict arose. In 1857 growing social discontent in India culminated in the Great Rebellion. A mutiny at three Indian cavalry regiments triggered a series of military and civil revolts across Northern India. It began when Indian troops (sepoys) in the service of the British East India Company revolted in Meerut and then spread across Northern India to Delhi, Agra, Cawnpore, and Lucknow. British rule was seriously threatened, but from the time of the rebels’ seizure of Delhi, Britain gradually organised operations to suppress the mutiny, resulting in a merciless victory in the spring of 1858. A grim feature of the mutiny was the ferocity shown by both sides. After bitter fighting, heavy casualties and brutal acts of vengeance, the uprising was crushed. An immediate result was that the East India Company was deprived the last of its power. It ceased to exist as a legal entity in 1873.3

The causes of the Indian Rebellion have been much debated, but in somewhat simplified terms it may be said to have been the result of a growing discontent – with British rule, with its westernisation and its general attack on traditional Indian values and society, and with a growing economic exploitation and the continuous replacement of the old Indian aristocracy by British officials. The rebellion might be called unsuccessful, but a most significant causality was the East India Company itself when Parliament in London passed the Act for the Better Government of India in 1858. All powers were transferred to the home Government and India became a crown colony. A Secretary of State for India was established in London. The British Crown henceforward directly and formally governed India. The Court of Directors of the East India Company and the Board of Control were replaced by the India Office in London, a separate department of state headed by the Secretary of State for India, a British cabinet minister responsible to Parliament. In India the governing powers were vested in the hands of the Governor-General (later the Viceroy), aided by a miniature cabinet, also called the Executive Council. They were directly accountable to the Secretary of State and Parliament.4

The transfer of power in 1858 created more efficient means of achieving the priorities of British policy. Confidence in India was raised and main features of economic policy were balanced budgets and free trade. The search for revenue led the Government to promote mining and manufacturing activities as well as public utilities, especially railways and irrigation. Military intervention lost its place as an established means of enlarging the treasury, and the path was instead signposted towards strategic partnerships with landholders and princes.5

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The big revolt thus resulted in substantial administrative reorganisation, but in practice the changes in British rule were subtle. The East India Company had been a commercial fiction long before it was wound up and its employees were reappointed to corresponding new positions under Crown rule. A more profound change was a new general distrust, caused by the revolt. The three Swedes came to India to build ironworks in a society marked by military presence and with open hostilities in recent memory.

APOLOGISTS AND NATIONALISTS IN THE WRITING OF INDIAN HISTORY

As outlined in the introduction to this thesis, there have been, in very broad terms, two bodies of theory attempting to explain the differences in economic development in the world. The dependistas have stressed external factors as the prime cause of underdevelopment, and the modernising school has stressed internal factors. Studies of the economic history of India show affinities with this discussion of underdevelopment in general. They can be said to take one of two general positions, imperial apology or nationalist criticism.

The apologists have argued the benefits of colonial rule, with the British bringing in civilisation and new modes of organising society and the economy, and thus paving the way for development and increasing prosperity. And when economic growth was slow, this was because of social, cultural and religious traits deeply rooted “in the everyday life, customs and social organisation of the people”. The transfer of wealth “home” to the “mother country” was said to be a return for services or capital provided by the British. The positive effects of colonial rule in the world in general have been said to have paved the way for development. Colonial rule clarified territorial boundaries and created a unified administration that combined to create a sense of nationhood and to safeguard internal peace. In the economic arena the introduction of new crops in agriculture stimulated international trade. Growing exports of these, as well as of traditional crops, earned revenue that improved standards of living. Another lasting result of colonial rule was considerable investment in physical infrastructure, notably roads and railways, but also sea and river navigation.

In contrast, the nationalist critics have stressed factors that modified or impeded possible positive effects of colonialism. British colonialism destroyed or deformed a pre-colonial Indian economy that was functioning quite well, subjected it to foreign competition and removed indigenous sources of economic growth. This interference was compounded by a drain-off of Indian resources to Britain and by the support of an unproductive British administration in India. British rule forced India to become a supplier of raw materials to British industries and a consumer of British manufactures. The dynamic of the economy was to become functionally determined by the needs of the
metropolitan economy. Any limited industrialisation was dependent on alliances with foreign firms for technology. A system of export-led dependency was developed. “[A] parasitical symbiosis was established which benefited the alien usurpers and paralysed the host, who survived under a low-level equilibrium.” In the extension of such an argument, self-government and independence became a prerequisite for development.

In part these general analytical strands are also tied to the degree of belief in the positive effects and potentials of capitalism. In 1857 Karl Marx made an often-quoted comment on the importance of the railways in India. He based his view on his general conception of an Asian mode of production, i.e. a pre-class, basically static and unchanging Indian society, and expressed faith in the dynamic and progressive opportunities offered by British capitalism:

I know that the English millocracy intend to endow India with railways with the exclusive view of extracting at diminished expenses the cotton and other raw materials for their manufactures. But when you have once introduced machinery into the locomotion of a country, which possesses iron and coals, you are unable to withhold it from its fabrication. You cannot maintain a net of railways over an immense country without introducing all those industrial processes necessary to meet the immediate and current want of railway locomotion, and out of which there must grow the application of machinery to those branches of industry not immediately connected with railways. The railway system will therefore become, in India, truly the forerunner of modern industry.

Later Marx revised this view of British colonialism. In 1879 he wrote that the railways generally gave “an immense impulse to the development of foreign commerce, but the commerce in countries which export principally raw produce increased the misery of the masses.” Marx “came to hold that far from laying down the material premises of a capitalistic society, colonial rule destroyed much of the existing productive forces, retarded the development of new ones, flung the country backward, and laid the basis of its underdevelopment.”

In post-independence India the anti-colonial emphasis has dominated research on Indian history, although the socio-cultural line of reasoning is not forgotten and a static social structure, especially the caste system, is named as a major obstacle to development. Often external and internal causes of underdevelopment are seen as mutually reinforcing. The economic historian Sabyasachi Bhattacharya belongs to those who today emphasise the need for a balanced analysis. He maintains that the disjuncture in Indian history, the shift from a highly developed ancient culture to underdevelopment, cannot be explained only by invasions and foreign exploitation. Citing Damodar Dharmanand Kosambi’s work on ancient Indian history he traces explanations further back in the past. A long “degeneration” of Indian society and a technological stagnation can be attributed to the caste system. Amiya Kumar
Bagchi, one of the most influential present-day analysts of Indian history, has also underlined the importance of both the socio-political structure and the totality of the colonial system in any analysis of Indian development.17

The Kumaon and Burwai Iron Works were development projects introduced by British interests and became a point of contact between colonialism and Indian society. In their histories it is possible to see an interaction between destructive and positive effects of British dominion and also to find examples of a readiness of Indian society to incorporate new ideas as well as the obstacles raised by the legacies of the past. Within this framework, the histories of the Kumaon and Burwai Iron Works cross over to areas which are normally neglected in the writing of history of technology. They include conflicts in the transfer and non-Western use of technology rather than the process of innovation or the emergence of new technologies in developed societies. The histories are a study of “failures” rather than a story of success, and also incorporate an active discussion of capitalism, of which the colonial system can be said to have been an expression which is mostly taken for granted or seen as some kind of externality.18

The Builders of the Empire

British imperialism in India has long been the subject of a wide-ranging debate concerning its origins, methods of working and consequences. One powerful and influential theory of British imperialism in India was formulated by Karl Marx, who viewed the Indian Rebellion of 1857 and the transfer of administrative control in 1858 as a symbol of the spread of industrial capitalism. For him the 1850s were a decisive period of transition, when land interests and the obstructive “moneyocracy” and “oligarchy” of the City of London yielded to the progressive “millocracy”, that is the industrial capitalists of Manchester and its allies. This view was also coupled with a conviction of the importance of British intrusion in India in furthering economic development.19

A leading alternative to this interpretation of the Empire’s base in England was presented in 1993 by two British historians, Peter J. Cain and A. G. Hopkins, in British Imperialism, 1688–200020 They traced the ruling elite to a synthesis of the older landed aristocracy and the newly rich of the City of London controlling the service sector, including merchants, banking, insurance, shipping and the like, and presented the concept of “gentlemanly capitalism”. A consequence was the downplaying of the Industrial Revolution as a factor in British expansion and of what Marx called the millocracy, the industrialists of the provinces. The industrial bourgeoisie became an outsider.21

For example, Cain and Hopkins rejected Marx’s analysis of the Great Rebellion, and argued that the change rather illustrates the successive shift of power to the new alliance of gentlemanly capitalists. Principles of sound
money, free trade and efficient administration were gradually impressed on India and “the official mind became increasingly concentrated on maintaining the creditworthiness of the Raj and on ensuring that India’s mounting external financial obligations were met.”

**THE GENTLEMANLY MERITOCRACY AND INDIA**

The transition to Crown rule marked the “assumption of authority by the new gentlemanly meritocracy and its ‘like-minded’ associates in finance and commercial services, the quantitative expansion of the economic influence they represented, and the installation of the Gladstonian orthodoxies of free trade, sound money and balanced budgets. In India, as in other parts of the empire which had to make large remittances to London, financial priorities overrode the claims of British industry.”

The union of old landed gentry and new service interests was a gentlemanly elite with a common view of the world and of how it should be ordered. Gentlemanly capital “set the cultural tone, was closer to the centre of power and was the dominant influence upon the expression of that power overseas.” The most senior British officials, at home and abroad, were also drawn from the ranks of those with close ties with landed, rentier and service-sector wealth, rather than with industry. A gentleman adhered to a code of honour that placed duty before self-advancement. He required an income and preferably substantial wealth, but he was not to be sullied by the acquisitive process. During the nineteenth century landed wealth gradually gave way to wealth generated in the service sector. The imperial mission was the export version of the gentlemanly order. Lesser mortals needed uncompromising values and “the reforming principles of political economy were eagerly applied to distant land: approved property rights, individualism, free markets, sound money and public frugality provided discipline and purpose for both moral and material life.” A Parliamentary paper of 1854 even stated that gentlemen were ideal administrators because of “their capacity to govern others and control themselves, their aptitude for combining freedom with order, their love of healthy sports and exercise”.

**INDIA – A STRATEGIC CROWN JEWEL**

Britain’s rule in India was of vital importance in the British Empire. It was the “crown jewel” and the base from which her control and influence spread further east and it was her wall of defence against a possible further advance of Russia, past Central Asia. The Indian army became vital to Britain’s determination to maintain her position east of Suez, and therefore, without the revenues to sustain the army, Britain’s position as a great power would have been seriously impaired. The army and the civil service were the main instruments of British policy in India. The number of British officials was
small, but they controlled the means of coercion and they collected and allocated India’s vast revenues. From the 1850s appointments in India became a large, vested interest of the educated upper middle class in England.  

The central dilemma of policy remained the same after 1858 as before: how to raise revenue enough to sustain the Indian army and to meet other financial commitments, but without provoking internal discontent in India. The lessons learned during the Rebellion demanded a new policy. Military expeditions could no longer be used since the risks and costs had become bigger than possible gains. As raising taxes on land was ruled out because of the risk of civil disorder, the general road chosen was to raise revenue from foreign trade. This was done by making efforts to increase agricultural productivity, which was a long-term task, but primarily with pump-priming development activities, in other words Government investment expenditure designed to induce a self-sustaining expansion of economic activity. The closely connected railway construction in India from the 1850s, the rise in consumer demand in Europe and the opening of the Suez Canal in 1869 reinforced these efforts and the results were to be impressive. During the second half of the nineteenth century India became fully incorporated into the international economy. Agricultural exports increased dramatically: besides opium, industrial raw materials such as jute, cotton and indigo, and foodstuffs such as tea and rice. Jute and cotton were also processed in a growing textile industry. The trade links between India and Britain were to grow to great importance. In the 1890s, 85 percent of all imports to India came from Britain and India was Britain’s most important market in the Empire.

During the years that followed the Indian Rebellion the British Raj was gradually confirmed with the exclusion of an administration already established during Company rule.

**CONSOLIDATION, PUBLIC WORKS AND TECHNOLOGY TRANSFER**

Before the Rebellion, Dalhousie, the Governor-General from 1848–1856, had made Western technology, especially in the field of communications, the keynote of an economic development plan. After the Rebellion Britain began forcefully to consolidate her supremacy with an even wider variety of big public undertakings, establishing an infrastructure facilitating control, transport and commercial exploitation – a process in which the ironmaking projects of Barwah and Kumaon became parts. The aim was twofold: to strengthen the institutional basis of political stability and to expand trade as a means of increasing revenues.

Until the mid-nineteenth century these major public works were undertaken by military personnel under the control of the Military Board at Fort William in Calcutta, but in 1854–55 a Public Works Department (PWD) was
established. Under its administration a multitude of big investments were made, notably in improving transport and communications by building harbours, canals, railways, telegraphs, roads and bridges. This was a prerequisite for fast movement of military personnel, and for efficient transport of primary products from India and of industrial products to India. Irrigation, closely connected to the production of crops to be used by industries in Britain, was another huge undertaking. The Public Works Department was also in charge of the investments at Kumaon and Burwai. The transfer of iron technology to India was a part of a wide-ranging process of technology transfer from Europe (England) to India and the Public Works Department was the foremost agent of technology transfer to India.

Industrialists, Gentlemen and India

Britain’s export industries gained greatly from the extension of British sovereignty over India and the transfer from Company to Crown rule in 1858. According to Cain and Hopkins the full return on political investments was not realised until the second half of the nineteenth century. Then India became a vital market for Lancashire’s cotton goods and Dundee’s jute manufacturers, while steel producers in Sheffield also increased their stake in the subcontinent.

A basic dividing line between Cain and Hopkins and earlier analysts is the downplaying of the importance of the industrialists. Their main arguments are two.

First they argue that it has proved impossible “except in one or two exceptional cases, to establish that the business agitation which was so apparent in times of crises, both in Britain and on the frontier, actually influenced the policy-makers”. Manchester provides a crucial test of the extent to which industrial lobbies were able to influence imperial policy. Several times during the second half of the nineteenth century, import duties on textiles to India were reduced, following strong protests from Manchester. In spite of this, Cain and Hopkins argue that it is wrong to conclude that the millocracy had won a dominant role in the formulation of economic policy. The successes of the Lancashire lobby “were achieved largely because its aims were congruent with those of India’s rulers”. Yes, it is true that Manchester also pressed for public works, but these had already been an essential component of Government policies since the first decades of the nineteenth century. The Government did not need to be persuaded of the importance of railways in opening up the country. They were already a part of the Victorian conception of civilisation.

Secondly, Cain and Hopkins argue that in important cases Government policies were directly opposed to the interest of the industrial capitalists. Temporary inducements were offered to help prime the pump, but they were quickly discarded when fiscal problems arose. The Government of India re-
fused to provide financial guarantees for the construction of new railway lines during the period of financial stringency that followed the Indian Rebellion, despite the fact that pressure from Manchester was at its height. Balancing the budget was a higher priority. In 1862–63, just at the time when crucial decisions affecting the Kumaon and Burwai Iron Works were being taken, the Manchester lobby was firmly put in its place. Accumulated frustration led Manchester to campaign for the removal of the Secretary of State, Sir Charles Wood, but Prime Minister Palmerston shared Wood’s view of “parvenu capitalists” and he fully endorsed Wood’s view that “India was governed for India and . . . not for the Manchester people”.

LANCASHIRE AND INDIA

The emphasis on gentlemanly capitalists as the prime movers of imperialism has caused considerable research and debate and it raises a pertinent question of the reasons behind the efforts to build the Kumaon and Burwai Iron Works and the connection between them. What was the relationship between the industrial interests of England and the decisions taken in the cases of the Kumaon and Burwai Iron Works? The connection between the textile industry in Manchester and the centre of power in London seems to be rather well investigated, but much less seems to have been said about iron and steel and, for example, the Lancashire capitalists. The case of iron and steel also seems to be more ambiguous, the interests less clear cut.

The dominance of fiscal considerations over British home interests, which Cain and Hopkins describe as decisive when the tariffs on cotton goods were set in 1859, 1862, 1894 and 1903, was not of the same character in the case of iron and steel. In the case of cotton goods there were two opposing policies, raised import duties for fiscal reasons on the one hand free trade in the interest of the cotton manufacturers in Manchester on the other. In the case of iron and steel, British iron producers were of course also keen to see import duties to India kept low. They also opposed any Government intervention to support a new iron industry in India, a potential competitor that could win important shares in a lucrative market.

On the other hand a main interest of the Indian State, as a major consumer of iron goods, was to keep prices of iron and steel low. Low prices kept Government expenditure down. This could be achieved in either of two ways. On the one hand a new domestic iron industry could be fostered in India, which could sell iron without the expense of transport.

“Indeed, since local manufacturers economised on imports, helped to balance the budget and hence maintained the confidence of overseas investors, the Government of India had good reason for encouraging them. As Lord Northbrook observed in 1874: ‘I am very happy also on the progress of Indian manufacturers ultimately. Whisper it not in Manchester’. In the 1880s, Lord Ripon’s policy of favouring local manufacturers for government purchases
stimulated a wide range of industries and culminated in the development of a state-operated iron and steel plant.”

However there was a delicate balance to be maintained between expenditure and income. In the short run a newly established iron industry would need state support and protection behind a wall of duties. Costs could thus also be set off against possible increased income from duties. But this argument only held true as long as domestic production could compete with imports by lower prices. The second way of keeping Indian Government expenditure down was by setting trade free and opening up India for an import of cheap British produce. Can this ambivalence be seen in the histories of the Kumaon and Burwai Iron Works?

A COMPLICATED BALANCE

It may be hard to determine the causal relationship between the industrial lobby and the policymakers, but it should be noted that other observers, concentrating on this very issue, have been convinced that such a relationship exists. There was a powerful group of advocates of commercial free trade in England, with an imperial interest in limiting competition and securing markets for British industry. The cotton spinners of Lancashire and the iron and steel producers of Sheffield had fundamental common interests in this respect. They viewed India as a vital future market and considered it to be the duty of the Government to facilitate trade contacts and market penetration. This was to be done by means of better information about the tastes of Indian buyers and above all by fully fledged investments in infrastructure such as railways, roads, bridges, harbours etc.40

Political considerations complicate the balance. A cut in India’s tariffs in 1862, including reduced import duties on iron, was partly a move to increase the metropolitan grip when the Indian administration appeared to be strengthening its authority, and partly a move to capture the important Lancashire vote at a time of political uncertainty. In a similar way, the reimposition of cotton duties in 1894 could be considered a way of blunting the edge of nationalist opposition in India. There was a political balance to be maintained between cutting tariffs and giving free-trading liberal interests a stake in the Empire and alleviating the burdens placed on the Indian budget by the army and the bureaucracy.41

In an evaluation of the stake of domestic interests in the Indian market, it is, though, not enough to look at trade statistics alone. Equally important are the expectations of a future of expanding markets and shares. India’s share of Britain’s exports reached a peak in the early 1880s but then fell, partly because the market share captured by other countries increased, partly because the Indian market did not expand as rapidly as other markets. Belgian iron and steel, in particular, provided increasing competition after 1900. The expectations had been bigger than the eventual reality.42
However it is very important to remember, as noted by Cain and Hopkins, that British capitalism in relation to colonial India was neither Manchester, Lancashire nor British industry as a whole. As Cain and Hopkins point out, India attracted an increasing flow of direct investment from London, typically in commerce, service and plantations. Between 1865 and 1914 India was second only to Canada as a recipient of British investments. This can also be seen as a central part of colonial policy. The Indian Government had to keep a firm grip on expenditure, but also to generate a substantial surplus in her foreign trade in order to make up for her obligations to external creditors, which during the second half of the nineteenth century averaged nearly half the value of her exports. These “home charges” consisted of profits and interests on investments as well as pensions and the like to former servants of the Empire, payment for military equipment and stores, and interest on the public debt. India had a large trade deficit in her bilateral trade with Britain, but the total system of free trade allowed the system to work. Surpluses in India’s trade with the rest of Asia and Europe made up for the deficit and more. And the ensuing net remittances to Britain made it possible for Britain to settle her own deficits in her trade with North America and Europe.\(^4\)

### Kumaon and Nimar

- **Where the Works Were Placed**

Today the population of India is well over the one billion mark and the nation stretches from the high Himalayas in the north, across deserts and fertile river valleys, past the tropical forests to Cape Comorin or Kanniyakumari more than 2000 kilometres to the south. Within these geographical limits of present-day India, history shows a complicated and ever changing shift of boundaries and influence between different political entities with different kinds of sovereignty.

Today, the Republic of India is one of several sovereign nation states in the subcontinent that was the British Raj. It is itself a federation of twenty-nine states and six union territories with a relatively high degree of independence. Added to this is the diversity of cultural, linguistic and religious traditions, dividing the subcontinent into different patterns. Kumaon Iron Works was placed in the administrative division of Kumaon in present day Uttarakhand; the Burwai Iron Works was in the district of West Nimar present-day Madhya Pradesh.
KUMAON

In November 2000 Uttaranchal, of which Kumaon is the easterly part, became the twenty-seventh state of the Indian Union. The other administrative division of the state is Garhwal.44

Kumaon is situated in the Himalayan heartland, bordering with Nepal to the east. The huge variations in altitude within this region, more than 7,500 metres in the short span of less than two hundred kilometres, have resulted in a corresponding extreme diversity of flora and fauna. From the lower parts of Tarai on the border of the Gangetic plains, past the wooded Bhabar district, the region reaches the great Himalaya up to 7,816 metres above sea level (Nanda Devi) and the trans-Himalayan region touching the Tibetan plateau. Kumaon is on the geologically still dynamic northern margin of the Indian continental shield.

The distinct nature of the geographical borders has meant that the area known by the name of Kumaon has remained fairly constant throughout history, but in contrast ethnic diversity is great since Kumaon is border country. It borders not only with the rich Gangetic plain but also with the immense regions beyond the Himalayas and through the centuries it has been a melting pot of many influences.

Within present-day Uttaranchal, two important medieval dynasties merged, the Chands in Kumaon and the Panwars in Garhwal. The contradictions between these two dynasties and the limitations of feudalism weakened and divided them, circumstances that made the region a relatively easy prey for Nepalese Gorkhas advancing into the region around 1800. “Thus the feudalism of the Chands and Panwars was replaced by the tyrannical and oppressive military feudalism of the Gorkhas.”45 During this period thousands of people were sold as slaves or forcibly sent to Nepal.

After the Nepal war of 1815 British colonialism reached Kumaon and the rule of the East India Company replaced the reign of the Gorkhas. “The colonial system, which worked … was a new and oppressive system. … Although on the surface it looked as though the colonial system had put an end to feudalism, yet in reality, the new system carried within it many of the characteristics of the old system.”46

Initially the people tolerated the new rule as a relief from previous oppression. Colonial rule respected many characteristics of the old society and introduced novelties such as roads, schools and hospitals. Kumaon was also included in a completely new system of surveying, taxation, and new laws laying down the rules for land, trade, and excise. The bureaucracy was small and the region was governed by a succession of powerful commissioners with Gardener, Traill, Lushington, Batten and H. Ramsay holding the post during the period of the pre-history and history of the Kumaon Iron Works.

The Indian Rebellion spread throughout the plains, but calls for insurrection went largely ignored in the hills. Memories of Gorkha oppression and British deliverance kept Kumaon and Garhwal loyal. The local ruler, King
Sudarshan Shah, even supported the British with men and materiel. He also deployed troops to protect the Europeans who had fled the plains for Mussoorie and other hill stations.

Among the semi-urban literate an opposition however became visible in the press, but also in the villages discontent grew, especially regarding forced and unpaid labour (begar) and the infringement of forest rights, creating reserves and protected areas in the forests, which became a direct attack on the resource base of the mountain people. The total burden on the peasant’s income increased with the colonial government. The protests were voiced in important popular movements, but not until early in the twentieth century.

The Kumaon Iron Works consisted of four sites. Dechauri was the main site and the place of work of Ramsay and Wittenström. At Kaladhungi, approximately ten kilometres east, there were four small and inferior blast furnaces.
Until the autumn of 1862, this site was leased out to Mr. Davies, a blast-furnace keeper from Wales formerly employed at Dechauri. Khurpa Tal was mainly constructed as a retreat for the European workers at Kaladhungi. Two small blast furnaces were built but only cupola furnaces were used. At Ramgarh, further up in the mountains, there were rich finds of good ore. A blast furnace was begun, but never finished.

NIMAR

The name and boundaries of the geographical or administrative areas in which Barwah and the Burwai Iron Works were situated have changed over the years and easily give rise to confusion. Barwah has been on the border and subjected to several territorial and administrative shifts. This means that for the area in which Barwah has been situated there is no consistent administrative designation, such as there is in the case of the Kumaon Iron Works.

In the days of Mitander it was part of the autonomous princely state of Indore ruled by the Holkars. Malwa was vaguely the land north of the Narmada River and the Nerbudda territory was another vague geographical delimitation, this time of the region around the Narmada River. The Central Provinces was the British administrative region, with its boundaries changing over time.

Today Barwah is in the most northerly part of the district of West Nimar, which lies north of the Narmada River. But it is situated almost on the district border and historically its ties are closer to Indore in the north. In a geological sense it should rather be described as a part of the Narmada River Valley, below the southern outskirts of the Vindyan hills that form the northern confinement of the Narmada River. For ease of reference the focus of this thesis, the area where the Burwai Iron Works was situated, is named Nimar. The correctness of such a denomination is shown by the fact that the ironworks in some instances were called The Nimar Iron Works, also in public documents.48

The whole of the valley north of the Narmada, except what was called the Chandgarh Forest, was divided between different chiefs and rajas, the most important of them being the Holkars.49 The Chandgarh Forest was in the hands of the forest department. In the forests the population was scanty, mainly tribal. Barwah is situated on the border between two distinct areas. To the east is a barren, jungle-clad hilly tract of sandstones and quartzites, sparsely populated and little cultivated, a low jungle-clad plateau cut by gorges and ravines. Here the geological formations of the Vindhyans and the Bijawars come in. To the north the Vindhyans rise on average some 400 metres above the forest. An important geological constituent of the Bijawars is a breccia, in which iron ore, mainly hematite, is abundant.50 West of Barwah commences a plain covered by alluvial deposits, some 30 kilometres across at its widest. The black soil is very fertile, at the time considered to be well suited for the growth of poppy, wheat and other cereals.51 This part of the country is well populated.
The town of Indore, which was a trading centre of considerable importance, is approximately 62 kilometres north of Barwah. Indore became the capital of the princely state of the same name. When the British, led by John Malcolm, had militarily defeated the Holkars in 1818 the Queen of Holkar was obliged to sign a treaty through which control of the Holkar state was handed to the British East India Company.\footnote{52}

The state of Holkar or Indore had its capital in Indore, approximately sixty kilometres north of Barwah. It was under British administration after 1823, and a British Resident was placed in Indore. The princely state itself consisted initially of a number of geographically scattered areas. In order to make the Indore state more compact various exchanges of territory were effected between 1861 and 1868. During the period during which Mitander was at work in Barwah, Nimar was under the Governor-General of Central India (1854–1864). In 1868 the Barwah area was brought into the Holkar state of Indore as a part of an exchange.\footnote{53}

In the late 1850s Indore took an active part in the uprising against the British. The British Resident in Indore, Colonel Henry Durand, had earlier brushed aside any suggestion of a possibility of insurrection, but when the uprising started in July 1857 thirty-nine Britons were killed and the Resident only just managed to escape. Some months later the British had subdued the opposition, Indore was reconquered and the leader of the insurrection, Saad Khan, was sentenced to death and executed. In the aftermath of the uprising, and because of its strategic placing, the British military presence in Nimar, and in Barwah, remained large.\footnote{54}

**SUMMARY DISCUSSION**

**The Forces Behind the Power**

When Vasco da Gama first set foot on Indian soil in 1498, a new road to rewarding trade was opened. Initially all Europeans were guests and trading partners of marginal importance on this subcontinent of long histories, but in due course the Portuguese, the Dutch, the French and – above all – the British, became conquerors and masters. Established in 1600, the English East India Company became the tool of British rule, but its sovereignty gradually declined and from 1858, after the violent conflicts of the Indian Rebellion, the British Crown reigned supreme over India.

The London Government had the ultimate power and this was exercised through the India Office, headed by a Secretary of State for India. In India a colonial government resided in Calcutta. It was responsible for putting central policies into practice and under its administration were armed forces and a large number of civil servants. The Public Works Department (PWD) was responsible for building an Indian infrastructure, including the railways and, of special importance in our case, the build up of the ironworks.
According to an earlier and dominant theory the industrial capitalists of Britain and their allies, the millocracy, were the major social force determining colonial policies. New research has led to a revision of this view and has instead placed the emphasis on the importance of “gentlemanly capitalism”, the alliance of the landed gentry and banking, trade, shipping and other service interests of the City of London. This alliance was to form the style of colonial rule, combining moral and cultural guidelines with more openly economic interests. The creation of a sound basis for public expenditure, mainly by increasing incomes from foreign trade, became a long-term policy. In this context the Kumaon and Burwai Iron Works can be seen as a part of a general policy of maintaining British power over India, but the foregoing raises two further questions. How are the ambiguities and changes in relation to these works to be explained? How were the interests of the millocracy and of gentlemanly capitalism expressed in the histories of the ironworks? And was there really such a dichotomy between the millocracy and gentlemanly capitalism as is now depicted in recent research?
The Making of Iron and Steel

PART 1

Iron, Steel and Its
Content of Coal

The making of iron and steel are complicated processes, in which the properties of the end product are dependent on a wide variety of factors. Every shift in the quality and quantity of the raw materials and every change in temperature, in mechanical processing and in the timing of different processes influences the smelting temperature, hardness, toughness, strength and corrosive resistance of the iron and steel produced. The contents of other elements are also highly important. Some of these elements may be desired, and in modern steelmaking even added; they include silicon, nickel, chromium, tungsten etc. Other elements, such as phosphorus and sulphur are to be avoided since they seriously impair the quality.

The carbon content is the single most important defining factor in different kinds of iron and steel. It can be changed according to the processes, as can the basic microstructure of the metal produced.

Wrought iron is a very pure iron that contains very little carbon, less than 0.1 percent. It is soft and ductile and can easily be forged into a wide range of goods. Pure iron has a melting point of 1,538 degrees centigrade.

Pure iron is greatly hardened by the addition of small amounts of carbon. Steel is a malleable alloy of iron and carbon containing up to about two percent carbon. It can be wrought or rolled. These kinds of steel are today called carbon steels to distinguish them from modern special steels that contain other alloying elements. Stainless steels for example contain 16–26 percent chromium and up to 35 percent nickel. The properties of a steel may be further modified by heat-treating, by mechanical working, cold or hot.

Cast iron is hard – and brittle – due to a carbon content of approximately two percent or more. Pig iron, produced in the blast furnace has a carbon content of approximately 4.5 percent and has such characteristics. The smelting point rises as the carbon content is reduced and pig iron has a relatively low smelting point, 1,150 degrees centigrade.
Direct and Indirect Ironmaking – Bloomeries and Blast Furnaces

The first stage in production of iron is to refine iron ores found in nature. In this process two basic routes have been used in the history of iron-making, the direct bloomery route and the indirect, blast-furnace route.

**The Direct Bloomery Route**

Before sufficiently high temperatures to smelt iron ores could be achieved, wrought iron was produced in a solid state. Small quantities of selected iron ore and charcoal were fed into a furnace built of fire-resistant clay. Foot-operated bellows were used to produce a draught for the fire and the oxides in the iron ores were reduced. The result was a half-melted spongy and malleable mass of iron, a bloom. It was a mixture of solid iron, slag and unburned pieces of the charcoal, which had been used in the process. The slags were beaten out by hammering and successive re-heatings of the bloom. The iron produced was malleable and could be used without further treatment.

The Indian ironmakers that delivered the material for the iron pillar in Delhi in the late fourth or early fifth century used this *direct process* as did the Vikings in the ninth and tenth century.

**The Indirect Blast-Furnace Route**

In Europe a new technique of making iron, the blast furnace, can be traced back at least to the twelfth century. A blast furnace is a vertical shaft furnace in which flow of air is introduced under pressure from the bottom. Iron ore, charcoal, and flux are fed into the top.

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*The principle of making iron in a blast furnace. Drawing by Jan Lisinski, in Bohm, The Swedish Blast Furnace in the 19th Century, (Stockholm 1975).*
An efficient blast gives the process high temperatures, completely melting the ores, and fluid slags and iron can be drawn from the furnace. The process was continuous and the furnace did not need to be shut down while it was running. This increased production and saved fuel. The development of the blast furnace, in Europe sometime during the twelfth century, was a technological shift of paramount importance and the blast furnace soon became widely used and the commonest method of choice. This technique is still totally dominant in world iron production.

The iron tapped from the blast furnace was pig iron, which had to be further processed in a second stage to reduce the high carbon-content and give a usable, malleable iron. The process thus came to be called the *indirect process.*

Fining was done in hearths combined with different methods of hot forging.

In Sweden it is possible to trace the history of the blast furnace to 1200 ± 100 AD, but India never saw the shift to blast-furnace technology even if there is some evidence in written sources that molten iron could be produced in traditional bloomery furnaces. Indian iron production continued to rely on the bloomery process.

**Charcoal and Coke in Ironmaking**

Charcoal was long the basic fuel used in iron making, but from the end of the eighteenth century coke became the dominant fuel in most parts of the world. Both charcoal and coke have their origin in the organic kingdom.

Charcoal was made by heating wood in the absence of air, either in heaps or in specially designed furnaces. In some parts of the world, charcoal retained a position, both because of an abundance of forest resources but also because of its purity. The last charcoal-fired blast furnace in Sweden, in Svartå, was blown down in 1966. In England charcoal blast furnaces were already close to extinction early in the nineteenth century and in 1872 there were five small “relict” charcoal furnaces still in blast.

In Britain the expanding iron industry made demands on the nation’s timber that the forests could not bear and from the early 1620s the problem of charcoal shortage became steadily worse. Coal (mineral coal) was a likely substitute but attempts to use it for ironmaking were long unsuccessful. Iron combines easily with other elements, among them sulphur, making it “red short”, i.e. it crumbles if hit by a hammer while red-hot. Phosphorous, on the other hand, makes iron “cold short”; it crumbled if hit while cold.

Abraham Darby in Coalbrookdale found the solution in 1709, by coking the coal, in other words heating it to drive off unwanted impurities such as sulphur, after which it could be used successfully in the blast furnace. During the eighteenth century knowledge of this new method of making iron spread, but two major problems remained. Charcoal was still needed to convert pig
iron into wrought iron and dependence on waterpower still restricted production. When these problems were solved in the late eighteenth century with the reverberatory furnace (see page 208–210) and steam power, a new grand expansion of ironmaking in Britain began.

An important advantage of coke was its strength. It could bear heavier loads than charcoal and allowed the building of taller blast furnaces. Only certain types of coal, however, acquired the right physical structure in the coking process, that is, caked into solid lumps. This kind of coal was a relatively scarce commodity.
CHAPTER 2

Notes on Iron in India, Sweden and Britain

In the mid-nineteenth century Sweden, Britain and India were still basically agrarian societies, but, unlike India, Sweden and, even more so, Britain were rapidly being transformed by industrialisation.

Iron, important though it had been through centuries of human history, was to play an even more important role in this new industrial society and by the middle of the nineteenth century it had become something of a symbol of industrialism itself.

In Europe the blast-furnace method had for centuries been the basic means of making iron and this was also the technology that was to be transferred and used at both the Kumaon and Burwai Iron Works. But in India iron was still made in bloomeries, a process which had long since become of only minute importance in Europe.

To set the scene and to assess the representativity of the Kumaon and Burwai Iron Works this chapter will consider the history of ironmaking in India in the nineteenth century. Were the Kumaon and Burwai Iron Works typical of efforts to establish ironmaking based on European technology in India? And, as a basis for a later evaluation of the modernity of the technologies transferred and the forces against which they were to compete, what was the state of the art in British and Swedish ironmaking?

Nineteenth-Century Ironmaking in Britain and Sweden

A fundamental difference between ironmaking in Britain and Sweden was the raw-material base. Sweden had abundant forests, primarily fir and spruce, while Britain had rich resources of coal. During the eighteenth century this had given Sweden an increasingly important advantage over England, where charcoal became more expensive as forests were depleted while Swedish iron reached a world-leading position. Hundreds of Swedish blast furnaces and forges contributed about one-third of all iron traded on the world market and Great Britain was the market for about seventy percent of the exports.
As early as 1709 the British metallurgist Abraham Darby had succeeded in using coal to make iron, but it was not until the last decades of the eighteenth century that other strategic barriers to an expansion of the iron trade fell in Britain. In 1769 James Watt patented a steam engine with a separate condenser and some years later it was used for the first time for blowing a blast furnace. In 1784 the reverberatory furnace of Henry Cort's puddling process permitted the production of malleable iron using coal and in the same year grooved rolls were used for rolling for the first time. Coal and coke, the reverberatory furnace, the use of mechanical steam power and the rolling mill were the answer to many problems and this opened the way to an enormous expansion of British ironmaking, moving Britain to a top position among iron and steel producers of the world and forming the core of the country's industrial revolution. British iron became a serious threat to Sweden.

In 1720 Great Britain produced about 25,000 tons of pig iron, almost all of it made with charcoal, and supplemented it with a similar quantity of imports, mainly in the form of wrought iron. By 1806 domestic production had increased to 243,000 tons, nearly all made with coke or coal, and by 1862 to 3,827,000 tons. A considerable part was exported and the only significant imports were those of Swedish iron for steelmaking.\(^1\)
Swedish ironmasters managed to maintain their prosperity on a foundation of charcoal. They could not compete on the markets for cheap bulk products. Instead they set their sights on improving quality and making the most of Sweden’s charcoal and uniquely pure ores. Swedish high-quality wrought iron managed to preserve a privileged position on the British markets.1

In the nineteenth century. Swedish iron, especially the Walloon iron from Dannemora and surrounding ironworks, became a measure of superior quality, a symbol of excellence. If an iron, or steel, could match Swedish qualities it was excellent. Not much else needed to be said, and there is no difficulty in finding such references in primary material relating to India.

In 1828, the ironmaker-to-be in the Madras Presidency, Josiah Marshall Heath, gave a long explanation of the reasons for the good quality of Swedish iron, starting by saying that it is “a fact deserving the most serious consideration, that for her supply of this the most important of all substances in the arts [steel], England may be said to be now wholly dependent on Sweden and Russia. … The only iron distinguished by the name of first marks is the produce of the mine of Dannemora, in Sweden.”3

In 1855 Henry Drummond reported on iron in Kumaon and referred to the “superior iron of Sweden and Russia”.4

In 1859 a select committee of the British Parliament summarised an investigation into the general state of affairs in India. On iron it approvingly quoted testimony that mentioned Sweden. A witness had said that the iron made in the province of Madras was “as good as Swedish iron, and stated] that if it could be sold at a moderate price it would almost supersede the use of Swedish iron [in Sheffield]”.5 Other similar evidence had been given the year before, but on that occasion with reference to the iron ores of Madras, it being stated that the “prevailing iron ore is the black magnetic, like that which is obtained in Sweden and Norway; it is very rich and pure”.6

In 1860 William Sowerby, like Drummond an important figure in the story of Kumaon, commenting on a pronouncement on the Kumaon Iron Works, deemed the iron produced of “very fine quality, equal to the best Swedish, and more suitable for converting into wrought iron than castings.”7

And, lastly, in 1879, a Mr. Riley and a Mr. Forbes described an ore of the Chanda district as being a mixture of magnetite and hematite ores “equal in quality to the finest Swedish iron ores, so that there can be no question as to their suitability for producing the very finest iron or steel, when smelted with charcoal or coke”.8

Back in Sweden the stiff competition on the international market necessitated new solutions and a continuous and inventive adaptation of technical innovations to local conditions during the nineteenth century.9 The incentive to increase efficiency of production became an imperative and there was a continued rapid spread and import of technology from abroad. Only five years after the invention of the preheated blast in 1828, the method was introduced in Sweden. This both increased output and cut coal consumption per unit of produced iron. Intensive efforts were made to develop a blowing
engine that could replace the old bellows. In the 1830s J. P. Bagge developed a three-cylinder engine, which was set up at most blast furnaces and a large number of forges in Sweden during the latter part of the nineteenth century. Increasing efficiency in the roasting of ore was a result of the introduction of roasting kilns to the design of the Swedish engineers Starbäck (1840s) and Westman (1850s). Additional tuyeres were combined with the above and there were several other improvements in auxiliary machinery, logistics and work organisation. Crowning a period of big improvements and bringing in knowledge from Great Britain, a new type of blast furnace was introduced, at Långshyttan in 1859. It was taller than the conventional one and had thinner walls. Important economies of scale were achieved.

Simultaneously production was concentrated at fewer sites and ownership was centralised as the joint stock companies formed the core of the new age of ironworking. Nevertheless the site of an average iron-producing unit in Sweden remained small. As in olden days the Swedish blast furnaces and iron estates lay primarily in the ore-rich region of Bergslagen in Central Sweden. These units were closely integrated with the surrounding agrarian society, not least through their dependence on charcoal, mostly supplied by peasants.

Two basic series of data, the total production of pig iron and the number of blast furnaces at work, provide evidence of the ability of Swedish iron to adapt to new circumstances. Reliable aggregated data for Sweden are available from the early nineteenth century onwards. A slow but steady increase in total production can be seen all along, and a dramatic rise began in the second half of the nineteenth century, all the more substantial when the number of blast furnaces is considered. Figures for the number of blast furnaces in Sweden, and their production are given in the table on p. 69.

Even if the total Swedish share of the world market declined, concurrently with the industrialisation of iron production in Europe and the United States,
Swedish iron and steel continued to be in great demand, and exports, especially to Britain and the United States, remained the basis of Swedish iron and steel industry.\(^\text{12}\)

### Traditional Indian Ironmaking

There has been a long debate on the origin of Indian ironmaking.\(^\text{13}\) Formerly archaeologists used to be almost unanimously agreed that knowledge of ironmaking spread from a site of origin in the Anatolian-Iranian region and reached India around 400 BC.\(^\text{14}\) Now, however, it is also argued that iron technology evolved independently in India during or before the twelfth century BC.\(^\text{15}\) Whatever its origin, India has at least as long a history of ironmaking as either Britain or Sweden.\(^\text{16}\)

From the continued history of Indian iron there are two most explicit examples of the scale and excellence of Indian ironmaking. One is the iron pillar in Delhi, which together with a number of other very large, ancient iron objects shows the existence of a sophisticated and well-controlled production.\(^\text{17}\)

Another example is the pre-industrial steel called Wootz, often used to make sharp, tough swords.\(^\text{18}\) In the aftermath of the Indian Mutiny 1857–58 there was what could be called a direct confrontation between colonial power and the iron and steel heritage of India when the British enforced the collection of several thousand swords and knives and took them to Calicut. Many were beautifully engraved and some inlaid with gold and silver. The Govern-
ment decided that they must not get back into the hands of the people and had therefore to be destroyed. Charles Wood, then in charge of the Beypore Ironworks, was asked to arrange the destruction. It was impossible to break the swords, but with a pair of shears it was possible to cut them into smaller pieces, beginning from the soft, thick back edge. After cutting, they were sent to the ironworks in bullock carts in lots of 1,000 to 1,500, to be finally charged into the blast furnace.

There are numerous descriptions of Indian ironmaking by Europeans, mostly British, from the end of the eighteenth century and onwards. Most of these descriptions are closely connected to observations or iron ores and in an extensive bibliography on minerals of economic value in India, Thomas H. D. Touche could make some 300 entries in his list of reports of iron ore deposits in India. Approximately half of these contain references to traditional ironmaking, at least as noted by Touche. Most of the publications are from the nineteenth century and they refer either to ironworkings still in action, or sites where there was still a living memory of ironmaking having once taken place. There is no reason to believe that Touche’s overview is an exaggeration, rather the opposite. Many Indian ironmaking locations must

The Iron Pillar in Delhi (opposite page). Few objects made of iron have such a magic aura as the iron pillar of Delhi. It stands in the ruins of the mosque of Quwwat-ul-Islam, a world heritage site. It was made and raised to commemorate Chandragupta II and scientists have dated it to the late fourth or early fifth century.

The pillar still stands, untouched by the ravages of time, circular in cross-section, shining black, and crowned with an ornamented capital. For centuries visitors have tried to embrace it behind their backs in the belief that everyone who succeeds in bringing their hands together round it may see their wishes come true. Today a fence protects the pillar and the authorities have posted a couple of guards to watch over it. The pillar is welded, seven metres tall and weighs six tons. The exact reasons for the lack of any trace of corrosion are still a subject of debate, although the sheer size of the pillar indicates that the iron was the product of a sophisticated and well controlled process. But as soon as the guards turn their heads, visitors are ready to jump over the fence to reach the pillar. Photo: Peter Nyblom, 1997.

Sites of traditional ironmaking observed before the year 1922 according to references in Thomas H. D. Touche’s bibliography on metals of economic value in India. Map by Jan af Geijerstam after Touche (1918), p. 231-281. Artwork: Staffan Schultz.
have remained unaccounted for by foreign visitors. Touche’s list shows clearly that in the middle of the nineteenth century Indian ironmaking was still widely dispersed over the subcontinent and at all the sites where traditional ironmaking was observed the direct mode of making iron in bloomeries was the only one used.

DIVERSITY AND LOCAL ADAPTATION

The British observers considered the small scale Indian iron refining inefficient and wasteful, especially in its high consumption of fuel. It was often described as “primitive”, although the iron produced was highly esteemed. In fact, a forge at Ramgarh built by the Kumaon Iron Works was intended mainly to work iron bought from Indian iron producers in the vicinity and the rolling mill that Colonel Keatinge first brought in from England was used to roll Indian iron.

The transformation from the great past of the Delhi pillar to the supposed “primitive” state of later ironmaking was described as non-development in a changing world or even as a decline. “As in the animal world, the process of degeneration has produced forms which are but dwarfed representatives of their earliest progenitors.”

Even in later writings on traditional Indian ironmaking an ahistorical and sometimes pejorative conception prevails. Indian metal manufacturers are said to have shown little tendency to progress. One observer of the early twentieth century wrote that “The village worker in iron smelts his ore with the aid of a wooden bellow, handled by his assistants exactly as his fore-fathers did in the days when Alexander the Great raided the Punjab. He knows no better method, nor does he seek to know one.”

And even a historian like Daniel Headrick, known for his pioneering writings on technology as means of exerting power, has curtly dismissed the technology of Indian ironmaking as “the most primitive in the world”. A similar approach, partly showing an lack of acquaintance with the technology of ironmaking, is shown when first the Madras ironworks are described as largely based on traditional methods because they used charcoal for smelting and animal power for bellows and forging equipment, and then the Bengal Iron Works Company of 1874 is described as the “first recognisably modern iron works”. The widely renowned British archaeo-metallurgist R. F. Tylecote makes a similar remark in noting that ironmaking in parts of India was until recently in a pre-industrial state and that “it is reasonable to assume that techniques in these areas have changed little since the inception of the Iron Age”.

To say the least, some caution should of course be observed when equalising technology across a 3,000-year span or more, especially since a concept like “primitive” reflects a general conception of technology moving from an underdeveloped stage steadily closer to an ultimate state of perfection, from the “primitive” to the “advanced”. In part this conception is based on an
analysis of technology in isolation from its societal surroundings. If the analysis of societal needs is integrated into the study, it could definitely be more advanced to use the small-scale bloomery rather than the grand scale blast-furnace route.

The British introduced not only a new technology of iron production, but also a new market for its products. Through colonialism the whole social setting of iron production was transformed. A central question then becomes which technique was appropriate in which societal setting. In his pioneering work on the steamboats on the Ganges, Henry T. Bernstein used the much more accurate expression “India’s barehanded indigenous technology”, which he described as serving faithfully, but with relatively little change during the scientific and technological revolutions in the “Atlantic” world.

All these assessments bear signs of possible prejudice. In his wide-ranging studies Michael Adas has focused on the deployment of technology as a measurement of superiority and inferiority: “European observers came to view science and especially technology as the most objective and unassailable measures of their own civilization’s past achievement and present worth.” They even attributed the lack of material wealth to the inferiority of the primitive mind. A. K. Bagchi has made a similar point when he pointed to the fallacy of regarding the illiterate peasant as irrational. He noted instead that certain changes need collective action. Thus a passive government or a pre-capitalist or in other terms underdeveloped social structure, such as one with a high level of illiteracy, can limit development. The change and development of traditional ironmaking is also closely connected with a debate on deindustrialisation in India.

In a wider analysis of this technology, in its social and cultural context, the full complexities of technologies emerge in their interaction and interrelationship with the circumstances of nature and local society. This also applies to the technologies that, at a first glance, may seem to be the simplest. Technologies which, abstracted from their social and natural context, seem possible to place in a chronological timetable of development, show a fundamental adaptation to their different contexts. The capacity and the productivity of the Indian furnaces were low, but as a whole, the technology was certainly not primitive.

There was a great diversity in the methods used in different parts of the subcontinent. As Valentine Ball observed in 1881: “It would have been an endless task to have attempted in these pages to have given an account of the local methods of iron manufacture practised in different parts of India. There are variations in details as regards to almost every particular of the process.” Valentine Ball also compiled an impressive summary of the accumulated knowledge, and his notions on the degeneration of indigenous ironmaking are also followed by an account of indigenous ironmaking methods that differed from the normal in decisive ways and indicated a high degree of skill and advancement.

In spite of this and in spite of many important contributions to the history of Indian ironmaking, the possible existence of development in traditional
ironmaking in India during the latest centuries is unexplored. One important exception to this general statement is an influential article by Sabyasachi Bhattacharya on the possibility of transforming this trade into a basis for further development. During the last decade, studies closely linked to the anthropological tradition of Verrier Elwin have appeared. P. Sarkar has worked on the social organisation of ironmaking and its culture. Parallel to the notion of the primitive and unchanging Indian ironmaking, there were
continuously renewed ideas on the possibility of reform and a move towards the traditional direct route of ironmaking. Linked to this area of study of a surviving tradition of ironmaking, is the research of metallurgists since the middle 1990s who have tried to find out if this technology might be useful today. 

Today traditional ironmaking is an area of cultural conservationist interest in India, and its protection was codified on a national level in 1997 by an agenda signed by the Ministry of Science and Technology and others. The trade is also documented and interpreted by museums and technical research agencies, especially the Indira Gandhi Rashtriya Manav Sangrahalaya/Museum of Man, in Bhopal.

Traditional Ironmaking in Kumaon and Nimar

The prior existence of Indian ironmaking often told the British where to look for iron ore. This was so in Kumaon and Nimar, where there are several reports of bloomeries in the areas where the Swedes came to work.

Julius Ramsay himself mentioned on Indian ironmaking, but there is no evidence that he ever actually watched it. Instead he might have based his views on observations published by Becket and Henwood in the 1850s, which tell of how the Indian iron was made in the vicinity of the Kumaon Iron Works. In the early 1850s, no less than 52 smelting furnaces and 69 refining furnaces were reported to be at work.

Similar reports were given for the Narmada River Valley in which it was reported that iron smelting had “been the chief industry” of the lower Narmada Valley.

On an examination of the mineral districts of the Narmada Valley in 1853, Arthur Jacobs, assistant engineer to the Bombay, Baroda and Central India Railway Company, visited the village of Katkut north of the Narmada and

Kumaoni furnace for smelting iron ore, as recorded by Deputy Collector J. O’B. Becket, in 1850. He gave detailed information on both mining and ironmaking in the valleys of the Khetsaree and Kotelar, northwest of Nainital. Drawing in Becket, *Iron and Copper Mines in the Kumaon Division* (1850).
approximately 25 kilometres north-east of Barwah. In 1800 Katkut had been a flourishing town with fifty iron-smelting furnaces, but due to attacks from plundering bands most of these furnaces were closed. In 1820 only two were found working, but there was a living knowledge of ironmaking in the close neighbourhood of Barwah when Mitander came to the site in 1861. Jacobs hired one of the furnaces in order to find out how much iron could be extracted. He let the men work as usual, but carefully measured the inputs.

Neither of the observers maintained that they had managed to conduct a full and comprehensive inventory of any one area and the number of bloomeries probably varied over time in any one place. This made any calculation of the total number of furnaces or production difficult. The capital investment involved in setting up a bloomery was small. “Now each person sets up his furnaces wherever circumstances are favourable, and works on until his fuel or his ore becomes exhausted or too costly . . . he then removes; and this is no very costly process, when six or eight rupees will pay for the whole of his plant.” The fear of being taxed might also have added to a tendency to at least temporarily close down a furnace when a surveyor was in the vicinity.

Blast Furnaces in Nineteenth-Century India

During the nineteenth century iron production in India was widely dispersed and probably substantial, but during this period India was subjected to colonial rule and the efforts to remodel its economy to the needs of Britain, and also thrown open to competition from Europe. Traditional ironmaking was
gradually wiped out, as iron and steel were imported in large quantities. There was, however, also much discussion of the possibility of establishing iron-making in India along modern, European lines, that is, using the continuous blast-furnace process.

The Kumaon and Burwai Iron Works: Two of the Few

A limited number of the preliminary plans bore fruit, the number depending on how one defines the projects. In some cases, such as the ironworks in the Madras Presidency, blast furnaces at four different sites were part of one single project. In other cases a succession of different companies tried to introduce the blast furnace at the same site. Even so, if the Madras works is counted as one, there were no more than about ten attempts to introduce modern ironmaking based on European technology in India during the nineteenth century.

Some of these ventures were rudimentary, short-lived or intermittent. The Kumaon and Burwai Iron Works were two of the most whole-hearted and committed. In their day they were seen as strategically important trials, forming part of the process of building an independent iron and steel industry based on domestic raw materials and catering for the needs of a domestic market. It was hoped that they would lead to a gradual expansion, a build-up of knowledge and self-sufficiency in the supply of machinery and equipment. In short, they had the characteristics of outright development projects. They also started as government initiatives, as well as being expressions of government policy when they were closed down. It may thus also be said that they were expressions of the central policies of the colonial state, policies that formed the future of India. The histories of the Kumaon and Burwai Iron Works have a place in any attempt to tell the history of iron and steel manufacture in India.

Mahadev Govind Ranade, a judge in Bombay and an important spokesman for the growing nationalist movement in the late nineteenth century, was one of the early national critics of colonialism. In a speech at an industrial conference in Poona 1892 he delivered a devastating attack on colonial policies in the iron industry. He referred to the writings of the then Superintendent of the Geological Survey, Valentine Ball, and his observations on unused potential when the railways of India were built:

Mr Ball observes that if the Government had started the manufacture of Iron on an extended scale at the time of the first opening of the Railways, great benefits would have accrued to the State. If the State was justified in undertaking the construction of its own Railways, there was nothing inconsistent with principle in its undertaking the manufacture of its own Iron any more than in its manufacture of Salt or Opium. … This golden opportunity was allowed to pass, and we find ourselves in the anomalous situation that after one hundred and fifty years of British Rule, the Iron resources of India remain undeveloped, and the Country pays about ten
Crores [100 millions] of Rupees yearly for its Iron Supply, while the race of Iron Smelters find their occupation gone.45

Ranade’s summary could later be rephrased as a description of the position of the Indian iron and steel industry on the eve of Indian independence and even at the end of the twentieth century. It thus points to an important question, that of explaining the slowness and lateness in India’s development of an iron and steel industry. The story of the Kumaon and Burwai Iron Works may contribute something to the explanation.

WHY DID THE EFFORTS FAIL?

According to contemporary writers and later analysts the failure to introduce modern blast-furnace works in India was caused by a number of different factors, often interacting. The following account is based on three summaries, and the relative importance of the different causes will be discussed in the later analysis of the Kumaon and Burwai Iron Works.46 The factors listed by these authors are generally those discussed in the more detailed and often first-hand reports written on the various projects.

Obsolescent techniques are a first factor named as decisive. Morris D. Morris notes that the record of the nineteenth-century ventures must be carefully studied before any definite conclusion can be drawn, and he calls for caution, but he dismisses the Porto Novo works as an “effort to compete by upgrading indigenous technology with modest improvements in bellows and forging equipment”. Without mentioning Kumaon or Burwai, he calls the Bengal Ironworks Company’s plant of 1874 “the first plant designed along modern lines.” Daniel Headrick’s summary of technical causes of the inability of the British to produce iron in India is even more blunt than Morris’s: “… the methods they imported were not industrial, but the obsolescent techniques of preindustrial Europe.”47

Headrick seems to have equated obsolescent techniques with the choice of charcoal as fuel. The long-time failures using charcoal, the enormous growth of coal-based iron in Europe and America, and the discovery of important coal-fields by the Geological Survey of India are, according to Headrick, decisive reasons for maintaining that the choice of charcoal was a mistake. Valentine Ball attributed the failure mainly to deficiencies in either the quantity or the quality of the fuel. According to Ball, the charcoal-based works in the Madras Presidency and at Birbhum, and to some extent also the Kumaon Iron Works, had in fact, in spite of their limited size, denuded large tracts of country of forests. David Grout, in his PhD thesis “Geology and India”, also supports this line of reasoning. He writes that the shortage of fuel, and in consequence its expense, was one of the main reasons for the failures of Josiah Heath Porto Novo Iron Company and what he calls “the iron and copper mines of Kumaon” 48

A third group of causes concern traditions and skills. The task of starting new works in India and of catering for the market would be momentous,
especially since the tradition and economic structure of English ironmaking did not exist in India. In England “the surrounding population has been born and bred to the work”, it was pointed out, while in India there would for a long time be an acute shortage of skilled workers, which would cause delays, stoppages or heavy costs. According to Valentine Ball the commitment of skilled workers in the iron industry was especially important since “no industry in India requires the same amount of arduous and unremitting personal labour as that required from iron smelters and puddlers.”

Fourth, there are explanations linked to demand, markets and foreign competition. Valentine Ball warned that the profit margin would always be small and fluctuate dangerously due to the unhampered competition from abroad, and as the price of English iron changed. Ball also warned of the threat of British producers aggressively underselling new plants and potential competitors from India, since India was one of England’s largest customers. “[T]he manufactures of the Indian factories would be undersold till such time they were driven out of the market and the factories of necessity closed.”

Long-term tradition and very demanding specifications for the iron and steels delivered, combined with market prejudices, would also work strongly against new entrants in the iron and steel market.

Fifth and last, Government policies and attitudes were also seen as crucial, and in turn influenced by external and conflicting interests. Ball noted that government support had been indecisive and inconsistent in respect to iron production in India and argued that it would have been a big advantage if the Government had started the manufacture of iron on an extended scale at the time of building the railways, although such continuous production would have been unlikely, “owing to the opposing interests involved”. Ball underlined the advantages of having a specialised, strong and competent Department of State to support an iron industry. Such a department would be able to maintain a group of officers to allow for leave and casualties. It would give the managers at the local level of individual companies the prestige and authority needed to counter the “spirit of independence of action [which] soon grows up among European employees”.

Morris D. Morris argues along the same lines, stressing the importance of government policy. He starts out by asserting that the East India Company and later the British Government sought throughout the nineteenth century to stimulate economic development as a customer and by undertaking surveys, and granting subsidies. He also notes the lack of any tariffs to protect the infant iron industry. Summarising he asserts that “we are left with a sense of the ramshackle character of the technical and financial proposals and the impression that plans were formulated and operations conducted in impulsive, speculative and unsystematic ways.”

When Headrick discusses the difficulty of starting ironmaking based on pit coal his analysis raises interesting theoretical questions. The shift to coke had been problematic since the quality of Indian coals was inferior, but the main problems were, according to Headrick, rather technical errors, under-
capitalisation and foreign competition, behind which lay a more fundamental political question of what caused the lack of whole-hearted support from the Government. The political contradiction identified by Headrick lay in the split system of authority between the viceroy on the one hand, that is the British Government in India, and the India Office in London on the other.  

Indian Iron and Steel  
– An Unexplored History

The history of iron and steel in the old industrialised countries has been extensively researched and comparatively well written. The history of Indian iron has also been the subject of a substantial number of reports and studies. They range from contemporary or near contemporary reports of a more limited scope to general overviews. A number of systematic surveys with a specified aim and purpose have been carried out, as well as important case studies.

In research on Indian iron history most attention has been given to earlier, pre-colonial periods. Much interest has been devoted to the technology of ancient ironmaking, with a special emphasis on Wootz steel.

Another important field of research has been the long and prolific history of indigenous techno-scientific traditions. And during the twentieth century these observations have been supplemented by ethnoarchaeology, scientific studies within the discipline of ethnography, sometimes used as important sources in the interpretation of archaeological findings.

The development of ironmaking in India during the nineteenth century has generally been devoted little attention. Monographs on the iron and steel industry during the colonial era are broad overviews with a strong emphasis on the twentieth century. The same applies to economic histories of India, where the iron and steel industry during the nineteenth century is at most mentioned in passing.

The strong emphasis on the twentieth century is hardly surprising, but there are still remarkably few studies on the second half of the nineteenth century, a strategically important period of India’s history. A. K. Banerji has noted a “virtual blackout” in research on the balance of payments in the mid-nineteenth century and a similar statement could be made concerning the history of the iron and steel industry during this period, even if I would not venture to be as emphatic. But there is an absence of authoritative overviews and a lack of consensus on the general dynamics of the iron industry. No incisive research seems to have been published. There is even a lack of general, comprehensive descriptive studies. It is noteworthy that in several of the overviews, Burwai Iron Works, especially, is at most mentioned in passing and without any analysis. As one example, B. R. Tomlinson in The New Cambridge History of India has a total gap in the description of ironmaking
between the initial efforts of Joshia Marshall Heath in Madras and the Bengal Iron Works Company in 1874. In some cases Kumaon Iron Works has attracted somewhat greater attention, mainly due to the large number of contemporary official reports on the works. But these accounts, too, are mainly descriptive and non-analytical. They are not based on any research into primary material beyond the official reports.

In Sweden the work of the Swedish engineers in India has received very little attention indeed. Before the present research was begun, the only exception to the silence was a biographical essay on Gustaf Wittenström in which Kumaon Iron Works is mentioned.

Writings on the economy of India have dealt chiefly with agriculture and while industrial studies have generally been devoted to industries that have shown some kind of success, especially textiles, the absence of a dynamic steel industry has generally attracted little attention, although it is this lack of development that is most significant. Michael Adas has noted that P. Ambirajan, in a paper on science and technology in education, has said that it was not so much what the British did in the way of scientific and technological transfer, but what they failed to do, that determined their colonial legacy. “This observation may provide the most rewarding point of departure for continuing scholarship on the vital themes of scientific and technological transfer under colonialism.”

There are still big lacunas in studies of the earliest phases of industrial ironmaking, what might be called the preindustrial phase of unsuccessful experiments.

Turning to an even later period, post-independence India, the connection between ideology, politics and economics has been stressed in an analysis of foreign aid in India. Philip Eldridge discusses economic development in relation to financial and technological dependence in Indian iron and steel industry, evident in the course of negotiations on the conditions of the build-up of a governmental steel sector in the early 1960s, and he emphasises the “fundamentally political nature of [foreign] aid”. E. H. Solomon (1924) made a study of colonial tariffs on iron and steel and their impact on the steel industry in the early twentieth century. M. R. Chaudhuri calls his monograph on The Iron and Steel Industry of India (1975) an “economic-geographic appraisal”. Like Eldridge’s book on the politics of foreign aid, this book centres on the first decades of the post-independence era and the build up of the state-owned integrated steel plants, with only some five pages devoted to nineteenth-century developments. Although providing an extensive collection of facts, its lack of analytical stringency and its irregular treatment of data and references make this volume hard to use. Two recent theses have tried to fill important gaps in the literature. One is a PhD thesis on the development of geology in India up until the establishment of the Geological Survey of India in 1851. Dr. Andrew Grout, with an extensive background in the service of the British Geological Survey, undertakes a wide economic, social and cultural analysis. This work is essential in giving the framework of
geological surveying and prospecting leading up to the building of the Kumaon and Burwai Iron Works. The other is a master’s degree thesis by Jan McGrath on technology transfer in nineteenth-century India. This fills in the sociological background to the colonial economy and presents two case studies of technology transfer, namely of the rhea fibre and of iron technology. The latter study is mainly devoted to the efforts to utilise the coal of the Chandra district to produce iron during the last three decades of the nineteenth century. Of the Kumaon and Burwai Iron Works only Kumaon is described, and that only very briefly.

Moving some decades further, to the late nineteenth century, the prehistory of the Tata Iron and Steel Works in Jamshedpur (Tisco) has received substantial attention as a prime example of indigenous large-scale industrial development. Some recent works, which deal with industrial relations and labour questions at Tisco, are concerned mainly with events in the twentieth century.

For the nineteenth century there is no recent comprehensive yet both authoritative and systematic overview of the efforts to introduce the blast furnace, although there are a number of earlier compilations. These are in turn mainly based on three historical overviews dating from the decades around the turn of the century, i.e. three almost contemporary collections of information. Only in few cases has archival material been consulted and in no case have the actual sites in question been physically examined.

**Summary Discussion**

**Unexplored but Significant**

The role of iron and steel in the building of human society has been momentous. It was a strategically important part of industrialisation and even in the so-called information age, it plays an absolutely essential part in our lives.

Indian iron has a history dating back at least 2,500 years and at later stages it achieved marks of excellence. This is exemplified by the Iron Pillar of Delhi and by Wootz steel, but notwithstanding these examples of worldwide renown, Indian ironmaking – as far as is known today – remained based on bloomery iron. This was normally a small-scale mode of production, intended for local markets and often based on the family as a production unit.

In Europe, on the other hand, there was a fundamental and important shift when the indirect method of ironmaking, the blast furnace, was introduced somewhere around the year 1200. This paved the way for an expanded production, and continuous and gradual improvements in production methods ensued over centuries. Blast furnaces became the basis of continuous production on a large scale, needing heavy investments and working for distant markets.

Development was especially fast during the nineteenth century, when rising iron production was a basis for and an effect of a continued industrial
expansion, both in Britain and in Sweden, with an ongoing exchange of technological knowledge and international trade. In the case of Sweden, especially, development was very closely tied to both external markets and external supplies of technology, but the country could also show her strength in the technologically self-contained and independent growth of her steel industry.

In the nineteenth century the Kumaon and Burwai Iron Works were two of a few basically unsuccessful efforts to transfer European technology to India. These works are significant in an important period of technical, economic and political transition.

In contemporary commentaries, and in general overviews published during recent decades, a number of causes of the outcome of these attempts have been mentioned. Some concern the specifics of the sites, such as deficiencies in either the quantity or the quality of the natural resources, and others a lack of managerial and technical knowledge. Some concern the character of the technologies transferred, which are seen as obsolete. Some involve economic factors and market conditions, such as undercapitalisation and unrestricted competition from abroad. Yet others relate to the lack of an iron-making tradition or to government policies and attitudes. All these are factors which will be examined in the following analysis of the Kumaon and Burwai Iron Works.
PART II

The Stage
and the Key Players

Giving the chronological history
of the Kumaon and Burwai Iron Works
and presenting the key players
CHAPTER 3

Phase I: 1815–1860
Exploration and Planning
Before the Swedes Arrived

When Nils Mitander arrived in Bombay in 1860 his final destination was Barwah on the north bank of the Narmada River in Central India and when Julius Ramsay came to Calcutta one year later he immediately continued to the foothills of the Himalayas in Kumaon. These were the sites of the iron-works they were to build and manage, but how and why had these places been chosen?

One prerequisite for any ironmaking project was the availability of iron ore. In this sense it may therefore be said that the histories of the Kumaon and Burwai Iron Works began with the advent of exploration of the mineral resources and geological surveying of the province of Kumaon and the central portion of the Narmada River Valley. This chapter sets out to describe why these regions were chosen for mineral exploration and what events led up to the establishment of the first government works and the production of iron in Kumaon and Nimar? Who thought of making iron? Who decided how the new technology was to be introduced?

The interaction between individual players and institutions will be considered, as will the relationship between science and industry. Fundamental decisions were made, determining the course of future developments, at an early stage in the histories of the Kumaon and Burwai Iron Works. The account is circumstantial and events will be followed step by step, up to the arrival of Mitander and Ramsay.

At the end of the eighteenth century British authorities still showed a basic antipathy to mining. The East India Company itself resisted the idea of prospecting since it feared that it would lead to colonisation and a shift in the balance of power. Mining was associated with gambling – agriculture with stability, the rule of law and morality.1 Added to this there was a determination to safeguard the interests of producers back in England. An order from the Court of Directors in London to the Bengal Court expressed this in 1785.

[1] It is our positive order that you discourage, to the utmost of your power, the working of mines which produce ores from which are extracted any of those metals which constitute a very valuable part of the manufactures of this country.
These attitudes combined to delay the systematic mapping of India’s mineral wealth. Instead the geological exploration of India laid an emphasis on palaeontology, the science of fossils and their history.\footnote{The absence of any authoritative ruling on the rights to mines also created uncertainty and inhibited exploration and prospecting. A systematic knowledge of India’s mineral resources was lacking, far into the nineteenth century.} Two central components in the geological mapping of India can thus be identified. One is a general effort to increase scientific knowledge. The other is a geological surveying with a more specific utilitarian goal of finding mineral resources to exploit. In both cases, however, there was a definite colonial agenda. On the one hand “colonial science reinforced metropolitan science through research in geology, metrology, botany, agriculture and forestry.”\footnote{On the other there was a connection between commercial interests, technological change and government policy, established from the earliest days of the British presence.} Administrative, scientific and economic policy had a common interest, in which science and technology acted as instruments of control and commercial advantage. In science, exploratory activities aimed primarily at the discovery of natural resources, were focused by decisions which confirmed a close relationship between the metropolis and the periphery.\footnote{In science, exploratory activities aimed primarily at the discovery of natural resources, were focused by decisions which confirmed a close relationship between the metropolis and the periphery.}

In the history of the geological mapping of Kumaon and the Narmada Valley the balance and interaction between science and commercial economic interests shifts. From the more general exploration in the early days, there grew an interest in speculative investment in mining in India in the late 1820s and the 1830s. Confirmed reports and unverified rumours of large and quick profits from mines, minerals and metals reached India from Latin America and were a contributory factor.\footnote{But the desire for general knowledge, the belief in advancement of science and the wish to map all facets of nature, were also important incentives to British geologists.} The reports of the surveyors were often disseminated to wider audiences in printed form. They appeared both as papers from the Government and in the bulletins of the Geological Survey of India. One eminent, institutional network was the Asiatic Society, established at Calcutta in 1784 and subsequently playing a most important role in spreading information about India. The Journal of the Asiatic Society of Bengal, which is still published, contained articles from all parts of the scientific arena, including the natural sciences, humanities and technology. Here many of the earlier reports on mineral resources and geological exploration were published.\footnote{The reports of the surveyors were often disseminated to wider audiences in printed form. They appeared both as papers from the Government and in the bulletins of the Geological Survey of India. One eminent, institutional network was the Asiatic Society, established at Calcutta in 1784 and subsequently playing a most important role in spreading information about India. The Journal of the Asiatic Society of Bengal, which is still published, contained articles from all parts of the scientific arena, including the natural sciences, humanities and technology. Here many of the earlier reports on mineral resources and geological exploration were published.}

\textbf{NEW AGENDAS}

During the first half of the nineteenth century there was a move from general, all-embracing explorations of “new” land to more specific scientific investigations, parallel with the gradual institutionalisation of geological
surveying. These new surveys were not general in nature, unlike earlier surveys that included minerals among a whole range of other observations, of fauna, flora, culture and diverse matters that could be called curiosities, but had a more limited scope and were conducted by specialists with a scientific, professional competence. A basic characteristic of the surveys for iron ores was their fixed purpose; they were systematic searches for ore in a specific area of land.10

In the 1840s an important shift in attitudes to mining in India can also be seen. Coal and iron took the place of gold as symbols of potential wealth and the smoky image of Britain became a vision of civilisation which gave sanction to the mining of coal and iron.11 When prospecting now became more intensive, it was the strategic importance of coal, especially to the growing transport sector, with ships and locomotives being powered by steam, which triggered new initiatives. The first was the formation of the Coal Committee (1837–1845), whose purpose was to investigate the possible supplies of coal, and although its efforts were severely criticised, it established the need for collection of information and systematic, formal surveys.12 The East India Company now became determined to employ a geologist for India and in 1845 Professor Thomas Oldham, local director of the Irish branch of the Geological Survey of the United Kingdom, was appointed for a first five-year contract beginning in 1850. It was under his auspices that the science of geology was finally established in India through the formation of the Geological Survey of India (GSI).13

Another prime mover in the establishment of the Geological Survey of India had been John McClelland, Assistant Surgeon of the East India Company and earlier engaged in several surveys of India. He used the disappointing experience of the very first mineral surveyor sent to Kumaon in 1815 to argue for a fully fledged, well-organised geological survey of India. In 1835 he noted that a single individual could hardly succeed alone, and stressed the need for networks of experts for the advancement of geological science.14 Later Thomas Oldham and the Geological Survey also played important parts in events at both Kumaon and Burwai Iron Works.

Most of the surveys ended with rough general statements based on surface surveying and observation, on past knowledge and on an examination of samples collected from the surface. Sometimes old mining shafts permitted observations under ground and the bare rock faces of deep gorges also allowed an examination of different strata in the rocks, their dip and thickness. In such cases further conclusions could be drawn regarding the possible extent of the bodies of ore. Such elaborate evaluations were rare, however.

The estimates of the quality of the ores were normally also based on a kind of tacit knowledge. Normally the ores were not analysed on site and there is no evidence of any of the surveyors using the kind of small, portable chemical equipment that Mitander brought from Sweden. It is often unclear how samples were collected and selected to be sent away for chemical analysis.15
The First Mineral Exploration in Kumaon, 1815–1840

There was an early and important lineage of geological surveys in the great mountain chain of the Himalayas. The geological drama towering above the wide alluvial flats of the Ganges was in itself an attraction to any adventurer, geographer or geologist. It was a frontier, representing the limits of political and military control, between knowledge and imagination. It was recognised as the ultimate challenge to surveyors and also promised rich returns. Mountains were associated with rich mineral resources and the immensity of the Himalayas magnified such promises. The Western Himalayas also had the added attraction of the sources of the Ganges, the “discovery” of which was the purpose of an expedition in 1808, also resulting in notes on mineral resources. Surveying and the collection of information were also means of establishing and legitimising control over land. Geological science may be seen in a context of politics and assertion of power. In Kumaon, on the borders of the British Empire, this could have been of particular importance.

One of the earliest reports on the mineral wealth of Kumaon was written by a Scottish assistant surgeon, Francis Buchanan. He was stationed in Kathmandu in Nepal at the end of the eighteenth century, and compiled a comprehensive report on the region, including Kumaon, which at that time was not yet under British control. He named numerous working iron mines and marked them on a special folding map attached to the report.

In 1815, the very first year of British rule in Kumaon, the Government started prospecting for minerals. A second significant step was the issue in the same year by the first Commissioner of Kumaon of an order that all finds of minerals should be sent to the mint for examination. Two years later the Government appointed a mineral surveyor in Kumaon. These instructions were intended rather to increase the revenues of the new British administration than to form a basis for future production.

You should ascertain the existence or otherwise of mineral production applicable to purposes of public use, or available as a source of revenue; and report on the practicability of bringing them to account.

At the same time it was firmly stressed that British imports should not be endangered.

The existence of iron and copper ores in considerable quantity has already been ascertained; but as the working of these metals might injuriously affect important articles of British import, it is not designed that your attentions should be occupied in detailing any practical arrangements for that purpose.

A more extensive interest in minerals was still in the making, but the appointment of a Captain J. D. Herbert as the new mineral surveyor in 1823
was a significant development. He was a geographer by profession, but he
also had an interest in geology and had assembled large geological collections.
By 1829 his services had been deemed too expensive and disposed of, but the
reports he published remained influential, maybe because their enthusiasm
for the prospect of mineral exploitation created a climate favourable for the
organisation of new surveying parties.20

Less than a decade later, the Government was again persuaded to employ
an ambitious member of the armed forces with geological knowledge. Henry
Drummond was an officer of the Bengal Cavalry, but also a member of the
Geological Society, and in 1836 he had been involved in the formation of a
British-backed commercial “mining association” for the exploitation of the
metalliferous ores of the Himalayas, and in particular Garhwal and Kumaon.
The Bombay newspaper Friend of India had described this company as a
“nobler enterprise than that of the rail-road” and one that might lead India
not only to decrease her imports of metals from Europe, but even to “supply
from her own exuberant bosom the want of all Asia.”21

Accompanied by a professional Cornish miner, Mr. Wilkin, Drummond
began to explore Kumaon as an envoy of the British East India Company.
The party devoted special interest to copper and, while Henry Drummond
had to rejoin his regiment in Afghanistan, Wilkin stayed in Kumaon and
worked a copper mine for two years before going back to England.22 Drum-
mond later devoted an important part of his life to promoting European
mining in the sub-Himalayas.

River Navigation and Coal

In The Narmada River Valley, 1820–1850

If we move south, from the outskirts of the Himalayas to the Narmada Valley
in central parts of India, we find that “[t]he great variety of the rocks there
exposed, the picturesque beauty of many parts of the country, and the early
discovery of fossil remains” attracted the interest of geologists at an early
stage.23

One of the most influential Britons in Central India was Sir John Malcolm,
agent to the governor-general and responsible for the affairs of Malwa, a
region of Central India that also included the area around Barwah. During
the period of his appointment Malcolm put forward an ambitious plan for
an integrated survey of Malwa.24 One of its parts was a geological survey and
although this contained only very limited information on iron ores, some of
the few deposits noted were in the area east of Barwah. They were said to be
smelted further north “for the supply of the Indore and neighbouring
markets”. This report was a significant first contribution to the accumulation
of geological knowledge of the area.25

In the ensuing decades the geological investigations of the Narmada River
Valley were devoted to palaeontology and, more specifically, to the coal
deposits in the upper middle part of the valley.\textsuperscript{76} In the late 1830s there was a certain change of emphasis and surveys concentrated more on transport, on the Narmada River or by rail, or on mineral resources.\textsuperscript{77} The needs of Bombay, the capital of the presidency and a bridgehead for British interests, became a major consideration. Bombay was the big port of Western India and in order to cater for the growing number of steamships, supplies of coal had to be maintained there. At this time the Narmada River was seen as a possible transport route from the interior to the Indian Ocean and there were ideas of making Bombay independent of coal imports from England.\textsuperscript{78} Besides coal, there was an interest in iron ore. Possible use of iron ore was mentioned, discussed and positively assessed in most reports.\textsuperscript{79}

At the end of the 1840s a party of surveyors was sent to explore the river valley, and Richard Harte Keatinge from the Bombay Artillery, who was destined to become the single most important person in the history of the Burwai Iron Works, was one of its members. This time the main subject of interest was coal, but the party was also explicitly instructed to report on iron ore mines.\textsuperscript{80} Sir R. Hamilton, the British resident at Indore, made a personal visit to the surveyors. In his report he wrote that the “finest iron in this part of the country, not very inferior to the black main of Scotland, abounds on the right bank of the Nerbudda [Narmada], in the vicinity of Dharee, at Chandgur [Chandghar], Kautkot [Katkut], and along the lower hills.”\textsuperscript{81} The last two places were quite close to Barwah.

MOUNTAIN ORES
AND KUMAONI IRON, 1840–1855

In the early 1840s Colonel Henry Drummond’s hopes of initiating the extraction of minerals in Kumaon received a serious setback when the Commissioner of Garhwal and Kumaon, G. T. Lushington, reported that the copper mines of Drummond’s associate Wilkin could never become economically viable.\textsuperscript{82} Lushington reasoned that the mines were too far from the markets of the plain, carriage was slow and expensive, there was no coal for fuel, the mines had not been proven at depth and they would not be able to compete with imports from Britain. These were all arguments that were to recur in later discussions on the iron ores of Kumaon, but Drummond defended his case. Drummond maintained that Lushington had underestimated the significance of Wilkin’s finds. Wilkins had only scratched the surface, and rich ores could still be hidden below. Drummond also argued strongly for the benefits of settlements in the hills, fostering a sturdier breed of people compared to the subdued, effete and timid people of the hot and unhealthy plains.\textsuperscript{83} He sought support in the writings of J. D. Herbert (in this case writing on Darjeeling):

… if the experience of European colonization is ever to be tried in India, we cannot select a better spot than these mountains, whether we consider
Drummond’s arguments reflect a slowly changing attitude to colonisation. Both the East India Company and Governor Lushington had feared an influx of unsettled British miners as a breeding ground for criminal activity and loose morals. At the same time, British hill stations were examples of proto-colonisation, and for these minerals were sought, to meet needs arising during the build-up of new communities and as a general economic base for their future existence.

A little more than a decade after Drummond’s pamphlet, in the late 1850s, the board of directors of the East India Company acknowledged the importance of the railways as a market for possible iron produced at Kumaon. The prospects of rendering the mineral resources of Kumaon available “for the various public works and especially for the railways, now in progress or about to be commenced in Upper India” were to be explored.

This hope was also expressed by Hardy Wells, a civil engineer, in one of many reports on the ironworks. He placed the project in the context of a rapidly expanding market.

The extraordinary introduction of first class expensive Railways into a country which, comparatively speaking, was without roads of any kind, caused the Government again to pursue the subject of the value of the metalliferous deposits of the Himalaya mountains, and particular attention was called to the supposed rich iron deposits. It was naturally supposed that a large supply of iron was necessary to the rapid progress of India, as it is to that of every country, in all departments of industry and arts, in civilization, and the material well-being of the people; but to make the iron ore of India profitable appears to me a matter of vast political importance, quite independent of its usefulness as a means of improving the lines of communication through the country.

It is not clear what Hardy Wells means by his expression “political importance” and the sentence would be clearer if the introductory “but” was dropped. It is clear anyway, without a doubt, that he strongly supported an ironmaking project. His concluding remark shows an almost sanguine belief in the possibilities, stating that those regions “will become one of the richest sources of revenue connected with the empire of the East.”

The mineral surveys of Kumaon in the 1850s were coupled with a continuing and strenuous effort by a small group of British experts of different professions to promote and develop ironmaking. As they collected information on the natural resources of the region, they began to recommend an investment by the colonial government or by private companies. Some of these men combined several different roles, but most of them had limited personal experience of ironmaking. In most cases they were also to have direct
personal interest in the ironworks, either through their employment and practical work, or as investors.

At the beginning of the 1850s Kumaon was again explored by Drummond. He was convinced of the commercial potential of Kumaoni ironmaking and in 1852 he again circulated a pamphlet in England, now entitled “On the Importance of Establishing Ironworks in Northern India”. In this he suggested that a small rolling mill should be sent to Kumaon to roll “native bloom metal into bars”. Nothing came of this proposal directly, but three years later the board of directors took further steps to investigate the possibility of making iron in Kumaon.

In 1855 William Henwood, “sometime Her Majesty’s Assay-master of Tin in the Duchy of Cornwall”, was asked to make further investigations. From the outset it was clear that no mineral coal was available in Kumaon and Henwood started his assignment by travelling to the ironmaking districts of Styria in Austria. He wanted to learn more about ironmaking with charcoal as fuel, and Styria was renowned for its charcoal iron. Rees Davies, an ironmaster from Wales, was Henwood's metallurgical assistant on the trip and later, when these two men passed Alexandria on their way to India, two other surveyors joined them. Thus there was a party of four to carry out the geological examination of Kumaon.

They reached Kumaon in January 1855 and a report was submitted in May the same year. It said that they had examined “every metalliferous district known in Kumaon and Garhwal [Garhwal]” and their findings constituted evidence of sufficient iron ore for starting an experimental furnace. In this report Henwood not only discussed the availability of iron ores but also submitted suggestions on how to improve mining operations, how to preserve the forests, and “experiments in mining and smelting”. His assistant Rees Davies devoted his time to watching the operations of the “native smelters”. “[H]e declares himself unable to make any improvement; compatible, I presume, with preservation of their principles of smelting. Nothing is therefore left us, in his opinion, but the introduction of the European method …” As the best site for a possible experimental works Henwood suggested the Ramganga district some 60 kilometres west of Nainital. Here there was already mining and, as he had reported, the rapid fall and powerful flow of the river would offer “every facility for the erection of machinery”.

At this time Colonel Henry Drummond had also been deputed by the Government of India to carry out the “investigations necessary to satisfy the public in England that sufficient inducement existed for the investment of capital in iron-works.” In the middle of August he submitted a report, as did William Sowerby, a civil engineer employed by the East India Railway, a couple of weeks later. Like Drummond, Sowerby was to become one of the most ardent advocates of ironmaking in Kumaon and one of the main figures in the Ironworks project.

The reports of Drummond and Sowerby dealt at length with the lower parts of the Bhabar district in the foothills, since Henwood had earlier given
inconclusive information on the ores in this area. This area was of special interest since it both contained rich forests and enjoyed easier access to the markets in the south.

These new examinations changed the priorities. Drummond had now given up his former idea of working up metal bloomery iron into bars, and instead found it better to start with “foundry iron”, i.e. pig iron, right away. “[W]e shall now in consequence of the discovery be able to make our own rough castings for the machinery, only getting at the first start the rolls, the screws, and the nuts for the rolls from England.” He also referred to Rees Davies, the smelter and assistant to Henwood, “who fully agrees with me with regard to the plan referred to being a good one, and an expeditious and practical method of bringing Kumaon iron at once into the market in a proper shape.”

The finding of an abundance of easily accessible ores, albeit of relatively low iron content, also led them to propose Bhabar, close to Nainital, as the site of an experimental works. Dechauri, in a fertile, wooded valley in the foothills, opening towards the south-west and the plains, became the centre of activities. During the following years the nearby districts of Kaladhungi and Khurpa Tal and Ramgarh, both further up in the hills, were chosen for further development.

This was the beginning of British ironmaking in Kumaon, directly leading to what was to become the Kumaon Iron Works.

LOCAL INFORMANTS

In general, British explorers and mineral surveyors, mapping the natural resources of India during the nineteenth century, depended on local traditions and local knowledge. The scientific understanding of the geology of India grew through a continuous acquisition, incorporation and systematic processing of existing knowledge.

This was apparent in the geological mapping, where local informants showed the way, and indicated the location of mines and smelting works. The close connection between local mining and ironmaking and a growing colonial knowledge of Indian geology and mineral resources is clearly demonstrated in British reports on India’s iron ores. The local knowledge of Indians working in the still thriving, traditional ironmaking was indispensable to the British surveyors and seeing the remains of old transport routes, mines and smelting works, the European could draw conclusions about the surroundings. The local cultural and economic setting and heritage were used in interpreting not only the physical remains of past and present activities, but also the potentials for the future.

The relationship between the informant and the recipient was never simple and it sometimes involved strategies of opposition, trying to safeguard local interests against British taxation or even appropriation. Cases are recorded where mineral surveyors were openly denied information, as when the fire
in some forty furnaces in one single village were extinguished when a surveyor approached. However, such examples of more or less open obstruction have not been found in the material on the Kumaon and Burwai Iron Works.

The decisions to invest in the Kumaon Iron Works were established on the results of ore prospecting in the 1850s. The British surveyors covered vast areas, and existing mines guided them to the ore deposits. Mines in use or recently abandoned were recorded and interest was often – at least at first – focused on these areas.\(^5\)

In due course, after extensive exploration, new deposits of iron ore were also found, most notably on the surface in the lower hills of the Bhabar.

Several of the surveyors that covered Kumaon were experienced geologists. William Henwood had, as noted earlier, extensive experience from...
Cornwall and Henry Drummond was a fellow of the Geological Society of London and Wernerian Society of Edinburgh. This past experience improved the accuracy of their observations. The prospecting was basically a combination of personal surveying and manual examination of collected samples. The surveyors picked up stones from the ground, weighed them in their hands, looked at them and drew conclusions from the general context of topography, rocks and vegetation. This is still a basis of a first phase of mineral prospecting and experienced amateurs often find ore bodies that can lead to major commercial undertakings.

The amount of systematic, scientific knowledge of geology was limited and thus the surveyors could only draw tentative conclusions on the extent of the ore bodies. In a report on the iron ore deposits of the Kotelar and Khetsaree valleys written in 1852, J. O’B Becket referred to this uncertainty. He wrote that the iron ore was found in a range of hills thirteen miles long, “... but a further statement would be merely hypothetical”.

In his report from 1852, Becket wrote that he believed the quality of the ore to be good, but he even lacked the equipment for ascertaining the exact percentage of iron. This was done in later surveys, but all the same some uncertainty remained, geological structures of the lower Himalayas being extremely complex. The sequence and extent of beds is difficult to deduce in the young and greatly deformed rocks, which has been called the “Dynamic Himalayas”.

In the end two different areas, with two different qualities of iron ore, were considered for working in Kumaon: the surface deposits in the foothills of the Bhabar region and the rock ore above Ramgarh.

The Bhabar deposits close to Dechauri and Kaladhungi were considered as the more important. Their iron content was lower than the Ramgarh ores, but they were extensive and easily accessible. Thus Henry Drummond suggested a start by erecting a blast furnace at Dechauri. Essential raw materials were to be found there, combined with the good possibility or reaching “the great markets of consumption”. The unanimous judgement of all observers was that the ore reserves were extensive enough to supply all the needs of even big-scale ironworks.

As mentioned the Bhabar ores had low iron content and it may be noted that Indian miners and ironmakers had ignored these clearly visible and easily accessible sources. Henry Drummond even found it necessary to try to explain why these ores had not been previously used.

It may be a matter of surprise to some, that the native miners and smelters allowed such valuable deposits to remain unnoticed, and that the fact of their occurrence was quite unknown to them, no traces of former working having been found from Dechauri to Burragur, but this is explained by their [the natives’] rude process being ill adapted for the smelting of such ores. I had however trials made of them by that process, using limestone as a flux, with which the natives were unacquainted, and succeeded in obtaining bars of iron.
William Sowerby made serious efforts to show that he understood his findings in a wider geological sense and made assumptions on the general structure of the beds of different geological formations and the forces forming them. He noted that his lack of instrument and inaccurate maps of the region prevented him from producing any reliable section of the beds, but all the same he was absolutely certain of their extent. “If works are established on ever so large a scale, they would, in the course of ages, produce but a feeble impression on the beds.”

The possibilities of making more detailed analyses of minerals improved, which was also important. Chemical analyses of rock-samples, concerning for example the phosphor- and sulphur content in the minerals, were referred to more frequently and samples were sent to laboratories in either India or England for testing.

THE SEARCH FOR IRON IN THE NARMADA VALLEY IN THE 1850S

In the early 1850s the mineral exploration of the Narmada Valley assumed a more scientific character, but at the same time the feasibility of making iron became a more pressing question. The Government was dissatisfied with the “indefinite and inconclusive” calculations of previous reports, and it decided that a survey by a professional, qualified, full-time geologist was needed. The first to step into this role was an assistant engineer and geologist to the Bombay, Baroda and Central India Railway Company, Arthur A. Jacob. He was commissioned to make a five-month journey to explore the coal and iron ore measures in the Narmada Valley in the winter of 1853/54. When he reported on his findings he noted a number of iron ore deposits and mines close to Barwah.
Jacob assessed the economic feasibility of ironmaking. In his report of 1853/54 he emphasised that the rich deposits of nodular ore, the agglomerations of lumps of ore on the surface, and the rich forests – well suited for charcoal-making – represented big opportunities. He refrained from making detailed cost estimates, but said that the mere fact that the local population could make iron costing less than £4 16s. per ton was justification enough. With modern equipment iron could be produced even more cheaply. Although the ideas were very general, this was probably one of the very first times the idea of building a new iron-producing facility in Nimar was actually put to paper.

In the course of his journey Jacob met Richard Keatinge. Jacob reported that “Mr. Keatinge wished to find a mine close to Ponassa [Punasa], in order to employ the prisoners in the manufacture of iron, and having offered a reward of R. 25, he was shown two mines, which I have since examined. One of them is of much value.”

After describing a visit to some potentially useful coalfields and Tendukhera, a renowned ironmaking area further up the river, he concluded his report with the words, “the whole district is of the greatest interest, as well to the capitalist as to the geologist.”

Jacob’s report was later fully endorsed by J. P. Kennedy, the head of the railway company by which Jacob was employed. Kennedy compared the costs of building bridges with imported British iron and with Indian-made iron. He was firmly convinced of the advantages of starting to produce iron in India, especially since he believed that iron prices would continue to rise. The only way for a railway company to lessen its costs was to manufacture iron of its own.

Kennedy therefore suggested the establishment of “a native iron foundry”. Exactly what he meant by this expression is not stated, but considering the amount of iron that would be needed he could hardly have considered employing the Indian mode of ironmaking, heavily criticised by himself in the ensuing sentences. He thought rather of a modern plant using the blast furnace and European technology. For similar reasons his term “foundry” seems to be out of place. What he was really talking about was an integrated plant producing forged and rolled material for bridges, rails and other railway equipment, starting from the ore. Kennedy endorsed the choice of Punasa as the site for this “foundry”, as suggested by Jacob.

It is also worthy of note that Kennedy considered both coke and charcoal as possible fuels. The starting point would be the easily accessible supply of “charcoal jungle”. In the longer term, if the supply of charcoal ran out, there were also the supplies of coal further up the river, to be reached by the future railway.

When, a year later, E. Impey, surgeon at the Bombay medical establishment, reported on the possibility of using the Narmada River for transport, he also commented on the mineral resources of the valley, using Jacob’s report as his chief source.
It can scarcely be denied that these estimates, rough though they may be, furnish ample grounds to justify a commencement [of ironmaking] at least; and if the value of iron depends on the richness of ore, facility of extraction, and the existence of eligible adjuvants, no more favourable conditions could surely exist.66

As soon as there had been time for the most recent improvements and machinery, which cheapened and expedited iron-working, to have an effect, “the full capabilities of the Nerbudda valley in this particular mineral [iron]” would be appreciated, Impey believed. He thus set the agenda for the future Burwai Iron Works and his list of possible technological improvements shows the state of knowledge in the international arena: “Mr. Neilson’s hot blast … the economizing of waste gases on the continental plan; the American process of pulverizing the ore and charcoal … and the application of electricity to iron while hot … Naysmyth’s hammer &c”.67

E. Impey was not a geologist, for which he apologised, but with the arrival of Thomas Oldham in India, the highest level of geological competence was available. Oldham was the head of the Geological Survey of India and also the undisputed and most highly esteemed geologist in the country. It is in this context that his later extensive work on the Narmada River should be noted.

The aim of geological surveying was now to give general, systematic knowledge. The purpose was not only utilitarian, but also to advance science. Thomas Oldham noted the utility of mineral deposits found in a survey of the Narmada River Valley, but he explicitly stressed the importance of the finding in augmenting scientific knowledge in general. “[I]n a purely geological point of view, the Districts of Central India will afford the best and clearest key to the true succession of the rocks in India.”68

Other commitments prevented Thomas Oldham from surveying the Narmada Valley in 1854 himself, and the assignment was delegated to the Medlicott brothers, Joseph and Henry. Joseph was a geologist at the Geological Survey of India and became the head of the survey party. He was assisted by Henry, at that time recently appointed Professor of Geology at the Roorkee College.69 The brothers worked in the field for four months in the winter of 1854/55 and Henry Medlicott returned to the area during the following two seasons.70

The first report by Joseph Medlicott seems to be a careful and systematic analysis, not limited to immediate field observations. He tried to assess the extent of the resources from a consideration of the geological structures.71

Starting upriver he moved downwards, to Punasa and Chandghar, fairly close to Barwah, and noted a number of villages around Chandghar where deposits of gravel composed of pebbles of rich heavy ore were worked. These ore deposits were thin and were soon exhausted at any one site, but Medlicott was certain that the original veins were never far off. At one of the villages, he found the ore worked in situ, a “fine specular iron ore, with a clean metallic lustre on the fresh surface, and bright red streak” and he could trace the bed
or vein for miles. His conclusion was very positive: “This is decidedly the most prolific source of iron that I have seen in the valley, and seems to me to offer a supply of material practically unlimited.” He supported the observations of Mr. Jacob, but he suggested that the future ironworks should be sited north of the river, to facilitate transport of both ore and charcoal, just where the Burwai Iron Works was later built.72

There were numerous surveys of coal and iron in the Narmada River Valley during the mid-1850s, but apparently the Court of Directors was still not convinced and feared that the reports were overoptimistic.73 Therefore yet another survey was ordered.

A year later, in the winter of 1855-1856, Thomas Oldham also visited the districts around Punasa and Chandghar. Through the Bombay Government the Court of Directors of the East India Company had instructed him to examine whether the “glowing terms” in which the mineral resources had been described had any foundation in reality. The Company had also ordered the Government immediately to “establish works for the manufactures of iron on a sufficient scale to render it generally and commercially useful” – if the reports were positive.74

Even if Oldham believed that previous references to inexhaustible resources were wrong, he wrote “there is a large amount of very rich, valuable and easily wrought ores”. According to Oldham it was the lack of fuel that posed the most serious obstacle to ironmaking.75 Any plant must be placed where there was fuel. He described traditional Indian ironmaking in detail and gave his unequivocal support to Keatinge and his attempts to make traditional Indian iron at a smaller rolling mill and sell it in open competition with imported iron from England. These efforts were apparently well under way and widely known at that time.76 This was also a direct parallel to the Henry Drummond’s first notion of how to make use of iron from Kumaon, by working “native” bloomery iron in a small rolling mill.77

Geologists often worked under difficult conditions and with inadequate resources and this limited the reliability and completeness of their reports. Thomas Oldham described the situation in 1860:

European Geologists seldom realise fully the difficulties, which attend the steps of their brother labourers in this country. Districts without maps, without roads, without supplies, without inhabitants, meet you frequently. To go where you wish is often simply impossible, and you must only rest content to go where you can. The most malarious and deadly parts of the jungle are often those which give the best, or perhaps the only sections visible. Seldom is it possible to return to the same place a second time, to correct an error, or supply an omission.78

In the history of mineral surveying in the region there was an inflation of positive assessments of the minerals found. On insufficient evidence, many travellers gave unambiguous recommendations on commercial exploitation, which reached far up in the colonial bureaucracy. In his general overview of
reports on the geology of the central portion of the Narmada River Joseph Medlicott was sometimes slightly sarcastic, noting “the tendency of Indian Geologists to exaggerate everything supposed to be favo[u]rable to the existence of valuable mineral resources”. In spite of this scepticism, the reports from the leading authorities on Indian geology, the Medlicott brothers and Thomas Oldham, had now essentially endorsed the first optimistic reports on the iron resources in the valley. The road was signposted for future ironmaking projects.

Establishment of the Ironworks

The plans to start making iron in India seem to have had quite solid support at the end of the 1850s, at least in the central circles of the administration in London. In 1859 a select committee of Parliament was working on the subject of colonisation and settlement in India. In March, Charles Atkinson, Mayor of Sheffield, and Robert Jackson, Master Cutler of that city, were called and asked about the connections between Sheffield and India. Their joint opinion was that an expansion of production of iron in India would provide good support to their own business. India could supply them with excellent cheap iron to reduce imports of expensive iron from Sweden and Russia. The local supply of rails and other equipment would also accelerate and reduce the cost of building railways and thus help to open a huge new market for domestic products. In the same year these arguments were explicitly quoted as reasons for proceeding with the Kumaon Iron Works and the general conclusion was also summarised approvingly in the parliamentary committee’s report. Both the Narmada Valley and Kumaon were explicitly mentioned as important possible areas for development.

As indicated above, the histories of the two ironworks at these two sites are almost, but not exactly, congruent in time. While Keatinge started at Burwai on a small scale by processing iron made in local bloomeries some time around 1854, the Kumaoni project was basically planned as a European blast-furnace project from the start. The Kumaon Iron Works was already in existence as an ironworks when Julius Ramsay arrived in December 1861.

THE FIRST BRITISH IRONWORKS IN KUMAON

The enthusiastic reports from the mineral surveyors convinced the board of directors and the Government of India that the process should continue. In November 1855 William Sowerby could report that the clearing of the jungle in Dechauri had begun and that the first stones of a foundation for a blast furnace had been laid. He could also report, with some satisfaction, that the site had already been visited by the Commissioner of Kumaon, J. H. Batten.
The first ironmaking experiments were initiated by William Sowerby in 1855/56. With William Sowerby as the official manager, his Welsh assistant Rees Davies started the blowing-in of Kumaon’s first blast furnace on 24 March 1856, but he had to stop both this and another blow two weeks later within 24 hours. No regular tapping was achieved, but a piece of iron which was said to be of “the very best quality” was obtained.83

This result was considered good enough to justify further efforts. In the summer of 1856 Rees Davies’ two sons arrived at Kumaon and Henry Ramsay, recently appointed Commissioner of Kumaon, again engaged Rees Davies to rebuild the furnace.84 In early 1857 the first pig iron was tapped, a total of 8.3 tons in four days. Thus it “… was proven that serviceable iron could be reduced from these ores with charcoal.”85

The results achieved by Rees Davies led the Court of Directors of the British East India Company to engage in a bigger undertaking. In July 1857 they decided that no time was to be lost in taking “such steps as would secure the prosecution of the smelting operations at Dechoure [Dechauri] on an extended scale as soon as the season would permit.”86

William Sowerby was appointed manager of the works and the Court of Directors stressed the importance of handing over the works to a private company.87

In the following winter William Sowerby began his work, but the planning and building took a long time. Instead of iron, the main product was a extensive printed account, *Report on the Government Works at Kumaon with The Dechauri valley*. The drawing shows the western part of the Dechauri valley, the site of the iron works. Even at this time the vegetation seems to have been sparse, as is also shown in Gustaf Wittenström’s photographs some five years later after several years of ironmaking. The first blast furnace is in the very centre of the picture, just behind the field shown as a whitish space. The new works of the Swedes was to be built on the same level and to the left. Drawing by Richard Strachey, Folio 61a, Strachey collection, WD2331, OIOC.
Plans, Specifications and Estimates for Establishing Ironworks in Kumaon and Remarks on the Iron Deposits of the Himalayas, which he completed in 1859. It was William Sowerby’s most important publication, but despite its title it dealt mainly with Sowerby’s experiences during his travels to the iron districts of Central Europe in 1856 and 1857.88 In fact Sowerby’s account of his travels was criticised for its excessive volume and details. Reviewing it, the Engineer’s Journal wrote that most was said on the points they cared least about.

With all this talk, and writing and fuss, and with this big volume before us, we want to know, have fifty tons of iron been yet turned out at Kumaon. Mr. Sowerby has been at work for four years and the result of it has been a thick book, but no iron.89 During 1859 scepticism and criticism grew and Hardy Wells, a civil engineer, was sent to Kumaon to investigate the past, present and future of the works.90 His report was exceedingly discouraging and very critical of William Sowerby. In his comments on this report Charles Wood, Secretary of State for India, dismissed Wells’ criticism of the large scale of the operations as such and said that this was as intended. Rees Davies’ trials had already demonstrated that iron could be made in considerable quantities. The aim was now to establish a full-scale plant. At the same time Wood’s criticism of Sowerby’s way of handling matters was stern. He had taken it upon himself to make all the decisions and he “appeared to consider himself rather the harbinger of an embryo Company than the servant of government”. Among criticisms of Sowerby were “unsatisfactory character of statements”, “evasion of obedience in small matters” and an “aptitude for offending and prejudicing almost all
with whom he comes into official contact. In January 1860 the Government of India ordered Sowerby immediately to limit all expenditure to a minimum and to restrict the works at Dechauri to the completion of the blast furnaces and additions absolutely necessary for casting iron rails.

By this time the new blast furnace was finished at Dechauri and it was commissioned in February 1860. In spite of all his extensive study tours and in spite of heavy investments, Sowerby experienced major technical setbacks. The furnace was closed in March 1860 after only 43 days. The immediate reason was said to be a badly constructed waterwheel. After several stoppages the wheel finally broke down beyond repair. This was later attributed to the technical incompetence of Sowerby. Due to the many stoppages the total blow time was short and thus the blast furnace itself never had a fair trial.

Once more there were recriminations. The Government stopped the project and William Sowerby was dismissed. According to Superintendent of the Geological Survey of India, Thomas Oldham, the failure was due to incompetence and wasteful expenditure. The ironworks was put up for sale.

As noted earlier it was made clear from the start of the East India Company’s engagement with Kumaoni iron that the intention was to hand the workings over to a private company and the role of the East India Company was only to get things started. The aim was to demonstrate the financial and physical possibility of operating an ironworks as a profitable concern in the province and to induce investors to become involved. William Sowerby was to hand the works to British private ownership as soon it showed a profit.

Prior to and parallel with these developments in late 1860, Rees Davies, when relieved of his position as responsible for the government works in Dechauri, started a private company of his own and built three small blast furnaces in Kaladhungi. The site of these was in the Bhabar region too, and had been contemplated as a possibility in earlier surveys. In addition to these works, Davies built another works on a site in Khurpa Tal, at a higher altitude in the mountains, just as Ramgarh was built to supplement the Dechauri works.

In February 1860 Henry Drummond, one of the earliest advocates of ironmaking in Kumaon, offered to take over the works. The government officials did not accept his first offer, but after further negotiations Drummond’s company, The North of India Kumaon Iron Works Company Limited, raised its bid and undertook to produce 1,500 tons of iron annually. This output compared reasonably well with the average production from Swedish blast furnaces, amounting in 1861 to approximately 750 tons per year per furnace, all furnaces included. Later blast furnaces built in Sweden were considerably larger. By 1885 the average output had risen to 2,600 tons per blast furnace per year.

In October 1860 the London Government sanctioned a deal and the Kumaon Iron Works was sold to the company. After returning home to Sweden from Kumaon Julius Ramsay said that he considered the terms of
the takeover very generous, including, as they did, extensive rights to forests and minerals, at a low purchase price.98

Early in 1861 the companies of Drummond and Davies were amalgamated to form the North of India Kumaon Iron Works Company Limited.99 It was now a vital concern to find a capable manager for the works, and this was the start of the Julius Ramsay era there.

**START-UP OF THE BURWAI IRON WORKS**

Practical trials were necessary if the ultimate aim was to exploit the resources. In 1855 E. Impey noted that the Narmada coal had “the advantage of the minute analysis of the chemist”, but to establish if it was suitable for firing marine engines or locomotives the practical knowledge of the stoker might “be assumed to be the most essential investigation, intelligent stokers only being able to treat fairly and openly different kinds of coal, according to the very different modes of firing each needs.”100 In the end it was a series of practical trials, not contradictory chemical results, that led Impey to reach his conclusion.101

The practical experiments to determine whether ironmaking could be viable follow a similar line of thinking. Although knowledge of the composition of the iron ores was meagre, full-scale experiments were initiated. Practical trials had the additional advantage that they used larger quantities than chemical testing, which reduced the risk that the difficulty of taking a truly random sample for testing might lead to unreliable results.

The persistent exploration of the mineral resources of the Narmada Valley eventually gave rise to plans to utilise the iron ore.

In a letter of 18 January 1858 one of the mineral viewers, J. Howard Blackwell, suggested that minerals and coal in the Narmada Valley should be made available to a private company for exploitation. He proposed that he himself should be sent to England.102 He also referred to his own report of 1857 on exploiting the mineral resources of the Narmada Valley.103 He was unequivocal in his recommendation: “I should … strongly recommend the erection of the machinery at Burwai, where iron ore, limestone, and fire clay are found, and where an abundant supply of fuel may be obtained.” He stated that he had no doubt “that the experiment would be sufficiently successful to induce the working of the mines by private enterprise.”104

The Government agreed to Blackwell’s proposals, and the Public Works Department laid down five special conditions for the workings. The expenses of the company should be audited in the same way as the accounts of the railway companies. The start must take place within a stipulated time. The use of forests must be limited to what the company needed for furnaces and buildings, the fellings must be controlled and large-dimension timber must be saved for the use of the Government. A final condition was a royalty of one rupee per ton of iron and 2.5 annas per ton of coal sold. The Department
did not approve of the suggestion that the railway companies should be obliged to buy from the company even if the prices were not competitive.105

What happened after this is not known, but apparently the full responsibility for building the works was taken over by Richard Keatinge, probably because he had already started experiments on the processing of bloomery iron in Mundlasir, this, too, a government undertaking. Keatinge was to become the single most important figure in the early history of Burwai and it is hard to believe that the Burwai Iron Works would ever have been built without his enthusiasm and persistent conviction of its potential benefits.

The idea of using the Nimar iron ores was first formulated by Richard Keatinge, during his time as Political Agent and Superintendent of Nimar. The ores were to be used “beyond the limited extent to which they are worked by native miners, and in suppression of their primitive and wasteful mode of working”. At his suggestion a small steam engine and a rolling mill were bought to roll rough lumps of indigenous iron into bars, and in the summer of 1857 this equipment was on its way from England. The rolling mill was eventually installed in the Mundlasir Jail Workshops and re-heating furnaces were built.106 Keatinge had been stationed in Nimar for fifteen years and it had long been his ambition to be the means of utilising its mineral wealth.107 It is not known if this was the very first time Barwah was mentioned as a suitable place for an ironworks, but judging from the phrasing of his letter to the Government of India it must have been one of the very first.

Keatinge’s suggestions were in accordance with the general policies of the colonial authorities. The intention not only to explore but also to exploit the mineral resources of India had been clearly stated in 1856. According to a dispatch of 1856 mineral viewers were to report iron ore deposits to the Government, which would then have the option of granting money for “experimental manufacturing of iron”. It was thought that such encouragement would be necessary in order to secure the investment of private capital.108

When Keatinge was on leave in England in 1859 he was informed that difficulties had arisen in Mundlasir. The furnaces, which had been built from drawings in an English textbook on metallurgy, had proved useless when wood and charcoal were the only fuel. It is not known whether this problem was ever solved, but Keatinge was given permission to visit ironworks in Germany to learn more about how to transform cast iron into bars and sheet “only using vegetable fuel”. On his return to India the project developed a step further.

Keatinge obtained permission to build an experimental works at Barwah, where the rolling mill and steam engine at Mundlasir were to be used. The target this time was set higher. The rolling mill was going to be a part of the larger whole, with pig iron being produced and the products further processed. The works were to include a blast furnace, forges where the blowing engine would be driven by a fifteen-horsepower steam engine, a small steam hammer, a steam-driven pump and a small fitting shop, together enough to make
cast iron and wrought iron. All would be built “in a small but practical scale” and, as already noted by Blackwell, the Burwai Iron Works would be a trial plant.109

**SUMMARY DISCUSSION**

**Science and Utility**

To the Europeans India was a land to explore and discover, a land to control and to exploit.

The purposes of exploring the geology of Kumaon and Nimar changed over time. From a general Linnaean spirit of discovery the motive changed to a more strictly defined scientific, later increasingly closely linked to utilitarian objectives.

Both the Narmada River Valley and the Himalayan mountain range were the result of dynamic and dramatic forces exposing geological changes to direct observation. With the gradually increasing importance of geology as a science, the areas were thus considered to be of vital interest. The discovery of interesting fossils gave extra emphasis to this argument and there were also reasons that might be considered more ephemeral. Kumaon attracted attention with the lure of the high Himalayas, the Narmada Valley for its “picturesque beauty”. Kumaon’s position close to the Tibetan and Nepalese border added a strategic element to its importance.

Members of the armed forces often had a decisive influence and acted as the forerunners of “European civilisation” and their weapons of conquest were not only guns but also a wide-ranging knowledge of different areas of science, engineering and social planning. During the first half of the nineteenth century there was also a gradual professionalisation and an increase in the importance of experienced geologists in the surveys. Gradually a group of scientifically competent, professional geologists emerged and Professor Thomas Oldham, head of the newly instituted Geological Survey of India (1851), played a decisive role.

The stress on the practical use of minerals, especially coal and iron, gradually increased over the first half of the nineteenth century. There were close ties between science – i.e. the mapping of natural resources – and colonial, commercial interests. Science and industry were closely connected. This shift can also be seen in the process that led to the establishment of the Kumaon and Burwai Iron Works.

Here too individual actors played a decisive role in the process. The iron-works are hard to imagine without the inputs of men like the geologist Henry Drummond, the at least partly amateur metallurgist William Sowerby or the persistent and skilful organiser Richard Keatinge. They formulated ideas and implemented them, energetically and without sparing themselves. They set their decisive imprints on the subsequent history. The colonial government
in India, however, made the final decisions in close consultation with the board of directors of the East India Company in London. The aim was to promote a more rapid development of Northern India by supplying public works and railway construction with iron produced in the country. It was thus the combined efforts of deeply committed individuals and the colonial state that implemented the first plans to transfer ironmaking technology from Europe to India.
When Julius Ramsay and Colonel Richard Strachey met at the East India United Service Club in London in October 1861 to sign a contract of employment they met across boundaries both national and politico-economic. Like Mitander a year earlier, Ramsay represented Swedish knowledge of ironmaking. Like Richard Keatinge, Richard Strachey represented those who set the agenda for the projects in which the Swedes were to serve.

The histories of these meetings raise questions. In the early 1860s Britain was one of the major iron and steel producers of the world and a centre of dynamic technological development. Why, then, were two young Swedes, and later Gustaf Wittenström, recruited to take charge of two pilot projects of the British empire in India? How did the international networks of ironmaking knowledge work and why were the Swedes judged competent? And, from a different perspective, what led Julius Ramsay to abandon his new iron foundry in Örebro to engage in a hazardous undertaking on the slopes of the Himalayas? What took Nils Mitander from the snowy woodlands of inland Sweden to a small town in the Narmada Valley?

Reflection on the events leading up to the formal engagement of the Swedes prompts questions on the networks of ironmaking knowledge. What individual and institutional networks were there, and how did they interact?

Both Julius Ramsay and Gustaf Wittenström were only in their early thirties when they arrived in India. Nils Mitander was even younger. In spite of their relative youth, all three had solid backgrounds in Swedish ironmaking, in part different, in part similar.

Their families also represented three different parts of the ironmaking society of Sweden. Mitander came from a more traditional, upper class, ironworks-owning class firmly based in the ironmaking districts. Julius Ramsay was from Stockholm with strong Finland-Swedish family connections, and Wittenström came from a family of builders and sub-contractors at ironworks, without any proprietorial interest of their own.
NILS MITANDER

Nils (Wilhelm) Mitander (1833–1903) represented the third generation of an ironmaking family. His grandfather (Nils Philip, 1767–1841) had worked his way up from being an apprentice at the offices of an ironworks to become one of the most important ironmasters in the province of Värmland and when he died his son, Nils’ father (Nils Philip Mitander, 1824–1862), inherited the Alkvettern estate.

When Nils went to India his father was nearly sixty, and it might seem reasonable to expect that Alkvettern would once again have passed to the next generation. A series of events seems to have blocked that possibility. His grandfather’s will had decreed that the ownership of the estate must be handed down in equal shares to his children and grandchildren, who were not allowed to sell. The estate thus acquired a corporate structure. Nils’ father, Nils Philip, became the managing director, but increasing antagonism arose between him and the board of the company and in 1857 he was dismissed. He and his wife Ulrika (Ulla) Eleonora Nordenfeldt (1812–1896) and their six children moved to Ullvettern, a smaller mansion belonging to the estate. When Nils Philip died in 1862, while Nils was in India, it was discovered that he had quite a substantial debt to the company. For a short time Ulla was able to continue living in the mansion, but she soon left her former life and moved to the town of Kristinehamn.

Nils was born in 1833. He was the eldest of six children and received a sound education, leading to a diploma from the University of Uppsala in 1852. Even if Nils himself would not inherit Alkvettern and the financial position of his parents was shaky, he had many options open to him, at least at this time. There was a tight web of interrelations between families in the ironmaking community of Bergslagen, and its members were provided for. Even if times could be hard, the word went round when someone needed a position. In one way or another doors were opened and few were left out in the cold. While Mitander was in India, however, it is evident that he did become increasingly uncertain of whether he would find a satisfactory position back in Sweden and this became one of his main reasons for trying to stay abroad.

JULIUS RAMSAY

Julius Ramsay (1827–1874) was the only son of Major Johan Wilhelm Ramsay (1788-1844) and Gustafva Charlotta Margareta Pinello (1800–1877), both of noble birth. Julius was born in 1827 in Stockholm, to which his parents had moved from the southern, Swedish-speaking parts of Finland. Like Mitander, Julius Ramsay received a good education and gained a higher school certificate in 1845. He had two sisters. The older of the two died in 1863 only 38 years old, during Ramsay’s sojourn in India.

His parents did not have any direct connection with ironmaking but his uncles became deeply involved in the industry in southern Finland, as owners
of Dalsbruk and Högfors, two of the most prominent ironworks in that region. Later Julius’ cousin Wolter took charge of Dalsbruk, where Gustaf Wittenström was working when Ramsay later asked him if he was interested in going to India.⁶

In 1860 Ramsay moved from Stockholm to the mid-Swedish town of Örebro, where he had bought a small foundry and planned a future, at least in the short term, as a factory owner and maker of outdoor furniture in cast iron.⁷

GUSTAF WITTENSTRÖM

Gustaf Wittenström (1831–1911) had a most interesting career, moving from simple origins via a wide range of interests to become the most widely known of the three Swedes with his most striking achievement the planning and construction of the ironworks of Domnarvfets Jernverk 1872–1877, at that time Sweden’s biggest.⁸ He was born in 1831. His father, Petter Wittenström (1795–1839), was a master builder in great demand at the ironworks of Central Sweden, but when he died in an accident at the age of 44, his family was left in very modest circumstances. His wife Christina Fichtelius had to care for her three children on a small farmstead in western Värmland and Gustaf had to fend very much for himself. At first he received some basic education at home, but he was also taught by a peripatetic teacher travelling between ironworks. He was soon discovered by a building contractor who, among other things, taught him some of the basics of mathematics and mechanics.
and at the age of nine Gustaf could enrol in an elementary school in the provincial capital of Karlstad. From here he got a good start to his upward climb in society.

Institutional Networks and Professional Schooling

Connections between men can be established on a personal level and depend on purely individual relationships. Or they may be mediated by institutions that sometimes appropriate the role played by personal networks in a more strictly defined, bureaucratised agenda. These individual and institutional networks reinforce each other and are the means by which transfer of technology takes place. There are no limits to these kinds of networks within an organisation since the institutions are made up of individuals, but men can also form part of individual networks outside any formalised organisation and institutions can give personal networks a form that can maintain them beyond the individuals concerned.

Mitander, Ramsay and Wittenström came from an ironmaking environment where technological knowledge had to some extent become institutionalised. This institutional superstructure was largely based on the close physical proximity between iron-producing units. To take one example, in the mining district of Norberg in Sweden, blast-furnace experience went back at least 700 years in the 1860s. In 1860 there were 19 blast furnaces at work within 20 kilometres of the mines, providing an intricate web of experience and tacit knowledge of a more private, personal character. The situation was similar all over central Sweden.

Formal Education

There were societies for both social gatherings and professional exchange of experience, principally the Swedish Iron Masters’ Association (Jernkontoret) established in 1747. The journal of the Association, *Jernkontorets Annaler*, had appeared regularly since 1817 and gave extensive information on technical aspects of ironmaking and processing. This national organisation and this publication also had regional equivalents.

In the middle of the nineteenth century there were two schools providing formal education for prospective managers of ironworks. One was the well-renowned Fahlu Bergsskola, an institution for the training of mining engineers and metallurgists, which was the first civilian engineering college in Sweden. The other was Bergs Elementar-Scholan in Filipstad, established in 1832, which still exists under the name of Bergsskolan. As the old name indicates, it was considered to give the lower, more elementary, education of the two.
Bergsskolan in Falun had been founded in 1819 and the curriculum consisted of economics, mining, metallurgy, forestry and the sciences in general. Both Julius Ramsay and Nils Mitander graduated from here, Ramsay in 1852, Mitander in 1854. This was where they received their basic education as metallurgists and future ironworks managers.14

Bergsskolan was situated close to the heartlands of the ironmaking area of Bergslagen. Education was theoretical, but lectures and reading could be closely related to practice, either in the laboratory, on the drawing board at the school, or during excursions and field studies and in personal practice in mines, forests and ironworks.

The timetables of instruction at the school show the wide range of subjects studied. Taken together the young graduates from Falun knew the basics, in theory and practice, of the whole process of manufacturing ironware for the market, starting out with the earth itself and the forests as the basic raw materials. They could identify and chemically analyse iron ores. They knew how to fell trees and replant them. They were acquainted with charcoal-burning and how to build a road. They knew the particulars of blast furnaces, from laying the first stone of the foundations and the process of brickmaking to the details of running it. They knew how to make drawings and build models and they knew the different methods of refining pig iron. And they knew rolling mills and forging and the elements of economics. They became designers, metallurgists and business executives, all in one.

The experiences of Mitander and Ramsay were basically the same, and details of Mitander’s two years at the school give full evidence of the breadth of the education.15 His first year at school, 1853, included instruction in: laboratory practice and analytical chemistry, analysis of minerals and different blast-furnace products, mechanics and machine drawing, mineralogy with excursions, land surveying and drawing of maps, as well as extensive summer tours to more than thirty different sites in central Sweden, ironworks and mines, a practical course in forging at one of the works, and construction and modelmaking.16

During the second year, 1854, still more areas were covered: ore analysis in the laboratory; analytical chemistry; theoretical and practical education in blast furnace management; geology; special site visits to study blast furnace running and forging; forestry; bar-iron forging; there was a new and extensive study tour, this time also to workshops.17 It should be noted that in this particular year the teachers introduced three significant reforms at the blast furnace at which the students practised (less coal charged, increased blast, piecework wages instead of payment by the day to the workers).18 The school in Falun was apparently also a place of innovation and technical development.

After qualifying, Mitander and Ramsay gained wide experience, both by working at various ironworks in Sweden and by travelling in Europe, studying the processes of the time.

Two years at Bergsskolan was a start and often the first years of employment were a kind of apprenticeship with periods of work at different ironworks,
gradually learning the trade, often helped by more experienced colleagues. A small group had the special privilege of being awarded scholarships at Jernkontoret. This happened to both Mitander and Ramsay and during the period of their scholarships they had the opportunity to become closely acquainted with the ironmaking of the time, seeing both outmoded ways of producing iron and the most modern ones. The travels of Mitander’s years at school and his six years of work in Sweden, before he left for India, are summarised in the map on p. 117. Two of Mitander’s assignments should be specially noted, since they later became relevant to his work in India. During the years 1856–1857 he spent a lot of time working at the blast furnace of Silverhyttan and in 1858 he assisted at the pioneering trials in the blowing of Bessemer steel at Edsken. Here the method was successfully used in practice for the first time.

The years at school and the years of peripatetic work and apprenticeship were years of establishing a network of contacts with other experts in the field. And it was during this time as holders of scholarships at Jernkontoret that Mitander and Ramsay developed links with one of the directors of Jernkontoret, Andreas Grill. Grill was one of the most renowned metallurgists of his day. Mitander was salaried by Jernkontoret for five years, most of the time as an assistant to Grill, and Grill became something of a mentor to him.

Gustaf Wittenström did not get the same kind of start as his two friends. After six years he abandoned his schooling in Karlstad without completing it, and his plan to study at the University of Uppsala, as both Mitander and Ramsay had done, had to be relinquished. Instead he began a job at the glassworks and ironworks of Johannisholm in the province of Dalarna. At the age of eighteen he enrolled for lower elementary education in the iron trades at Bergs Elementar-Scholan in Filipstad. After graduating he soon found his first regular employment, as a bookkeeper at a small ironworks, but he had other ambitions. He left work and went to Stockholm to join the Academy of Fine Arts and take a two-year course as an architect. To support himself he worked as bricklayer, draughtsman, photographic technician and illustrator. By now Wittenström was well-known and he could choose between different offers of work. He was to build the new ironworks and workshops of Nyköping and in 1857 he was engaged to take charge of the building and start-up a new ironworks in Russia. After study trips in Europe he was employed by the uncle of Julius Ramsay, Wolter Ramsay, at Dalsbruk in southern Finland. While he was employed here he received two more offers: either to become the chief engineer at the workshops of Motala, an establishment of world renown – or to go to India and join Julius Ramsay.

To sum up, the Swedes were professionals. They possessed skills based on systematic and theoretical knowledge. They acquired their knowledge from an exacting and specialised training. They had completed the formalities of the profession that certified their competence. They came from a context of a self-regulating and state-sanctioned organisation that enforced standards and where a strong sense of corporate identity was maintained in the profession.
Besides the three Swedes, many of the other Europeans engaged at the works, miners, engineers as well as skilled workers, had a wide international experience. At an early stage in the Kumaon Iron Works the mineral surveyor William Henwood and his mining assistant Mr. Gray were said to have had “a long acquaintance” with Brazil. Some years later it was stressed that the metallurgical assistant at the works, William Gower, had been employed in various parts of the European continent as a workman for several years. And much later it was recorded that Bernard de Villeroi, who was in charge of the blast furnace in the 1870s, spoke of having worked at blast furnaces in North and South America.
In general, references to international experience seem to have been an important qualification and possibly they should be treated with some caution. William Sowerby, manager in the last period of government ownership before Julius Ramsay, maintained that he had been to Southeast Africa “to investigate the iron and coal fields there with the view of supplying the Indian market.”

In his report Hardy Wells cast doubt on Sowerby’s reference about the big iron and coalfields of South Africa. “I do not doubt Mr. Sowerby’s veracity, yet I cannot help thinking he has mis-written the Colony of Natal for some other place.”

In an examination of the achievements at the works, Hardy Wells later noted that Sowerby had for a short time been “an unsuccessful colonist at Natal” but to the writer’s knowledge there was no evidence that he ever conducted any geological investigations there.

International Knowledge Networks

Since the very first steps of European industrialisation, and maybe even forming a prerequisite for it, technology transfer by the movement of people and the flow of information has been a basic feature of history. In the Swedish iron and steel trades, this exchange has also been an explicit aim of Jernkontoret, thus creating an institutional base for an international network of knowledge. Ever since its inception in 1747 the organisation has had formalised tools for systematically increasing this exchange.

Metallurgists travelled...
to acquire new information. Beginning in the eighteenth century, an international cadre of engineers with an affinity transgressing national boundaries was formed. With similar education in different countries, they used standardised and formalised methods of depicting technological solutions in drawings and they exchanged views in different kinds of publications. As during earlier centuries, the travel of craftsmen and engineers in order to learn and or to bring technological knowledge was still the most important form of technology transfer.

This pattern was well established and became an important part of life for many engineers in the eighteenth century and even more so in the nineteenth century. Carried forward through family networks, by friends and colleagues, and through the array of networks of Jernkontoret and the institutions, knowledge of innovations spread quickly and new technology was adopted. The technology of industrialised iron and steel making became international. The prevailing methods of refining pig iron all bear their origins in their names, some of them the result of an inflow of immigrants bringing new skills to the Swedish iron industry.

Since the eighteenth century England, Wales and Scotland had been the hub of metallurgical innovation and development and the iron-and-steel-producing areas were natural places to visit for any ambitious Swedish metallurgist. The exchange of knowledge between Sweden and England was continuous and characterised by mutual respect and interest. One example of such reciprocal interest and exchange of knowledge is provided by Andreas Grill, director of Jernkontoret, and the eminent British metallurgist John Percy, who was the initial connecting link between Keatinge and Sweden. He was an important actor in the international network of iron technology and he had close links with Grill.

The ironworks of Sten. The ironworks of Sten (Graversfors) were established at the outlet of Lake Näkken. The first blast furnace was built in 1859 with Nils Mitander as the chief designer in close collaboration with Andreas Grill, director of Jernkontoret and Mitander's mentor. A second blast furnace was built in 1884. They were both rebuilt in 1904-05 and the picture shows the works in 1914. To the left is the blast-furnace houses and to the right two calcining kilns. In front is the forge built on the stream and behind the works is a huge slagheap. The works were closed in 1936. Watercolour by V. Bergström 1914. The archives of Jernkontoret.
At that time Percy was preparing what was to become his magnum opus, *Metallurgy: The Art of Extracting Metals from Their Ores, and Adapting Them to Various Purposes of Manufacture* (1864), a central work of British metallurgy. Percy published technical descriptions of Sten blast furnace in Sweden, for which he received all the material from Grill and for which he thanked Grill in the preface to his book.32

The transfer of knowledge was extensive, but it was not free. When Great Britain became established as the leading industrial nation towards the end of the eighteenth century a number of rules and regulations were introduced to limit the transfer abroad of tools, machinery and technical knowledge. This policy was designed to protect the industries which had the advantage of using new technology, but it was not unopposed. The parts of the manufacturing community whose business was making and selling machinery criticised it and a growing liberal sentiment strongly opposed the efforts to curb exports of machinery and the travel and emigration of technicians. In 1843 restrictions on both emigration and the export of machinery were removed.33

One example of international interaction is the wealth of reports in Swedish archives by Swedish metallurgists visiting different parts of Europe.34 Jernkontoret had a consistent policy of financing such travel, to see and to learn. Reinhold Angerstein’s diary of his journey through England in the middle of the eighteenth century is an example.35 Julius Ramsay also made a visit of this kind to Germany and France in the summer of 1859.36 The report of Julius Ramsay on his visit to India is one of a multitude of such travel reports collected by Jernkontoret – many of them published in the Association’s journal, *Jernkontorets Annaler*. The appointments of the three Swedes in India can be viewed as a part of a much bigger exchange of engineering work across borders.37

The world fairs became important information channels for the introduction of new technology. This is directly visible in the primary material of the
Kumaon Iron Works. Andreas Grill represented Sweden as one of many judges at the International Exhibition in London in 1862. From the section on manufactures of iron he reported directly to Julius Ramsay in Dechauri: “Krupp and Bessemer have the most beautiful display. Krupp dense ingots, 1.2 metres (2 aln) in diameter, Bessemer the same, 0.6 metres (1 aln), not forged, but turned and polished.”.

William Sowerby’s ambitious trip to Europe in 1858 is another example. During seven busy weeks he visited ironworks in England, Belgium, Prussia, Austria and Styria. His purpose was to gather information on how to make iron using charcoal as fuel and, at least according to his own report, he received a most generous reception everywhere. As far as his schedule permitted he had the opportunity to study and record the technical details of different aspects of ironmaking. The community of ironmaking seems to have been generously open.

India was on the periphery of modern ironmaking in the middle of the nineteenth century, but it is still striking how fast the knowledge of technical achievements spread to this far-off fringe. In spite of slow communications it is possible to see that news of new achievements did not take long to reach India. For example, news of the Bessemer process arrived during the last years of the 1850s, at least in the form of brief notices in *The Engineer’s Journal and Railways, Public Works and Mining Gazette of India and the Colonies*. The journal covered a wide field, with a focus on railroads, but contained articles on many other subjects, such as photography and metallurgy. In the middle of January 1858 “Bessemer’s American patent and the Indian patent laws” were discussed. A year later, one author maintained that a new process, invented by Mr. Farrar, was an improvement on Bessemer. This claim proved false, and five years later reports on “the manufacture of Bessemer steel” again appeared.

Although such news could be both incomplete and sporadic, it nevertheless indicates a vivid interest and an ambition to spread information, even if the articles did not in any way match the detailed technical reports carried by a journal such as *Jernkontorets annaler*.

**A Network in Action**

The person behind the building of the Burwai Iron Works was Richard Keatinge, and throughout the history of the works he remained committed to seeing it develop. It was also he who engaged Mitander and he was one of the links connecting both the Burwai and Kumaon Iron Works projects with Sweden.

No explicit reasons for turning to Sweden have been found in the case of the Burwai Iron Works, but in the case of Kumaon there is a clear motive. In a letter, seemingly somewhat haltingly translated from English and carefully preserved by Julius Ramsay, the qualifications of a future manager of the
Kumaon Iron Works are specified. The provenance of this letter is uncertain. The addressee was probably Andreas Grill, since the sender refers to Dr. John Percy. He directly asks for help in procuring a manager for an ironworks in northern India. The letter could have been written by Richard Strachey. The reasons for turning to Sweden are explicitly stated, namely the lack of coal and the necessity for using charcoal reduction and smelting processes, of which there was so much knowledge in Sweden:

This has led me to turn rather to Sweden than to England to procure a person suited to undertake the management of these works and as the business of the company is still in its infancy it is important as soon as possible to procure the aid of a person experienced in the most acknowledged way of work in a country such as Sweden, where forests are the foremost fuel.  

The same opinion was later referred to by Ramsay in his report to Jernkontoret. As Sweden was highly renowned for its high-quality charcoal iron the directors decided to engage a Swede “as having more general experience and understanding of ironmaking based on charcoal than is the case with Englishmen in general.”

The qualifications needed were extensive. The manager was to know how to treat the iron ore and knowledge of forest care and management was especially important. Since the works were located deep in the interior of the country and distant from any mechanical workshop he would have to manage all matters concerning machinery and mechanical engineering himself. It was important to start production of iron bars as soon as possible, since the market for cast iron was vanishing. Proficiency in both these branches of iron production was thus significant. Good knowledge of geology and metallurgical chemistry was also required.

Experience of India and a command of the language were apparently considered less important than a deep and extensive knowledge of building and managing ironworks based on charcoal.

Since it was difficult to find a qualified manager in England to supervise a charcoal ironworks, Keatinge was sent to Sweden, at his own suggestion, to find a manager. At the same time he would also broaden his own knowledge of the making of charcoal iron.

The general view that Swedish ironmaking was usually synonymous with quality was in all probability a powerful argument for looking to Sweden for engineers able to manage the new works. This was all the more relevant since the Indian works were to be based on charcoal and England had left charcoal iron behind. In Sweden engineers knew this trade well, and ought to be competent.

Few details are known of Keatinge’s visit to Sweden, but such as they are they give a picture of the kind of combination of coincidence and intentional action which often shapes the course of events. Of prime importance at this stage was Professor John Percy of the Government School of Mines in London.
On his arrival in Sweden Keatinge met Andreas Grill, director of Jernkontoret, and “one of the most eminent iron engineers of Sweden” as Keatinge described him in a report on the Burwai Iron Works. On Grill’s advice Mitander was chosen for the job and plans for the proposed works were drawn up under the supervision of Grill. The close contact with the Swedish experts on making iron with charcoal was later commented on: “It was hoped that, with such practical and professional help, the Natives of this country might be instructed in those portions of the work connected with the manufacture of iron which require skill and practice.”

Mitander and Keatinge met at Andreas Grill’s mansion at Mariedamm on 23 May 1860 and probably agreed on all the essential details. Keatinge seems to have stayed in Sweden some weeks longer, maybe to improve his knowledge of ironmaking. But like Mitander he also took action on his future undertakings in India. In a letter from Sweden at the end of June he informed the Storekeeper-General in London that a manager had been engaged and he asked for the name of a factory that could manufacture the necessary equipment. By that time Keatinge had actually already met Ramsay.

Besides Mitander’s and Ramsay’s earlier acquaintanceship at Bergsskolan there is evidence of an Indian connection between Mitander and Ramsay at an early stage. On the steamship from Stockholm Richard Keatinge happened to meet Ramsay. When Keatinge learned of Ramsay’s profession he told him the purpose of his visit. Ramsay wrote that he was even provisionally offered the position, should Mitander not accept it.

To Ramsay’s disappointment, Mitander did accept the offer and in June Mitander departed for England to sign a contract and make the first orders for castings for the works. Ramsay bided his time in Orebro, but he did not have to wait very long for a new opportunity. The contact between John Percy and Andreas Grill continued and a new chance appeared when the position of manager of the Kumaon Iron Works had to be filled. It had been offered to another Swedish colleague, Harald Dillner, who had even been to London to finalise the agreement, but shortly before his he was due to depart from Sweden he had turned the position down and in the summer of 1861 Ramsay was contacted again. He was given keen support by Andreas Grill and he did not hesitate. As the owners of the company wanted the manager to start work in the coming cool season, there was little time to waste. Ramsay had no more than a month to decide and to arrange his journey.

Expectations and Adventure

When the British tried to procure Swedish metallurgists it seems quite clear that they were looking for independent metallurgists specialised in using charcoal but with a wide competence in all aspects of setting up and running an ironmaking industry. But why did the Swedes prefer such a hazardous adventure to a comfortable future in Sweden?
The very nature of ironmaking knowledge probably points to an answer. The world did not end at the limits of the Swedish ironmaking districts. Each and every ironworks was dependent on exports and this also meant that they were deeply affected by any change in technology that might alter the balance of power in the markets. As a metallurgist or ironmaster you needed to be continually informed on developments that could affect your competitive position. This made international contacts and travel not only a necessity for a country’s iron industry as a whole, but also a valuable asset in any metallurgist in the search for a better social position.

In the individual cases of the three Swedes, the picture becomes more complex and fragmented. Also rifts appear in the apparently solid social networks of Swedish ironmaking society, as when Mitander had decided to continue his stay in India after the end of his first contract, looking to save money for his retirement, instead of trying to get a job in Sweden, “and beg my way to an uncertain employment”.56

The first half of the 1860s became a turning point in the Swedish iron industry. At this time began a century-long decrease in the number old blast furnaces. At the same time new work with modern technology meant an overall rise in productivity.57

The Swedes’ personal reasons for going to India were probably a combination of financial difficulties at home and the inducement of good pay in British service, the social and professional challenge of heading new and, as it appeared, big ironmaking projects, and also the lure of the magical image of India – the adventure.

Among these reasons, financial ones are most evident in the sources, especially in the case of Julius Ramsay, who appears to have been repeatedly in financial difficulty. Before his departure his letters to his relatives abound in references to money problems. He apparently had a rather extravagant lifestyle and borrowed to sustain it. This seems to have been a part of his character and he must have welcomed a high and regular salary.58

His contract promised him 1,000 rupees per month, plus all travel expenses and accommodation.59 In a letter to his mother he wrote earlier that he had been offered 12,000 riksdaler a year on similar conditions, provided that Mitander did not accept the position at the Burwai Iron Works.60 According to later letters from India Ramsay was able to remit 700 rupees a month of this back home, which, according to the exchange rate quoted by himself, was equal to between 1,225 and 1,260 riksdaler. In January 1862 he arranged for complicated remittances of money home to Sweden in order to settle a debt.61

It may also be noted that even Gustaf Wittenström was without hesitation advised to accept Ramsay’s offer to go to India, although he apparently had a very good chance of a very prestigious position at the workshops in Motala.62
The Road to India

In the autumn of 1860 Mitander left his home in Värmland and set out on his long journey to India. One year later Ramsay followed the same route and left Sweden from Gothenburg, heading first for Hull and London.

MITANDER’S OUTWARD VOYAGE

On 20 September 1860 Nils Mitander embarked on a steamship at Gothenburg, the big port on the west coast of Sweden. He was unmarried and only 27 years old. His first destination was Hull, whence he continued to London by train.

The tightly knit web of contacts between people in the ironmaking industry in Sweden extended to England as well. Even on his very first day in England Mitander had an extremely busy schedule. He made several arrangements for his onward journey to India, and he also had appointments of a social character. London was a very big city and communications were difficult, but all the same Mitander seemed to consider it unremarkable that on

[Map of the journey to India. Both Mitander and Ramsay started out from Gothenburg and on their forward journey to India, they travelled from Southampton via Alexandria and Suez. From there they continued by sea towards India, stopping only in Aden. Mitander went directly to Bombay, while Ramsay continued southwards, touching land at Galle and Madras before arriving in Calcutta. From Bombay and Calcutta they continued inland, Mitander more than 500 kilometres by train, bullock cart and on horseback to Barwah. Ramsay approximately 1,500 kilometres by horse-drawn cart and palankin to his first destination in Kumaon, Kaladhungi. They reached their destinations more than two months after departing from Sweden. On this map, Ramsay’s and Mitander’s itineraries are only marked approximately. Map adapted Jan af Geijerstam from Lind af Hageby (1866). Artwork: Staffan Schultz.]
his first day there, he met three of his compatriots, “Helling, Christer and Sten”.⁶³ “Christer” was Christer Peter Sandberg, who in 1860 was appointed Consulting and Inspecting Engineer in England for the Swedish State Railways. Sandberg had then commenced a lifelong residence and practice in England, which he came to regard as his home.⁶⁴

The four spent the following few days together in good, sometimes even merry, humour, perhaps such as could be expected when young friends meet. They visited the geological and British museums and other places of interest, discussed India and combined to help Mitander arrange practical details. After a couple of days in London Mitander continued his journey and Chris
ter Sandberg accompanied him all the way to Southampton, and even out to the steamer *Indus*, at anchor in the Southampton roads. “An orchestra live-
ed up the embarkation,” Mitander wrote in his diary. “As Christer and I were rather hungry we had some Sherry and biscuits. . . . nice, at the last moment, to have a friend, a comrade and fellow countryman at my side – I could see him for a long time on the steamboat that carried him back to the shore.”⁶⁵

The students of Fahlu Bergsskola 1851–52. One of Julius Ramsay’s classmates in Fahlu Bergsskola was Christer Sandberg. In this picture, showing the students of 1851–52, Sandberg is standing second from left in the back row. According to the notes on the back of the photograph Julius Ramsay is sitting to the far right in the front row. Christer Sandberg was later appointed Consulting and Inspecting Engineer in England for the Swedish State Railways in 1860, and thus commenced a lifelong practice in England. When Swedish metallurgists passed London he was a given point of reference. Sandberg was a close friend of both Julius Ramsay and Nils Mitander. Mitander stayed at his home in London on his way to India and even had Sandberg’s photograph with him in India. Photo from the collections of Jernkontoret.

*The Indus* carried Mitander on the next leg of his journey from Southampton to Alexandria. The days onboard ship followed well-organised routines. Meals, afternoon teas, games and pleasant conversations with fellow passen
gers, leaning on the rails and looking out over the waters. The days were concluded with “God Save the Queen” and a toddy.

For Mitander the voyage became a time for reflection: “In a sense I feel alone, more than before, but I also have a certain feeling of independence and self-confidence.” Mitander specially noted how he enjoyed reading one of the best-known lyric epics of Swedish national romanticism, *Frithiofs saga,*
by Esaias Tegnér, published nearly forty years earlier. “I have never before read it with such consistency, continuity and reflection.”

On the fifteenth day the Indus touched land at Alexandria and the passengers had to disembark to catch a train to Suez, since the Suez Canal was still under construction. For the first time Mitander encountered the “Orient”: “… a frightful lot of Egyptian Turks met us in barges and smaller boats, and made a terrible noise.” Mitander carried his most important belongings himself as hand luggage: a dispatch case, probably containing drawings and ideas for his work in India, in one hand and a small night bag with his money in the other.

In Suez, Mitander embarked on the Orissa. His companions on board were Britons: Major Sappit, Mr. King, Lieutenant Reed, the Campbells, Watson, Gibson and others, when Mitander went ashore in Aden on 18 October he had a beer and played a game of carambole.

During the passage to Bombay Mitander discovered that his black dress suit had disappeared, probably stolen from his night bag. The same day they ran out of soda water, but it was, as Mitander puts it, fortunately the last day onboard the Orissa. On 26 October 1860, five weeks after leaving Gothenburg, Mitander arrived in India and with awe and wonder saw the first contours of land.

How can I ever describe my feelings this morning when I first saw this land, old India, where I am to work for four years, the Almighty willing. At six o’clock we saw the sharp contours of mountains suggesting land and at a quarter past eight in the morning the anchor was cast in the harbour of Bombay. The view of Bombay this morning was said to be far from the best. A heavy fog still hung over parts of the city and the surrounding area. We had breakfast onboard and then all of us prepared for disembarkation, took a rather light-hearted farewell, so many people brought together for a month, now possibly never to meet again in this life.

Mitander went directly to the Clarendon Hotel, together with a Mr. Hutton, and they put up in the same tent in the garden of the hotel. “Here we received refreshments, a lemonade and soda water with ice. How well this tasted in the heat, compared to the Orissa, cannot be described.” After taking a bath and a change of clothes, the old ones soaking wet with perspiration, they went downtown to attend to their affairs.

Mitander stayed for ten days in Bombay, arranging practical details or gleaning information concerning the state of ironworking in India.

He collected his belongings from the customs, reported his arrival to the authorities and changed money. He bought some equipment for his future home and procured tickets for his onward journey. He bought new sulphuric acid as part of his ore-testing equipment, to replace a bottle that had been broken.

Mitander was a professional, and to judge from his notes he considered what he saw without prejudice, assessing it by the same standards as he would...
have applied in Britain or Sweden. He spent most of his time in Bombay on study visits. He carried an introductory letter from Richard Keatinge and this opened the doors to a number of industrial establishments, many of them closely linked with the British armed forces. He visited the wharf, the fort and the railway works. All in all he seems to have been generally impressed by the technical standards he saw, and he noted “a machine for making bullets, which was rather interesting and deserved more attention”.

He made observations of direct relevance to his future work. A smithy of the dockyard that was under construction was to include two puddling furnaces, two steam hammers, one rolling mill and a finery. He also noted that at the foundry of the gun carriage manufactory at Calaba a third of the pig iron used came from the East India Company in Beypore, while two-thirds of the charges came from Wales. When he visited the dockyard and a smithy under construction he put a question in his diary that was intrinsic to his mission: “How it can ever pay to bring coal and pig iron from England to work it here, I, at least, cannot understand.” The answer to this question was to become of fundamental importance to his future in India.

Some observations also indicate that he had certain preconceived notions of the abilities of the Indians. As a subtext it seems self-evident that the British represented technological competence. Almost with surprise he gradually noted that Indians had important roles in production. Thus he particularly noted that “natives” carried out all fabrication of, for example, guns and ammunition at the fort. He made a similar explicit observation at two different foundries. At one of them there were only two Europeans, as supervisors, and at the other, at the railway workshops he saw a casting made only by “natives”. On the fabrication of guns and ammunition at the fort he briefly noted: “All with natives.”

“This land, old India!”, Mitander had exclaimed in his diary and his expression carries a connotation of an ancient culture. It is however far from clear what he really knew or had tried to find out about the country to which he was travelling. While in London he had dinner at the home of a Mr. Simpson together with Christer Sandberg and Sten and they saw “a Diorama of India and many other things from there.” And just before disembarking at Alexandria he spoke to several of the other passengers “and heard nothing but good about India.” In Bombay he read a book “describing the mutiny in India of 1857 and 1858.”

It may also be noted that there were links between India and Sweden and a dissemination of general information in other areas of society. India was not total terra incognita to all Swedes. Books and articles had been published, some of them written by Swedes who had travelled to India in the middle of the nineteenth century. The Swedish painter Egron Lundgren reported on the uprising of 1857–58. A Swedish naval officer, Axel Lind af Hageby, was a member of the British armed forces at approximately the same time and wrote a lengthy, pro-British book on his experiences. The reports compiled by Herman Annerstedt on the iron and steel trade of the Swedish government
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with India in the late 1850s should also be mentioned, although they were not printed until ten years later.83

“Not without a peculiar feeling I went to bed the first night in Bombay, and in my tent I thought about the stories I had heard of snakes as bedmates”, Mitander wrote in his diary, but otherwise he very seldom expressed any specific expectations – or preconceptions – regarding India. The prevailing tone of his diary has a fearless and almost unprejudiced curiosity and matter-of-factness. However, on his continued journey inland towards Barwah, he made a diary entry that reveals certain shortcomings in his knowledge of India.

A bullock had, apparently dropped from overexertion and lay dead close to the road, food for dogs, hawks and other predators. I was surprised that an animal like that was left so close to the road, instead of, as with us, being slaughtered for food. I was informed that Hindus do not eat meat, curiously enough.84

LAST LEG OF MITANDER’S JOURNEY TO BARWAH

Bombay was but a station en route for Mitander. To reach his final destination he had to travel north-east into the interior of the subcontinent almost 500 kilometres as the crow flies. Two men were sent by Richard Keatinge to meet him in Bombay. At least one of them followed him towards Barwah.85

At first the party could use the railway, but after only half a day’s journey, the Great Indian Peninsular Railway train reached the railhead at Wassind, eighty kilometres from Bombay. At that point, where the construction of an extension of the railway was in progress, Mitander left what he considered to be normal public transport. For the rest of the journey, twelve days, he rode mainly on bullock carts, but for some days towards the end, he had a horse and was able ride, while his luggage was pulled on carts.

The climate was hot and heavy, the journey strenuous. During the first seven days the party was on the road for fourteen hours out of every twenty-four, mainly during the cool of the night. During the hot mid-day hours they rested. According to Mitander’s own estimates they travelled 38 kilometres per day, on average.86 On the morning of the fourteenth day they crossed the River Taptee: “the passage across the river was dangerous and the road close to the river harder and harder to pass for carts. At every moment I feared that the current would seize my cart and on land that it and all my belongings would be shaken into pieces.”87

Some days later Richard Keatinge joined Mitander on his journey and the next day, nearly two months after leaving Gothenburg, Mitander arrived on the southern bank of the Narmada River.

[We] arrived on the Nerbudda [Narmada River] at dusk. European soldiers were camped there and had just crossed the river. We embarked on a
kind of ferry-boat and reached Burwai [Barwah] shortly after six, 24 miles from my destination here in India. Two tents were raised here and we soon had dinner and were in good spirits.

The very next morning he began work.

**RAMSAY’S OUTWARD VOYAGE**

The final formalities of his employment were not even settled when Ramsay embarked on his long voyage to India. He left Sweden on 4 October 1861, just two weeks later than Mitander the year before, and travelled to London. And once again the network of contacts between Sweden and England becomes apparent, now in the case with which Julius Ramsay arrived in the capital, met friends from Sweden and was received by British colleagues.

At the East India United Service Club on St. James’ Square he met Colonel Richard Strachey, the trustee of the company, and agreed on the conditions of employment.

Strachey was a man of importance, of which Ramsay was well aware. He belonged to the Royal Engineers and had spent a good part of his life in India; and his brother was Commissioner in Madaba and one of the shareholders in the company. Soon after his meeting with Ramsay Strachey was also appointed Head of the Public Works Department in India, involving responsibility for most big infrastructural projects. As such he also became ultimately responsible for Mitander’s work at Barwah.

Strachey gave Ramsay “much extremely valuable information on life out there and on the journey there.” At the Club in St. James’ Square they studied a map of India and Ramsay was able to locate both the position of Nainital and see the best route to it from Calcutta. On the whole Strachey seems to have been overwhelmingly enthusiastic about the future of the company. The climate was good, the people easy to manage, everyone hospitable and the language easy to learn. The executive board, and managing directors Read and Drummond, resided on site and among the shareholders was Colonel Henry Ramsay, the highest ranking official in the province. After letting a lawyer finish the draft they were able to sign a contract. The details of his duties were vague, but Ramsay was to “submit himself to all reasonable orders and instructions of the trustees.” The exact content of his work was to be established on arrival in Kumaon. The company undertook to pay for all Ramsay’s travel costs. The salary was to be 1,000 rupees per month and the agreement was signed for three years. Ramsay would be able to leave his assignment at six months’ notice. Ramsay described Strachey as a “thorough gentleman, whose looks were more a scientist’s than a warrior’s”. Only six days later Ramsay left England on one of the weekly mail freighters to India.

The journey of Julius Ramsay followed almost the same route as Mitander’s, starting from Southampton from where the steamers of the *Peninsular and Oriental Steam Navigation Company* departed once a week to convey not only
passengers but also mail. In Egypt Ramsay could not follow the normal route by train from Alexandria to Suez, since the railway had been damaged by a flood. Instead he and the other passengers travelled up the Nile to Cairo by steamer. Like Mitander, Ramsay continued from Suez, but instead of going to Bombay, he caught one of the steamers going to Calcutta via Galle, the port of Ceylon. Here the mail was sorted and parts of the cargo were forwarded to China or Australia.

The company have no less than 50 steamers at its disposal for these routes ... [and on] the steamer I travelled no less than 1,200 cases were carried: 400 to India, 300 to China and 500 to Australia. Each case is 3 feet long, 2 feet wide and 1 1/4 feet high and thus contains a substantial amount of letters and journals.

Ramsay continued his journey northwards and arrived at Calcutta on 30 November 1861, about forty days after leaving Southampton. One of the first things he did was to pick up a letter from Nils Mitander in Barwah. A well-functioning communications network thus seems to have been working, connecting one Swede on an assignment in West Central India to another just arriving in India after a forty-day journey from England.

LAST LEG OF RAMSAY’S JOURNEY TO KUMAON

There was nobody to receive Ramsay in Calcutta, but he had got to know a Lieutenant John Birney of the Bengal Engineers on board ship. They had the same route to travel and as Birney knew the country, Ramsay gladly accepted the offer of his company. They had dinner together at the home of Colonel Yule, who was Secretary at the Public Works Department and they started out on the final stage of their journey on the evening of 5 December.

They travelled together for nearly 1,500 kilometres, first using a “dak company”. Horses were changed regularly and the travellers could rest, wash and have a meal in special dak bungalows. They travelled day and night, and the only break was in Allahabad where Ramsay met General Henry Drummond, who was, as Ramsay wrote:

The founder of the company, for the sake of which I travelled to India, and actually the first Englishman, who drew attention to the iron ores in the Himalayan Mountains, especially in the province of Kumaon. It was extremely pleasant to make the acquaintance of this charming old man. He was now about to leave India forever, but was warmly interested in the business he had founded. But, he was too much of an enthusiast and could only foresee success and immediate profit, without the least heeding the many troubles to be overcome in founding a new company, especially in such a remote corner of the world. I later had many letters from him in England, all of them full of sanguine computation of expected results at the ironworks, but I am sorry to say that the reports I sent to him were far from equally spectacular.
Friends in India. One of Julius Ramsay’s closest acquaintances in India was John Birney from the British armed forces, whom he got to know on the ship on his way to India. Continuing west from Calcutta, they kept company. Later they were to keep in contact by letters. According to a note on the back of this photograph it shows, from left to right, John Birney, Bengal Engineers, Doctor Guthrie, Doctor Southerland and Captain Humphrey, Bengal Engineers. Unknown photographer, Ramsay’s collections, F1:1.26.

Ramsay and Birney parted in Meerut, from where Ramsay had still 200 kilometres to go, and he reached Dechauri only one week after his departure from Calcutta, being carried over the last part in a palankin. During this last part of the trip he was aided by nine bearers. Four at a time carried his palankin while two rested, one was in charge and two carried his belongings.

Julius Ramsay had left Sweden early in October 1861. More than two months later, in the middle of December, he reached his final destination.

I arrived at Kalleedoonje [Kaladhungi], one of the ironworks, on December 13, and found that I was still totally unexpected. The letter from Colonel Strachey, which was to notify the Directors that I was on my way out, had not reached them. The Directors, who did not live at the place at all, were not expected until after Christmas, and until then I could of course
do nothing. I was though put up by a Mr Oldfield, who was the Company’s Accountant and seemed to be the one who best knew the situation and the state of things. To my surprise I found much more built than I had expected, although everything more or less unusable. There were no less than eight blast furnaces erected at different sites, but there were still no dwellings. Mr Oldfield and the British blast-furnace workers were living in tents.

The eight blast furnaces mentioned by Julius Ramsay were all close to Nainital, at Dechauri, Kaladhungi, Khurpa Tal and Ramgarh, and they were at different stages of development: All of them, except the one in Dechauri, were either not completed or very small. The only ones actually used besides Dechauri were two, possibly three, of the furnaces in Kaladhungi. Julius Ramsay later called these “very small and of a very imperfect design.” He formed the same impression after visiting Dechauri for the first time on 17 December 1861. He called the works “as far as externals go pretty impressive but otherwise I did not like it”.

He was struck by the grandeur of the country and the bounty of nature. He described at length an animal life that he had never seen before, with monkeys, beautiful birds, wild elephants, deer, wild boar, leopards, jackals. After his first visit to Dechauri he rode back to Kaladhungi through the jungle, together with Mr. Oldham. It was already night, but the moon was up. “[W]e heard a strange roaring, sometimes close, sometimes faraway and finally saw a leopard hunting a deer.”

The representatives of the company in Kumaon were “a Mr. Reed and a Doctor Pearson, the only investors in the vicinity and thus the only ones able to undertake such an assignment.” According to his contract Read and Pearson were to detail what he was to do, but it soon turned out that none of them had any experience of ironmaking whatsoever. In practice, Ramsay was alone in his knowledge and the introduction given by the directors was very brief: “After one day, the directors left me and I was now all alone amongst a strange people. I had more than enough to do, but this was easier said than done. There was nothing at the site. Everything, from building materials to workers, had to be brought from outside.”

Ramsay was to restart iron production in Sowerby’s blast furnace. At the same time he was to build a major new iron and steel mill with two big blast furnaces “constructed in the same manner as our Swedish ones” and furnished “with all modern improvements, such as gas roasting kilns, hot blast stoves, blowing machinery etc.” In practice he was left with a decisive influence on planning and layout.

The directors and Julius Ramsay decided to abandon all further development of Ramgarh and to concentrate their efforts on Dechauri. The works in Kaladhungi and Khurpa Tal were first leased to Rees Davies, but even when they were later incorporated in the parent company, they remained of minor importance. Dechauri became by far the most important site for development, and the analysis in the rest of this thesis therefore concerns this site.
SUMMARY DISCUSSION

A Web of Contacts

Globalisation and international networks are keywords repeated as mantras in descriptions of present-day society.Implicitly we are made to believe that these are new characteristics of society, which cannot be applied to days gone by. The histories of the Kumaon and Burwai Iron Works show the opposite and expose how by the mid-nineteenth century a web of international ties already made it possible to enrol three Swedish engineers to build iron-and-steel works in British India. This was the second phase of the histories of the Kumaon and Burwai Iron Works.

Although from differing backgrounds, the Swedes were highly qualified. They had family ties with ironmaking society and Julius Ramsay and Nils Mitander had also received the highest education available from the School of Mines in Falun. On top of this formal schooling they also had, in spite of their young age, extensive practical experience of both designing and managing ironmaking operations based on charcoal, either through many extensive study tours or through work in Sweden.

There was an international network of contacts in the ironmaking trades, in spite of difficult and sometimes very slow communications. Through institutions, by personal contact and in printed material, information was spread around the globe and personal relationships were maintained across time and space.

Several of the closely related mechanisms of personal and institutionalised networks were involved when the Swedes were recruited to work in India by John Percy, professor of metallurgy at the Government School of Mines in London, and Andreas Grill, of Jernkontoret, who together formed the connecting link between on one side the British initiators of the ironworks in India and on the other Mitander and Ramsay.

In drawing attention to the mechanisms by which the international networks were upheld, I have also tried to present an important part of the framework of colonial contact and dominance. Efficient collection and dissemination of information was a vital necessity for the administration of the British empire. A safe and reliable transportation system was essential not only for the flow of information but also for international trade and the transfer of the physical artefacts of technology.
Phases III and IV: 1860–1880

The Swedes at Work and Afterwards

Coming to India, Nils Mitander and Julius Ramsay faced momentous tasks. They were to build ironworks – and to make iron – in totally new settings that lacked industrial ironmaking tradition and most of the necessary infrastructure needed for an iron and steel industry. They were virtually alone in that only they possessed the technical knowledge essential for the success of their projects.

In this chapter I will trace the course of events that followed the arrival of the Swedes. How did they tackle their duties and what phases did their projects go through? What did they achieve and what problems did they encounter?

At first it might seem as if Mitander and Ramsay were given the power and resources to act and steer their course as they wished, at least in the confined settings of Barwah and Dechauri. But in what sense could they really be considered to be carriers of technology? To what extent were they only pawns in a larger game? What were the limits of their powers?

This chronological description concentrates on the few years in the early 1860s when the Swedes managed the ironworks – a third phase of intense activity. This chapter also extends into a very last period of the ironworks, a fourth and final phase of gradual decline and final closure.

The histories of the Kumaon and Burwai Iron Works continue until 1879 and beyond 1880 respectively, but the periods of intense development under the Swedish engineers were substantially shorter, some 15 months at Dechauri and a little more than two years at Barwah.¹

Burwai Iron Works
November 1860–March 1862

Mitander Arrives at Barwah and Starts Work

Following Mitander’s arrival at Barwah, on 18 November 1860, his life seems quickly to have acquired a kind of everyday normality. Although mentioning that he misses his friends and kinsfolk in Sweden, and commenting on the
tropical heat and various other exotic conditions, Mitander describes his working life almost as if he were at home.

From the very first day, the planning and building of the ironworks occupied all his time. The first two tasks were to find good ore and to decide exactly where to build the blast furnace and the ironworks. In his first week Richard Keatinge, his principal and future friend, stayed at Barwah and gave him certain guidance. From the second week onwards Mitander shouldered the responsibility for the project alone, even if he regularly reported all matters to Keatinge, who continued to visit him to discuss the work. “It was really a bit difficult to feel all alone today”, Mitander noted in his diary, when Keatinge had left him for the first time.2

During the first few months Mitander visited a number of possible mining sites. The mine at Nandia, just a few miles from Barwah, was chosen for further exploitation immediately and this was to remain important throughout his stay. The workings were old, and a lot had to be done in order to resume production. Mitander designed machinery to hoist the ore and carpenters began to build it at Nandia.

As time went by, several other sites were investigated, most of them uncertainly spelt in Mitander’s diary and unidentifiable today. Two important sites were Kummulpoor and Korundia, however.

In his very first week at Barwah he surveyed a site for the future works and was able to start the detailed planning. During his third week he was at his desk, drawing and planning, designing and calculating. He evidently had ample freedom to plan the works, all the way from the first rough outlines, through blueprints of minor details such as brickwork and cast iron compo-
ments, to the finished buildings. Notes on his work at the drawing table occur
time and time again in his diary.3

Mitander was not entirely alone in this practical work. He had at least one
subordinate, Harry, to help him. Harry’s identity is unknown, but by the
second week he was testing ores in a crucible, and he could interpret blueprints
and help Mitander to draw them.4 The building of Mitander’s bungalow,
just above the future works, began in the middle of December 1860,
and at
Christmas Mitander went to the nearby town and military headquarters of
Mundlasir for the first time and visited Keatinge and several others at their
homes. A small group of men spent Christmas Eve together.

[We] smoked and talked and thought sincerely of all our friends elsewhere
this festive evening. Many times we toasted “absent friends”. We were of
groups here, I Swedish, [Doctor] Mackenzie Scottish, [Captain] War-
den English, and [Captain] Thompson Irish.5

In January 1861 the lime kiln and the brick furnace were finished and before
the end of the month Mitander could collect his first fired bricks. This meant
that the building of the ironworks could begin in earnest – while Mitander
continued to plan the details at the drawing table. Charcoal was made for the
first time and extensive felling of trees went on. He made blueprints and
ordered equipment from England.

All the plans had to be approved by Mitander’s employers, which usually
meant his immediate superior, Richard Keatinge, but only once did Mitander
record a disagreement, when Keatinge had rejected a blueprint of the casting
house.6 Otherwise Keatinge approved his work.

The Burwai Iron Works. The iron-
works in Barwah were placed on a
hill on the western bank of the Cho-
ral River. The blast-furnace house
is the partly hidden building to the
right, while the dominating chim-
ney and the buildings to the left are
the former brewery, today used by
the Government Boys’ Higher Sec-
ondary School. In the background
parts of the town itself can be seen.
SOCIAL GATHERINGS

AND THE FIRST SPRING

Mitander was also alone in his metallurgical knowledge. Richard Keatinge and all the other Britons of any skill and education were members of the armed forces. Many of them had considerable knowledge of engineering matters, but they had little or no experience of ironmaking. Only Mitander combined knowledge of both metallurgy and building, an essential combination for building an ironworks.

In February Mitander had his first visit of any length to Mundlasir, enjoying the daily company of fellow Europeans and continuing his desk work on drawing and calculations. He also made several study visits, one of these to the rolling mill in the jail, the mill which was to be transferred to Barwah. Apparently work at Barwah continued well during his absence. He had nothing negative to say after inspecting the site on his return after twelve days.

At this time a serious accident occurred at Nandia. Two workers fell to the bottom of the shaft, nearly eight metres, and another was stopped by timbering half way down. One of the miners was killed. The next day Mitander went to Nandia to carry out an inspection. “I turned to the mourners and the wounded. There was a terrible lamentation. There were about twenty people wailing at the top of their voices (one of the customs of natives to bear witness to their grief, whether it is real or not).”

Mitander prepared cost estimates and the work continued at all the main sites: at the mine, in the forests, and at the ironworks site, with masonry work and land surveying. Prospecting continued and the first stones of the foundation of the blast furnace were laid.

A second possible site for mining, besides Nandia, was discovered in March 1861, close to the Pangria mine. “With great satisfaction I saw there good prospects for starting a good mine”, Mitander wrote in his diary. At first the new site was also called Pangria, but Richard Keatinge chose to name it Mitanderoor. Mitander must have been flattered and proud. Back home in Värmland his uncle had named a small ironworks site Mitanderfors. Now Mitander’s family name was also inscribed on the other side of the globe.

The ores found in the course of these prospecting activities were examined and tested by Mitander, but they were also sent for closer examination to the Public Works Department and to Captain Meliss. The chemical analyst to the Bombay Government also examined the limestone.

Later during the spring the first item of machinery arrived, the used rolling mill from Mundlasir. In May, as Mitander was approaching the completion of his first six months in Barwah, the weather was growing hot, but the firing of brick and brick masonry work continued without interruption, and the blast furnace had now begun to rise. More works buildings were planned and marked out in the terrain. Towards the end of May the first items of equipment from England were unloaded in Bombay.
In June there was, for the first time, water in the new well. This was the rainy season, but conditions were not at all like those in other parts of India where the south-westerly monsoon could bring torrents of rain and make all work impossible. Mitander was able to continue his projects through the summer and only on one day was work interrupted by heavy rain. Instead the major obstacle was transport.16

TRANSPORT AND DELIVERIES

As the construction of the Burwai Iron Works proceeded Richard Keatinge was for the most part very optimistic, but one of the main problems he noted was the lack of information on the deliveries of materials and machinery from England.

Transport from England was both long and hazardous. When deliveries were late, building-work was affected. Work on the blast furnace, for example, came to a halt waiting for foundry work and it became impossible to continue preparations for installing steam engines and boiler due to a lack of blueprints.17

Keatinge had not received a single message from the Storekeeper-General in London since he left England in August 1860. The construction of the blast furnace was halted by the failure of parts to arrive from England. It was impossible to proceed with preparations for the steam engines without drawings. Iron beams and plates were needed before work could continue on the blast furnace. It would have been possible to complete the furnace by substituting arches for the iron beams, but Keatinge strongly advised against this since it would be a weaker structure.18

These castings were to have reached Bombay in September the year before, 1861, but it was not until the end of October 1862 that Mitander could record their arrival in Barwah.19 A similar situation stopped further work on the engine house and boiler house.

Keatinge had written to the Storekeeper-General in London from Sweden the year before, in June 1860, when Mitander was recruited. The Bridgewater Foundry Co, near Manchester (part of Naysmyth & Co.), had been selected to supply the machinery to Barwah and a meeting was held in London. When everything was settled Keatinge had left for India, but since then he had heard nothing. Now Mitander was in desperate need of detailed drawings of the equipment ordered in order to be able to proceed.20

On other fronts work continued as planned. 2,780 cords of wood for charcoal, each 4x4x10 feet, had been cut and some had been brought into Burwai. This was equivalent to nearly 12,000 cubic metres, a substantial amount which gives a good picture of the extent of the works. The cast house was ready and could be used as a workshop for carpenters and blacksmiths, and Keatinge could also report that the cost was actually 14 percent less than anticipated.21 The building of the coalhouses began. Mining had begun. In July 1861 Mitander also took his first lessons in Hindi.
In August Mitander planned to start up the rolling mill, but when he returned to Barwah he found that all the piping and copperwork were so poor that everything had to be done again. Ten days later, with everything remade, the rolling mill was running. And now, at last, Keatinge could report that a steamer carrying the castings needed for the blast furnace was approaching Bombay, but he had heard nothing of the rest of the equipment and feared that work would be “very considerably retarded”. It was not until the end of November, another three months, that the shipments began to reach Barwah. At that time the steam-engine machinery was still on its way and was not expected to reach Bombay before January 1862. And at the end of September work was going ahead on the building of new charcoal pits. Soon the first of these pits was lit and charcoal as well as wood was steadily collected and stored at the ironworks.

Iron from Britain. The hearth arch of the blast furnace in Barwah. The beams to support the walls above the arches were imported from Britain. Today only one of them is still visible. The others are either hidden by new masonry or have been pulled away. Photo: Jan af Geijerstam, 1997.

Possible Markets

A year had now passed since Mitander’s arrival, and at the end of November 1861, at last, some of the equipment for the blast furnace arrived and construction work could continue. During the following weeks more items arrived from England. At this time possible markets for the future output of the works were also discussed. Keatinge asked for the help of the Government Railways Department in trying to procure an order from the Great India Peninsula Railway Company for chairs or other small castings that might be needed in large quantities. He stressed that charcoal iron from pure hematite would be of excellent quality and that Barwah was well situated, not twenty kilometres from Khundwa, which would be the most important railway station in Nimar once the railway was completed. Keatinge was now, in January 1862, convinced that production could start in the autumn of the
same year. Only a week later he suggested yet another option, since he had heard that castings could be used in connection with the building of the telegraph. The line between Khundwa and Indore would be excellent for such an experiment, since Barwah was about halfway along it.

In December 1861 there was a lot of charcoal-making and during the following months work progressed steadily. The blast furnace grew in height and it was a very busy time for Mitander. “Once again my life is becoming very monotonous. I have been so busy that I have had no opportunity to visit Mundlasir since Christmas and it seems as if I will be more and more tied up here. The work proceeds and progresses daily.” In the ensuing months construction work continued, although more periods of partial standstill occurred, pending a new shipment of machinery from England.

And, as in the foregoing year, Mitander celebrated Christmas with a kind of short vacation in the company of his new friends in the British colony of Mundlasir. Again the social, private network Mitander had been able to create is illustrated. He missed his Swedish home festivities on Christmas Eve, but on Christmas Day he had dinner at the Williams, together with Baigrie, Cadell, and Colonel Manson from Mhow. “Williams dressed up as an elderly female. Jocular and merry dinner. Afterwards card-playing.” After passing through Barwah to inspect his works Mitander continued to Bureea, twenty kilometres to the southeast. He had been invited by Captain Baigrie to spend some days there together with the society of Mundlasir, Dr. and Mrs. Williams, Mr. and Mrs. Brockman, Colonel Manson, Lieutenant Glasspole and Captain Baigrie himself, who all happily slept in tents and celebrated the first dinner with champagne, followed by cards. Mitander celebrated the New Year alone. He read newly arrived letters from his father and his mother and from Johanna Hafelin who also sent him her portrait. The letters also contained small written notes from four other women of his acquaintance. He spent the evening of New Year’s Eve writing a letter to Keatinge.

At the beginning of January 1862, when Mitander at last received a list of the equipment to be delivered by the Margaret to the port of Bombay, he remarked that the new shipment was worth “the enormous sum of 4,028 pounds sterling.”

I am sure I will have responsibility and work enough. How long will I be alone with all this? The Major [Keatinge] and I get on well together and as yet we have not had the slightest disagreement. Since our work continues in untroubled harmony and happy friendliness, I hope it will be crowned by satisfactory success.

Parts of the biggest and heaviest equipment were delayed even longer en route from Bombay to Barwah. Other items were damaged and had to be reordered.

Extremely little is said about the workmen at Barwah. I will return to this observation in Chapter 10, but some remarks may be in place here. Judging from the work done – logging, charcoal-making, mining, transport, lime and
The Burwai Iron Works in 1863. Watercolour of the Burwai Iron Works by Mr. Knight, clerk in the office of the Political Agent in Nimar. From left to right a shed for charcoal, the bridge to the blast-furnace house (with the calcining kiln to the left, steam engine and blowing machinery in the middle section and the blast furnace itself to the right). In the continuation of this building, with a roof in two sections, is the foundry and the machine shop. The two buildings with the gables facing the viewer are, to the left, the smithy, with steam hammer, and, to the right, the rolling mill. On the far right are two charcoal houses. Compare plan p. 176. Drawing in Captain Melliss to PWD, Government of India 11 May 1863, L/PWD/3/346, OIOC.

The layout of the Burwai Iron Works in 1863. After the unsuccessful blow in Barwah, a discussion arose on the future of the ironworks. Captain J. G. Melliss made a detailed report on the status of the works, accompanied by a block plan. The letters in the plan denote, from a to x and according to the explanations given in the plan: a. Superintendents residence with outhouses; b. Engineers residence with outhouses; c. Charcoal house no. I; d. Calcining and lime kiln; e. Bridge to blast furnace; f. Gas calcining kiln; g. Boiler and blowing engine house; h. Blast furnace; i. Cast house; j. Workshed for carpenters and blacksmiths; k. Fitting shop; l. Pattern shop; m. Machine shop; n. New well; o. Aqueduct; p. Old well; r. Forges and steam hammer; s. Rolling mill; t. Water trough no. 1; u. Office and store room; w. Charcoal house no. II; v. Charcoal house no. III; and, x. Bridge between charcoal houses. Compare to the plan on page 176, made according to measurements in 1997 and 2003. Drawing in Captain Melliss to PWD, Government of India 11 May 1863, L/PWD/3/346, OIOC.
brick making and construction work – the number of employees must have been substantial. Some of these people were employed directly by the ironworks, others were engaged through contractors. In January a totally new source of manpower was described, possibly being introduced at that time. Mitander noted a letter in which Keatinge wrote that the Government had “sanctioned a unit of troops to guard the prisoners. He thus aims at creating a kind of crown penal company here in order to not run short of workmen.”\(^33\) At this time he had some 200 prisoners and some 400 coolies employed together with wives and children.\(^34\) Meanwhile, however, Keatinge had been appointed political agent in Gwalior and Mitander expressed utter despair at his imminent departure in his diary.\(^35\) A couple of days later Mitander went to Mundlasir to say goodbye to the Keatinges.\(^36\)

Summarising Mitander’s first fifteen months we may say that most matters seemed to have turned out according to plan. Construction work was progressing, ore and charcoal sources were established. He had a workforce at his disposal and a network of social contacts to rely on in days of trouble and loneliness. The cause of delay was the late and uncertain deliveries of equipment from Britain. In a way, all the positive developments made the blow of Richard Keatinge’s sudden announcement of his departure all the harder. Mitander compared his trip to Mundlasir to “travelling to the Major’s funeral.”\(^37\)

**Kumaon Iron Works**  
*December 1861 – September 1862*

**Ramsay Arrives at Kumaon and Makes Plans**

When Mitander was facing the disappointment of Keatinge’s departure, Ramsay had been in India for about half a year.

From the very beginning it became evident that Ramsay would be much more lonely at work than Mitander. Mitander had been met on his way to Barwah and introduced to his work at the site. Later he also had continuous contact with a close superior who had even been to Sweden and seen ironworks and who had rolled iron in India.

When Ramsay arrived at Kaladhungi on 13 December 1861 he discovered that he was totally unexpected and he simply did not know what to do. The introductory letter from Colonel Strachey had not arrived and, contrary to what he had been promised, the directors, Mr. Reed and Dr. Pearson, did not live near the works. They were not expected until after Christmas and Ramsay could do nothing until they arrived.\(^38\)

He lodged with the accountant of the Company, Mr. Oldfield, who turned out to be the person best informed on the situation. Thus Ramsay soon found that he had been under a misapprehension not only concerning where the
directors lived, but also with regard to the extent of the works, “although everything [was] more or less useless”. The two main sites were Dechauri and Kaladhungi in the foothills of the mountains. At Dechauri the blast furnace built and started by William Sowerby was in working order and at Kaladhungi there were four smaller furnaces. At Dechauri there were also the remains of the very first blast furnace built, now out of service, and the beginnings of a new one, far from complete. Khurpa Tal with two furnaces and Ramgarh with one were further up in the mountains. These furnaces were not ready to blow.

Ramsay also noted, without any special comment, that both Mr. Oldfield and the British blast furnace workers lived in tents. He later wrote that he also started his journey believing that he was to work for a rich and powerful company, especially considering his own salary. “On my arrival I in part discovered my mistake and it did not take long before I was acquainted with the real position of the Company.”

It was more than two weeks before the directors turned up to discuss what to do, and it was agreed by all concerned to concentrate efforts on Dechauri. Nothing would be done at the works at Ramgarh and Khurpa Tal, mainly because they were a long way away. Instead Rees Davies, the Welsh blast-furnace master, was allowed to lease these works from the company.

At this first meeting the general programme of work at Dechauri was agreed. Sowerby’s blast furnace was to be blown in at once, but the other blast furnace would be abandoned since it was of an inferior type and badly sited. Instead two new furnaces would be built, constructed “like our Swedish ones, and equipped with every modern improvement, such as gas roasting kilns, hot blast machinery, blowing machinery etc”. Ramsay was also to build eight Finnish coal kilns, in order to make coal as economically as possible and “eventually become independent of the natives, who ruined a lot of forest and supplied weak, soft coal.” The important thing was to produce bar iron, not pig iron, since there was no market for pig iron in India and the market for castings was limited. For that purpose a big forge would be wood-fired with puddling furnaces and steam hammers and rolling mills, big enough to work all the pig iron produced in five or six blast furnaces. Offices and lodgings, for Ramsay himself and for the British workers, would also be built at once.

Having outlined these ambitions, the directors departed after only one day, leaving Ramsay rather disconsolate at the size of the task facing him: “… I was now all alone amongst an unknown people. I had more than enough to do, but it was easier said than done. There was nothing at the place. Everything had to be brought from outside, from building materials to workers.” The other European at the site, Mr. Oldfield, was fully occupied with
the accounts and the only other assistants Ramsay had were two native interpreters. The situation was especially troublesome since he anticipated difficulty in procuring labourers. Most workers were already engaged in other work, and the cool season, during which work should be in full swing, was well advanced.43

Ramsay began by arranging for the start-up of Sowerby’s blast furnace. He engaged two British furnace keepers, previously employed in Dechauri, and some minor technical adjustments were made to the furnace.44 Ramsay considered the British furnace keepers to be “able workers and they know the language fairly well, since they have worked here for three years” and at the end of January 1862, they made a first blow.45 Ramsay was very anxious to achieve good results, because “on this depends my reputation both among the owners of the Company and among the workers from England.”46 After only a few days, serious trouble was encountered when the stone masonry of the furnace cracked, according to Ramsay due to its inferior construction. Since the inner fire-brick lining of the pipe remained intact, however, the blow could continue.47

At this stage, Ramsay had quite a large workforce at his disposal. As well as the two blast furnace-men he had one master mechanic and one foundryman, both from England. In the office, Mr. Oldfield was in charge, aided by a baboo, a native accountant who spoke both Hindi and English. To help them, there were four munchis, native accountants who only knew Hindi. On the site, there were six chapprassies or supervisors, and four chokidars in charge of the materials and tools. Ten or twelve smiths, 24 carpenters, 40 masons and 150–200 coolies completed the personnel.48

Besides arranging the blow-in of Sowerby’s blast furnace, Ramsay had started work on the building of the new works: digging a canal down to the works, excavating the foundation for the new blast furnace, building coal kilns and a bungalow for European workers. A contract for the delivery of 300,000 bricks was also signed. All this Ramsay had to administer himself, aided only by an interpreter. “… I am therefore always occupied and very tired in the evenings …” he wrote, and “… I have no one to rely on. I must see to everything myself”49.

In February Ramsay and his helpers started a new blow in Sowerby’s blast furnace and they managed to keep it running for two weeks, but Ramsay was not satisfied with the results even if they were better than before. He attributed the outcome to a combination of inferior raw materials (low-grade ore, damp charcoal) and inefficient technical equipment (cold blast). He was however confident that he would be able to raise production by another two-thirds, from 13 to 22 tons per week.50

Two conclusions were drawn from the evidence of these blows: that better charcoal was needed and that the possibility of bringing better iron ore down to Dechauri should be explored. The old charcoal had been made during Sowerby’s time and had been exposed to two rainy seasons. It had to be used, but Ramsay also needed better quality and thus also coal sheds to protect it.51
Even at this stage, in February 1862, only two months after Ramsay’s arrival, there was a tone of annoyance and mounting trouble in his letters home. He was running a big site, having just sent for 200 new workers, but work was not advancing as fast as he wanted and he saw the end of the working season approaching.52

At the same time Ramsay’s responsibilities were extended and he was to take charge of all the company’s business, including supervision of the work done by Rees Davies at Kaladhungi and Kurpa Tal. He now became the managing director of the works, but was still the executive engineer and master builder. He found it impossible to deal with all this and therefore asked his employers for permission to employ assistants. The request was granted and Ramsay wrote to his friend Gustaf Wittenström to invite him to join him as works engineer. Wittenström was at this time employed at the ironworks of Dahl in southern Finland, owned by Julius’ cousin, Wolter Ramsay.53 As already noted, Wittenström had at that time also been offered a prestigious position as chief engineer at the rolling mill in Motala, Sweden, but he was still happy to accept the position in India.54

Ramsay’s misgivings turned out to be justified. At the end of March workers began to depart and by April almost all work had stopped. Ramsay himself “held out” till June 15 when the rains started and even his own servants were leaving. When hot season began, Ramsay was approximately where he had started.55

Managing the workforce was not Ramsay’s only difficulty. He was also bothered by a number of problems that might seem trivial, but still obstructed his work. When he arrived at Calcutta, he had taken care to send his two cases of books and instruments in advance, but in January they had still not arrived. For this reason he could not get properly started on his design work, although he needed drawings at “every moment”.56

In March 1862 Ramsay engaged an inspector at Kaladhungi, a Mr. Hamilton with sixteen years’ previous experience in India on the railways and at the Public Works Department. Hamilton was to take charge of the blast furnaces at Kaladhungi. At that time Ramsay hoped for much help from Hamilton, especially since the Directors “take to their heels as soon as I ask them to make a decision on any matter of importance. I have to do everything on my own responsibility”.57

The responsibility for Kaladhungi added to Ramsay’s burdens. He deplored the fact that he had to devote too much time to correspondence and to travelling between the different works and he looked forward to the arrival of Gustaf Wittenström, who was badly needed for preparing drawings for the new works at Dechauri. For the first time, he also voiced concern about the financial situation of the company. Too much money was being wasted on salaries to European assistants and workers and Ramsay feared for the company’s survival unless a facility for making bar iron could be brought into production. Only this could meet the heavy expenses.58

In total the ironworks of Kumaon at this time were four and equipped as
follows: 1. Dechauri, the main works, with three blast furnaces, refining in puddling furnaces and a rolling mill. 2. Kaladhungi with four blast furnaces, three running at a time, making pig iron and some castings. 3. Khurpa Tal as a summer retreat for the European workers, making castings in two cupola furnaces. 4. Ramgarh, where the construction of a blast furnace was at a standstill, but efforts were being made to arrange for the richer Ramgarh ores to be brought down to Dechauri. 59

And slowly Ramsay’s animosity towards the directors grew. They delegated all responsibility to him. He considered this bad enough, but they also sent him letters full of petty criticism. Ramsay wrote home to his friends that “I am most unwilling to stay in the Company’s service” since the directors after only four months already found reasons to accuse him of negligence. He described the relationship as “tense”, a relationship that worsened when Ramsay dared to say no when one of the directors asked him to employ a brother-in-law. But Ramsay still needed all the support he could get from them: “They understand nothing of ironmaking, but since they have both been in India for twelve or fifteen years, and know the conditions well, they could be of great benefit to me if they wished to.” 60

With all this brewing up, Ramsay received an encouraging letter from a Dr. Morton, one of the shareholders, who had joined the Directors. He promised to come to Nainital next cool season to lend a helping hand for some three or four months. “I can see from his letter that I have frightened the other Directors and they do not know how to handle me.” 61 At a first meeting with Dr. Morton, in the district capital of Almora, Ramsay formed the impression of a very able man, although one who nonetheless overestimated his own capacity. He believed it would be as easy to build five new blast furnaces as building two in Dechauri. Ramsay now saw that he needed to make Dr. Morton understand that it would be no small order to build two big blast furnaces, a rolling mill, a steam hammer, puddling furnaces and a number of residences and stores, all in only one year. 62

At the same time friction had developed between Ramsay on the one hand and Mr. Davies and his three sons at Kaladhungi. Ramsay even wrote that Davies was doing everything in his power to obstruct him and he said that one of his priorities was to persuade the directors to sack Davies. According to Ramsay the blast furnaces were mismanaged and Kaladhungi was causing the company big losses. 63

Ramsay paid a visit to the workshops at Roorkee in April 1862. 64 He expected that he would soon have to go up to Nainital for the summer, but he hoped to be able to use the summer to finally complete his plans and drawings for the new works. He expected to have full plans to present to a shareholders’ meeting in September. 65

When Ramsay moved up to Nainital in the middle of June 1862, he stayed in a house “unbelievably damp and … crawling with worms and insects”, but he still felt that this was a kind of summer vacation. He was spared from the daily troubles of management, correspondence was limited and he could
devote his time to preparing drawings. He now also came into close contact with the formalities of British society life – which he preferred not to become involved in.66

Ramsay stayed in Nainital throughout the rainy season, from 15 June till 20 October, approximately four months. When he returned he felt well prepared and full of energy. He was acquainted with the local conditions. He had been able to procure a big workforce, and had arranged for a full supply of building materials.67

In June Julius Ramsay expressed considerable worry about the financial standing of the company. The split between four different sites constituted a heavy financial drain and there was an urgent need to raise more capital. At the same time he also reported on negotiations with the Government on a contract to supply cast iron rails for a small railway, a delivery that would ease the financial situation of the company.68

The financial situation led to a deep crisis in relations between Ramsay and the directors. On 30 June the directors told Ramsay to withdraw his invitation to Wittenström to come to India. But the order came far too late.

Nainital, the summer resort. The Nainital Lake, nestling at 1,938 metres, was first discovered by the British in the 1840s. With its pleasant climate, the valley soon became a popular hill resort and during the big uprising in 1857–58 it assumed new importance as a place of security and refuge. In 1862 it became the summer seat of the North Western Provinces and began to grow rapidly. The Illustrated London News, 15 August 1857.
Only two days later Ramsay received a letter from Wittenström, sent some seven weeks earlier from Finland, in which he accepted Ramsay’s offer, risking a bright future in Sweden and promising to be in Kumaon at the beginning of the cool season. “I intend to learn to photograph and will bring a small apparatus to India, with which, in our spare moments, we will take souvenirs of this charming country.”

“The directors will pay for this joke”, Ramsay commented on the order from the directors and he was deeply worried that he had caused Wittenström to miss out on the position at Motala, “the most highly spoken of in Sweden”.

Two other conflicts also developed into problems of some dimensions during the summer of 1862. Ramsay became increasingly dissatisfied with Mr. Oldfield, his accountant and assistant manager. At the end of August he felt obliged to write Oldfield a letter of warning. He considered this as an extremely unpleasant business, but at that time the accounts were three months behind, unacceptable in view of the coming meetings with the directors and the shareholders.

The financial problems became steadily more acute and it was increasingly apparent that the resources were too small for the scale of the ambitions. During the summer of 1862 Ramsay advertised for fresh capital. It is not clear what authority he had to do this, but he called for an additional 235,000 rupees from a new issue of shares, to increase the paid-up capital to a total of 700,000 rupees. Ramsay was more than satisfied with the response. He reported that he received letters daily from all over India applying for shares and after only a month shares for 200,000 rupees were subscribed for. If it were not possible to raise the whole amount in India, Ramsay believed there would be no difficulty in finding backers in England. This would be, though, something of an emergency solution. Ramsay did not wish to fill the gap with English capital, since he feared he would be “overburdened with reports and correspondence”.

Ramsay’s main work in the summer months was to plan the future works, make drawings and prepare a budget. A target date for completion of all this planning was the shareholders’ meeting that was to be held on 24 September.

The picture of Ramsay’s first six months is somewhat ambiguous. On the one hand it is evident not only that the directors were ignorant, but also that the company was in deep financial trouble. There had also been a serious lack of communication between Ramsay and the directors and there was a growing sense of mutual dissatisfaction. On the other hand, compared to Mitander at a similar time, Ramsay was far behind in his planning of the new works. Whether this was caused by his own incompetence, the negligence of the directors or the excessive burden of work on the existing plant, is hard to decide. Maybe it was a combination of the three.
The Catastrophe when Keatinge Leaves becomes the Eve of the First Blow

When Richard Keatinge was promoted and had to leave Nimar in March 1862, Mitander was in despair. In a long diary entry he gives voice to his worries and feeling of loneliness.

Thursday 20 March 1862. Burwai. Opened the rectangular coal oven. Wrote home with tears in my eyes and told the sad tiding, that I will probably, within a short time, lose the support and friendly and fatherly treatment I have had in every matter from Major Keatinge; Gwalior is so far from here, that I will surely never again meet him or his good wife, they have both become so dear to me that I do not know how I will be able to gather strength to bear the coming parting and the two long remaining years of my time out here. I have not heard anything about the future, only the telegram and the letter from the Major, which hopes for the best. From the telegram it seems that the Major’s successor is named Wood. Whether he is such a wise, intelligent, knowledgeable and practical man as to be my employer I do not know. In my tedious loneliness I may be seeing everything in a gloomier light than I would do if I had someone to talk about situations and conditions. I have found myself so exceedingly fortunate and satisfied with my occupation and life in recent times, that it is not strange that it could not continue any longer. God grant that the change will be not too great for me. I hope my friends Cadell and Williams will stay for some time in Mundlasir, but you cannot be sure, because Europeans here in India live an ambulatory life and of course they seek promotion and better incomes at the first possible chance. There is no love for the country, and the ambition of everyone is of course to accumulate the means for an independent life in Civilised Europe and return there to friends and relatives as soon as possible. More than ever I now wish to be able to have an opportunity to offer Louise a lonely home here, as long as I remain here, but it perhaps would be too daring and none can foresee the consequences of all the responsibility that would rest upon me.75 If the Major and his wife had stayed in Mundlasir and everything been as before, there would have been some recreation there from time to time, but now I would be bringing her into a desperate loneliness, burdensome enough for me, without causing it for anyone else. It is now turning rather hot, more and more every day, and I fear I will feel the heat more than last year. I am sure, when I meet the Major, he will give me a good word, and that next time I may write in a happier mood. Now I need good letters, many letters from friends, encouraging me in my great troubles.76

But Mitander was not without support. He soon received an exceedingly friendly and encouraging letter from Cadell, who, although acknowledging his disappointment also told Mitander not to worry about the future. In a letter that Mitander quoted in his diary, he described Keatinge’s successor
Captain Wood as a “first rate officer” and “thorough gentleman” and wrote “a better man than Wood could not have been appointed as Keatinge’s successor”.

“Keatinge thinks him just the very man of all others who will take an interest in the Ironworks and all his other projects and who will conscientiously exert himself to carry them out,” Cadett continued. “He is a first rate man of business. Cheer up therefore, old fellow. Nothing is bad that might not be worse and all’s well that ends well, as I am sure this will.”

These consoling words did not help Mitander much at first, but in due course it seems as if things turned out all right. At first Mitander regarded Captain Wood as “totally ignorant” of the kind of work done at Barwah, but when Captain Meliss, the Executive Engineer of the Mhow division and one of Keatinge’s friends, became responsible for Burwai, things at once seemed better. Mitander was very satisfied, although it later turned out that Captain Meliss had never even visited an ironworks before. Mitander’s doubts about Captain Wood himself, though, lasted longer. Three months after his appointment Mitander wrote that he began to believe that Captain Wood was “pig-headed” and not at all interested in the Burwai Iron Works. When Wood visited the works a month later, however, he seemed to be more interested than expected.

A week after the big changeover everything was again as busy as normal. As early as 15 March 1862 Mitander had begun working on the gas outlet in the blast furnace, which meant that the shaft itself had risen to its very upper sections and in May he started on the outer walls of the blast-furnace house.

Still more machinery arrived, but tardy and uncertain deliveries remained a problem. “I am happy the machinery is not at the bottom of the ocean”, Mitander noted in February 1862, “that would have caused at least a year’s wait for a new delivery.”

Only a few weeks later, however, it was reported that a blowing cylinder shipped from England had been “utterly destroyed by a mishap” at the railway station in Bombay. It would have been possible to order a replacement in Bombay, but before leaving Keatinge ordered a replacement through the Storekeeper-General’s office of the Indian Office in London without specifying his reason for this. He emphasised the importance of immediate action, which at least the Public Works Department in Calcutta seemed to accept. If the order was hurried he hoped to have the cylinder delivered next October or November, i.e. in eight or nine months.

The damage to the blowing cylinder was serious, but also equipment in general was often roughly handled and damaged in transit. At the beginning of May 1862 Mitander unpacked the steam cylinder of the blowing machinery that had arrived some days earlier. His first task was to clean it. It was rusty after its journey around the Cape of Good Hope and he noted that two months had passed since it arrived at Bombay.

Yet another accident occurred to the heavy anvil of the steam hammer. At first it had to wait in the Ghats above Bombay until another section of the
railway had been opened. Then it was transported on an artillery carriage drawn by elephants until, while crossing the Taptee River, it was dropped in the middle of the river. Captain Melliss informed Mitander that it had to be raised before the rainy season, which was only a month away. Otherwise it would be lost in the sand. Mitander deplored the delay, since a functioning steam hammer “would be very useful to us from the first day it was ready”. In the same diary entry he said it would be “a stroke of luck” if he could get the third boiler delivered before the dry season. “The rainy season has begun and the roads are almost bottomless”.

Early in August 1862 the blowing machinery was started up for the first time and on the 12th the final stone of the blast furnace was laid, less than five months after the first stone of the foundation. Some weeks later failure of piping and copper in the steam engine of the rolling mill caused a delay of one month, since everything had to be done over again. For the previous three months Mitander had had the assistance of a furnaceman, Benjamin Robb.

In the autumn of 1862 Mitander began to wonder whether to stay in India or return to Sweden after the end of his contract, which extended until the end of May 1864. He valued his economic independence and his social position in India, and he had the works very much at heart. At the same time he desperately missed his family and friends. His fear of returning to Sweden without a job was also a factor.

At present my future is not bright at home and I am thus almost forced to take whatever I can get here. It is hard not to be among kinsfolk and friends, but a lazy and idle life among them would in the end become more unbearable than my solitude here. As long as I am in good health I cannot but think with gratitude of the position I have and count myself fortunate for the confidence I have acquired.

At the beginning of October the plant was so nearly ready that Mitander endeavoured to have a painting made of it and on 20 October 1862 he proudly noted in his diary: “My blast furnace is finished except a few gas pipes …” At the same time it was decided to delay starting the furnace until Keatinge could be present. “I hope everything will work well. They will be days of responsibility for me to go through. I hope I will have the same good luck as in Sweden, where all my first blows have worked well.” After much deliberation Mitander now also took an important decision on his future. He would stay in India.

I believe I have decided my future. If I live, I will go home in June 1864, return in September 1865 for a new contract, and serve here till I can get a pension and retire. I do not want to start work in Sweden again, and beg my way to an uncertain employment.

Again, the unsure prospects back in Sweden were his main argument. To console himself he had argued that even if he were to die, he would at least
have saved something which would benefit his parents and his brothers and sister. He began to feel very satisfied with life, better than ever before, even in Sweden. He had plenty to do at work. People passed through and called on him regularly.  

And on Saturday, 6 December 1862, two years after Mitander’s arrival at Barwah, it was finally time for the first blow.

**Kumaon Iron Works**  
**September 1862 – March 1863**  

**Shareholders’ Meeting in Almora and a Grand New Start**

In September 1862 the shareholders of the *North of India Kumaon Iron Works Company Limited* met in Almora. The meeting was meticulously prepared by Julius Ramsay and anticipated with both anxiety and hope. It was of paramount importance for the future of the works.  

Ramsay presented a number of detailed plans for the future and the decisions made were all in accordance with his wishes, although they caused him “a lot of trouble and a many times greater responsibility.” First of all he had, as he himself expresses it, got rid of Rees Davies and his three sons, “a gang consistently working against me and having a bad influence on the other English workers”. The annulment of Davies’ lease of Kaladhungi was decided in open conflict as Davies himself was one of the shareholders and present at the meeting. A third son of Davies, working as a master mechanic, had been fired earlier by Ramsay and now his two brothers, both foundrymen, were sacked too. The new English foundrymen employed in their place by Ramsay only got half their pay. On top of this Mr. Oldfield was finally dismissed. He had “notwithstanding incessant reminders evinced so much negligence and disobedience that we had lost all confidence in him”, Ramsay wrote.  

Ramsay presented his drawings, work plans and cost estimates both at a board meeting and at the shareholders’ meeting. Two alternatives were submitted. One was conservative, using only the plant as it stood. This would hardly yield a profit. The other required the procurement of capital and entailed the building of new facilities. This would, Ramsay calculated, show a profit as soon as the works was running.

According to Ramsay the latter alternative was approved unanimously and he was given extensive authority to plan and run the business as he wished. After the arrival of Wittenström a month later he prepared a number of more detailed plans and again his de facto power was confirmed. The directors showed no interest in studying them and Ramsay had a free hand. If he just decided what to build, they would provide the money.  

It was also decided to make a serious effort to increase the capital. The ambition was now to more than double it, from 465,000 to 1,200,000 rupees
The plan was to raise the capital both in India and in England, and it was seen as very desirable to engage a prominent British iron manufacturer in England. A special committee of two was appointed, General Henry Drummond in London and General J. Ramsay in India. “If this fails the company will soon be bankrupt,” Ramsay observed.97

It was a relief for Ramsay to get rid of Davies, but the change also meant that he became fully responsible for Kaladhungi.98 He now decided on a three-stage programme for these works: to modify two of the blast furnaces and begin to blow iron, to totally rebuild the other two furnaces and supply them with a hot blast and, thirdly, to complete the foundry and build a new coal shed. To manage the Kaladhungi works a Mr. Mathews was employed.99

Bridge between Nainital and Almora. On their way to the important board meeting in Almora in September 1862 Julius Ramsay passed several bridges built by the colonial government. Bridges like this could be a reminder of the need of iron—and of the potential for producing it in Kumaon. Discussing the prospects of making iron in Kumaon, Hardy Wells wrote in 1859: “If Mr. Henwood had proposed a large blast furnace, I think he would have been wrong, but had the furnace been built as he proposed, it might now, I believe, economically have been turning out the iron necessary for the bridges required in the interior of Kumaon and Gurhwal, instead of which, in sight of the whole range of hills full of iron ore, I saw, when I was there, a bridge being built by the Civil Authorities over the Ramgunga, and the iron of the picks for breaking the stones came from England.” (Hardy Wells, 1859, December, p. 16). Photo: Gustaf Wittenström, C15248.

Summarising Ramsay’s first year in India, we see that his position and responsibilities had changed completely. He came to India believing that he was to be in charge of ironmaking and construction work. After ten months he now found himself fully responsible for all the affairs of the North of India Kumaon Iron Works Company Limited, great and small. “You cannot imagine what a businessman I have become on the spur of a moment”, he wrote to one of his friends.100

At the start of the new working season he anticipated his duties with some trepidation. After the decision to raise new capital a new board was constituted in London, which Ramsay feared would increase the volume of correspondence and reports to which he had to attend. He anticipated being on the move a lot, since he was in charge of both Dechauri and Kaladhungi and never placed great faith in his new assistants. According to Ramsay, Mr. Willis at Dechauri and Mr. Mathews at Kaladhungi were no more than accountants and Ramsay himself, now for the first time, had to arrange for all supplies to
the works and also the recruitment of a large labour force. In his report to Jernkontoret he even described his two assistants as unqualified and only capable of simple tasks. Ramsay therefore considered that he had to attend to almost all aspects of bookkeeping and all the details of making contracts, handling money transactions and reporting to the board.

During the autumn of 1862 Ramsay encountered a shortage of European workers, and he had to employ British soldiers with prior experience of ironworks. After many troubles, five such British workers stayed on at the works.

At last, but on schedule and in perfect time for the new working season, Gustaf Wittenström arrived at Dechauri on 25 October 1862. He was to be the executive engineer, in charge of construction work. Ramsay, for his part, expected to be tied to his desk with accounts, correspondence and contracts most of the day, except for a short inspection tour in the mornings and possibly in late afternoon before sunset. Ramsay reports that work now accelerated.

Wittenström’s arrival also meant a welcome relief from Ramsay’s long, lonely evenings. The two spent the night talking about home and Europe, and Ramsay struggled to teach Wittenström some more English. After only three weeks, however, he observed sadly that Wittenström “unfortunately seems to make relatively little progress”.

Ramsay’s long-term plan for the works was now being implemented. Three blast furnaces were made ready for production the coming winter: Sowerby’s furnace in Dechauri and two of Davies’ in Kaladhungi. The other two furnaces in Kaladhungi were to be totally remade and blown the next season.

At the same time the building of the blast furnaces of the new works in Dechauri continued. They were going to be the biggest yet constructed.
anywhere in India, 15 metres high and “suitable for the Bessemer method that I hope to introduce here”. The total extent of the project was spectacular, with its fully integrated iron and steel plant, and the plans to build Bessemer converters are of special interest. If completed successfully, it would have made the works among the most modern in the world. To start with, puddling furnaces were to be used, however.

In the middle of November detailed plans for the new works were approved, making full use of the terrain to move materials through the process. Wittenström had now begun to build the foundations for a “grand rolling mill” equipped with puddling furnaces until the Bessemer process was running. The expansion was planned in steps, and Ramsay mentioned three basic reasons: most of the equipment needed had to be made on site, the work force was inexperienced and, most important – capital was scarce. But Ramsay also added:

>[A]s the resources of iron ore and forest are sizeable and the Company hopes to get substantial capital from England before long, everything must now be constructed to a plan that will allow it to be enlarged into a big plant. Water power will then be completely inadequate, but steam is obtained almost for nothing, by using excess heat from the furnaces.

Another enormous task was the construction of an infrastructure for transport. There were no roads, but they had to be built for the transport of various raw materials to the works and of the finished products to the market.

After one year Ramsay was in a very good mood. “Gradually I have familiarised myself with the conditions and all the troubles, which at first seemed to be almost insurmountable, are now gradually disappearing.” Ramsay became more accustomed to the work, more settled and managed to establish a daily routine. Sometime towards the end of 1862 his letters also become thinner and apparently there was less that he considered to be worth recording, or maybe his daily duties took too much of his energy. At this time Ramsay estimated the total number of workers at more than 2,000.

Wittenström was at work for eight months past the winter of 1862-1863, energetically and enthusiastically carrying out his assignments in spite of his rudimentary knowledge of English. He made the drawings for the blast furnaces and the rolling mill, as well as a number of detailed drawings for machinery. He put the mechanical workshop in order and even constructed a small Bessemer furnace.

All the same, concerns began to grow. At the beginning of 1863 Ramsay records that he doubts whether he will be able to finish all the planned work before his three-year term ends: “everything moves so slowly”. In a letter written the same day, he also asserts that every job needs ten times the workforce required in Sweden.

And still the directors took neither part in nor responsibility for the work. Ramsay and Wittenström were utterly alone in all their decisions and their work, as Ramsay had been before Wittenström’s arrival. This was an impor-
tant difference by comparison with Mitander, who had regular contact with superiors who were also knowledgeable in engineering matters, discussed questions big and small, made joint decisions and scrutinised plans and drawings. At Kumaon not only were the employers ignorant of ironmaking, they almost never visited the works. Mr. Read, one of the three directors in the board, had not set foot in Dechauri during the whole of 1862, although he had spent six months in nearby Nainital. Dr. Morton had never even seen Dechauri, in spite of his explicit promises at the end of April the year before.115

When Dr. Pearson, the third director and board member, arrived at the works in the company of Mr. Colvin, Senior Assistant Commissioner of Kumaon in February 1863, it was his first visit in ten months and thus a rare occasion and an event of great importance. The visitors stayed for three nights, put up seven or eight tents, brought horses and servants, an elephant and four or five camels. In spite of this grand display, the results of the visit seem to have been meagre. Ramsay only refers to two remarks by the visitors. First, Mr. Pearson was displeased with the slow progress of the works. Second he was very satisfied to see that the new works were built to a distinct plan, which the old Sowerby works had totally lacked. At this time Ramsay had again begun to make iron, but only in two of the Kaladhungi blast furnaces due to shortage of coal. He wrote that he was satisfied with the results, but in his letter home he admitted that the yields must seem incredibly low. He attributed the result to the low-grade ores and the lack of hot blast.116
In the end the inability to procure fresh capital weakened the company beyond repair. As a joint stock company, under the Limited Liability Act it could not incur debts above its paid-up capital. A new issue of shares was the only solution. As long as the balance was positive there were many who declared an interest in buying new shares to Ramsay, who also believed that a substantial sum could be raised in India. But the board of directors thought interest would be insufficient and decided to turn to England. The aim was to create a new company, into which the present stockholders could enter with the value of their shares. A board of directors was formed in London “with a number of well-known and influential names”.

The Burwai Iron Works
December 1863–March 1864

The First Blow in Barwah is the Last

The first blow at Barwah, on 6 December 1862, was the most important single event during Mitander’s stay in India.

The furnace was charged and the following morning the fire was lit. Everything went all right with the first tapping, but within 24 hours iron and slags hardened in the bottom, the tuyeres choked up and the furnace became unworkable. An unsuccessful first blow like this is not uncommon and considering all the unknowns in the case it would have been a surprise if everything had gone smoothly. There was little understanding of this, however, and the first unsuccessful blow became the beginning of the end.

In a letter to Julius Ramsay a month after the unsuccessful blow, Mitander dejectedly wrote: “We Europeans worked desperately but soon had to give up. The result was that the hearth could not be emptied of either iron or slag” and Mitander feared that the whole furnace would be clogged with a solid mass. “This has never happened to me before and I suppose not to you either,” he wrote to Ramsay. The time that followed became a time of waiting, and tidings from home in Sweden added to Mitander’s dejection.

I will return to the details of this blow in Chapter 12 as well as to an analysis of the causes of the failure, but the main conclusion was that experienced furnace-men were needed.

When the Chief Commissioner of the Central Provinces, Richard Temple, visited Barwah in the summer of 1864 and summarised his impressions and suggestions for the future he also wrote a short description of the unfortunate blow based on a discussion with Captain Melliss. According to him, the main reason for the failure was incompetence of the workmen. “These men, being inexperienced, could not perform the operation with the requisite skill and promptitude; nor was it possible for Mr. Mitander alone, even with all his knowledge, to effect what was necessary without some trained assistance.”

This letter telling about the first blow had a black border. Mitander had received sad news from home, namely of the death of his father.
I had a heartfelt hope to once more see my dear home intact and my dear family circle undivided. So many times have I thought about the reunion and always hoped I could experience it “with a happy face”, the very last words in Swedish I heard from Christer on Southampton Water when we parted. This is no longer possible, and if I ever may return home, my remaining months will, I fear, pass slowly with all the pains of yearning and melancholy.\textsuperscript{124}

The futile attempt to get the blast furnace running, and the word of his father’s death, brought growing uncertainty concerning his future in India. He wanted to return home and now he was uncertain if he would ever want to return to India, “this miserable country”.\textsuperscript{125}

The details of the time that followed are few since the second part of Mitander’s Indian diary, if there ever was one, has disappeared, but he had no opportunity to return home to Sweden before his contract was finished. He had to fulfil his commitments and gradually he became resigned to the situation and again concentrated fully on his task. He would stay the agreed time and get iron production started.

As Mitander laboured to achieve his objective, another agenda was being set, far away from Barwah. By the middle of November 1862 one can discern the growth of a more cautious or even critical attitude to the Burwai Iron Works from the Government of India. At that time Richard Strachey, head of the Public Works Department, requested the executive engineer in Mhow, J. G. Melliss, to ask Mitander for a clear assessment of future developments. “It is essential that the Government of India should be placed in a position to judge of the extent to which this experiment should be carried, at the earliest possible date.” He also asked for “a distinct scheme” for the workings during 1863. The Government had to be fully informed of all actions taken and nothing was to be done that was not in accordance with decisions of the Government. If any uncertainty arose, the Government was immediately to be contacted.\textsuperscript{126}

After the unsuccessful blow these matters became critical. Mitander himself had raised the stakes in the debate, since he would not make a new blow before he had procured experienced help.\textsuperscript{127}

In the summer of 1863 the discussion culminated in a debate involving the members of the Council of the Governor-General. Different opinions on the undertaking were openly voiced and important arguments put into print. The discussion arose from a suggestion to increase Government spending on the Burwai Iron Works by 50,000 rupees, approximately doubling the outlays so far, excluding machinery.\textsuperscript{128}

This was severely questioned and in the end the matter was referred to the Governor-General, Lord Elgin. In a minute of 22 July 1863 he concluded that the Government would not invest any more money, but that measures should immediately be adopted to ascertain whether any company or individual “would take these works off our hands”. In view of the importance that had been attached to the experiment, Lord Elgin said he “would rather
give the plant for nothing to persons willing to carry on the work than sell it for its value to others”. The matter was handed over to the Public Works Department for action and in September four newspapers were asked to advertise the works for sale, *The Bombay Times*, *The Englishman*, *Hurburu* and *Friend of India*.

In spite of these efforts to spread the word, no buyer appeared.

Eight months after the decision by the governor-general to put the works up for sale, formal support for this course of action also came from the government in London. However, the commentary was somewhat critical of the handling of the project as a whole, and it was with some reservation that the final decisions were supported:

The object with which the establishment of these works was sanctioned in 1862, was to ascertain whether the iron ore of the Nerbudda Valley can be profitably worked, Government proposing in this instance, as it had already done in those of tea cultivation, and of sea and river navigation, to set an example which, if successful, might be advantageously followed by private enterprise. Whether such interference on the part of Government was really desirable in this case may now be questioned, but after a sum of at least two lakhs of Rupees [20,000] had been expended on preparations for an interesting experiment, it might have seemed desirable to proceed far enough to arrive at some practical result instead of risking the almost certain loss of most, if not all, of the previous outlay, by stopping short prematurely. In the actual circumstances of the case, I am, however, disposed to think that the course adopted may have been the best.

The Government went on to express its appreciation of Mitander’s contribution, but also argued that he had announced his return to Sweden at an early stage and that this had increased the difficulties.

Mr. Nils Mitander, the active and zealous Superintendent, under whose intelligent direction all technical arrangements had been made, had given notice of this intention to return to Europe at an early period, and it was felt that operations could not be continued satisfactorily unless not only a successor to Mr. Mitander of equal qualifications, but also some good workmen were procured from Sweden. The certainty of delay and of increased expenditure, however, as well as the chances of failure involved in this condition justify in my opinion your resolution to sacrifice the money already sunk rather than to run the risk of wasting a much larger amount.

It is unclear from where the Home Government had got the notion that Mitander had decided to return home “at an early period”. At best there must have been a misunderstanding somewhere on the line. Mitander’s ambition had been to stay, and as late as the summer of 1863 he had no idea of what was coming and was honestly upset when he commented on what had happened in a letter to Julius Ramsay. If the reason was not a misuder-
standing it must rather have been a way of escaping part of the responsibility by putting the blame on a subordinate.

You can understand what a blow this was to me. Anger took such control that it choked all sense of dejection. Since 20 May we have waited for the answer that would send me home to bring workmen back with me to start the works. Instead I found, the other day, without further notice, in the Government Gazette, my work put for sale. I immediately went up to Mhow and consulted Captain Melliss. The consequence is [will be] a totally useless correspondence showing that no company with any sense will be willing to take over the works at their original cost. When after six months the government is convinced of this, only two extremes remain: to procure men and provide for them here or let the works fall into ruins. To recruit men for the next cold season is now too late, and thus I will not be able to see the results of my work, since my time ends on 1 June.135

Julius Ramsay wrote to his friends saying that Mitander was “most exasperated with the English” for their treatment of him. He also reported that he had received a letter from the government during the spring, saying that it wanted to engage two blast-furnace masters for the Burwai Iron Works. But the letter had come too late since all workers had already been dismissed from Kumaon.136

In March 1864 Mitander received a letter from J. G. Melliss permitting him to return home to Sweden. Melliss said he deeply regretted the decision of the Government and that under Mitander’s “zealous superintendence it would have proved pecuniarily successful. The difficulties in commencing the works were many, but you had successfully overcome them all”.137 And, as still one more sign of appreciation, the head of the Public Works Department in India himself, Richard Strachey, wrote to Melliss, that the resolution of the Government to abandon the works had “in no way been come to from any want of reliance on Mr. Mitander or yourself, but solely of general principles.”138

Mitander’s exact date of departure from Barwah is unknown, but, anxious to start his journey before the onset of the monsoon and the rainy weather, he probably left sometime late in April 1864. In all he thus spent almost three and half years at Barwah.

As to the results of the trial, most commentators were unanimous: there had been no real test and no well-founded conclusion could ever be reached on the practicability on using the ores of Nimar on the basis of the efforts in Barwah. In 1864 Richard Temple was highly critical of the decision to close down, which he considered to have been premature. The Government decision gave the project a bad name and thus it was that a great failure arose from a small cause.

… without proving any impracticability thrown doubt on the possibility of producing iron … now it has accomplished nothing, either in the way of proof or disproof. So great has been the discredit thrown on the works by the first experiment that, despite advertisements, no private person has come forward to purchase the works.139
Kumaon Iron Works  
March 1862 – September 1863

The Story of a Financial Dead End

While a board of directors was formed to mobilise new capital and reinvigorate the project in Kumaon, the funds were depleted. On 4 March 1863 Ramsay was given the direct order to stop all work and dismiss all employees. All construction was left not even half-finished. At that stage Ramsay had believed he could have the works running within a year, but he was not surprised by the turn of events. Wittenström and Ramsay were given notice until the beginning of September, but Ramsay believed that they both would be asked to return to London long before in order to report to the London directorate. According to Ramsay the directors expressed their full satisfaction with the way Ramsay had handled affairs and hoped that he would be willing to return as soon as new capital had been raised.

Ramsay wrote that the status of the company had been weak from the beginning, but that the directors had followed his advice to cut one’s coat according to one’s cloth. But this description of the course of events is not consistent with the information previously given in Ramsay’s letters, where it is quite clear that Wittenström and Ramsay were the initiators of the big expansion. Now, six months later, he wrote “I fear that this undertaking will devour millions, but never become profitable.” According to Ramsay he had pointed out the risks in a long statement of the different alternatives, but the directors had not listened. Their main concern was to get a new company to take over the company at a good price.

The East Indian Correspondence Co. dismissed. As soon as Ramsay learned of his dismissal he also sent a note to one of his friends who was responsible for circulating his letters to the members of the imaginary East Indian Correspondence Co.: “My dear Sir, Herewith I beg to inform you that your services as Manager of the East Indian Correspondence Co. at Örebro will not be further required and you are at liberty to engage yourself elsewhere. Believe me, my dear Sir, Yours faithfully, J. W. Ramsay.” Letter from Ramsay to his friends, 15 March 1863, Ramsay’s papers, E:1:1.04.
The winding up of the business was expensive. Several of the dismissed British workers had three-year contracts with their travel back to England paid and when their claims had been settled only a small amount of money remained in the company, enough to maintain the works in a reasonable condition for possible future sale. During the spring of 1863 Ramsay continued to produce iron in two blast furnaces. The marginal costs were minute since there already was charcoal and ore in abundance, and the workers could just as well stay and work as return home at once. They were on full pay in any case.143

The directors were totally confident that Ramsay would continue his contract under a new company and they had put his name on the prospectus procuring new capital in England without asking him.144 This apparently made Ramsay angry and he sent a very frank letter to Dr. Pearson, ending with a paragraph cutting all strings:

I have so little hope about the success of the enterprise you may not wonder that I am unwilling to have anything further to do with it. Disliking India to the highest degree I did never intend to stay here any longer than bound to by my Agreement, but that now being cancelled I shall feel very happy to return to my home as soon as possible.145

Still Ramsay had to stay in India till his term ended on September 4. He was biding his time, settling accounts and planning his trip home. “Recently this was such a lively place, now it is deathly still”, he wrote of his workplace one month after the closure.146

The directors of the new company in London had managed to get a substantial portion of the stock subscribed for and towards the end of spring 1863 they asked Wittenström and Ramsay to come to England to discuss the matter and procure men and machinery to take out to India. Since the local board could not spare Ramsay from Kumaon, only Wittenström left Dechauri, setting off for London on June 9. According to Ramsay, Wittenström did not consider returning to India, but Mr. Jones, a blast-furnace keeper who travelled with Wittenström back to England, was willing to return, although only if he could bring his wife with him.147

Ramsay stayed in Nainital and settled the accounts and led a peaceful and rather comfortable life. In the meantime it turned out that the efforts to attract enough new capital had been in vain and Wittenström wrote to Ramsay that they “are severely mistaken if they believe that capitalists in England would want to put their money into such a fraudulent undertaking.”148

At last, the London board was forced to acknowledge the failure:

Finally, at the beginning of September I was notified that there was no longer any hope of getting the Company straight this year [1863] and that I was free to return home whenever I wanted. This was at the same time both happy and painful news. Surely nobody who has spent such a long time so far from home, can receive permission to return home without joy. On the other hand it is rather trying to have to leave so
many unfinished projects, all which I cherished as a father, and at the same
time renounce the extensive power which I have exercised almost without restriction for two years.149

Ramsay was given two days’ notice and had to negotiate to obtain his pay for the two months for travelling home, according to his contract. He left Nainital on 26 September 1863 and reached home two months later, on Christmas Eve 1863.150

_Burwai Iron Works_ 1864–1884

The Gradual Winding-Up

The final word had not been said when the Swedes left India, either for the Burwai Iron Works or for the Kumaon Iron Works. Their fate was still to be discussed ten, twenty – even one hundred years later.

The story of the Burwai Iron Works did not quite end with the decision of Lord Elgin in the summer of 1863. No buyer appeared, and while Nils Mitander left the scene, the case lingered on. The works were still owned by the Government, physically ready to make iron and representing an investment on which there had as yet been no return In the spring of 1864, there were occasional decisions in the Public Works Department on how to maintain the works in good order until they were sold or otherwise disposed of.151

The question of resuming operations was bound to rearise.

During this time Nimar had become part of the Central Provinces and during a tour of the District in July 1864 the officiating Chief Commissioner for the Central Provinces, Richard Temple, visited the works. This resulted in a detailed report on their condition, and since it discussed a possible future for the plant it also contained an assessment of its recent failure.

It is clear that the experiment has not yet had a fair trial – indeed it has not had a trial at all. … There remained but one small step to be taken, in order to ensure some result at least in the shape of proof, either negative or positive. … the large expenditure already incurred, which will otherwise be fruitless … will become fruitful of some definite result, either positive or negative.152

Temple was convinced of the economic potential of the works and he suggested to the Central Government in Calcutta that Mitander should be asked to come out again, accompanied by four able workmen, two for the blast furnace, two for the rolling mill. The total salary and travel cost would be 3,500 pounds sterling for a two-year contract for Mitander, and a one-year one for the workmen. If Mitander would not accept the offer, Temple suggested that Andreas Grill should be authorised to find someone else in his place. Even a failure would have advantages. With a new start a final
result would be achieved, and a negative result would at least make it possible to convert machinery and buildings into cash. In the event of success the iron ore in the Narmada Valley could be used in large quantities.

Lieutenant Colonel C. H. Dickens, now Chief Engineer of the Central Provinces, had made a short stop, not more than an hour, at Barwah on his way from Bombay to Calcutta in November 1863. He had followed the correspondence on the matter during his time as Secretary to the Government of India at the Public Works Department, and he had met both Wood and Mitander at Barwah. “I was much struck with the regularity, neatness, and good workmanship of everything I saw. The buildings were excellent and all the arrangements, so far as I was able to judge, very good.” When, in the following summer, he was asked by the Chief Commissioner to give his views, Dickens emphasised that he had no intention of preparing any report himself, but in general terms he concurred with Temple’s conclusions. What was most important was that the works had stopped because the Government had decided to sell it – and that nobody wanted to buy it since no conclusion had ever been reached regarding the prospect of making iron.

The proposal from the Central Provinces met with no sympathy. The Government maintained its determination to sell the works and in 1865 a new advertising campaign began. The works were going to be advertised in the *Gazette of India*, the *Government Gazette* (Bombay) and in the *Central Provinces Gazette* and in *The Times* in England. This time the Great Indian Peninsular Railway announced an interest. Through its agent, Captain Osborn of the Royal Navy, the company wrote that it had understood that the works was to be sold at “a sacrifice”, and wanted to extend the time allowed for a tender to six months. The company would soon be placing a big new order for iron sleepers. A representative had already been sent to the ironworks of Porto Novo in the Madras Presidency to investigate the costs there, but when the railway reached Kundwah, production of sleepers at Barwah would probably be more economic. The tender period was subsequently extended till the middle of March 1866, and the government even decided that no other bid would be accepted in the meantime. The Railway Company was given absolute priority and a pre-emptive right to buy the works.

In the meantime, while this question was handled, there was also an inquiry from the Public Works Department of the Central Provinces as to whether single pieces of machinery could be produced, and if so, at what price. The answer to this enquiry was postponed till the end of the tender period. Neither of these overtures led to anything. No documents relating to the Great Indian Peninsular Railway and the works in 1866 have been found, but the ironworks reappear when an exchange of land between the Central Provinces and the Holkar State is discussed in 1866 and 1867.

At that time the works were still being maintained. The Government of India had sanctioned action to repair the buildings and preserve the machinery. Among other things, three policemen guarded the works.
In late December 1867 it was decided that the Maharaja Holkar would buy the works at a price of 50,000 rupees. In April 1868 the works were handed over to Holkar. From then on, they remained unused.

In 1876 the Holkar was asked informally about the state of the works, and the answer was received that the machinery was in a very good condition and the buildings in a decent state. No iron had been produced since the transfer eight years earlier. His Highness wanted to keep the plant, on condition that he could “with profit manufacture iron with the aid of British officers or their advice, in which case he would feel obliged to the British Government.” If this arrangement was not possible, Holkar would be pleased to sell the machinery to the British Government at a “reasonable price”, but not the buildings nor the land.

At that time the Public Works Department of the Central Provinces had already borrowed a blowing machine. “[E]xperiments have been ordered by government of India to be undertaken at Warora in the manufacture of Iron.” The project, initiated in 1875, ended eight years later when the machinery was returned. In 1884 the Maharaja Holkar finally abandoned the idea of making iron.

It is not known what happened to the machinery of the works, but some twenty years later there is one more example of the enduring recognition of Barwah as a potential area for ironmaking. The Tatas were one of the most influential Indian entrepreneurial families in India at the turn of the last century. At that time they had ambitious plans to build a big, modern integrated steel plant in India, which later became the Tata Iron and Steel Company (Tisco) in Jamshedpur. Jamshedji Tata was the head of the family and in 1902 he travelled to the United States, partly to study modern steel plants.

At the same time his son Dorab examined possible sites for the new works, and even the mines of Barwah were discussed, but Jamshedji rejected this possibility in a letter from Chicago.

As regards the rich iron ore-field in the Indore Territory, about which the Resident spoke to you, it is a place I know. The Government of Indore spent many lakhs of rupees on it, and about three years ago advertised the mines at Burwai for sale. Nobody replied, and I believe they are still in possession of that Government and unworked; but our hands being already full in the Chanda District, I do not think that we should at all try to get these mines at Burwai, as I do not think they will be taken up by anybody within any reasonable time.

After that the Burwai Iron Works would seem to have been consigned to history, were it not for still unverified information on investigation into the feasibility of a new start in 1960. But why this effort came to nothing remains unknown.
A Long Standstill and a Final Try

Like the Burwai Iron Works, the Kumaon Iron Works had a long post-history, although not one that stretched into the twentieth century.

When Ramsay left Nainital on 26 September 1863 there began a long period during which nothing happened at the sites of the Kumaon Iron Works.

I left everything in the hands of Mr. Mathews, the Inspector at Kaludongar [Kaladhungi], who was the only one of all the servants of the Company who was retained to keep watch over their property and belongings. Since then I have often received news from him. Everything is still in the same desolate state.

All work at the sites ceased for more than a decade, but in the meantime the reasons for previous failure were examined and the future of the Kumaon Iron Works was discussed. In the second half of the 1860s the company and the government were involved in a long controversy on whether the owners had been promised a tramway or railroad to the works – and whether the absence of this investment had caused the failure. The question contains many legal details, but the essential argument was that the private investments were made in the firm belief that a railway would be built and that this was important to decisions taken by the investors.

The hope of restarting the works was also held out. At first the shareholders of the ironworks appear to have been amongst those who pressed most urgently for a new start in an effort to safeguard their investment. Contacts between the owners and Julius Ramsay and Gustaf Wittenström were maintained at least until 1866 when Wittenström sent Henry Drummond information on the costs of Bessemer steel in Sweden in a letter from Motala Ironworks in Sweden.

In the early 1870s a renewed interest in restarting production was manifested by the colonial authorities. The Government of the North Western Provinces took over the property of the North of India Kumaon Iron Works Company Limited and expressed its firm belief that production ought to be speedily resumed and carried out on a large scale. The Government of India postponed the decision, but it marked an important shift in its position. Irrespective of the history of the works and any claims from the company originating in the past, “a deliberately formed scientific opinion should be recorded”. Kumaoni iron should be considered, but also iron ore deposits in other parts of the country that might be more readily accessible. The Kumaoni iron ores were thus placed in the context of the totality of Indian iron ores.

In 1872, a thorough and formal valuation of the works was made, putting the value of the whole works at 126,733 rupees, as compared with 79,490 rupees when it was taken over from the Government by the company in 1862. In 1872 the works was still fully equipped with machinery and materials.
At the local administrative level there was little appreciation of the initiatives. The Commissioner, Henry Ramsay, appears to have been exceedingly tired of the seemingly endless discussions on the Kumaon Iron Works.

The Government of India is probably not aware that the iron localities of Kumaon have been the subject of constant reports, and correspondence for the past 20 years, in fact, so much has been written that, if collected and bound up, they would form many volumes. The matter has been so thoroughly exhausted, that I question if it would be possible to draw out one additional fact, even if fresh reports were admitted annually for another 20 years to come.175

The outcome of the renewed studies was however that a new start was decided on, under the influence of the persuasive opinion of one of the mineral surveyors. An important factor was that possible competitiveness had been improved by the rise in the price of imported iron from England.

Compared with the phase of affairs 12 years ago, when the Kumaon Iron Company stopped operations, circumstances are much more in favour for the possibility of Indian manufactured iron competing with Home produce. The high price of coal in England has led to such an advance in the cost of iron of all kinds at the present day, that there is now a prospect of India being able profitably to work her own raw materials.176

The works had one last try when the government resumed iron production in 1877. The Sowerby blast furnace, now supplemented by a hot blast, was used in seven different campaigns, from January 1877 until September 1878, and a total of 1,580 tons of pig iron were made.

In 1880 the results of the blows were summarised and analysed in a long report by W. Ness, mining engineer of the Wardha Coal State Railway. He concluded that Kumaon iron could never compete with imported iron. Although Ness was allied to mineral coal interests and there might have been a conflict of interest in his report, his conclusion was supported by Colonel Brownlow, Secretary to the Government of the North Western Provinces.

If we attempt to manufacture on a large scale, fuel and water power will fail us; while any attempt at manufacture on a small scale will be swamped by the cost of establishment, block and machinery and of improvements in communications, without which no economical manufacture seems possible.177

This became the final judgement and the Government of the North Western Provinces decided finally to abandon the works. The Government of India – and the Home government in London – sanctioned the decision soon afterwards.178 In a Public Works Department dispatch, dated 25 November 1880, the Marquis of Hartington, Secretary of State for India, wrote to the Government of India in Calcutta.
While regretting the failure of this attempt to manufacture iron in India, I concur with your Excellency in considering that no more outlay should be incurred on the works in question and that the time has consequently arrived for closing them.\footnote{179}

But, there was also a last paragraph in the dispatch, written but deleted in a final revision, evidence of the deep commitment to the project and the inability really to bring it to a final end.

I will only express the hope that at some future period circumstances may so change as to furnish ground for the expectation that they may be reopened and profitably worked through private enterprise.

Changed circumstances could not be expected, however, and the decision came to mark a final and definitive verdict.\footnote{180} This was the terminus for British ironmaking in Kumaon.

**SUMMARY DISCUSSION**

The Questions Beyond the Chronology

In a chronological sense, the histories of the Kumaon and Burwai Iron Works have outlined in four steps. The first phase (1815–1860) was the exploration during which the plans for the works were conceived for the first time. The second phase (1860–1862) was when the Swedes were recruited through an international knowledge network. With this chapter the chronologies have been brought past the third phase (1860–1864), a most dynamic phase of change under the Swedes, and finally through the fourth lingering phase leading up to the final closures (1864–1880).

This story can be seen as the outer shell of the history of the works, providing the setting for a continued discussion of the causes of the closures, which are more complex than they might at first seem, a failed first blow and exhausted funds.

During their few years of active work in India the Swedes personified the transfer of technology and they were very strongly placed to guide the course of the works. Julius Ramsay was at first entirely alone in his technological knowledge, but later aided by Gustaf Wittenström. Although Mitander had valuable help from Richard Keatinge, self-taught and keenly interested in the art of ironmaking, he too was to shape the works himself. In an analysis strictly confined to their periods of active work on the construction of a future, the Swedes were the carriers of the technology. There were clear limits to the Swedes’ power to act and these limits will be the focus and object of investigation in the following chapters.

Changing circumstances to which they had to respond arose regularly during the history of the works. The availability and quality of iron ore and
charcoal were key questions during Mitander’s first months and seasonal climatic variations set clear patterns for work at Dechauri. The choice of technology in general and of machinery in particular determined the layout of the works and transport determined the timing of construction work. The uncertain availability and skill of the workforce was an ever-present problem for Ramsay and probably an important cause of the failure of the first blow in Barwah. The social networks formed the platform for everyday work, but they were also the framework for information exchange. Markets, prices and the political structures determined the ultimate rules of the game. Questions on these and associated matters are raised, discussed and answered in the following chapters, which probe more deeply into the central question of this investigation: Why were the Kumaon and Burwai Iron Works never brought into full and continuous production?
PART III

Technology Carried

Describing historical landscapes of ironmaking,
analysing the technical set-up
of the Kumaon and Burwai Iron Works
and giving the results achieved
when iron was made
The man-eating tigers of Kumaon have since long disappeared from the jungles of Dechauri and nowadays liquor is bottled in one of the buildings of the Burwai Iron Works in Barwah. But although time has passed, the essential features of what were once the workplaces of the Swedes remain very much the same. Here there are two historical landscapes of industry to be explored. A picture of the ironworks can be reconstructed by walking the sites, guided by historical sources and by local inhabitants. This gives a description on a micro level and at the same time enables the different challenges posed and the different solutions chosen at the Burwai Iron Works and the Kumaon Iron Works to be compared and. What was the physical layout of the ironworks? How were the works adapted to the landscape and local conditions? Can field studies even help us to answer the central question of the reason for the closures?

The Burwai Iron Works

Barwah is a small town. The main road, from north to south, passes straight through it, carrying rumbling buses and lorries emitting black clouds of diesel. Retailers and craftsmen’s workshops line the street and there are several small restaurants and a hotel.

Down to the left as one faces south is the centre of the town, a narrow, busy, business street, filled with shops. The few cars can only slowly edge their way through the crowds of people. Some buildings reveal a colonial heritage and further down there are the worn and decayed ruins of a fort from the beginning of the eighteenth century, in other words predating the British.1

Beyond the fort, towards the Choral River, the houses thin out. The street turns into a road that crosses a bridge. The dusty roadbed after the bridge is at first lined with trees and bushes, further on with houses. There is a modern area of concrete housing to the left, partly fenced in by walls and barbed wire. To the right is a growing village-like town of well-kept small houses.
And there – just a small distance ahead, are the ruins of the Burwai Iron Works, the ironworks of Mitander.

**THE INDUSTRIAL LANDSCAPE OF BARWAH**

Even at a first quick glance it is possible to grasp the extent and layout of the Burwai Iron Works: the blast-furnace building, the workshops, up on the hillside the ruins of two bungalows and a little further away the limekiln.2

At first the neighbours of the site seemed to be totally ignorant of the earlier history of the works. It appeared to be beyond their imagination to think that iron had been made here, and they often referred to the buildings as the distillery, as the works have also been used to make liquor and the workshop building is still used for bottling.3 But there were exceptions to this ignorance. During the field study in 1997 an elderly woman had something very urgent to tell me. Through an interpreter, her story was translated, at least in part.4

The leading character in her story was Chimani Saah Baba, Baba Chimney, a religious preacher and holy man. When the ironworks were built on the site where Baba used to preach, the builders had promised to provide him with somewhere else, but this was never done and Baba Chimney swore revenge. This was why the fire did not kindle properly the first time the furnace was lit.5 Soon Baba also appeared to the factory owner in a dream, and told him to go away, or else he would be killed. So it came about that the owner left and the ironworks were closed down.

Baba Chimney is still revered. At the foot of one of the two tall chimneys still standing, there is a small place of worship, Baba Ki Mazaar – a religious place. Inside the chimney itself there is a shrine and the area around it is beautifully painted in blue, green and white and always taken care of. In
2003 the caretaker collected money in order to relay the concrete surface in front of the shrine.

This story might be taken as a piece of religious fantasy, but it represents a part of a living, oral history. It may also carry a deeper meaning. For generations it has been told and retold. Maybe it even has its roots 140 years back and is a reflection of sentiments when foreign intruders burst onto the scene and started to build one of the biggest buildings ever seen in the vicinity, to be used for unknown purposes. The story is a reminder of the socio-cultural complexities of technology transfer.

*Baba Ki Mazaar.* The shrine of Baba Chimney at the Burwai Iron Works, incorporated in one of the chimneys. This one was probably originally built for the hearths of boilers of the blowing machinery. Photo: Jan af Geijerstam, 1997.
THE LAYOUT OF THE WORKS

All detailed drawings and plans of the Burwai Iron Works seem to have been lost at an early stage. The lack of information on the trials was already being deplored by the early 1870s in a report to the House of Commons in London. “No record has even been preserved of the experiments and plans of Mr. Mitander for burning and storing of charcoal, and for other processes, which could have been useful hereafter.” Nevertheless there are two important sources to be used as guides to the industrial landscape.

A block plan made by Captain Melliss in 1863 and a contemporary water colour painted by Mr. Knight, a clerk in the office of the Political Agent in Nimar, have been of great value in identifying buildings still standing and the sites of the ones that have disappeared. Generally these two representations are consistent with other archival sources, and also with still existing buildings. Some buildings contemporary with the iron works, such as the charcoal furnaces and the brick kilns described in detail by Mitander, were not included in the plan and after it was drawn new blocks of buildings have been built. The complex of buildings east of the blast furnace was built as a brewery, and is now used as a school, the Government Boys’ Higher Secondary School (1. School, former brewery). Several new housing units have also been built to the south and west of the works. A hostel for Adivasi (tribal) children covers the western part of the former ironworks (2. Hostel). When the foundation for the hostel was laid, according to the block plan at the site of the rolling mill and Lancashire furnace, lots of old objects were found, such as nails, bolts, nuts, roofing sheets and numerous other unidentified iron objects. All this was sold for scrap.”
The ruins of the ironworks are just beside and below a hill, on which stand the premises of the Central Industrial Security Force (CISF). This is a state-run training establishment for security officers guarding publicly owned industries and official institutions and its premises in Barwah were meticulously screened off, with a wall or a tall fence crowned by barbed wire, as marked by the straight line in the plan (3. Fence). The fence divides the area of the former works in two. The area north of the fence, including parts of the bridge leading to the blast furnace, the lime kiln etc, is not accessible.

**A LOCAL INFRASTRUCTURE**

The Burwai Iron Works was built as an integrated mill. Iron ore and lime, wood and charcoal, were brought from mines, quarries and forests to the works. From the works not only pig iron, but also castings, wrought iron goods and rolled metal were to be turned out, to a considerable extent as finished products.

Features found in the Barwah landscape are representatives of a local infrastructure or external production units supporting the build-up of the works and the integrated flow of material through the works itself. Five such features are the topography and its use, the relation of the works to the supply of water, evidence of brickmaking, remains of charcoal stores and ruins of residences for works employees.

**The Use of the Topography**

Even a very short inspection of the Burwai Iron Works makes it quite clear that care was taken to use the topography. The terrain is hilly and deliberate use was made of this in the layout of the plant. The importance of such a siting and layout was emphasised in contemporary text books on ironmaking; similar use of the terrain was frequently made in Swedish blast-furnace building.10

The works are placed on level ground and on the south slope of a rise behind it. A steeper slope leads down towards the Choral River and the works are adjacent to a higher hill.

A small dirt road ran through and past the works on level ground (4. Village road). Today it is partly included in the residential area south of the works and a new dirt road (not marked on plan) has been made passing just south of the former workshop and fitting shop (today a bottling plant). The blast-furnace and the calcining kiln were placed at the foot of the steep slope, while one charcoal house and the ore storage were placed higher, at the top of the hill. A bridge led to the top of the furnaces, for the explicit purpose of facilitating transport. This made it easier to charge the furnace during the frantic activity of a blow. A road for the transport of materials up the hill was built by convict labour and its general course was still discernible in 2003 even if it had long been disused (5. Hill road).11
Water Supplies

The Burwai Iron Works were placed at a distance from and above the Choral River and it is evident that the river was of little or no importance to the works. Like that of many Indian rivers the flow of the Choral is extremely irregular, with heavy flooding during the monsoon and an almost total drought at the end of the dry season in spring. In general the flow of water does not coincide with the time when the conditions are most suitable for work as it ebbs away right at the beginning of the cool, dry winter months. When the rain comes, the floods can be such as to demand a defence, rather than permit productive use.

The Burwai Iron Works were built with no thought of using the river to supply power to the works. Water was only to be employed to cool the tuyeres of the blast furnace and for the steam engines, and it was brought up from two dug wells.

One was of earlier origin, and a new one was dug in 1861. According to the site plan one was in extreme south-west part of the area (6. Well no. 1) and
one in the workshop building. From well no. 1, a small masonry canal was built to the works. This ran parallel to the north wall of the smithy, below the hill. According to measurements at the site, well no. 1 still exists, just south of the road from the centre of Barwah. In the block plan well no. 1 is called “old well” and no. 2 “new well”. This is somewhat confusing since Mitander reported that the well he had built was 12.9 metres deep and 3.15 metres wide at the top, and new measurements of well no. 1 seem to agree with this. In 2003 the well was measured as 11 metres deep and 3.4 metres wide. The well was nicely kept, but totally dry.

**Brickmaking**

All brick necessary for the construction of the works was burnt at the site and closely supervised by Mitander. During the first months of 1862, some 18,000 bricks were produced. In 1861 he noted that his bricks were unevenly fired: “Insufficiently fired in the top layers, well fired in the middle and closest to the bottom altogether fused together.”

In 1997 such partly melted bricks were found halfway down to the river from the ironworks. The bricks were probably quite recent, clearly marked with what looked like a modern stamp, but as Mitander reported that his brick furnaces were “on the Choral” it is not improbable that they were found at approximately the same place as these modern remains.

Bricks are still made in Barwah. In 2003, on the outskirts of Barwah, a few hundred metres south-west of the former ironworks, bricks were laid out to be sun-dried before being burnt. Side by side with these fields of drying bricks lay bricks piled in heaps, either dried in preparation for burning, or already burnt.
Making and Saving the Charcoal

Some charcoal was burned close to the place of felling in the woods, but for greater efficiency Mitander worked hard to construct different kinds of pits, furnaces and heaps for burning close to the works.

He first dug two small pits, lined with firebrick and covered with lids of sheet iron. Each of them held 13.5 cubic metres of wood. In 1862, two new rectangular furnaces were dug into the ground to a depth of 3.6 metres. Like the pits, they were lined with firebrick and covered by iron lids, but they were considerably bigger, and could hold about 200 cubic metres. A third, even bigger, furnace of this kind was also built.

It is probably one of these pits that still existed in 2003, in the eastern part of the brewery (school) building, roofed but unused. Here there was a pit carefully lined with stone coloured black like carbon, approximately 1.8 metres deep, 3.3 metres wide and 24.8 metres long. Both the black of the masonry and the volume of the present pit, approximately 150 cubic metres, seem to indicate that it was a former charcoal pit. Outside and behind this building there are also three bigger pits, partly irregular in shape and partly in ruins. These are made of concrete and probably substantially younger than the 1860s. Their former use is unknown.

Mitander also built a bigger charcoal pile, but the site of this has not been found. It was built of firebricks and clay mortar, approximately 15 × 2.6 metres inside, 1.8 metres high at one end and 1.2 metres at the other. It held approximately 49 cubic metres of firewood. The pile was covered with charcoal powder and sand when burnt.

When ready, it was essential to preserve the charcoal by protecting it from rain. Three charcoal sheds were built. In contrast to Swedish charcoal houses, most often covered by a roof of tiles and with thin board
Remnants of possible coal oven (left). A pit, nearly two meters deep and 25 metres long, in the very westernmost part of the brewery building, is probably a part of a former coal oven built by Mitander. Photo: Jan af Geijerstam, 2003.

Building of remnants of possible coal oven (above). The big block of buildings west of the blast-furnace building was erected for a brewery, but an unverified part of it was also part of the ironworks. One of the buildings, down towards the river, houses what was probably a charcoal oven. Photo: Jan af Geijerstam, 2003.
walls on a wooden framework, the sheds in Barwah were built of solid brick and masonry. From the amount of coal delivered to the works it is estimated that they held at least \( 800 \) cubic metres of charcoal each.\(^{21}\) Two of them were built on the same level as the blast furnace, and parts of the bridge leading between the small mounds on which the southern façade rested and a section of a wall still survive, today forming part of a wall of a small dwelling.

According to the block plan of 1872 the iron ore brought to the works was stored in the open, up on the hill (\(9.\) Ore storage).

**Residences and Office**

The residences of the employees were built on the hill above the works. The standard varied considerably according to the status of the occupants, from the bungalows of Mitander and his assistant-to-be to the simple sheds put up to house the prisoners brought into the works. The living quarters of the prisoners cost only a fraction of the cost of the two bungalows.\(^{22}\)

Work on the construction of Mitander’s residence was started soon after his arrival and he was able to move into the bungalow in the middle of March 1861 (\(10.\) Mitander’s Bungalow).\(^{23}\) A residence for an assistant superintendent was built as well (\(11.\) Assistant Supervisor’s bungalow). Both bungalows were one-storey, built of brick and plastered.\(^{24}\) A “grass shed” for a “prisoners’ camp” was also completed (\(12.\) Prisoners’ camp).\(^{25}\)

An office and a smaller storehouse were contained in a single building erected west of the blast-furnace house (\(13.\) Office and storehouse).\(^{26}\) The rooms were to be 6 by 4.8 metres each and a veranda of 2.4 metres was built on three sides of the building. A grass shed was built as a temporary hospital for the native doctor, directly adjoining the office.\(^{27}\) All these buildings are on CISF ground. Any remains of the office and storehouse were hidden in 2003 under the new hostel.
FROM ORE TO MALLEABLE IRON

The single most imposing structure at the Burwai Iron Works is today the ruin of the big building in which the blast furnace itself was housed. It was built perpendicular to the hill with the blast furnace in its southern part (14. Blast furnace). This was the heart of the works and no other part of the works is mentioned so often in Mitander’s diary. The building was also the largest single item of expenditure, costing almost as much as all other building and construction work put together (46 percent of total expenditure on building construction).28

The walls of the blast-furnace building are approximately fifteen metres high and its gables reach more than 18.5 metres. It is built mainly of brick and has a foundation of masonry, held together by a number of anchoring irons. The kind used in Barwah was of the same basic design as those in the figure of Sten blast furnace, which could indicate a connection. But it is no unequivocal proof. This kind of iron was commonly used in Sweden, but it is uncertain if it was used in Britain.29 In total the building is approximately 29 metres long and nine metres wide. The part of the building which stands higher up the hill is thirty metres long. In three sections of approximately equal size it once contained the blast furnace, the steam engines (15. Steam engines) and the calcining kiln (16. Calcining kiln).

Blast-furnace house today. At the end of May 1862 Mitander could report that he had the exterior of the blast furnace house almost finished, ready for the mounting of the roof trusses (Mitander’s diary, 20 May 1862). This building is still generally well preserved. Photo: Jan af Geijerstam, 1997.
According to archival sources the calcining kiln “on the Swedish model”, placed in the northern end of the blast-furnace house, was ready sometime before September 1861. All that could be seen of this in 2003 was a clear change in elevation in the northernmost part of the interior of the blast furnace edifice. The first combined lime and calcining kiln is further east (17. Lime and calcining kiln).

There was no windlass to transport ore and coal to the top of the blast furnace. Iron ore, charcoal and lime could be pushed on rails on level ground to the tops of the calcining kilns and of the blast furnace. The bridge from the hill and to the furnace house is today in ruins, but the arches carrying it are still standing (18. Bridge). It was mainly to facilitate this transport of materials that the road up the hill, big enough for carts, was constructed. The upper wooden floor of the furnace building has gone, but all along the inside of the walls, notches for the joists of the top floor can be seen, and the blast furnace reached up to and above this level.

All the equipment in the blast-furnace building has gone, but in the middle section there is a big hole in the wall leading directly out to the eastern chimney. This is the chimney in which the Baba chimney shrine is placed and

(Opposite page) Interior of blast furnace house, from calcining kiln towards furnace. Nothing remains of the interior equipment of the blast-furnace house. Looking from the northern part of the building, from the hillside, it is however quite possible to discern the space for the calcining kiln, the blowing and heating machinery and of course the blast furnace itself, which is still, at least in part, extant. Photo: Jan af Geijerstam, 2003.
it is approximately 14 metres tall. The hole probably led the exhaust from the steam engines to the chimney.

The height of a blast furnace is a decisive measure of its capacity and is thus important to determine in the case of the Burwai Iron Works.

Except for the limekiln, the shaft of a furnace is the only part of the central production units still standing. In 2003 its interior height was estimated at approximately 11 metres, but its original height was probably 13.5 metres (see further discussion in Chapter 7, p. 224–226).31
Refining and Finishing the Iron

A foundry was built as a direct continuation of the blast-furnace building and in 2003 its walls up to and including the arches were still standing for half its length (19. Foundry). Built in the spring of 1861, the foundry was fifteen metres long and six metres wide. According to the drawing of the works this part had two storeys, but no indication of this was found in the ruins. During the construction of the remaining parts of the works it was used as a workshop for carpenters and blacksmiths.

To refine the pig iron, a Lancashire forge was built, 22.5 metres long and 12 metres wide (20. Lancashire forge and steam hammer). The forge was perpendicular to the blast-furnace house, below and alongside the hill and the water channel. It was built in November 1862 when the blast furnace was almost finished and Nils Mitander commented that he could not make the hearths until he could produce his own castings. Originally Mitander seems to have planned more than three Lancashire hearths, but he had to limit himself to three “since one of the blowing cylinders has broken on its way to Bombay”.

Foundry part of building. The arches of the foundry, built as a direct continuation of the blast furnace building itself, are still standing for half their length. Photo: Jan af Geijerstam, 2003.
A steam hammer was installed in one end of the forge. “I have now had a visit from the Prince who visited me a year ago, when I was still living in a tent … and when I told him that I expected a steam hammer weighing one ton with every blow he was even more surprised."38

Finally the rolling mill and the workshop/fitting shop units of the iron works should be mentioned, both constructed for the fabrication of market-ready products. A rolling mill was built just beside and parallel to the forge, but it was somewhat smaller, 21 metres long and 7.5 metres wide (21. Rolling mill).39

The products of the foundry and the rolling mill were to be further processed and finished in a small but well equipped workshop (22. Workshop and fitting shop).40

The workshop machinery was placed in the carpenters’ and smiths’ shed, 21 × 9 metres in area, and in the fitting, pattern and machine shop, 36 × 7.5 metres (25. Fitting shop).41 In the fitting shop different parts were to be adjusted and assembled into bigger units. In the pattern shop the patterns for the moulds in the foundry were to be made, a carpentry job of crucial importance in a foundry and one demanding great skill.

All together these units completed and formed the last leg of the small, but well-integrated ironworks built in Barwah, based on local raw materials and intended to produce products for a local market.

The Kumaon Iron Works

The Kumaon Iron Works consisted of four different sites, Dechauri, Kaladhungi, Kurpa Tal and Ramgarh. At all these sites there are remains today and they are briefly presented in the pictures and captions below. They would each merit a more thorough examination, but the present study has been confined to Dechauri. It was the focal point of efforts during all the epochs of the Kumaon Iron Works and it was the only place where any significant iron production took place. During the years when Julius Ramsay and Gustaf Wittenström were engaged, Dechauri was also their home.

Today Dechauri is a small, and, at least to a casual visitor, seemingly thriving, farming village, not very densely populated. There is water running in canals, and the fields look healthily green. The village is in the upper part of the Bhabar, the forest-clad lower slopes of the Himalayas. Here the mountains level out into the Ganges plain in a stretch of moraine which has been washed down from the mountains. Today, as in the days of the Kumaon Iron Works, all the buildings are situated on the northern slopes of the Baur River Valley. The terrain is very hilly, rising from approximately 600 metres above sea level on the banks of the river below the village, to a summit of 1,460 metres just three kilometres away.

Ramsay once considered the site excellent for the establishment of an ironworks. The slopes of the surrounding hillsides were covered with stones
or boulders of iron ore although of low iron content. The topography of the site itself, levelling off in four main terraces, between six and nine metres high, provided levels suitable for buildings and storage, and below all this there were many kilometres of dense forest. In addition the Baur River could be a source of power and Dehauiri was at a sufficient altitude to give a favourable climate, even for Europeans.42

THE IRONWORKS AND THE VILLAGE

The local inhabitants and the official maps call the ironworks site Rurki. This is a first and immediate sign of the industrial heritage. The name is derived from the pioneering government workshops of Roorkee – from which some of the equipment for the Kumaon Iron Works was bought.43

All the general block plans of the Kumaon Iron Works seem to have been lost. The combination of the notes of Julius Ramsay, the assessments of 1861 and 1872 made in anticipation of changes in ownership, and the photographs of Gustaf Wittenström give quite a full picture, but all the same it would be
impossible to visualise the layout of the former works without field studies. After 140 years the remains of the Kumaon Iron Works are important sources for a reconstruction of the full works complex.

The Kumaon Iron Works had in one sense reached a later stage than the Burwai Iron Works. Production started and iron was made during several periods in 1859–62 and 1877–78. The works had thus passed the first phases of experiment and had moved on to active production. In another sense the Kumaon Iron Works was at an earlier stage when they were closed down, since the big new works was abandoned before it was complete. These two phases of history form a general background to the following walk through the site.

At the crossroads where the main paved village road turns left, the bus stops, and there is a small tea hut. On the opposite side of the road there is a big, well-kept farmhouse. This is the home of Pramod Kumar Tripathi and his family, who currently own the property where the ironworks were once located.

When Julius Ramsay summarised his experiences in India in 1864 he described Dechauri and its climate as a place where “decay is as fast as the vegetation is unbelievably luxuriant”. He believed that all buildings “would soon fall into ruin or at least be covered with forest”.44

Looking back, Ramsay’s description was exaggerated. Although Dechauri today has few obvious and striking signs of having once been a lively site of construction and ironmaking, there are traces in the landscape. These signs are to a considerable extent obscured by intensive agriculture, but they can still be found, without much trouble, by anyone who knows what he is looking for, and it has been human action rather than “nature” that has obliterated the traces of the works.

A WALK THROUGH
THE KUMAON IRON WORKS

Within a distance of about 500 metres from Mr. Tripathi’s house and the teahouse, up the road and down the terraces levelling off towards the river, traces of the works can be found. Among the shrubs there are heaps of iron ore. On a slope there is black iron slag. Along the borders of the fields are pieces of brick. On a hill there is an ancient bungalow and further down the slopes there are imposing stone walls. And incorporated into farm buildings are old bricks and even parts of walls.

The exact sites of the buildings of the 1860s have not all been identified. This applies to both numerous lesser buildings such as workmen’s houses, chokidar (watchmen’s) houses and privies and also some of the bigger buildings. In contrast to the Burwai Iron Works there are no comparable major remains of buildings belonging to the production units of the ironworks and much has totally disappeared. The landscape has, at least in part, been intensively cultivated for approximately 120 years and the archival sources
are partly fragmentary. In spite of this, and even without archaeological excavation, field studies in 1997 and 2000 have made it possible to identify a number of important checkpoints in the landscape and to build a general picture of the works. 45

Dwellings, the Gool and the Water Mill

Just above the tea hut, behind the trees on a wooded hill, is a bungalow (1. Bungalow). When Julius Ramsay arrived in Dechauri, Mr. Oldham, the accountant and assistant manager, was living in a tent and Ramsay saw it as
one of his first tasks to build two bungalows, one for himself and one as a combined office and residence to be used by Mr. Oldham. One these survives and is used for temporary guests as a forest lodge. Comparing its present state with Wittenström’s photograph and a plan drawn by Ramsay in one of his letters it is evident that it is preserved almost exactly as it was built in the early 1860s. Compared with Mitander’s bungalow in Barwah, it is a generous and well built residence, clearly marking the status of its occupant. Behind the bungalow there is an old shed, built of stone, and adjacent to this the residence of the custodian of the forest lodge.

Dwellings for European workers were placed higher up the hillsides. These sites have not been visited, but according to information from local inhabitants nothing can be seen of them today, at least not on the surface. Just as in Barwah, the planning of the works thus shows a social division at the site. Class differences are also readable in the historical landscape (see also Chapter 10, p. 306–307). It is no coincidence that the residence of the manager at the Kumaon Iron Works still stands while there are no remains of the lesser buildings of the workers.

Below the bungalow the road and the watercourse run through the valley. Following them upwards, there is first a flour mill, driven by a horizontal water wheel (2. Flour mill). According to inhabitants of the village, the mill was built “in British times”. There are no notes of such a mill in the archival material on the Kumaon Iron Works so it is probable that it was built later.
It is still in use and just behind it there is a fairly new house, the residence of the miller. This might be where an “old dwelling” from 1860 was standing when Ramsay arrived.

At Kumaon, in contrast to the situation at Burwai, water was to be used as a major source of power. A canal runs parallel to the road and according to data from the 1860s it was approximately 2,100 metres long. It was also called a gool, and it was the central artery of the ironworks, connecting its different parts. It is not known whether it was constructed specifically for the works, since the British colonial administration built an extensive system of canals in the Bhabar to carry water from the mountains down to the villages. Without canals the water quickly drained away into the moraine gravel forming the boundary zone between the mountains and the plains. The gools of Dechauri are today used for agricultural purposes and have probably been extended down the valley since the days of the ironworks. This one is solidly built of stone and well maintained. It winds beside the road (g. Gool) after catching its water supply up the valley, but its total extent has not

Flour mill. The flour mill, just above the house of the Tripathi family, is still in full use. The grindstones are driven by a horizontal water wheel in the gool just below the site of Sowerby’s blast furnace. The mill is said to have been built during colonial times. Photo: Peter Nyblom, 2000.

Photo of Bungalow 2000. Today one of the two bungalows is still standing. The lower parts of the exterior are unchanged, but an addition has been made on the roof. According to our guides this was built to improve the air circulation and hence, the interior climate during the hot season. Photo: Peter Nyblom, 2000.

Interior of Bungalow 2000. One of the two bungalows built in the 1860s has disappeared, another is still standing and well preserved. Almost no changes seem to have been made to the interior since the 1860s, the ground plan, fireplaces and ceilings being intact. Photo: Peter Nyblom, 2000.
been investigated, nor has whether there are any traces of Sowerby’s bunds in the river or of the landslide that so decisively stopped the blows in 1860.

A little further up there are houses on the left side of the road (4. Residence houses). Judging from the architecture they date, at least in part, from the nineteenth century. These may quite possibly be the dwelling for eight to ten European workers referred to by Ramsay and planned to be built early in 1862.49

Sowerby’s Blast Furnace of 1859

Some 150 metres past these houses are the remains of the blast furnace built by Sowerby in 1859 (5. Sowerby’s blast furnace). The shaft of the furnace was made of bricks, bound with iron and lined with dressed stone. Leading to the top of it was an iron ore and charcoal bridge, made of timber. Adjoining the furnace building were a casting house and an engine room, including a water wheel. In the early 1980s, the furnace itself was still standing and the access bridge leading to its top was a playground.50 Early in 1997 a last brick arch was still standing and small parts of the inner lining of the furnace, with green, glassy slags, could be collected. In 2000 the remains had been totally levelled and the terrace of the blast furnace was cultivated. The only parts remaining above ground were the brick walls supporting the gool and formerly the water wheel. Parts of the foundation of the last pillar of the bridge to the furnace could also be seen. Bricks from the blast-furnace building have been used in the small farmer’s adjacent house.
There is a general absence of detail on the construction of this blast furnace. Even the figures for its height vary, but it was probably 10.2 metres (34 feet). The total volume of the furnace was stated to be 12.6 cubic metres (1,400 cubic feet).

Attached to the furnace was a blowing engine sufficient for two furnaces, powered by a 12-horsepower overshot water wheel in a separate wheelhouse. A major drawback in the general arrangement was the lack of hot blast. This was only added for the last trials in the 1870s. Nor were there any roasting kilns for the ore. The iron ore was roasted in pits.

In the spring of 1860 a second blast furnace had been commenced, about 100 metres from the first one. Ten of the seventeen arches of the casting house had been completed at that time. The masonry for the support of the bridge to the furnace was well advanced and the casing of the furnace itself had been commenced. The second furnace was built of rubble masonry with red brick dressings. When Julius Ramsay arrived, this project was abandoned. This furnace was, as Ramsay put it, “of a poor design and in an exceedingly unsuitable location”. According to a letter from Ramsay, it was placed on the “second terrace”, counting the terrace of Sowerby’s furnace and the bungalows as the first. As Ramsay, at the same time, wrote that he was planning to build a rolling mill on this site, the comment is somewhat confusing. Probably the idea of siting a new rolling mill here was later abandoned. Except for the details quoted, there is very little information on this blast furnace and its location has not been determined.
On the northern slope of the site of Sowerby’s blast furnace there are massive deposits of slag (6. Slag dump). As the furnace was blown during several periods it is probable that the slag on the surface is from the most recent campaigns in the late 1870s. Trenches in the slope could possibly disclose slags from the different blows and the differences between them. On the opposite side of the road, north of the former blast-furnace bridge, in an area covered with sparse vegetation, there are heaps of brittle, reddish-brown, iron ore (7. Iron ore storage).

Along the Underground Canal towards the New Works

Turning back along the road, down to a point just above Mr. Tripathi’s house, brings one to a fork in the gool. The left branch veers away from the road and disappears underground. According to Ramsay himself, who once built it, this underground canal is approximately 120 metres long. Following its general direction with the big residence of the farmer on the right, one passes close to the combined cowshed and outhouses. At the far end of this building are the remains of the eight “Finnish charcoal kilns”, mentioned by Ramsay. The measurements of the foundations of the walls exactly match the surviving drawings (8. Finnish charcoal kilns). On this terrace two big charcoal sheds were also being built in 1862, one 41×10 metres and one 11×10 metres, but their exact locations have not been identified (9. Site of charcoal sheds).
The New Ironworks

Some thirty metres further down from the charcoal kilns is the end of the first terrace and beyond that come two more terraces approximately six and eight metres wide. At a level approximately 21 metres below the first terrace, just beside a large cultivated field, is the largest preserved structure from the ironworks, a big stone wall, approximately fifty metres long and six metres high. At one end the water from the fork of the underground gool reappears.61

This was to be the central part of the new works begun in 1862/1863, with two blast furnaces, puddling furnaces, a rolling mill and a forge, and later, according to the plans, Bessemer converters, all designed by Julius Ramsay and Gustaf Wittenström (i.e. Site of new blast furnaces). The retaining wall was built behind the blast furnaces to support the next terrace. Ramsay described the new blast furnaces as “almost like the newer Swedish ones, fifty English feet high”.62

The measurements taken at the site, information in the written sources, and Gustaf Wittenström’s photographs and plans seem to agree. Today the terrace on which Ramsay’s blast furnaces were to be built is partly cultivated. Parts of the foundations of what was probably one blast furnace can be seen. It is quite apparent that it was an ambitious project. The site bears witness to the “enormous work done”, as mentioned by Ramsay in 1863.63

The new works used the topographic potential of the site with care. The gradient was used to organise and facilitate the flow of raw materials and products from the charcoal kilns at the top all the way down to the rolling mill on the lowest terrace. The blast-furnace charging floors were to be on the same level as the top terraces above, to facilitate the charging of the furnaces with ore and charcoal. Bessemer converters were to be placed below the blast furnaces. Then liquid iron would be tapped directly down into the converters for further refining.64

The deliberate use of the terrain is repeatedly emphasised by Ramsay and he apparently considered this a very important feature of the design of the works, much as Nils Mitander did.65

The Bessemer converters were actually never built, but according to Ramsay, Gustaf Wittenström also “constructed a small-scale Bessemer furnace and arranged several trials with our pig iron.”66 Since a Bessemer converter needs liquid iron this trial converter must have been placed close to Sowerby’s blast furnace, the only one in blast at the time.

The finery below the new blast furnaces was planned to be 54 metres long and at least the springing of the arches had been completed when construction work was stopped in 1863.67 The masonry work of this building has totally gone, but in the cultivated field in front of the blast-furnace terrace, signs of buildings are seen as lighter shades in the growing wheat and there are bricks on the edges of the field. On this level, the construction of a forge and the rolling mill was also begun. Ramsay called the rolling mill “magnificent”, temporarily equipped with puddling furnaces, until “we become the masters of the Bessemer furnaces.”68
The blast furnaces, the refining units and the rolling mill were all to be closely integrated at the Kumaon Iron Works, just as they were at Burwai, but the total area of the works buildings was almost ten times larger. The rolling mill at Barwah was 152 square metres plus the additional 270 square metres of the Lancashire forge. The rolling mill at Dechauri was to occupy a total of 1,620 square metres, or including puddling furnaces, hammers and machinery to handle the output of the rolling mill, an area twice as large, 3,240 square metres. The new rolling mill at Dechauri was to be ninety metres long and eighteen metres wide. All around this building there were to be verandas, each nine metres wide and making a total width of 36 metres, for fourteen puddling furnaces, as well as other equipment for cutting and punching the products from the rolling mill. The puddling furnaces were only to be temporary until the Bessemer process was running and there was to be ample room for expansion. At first one stand of rolls and one steam hammer would be installed but the building would be large enough for three steam hammers and four rolling mills for flat products as well as rail and different kinds of bar iron. Like the finery, this building was never completed. In 1872 a total of 64 pillars of the rolling mill could be seen, varying in height (11. Site of rolling mill).

The rolling mill was aligned parallel with the hillside, west of the blast-furnace building with the puddling furnaces all along the upper side, and with the exhaust gases led through three sloping canals up the hill to be used to dry wood at the top. Not surprisingly, since only the pillars were finished, there is very little to be seen of this big building today. There is, however, a sharp edge of a shelf along the lower part of the hill.

Outlet of underground gool (left). The water channel leading from the main gool close to Mr. Tripathi’s farm reappears just by the place were Ramsay’s and Wittenström’s blast furnaces were being built. It discharges its water several meters above the ground in the high-rising masonry wall behind the blast furnaces to be built. Photo: Peter Nyblom, 2000.

The building site 2000 (right). Except for the terraces of the blast furnaces and the big wall behind them, it is not possible to identify features of the Dechauri site at a hasty glance today. The big field in front of the furnace site is cultivated, and all that remains, at least above ground, of the foundations of the rolling mill etc. are some scattered bricks by the walls of the field. An archaeological investigation would probably determine the position of the rolling mill and other buildings. Photo: Peter Nyblom, 2000.
Sowerby’s Foundry, Forge and Fitting Shop

One preserved remnant of a building has not been positively identified. Some 300 metres from the bungalow, down the road, old brick walls are integrated into a new farmhouse. One complete arc stands alone, and frames the view down towards the river. This was possibly part of the buildings that once belonged to Sowerby’s ironworks, already built when Ramsay arrived. According to Thomas Oldham a foundry, forge and fitting shop were originally meant to be built together in a T-shaped building, but, as it turned out, the forge was placed 225 metres from the foundry and 880 metres from the nearer blast furnace (of the two to be built). The differences between these two figures, some 655 metres, fits very well the distance from the site of Sowerby’s blast furnace to the arch and other remains found at the farmer’s house. This was therefore probably a part of Sowerby’s foundry.

The site of the forge has not been identified, but was possibly the site of a present-day teahouse further down the road. This conclusion is also consistent with a description in a letter from Ramsay. In this letter he mentioned a foundry and a small mechanical workshop on the “third terrace”, again counting the terrace of Sowerby’s blast furnace and the bungalows as the first.

In comparison with the comprehensive and concentrated layout of Ramsay’s new works, using the topography to minimise transport, especially of hot metal, the layout of Sowerby’s works was almost puzzlingly sprawling. In one of his first plans of the prospective works he sketched a layout similar to Ramsay’s, with the blast furnace placed by a steep slope. Apparently he never put this idea into practice, but built the works along the much more gently sloping course of the major gool. On one of the very rare visits from the directors of the company, Dr. Pearson also complimented Julius Ramsay on his integrated plan for the works as a whole, a plan which had been lacking in Sowerby’s earlier works.

Finally, the remains of Davies’ first blast furnace can be found on the same level as Ramsay’s new works, some 200 metres further north. This furnace was used in the experiments of 1855 and rebuilt the next winter. Pig iron was made there for the first time in 1857. It was, on some occasion, “washed down in the rains”. Later it was relined with stone up to the boshes and a new hearth was put in. In the spring of 1860 it was still possible to use. It is even possible that Ramsay used it for some time since references are made to his use of two blast furnaces.

Infrastructural systems

A most important part of the landscape, and one clearly visible, is the system of roads. Some of these roads are most certainly old. Across a lower gool below the site of Ramsay’s new works, there are a couple of skillfully built
stone bridges, no longer in use. Close to these bridges there is a sloping road, paved with stones and part of a transportation system also no longer used. A bridge intended for the conveyance of the ore from the mines south of the Boer was under construction in the spring of 1862, designed for a 3.6-metre wide roadway. A bridge crosses the river today somewhat south of the works site, but neither this bridge nor any mining sites have been studied during the field visits. Up the valley, above the works, is another road, which must have been in use for a long time. The trees on either side are full-grown and the road is cut into the steeply sloping hillside. This road once connected the ironworks to mines in the interior.

SUMMARY DISCUSSION

Historical Landscapes of Integrated Iron Mills

The archival material on the Kumaon and Burwai Iron Works is scattered and incomplete, but it is possible to dig deeper by closing the door to the archives for a while. Field studies have supplied meaning to information otherwise hard to interpret and helped to fill in gaps. They have demonstrated the extent and complexities of the two works.

The locus of the industrial landscape of Barwah is relatively small in area on and below a hill. The size and layout of the works reflect a detailed and comprehensive planning. At the works itself transports were short with a definite line in the logistics, from the arrival of coal and ore to the final manufacture of rolled or cast products.

The Kumaon Iron Works shows a more complicated layout with its longer history and two different ways of approaching the planning of the works. The first works, laid out by William Sowerby, was spread across the landscape, which must have caused problems, with long distances for transport of material from one part of the works to another. This contrasts sharply with the plans made by the Swedish engineers. Here again, as at Barwah, the plant was concentrated and the topography of the site was consciously used to minimise the need for transport.

Two important differences between Kumaon and Burwai stand out after a visit to the sites. One concerns the balance of water and steam power and the other the scale of the works.

The layout of the Kumaon Iron Works, with its placing of the different stages of the production process and the layout of the gools, stresses the use of waterpower. Efficient use was made of the energy obtained from water not once but several times during its flow downhill. At the Burwai Iron Works this was not even considered, since the dramatic rise and fall in the water levels of the Bauer River made the use of waterpower far too difficult. Here steam was instead to deliver the ever-necessary power.
The great, and in view of the economic resources maybe even huge, size of the new Kumaon Iron Works became apparent at Dechauri, and is shown in the reconstruction drawing of the works. This reinforces the suggestion that at least the Kumaon Iron Works was too ambitious for the resources at hand. The Burwai Iron Works appears to have been more of an experimental project, with less money tied up in the plant and its buildings and machinery from the beginning. Both ironworks were to be fully integrated, encompassing all steps in the process from the extraction of raw materials from local sources to the final products for the market. This entailed a system of production, including not only the sites of the works, but also the surrounding landscape.
The Making of Iron and Steel

PART 2

The Charcoal Blast Furnace and Its Auxiliary Equipment in the Mid-Nineteenth Century

The production of wrought iron or steel by the blast-furnace route can be seen as having three parts. The first is the preparation of the raw materials, the second the making of pig iron in the blast furnace, and the last the refining stage. The blast furnace is the heart and focus of the process, the centre in the layout of an ironworks. It is a dominating physical structure, even if other stages of production are geographically widespread and occupy the great majority of the work force.

THE PREPARATION OF THE RAW MATERIALS

The main requirement for the making of pig iron was to supply the furnace with raw materials: iron ore, charcoal or coke, and flux, mostly lime. According to John Percy, as a rule of thumb for Swedish blast furnaces of the middle of the nineteenth century, these raw materials were added in the proportion 2 tons of rock iron ore + 0.2–0.3 tons of limestone + 0.8–1.2 tons of charcoal to produce one ton of pig iron. Percy also gave figures for British blast furnaces, see table on p. 204, which all show radically larger charcoal/coal consumption than in Sweden. Percy explained this in terms of the greater importance attached in Sweden to reducing fuel consumption. The high-grade ores of Sweden were also a major asset, as the amount of material to be smelted greatly influenced the amount of fuel consumed. The measurement of coal consumption causes difficulties. In Sweden charcoal had long been measured by volume, whereas in Britain and in most cases concerning the Kumaon and Burwai Iron Works it was measured by weight. A direct comparison between Swedish figures and the Indian cases is thus difficult. Both methods have drawbacks when a uniform measurement of the heat content or efficiency of the coal is desired. Weight does not show
Charges of blast furnaces, per ton pig iron produced

<table>
<thead>
<tr>
<th></th>
<th>Ore</th>
<th>Lime</th>
<th>Fuel</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Russell’s Hall</td>
<td>2.07</td>
<td>0.62</td>
<td>1.27</td>
<td>27 December 1851.</td>
</tr>
<tr>
<td>Aberdare &amp; Abernant</td>
<td>2.00</td>
<td>0.37</td>
<td>1.72</td>
<td>Five furnaces, first week of July 1863.</td>
</tr>
<tr>
<td>Newland</td>
<td>2.8</td>
<td></td>
<td>2.9</td>
<td>The amount of lime, if any, is not stated. Charcoal.</td>
</tr>
<tr>
<td>Blaenavon</td>
<td>3.5</td>
<td>1.0</td>
<td>2.7</td>
<td>Old furnace, cold blast.</td>
</tr>
<tr>
<td>Average for Sweden</td>
<td>2.5</td>
<td>0.33</td>
<td>2.0</td>
<td></td>
</tr>
</tbody>
</table>

Iron Ore

After the tedious and time-consuming work of collecting, crushing, sorting and transporting the ore to the blast furnace it was normally calcined (roasted) to remove volatile components, to burn out impurities, to increase its permeability and to make its size suitable for the blast furnace process. Calcining was initially done in open pits. In Sweden systematic trials to develop calcining kilns in order to reduce fuel consumption were initiated in the late 1820s. In 1840 the first successful kiln fired with exhaust gases from the blast furnace was built and ten years later, in 1851, the Swedish metallurgist E. W. Westman presented a new type of gas calcining kiln. The model was continually improved and was fully developed in the 1860s. Westman’s calcining kiln became the dominating model in Sweden into the twentieth century. In England the roasting of ore does not seem to have attracted any greater interest and in most treatises on ironmaking there is a noticeable lack writing in this subject. According to R. F. Tylecote heap roasting was probably the sole dominant mode of roasting in England, due to the abundance of cheap coal. In Britain heap roasting was maintained well into the twentieth century.

Charcoal

The making of charcoal needed the work of a large number of people and the availability of large tracts of forest to supply the wood. It had vast socio-cultural consequences for the regions in which ironworks were established. The making of charcoal involved the felling of trees, the burning of the charcoal, the charring (either in the felling areas or at the ironworks) and the transport of both wood and the charcoal produced.

There were two materially different methods of making charcoal: charring in meilers or heaps, and charring in ovens. The goal was to prevent open fire and to achieve a partial combustion where most of the material was left as charcoal. The favored mode in Sweden used the standing meiler. The wood was erected according to certain rules and the heap thatched with charcoal dust, dirt or sawdust in order to prevent the admittance of air. The temperature in the meiler was maintained by the combustion of a part of the wood forming the meiler itself. The meiler required much preparation, skill and care, to obtain good results.

In an oven the combustion of wood took place in a covered retort. Burning separate fuel outside the retort produced the heat needed. Atmospheric air did not come into immediate contact with the wood to be charred.

Like the ore, charcoal had to be of the right size, and also the right strength, in order not to be crushed by the weight of the charge and hinder the free flow of hot burning gases up through the furnace.

Charring in ovens or kilns had decided advantages. It gave a bigger scale of production and did not require such large stores of charcoal. It could also
save labour, and, maybe most important, it was less subject to the errors of workmen who could not manage the process.  

*Limestone*

Lime was the flux usually used to help the impurities in the ore to form a slag easily separated from the iron. The preparation of the limestone was the least complicated part of the supply of raw materials to the blast furnace. When the right quality of limestone had been located it had to be mined, mostly from open pits, crushed into suitable sizes and transported to the furnace.

**The Blast Furnace**

A blast furnace was, and is, a tall shaft furnace in which raw materials were continuously added from the top. Their progress down the shaft of the furnace continued in a complicated sequence.

During the process the oxides of iron in the ore were reduced when they reacted with the gases formed by the combustion of coal. The result was iron and combustible carbon gases. The ore melted in the process and the iron absorbed carbon. The melted material collected in the bottom of the furnace, from where it was tapped in liquid form. A lighter slag of impurities and residues flowed on top of the heavier iron. Slag and iron could thus be tapped separately and this was done at regular intervals. From the furnace the fluid iron was mostly tapped into moulds lined up along a central runner (the sow). The moulds looked like suckling pigs getting their bellies full and thus gave the product its name, pig iron. This was an alloy of iron and carbon (about 4.5 percent). The high carbon content made the iron brittle, but it could be cast directly.

The management of the blast was an essential and strategic part of the set up. Air was forced into the lower part of the furnace through nozzles, known as tuyeres. The number of tuyeres, their angle into the hearth etc all influenced the working of the furnace.

The introduction of *hot* blast greatly increased yields and reduced coal consumption. Hot exhaust from the top of the furnace could be used to heat
the blow. In England hot blast was first put into operation in 1829 using a method patented by the Scot James B. Neilson in 1828. The invention had a momentous influence on the productivity of ironmaking and soon became widely used.10 In Sweden the method was first used in 1833 and even at these first trials the production of pig iron was increased by fifty percent and charcoal consumption was reduced by nearly thirty percent.11

Among the complex variables in the design of the blast furnace was the shape of the shaft, which influenced the way the charge moved and the process itself.12 The time spent by the ore in the strongly reducing conditions of the furnace became longer in a tall furnace. Productivity was increased, as was the importance of a continuous process since so much of heat and material was bound up in the shaft at any one time. Every blow-down became costly.

From the blast furnace pig iron was moved to the final refining processes in the making of malleable iron or steel.

**Refining Methods in the Mid-Nineteenth Century**

The pig iron produced in the blast furnace was an alloy rich in carbon. In order to make usable steel the carbon content had to be adjusted and remaining impurities removed. The iron has to be fined.13 Numerous different methods were used, each with its technical specifics and socio-cultural origin, and two different welding methods and one steel ingot process were considered for use at the Kumaon and Burwai Iron Works.14

All three refining methods were part of a revolutionising transformation of iron making. They were closely connected to the industrialisation of iron-making leading to a bigger scale of production and more uniform products. They were necessary prerequisites for the big expansion of the rolling mills during the second half of the twentieth century.
The blast furnace, parts and names. Like other trades, the running of a blast furnace was an occupation which evolved its own language, facilitating communication and making it more precise. Each step of the work and each part of the furnace had its name. The charging floor by the mouth on the top, past the widest part, the bosh, down to the bottom, the hearth. Part of drawing by Gustaf Wittenström. Gustaf Wittenström archives, National Museum of Science and Technology, Stockholm, FDCM9-18. Artwork Staffan Schultz.


WELDING PROCESSES

Refining was achieved by a great many different welding processes in which the pig iron was re-heated and agitated in an oxidising blast to burn out excessive carbon and then immediately worked under a hammer or often a “squeezer” in the case of puddle iron, to drive out slag and other unwanted contamination or inclusions. The final product was a slab of soft iron forged into a desired shape.\(^{15}\) Two different methods were considered at the Kumaon and Burwai Iron Works, British puddling and what was known in Sweden as Lancashire refining.

Puddling

In puddling the iron was melted in a reverberatory furnace. Reverberatory means that the coal was burnt in a separate compartment, in one end of the furnace. On their way to the chimney the hot gases were led over the iron and since there was no direct contact between fuel and iron, poor quality coal could be used without risking contamination of the iron.\(^{16}\) The method evolved during the second half of the eighteenth century and was patented in 1784 by Henry Cort and puddling soon came to dominate British ironmaking and rapidly spread over the Continent. Sweden was an exception with its rich resources of fine charcoal. In Finland puddling became relatively widespread.\(^{17}\) The iron was smelted under constant, manual agitation, and thus thoroughly exposed to air. At first the iron was liquid, but as the carbon content was reduced the smelting point rose and the iron gradually turned into a spongy mass. The puddlers had to be strong men to move the heat of iron.\(^{18}\) Puddling radically increased the productive capacity of the British iron and steel industry.

Lancashire

The so-called Lancashire method was, despite its name, developed in Sweden in the 1830s by Gustaf Ekman, a Swedish metallurgist. Pig iron was here fined in a closed furnace on a hearth of charcoal. Here too the iron was constantly agitated with a lever to expose it uniformly to the reducing power of the air. The name of the method is an acknowledgment of the transfer of technological innovations from Britain and it may be considered a response to increasing competition from rolled products produced from puddled iron in Britain. Lancashire refining increased the production of charcoal iron and catered for the needs of an expanding rolling-mill capacity in Sweden.\(^{19}\) Lancashire became totally dominant among welding methods in Sweden and the method was used even long after the introduction of the steel ingot processes. The very last Lancashire forge in Sweden, in Ramnäs, was closed in 1964.\(^{20}\)
During the second half of the nineteenth century the steel ingot process was introduced. The use of higher temperatures allowed the steel to remain fluid during the refining process and the finished steel could be cast into ingots that were ready for rolling. These steel-making processes made the transformation to a new era of industrial steel making and the Bessemer process was the first. This process was actively considered for use at the Kumaon Iron Works.

Air was injected from the bottom of a converter filled with hot, molten pig iron tapped directly from the blast furnace. In this way excess carbon, together with other unwanted substances, was burned off and it was possible to control the carbon content with great precision by judging the colour and sound and other properties of the gases emerging from the converter. Like the Lancashire hearth refining method, the development of the Bessemer process was a complex case of technology transfer and combined efforts crossing national boundaries. It was developed by Henry Bessemer in Britain but first successfully used at Edsken in Sweden in 1858 and more widely introduced from the early 1860s. The Bessemer process was later to a great extent superseded by open-hearth processes, notably the Martin process, which could use scrap.

**BESSEMER**

**AN INGOT-STEELMAKING PROCESS**


The Bessemer process. The Bessemer converting vessel at the John Brown & Co’s Atlas Steel Works in Sheffield in which iron from the East India Iron Company was converted and later shown at the Great Exhibition in London 1862. Section of vessel and side view of ladle. Figure: *Practical Mechanic’s Journal*, 1862, p. 172.
Rolling

A common feature of integrated iron and steel plants in the nineteenth century was not only the continuous line of production from iron ore to finished product, but also the wide variety of the goods delivered, from forged nails to rolled rails, from cast machine parts to drawn wires and tempered knives.

Rolled metal was becoming a major product from the new iron-works, standardised and capable of being produced on a large scale. The technology and size of the rolling mills went through a period of radical development during the middle decades of the nineteenth century.

The rolling of iron, mainly into sheets, bars and wire, had a tradition to the middle of the sixteenth century in Germany and England. In Sweden it was certainly used for copper at the mint in Avesta from the early seventeenth century although it until the very late eighteenth century that rolling became widely practised in ironworks.\(^{24}\) During the early years of the nineteenth century rolling became faster, more accurate and much more versatile.\(^{25}\) The basic process involved the passage of hot iron between two rolls which squeezed the piece and made it thinner – and broader or longer. By using grooved rolls, round or square bars could be made. This involved several passes through the rolls, successively changing the size and shape of the piece was successively changed.\(^{26}\) The grooved roll was patented by Henry Cort in the 1780s, but had previously been devised sometime around 1740 by the Swedish inventor and pioneer in the field of rolling, Christopher Polhem.\(^{27}\) The grooved roll also paved the way for construction rolling mills to make rails.

Puddling and Lancashire made it possible to make enough wrought iron for the rolling mills and subsequently the development of the three-high stand of rolls eliminated another bottleneck in production. With a two-high stand of rolls, the piece was returned over the top of the rolls from the exit side to the entry side before a new pass could be made. This put severe limitations on the work since the iron lost heat in the process. In the three-high stand of rolls, introduced in the early nineteenth century, the return pass was also used for rolling.\(^{28}\) In Sweden this type of rolling was first introduced around 1830, but the two-high stand remained the most com-
mon type. Later two or more stands of rolls could be coupled together into
a train, making continuous rolling possible.

The first rolling mill for rails in Sweden was imported from England to
Finspång in 1853 and from this U-rails of Lancashire iron were delivered to
some of the very first railways of Sweden. Another early ironworks at which
rails were rolled was at Motala. Both of these were well established by the
time the Swedes left for India. The iron from the blast furnace at Sten, at
which Mitander had worked, was delivered to Finspång. Wittenström was
offered employment at Motala, but decided instead to go to India.
Technology Transferred

The buildings and the geographical setting presented in Chapter 6 constitute the exterior industrial landscape of the Kumaon and Burwai Iron Works. This chapter moves on to the machinery and equipment of the ironworks, its characteristics and origins and together these two parts constitute a physical representation of the transferred technology.

From where did the technology come? What can be traced to Sweden and what to Britain – or possibly to other countries? Or does it rather belong to a general body of international technology, whose specific national origins are irrelevant? Investigation of roots and origins may throw light on development effects and sustainability. To what extent did the Swedes order or consider the use of equipment made in India or at the works themselves? And did they consider the future maintenance of the equipment?

In the search for the origins of the technology, we examine possible connections with prototypes. These will be used as references in a discussion of four main parts of the works: first charcoal-making, second the blast furnace with its auxiliary equipment, third the hearths and furnaces to make wrought iron, and fourth the rolling mills. Ironmaking underwent radical changes and development during the middle of the nineteenth century. How were these changes manifested at the Kumaon and Burwai Iron Works?

In the late 1850s, the blast-furnace method was generally considered the obvious route to an expansion of ironmaking in India. Other options were briefly contemplated, as when Richard Keatinge acquired a rolling mill from Britain in order to process Indian-made bloomery iron, but bloomery production was soon abandoned in favour of the Burwai Iron Works project.

In Kumaon the choice seems to have been clear from the outset. William Sowerby did not hesitate to commit himself completely to an ironworks based on European technology. He had earlier seen traditional ironmaking in southern Africa and on the subject of Indian iron he noted that he had “seen as good iron manufactured by savages in the Zulu Kaffir country as in any part of India”. It said little, he added, “for the progress of science in India to find one of the most important branches of manufacture in the world no further advanced than it is amongst the uncivilised tribes of Africa.”
When the blast-furnace option was chosen, it was a qualitative shift in the mode of making iron in India. And in general, the ironworks to be built would be of a scale, mode of organisation and mechanical ambition not previously seen in either Kumaon or Nimar. In 1862 the commissioner of Kumaon returned from a journey during which he had seen a railway for the first time, and Julius Ramsay commented, “Up here [in Kumaon] there are many old men, who never have seen even a steamboat.”

Mitander made all the plans and drawings for the Burwai Iron Works. In this demanding task, carried out in an unfamiliar setting, his only professional aid was Richard Keatinge, who examined the designs. His assistant Harry Baboo also helped Mitander with practical tasks. Very little is known about this Indian clerk, but he was apparently very versatile. He not only met Mitander in Bombay and was his guide on the journey to Barwah, but also helped Mitander test the ores. Mitander put him to work on writing letters, or drawing a map of Nimar and quite possibly on other tasks.

Richard Keatinge had acquired extensive practical experience of complex engineering projects both during his long service in the Indian army, starting in the Bombay Artillery in 1842, and in Government service as political officer and in charge of many extensive infrastructural and construction works. His practical experience of ironmaking was, however, limited, despite his quite extensive study tours in England, on the Continent of Europe and in Sweden. In his solitude, Mitander was ultimately responsible – for finding the solutions and making adjustments to local conditions. He had to rely on his own knowledge and experience.

The situation was similar at the Kumaon Iron Works, although the responsible Swedes were two in number for a while, but in technical matters...
the support from those around them was little. Their word on these matters carried weight and they, too, had a big responsibility.

Ironworks in Sweden and Finland as a Reference

Both Nils Mitander and Julius Ramsay referred to models in Sweden when they planned their ironworks in India. Mitander explicitly mentioned the ironworks at Silverhyttan, but there is also good reason to believe that the blast furnace at Sten was an inspiration. Julius Ramsay described the new blast furnaces planned at Dechauri as “the nearest equivalent to the newer Swedish ones, fifteen metres high”. He made no explicit reference to any special models, but it seems very probable that the ironworks of Långshyttan in Central Sweden, and especially its new blast furnace, was well known to both Ramsay and Wittenström. The blast furnace was the newest and most talked about in Sweden around 1862, built in 1859 to a design common in England and considered to be the best in Sweden all through the 1860s. The new works at Dalsbruk in Finland was probably also another influence, since Gustaf Wittenström came directly from there to India, after supervising the building and commissioning of the plant.

These four ironworks, Silverhyttan and Sten, Långshyttan and Dalsbruk, will be used in the rest of this chapter as a frame of reference in a discussion of the technology at Kumaon and Burwai.

Silverhyttan and Sten as Models for the Burwai Iron Works

When Nils Mitander came to India in 1860 he brought with him plans of blast furnaces from Sweden and when he started with the outer brick wall of the building for the blast furnace and calcining kiln he noted that it would “be like Silverhyttan, under one common roof. Quite neat I hope, with the steam engine and its boilers between the two furnaces.”

Silverhyttan was a blast furnace in the western part of the ironmaking districts of Central Sweden, some twenty kilometres north of Karlskoga and Bofors. The site is in a densely wooded area, beside a stream. The works once turned out silver, but in 1685 the owners decided to change over to ironmaking, using ore from nearby mines and the ample resources of water power and timber. Nils Mitander worked on a blast furnace of Silverhyttan built in 1852. He was there for several periods between 1855–1862, made major changes to the furnace and was twice in charge of starting it up. The last time he visited Silverhyttan, before going to India, was 31 May 1862.
Unlike the Burwai Iron Works, Silverhyttan was wholly dependent on water power. It was equipped with a gas calcining kiln and the blast furnace had three tuyeres, was free-standing, had a hot blast from a tubular hot blast stove. It was smaller than the blast furnace built by Mitander in Barwah, being approximately 11 metres high.9

The ironworks at Silverhyttan was closed in 1872, and replaced by a sawmill. Today no more than traces of masonry are left, hidden in the undergrowth beside Trösälven, a small river, on the northern shore of the lake called Hällsjön. No drawings or pictures have survived, and today even the sawmill has gone. The most prominent remains are the ramps of heavy masonry that once led up to the two charcoal sheds. The dams that provided a steady supply of water power, creating a water reservoir in Hyttdammen (approximately “Smeltery Dam”) and the canal leading past the works down to Hällsjön, are also still intact.10

Another point of reference is the blast furnace at Sten (also known as Graversfors), fifteen kilometres north of Norrköping, which was built in the late 1850s to a plan by Grill and used by John Percy in his Metallurgy as an example of a typical Swedish blast furnace of the time.11 Andreas Grill supplied the material to Percy, and he was amply acknowledged in the foreword, but it was Nils Mitander who was in charge of the construction of Sten blast furnace for five months in 1859, and in February 1860 he spent five days making a fair copy of the drawing of it.12 It is not unlikely that Mitander made the drawings for John Percy’s book.13 The new ironworks at Sten was started in 1860 as an important supplier of pig iron to the big ironworks of Finspång, where the first rolling mill for rails in Sweden had been started in 1855.14 A second blast furnace was later built at Sten. It was finally blown down in 1933 and the works was demolished in 1936.15

It is probably the ironworks at Sten that Richard Temple referred to in his assessment of the Burwai Iron Works in 1864.

The buildings are excellent in every way – spacious, lofty and entirely suited to the purpose. The structure is one that does credit to the designers and the builders. The designs were partly prepared by Mr. Grill himself. I learn that Doctor Percy, lecturer at the Government School of Mines, Jermyn Street, has adopted this very plan, as the one best suited for blast furnaces.16

The ruins of the Burwai Iron Works fully confirm Temple’s general assessment of the excellence of the buildings and the mere fact that two of the chimneys, the arcs and the blast furnace itself remain almost as new clearly speaks of solid workmanship.

It is difficult to find proof of a direct and unique connection between specific Swedish models and the Burwai Iron Works, especially since the affinity in design was close between modern Swedish works and British ones. John Percy described the blast furnace of Sten as “similar in all essential respects to English furnaces”.17
Details of the existing buildings and a comparison with the drawings of Sten blast furnace do however show similarities that indicate a direct connection with Swedish tradition. The anchoring irons, as discussed earlier, are one example and, as will be further discussed below, the Lancashire hearth, planned to be used at the Burwai Iron Works, was a Swedish technological adaptation.

**Långshyttan and Dalsbruk as Models for the Kumaon Iron Works**

The new ironworks at Dechauri were planned to be a commercial undertaking and, as such, bigger than the experimental plant in Barwah. The process of making iron conformed to a general pattern and no unique correspondence between Kumaon Iron Works and ironworks in Sweden has been found. There are, however, strong reasons for assuming that Långshyttan and Dalsbruk had an important influence and can thus be used as references.

The new blast furnace at Långshyttan and the design of the new furnaces at Dechauri show a marked similarity. Both were free-standing with three tuyeres. Both utilised a hot blast with the air heated by exhaust gases from the blast furnace in a tubular heater, blowing machines of a similar design, a calcining furnace, heated by the exhaust gases of the blast furnace, Lancashire hearths and fixed Bessemer converters. The difference was the size. At Långshyttan the volume was 62.3 cubic metres, Ramsay’s new furnaces would be approximately 51 cubic metres.

In the early 1850s Dalsbruk, situated in Swedish-speaking South-West Finland and on the Baltic, was a small ironworks with a blast furnace, gas calcining kiln and oven for burning charcoal. The main product was pig iron, delivered to forges in the region, but there was also a foundry and a mechanical workshop producing mainly for a very local market. In 1856 Wolter Ramsay, a
cousin of Julius Ramsay, became owner of the works and within a few years he initiated a profound restructuring and expansion. Gustaf Wittenström was engaged to plan, design and build the new works, which, when completed, encompassed five puddling furnaces, five mill furnaces, two steam hammers, and a rolling mill with trains of rolls for different products. Fundamental differences from Swedish works were its coastal location and its use of coke. The works was placed on an island and was totally dependent on steam as a source of energy. Good sea transport was an important reason for the location. The iron from the old blast furnace was not sufficient for the new works, so iron was also imported from Sweden. The furnaces were heated with imported coke and the rolled products were sold to customers in Russian seaports.

The new works were started up in 1861 and when they were in full production in 1862 some forty workers were employed at the puddling furnaces. It was at this stage that Wittenström received the offer from Julius Ramsay and decided to leave for India.

Charcoal Piles and Ovens

At both Kumaon and Burwai Iron Works extensive charcoal-making took place close to the felling areas (forest-charring). Since carbonising reduced the weight and volume of the fuel this cut the transport costs compared with bringing in wood for charring at the works. However there was a big risk of damaging the charcoal in transit, reducing the size of the coals or even turning them into useless dust.

Forest-charring was most common in Sweden too, but the method differed. In India the wood was piled up in loose stacks, whilst in Sweden was carefully built up in heaps, known as meilers, covered with coal dust or earth and closely tended during the burning. Although charcoal-burning in meilers was the most important mode of producing charcoal to meet the very large demand of the Swedish iron industry, different types of charcoal kilns were also used, but to a limited extent.

Meilers and, especially, kilns were more efficient than the stacks. They gave more charcoal from the same amount of wood, but at the same time the
The construction of Finnish charcoal kilns. Looking north up towards Sowerby’s blast furnace, the Finnish charcoal kilns are seen under construction. Photo: Gustaf Wittenström, C15269.

The charcoal stack was probably more easily managed in India since the technique was well known. At both Barwah and Dechauri most of the charcoal was bought from independent producers and most probably the loose stacks were used, a method that involved no investments in permanent structures and could be moved along to new felling areas. It was also a practice well-known among local producers and might thus in a broader socio-technical sense have been the most efficient method.

Drawing of charcoal kilns. The charcoal kilns to be built were designed by Gustaf Wittenström to Finnish models. The fire was separate from the wood to be charred, in an effort to reduce losses. The drawing of the charcoal kiln perfectly matches the foundation walls still survived, see p. 197. Source: Wittenström’s drawings FDCM10-25.
At the same time Nils Mitander noted several times that a secure and sufficient supply of charcoal was difficult to achieve. This was probably an important reason for the Swedish managers at both ironworks, but particularly at Burwai, showing a definite intention to make at least a partial shift from this system of subcontractors to on-site charring at the works. This also meant a shift of technology to a more industrialised form of charring in big heaps, charcoal pits and ovens.

Mitander considered the pits to be the best as the coals produced were big, hard and strong. He was also very satisfied with the yields, 45 percent of the volume of wood as charcoal. In a summary report a somewhat lower yield was reported, however, possibly as an average of all charcoal-making, 35 percent of the wood by measurement, i.e. by volume.

The appearance of the coal pits and ovens is not known and there is even an uncertainty in Mitander’s terminology. One of them, the third one, which he called rectangular, was drawn by Mitander as suggested by Andreas Grill. In later correspondence Mitander called this a “scissor furnace.” He might have been referring to a method of putting five different outlets of the charring fire in a regular, scissor pattern, one outlet in the middle of the furnace, one in the direction of each corner. A permanent coal heap at the works was also created, with walls of firebrick and mortar.

At Dechauri Julius Ramsay and Gustaf Wittenström began to build “Finnish charcoal kilns” as a part of the new works. The use of ovens seems to have been more common in Finland and the design of the kilns in Dechauri was probably brought by Wittenström from Dalsbruk, where they were introduced by Carl August Ramsay, uncle of Julius Ramsay, sometime before the 1840s.
The Blast Furnace and Auxiliary Equipment

At the heart of the ironworks was of course the blast furnace. Its size determined the amount of raw material needed and the size and extent of the surrounding facilities. Its rhythm determined the organisation of work.

Calcining Kiln

The meilers and the charcoal kilns were the first step towards bringing the fuel to the blast furnace. Similarly calcining was the first step in processing the ore. At both Kumaon and Burwai gas calcining kilns were to be used, closely integrated with the blast furnace.

As early as September 1861 Colonel Strachey reported that a “calcining kiln on the Swedish model has been erected at the Burwai Iron Works to calcine the ore before smelting. It was 14 feet high, and 5 1/2 feet interior diameter”.29 At the same time a calcining kiln beside the blast furnace was under construction but at the first blow in December the following year it was still not ready. During his first periods of blow Mitander planned to make castings and to use them to finish the kiln.

The explanation of the seemingly contradictory notes on two calcining kilns lies in a double use of the limekiln. Mitander had this ready to burn lime by the middle of February 1861.30 During the period of building the works the kiln was used to produce lime for mortar, but as the blow approached in 1862 Mitander also used it to calcine ore, hence the somewhat erroneous designation “calcining kiln”.31 In Captain J. G. Melliss’ report and block plan to the Government in 1863 it was given a more correct designation, “calcining and limekiln”, although the order could have been reversed, to reflect the primary use of the kiln.32

It is not known what Strachey meant by saying that the lime and calcining kiln was built “on the Swedish model”. There are no preserved drawings and it was not available for inspection during the field studies since it was on land screened-off by the Central Industrial Security Force (CISF).

Turning to the calcining kiln proper, the one to be built beside the blast furnace, the only specific information on its construction is that the foundation was 4.65 metres in diameter and 1.2 metres deep.33 From measurements at Barwah in 1997 and 2003, it could at most have been six metres high, calculated from the very bottom of the foundation. It is also of major importance that it was a gas calcining kiln, which is fundamentally different from the lime and calcining kiln. The former was to be heated by hot gases from the working blast furnace, the latter by the burning of charcoal and wood in the kiln.

In the new works at Dechauri Ramsay and Wittenström planned a similar change of technology to that at Burwai. The case here seems clearer. In
"Design for 2 blast-furnaces in combination with Bessemer-aparatus". "Dwellings and existing workshops were placed on one of these vast terraces and we placed the two new blast furnaces on the terrace immediately below. The difference in altitude was about 60 feet and as the blast furnaces, which were supposed to be 50 feet tall, were built on the slope of the hill with the charging floor level with the upper level of the hill, we used the rest to build a 10 feet platform to place the planned Bessemer converters so low that iron could be tapped directly into them and still leave enough room for casting pits, cranes etc. Immediately behind the furnaces was a wall against the slope and approximately halfway up it was a platform big enough to leave ample room for two gas calcining kilns and two heating units." (Ramsay’s report, p. 39-40). Wittenström’s drawings, FDCM9–18.
Ramsay’s drawing of the blast furnaces, he also showed two horizontal sections of a gas calcining kiln, one at the level of the gas entrances from the blast furnace, the other at the level of the outlets. The design bears a very close resemblance to the very first drawings of a gas calcining kiln presented by the Swedish engineer E. Westman in 1851. The diameters of Westman’s kiln and the one in Ramsay’s drawing are almost identical, approximately 4.6 metres (16 ft). The number of gas inlets was the same, eight, as was the number of outlets, four.34

Wittenström and Ramsay planned a gas calcining kiln of Westman’s model and a hypothesis is that Mitander, too, was building such a kiln. According to Braune this type was the perfect embodiment of a gas calcining kiln “…the construction of which in all essential respects remains unchanged today [1904].”35. It seems improbable that Mitander considered any model other than this type, well tried and considered superior to other solutions. The diameter of Westman’s calcining kiln corresponds very closely to the diameter of the foundation of the gas calcining kiln to be built at Barwah. The construction of the new iron and steel works in Dehauwi, in early 1863. In December 1862 Julius Ramsay wrote that “I do not believe I exaggerate when I say that we have 2,000 workers of all kinds.” (Letter from Ramsay 1 December 1864, E1:1.24). In the centre of the photograph the lowest part of one of the blast furnaces is seen. In the front a man carrying water. Photo: Gustaf Wittenström, C:15057.
A Westman gas gas calcining kiln. In 1851 E. Westman presented his design for a gas calcining or roasting kiln which was to become the totally dominating model in Sweden during the rest of the century and into the next. The close correspondence between the design of this kiln and the design presented by Ramsay and Wittenström for the new blast furnace in Dechauri indicates that it was planned to use a kiln (left) of Westman's design at Dechauri too. “Design for a blast furnace (or two) at Dechauri” with detail of the bottom section of the calcining kiln and as a comparison Westman’s design for his kiln as it was first presented in Jernkontorets Annaler in its volume for 1852 (right), printed in 1856. Figures: JkA, 7, 1852 and Wittenström FDCM 10-7. The height and volume of the blast furnaces

Except for the lime and calcining kiln, the shaft of the furnace at Barwah is the only part of the central production equipment still standing. In 2003 its interior height was 10.25 metres, measured from the present rim of the shaft,
down to a heap of stone rubble at the bottom. This heap was approximately 0.8 metres and the total interior height of the present shaft can thus be estimated at approximately 11 metres. A report from 1876 gave a height of 13.5 metres.39

According to local informants one million rupees were sanctioned in 1960 in an attempt to renew the furnace at Barwah to resume charcoal iron production. Two companies started work, but after a time they reported that the charcoal blast furnace technology was not economically viable.40 Several details of the present shaft indicate that the blast furnace was rebuilt in the process. A ramp of concrete leads up to the present rim, and the rim itself is finished off with concrete.

The top of the present shaft is approximately 1.85 metres below the earlier top floor which was used for the charging and “… by the tramway for feeding the furnace.”41 If this extra height is added to the present shaft height of 11 metres the result is 12.85 metres. Allowing for measuring error there is no real reason for not accepting the 1876 height of 13.5 metres.42

Another sign of the reconstruction is the carefully closed openings, which are today approximately 1.8 metres below the top edge of the shaft. These were probably the gas outlets. And if we assume the taller shaft, the gas outlets would have been approximately 8 metres from the bottom and 5.5 metres from the mouth of the shaft. This is a position very consistent with the normal layout of the blast furnaces of the day. In one of the Swedish blast furnaces, the one at Vellnora, built in 1859, the gas outlets were placed somewhat above the middle of the shaft. Later they were moved considerably higher since the low placing could mean that too much heat was taken from the furnace, leading to a loss of efficiency.43

At the end of the 1850s the shaft height in new Swedish blast furnaces was increased from 9–10 metres to 11-13 metres and the volume was increased by adding a middle, cylindrical part of the shaft, the bosh. Mitander chose the new, larger dimensions for charcoal blast furnaces.44

At the same time as Mitander noted that 7.8 metres remained of the shaft, he wrote that he began building “the third compartment in the blast furnace.”45

According to measurement in 1997 and 2003 the blast-furnace house in Barwah is nearly 44 metres long and 18 metres to the ridge. At the far end of the building the placing of the gas calcining kiln is marked and the front end the approximate contours of the blast furnace itself, 11.1 metres tall to the rim at present. Originally it reached 13.5 metres, up to the upper floor, marked by the top arched openings. Photo: Jan af Geijerstam, 1997. Artwork: Staffan Schultz.
furnace”. The concept of compartments was used in contemporary literature to describe the different levels of a blast-furnace shaft, formed as two cut cones placed perpendicularly with a cylindrical part between them to make the shaft longer. The shaft was thus, in its upper part, a slowly narrowing cone with its base down. In its bottom part, the boshes, it was a cone with its base up. The question is what Mitander meant. Where did this (third) section start? The greatest width of the present shaft is at approximately 3.8 metres, where a distinct boundary can be seen. Possibly this was the upper part of the boshes, but the proportions are in that case very different from those of most of the blast furnaces described by Hjalmar Braune. The blast furnace at the Burwai Iron Works would in that case have had a short cylindrical section.

The inner diameter at the mouth was given as 1.8 metres in the assessment of 1876. The measured inner diameter today, at a level of 11 metres, is 2.0 metres. These measurements correspond very well, bearing in mind a slow tapering inwards of the shaft that extends another 2.5 metres.

**BLOWING MACHINERY**

The supply of blast to the blast furnace was vital and a lot of attention was devoted to the question of blowing machinery, to producing a hot blast and to the design of a hot blast furnace. There were a wide variety of solutions, with distinctive national traits.

A first option for any Swedish engineer building a blast furnace in the mid-eighteenth century was to install a blowing machine to Jonas Bagge’s design. This model was first constructed in the mid-1830s and soon became widespread in Sweden. Its special design, with three co-ordinated pistons, enabled it to give a steady and continuous blast. Since its introduction it had, Braune wrote in 1924, “held its own until our own day, when it has only gradually been superseded by more modern, stronger machines.” Bagge’s model was for example used at Sten, with three single-acting cylinders, each about 1.14 metres (45 inches) in diameter and with a 1.14-metre stroke.

Mitander probably chose a British model with only one cylinder, even if there is conflicting information. In one diary entry Mitander wrote of the cylinders – in the plural – of the blowing machine and how they were placed on their sole plate. Three blowing cylinders arrived at Bombay on the *Margaret* early in 1862 and they were marked as numbers 658, 666 and 675. These three cylinders did not, however, belong to one and the same machine, but rather to what in most other sources was described as three “steam blowing engines”, with the blowing machinery and the steam engine treated as separate entities. One of these engines was for the blast furnace and two were for the forges. The three cylinders were thus meant for three different blowing engines, not just one. When Mitander wrote that he began “setting up the blast reservoir” this also indicates a one-cylinder solution, since this gave a
more uneven flow of air, which had to be equalised in some kind of chamber before being admitted to the furnace. In this case a transfer of technology from England seems to be the most probable.

Blowing Machine in Dechauri

It is uncertain exactly what kind of blowing machine was used or was to be used at Dechauri, but this item of equipment was going through a period of rapid development from the somewhat crude wooden solutions employed in the mid-1850s by Davies in his first furnace at the Kumaon Iron Works to the modern engines Ramsay and Wittenström planned to use in the new works less than ten years later.

At the first blast furnace in Kumaon, built by Davies in the middle of the 1850s, there was a “blowing machine made entirely of wood and using hollowed-out logs for the blast pipes”. This proved unsatisfactory and Sowerby next proposed a slightly modified solution, but still one using wood.

The blowing machinery at one of the other ironworks sites in Kumaon, Khurpa Tal, was also wooden, and Julius Ramsay described the difficulties encountered. It “of course became unusable when after the end of the rainy season it was subjected to eight months of drought, in such a burning climate as this”. At Kaladhungi and at Dechauri the machines were of iron and had been made at Roorkee. Ramsay considered the one at Kaladhungi rather well designed but badly constructed. It was a “balance-machine” with two standing, double-acting cylinders.

The blowing machine at Dechauri, the successor of the previous wooden ones, was also praised by Ramsay as “outstandingly well constructed and more than sufficient for two blast furnaces”. It had two horizontal, double-acting cylinders with a diameter of 1.35 metres.

Sowerby’s alternative blowing machine.

The first blowing machine built under the guidance of Rees Davies and William Sowerby in the beginning of 1856 was made of wood. The capacity of two cylinders, each 0.9 metres square and 2.1 metres long, was calculated to be approximately 32 cubic metres of air per minute. A receiver was built immediately under the cylinders, to act as a regulator before the air was forced into the furnace. Due to the shrinking of the wood the apparatus was found to leak too much. Figure: Sowerby (1856, April), p. 93.
Horizontal blowing cylinders were chosen for the new works too, driven by a water wheel. The drawings show that the cylinders were to have a diameter of approximately 1.8 metres and a stroke of 1.8 metres.\textsuperscript{53}

This machine was of British design, patented by E. F. Jones in 1857 and only intended for the use of water power. The design was presented in Sweden the same year, but considered somewhat prone to wear.\textsuperscript{59} According to Andreas Grill, however, this could be easily overcome.\textsuperscript{60}

The horizontal mode was an uncommon design for a blowing machine in Sweden, even if it was chosen in the new works at Långshyttan, with two horizontal cylinders each operated by a 27 horsepower water turbine.

\textit{Hot Blast in Dechauri and Barwah}

Sowerby’s furnace at the Kumaon Iron Works used only cold air, which was a major drawback and not attended to until the last blows in the late 1870s. This was also emphatically criticised by Andreas Grill in one of his letters to Julius Ramsay.

It was a mistake not to make an effort to get hot blast at once, because this is the only thing that would have helped in a blast of cast iron with wet coals. A brilliant result in the beginning helps the faint-hearted keep their spirits up.\textsuperscript{61}

Hot blast was not used in Sowerby’s blast furnace until the last trials in the 1870s. It is not clear why Ramsay never installed any heating arrangements, but it may have been his general wish to build a new plant that made him reluctant to invest in the old furnace. This general aim and the direction of his efforts caused some displeasure to the owners and even Andreas Grill wrote from London and urged him to use whatever was already built. He advised Ramsay to “carefully consider and calculate what further sacrifices could be profitable” in order to increase productivity at the works already built. If the buildings were found totally unfit, and new ones had to be erected, the seemingly cheap purchase of the works might turn out to be an expensive one.\textsuperscript{62}

At both the Burwai Iron Works and the new works at Dechauri, hot blast was to be used.

There were several possible ways of heating the blast and there is no clear description of what kind was used at Barwah. The remains at the site give little help.

The tubular hot blast stoves were the most common in Sweden. In these the air to be heated was circulated in pipes in the heating furnace, well suited for both low blast pressure and a maximum blast temperature of 450 degrees Centigrade “…or for such conditions as are common at blast furnaces in Sweden.”\textsuperscript{63} Such a stove was also used at Sten.\textsuperscript{64}

A description of Burwai Iron Works from 1876 described how the blast from the engine was carried “through the chimney on the west in a series of pipes and heated there before going to the furnace.”\textsuperscript{65} A tubular hot blast
stove was also built of masonry, which might explain why Mitander wrote that “the bricklaying of the warming apparatus is under way”.66

Just as at Sten, Mitander installed three tuyeres and a combined notch for iron and slag. The tuyeres could be placed in many different ways in the hearth, at different heights, pointed upwards or downwards, or somewhat off-centre, whichever gave the best possible effect. In 1997 there were no traces of any tuyeres in the interior of the shaft. The reason for this is not known. At the Kumaon Iron Works there are of course no physical remains left to study.

**Hearth and Tuyeres**

Mitander installed three tuyeres and Ramsay and Wittenström planned to build furnaces with the same arrangement. According to Braune this set-up was commonly used around 1860, but during the following decade they were again reduced to two since it was not considered a very good solution.67 The normal solution was then four notches, one slag notch, one iron notch and two tuyere notches. “[I]t was found that the blast furnace ran better with only two opposed tuyeres and the back tuyere was therefore removed.”68 A model of 1855 of a Swedish blast furnace with three tuyeres was placed at the College of Mining and Metallurgy in Filipstad, however, and the new blast furnace in Långshyttan, which marked a new epoch in the history of the Swedish blast furnace, had three tuyeres.69 Grill’s furnace at Sten, described by Percy, had three tuyeres too. Water-cooled nozzles were a well-established innovation used by Mitander. They were necessary when hot blast was used, as the nozzles would otherwise have melted. Water-cooled nozzles had been introduced in Sweden in 1832.70

**Power**

The iron industry needed a high and continuous supply of power and water power was the only traditional source. Until the 1890s and the development of the ability to transmit electric energy over longer distances, Swedish ironworks were therefore located in places where there was water power. This almost total dependence can still be discerned at each and every site of existing or closed ironworks in Sweden.71

As there was intense competition for scarce resources of charcoal, the use of steam power was basically ruled out at Swedish ironworks.72 The dependence on water power governed the yearly cycle of work at the ironworks and at times the scarcity of charcoal even limited the time during which the blast furnaces could operate.73

An alternative was to use thermal energy and the steam engine, especially at mines, which were as immovable as the waterfalls. This led to the first efforts to introduce steam power technology into Sweden as early as the first decades of the eighteenth century.74
In general, however, steam engines were well known in Sweden, and Swedish metallurgists travelling abroad noted that the general rule outside Sweden was to use steam as a power source. The cheapness of fuel in England was reported as the major reason for the generous use of steam power. In Sweden the opposite applied, but water-power was generally amply available, although periods of low water level forced ironworks to limit production. At the end of the 1850s a period of low precipitation was taken as a reason to experiment with the use of a steam engine for a hammer, but only as an auxiliary machine.

Even the very big iron and steel works erected in the early 1880s at Domnarvet in Central Sweden, were totally dependent on water power. Gustaf Wittenström was chief engineer and responsible for the design of the works, consisting of four 16.5-metre blast furnaces, Bessemer converters and big rolling mills. The River Dalälven contributed 5,000 horsepower, a gigantic amount by the standards of the day.
Hearths and Furnaces for the Refining of Pig Iron

Three methods of refining pig iron were considered for the Kumaon and Burwai Iron Works: Lancashire hearths, puddling and Bessemer, each of which constituted a blend of Swedish and British technology.

Lancashire and Puddling

Mitander planned to set up three Lancashire hearths at Barwah, an exotic element, despite its name, in British ironmaking tradition. He did not comment on this choice, but it was a natural choice to a Swede setting up an iron works based on charcoal. At the Kumaon Iron Works both puddling and Bessemer were planned.

Wittenström’s engagement in puddling in Finland, India and Sweden is an example of a transfer of technology. Until he left for India, he was in charge of the building of a big new rolling mill at Dalhbruk at which he had five puddling furnaces installed. Here the fuel was imported coke, but at Dechaurni he was to shift to charcoal, or possibly in part to wood, although the latter is nowhere clearly stated. Drawings he made show that he was open to innovations at any time. It should also be noted how he, as a Swede, not

Wittenström’s drawing of a puddling furnace for Dal. Gustaf Wittenström had built his first puddling furnaces at the ironworks of Dal in the southernmost part of Finland. This drawing, entitled “Puddle furnace for Mineral coal at Dalhbruk in Finland”, was made in 1862, the year Ramsay left for India. It is thus not too bold to conclude that the furnaces to be built in Kumaon would be of a very similar model. The two ensuing drawings, showing a puddling furnace for mineral coal at Motala Workshops in 1866 and a furnace for firewood at Surahammar of the same year, were also made by Wittenström. Together they show not only Wittenström’s systematic and detailed comparative studies of the process, but also how seemingly minute details were studied in an effort to improve the process. Figure: Wittenström’s drawings, 8.577M.
only brought the British method of puddling to Kumaon and carried on the work he began in Finland, and continued in India, but also, when he came back to Sweden, continued to work on this process.79

THE BESSEMER PROCESS

India was on the periphery of the European network of technological knowledge and it is startling how fast the news of the Bessemer process reached the far interior of the subcontinent.

The definite breakthrough of this process was at the International Exhibition in London in the spring of 1862, but by that time it was already in use in India. The Beypore Iron Company, in the Madras Presidency, had obtained one of the first licences in the world to use it and the company could even display jungle knives made by Indian smiths from Indian-made Bessemer steel at the Exhibition. Charcoal iron from India had also been refined in the Bessemer process at the Atlas Works in Sheffield, and used to produce various fine articles.80

But the story of the Bessemer process in India goes back further, at least to January 1858, when references are found in The Engineer, published in Calcutta.81 In Kumaon, William Sowerby appears to be the first to have voiced the idea of introducing the Bessemer process. When visiting England in the spring of 1858 he had met Henry Bessemer himself, who “was of course like all patentees very sanguine on the subject”. Since the ore of Kumaon was free from any “deteriorating matter such as sulphur” the Bessemer process would, according to Sowerby, be very suitable. Sowerby even described the process as “most simple”, but he did not present any plan of the furnace or other machinery needed, explaining that this was because Bessemer himself varied the operational details so frequently. This would not cause any problems, however, since, as Sowerby put it: “Any competent Engineer having faith in the process will find no difficulty in devising a proper plan.82 In view of the problems encountered in the development of the process in Britain and Sweden, Sowerby showed a naive optimism. He was a man of many words and he himself did not do anything to start Bessemer-blowing at Dechauri. Instead it was Julius Ramsay and, more particularly, Gustaf Wittenström who took up the idea.

The Bessemer process was difficult to control and it was only at about the time when Sowerby was writing about his meeting with Henry Bessemer that the first successful attempts to blow Bessemer steel were made at the Edsken ironworks in the province of Gästrikland, Sweden.

Richard Keatinge was also fully aware of the Bessemer process as a possibility for the Burwai Iron Works, but in 1860 he advised against its use in Nimar. While visiting Sweden in 1860 he learnt how the process, which in England had so far “made but little progress”, had in one establishment in Sweden “obtained perfect success”. He attributed the accomplishment to the pure quality of the ores used, and he was sure there were equally pure
materials in Central India, and that “we too, ere long shall be able to produce steel with this process”. He was aware that the East India Iron Company had already begun to introduce the process at their works, but he still believed it to be difficult to try it in Nimar, both because it needed a 62 hp engine for the blowing apparatus and because the market for its output would be too small.83

Nils Mitander was present at the pioneering Bessemer blows in Edsken to which Keatinge referred, but there is no evidence that either Ramsay or Wittenström took part in these experiments.84 When Ramsay left for India in 1861 only a few Bessemer converters had been built in Sweden, but when Wittenström started his journey a year later, he seems to have decided to learn as much as he could of the process before setting off for India. During the spring of 1862, discussing his engagement in India, Wittenström wrote to Ramsay that he had studied the “Bessemer-steel plants” in Sweden. Later, on his way to India, he visited the workshops of both Bessemer and Brown in Sheffield.85

When he arrived at Dechauri, Wittenström put the small mechanical workshop in order and also constructed a small-scale Bessemer converter and conducted several experiments with our pig iron, which proved unfit for the purpose. There was though ample evidence that pig iron blown from the rich ores of Ramgarh, would be fit for this purpose . . .86

Judging from Julius Ramsay’s drawing of the planned blast furnaces, the plan was to use a stationary model of the Bessemer converter in Dechauri, very similar to the type used during the first successful blows in Edsken in 1858. Since all further work at the Kumaon Iron Works was stopped in 1863, Julius Ramsay and Wittenström never got the opportunity to start any regular Bessemer blows, but Major General Drummond later supported their plans.
In 1866 he maintained that the Bessemer process was the most suitable way to make steel in Kumaon, mainly because the “natives have not sufficient strength and energy for puddling iron, and hence for the fabrication of wrought iron rails, a large establishment of Europeans is indispensable.”

That method does away with the necessity for puddling, and substitutes mechanical power for skilled labour. In charcoal iron districts it is very valuable, as atmospheric air takes the place of fuel in the conversion of iron from the blast furnace into steel, thus saving a large consumption of wood, as compared with the manufacture of wrought iron.87

It seems as if Wittenström was the most active agent of the Bessemer experiments in Kumaon. As in the cases of the puddling furnaces and the charcoal kilns already discussed, he was receptive to new ideas, actively assembled new knowledge, processed it and put it to use. Wittenström seems to have been a very active carrier of technology.

His endeavours in India were no short-lived impulse. After his return to Sweden he even lamented the slow introduction of the Bessemer process in Sweden. “[W]hat a long time the latter has needed to acquire confidence and what a long time it will take before it becomes more commonly used in places where there are suitable materials …”88

Rolling Mills

Although there were both foundries and forges at the ironworks at Dechauri and Barwah, a big effort was made to build a capacity for rolling. A major objective of the Kumaon Iron Works, especially, was to supply rails to one of the main markets for iron in the world, the Indian railways which were under construction.

It is not known what type of rolling mill was transferred to Burwai or planned at Kumaon, since hardly any specifications are given.

Again Wittenström seems to have been by far the most active carrier of technology. He came from Dalsbruk having been in charge of the building of a new rolling mill and within a couple of months after his arrival to India he presented the plans for the mill in Dechauri. The rolling mill building was to be ninety metres long. According to Ramsay there were to be four trains in the rolling mill, one puddling train, one rail train, one plate train and one guide mill train.

Wittenström’s drawing of the mill is very schematic and hard to interpret, but a possible reading is that the four trains mentioned by Ramsay could be as follows. The puddling train is the series of puddling furnaces along one side of the mill, probably fourteen in number. The guide mill train was in the far left corner of the mill, and consisted of heating furnaces for the blooms delivered from the puddling furnaces and a hammer in which the blooms were formed to an appropriate size for the rolls. A crane helped to bring the
bloom from the heating furnaces to the hammer. The rail train and the plate train were the two central units. The rolling direction was from the bottom up. Rolling engines were quite large and placed on either side of the two-stand-high rolls. This meant that the maximum length of the heats was not more than around six metres. The length of the heat was also limited by the capacity for handling heavy weights. The circle marked at the place intended for the rolls might represent a big wheel regulating the distance between the rolls.89

The rail train and the plate train are the two sections in the middle of the line. They were probably two-high, in which case the heat had to be returned over the rolls in a dead pass. The rolling direction would then be vertical. The two big rectangles on either side of the two units would mark the engines, although a peculiarity of the sketch is the big units of similar size on either side of the presumed rolls. The products could not be very long.

At the Burwai Iron Works the ambitions were far more modest and Mitander simply took over the rolling mill imported by Richard Keatinge. At Barwah the rolling mill building was no more than 21 metres long and 7.5 metres wide. The rolling mill, including both the steam engine and the rollers, had been imported back in 1857. It was first placed in the garrison town of Mundlasir, half a day’s ride from Barwah, where Richard Keatinge ran his trials of traditionally made Indian bloomery iron. In the spring of 1861 it was moved to Barwah.90 In late summer of 1862 Mitander had everything
The new rolling mill of the Kumaon Iron Works. “The full length of the rolling mill was 92 metres and the middle part was eighteen metres wide, constructed to include three steam hammers of different sizes and four different strands or rolls, trains. On either side all along the building were nine-metre wide verandas. The upper one, parallel to the slope, was meant solely for puddling and welding furnaces and related steam boilers. The lower part was to contain cutting, punching and shearing machines for finished iron. The hot exhaust gases were led through one common smoke duct under the floor and on through three sloping ducts up the hill to chimneys on the upper level. On the way up the hot gases were used to dry wood in two wooden buildings placed on the slope. (Ramsay’s report p. 40–41) Wittenström’s drawings, FDCM9-14.

At the Kumaon Iron Works the rolling mill was to be eighteen metres wide and puddling furnaces were planned all along its length.

At both sites two-high stands were probably used. Three-high stands were a more complicated mechanical solution and were not in use at the time. Rails would have been a major product and it should be noted that iron rails were first rolled in Sweden in 1864, but the first large-scale works for rails were built in Domnarvet in the 1880s with Wittenström as the chief engineer.

Workshops
The investigation has so far principally concerned the ideas, the conceptions of how to construct the physical artefacts, the machinery and appliances that formed the interior physical representation of the technology transferred at the Kumaon and Burwai Iron Works. In several cases it has also been possible
to discern how the artefacts representing the technology were themselves brought from England to India. A study of the archival material concerning the workshops gives more such information, with details of the companies that made the machinery.\textsuperscript{95}

The foundry and, especially, the fitting shop at the Kumaon Iron Works were equipped with a large number of machines for working the iron, shearing, planing, boring, drilling etc. Nearly all of them were imported from Britain, together with spare parts and auxiliary equipment such as tools.\textsuperscript{96}

There was also a wish to produce machinery locally, mainly because of the expense, slowness and unreliability of transport from England. Machinery was lost on its way or at least so delayed that it seriously hindered the progress of the works.\textsuperscript{97} A local supply would not only make for simpler logistics and a better control of the schedule during the building process but could also facilitate future developments, and meet the need for spare parts and repairs. One example of difficulties otherwise encountered occurred when one of the blowing cylinders to the Burwai Iron Works was damaged at the port of Bombay, necessitating a delay of at least eight months before a new one could arrive in Barwah.\textsuperscript{98} Lessons learnt from incidents like this were taken to heart, even if Mitander seems to have had few alternatives since no mechanical workshops were at hand in the Nimar region. One action he did take was to postpone the final work on the calcining furnace until he could make the necessary equipment for its construction in his own workshop.

Ordinary building materials were the only supplies that he ordered from local suppliers. The sole exception to this general rule seems to be the roof trusses and beams that were fabricated in Mhow.\textsuperscript{99}

The existence of the well-established government workshop in Roorkee meant that there was a different situation at Kumaon. In 1855 Henry Ramsay, assistant to the Commissioner at that time, had strongly recommended that all necessary ironwork for a new blowing machine and water wheel be ordered from Roorkee. Later Julius Ramsay also ordered a steam hammer and two boilers for the new works from there.\textsuperscript{100} In the assessment of 1872, it was noted that a blowing machine had been made at the Roorkee workshops.\textsuperscript{101}

With these exceptions, however, machinery was imported from England. For the Burwai Iron Works the deliveries were detailed in the bills of lading of two ships, \textit{Margaret} and \textit{Howden}, making their way around the Cape of Good Hope.

In 1862 Richard Keatinge had chosen the Bridgewater Foundry Co of Nasmyth and Co, near Manchester, as his main supplier.\textsuperscript{102} This was one of the most renowned workshops of Great Britain, founded by the Scotsman James Nasmyth, celebrated for his construction of a steam hammer, patented in 1842.\textsuperscript{103} When Richard Temple inspected the Burwai Iron Works in 1864 he described the machinery as “of the best kind”.\textsuperscript{104}

The machinery imported from Britain to become one of the biggest areas of expenditure in the construction of Burwai Iron Works and this shows, very clearly, a heavy dependence on British technology.\textsuperscript{105}
Machinery, mainly at the foundry and fitting shop,  
*Kumaon Iron Works 1872*

<table>
<thead>
<tr>
<th>Specification of machinery</th>
<th>Place of manufacture</th>
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<tbody>
<tr>
<td>Portable engine, No. 2 528, 12 HP,</td>
<td>Ransome and Sims, Ipswich</td>
</tr>
<tr>
<td>2 cylinders, 7 3/4 diameter, stroke 12</td>
<td></td>
</tr>
<tr>
<td>Lloyd’s patent noiseless fan, 25” diameter</td>
<td></td>
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<tr>
<td>with pulleys</td>
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</tr>
<tr>
<td>Double purchase crab winch</td>
<td>Muir of Manchester</td>
</tr>
<tr>
<td>Shearing machine</td>
<td>Muir of Manchester</td>
</tr>
<tr>
<td>Small planing machine, to plane 6’ x 2’ x 2’</td>
<td>Muir of Manchester</td>
</tr>
<tr>
<td>8” Boring bar with self-acting feed motion</td>
<td>Not stated. In all probability from Britain</td>
</tr>
<tr>
<td>9” Screw cutting and self-acting lathe,</td>
<td>Whitworth of Manchester</td>
</tr>
<tr>
<td>will take 4’4” between the centres, total length of bed 8 feet.</td>
<td></td>
</tr>
<tr>
<td>10” self-acting and screw cutting lathe</td>
<td>Muir of Manchester</td>
</tr>
<tr>
<td>6 inch, double-gared foot lathe,</td>
<td>Muir of Manchester</td>
</tr>
<tr>
<td>length of bed 8 feet</td>
<td></td>
</tr>
<tr>
<td>Double geared wall-drilling machine,</td>
<td>Muir of Manchester</td>
</tr>
<tr>
<td>to take in 2’4”</td>
<td></td>
</tr>
<tr>
<td>Grindstone and frame</td>
<td>Not stated</td>
</tr>
<tr>
<td>Circular saw bench, will take in a saw 39” diameter</td>
<td></td>
</tr>
<tr>
<td>Haley’s patent screw jack to lift 5 tons.</td>
<td>Not stated</td>
</tr>
<tr>
<td>Whitworth’s surface plates 35” x 20”</td>
<td>Not stated</td>
</tr>
<tr>
<td>Large weighing machine</td>
<td>Roorkee</td>
</tr>
<tr>
<td>Pillar weighing machines</td>
<td>Roorkee</td>
</tr>
<tr>
<td>Pillar weighing machine</td>
<td>Pooley and Sons, Liverpool</td>
</tr>
<tr>
<td>Set of screw stocks, taps and dies, D size</td>
<td>Muir of Manchester</td>
</tr>
<tr>
<td>Box of taps, dies, stocks and wrenches, E size</td>
<td>Muir of Manchester</td>
</tr>
<tr>
<td>Ratchet brace, C-size</td>
<td>Ibbotson Brothers’, Sheffield</td>
</tr>
<tr>
<td>9” slide lathe</td>
<td>Whitworth of Manchester</td>
</tr>
</tbody>
</table>

In 1862 two ships arrived from England with equipment destined for the Burwai Iron Works. The Margaret, which sailed from England on 23 September 1861, and the Howden. The shipment on the Margaret was valued at what Mitander called “the enormous sum” of 4,028 pounds sterling, the second at 735. In his diary Mitander noted what machinery was on its way.

The two shipments on the Margaret and later on the Howden contained: one 14 HP steam blowing engine for the blast furnace, two 14 HP steam blowing engines for the forges, one steam engine for the rolling mill, one donkey pumping engine, one steam hammer, one steam pumping engine, twelve boilers for above engines, one one-ton crane, one screw-cutting and turning machine, one planing machine, one drilling machine, two punching and shearing machines, one Nasmyth’s blowing fan, two weighing machines, and, besides all this, a lot of other equipment such as iron chains, water-cooled tuyeres, casting boxes, water pipes etc. An overhead travelling crane of wrought iron, to move the liquid pig iron from the blast furnaces in the foundry of the Burwai Iron Works, was also imported from England.

In Kumaon, greater independence of Britain might have been made possible by the existence of the Roorkee workshops. It is not known how these would have been used in building the new works, but in the workshops already working the machinery had been brought in from Britain. Just as at Burwai, some the major workshops of Britain were used, Ransome and Sims, W. Muir of Manchester, Whitworth of Manchester, Henry Pooley & Sons and Ibbotson Brothers’ of Sheffield, (see table on p. 238).

Ramsay’s plans for the future can be used to reveal the organisation of the work. First, it shows a fundamental and evident divide between the British and the Indian employees. Second, it gives evidence of social hierarchies within these two groups.

**SUMMARY DISCUSSION**

**Networks Maintained and Machinery Imported**

Ideas of new technologies moved rapidly across the world, even to such seemingly distant outposts as the foothills of the Himalayas in Kumaon or the Narmada River Valley, and the technology brought to the Kumaon and Burwai Iron Works was the most modern of its time, which rules out the possibility that the lack of success was caused by obsolete technical solutions. The technology was new to all involved, to the Indian labourers and to the British who were going to work with it or invest in it, yes, in its totality it was also new to the most knowledgeable in the arena, the three Swedes, who were to combine and adapt techniques of different origins in a new setting.

The techniques procured from Europe were chosen to suit local conditions and also arranged and adapted at the sites. Lancashire hearths and charcoal
furnaces were the most evident adaptation to the fuel resources available – forests for charcoal. The use of steam was a necessity at Barwah and an essential complement to water power at Dechauri. The choice of charcoal kilns and the discussions on the Bessemer furnaces constituted an effort to procure a technology within the framework posed by the socio-cultural setting, in the first case to cope with the irregularities of charcoal deliveries from a system of independent charcoal burners, and in the second case to meet what was considered to be the physical inability of the Indian workers to manage heavy puddling work. The projects were in their very essence examples of the links across the oceans. There was an almost total dependence on European technical solutions, on imported machines, spare parts and tools.

The flexible combination of technical solutions of different origins at the Kumaon and Burwai Iron Works was in itself international, and almost every part of the machinery at the works had a complex history of transfer and contacts. Ramsay wrote on the charcoal blast furnace “of the Swedish model”, of puddling furnaces – well known to British workers, but not in Sweden, of Finnish coal kilns and of the Bessemer process, originally conceived in England but developed and applied in practice in Sweden. There is also evidence of a clear ambition to obtain all possible deliveries of machinery from local producers – at least in the long run.
CHAPTER 8

Technology Tested

The aim of the ironworks at Barwah and Dechauri was to explore the possibilities of producing iron, but the ultimate measurement of this possibility was technical efficiency and economic viability. This applied to the grand scale commercial undertaking of the new Kumaon Iron Works as well as to the more experimental project at the Burwai Iron Works.

In the processes of technology transfer in which the Swedes were engaged neither of these goals was achieved. In Dechauri pig iron was only produced in Sowerby’s old blast furnace, while the new works that the Swedes had designed were abandoned. In Barwah the first blow failed.

Yet, the experiences made can still give important clues to the appropriateness of the technology to be transferred. From Dechauri figures from a series of blows are available for calculating efficiency. From Barwah a detailed description of the failed blow can aid us to an understanding. Production at the ironworks involved a process of learning and these figures give clues to the possibility of this essential part any transfer of technology. How much iron was made? How much charcoal and ore was used to produce a ton of pig iron? What was the knowledge generated, what were the lessons learnt? Is it possible to see any change in efficiency over time that resulted from an increase in knowledge and experience?

At Barwah, the only blow took place in December 1862 and it resulted in a rapid blow-down. What caused the failure? How did it compare with first blows in Sweden? And to sum up, do the results indicate the futility of the projects, or, on the contrary, the possibility of a future?

Besides total output itself, there were two other measures of the productivity and efficiency of blast furnaces: first, the amount of coal needed to produce a given quantity of iron, and second the yield from the ore, measured as the amount of iron, normally pig iron, produced as a percentage of the ore input. A low coal consumption and a high iron yield were desirable but these two measures must be weighed against the value of achieving a big daily output.

Within certain limits, a higher total output of iron was the goal, since it meant that every man-hour put in was better used and every penny spent on raw material showed a greater return. But higher production could mean an
increased relative consumption of charcoal and iron ore. As comparatively detailed figures are preserved for some of the campaigns at the Kumaon Iron Works, it has been possible to calculate these ratios. The figures are presented in detail and appear accurate.

The Kumaon Iron Works under British Government Management

Between the first and the last blow at Dechauri, more than twenty years passed. The effective production time, however, was only a minute part of this, and production figures are known for only 341 days, from four different periods, mainly during the time when the works were run by the Indian Government.

THE FIRST CAMPAIGN, 1856

Rees Davies had been responsible for the construction of the first blast furnace in Kumaon. He was also in charge of operations during the first blow in the furnace in March 1856. William Sowerby, who wrote the report on the blows, had formal responsibility.

The gradual start-up of the blast furnace followed the normal pattern. It started with the slow preheating of the furnace, which was followed by the first charge of ore, charcoal and flux and the start of the blast, and a gradual increase in the ore charges. In March 1856 the furnace was preheated for five days with wood and charcoal, and the first charge of ore, charcoal and flux was inserted on March 23. The blast was introduced the next day. For a while, everything worked well, but it soon became apparent that the blowing apparatus was inadequate. The wooden pipes and the air chamber leaked, and, as the wood dried, more and more of the blast seeped out. The blow had to be stopped in order to save the furnace from damage. When the hearth was later cleaned out, a small quantity of reduced iron was collected. This was later resmelted and found to be iron of “the very best quality” or “No. 1 Grey metal pigs first quality”.1

Two weeks later the blowing apparatus had been repaired. The air chamber was removed, all the pipes were tarred and recaulked, and the blast was resumed. This time it was stronger, but as the regulating chamber had been removed, the blast came directly from the pistons in an alternation of stronger and weaker blows. Everything worked better, in spite of the intermittent nature of the blast, but, after twelve hours, the charge began to descend too quickly and without fully liquefying. William Sowerby believed this was due to a disproportion between the lime and the ore and charcoal making up the rest of the charge. In addition only a small portion of the iron ore had been calcined, which also might have had a negative effect.2
Sowerby mentioned another circumstance in one of his earlier reports. The schedule for the first season was very tight. There was not enough time to prepare and burn the firebricks. Rees Davies therefore decided to complete the furnace with unburnt bricks. The idea was to burn them in place, inside the furnace, when blowing-in commenced. “This is a somewhat uncertain experiment, and may lead to a failure, unless very great care is taken,” Sowerby commented. Of a total of 5,000 bricks used in the furnace, only 500 were pre-burnt. According to Sowerby, however, this did not influence the outcome. Henry Drummond’s description of what happened put more emphasis on the work done at the furnace, on the role of competence and skill.

Mr. Davies was able by the most violent physical exertions to keep the work going for some hours … but the labour entailed upon him, combined with his previous constant watching, tasked his energies beyond their power, and his strength began to fail, when an accident to his eye entirely disabled him. … The work was continued till day-break on the 14th, by Native workmen under Mr. Sowerby’s superintendence, but not being possessed of the requisite skill, they were unable to prevent the accumulation of the cinder in the hearth, and consequently the liquid metal could not be drawn from the furnace. … The work has been stopped only from want of trained hands.

To sum up, there were two major factors in the failure: first, inadequacies in the design of furnace and machinery; second, partly due to pressure of time, a lack of skill and experience. These factors can in turn be traced to a number of causes. The shortage of time was due partly to a lack of capital, partly to a lack of financial reserves, and partly to climatic conditions, since the sequence of blowing the blast furnace had to be completed within the limited period of the dry season. Beyond the criticism of lack of skill it is also possible to discern the exceptional demands made by inadequate technical solutions and maybe also a lack of communication between the British and the Indian workers. A third factor might also have been a faulty combination of raw materials.

THE SECOND CAMPAIGN, 1857

While William Sowerby was in England, assisting Henry Drummond in his efforts to form a company for the manufacture of iron, the Commissioner, Henry Ramsay, ordered Rees Davies to make a new try in the spring of 1857. Meanwhile Davies’ two sons, who had arrived from England, joined him at the blast furnace. On this third occasion the blow was successful. In four days 3,276 kg of pig iron were produced.

The output reported by Hardy Wells was impressive. He was an engineer deputed by the Government of India to report on the Kumaon Iron Works and according to his figures, 100 seers (90 kg) of iron ore and 85 seers (76.5
kg) of charcoal gave one maund (36.3 kg) of pig iron. This represents a comparatively low consumption of charcoal, only 2.11 kg per kg of pig iron, a figure that compares favourably with that for the blows with a hot blast in Sowerby’s bigger furnace some twenty years later. No other details are known from this trial, but Julius Ramsay was later impressed: “You cannot but admire his [Davies’] unusual energy and his ability to achieve anything at all – in the utter wilds, with such small facilities available.”

As far as is known, no major alterations were made to the furnace between the first and second campaign, except, of course, that the bricks of the furnace were now thoroughly burnt. Possibly the combined efforts of the three experienced blast-furnace men, Rees Davies and his two sons, made the difference and led to the successful blow. After the second campaign Rees Davies moved to Kaladhungi with his sons to continue pig-iron production as a private enterprise.

A THIRD CAMPAIGN, SOWERBY’S BLOW IN 1860

During the last three years of the 1850s William Sowerby assumed responsibility for the project and set about building his new works, and in February 1860 he was ready to put the new furnace into blast.

Preheating began on 12 February and the first charge of ore and flux was put in four days later. The furnace worked according to plan for about one month, until the water wheel began to give trouble. This continued, and the furnace had to stand idle without blast on five different occasions before the final breakdown of the water wheel on 31 March, after which the furnace was cleaned out.

Thomas Oldham reported on the blow to the Government.

During the progress of the work it would appear that almost every change was tested. The tuyeres were changed and re-changed, from those having nozzles of three inches [7.5 centimetres] to those of only one [2.5 centimetres]. The blast was diminished one-half by throwing out of gear one of the blowing cylinders, and working with only one. ... And great changes in the relative proportions of the materials were made, (though I cannot see that this was done on any system).

Oldham believed the blast was too strong for a cold charcoal blast furnace, resulting in too low a temperature in the furnace.

I am confident that a simple inspection of the tuyeres during the working of the Furnace would have shown them that they were far indeed from being at that white heat which they should have been.

The excessive power of the blowing machine was also undesirable, he thought, on the grounds that it must have been unnecessarily expensive. On the whole, though, he was positive. He said that the high quality of the output, in difficult
**Sowerby's blows at Dechauri, 18 February–30 March 1860**

*Daily output, ore yields and charcoal consumption*

<table>
<thead>
<tr>
<th>Date</th>
<th>Pig iron in kg</th>
<th>Coal/pig iron produced</th>
<th>Yield of iron as percent of ore</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>February</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>18</td>
<td>472</td>
<td>6.2</td>
<td>13</td>
<td>Blowing in and thus a high consumption of charcoal.</td>
</tr>
<tr>
<td>19</td>
<td>545</td>
<td>4.0</td>
<td>15</td>
<td></td>
</tr>
<tr>
<td>20</td>
<td>1,231</td>
<td>2.9</td>
<td>32</td>
<td></td>
</tr>
<tr>
<td>21</td>
<td>1,470</td>
<td>2.9</td>
<td>25</td>
<td></td>
</tr>
<tr>
<td>22</td>
<td>1,515</td>
<td>2.4</td>
<td>36</td>
<td></td>
</tr>
<tr>
<td>23</td>
<td>1,612</td>
<td>1.9</td>
<td>45</td>
<td></td>
</tr>
<tr>
<td>24</td>
<td>1,416</td>
<td>2.4</td>
<td>31</td>
<td></td>
</tr>
<tr>
<td>25</td>
<td>1,526</td>
<td>2.5</td>
<td>23</td>
<td></td>
</tr>
<tr>
<td>26</td>
<td>1,622</td>
<td>2.7</td>
<td>33</td>
<td></td>
</tr>
<tr>
<td>27</td>
<td>1,442</td>
<td>2.3</td>
<td>37</td>
<td></td>
</tr>
<tr>
<td>28</td>
<td>1,724</td>
<td>2.6</td>
<td>34</td>
<td></td>
</tr>
<tr>
<td>29</td>
<td>1,761</td>
<td>2.7</td>
<td>33</td>
<td></td>
</tr>
<tr>
<td>March</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>2,051</td>
<td>2.3</td>
<td>34</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>1,584</td>
<td>2.6</td>
<td>29</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>2,096</td>
<td>2.2</td>
<td>36</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>2,196</td>
<td>2.2</td>
<td>33</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>2,219</td>
<td>2.1</td>
<td>37</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>2,219</td>
<td>1.9</td>
<td>26</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>1,874</td>
<td>2.1</td>
<td>34</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>1,379</td>
<td>3.1</td>
<td>21</td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>1,960</td>
<td>2.2</td>
<td>32</td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>2,387</td>
<td>2.0</td>
<td>38</td>
<td></td>
</tr>
<tr>
<td>11</td>
<td>2,541</td>
<td>1.5</td>
<td>53</td>
<td>Maximum output and productivity were reached. Possibly because of a successful gradual fine-tuning of the furnace, possibly because the breakdown of the water wheel was anticipated and the furnace was prepared for a blow down. On March 11 “specially picked charcoal” was used.</td>
</tr>
<tr>
<td>12</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>Standing (blowing in)</td>
</tr>
<tr>
<td>13</td>
<td>472</td>
<td>4.8</td>
<td>17</td>
<td>Standing</td>
</tr>
<tr>
<td>14</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>15</td>
<td>1,379</td>
<td>2.3</td>
<td>34</td>
<td></td>
</tr>
<tr>
<td>16</td>
<td>1,406</td>
<td>2.2</td>
<td>34</td>
<td></td>
</tr>
<tr>
<td>17</td>
<td>1,180</td>
<td>2.8</td>
<td>26</td>
<td></td>
</tr>
<tr>
<td>18</td>
<td>1,452</td>
<td>2.2</td>
<td>34</td>
<td></td>
</tr>
<tr>
<td>19</td>
<td>1,016</td>
<td>2.9</td>
<td>27</td>
<td></td>
</tr>
<tr>
<td>20</td>
<td>1,095</td>
<td>2.7</td>
<td>29</td>
<td></td>
</tr>
<tr>
<td>21</td>
<td>1,470</td>
<td>2.0</td>
<td>42</td>
<td></td>
</tr>
<tr>
<td>22</td>
<td>1,289</td>
<td>2.7</td>
<td>34</td>
<td></td>
</tr>
<tr>
<td>23</td>
<td>1,443</td>
<td>3.2</td>
<td>24</td>
<td></td>
</tr>
<tr>
<td>24</td>
<td>1,289</td>
<td>3.6</td>
<td>22</td>
<td></td>
</tr>
<tr>
<td>25</td>
<td>1,135</td>
<td>3.8</td>
<td>24</td>
<td></td>
</tr>
<tr>
<td>26</td>
<td>1,164</td>
<td>3.1</td>
<td>29</td>
<td></td>
</tr>
<tr>
<td>27</td>
<td>744</td>
<td>4.1</td>
<td>26</td>
<td></td>
</tr>
<tr>
<td>28</td>
<td>643</td>
<td>5.0</td>
<td>19</td>
<td></td>
</tr>
<tr>
<td>29</td>
<td>757</td>
<td>5.2</td>
<td>22</td>
<td></td>
</tr>
<tr>
<td>30</td>
<td>926</td>
<td>3.3</td>
<td>26</td>
<td></td>
</tr>
<tr>
<td>Feb.–March</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>31</td>
<td>38,331</td>
<td>2.4</td>
<td>31</td>
<td>The period when the furnace was working without interruption.</td>
</tr>
<tr>
<td>Total</td>
<td>57,771</td>
<td>2.8</td>
<td>3.5</td>
<td>The whole blowing period of 41 days. Including blowing-in.</td>
</tr>
</tbody>
</table>

Note: Figures have been calculated retrospectively. Quotation marks denote direct quotation from Drummond’s summary table. The averages given correspond closely to the medians, 2.3 and 33 respectively. Source: Oldham (May 1860), Appendix B, p. 44 and p. 14–15.
technical conditions, spoke strongly for the energy and practical skill of the furnace keepers.\footnote{11}

Sowerby’s blast in 1860 was the first full campaign carried out at the Kumaon Iron Works, although it was severely hampered by technical shortcomings or miscalculation. The inadequate temperature and excessive force of the blast lowered efficiency. In the end, the failure of the water wheel finally stopped the blow.

Statistics show clearly that a lot of charcoal was needed during the blowing-in of the furnace, whereas consumption levelled out once the system was running. As soon as difficulties arose and the furnace had to be stopped, for example due to failure of the blast, more ore and charcoal had to be used to start it up again. Experimental use of different kinds of raw materials also influenced the results. An addition of “clay-stone” seems to have led to a marked decrease in productivity. The very best results were achieved on 11 March when something called “specially picked” charcoal was used.\footnote{12}

### The Privatised Kumaon Iron Works under Swedish Management

#### The Four-Month Blow in 1862

At the beginning of January 1862 Julius Ramsay prepared what was to be the longest continuous blast-furnace blow in Kumaon. It extended over four months, in fact 125 days, virtually without stoppage.

At the beginning of next week I will start to blow in the blast furnace and I will then have the opportunity to test the ores, which I as yet know little or not at all. I have two English blast-furnace keepers, who are able workers and know the language fairly well, since they have worked here for three years. It is very important for me to achieve good results in this blow. On this depends my reputation, among the owners as well as among the workers from England.\footnote{13}

Once under way, the blow seems to have continued without much trouble. There were some stoppages for repairs, but, judging from the charcoal consumption, Ramsay apparently managed to keep the furnace hot during these interruptions. In his letters home to Sweden, Ramsay wrote very little on the blows during the spring. In the latter part of May, he even took time to make a six-day expedition to Ramgarh to look into the possibility of building a road.\footnote{14} The only time when he assessed the results was after two weeks.

The blast furnace has now been in blast for fourteen days, but I cannot boast of its results, even though they are better than they were before, but the reasons are several. The ore is poor and gives only 30 percent and it needs about 50 percent lime to go well, which is unheard of. The
<table>
<thead>
<tr>
<th>Date</th>
<th>Pig iron produced Weekly averages per day of blow (kg)</th>
<th>Iron as % of ore</th>
<th>Coal/iron</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Jan. 28</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>– Feb. 1</td>
<td>886</td>
<td>24</td>
<td>7.6</td>
<td></td>
</tr>
<tr>
<td>2–8</td>
<td>1,514</td>
<td>34</td>
<td>3.7</td>
<td>From here onwards a varying amount of wood is put in. For the season as a whole 569 tons of charcoal and 98 tons of wood were put in.</td>
</tr>
<tr>
<td>9–15</td>
<td>1,732</td>
<td>36</td>
<td>2.4</td>
<td></td>
</tr>
<tr>
<td>16–22</td>
<td>1,672</td>
<td>36</td>
<td>2.1</td>
<td></td>
</tr>
<tr>
<td>Feb. 23–March 1</td>
<td>1,416</td>
<td>34</td>
<td>2.2</td>
<td></td>
</tr>
<tr>
<td>2–8</td>
<td>1,359</td>
<td>36</td>
<td>2.1</td>
<td>“The furnace was stopped for 3.5 days for repair of waterwheel.”</td>
</tr>
<tr>
<td>9–15</td>
<td>1,222</td>
<td>31</td>
<td>2.4</td>
<td>“The furnace was stopped for one day for repairing of the gool.”</td>
</tr>
<tr>
<td>16–22</td>
<td>1,239</td>
<td>32</td>
<td>3.0</td>
<td></td>
</tr>
<tr>
<td>23–29</td>
<td>1,234</td>
<td>36</td>
<td>2.2</td>
<td>“The furnace very bad, has not yet recovered after stoppage.”</td>
</tr>
<tr>
<td>March 30–April 5</td>
<td>1,286</td>
<td>34</td>
<td>2.9</td>
<td>“Scrap put up for seven days for to get the bottom warm again.”</td>
</tr>
<tr>
<td>6–12</td>
<td>1,260</td>
<td>35</td>
<td>3.3</td>
<td></td>
</tr>
<tr>
<td>13–19</td>
<td>1,048</td>
<td>34</td>
<td>3.8</td>
<td></td>
</tr>
<tr>
<td>20–26</td>
<td>1,114</td>
<td>35</td>
<td>3.2</td>
<td>The charcoal and wood put up is not weighed, only measured with buckets. One bucket of charcoal = 20 seers. One bucket of wood = 16 seers. It is unclear if this applies to whole series.</td>
</tr>
<tr>
<td>April 27–May 3</td>
<td>783</td>
<td>29</td>
<td>3.4</td>
<td></td>
</tr>
<tr>
<td>4–10</td>
<td>854</td>
<td>20</td>
<td>3.9</td>
<td>“The blowing machine was stopped about 9 hours for repairing and cleaning.”</td>
</tr>
<tr>
<td>11–17</td>
<td>1,136</td>
<td>25</td>
<td>3.2</td>
<td></td>
</tr>
<tr>
<td>18–24</td>
<td>996</td>
<td>27</td>
<td>5.6</td>
<td></td>
</tr>
<tr>
<td>May 25–June 1</td>
<td>1,198</td>
<td>35</td>
<td>4.8</td>
<td></td>
</tr>
<tr>
<td>1–7</td>
<td>1,027</td>
<td>40</td>
<td>4.2</td>
<td></td>
</tr>
<tr>
<td>TOTAL</td>
<td>185,245</td>
<td>34</td>
<td>3.1</td>
<td>125 days of blows</td>
</tr>
</tbody>
</table>

Note: Remarks within quotation marks taken directly from Ramsay’s table. Source: Weekly reports from the blast furnace at Dechauri, 1862. Ramsay’s papers, F1:1.14.
charcoal, which has been lying in the open for two rainy seasons, is as wet as sponge and largely unusable. Added to this is cold blast, which of course does not increase production.15

Judging from the figures given, the results did not improve during the rest of the campaign.

By the middle of May Julius Ramsay had moved up to Nainital, and it was soon time for the annual shutdown for the rainy season.16 In the first week of June the furnace was blown down.

This blow was notable for its length, more than four months, but maybe most of all for the small, but still apparently decreasing, daily production of pig iron, while the coal consumption was rising. The reasons for this are unclear, but since the most apparent change is towards the end of the season, it may be the approaching hot, rainy and humid weather that made the blows more difficult.17 It is known that high humidity reduces the oxygen content in the air and an increased blast is then needed.

THE BLOW IN FEBRUARY 1863

At the beginning of 1863 Ramsay reported that he was using two of the old blast furnaces, probably Sowerby’s blast furnace and Davies’. The exact dates of this blow are not known, but it must have been started in January. For the first part of the season no exact figures are recorded, but Ramsay wrote that he could not “boast of any beautiful results”, although he did not explain why.18 In another letter, dated the same day, he seemed very downhearted.

I feel depressed when I look at the wretched results of all my efforts, but I am unwilling to admit that the fault is mine. I believe that even a person with full knowledge of India could have accomplished very little more.19

For one week, February 8-14, there is a full report with production figures. This was only a few weeks before the company stopped all work and Julius Ramsay was given notice.20 He was now more satisfied. He used two of the old furnaces and produced nearly 18 tons of good cast iron during the week as compared with thirteen tons for the best week’s blow in 1862 (January 9 – 15) or an average per week of well below ten tons in 1862.21

Compared with those for 1862, the figures given by Ramsay are puzzling. The production stated in the letter just quoted refers to two furnaces, but still it corresponds very closely to the figures used for the table on page 249 that refer to “the blast furnace in Dechauri” – in the singular.
Renewed Government Efforts in Kumaon: The Last Trial, 1876–79

The final efforts to make iron in Dechauri, in the late 1870s, offer yet another illustration of the complexity of starting up a blast furnace. No less than seven different blows took place. This time a hot-blast system had been added.

**BLOW NO. 1**

The first blow was directed by Angus Campbell and started on January 1, 1877. When the furnace was only partially filled an explosion of considerable violence took place. The water supply to the tymp, which was of Campbell’s own new design, failed. The tymp melted, gave way and an almost immediate blow-out resulted; parts of the cap and cone charger on the top of the furnace fell into the furnace, melted and were cast into pigs.

**BLOW NO. 2**

Only a week later a new furnace keeper, Bernard deVilleroi, arrived. After about two months he had the furnace ready for a new try. A smaller explo-
sion of gas occurred this time, too, but the main problem appeared when the charge got down to the tuyeres and became so cool that the furnace “gobbled up”, or choked. This was, according to deVilleroi, caused by the new tymp, which exposed a large chilled surface to the interior of molten iron and slag.

**BLOW NO. 3**

A new blast started a month later, on 3 May. A stone tymp had been inserted and everything looked well, deVilleroi wrote.

> I had been at work for thirty-two hours; and feeling knocked up, laid down to sleep in the shed on an old bellows. When I awoke, I found that the natives, whom Mr. Campbell had given me as competent hands, accustomed to furnace work, had not kept the slag moving … the furnace gobbled up …

The furnace became choked around the tuyeres and was blown out after two days.

**BLOW NO. 4**

During the ensuing stoppage, a major change was made, a third tuyere being added and a thicker stone tymp employed. When a new start was made on 17 June, everything at first went well, but after two days, the lining and the stone of the tymp began to disintegrate rapidly. According to Bernard deVilleroi, he pointed out the trouble, but Campbell was satisfied with everything and left for Roorkee after nine days. By the night of the 27 June, after ten days, the problems had become worse. Fire was blowing through the top of the side tuyere and under the tymp arch. In the morning, the hearth rose rapidly. It was decided to blow out and it was noted that the interior firebrick lining of the hearth of the furnace was entirely eaten away. deVilleroi argued that the cause was the inadequate amount of silica in the charges. Twenty-six tons of pig iron had been produced before the lining gave way. This was the first iron produced during the trials. It is not known what happened during the ensuing months, but in November 1877, Bernard deVilleroi asked to be relieved of his duties, since he did not want to carry the blame for a blast-furnace failure. Campbell refused, reminding him of their agreement on a two-year employment. At this stage, Mr. deVilleroi had written a pamphlet, a “white book … in order to save myself from the consequence of a groundless charge of incapacity and ignorance, and to show the Public Works Department, the road to success”. He printed it, but never released it. Mr. Tytler, assistant engineer, asked for copies and sent one to Angus Campbell. As a result, deVilleroi was discharged as of January 15, 1878.

deVilleroi left behind him a number of unsuccessful blows and the question is whether he was incompetent, or whether his forceful repudiation of the
efforts showed that he was shrewd enough to see insurmountable difficulties and also bold enough to be first to say “no”. The white book of deVilleroi is today the major source of information on the blows of 1877–78. His pamphlet may represent special pleading, but nevertheless it seems to have been written by a very knowledgeable man and as nothing to contradict his account of events is to be found in any other sources, there is no reason to doubt his information.

**BLOW NO. 5**

A new blast-furnace keeper, Mr. Cameron, was engaged and brought out from England, and on 27 May 1878 blast number five was started. This time 46 tons of pig iron was produced before the furnace gobbled up after twelve or fifteen days.

No more blasts were carried out until 1879, when there was one during the spring and one during the summer. They were the longest and most successful of the blasts of the 1870s.

**BLOW NO. 6**

Over a period of 96 days in February, March and April 1879, a total of 328 tons of pig iron was produced. The only reason for stoppage was the failure of the water supply. The level of the river dropped too low and the pressure of the blast became insufficient.

**BLOW NO. 7**

The furnace was again put in blast at the end of July. This time 200 tons of pig iron were produced before the river bank was washed away on 12 September. With it went 92 metres of the canal carrying water to the water wheel and the furnace had to be blown down. This was the end of the blast-furnace trials in Dechaurei.

The last trial in 1879 gave a slightly lower yield of ore and a higher charcoal consumption than the previous blows. In spite of this, W. Ness, the mining engineer who wrote a final report on the ironworks in 1880, considered it the most successful. Two circumstances account for this assessment. First, the proportion of the more expensive Ramgarh ore was only 21 percent in the seventh blow, compared to 28 percent in the sixth. Secondly the daily production was substantially bigger during the seventh blow, 4.9 tons per day compared with 3.3 tons. The cost of labour, management and sundry stores, as well as establishment charges, was thus substantially lower, counted per kg of pig iron, during the seventh trial.28
## Results of blast furnace blows in Dechauri 1856–1879

<table>
<thead>
<tr>
<th>Date</th>
<th>Blast-furnace keeper and blast furnace</th>
<th>Days of blow</th>
<th>Iron produced per day (tons)</th>
<th>Pig iron produced (tons)</th>
<th>Iron produced as % of ore</th>
<th>Charcoal/kg iron produced, kg</th>
<th>Ore, flux and scrap</th>
<th>Technical notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. 1856</td>
<td>Davies in his own blast furnace</td>
<td>-</td>
<td>-</td>
<td>None</td>
<td>Mainly raw, not calcined</td>
<td>Bhabar</td>
<td></td>
<td>Leaking blowing machine, blast too weak.</td>
</tr>
<tr>
<td>March 17–24</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Bhabar ore</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. 1856</td>
<td>Davies in</td>
<td>-</td>
<td>-</td>
<td>None</td>
<td>Mainly raw, not calcined</td>
<td>Bhabar</td>
<td></td>
<td>Cinder descending too fast, not fluid.</td>
</tr>
<tr>
<td>April</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Bhabar ore</td>
<td></td>
<td></td>
<td>Lack of trained hands, not calcined ore, admixture of charge,</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>unburnt bricks in blast furnace.</td>
</tr>
<tr>
<td>3. 1857</td>
<td>Davies’ blast furnace</td>
<td>4</td>
<td>2.2</td>
<td>8.3</td>
<td>40</td>
<td>2.1</td>
<td>Bhabar</td>
<td>Part of the pig iron was</td>
</tr>
<tr>
<td>spring</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>sent to Roorkee for analysis.</td>
</tr>
<tr>
<td>4. 1859</td>
<td>Davies’ blast furnace</td>
<td>-</td>
<td>-</td>
<td>25.9</td>
<td>41</td>
<td>2.48</td>
<td>Bhabar</td>
<td>T. Oldham was sure there was some kind of mistake in the figures.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Yield too big.</td>
</tr>
<tr>
<td>5. 1860</td>
<td>Sowerby’s blow in his new furnace</td>
<td>43</td>
<td>1.3</td>
<td>56.8</td>
<td>29</td>
<td>2.76</td>
<td>Bhabar ore, Lime</td>
<td>Water wheel broke down.</td>
</tr>
<tr>
<td>Feb. 16–March 31 (several stops)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Blast too strong.</td>
</tr>
<tr>
<td>6. 1862</td>
<td>Ramsay’s blow in Sowerby’s furnace</td>
<td>125</td>
<td>1.2</td>
<td>152</td>
<td>31</td>
<td>3.4</td>
<td></td>
<td></td>
</tr>
<tr>
<td>28 Jan–7 June</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7. 1863</td>
<td>Ramsay’s blow in Sowerby’s furnace</td>
<td>(7)</td>
<td>(2.5)</td>
<td>(17.5)</td>
<td>(32)</td>
<td>(2.6)</td>
<td></td>
<td>Scrap deducted.</td>
</tr>
<tr>
<td>Jan-Feb (of this Feb. 8–14)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>8. 1877</td>
<td>Campbell’s blow in Sowerby’s furnace</td>
<td>0</td>
<td>-</td>
<td>None</td>
<td>Mainly raw, not calcined</td>
<td>Bhabar</td>
<td></td>
<td>Tymp gave away. Gas explosion.</td>
</tr>
<tr>
<td>January</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Bhabar ore</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Date</td>
<td>No.</td>
<td>Details</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>----------</td>
<td>-----</td>
<td>-------------------------------------------------------------------------</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>9. April</td>
<td>1877</td>
<td>Campbell’s (deVilleroi) blow in Sowerby’s furnace with hot blast</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>2 - None</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Cool tymp choked up.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10. May</td>
<td>1877</td>
<td>Campbell’s (deVilleroi) blow in Sowerby’s furnace with hot blast</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>2 - None</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Furnace choked around tuyeres. “Lack of competent hands”.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>11. June</td>
<td>1878</td>
<td>Campbell’s (deVilleroi) blow in Sowerby’s furnace with hot blast</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>10 2.6 26</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Firebrick lining gave away</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>12. May</td>
<td>1878</td>
<td>Campbell’s (deVilleroi) blow in Sowerby’s furnace with hot blast</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>12 or 15 46</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Furnace gobbed up.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>13. Feb</td>
<td>1879</td>
<td>Campbell’s (Cameron) blow in Sowerby’s furnace with hot blast</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>96 3.3 318.8 41 1.99</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Scrap added to charge, but deducted, 28% Ramgarh ore</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>14. July</td>
<td>1879</td>
<td>Campbell’s (Cameron) blow in Sowerby’s furnace with hot blast</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>40 4.9 196.2 39 2.14</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Scrap added to charge, but deducted, 21% Ramgarh ore</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Water canal washed away, no blast</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Burwai Iron Works – The Blow

The first blow of the blast furnace in Barwah was postponed again and again. “It is unbelievable how small matters take time to get done”, as Mitander wrote in his diary while finishing the hearth.29

When everything was almost ready, except for some gas pipes, Mitander waited for Keatinge to come. He was stationed 900 kilometres from Barwah, as the crow flies, but Mitander wanted to start the blast with his friend and former boss present “so that he might have the honour of starting up the creation that has been his great idea for so long.”30

The first blow was to be the big test of Mitander’s work. He was well aware that the first blow of a new blast furnace was loaded with uncertainties, in this case more so than ever, with a totally new combination of raw materials, in a totally new climate, and with a totally inexperienced crew of assistants. “I hope everything will go well”, he wrote. “I wish I could have the same good luck as I have had in Sweden where all my blows have gone well.”31

When Richard Keatinge had arrived in the first week of December the final preparations were made. The operation was led by a group of four Europeans: besides Mitander and Keatinge, also the Executive Engineer Captain J. G. Melliss and Lieutenant Marryat. Mitander gives a detailed report on the course of events, with dramatic details. It paints a vivid picture of four days of strenuous work at the blast furnace – before it was totally gobbed up.

MITANDER’S BLOW

To start with, although Mitander did not include this in his description, the blast furnace was preheated with charcoal.35 Mitander reported:

The furnace was filled with charcoal, ore and limestone on the sixth of December, and the blast was let into the furnace the following morning, the seventh. In the evening of that date, we had good smelting and slag of best quality running, also a small tapping of iron. On the eighth, as the charges of charcoal came down, more and more loaded with ore and limestone, for every hour the hearth soon became filled up, and we were unable to tapp slag and iron properly, nor could we by hooks or bars keep the hearth clean. Slag and iron was, however, running over the dam stone. On the ninth, the hearth became so filled up that slag and iron took its way through the tuyeres, and only a small portion of it could be kept running between the tym and damstone. The blast was stopped, and we commenced the work of cleaning the three tuyeres, and to make an opening from the fall house side. In the evening of that date the tuyeres were cleaned, and a passage from the back tuyere communicating with the small opening in the fall house side effected. The blast was again started, and although there was no light in the tuyeres, slag and iron was running during the whole night under the timp stone which was left open, and we had a last hope that the smelting should make its own way. On the morning of the tenth, however, the small opening on the fall
house side became less for every hour, and it was clear that the furnace by
utmost labour could not be kept open, nor was there any chance that the
accumulated masses could be smelted, as for every attempt the tuyeres
were shut up. Therefore, to save the hearth and to prevent the lower part
of the furnace to become a solid mass of half smelted materials, it was
decided to draw the charges and empty the furnace, which commenced
at noon the tenth.36

In a letter to Julius Ramsay a month later Mitander reported dejectedly:
“We Europeans worked desperately and soon collapsed,” and went on to say
that such an unsuccessful blow as that had never happened to him before
and, he presumed, not to Ramsay either.32 To add to the general gloom, this
letter was edged in black, Mitander having been reached by news of his father’s
death.33

In the ensuing analyses an almost unanimous conclusion was reached. The
main cause of the failure was the lack of trained manpower. Richard Temple,
Officiating Commander of the Central Provinces, who reported on the trial,
summarised the blow:

[The men who did the work] consisted of a few Natives, and some Euro-
pean soldiers employed for the occasion. These men, being inexperienced,
could not perform the operation with the requisite skill and promptitude;
nor was it possible for Mr. Mitander alone, even with all his knowledge,
to effect what was necessary, without some trained assistance.34

The Intricate Balance
of a Blast Furnace

The difficulties encountered at the Kumaon and Burwai Iron Works were far
from unique. In the multiplicity of factors to consider and balance when
starting up a furnace, in every detail of the technical set-up and running of
the furnace, in the almost infinite variations in the combination of raw
materials, problems of many different kinds could appear during the ordinary
blowing of the furnace. The start-up of a furnace was, and still is, especially
sensitive. The difficulties experienced are probably as many as the number of
blast furnaces.37 A recent example from Sweden, in a sense building a bridge
over 700 years, is the encounter between the expertise of volunteers trying
to start up the reconstructed, medieval blast furnace of Lapphyttan in Nor-
berg and workers at the modern blast furnace of the steel mill in Oxelösund.
In Norberg a fifth try was made in August 2003, nine years after the first
experiment, but still without success. At Oxelösund the start-up after the
yearly summer vacations is always a delicate task requiring great knowledge
of the personality of the blast furnace.38

After the gradual warming up of the furnace, which might take several
weeks, the regular blow could begin with a slow increase in charges of ore
and lime. Writing in the late eighteenth century, the Swedish metallurgist Johan Carl Garney, stressed that the character of both the charcoal, particularly its strength, and the ore, especially how hard it was to smelt, influenced the way in which the charges could be increased during the blow-in of the furnace. In his book on metallurgy Martin Nisser advised that the charges should be increased with great care “since too sudden and careless charging causes disorder in the pipe that, once it has begun, tends to continue throughout the blow”. Charging too slowly, on the other hand, would cause an unnecessarily high consumption of charcoal and in rare instances even more serious problems might ensue because of excessive temperatures.

John Percy in England refrained from any elaborate description of the working of the blast furnace, “being persuaded that for purely practical men [it] would be superfluous, and that for purely scientific men [it] would have no interest.” Thus, Percy’s section on blowing-in is not more than a page in length. However, he underlined the subtle but still considerable difficulty of working a blast furnace.

The blast-furnace, to persons not practically acquainted with its working, may appear a very simple kind of apparatus, and not likely to get out of order. But it is far otherwise; and to be managed with success requires much skill, which can only be acquired by long experience. It is, in reality, extremely sensitive, its action being affected by apparently trifling causes.

William Sowerby, too, discussed the kind of knowledge needed to run a blast furnace.

The proportioning of the lime and other furnace materials can only be ascertained by actual practice with the furnace, and the proportions require changing frequently just as the furnace works, according to the judgement of the keeper. … This requires an amount of manual dexterity and practical acquaintance with the subject, which can only be acquired by a long apprenticeship to the business of a furnace keeper.

Accounts of single blows can also be found in numerous articles in *Jernkontorets Annaler*. Here are, for example, the not very overwhelming results of the first blow in the new blast furnace of Långshyttan in 1861. Another example is provided by an account of the problems encountered by A. W. Schedin in 1864, when the blast furnace of Harnäs was blown in, and the hearth was burnt out in only five weeks, mainly because of the cold weather. The importance that may be assumed by minor details was shown when Mitander reported on the problems met with at Silverhyttan in 1856 as a result of the combination of the particular angle of the blast and the special characteristics of the iron ore.

The difficulties faced at the blast furnaces in Dechauri and Barwah should thus have been no surprise to anyone who knew the trade. The risk of diffi-
ulty during the first blowing-in of the blast furnace, and even of prolonged trouble, should have been allowed for in the budget from the beginning. It should also be emphasised that nowhere is any blame put on Mitander himself or on his way of managing the work and the first blow. However, it should also be noted that the main cause of the problem to which many observers refer, the lack of knowledgeable assistants, was possibly only one of a set of coinciding factors that caused difficulties.

Productivity Compared

In old Swedish furnaces an average daily output was approximately 6 tons (42 tons per week). Coal consumption was 51.5 hl per ton in new furnaces, 55 hl per ton in old ones. In 1862 approximately 16 tons of pig iron per day was produced in the new blast furnace at Långshyttan and for every ton produced approximately 125 kg of charcoal and 1.7 tons of iron ore was used (60 percent iron). In 1856, when Mitander worked at Silverhyttan, the blows caused trouble, but approximately 63 tons of pig iron per week was made. Two years later the output, reported at that time as a daily figure, was approximately the same, 8.9 tons. The results achieved in Dechauri in the 1870s came relatively close to Julius Ramsay’s estimates of the results to be achieved in the new works he was planning. According to Ramsay, the new plant would give 30 percent pig iron using only Bhabar ore and 45 percent with a fifty percent admixture of Ramgarh ore. The two blows of the 1870s gave an average of around forty percent. In Ramsay’s planned works charcoal consumption would be reduced to 2.00 kg and 1.18 kg charcoal per kg of pig iron in these two cases respectively. The figure achieved in the 1870s was slightly above 2 kg of charcoal per kg of pig iron.

The weekly production in the two blast furnaces at Dechauri was at first planned to be 20 to 25 tons. The projected operation at Barwah give a similar big difference in output by comparison with Swedish figures. The furnace was to produce 5 tons of pig iron a day. The contemporary blast furnace of Åg in Sweden was about equal in height, 13.4 metres, but gave 10.3 tons per day, while the furnace in Svartnäs, 11.1 metres high, gave 8.5 tons per day. No plausible explanation has been found for the low figure for Barwah.

Julius Ramsay wrote to his friends in Sweden that they would probably find 18 tons of pig iron, which he was able to achieve in February 1862, an “unbelievably small” figure, but he put it down to the low-yielding ore. With new furnaces and a hot blast he believed he could increase production to between 25 and 30 tons. It is unclear whether he also considered using Ramgarh ores to achieve this. He described these as “as rich as the Swedish” but also deplored the fact that the total lack of roads made their transport down to Dechauri impossible.
Plans and Practice

The planned production was low, but two basic facts seem to point to decisive advantages in the route chosen and the possibility of better results.

With regard to any improvements that can be suggested on the present manufacture, very little good can be done. ... It is evident therefore, that nothing can be more wasteful and expensive than the present system.57

The blast-furnace route was considered far more efficient and contemporary figures on the output from Kumaoni bloomeries in the 1850s support this judgement.58

According to J. O’B Becket’s observations on the production of bloomery iron in Kumaon around 1850 a total input of 837 kg of ore gave 295 kg bloom-metal, giving 73.6 kg of bar iron. This means that 100 kg of ore was needed in order to produce 8.8 kg of bar iron. "[A] truly miserable result!", Becket exclaimed.59 The output in the bloomery stage thus appears to be good, but not even one quarter of the bloom was left as bar iron when refining was finished. Corresponding figures on the amount of charcoal used were 326 kg (340 seers) in smelting and 294 kg (327 seers) in refining. Thus every kg of bar iron produced needed 8.15 kg charcoal.

The accuracy of these projections must of course be considered with caution, being so far below contemporary results in Sweden and at the same time comparing well with results already achieved during the mostly short and intermittent blows at Dechauri.

Excluding all consideration of socio-economic effects of the technological shift it is thus clear that the blast furnace, even if we take only the results from the first blows at Dechauri as the basis for comparison, was far more efficient.

Secondly, a comparison of the results achieved in the successive blows at Dechauri also gave hope of better results as experience was gained and the works tuned in.60

The results of Julius Ramsay’s two blows in 1862 (no. 6) and 1863 (no. 7) clearly show that the works were substantially less efficient than contemporary Swedish blast furnaces of comparable size. Coal consumption was approximately three times higher and ore yield at least ten percentage points lower. The old blast furnace in Dechauri had many deficiencies and the low quality of the ore added to the problem.

However, the figures show increases in efficiency, from the first to the last of Ramsay’s campaigns. Since no substantial changes were made to the technical equipment between the campaigns, this increase must be attributed to more efficient organisation of production and/or increasing skill. When a hot blast was added to Sowerby’s old furnace in the late 1870s (nos. 13 and 14), and some Ramgarh ore was used, the results were even better. Charcoal consumption was reduced by one-third compared to the amount used during Ramsay’s last campaign.61
A similar increase in efficiency was also seen in two successive years of ironmaking in the smaller furnaces of Kaladhungi. In early 1863 Julius Ramsay made iron in two of Davies’ blast furnaces in Kaladhungi. The result was 17,850 kg of good foundry iron a week compared to 12,750 kg the year before. All the same, efficiency was low, mainly due to the very low iron content in the charge and the lack of a hot blast. Three kilograms of charcoal were needed for every kg of pig iron.62

Once they were running smoothly, Ramsay’s new works would probably have given substantially better figures than the ones achieved in 1877–79 – and thus better ones than his own estimates. His furnace would have been bigger and better equipped than the improved Sowerby furnace of the late 1870s.

**SUMMARY DISCUSSION**

Technology Employed and Productivity Enhanced

The main problem arising in Barwah, forming an end-point at the Burwai Iron Works, was, as in all start-ups of blast furnaces, to get the iron running. Managing a blast furnace has in most ages been a matter of practical knowledge, continuous trial and error, and accumulated experience. Each new blast furnace, with its individual combination of a multitude of different conditions, has needed time to be blown in and made fully operational. The first unsuccessful blow at Barwah should therefore not have been a surprise and should definitely not have been a reason for a stoppage of the ironmaking trials.

At the Kumaon Iron Works, these initial problems were overcome and under the auspices of Julius Ramsay, productivity was gradually increased. This was clearly seen in the results when Julius Ramsay managed the blows in 1862 and 1863, but especially when comparing the first trials with the last blows in the late 1870s, by which time the blast furnace had been supplemented by hot blast. The results show the importance of continuous production and the overall improvement in efficiency over time also indicate that it was possible to gradually get to know the specifics of raw materials and other conditions. The results illustrate the possibility of gaining experience by trial and error and the importance of learning.
CHAPTER 9

Natural Resources:
Inventory and Utilization

The changeover from charcoal to coal in the late eighteenth century opened a new era in the history of British iron and steel. Expansion was no longer hindered by the shortage of charcoal.

In Sweden, on the other hand, the iron industry enjoyed not only an abundance of high quality iron ore and ample running water as a source of energy, but also a wealth of forest of fir and spruce. There was also an essential cadre of competent and experienced workers and a solid foundation in a long tradition of ironmaking. This combination had given Swedish charcoal iron a worldwide reputation for high quality that was to help to keep its place in the important export market.

As in Sweden charcoal was chosen as the fuel for the ironworks in India. The success of the Swedish example was one important argument for this choice, easier access to the forests resources than to the still unexplored deposits of coal was another. But one most pertinent question was whether the forests would be large enough to sustain the works.

A similar question concern the iron ores. The general earlier history of prospecting for iron ores, leading up to the decisions to invest in ironworks in Nimar and Kumaon, has already been described and the aim of this chapter is to examine, in greater detail, this assessment of ore potential. How much was really known about these vital resources? How was the knowledge acquired? In a figurative – and material – sense, how deep did the prospectors penetrate? Were the resources large and rich enough to sustain the works?

And, at last, another important group of factors considered in this chapter, is the role and importance of the climate. Did the climate influence the employees and the work done? What was the availability of hydro power?

There is a difference between nature as such and natural resources. The magnitude of a natural endowment can be said to be given, defined by “nature”, given by God or however one wishes to describe it. But, how this endowment is considered available for human use, as a natural resource, is socially defined. This difference is crucial and it is central in all discussion of the exploitation of nature by man. New priorities can justify greater social disruption and economic sacrifice for the sake of using a resource. Even if it
was once considered out of bounds, a natural endowment can thus be redefined as a resource for human use.

The question was thus not only whether there was enough iron ore or forest in Kumaon or Nimar, but rather how much human labour it was reasonable to invest in putting them to use. This consideration is always open for negotiation, using arguments of a social, economic or cultural character. Thus man can imbue a natural endowment with a new meaning. Or, as Andrew Grout quotes Antoine de Saint-Exupéry: “A pile of rocks ceases to be a rockpile the moment a single man contemplates it, bearing within him the image of a cathedral.”

In this way, the rocks and forests in Kumaon and Nimar acquired new significance during the mid-nineteenth century. In the eyes of British observers, they were not only transformed into iron-bearing minerals and fuel, but also into possible raw material resources of high socio-economic potential.

**Iron Ores in Kumaon**

Iron-ore mining and the manufacture of iron were well established in Kumaon when the British arrived and began to take an interest in the mineral resources of the area.

When Julius Ramsay came to Kumaon in 1861 he continued the work done by the British and basically relied on earlier prospecting results. The Bhabar ores close to Dechauri and the mines of Ramgarh were the two possible sources of supply to the ironworks.

In 1862 he described the ores in Dechauri as loose stones or big lumps spread over the slopes of the hills and he believed there were enough “for many, many years, without going to any depth”. Nearly three years later, in his report to Jernkontoret, he described the Bhabar ores as tolerably poor Sphaerosiderite, called “argillaceous ore” [clayey ore] or more commonly “clay-ironstone”. The ore was found on the ground in blocks of different sizes and its iron content varied between 20 and 35 percent. At that time he still considered the ore so common that proper mining could not become necessary “for a long time”. Apparently he concluded that the easy access to the ore outweighed the disadvantage of its low iron content.

In spite of this Ramsay was worried. In the blast furnace, he said, the Dechauri ore “never gave more [iron] than 27 percent [of its weight] and it needed an addition of 50 percent lime. The charge thus gave only 18 percent and under such conditions production could not become profitable, but I had to blow this ore alone.”

Compared with other figures the iron content given by Ramsay seems to have been on the low side, but it is not known on what kind of sample it was based. At the end of the 1870s, iron ore samples from Dechauri gave an average of 38 percent iron. The mode of sampling seems to have been careful in this case, and the percentage might be taken as a fair average. This may be compared with W. H. Hughes’ analysis in 1872, which gave 55 percent.
The landscape of Dechauri. “The landscape was both beautiful and magnificent, but lacked the traits that usually distinguish tropical landscapes: fertile plains with groups of palms and banana trees alternating with villages and temples among weeping willows and acacia.

Here everything was wilder and although the vegetation was rich, the palms had already left room for trees of a temperate climate. In the background the Himalayas rose majestically, their lower parts, though steep and inaccessible, well wooded, their barren crests blue against the sky.

Dechowrie (Dechauri) was right at the foot of the mountains on a wide terrace, forming one of the first steps climbing them. A small mountain stream tumbled out of a deep, narrow gorge to water beautiful and fertile fields below. The water was collected in a masonry channel that wound several miles up the mountainside into the ravine. On the south side, below the fields, the view was limited by a vast forest of hardwoods, mainly Saal and Haldoo, both of them quite tall and giving a good solid wood, constituting the fuel on which the works depended.” (Julius Ramsay’s report, p. 20.) The picture shows a masonry watercourse, a gool, just above the site of the blast furnace in Dechauri. Photo: Peter Nyblom, 2000.
<table>
<thead>
<tr>
<th>Area examined</th>
<th>Year</th>
<th>Observer</th>
<th>Comments</th>
<th>Observation, iron content in percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dechauri</td>
<td>1855</td>
<td>W. Sowerby</td>
<td>Field observation</td>
<td>Sample 1. 50% iron, enormous reserves. (1)</td>
</tr>
<tr>
<td>Dechauri</td>
<td>1855</td>
<td>H. Drummond, member of the Geological Society of London</td>
<td>Field and laboratory examination (Mr. Piddington, Museum of Economic Geology and Dr. Macnamara Chemical examiner to Government).</td>
<td>Sample 2. Chosen sample 66.3%, ordinary sample 55.6%. (2) Sample 3. Other stuffs 46.9, 55.47%. (3) Sample 4. 47.6, 50.96%. (4) Sample 5. The average is upwards 40%. Inexhaustible reserves. (5)</td>
</tr>
<tr>
<td>Ramghar ores</td>
<td>1864</td>
<td>Wittenström</td>
<td>From two different mines close to Ramghar.</td>
<td>Sample 7. 61 and 54% respectively. Analysed at Falu Bergsskola, Sweden in 1864. (7)</td>
</tr>
<tr>
<td>Dechauri</td>
<td>1872</td>
<td>Hughes</td>
<td>Sample “Somewhat above average quality.”</td>
<td>Sample 8. 55%. (8)</td>
</tr>
<tr>
<td>Dechauri</td>
<td>1877</td>
<td>Riley</td>
<td>543 kg from different places, pounded and sampled.</td>
<td>Sample 9. 38%. (9)</td>
</tr>
</tbody>
</table>

Hughes’ samples were picked from the ground, but how they were selected is not known, only that he called them “somewhat above average quality”.

In spite of the increasing possibility of chemical analyses the vast differences in iron content shown in the table on p. 264 illustrate big methodological deficiencies. The way the samples were picked was of vital importance, especially in the Bhabar area where the ore was intermingled with sandstone. This meant there could be various-sized pockets of richer ores. It is striking that the collection of samples of 1855 all showed high iron contents. The general estimates of the average iron content, by Drummond in 1855 as well as by Julius Ramsay in later years, were substantially lower.

Ramsay devoted particular attention to the richer finds of rock ore in the Ramgarh area and he called these ores “as rich as the Swedish”. These “rich resources of magnetic iron ore” were attractive, but due to the lack of good roads in the mountains, they were hard and costly to bring down to the works in Dechauri.

From a very early stage one of Ramsay’s main ambitions was to build a road for this transport. In May 1862 he went up to Ramgarh with one of the British blast-furnace keepers. A letter vividly describes the hardships of the expedition, crawling on all fours through the brushwood or coming down tracks with hairpin bends every few metres. The round trip took six full days, but in spite of the difficulties he became convinced of the possibility of building a road.

With time the estimates of potential resources were gradually revised. Even the Ramgarh ores so highly esteemed earlier were downgraded. During the last effort to operate the works in Dechauri, in 1876–79, Ramgarh ore was used. In the winter of 1879–1880, mining engineer Walter Ness found an average of 42 percent metallic iron in this ore, only traces of sulphur, 0.11 percent phosphoric acid and an average of 1.5 percent of oxide of manganese. He concluded that the poor iron content would not warrant the transport costs.

But even if the most overoptimistic estimates were discounted, positive assessments of the iron ore resources of Kumaon continued to be relevant. Jim Corbett, best known for his stories of man-eating tigers in Kumaon, lived most of his life in Nainital and Kaladhungi. In one of his books, he described how he climbed the peak of Cheena, above Nainital. He depicted the breathtaking view to the north, towards the snow-clad peaks of the High Himalaya with Nanda Devi, one of the highest summits in India, reaching towards the skies. Turning around he looked over the hills that rapidly descended towards the Ganges plain. He described the foothills as being “almost entirely made of iron ore”. Photo: Jan af Geijerstam, 1997.

The connections between the Kumaon and Burwai Iron Works and indigenous iron-making will be dealt with in Chapter 11, but in this context Corbett’s conception of rich and inexhaustible sources of iron ore is also worth noting. This idea accompanied the Kumaon Iron Works from the outset and it became a strong influence on the history of the works and, judging
Map showing the proposed new road between Deh-sawar and Shingar.  
\[\text{By J. W. Thomson.}\]
from Corbett’s writing, apparently had a longevity that far outlived the works themselves and contributed to the momentum gained by the project.

Coming even further forward in time, to the late twentieth century, surveys of the mineral resources of Kumaon do not even refer to iron ores. In a textbook on the geology of the Himalayas a number of mineral deposits are listed, but they are described as possible to mine only “in times of acute need and emergency”. Iron ore deposits are not even mentioned.14 The same applies to a recent text on the economic geology of Kumaon, where copper ores are described, but iron ores remain unmentioned.15 This reflects not only a redefinition of the feasibility of mining or a real scarcity of iron ores as such, but also the present economic value of the mineral deposits in relation to present-day technology and after discovery of iron ores in other areas.

Remains of old road. Still visible in the vicinity of the ironworks of Kumaon are remains of old roads, but today little used. Photo: Peter Nyblom 2000.

Road planning by Julius Ramsay (opposite page). In May 1862 Julius Ramsay spent six days with one of his blast-furnace keepers examining the possibility of building a road from Ramgarh down to Dechauri. As a result of the expedition, Ramsay concluded with satisfaction that a road could be built at an acceptable cost. He was overwhelmed by the dramatic beauty of the scenery, and wrote that he would remember this trip all his life. As a record, but also as a memento, Ramsay made a map. (Ramsay’s letters to his friend, 30 May 30, 1862.) Source: Ramsay’s papers, F1:1.24.
Compared with Ramsay, Mitander was more of a pioneer among Europeans using the ores and he had to begin with a thorough survey of those that were available. One of his first tasks was therefore to find and decide which mines to use and his many diary notes on this subject indicate the importance of this work during the first part of his time in India.

Mitander began his surveys the day after his arrival in Barwah. At first, he only looked at mines previously used by Indian ironmakers. They were small, opencast sites, but they might indicate bigger deposits. To check their quality Mitander analysed samples with the laboratory equipment he had brought from Sweden.

Mitander was extremely disappointed by the results of the first few days of assays. Richard Keatinge was more optimistic, but he also felt obliged to reassure Mitander that if no ironworks was built at Barwah, Mitander would in any case be employed at the rolling mill in Mundlasir, and thus have an ironworks to manage.

But this first despondency soon seemed somewhat premature. Gradually Mitander’s disillusionment turned to optimism.

Three basic kinds of ore were found, an ochreous rock with globular lumps of ore, a breccia with ore cemented with other material and almost pure haematite. Two mines were chosen to supply the ironworks with iron ore, Nandia and Mitanderpoor.

The largest amount of work was done at Nandia, an old working, three miles west of Barwah. This was the first mine selected by Mitander. He plan-
ned underground mining or at least a deep opencast mine. By the third week he had ordered carpenters to construct a hoisting arrangement and made a drawing of a barrel to bring ore up out of the mine. Two months after his first trials of the Nandia ore, he was satisfied: “Weighed the samples of roasted and non-roasted Nandia with satisfaction. The former gave 56 percent and the latter 48 with beautiful slags.” The ore was a hydrated iron oxide in globular lumps, which was found in seams in yellow ochreous rock. The richest samples contained 57.95 percent iron, an average sample of good ore between 48.5 and 52.63 percent and an average of eight random samples 56.4 percent.

In his continued search Mitander tested ores from other places: Korundia and Nandia, Park Emlu, Cummulpooor (both north and south), Druidabra, Corundia, Seerlie. The ore found here was mainly what Thomas Oldham called a breccia made up of broken fragments of ore and other materials cemented by crystalline carbonate of lime. An accurate estimate of such ores was hard to make, since it was far from homogeneous.

In February 1861 Mitander discovered many excellent samples of ore, spread on the ground close to the old mines of Cummulpooor and Dudabro. This new site was first named Pangria, but since it was three miles distant from the original Pangria mine, Keatinge renamed it Mitanderpoor. Digging yielded scattered finds of very good ore and at a depth of three metres a solid bed of ore was reached. One early trial from Mitanderpoor gave 52 percent iron. The ore was a crystalline massive haematite or specular iron ore, with impurities mainly of silica. One rich sample gave 62.22 percent iron, but an average sample from the lowest level gave 45.98 percent and the average for all mined ore was 43.6 percent. The extent of this find was regarded as considerable and together with Nandia, Mitanderpoor was selected as one of the main mines. A rich sample was analysed by Thomas Oldham. He described it as a piece of almost pure haematite, part of a vein. He compared it to a pure haematite, which would give 70 percent iron. According to the Calcutta Gazette Mitander considered Oldham’s analysis too favourable for a working estimate. The specimens that were forwarded to Dr. Oldham were probably richer than the average produce of the mines. The iron contents mentioned by Mitander roughly correspond with results of later analyses that are cited in twentieth-century literature. The ores used by Mitander were later described as part of the Bijawar series in the Narmada Valley. They occur as a matrix of a breccia that is unevenly distributed in the region. Among the sites mentioned by later writers are also several of the mines of Mitander. The ores are said to form a band between three and four metres thick. Analyses cited in 1954 state that the Barwah ores contained 80.44 percent haematite (Fe₂O₃), 0.90 percent iron oxide (FeO), 16.77 percent quartz (SiO₂), 0.01 percent phosphorus (P) and 0.01 percent sulphur (S). The total content of pure iron was 57.01 percent. It is unclear where these samples were taken.

In May 1861 mining was under way at both Nandia and Mitanderpoor and a year later, in the spring of 1862, a considerable stock of iron ore had
been collected and stored. In July 1862 Mitander estimated that he had ore to run the blast furnace for three months.29

The West Nimar district gazetteer of 1970 stated briefly that the district is devoid of any mineral resources that could form a basis for the industrial development of the region. However, the existence of iron ore in a band of Bijawar breccia, around three metres thick, “between Katkut and the Kanar River and at other places near Barwah”, was mentioned in passing.30 The corresponding gazetteer for Indore, also covering the region south of the city down to and including the northern part of the alluvial plains of the Narmada River Valley, quotes a mineral survey of the state carried out in 1924. Here reference is made to the “only known metalliferous deposits of value … the rich haematites met with in the sand-stone outcrop near Barwaha.” The Burwai Iron Works is also mentioned. In conclusion, the Gazetteer passed an unequivocal judgement, “the poverty of the District in respect of mineral wealth becomes obvious”.31

To sum up, any conclusion regarding whether the iron ore resources of Kumaon and Nimar would suffice as a basis for the ironworks is uncertain. In the Kumaoni case there appears to have been a substantial gap between the sanguine hope of a great expansion and the actual meagre resources of good iron ore, especially as the commercial viability of the works was an absolute necessity.

In Nimar on the other hand, the scale of the works appears to have been quite appropriate to the iron ore resources, even if in retrospect they are far from enough for large-scale ironmaking.

As an inheritance from the formative history of geological surveying in India there remained a combination of a utopian preconception of valuable resources in India, just waiting to be used, and an often fundamental lack of

*The mine pits of Nandia* are in an open, slightly undulating and cultivated landscape. Fields of cotton dominate and the soil is mainly heavy black. On the ridges there is a clearly reddish and stony soil and the rock below is often iron-bearing. Nandia was first used by Indian ironmakers, later by Mitander. Photo: Jan af Geijerstam, 1997.

*The iron ore of Nandia.* The mines of Nandia were one of Mitander’s main sources of iron ore. His own trials in the end of January 1861 this ore gave between 48 and 56 percent iron. Photo: Jan af Geijerstam, 1997.

*Mr. and Mrs. Kalubhai own some of the fields at Nandia and when we talked to them they said they hoped that the mines would be opened again. Knowledge of the iron ores was quite evidently within living memory.* Photo: Jan af Geijerstam, 1997.
knowledge. There was a legacy of overoptimism, in which contrary evidence had a tendency to be discounted.32

During the first phases of the exploration of the iron-ore resources of Kumaon, the enthusiastic reports of Sowerby and others in Kumaon travelled all the way to the highest decision-making levels in both Calcutta and London. In several instances, the reports on the mineral deposits were considerably over-optimistic. Whether this was deliberate or not is hard to say, but it could have been an example of the “information distortion” common when development potentials are evaluated. When the resources are seen through the perceptual filter of a surveyor, anxious and prepared to make discoveries, potentials are exaggerated.33

*Mines in the forest.* As noted by Mitander, the area east of the Choral River abounds in places in heavy, reddish-brown iron ore stones scattered on the ground. Aided by local informants it is not hard to find one’s way to old workings, although I could not with certainty identify the mines that we reached without proper navigating instruments. One of the sites was named Goalbedi, Photo: Jan af Geijerstam, 1997.
Charcoal, Wood Consumption and Forest Regeneration

Many studies of the iron industry focus on the very heart of the industry, the ironworks themselves, their technology and their social organisation. But around this core there was also a widespread system for supplying the works with raw materials. The extent of this technological system was of particular importance when charcoal was used as a fuel. The work of felling the timber and transporting it, of making the charcoal and bringing it to the ironworks, gave work to many. Charcoal-making was an important part of the economic structure of the countryside around the ironworks.

The experience of deforestation in Britain was transferred to India and added to the general scepticism of the home government towards mining and ironmaking in the colony. The failures of the iron company at Porto Novo as well as of the ironworks in Kumaon were commonly attributed to the fuel problems.

All the same there was from the beginning a definite intention to use charcoal as fuel at both Kumaon and Burwai. There were no deposits of coal in Kumaon and Nimar and at least when the ironworks projects started the British considered the forest resources an unused and ample, almost inexhaustible, resource. In general charcoal was more readily and easily accessible than coal, which would have required continued extensive surveys to find the special qualities needed for ironmaking. If and where these had been discovered, the use of coke would also have entailed big investments in mines and coke-making.

The use of the forests was, at least in the short run, less complicated in terms of machinery and capital investment. Another reason why the British put such an emphasis on charcoal iron was probably the importance attached to procuring high-quality steels to replace expensive imports from Sweden and Russia and to complement the steels made with coal in Great Britain.

In Kumaon the decisive reason for siting the ironworks at Dechauri and Kaladhungi in the Bhabar was the proximity of fuel in the wooded stretch of the foothills bordering the plain. There was an option of placing the works in Ramgarh, but the carriage of heavy, bulky loads of firewood – or brittle charcoal – was to be avoided. In Barwah the works were placed on the western edge of extensive forests stretching along the northern bank of the Narmada River, between the river and the Siwlakis hills.

ESTIMATES AND UNCERTAINTIES

In a longer run, the use of charcoal was an extremely complex undertaking, deeply influencing social and ecological systems and necessitating a system for regeneration of forest resources. Therefore the methods used to estimate
the inputs in this balance between use and regeneration became crucial at Kumaon and Burwai.

It was a complicated task to estimate the possible consumption of timber from the forests, even if the social consequences were disregarded. A number of more or less unknown variables concerning the rate of forest growth and regeneration and market prices had to be combined, resulting in calculations with a big margin of uncertainty. At Kumaon the guesses were very wild, with William Sowerby’s as the most extreme. At the beginning of 1856 he even wrote that the forests could supply sufficient fuel to keep 200 blast furnaces at work, producing 200,000 tons of iron.35 This was pure fantasy.

In 1857 a more thorough and careful calculation of the forest resources available for use at Barwah was made by J. Howard Blackwell. One by one he listed the factors that had to be considered in an analysis of the charcoal potential of the Narmada River.36 His calculation went through six steps and his method of computation clearly illustrates the uncertainties involved. The estimates were rough guesses and based on somewhat imaginative parallels with other parts of the world. The resulting figures were at best the roughest of approximations.

First, Blackwell started out from the current price of charcoal in the Narmada Valley, between three shillings and sixpence and six shillings per ton. He took a price of five shillings per ton.

Second, Blackwell thought that the maximum price that could be afforded by an ironworks would be twenty shillings per ton and, accepting the market price assumed in the first step, this would leave fifteen shillings for transport to the works.

Third, based on the cost of transport with buffaloes, this would give a possible catchment area with a radius of 48–64 kilometres.

Fourth, if a light tramway was built this would cut the cost of transport to one-sixth. Blackwell considered a 64-kilometre radius reasonable. This would correspond to 12,800 square kilometres. Prudently, however, Blackwell reduced this to one quarter, 3,200 square kilometres.

Fifth, Blackwell used the yields from European forests (160 tons of charcoal per square mile per year). This meant that the 3,200 square kilometres of forest would give 192,000 tons of charcoal per year. This Blackwell also reduced to one quarter, to 48,000 tons.

Sixth and last, assuming that three tons of charcoal was needed per ton of wrought iron this would be enough to make 16,000 tons of wrought iron per year or 300 tons per week if continuous all-year production were assumed.

The quality of Blackwell’s attempt to estimate the potential for iron production with charcoal made from local resources is difficult to judge, and, as often, such a calculation has to be tested in practice.

Blackwell’s calculated catchment area for wood and charcoal was much bigger than the one actually used by Mitander. While Blackwell counted on transport from up to 64 kilometres, the most distant place from which charcoal was brought to Burwai Iron Works was only nineteen kilometres away.37 The
area used by Burwai during the first years was approximately 371 square kilometres north of the Narmada and 26 square kilometres south of the river, not more than three percent of the area envisaged by Blackwell.38

The difficulty of correctly estimating not only the rate of regeneration of the forests but also the actual quality of it appears to have been realised at Burwai. In 1863 Captain Melliss of Mhow, apparently after discussing the matter fully with Nils Mitander, reported that the yield of charcoal was 35 percent of the wood used by measurement, that is, by volume, and 25 percent by weight. In Sweden comparative figures were 48 to 75 percent by volume, but little different by weight. And he notes that while one cubic metre of Swedish charcoal weighs about 150 kg, the corresponding volume in India weighs 233 kg, “however, the residue of ashes from our charcoal is much greater”.39

Considering all these opinions, it seems as if Blackwell made an estimate, which at least as regards the end result matched the results obtained by Mitander in practice. In six months of 1862 a total of 2,910 cubic metres (108,000 cubic feet) of charcoal was made. According to Mitander 2.7 cubic metres (100 cubic feet) of charcoal weighed 630 kg (1,400 lbs), or 0.63 tons. This means that Mitander produced approximately 680 tons during half a year or 1,360 tons per year.40 According to Blackwell’s calculations an area as big as the one used by Mitander would have given 1,464 tons (1,440 British long tons), and the figures thus match remarkably well. The final and crucial uncertainty, however, concerned the regeneration rate of the forest. How many years would it take before the forests were ready for a new harvest?

Blackwell’s comparison with conditions in Europe and North America must be considered adventurous, especially since Blackwell’s most important argument was that the yields in Europe were so much lower than in America that they hardly could be lower in India.41

Like Blackwell, Richard Keatinge considered fuel to be a crucial bottleneck in production.42 But he noted additional difficulties, which Blackwell did not even consider, in procuring it. According to Keatinge the inhabitants in this part of the country were totally unacquainted with charcoal-making and there would be substantial problems in transporting and storing the huge amounts of charcoal needed.43

In Kumaon the first overwhelmingly optimistic estimate by William Sowerby was soon abandoned and replaced by what appear to have been more sober calculations.

According to Ramsay, the yearly fuel requirement of the Kumaon Iron Works, once completed, would be 53,000 cubic metres of wood per year. This would cater for 6,330 tons of pig iron and 4,220 tons of wrought iron, using both Bhabar and Ramgarh ores in five blast furnaces (two in Dechauri, four in Kaladhungi) for seven months a year. As the next step an estimate of the quantity of wood possible to take out of the forests “without risk of exterminating them” became a “question of vital importance”. Ramsay
emphasised the availability of wood as the determining factor governing the size of the works.44

Although Ramsay had received a basic education in forestry, he admitted his own lack of expertise and decided to ask for a special forest manager. “Even if the forest is very fast-growing, felling without a system will inevitably destroy it within a few years.” At this time, the end of January 1863, he wrote that he had tremendous difficulty in cutting the forest and procuring coal, but he did not explain why.45

The period needed for the regeneration of the forest was a key question and apparently a subject of what can only be called speculation. In 1855 Lieutenant Greathead maintained that eight years would be enough for reproduction after felling in the forests around Dechauri.46

Ramsay regarded 15 years as the regeneration cycle. This could yield approximately 84,000 cubic metres in the forest allotted to the works. With twenty years as a regeneration cycle, which Ramsay was advised to use by a Dr. Brandes, the possible yield was reduced to approximately 71,000 cubic metres.47 Compared with the estimated need (53,000 cubic metres), this was still more than enough.

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Charcoal made for the Burwai Iron Works

Charcoal made for the Burwai Iron Works (cubic metres)

<table>
<thead>
<tr>
<th>Site</th>
<th>January 1–March 31 1862</th>
<th>October–December 31, 1862</th>
</tr>
</thead>
<tbody>
<tr>
<td>Burwai</td>
<td>515</td>
<td>311</td>
</tr>
<tr>
<td>Bainpoor</td>
<td>246</td>
<td>113</td>
</tr>
<tr>
<td>Buckutgur</td>
<td>179</td>
<td></td>
</tr>
<tr>
<td>Bulwara</td>
<td></td>
<td>148</td>
</tr>
<tr>
<td>Chiktree Modree</td>
<td></td>
<td>138</td>
</tr>
<tr>
<td>Curundia</td>
<td></td>
<td>378</td>
</tr>
<tr>
<td>Ghutia</td>
<td></td>
<td>688</td>
</tr>
<tr>
<td>Jayaghrur</td>
<td></td>
<td>466</td>
</tr>
<tr>
<td>Poonassa</td>
<td>355</td>
<td></td>
</tr>
<tr>
<td>Seylance</td>
<td>51</td>
<td>313</td>
</tr>
<tr>
<td>Soortipoora</td>
<td></td>
<td>117</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td><strong>1,346</strong></td>
<td><strong>1,564</strong></td>
</tr>
</tbody>
</table>

Sources: Progress report from the Burwai Iron Works, Proceedings, November 1862, Industrial no. 3-5, Public Works Department, National Archives, New Delhi. India Public Works, Collections to despatches 1864, L/PWD/3/346, OIOC. Volumes converted from cubic feet.
Not only the amount of coal available, but also its quality was important. In Sweden, fir and spruce were the most common species for charcoal, and birch and other deciduous trees were used only to a limited extent. In the new surroundings there was a multitude of species, unknown both to the British and the Swedes, especially as far as their suitability for charcoal-making was concerned. According to Mitander, the charcoal yield was much better in Sweden than in India, but only when measured as volume. Measured as weight, the yield at Barwah equalled yields in Sweden since Indian wood was heavier. At the same time the ash content was higher in Indian charcoal. In Nimar the main species used for charcoal-making was mahogany, but in Kumaon a number of different species were considered. In a letter to Henry Drummond, William Jameson, Superintendent of Botanical Gardens in the North-Western Provinces, described fourteen different species of timber trees in the Bhabar, and maintained that all of them were excellent for making charcoal. First of all he placed Saal or Saul – *Shorea* (*Vatica*) *robusta*. The kind of wood used in making the charcoal influenced its heat content, the amount of ash it left after burning, and its ability to carry the weight of the ore in the blast furnace without being crushed. At the beginning of his stay, Ramsay was quite ignorant of the different species, but as time went by he gradually learned more. Even if he complained that the “natives delivered weak and loose coals”, he generally thought that Saal and Haaldo, the two main species used for charcoal-making, gave a “firm, good wood”, which also implied a good quality charcoal.

The correctness of all these calculations and considerations is hard to judge and the fuel question caused long and continuing discussion.

In 1881 the geologist Valentine Ball noted that the question of fuel had been discussed “over and over again.” His conclusion was unequivocal: with strict conservation and replanting, consumption would not exceed the available supply, but the carriage of fuel would necessarily be an expensive item if only fully grown trees were taken from the forests, here and there.

The Commissioner of Kumaon, Sir Henry Ramsay, basically agreed and was confident that fuel problems only could exist in “the distance” and would scarcely be noticed for many years, given careful replanting. The chronicler of the Himalayas, Edwin T. Atkinson, was more pessimistic.

The absence of coal and the increasing cost of wood fuel, with the distance it has to be carried when the forests near the mines have been exhausted, materially enhances the cost of production, while the difficulties of carriage in the tracts where the mines lie are often such, as almost to preclude the transport of ore for smelting, and the forests in the neighbourhood of most mines only suffice for the most moderate requirements.

In summary it seems safe to conclude that at least the Burwai Iron Works, on its experimental and rather limited scale, well matched the available forest resources. At the Kumaon Iron Works such a conclusion seems to be much more doubtful. Even some of the most ardent advocates of the works were...
forced into quite tortuous arguments to prove the long-term sustainability of the forest resources. The scale of the works and its commercial footing would add to the strain.

**MAN AND THE ENVIRONMENT**

The production of charcoal highlights the interplay between man, his technology, and the ecological system of which he is a part. But at the Kumaon and Burwai Iron Works the question of fuel was also intimately linked to the question of power. The ironworks represented use of the forest on a totally new scale with an intensity and to an extent never seen in the region before.

The use of the forest was closely linked to a knowledge of its biological life but with the arrival of the British its wealth was appropriated in accordance with sets of formalised rules determined by the new rulers. The points of conflict in the triangle of the ironworks, the state and the local community were many.

In the Kumaoni case, on which material is more readily available, the social implication of the use of the forest is evident. No single question has so greatly concerned living conditions in Kumaon, since the forests formed the basis of life. If the previous discussion has given a picture of the difficulty of the technical and ecological problems of procuring charcoal, the discussion on the forest resources in Kumaon, ranging over decades, also fully illustrates the socio-economic effects of their use. The main lines of argument were already clear in 1855, before the experiments started.

In the 1855 report of William Henwood on the metalliferous deposits of Kumaon and Garhwal, one main point was that the supply of fuel to the smelters would be seriously threatened, unless it was protected from incursions by the farmers and their cattle.\(^5\) Henwood also argued that the use of the forests by miners and smelters should be subject to the control of a government mineral surveyor and that a nursery for new seedlings should be established.\(^5\)

When a letter containing excerpts from Henwood’s report was distributed, several critical comments were made, most of them representing a more optimistic view of the potential of the forest. The Government of India discussed different measures to cope with what was called “the wanton destruction of the forests”. It supported the view of William Henwood that forest should be reserved for the needs of the iron industry and that it should be protected from grazing. The Government also emphasised the need for nurseries and new plantations close to the best iron mines in order to ensure a continued supply of wood.\(^5\)

There appears to have been no legal obstacle to declaring the forests Government property in order to guarantee a sufficient forest reserve for mines and ironmaking. The wording of a letter from Henry Ramsay showed a casual attitude to the rights of the villagers.
The exclusion of such waste [i.e. forest] lands would in most cases be no great hardship, because sufficient land might be left within the boundary of each village for its cattle. If any individuals had large herds of buffaloes or cows, which would be a very rare case, they could be removed [sic!] to more extensive pasture lands, where the forests were not protected.57

Henry Ramsay emphasised that the companies should lease the mines and the forests attached to them. If the forests were worked by a “native lessee, it would be hopeless to expect the charcoal-burners to observe any organized system.”58

Large Scale and Scientific Management

When Commissioner Batten summarised the first debate on the forest resources in a report to the Government of the North Western Provinces in 1855, he argued that increasing the scale of production in the mines and in ironmaking would solve the problems of fuel supply.

The operations at the mines have been on such a comparatively-speaking small scale, that the women and children belonging to the smelters have been able to produce all the fuel required from their daily visits to the forests in the immediate vicinity of the furnaces. Under a system of big machinery and extensive out-turning of iron, a market for fuel would be created, and the villagers bordering on the remoter and more extensive forests, both of pine and oak, would soon see the profit of stacking wood near their homes and selling charcoal according to the demand at the mines.59

John Strachey, too, put the shortage of fuel down to the modest scale of the operations. Since the total need of fuel was so small, its selling price could only support carriage over small distances. The town of Almora, with a population of 8,000 people, was further from sources of fuel than anywhere else in Kumaon. In spite of this, there was no place where fuel was cheaper. The bigger volume of production gave economies of scale. This would also be the case if an ironworks was established.60

Control and Obedience

To protect the forest close to the mines, Batten believed that all felling would need to be carefully controlled. To issue orders and enforce them would be no trouble: “… in Kumaon the people are accustomed to obey the orders of authority”.61

When Thomas Oldham reported on the Ironworks in the spring of 1860 the exclusive right to all Sal timber was reserved for the Government. The Sal was such a vigorous species that in any place where the rest of the forest was cut down, Sal would soon establish itself as dominant. “Sal is decidedly the best timber for making charcoal, which will grow freely in the Bhabur,
and the point is therefore of vital importance, and calls for immediate decision." He added that whenever the forest was cleared, the local villagers soon cultivated the land on which it had stood. This was, according to Oldham, welcomed by the local authorities, but at the same time it seriously interfered with the supplies of fuel to the ironworks, and Oldham therefore urged that “unlimited and unrestricted control of the portion of the forest set apart for the uses of such works must be handed over to the managers of these”.63

The British took a somewhat ambivalent view of the use of forests. Commercial exploitation, with some degree of official control, was basically to be encouraged, but the traditional use of the forests by the peasants and other inhabitants of the area was usually seen as a threat that had to be staved off by a firm enforcement of rules and regulations.

A special example of the relationship between man and environment was the delicate balance between burning, felling and preservation. In July 1855 W. C. Watson, Senior Assistant Commissioner in Gurhwal, the western part of present day Uttaranchal, wrote to John Hallet Batten, Commissioner of Kumaon. He referred to the area around the mine of Semul Khet in Gurhwal, but his arguments were of wider relevance. First he noted that the grass of the hillsides was either accidentally or deliberately set on fire once or twice every year, but the flames, although fierce, did not injure the trees. He agreed that the wasteful cutting of timber for fuel must be stopped. Every part of every tree must be used, both trunk and branches. Otherwise the remnants would be left on the ground to dry and might hurt other trees by catching fire. There was no need for any nurseries or any system for planting out young trees. Natural regeneration would be sufficient.64 John Strachey supported this view and even maintained that the fires were beneficial to the growth of the trees.65

Batten was emphatic in dismissing the ideas of preventing fire and planting trees. Except during extreme dry periods only the grass was burnt and in any case “… ten goats or sheep …[cause] more harm than a hundred fires of ordinary seasons.” Plantations of seedling trees, taken from nurseries, would be an absolute impossibility, argued Batten. If planted on flat ground the new forest would use land needed for the production of food. “On bare hillsides, the preservation of planted-out pine trees could not be effected without an army of watchmen, attended by another army of water-carriers”.66

The ultimate social effects of these discussions will not be investigated here, but the ironworks was granted extensive forest rights. The rules of forestry were eased for the ironworks and it was granted exclusive privileges over large areas of forest.67 Even in the 1890s, these areas were still referred to as the “Kumaon Iron Works Company’s Grant”.68

Ramachandra Guha, historian and social scientist, has made important studies of the peasant movements against commercial forestry in Uttaranchal. His focus has been on the first half of the twentieth century, but the general background he portrays is applicable to earlier times as well. Using the concept of cultural ecology he has stressed the dependency of the hill peasant on
forest resources “… institutionalised through a variety of social and cultural mechanisms …” including “a highly sophisticated system of conservancy.”

**Human Cultivation of the Wild**

Henry Ramsay, at that time Senior Assistant Commissioner in Kumaon, dismissed the idea that the forests were disappearing and even painted a vivid picture of man’s struggle against the dangers of an untamed forest. He presented this almost as an ideological support for the exploitation of the forests. It would not only give an economic gain, but was also in part a civilising mission.

> [The] extensive undisturbed jungle harbours so many deer, bears and tigers, that the animals soon become more powerful than the villagers, and the destruction of life and crops becomes so great that the village is abandoned, the waste land before long becomes a forest and its wild animals make their attacks on another village.

Later the Commissioner of Kumaon, John Hallet Batten, repeated this line of reasoning.

> [In many places the inhabitants maintain] a constant war (not always successful) against wild beasts, both those that destroy life and those that destroy food. … the forests of Kumaon and Gurhwal are boundless … inexhaustible … require no human care to preserve them … every encouragement ought to be given to their diminution for the sake of the inhabitants.

A physical artefact recollecting a trace of wildlife is this brick from the now demolished blast furnace of Dechauri. It was found in a heap of broken bricks in the winter of 2000 and must have been a part of the bottom section of Sowerby’s blast furnace. Some time in the late 1850s it had been laid on the ground to dry before firing and an animal had run across it. The print was probably made by a species of wild dog (Canis), possibly a pup. Photo: Peter Nyblom, 2003. Discussion on determination of species: personal information from Olavi Grönwall, Department of Vertebrate Zoology, Swedish Museum of Natural History, Stockholm.
Rain, Heat and Disease

The Dechauri climate caused constant animated discussion. Was it right to place the works in Dechauri? Would the Europeans be able to stand the climate and avoid disease? Would it be possible to keep the works going during the hot, humid summer? Could the hazards be tempered by felling the forest for farming? In Nimar there was no such discussion, although the seasonal nature of the rainfall had to be considered when planning to use water power.

Mitander, Ramsay and Wittenström came from a climate where the seasons determined the yearly cycle of work at an ironworks. During winter, temperatures fell well below freezing point. Rivers and lakes froze and the ground was covered by snow. This facilitated communication, making it easy to cross the lakes and go through the woods on sledges. Winter was a time for transport, of both charcoal, timber and finished iron products. At the same time water power failed and the ironworks lay idle.

In Sweden there were no great seasonal differences in precipitation, but in spring, when temperatures rose, snow and ice melted and filled the streams and rivers with a spring flow that could sometimes be very heavy. Spring was the beginning of a period of intensive work and water was also conserved in dams for later use during summer.72

Precipitation and Temperatures

In Barwah and Dechauri

In Nimar the year can be roughly divided into three seasons: a dry cool winter (mainly October – February), a hot spring-summer (mainly April–June), and a monsoon from June to September. In winter, between November and February, the temperature may fall to about ten degrees Centigrade. In summer, from April to June, noon temperatures reach a peak in May, of 45 degrees or more, while nights are still pleasant when cool breezes sweep down from the Malwa plateau.

The climate is dry except during the south-westerly monsoon between June and September. The average annual rainfall is 965 mm, of which 92 percent falls during this period. However, the variations between years are substantial. It may rain as much as 1,500 mm in a year, or as little as 550 mm.73

The temperature starts to rise quickly in March, and April to June are the hottest months. Heavy thunderstorms may give some temporary relief. During the months of the monsoon, the temperatures are lower, and after October they fall further. In February the average minimum temperature is 11 degrees. During occasional chilly spells, the temperature may even fall to near the freezing point.74

During Mitander’s first summer the rains were long and sometimes heavy. On 25 July 1861 he noted that it was the “first day without rain for a long time. Some work could be done outdoors”.75 That summer he spent three
weeks in Mundlasir, during which time no work was done, solely because of the rains. The summer of 1862 was better, and in August Mitander noted that his work had been stopped for only two days.

He had also noted a very hot spell of several days in April 1861. The temperatures were in no way exceptional, but Mitander moved his bed out onto the veranda and he used an ancient Indian method of cooling his rooms. Water was thrown on a door or on a roller blind made of grass covering the entrance to the room. Work continued without interruption, however, in spite of the heat.

Very hot day. 28 1/2 degrees indoors with water on the grass-door. 37 degrees in the shade outdoors and in the rooms without a watered grass-door. Windy in the evening and rain-like. Had to move my bed inside during the night.

A year later he spent some time during a hot spell in Mhow and Mitander noted how his British friends played a game of billiards, “totally casual in shirtsleeves”.

Mhow is approximately 480 metres higher than Barwah and there was a great difference in climate and temperature. In Barwah there is now a hot wind blowing, night and day, as from a big fire, and it is impossible to sleep indoors. Here there was a pleasant refreshing air and you risked catching a cold if you slept under the open sky as in Barwah.

As in Nimar, rainfall in the Bhabar region of Kumaon was extremely unevenly spread over the year, with approximately 85 percent falling during four months, June–September. At the same time temperatures rose to a maximum in June, with a daily mean temperature of 29°C. In both Nimar and Kumaon the summer months were hot and humid, but in Kumaon the rainy season was longer and the rains much heavier. The Bhabar was known as unbearable and disease-stricken during the summer.

HYDRO POWER

Like in Sweden, there was a direct connection between the climate and the supply of power to the ironworks; the meteorological conditions at Barwah and Dechauri had a direct influence on the technological design of the works. In Sweden there were good prospects of obtaining a steady supply of water power, but in India the likelihood was less. The extremely uneven distribution of rainfall over the year necessitated the construction of dams both strong enough to hold the flood water and big enough to suffice for the dry season. High temperatures also caused a substantial loss of stored water through evaporation.

The Narmada River flows through a long cleft with hilly tracts usually rising along both banks. The combination of a concentrated rainy season,
during the summer’s south-westerly monsoon, and a rather narrow valley with hills on either side gave extreme variations in the flow. Most of the tributaries, such as the Chooral River passing through Barwah, are short and steep, and drain the mountains very fast. In 1853 the Narmada was reported to have risen to a depth of 27 metres at one point, but subsided within an hour or two. The normal depth of the river was about 22 metres during the flood, compared with a dry season level of 1.5 metres.83

In Kumaon the Bhabar area in the lowest foothills of the Himalayas, the lower Siwlakis, exhibit a very specific geology, which was very relevant to its cultivation. Extensive moraine deposits wash down from the mountains to the borderline of the plain effectively drained off much of the surface water coming down in streams and rivers. To counteract this the British set out to build extensive channels that kept and carried the water on the surface for various uses in cultivated fields and villages, including energy production. The masonry-lined channels that still are in use in Dechauri today were thus built partly for irrigation purposes, but also to supply the ironworks with water.

In Dechauri the level of the River Boer subsided dramatically during the dry season and was especially low in April and May. William Sowerby suggested the building of bunds and reservoirs, and also making the most of the supply of water from the masonry channels, the gools, by arranging high falls and large wheels and bringing the water down in well constructed culverts “to prevent evaporation and escape”.84 In 1855/56 bunds were built across the river at the head of the watercourses. They were built of rough boulders and stones and care was taken to provide a solid rock foundation. The bund was built at an oblique angle to the river to lessen the strain when the flow was high.85

In spite of these measures steam power was still going to be needed in the new works in Dechauri, but the use of water power played a part in the physical planning of the new works.86 The slopes and the series of terraces were not only intended to assist the transport of ore and charcoal. Great care was taken to use the power of the falling water more than once and the possibility
of doing this was even an important reason for Ramsay’s choosing Dechauri as the site of the main works.87

The idea of Sowerby and others was to use steam power as a back-up for water power when flow was low. Strachey argued the opposite. He considered steam to be the more reliable source of power and recommended that arrangements might be made “by which the existing water-power might, on an emergency, be made to drive part of the machinery if the steam engine got out of order”.88

“The Pestilent Climate of the Bhabar”

The warm moisture of the summer made Dechauri a good breeding ground for disease of different kinds. Mosquitoes thrived and many people suffered from malaria.

Jory Henwood wrote of the “pestilent climate of Bhabur [Bhabar]” and John Hallet Batten, Commissioner of Kumaon from 1848–56, could not “conscientiously recommend the employment of Europeans at Dechoure in the rains and autumn, or even in May”.89

Thomas Oldham, however, emphatically disagreed with the Commissioner. The unhealthiness of Dechauri was not an immutable fact of nature, he argued, and others agreed with him. Clearance of the forests would make the site less hazardous. According to Oldham the Commissioner had not seen Dechauri since the works commenced. With large tracts of forest cleared, Dechauri would be as healthy as other places in the Bhabar area, successfully inhabited by Europeans.90

Hardy Wells also alluded to this change of climate in a report in 1859, in his usual eloquent style.

If ten years ago any one had proposed to take up his permanent residence in the Loha Bhabur [Bhabar], he would have been looked upon as a madman, as it was considered certain death for any European, twelve years ago, to travel from Moradabad to Nynee Tal [Nainital] during the wet summer months, yet now the most delicate ladies and children travel over the ground under the inducement of ‘getting to the hills’.91

In the early 1860s Wittenström’s descriptions portray Dechauri, and even Kaladhungi, as almost denuded of forests. Julius Ramsay generally confirmed that the Bhabar was an unhealthy area and he wrote that fevers were quite common and cholera was rife.92

Concerning himself, however, he repeatedly stressed that his health was perfectly good. “I myself have never felt as healthy as now”, he wrote home to his friends at the beginning of the hot season in 1862, discussing the poor health of some his friends back home in Sweden. He added that from time to time he felt a little faint because of the heat, which at that time had reached
its peak at 34 to 36 degrees Centigrade indoors. “Otherwise I have nothing to complain about.”

The summer was a season of standstill and this was considered an immense loss to the company. In 1859 Captain Strachey wrote that “…the first element of success in this manufacture is continuity of operations.” And four years later Wells referred to this passage and repeated the message.

That is a very serious warning to the Government, considering that the only object for stopping a blast furnace, properly constructed, is to reconstruct its refractory lining. Some of the furnaces at Merthyr Tydvil have turned out iron for ten years without requiring any extensive repairs.

Ramsay was confident that the situation could be changed, however, and in the very first year he stayed at work in Dechauri longer than anyone before him.

It is only a matter of overcoming old prejudices. When I have managed to get better accommodation ready, I am planning to continue work all year round. Most of the farmers in the vicinity stay the whole year and do not complain about the climate.

It should also be noted that of the very last blows at Dechauri, in the summers of 1878 and 1879, the 1878 blow continued well into the second week of June and that of 1879 was resumed at the end of July to continue throughout August. In this year, the works lay idle for climatic reasons only when the river dried up in late spring.

THE CLIMATE OF NIMAR
AND CENTRAL SWEDEN COMPARED

The climate in Barwah is mainly dry, except during the southwesterly monsoon, June-September. The average annual rainfall in Barwah is 965 mm, of which 92 percent falls during this period. The variation between years is substantial. It may rain as much as 1,500 mm a year, or as little as 550.

There are no exact meteorological observations from Barwah, but the general conditions are said to be similar all over West Nimar. Temperature starts to rise fast in March. April to June are hot months, with daily maximum temperatures in May at 41 degrees Centigrade, or even higher. Heavy thunderstorms can give some relief. During the months of the monsoon, the temperatures are lower, and after October they sink again. In February the average minimum temperatures are 11 degrees. During occasional chills, the temperature can even fall to only a few degrees above freezing point.

These climatic conditions were of course very different from those that the Swedes were used to in Sweden. Godegård, one of the residences of
Monthly precipitation in Godegård, Barwah and Haldwani. Precipitation in Godegård in central Sweden is quite evenly spread over the year, but it falls mainly as snow in the winter months, December-March. In India the effect of the south-westerly monsoon is dramatic. In Haldwani, close to Dechauri, most rain falls during the rainy season, June-September. The same applies to Barwah, where a very dry season extended over at least half a year. These differences over the year severely excluded the possibility of using hydro-power at Barwah. A steady supply of fresh water from the mountains made the difficulties much less in Dechauri.


Monthly temperatures at Godegård, Khandwa and Kalsi. Exact data over temperatures for Barwah and Dechauri have not been found. Instead figures for fairly adjacent communities at similar altitudes have been chosen, Khandwa to represent Barwah and Kalsi to represent Dechauri. This should give a reasonably good idea of the shifts over the year. The high peaks in temperature in the Narmada River valley is in April to May, but the rainfall is limited in this period. In the foothills of the Himalayas there is a combination of heavy rainfall and high temperatures during summer.

Andreas Grill, where Mitander did a lot of work, is situated in the southern part of Bergslagen, the area that was the locus of Sweden’s iron industry. Total precipitation is approximately 650 mm, much below the averages of both Barwah and the region around Dechauri. Another major difference is that in Sweden precipitation is quite evenly distributed over the year. However, the difference in mean temperatures in Bergslagen is dramatic. The daily mean temperature at Godegård rises above ten degrees only during May-September, but it stays below freezing point from December to March. It was these seasonal changes in temperature that determined the yearly cycle of the iron industry in Sweden.

### Summary Discussion

#### Natural Resources Socially Defined

The natural resources available for the Kumaon and Burwai Iron Works were assessed both scientifically and intuitively. There were a number of published reports on the two regions in question, not least on their geology. On the other hand, most important problems had to be solved in practice, by trial and error.

In some cases answers could be quickly obtained, as when Nils Mitander was able to test a sample of ore using methods he had used in Sweden. Most questions were harder to answer and in the case of the resources of charcoal, conclusions were based on qualified guesswork.

Iron ore was found in several places in Kumaon. In the interior, there were deposits of rich haematite that had to be mined underground. In the lower hills, bordering the plains, there were extensive deposits of sedimentary ores with a lower iron content. These were so abundant that enough ore could be picked from the surface. At the same time, the lack of systematic knowledge of the geology meant that there was great uncertainty. The planners had only a very vague knowledge of the total extent of the ore deposits and there were even uncertainties on the iron content of the ores, probably because of the unsystematic way samples were collected.

The estimates of the forest resources suffered from similar or worse deficiencies. Two factors of importance were known: the areas of land theoretically open for cutting and the quality of the charcoal made. But there was one unknown which would be especially important in the long run: How often could the forest be cut down before shortage of timber became a problem? The rate of forest regeneration could not be established by any simple experiment, only by a long period of practice. At both ironworks there were thus uncertainties, but it should be remembered that these would not come into play in the short run. For a while, possibly even long enough to repay investments, the resources would apparently have been large enough. There was ample iron ore, and the forest yields appears to have been calculated
with good safety margins. It can thus be argued that the Kumaon and Burwai Iron Works could have formed a bridge to a future primarily based on coal.

It may be observed that the agenda and the methods of solving the problems were firmly decided by the British and the Swedes. There is no sign, except in isolated cases, of whole-hearted co-operation between the British and Indian ironmakers. The indigenous knowledge of iron ore resources was incorporated into the surveys and local informants seem to have been used. But in general, one may wonder whether the barriers between British colonisers and Indian inhabitants did not mean that a wealth of knowledge and experience was disregarded. The outright appropriation of land and wealth by the British must have militated against any possibility of exchange of knowledge.
PART IV

Projects
in a Global System

Analysing the Kumaon and Burwai Iron Works
in their geographical and social setting
and in a larger context
of dominance and dependence
CHAPTER 10

Social Systems of Production and Transfer of Knowledge

The construction of a social system of production was an inseparable component of the technology transfer to the Kumaon and Burwai Iron Works. Extending the study to the totality of a socio-technical system sets the focus on the social position of Mitander, Ramsay and Wittenström and on the networks of which they were part. It also takes the analysis beyond their role as carriers of a new technology, to the men and women who were to use the new technique.

In the following text I will deal with those whom we meet at the workplaces, the Swedes the British workers and the Indians. What were the characteristics of the social systems at the Kumaon and Burwai Iron Works? How did the Swedes live their lives and what were their positions in relation to other parties on the scene? At what levels of the organisation were the European workers, and which part of the work were they doing? Where do we find Indians? Where and how were employees of the works recruited? How were dominance and subordination reflected in the social system and what was the extent of conflict and co-operation in the three-tier structure of Swedes, British and Indians?

The needs of an industrial enterprise are not momentary or occasional. To achieve a successful transfer of technology a durability is needed in the new totality, a commitment on the part of both carriers and operators of the technology. Was it possible under the ruling circumstances to create a durable social system and a transfer of knowledge at the Kumaon and Burwai Iron Works?

The Swedes and Their Social Sphere

When Richard Keatinge visited Sweden in 1862 he was well aware of the problems awaiting the prospective manager at the Burwai Iron Works. He described the assignment as “the very difficult task of starting an ironworks with the disadvantages of untried materials, untrained workmen, and a tropical climate to contend with”.

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The task at Kumaon was hardly easier, and the Swedes at both works often felt very lonely, both socially and professionally, in the middle of a strange country.

“You might wonder why I talk about loneliness in the middle of a big ironworks, full of people and bustle, but don’t misunderstand me,” Ramsay wrote to his friends in Sweden, “here are indeed 15–20 English workers and hundreds of natives, but they are no company. The only company I have is Mr. Oldfield, my accountant and nearest man, but I sympathise very little with him. There is nowhere in the neighbourhood except Nainital, but that is too far to go to for pleasure. Although it is only twenty kilometres, you need five or six hours to ride up there, so it is impossible to go there to spend a merry evening in pleasant company.”

And in Barwah, some days into the New Year of 1862, Nils Mitander made one of his very few notes on his labour force, numbering them at about 415 employed men and women plus approximately 100 convicts. But all these people were far from relieving his loneliness. On New Year’s Day, only some few days earlier, Mitander had made one single note in his diary: “In my usual solitude. Four elephants passed through this morning.”

It was a somewhat contradictory picture the Swedes gave of their lives in India. As professionals, practising engineers and managers, they were full of energy and confident of being able to cope with the technical problems encountered. At the same time they depicted themselves as lonely outcasts – despite their bustling workplaces. The solitude Mitander and Ramsay wrote about was a search for equals.

But a closer perusal of the notes of the Swedes gives a slightly different picture of their place in society. Their social network was more tightly knit than first apparent. Both were part of formal and informal webs of contacts, which they tried to maintain, strengthen and extend.

The closest confidants of Nils Mitander were Richard Keatinge and his wife. The Major was an enthusiastic and caring employer who did everything he could to make the lonely Swede feel comfortable and at home. “He is remarkable”, Mitander wrote of Keatinge, “thinking of everything and remembering everything. For example, he sent me eleven orange trees to plant in my garden the other day.” Mitander could even write to Mrs Keatinge and tell her about Emil, a young relative, now seven and able to read Mitander’s letters. “I think it will please her as much as it pleases me,” he recorded.

The great importance to Mitander of both Mr. and Mrs. Keatinge, personally and professionally, became apparent when Richard Keatinge was appointed Political Agent in Gwalior in March 1862 and had to move from Nimar. It was a blow to Mitander. “Nice letters are needed now”, he wrote in his diary, “Many letters from friends, cheering me up in my great concern.”

A conscious effort was made to create the same kind of relationship between Mitander and his new principals as had existed between Mitander and
Keatinge. “I shall always be ready to help you or the works”, Keatinge wrote to Mitander.7

Keatinge also wrote to both Bombay and Calcutta, suggesting that Captain Melliss of the Bombay Staff Corps, and Executive Engineer of Mhow Division, should take over responsibility for the supervision of the works, and on his departure Keatinge wrote a comprehensive summary of the works and laid down the general outlines for their future management.

[Mitander] is an able and honest and an industrious gentleman, but his knowledge of engineering in India, of the materials, and the people of the country, is of course very limited. I fear that, unaided, he would experience very considerable difficulty in overcoming an unexpected obstacle, or in managing a large body of native workmen. ... He is anxious to do this work for the work's sake, believing as I do, that the establishment of an ironwork on the Swedish model may prove an event of importance in the history of the Nerbudda valley. 8

Captain Melliss did his best to smooth the change. He sent Mitander three flower pots and at the same time asked him to go up to Indore to meet the new Agent to the Governor General for Central India, Major Meade. Melliss noted that Meade was said to be very interested in the ironworks and wanted to speak to Mitander. “In advance I am a little proud of this distinction. I have every reason to hope that it will lead to something good."9

All this helped restore Mitander’s confidence, and he repeated that “everything looks reasonably bright again”.10

Mitander’s closest British friends lived in Mundlasir, half a day’s ride or approximately forty kilometres away, and in the regimental town of Mhow some twenty kilometres further on. Sometimes his acquaintances visited him and he himself went regularly to both Mundlasir and Mhow. He reported on the progress of his work to Richard Keatinge, but also enjoyed relaxing in the company of his new friends. They hunted, swam in the river, watched games of cricket, played billiards – and listened to music outside the library in Mhow. They took pleasure trips on the Narmada in a new steamer and in order to feel more at home in society Mitander even ordered a new dress suit from Messrs Watson and Co, tailors in Bombay, to replace the one that disappeared en route to India from Suez.

At the beginning of May 1862, he spent a couple of days in Mhow.

Visited Captain Glasspoole and the officers’ mess of the 4th Rifles. Few of my former acquaintances were there, as many were out on a tiger hunt. Colonel Manson was very polite and talkative. After dinner everyone gathered around the billiard table: The Colonel, the Captain and the Lieutenants all together, quite casual in shirtsleeves. ... At dusk I heard music from one of the regiments, as always delighted to hear the last piece, God Save the Queen to the same wonderful tune as our Swedish folk song.11
Compared with these relatively close and informal contacts Julius Ramsay’s interaction with the British at Dechauri and Nainital was considerably less confident. Ramsay wrote very little on the kind of gentlemanly gatherings in which Mitander participated, and instead women seem to have dominated his social ambitions.  

After six months in Kumaon Ramsay deplored that he only a few times had been in the company of women, twice in Nainital and once in the neighbouring small Bhabar town of Haldwani.

Twice Mrs. Ramsay, the wife of the commissioner, briefly visited Dechauri. Ramsay described her as “a small, high-class lady, recently back from England, where she put her children in a boarding school. She was very interested and found everything [at the works] ‘very nice’.” These visits were from another world, and Ramsay regretted that he could not expect such visits more often, because of the state of affairs at Dechauri.

Such distinguished visitors always come riding on elephants. … Strangely enough the European women cannot do without their beloved crinolines, even when they ride elephants in the jungles of India. I cannot understand how they do not realise how ridiculous they make themselves.

During the working season his contacts were rather few, but in summer, when Ramsay had moved up to Nainital, he came closer to society and the fifty or sixty British families that lived up there. But he disliked British rituals, the need to be a man of good breeding and the necessity to make formal social calls. It was not enough to have introduced oneself to a lady when meeting out of doors or at a ball. Such an acquaintance was subsequently totally ignored, and Ramsay could not bring himself “to run about calling upon all the ladies in the station.”

Instead he longed for home and he wrote to his friend Petre that he sat in his “dark, uncomfortable and dirty rooms” and imagined a ball in a splendid hall back home. He saw his friends dancing and …

… most of all, a number of young, merry and beautiful women, who spread an enchanting grace over the scene. If you, as I, did not see or have any opportunity to speak to a woman for months, you would esteem their company as much as I do. The only women I have the chance to see are these half-naked, blackish brown Indians, who are so abominably dirty and ragged, that they only evoke disgust at all women. The wives and daughters of wealthier Indians are probably better, but you are not permitted to see them. They are under lock and key.

THE SWEDES IN AN INTERMEDIATE POSITION

The position of the Swedes was somewhere in between the British colonial masters and their Indian subjects, and the sources depict a complicated ambivalence on the part of the Swedes. In spite of Mitander’s close and some-
times affectionate relationship with the British he retained a fundamental uncertainty about his position in colonial India. In an entry in his diary in the spring of 1862 he wrote:

However, everyone tells me that whoever has overall responsibility at Burwai, I may rest assured of all possible courtesy, particularly as I am not an Englishman, but a totally lonely stranger in this country. (Mitander’s italics)

The Swedes were at times deeply critical of the British, but basically they shared a cultural background that was in many ways similar and familiar. Ramsay, in particular, as illustrated earlier, had a derogatory and somewhat racist view of Indians, but it was not unambivalent. At times, at least, he combined it with a kind of affinity for the Indian subjects of British power that sometimes bridged basic differences of class and culture.

Wittenström’s photographs may be seen as an illustration of the middle position of the Swedes. Most of them depart from what could be considered the typical agenda of colonial photography, which reflected and reinforced “the cultural interests, privileged viewpoint and social prejudices of the imperial ruling class.” Wittenström’s pictures depict work in progress, show different parts of the works in landscape views, and portray not only the Swedes themselves or the Britons, but also Indian employees. These latter portraits reflect a relationship or even some kind of accord between the objects of the photographs and the photographer. The Indians pose confidently and proudly on the step of Ramsay’s bungalow in Dechauri. And there seems to have been no hesitation on the part of Ramsay in posing with his subordinates. His position is marked, above and behind, but they are also close together. At the same time, on other photographs, the British employees look rather like shadows, heavily marked by a hard life in exile. Wittenström’s pictures stand out as extraordinary in relation to the mainstream of Indian photography of the time, which depicted buildings of age or imperial importance, ancient objects or portraits of Indians either as romanticised Orientals or as scientific specimens.

Other sources also give evidence of a remarkable openness to Indian culture – but also of prejudices and preconceptions.

It was with a surprising self-assurance that Mitander travelled from his frosty native land, into a strange world. One day in March 1862 he described at length how he had visited a “native wedding” and his diary shows a readiness to absorb, to see and to meet India. In spite of “smelly oils” and “wailing music” he described the occasion with a kind of respect and when he felt uncomfortable it was not simply the fault of others. Mitander did not adopt a scornful or supercilious attitude to the unfamiliar. He also laughed at himself, as when he set off homewards from the wedding.

All the time I was fanned from behind and my shock of hair, which has now gone uncut for two months, being fairly long, flew in all directions.
Julius Ramsay, with some of his men.
Julius Ramsay, approximately 36 years old, sitting on the steps of his bungalow in Dehauri with some of his workmen. Photo: Gustaf Wittenström, C15058.

Three British workmen. Mr. Russell, Mr. Edwards and Mr. Louis. Photo: Wittenström, C15249.
and was a great nuisance. I had men carrying torches as company as I rode home in the night. 20

Ramsay, for his part, was very critical of the role of the British in India “What do they think they can accomplish in India, and by what right have they intruded in this country?” he asked in a letter to Nils Mitander in the summer of 1862. 21

They themselves admit, without hesitation, that they govern by force and will probably never be able to introduce Christianity or European civilisation. Their tenacity and above all their national vanity stops them leaving India. They will continue to send out thousands and thousands of young men to endure a dull life here. It is pathetic to learn of their deadly monotonous life and their “hopeless views” of the future. Their only hope, which is seldom realised, is to return home, but if they do return, it is often only at the cost of a health broken forever. 22

Six months later, he appeared confounded by what he met in India. He saw clearly the foreign yoke, but could find no rational explanation of why the Indians did not revolt. He seemed to have forgotten the great uprising quelled by British forces only a few years earlier.

All Oriental people must more or less lack the ability to govern themselves and thus also the love of independence that distinguishes the European races. How else can you explain why Hindus can patiently bear the foreign yoke and submissively consider every white man their Master. Another explanation is that for centuries the country has been divided and oppressed by domestic tyrants … The English government tries to be fair and to levy moderate taxes, never to resort to random extortion, so the people will begin to recover. 23

Racist or not, Ramsay apparently saw racial characteristics as subordinate to ordinary conflicts of class and power. He saw clear limits to British domination.

In the long run I doubt whether this system can endure. The differences between the two peoples are too big. The whites will never treat the natives as their equals and the latter will sooner or later grow tired of being constantly humiliated. … [Today] the most distinguished and well-educated man, if he has a single drop of black blood in his veins, must defer to the crudest English soldier. 24

In the same letter home Ramsay even expressed the view that the only benefit that England could derive from India was to use it as a gigantic reservoir for its own excess population. Every year, thousands came to India who never returned home, he maintained, and at home in England it was so crowded that they were not even missed! 25 Life in India was strenuous and according to Julius Ramsay few soldiers could ever return to England after their service

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in India. To his friends in Sweden he wrote that a tenth of the soldiers in every regiment died every year.26 He saw the despairing fate of some six or seven hundred sick at the recovery camps and hospitals of Nainital. “It is really too bad to see these pale, gaunt figures dragging themselves along. A large number of them are sent home each year, but most have no prospect of ever leaving this country.”27

Mitander hardly ever showed any dislike of the British. His relations were mostly good, and there are only a few examples of the opposite, as on two occasions when he was bluntly patronised by British guests. While he was still living in the state bungalow he one day returned from work at Nandia and found the bungalow occupied, without notice, by Doctor Scott, Inspector General of Hospitals, and Mitander had to return to his tent to have his meals. The next day he showed Scott around, but he was never presented to the “lady” Scott had brought with him and whom Mitander heard singing while he was in his tent.28 On a later occasion a hunting party of four British officers, led by Lieutenant Walter, arrived. Mitander treated them to beer, tiffin, coffee, soda water and dinner. “A thirsty and hungry company,” Mitander observed. “Otherwise not very agreeable. Squabbling all the time.”29

A LINK TO SWEDEN, MAIL AND LETTERS

Apart from personal meetings a regular correspondence was both Ramsay’s and Mitander’s main means of communication – at times there were daily messages between Mitander and his boss Richard Keatinge. Letters also provided the only contact with Sweden, the place on earth that held their hearts and was the cradle and core of their professionalism.

In India Mitander and Ramsay also corresponded regularly with each other, exchanging news of their own work as well as from Sweden, including papers and magazines from home.30 To keep in touch with Sweden they were dependent on the British mail carriers coming in by sea to Bombay. The letters from home often came several at a time, when a ship had called at the port, normally once a month. In this way news was also brought in by papers and Mitander could, for example, be informed of what was happening in the American Civil War.

Mitander’s and Ramsay’s correspondence with friends and kin in Sweden was a way of keeping track of social happenings and family, but it was also a way of keeping informed of news within their profession. When Mitander’s friend Mårten Waern wrote to him, the only note Mitander made in his diary was the price of pig iron from the small ironworks at Persberg in Western Sweden.31 He sent blueprints to Andreas Grill, but also, at the same time, jotted down a brief comment on his recollections of the formalities of social life in Kristinehamn.32

For both Swedes the correspondence home was an absolutely essential part of life, a kind of link with the past and future, and the letters Mitander
longed for most were his letters from his beloved family, his mother, fathers and sister.

On 3 December 1860 Mitander mentioned his work at the mine in Nandia and a newspaper sent from Richard Keatinge “but letters from Sweden, much longed-for – none!”33 Twelve days later his desolation turned to happiness. “Letters from home, from Mum and Louise what inexpressible joy!”34 Ramsay on the other hand got to know the essentials of social events at home through the East India Letter Company, with which he and a close circle of friends amused themselves in an almost institutionalised manner. Letters of a more private character, to and from his family, are missing in the archives.35

**ENGLISH – A FOREIGN LANGUAGE**

At a more formal level, Mitander had to deal with the very top of the colonial hierarchy. The Burwai Iron Works was a concern not only of the Public Works Department and the Government in Calcutta, but also of the Home Government in London. With both a personal and a bureaucratic control, which created a climate very different from the almost total freedom to organise their daily work which Ramsay and Wittenström enjoyed in Dechauri, the authorities wanted to keep a close watch on all developments at Burwai. Mitander’s notes abound in references to reports, inspection tours, correspondence and discussions. In September 1861 the Public Works Department demanded monthly progress reports, including a summary of accounts. Some months later a compromise was reached, however, and Mitander was asked to submit reports only quarterly.36 The co-operation – and friendship – between Mitander and Richard Keatinge was a big help with these formalities and when the forms for presenting accounts caused trouble, the government even allowed Keatinge and Mitander to show income and expenditure in the manner they found most convenient.37

There was nothing of the same surveillance at Kumaon; for better or worse Ramsay was not subject to the same bureaucratic control as Mitander. At the same time there was a void and a freedom of choice that may have led to plans that lacked economic realism. Richard Keatinge gave Mitander great support on questions of engineering, logistics and the intricacies of colonial politics. Ramsay grappled with all these matters practically alone.

Almost inevitably, the different native tongues of all involved created barriers that reinforced differences of class and religion – or obstructed communication between the Swedes and their superiors. English was a foreign language to the Swedes, a difficulty they might overcome with some ease – or hardly at all. Among the Indians the prevailing language was Hindi, but Urdu was also used. Language was an obstacle in their daily work – and in the communication of knowledge.

Mitander’s knowledge of English was limited, at least to start with. In a note on an order for monthly reports from the Burwai Iron Works Keatinge
wrote that Mitander: “can now write English quite well enough for this purpose, and You will, I know, excuse any slight errors.”

But Mitander himself found it difficult to use English.

The Major was very satisfied with my report (very good). This pleased me a lot: I have always been a poor and slow writer … the annual report to Jernkontoret, in my native language, was always ready at the last moment and of little value. How much worse a report in a strange language; now, however, it is completed, but the same thing will come again every three months.

Reading books was one of Mitander’s spare-time pursuits, and it is not hard to imagine him sitting on his porch with a lamp in the blackness of an Indian night, broadening his knowledge in general, but also increasing his knowledge of English. He read Sir John Malcolm’s *A Memoir of Central India Including Malwa and Adjoining Provinces*, published in 1823 and a classical reference book for Central India. He read *Uncle Tom’s Cabin*, first published in 1852 and considered to be the first best-seller in America. When Mitander read it, it was not only moving but controversial and topical at a time when slavery was not yet abolished in America. And with special pleasure he noted that he had read the account of the travels of a Horace Marryat, who had spent a year in Sweden, *One Year in Sweden, Including a Visit to the Isle of Gotland*.

By comparison with Mitander, Ramsay seems to have crossed the language barrier with some ease. His life was so dominated by English that sometimes he even started his letters to friends in Örebro in English. One such instance was only nine months after his arrival in Dechauri. It may have been a way of showing off, but it seems very genuine. Wittenström’s difficulties were far greater. He was not a very good writer, even in Swedish, and Ramsay wrote that Wittenström “would be able to accomplish twice as much if he was not so poor at English”.

The Complexity in the British Presence

As will be shown below, there were barriers and friction between the Indians and the British. From the Kumaon Iron Works there is also ample evidence that internal tensions between the Britons involved, sometimes caused by the incompetence of some of them, could be a serious threat to the success of the projects. There were innumerable lengthy disagreements over the management of the works between different British parties. The causes of conflict were many, from differences of opinion on financial calculations to personal antagonism, from general policy questions concerning the future of the works, to practical everyday matters.
One example of strife and conflict among the British, originating in a technical failure, occurred when the water wheel in Dechauri broke down in 1860.\textsuperscript{46} The incident meant the end of government ironmaking in 1860, before the transfer to the \textit{North of India Kumaon Iron Works Company Limited}, and therefore attracted great attention. Extensive interviews and inquiries took place, almost taking the character of a court trial with cross-examinations.

The breakdown occurred early on a Sunday morning in March 1860. From the beginning there was a strong suspicion of sabotage. Statements were taken during the spring, but as work was in progress and an investigation could “excite ill will” between William Sowerby and his workmen, it was postponed until summer, when work was normally at a standstill. Commissioner Henry Ramsay interrogated witnesses personally for three days at the end of June and again a month later.

Top officials and foremen were questioned: the Manager William Sowerby, the principal furnace-keeper Mr. Cresswell, the furnace-keeper Mr. E. Bird, the foundry-keeper Mr. J. McDougal, the engineer or fitter Mr. E. Heslop, the pattern maker Mr. Liddell and the clerk, Mr. Gunga Dutt. The native enginemen had left the site for the summer, and could not be questioned.\textsuperscript{47}

William Sowerby argued that the breakdown was due to “malicious attempts” at sabotage. He maintained that an iron bolt had been thrown between the cogwheels and stated that he did not suspect anyone in particular – but asserted that generally there was much jealousy of his works and himself from others engaged in similar pursuits in the neighbourhood. Since the only similar project in the whole of Kumaon was Rees Davies’ in Kaladhungi, this was an accusation that Davies was “the strange European” who allegedly had entered the wheel-house some time before the breakdown.

Thomas Oldham, head of the Geological Survey and official observer at the Kumaon Iron Works, had been sure of a different explanation since the spring: Sowerby was only trying to cover up his own incompetence. The cause of the accident was bad design, Oldham argued, basing his opinion on several of the depositions. Mr Liddell, the pattern-maker, described how the wheel had been “striking against the masonry, the bolts were always being ground down. At last the joinings opened, and the wheel went to pieces.”

Oldham summarised: the wheel was “too broad for its pit, was too weak, and was highly faulty in design”.\textsuperscript{48} Not only was it badly constructed, having needed repair several times before the final breakdown, but a bolt of the size described by Sowerby could never have caused the damage. Some months later Oldham wrote not only that Sowerby had lied, but that “Sowerby’s attempt to induce others to join him in such a statement appears to me little, if at all, short of an attempt at conspiracy to deceive the Government”.\textsuperscript{49}

He called Sowerby’s answers “a tissue of the most transparent quibbling”.\textsuperscript{50} The evidence given seems to be convincing. Whatever actually happened,
the investigation clearly reveals not only severe technical problems, but serious conflicts.

No one in the history of the Kumaon Iron Works was more thoroughly criticised than William Sowerby. In 1859 Rees Davies was reported to have said that Sowerby did not know anything whatever about ironworks, except what Davies himself had taught him, and the deep rift is confirmed by the investigation of the failure of the waterwheel in 1860. Thomas Oldham, prior to the final dismissal of Sowerby in the summer of 1862, summarised the situation.

Government has been in all this matter most seriously misled, and I am unwillingly compelled to add that they [the estimates on the possible profitability of the ironworks] are such as prove to my mind conclusively that the person making these Estimates in the first instance had not mastered even the first elements of the knowledge he claimed to possess.

Another kind of incompetence and deception was attributed to William Gower. He was in charge of the works at Ramgarh and was dismissed after being found “guilty of gross misconduct in retaining several sums of money due to workpeople”. And nineteen years later severe criticism was again voiced, during the last effort to resume ironmaking in Dechauri. Mr. Campbell, Superintendent of the Canal Foundry at Roorkee and in charge of operations, was described as “practically ignorant of the work he has undertaken”.

Ramsay’s dissatisfaction with the directors of the company could also be scathing. At times their perception of facts differed, at times personal antagonism led to open quarrels. Collectively Ramsay referred to them as “… English gentlemen, of which this country can show so many unsuccessful specimens” and in April 1862 he wrote that “[m]y relations with the directors are already tense.”

New Technology
and a New Social Organisation

The blast-furnace route of making iron demanded a new social organisation. Whether it was William Sowerby’s older furnace or the new ones planned by Ramsay, Wittenström and Mitander, the new technology demanded a larger scale of production than ever previously attempted in traditional Indian ironmaking. This in turn demanded a larger supply of fuel and iron ore, and heavy investment in the plant itself and in all the infrastructural arrangements. The new technology meant increased productivity, and it needed a lot of workers, some skilled, but mostly unskilled. All this meant a substantial division of work and required a great deal of planning. The new methods of making iron called for a new organisation of work.
The close relationship between technology and social organisation thus indicated has been called a technical imperative. The concept may be questioned as implying a one-way dependency and disregarding the dialectical, reciprocal interaction between the technology on one side and social circumstances on the other. In the transfer of the blast-furnace technology to the Kumaon and Burwai Iron Works there were certainly demands that were very close to imperatives embodied in the technology. The blast-furnace route would never have been contemplated without continuous production and the larger scale. At the same time there was certainly a close interaction between the realms of technology and society.

There were two phases of work at Barwah and Dechauri, an initial phase of construction and a second phase of ironmaking. The second was of course the goal of the projects and in part it never became a reality.

The initial period of construction was transitional but iron production was to continue hour after hour, day after day, preferably all year round. In both phases the ironworks sites themselves were only the central core of the total socio-technical system of work. Two new communities were built, with the ironworks at their heart, but with a totality encompassing all aspects of human life. During the construction period an array of different products were needed to complete the works, from stones for masonry – of local origin – to machinery and tools imported from England. When iron production started, the blast furnace devoured iron ore, lime and charcoal. It needed a steady supply and a big supporting structure. A system of subcontractors was organised. In this way the works affected big areas and many people.

In order to permit sustained production, either all the details of the ironmaking in a modern iron mill had to be taught to Indians, or a staff of British workers had to be imported, prepared to stay not only the first year, but also the next and the following year. In both cases the employees had to be committed to their tasks and a durable social system had to be created. A functioning transfer of knowledge required the coinciding interests of the teacher and the student, and a social and cultural set-up that permitted a meeting.

THE OPERATORS

- WORKERS AND WORK ORGANISATION

It has not been possible to establish a full and comprehensive picture of the number of people working for the Kumaon and Burwai Iron Works, either in the construction, or in the production phase. The information on the number of employees at the sites themselves is fragmentary and the uncertainty is even greater concerning the whole system of production, including the supply of raw materials.

The works consumed large volumes of raw materials and in the totality of its socio-technical system the number of people needed to provide the supplies of lime, ore and charcoal was far greater than the number of employees.
at the works themselves. An indication of how much purely logistical work, fetching and carrying, there might have been is supplied by the figures on the workforce at the blast furnace itself. Although work here was comparatively mechanised and supervised, 14 of Ramsay’s 22 blast-furnace workers in 1862 were coolies, that is ordinary unskilled workers engaged basically in bringing ores, charcoal and lime from the stores at the works to the furnace, and taking iron and slags from it.

Figures from other periods of the history of the works vary considerably. William Sowerby had more than 300 persons employed only one month after starting work on the Kumaon Iron Works in 1855. In 1859, 17 Europeans were employed and William Sowerby estimated the number of common labourers at 1,200, including charcoal burners, but excluding woodcutters. During the six weeks when Sowerby’s furnace was in operation in the early spring of 1860 the workforce at the blast furnace was usually between thirty and forty coolies, four smiths and two water carriers. In January 1862, Julius Ramsay listed the employees as one accountant and assistant manager, one native accountant who knew English, four other native accountants, six supervisors, four tool supervisors, 10–12 blacksmiths, 24 carpenters, 40 masons and 150–200 coolies. Six months later, in June 1862, he needed 22 men to run Sowerby’s blast furnace, with the employees divided between one day and one night shift. In December 1862, when the construction of the new works was well under way, Julius Ramsay estimated that there were “2,000 workers of all kinds”. This was the highest figure ever given and it is not known how it was arrived at, or whether it included or excluded employees of subcontractors.

For the Burwai Iron Works the material is even scantier. No detailed cash accounts for the project have survived, only very general summaries of expenditure broken down according to final use at the works: iron ore, transports, machinery etc.

Regular pay days are noted by Mitander. At the same time contractors were used for many tasks. At least ore and charcoal were delivered on a contract basis and in January 1862 it seems that a contractor was used to prepare one of the roads for the transport of iron ore from Mitanderpoor.

Most of the work of mining, woodcutting, charring and transport was done by subcontractors, but details are extremely sparse. Ramsay, for example, refers only briefly to the supply of charcoal in his report.

Everything is brought in by contract workers. I have already signed contracts for not insignificant amounts of ore and lime, coal and firewood, timber, planks and boards, brick, cut stone and masonry sand. Each individual worker does not do much good, but the number of them has to make up for this.

According to some brief notes at the closure of the Burwai Iron Works project the creation of a subcontracting system had been difficult. The effort put into the build-up of an organisation for procuring charcoal was even advanced
as an argument against abandoning the project. It was pointed out that it would be difficult to rebuild if it was demolished. This complicated network of subcontractors was only established with great difficulty.

THE PAYROLL IN RAMSAY’S PLANS

Since no payrolls or the like have survived from either of the works, it is hard to be sure of the exact composition of the workforce at any one time. Instead an estimate of the future of the Kumaon Iron Works, compiled by Julius Ramsay, can be used to draw a picture of the social organisation at an iron-works (Appendix 2). The estimate is not a description of a situation that ever existed, but it serves to describe the general set-up. There is no real reason to believe that this estimate differs significantly from general conditions of employment that already prevailed at Kumaon, at least as far as wage differentials and employment periods are concerned. Ramsay’s estimate should give a picture of both what Dechauri was – and what it was intended to become.71 The estimate not only reveals the scale of the new works, but also gives valuable information on the social system there.

Ramsay’s estimate was that there would be 118 Indian employees at the blast furnace and 287 in further processing. The foremen, furnace keepers and smelters, mechanics, puddlers, balers and rollers, 24 in all, would be European. In addition there would have been a managerial staff of six European officers and approximately twenty in the native establishment.72 In total it was planned that there would be thirty Europeans and 425 Indians. If the production of pig iron had been increased, using Ramgarh ore, the refining section would have been extended and 146 more employees would have been needed, in that case making the grand total 601.

A HIERARCHY

As Julius Ramsay envisaged it, the Kumaon Iron Works would have different categories of employees, distinguished by level of pay and form of employment.73

At the top of the hierarchy would be Europeans, employed in the highest decision-making positions, as manager, engineers and administrators (six people in the future works). All were to be employed on a permanent basis and paid the same monthly salary all year round (the manager 1,000 rupees per month, the engineers 600 and the forest superintendent 400). Ramsay called his own conditions of employment “very favourble”.74 The 24 British craftsmen in middle positions constituted a next category of employees paid between 100 and 250 rupees per month and employed all year round.

Two groups can be distinguished among the Indians. A minority of them, 178 in number, would be employed all year round, but their pay would be reduced to one half during the five months of standstill in the summer. These
were the men who were to have some working knowledge of importance. They were rather harder to replace and the company wanted to retain them from season to season. One third of the annually employed Indians – masons, blacksmiths, carpenters and bookkeepers – in all, would be comparatively better paid, fifteen or twenty rupees per month during the seven working months. The other hundred workers would get eight or ten rupees per month.

Besides these two big groups were two moonshies (interpreters, writers) and two chokidars (watchmen) to be employed on a monthly salary of twenty and five rupees respectively, all the year round.

The last category, at the bottom of the hierarchical ladder, were common labourers, to be employed and paid only for seven working months. Their pay was to be only four to eight rupees a month.

The salaries thus show immense differences that reflected, created and reinforced social barriers. The manager would receive 12,000 rupees a year, the engineer 7,200 rupees and a European worker like a puddler or roller 2,400 rupees. The Indian workers would get from 56 rupees for seven months of work up to about 300 for a whole year. Or, put in another way, one European roller would earn as much as of 33 of his helpers, without counting the fringe benefits, such as housing, of the European employees.

Turning to Burwai Iron Works, we know very little about stratification of the kind revealed in Ramsay’s plans, but here too there were Indians in important middle positions, as links between the managers and the workmen.75

At both works the social gradations were also manifested in sometimes slight, but always visible, differences in the form and planning of residences. At Dechauri, Wittenström’s photographs help us form a picture of the social landscape. Ramsay and his accountant relaxed in spacious bungalows while the rank and position of others could be read all the way from the lofty houses of British workers up on the hillside to the hut of the common Indian coolie.
At Barwah, not much remains to be seen and there are no pictures from the time, but it is known that Mitander’s bungalow was much smaller than Ramsay’s. In a letter to Ramsay, Mitander even expressed some dissatisfaction with his lot. The bungalow was still big enough to mark his position. It cost 2,714 rupees to erect Mitander’s residence, while 415 rupees was enough to pay for the building of sheds for 100 prisoners. Like the bungalows in Dechauri, the residences of Mitander and his chief engineer were well situated, overlooking the works.

Both Mitander and Ramsay thus enjoyed quite a good standard of comfort. Ramsay had the help of a staff of six or seven servants – although he lamented the fact that together they could not do more than his “dear Christina”, apparently a housekeeper, did at home in Sweden. Six personal

“In the cool breeze. Residence of the British workers, placed on the hillside above the ironworks. During the hot season every metre gained in height was important, less humid and cooler. Photo: Gustaf Wittenström, C15060.”

“In the cool breeze. Residence of the British workers, placed on the hillside above the ironworks. During the hot season every metre gained in height was important, less humid and cooler. Photo: Gustaf Wittenström, C15060.”

“Weft for the Indians”. Wittenström documented three very different kinds of housing, each with its distinctive marking of social position. The grass shed of Indian workers, the stone houses, higher up the hillside, giving the British furnace workers better living conditions, and the big bungalows of Julius Ramsay and his accountant, a couple of single Europeans managing the works. Photo: Gustaf Wittenström, C15064.”

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aides cost him 40 rupees a month: one sirdhar (bearer, domestic servant), one konsomah (most commonly house-steward, but Ramsay used this term for his cook), one dobie (washerman), one seiz (ryze or scise, horse-keeper) one metar (sweeper) and one bisther (bheesty, water carrier). And although, as will be seen below, Mitander’s bungalow was smaller than Ramsay’s, he had an even bigger staff of servants, a total of nine.

THE RECRUITMENT OF SKILLED WORKERS

The recruitment of a sufficient number of labourers and skilled workers was often a pressing need at the ironworks. Time and time again, the subject is mentioned and major setbacks at the ironworks were attributed to the shortage of skilled workers. Henry Drummond stated the problem as early as 1855. He saw it as having two parts. First there was the matter of recruiting enough labourers.

One consideration yet remains to be noticed, namely, the command of cheap labour. This has been found a serious obstacle in other countries where iron ore abounds, as in Australia, the Cape of Good Hope, and parts of America. Here, on the other hand, we have native miners and smelters, the latter being well acquainted with iron and the first rude modes of making it; they also display considerable dexterity when working, and readily comprehend anything that may be suggested to them. Of ordinary labour we have an unlimited supply.

Secondly there was a need for skilled workmen. There would require, however, to be introduced into the country properly qualified head-workmen from Europe, for superintending the different departments of labour. The selection of these superintendents is a matter of the most vital importance, as on them in a great measure depends the success of the undertaking. Every precaution will therefore be necessary to secure good men.

At the Burwai Iron Works information on skilled workmen is generally very rare. Now and then the need of British craftsmen was noted and apparently Richard Keatinge made efforts to recruit them. In the spring of 1862 he tried to procure a foundry worker and at the same time he engaged an apprentice in the Indian Navy, Benjamin Nobb, as mechanic.

The need for experienced helpers was mentioned more frequently as the time for the first blow approached. Mitander received a letter from Julius Ramsay in Kumaon who said that he could not understand how Mitander could plan a blow without a British furnace keeper. Indians were not to be trusted with this work and the art of blowing a blast furnace was not learnt in haste. Mitander himself wrote that he had “too many irons in the fire” and that he could not blow the furnace alone. His ambition was to get an
assistant, and in case of continuous blows all year round, it would pay to bring a furnace keeper from Sweden.\textsuperscript{85} Two weeks later four foundrymen arrived.\textsuperscript{86} Their efforts were apparently not sufficient, and when Mitander reported on the first blow, he wrote that “inexperienced workmen were . . . the cause of our lack of success” and this explanation seems to have been accepted by most observers. The lack of trained hands was said to have been decisive, indeed the only reason.\textsuperscript{87}

Had there been at that moment but four, or even but two, trained European furnacemen this failure in all probability, could not have occurred and the Indians could have been taught to handle the process.\textsuperscript{88}

The difficulty of procuring skilled hands reflected the lack of an infrastructure of metallurgical knowledge outside traditional ironmaking. This explained the price the Kumaon and Burwai Iron Works had to pay in order to procure experienced workmen.

William Sowerby was one of many who complained of the difficulties. The kind of work to be done was new to India and no preparations had been made to obtain either workmen or tools.\textsuperscript{89} One of the conditions Julius Ramsay laid down for continuing his work was money to employ a larger number of experienced British workmen.\textsuperscript{90} “A great deal of my time here has been wasted due to a lack of capable workmen”, he said.\textsuperscript{91}

This opinion marks a definite intention to include Indians in the skilled workforce – as far as it was possible. It was considerably dearer to employ British workmen, even if any one of them was equal to ten or more Indians – as was sometimes maintained.

Some workmen were brought directly from England or Wales, but the number who wanted to come to India was limited and in some cases Ramsay had to employ British soldiers, formerly employed in the iron industry back home. The company supplied the funds necessary to buy them out of the army and for Ramsay to sign new contracts with them. This was apparently not the best of solutions.

It was not long before I learned that the recruited soldiers are the worst lot of riffraff, because you cannot control them even with the firmest discipline. I was soon forced to discharge three of them for drunkenness and the bad example they set. Three others ran away after getting up to their ears in debt to neighbouring merchants. In the end I had only five British workers left, who had come from Wales, and were excellent fellows once one in their team, who was drunk and aggressive, had left.\textsuperscript{92}

India was probably like exile to many of the British workers, especially those who were recruited from the British armed forces.\textsuperscript{93}
recruitment of unskilled workmen

The erection of the first trial plant at Dechauri was begun in great haste in the late autumn of 1855. During these first few weeks, trees were felled and squared for machinery, the foundation for the furnace was dug, bricks were made, stone was quarried, walls were built, and the foundation of the water wheel was cut and laid. The number of workers grew very fast and new employees entered the ranks almost daily. Starting from nil at the end of October William Sowerby had 260 employees one month later (21 carpenters, eight sawyers, 36 stonemasons, two blacksmiths, ten brick-makers and 182 coolies). Over one single weekend, from Saturday 17th to Monday 19th November, the number of coolies doubled, from 99 to 181. In this period Soverby was reported to have spoken very favourably of the labourers who had worked under him. It has not been possible to find out from where the workers to the Kumaon Iron Works were recruited. The provinces of Nimar and Kumaon were, like
the rest of India, predominantly agricultural, but closely linked to this was a section of the population who were engaged in metalworking. In a Kumaoni census of 1872 there was a big group classified as *Lohars*, blacksmiths. Blacksmiths were employed at Dechauri and it is highly probable that these men were experienced and already practising the trade, but there is no evidence that either local miners or ironworkers were employed at either of the works.

A very special solution to the problems of procuring labourers was found at the Burwai Iron Works. Here Mitander was given a sizeable contingent of convicts to work for him. Keatinge had earlier reported that the rate of sickness at the works was high and that the need for labourers was acute. The allocation was said to protect Mitander from a shortage of labour. Mitander did not make a big issue of this. In January 1862, he merely noted, very briefly, that of his total workforce of 515 men and women about 100 were convicts. One of their chores was to build the roads within the works area and two ghats to facilitate transports up the hill behind the blast-furnace building. The government sanctioned a detachment of soldiers to guard them.\footnote{Indian workers. “One tjuprasik (supervisor), one meter (subordinate supervisor) and four kuli (simple workers).” (Note on photograph.) Photo: Gustaf Wittenström, C15054.}
A perennial workforce problem, especially in Kumaon, was that of keeping operations running over the summer months when a hot and rainy climate drove Indian workers away from the pestilential lowlands. Such a long standstill undermined the efficiency and profitability of the undertaking as a whole. Not only was the capital idle. Skilled workers and managerial staff who were employed on a permanent basis were also idle. There was also a perpetual uncertainty at the start of every working season as to whether enough workers could be recruited.

The question was how to induce the workers to return and how to keep them committed to their work. This was also a prerequisite for increasing skills and adaptation to an industrial way of work and life.
In order to retain a good part of the Indian employees at the Kumaon Iron Works without excessively burdening the budget, one measure was to reduce their pay in summer. Julius Ramsay described the problems in a letter to his friends in Sweden.

[T]here are no permanent settlers here. They all go up to the mountains at the end of March and then we have no men who can undertake contracts to deliver charcoal, ore, lime or building materials. A big part of the workforce is from the mountains, and they are hard to keep here. Men from the plains are generally more expensive and usually great rascals.

During the summer all the Indian workers “disappear” and “… the works are totally abandoned during the wet season.”

Several years earlier William Sowerby had described exactly the same problems, but he called the Kumaoni labourers “a steady hard-working race”.

Whether it would be possible to make the workers stay in the Bhabar more than six months “time only can settle”, Sowerby wrote and added, “some of them will doubtless be induced to remain by higher pay.”

One can suspect a very close connection between the total “disappearance” of Indian workers during the summer months and the organisation of Kumaoni society as a whole. There seems to have been an established pattern of migrant labour in Kumaon and Hardy Wells reported on this after a visit to the Ketsaree Valley on the western boundary of Kumaon in 1866.

The emigrants who make iron in the locality are also cultivators elsewhere, perhaps 60 miles (100 kilometres) off, and, at the end of the cold weather, when the rains prevent their operations, they return, leaving their very temporary works to fall to ruin …

The reason for the seasonal migration was not only the negative push of a pestilential climate, but also the positive pull of other work. The Indians were part of a society and economy outside the control of Europeans. Ramsay himself believed that the climate was only a part of the full explanation.

I am convinced it is mainly humbug from these hill people. The neighbourhood is far from as unhealthy as they make out and this is best proven by big areas of recently cultivated land where the farmers and their families stay the whole year.

He suggested the need for wider socio-economic structural changes to solve the problem and was sure people would stay if dwellings and provisions were
supplied. There is much evidence that he was right. During the last campaign
work was carried out all summer long and structural changes also influenced
the supply of labour. Strong forces from the outside exercised a continuous
pressure on traditional society and it was changing. Twelve years after Julius
Ramsay left Kumaon, the Commissioner of Kumaon reported that new
market conditions for different products combined to change the society:

Iron and copper abound, but at the present value of labour the mines are
worth very little. The sons of miners have, as a rule, given up their old
trade and taken to contracts. The great attraction to miners in former
times was the cheapness of grain in the Khetsaree valley, where iron was
most extensively manufactured. This advantage no longer exists, for the
market at Rannekhet has doubled the price of grain, and the miners would
be no longer content to exchange their labour for the small profits on iron.

The Commissioner’s remarks also show how a market for labour had
developed. Tea gardens and other labour markets offered better terms than
copper mining, especially since copper from England could be bought cheaply
in the markets.¹¹⁰

Transfer of Knowledge:
Possibilities and Obstacles

There are numerous examples of considerable technical change in India ef-
fected during the British Raj, in agriculture, handicrafts and engineering.
Indian workmen had, for example, little difficulty in acquiring the skills
needed to operate modern textile machinery.¹¹¹ Other examples are exten-
sive public works and the building of the railways in the nineteenth century,
involving big, socially and technically complex, projects.¹¹² In a later period,
the rapid development of the Tata Iron and Steel Company (Tisco) in
Jamshedpur and its supporting infrastructure in the first decade of the twen-
tieth century also show a fundamental readiness to adopt new technologies
and new methods of work.¹¹³ The experiences at the Kumaon and Burwai
Iron Works do not contradict this.

In the early 1900s recruitment of Indians to positions requiring technical
knowledge, or to qualified technical education, was often blocked by racial
prejudice or open, formal discrimination.¹¹⁴ At the Kumaon and Burwai Iron
Works archival material tends to indicate a totally different policy. There
was, at least in plans and reports, an open-minded and positive intention to
replace the Europeans with Indians although the projects never reached the
stage where this actually happened.

By comparison with Indians, the British workers were highly paid and
their salaries were a big item on the balance sheets. In order to lessen these
costs the Indians were to learn the trade. The transfer of knowledge was thus
consciously seen as a crucial part of the technology transfer. For economic viability the work of Europeans would have to be taken over by Indians after on-the-job training.

Ramsay, Wittenström and Mitander all had a formal education, but their skills had still been developed in the course of extensive experience of making iron in practice and even if the importance of book knowledge increased during the nineteenth century, practice remained the cornerstone of ironmaking ability far into the twentieth century. Even today it is not possible to learn how to handle a blast furnace at a school desk. The knowledge has to be gained in practice, and then acquired again at every new ironworks. This fact was also widely recognised in India. Two examples may be used to illustrate it, one concerning the mining of copper ores in Kumaon in 1855 and the other a suggestion to gradually reform traditional Indian ironmaking, presented in the early 1870s.

It was probably especially true in nineteenth-century India, as the body of institutionalised knowledge was small. Knowledge had to be carried and transferred by individuals in practice, as William Sowerby concluded in 1858:

... the various shapes of blast furnaces, modes of obtaining power and applying it, mixture of ores, fuel fluxes; and in erecting Ironworks, the practical Engineer must rely more on his own judgement and experiments, than upon anything that may have been written or said upon the subject by the most scientific men.\textsuperscript{115}

When Mark Fryar, Mining engineer to the Geological Survey of India set an agenda for a plan to introduce new technology into Indian ironmaking in 1872, he argued the necessity for good examples (see p. 354). From such practices local craftsmen and workers would be able directly to experience the benefits of a shift in technology.

We must take into account that only a part, and mainly the broad lines, of technical knowledge is codified by non-personal means of intellectual communication or communicated by teaching outside the production process itself.\textsuperscript{116}

The role of the individual practitioner has thus been strong in technology transfer throughout history. Especially if the places involved are geographically far apart.\textsuperscript{117}

It is open to question whether any such transfer of knowledge ever had time to take place at the Kumaon Iron Works, but some positive examples are mentioned in the sources. In 1855 William Sowerby described how he had experienced difficulty in “obtaining labourers of a suitable kind, owing to the work being new and the men not accustomed to it”.\textsuperscript{118} In a craft like the making of firebrick he also noted clear instances of progress once work was started. In the beginning work had been “found somewhat difficult, owing to the material used being quite new to the native workmen.”\textsuperscript{119} But only
one month later the work was proceeding better and about 500 bricks had been burnt, “the workmen having gained confidence in the material”.  

Thomas Oldham had also pursued a similar agenda. Eight British workers would be sufficient to manage two blast furnaces and a forge: three furnace keepers, one moulder, one fitter, one pattern-maker and two forgemen. In this case he was probably thinking of much smaller furnaces than Ramsay later set out to build, but the line of reasoning was the same. He compared them with the English ironworks in the Madras Presidency and was quite confident that a small staff of superintendents would be enough.

Once started fairly, there is no great difficulty or labour required in the Furnace Works. Natives under European superintendence do all this work, and do it well at Porto Novo and other places in Madras, and there will be no difficulty in teaching them to do it here.  

The general idea of creating a group of skilled Indian workers persisted over the years. In a letter on the restart of the works in the 1870s, the Commissioner Henry Ramsay stressed the importance of introducing Indians into the work.  

I have but little doubt that if put under a proper system of management (viz. European Supervisors with Native workmen only) that iron can be made at cheaper rates than it can be imported from England.  

The very last furnace keeper at the works, Mr. Cameron, was even criticised for not seeming in the least “to have taken advantage of the Native labour available, so that they might both learn the work and help him with it.”  

Most of the previous quotations focus on the training of ordinary workmen and it is uncertain how the British looked on the possibility of a total transfer of the works into Indian hands. It is clear, however, that the limits to what was possible were actively discussed. In 1865 William Sowerby was criticised for his “needlessly large staff of European assistants.” His employment of British workers for certain positions, such as house carpenter and charcoal manager, was almost ridiculed: “…as if there were no carpenters in India, and as if charcoal-making was not practised more extensively there than in England.”  

A most explicit and detailed manifestation of this ambition to transfer knowledge was the staffing planned for the new works. Julius Ramsay’s plan, quoted earlier, for the number of employees at the new works gives valuable information on the social system at the works, but it may also be seen as an expression of Ramsay’s plans with regard to training and knowledge transfer. All the European workers except the furnace keepers and the mechanics had Indian counterparts. This might be interpreted as an intention to increase the extent of Indian staffing.  

Finally, since the works were never in full production, there is naturally less information on the Burwai Iron Works as regards knowledge transfer,
but it is clear that Mitander had Indian foremen and that he carried a positive impression of Indian skills from the time of his very first encounter with Indian metal trades in the workshops of Bombay.

The potentials for a transfer of knowledge can also be illustrated by an early example of technology transfer to Kumaoni mining and metalworking trades.

In a lengthy report on copper and iron mines written in 1850, J. O’B. Becket described in detail the methods used in rock mining in Kumaon – and also ways to improve them. A “miserable iron hammer, wedge and crowbar, constitutes all the apparatus that the native miner has to depend upon.” This meant that the galleries were kept as small as possible. Young boys picked up the ore, put it on pieces of hide and pulled these loads to the surface. Often they had to crawl on all fours through narrow galleries. Becket’s suggestion was to make the galleries bigger and to use wheelbarrows or four-wheeled carts. His advice was later repeated by William Henwood, who described the traditional modes of copper-mining as “rude, painful, wasteful and unsystematic”. He did, however, especially note one exception, a mine where a Mr. Wilkins had been in charge in the late 1830s. Here various measures were taken “in a workmanlike and efficient manner” and “Mr. Wilkins’ valuable practical lessons [were] still gratefully remembered.” Henwood also added that improvements like these should “best be decided by the local authorities, who have an acquaintance with the habits, feelings and prejudices of the people, to which we do not pretend.” He suggested that Government mining agents should supervise the mines. These agents should be “practical miners: a mere theorist without experience would probably, if possible, render what is bad now still worse.” Both of these comments show an awareness of two factors that were important to a successful transfer of knowledge in the cases studied: a familiarity with local conditions, and a practical, rather than theoretical, experience of the technique to be used.

Julius Ramsay observed that the methods and tools of the Indian workers were very different from those used in Sweden. He admitted the skill of the workers, but mainly with regard to fine work. At times he grew very annoyed at Indian methods, at the same time expressing resignation, especially with regard to the Indian practice of squatting.

All craftsmen are used to working sitting, usually resting on their feet with their knees under their chins. You can imagine that they cannot achieve the mobility and strength of a worker standing. You often see bricklayers crouching like crows on the wall they are building. Each one of them turns and shapes the brick on all sides before putting it in mortar, and he considers himself very industrious if he has laid fifty bricks during a day. In this position he cannot reach very far either, and you need one man for every five feet of the wall. Carpenters work in roughly the same way, except that they often use their feet as an extra pair of hands, holding their piece of work ... More ridiculous than anything else, though, is to see an Indian blacksmith by his little hearth. He sometimes works ten
Indian blacksmiths. Indian blacksmiths at work beside one of the ironworks buildings at Dechaauri. The equipment was easy to move and set up. From left to right the bellows operator, the blacksmith himself and three other assistants, with a basket of charcoal and a sledgehammer. In the right foreground water tempering. Photo: Gustaf Wittenström, C15265.

A hierarchy of work. The concepts of ethnicity and culture, gender and class are all represented in this detail from a view of the building site in 1862/63. On top of the wall of the future rolling mill, three masons are squatting. The habit of squatting was probably the single aspect of working practice most symbolic of the differences between the Europeans and the Indians. Below them, standing with baskets probably filled with mortar, are two women. These two are the only working women in Wittenström’s pictures. On the far right, a foreman is supervising the work of the kulis. He is dressed in trousers and shoes, and it looks as if he is writing. Photo: Gustaf Wittenström, A6170.
hours a time squatting on his haunches. His assistant, sitting huddled up in the same way, sometimes has to rise to give his sledgehammer more force. In order to keep level with the anvil he has dug a pit to stand in.

Examples like this, without casting any doubt on the correctness of Ramsay’s observation, sometimes seem to achieve a life of their own. They grow into symbols of the alienation of the others and in themselves confirm and reinforce prejudices and conflicts. In general great caution must be taken in interpreting such accounts. Sometimes descriptions of different cultural traditions seem to become something like modern nomadic myths, maybe saying as much or more about the storyteller and his relations to his surroundings, as about the reality described.

A recurring story of Indians not understanding the use of wheelbarrows illustrates this. Instead of rolling them, Indians were said to have filled them up and carried them on their heads. In his book on the building of the railways of India during the nineteenth century, Ian Kerr retells a story like this – with only the merest flicker of doubt. The story contains most of the characteristics of a migratory legend: someone writes about a fact which he has not seen himself but has heard of.

The case described by Ramsay was based on his own experience and his examples are also depicted in Wittenström’s photographs from the building of the new rolling mill and of the black smiths and carpenters. It also contains a strong element of change. Ramsay wrote that he could not, “of course”, use smiths who worked squatting and all his blacksmiths had to stand up while working. “Among our English workers there was a rather skilful smith, who showed them our way of work in practice and taught them to use appropriate tools.”
It is not known to what extent Ramsay really managed to change the working methods of his smiths, but he did not report any definite “success”, rather the opposite. “There is of course no use in trying to reform these bad habits. You are met everywhere by a silent but stubborn resistance.”

Besides the two confrontations previously mentioned, which resulted from a kind of British cultural ignorance, the open conflicts that are found in the sources had a “classic” class basis. The cost of labour was a matter for negotiation, which resulted in walkouts or strikes, similar to conflicts in industrially developed settings with an organised labour force. Ramsay in particular referred to the confrontations in such a way as to indicate that they were not exceptional. “We are very dependent on the wretched workers,” he said. “As soon as they see they are indispensable they come and ask for a rise in pay. Moreover, as their pay is not related to their work and therefore cannot be raised, they conspire together and leave work in great numbers. In this way I have lost 100 carpenters in a few days.”

At Burwai there was at least one open conflict about pay. In September 1862 Mitander noted how the foundry workers “had a ‘strike’” for higher pay. The result of this strike is not known but it lasted five whole days.

The hierarchy previously described was thus not unambiguous. There was a strong element of mutual interdependence between the Europeans and their Indian employees.

**Religion and Caste**

There is a long tradition of attributing India’s economic difficulties to circumstances of religion and caste. There are some remarks indicative of this in the notes of Mitander and Ramsay. They are worth quoting, if only because they are so infrequent as to suggest that the importance of religion and caste was less than normally assumed.

One extremely clear example occurs when Ramsay records that Mr. Matthews, the inspector at Kaladhungi, slaughtered a cow near the office building at Kumaon. The native bookkeepers refused to enter the office “and they claim the place is desecrated. Mr. Matthews is furious and wants to dismiss them at once, but this cannot be done. We have none to put in their place.”

The other example is a general consideration by Ramsay. Early in 1862 he gave quite an extensive analysis of his work. His greatest problems were a total lack of all kinds of roads and, second, “the sluggishness of people and the innumerable ingrained prejudices.” He described how the British East India Company had formerly ordered its officials strictly to respect the institutions of caste and religion. In this situation the Brahmins had taken the opportunity to revitalise the institutions of caste in order to advance their own position. The Indian Mutiny altered the situation, and according to Ramsay, the forceful response of the British reduced the power
of the Brahmins and he could even count a large number of them among his lowest workers. Ramsay added a hope, somewhat reminiscent of the optimism of Karl Marx:

[O]ne may hope that the introduction of railways, factories and public works will gradually wipe out the division into castes, which has hitherto paralysed everything in this country, to which nature has been so bounteous.\textsuperscript{139}

But it should be remarked that this note was made one year after his return to Sweden, when he was seeing his experiences from a distance. He might have had a clearer view of his situation by that time, but he might also have been influenced by the general tone of discussions at home, somewhat remoulding his memories.

And in his report to Jernkontoret he gave a slightly different summary, according to which Julius Ramsay had no difficulty in appreciating the possibility of a transfer of knowledge. Recalling his experience of a visit to the Government workshops in Roorkee in the spring of 1862 he summarised:

The Hindus, but still more the Muslim population, are most intelligent and grasp with great ease what you try to explain to them or teach them. I am convinced that they will by and by be the equals of our workers, if not better, but time must be allowed to overcome a number of bad habits and prejudices and train totally new methods.\textsuperscript{140}

It has been outside the scope of this study to explore the question of religion and caste more deeply, but as the sources immediately available are normally silent on the matter, it does not appear to have been of any great concern at the works.

Other comments concern general working practices as illustrated earlier, but no direct connection is made with either caste or religion.

**BARRIERS OF LANGUAGE**

There was also a major language barrier between English and Hindi, which had big practical consequences. Richard Keatinge complained in a letter to the Public Works Department of the difficulty of keeping accounts since his book-keepers used hindi “I have no person here who can assist me in the matter. Have great difficulty too in procuring English writers at a moderate salary.” He even stated that “the accounts for May and June are still in the vernacular”.\textsuperscript{141} The accounts were thus in Hindi and Keatinge excused several faults in them since they were hard to check and errors occurred when they were translated from the Hindi original.\textsuperscript{142}

Ramsay for his part especially noted the trouble in keeping most accounts and especially contracts in two languages, English and “Hindostani”.\textsuperscript{143} At the same time he argued that he was learning more and more Hindi and thus growing less dependent on interpreters.
Language studies do not seem to have been unusual among the British. When Mitander mentioned that Captain Melliss had two children, he especially noted that they only spoke “hindostani”. In the autumn of 1862 Mitander himself started to take lessons in Hindi.

The Building of a Durable Social System

The Kumaon and Burwai Iron Works were construction sites, with people coming and going. Everyone was always on the move. Most of the British colleagues of Mitander and Ramsay were in India only for a part of their lives, and this was even truer of Ramsay and Mitander. It did not take more than six months after Ramsay’s arrival for him to start writing of his homesickness: “I have not lost heart, but I daily take a greater dislike to this unfortunate country and I will probably not stay a day more than I am bound to by my contract.” He missed his friends and his family and he pondered over the possibility of finding a wife. Mitander, however, was much more committed to his work and at one time even seriously contemplated staying in India until his old age.

The site was somewhat like a camp, with men thrown together, devoid of many of the links that hold a society together in normal life. This lack of permanence was a theme in almost all episodes of conflict at the works. Often very little kept the employees from leaving and the threat to leave was a weapon in conflict, as effective as the strike.

Henry Drummond compared the setting to the settler economies of Australia, America and South Africa. In India the British entered as masters into an ancient society and there was an abundance of cheap labour, but for experienced workers the opposite was the case: “no real colonisation takes place here, because no one goes to India, as to America or Australia, to settle for life.”

The heading of this chapter refers to the men who did the work. The phrasing is intentional. Their prominence in the historical sources and their total predominance as decision-makers and employees suggest that men were almost the only agents in this history.

The number of women at the ironworks was probably small. Their number is nowhere explicitly stated, and there are only two pieces of evidence of women actually working at the sites of the Kumaon and Burwai Iron Works. One is the picture of the building of the new rolling mill at Dechauri, with a couple of women carrying mortar in baskets. The other is a note by Nils Mitander stating, without specification, that he had a working force of about “415 men and women and additionally approximately 100 prisoners.”

But, as already described, Mrs. Keatinge meant a lot to Nils Mitander. The letters and dreams of both Mitander and Ramsay express their deepest longing, their professional unease in a setting without the full and varied life...
of a more normal society – of which women and a family life were essential parts. Except in very special circumstances, it is not possible to build a durable social system consisting only of men.

In the world of ironmaking from which Ramsay and Mitander came, women also played a part in professional life. They were the locus of social life, maintaining contacts with the networks of ironmaking, and the basis of exchange of news and knowledge of markets, technology and other matters of central importance to any iron producer.148

A few of the British seem to have had their wives and families with them, and in one case the importance of allowing them to bring families out was explicitly discussed.

In the spring of 1860 one of the British furnace keepers at the Kumaon Iron Works, Mr. Cresswell, demanded not only a rise in pay, but in a letter to the superintendent of the Kumaon Iron Works he also that his family should be brought out to India.

The Willis family. Mr Willis, a book-keeper, together with his wife and sister-in-law, Miss Briant. According to the text on the photograph they were Irish. Photo: Gustaf Wittenström, C15248.
I beg to request that You will be good enough to bring to the notice of Her Majesty’s Indian Government that, having now served in the capacity of Furnace-keeper and manager at Dechoureec for some time, and the works having been brought to a successful result and the period of my engagement will shortly expire, I will be willing to renew my engagement for a further period if the Government will increase my pay and bring out my family. As You are well aware, I am obliged to work at the present time 16 hours daily, and frequently much longer.

As you are well aware, I have willingly done other work for which I was not particularly engaged, in order that everything should be pushed on as rapidly as possible. I trust that the government will consider these things. I left, as you also know, a very good situation in England to come to India, where I was almost as well paid as I am here, hoping that, if the works were successfully carried out, I would be promoted, and as they have been so, I trust the Government will not think it unreasonable to give me the appointment of head-furnace keeper at a salary such as is always given in England, namely, £500 per annum.”

Thomas Oldham, reviewing the manning of the works, agreed with Cresswell. He thought the pay Cresswell asked for was acceptable, and also that it was a very fair request to bring the family to India. “I would advocate the allowance of a certain sum for the bringing out of the families, wife etc., of any of the men who wished it. I do not know of anything which would tend to render them more comfortable, or more contented.”

A DURABLE SYSTEM
AND THE TRANSFER OF KNOWLEDGE

The transfer of technology, and the building of a foundation for future development, depends on a transfer of knowledge.

The Kumaon Iron Works was a British undertaking, financed by British interests, using European technology. At the same time the work was by necessity to be done by Indians, although led by British or Swedish engineers and British skilled workmen. Embedded in this division were boundaries between power and the powerless as well as a number of other differences, economic, linguistic and cultural, all intermingled and often mutually reinforcing.

Conditions of employment at the works reinforced the differences between groups of employees. The social differences in contemporary England or Sweden were certainly wide, but in colonial India, the national and cultural provenance of the British emphasised the differences and formed a rigid system of socio-cultural barriers. It is a fair hypothesis that these differences made the transfer of knowledge difficult.
SUMMARY DISCUSSION

A Brittle System Established

In the social systems of the ironworks, four different categories of people stand out. First were the British management, the representatives of the ultimate-decision making power at the works, second were the Swedish engineers who were to lead the daily work and put plans into practice, third were the British skilled workmen and fourth came the majority, the Indian workmen, who carried the loads, built the walls and charged the furnaces. The boundaries between these groups were reinforced or weakened by factors such as culture and power and as a totality this social system represents a changing and sometimes conflict-ridden unification of the local setting with new elements brought in by the British.

The build-up of a durable social system as a part of the ironworks was essential for sustained production. In such a setting, with a reciprocal commitment to the works, there would be good prospects of a supply of workers and the transmission of skills and knowledge needed that is an essential part of any transfer of technology.

Both the Kumaon and Burwai Iron Works were big working sites, especially during the periods of construction. At times it was difficult to procure enough unskilled workers, but the obstacles were overcome and it is startling how in a totally alien environment could manage to recruit the many hundreds of people needed and also to organise the complicated system for supplying the works with raw materials.

It was a more difficult problem to recruit a sufficient number of skilled workmen and the solution used was to employ British workmen, either directly from Britain or from the armed forces stationed in India. In both these cases, this entailed considerable extra cost. The lack of skilled hands was mentioned time and time again as a basic cause of serious problems.

Transition and discontinuity were features of the Kumaon and Burwai Iron Works. There was the potential and there was also an outspoken will on the part of many central agents to transfer knowledge to the Indians, but the brief life of the works, their intermittent operation and the failure to complete them meant that the durable social system of committed people was never created. The most central part of any transfer of technology, the transfer of knowledge, could never be put into practice.
A Local System
in a Colonial Context

The Kumaon and Burwai ironworks were planned as integrated units of production, embracing every stage of ironmaking from mining and forestry to finished products. As such they were planned local technological systems, encompassing the resources of raw materials, machinery and buildings, all the men doing the work, their collective knowledge and also the mode of organising and integrating all the parts of the process.

In this final chapter the horizon is lifted beyond the local limits of the works and the analysis is widened to what I have called the question of separation or integration, that is how the works were parts of an ambient societal setting comprising technology, markets and politics. The discussion is closely tied to the concepts of technological systems and projects. The aim is to examine the boundaries of the projects, and the degree of their self-containment and dependence. To what extent were the works, in spite of the ambitions on a local level, isolated enclaves in the sociotechnical setting of India?

What chance did the works have of surviving in a market in conditions determined by colonialism and empire-building? What were the causes and effects of political decisions on infrastructural investments like the building of railways and the level of customs duties, and on the ironworks themselves? And is there any explanation for the seemingly highly contradictory policies of the Government? On the one hand it showed extraordinary patience in promoting the ironworks projects, especially in Kumaon. On the other the support was half-hearted and indecisive and – finally – government decisions ended the life of the projects.

The Swedish engineers had a decisive influence on many aspects of the ironworks projects at Barwah and Dechari. This is especially so in the case of the Kumaon Iron Works, where Julius Ramsay and Gustaf Wittenström were the prime movers when the technical layout and scale of the new works was decided. Their employers were ignorant of ironmaking and the Swedes had most of the cards in their hands. They knew about making iron and steel, they had the capacity to calculate the need for manpower, iron ore and charcoal. Nils Mitander had greater help from Richard Keatinge, his British counterpart, but he was still the most important carrier of technical knowledge.
at Burwai. And yet, looking back at the history of the works, it seems as if their inability to influence the fundamental conditions under which the works were to operate in the end only made the local players pawns in a bigger game. They had neither the tools, nor the power to build the infrastructure of knowledge, supplies and markets needed to support their work. They could not mobilise the capital that they considered necessary.

**Technological Separation and Integration**

The placing of the Kumaon and Burwai Iron Works was primarily determined by contemporary knowledge of local supplies of raw materials and the majority of those who built and ran the works were recruited locally. In these ways it might seem as if the works were tightly integrated into a local setting, but as has been shown in earlier chapters a closer examination clearly indicates the opposite. The local employees had no strong commitment of any kind to their work, and since the ironworks were initiated, financed and built by the British, albeit with Swedish assistance, they were in most essential respects international.

This also applies to the technology used, as it was transferred from Europe and was a total novelty on the Indian scene. The works were separated from all earlier systems for making iron in the regions in which they were sited. With minute exceptions there are no signs whatsoever of any effort being made to create connections between local knowledge and the new works and there was never the time to implement the intention to transfer knowledge to Indian employees that was voiced by some of the initiators.

A similar pattern of very weak connections is also apparent if the analysis is raised to the level of the Indian subcontinent.

**A Thin Web of Ironmaking and Blast Furnaces in India**

As shown in Chapter 2, British interests and individuals had a number of plans for modern ironmaking in colonial India during the nineteenth century and some practical attempts took place. The Kumaon and Burwai Iron Works were not entirely alone, but the network of ironworks was extremely thin, in fact virtually nonexistent.

Compared with Sweden, there were fundamental and striking differences. In Sweden, as in Britain and parts of continental Europe, ironworks had solid foundations in a long-established knowledge of ironmaking. There were institutions of different kinds to preserve, convey and develop the knowledge of ironmaking and to protect the interests of the trade. This continuously changing foundation of knowledge was expressed in the regular appearance
of a wealth of publications, both books and journals. Possibly even more important were the literally hundreds of Swedish blast furnaces and forges, often forming the centres of local communities, particularly in a belt across central Sweden (see figure above). These institutions and working sites were the hub of the lives of hundreds and thousands of people, tightly tied to their trade. Together they formed a web of support in case of trouble and change at any one working site. There was always someone who could extend a helping hand. In the Swedish iron industry nobody was very far from colleagues, working blast furnaces and foundries or mechanical workshops. There was a tight network of supporting structures, relating to both the production of equipment for the works, the exchange of knowledge and the supply of skilled personnel.

No more than an embryo of a similar structure existed in India, which made the Kumaon and Burwai Iron Works weak and the possibility of building a sustainable production considerably less.

ENGINEERING WORKSHOPS

Engineering workshops and colleges in India that could have been points of support in a web of technological knowledge were also very few and the most striking effect, and cause, of this situation is the almost total dependence on imported supplies when the Indian railroads were built.

As already mentioned, the equipment for the Kumaon and Burwai Iron Works was imported from Britain, as was almost all the machinery and engineering needed for the build-up of the infrastructure, in industries and other manifestations of the European presence. The railways, whose large

Blast furnaces in India and in Sweden

The nineteenth century was a dynamic period in the technical history of ironmaking. India stood largely outside these developments. The attempts to build modern ironworks based on European technology were very few during, about ten during the century as a whole. (see p. 78). In Bergslagen, the area of iron and steelmaking in central Sweden wherefrom Mitander, Ramsay and Wittensström came, the situation was totally different. In 1860 there were about 200 blast furnaces in use, most of them in the Bergslagen (see map). In Sweden nobody was very far from colleagues. There was a tight web of supporting structures. Map adapted from Eriksson, Bruksdöden i Bergslagen (Uppsala 1955). Artwork: Staffan Schultz.
scale and long production series would have provided a basis for an industry, imported virtually all supplies except cheap raw materials that could be found in India, such as timber, and low-level manufactures, such as bricks. Heavy industrial engineering, such as rails, bridge girders and engines, both stationary ones and locomotives, was imported. The ironwork for the big railway bridges was prefabricated in England, which limited the technological and economic benefit enjoyed by India. In the early twentieth century this system of building led British engineers to adopt a somewhat patronising attitude to their Indian colleagues. The lack of local workshops and engineering facilities was also a handicap to the pioneering entrepreneurs, who had to provide their own repair shops and power supplies.

In India as a whole there were isolated examples of both workshops and colleges for at least an elementary education, primarily in mechanical engineering, but nowhere was the aim to lay a foundation of knowledge of modern ironmaking. In 1845–46 Roorkee, some 160 kilometres south of Dechauri, had become the technical headquarters of the Ganges Canal, and the site of its workshops and iron foundry. At the same time the first college of technical education, the Thomason Engineering College, was established in Roorkee. By the mid-1860s three more engineering colleges had opened in India, in Calcutta, Madras and Poona. The colleges were established specifically to serve the needs of the Public Works Department, but they were far from sufficient. Nearly all of the engineers in charge of the big public undertakings came from abroad, most of them being British.

There was however no doubt that India had a potential and capability to supply all necessary equipment for the railways. This was shown in the field of rolling-stock manufacture. India’s first locomotive was built in 1865, the same year as the first locomotive was built in Canada, and a total of 700 locomotives were built in India before independence. This was, however, no more than a minute part, four percent, of the total needs. Some 14,420 locomotives (80 percent) were instead ordered and imported from Britain, the rest were German or American.

Even during his very first days in India Mitander expressed his admiration and surprise, when he saw advanced mechanical engineering work being done in workshops in Bombay, under Indian supervision and with only Indian workers. Julius Ramsay was also most impressed after a visit to workshops in Roorkee in the spring of 1862. There seems to be no doubt that Mitander and Ramsay considered the Indians highly capable of carrying out the work needed.

The workshops were established fifteen years ago and with the exception of the director and some officials, only native workers are now used. It was good to see the degree of skill they had achieved. All kinds of machinery are made there and I decided on a steam hammer and two boilers for our needs. There is also a department for the production and repair of mathematical instruments, which requires not only highly skilled workmanship, but certain insights and studies. Their work was quite good and
is used all over India at the many kinds of engineering works that are now in progress everywhere.

There is also a technical college at Roorkee. It is partly used by young men from the English army, who then find employment in the Public Works Department, but mainly by natives. The pupils who qualify are considered quite skilled and have no trouble in finding employment on the railways or on public works.

In this context the significance of the Kumaon and Burwai Iron Works becomes all the more apparent. They were pioneering projects. Their aim was to explore the possibility of making iron in India and blaze a trail for others to follow. This made the commissioning and start-up of the works potential landmarks in the history of industrial development. Both Dechauri and Burwai were seen as important not only as production units supplying the needs of empire, but also as pilot plants, experiments which would yield knowledge. In Kumaon Colonel Ramsay acknowledged this in a report to the Government in 1872, where he emphasised the opportunity for knowledge transfer, being unable to find any "reason whatever why, after a few years, a class of native artisans could not be trained under European supervision", and believing that "past failures would prove excellent lessons for the future".

At Burwai Mitander was aware of his role as a pioneer and when Colonel Keatinge sent him a piece of ore from Gwalior in May 1862, Mitander commented in his diary that when "we have shown how we can manage here I believe there will be considerable ironworks up there".

And Hardy Wells, a civil engineer from Roorkee, compared the Kumaoni ironmaking trials with American ironmaking. He concluded that experiences from America "give some hope that ironworks carried on according to the dictates of prudence, and wasteful expenditure prevented by the hand of wholesome supervision, may yet be shown to be profitable to the State, and the manufacture in India a blessing, as it has been to the Americans".

Against this background, the summary of the project given in the House of Commons Papers some twelve years later is worth quoting at length.

The enterprise of the Government in the Narbada valley, however, promised well, and might have been most successful. Works were erected at Burwai, on the Narbada, under the auspices of Colonel Keatinge. Mr. Mitander, a very able Swedish metallurgist, was induced to take charge of the works, and, after many experiments, all difficulties were overcome, and the works were ready for the production of iron. Suddenly, in 1864, the Government, after spending 75,000 l. [pound sterling] on these preliminary expenses, dismissed Mr. Mitander, closed the works, and offered them for sale, without success. They have now, with the ground on which they stand, been made over to Holkar. Iron ore and limestone abounded in the neighbourhood; large forests, furnishing supplies of charcoal, extended for many miles to the east and north-east; and Mr. Mitander was an excellent manager as well as a scientific metallurgist. No record has
even been preserved of the experiments and plans of Mr. Mitander for burning and storing of charcoal, and for other processes, which could have been useful hereafter.12

The lack of reflection and systematic evaluation apparently struck contemporary observers as surprising. The works were isolated enclaves in India when they were created, with their technologies linked uniquely to Europe. Their transformation into centres of diffusion of technological knowledge would have taken a longer and continuous period of time. A new unit had to be integrated into its surroundings if it was to be likely to survive.

Economic Integration or Separation

In a technological sense the Kumaon and Burwai Iron Works were extraneous to their Indian setting, but at least the initial aim had been that they should become integral parts of India’s economy, serving its growing market for iron and steel products. A first explanation of their closedowns is that the Home Government insisted on the competitiveness of new investment in production. Market developments became vital to the ironworks of Kumaon and Barwah.

In 1862 Thomas Oldham had called for a united effort by state and private capital to foster development. He said that private companies were better able to adjust rapidly to changing market conditions, but he also recommended strong government support. What might be a loss to a private company might be a major gain for the country, he argued.13 The solution to this problem was to make the market the final, long-term judge of the feasibility of ironmaking projects. Whether the Government or private capital financed the works, its products had to be able to compete.

AN ALMOST INFINITE MARKET

An essential area of government policy in industrialising and industrialised societies has always been transport, and especially railways. Such heavy and extensive infrastructural undertakings required immense resources, beyond the capacity of individual enterprises, and demanded the central co-ordinating power of the state. Railways were the arteries of trade and transport was indispensable for the growth of heavy industry and of the capital goods sector. They extended the possible markets and made it possible to achieve a reasonable scale of production and standardisation. This lowered prices and the cost of capital investments in industry in general.14 The railways were especially important to the iron and steel industry, not only as a means of transporting often heavy products to and from the works, but also as a market in themselves – with rails as a big bulk product.15

The very first railway in India, a thirty-eight-kilometre section of the Great Indian Peninsular Railway, was opened in April 1853 from Bombay to Thana.16
This was the start of more than half a century of expansion. By the end of 1861, when the Swedes arrived, more than 2,500 kilometres of line was open to traffic and almost as much was under construction. By 1910 India’s railway system had grown to be the fourth largest in the world.

This of course became a market of enormous proportions for an ironmaking industry, whether based in India or in Britain. According to evidence given to a committee of the House of Commons in 1858 all necessary decisions had at that time been taken and contracts finalised for the delivery from England to India of 1.75 million tons of iron for the railways. And five years later, by the end of 1863, approximately 2.8 million tons of railway materials had been shipped to India: rails, sleepers, locomotives etc. This had entailed the use of 3,572 ships.

As an indication of the potential of the Indian market, and also of close interconnections at the global level, it should also be noted that at the end of the 1860s, some years after the start of the Kumaon and Burwai Iron Works projects, the Swedish Government deputed Lieutenant Herman Annerstedt to investigate the possibility of exporting iron to India and the Far East. The result was two lengthy reports, published in 1868 and 1870 that also give information on the market during the years around 1860.

Annerstedt reported that during the ten years up till 1866 the value of imports, mainly from Great Britain, of machinery, cutlery, hardware and castings to Bombay had multiplied eightfold. Imports of bar iron, sheet metal and wire had doubled. Most impressive of all was the increase in exports of machines and assembled equipment, rising 12.5 times between 1856 and 1866. Annerstedt’s figures included neither rails nor other railway equipment. In 1866/67 the value of rails alone was the equivalent of 75 percent of the value of all non-railway and non-telegraph iron imports to Bombay.

Swedish iron and steel producers were both directly and indirectly affected by the moves on the Indian market and India’s importance grew as trade in
iron became more and more international. East India was an important market for Swedish bar iron and steel throughout the nineteenth century and also the re-export of foreign iron through London had been growing in importance ever since the beginning of the century. Between 1856–1860 and 1881–1885 sales of Swedish iron and steel on the East Indian market quadrupled. And by the 1880s this market had grown to fourteen percent of Swedish iron and steel exports.

“It is without doubt most advantageous to sell as much at home as possible, but in every trade there is likely to arise an overproduction, permanent or temporary, with which we have to go abroad,” wrote Herman Annerstedt and he looked in particular towards the Oriental markets as there was less reason to fear future competition from a growing local production. The reason was race. If sales were made on markets among people of the “same race as ourselves”, Annerstedt argued, there was always a risk of local production starting. But from the Orientals there was less to fear. The Chinese, in particular, also the Japanese, were industrious and skilled craftsmen, but “concerning work supported by capital there is so much in their character and their institutions working against it, that we will not need to fear any factory-based industry for a long time yet.”

This general character was common to all natives of the Orient, Annerstedt argued, and normally they never did more than they “were forced to”. He also emphasised that the customs tariffs of India were no obstacle, since they were erected only for financial reasons, not to foster an indigenous industry, and they were equal for all who wanted to sell to India.

Both the potentials of the markets and the direct importance of transport and communications for reaching them are reflected in the histories of the Kumaon and Burwai Iron Works.

The prime reason for establishing the Kumaon and Burwai Iron Works was to supply iron for the big colonial public works, such as irrigation schemes,

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**Exports of iron and steel from Sweden (rounded figures)**

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<th>Year</th>
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<td>8</td>
<td>6,000</td>
<td>8</td>
<td>26,000</td>
<td>14</td>
</tr>
<tr>
<td>Total</td>
<td>50,000</td>
<td>100</td>
<td>75,000</td>
<td>100</td>
<td>182,000</td>
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</tr>
</tbody>
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transport infrastructure, the railways, the telegraph system and the military establishment.

In 1857 the board of directors of the East India Company decided that the railways were the main market for the Kumaon Iron Works. The aim was to explore whether the mineral resources of Kumaon could be made available “for the various public works and especially for the railways, now in progress or about to be commenced in Upper India.”

Thomas Oldham, for example, saw a clear role for a future Kumaon Iron Works – but only if the markets were made accessible and opened up by the construction of railways. A future for Kumaoni ironmaking also lay in supplying railway building projects with heavy material. Rails could be fairly easily produced and as they were of relatively low value for their weight they could more easily compete with imports that were burdened with transport costs. Such a bulk product would not have the same opportunity as costly manufactures of bearing costs of carriage from England.

During the Ramsay and Wittenström period at Kumaon, approximately 44 tons of cast iron rails were made for the Government at Dechauri. Rails of six different patterns were delivered to Allahabad in 1862 and were tested several years later, in 1869, under the auspices of the Roorkee Workshops. The results of the tests were not altogether satisfactory, but a report written by Lieutenant K. C. Pye concluded that “it should be thought right to encourage the production of native metal, and make an Indian Railway of Indian iron and Indian wood, this may be done without danger, without fear of loss, and possibility of success.” Some years later the markets had grown even larger and the Commissioner at Kumaon, Henry Ramsay, stressed the continued importance of the railways as a customer, and also the increased demand for sheet and bar iron, machinery and tools.

For the Burwai Iron Works many products were discussed, from chairs or small castings for the Great Indian Peninsular Railway Co. to telegraph poles. At one stage moving the iron department of the arsenal at Bombay, including foundries and ammunition works etc., to Barwah was even considered.

In October 1862 the Public Works Department informed all its units that the ironworks at Barwah were ready to take orders for castings at a cost of 100 rupees per ton and up to a volume of 5 tons per day. Later Chief Commissioner Richard Temple reported that there was a great demand for wrought iron.

Natives do prefer country-made bar-iron to English bar-iron, the former being softer and more suitable by reason of its being made with charcoal. This is, I learn, the reason why Swedish iron is esteemed the best in Europe…. The Swedish iron is indeed highly esteemed in Central India, and is found in most of the large bazaars under the name of ‘Sicca’.
THE KUMAON IRON WORKS
AND THE TRAMWAY

A proposed local tramway from the foothills of the Himalayas and southwards to the Ganges Canal – a railway with wagons drawn by animals – was an important part of the strategy of the Kumaon Iron Works and is a good example of the intimate interrelation between the railways as markets in themselves and as routes to markets. While being constructed the tramway would be a reliable customer for rails and when ready it would be a means of transport for products as the main connection with the Indian railway system.34

The project had first been discussed in the late 1850s, when a special pamphlet promoting it was published.35 On its first page a “Report of Proceeding of Last Meeting of Scinde shareholders” states: “We shall never be able to export Cotton in any great quantity without long and cheap Railways, and they can never be constructed until we can use native iron.” The author was the chairman of a proposed company, for whose founding this was a prospectus. The object was to introduce a new transport system in the Province of Rohilcund and adjacent territory, to connect the Ganges River to the Indus and the Iron Districts of Kumaon and Gurhwal. The acting engineer for this North of India Tramway Company was William Sowerby. It was to be cheap to build, costing only half, or even a quarter, of the amount of a normal railway in India. It was to use horses as motive power. This would mean slower transport, but the products would be brought down from the slopes of the Himalayas.36

The tramway became of strategic importance to the Kumaon Iron Works during the time of Julius Ramsay. When a new issue of shares to raise fresh capital was announced in August 1862 the tramway was one of the most important arguments and the notices particularly stated “The Company expects to secure a contract for a portion of the Rohilcund Tramway.”37

One month later Ramsay wrote that he was receiving letters daily from “all over India” applying for shares. Some weeks afterwards, preparations were being made for an even larger issue of new shares, mainly directed at investors in Great Britain.38 “If this issue fails, the company will go bankrupt”, Ramsay wrote.39

The final blow to the Kumaon Iron Works, confirming Ramsay’s fears, seems to have fallen when no decision to build the tramway was taken. Sir Charles Wingfield, acting as the chairman of a committee of the shareholders of the company residing in England, later summarised what happened. If the Home Government had sanctioned the tramway between Korrjah and Kaladhungi in 1862 the company would have been able to go on producing cast iron and been in a favourable position to raise more capital in London. This would have made further development possible, but the project “... lay in abeyance, and the Kumaon Iron Company, after making ineffectual efforts to raise additional funds, was compelled to close its Works.”40
As has been described in Chapter 5 the deficits were a fact and the company had stopped all work even before final results of the efforts to raise new capital was known. Ramsay had at that time become openly pessimistic about the prospects for the project. He even wrote that the owners, against his advice, had insisted on building the works on too big a scale. 41 Although the directors of the company begged Ramsay to stay and possibly to supervise a new start, he declined. By this time Wittenström had already left. 42 In September 1863 Ramsay wrote that Wittenström had informed him from London that all efforts to form a new company in England had been in vain. 33

In the wake of this failure to raise new capital, the owners embarked on a long discussion with the Government, demanding financial compensation because the tramway was never built. They considered the cancellation of the tramway project decisive in the failure of the works, but no compensation was ever granted. 44

Caution must be observed in interpreting the arguments. At that time the shareholders had an immediate financial interest in blaming the Government, in the hope of recovering some of their lost investment.

The great importance of the tramway was referred to again and again in the official correspondence. In a memorandum of 1866 the secretary of the Public Works Department did not hesitate to state the lack of a rail connection to be the only reason for the failure of the works: “When the Company engaged in the undertaking, they entertained a well founded belief that a tramway was about to be made by Government which would connect their works with the East Indian Railway, and in the construction of which their iron would be employed. Government, however, suddenly changed its intention with respect to the tramway, for which up to this time no preparations have been made, and the consequence was that, finding no demand for their iron, the Company after producing 500 tons, closed their works in 1863.” 45

RAILWAYS – OPPORTUNITY AND THREAT

As described in Chapter 4, a functioning system of communications was a prerequisite for the recruitment of the Swedes as well as for participation in the international web of technological knowledge in general. International communications played a similarly important part role in what has been called a phase of consolidation of imperialism in the second half of the nineteenth century. 46 During this period the ties of the colonies with Europe were strengthened with an array of technical innovations and big infrastructural investments, most notably the arteries of railways connecting vast inland regions to the ports, overseas steamship connections and the telegraph, both overland and submarine. 47 Together they combined to facilitate colonial dominance, trade and exploitation and in part they were also necessary prerequisites for the interdependence of colony and mother country.

In such a way it can be argued that all these technical innovations that facilitated international communication were for good or for bad, all depending
on the view taken of the colonial relationship. Mail and telegraph across the Indian subcontinent had served to coordinate British forces during the big uprising, and they also became a means of exchange of commercial information and of unification of an Indian market.

With or without the telegraph, however, the possibility of an exchange of information across the Indian subcontinent was already evident in a comparison by J. H. Blackwell in 1857 between the prices of charcoal in the Narmada Valley and in other parts of the country, in Madras and in Kumaon. And five years later knowledge of the competence of Mitander travelled across the subcontinent. His reports on the Burwai Iron Works were published in the government gazetteers and thus widely disseminated. One reader was a Colonel Turner, head of the workshops at an arsenal in the Bengal Presidency, and Mitander’s report led Turner to send a letter asking for advice. A lot of scrap iron had accumulated over the years and now the installation of a wood-fired furnace was being discussed. Colonel Turner wanted the expert advice of Mitander on how to use such a furnace to melt the scrap. “I am very flattered by this faith shown in me”, wrote Mitander, “I feel just like a professor and will do my best to fill the part.”

And for better or worse, the railways were built. They offered a big opportunity to any prospective Indian ironworks, but at the same time they also represented a big threat, since they made it easier for European, and especially British, producers to reach the Indian market. “Every day is opening up new facilities of carriage from the ports, and the enormous advantage of carrying manufactured articles instead of raw materials will, on the opening up of improved means of communication, immediately begin to tell.”

As already indicated, the bright side of the coin, the market potential that could have given a basis for an Indian steel industry, was however never used. “The railways’ great demand for ferrous metals – the classic backward linkage – had leaked abroad.”

PRICING AND COMPETITIVENESS

The Kumaon Iron Works showed poor production figures compared to similar blast furnaces in Sweden and England. Yet the investors showed confidence in the enterprise. The low production costs and – maybe most of all – the optimistic view of the future were decisive. Uncertainties were hidden in absolute forecasts expressed in rupees per ton which fuelled optimism about the project. Even if Ramsay began to feel very doubtful of the likelihood of achieving economic production, he continued along the path already taken in his everyday duties, rather than openly criticising the project.

There were a number of estimates of the cost of iron produced at Kumaon. In 1855 Rees Davies believed it would be possible to bring it down to 15 rupees a ton, with four or five furnaces at work, manned by Indians. In 1860 the production planned by William Sowerby was 40 tons of pig iron per week at a cost of 20 rupees per ton during a six-week campaign, but in
In March 1863 Julius Ramsay estimated the cost of production of pig iron and of finished rolled iron at the works which were under construction. If he could use richer Ramgarh ores in the charges, then less limestone and less fuel would be needed in the blast furnace and the cost of the pig iron would fall from approximately 50 to 38 rupees per ton. In the end, the unit cost of malleable iron ready for the market would be brought down from 161 to 126 rupees/ton if Ramgarh ore alone was used. By comparison, Ramsay stated that the price of common English bar iron delivered to any larger market place in the North West region was 140 to 150 rupees/long ton.

There could thus be a margin, but it would be extremely small; and if production were confined to the Bhabar ores, “iron manufacture at this place will never pay.” At that stage Ramsay was very cautious and added a warning: “Success still depends on the possibility of procuring the materials required at the present rates. In the above estimates I have increased the rates for wood and charcoal by nearly 10 percent; as larger quantities are required and the distance of cartage gets longer, I am sure the cost will be still higher.” In February 1862 Ramsay regretted that he would not be able to raise output further, but since the market was good he anticipated that even this output would pay.

Later, in his report to Jernkontoret written after his return home, his opinion of the market was less favourable. Even if the cast iron rails made were of good quality and compared well with imported ones, cast iron was made only for consumption at the works while the pig iron remained unsold. It could not compete with imported iron.

When iron production was resumed more than fifteen years later, Ramsay’s misgivings seem to have been confirmed, but even in 1879, when the old Sowerby furnace was used, albeit with added preheating equipment for the blast, the cost of producing pig iron at the Kumaon Iron Works was approximately 140 rupees per ton (5 rupees/maund) compared with a market price of 84 rupees per ton (3 rupees/maund).

Two reservations need to be made. First, the greatly expanded works planned by Ramsay and Wittenström would most possibly have reduced costs. Second, and working in the opposite direction, market conditions were changing and would have made competition much keener. The combined effect of these two trends – lower production costs and lower market prices – is hard to estimate. There is however no doubt that the situation would have been difficult, at least in the longer run.

All estimates of future costs and prices encouraged views of a bright future. In the summer of 1864, in his report on the Burwai Iron Works, the chief commissioner of the Central Provinces, Richard Temple, discussed whether the works would be able to sell iron at below the prevailing market prices. Referring to calculations made by Mitander, Keatinge and Melliss, Temple maintained that it would have been possible to produce bar iron at a cost of 132 rupees per ton. When this calculation was made, British bar iron in Indore
was 180 per ton and Swedish iron 280. According to Melliss, who had asked dealers in Mhow and Indore, 100 tons were consumed yearly at these prices. In addition the Public Works Department could be a big customer. Wood was currently being used instead of iron in the building of barracks. During the previous four years, the Public Works Department in Mhow alone had used about 2,500 tons of iron. This would mean that this body by itself could easily use the total output of the Burwai Iron Works, which was 500 tons.60

TARIFFS ON IMPORTED IRON

The tariff policy of the East India Company and later of the Crown was framed to give most favoured treatment to British economic interests and its effects have been a central question in many discussions on the economic history of India.

As early as February 1840 the East India Company presented a petition to Parliament in London for the removal of duties that discouraged Indian industries. A Select Committee was appointed to look into the matter. And one of the witnesses called was the pioneering Josiah Marshall Heath of the ironworks in Madras. Before the Committee Heath protested against the duty imposed on Indian iron imported to Britain, when British iron going to India paid no duty at all. The duties on iron imported to England and to India are of course very relevant to the feasibility of building ironworks in India. Heath considered the duties prohibitive when exporting to England, all too liberal when exporting to India.62

It is possible to discern three basic aims of the policies. First were the needs of the government where tariffs were used as a revenue-yielding tax. Second was the ambition to use duties as a discriminatory protection against Britain’s chief competitors on the international stage. Products to and from Britain were subject to lower tariffs. Third was an ambition to favour Indian domestic producers. Superimposed on these specific considerations was also the generally prevailing free trade doctrine of the second half of the nineteenth century. 63

In 1859 the serious state of public finances after the Indian Rebellion led the government of India to raise import duties sharply to 10 percent on most goods (20 percent on luxury goods, 5 percent on cotton twist and yarn). This met with great opposition in Britain, especially from cotton spinners and cloth manufactures and from the British merchants in India. As a result the increases were largely withdrawn.64

One of the most radical reductions that was ultimately made concerned the duties on imported iron. To serve British interests, the import duty on iron was reduced in 1863 from ten percent to just one percent and machinery was totally exempted from duty.65 As reported by Sir C. E. Trevelyan, Financial Member of the Council of the Governor General, the basic reason for this was that India depended on England for the supplies of iron for the vast infrastructural construction works being undertaken.
At a very much later date, in the early 1920s, when the development of an Indian steel industry remained an important political issue, tariffs would be a way to support a young and sensitive iron and steel industry if one “inclines to the view that its [the steel industry’s] development requires to be accelerated, in view of its being a ‘basic’ industry.” At the same time tariffs could be a threat by blocking possible positive effects of international competition, which could hamper productivity and raise prices on iron and steel.

When the idea of starting up production in Northern India arose around 1850, old methods of iron production were still being practised in Europe and ironmaking in India for its domestic market could have been competitive. By the 1870s the Bessemer and open hearth methods had broken through, mass production of steel had started in Europe and freight costs to India had fallen. The Suez Canal was officially opened in 1869, reducing the distance between Europe and Asia by approximately 7,000 kilometres, or the distance between London and Colombo in Ceylon by 36 percent. This and the advent of the steamship made it much easier to bring ironware to India from Great Britain at low cost and radically changed the situation. With the opening of the Suez Canal in 1869 and the gradual extension of the railways, the fate of the ironworks projects was sealed.

**Political Integration – and Separation**

The colonial government invested heavily in both the Kumaon and the Burwai Iron Works, and both projects were important in the context of colonial policy at the very highest levels of decision-making of the Government of India in Calcutta and the India Office of the Home Government in London. At first sight this is fully consistent with the fact that the sustained and continuous support of the state has been a hallmark of successful heavy industries throughout the history of industrialism, sometimes taking the form of general concessions and favourable financing, sometimes involving the starting of industries as government undertakings, bearing the initial heavy costs until they are ready to work independently as private companies. There are often a multitude of different forms of co-operation between state and private bodies. The ironmasters of Pennsylvania presented the US Congress with a resolution in 1849, which was quoted in the arguments of the Kumaon Iron Works a decade later.

That it has been the policy of every civilized Government to extend a fostering care to the production of iron, and that the example of Great Britain is especially worthy of notice, who, by an unswerving course of favouring legislation, sustained the business in its infancy, when its prospects, without that aid, were far less encouraging than they now are in this country, and never removed its protecting care until it reached a development unparalleled in the history of trade, by which the consumer
is supplied at the lowest rates, and the manufacturer defies the competition of the world.  

As noted previously, Thomas Oldham also spoke, some years later, of the importance of government support in the initial phase of a country’s mineral production, and drew a parallel with developments in Australia.  

Parallel to the Government stakes in the Kumaon and Burwai Iron Works, there is however a long history of inconsistency in the support of works. The policies were never clear-cut and the conflicting interests and inconsistency of the support were already apparent in 1817 regarding Kumaoni ironmaking. At that time, Mr. A. Laidlaw was appointed mineralogical surveyor on a mission in Kumaon, but his assignment was somewhat ambiguous. His main task was to consider whether metallic ores or other useful minerals could be raised and brought to the market. But, at the same time, he was told to take great care: “as the working of these metals [iron and copper] might injuriously affect important articles of British import, it is not designed that your attention should be occupied in detailing any practical arrangements for that purpose.”  

In 1853, thirty-five years later, a similar fear of competition was repeated in a petition from the manufacturers of Sheffield to the Select Committee on Indian Territories. The producers were convinced that the East Indian Company had hindered their trade with India. The British Parliament should take over the control but “beyond making useful experiments the Government should not be permitted to become cultivators, manufacturers or traders”. Instead the Government should create favourable conditions for an increased production of “cotton and other valuable raw materials”. One of the chief measures for achieving this would be to use the Public Works to cater for all “engineering agencies required in a civilized and commercial country”. The public works mentioned were the main lines of railways, roads and bridges, navigable rivers, reservoirs and canals, piers, harbours, breakwaters and light-houses.  

The decision to initiate ironmaking projects in India seems however to have had quite a firm foundation at the end of the 1850s, not only in the central circles of the administration in London, but even from Sheffield. A Select Committee of Parliament was working on the issue of colonisation and settlement in India and this is one example of British official bodies advocating the development of an iron industry in the 1850s. The minutes of evidence taken by the committee in the spring of 1859 indicated the importance of the iron industry of India in British colonial policies.

In March, Charles Atkinson, Mayor of Sheffield, and Robert Jackson, Master Cutler of Sheffield, were called and heard on the connections between
Sheffield and India. Their joint opinion was that an expanded production of iron in India would give valuable support to their own business. India could furnish them with excellent cheap iron to reduce the cost of importing expensive iron from Sweden and Russia. As a supplier of rails and other equipment it would also speed up and reduce the expense of building the Indian railways and thus help to open a huge new market for their own products. These views were quoted later the same year as an argument for continuing with the Kumaon Iron Works project and the general conclusion was also summarised approvingly in the joint report of the parliamentary committee.

One of the questions of the select committee of 1859 was why the railway companies had not engaged in creating a supply of cheap rails and machinery produced in India. Mr. Jackson said that he was not ready to answer the question but still stated that “the railway companies want a little time to turn themselves around”. Building furnaces and getting the ore together could not be done in a day.72 “The introduction of a new enterprise like the manufacture of iron into any country must be a matter of some difficulty in the outset. This has been fully exemplified in many instances both in Europe and in America, where circumstances and climate are both favourable,” William Sowerby noted.73

Both the Narmada River Valley and Kumaon were mentioned as important possible areas for further development and it was said that Indian iron had been found to be “very good in every respect” for making steel. At the same time India, “with its teeming population, would find us an excellent market for our surplus manufactures”.74 This implied further reasons for encouraging an expansion of ironmaking in India. For one, it was said that in order to make the inland markets accessible for British manufactures, railways should be built, and these could be built more cheaply and rapidly with rails produced in India.75 It was also noted that it could be advantageous to import iron from India, since it was not only of good quality but also very much cheaper than comparable qualities from Sweden or Russia. Robert Jackson spoke optimistically of the new trade, rapidly expanding since the East India Company lost many of its monopoly privileges, “… we have imported the natural products of India, such as iron, ivory, cotton, and silk, and we have sent back in payment or exchange our own manufactures, which is a very important thing.”76

This portion of the minutes of evidence was summarised approvingly in the report of the committee. It stated that “[n]o measure will be more favourable to the rising prosperity of India and to the encouragement of British settlers there, than the development of its coal and its iron.” Both the Narmada River Valley and Kumaon were explicitly mentioned.77

And again in 1862 the exploration of India was an investment in a possibly profitable future, as was expressed that year in the records of the Great Exhibition in London: “We are only now beginning to understand in what the mineral wealth of India really consists, and it is gratifying to learn that
the coal and iron resources have so increased in development as to occupy very prominent positions in this collection.” The exhibits of the East Indian Iron Company in the Madras Presidency attracted most attention at the Exhibition, especially specimens of cutlery made of Bessemer steel from the Beypore works, both by “native smiths” in India and in Sheffield. The Kumaon Iron Works also furnished samples of its products, but no details of them were given in the description of the Exhibition. The exhibits showed that India was a possible target for British investors and also that for British users Indian iron could be a good alternative to the charcoal irons from Sweden. “We are only now beginning to understand in what the mineral wealth of India really consists”, Mr. M. C. Cooke commented in *The Practical Mechanic’s Journal* and paid tribute to the work of Professor Oldham.

At the same time a combination of encouragement and lack of decisive support characterised the policies of the colonial state with regard to the ironworks. In Kumaon the Government dealt with the affairs of the works hesitantly, slowly and even inconsistently, all adding to the uncertainties of the potential iron producers. The ambiguities and inability to make final decisions crippled the project.

In Nimar the end was more definite and the minutes of the discussion which took place in the summer of 1863, when the fate of the Burwai Iron Works was decided, are probably one of the most significant documents relating to the two cases studied. They expressed the view at the very top of Indian decision-making and hint at the reasons for the final closure of the Burwai Iron Works. By extension the arguments and the opposing views are also relevant to the fate of Kumaon.

In the summer of 1863 the discussion of the future of the Burwai Iron Works culminated in a debate involving the members of the Council of the Governor General. Different opinions on the undertaking were voiced and weighty arguments put on record. The discussion arose from a proposal to increase Government spending on the works by 50,000 rupees, approximately doubling the outlays up till then, excluding the cost of machinery. This discussion is highly significant for this study and motivates an extensive account of the arguments presented.

“TO TAKE THESE WORKS OFF OUR HANDS”

The discussion on the Burwai Iron Works in the Council of the Governor General started with a minute by Sir C. E. Trevelyan, dated June 13, 1863. He questioned the desirability of incurring greater expenditure on the works and referred to the only two ironworks in India based on “English principles”, the works in Porto Novo and Kumaon, both of which had turned out unprofitable. Underlying his argument was a strong belief in the blessings of private enterprise and he asked: “Is it, therefore, probable that the
Government will be able to carry on with profit an industrial undertaking which failed to answer with every advantage of private activity and thrift. After a somewhat questionable assertion that it was easy to produce pig iron, he went on to a passage that was central to his argument, not far removed from David Ricardo’s economic theory of comparative advantage.

England possesses in perfect combination cheap iron, cheap coal, cheap capital, workmen endowed with strength, hardihood, and skill, and an unlimited command of the most improved machinery and of the means of repairing or replacing it. It is a misdirection of the resources of India to enter into competition with England in this branch of industry. On the other hand, India has, in the cultivation of the rich produce of her prolific soil and climate, resources of her own, the development of which is limited only by the insufficiency of labour and capital. To divert these elements of production [labour and capital] from a profitable to an unprofitable employment, is surely a mistake. Our true course is to adhere to the great division of labour which nature herself has established.

Trevelyan continued to argue that the recent reduction in the import duty on iron, from ten to one percent, had been made on the general understanding that India would have to depend on England for iron to supply the vast works in progress in the country. Here he also referred to the rapidly improving transport facilities. First, the imbalance in Indian trade provided very cheap freight rates for imported iron. It could be brought in as ballast on the ships coming to fetch agricultural goods for England. Second, the extension of Indian railways was continually facilitating the conveyance of iron into the interior of the country. All this led to the conclusion that “in setting up Government Ironworks we are competing, at the public expense, against the English Iron Trade and the English Mercantile Community.” Instead of an additional investment in the Burwai Iron Works he suggested expenditure “on Cotton Roads or Irrigation Works”.

Three contributions to the ensuing debate, dated June 13 and 15, must be considered, and they were in part divergent. Major General Sir R. Napier, president of the council, stated that in general he dissented from the views of Sir C.E. Trevelyan. He believed it to be the duty of the Government to foster the natural production of the country. “All the great improvements of India have required and benefited by this action of Government, and I would not withhold it from iron.” His view was extremely clear, and he believed he voiced a general opinion of “not throwing the country entirely at the mercy of the foreign supply of iron.” He saw no need to advance further arguments in support of his view.

H. P. Maine, the second speaker, was in general, but only in general, critical of Trevelyan. Concerning the natural endowments of India, he observed that “in a country as vast as India, it is quite possible that at certain points mineral wealth may be exceptionally developed”. Government expenditure on experimental ironworks might be just as defensible as expenditure on cotton roads.
and irrigation works. In the case at hand, Maine did not dissent from Trevelyan’s view, but delegated the decision to the Governor General. He felt that he had not enough material to come to a satisfactory conclusion himself.

The third participant in the debate, W. Grey, definitely thought that the project should continue. In principle he admitted that the Government should not engage in undertakings “of a commercial character”. This did not apply though, he thought, to those cases in which the Government had already taken the field, and already incurred an outlay, “unless some private party were prepared to come forward and relieve the Government from the undertaking on fair terms”.

At last the question was referred to the Governor General, Lord Elgin. In a minute of July 22, 1863 he began with a clear statement of policy. On the one hand, he was not prepared to affirm that it was a misuse of the resources of India to enter into competition with England in the production of iron for the Indian market. On the other hand, he was ready to admit that it was no part of the duty of the Government to test the feasibility of doing this. This ought to be left to private enterprise.

Lord Elgin believed that the big investment in Indian railways made it reasonable to suppose that a domestic production of iron would not be neglected if it could be profitable. The railway needed iron and connected to the railways were numerous employees acquainted with the trade in, and production of, iron. It was not the duty of the Indian Government to engage in an unprofitable production of iron in order to safeguard the railways against an interruption of supplies from England. Therefore he had never looked on the permanent retention of the Burwai Iron Works as a government undertaking, and now certain circumstances had made it advisable for the Government to take early steps to divest itself of the concern. The first of these circumstances concerned the manning. According to Lord Elgin, Richard Keatinge had earlier stated that the works “might be started almost entirely by native agency”. This had proved wrong, and now the endeavour to obtain European skilled workmen in India had failed. Keatinge’s present suggestion of sending Mitander back to Sweden to hire five Swedish workmen would both be too expensive and delay the operation of the works. Moreover Lord Elgin had been convinced that the works could never be economic with only one blast furnace, but the cost of fuel and the limited availability of ore precluded the Government from investing any large amount of capital in the extension of the works to include more. Lord Elgin’s decision was therefore that measures should immediately be adopted to ascertain whether any company or individual “would take these works off our hands”. Considering the importance that had been attached to the experiment, Lord Elgin “would rather give the plant for nothing to persons willing to carry on the work than sell it for its value to others”.

There is at least one basic question, partly rhetorical, that has to be posed concerning these arguments:
Was the division of work of which Lord Elgin spoke really a reflection of the grand scheme that nature herself had established? Or to what extent was it also a social construction? The quantities of iron ore and of coal in India were, without a shadow of a doubt, substantially greater than those in England. And the advantages of British industry that Trevelyan listed – capital, workmen and a system of knowledge and industry – were they only the result of nature? Or was it rather that the primacy of British iron and steel producers could not in the end be challenged?

**THE ULTIMATE POWER OVER INDIA**

Although the histories of the demise of the two works seem to differ, there was an essential common feature. In the case of Burwai the decisive reasons for the colonial government’s refusal to put in more money to finish the experiment was the wish not to interfere with free competition and the interests of the home producers. In the case of Kumaon the impossibility of raising willing risk capital was the decisive cause, a situation clearly governed by the extremely unsure conditions of competition.

Factors outside the immediate realm of the works determined their fate, with the policy of the colonial state the final and decisive factor: The preference was for private enterprise and the ambition was to minimise the role and expenditure of the Government. The main concern was not to harm British domestic interests and instead to place the emphasis on the production of raw materials in India. This, together with market forces and conditions, decided the destiny of the works.

The ultimate power over India, the British Raj, lay with the Government in London, appropriately called the Home Government. India, the subcontinent, was on the outskirts of an empire, although of great importance. Contradictions within this entity, especially between Britain and its representatives in India, may be crucial to an understanding of the outcome of the Kumaon and Burwai Iron Works projects. In the case of products using minerals as raw material, local needs could be catered for by imports from Europe, not by the use of local resources. This could occur against the wishes of the local British administrators, “whose agenda were often at odds with those of the East India Company and the mineral trading houses of Britain”.

Two lines of reasoning can be seen in the history of the ironworks, evident also at the central levels of the Governments in Calcutta and in London. In 1859 there was a strong move to establish iron manufacture in India, at least for the immediate needs of the railway companies, but in 1863 this had shifted to a definite policy where the state’s involvement in this had to be minimised. A central conclusion that can be drawn from the histories of the Kumaon and Burwai Iron Works is that the development of a modern mode of ironmaking in India was entirely dependent on decisions made in Britain. To the extent that measures were taken, the aim of British policies was not to
develop India’s ironmaking and steelmaking capacity as such, but rather to cut public expenditure. The overriding objective was to pave the way for an expanding British trade. Indian development was to fit in with the growth of British trade, and in this ambition the City and the iron and steel producers of Britain often joined hands. The combined result of pursuing this goal was the indecisive policies of the Government with respect to ironmaking projects. The need for a rapid return on investments also reduced the possibility of success.

**COINCIDING AND CONTRADICTORY INTEREST**

According to Cain and Hopkins, the main dynamic of gentlemanly capitalism was to create an international trading system centred on London, mediated by sterling and held together by free trade, which would encourage specialisation, cut transaction costs and create an interlocking system of multilateral payments.87 Cain and Hopkins also maintain something of a dichotomy between gentlemanly and industrial capitalism, placing the decisive power in the City of London. Although it lies outside the scope of this thesis to explore this balance of power, it seems reasonable to shift the centre of gravity closer to industry. At least in final practice and as expressed in the histories of the Kumaon and Burwai Iron Works, there must have been a strong community of interests between the city and industry.

Complementary products, in the spirit of David Ricardo’s theories of competitive advantages, meant profits for both traders in the City and industrialists. In contrast an increase of ironmaking and manufacture in India would have increased India’s economic independence and self-sufficiency. Not only would this have injured British iron and steel producers, but also trade between Britain and India would have been diminished.

In their studies of British imperialism Cain and Hopkins have maintained that it is hard to establish that business agitation actually influenced policymakers. It may be hard to determine the causal relationship, but I would certainly conclude, from my own evidence, that the opinions of industrialists were important or, at least, that there were fundamental joint interests between the millocracy and the service sector in England. In every respect, iron production in India would have moved power and incomes away from England. Manufacturing interests would have lost. Trading and finance would have lost. And thus there grew a strong joint interest in not supporting the adventurous or even risky task of building an Indian iron industry. In view of the prime importance attached to maintaining the sound economy of the state it was also deemed too hazardous and speculative to invest in an iron industry that could only give uncertain incomes in the long term. This to some extent modifies the alleged dichotomy between gentlemanly capitalism and industrialists.88
The interests are interlocked and the question of whether or not to start making iron in India must have been a matter of strategy. Gentlemanly capitalism could in some cases foster such an interest, for example in order to encourage and ease the building of a transport system. On the other hand, the arguments against could also be encompassed in the gentlemanly strategy: fostering trade, specialisation and a secure foundation for public finances. The reasons for the choice made, the interests that were paramount, may thus be hard to distinguish.

The Government united the gentlemanly industrialist interests at home with the local Indian British interests by creating the prerequisites for establishing and maintaining colonial power and control over India, but at the level of the details of iron and steel, contradictions became apparent. The Home Government seems to have been torn between the opposing wills of local interests and the strong lobby at home, which not only opposed all efforts to hamper free competition, but also worked against all efforts to spend public money on uncertain ironmaking experiments in India.

This discussion on the Kumaon and Burwai Iron Works can also be related to the fact that during the second half of the nineteenth century Britain moved from self-sufficiency in basic foodstuffs to a dependence on imports for roughly half her annual consumption. “Arable agriculture was the first outstanding victim of Britain’s mid-century commitment to the international division of labour …”. The other side of this coin was of course a greater dependence on exports, to guard old markets and conquer new ones.

The contradiction inherent in the encouraging of surveys and mining activities but the discouraging of the processing of the minerals that were mined permeates the entire history of colonial rule and had serious long-term effects on industrial entrepreneurship. A similar example, from another industry, may be found in the attitude to oilseed in the early twentieth century. It was permissible to export oilseed but not even the oil extracted from the seeds! On a local level the Madras Government showed an unexpected stubbornness in industrial promotion until the Secretary of State himself intervened.

The losses experienced by the Kumaon Iron Works could not, the Government of the North Western Provinces wrote in 1872, “in part at least, be separated from Government action”. In this sense there are strong similarities with present-day interaction between state and private companies, in cases when market forces are considered unable to guarantee development and the state lends a helping hand. State intervention has been important all through the history of iron in Sweden and the attitude of the state was no less crucial in the histories of the ironworks at Kumaon and Burwai.

**PERSEVERANCE AND MOMENTUM**

The powerful interlocking and partly conflicting interests in Britain formed colonial policies which affected the Kumaon and Burwai Iron Works. In the case of Burwai its history is fairly short and clear-cut, but concerning Kumaon
it may be asked, how the long-lived and recurring interest in the project can be explained. A part of the answer is probably to be found in the combination of highly committed individuals, the close ties between many of them and British Government administration and lastly the momentum acquired by the project over time.

On a local, and partly on an all-Indian, level, explorers, scientists and entrepreneurs with a strong personal interest were the most active agents in developing ironmaking. In most instances, these individuals were also part of the administration or the armed forces. In some cases they were Englishmen who had previously developed a strong affinity for India in a professional life there. All the individuals we have encountered earlier in this story, such as Richard Keating, Henry Drummond, Thomas Oldham and William Sowerby, belong to these categories.

A most interesting example of a collective of advocates of ironmaking is a list of the shareholders of the North of India Kumaon Iron Company Limited, preserved in the archives of Julius Ramsay in Sweden.93

The joint stock company was owned by 47 different shareholders, between them holding 465 shares. Nine of them had non-British names and were probably native Indians, but together these owned no more than 65 shares (14 percent of the total number). The strength of the enterprise was in the British community of civil servants and members of the armed forces in India: 118 shares (24 percent) were owned by British residents of Kumaon and 252 (54 percent) by Britons living elsewhere in India. Many of them were high officials or other influential people, foremost among them the former Commissioner of Kumaon, John Hallet Batten. Even the Kumaon mission in Almora had bought ten shares. The remainder of the stock (95 shares, 20 percent) was owned by people living in England. The great majority of the shareholders were British and had long experience of India.

Julius Ramsay commented that most of the investors “knew little or nothing about the company. They only sought an opportunity to invest money”.94 Some of them did visit the works, however, for example Major Rob. Ramsay, brother of the Commissioner of Kumaon, and Major Baugh, both newly retired and on their way back to England when they came to Dechauri in 1862. They were “of course interested in the works in which they had placed a large part of their savings from India.”95

There was also a strong personal link between the colonial state and the privately owned Kumaon Iron Works. As already noted, the future head of the Public Works Department, Colonel Richard Strachey, signed the contract when Julius Ramsay was engaged in 1861 and Strachey’s brother was not only the Commissioner in Moradabad, but also a shareholder in the Company.96 The two directors of the company, Dr. Pearson and Mr. Read, both had important official positions in Kumaon and were firmly established in India. Dr. Pearson was responsible for vaccinations in the province, and Read was inspector of Government forests. Pearson had lived in the country for thirteen years, and resided in Almora with his wife. Read lived with his wife and children in Nainital.97
The Indian shareholders in the Kumaon Iron Works list can possibly be interpreted as a sign of the emergence of an embryonic Indian capitalist class, finding it profitable to collaborate with British business groups and British rule in general.\textsuperscript{98} All the same, the predominance of British residents in India and in the UK in the Kumaon Iron Works shareholders’ list corresponds well with Bagchi’s observations on the lists of owners of Indian companies some forty or fifty years later.\textsuperscript{99}

The strong foundation in the form of a number of committed individuals can be seen as one important reason for the longevity of the projects. Another may simply be a matter of momentum.

The long history of the Kumaon Iron Works, in particular, raises the question of how the idea and the project could have been pursued for so long. One important answer is of course in the perception of the potential – in spite of difficulties at the sites and the general sluggishness of progress. Another part of the answer could be that the projects, and again especially the Kumaon Iron Works, developed a momentum of their own. Eventually so much had been written about Kumaoni iron, so many people had devoted so much time and energy to exploring it, that the value of the area as an iron-producing region had been established by the sheer fact of the interest it had aroused. “The amount of iron which has been manufactured bears but a small proportion to the number of the reports which have been written upon the subject”, as Valentine Ball wrote in 1864.\textsuperscript{100} Or, as the Commissioner of Kumaon noted in 1872, arguing for continuing efforts: “… with buildings and machinery on the spot, the produce of these works must be available, long before similar works could be in operation other parts of the country.”\textsuperscript{101}

Awareness of the implications of a failure must also have strengthened the will to continue. Sowerby referred to the consequences of the Madras Ironworks and wrote that “whenever there is any proposition made to manufacture iron in India, the Madras Works are alluded to and pointed at as a failure.”\textsuperscript{102}

A History of Choices

The efforts to develop the Burwai and Kumaon Iron Works were a part of a much broader exploration of the possibilities of making iron in India. The Madras Ironworks, small and based on charcoal, came before it, and from the late 1870s attention turned to ironmaking based on coal (coke).\textsuperscript{103} When the idea of making iron in Kumaon was put aside in 1879 new developments were already taking place in Bengal, in the form of a long-range project for using India’s big resources of coal to make iron.\textsuperscript{104} The history of ironmaking in India using coal is not explored in this thesis, but problems included certain unfavourable properties of the iron ore and, especially, of the coal, such as the lack of good coking coal, the high sulphur content and the large amount of ash.
Developments during the 1870s and thereafter reflect the marked ambiguities of British policies. It is a fact that Indian ironmaking continued on a downhill road (de-development). As the markets for iron goods expanded, Indian ironmaking decreased. And it seems as if the Government of India except in isolated cases did little to encourage interest in the development of the iron resources of the country.

In the early years of the twentieth century the most important iron-and-steel works commissioned was Tisco (Tata Iron and Steel Company), and important facilities were also established at Bhadravati (charcoal-based works in Mysore) and Iisco in Bengal. Nevertheless, the gigantic iron ore measures of India remained mainly unused and coal resources were used primarily for general power generation. On the eve of independence the Indian iron and steel industry was still minute in relation to the country’s resources and needs.

It may be illuminating here to jump from the nineteenth century to the period immediately following independence. Again the relevant issue is the role of the state.

At the dawn of independence the work of the subcommittees of the National Planning Committee, appointed ten years earlier under the chairmanship of Jawaharlal Nehru, was at last published. The subcommittee on mining and metallurgy summarised:

Indian opinion is convinced that the British Government, while it held power in this country, was deliberately inclined to put a brake upon the progress of Mining and Mineral or Metallurgical Industries in the Country. For if India attained a degree of self-sufficiency in the matter of minerals to meet her own demands in respect of tools, implements or machinery, a very considerable market for Britain’s own production would be lost. There was consequently no policy to develop the existing resources, which, if adequately and effectively developed, might suffice for our needs in the initial years at least.105

And central planning became a vital element of the building of an Indian iron and steel industry in independent India.106

Counterfactual reasoning is a core of historical research, whether explicit or implicit. This long history poses the urgent question of whether there were alternatives to the roads actually chosen. Without them, history would become totally deterministic and descriptive. The possibility of choice is at the core of humanity and of democracy. If the “if” or “if not” were not present, why speak of power and might? The thrill of studying history lies in discovering the choices, the focus of contrasting powers that can turn events one way or the other. The histories of the Kumaon and Burwai Iron Works can also be viewed and discussed by approaching other possible roads to the making of iron in India.

An important task of history is to show the choices made and the variety of possible courses of development in the past, including those that were not
chosen. History cannot repeat itself, but by writing history, we can spread knowledge of the influence of human actions and choices on our destiny.

Whose history are we writing? To escape determinism and passivity we must ask why the trend of events did not turn out otherwise. “[Antonio Gramsci] believed that history changed when people changed it. In this view, the past is not a line leading to the present but a series of roads not taken.” 107

If we assume that history is not one single straight line from then to now, and that it has been and is possible for people to influence history, it should be an important task of historiography to study the roads not taken, the alternative roads of development.

At the time of Mitander and Ramsay it is possible to construct four possible roads to meeting the present and future need for iron in India. The first and most obvious, which has been in the sharpest focus in this text, was to base production on indirect ironmaking using charcoal, with a conscious venture into a combination of imported technology and use of India’s own natural resources. The second choice, which came to be the closest to hand, was to meet the need with imports, by buying iron from the consistently more efficient British iron and steel industry. A third road, the use of modern ironmaking based on mineral coal, was also discussed, but for various reasons this possibility was not the first choice. The resources of coking coal were unexplored and the coal found had a very high ash content, making its use difficult and expensive. The start of coke-based ironmaking also entailed higher investment costs. The use of charcoal permitted the use of smaller units and a more flexible approach to capital investments. A fourth road, at first sight close at hand, would have been to make a systematic effort to expand the widespread and firmly established traditional native ironmaking in India, on a small scale and based on charcoal and local raw materials. This fourth alternative fully illustrates the complexity of the connections between technology and culture and social organisation.

In a minute to the Government of India, Mark Fryar, Mining Engineer to the Geological Survey of India, in 1872 drew attention to the question of how to improve ironmaking in the principal iron-producing districts of India. He began by drawing a comparison with the situation when modern technologies were introduced in Europe. This large-scale production “requires the expenditure of so a large sum of money as to make any experiment on a similar scale and in a new country, for such works, like India, exceedingly hazardous and inadvisable”. 108

Instead Mr. Fryar advocated an initial step in “cautious degrees”. This would foster an expansion of demand and make it possible to gradually ascend in scale …

... from elementary appliances, to the higher and more expensive mechanisms of the art, so that, of the raw material to be dealt with, the experimental knowledge essential to success may become surely and correctly developed, and that the artisans and workmen may undergo a process of sound education in their respective duties. 109
Mr. Fryar underlined the desirability of setting good models, making gradual improvements and continuing the process of learning. His idea was illustrated with two examples. In Jabalpur, in the Central Provinces, Mr. W. Olpherts, engineer of the East Indian Railway Company, had proposed an elaborate plan for improving the methods of ironmaking. Mr. John Donaldson, civil engineer at Hasaribagh in Bengal, suggested a mode of production that in most essentials was similar to Olpherts’. The suggested set-up, as shown in a drawing published in *The Colliery Guardian* in 1872, consisted of a number of bloomery furnaces of a traditional Indian model arranged in two rows and supplied with blast from a common source, a steam-powered blowing engine. Two small steam hammers would be used for the refining stage. Besides this a small blast furnace would be set up for training purposes.

The new type of blast suggested by Mark Fryar was a detail of his setup which illustrates how new technologies go beyond the simple facts of mechanical rationality and time measurement. Fryar described how the traditional furnaces were supplied with blast from manually operated bellows, and he added that “often one sees the wife or daughter working the skins for their relative.” With the new method the role of women would disappear or be radically changed. It is not known if any efforts to put a system like Fryar’s into practice were ever made, but his solution points to obstacles in the social content of a technology. In an article of 1966 Professor Bhattacharya, economic historian at the Jawaharlal Nehru University in New Delhi, argued that the prevailing view among many sociologists and economists was that the main obstacle to technological innovation and economic advancement was cultural and that this view revived stereotypes of the colonised as “lethargic, indolent, mentally averse to innovation, etc.” Bhattacharya analysed the reasons of native artisans for not adopting suggestions like Fryar’s
and found a number of connected factors. The family unit would be disrupted by the innovations, as would the bond of interdependence between the social groups of smelters and blacksmiths. The concentration of many production units in one place would also change the social organisation of production. Lastly the new machinery would be beyond the financial reach of the limited resources of the artisans and would necessitate the entry of an investor and would thus mean a separation of the ironworkers from the ownership and control of the means of production.

Professor Bhattacharya has since returned to the issue and summarised the complexity of the situation in the words of an old village blacksmith (Lohar), who, when asked why he preferred the traditional leather bellows to the modern blowing machine, replied: “This new machine will win in the end, but it will blow my family away.”

Bhattacharya carries the argument a step further.

This village Lohar taught me to ask some questions we in the academic world fail to ask. Did this village Lohar reveal values and attitudes typical of a “culture of backwardness” and an irrational response to a more efficient technique? Is there just one economic rationality based on input-output accounting or are there different orders of rationality? If economic accounting of costs and output bypasses the totality of the human situation, is it an adequate measuring rod?

Under colonialism, there were some efforts to introduce new industrial technology but these were effectively hampered by the overriding goals of the colonial power and the commercial interests determining its actions. In the words of Ian Inkster, officialdom in India was “hamstrung through a removal of effective sovereignty over decision making”. Even without consideration of which road to social development would have been the best, this is even more evident with regard to the traditional techniques. If the implementation of the transferred European technology was restrained, any systematic support or encouragement of traditional ironmaking was out of the question. The spokesmen for this trade were denied all right of speech. Continuation or any gradual development of these techniques was not even on the agenda of the Europeans, except for a few, whose small numbers confirm rather than refute the conclusion.

**SUMMARY DISCUSSION**

Islands of Modern Technology

The Kumaon and Burwai Iron Works showed a near total dependence on European technological solutions, including imported machines, spare parts and tools, knowledge and skilled manpower from Europe. And even if the Swedes envisaged a flexible combination of technical solutions of different
origins, only some few pieces of heavy equipment were ever ordered from local suppliers.

The problems in recruiting skilled personnel and in bringing technical implements like machinery to physically inaccessible locations were aspects of the lack of integration into any system of ironmaking, of markets and of knowledge on a middle level between the local and international. The technology chosen was deeply alien to the existing technical and socio-economic system of India. The connections in the realm of technology and knowledge between the Kumaon and Burwai Iron Works and their surroundings were almost non-existent. They were enclaves, isolated islands, which jeopardized their survival and increased the need for long-term government support in the build-up of a system.

The Kumaon and Burwai Iron Works never became integrated into any Indian social and economical context that could have carried them forward. The works were parts of bigger systems, of knowledge and of production and were fundamentally part of other social, economic and political systems. This finally determined their fate. The Government handled the affairs of the works hesitantly, slowly and inconsistently, which all added to the uncertainties of the potential iron producers. The ambiguities and inability to make final decisions crippled the projects.

During the second half of the nineteenth century both new developments in the technique of iron and steelmaking and ever better communications between Britain and India and altered the balance on the markets. Iron imported to India became cheaper. A stronger emphasis of British policy was laid to foster the production of raw materials for British industry, to make the most of India as a market and to avoid any competition with British manufacturers. During the second half of the nineteenth century these goals became congruent with the aim to minimise public expenditure for maintaining the Indian Empire. The British millocracy and gentlemanly capitalism could join hands.

In the 1860s there seems to have been a clear possibility to take the first steps of building an Indian iron- and steel industry. With the decisions to end the projects of the Kumaon and Burwai Iron Works this window of opportunity was closed and it would become still more difficult and demand still stronger efforts to open it again.
Final Discussion

In which the results of the research are summarised
FINAL DISCUSSION

Brittle and Bonded Projects in a Global System

The aim of this thesis has been to present a detailed empirical study of the Kumaon and Burwal Iron Works – two colonial projects planned to introduce modern steel technology into British India in the mid-nineteenth century. The role played by three Swedish metallurgists, commissioned to head the projects, has been a focus of the study and a central question has been why the works were never brought into full and continuous production.

It has also been my aim to place the investigation in a wider theoretical and methodological framework: First to explore the significance of the projects in a search for explanations of the late development of Indian iron and steel industry and second to investigate how the historical landscape of the iron works can be used to understand their histories.

On a general level I have concluded that the outcome of the ironworks projects, which are to be considered processes of technology transfer rather than fully fledged and completed transfers, was the result of the interplay between the local and the global, between on the one hand a diversity of concrete factors influencing the construction of the works and their running, and on the other hand their colonial character. The study emphasises the importance of technological systems and networks, on a micro as well as a macro level. Crossing boundaries in time, passing from the well known to the still unfamiliar, underlines the importance of a close acquaintance with local settings and conditions, where history is manifested in a physical presence.

Individual Pioneers and Government Support

During the first half of the nineteenth century British rule over the Indian sub-continent was gradually extended. Being a part of a growing British Empire, India was to pay for itself, as a utility for an industrial country on the move. It is in this context that the history of the ironworks should be traced. India was a land to explore and discover, a land to exploit and control.

Members of the armed forces were the forerunners of imperial expansion – called by some a spread of European civilisation. Their weapons of conquest
were not only guns, as when the great Indian Mutiny was quelled in 1857–58, but also a wide knowledge of different strands of science, engineering and society-building. During the first half of the nineteenth century there was also a growth in the role of experienced and professional scientists among those who conducted surveys and compiled reports. Their collective tasks included a mapping of natural resources, among them iron ore.

The Narmada River Valley and the Himalayan mountain range were prominent items on the agenda of geology as a science. The two regions had been created by dynamic and dramatic forces which had laid geological structures open to direct observation. The discovery of interesting fossils stimulated further scientific curiosity, and there were also more ephemeral reasons for paying attention to these two regions. The attractions of Kumaon were the high Himalayas, promising rich returns of minerals and the Narmada River Valley, with its “picturesque beauty”. At first the possibility of using the Narmada River as a transport route was another argument for investigating the area, and Kumaon’s position as a staging post for the lucrative Tibetan and Nepalese trade added a strategic element.

In the first half of the nineteenth century the general exploratory character of the surveys gave way to an increased emphasis of the practical use of the minerals, especially coal and iron. There evolved a closer connection between science – i.e. the mapping of natural resources – and colonial, commercial interests, between science and industry. Enthusiastic reports from mineral surveyors helped to persuade the board of directors of the British East India Company and the Government of India to try to start manufacturing iron, first in Kumaon and then, some years later, in Barwah in Nimar.

The course of the ironworks projects was a result of the interplay of actors on different levels. Individuals played a major role in setting the detailed agenda and the projects are hard to imagine without the input of men like the experienced geologist Henry Drummond, the enthusiastic but maybe not always fully competent engineer William Sowerby, or the persistent and skilful organiser and army officer, Captain Richard Keatinge. Technological experts such as William Henwood and Rees Davies were actively engaged at the Kumaon Iron Works and it was such individuals who formulated the ideas and worked strenuously and self-sacrificingly to implement them. At the same time ironmaking was also a business of the state at central government level. Behind and above individual actors at the Kumaon and Burwai Iron Works there was thus the colonial government in Calcutta, and, above that, first the board of directors of the East India Company in London and, from 1858 onwards, the Home Government in London.

The immediate aim was to explore whether public works and, especially, the gigantic railway construction that was planned in India could be adequately supplied with iron produced in the country. The projects were a matter for consideration and decision at the very highest level of the colonial hierarchy.

In the early 1860s the task of planning and building the ironworks was entrusted to three Swedish engineers, Nils Wilhelm Mitander, Julius Ramsay
and Gustaf Wittenström. By that time British ironmaking had become almost solely based on coal, while the renowned Swedish iron and steel industry was still based on charcoal. Since the ironworks in India were to be fuelled with charcoal, the British turned to Sweden to find competent managers for the works.

During Mitander’s and Ramsay’s time in India the ambitions and hopes of both ironworks reached a peak. The Swedes became full-time managers of the works, responsible for each and every aspect of their construction and operation, and they were the active link between Britain and Sweden on the one side, and India on the other. They had a strong position from which to guide developments at the works. They personified the processes of technology transfer. In this respect they were the carriers of technology and the enterprises gained exclusive and extended rights from the government.

In 1860 Nils Mitander was engaged to direct the Burwai Iron Works in close collaboration with Captain Richard Keatinge, who had brought in a rolling mill from Britain at the Government’s expense in 1857 and obtained permission to build an experimental works in the small town of Barwah. The works was to include a blast furnace to produce pig iron and all the facilities for the further processing of the pig iron into market-ready iron, cast, forged or rolled.

Julius Ramsay was engaged as manager of the Kumaon Iron Works at Dechauri. At this site William Sowerby, civil engineer of the East India Railway, had been one of the most ardent advocates of ironmaking and back in 1856 he had built a blast furnace and produced some pig iron. This led the Court of Directors of the East India Company to embark on a more ambitious undertaking and a new blast furnace was finished and set in blast in 1860. Pig iron was made during an extended blow in the spring, but the operations were repeatedly interrupted and results were inconsistent. At that time four small blast furnaces had also been built in adjacent Kaladhungi and work had begun on two new sites in Kurpa Tal and Ramgarh, further up in the hills. Dechauri was the main plant, however.

From the very beginning the aim had been to transfer the Kumaon Iron Works from public to private hands and in February 1860 a newly formed company, the North of India Kumaon Iron Works Company Limited, took it over. The company took direct charge of the works at Dechauri and Ramgarh. The smaller and in this story peripheral sites of Kaladhungi and Kurpa Tal remained in the hands of the first blast-furnace keeper at Dechauri.

The Swedes spent only a few years in India, but the results they achieved were substantial. Nils Mitander arrived at Barwah on 18 November 1860 and his first important task was to search for iron ore. He visited a number of possible mining sites. Soon after his arrival he also set about the enormous undertaking of designing and building the ironworks. Besides building the plant itself, which was placed on a hillside just outside Barwah, he had also to devise systems for supplying necessary materials during the construction period as well as charcoal and iron ore for ironmaking once the works was up and running.
Over a period of two years the Burwai Iron Works, a small integrated ironworks, was built up from nothing. On 6 December 1862 Mitander started the first blow in the blast furnace, but he was forced to stop it four days later. The stoppage should not have been unexpected, since a first blow in a new blast furnace was always uncertain, but this single incident became a turning point. The Government decided to put no more money into the project and Mitander’s mission ended when he left Barwah at the end of April 1864.

Julius Ramsay arrived in India a year after Mitander and the situation he found was quite different from Mitander’s. More was already built, but his assignment was bigger. The main lines of his mission were, first, to get the blast furnace in Dechauri into working order and make iron, second to plan and start implementing a big expansion of the ironworks. It was to become an integrated steelworks matching the most modern in Sweden.

A year later Ramsay brought the ambitious and skilled engineer Gustaf Wittenström from Sweden to help him. Under Wittenström’s direction the new works at Dechauri assumed its final shape and construction work started. But Wittenström had not been in India for more than a few months of the winter 1862/63 before the project was stopped. The company’s funds were exhausted and no more capital could be raised. Wittenström left Kumaon in the spring of 1863 and Ramsay during the last days of September in the same year.

After the first blow the Burwai Iron Works sank slowly into decay and the ironworks was never again used as originally intended. At Dechauri new attempts were made in the old blast furnace in the late 1870s. Although productivity gradually improved during these trials, efficiency was still considered too low and costs too high. Like the Burwai Iron Works, the Kumaon Iron Works was abandoned.

A Diversity of Factors

An aborted blow at Barwah, followed by a decision of the Governor General in Council. A lack of funds and, later, an unsatisfactory productivity in Dechauri. These were the immediate reasons for the closures of the Kumaon and Burwai Iron Works. But, beneath these immediate explanations, were there deeper-lying reasons for the decisions to abandon the projects?

Contemporary commentaries and historical overviews have mentioned a number of reasons. Some concern the specifics of the sites, such as deficiencies in the quantity or quality of the natural resources, others are the lack of managerial and technical knowledge. Some sources stress the obsolete character of the technology transferred, while others emphasise economic factors and market conditions, such as under-capitalisation and unrestrained competition from abroad. Yet others point to the lack of an ironmaking tradition or to government policies and attitudes.
The importance of such factors may be analysed by abstracting systems on two levels. The first level is that of the tangible but geographically confined historical landscapes of the sites and the technical and social system of production. The second is the political system of trade and power in India and internationally, within which the processes of technology transfer took place.

Local Systems of Production

The local systems of industrial production included the works themselves, with charcoal ovens and lime kilns, calcining kiln and blast furnaces, and including the rolling mills, forges and workshops. They also included an extensive organisation and physical arrangements for supplying the works with raw materials, especially iron ore and charcoal.

The local historical landscapes of production still offer evidence of how these works were set up and how energy was supplied and transport organised. The system of production also encompassed a social organisation, and in the process of technology transfer the durability of the sites became a prerequisite for success. Only if production had been sustained over a longer period of time would it have become possible to build a foundation of knowledge on which to base the running of the works.

Natural Resources

The main site of the Kumaon Iron Works, the ironworks at Dechauri, was in the Himalayan foothills, in a wooded border zone called the Bhabar, between the steeply rising slope of the mountains and the wide alluvial Gangetic plain. Further up in the hills, there were deposits of rich haematite that had to be mined underground. In the Bhabar there were extensive deposits of sedimentary ores with a lower iron content. These were so abundant that adequate ore could be picked from the surface. They were to be the mainstay of the ore supplies, although the richer haematites were seen as a potential way of increasing productivity.

The setting of the Burwai Iron Works, just outside Barwah, was less dramatic, but in one sense similar, with the Siwalaki mountains behind and the Narmada River as a southern boundary. In Nimar there were both veins of high-grade iron ore and also ore irregularly dispersed in conglomerates. Two mines, the first long used by local iron makers, and the second discovered and explored by Mitander, gave the ore for the first blow.

At both works the ores were deemed adequate for the project, but in the longer run a lack of systematic knowledge of the geology caused uncertainties. There was only a vague knowledge of the total extent of the ore deposits and a question is how long they would have lasted. The extent of this problem
was also a matter of market prices. How much work, how much expenditure, would have been economic?

In spite of the almost total dominance of coal as fuel for ironmaking in Britain, the British Government chose charcoal for the works in India. The reasons were basically three. First, charcoal iron and steel were highly esteemed products, with Swedish charcoal iron representing a standard of excellence. Second, charcoal was also considered a free and readily available commodity. Charcoal-making needed only limited investment and at least in the short run the estimates of the extent of the resources seem to have been made with safety margins. The reaction of the local communities when their forests were expropriated and exploited was hardly considered, however, and in a long run there were greater uncertainties. Third, the alternative of coke was as yet an unexplored resource in India.

For motive power, primarily to run the blowing machinery, both water and steam were used. At Dechauri extensive investments were made in the construction of water channels to utilise the river flow and the layout of the ironworks was closely geared to the use of water. But due to the extreme variations in rainfall steam power was a necessary back-up at Dechauri. In Barwah the dramatic change from the dry winter to the monsoon flood made a total reliance on steam power a necessity.

**Technology**

Mitander, Ramsay and Wittenström planned and built ironworks using a flexible combination of technical solutions of different origins. The works were in themselves international and almost every part of them revealed a complex history of transfer and contacts. Ramsay wrote of the charcoal blast furnace “on the Swedish model”, there were puddling furnaces – well known to English workers, but used only at single ironworks in Sweden – and there were Finnish charcoal kilns. The Bessemer process was originally conceived in Britain but was developed on a production scale in Sweden. Big changes in the construction of blast furnaces came in the middle of the nineteenth century. The impulses came primarily from Britain, but it was the Swedes that first took the new technologies to India.

The technology to be transferred to the Kumaon and Burwai Iron Works under Swedish management was the most modern possessed by two of the leading iron and steel producing countries in the world and there are no signs of any formal barriers to this transfer from Europe.

The novelty of the technique may be regarded as both an advantage and an obstacle. On the one hand a big development stride could be taken at once. On the other, the scale of the works and, certainly, the early introduction of the Bessemer technique were adventurous, at least under the uncertain financial conditions that prevailed at Kumaon.

The basic difficulty with the technology, however, lay not in this kind of novelty, but in the more general relationship between the process of tech-
nology transfer and the society into which it was introduced. Time would be needed to build the social systems for iron production and for passing on knowledge. Managing a blast furnace has in all ages been a matter of tacit knowledge, of continuous trial and error and accumulated experience. Even in the early twenty-first century, in our times of systemised science and digitalised engineering, blast furnaces are attributed a life of their own, almost as living beings. Certain characteristics were of course common to most blast furnaces, but, despite this, every new blast furnace, with its particular combination of a multitude of different conditions, needed time to be blown in and fully managed, even if run by the most experienced of practitioners. All start-ups are uncertain ventures.

The techniques procured from Europe were chosen to suit local conditions. Lancashire hearths and charcoal furnaces were the most obvious adaptation to the available fuel resources – forests for charcoal. The use of steam as a supplement to water power has already been mentioned. The choice of charcoal kilns showed an effort to employ a technology within the constraints of the socio-cultural setting, in this case in order to cope with the irregularities of charcoal delivery from a system of independent charcoal burners. And the Bessemer furnaces were considered to suit the abilities of the Indian workers, who were judged to be too weak to manage heavy puddling work.

The adaptation to local conditions is also evident in the physical planning of the works. The locus of the industrial landscape of Barwah comprises a rather small area. The works is placed on and below a hill and transports were kept short, with a clear logistical line from the arrival of coal and ore to the final manufacture of rolled or cast products. The Kumaon Iron Works shows a more complicated layout with its longer history and displays two different styles of planning. The first works, laid out by William Sowerby, were spread widely over the landscape, and the layout must have caused problems with material being moved long distances from one stage of production to another. This stands in contrast to the plans made by the Swedish engineers. Here, as at Barwah, the plant was to be concentrated and the topography of the site was consciously used to minimise the need for transport – and to maximise the use of water power.

THE NEED OF A DURABLE SOCIETY

The Swedish engineers, their British principals, the British skilled workers and the majority, the Indian workers, were the four groups of people that set up the Kumaon and Burwai ironworks. Together they made up a local social system, with its co-operation and conflict. There were strict hierarchies, as at most industrial sites of the time, but in this case the bonds and differences were accentuated by such cultural elements as language and religion. And in essence, the British came from outside, into a local society, and with the backing of a mighty Empire. They represented power.
The ultimate decisions concerning the works lay in the hands of the owners, represented in Kumaon by the local directors, and in Nimar by Colonel Richard Keatinge and his successors. But at the same time it was the Swedes that moved the projects forwards, both in preparing the plans for the future and in managing the daily work. Their views were decisive, especially since they almost alone possessed the expert knowledge needed for making iron at the works.

The Swedes were highly qualified for their jobs. Nils Mitander and Julius Ramsay had deep family roots in the Swedish or Finnish ironmaking community. They had had the highest relevant formal education available in Sweden, and a thorough theoretical and practical introduction into all aspects of building and running ironworks. Gustaf Wittenström had a less traditional background. His father was a master builder at ironworks in central Sweden, but died young. Gustaf had less formal education in metallurgy than his Swedish colleagues, but had talents that soon led him to positions of responsibility in designing and constructing new ironworks, both in Sweden, Russia and Finland.

Skilled British workers were essential at the works and shared their ethnic background with their British superiors and were, like them, agents of imperial power in the Indian society in which they had been placed. At the same time they were part of the British social system, with its hierarchy of rank and class. At Kumaon British workers were employed, recruited either directly from Britain or from the armed forces stationed in India. This entailed considerable extra cost. At Burwai the problem of scarcity of skilled workers was never really solved although the few men with any previous experience did their utmost during the first blow. The lack of skilled hands was repeatedly cited as a serious problem.

The Indian workers were the unqualified users of the technology, subject to British authority, but also independent and self-reliant in relation to the British. And somewhere in between these groups were the Swedes, employees like both the British skilled workers and the Indians, but still the definite superiors of both. All three were quite young, with Julius Ramsay in his mid-thirties the eldest, but they were employed to lead pioneering ironmaking projects in British India. They shared with the British the cultural experience and heritage of being European, but they were not British and they could take a step back and regard British culture as something strange and alien, and also see the conflict between the colonial power and the subordinate Indian society.

In these social settings many differences of culture and class were overcome, but nothing that might be called a durable social system was created at the sites. Iron and steelmaking demanded a build-up of infrastructure and other supporting structures. An iron- and steelmaking plant also involved big investments and the economy of the enterprises needed time enough to pay back their initial investments.

Work itself also demanded time. The Kumaon and Burwai Iron Works were two new iron and steel mills in a virgin metallurgical setting. A long
period of trial and error would have been needed in order to tune in to the unfamiliar combination of a new technique, raw materials and climate. Instead transition and discontinuity characterised the ironworks, especially during the construction period. A sense of commitment and continuity would have facilitated recruitment of future workers and the transmission of skills and knowledge that was needed in order to keep the new technology running over an extended period of time was never created.

PROCESSES OF TECHNOLOGY TRANSFER

A technology transfer is a geographical relocation of a technology to a setting where it was not established before. In a superficial sense the Kumaon and Burwai Iron Works were two cases of technology transfer. The technology brought to the works was to be modern, and it was certainly new in its Indian surroundings. In some respects it was even new to the most knowledgeable in the arena, the three Swedes. The Kumaon and Burwai ironworks can thus be seen as examples of transfer of a conglomerate of technologies developed in north-western Europe.

In a deeper sense the most pertinent question to be answered is however whether the Kumaon and Burwai ironworks ever really became cases of completed technology transfer.

The Norwegian historian of technology Kristine Bruland has described learning as the central aspect of technology transfer. At Kumaon and Burwai it is questionable whether there ever was such a transfer of knowledge. In the local settings, with their isolation and the temporary character of the works, no lasting learning processes were established. The projects were enclaves. No room was created for a technology transfer in the full sense.

Even if technique was transferred, in the form of machines and ideas physically manifested in roads, buildings and the like, some of which are still visible even today in the historical industrial landscapes in Barwah and Dechauri, there was very little actual diffusion of the knowledge and technique. Kumaon and Burwai remained European works and the knowledge of how to manage them remained a European knowledge. In the end, one conclusion must be that there were two processes of technology transfer, but that we do not have two cases of technology transferred.

Networks of International Dependence

Technology transfer can also be analysed in terms of its integration into a bigger entity, in the cases of the Kumaon and Burwai into an Indian socio-technical system. In this respect, too, the works remained enclaves, with their essential ties being primarily with Britain. The reason for this was not any
inherent characteristic of the technique, but rather the policies of the colonial power, which determined the general conditions for the transfer.

The local systems of production were intrinsic parts of bigger wholes. India was a geographical entity that during British rule in itself became increasingly more integrated despite cultural and economic differences. In turn India was a part of the British Empire, a colony subject to foreign rule. The Kumaon and Burwai ironworks were physically sited on the Indian subcontinent, but at the same time their most important ties were across the ocean. The works remained unilaterally dependent enclaves in their Indian context, lacking the interdependent local networks of knowledge, technology and trade that would enable a self-contained whole, with its own dynamics, to survive and develop. It is in the interplay of the local and the international, colonial contexts that the basic explanations for the fate of the works can be found.

DEMANDING LOGISTICS

A most vital part of any network is well-working communication systems and in the mid-nineteenth century great effort was devoted to improving and accelerating communications between Britain and India. International sea routes, the telegraph, the steamships and the railways were the basic means by which the international network of contacts within the ironmaking community was upheld, and they were also a way of maintaining colonial dominance. Efficient collection and dissemination of information was a vital necessity for the administration of the British Empire. A transport system was essential to international trade and the transfer of the physical artefacts of technology.

The histories of the Kumaon and Burwai ironworks projects reveal surprisingly efficient systems for the spread of technical innovation. A web of contacts across the world, between Sweden, England and India, not only made it possible to enrol the three Swedish engineers, but also ensured a fast spread of news of advances in metallurgy. In the spring of 1858 William Sowerby met Henry Bessemer in Britain and was introduced to Bessemer’s new steelmaking process. This was still in the course of development and it was only in that year that the first successful trials of the Bessemer method took place in Sweden. All the same, William Sowerby immediately brought the new ideas with him back to Kumaon.

At the same time the histories of the ironworks also show how transport problems seriously delayed construction and transport costs for the supply of raw materials were one of the most important items on the balance sheets. The raw materials and other low-value bulk supplies to the Kumaon and Burwai ironworks were brought in from very local sources and producers, but almost all high-value products, such as machinery and other technical equipment, were ordered and imported from Britain, mostly from renowned mechanical engineering companies. In spite of all the logistical problems
caused by this dependence, only a few parts were ordered from local producers, the machinery from the workshops at Roorkee being the most important. However this did illustrate the possibility of local supply and, once running, the ironworks might even have achieved self-sufficiency, making most spare parts and machinery in their own workshops.

The build-up of transport facilities was also a factor affecting the market position of the works. With good communications a bigger market could be reached and profitable production would become more feasible. At the same time this could also be a threat. Good communications also opened the door to competition from elsewhere, especially from producers in England. In the case of the Kumaon Iron Works communications proved a factor of great importance. According to contemporary observers the final blow to the project came with the decision not to build the Rohilcund Tramway, which would have connected the works to the Indian railway network.

Dependence and Colonial Dominance

In view of the multiplicity of unknown circumstances and often adverse conditions, the accomplishments at Barwah and Dechauri were significant. The Swedes came as total strangers, but during their time there they proved that the difficulties could be coped with. Iron was produced at the Kumaon Iron Works and the unsuccessful first blow at Burwai ought to have been only a step on the road. The various difficulties were overcome and the technicalities were solved. In fact, in spite of all the difficulties, local systems of production were constructed. The path lay open towards further development and steps were taken along it. Considered as experiments, the outcome of the projects could have been regarded as “excellent lessons for the future” – as the Commissioner of Kumaon, Henry Ramsay, put it. At the same time contemporary observers, having followed the trials from close quarters, thought that the projects were never given a fair chance. “[T]here is every reason to believe that, if carefully supervised and fed with capital, the [Kumaon Iron W]orks should at least turn out as favourable under any circumstances as the East India Railway.” And on the Burwai Iron Works an authoritative contemporary observer wrote that the experiment had “not yet had a fair trial – indeed it has not had a trial at all”,1

The decisive reasons for the fate of the works are to be found outside the realm of technology and the immediate geographical and social area of the works. Markets, prices and political structures set the ultimate rules of the game. The Kumaon and Burwai ironworks were British and as such also subject to British rule and policies that were designed primarily to make the most of the colony as an economic asset, a supplier of raw materials and a buyer of fabricated goods. The crucial decisions were taken at a socio-political level. This is most evident in the case of the Burwai Iron Works as the
reasons for abandoning the experiment were clearly recorded. At Kumaon the grand new scheme could never be put to the test because of the failure to raise new capital. And when the smaller works were left idle for fifteen years, surrounding social conditions had time to undergo fundamental changes. By the time of the last attempt to make iron, imports of cheap British iron were well established and coal-based ironmaking had become the standard method in the efforts to build an Indian iron industry. The agenda had been rephrased.

A direct involvement of the state through ownership or close co-operation between state and private enterprise has often been a hallmark of a successful iron and steel industry. The importance of such sustained and continuous support is evident in the detailed state management or regulation of Swedish iron and steel production and trade, at least from the seventeenth century up until the heavy involvement of the state in the restructuring of the Swedish steel industry in the 1970s. The construction of a technological system of iron and steelmaking requires heavy investments and great perseverance. This has often been shown when former colonies have endeavoured to industrialise by creating an iron and steel industry, which has become a symbol of society-building, nationhood and economic independence. In India the build-up of an iron and steel industry after independence in 1947 was a public undertaking. It needed central planning and investment requiring a large part of the government budget. It has also required continued government support and still does so, more than half a century later. In the cases of the Kumaon and Burwai ironworks the British Government took the first steps, but did not go on either to create the infrastructure for the ironworks or to protect them from intensive competition from abroad in order to carry them through their teething troubles. The Kumaon and Burwai ironworks remained isolated islands, enclaves, and without long-term support any disruption was serious, since there was no margin for second attempts. No setbacks were allowed, nor could they be excused as development costs.

The colonial government had to reconcile its wish to make full use of the wealth of the colony and the strong commercial interests in England that wanted to protect their position on the markets. This was a conflict that arose time and time again throughout the history of the ironmaking projects and it was openly discussed in the debate on the Burwai Iron Works in the summer of 1863. In the case of Kumaon the government dealt with the affairs of the works hesitantly, tardily or even inconsistently. The ambiguities and the inability to make final decisions exhausted the project. Paraphrasing Andrew Grout’s verdict on the mining policy of East India Company days: “the policy of [the British Government] towards [ironmaking] in India was usually at best ambiguous and at worst obstructive”.

This half-heartedness of government policies might be explained by the influence of the banking and trade interests of the City of London, the so-called “gentlemanly capitalism”, and of the industrial capitalism of the iron and steelmaking districts of Britain.
In this context the Kumaon and Burwai Iron Works can be seen as a part of the general policy of confirming British power in India, which was a joint interest not only of gentlemanly capitalists and the millocracy in Britain, but more particularly of British residents in India, who advocated the consolidation of British power and national economic development. But in the case of iron and steel, contradictions were evident. The Home Government seems to have been torn between the opposing wills of local interests in India and a strong lobby at home, which not only opposed all efforts to hamper free competition, but also worked against any effort to spend public money on chancy ironmaking experiments in India. The fate of the works could be seen as a victory for the joint influence of gentlemanly capitalism and the millocracy over colonial interests. Iron production in India would have moved power and incomes away from England. Manufacturing interests would have lost. Trade and finance would have lost. And thus there grew a strong joint interest in not supporting the adventurous or even risky task of building an Indian iron industry. In view of the great importance attached to maintaining the sound economy of the state it was also deemed too hazardous and speculative to invest in an iron industry that could only give uncertain income in the long term.

The interests were interlocked and the question of whether or not to start making iron in India must have been a matter of strategy. Gentlemanly capitalism could in some cases foster such an interest, for example in order to encourage the building of a transport system. On the other hand, the arguments against could also be encompassed in the gentlemanly strategy: fostering trade, specialisation and a secure foundation for public finances. Such an explanation would thus to some extent bridge the alleged dichotomy between gentlemanly capitalism and industrialist.

**THE DEVELOPMENT OF UNDERDEVELOPMENT**

The histories of the Kumaon and Burwai ironworks belong to an important period of economic and political transition in India. At the same time as preparations were made to meet rapidly growing needs for iron and steel in India the technologies to make iron and steel went through dramatic changes. The second half of the nineteenth century should have been an ideal time to make a determined effort to build an Indian iron and steel industry. However, in the words of Mahadev Govind Ranade, “this golden opportunity was allowed to pass” and the histories of the Kumaon and Burwai Iron Works form a link between the mid-nineteenth century and our times, highly relevant in our understanding of the overall history of the Indian iron and steel industry.

In the middle of the nineteenth century, a radical transformation of India’s iron industry began. While a traditional iron industry was being phased out, efforts were being made to build a new industry, utilising modern, large-
scale technology. In this two-way process there was no dynamic, positive restructuring of the existing iron industry. External influences forced the phasing out and neither traditional knowledge nor substitutes found room in any developmental process. A brake was placed on the development of Indian iron production.

The dynamics of the colonial economy of India were determined by the needs of the metropolitan economy. India supplied primary products and consumed imported secondary products in an unequal exchange. And any limited industrialisation was dependent on alliances with foreign firms for technology. The first successful industrial establishment of ironmaking did not start work until the last decade of the nineteenth century and it was only after independence that India could start building a more substantial iron and steel industry of its own.

In spite of seemingly excellent preconditions for development, in spite of its size, its natural bounties and human resources, India at the turn of the century showed clear signs of an underdeveloped, dependent economy, with its trade characterised by the export of raw materials and the import of manufactured goods. India’s iron industry during colonialism was marked by deindustrialisation and a growing degree of dependence rather than by industrialisation and self-reliance.

The long-term course of development and growth of British and Swedish iron and steel, through crisis and new starts, contrasts sharply with this course of events in India. Lines of connection and interdependence can however be supposed.

The exports of iron and steel from Britain to India grew to important dimensions in the second half of the nineteenth century. The British iron and steel producers had primacy on the Indian market and the gigantic need created by the building of the Indian railways was an important outlet for its products. I have not explicitly explored, still less quantified the workings and magnitude of the effects of this export for the British iron and steel industry. Neither have I explored its importance for other iron and steel producing countries in Europe, but it seems reasonable to suppose that there were positive, secondary effects that also spread beyond Britain.

Britain was, as an example, by far the biggest single market for Swedish iron and steel. The investigation later conducted by Herman Annerstedt in the mid-1860s is evidence of the importance that the government of Sweden attached to this market.

And thus a circle is closed.

When I went to India in 1987 with Peter Nyblom from Fagersta, I was a rather ignorant visitor making his first contact with the Indian iron and steel industry. Our prime objective was to visit the small mill of Bhoruka Steel in Bangalore. We also wanted and to explore the current state of Indian ironmaking. We visited Tata Iron and Steel Co (Tisco) in Jamshedpur, the offices of the Steel Authority of India (Sail) in Delhi and the Ministry of Steel and Mines in Delhi.
During this first travel I experienced the deep differences between the Indian and the Swedish iron and steel industries and also understood the determined efforts and big sacrifices that had been needed to build an Indian steel industry in the post-colonial era. When I now also have probed back into the past I have discovered a long history of connections across the world. The physical remnants of the Kumaon and Burwai Iron Works manifest a past that in a complicated web of interconnections across time and space is a history also to Harry Pettersson in Högfors and the workers of No. 2 Steel Mill in Fagersta.

Further Questions
– and a Postscript

This book presents the results of my effort to retrace ties across time and geographical boundaries. The study has indicated a vast and in many respects untouched field of studies in the global history of technology.

A wealth of primary material remains unexamined in the archives of former colonial powers and their allies and a combination of materials of diverse origin would offer new insights into the socio-cultural history of technology. Of special interest is the important period of the second half of the nineteenth century, when in many cases the pattern was set and the path chosen for the century to follow. The history of the use of India’s rich resources of mineral coal in metallurgy, only just started when the Kumaon and Burwai ironworks were abandoned, is but one example of an important field of research. In contrast to Sweden, where charcoal was the dominant fuel far into the twentieth century coal was to become the basis for its iron and steel industry. But why did it last till the last decades of the nineteenth century before the first coal-based iron works were set up? What were the similarities and differences between the experiences at Kumaon and Burwai and these first attempts? Jan McGrath’s study of technology transfer during the nineteenth century is an important start, but much remains to be done. In this connection it should be remembered that the investigation of uncompleted endeavours, sometimes called failures, can shed light on prerequisites for success. Such factors are often harder to identify in the more common studies of success stories that tend to become more like closed boxes.

The travels and experiences of individual engineers in diverse assignments of technology transfer and co-operation is another possibly rewarding field of research. The meeting across borders can cast light not only on aspects of power and subordination, but also on the importance of culture in a technology transfer. Examples are numerous. Only in the field of iron and steel and Swedes working in India during the colonial era there are at least two exam-
ples besides Mitander, Ramsay and Wittenström. The first is Axel Sahlin who was one of the part-owners of the New York-based engineering consultancy of Julian Kennedy, Sahlin & Co that prepared the plans for Tisco in Jamshedpur. Sahlin himself worked in the jungles of Sakchi, the future site of Tisco, in 1908. The second, and somewhat later, is Olof Sahlin who was engaged for the charcoal-based integrated steel works of Badhravati in 1925.

And in our time there are of course many examples of processes of technology transfer to be investigated, the furnace exported to Bhoruka steel in the 1980s being only one example. In the field of education and research in metallurgy a program for collaboration between the Royal Institute of Technology (KTH) in Stockholm and India should also be mentioned. Initiated by Prof. Seshadri Seetharaman at KTH in now includes an exchange with different parties in India, among them the Indian Institute of Technology in Roorkee.

Epilogue

When Nils Mitander, Julius Ramsay and Gustaf Wittenström returned home they tried to resume their lives in the ironmaking community of Sweden. Wittenström became the most successful, but there is no evidence that the value of their experiences was ever recognised, neither in his case nor in the case of Mitander and Ramsay. Their demanding assignments and extraordinary accomplishments in India remained unnoticed.

Julius Ramsay wrote a long report to Jernkontoret on his experiences in India. It was submitted to Jernkontorets Annaler, but never published there, as many other travel reports were. And the report that Mitander wrote is today nowhere to be found. A lecture given by Ramsay concerned only his actual journey to India. The critical remark in the official statement on the condition of India of 1872–73, looking back at the Burwai Iron Works, was doubly true, at least in the case of these works: “no record has even been preserved of the experiments, … which could have been useful hereafter”. Back in Sweden their experiences seem to have been considered of interest only to their inner circle of friends and family and around a dinner table.

Their contacts with each other also appear to have been limited. Early in 1865, Nils Mitander and Julius Ramsay met again in Örebro, accompanied by Andreas Grill, and when one of Mitander’s acquaintances from India, Captain Cadell of the Bengal Staff Corps, visited Sweden in 1866, Mitander wrote an introductory letter to Ramsay. Ramsay and Wittenström corresponded on professional matters, at least during the spring of 1865.
Mitander returned to Sweden in June 1864 and immediately found a new job with the assistance of the director of Jernkontoret Andreas Grill. But when he tried to renew his metallurgical scholarship, he was refused. A younger colleague, who had a university degree from Uppsala, was preferred. Instead he was engaged by Carl Ekman, proprietor of the big ironworks in Finspång, for whom he studied cannon foundries in Germany, Belgium, France, England and Scotland. In 1867 he was put in charge when a new cannon foundry was established in Finspång. Between 1868 and 1876 he worked as the agent in America of an iron and engineering wholesaler, Höglunds & söner in Stockholm. He married a Cuban girl in Washington in 1875, Lizzie Debora Schumacher, but she died in childbirth the following year, as did the baby. Mitander’s wife and daughter were buried in Philadelphia and when he returned to Sweden he was described as “being marked by grief”. This time Mitander stayed in Sweden for good. He first bought a house in the centre of Kristinehamn and in 1896 he bought the Hygn estate on the north eastern shore of the lake Vänern. By this time he had turned to agriculture and become the owner and manager of a dairy. Mitander died at Hygn in 1903, seventy years old and without remarrying.

Ramsay

Ramsay had originally asked for three years’ leave from Jernkontoret, but when his appointment was terminated prematurely he wrote to Jernkontoret in May and asked to be reinstated in his previous position. Ramsay was
reinstated but in December 1865 asked to be relieved of his post. During at least the next two years, 1866 and 1867, he was registered as a former mining engineer and worked as agent in Stockholm for Finnish ironworks. By 1870 he was registered as manufacturer and running a horseshoe factory in Central Stockholm called Ramsay & Co. He lived at the same address as the factory, together with his mother and one of his sisters. He had two servants, a bookkeeper and seven employees.

Julius Ramsay died unmarried in Montreux, Switzerland in 1874, only 46 years old. The cause of death was a chest condition.

WITTENSTRÖM

Of the three Swedes it is notable that Gustaf Wittenström, who had the least formal education, became the most celebrated. In 1966 he was even awarded a commemorative medal for outstanding contributions in the fields of activity of the Royal Swedish Academy of Engineering Sciences.

Wittenström made major contributions to the expansion of the works at Motala in 1863–72 and was the chief designer of the new ironworks at Domnarvet, Domnarvfets Jernverk, in 1872–77. This was Sweden’s then largest ironworks, and had all the units we know from Dechauri, although on a bigger scale: four blast furnaces, two Bessemer converters, two open hearth furnaces and six heavy rolling mills. Among other achievements Wittenström made pioneering contributions as an inventor, best known for his contributions to the technology of steel casting.

Gustaf Wittenström died in 1911, almost eighty years old.
Appendices

Appendix 1

Measurements

Measurements have been recalculated to the metric system. The following rates of conversion are used.

Length
1 inch = 2.54 centimetres
1 foot = 0.3 metres
1 Swedish aln = 0.59 metres
1 yard = 0.9 metres
1 fathom = 6 feet = 1.8 metres
1 mile = 1.6 kilometres

Area
1 square foot = 0.09 square metres
1 square mile = 2.56 square kilometres
1 cubic feet = 0.027 cubic metres

Volume
1 cubic foot = 0.027 cubic metres
1 hectolitre = 100 litres
1 tunna (1 Swedish tunna charcoal) = 1.47 hectolitre

Weight
1 pound (lb.) = 0.45 kilogram (kg)
1 seer = 0.9 kg
1 Swedish lispund = 8.5 kg
1 maund = 36.3 kg
1 centner = 42.5 kg
1 cwt (long, British, hundredweight) = 112 lbs. = 51 kg
1 Swedish skeppund tackjärnvikt = 26 lispund = 221 kg
1 (British) long ton = 1,017 kg
The equivalent for maund and seer have been calculated from the figures given by Ramsay: “The maund used is the one fixed by the government and used at all government works as Roorkee etc: 1 Maund = 40 Seers = 80 English pounds, 1 Seer = the weight of 20 rupees. It is much easier than the complicated tons and hundredweight. 28 maunds are 1 ton.” Ramsay was using the British long ton. These equivalents are approximate. The accuracy of the original measurements does not call for more accurate conversion. Nor do the arguments depend on more accurate measurements.

*From Volume to Weight*
1 basket of charcoal = 4.5 kg
1 basket of ore = 27 kg

*Indian Numbers*
In certain quotes special Indian numerals are used:
1 lakh = 100,000
1 crore = 100 lakhs or 10 million

**Appendix 2**

**Number of Employees at the Planned Kumaon Iron Works**

*Julius Ramsay’s estimate of the number of employees and their monthly pay in rupees at the new plant of the Kumaon Iron Works in Dechauri. Limited production using only Bhabar ore and including the work force for two modern blast furnaces at Dechauri and three small blast furnaces at Kaladhungi.*

<table>
<thead>
<tr>
<th>Category</th>
<th>Europeans</th>
<th>Indians</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of months employed per year</td>
<td>Employed 12 months per year</td>
<td>Employed 12 (7+5) months per year (Salary during seven working months, halved during 5 months of standstill)</td>
</tr>
<tr>
<td><strong>Management</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Manager</td>
<td>1 (1,000 Rs/m)</td>
<td></td>
</tr>
<tr>
<td>Engineer</td>
<td>1 (600 Rs/m)</td>
<td></td>
</tr>
<tr>
<td>Forest superintendent</td>
<td>1 (400 Rs/m)</td>
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<td>Accountants</td>
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<td>Storekeeper</td>
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<td>Native establishment (year round pay)</td>
<td>6</td>
<td>20 (25/Rs/m²)</td>
</tr>
<tr>
<td><strong>TOTAL management</strong></td>
<td>6</td>
<td>20</td>
</tr>
</tbody>
</table>

378
### Manufacture of Pig Iron

<table>
<thead>
<tr>
<th>Activity</th>
<th>Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Smelters or furnace keepers</td>
<td>100 Rs/m</td>
</tr>
<tr>
<td>Smelter or furnace keeper in reserve in case of sickness</td>
<td>15 Rs/m</td>
</tr>
<tr>
<td>Smelters</td>
<td>20 Rs/m</td>
</tr>
<tr>
<td>Carrying away the cinder</td>
<td>7 Rs/m</td>
</tr>
<tr>
<td>Charging the furnace</td>
<td>6 Rs/m</td>
</tr>
<tr>
<td>Bringing up the material</td>
<td>6 Rs/m</td>
</tr>
<tr>
<td>Weighing and storing the pigs</td>
<td>6 Rs/m</td>
</tr>
<tr>
<td>Engine men</td>
<td>6 Rs/m</td>
</tr>
<tr>
<td>Blacksmiths</td>
<td>6 Rs/m</td>
</tr>
<tr>
<td>Strikers for blacksmiths</td>
<td>6 Rs/m</td>
</tr>
<tr>
<td><strong>Total manufacture of pig iron</strong></td>
<td>108</td>
</tr>
</tbody>
</table>

**Total for manufacture of wrought iron:**

<table>
<thead>
<tr>
<th>Activity</th>
<th>Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mechanics in charge of the workshop, one daytime, one at night</td>
<td>300 Rs/m</td>
</tr>
<tr>
<td>Puddlers</td>
<td>20 Rs/m</td>
</tr>
<tr>
<td>Rabblers (stirring the iron with rabbles, i.e. rakes)</td>
<td>64</td>
</tr>
<tr>
<td>Ballers</td>
<td>20 Rs/m</td>
</tr>
<tr>
<td>Helpers to ballers</td>
<td>8 Rs/m</td>
</tr>
<tr>
<td>Firemen</td>
<td>6 Rs/m</td>
</tr>
<tr>
<td>Rollers</td>
<td>15 Rs/m</td>
</tr>
<tr>
<td>Rollers, helpers</td>
<td>6 Rs/m</td>
</tr>
<tr>
<td>Heaters</td>
<td>15 Rs/m</td>
</tr>
<tr>
<td>For cinder cleaning of the iron</td>
<td>10 Rs/m</td>
</tr>
<tr>
<td>For assortment of the iron</td>
<td>10 Rs/m</td>
</tr>
<tr>
<td>Crop shearers</td>
<td>10 Rs/m</td>
</tr>
<tr>
<td>Straighteners</td>
<td>24 Rs/m</td>
</tr>
<tr>
<td>Surveyors</td>
<td>15 Rs/m</td>
</tr>
<tr>
<td>Gaugers</td>
<td>15 Rs/m</td>
</tr>
<tr>
<td>Shinglers</td>
<td>10 Rs/m</td>
</tr>
<tr>
<td>Enginemen</td>
<td>10 Rs/m</td>
</tr>
<tr>
<td>Machinists</td>
<td>10 Rs/m</td>
</tr>
<tr>
<td>Boiler men</td>
<td>10 Rs/m</td>
</tr>
<tr>
<td>For landing and drying wood</td>
<td>8 Rs/m</td>
</tr>
<tr>
<td>Helpers for landing and drying wood</td>
<td>4 Rs/m</td>
</tr>
<tr>
<td>Blacksmiths</td>
<td>6 Rs/m</td>
</tr>
<tr>
<td>Strikers for blacksmiths</td>
<td>6 Rs/m</td>
</tr>
<tr>
<td>Masons</td>
<td>6 Rs/m</td>
</tr>
<tr>
<td>Coolies (hired labourers, burden-carriers) for masons</td>
<td>4 Rs/m</td>
</tr>
<tr>
<td>Extra workmen</td>
<td>5 Rs/m</td>
</tr>
<tr>
<td>Moonshies (interpreter, writer, year round pay)</td>
<td>216 Rs/m</td>
</tr>
<tr>
<td>Chokidars (watchmen, year round pay)</td>
<td>5 Rs/m</td>
</tr>
<tr>
<td><strong>Total for manufacture of wrought iron</strong></td>
<td>139</td>
</tr>
</tbody>
</table>
**APPENDIX 3**

List of Shareholders of the Kumaon Iron Works

<table>
<thead>
<tr>
<th>Shares number</th>
<th>Names</th>
<th>Number of shares</th>
<th>Residence</th>
<th>Party, from whom transferred</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>–20</td>
<td>General J. Ramsay</td>
<td>20</td>
<td>London</td>
<td></td>
<td></td>
</tr>
<tr>
<td>21–39</td>
<td>Doctor F. Pearson</td>
<td>19</td>
<td>Almora</td>
<td></td>
<td></td>
</tr>
<tr>
<td>40</td>
<td>Doctor G. E. Morton</td>
<td>1</td>
<td>Almora</td>
<td></td>
<td>Doctor F. Pearson</td>
</tr>
<tr>
<td>41–60</td>
<td>J. O. B. Becket, Esq.</td>
<td>20</td>
<td>Garhwal</td>
<td></td>
<td></td>
</tr>
<tr>
<td>61–70</td>
<td>Kumaon Mission</td>
<td>10</td>
<td>Almorah</td>
<td></td>
<td></td>
</tr>
<tr>
<td>71–98</td>
<td>F. Read Esquire</td>
<td>28</td>
<td>Nynee Tal</td>
<td></td>
<td></td>
</tr>
<tr>
<td>104–105</td>
<td>Capt'n W. J. Gray</td>
<td>2</td>
<td>Meerut</td>
<td>ditto</td>
<td>F. Read Esquire</td>
</tr>
<tr>
<td>106–110</td>
<td>Motec Lall</td>
<td>5</td>
<td>Agra</td>
<td>ditto</td>
<td>Mr. Rees Davies</td>
</tr>
<tr>
<td>111–120</td>
<td>Major G. Macbean</td>
<td>10</td>
<td>Saugor</td>
<td></td>
<td></td>
</tr>
<tr>
<td>121–128</td>
<td>C. Horne, Esq. C.S.</td>
<td>8</td>
<td>Benares</td>
<td>Mr. Rees Davies</td>
<td></td>
</tr>
<tr>
<td>129–133</td>
<td>W. Dashwood, Esq.</td>
<td>5</td>
<td>Dumoh C.</td>
<td>ditto</td>
<td></td>
</tr>
<tr>
<td>134–135</td>
<td>Genl G. C. Smyth</td>
<td>2</td>
<td>Mussoorie</td>
<td>ditto</td>
<td></td>
</tr>
<tr>
<td>136–160</td>
<td>C. Wingfield, Esq. C.S.</td>
<td>25</td>
<td>Lucknow</td>
<td></td>
<td></td>
</tr>
<tr>
<td>161–170</td>
<td>Motec Ram, Shah</td>
<td>10</td>
<td>Nynee Tal</td>
<td></td>
<td></td>
</tr>
<tr>
<td>171–180</td>
<td>Byjnath &amp; Gunga Persad</td>
<td>10</td>
<td>Moradabad</td>
<td>Motec Ram, Shah</td>
<td></td>
</tr>
<tr>
<td>181–200</td>
<td>A. Ross, Esq. C.S.</td>
<td>20</td>
<td>Agra</td>
<td></td>
<td></td>
</tr>
<tr>
<td>201–210</td>
<td>P. Carnegie, Esq. C.S.</td>
<td>10</td>
<td>Fyzabad</td>
<td></td>
<td></td>
</tr>
<tr>
<td>211–215</td>
<td>I. H. Batten, Esq., C.S.</td>
<td>5</td>
<td>Mynpoorie</td>
<td></td>
<td></td>
</tr>
<tr>
<td>216–220</td>
<td>Dabe Dass</td>
<td>5</td>
<td>Nynee Tal</td>
<td></td>
<td></td>
</tr>
<tr>
<td>221–225</td>
<td>Jai Shah, Treasurer</td>
<td>5</td>
<td>Almorah</td>
<td></td>
<td></td>
</tr>
<tr>
<td>226–235</td>
<td>Saadut Ali</td>
<td>10</td>
<td>Rampore</td>
<td></td>
<td></td>
</tr>
<tr>
<td>256–162</td>
<td>Daim Khan</td>
<td>5</td>
<td>Rampore</td>
<td></td>
<td></td>
</tr>
<tr>
<td>261–280</td>
<td>J. Strachey, Esq. C.S.</td>
<td>20</td>
<td>Nagpore</td>
<td></td>
<td>Dr. F. Douglas</td>
</tr>
<tr>
<td>281–320</td>
<td>Captain Gordon</td>
<td>10</td>
<td>Natchigoan, Nagpore</td>
<td></td>
<td>Lucknow</td>
</tr>
<tr>
<td>291–300</td>
<td>Doctor J. Campbell + C. B. Brown</td>
<td>10</td>
<td>Umballah</td>
<td>ditto</td>
<td>Lucknow</td>
</tr>
<tr>
<td>301–310</td>
<td>Am Ferguson, Esq.</td>
<td>10</td>
<td>Beyla Benares</td>
<td>Lt Coll D. C. Vanrenem</td>
<td></td>
</tr>
<tr>
<td>311–315</td>
<td>Luchmeenarain</td>
<td>5</td>
<td>Bareilly</td>
<td></td>
<td></td>
</tr>
<tr>
<td>316–325</td>
<td>Raja Sheoraj Sing</td>
<td>10</td>
<td>Kasheepure</td>
<td></td>
<td></td>
</tr>
<tr>
<td>326–335</td>
<td>A. Shakespear, Esq.</td>
<td>30</td>
<td>Benares</td>
<td></td>
<td></td>
</tr>
<tr>
<td>356–367</td>
<td>Major Genl J. Clarke</td>
<td>12,5</td>
<td>England</td>
<td></td>
<td>No. 365 belongs half to Major Gnl Clarke, &amp; half to Cptn Thurburn</td>
</tr>
</tbody>
</table>
Nineteenth century blast furnaces in India

Ironworks based on the blast furnace were built at about ten different sites in India during the nineteenth century. The Kumaon and Burwai Iron Works were two of these and the aim of this short overview is to present the others, to place them in time and geographically, and briefly to summarise the explanations put forward for the outcome of the projects concerned. The material is based on secondary sources.4


Comments: Most of the names noted in the shareholders list correspond to the list published in the advertisement for additional capital 30 July 1862 (Ramsay’s letter to his friends, 1 September 1862, Ramsay’s papers E1:1.04). Names are written as interpreted from Ramsay’s list. In the advertisement Douglas (20 shares), Venremen (10 shares) and Rees Davies (25 shares) were all shareholders, but had sold all their shares. Still four shareholders sold part of their holdings, Pearson (sold 1 of 20 shares), Read (sold 12 of 40), Ram (sold 10 of 20) and Drummond (sold 20 of 25). It should thus be noted that five of the bigger shareholders sold all or big parts of their holdings and that three of these, Read (one of the directors), Davies (one of the pioneers) and Drummond (the enthusiastic forerunner) were or had been directly involved in the project; C.S. = Civil Service and C.P. = Central Provinces.

APPENDIX 4

Nineteenth century blast furnaces in India

Appendix
Two later ironworks, built during the twentieth century, should also be mentioned in order to complete the list of works built during colonial times. The more important was Tata Iron and Steel Works Co. (Tisco), initiated by Jamsetji Nusserwanji Tata in 1882. Due to a stubborn lack of support from the government it was not until the beginning of the twentieth century that works were established at Sakchi in Bihar, where there were rich deposits of coal and iron ore. The capital for the works had been raised in India. The layout of the works was planned by a New York engineering firm, Julian Kennedy Sahlin & Co. The Swedish engineer Axel Sahlin played a major part when the site of the works was laid out in 1908. The first blast furnace was started in December 1911. Today Jamshedpur ranks among the largest industrial complexes in India.

The second ironworks established in the twentieth century was the Mysore State Ironworks in Bhadravati in present day Karnataka. After a local Indian initiative, the French metallurgist Charles Page Perin was engaged to make a feasibility study, presented in 1916. The Tatas became managing agents of the undertaking and a blast furnace was lit in 1923 with the State of Mysore as financiers. The works used charcoal as fuel.

Charcoal based ironmaking in the Madras presidency (1830–1875)

The charcoal-based ironworks in the Madras Presidency was a long-term endeavour, but was always on the verge of close down. A former employee of the British East India Company, Josiah Marshall Heath, established the works at Porto Novo in 1830, on the coast of present-day Tamil Nadu. When the company became bogged down, Government assistance was given. Successive periods of trials, and of companies restructured under different names, ensued during the following decades, and smaller works were also established at Pulampatti/Palampati on the Cauvery River, at Tiruvannamalai (both in Tamil Nadu) and at Beypur on the coast of Kerala. The furnaces were all small and in intermittent production between 1833 and 1867. The works were finally closed and abandoned in 1867 and the company dissolved in 1874, mainly because of inefficient production and high costs. Iron produced at the works was exported to England, and possibly used to build the Menai Britannia tubular bridges in North Wales.

At an early stage the steel produced was reported to be excellent and tested in Britain. According to Valentine major difficulties were that charcoal was brought from long distances (40 kilometres) and only seashells could be used as flux. Another big difficulty was that of guaranteeing a steady supply to the customers. There were difficulties in shipping the iron from India and the blast furnaces were seldom in work for more than four months of the year, mainly because of the climate.
Birbhum (Beerbhum) charcoal works, Bengal
(1779–1875)

Traditional Indian ironmaking in the Beerbhum district of Bengal was highly developed, with large furnaces and high efficiency. The iron was reduced to a molten condition and fined by a second operation resembling puddling. One major centre of manufacture was Mohamad Bazar, where about 70 furnaces were in work in 1852, producing 2,380 tons of iron per year.\(^{10}\)

A first effort to establish modern works was made at the end of the eighteenth century, 1779–1789, but nothing came of it.\(^{11}\) The records of this attempt are scanty, but they are rich in accounts of disputes and contests with local residences on financial matters.\(^{12}\) A second try was made beginning in 1855 at Mohamad Bazar. As earlier, the works were based on charcoal and suffered heavy losses.\(^{13}\) In 1858 two tons of pig iron was made per day.\(^{14}\) Production was stopped after a couple of years, financial aid from the government was asked for, but refused, although the quality of the iron produced was, according to a report of 1862, superior to English iron. It was reported that with additional capital and increased production, the costs might be greatly diminished and that the supplies of raw materials were sufficient for moderately sized works.\(^{15}\) In 1875 a third effort was made, but the works were abandoned after a few months as unprofitable.\(^{16}\) Scarcity of fuel was said to be the main reason for failure.\(^{17}\)

Valentine Ball summarises the history of ironworks at Birbhum: “The same sanguine hopes, the same attempts to carry on work in spite of discouraging circumstances, the same failures and the final loss of expended capital, are recorded in the accounts for each attempt.”\(^{18}\)

Barddhaman (Burdwan) district, also called the Raniganj field
(Bengal, circa 1855–)

The first attempts to smelt iron with coke were made in the Barddhaman district in 1839 and the Bengal Coal Co took steps to establish smelting works, but they were soon abandoned.\(^{19}\) About half a ton of ore was used, but it could never be smelted.\(^{20}\) Several years later, in 1852, 1853, and 1874, different reports followed.\(^{21}\) Works were then started in 1875 at Kulti near Barakar by a private company in 1879 but the enterprise proved unsuccessful because of shortage of capital. Two furnaces appear to have been erected, each capable of producing 20 tons of pig iron a day.\(^{22}\) Important reasons for subsequent problems seem to have been the insufficiency of capital and technical problems resulting from high ash content in the coal and impurities in the raw material, together giving a pig iron with a high phosphorus content.

The works were taken over by the government and in 1889 transferred to the Bengal Iron and Steel Co (Bisco) who remodelled and expanded them to three blast furnaces.\(^{23}\)
The continued history of these works is one of endeavours to make steel in 1905–06 that failed because of the high phosphorus content of the ore. New works and company mergers ensued and finally the establishment came to form the Burnpur ironworks of the Steel Corporation of Bengal in 1952.

**Chanda, Central Provinces**

In 1857 experiments took place at Warora in the Central Provinces (Madhya Pradesh) with the use of local ore and Warora coal. Two trials were carried out, for four and five days, but neither of them resulted in liquid iron and the project was abandoned. The failure was mainly attributed to a high ash content and other impurities in the coal employed. According to some observers, however, the amount of foreign matter put into the furnace was not much in excess of many mixtures in England.

**Sirmur**

About 1880 the Raja of Sirmur erected a blast furnace at Nahan, but it was apparently never blown in.
Notes


2 For a description of the fate of No. 2 Steel Mill in the years leading up to its closing, see Jan af Geijerstam & Peter Nyblom, Mitt i världen – mitt i tiden [In the Middle of the World – In the Middle of Time] (Stockholm 1993), p. 59–101 and Torgny Karnstedt & Julie Leonardsson, I själva verket: de sista hundra dagarna i Stålverk 2, Fagersta Stainless [Hearts of Steel: The Last Hundred Days at No. 2 Steel Mill, Fagersta Stainless] (Stockholm 1986).


4 Personal communication from Bertil Reichman, Svenska Monex AB, Stockholm 7 March 1985.

5 No. 2 Steel Mill of Fagersta was later sold to a South Korean company, PMX, of Cedar Rapids, Iowa, United States (subsidiary of Poongsan Metal Corporation, Seoul). According to direct information from PMX, parts of the continuous casting machine were in use at the beginning of 2000, but the rest of the machinery was lying dismantled in the company’s yard. PMX produces copper, brass and bronze. (Personal e-mail communication from Allen Merta, Vice President Economic Development, Cedar Rapids, 19 October 1998, fax from Mi Ryu Ahn, president of PMX Industries, Cedar Rapids, 28 January 2000 and e-mail from Timothy Suh, PMX industries, Cedar Rapids, 27 January 2000.)

6 Geijerstam & Nyblom, Mitt i världen – mitt i tiden.


Questions Raised

And Investigative Method

1. I will use the term underdevelopment (and underdeveloped) to denote the position of the relatively poor countries of the world, in spite of connotations of the word, such as the notion of higher and lower forms of human culture and a specific path between them. “Underdeveloped” should not be understood as unchangeable.


4. A comprehensive introduction to the dependency school, the “dependencyistas”, with Andre Gunder Frank as a prime mover, is found in Chew & Denemark (eds.), The Underdevelopment of Development, especially Frank’s article, “The Underdevelopment of Development”, p. 17–55. See also Andre Gunder Frank, Capitalism and Underdevelopment in Latin America: Historical Studies of Chile and Brazil, (New York 1967).


Inherent characteristics of a technology have been used by Edquist and Edqvist naming a series of different characteristics, from the complexity of the technology, to its scale of production and geographical extent (Edquist & Edqvist, Social Carriers of Techniques, p. 15–18). In The New Industrial State John K. Galbraith distinguished six imperatives of technology, focusing on the late 1960s and on changes over time during the development of industrialism. He noted an increasing time span from the beginning to the completion of an industrial undertaking, an increase in the capital, that the commitment of time and money tended to be more focused and destined to a certain specialised task, that flexibility decreased, a more specialised manpower, an increase need of organisation and planning. (John K. Galbraith, “The Imperatives of Technology”, in The New Industrial State (1967, rev. ed. London 1972), p. 11–22. In his works on technology transfer and comparative studies of economic development in India, Australia and Japan, Ian Inkster has used Galbraith’s concept in slightly rephrased wordings. Ian Inkster, “Prometheus Bound: Technology and Industrialization in Japan, China and Japan prior to 1914 – A Political Economy Approach”, Annals of Science, 45, (Basingstoke 1988), p. 399–426, p. 426.

Ian Inkster has defined technology transfer as “the movement of a technology or product from the context of its original invention and diffusion to a different economic context, … normally conceived of as occurring between nations” (Ian Inkster, Science and Technology in History – An Approach to Industrial Development, Basingstoke 1991, p. 20).


24 Jeremy, Artisans, Entrepreneurs and Machines, p. 3. See also Jan af Geijerstam & Peter Nyblom, Mitt i världen – mitt i tiden [In the Middle of the World, in the Middle of Time], (Stockholm 1993), 154 pp.


27 As in Svante Lindqvist’s study on the introduction of the Newwomen steam engine to Sweden in the early eighteenth century, Lindqvist, Technology on Trial. The five factors are here given as summarised in Lindqvist, “Social and Cultural Factors in Technology Transfer”, p. 36. Lindqvist argues that modern studies of technology transfer only take into account a limited number of these factors.


30 William Sowerby (1858, August), Report on the Government

Notes p. 25–27


39 See for example Mats Fridlund’s thesis on development pairs and the Swedish electric power technology. He explicitly notes the importance of the sites where the development of technology actually took place. This, he argued, gave insights into the physical scale of the work done and the physical closeness forming a prerequisite for the close co-operation between different parties in the development process (Mats Fridlund, Den gemensamma utvecklingen: staten, storföretaget och samarbetet kring den svenska elkraft-tekniken [The Mutual Development. The State, Big Industry and Co-operation in Swedish Electric Power Technology], (Eslov, 1999), p. 25).


42 Se for example Svante Lindqvist’s analysis of the physical remains of one of the first steam engines in Sweden (Lindqvist, Technology on Trial.)
43 The method of describing and analysing an industrial heritage site has been set out and skilfully presented by the Historic American Engineering Record (HAER). Several of their documents are available on the net (http://lcweb2.loc.gov/ammem/ihhtml/). Some of these works on the iron and steel industry are used in Robert B. Gordon, *American Iron: 1607–1900*, (Baltimore 1996). Early and pioneering work may be seen in the architectural drawings, part of the historical analysis and description of an ironmaking site in Marie Nisser’s article in Bengt Holtze (ed.), *Engelsberg Ironworks: a Pilot Project*, (Stockholm 1975).

44 Personal information from Pradeep Pandey, Omkareshwar, 2 April 2003.

45 Unfortunately I lost contact with Jayashree Bhatnagar and her husband Amit before she was able to send me the full survey report. What I have is a shorter version, made immediately after the field visit.

46 In the evaluation submitted by W. R. S. Jones in 1872 (W. R. S. Jones (1872, June), “Report on the Valuation, and State of the Kumaon Iron Works”, India Public Works, Collections to Despatches (1872), L/PWD/3/184) there are several references to drawing in the company’s office (p. 52) as well as to tracings concerning additions to the works made by the company (p. 56).

47 In the case of the Kumaon Iron Works: Jones (1872, June). In the case of the Burwai Iron Works: Office of Agent, Governor General for Central India, file no 1215, Holkar’s exchange 1867–76, Transfer of Burwai Iron Works to Maharaja Holkar and Payments Thereof, NAI. Also in PWD Proceedings, September 1864, NAI.

48 Captain J. G. Melliss, letter 533, Mhow 11 May 1865 to PWD, Government of India, in Collections to the Public Works Despatches to India, L/PWD/3/146, OIOC.


51 Gustaf Lundberg, *Karlskoga bergslag* [The Ironmaking Region of Karlskoga], 2 vols, (Stockholm 1895–1897), p. 29–30, 1895 and Erik Fornom, *Beskrifning över Värmland*, [Description of the County of Värmland] (Karlstad 1898), p. 196. The most extensive treatise is in Stig Hegardt, *Alkveterne: ett gammalt gods anor* [Alkvetern, an Old Manor of Traditions], (Stockholm 1946), p. 154–166 but this gives no information on the layout or buildings of the ironworks. Among the archives visited or investigated were Karlskoga hembygdsföreningars arkiv, Karlskoga, Stadsarkivet och bildarkivet in Kristinehamn, Skyllbergs bruks arkiv, Värmlandsarkivet Karlstad. No hits of importance were made in the search for material on Mitander, Ramsay or Wittenström.

52 Studies of the Gotha Canal in Sweden, for example, had previously mainly based on primarily Swedish archives, and investigations into the life of the British engineer Thomas Telford mainly on British archives. When the archival material in the two countries was studied in combination, new knowledge was generated and old conclusions revised. See Lars Strömback, Baltzar von Platen, Thomas Telford and Göta canal, *Entrepreneurship och tekniköverföring i brytningstid* [Baltzar von Platen, Thomas Telford and the Gotha Canal: Entrepreneurship and Technology Transfer at a Time of Transition], (Stockholm 1993).


54 Mitander’s diary has a somewhat curious history. It is kept in the Kinship Centre (Emigrantenregistret) in Karlstad, Sweden, an important archive in Western Sweden and close to Kristinehamn where Mitander is buried. The diary was donated to the archives by a Canadian military officer on a temporary visit. How it came into his possession is not known, but it would seem likely to have some connection with Mitander’s marriage to a Cuban woman in the United States who soon died in childbirth. The second part of Mitander’s diary has not been found. In the search for more material after Mitander I have examined a great number of the archives that might be relevant at national, regional or local level (Riksarkivet, Nordiska museets arkiv, Örebro läns museums arkiv, Landsarkivet i Vadstena, Värmlandsarkivet med Emigrantenregistret i Karlstad, Uppsala landsarkiv, Stadsarkivet Örebro, Karlskoga hembygdsföreningars arkiv, Kristineharns stadsarkiv, Kristineharns museums arkiv, Visnums-kils hembygdsmuseum, Skyllbergs bruks arkiv, Arkivcentrum i Örebro etc.). I have also written to a great majority of the Mitander family today. This has produced a very limited response, however.

55 See for example letter from Ramsay to his friends, Calcutta, 3 December 1861, Ramsay’s papers, E1:1.04.

56 Letter from Ramsay to his friends, Kumaon Iron Works, Nainital, 12 June 1862, Ramsay’s papers, E1:1.04. Probably it was a part of the arrangement that the addressees of these letters should keep the letters and hand them over to Ramsay on his return to Sweden. This would explain why these letters were later in the hands of Ramsay’s descendants and handed over to the Swedish Museum of Science and Technology. The letters can thus be regarded as a kind of diary.

57 There are 17 letters to the Correspondence Company in Örebro, 9 from Andreas Grill, 17 from Wittenström, 19
from his friends in Nora and Örebro and no less than 152 letters written in English, from various senders in India. These collections were donated to the Swedish Museum of Science and Technology. Unfortunately the donors, relatives of Ramsay, decided to keep all family letters of a more personal character. These have not been found.

58 Ramsay’s collections, F1:1.26. Ramsay’s letters to his friends, Nainital and NWP and India, 14 August 1863, Ramsay’s collections, E1:1.24. Photography was at that time rather well known, spread, and in India well established on both amateur and professional level (John Falconer, “Photography in Nineteenth-Century India”, in C. A. Bayly (ed.) The Raj, India and the British 1858–1947, (London 1999), p. 265). Daguerré made the first public statement of his process in August 1839 and in December of the same year the Bombay Times published a translation of his pamphlet. There are preserved photographs taken in Calcutta 1842 (Falconer “Photography in India”, p. 267). During the time of Wittenström’s stay in India there were Indian photographers running their own establishments and photography was taught at the Madras School of Arts (Falconer “Photography in India”, p. 275).

59 This letter was written in English, although addressed to one of Ramsay’s Swedish friends (Julius Ramsay’s letters to his friends, Nainital and NWP and India, 14 August 1863, Ramsay’s collections, E1:1.24). Photography was at that time rather well known, spread, and in India well established on both amateur and professional level (John Falconer, “Photography in Nineteenth-Century India”, in C. A. Bayly (ed.) The Raj, India and the British 1858–1947, (London 1999), p. 265). Daguerré made the first public statement of his process in August 1839 and in December of the same year the Bombay Times published a translation of his pamphlet. There are preserved photographs taken in Calcutta 1842 (Falconer “Photography in India”, p. 267). During the time of Wittenström’s stay in India there were Indian photographers running their own establishments and photography was taught at the Madras School of Arts (Falconer “Photography in India”, p. 275).


64 Brian Roger Tomlinson, The Economy of Modern India 1865–


9 Reynolds, Economic Growth, p. 42. In the case of India, Sunil Kumar Sen has asserted that colonial critics seriously underestimate the positive effects of colonial rule on the infrastructure, especially the railways (Sunil Kumar Sen, Studies in Economic Policy and Development of India (1848-1926), Calcutta 1966).


19 As described in Cain & Hopkins, British Imperialism, 1688-2000, p. 276.

20 Referred to earlier. Cain and Hopkins’ work was first published as in two separate volumes, but later republished in a, combined and somewhat enlarged edition, P. J. Cain & A. G. Hopkins, British Imperialism, 1688-2000, (2 vols. 1994, 2nd ed. Harlow 2002). Their work has been called “an important work, maybe a benchmark in the historiography of the British Empire” (Raymond E. Dumett (ed.), Gentlemanly Capitalism and British Imperialism: The New Debate on Empire, (London 1999), p. 1.)


24 Cain & Hopkins, British Imperialism, 1688-2000, p. 32.


26 Cain & Hopkins, British Imperialism, 1688-2000, p. 287.


29 “The Raj” or “the British Raj” is the commonly used Indian term for British rule over India.

30 The archives of this department are huge and much of this material is still unused. The material combines information on strategic and political considerations with technological specifics and very detailed drawings. The records of the India Public Works Department in London comprise approximately 4,500 large folio volumes covering the period 1839-1931 (Martin Moir, A General Guide to the India Office Records, The British Library, (London 1996), p. 188-192). This provides a wealth of information for any student of the history of technology.

31 In 1874 a sixth ordinary member was added to the council of the Governor, the head of the Public Works, a sign of the immense importance of infrastructural investments.
Quite significantly this department was renamed the Department of Commerce and Industry in 1924.


20 Views on India and on Indian iron and steel were expressed by the business communities and a wide range of other actors in extensive reports from parliamentary enquiries, Report from the Select Committee on Colonisation and Settlement (India), London, House of Commons, 1859 and others, now reprinted in a total of 22 volumes, covering 1805–1874. These are also the main sources in Ian Inkster, “The ‘Manchester School’ in Yorkshire: Economic Relations between India and Sheffield in the Mid-Nineteenth Century”, in Indian Economic and Social History Review, (New Delhi 1986) 23 (1), p. 311–321. The connection between the free-trade doctrines of the Manchester school and British imperial interests has been explored by Peter Harnett, Imperialism and Free Trade: Lancashire and India in the Mid-Nineteenth Century, (Vancouver 1972).

28 PWD Proceedings, February 1861, NAI.
29 The following description is mainly based on P. N. Bose, “Geology of the Lower Narbada Valley Between Nimawar and Kawant”, in Memoirs of the Geological Survey of India, 21, (Calcutta 1885).
32 Sir Malcolm later wrote the “Memoirs of Central India”, which also became important reading for Mitander. See Mitander’s diary, 26 January 1861.
34 Indore was a princely state until independence in 1947. The privileges of the Holkar dynasty came to an end when Indira Gandhi abolished all state pensions to the families of former rulers. A main source of this short overview is Encyclopaedia Britannica, (www.ee.ualberta.ca/~naik/holkar.html, accessed 25 July 1998).

THE MAKING OF IRON AND STEEL
PART 1

2 Pig iron takes its name from the particular shape of the mould into which the iron was tapped from the furnace, resembling sucking pigs feeding from the sow.
3 The transition was gradual in Sweden. Not until the sixteenth century did a considerable decline in direct iron production occur. The process of making iron in bloomery furnaces survived in Sweden until the mid-19th century, among peasants in northern Dalarna and Härjedalen (Magnusson, “The Cultural Landscape of Iron”, p. 54).

CHAPTER 2
NOTES ON IRON IN INDIA, SWEDEN AND BRITAIN

2 Marie Nisser, “Swedish Iron and Steel – the Historical Per-
Artur Attman, 
Reports from the Select Committee on Colonisation and Settlement
9 It was not until the middle of the twentieth century that

7 Letter 16 January 1860, attached to Hardy Wells (1859, De-
5 Reports from the Select Committee on Colonisation and Settlement
3 Heath continues the discussion for several pages, Correspondence Relating to the Porto Novo Iron Company, House of Commons (London 1853), p. 143.
5 Reports from the Select Committee on Colonisation and Settlement in India with Proceedings, Minutes of Evidence, Appendices and Indices 1859, reprint in Irish University Press series of British Parliamentary Papers, Colonies, East India, 18, (Shannon 1868–), “Report”, p. x and “Minutes of Evidence”, 1864 (given by Captain John Ouchterlony, with nine years’ experience from the grand trigonometrical survey of India, mainly in the South).
6 Reports from the Select Committee on Colonisation and Settlement in India with Proceedings, Minutes of Evidence, Appendices and Indices 1857–58, reprint in Irish University Press series of British Parliamentary Papers, Colonies, East India, 17, (Shannon 1868–), “Minutes of Evidence”, 3333 (given by Charles Atkinson, Mayor of Shefield).
8 Quoted in William Hackney (1879, February), Iron Ore and Coal from the Chanda District of the Central Provinces of India, India Office, London 1879, in Public Works Department, Departmental Papers 1880, 868, Departmental Papers: Public Annual Files (1872), L/PWD/6/42, OIOC, p. 4.
9 It was not until the middle of the twentieth century that the last charcoal blast furnaces in Sweden were closed. As late as 1950 there were still 22 charcoal blast furnaces at work, several of them at important steel-producing sites such as Sandviken, Hofors and Fagersta, continuing production and maintaining a respected tradition into the twentieth century. The last three charcoal blast furnaces were shut down in the 1960s: Sandviken (1960), Bredsjö (1962) and Svarø (1966) (Jan-Erik Pettersson, Från kris till kris. Den svenska stålindustrins omvandling under 1920- och 1970-talen) From Crisis to Crisis. The Restructuring of the Swedish Steel Industry during the 1920s and the 1970s, Stockholm 1988, p. 46–47.
11 The name Bergslagen is usually interpreted as deriving from the Swedish words for [iron] mountain (berg) and team (lag), the latter element being the name of the co-operative production unit of olden days, both at the individual ironmaking site and in greater areas given privileges by the Crown. Another, slightly different interpretation is that lag in Swedish also means “law”, thus representing the area governed by law. The two interpretations do not seem mutually exclusive, since every social organisation (lag = team) must be governed by some common rules (lag = law).
12 Attman, Svenskt järn och stål, p. 9–22.
16 As in India, the date of the start of iron production in Sweden has been revised, being shown to be further back in history by continue archaeological research. The production and use of iron was common and widespread in Sweden by about 600 BC, but iron slags have been found in connection with workings of copper and bronze from as early as 1100 BC. As in India, there is a case for assuming an indigenous development of ironmaking in Sweden, with a long, continuous augmentation of knowledge and skills. Gert Magnusson, “The Inception of Iron Production in Sweden and the Development during the First Two Millennia”, in Girija Pande & Jan af Geijerstam (eds.), Tradition and Innovation in the History of Iron Making An Indo-European Perspective, p. 62–69.
18 Historical evidence on Wootz includes the mention by


32 For important contributions to anthropological research on ironmaking communities in India see Verrier Elwin, *The Agaria*, (Calcutta 1942). Sabyasachi Bhattacharya has written an important article on the possibilities of combining the mode of production associated with industry with the family-based traditional ironmaking of India (Bhattacharya, Sabyasachi, “Cultural and Social Constraints on Technological Innovation and Economic Development: Some Case Studies”, in *Indian and Social History Review*, 3(1) (New Delhi 1966), p. 240–267). See chapter 11.


37 Minutes of the Proceedings of the Experts Meet Held on Traditional Iron-Smelting Technology, held on 9 and 10 July 1997, in Indira Gandhi Rashtriya Manav Sangrahalya, (Bhopal).

39 Two early such reports were published in the 1820s: J. D. Herbert, “On the mineral productions of that part of the Himalayas, lying between the Satlaj and the Kali (Gagra) rivers considered in an economical point of view, including an account of the mines, and methods of working them, with suggestions for their improvement”, *Asianic Researches or Transactions of the Society, Instituted in Bengal, for Inquiring...*

Ramsay’s report, p. 7–8.

J. O’B. Becket’s report (Beckett, 1850, January), Iron and Copper Mines in the Kumaon Division, Selections from the records of Government, North Western Provinces, 3 (10), (1855), p. 67–75.) has been extensively used in writing on traditional ironmaking in the Himalayas, for example in Edwin T. Atkinson, The Himalayan Districts of the North-Western Provinces of India. The Himalayan Gazetteer, (Allahabad, 1882–1886, reprint New Delhi 1996), 1, p. 269–271. William Jory Henwood (1855, May), Report on the Metallicores Deposits of Kumaon and Garhwal in North Western India, Selections from the records of the Government of India, 8, (Calcutta 1855), is another important report, also giving figures on the number of furnaces in work and the number of families engaged in ironmaking.


Ball, A Manual of the Geography of India, p. 345.


Ball, A Manual of the Geography of India, p. 345.


An important source of this research is the expert committee on iron and steel history formed under the auspices of Jernkontoret (The Swedish Steel Producers’ Association).


Among the previously mentioned monographs on Indian iron and steel published in the twentieth century the following have been found to refer to the Kumaon and Burwai iron ore, *Iron and Steel in India*, on Kumaon p. 32, and Burwai p. 33; Fraser, *Iron and Steel in India*, Kumaon p. 8, Burwai no mention; Krishnan, *Iron ore, Iron and Steel*, Kumaon p. 98–100, Burwai p. 102–121; Srinivasan, *Iron and Steel Industry of India*, Kumaon p. 6–7, Burwai p. 7; and Touche, *A Bibliography of Indian Geology*, Kumaon p. 281, Burwai p. 252.


Johnson, *The Steel Industry of India*, devotes, in spite of its title, but marginal interest to the colonial background of the steel industry before the start of the Tata Iron and Steel Company (p. 8–9).


Grout, *Geology and India*.


**CHAPTER 3**

**PHASE I: 1815–1860**


2 Quoted in Grout, *Geology and India*, p. 42.


4 Grout, *Geology and India*, p. 51.


7 Grout, *Geology and India*, p. 47.

8 On the Asiatic Society, see Grout, *Geology and India*, 1772–1851, p. 86–95.


10 An important question in the general quest for ore resources was who could be trusted as a surveyor or scientist; this is also evident in the strategies used to attain respect by diverse actors in their reports to the colonial authorities (Anders Carlsson, “De morka bergens hemligheter: kontroversen kring Kirunavaaras malm, 1880–1916” *The Secrets of the Dark Mountains: The Controversies on the Ores of Kirunavaara*, in Sven Widmalm (ed.), *Vetenskapsbärarna [The Carriers of Science]* (Hedemora 1999), p. 77–116).

11 Grout, *Geology and India*, p. 64.


13 The formal foundation date of the Geological Survey of India (GSI) is said to be the date of Thomas Oldham’s arrival in India, although the Survey was not formally organised as a department until years later. Sir Lewis Leigh
Fernor, First Twenty-Five Years of the Geological Survey of India, Geological Survey of India, Miscellaneous Publications, 39, (New Delhi 1976), p. 1–5. The GSI soon began to publish its own series of reports and these became the most important channel for expressing and acquiring knowledge of Indian geology and mineral resources. During the mid-nineteenth century the importance of scientific research in education in geology increased in Sweden, as did the institutionalisation of geology. The Swedish Geological Survey was established in 1858 (Anders Carlsson, “De mörka bergens hemligheter”).

One such example was when H. Piddington, curator at the Furnace and discussed ways to increase the yields. This is wrote on the local mode of mining, described a Kumaoni Bengal furnace and discussed ways to increase the yields. This is


One such example was when H. Piddington, curator at the Museum of Economic Geology in Calcutta, made a detailed analysis of samples of iron ore from Henry Drummond in August 1855. Besides the iron peroxide content, the amount of arsenic was especially noted (Appendix to Drummond, H., 1855, August, p. 37).

Grout, Geology and India, p. 172.

Dag Avango explores a connection between science and territorial interests in his researches into Swedish mining interests at Svalbard, at the Dept. of History of Science and Technology, Royal Institute of Technology, Stockholm (Industrial Heritage Research). Grout mentions the possibility of a connection but maintains that “the government never used science to justify territorial conquests”, in connection with Afghanistan in the 1830s (Grout, Geology and India, p. 193).

Francis (Hamilton) Buchanan, An Account of the Kingdom of Nepal and of the Territories Annexed to This Dominion by the House of the Gorkha, (1819, reprint New Delhi 1996), p. 76–83. Later Buchanan was also to travel in South India, when he made his widely quoted observations on traditional ironmaking (A Journey from Madras through the Countries of Mysore, Canara and Malabar, 3 volumes, (London 1827)).

Quoted from Edwin T. Atkinson, The Himalayan Districts of the North-Western Provinces of India, The Himalayan Gazetteer, 1, (1882–1886, reprint New Delhi 1996), p. 260 and the full reference, given in Grout, Geology and India, p. 173–174 is, Mackenzie to Laidlaw, Calcutta, 6 June 1817, OIOC F/4/622 BC.13497, p. 12–13. A similar line of reasoning was followed in 1772 when the very first proposal to start a mining enterprise was turned down by the Bengal Council (Grout, Geology and India, p. 34).

John Hallet Batten (ed.), “Journal of Captain Herbert’s Tour from Almora in a N.W., W. and S.W. Direction, through Parts of the Province of Kemaon and British Gurhwal, Chiefly in the Centre of the Hills, Vde –66, Indian Atlas”, in Journal and Proceedings of the Asiatic Society of Bengal, 13, (Calcutta 1844), p. 714–764 In 1829 Herbert wrote on the local mode of mining, described a Kumaoni furnace and discussed ways to increase the yields. This is extensively referred to in Atkinson, Himalayan Gazetteer, p. 267f after the original of J. D. Herbert, “On the mineral productions of that part of the Himalayas, lying between the Satla and the Kali (Gagra) rivers considered in an economical point of view, including an account of the mines, and methods of working them, with suggestions for their improvement”, Asiatic Researches or Transactions of the Society, Instituted in Bengal, for Inquiring into the History and Antiquities, the Arts, Sciences, and Literature of Asia, 18 (1), (Calcutta 1829), p. 227–238.


Sir John Malcolm initiated the Military Literary Society at Mhow. It was established in 1819, and in spite of its being very short-lived and having a somewhat misleading name, it was an expression of an interest in natural history and geology within sections of the army’s officer corps (Grout, Geology and India, p. 115–116).


Three articles on palaeontology are noted in Medlicott, “On the Geological Structure”, p. 113–114.

The survey during the 1850s showed that the Narmada River was unsuitable for navigation. Unlike most rivers in India it has no level portion, flowing through a cleft in the hilly tracts usually forming its shores. The combination of a concentrated rainy season during the summer south-westly monsoon, and a rather narrow valley with hills on either sides, accounts for extreme variations in the flow. See especially E. Impye, (1852a), Memoir on the Physical Character of the Nerbudda River and Valley with Remarks on the Practicability, or Otherwise, of This River Being Rendered a Navigable Stream, in Selections from the Records of the Bombay Government, 14, new series, (Bombay 1854), p. viii, i–12.

E. Impye (1854b), Descriptive Detail of the Mineral Resources of the Nerbudda Valley, in Selections from the records of the Bombay government, 14, new series, (Bombay 1855), p. 19.
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29 The earlier part of these developments is covered in Impey (1855c) and Papers on the Coal of the Nerbudda Valley, Tenasserim Provinces, and Thayat-Myo (1854–1855) in Selections from the records of the Government of India 10, (Calcutta 1856).
31 E. Impey (1855c) Analysis of the Past Correspondence of Government on the Subject of the Coal-Beds in the Vicinity of the Nerbudda; and of the Practicability of the Navigation of the River, in Selections from the records of the Bombay government, 14, new series, (Bombay 1855), p. 61.
32 Lushington “Account of the Experiment.
33 Grout, Geology and India, p. 56–57.
34 In a pamphlet first published in 1845 and reprinted in 1857 as Colonization of the Himalaya. Henry Drummond (1847) p. 6, as quoted in Grout, Geology and India, p. 54.
35 When the charter of the East India Company was going to be renewed in 1833 there was considerable agitation in England in favour of settlement and as a result the Company was forced to allow British settlement including the right to purchase and hold land. Grout, Geology and India, p. 57.
36 Despatch 126 of July 29, 1827. Quoted in a letter from PWD, 4 February 1862, to the Secretary of State for India, Charles Wood, Correspondence with India (1862), L/PWD/3/328, OIOC.
38 Wells (1859, December), p. 23.
42 William Jory Henwood (1845, May), Report on the Metalliferous Deposits of Kumaon and Garhwal in North Western India, Selections from the records of the Government of India, 8, (Calcutta 1855), p. 1–2; Wells (1859, December), p. 5; Ramsay’s report, p. 8–9. The assignment in Kumaon was Henwood’s last big job. He retired from active work in 1858 due to ill health (Sidney Lee, The Dictionary of National Biography, Oxford 1917). Far later (1871), however, an extensive paper of his was included in the Transactions of the Royal Geological Society of Cornwall. It is interesting to note that this paper has many explicit features of a scientific article, extensive footnotes, comparative studies, and an extensive use of figures as a means of analysis (William Jory Henwood, “On the Metalliferous Deposits of North-Western India”, in Transactions of the Royal Geological Society of Cornwall, 8, (London 1871), p. 1–61).
43 Henwood (1855, May), p. 32.
45 Drummond (1845, August), p. 20.
46 Drummond (1845, August), p. 32. See also note by the editors of the Selections of the Records, noting that Davies did not concur with Henwood’s conclusion, but agreed with the conclusion that Henry Drummond later drew, thinking the experiment could be best made “in the yet undeveloped district and pestilent climate of the Bhabur” (Henry Drummond, (1855, May), p. 38).
47 The small town of Nainital was established in 1842 and became an increasingly important recreational and health resort of the British. From 1862 Nainital was the summer seat of the government and administration of the North West Provinces (Ajay P. Rawat & Deepak Singhal, Corbett’s Nainital: Travails of a Crumbling City, (Nainital 1998), p. 25–28).
48 On the disparate systems of information in India and the efforts and failure of the British to gain control and fully encompass the indigenous system of information dissemination, see, Christopher Allan Bayly, “Knowing the Country: Empire and Information in India”, in Modern Asian Studies, 27, (London 1993), p. 3–43. Grout, Geology and India, p. 74–76.
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52 Drummond (1855, August), p. 22.
54 In a recent popular educational book on geology: K. S. Valdiya, Dynamic Himalaya (Hyderabad, 1998).
55 Drummond (1855, August), p. 23–24.
56 Drummond (1855, August), p. 26. Analyses of these bars are presented in an appendix to Drummond’s report.
57 Sowerby (1856, January), p. 43–44.
58 Letter from G. A. Bushby, Secretary to the Government of India, to A. Mallet, Chief Secretary to the Government in Bombay, 13 May 1848, in Impey (1855c), p. 88; and Letter from Court of Directors to Government in Bombay, 8 November 1848, in Impey (1855c), p. 104.
60 Jacob (1854, April a), p. 138.
61 Jacob (1854, April a), p. 141.
62 Kennedy (1854, April), p. 132. The cost per mile with Indian iron would be only 46 or 57 percent compared to the two alternative ways of building, using iron from England (Kennedy 1844, April, p. 155–156).
63 J. P. Kennedy (1854, April), Extracts from a Report (1854) Relating To the Mineral Districts etc. of the Nerbudda Valley; by Lieut.-Col. J. P. Kennedy, Selections from the records of the Bombay government, 14, new series, (Bombay 1855), p. 132.
64 Kennedy (1854, April), p. 132.
65 Impey (1855b), p. 16.
66 Impey (1855b), p. 23. The three principal spots that he favoured were all further up the valley, however, close to Jabalpur and Hoshangabad.
68 Thomas Oldham to W. Gordon Young, Under-Secretary to the Government of Bengal, 2 March 1854, in Papers on the Coal of the Nerbudda Valley (1844–1855), p. 3.
72 Medlicott (1855, June), p. 27–28.
73 Jacob (1854, April a and April b), J. P. Kennedy (1854, April), E. Impey (1855 a, b and c), Medlicott (1855, June).
74 Oldham (1856, April), p. 271.
75 Oldham (1856, April), p. 271.
76 Oldham (1856, April), p. 277.
77 Drummond (1855, August) p. 32.
79 Medlicott, “On the Geological Structure”, p. 110. According to Medlicott not one new locality and not one useful observation had been added since Colonel Ousley’s reports around 1850 (p. 109).
80 The evidence given is covered in question 3718–3805, Reports from the Select Committee on Colonisation and Settlement in India With Proceedings, Minutes of Evidence, Appendices and Indeces 1859, reprint in Irish University Press series of British Parliamentary Papers, Colonies, East India, 18, (Shannon 1968–), p. 246–252. This was also explicitly quoted in Wells (1859, December), p. 3–4.
81 Wells (1859, December), p. 3–4. British Parliamentary Papers, Reports from the Select Committee on Colonisation and Settlement in India 1859, Colonies, East India 18, p. x.
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83 Sowerby (1856, April), p. 100–103.
84 Wells (1859, December), p. 11.
85 Wells (1859, December), p. 12–11.
86 Despatch 126 of 29 July 1857, referred to in Governor General Canning’s letter to Charles Wood, 4 February 1866, Correspondence with India (1866), L/PWD/3/328, OIOC.
88 There are extensive reports on the tours in Sowerby (1858, August), p. 1–103.
89 The Engineer’s Journal, 2 January 1862, p. 1.
90 Wells (1859, December), p. 15.
91 Letter from Charles Wood, Secretary of State for India to the Governor General of India, Public Works 69, 31 October 1860, Home Correspondence 1871–1879, L/PWD/2/30, OIOC.
92 Letter from H. Yule, Secretary to the Govt. of India, 42, 7 January 1862. Enclosure attached to Wells (1859, December), p. 29.
94 Sowerby (1858, August), p. 61. See also Wells (1859, December), p. 12 and Commissioner Henry Ramsay’s summary of the position and history of the Kumaon Iron Works Company, letter 525 of 1872, to the Secretary to the Government, NWP, India Public Works, Collections to Despatches (1872), L/PWD/3/384, OIOC.
95 Referred to in a letter from Thomas Oldham, 14 (a), 21 April 1862, in Oldham (1865, May), p. 55.
97 Letter from Charles Wood, Secretary of State for India to the Governor General of India, Public Works 69, 31 October 1860, Home Correspondence 1871–1879, L/PWD/2/30, OIOC.
99 Also the summary by the Commissioner of Kumaon, H. Ramsay, of the position and history of the Kumaon Iron Works Company, letter 525 of 1872, to the Secretary to the Government, NWP, India Public Works, Collections to Despatches (1872), L/PWD/3/384, OIOC.
100 Impey (1854b), p. 18. Herbert Giraud, Professor of Chemistry at the Grant Medical College, examined samples of coal in 1847 and analysed their content of solid carbon, gases and ashes (Impey 1855c, p. 48). Giraud’s conclusions were negative (low proportion of solid coal, a lot of ash). On practical experiments, which gave positive results, see for example the reports on steam-boat trials off Bombay in 1839 (p. 42–44), and 1847 (p. 49–50), in Impey (1855c).
101 Impey (1855b), p. 18–19.
102 In a letter from W. Hart, Secretary to the Government, to C. Beadon, 4 February 1858, Home Department, Pub., 9 April 1858, 149–51, National Archives, New Delhi.
105 Home Department, Pub., 9 April 1858, 149–51, National Archives, Delhi.
106 Note by Lieutenant Colonel R. Strachey, Secretary to the Government of India, PWD, on the subject of experimental iron works lately established at Burwai, in Nimar, 12 April 1862, PWD Proceedings, April 1862, NAI.
107 Letter from Major R. H. Keatinge, late political agent in Nimar to Secretary to the Government of India, PWD 27 March 1862, in PWD Proceedings, April 1862, NAI. Also in Mitander’s diary, 31 March 1862.
108 Despatch 18, 19 March 1856, referred to in letter from W. Hart, Secretary to the Government, to C. Beadon, 4 February 1858, in Home Department, Pub., 9 April 1858, 149–51, Nat. Archives Delhi.
109 Note by Lieutenant Colonel R. Strachey, Secretary to the Government of India, PWD, on the subject of experimental iron works lately established at Burwai, in Nimar, 12 April 1862, PWD Proceedings, April 1862, NAI. Blackwell (1857), p. 24.

CHAPTER 4

PHASE II: 1860–1862

1 The importance of families and personal networks in maintaining, expanding and developing Swedish ironmaking has been illuminatedly exposed in a Ph.D. thesis by Ylva Hasselberg, establishing the concept of the “embedded economy”, in Swedish the “social economy” of ironmaking. Ylva Hasselberg, Den sociala ekonomien: familjen Clason och Furudals bruk 1824–1856 [The Embedded Economy: The Clason Family and Furudal Ironworks 1824–1856], (Uppsala 1998).
2 Stig B. Hegardt, Alkvettern: ett gammalt gods anor [Alkvettern, Traditions of an Old Manor], (Stockholm 1946), p. 111. When an act of parliament (passed by the Swedish riksdag) made this possible, the estate was transformed into a joint stock company in 1864, A. G. Petersson, Alkvetterns säteri i Bjurkärn [The Alkvettern Manor in Bjurkärn] (Kristinehamn 1930), p. 113.

11 Gösta A. Eriksson, Bruksläden i Bergslagen efter år 1852: med särskild hänsyn till Kolbäcksin deltagare, [The Decline of the Small Blast-Furnaces and Forges in Bergslagen after 1852: With Special Reference To Enterprises In the Valley of the Kolbäck River], (Uppsala, 1955), Map 1.

12 For example Wermålsdans bergsmannaföreningens Annaler [Annals of the Association of Bergsmän in Wermland], Örebro, and Blad för berghandteringens vänner [Papers for Friends of Mining], Örebro. Both these journals mention or contain contributions by Nils Mitander and/or Andreas Grill.

13 Fahlu Bergsskola was transferred to the predecessor to the Royal Institute of Technology in Stockholm in 1869. With it came more than 2,000 books from school’s library, mostly on metallurgy and chemistry, forming a most valuable part of the collections of the library of the Institute (www.lib.kth.se/TH/aldre_e.html, accessed 21 May 2003).

14 Bergman, Fahlu Bergsskola.


19 As holders of a scholarship their doings during these years can be closely followed in their yearly reports to Jernkontoret, summaries of which were published in JkA. The series is especially complete for Mitander. In the archives of Jernkontoret at the National Archives of Sweden (Riksarkivet) in Stockholm reports are found for the following years: 1853, 1856 and 1857 (Fle1:1); 1859 and 1866 (Fle2:2). The last report was written and sent from India, “Burwai in East India 19 February 1861”). Corresponding material was published in JkA in 11, (Stockholm 1862) p. 227–228, concerning 1854; in 12, (Stockholm 1863) p. 227–29, concerning 1856; in 13, (Stockholm 1859), p. 311, concerning 1857; in 14, (Stockholm 1861) p. 281, concerning 1858; and in 16, (Stockholm 1861) p. 101, concerning 1862.

20 On Silverhyttan, see the archives of Jernkontoret at the National Archives of Sweden (Riksarkivet) in Stockholm Fle1:1 and on Edsken, see Jernkontorets diarium, 3 May 1859, and letter from Andreas Grill, Jernkontoret. Fullmäktige BIIa:94.
21 Andreas Grill (1827–1889) was the director of metallurgy at Jernkontoret from 1856. He was married three times and his wives gave birth to a total of fifteen children. Andreas Grill became the manager of the family estate of Mariedam in 1851 (Johan Wilhelm Grill, Grilliana. Conceptbok till Grillskas sägents Historia [Grilliana. Draft of the History of the Grill Family], manuscript approximately 1864 and genealogical table, both through personal communication with Claes E. Grill, Vallda, in January 1999).


26 Sowerby (1858, August), p. vi.

27 Hardy Wells (1859, December), “Report upon the Kumaon Iron Fields in Connection with the Government Ironworks at Dehourree and Ramgarh”, Correspondence with India (1860), L/PWD/3/328, OIOC, p. 15.

28 Wells (1859, December), p. 15.


34 Specific study tours were often institutionalised, through schools or through industrial organisations. For example technicians and workers could apply for special grants at the Royal Institute of Technology to go abroad to study their trades. In return they had to present a formal report. A total of 259 such travel accounts (1849–1922) have been preserved. Of these only a few deal with mechanical workshops and none with metallurgy (Maja Hagerman, Berättelser från utlandet. Svenska tekniker och arbetare på studieresor i Europa och Amerika under 1800–talets senare hälft [Accounts from Abroad. Swedish Technicians and Workers on Study Tours in Europe and America during the Latter Part of the Nineteenth Century], Royal Institute of Technology Library 2008, (Stockholm 1981), p. 6 and attachment 2). Note however that the travel account of Axel Waldemar Karlsson, 52, is incorrectly said to deal with metallurgy. The subject was finer steel manufactures at the great exhibition in London and workshops in England in 1862.

35 Angerstein, Illustrated Travel Diary, 1775–1775.


37 This could be a rich field of further systematic study. The
collection of portraits and short biographical notes on Swedish metallurgists and engineers in the archives of Jernkontoret could be analysed, as well as the full collection of travel reports kept in the archives of Jernkontoret at the National Archives in Stockholm.

38 Letter from Andreas Grill to Julius Ramsay, 8 May 1862, Ramsay’s papers, E1:1.05. Grill represented Sweden in the jury of Class XXXI, Section A, Hardwares – Manufactures in Iron (Medals and Honourable Mentions Awarded by the International Juries with a List of Jurors, and the Report of the Council of Chairmen, International Exhibition (London 1862), p. xviii). It was at this fair that Bessemer steel iron from the Beypor ironworks in Madras was exhibited.

32 Sowerby’s study trip provided the material for his report on the Kumaon Iron Works published in 1859, accompanied by more than one hundred figures (Sowerby 1858, August, especially p. 1–48). On his journey in Europe Sowerby was accompanied by William Gower, an experienced blast furnace worker who acted as his metallurgical assistant and who was to accompany him to work at the Kumaon Iron Works in India. In India Sowerby and Gower also studied some of the works of the Madras Iron Works.

31 There were, however, certainly many areas, in the forefront of technological development, which were much more secluded. The Bessemer process was protected by patents from the start and the development of this process at Edsken in Sweden was protected against too much observation (Per Carlberg, “Bessemermetodens genombrutt vid Edsken och Högbo” [The Breakthrough of the Bessemer Process at Edsken and Högbo], Med hammerare och fackla, 22 (Stockholm, 1962), p. 15–16 and 92).

30 “Bessemer’s American patent and the Indian patent laws”, in The Engineer’s Journal and Railways, Public Works and Mining Gazette of India and the Colonies, 1, 18 January (London 1858), p. 17.


44 Letter, in Swedish, from unknown sender and not dated, Ramsay’s papers, E1:1.05. It is not far-fetched to assume that it is a translation from English of a letter to Andreas Grill asking for his help.

47 Ramsay’s report, p. 18.

45 Ramsay’s papers, E1:1.05.

46 Note by Lieutenant Colonel R. Strachey, Secretary to the Government of India, PWD, on the subject of experimental ironworks lately established at Burwai, in Nimar, 12 April 1862, PWD Proceedings, April 1862, NAI.


49 Letter from Julius Ramsay to his sister, Örebro 19 June 1862, The Collections of Helmer Lagergren, City and County Library of Falun.

50 Letter from Keatinge, 23 June 1861 to PWD, PWD Proceedings, August 1861, NAI.

51 Letter from Julius Ramsay to his sister, Örebro 19 June 1862, The Collections of Helmer Lagergren, City and County Library of Falun.


53 Transcript translated from letter in English, from unknown sender and date, Ramsay’s papers, E1:1.05. Letters from Andreas Grill to Julius Ramsay, 14 August and 27 August 1861, Ramsay’s papers, E1:1.05.

54 Grill especially stressed that two other young Swedish metallurgists had been forced to decline or missed the offer. Harald Dillner had signed the contract, but had fallen ill, and Grill had not been able to get in touch with Oskar Troili (Letter from Andreas Grill to Julius Ramsay, 14 August, 1861, Ramsay’s papers, E1:1.05).

55 Ramsay’s report, p. 1–2. There was thus at least one more metallurgist, who considered the possibility of going to India. It would be interesting to know why Harald Dillner backed out, as this might possibly give a new perspective on the decisions by Ramsay, Wittenström and Mitander.

56 Letter from Mitander to Ramsay, 25 October 1862. Ramsay’s papers, E1:1.27. Also in Mitander’s diary, 6 November 1862.

57 Eriksson, Braksdöden i Berglagen efter år 1852, p. 97–98.

58 In 1849–1851 Ramsay had a grant but according to his cashbook the most apparent expenditures were different kinds of entertainment: ticket for ball, port toddy, concert tickets etc. In 1849 his expenditures amounted to 515 riksdaler, of which loans had to be taken for 300. In 1850 his “incomes” amounted to 565 riksdaler, 40 shilling of which 50 riksdaler were actually loans. (Inkomst och utgiftsbok för Julius Ramsay [1849–1851] [Cash Book of Julius Ramsay 1849–1851], belonging to Captain Anders Ramsay, Helsingborg.) Mention of these kinds of difficulties also abounds in Ramsay’s letters to his mother in 1849, such as when he writes on his debts but happily reports that his travel to Stockholm would be cared for by a win in a card game with some friends (Örebro, 14 January 1859, Letters from Julius Ramsay to his sister, Örebro, 14 January 1859, Letters from Julius Ramsay to his sister, Örebro 1859, Letters from Julius Ramsay to his sister, Örebro 1859, Letters from Julius Ramsay to his sister, Örebro 1859, Letters from Julius Ramsay to his sister, Örebro 1859).

59 Ramsay’s papers, F:1.1.03.


61 Letter from Ramsay to his friends, Nainital and Dechauri, 14 January 1862, Ramsay’s papers, E:1:1.04.

62 Letter from Gustaf Wittenström to Julius Ramsay, Åbo and Dalshärk, 12 May 1862, Ramsay’s papers, E:1:1.04.

63 Mitander’s diary, 25 September 1860.

64 Together with Andreas Grill, Christer Sandberg (1832–1911) is one of the people specially mentioned and thanked in the foreword of Percy, *Metallurgy, Iron and Steel*, p. v. Sandberg’s arrival in England coincided with the introduction of the Bessemer process and he realised its usefulness in the fabrication of steel rails and was to become an authority on rail steel. He established a general consulting practice, and also worked on consultancy assignments in Asia, for the state railways of Siam and China. “Sandberg, Christer Peter, Obituary”, Minutes of Proceedings of the Institutions of Civil Engineers, 198, (London 19159, p. 147–148.

65 Mitander’s diary, 25–27 September 1862.

66 For the symbolic importance of *Frithiofs saga* [Frithiof’s Saga: A Legend of the North] (first edition 1823) see preface to Ake K. G Lundquist (ed.) *Esaias Tegnér:s samlaade dikter* [Collected Poems of Esaias Tegnér], 4, “Frithiofs saga”, (Bjärred 1986) and Ulla Törnqvist (ed.), Mötens med Tegnér [Meetings with Tegnér] (Lund 1996). As a curiosity but also as a parallel to Mitander’s reading it may be mentioned that Roald Amundsen in 1911 carried a Norwegian miniaturization of the epic, published in 1860, as his only reading on his travel to South Pole (Ewert Wrangel, *Minnen från ett tre-årigt vistasande i engelsk örlögssjöman 1857–1859: anteckningar* [Memories of Three Years in the British Navy 1857–1859: Notes], (Stockholm 1865).

67 Mitander’s diary, 3 November 1860.

68 The Suez Canal was the major project to ease and speed up communications between Europe and Asia. A joint French-Egyptian company started its construction in 1859 and it was completed ten years later. In 1875 Britain bought approximately 45 percent of the shares in the company to safeguard her imperial interests.

69 Mitander’s diary, 11 October 1862.

70 Mitander’s diary, 25 October 1862.

71 Mitander’s diary, 26 October 1862.

72 Mitander’s diary, 26 October 1862. I have not been able to decide how the ice that Mitander enjoyed had been made. The history of ice in India would be a most interesting subject for further research, from the preindustrial modes of manufacture by evaporation of water during chilly desert nights, to the transfer of industrial technologies in the wake of colonialism. For the history of ice-making, see Roger Thévenot, *A History of Refrigeration Throughout the World*, (Paris 1979), p. 22–25, 36–39, 66–72, 416–417. As far as I know, there was at this time no way of making ice in Bombay. The ice that cooled the lemonade of Nils Mitander and Mr. Hutton could instead have been brought from America. This somewhat amazing trade is described by Daniel Boorstin in “Inventing Resources — Ice for the Indies” (Daniel Boorstin, *The Americans: The National Experience* (New York 1965), p. 12–16."

73 Mitander’s diary, 3 November 1860.

74 Mitander’s diary, 27 October–1 November 1860.

75 Mitander’s diary, 31 October 1860.

76 Mitander’s diary, 27–31 October 1860.

77 Mitander’s diary, 29 October–1 November 1860.

78 Mitander’s diary, 26 September 1860.

79 Mitander’s diary, 8 October 1860.

80 Mitander’s diary, 4 November 1860.


83 Herman Annerstedt *Rapporter: Rörande importen till Bombay af svenska järn och stål under åren 1855–1856* [Reports: Concerning the Import to Bombay of Swedish Iron and Steel 1855–1866], (Stockholm 1868); and, *Slutrapport till H. Exc bryr stats minister for utrikes ärendena rörande handel och sjöfart i India och China* [Final Report to the Minister of Foreign Affairs Concerning Trade and Shipping in India and China], (Stockholm 1870).

84 Mitander’s diary, 14 November 1862.

85 Mitander’s diary, 26 October 1860.

86 32 kilometres per day as the crow flies according to measurements on maps. Mitander seems to have been very accurate in recording the distances travelled.

87 Mitander’s diary, 13 November 1860.

88 Mitander’s diary, 18 November 1860. This was not Barwah proper, the small town that was his final point of destination, but just the ferry landing on the north bank of the river.

89 Ramsay’s report, p. 2–3.


92 To avoid ambiguity because of the identical surname of Mr. Henry Ramsay, Ramsay. Henry Ramsay was promoted to Commissioner of Kumaon Henry, the latter will be referred to as Commissioner Ramsay. Henry Ramsay was promoted to Commissioner in 1856.

93 “Agreement for employing Mr. Ramsay as manager”, Ramsay’s papers, F:1:1.03, and letters from Ramsay to his friends, London, 15 October 1861, and Kaladhungi and Nainital, 18 December 1861, Ramsay’s papers, E:1:1.04.
CHAPTER 5
PHASES III AND IV: 1860–1880

1 This first part of this chapter is based mainly on Mitander’s diary, 19 November 1860–20 October 1862 and on Ramsay’s report to Jernkontoret and his collection of letters to his friends, all in the Ramsay collection at the National Museum of Technology in Stockholm.

2 Mitander’s diary, 27 November 1862.

3 Unfortunately I have found none of Mitander’s own drawings.

4 Mitander’s diary, 17 May and 6 June 1862.

5 Mitander’s diary, 24 December 1861.

6 Mitander’s diary, 21 March 1862.

7 Mitander’s diary, 24 February 1861.

8 Mitander’s diary, 25 February 1861.

9 Mitander’s diary, 19 March 1861.

10 Mitander’s diary, 18 March 1861.

11 Letter from Keatinge to PWD, 23 June 1861, PWD Proceedings, August 1861, NAL.


13 Letter from Keatinge to PWD, 23 June 1861, PWD Proceedings, August 1861, NAL.

14 Report from Mitander from his arrival until the end of September 1861, summarised in Note by Lieut. Colonel R. Strachey, Secretary to Govt of India, PWD, on the subject of experimental ironworks lately established at Burwai, in Nimar, 12 April 1862, PWD Proceedings, April 1862, NAI.

15 Letter from Keatinge to PWD, 20 August 1861, PWD Proceedings, September 1861, NAL. Proceedings, Industrial, September, NAI.

16 Mitander’s diary, 17 June 1861.

17 Mitander’s diary, 23 June 1861.

18 Letter from Keatinge to PWD, 23 June 1861, PWD Proceedings, August 1861, NAL.

19 Letter from Keatinge to PWD, 22 August 1861, PWD Proceedings, September, NAI 1861. Mitander’s diary, 20 November 1862.

20 Letter from Keatinge to PWD, 23 June 1861, PWD Proceedings, August 1861, NAL.

21 Letter from Keatinge to PWD, 23 June 1861, PWD Proceedings, August 1861, NAL.

22 Mitander’s diary, 14 and 15 August 1861.

23 Letter from Keatinge to PWD, 22 August 1861, PWD Proceedings, September, NAI 1861. Mitander’s diary, 20 November 1862.

24 Letter from Keatinge to Railway Dept., Govt. of Bombay 28 November 1861, PWD Proceedings, January 1862, NAI.

Note p. 130–140
25 Letter from Keatinge to Railway Dept., Govt. of Bombay, 28 November 1861, PWD Proceedings, January 1862, NAI.
26 Letter from Keatinge to PWD, 5 December 1861, PWD Proceedings, January 1862, NAI. Lieutenant Colonel H. Yule, Secretary to the Government of India, PWD forwarded Keatinge's suggestion to the Home Department (Letter 4556, 26 December 1861, PWD Proceedings, January 1862, NAI).
27 Mitander's diary, 20 February 1862.
28 Mitander's diary, 25 December 1861.
29 Mitander's diary, 28–29 December 1861.
30 Mitander's diary, 31 December 1861.
31 Mitander's diary, 7 January 1862.
32 Mitander's diary, 7 January 1862.
33 Mitander's diary, 9 January 1862.
34 Letter from Mitander to Ramsay 2 February 1862, Ramsay's papers E1:1.04.
35 Mitander's diary, 19 March 1862.
36 Mitander's diary, 21 March 1862.
37 Mitander's diary, 21 March 1862.
38 Ramsay's report, p. 6.
40 Ramsay's report, p. 18.
41 Ramsay's report, p. 18.
42 Ramsay's report, p. 19–20. For simplicity the older blast furnace will be referred to as “Sowerby’s blast furnace” in view of its origin. It should be noted that there is no mention of any Bessemer converter at this stage.
45 Letter from Ramsay to his friends, Nainital and Dechauri, 14 January 1862, Ramsay's papers, E1:1.04. His praise for these workers continued after their first real trial, the blow in of Sowerby’s furnace during the following month (letter 13 February 1862).
46 Letter from Ramsay to his friends, Nainital and Dechauri, 14 January 1862, Ramsay's papers, E1:1.04.
48 Letter from Ramsay to his friends, Nainital and Dechauri, 14 January 1862, Ramsay's papers, E1:1.04.
49 Letter from Ramsay to his friends, Nainital and Dechauri, 14 January 1862, Ramsay's papers, E1:1.04.
50 Letter from Ramsay to his friends, Nainital and Dechauri, 14 January 1862, Ramsay's papers, E1:1.04.
51 Ramsay's report, p. 35.
52 Letter from Wittenström to Ramsay, Åbo and Dahlsbruk, 12 May 1862, Ramsay's papers, E1:1.08.
53 Letter from Ramsay to his friends, Kumaon Iron Works, Nainital, 29 April 1862, Ramsay's papers, E1:1.04. Some weeks later Ramsay had met Dr. Morton in Almora (Letter Himalaya, Piorerar (?) bungalow, 12 May).
54 Letter from Ramsay to his friends, Kumaon Iron Works, Nainital, 29 April 1862, Ramsay's papers, E1:1.04.
56 Letter from Ramsay to his friends, Kumaon Iron Works, Nainital, 29 April 1862, Ramsay's papers, E1:1.04.
57 Letter from Ramsay to his friends, Kumaon Iron Works, Nainital, 29 and 30 March 1862, Ramsay's papers, E1:1.04.
58 Letter from Ramsay to his friends, Kumaon Iron Works, Nainital, 29 April 1862, Ramsay's papers, E1:1.04.
60 Letter from Ramsay to his friends, Kumaon Iron Works, Nainital, 29 April 1862, Ramsay's papers, E1:1.04.
61 Letter from Ramsay to his friends, Kumaon Iron Works, Nainital, 29 April 1862, Ramsay's papers, E1:1.04.
63 Letter from Ramsay to his friends, Kumaon Iron Works, Nainital, 29 April 1862, Ramsay's papers, E1:1.04.
64 Letter from Ramsay to his friends, Kumaon Iron Works, Nainital, 29 April 1862, Ramsay's papers, E1:1.04.
65 Letter from Ramsay to his friends, Kumaon Iron Works, Nainital, 29 April 1862, Ramsay's papers, E1:1.04.
66 Letter from Ramsay to his friends, Kumaon Iron Works, Nainital, 29 April 1862, Ramsay's papers, E1:1.04.
67 Ramsay's report, p. 25.
68 Letter from Ramsay to his friends, Kumaon Iron Works, Nainital, 29 April 1862, Ramsay's papers, E1:1.04.
69 Letter from Ramsay to his friends, Kumaon Iron Works, Nainital, 29 April 1862, Ramsay's papers, E1:1.04.
70 Letter from Ramsay to his friends, Kumaon Iron Works, Nainital, 3 July 1862, Ramsay's papers, E1:1.04.
71 Letter from Ramsay to his friends, Kumaon Iron Works, Nainital, 3 July 1862, Ramsay's papers, E1:1.04.
72 Letter from Ramsay to his friends, Kumaon Iron Works, Nainital, 3 July 1862, Ramsay's papers, E1:1.04.
73 Letter from Ramsay to his friends, Kumaon Iron Works, Nainital, 3 July 1862, Ramsay's papers, E1:1.04.
74 Letter from Ramsay to his friends, Kumaon Iron Works, Nainital, 3 July 1862, Ramsay's papers, E1:1.04.
75 Letter from Ramsay to his friends, Kumaon Iron Works, Nainital, 3 July 1862, Ramsay's papers, E1:1.04.
76 Louise was Mitander's younger sister, who had recently fallen ill.
77 Quoted in Mitander's diary, 21 March 1862.
78 Mitander's diary, 22 March and 21 April 1863, and “From Major R. N. Keatinge, late Pol. Agt. in Nimar, to Lieut.
Coll A. Strachey, Secr. to the Govt of India, Public Works Dept, Fort William. Indore 29 March 1862” — reference in Mitander’s diary, 31 March 1862, in which the letter is quoted. The appointment was confirmed by the government a month later (Letter from Colonel Turner to PWD 26 April 1862, PWD Proceedings, May 1862, NAI).

The process was patented in England by Bessemer in 1856 and first successfully brought into production in Edskens, Sweden, in 1858 (Bertil Aronsson, A Tribute to the Memory of One of the Great Swedish Industrialists of the Nineteenth Century Göran Fredrik Göransson Given at the 1997 Annual Meeting of the Royal Swedish Academy of Engineering Sciences, (Stockholm 1997); Per Carlberg, “Bessemermetodens genombrott vid Edskens och Högbo” [The Breakthrough of the Bessemer Process at Edskens and Högbo], Med hammare och fackla, 22, (Stockholm, 1962), p. 9-135). In fact Ramsay’s Swedish colleague in India in the 1860s, Nils Mitander, had participated in these experiments (Carlberg, “Bessemermetodens genombrott”, p. 75). The experiments on the Bessemer method seem to have been well known among engineers in India from the start (“Bessemer’s American patent.” 1858, p. 18f). Very early trials with the Bessemer converter are also mentioned in connection with the South Indian ironworks in Beypore (R. H. Mahon, A Report upon the Manufacture of Iron and Steel in India, (Simla 1899), Appendix 2).

According to Ramsay the sons of Davies were capable, and they were all employed at the ironworks of Beerbhum. The old man contracted dysentery and died soon after his arrival at Calcutta. Ramsay’s report, p. 42-43.

Letter from Ramsay to his friends, Nainital, 2 October 1862, Ramsay’s papers, E1:1.04.

Letter from Ramsay to his friends, Nainital, 2 October 1862, Ramsay’s papers, E1:1.04.

Letter from Ramsay to his friends, Nainital, 2 October 1862, Ramsay’s papers, E1:1.04.

According to Ramsay the sons of Davies were capable, and they were all employed at the ironworks of Beerbhum. The old man contracted dysentery and died soon after his arrival at Calcutta. Ramsay’s report, p. 36–37.

Letter from Ramsay to his friends, Nainital, 2 October 1862, Ramsay’s papers, E1:1.04.

Letter from Ramsay to his friends, Nainital, 1 December 1862, Ramsay’s papers, E1:1.04.


Letter from Ramsay to his friends, Kumaon Iron Works Nainital, 1 December 1862 and Nainital East India, 31 January 1863, Ramsay’s papers, E1:1.04.

Ramsay’s report, p. 41.

Letter from Ramsay to his friends, Nainital East India, 31 January 1863, Ramsay’s papers, E1:1.04.

Letter from Ramsay to his friends, 15 February 1863, Ramsay’s papers, E1:1.04.

Letter from Ramsay to his friends, 15 February 1863, Ramsay’s papers, E1:1.04.

Ramsay’s report, p. 43–44.

Letter from Captain G. J. Mellis, to the Chief Engineer at the Presidency, Bombay, 12 December 1862, PWD Proceedings, January 1863, NAI.

Letter from Mitander to Ramsay, 6 January 1863, Ramsay’s papers, E1:1.07. Also in Mitander’s diary, 6 November 1862.

The Chief Commissioner seems to have misunderstood the
date of the blow as towards the end of January 1863. Compare Letter from Mitander to Ramsay, 6 January 1863, for the correct dating. Ramsay’s papers, E1:1-27.

122 Temple (1864, July).

123 Mitander’s father died on 23 October 1862 and on 20 November Mitander entered the last note in his diary. These two events were not related, however, since Mitander did not yet know of his father’s fate. This is apparent from a letter he wrote home to Sweden, 6 December 1862 (Kinship Centre, in Karlstad).


125 Letter from Lieutenant Col R Strachey in reply to Executive Engineer in Mhow, 17 November 1862, PWD Proceedings, November 1862, NAI.


127 The minutes, letters and notification are collected in “Burwai Iron Works, Central India”, Public Works Proceedings, August 1863, P/192/76, OIOC. They are also to be found in “Burwai Iron Works”, Collection to Public Works Despatches to India (1864), L/PWD/5/156, OIOC, p. 20–24.

128 A full account of this important discussion will be given in Chapter 11.

129 PWD Proceedings, Index, September 1863, NAI.

130 Full information on the decisions was published in the PWD Proceedings, Index, September 1863, NAI.


133 Letter from Mitander to Ramsay, 6 January 1863, Ramsay’s papers, E1:1-27.

134 Letter from Her Majesty’s Secretary of State for India to the Government of India, 31 March 1864, PWD Proceedings, May 1864, NAI.

135 Letter from Her Majesty’s Secretary of State for India to the Government of India, 31 March 1864, PWD Proceedings, May 1864, NAI.


139 PWD Proceedings (B), March 1863, NAI. PWD Proceedings (B), June 1864, NAI. The reports themselves have not been found, only summary references in the indexes.

140 Ramsay’s report, p. 42 and 44.


142 Letter from Ramsay to his friends, Kumaon Iron Works, 15 March 1863, Ramsay’s papers, E1:1-24. The statement he refers to is probably his “Estimate of cost of manufacture of pig and wrought iron at the Kumaon ironworks, the works once completed”, Ramsay’s papers, E1:1-18.


145 Letter from Ramsay to Dr. Pearson, Dechauri, 4 April 1863, Ramsay’s papers, E1:1-24. The decision is also commented on in a letter from Ramsay to his friends, Nainital, 18 April 1863, Ramsay’s papers, E1:1-24.


147 Ramsay’s report, p. 45–46.


149 Letter from Ramsay to Dr. Pearson, Dechauri, 4 April 1863, Ramsay’s papers, E1:1-24. The statement he refers to is probably his “Estimate of cost of manufacture of pig and wrought iron at the Kumaon ironworks, the works once completed”, Ramsay’s papers, E1:1-18.

150 Letter from Ramsay to his friends, Nainital, 14 July 1863).


152 Letter from Ramsay to his friends, Nainital, 14 June 1863, Ramsay’s papers, E1:1-24 and Ramsay’s report, p. 45–46. Wittenström and Jones left Calcutta on 23 June but the ship was hit by a severe storm, the propeller shaft broke and it was a week before a new vessel was ready (Letter from Ramsay to his friends, Nainital, 14 July 1863).


155 PWD Proceedings (B), March 1863, NAI. PWD Proceedings (B), June 1864, NAI. The reports themselves have not been found, only summary references in the indexes.

156 Temple, R. (1864, July).

157 Memorandum by Lieutenant Col C. H. Dickens, File no 1215, Holkar’s exchange 1867–76, Transfer of Burwai Iron Works to Maharaja Holkar and Payments Thereof, NAI. Also in PWD Proceedings, September 1864, NAI.


160 PWD Proceedings (B), March 1863, NAI. PWD Proceedings (B), June 1864, NAI. The reports themselves have not been found, only summary references in the indexes.

161 PWD Proceedings (B), March 1863, NAI. PWD Proceedings (B), June 1864, NAI. The reports themselves have not been found, only summary references in the indexes.
Notes p. 165–167

Thereof, NAI. Also in PWD Proceedings, September 1864, NAI.

Letter from Lieutenant. Col C. H. Dickens, Secretary to the Government of India, PWD, 6 April 1865, PWD Proceedings, May 1865, NAI and letter from Government of India to Her Majesty’s Secretary of State for India, 8 April 1865, PWD Proceedings, May 1865, NAI.

Letter from Captain P. Osborn, agent of the GIP Railway Company, 13 September 1865, to Consulting Engineer for Railways, Bombay, PWD Proceedings, November 1865, NAI and Letter from Lieutenant-Col. C. H. Dickens, Secretary to Government of India, PWD, to acting Secretary to Government of Bombay, PWD, Railway Branch, 18 October 1865, PWD Proceedings, November 1865, NAI. The question of the option was dealt with in From the Government of India to Her Majesty’s Secretary of State of India, 9 December 1865, PWD Proceedings, December 1865, NAI.

Letter from W. Maxwell, Secretary to Chief Commander Central Provinces, in the PWD to Secretary to Government of India, PWD 11 October 1865, PWD Proceedings, November 1865, NAI and Letter from C. H. Dickens Secretary to Government of India, PWD to Chief Commander Central Provinces 28 October 1865, PWD Proceedings, November 1865, NAI.

See especially Office of Agent Governor General for Central India, file no 1215, Holkar’s exchange 1867–76, Transfer of Burwai Ironworks to Maharaja Holkar and Payments Thereof; and file no 1213, Holkar’s exchange 1865–67, Transfer of Burwai Ironworks to Maharaja Holkar and Payments Thereof. Also, PWD Proceedings (B), August 1867, NAI.

From Lieutenant Col R. J. Meade, Agent to the Governor General for Central India, to Secretary Government of India, PWD, 9 November 1866, in PWD Proceedings January 1867, NAI. From Lieutenant Colonel C. H. Dickens, Secretary to Government of India, PWD to Agent to the Governor General for Central India, 9 December 1866, in PWD Proceedings January 1867, NAI.

Letter from the Superintendent of Police, Nimar, 30 October 1865, Office of Agent Governor General for Central India, file no 1213, Holkar’s exchange 1867–76, Transfer of Burwai Ironworks to Maharaja Holkar and Payments Thereof.

Letter from Agent, Governor General for Central India to Chief Commissioner, Central Provinces 21 December 1867, in Office of Agent Governor General for Central India, file no 1213, Holkar’s exchange 1865–67, Transfer of Burwai Ironworks to Maharaja Holkar and Payments Thereof.

Letter from Ass. Secretary to the Government of India, PWD to Foreign Department, 7 December 1875, Proceedings of the Government of India in the Foreign Department, January 1871, NAI.

Letter from R. Ragoona Rao to D. W. K. Barr 22 June 1876, in Office of Agent Governor General for Central India, file no 1215, Holkar’s exchange 1867–76, Transfer of Burwai Ironworks to Maharaja Holkar and Payments Thereof. In 1876 an engineer was ordered to investigate the fate of the buildings and machinery of the works (Letter from the Officiating Apte. Secretary to the Government of India to the Agent to the General for Central India, 6 June 1876, in Office of Agent Governor General for Central India, file no 1215, Holkar’s exchange 1867–76, Transfer of Burwai Ironworks to Maharaja Holkar and Payments Thereof.)


An extensive collection of papers on this question is found in Public Works home correspondence collection 21 Home Correspondence 1871–1879, L/PWD/2/29, OIOC, relating to the claims of Kumaon Iron Company, 1866–1871. The question is also described in the summary by H. Ramsay, Commissioner of Kumaon, of the position and history of the Kumaon Iron Works Company, letter 525 of 1872, to the Secretary to the Government, NWP, India Public Works, Collections to Despatches (1872), L/PWD/3/384, OIOC. It is also described in “Memorandum by the Secretary in the PWD”, signed W. T. T., India Office 12 October 1866, and the same, signed India Office 28 November 1866, both Home Correspondence 1871–1879, L/PWD/2/10, OIOC.

Letter from Drummond to the Under Secretary of State for India, 21 November 1866, and reply approved in coun-
Notes p. 167–182

1 According to personal information from Jayashree Bhatnagar after a field visit in May 2000.

2 Three years later this story was confirmed when Jayashree Bhatnagar returned for a field visit.

3 According to Jayashree Bhatnagar the story says that the chimney, known to the locals as a “well”, was at first filled with lime, coal and wood. The accuracy of this observation is remarkable, since there is no mention of iron ore. The first step in the kindling of a new blast furnace is to heat it up. This is done with a pure charge of fusible products as wood and coal. How lime comes in at this particular stage is not clear, but it should be noted that the story is correct in its reference to the general use of lime in the ironmaking process, not used in the local, traditional making of iron.


5 In Captain J. G. Melliss, letter 533, Mhow 11 May 1863 to PWD, Government of India, in Collections to the Public Works Despatches to India, (1864), L/PWD/3/346, OIOC.

6 According to the principal of the school, S. R. Chaurey, who could only give a hazy description of the earlier history.

7 According to personal information from Jayashree Bhatnagar after a field visit in May 2000.


9 According to personal information from Jayashree Bhatnagar after a field visit in May 2000.


11 Report 3 from Mitander till Melliss 22 October 1862, PWD Proceedings, November 1862, NAI.

12 Mitander’s diary, 8 June 1861. Report 3 from Mitander to Melliss 22 October 1862, PWD Proceedings, November 1862, NAI.

13 Office of Agent Governor General for Central India, File no 1215, Holkar exchange 1867–76, Transfer of Burwai Iron Works to Maharaja Holkar and Payments Thereof, NAI. Also in PWD Proceedings, September 1864, NAI.

14 Report 3 from Mitander to Melliss 22 October 1862, PWD Proceedings, November 1862, NAI. The report covers the period January to March 1862. Brickmaking is still a small industry in Barwah. Some 300 metres south-west of the works, on the edge of the town there were in 2003 several big stacks of bricks awaiting firing.

15 Mitander’s diary, 15 April 1861.

16 Mitander’s diary, 17 November 1862.

17 Summary of report by Mr. Mitander, on the progress made in the experimental iron works at Burwai, from their commencement to the end of September 1861, in Note by Lieutenant Colonel R. Strachey, Secretary to Government of India, PWD, on the subject of experimental iron works lately established at Burwai, in Nimar, 12 April 1862, PWD Proceedings, April 1862, NAI. Mitander’s diary, 12, 14 and 15 August 1861.

18 Mitander’s diary, 28 January 1862. Report 3 from Mitander

CHAPTER 6
INDUSTRIAL LANDSCAPES
AND SYSTEMS OF PRODUCTION


2 The following description is primarily based on fieldwork done in December 1997 and April 2003. The site of the works was inspected with the aid of local informants. In the first instance buildings and the overall layout of the plant were measured with a folding rule and a homemade plumpline, at the second visit using a simple infrared measurer. In addition photographs were later used to complement measurements taken on site by analogy and extrapolating measured details.
20 Report 3 from Mitander to Melliss, 22 October 1862, PWD Proceedings, November 1862, NAI. The report covers the period January to March 1862.
21 Report 3 from Mitander to Melliss, 22 October 1862, PWD Proceedings, November 1862, NAI. The report covers the period January to March 1862.
22 Letter from H Marten, Controller and Examiner PWD Accounts, North West Provinces to Secretary to Government of India, PWD, 30 April 1864, PWD Proceedings, May 1864, NAI.
23 Mitander’s diary, 22 January and 14 March 1861.
24 Office of Agent Governor General for Central India, File no 1215, Holkar exchange 1867–76, Transfer of Burwai Iron Works to Maharaja Holkar and Payments Thereof, NAI. Also in PWD Proceedings, September 1864, NAI.
26 Mitander’s diary, 29 January and 18 February 1862.
27 Report 3 from Mitander to Melliss, 22 October 1862, PWD Proceedings, November 1862, NAI.
28 Letter from H Marten, Controller and Examiner PWD Accounts, North West Provinces to Secretary to Government of India, PWD, 30 April 1864, PWD Proceedings, May 1864, NAI.
29 According to e-mail from John Fidler, Director Conservation, English Heritage, 31 July 2003 who from a structural engineering viewpoint had never seen configurations of iron tie bars like the one in Barwah in the United Kingdom.
31 Office of Agent Governor General for Central India, File no 1215, Holkar exchange 1867–76, Transfer of Burwai Iron Works to Maharaja Holkar and Payments Thereof, NAI. Also in PWD Proceedings, September 1864, NAI.
32 Mitander’s diary, 4 May 1861.
33 Summary of report from Nils Mitander from the beginning till the end of September 1861, in note by Lieutenant Colonel R. Stachey to Government of India, Public Works Department, on the subject of experimental ironworks lately established at Burwai, in Nimar (12 April 1862), Consultations 25 April 1862, PWD Proceedings April 1862, NAI. The measurements do not agree with my own, which show a width of 9 metres. The difference could be explained if the above-mentioned measurement concerns the inner core of the building, not the veranda-like extensions, covered by a roof, along the sides.
34 Office of Agent Governor General for Central India, File no 1215, Holkar exchange 1867–76, Transfer of Burwai Iron Works to Maharaja Holkar and Payments Thereof, NAI. Also in PWD Proceedings, September 1864, NAI.
36 Mitander’s diary, 6 November 1862.
37 Mitander’s diary, 7 March 1862.
38 Mitander’s diary, 6 March 1862.
40 Mitander’s diary, 7 January 1862.
41 Calcutta Gazette, 19 August 1863, p. 2538–2539. The more detailed information on manufactures etc is given in Letter from First Assistant Agent for Central India in charge of the residency, D. W. K. Barr to the Secretary to the Government of India, Foreign Department, 8 July 1876, in Office of Agent of the Governor General for Central India, File no 1215, Holkar’s Exchange 1867–76, Transfer of Burwai Iron Works to Maharaja Holkar and Payments Thereof, NAI. Also in PWD Proceedings, September 1864, NAI.
42 Letter from Ramsay to his friends, Nainital and Dechauri, 3 January 1862, Ramsay’s papers, E1:1.24.
43 In 1845–46 Roorkee had become the headquarters of the Ganges canal workshops and iron foundry. Here the first embryo of the Thomason Engineering College was established in 1845 (“Roorkee Town”, in Imperial Gazetteer of India. 31, (Calcutta 1928), p. 315). Ramsay, who visited the workshops, gave a general description of Roorkee (Ramsay’s report, p. 25–26). Rurki is also used at other localities to designate a place where big machinery has been used.
44 Ramsay’s report, p. 42.
45 No plans of the layout of the works have been found. During the 1856–1857 session of the Institution of Civil Engineers in London, William Sowerby submitted a paper on iron ores of Kumaon (William Sowerby, “Some account of the recently-discovered deposits of iron ore at the foot of the Himalayas, in Kumaon, Northern India”, in Minutes of Proceedings of the Institutions of Civil Engineers, 16, (London 1857), p. 82–84). In this a reference is made to “views of the locality and of the work erected” that accompanied the paper. According to personal information of 16 October 2002, no such paper is saved in the archives of ICE.
46 The social structure at the works will be considered in detail in Chapter 10.
47 The length given as 1 mile, 25 chains or 2,310 yards (Oldham, 1866, May), “Report on the Present State and Prospects of the Government Ironworks at Dechoure in Kumaon”, Calcutta 1865, Home Correspondence 1871–1879, L/PWD/1/29, OIOC, p. 6). “Gool” is a transcript of a word in the local dialect meaning water channel. Also transcribed as gu or guli.
48 Scattered notes on the building of irrigation systems in the Bhabar, both Indian and initiated by the colonial regime,
49 Letter from Ramsay to his friends, Nainital and Dechauri, 3 January 1862, Ramsay’s papers, E1:1.04.
50 According to personal information from Pramod Kumar Tripathi and his nephew Naveen Chandra Palaty, Dechauri, March 2000.
51 Ramsay’s report, p. 29–30. Yet another figure is 11.7 metres (39 feet), given by H. Warth, “The Ironworks of Dechauri, in Kumaon”, in Indian Forester, 6, July 1880–April 1881, (Dehra Dun 1881), p. 214. Ramsay’s figure should be more reliable, since he was the metallurgist actually working with the furnace and fully acquainted with the mode of measuring heights of blast furnaces.
52 W. Ness, (1880 February), [Report from a visit to the Kumaon Iron Works and Mines, especially those from where the raw materials are obtained for the manufacture of pig iron at the blast furnace plant at Dechauri], in Public Works Departmental Papers 1880, 1218, Collections to despatches (1880), L/PWD/6/55, OIOC.
54 Oldham (1860, May), p. 2.
55 Ramsay’s report, p. 19.
56 Letter from Ramsay to his friends, Nainital and Dechauri, 3 January 1862, Ramsay’s papers, E1:1.04.
57 “400 feet”. Letter from Ramsay to his friends, 13 February 1862, Ramsay’s papers, E1:1.04.
58 Ramsay’s report, p. 18–19 and letter from Ramsay to his friends, 13 February 1862, Ramsay’s papers, E1:1.04.
60 In the evaluation of Dechauri their sizes are given as 11634 feet and 36134 feet respectively. Jones (1872, June).
61 The difference in height is estimated: Ramsay mentions a fall of 45 feet (16.5 metres), but it is uncertain to which points that measurement refers (Letter from Ramsay to his friends, 13 February 1862, Ramsay’s papers, E1:1.04).
62 Letter from Ramsay to his friends, 15 February 1862, Ramsay’s papers, E1:1.04. Similar descriptions are repeated in several other places, among them a letter from Ramsay to his friends, Nainital and Dechauri, 3 January 1862, Ramsay’s papers, E1:1.04.
63 Letter from Ramsay to his friends, 15 February 1862, Ramsay’s papers, E1:1.04.
65 Letter from Ramsay to his friends, Nainital, 15 November 1862 and 15 February 1863, Ramsay’s papers, E1:1.04. William Sowerby considered a similar set-up on the slope of one of the terraces. Two 10.8 metres blast furnaces would be placed with the tunnel head on the same level as the stores of calcined ore and charcoal (Sowerby, W. (1858, August), Report on the Government Works at Kumaon with Plans, Specifications and Estimates for Establishing Ironworks in Kumaon and Remarks on the Iron Deposits of the Himalayas, Selections from the Records of the Government of India, PWD Department, 26, Calcutta 1859, p. 70–71 and drawing “Kumaon iron works, General arrangement of furnaces, cast and blowing houses &c.”.
66 Ramsay’s report, p. 41.
67 Jones (1872, June).
68 Letter from Ramsay to his friends, 15 November 1862, Ramsay’s papers, E1:1.04. It is quite possible that aerial infrared photography would disclose much more information, especially on the location of these buildings where all remains above ground have been removed and which are today covered by growing crops.
69 Ramsay’s report, p. 40–41 and letter from Ramsay to his friends, 15 November 1862, Ramsay’s papers, E1:1.04 and Letter from Ramsay to his friends, 14 February 1863, Ramsay’s papers, E1:1.04.
70 Letter from Ramsay to his friends, Nainital, 15 November 1862, Ramsay’s papers, E1:1.04. The description of the equipment was repeated in a letter from Ramsay 15 February 1863, Ramsay’s papers, E1:1.04.
71 Jones (1872, June), p. 56.
72 Ramsay’s report, p. 40–41.
74 Letter from Ramsay to his friends, Nainital and Dechauri, 3 January 1862, Ramsay’s papers, E1:1.04.
75 Letter from Ramsay to his friends, February 15, 1863, Ramsay’s papers, E1:1.04.
76 Hardy Wells (1859, December), “Report upon the Kumaon Iron Fields in Connection with the Government Ironworks at Dechoure and Ramgurh”, Correspondence with India (1862), L/PWD/3/382, OIOC, p. 15.
77 Oldham (1860, May), p. 3.
THE MAKING OF IRON AND STEEL
PART 2


6. According to the location of production, charcoal-making was named either skogskölning (forest-charring) or plattkolning (site-charring) (Hilding Bergström & Gösta Wesslén, Om träkölning; till ä änt för underhållningen vid skogs- och kollareveköler samt tekniska underhållningssanstalter och för praktiskt bruk [On Charcoal-Burning. In the Service of Education at the Schools of Forestry and Charcoal-Burning, for Technical Education and Practical Use], (Stockholm 1915, 3 ed. Göteborg 1922), p. 12–13.)


9. Noted for example at Silverhytten during the blows in which Nils Mitander participated. In this case the angles and placing of the tuyeres were even considered in relation to the particular type of ore used (JKa, 12, 1857, p. 121–122.)


12. There are numerous compilations noting and describing the different shapes of the furnaces, see for example Percy, Metallurgy. Iron and Steel, p. 559–565, P. Tunner, Das Eisenhüttenwesen in Schweden: beleuchtet nach einer Bereisung der vorzüglichsten Eisenwerke dauernd im Jahre 1857, (Freiberg 1858) and Braune, “Om utvecklingen av den svenska masugnen”, for the 19th century especially p. 67–112.


15. John Percy named and described no less than thirteen different finery processes for making malleable iron, nearly all of the with names denoting a geographical domicile or origin (Percy, Metallurgy: Iron and Steel, p. 579–619).


18. A special variant of puddling with wood as fuel was developed in Sweden and in use 1845–1927. One such furnace is preserved in Surahammar of central Sweden (Marie Nisser (ed.), Surahammars brunksmuseet, (Surahammar 1971), p. 13–15).

For an investigation of the social structure or this refining method, see Barbro Bursell, Träskoadel: en etnologisk undersökning av lancashiresmedernas arbets- och levnadsförhållanden på Ramnäs bruk vid tiden kring sekelskiftet 1920 [The Clog Gentry: An Ethnological Study of Working- and Living-Conditions of the Lancashire Smiths at the Ironworks of Ramnäs around 1920] (Stockholm 1974).


23 The last Bessemer converter in Sweden, in Hagfors, was closed in 1969. One of the few remaining Bessemer converters in the world, probably the very last, was still in use in the metal works of Chusovoi, in the Urals, Russia, in the summer of 2003.


28 Gale, The British Iron & Steel Industry, p. 83–84

29 Sunström, “Om valsverket”, p. 132.


CHAPTER 7

TECHNOLOGY TRANSFERRED


2 Letter from Ramsay to his friends, Nainital and Dechauri, 3 January 1862, Ramsay’s papers, E1:1.04.


4 Mitander’s diary, 26 October and 30 November 1862, 24 February 1861, 8 January 1862.

5 The description is repeated in several places, among others in a letter from Ramsay to his friends, 15 February 1863, Ramsay’s papers, E1:1.04.


7 Mitander’s diary, 2 May 1862.

8 Mitander’s diary, 2 May 1862. Elev- och verkstadsrelationer 1859–1865 [Apprentice and Supervisor Relations, 1859–1865], Fie (1855, 1856, 1857 and 1860), Jernkontorets arkiv, The National Archives of Sweden. These extensive yearly accounts were also published as short summaries in JkA, for example, 1857, p. 125–129 and 1858 p. 371.

9 The height is given as 18 to 20 aln, that is 10.7 to 11.9 metres, but this concerns two different blast furnaces, (JkA, 8 (1), (Stockholm 1861), p. 88).

10 In search of more detailed material on Silverhyttan I have examined the archives of Jernkontoret, Stockholm; the county archive in Karlstad (Värmlandsarkiv), especially the Alkvettern archives, to which Silverhyttan belonged; the county museum archives in Örebro and Karlstad (Örebro läns museums arkiv and Värmlands läns museums arkiv); the historical association archives of Karlsga (Karlsga hembygdsföreningens arkiv) and the picture archives of the municipal museum of Kristinehamn (Kristinehamns museum, bildarkivet); and in addition made numerous on-site inquiries, at Silverhyttan and Alkvettern. At the National Museum of Science and Technology (Tekniska museet), Stockholm, Sweden there are single drawings of the saw-mill and the canal at Silverhyttan, but none that shows the ironworks.


13 While in India Mitander noted that he copied his drawings of the charcoal ovens and the blast furnace and sent the copies to Andreas Grill. The whereabouts of these copies are not known, however. Mitander’s diary, 18 and 19 May 1862. The personal archives of Andreas Grill seem to have disappeared. His descendants have nothing but odd items of material to show and the archives of Grill and Godegård at Nordiska Museet and Landsarkivet in Västena do not cover this period or contain only material on...
accounts and affairs of the Godegård and Mariedam estates in Sweden.

14 Karl Erik Bergsten, Östergötlands bergslag. En geografisk studie [The Ironmaking District of the County of Östergotland, a Geographical Study], (Lund 1946), p. 214–215. According to Percy the blast furnace was erected in 1857, which probably is a misconception on the part of John Percy.

15 “Graversfors’ hyttor rivas” [The blast furnaces of Graversfors are to be torn down”, in Östergötland Dagblad, 16 October 1916.


20 Mitander’s diary, 22 January and 23 June 1861.


23 Letter from Keatinge to PWD, 5 December 1861, PWD Proceedings, January 1862, NAI, and Mitander’s diary, 6 January 1862 and 28 January 1862.

24 Extract from a report by the executive engineer, Mhow division, 11 May 1863, Government of India, PWD Proceedings, August 1863, P/192/76, OIOC. Also in report from Captain J. G. Melliss, Ex. Engr., Mhow Division, to Secy. to Govt of India, PWD with Governor General, 11 May 1863, Enclosure to Despatch number 3 of 1864 from the Government of India, PWD, 11 January 1864, in Collections to Despatch 13, 31 March 1864, Collections to the PWD Despatches to India (1864), L/PWD/3/146, OIOC.

25 Mitander’s diary, 27 February 1862.

26 Mitander’s diary, 8 March 1862. In Swedish he used the word “saxad”.

27 Report 3 from Mitander to Melliss 22 October 1862, PWD Proceedings, Industrial, November 1862, NAI. The report covers the period January to March 1862.

28 Svedlin, Dalbruks järnverk, p. 227.

29 Summary of report from Nils Mitander from the beginning until the end of September 1861, in note by Lieutenant Colonel R. Strachey to Government of India, Public Works Department, on the subject of experimental iron-works lately established at Burwai, in Nimar (12 April 1862), Consultations, 25 April 1862, PWD Proceedings, April 1862, NAI. These measurements seem to correspond with observations at the site, although no close study was possible since the lime and calcining kiln is on CISF land.


31 Mitander’s diary, 23 May 1862.

32 Captain J. G. Melliss, letter 533, Mhow 11 May 1863 to PWD, Government of India, in Collections to the Public Works Despatches to India (1864), L/PWD/3/146, OIOC.

33 Progress report January–March 1862, from N. Mitander, Superintendent Ironworks in Nimar, to Executive Engineer, Mhow Division (Melliss), 22 October 1862, PWD Proceedings, November 1862, NAI.

34 E. Westman, “Utdrag af de berättelser, som Herrar Tjensteman på Jernkontorets stat till Herrar Fullmäktige i Jernkontoret afgivit för år 1861. 7:o Berättelser af Herrar Externti-ner, Mhow Division (Melliss), 22 October 1862, PWD Proceedings, November 1862, NAI.


It may be noted than neither Braune nor Attman discusses the use of steam power in their descriptions of the history of Swedish iron.


Lindqvist, "Technology on Trial.


Letter from Ramsay to his friends, Nainital 1 March 1862, Ramsay’s papers, E1:1.24. Svedlin, Dalbruksjärnverk, p. 244.

Wittenström is also mentioned in Marianne Lukala, Anneli Svedlin, Register öfver Jern-Kontorets Annaler, årgångarna 1817–1864 and to Tidskrift för Svenska Bergshandteringen årgångarna 1843–1845 [An index of the National Museum of Technology in Stockholm (Puddling furnace for pit coal, Dalshbru, Finland 1862; puddling furnace for pit coal, Motala verkstad 1866 and puddling furnace for Surhammar 1866, all 8,777 M)].


The Engineer’s Journal and Railway, Public Works and Mining Gazette of India and the Colonies, reported on the development in several issues as early as in January 1858 (“Bessemer’s American Patent and the Indian Patent Laws”, 1 January 1858, p. 17–18) and later on 17 September 1859 (“Bessemer Outdone”, p. 324).

Sowerby (1858, August), p. 8–9. It is worth noting that it was not until 1858 that the first charges of Bessemer steel were blown at Edsken blast furnace in Sweden.

Letter from Major R. H. Keatinge, Bombay Artillery, Political Agent and Supt of Nimar, to Under Secretary of State for India, 21 June 1862, PWD Proceedings 14 September 1862, P/192/48, OIOC.

Andreas Grill was one of the few Swedes who had first-hand knowledge of Bessemer blows and Mitander was sent to Edsken as his assistant. On Mitander, see Per Carlberg, “Bessemermetoden genombrott vid Edsken och Högbö” [The Breakthrough of the Bessemer Process at Edsken and Högbö], Med hammare och järkla, 22, (Stockholm, 1962), p. 71–79. The yearly accounts of Ramsay’s work are published in JkA and have been checked for the years 1857–1865 (vol. 13–16).

Attman, Svenska järn och stål 1822-1914, p. 46. Letters from Wittenström to Ramsay, Abo and Dalbrik 12 May 1862, Stockholm 14 June 1862 and London 2 September 1862. In the latter letter he mentions “Bessemer works in Dalarna”. (Ramsay’s archives, E1:1.08). Possibly he meant the works at Längshyttan. These works presented Bessemer steel at the exhibition in London, as did Edsken, although Bessemer-blowing in Längshyttan was still in an initial phase, started in 1861 (Attman, Fagerstahakens historia, p.279.)

Ramsay’s report, p. 41.

Drummond’s letter is based on a correspondence with Wittenström, then at the Motala Ironworks. Major General Drummond in a letter to the Under-Secretary, Staplehurst.
22 November 1866, Home Correspondence 1871–1879, L/PWD/2/29, OIOC. Extensively used in “Memorandum by the Secretary in the PWD”, signed W. T. T., India Office, 28 November 1866, Home Correspondence 1871–1879, L/PWD/2/29, OIOC.


89 This interpretation is based on an extensive e-mail discussion with Kurt Gedin, Oxelösund and Otto Stjernquist, Långshyttan.

90 Letter from Keatinge 23 June 1861 to PWD, PWD Proceedings, August 1861, NAI. Mitander’s diary, 1 April 1861.

91 Mitander’s diary, 5 March 1862.

92 Office of Agent to the Governor General for Central India, File no 2115, Holkar Exchange 1867–76, Transfer of Burwai Ironworks to Maharaja Holkar and Payments Thereof.

93 Mitander’s diary, 1 April 1861.

94 On Wittenström’s work at Domnarvet, see Carl Sahlin, Office of Agent to the Governor General for Central India, File no 2115, Holkar Exchange 1867–76, Transfer of Burwai Ironworks to Maharaja Holkar and Payments Thereof.

95 Names of suppliers given in the sources have been spelt and interpreted and/or corrected according to information received from the library of the Institution of Civil Engineers in London in August 2003.

96 The assessments of the works made in 1861 and 1872 give a detailed picture of all equipment, from the numbers of nuts and bolts. For the works at Dechauri alone some 600 different kinds of items are listed on 22 pages for 1861 and 900 items on 12 pages for 1872. A thorough analysis of this material could supply further information but this work has been beyond the scope of the present study. W. R. S. Jones (1872, June), “Report on the Valuation, and State of the Kumaon Iron Works”, India Public Works, Collections to Despatches (1872), L/PWD/1/384, p. 51–64, plus valuation forms (circa 150 pp.).


98 Mitander’s diary, 7 March 1862.

99 Mitander’s diary, 18 May and 12 July 1862.


101 Jones (1872, June).

102 Office of Agent Governor General for Central India, File no 2115, Holkar Exchange 1867–76, Transfer of Burwai Iron Works to Maharaja Holkar and Payments Thereof, NAI. Also in PWD Proceedings, September 1864, NAI. Letter from Keatinge 23 June 1861 to PWD, PWD Proceedings, Industrial, August 1861, NAI.

103 “Naysmyth, James” Britannica online, www.eb.com:180/cgi-bin/g DocF=micro/416/35.html>, February 12, 1998. In a following part there is a discussion on the production of equipment to the iron and steel industry and how well it was known in this area.

104 Temple, R. (1864, July).

105 This was no exception. As will be discussed later, the deliveries of rails, locomotives etc. to the Indian railways were totally dependent on Britain all through the period of the British Raj.

106 Mitander’s diary, 7 January 1862.

107 Mitander’s diary, 7 January 1862, and Letter from H. Martin, Controller and Examiner, PWD Accounts, North West Provinces to Secretary to Government of India, PWD, 20 April 1864, PWD Proceedings, May 1865, NAI.

108 Mitander’s diary, 24 August 1862.

CHAPTER 8

TECHNOLOGY TESTED


2 Sowerby (1856, April), p. 99.


4 Sowerby (1856, April), p. 90.

5 Reports... (1856), p. 88.

6 Hardy Wells (1859, December), “Report upon the Kumaon Iron Fields in Connection with the Government Ironworks at Dechouree and Ramgurh”, Correspondence with India (1859), L/PWD/3/328, OIOC, p. 11.

7 Wells (1859, December), p. 11.

8 Ramsay’s report, p. 9.
Various sources of learning can be identified, among them:

- Letter from Ramsay to his friends, Kumaon Ironworks February 15, 1863, Ramsay’s papers, E1:1.04.
- Ramsay’s report, p. 31.
- Ramsay’s report, p. 31.
- Letter from Ramsay to his friends, Nainital and Dechauri, January 3, 1862, Ramsay’s papers, E1:1.04.
- Letter from Ramsay to his friends, Kumaon Ironworks February 15, 1863, Ramsay’s papers, E1:1.04.
- Becket’s description of the process at the furnace is first-hand documentation based on his own observations.
- Various sources of learning can be identified, among them “learning by doing”, also relevant for the “minor improvements that determine the rate of productivity growth that determine the rate of productivity growth that major innovations are capable of generating” (Nathan Rosenberg, *Inside the Black Box: Technology and Economics*, Cambridge 1982, p. 120). The Swedish economist Erik Lundberg described the annual increase in man-hour production at the steel works of Horndal, in spite of a lack of investments. This study gave rise to the now internationally accepted term the “Horndal effect” (Erik Lundberg, *Produktivitet och räntabilitet: studier i kapitalets betydelse inom svenskt näringsliv [Productivity and Profitability: Studies of the Importance of Capital in Swedish Industry]*, Stockholm 1961).
- The comparisons are based on figures in Nisser, *Anteckningar i jernets metallurgi, Table III (the blast furnace in Finspång)*, and in Braune, “Om utvecklingen av den svenska masugnen”, Table III (the blast furnaces in Vestanfors, Wellnora and Långshyttan).
- “Papers regarding the closure of Dechauri ironworks”, Collections to despatches (1880), L/PWD/6/55, OIOC.
- Letter from Ramsay to his friends, February 15, 1863, Ramsay’s papers, E1:1.04.

### CHAPTER 9

#### NATURAL RESOURCES: INVENTORY AND UTILIZATION

2 Letter from Ramsay to his friends, Nainital and Dechauri, January 3, 1862, Ramsay’s papers, E1:1.04.
3 Ramsay’s report, p. 31.
4 Ramsay’s report, p. 31.
10 Ramsay’s letters to his friends, Kumaon Ironworks, Nainital, May 32, 1862, Ramsay’s papers, E1:1.04. The map is found in Ramsay’s papers, F1:1.24.
13 Jim Corbett, *My India*, (1952, Delhi 1997), p. 5–6. Although this passage has remained mostly unnoticed, or at least uncommented, it is probably the most widely spread mention of the British ironworks of Kumaon. As such it is an
interesting symptom of a deeply entrenched eurocentric view of Indian history. Even Corbett, who was an affectionate friend of the Kumaoni people, totally omitted all mention of Indian iron making.


The ores were described by Mitander in the Calcutta Government Gazette, 23 April 1865, and in a report by Thomas Oldham, quoted in Government of India, PWD Proceedings August 1863, P/190/97, OIOC.

Mitander’s diary, 2–4 December, 1860.

Summary of a report from Mitander for the period from January-March and October-December (Progress report from the Burwai ironworks, PWD Proceedings, November 1862, NAI and India Public Works, Collections to the Public Works Despatches to India 1864, L/PWD/3/146).
CHAPTER 10
SOCIAL SYSTEMS OF PRODUCTION AND TRANSFER OF KNOWLEDGE

From Major R. H. Keatinge, Bombay Artillery, Political Agent and Supt. of Nimar, to Under Secretary of State for India, 21 June 1860, PWD Proceedings, P/190/58, OIOC.

Letter from Ramsay to his friends, Kumaon Ironworks, Nainital 12 June 1862, Ramsay’s papers, E1:1.04.

Letter from Ramsay to his friends, Kumaon Ironworks, Nainital 29 and 30 March 1862. Ramsay’s papers, E1:1.04.

Letter from Ramsay to his friends, Nainital and Dechauri, February 13, 1862. Ramsay’s papers, E1:1.04.

Letter from Ramsay to his friends, Kumaon Ironworks, Nainital, 12 June 1862, Ramsay’s papers, E1:1.04.

Letter from Ramsay to his friends, Nainital and Dechauri, 20 February 1862.

Letter from Ramsay to his friends, Nainital and Dechauri, 19 and 20 March 1862.

Letter from Ramsay to his friends, Nainital and Dechauri, 31 March 1862.

Letter from Ramsay to his friends, Nainital and Dechauri, 31 March 1862.

Letter from Ramsay to his friends, Nainital and Dechauri, 32 June 1862.

Letter from Ramsay to his friends, Nainital and Dechauri, 22 March 1862.

Letter from Ramsay to his friends, Kumaon Ironworks, Nainital, 6 May 1862. Mitander’s note on “God Save the Queen” is a reminder of a cultural contact between Sweden and England. During the nineteenth century the term folksång (folk song) was used to denote the equivalent to a national anthem. A. N. Edelkrantz made a direct translation of “God Save the King” and it was played for the first time in 1805 as “Bever Gud vår kung” and it was used at least till 1862 as a folksång of Sweden. Hans Åstrand (ed.), Sohlmans musiklexikon, (1948–52, 2nd ed. Stockholm 1975–79), 1 (“Bever Gud vår kung”) and 3 (“God Save the King/Queen”).

While still en route from London to India, Ramsay related in a letter home that he almost fell from a ladder when he saw “two beautiful, white women’s legs” above him. Letter from Ramsay to his friends, London 15 October 1861. Ramsay’s papers, E1:1.04.

Letter from Ramsay to his friends, Nainital and Dechauri, February 13, 1862. Ramsay’s papers, E1:1.04.

Letter from Ramsay to his friends, Nainital and Dechauri, February 13, 1862. Ramsay’s papers, E1:1.04. These crinolines show another link between Europe and India. The wire used to make the crinolines was a very important product of some iron and steel works in Europe, among them the works at Sandviken (Artur Attnam, Svenskt järn och stål 1822–1914 [Swedish Iron and Steel 1800–1914] (Stockholm 1986), p. 19.)

Letter from Ramsay to his friends, Nainital, 3 July 1862. Ramsay’s papers, E1:1.04.

Letter from Ramsay to his friends, Kumaon Ironworks, Nainital, 29 and 30 March 1862. Ramsay’s papers, E1:1.04.

Mitander’s diary, 22 March 1862.


John Falconer, “Photography in Nineteenth-Century In-
50 Letter from Thomas Oldham to Secy. to Govt. of India, PWD, 23 July 1862, PWD Proceedings, November 1862, NAI.
51 See especially Oldham (1862, May) for a comprehensive summary of different points: inappropriate clay for firebricks (p. 3), lack of housing for Indian workers (p. 3), self-indulgent changes of original planning without consulting the PWD (p. 3), inappropriate placing of blast furnaces and other buildings (pp. 4, 6), extravagant and unnecessary investments (p. 7), faulty calculations of blast (p. 15) etc. etc.
54 Letter from Colonel A. Cunningham, chief engineer and secretary to Government of the NWP, PWD, no 1711 A, 11 October 1862, Correspondence with India (1862), L/PWD/328, OIOC.
55 Bernard deVilleroi, (1879, February), “Iron Manufacture in Kumaon. Why does it not succeed?”, attached to letter from C. P. Beauchamp, Under Secretary to Government NWP and Oudh, PWD to the Secretary to the Government of India, PWD, no 215A, 5 February 1879, in enclosures to Despatch 55, Public Works Department, Departmental Papers (1882), L/PWD/6/43, OIOC.
56 The lack of competence dated further back in the history of the ironworks (see for example Oldham 1862, May), but in this case see Ramsay’s report, p. 15.
57 Letter from Ramsay to his friends, Kumaon Ironworks, Nainital, 4 and 29 April 1862, respectively. Ramsay’s papers, E1:1.04.
58 The inherent elements of a technology have been used by Edquist and Edqvist in naming a series of different characteristics, from the complexity of the technology to its scale of production and geographical extent (Charles Edquist & Olle Edqvist, Sociala bärare av teknik; brygga mellan teknisk förändring och utvecklingsmiljö [Social Carriers of Techniques for Development], Lund 1985), p. 15-18). In The New Industrial State John K. Galbraith distinguished six “imperatives of technology”, focusing on the late 1960s and on changes over time during the development of industrialism. He noted an increasing time span from the beginning to the completion of an industrial undertaking, an increase in the capital, that the commitment of time and money tended to be more focused on and destined for a certain specialised task, that flexibility decreased, a more specialised manpower, an increased need for organisation and planning. (John K. Galbraith, “The imperatives of technology”, in The New Industrial State (1967, rev. ed. London 1972). In his works on technology transfer and his comparative studies of economic development in India, Australia and Japan, Ian Inkster has slightly reworded Galbraith’s concept (Ian Inkster, “Prometheus Bound: Technology and Industrialization in China and Japan Prior to 1914 – A Political Economy Approach”, in Annals of Science, 45 (Basingstoke 1988), p. 399-426).
60 Letter from Julius Ramsay to Nils Mitander, Mitander’s diary, 24 June 1862.
63 Oldham (1862, May), p. 44 (appendix 2). The term used for water carrier here is bittler. In a letter from Julius Ramsay he mentions a bittler as a water carrier (Letter from Ramsay to his friends, Kumaon Ironworks, Nainital, 14 January 1862, Ramsay’s papers, E1:1.04).
64 Letter from Ramsay to his friends, Nainital and Dechauri, 14 January 1862, Ramsay’s papers, E1:1.04.
65 Letter from Julius Ramsay to Nils Mitander, Mitander’s diary, 24 June 1862.
66 Letter from Ramsay to his friends, Kumaon Ironworks, Nainital, 1 December 1862, Ramsay’s papers, E1:1.04.
67 Mitander’s diary, 10-12 May, 19 June 1862.
68 Letter from Keatinge 23 June 1861 to PWD, PWD Proceedings, August 1861, NAI and Mitander’s diary, 9 September 1862.
69 Letters from Ramsay to his friends, Nainital, 15 November and Kumaon Ironworks, Nainital, 1 December 1862, Ramsay’s papers, E1:1.04. The supply of charcoal is briefly referred to in Ramsay’s report, p. 22. Letter from Ramsay to his friends, Nainital, 2 October 1862.
70 Letter from Ramsay to his friends, Nainital, 15 November 1862, Ramsay’s papers, E1:1.04.
71 “Estimate of Cost of Manufacture of Pig and Wrought Iron at the Kumaon Ironworks, the Works Once Completed”, Dechauri 13 March 1861, Ramsay’s papers, F1:1.18.
72 Ramsay does not specify the exact number of native ac-
countants and others in the “native establishment”. At the works the lowest paid European (smelter in reserve) earned approximately six times as much as the best paid Indian (smelter). Calculating on the same kind of span, there were approximately 20 “natives” in the establishment. “Estimate of Cost of Manufacture of Pig and Wrought Iron at the Kumaon Ironworks, the Works Once Completed”, Dechauri 13 March 1863, Ramsay’s papers, F1:1.18.

71 “Estimate of Cost of Manufacture of Pig and Wrought Iron at the Kumaon Ironworks, the Works Once Completed”, Dechauri 13 March 1863, Ramsay’s papers, F1:1.18.


73 The actual cost of procuring European employees was increased by the cost for travel to and from India, which meant approximately 620 rupees a year in passage money. They were contracted on a four-year basis.

74 Mitander’s diary, 7 March 1862.

75 Supplement to the Gazette of India, 17 February 1864, p. 61.

76 Letter from Ramsay to his friends, 13 February 1862, Ramsay’s papers, E1:1.04.

77 Letter from Ramsay to his friends, 13 February 1862, Ramsay’s papers, E1:1.04.

78 Letter from Ramsay to his friends, 13 February 1862, Ramsay’s papers, E1:1.04.

79 Compare Jan Breman, writing on research on Indian industrialisation and labour, who says “The key question was therefore how, as economic development progresses, the obstacles that hamper the quantity and quality of labour could be overcome “The Study of Industrial Labour in Post-Colonial India – The Formal Sector: An Introductory Review”, in P. Parry, Jan Breman & Karin Kapadia (eds.), The Worlds of Indian Industrial Labour, Contributions to Indian Sociology, Occasional Studies 9, (New Delhi 1999), p. 5.


81 Compare Jan Breman, writing on research on Indian industrialisation and labour, who says “The key question was therefore how, as economic development progresses, the obstacles that hamper the quantity and quality of labour could be overcome “The Study of Industrial Labour in Post-Colonial India – The Formal Sector: An Introductory Review”, in P. Parry, Jan Breman & Karin Kapadia (eds.), The Worlds of Indian Industrial Labour, Contributions to Indian Sociology, Occasional Studies 9, (New Delhi 1999), p. 5.


83 Drummond (1855, August), p. 29-32.

84 Mitander’s diary, 7 March and 17 April 1862.

85 Mitander’s diary, 13 August 1862.

86 Mitander’s diary, 28 August 1862.

87 For Mitander: Letter from Mitander, 28 January 1862 to Executive Engineer, Mhow Division, enclosure to letter 3, 11 January 1864, from the PWD, Calcutta to the Secretary of State of India, Collections to the Public Works Despatches to India (1864), L/PWD/3/346, OIOC; Melliss, Letters from Captain J. G. Melliss, to PWD and to Chief Engineer at the Presidency, Bombay, both 12 December 1862, PWD Proceedings, January 1863, NAI.


90 For Mitander: Letter from Mitander, 28 January 1862, to Executive Engineer, Mhow Division, enclosure to letter 3, 11 January 1864, from the PWD, Calcutta to Secretary of State of India, Collections to the Public Works Despatches to India (1864), L/PWD/3/346, OIOC.

91 Letter from Ramsay to his friends, Nainital, 1 March 1862, Ramsay’s papers, E1:1.04.

92 Ramsay’s report, p. 37.

93 Compare with the building of the Gotha Canal in Sweden where the initiator of the scheme, Gustaf von Platen, explicitly noted the problem of keeping the most competent British staff, in particular, from returning home. The general idea was to offer as good a wage as at home and in addition give a number of other benefits (Lars Strombäck, Baltzar von Platen, Thomas Telford och Göta kanal. Entrepreneuriskt och teknisk förvärv i brytningstid [Baltzar von Platen, Thomas Telford and the Gotha Canal. Entrepreneurship and Technology Transfer in a Time of Transition], (Stockholm 1993), p. 92-93.


97 Atkinson, The Himalayan Gazetteer 3, p. 442 and 444. Atkinson was somewhat ambiguous when giving these figures since he said that the labor were found “either as blacksmiths, when they usually receive some service land, or cultivators”. There was a close connection between traditional ironmaking and the agricultural society. Agriculture
was not only the main market, but there was also an intimate tie between the lohars and the agrarias and the agrarian society in the social organisation of their lives.


100 Letter from Keatinge to PWD 5 December 1861, PWD Proceedings, January 1862, NAI. Mitander’s diary, 6 and 9 January 1862.

101 As a reference point to the following discussion Amiya K. Bagchi’s characterisation of academic discussion of the characteristics of Indian labour may be used. According to him there have been two notions of Indian labour, both shown to be basically flawed when subjected to more detailed research. The first view, widely spread, considered Indian labour to be immobile, difficult to discipline and often scarce. The other view, called the myth of the rootless Indian labourer by Bagchi, depicts the workers as entirely governed by the rate of population growth and their price as the subsistence wage. (Bagchi, Private Investment in India, p. 117.)


103 Ramsay’s report, p. 22 and quotation from letter from Ramsay to his friends, Nainital, 1 March 1862, Ramsay’s papers, E1:1.04.

104 Letter from Ramsay to his friends, Nainital, 14 May 1861, Ramsay’s papers, E1:1.04. Ramsay himself left Dechauri for Nainital in the middle of June and he did not move down to Dechauri until late October, after the end of the rainy season (Ramsay’s report, p. 34–35). According to his own notes the working year of the Indians was even shorter, with a five-month break (Ramsay’s report, p. 22 and 34).


109 Sowerby (1856, April), p. 92. Sowerby discusses the brick-making process in some detail (p. 91).

110 Oldham (1862, May), p. 18.

111 Commissioner of Kumaon, H. Ramsay’s summary of the position and history of the Kumaon Ironworks Company, letter 525 of 1872, to the Secretary to the Government, NWP, India Public Works, Collections to Despatches (1872), OIOC.

112 Letter from H. Ramsay to Secretary to the Government, PWD, NWP, 49, 25 September 1873, enclosure 3 to Dispatch 49 Railway, Home Correspondence 1871-1879, L/PWD/2/10.

113 W. Ness (1882, February), [Report from a visit to the Kumaon Iron Works and Mines, especially those from which the raw materials are obtained for the manufacture of iron for the ironworks at Calcutta].
of pig iron at the blast furnace plant at Dechauri”, in Public Works Departmental Papers 1862, 1218, Collections to despatches (1882), L/PWD/6/55, OIOC.

Signed W. T. T., to October 1862, 44/8, Home Correspondence 1871–1879, L/PWD/2/30, OIOC.


Henwood (1855, May), p. 28.

Signed W. T. T., 10 October 1860, 44/8, Home Correspondence 1871–1879, L/PWD/2/30, OIOC.

Mitander’s diary, 1 and 6 September 1862. Mitander uses this temporary character of the work with most of the British engineers engaged in big public undertakings in India. They spent only a part of their life in India.

143 Letter from Keatinge 27 June 1861, PWD Proceedings, September 1861, NAI.

144 Letter from Keatinge to PWD 7 November 1861, PWD Proceedings November 1861, NAI.

145 Letter from Keatinge to his friends, Nainital, 15 November 1862, Ramsay’s papers, E1:1.04.

146 Letter from Ramsay to his friends, Nainital, 31 January 1865, Ramsay’s papers, E1:1.04.

147 Mitander’s diary, 25 September 1860.


149 Letter from J. Cresswell, furnace keeper, to Supt., Kumaon Ironworks, 19 March 1862, in European establishment of the Kumaon Ironworks, Consultation, 15 June 1862, PWD Proceedings, June 1862, NAI.


CHAPTER 11
A LOCAL SYSTEM
IN A COLONIAL CONTEXT


4 “Roorkee Town” in Imperial Gazetteer of India, 32 (Calcutta 1908) p. 335.

5 There are numerous detailed printed memoirs and other recollections of the experiences of British engineers in India during the second half of the nineteenth century, possibly offering a rewarding basis for further research into the confrontation between British engineering traditions and Indian society: Victor Bayley, Indian Artificer, (London 1953); Robert B. Booth, Life and Work in India. Embodying a Short Sketch of the History and Progress of Kathiawar from 1865 to 1899, (London 1912); Robert Mainland Breerton, Reminiscences of an Old English Engineer 1858–1928, (Portland 1928); Sir William Denison, Varieties of Vice-Regal Life, 2 vols. (London 1872); Lady E. R. Hope, General Sir Arthur Cotton. His Life and Work by His Daughter, first published London 1902, reprint by The Institutions of Engineers (India), (Calcutta 1964); J. J. McLeod Innes, The Life and Times...


7 Mitander’s diary, 1–3 November 1860.


9 Letter 1964, from the Government of the NWP to the Secretary to the Government of India, in the PWD, 6 August 1872, India Public Works, Collections to Despatches (1872). L/PWD/3/384, OIOC.

10 Mitander’s diary, 17 May 1862.

11 Hardy Wells (1859, December), “Report upon the Kumaon Iron Fields in Connection with the Government Ironworks at Dechwore and Ramgurh”, Correspondence with India (1863), L/PWD/3/328, OIOC, p. 11.


15 Other important aspects of the railways in the colonies were their function in permitting colonisation, as a point of entry for military power and colonialists, and as easily available transport facilities for industrial produce from outside and for raw materials supplying the industries of the colonial powers. The role of the transport sector in development in the colonial context is still disputed (Daniel R. Headrick, The Tools of Empire: Technology and European Imperialism in the Nineteenth Century, (New York 1988), p. 182–191.)


17 Kerr, Building the Railways of the Raj 1852–1920, p. 211.


19 Hardy Wells (1859, December), “Report upon the Kumaon Iron Fields in Connection with the Government Ironworks at Dechwore and Ramgurh”, Correspondence with India (1863), L/PWD/3/328, OIOC, p. 2.

20 Kerr, Building the Railways of the Raj 1852–1920, p. 22, quoting The Engineer, 19 August 1864, p. 120.

21 Herman Annerstedt, Rapport: Rörande importen till Bombay av svensk järn och stål under åren 1855–1866 [Reports: Concerning the Import to Bombay of Swedish Iron and Steel 1855–1866], (Stockholm 1868) and Herman Annerstedt, Slutrapport till H. Exc. herr stats minister för utrikes ärendena rörande handel och sjöfart i India och China [Final Report to the Minister of Foreign Affairs concerning Trade and Shipping in India and China], (Stockholm 1875).


23 Artur Attman, Fagerstabruks historia. Adertonhundratalet [History of the Fagersta Works. The Nineteenth Century], (Uppsala 1868), p. 29. East India includes British East India as well as Java and China, but the latter regions were of minor importance. The figures thus basically concern the exports to present-day India and neighbouring countries of the British Empire, from Afghanistan in the west to Burma in the east.

24 Attman, Fagerstabruks historia, p. 264.

25 All quotes from Annerstedt, Slutrapport, p. 20.


27 Oldham (1860, May), p. 29–32.

28 Oldham (1860, May), p. 18.

29 PWD Proceedings November 1869, NAI. It is not known if Lieutenant Pye’s report led to any direct measures. Ramsay also reported on cast rails from Dechauri being tried at Roorkee, and according to him well matching the best of English or Scottish iron, Ramsay’s report, p. 11.

30 Commissioner of Kumaon, H. Ramsay’s summary of the position and history of the Kumaon Ironworks Company, letter 525 of 1872, to the Secretary to the Government, NWP, India Public Works, Collections to Despatches (1872), L/PWD/1/384, OIOC.

31 Letter from Keatinge to Railway Dept., Government of Bombay, 28 November 1861, PWD Proceedings, January 1862, NAI and letter from Keatinge to PWD December 5, 1861, PWD Proceedings, January 1862, NAI.

32 Mitander’s diary, 12 August 1862.

33 The report itself has not been found. PWD Proceedings (B), October 1862, NAI.

34 The high expectations attached to the tramway are described in W. P. Andrew, Tramroads in Northern India in Connection with the Iron Mines of Kumaon & Garhwal, (Lon-

Andrew, Tramroads in Northern India.

41 The project attracted substantial interest and a number of articles were mentioned in Andrew, Tramroads in Northern India: Mining Journal 21 March 1857, the Morning Herald 21 March 1857, the Civil Service Gazette 21 March 1857, John Bull and Britannia (no date given), Times 18 March 1857, Morning Chronicle 18 March 1857, Daily News 18 March 1857, Morning Post 18 March 1857 and Allen’s Indian Mails 3 April 1857.

42 Letter 15 March 1863, Ramsay’s papers, E1:1.04.

43 Letter 19 September 1863, Ramsay’s papers, E1:1.04.

44 This caused extensive correspondence between the owners and the Government of India, especially those from which the raw materials are obtained for the manufacture of pig iron at the blast furnace plant at Dechauri.

45 “Memorandum by the Secretary in the PWD”, signed W. T. T., India Office 10 October 1860, Home Correspondence 1871–1879, L/PWD/2/32, OIOC.

46 Select Committee of the House of Commons, set up after a petition from the East India Company 11 February 1842. Questions 4610 and 4676, quoted in Dutt, The Economic History of India, p. 99.

47 Headrick, The Tools of Empire, p. 12.


49 Mitander’s diary, 20 July 1862.

50 Oldham (1860, May), p. 29.

51 Headrick, The Tentacles of Progress, p. 278.


53 “Memorandum by the Secretary in the PWD”, signed W. T. T., India Office 10 October 1860, Home Correspondence 1871–1879, L/PWD/2/32, OIOC.

54 “Estimate of Cost of Manufacture of Pig and Wrought Iron at the Kumaon Ironworks, the Works Once Completed”, Dechauri 13 March 1863, Ramsay’s papers, F1:1.18.

55 “Estimate of Cost of Manufacture of Pig and Wrought Iron at the Kumaon Ironworks, the Works Once Completed”, Dechauri 13 March 1865, Ramsay’s papers, F1:1.18.

56 Letter from Ramsay to his friends, Nainital, 2 October 1862, Ramsay’s papers, E1:1.04.

57 The committee had held a meeting in London on 28 October 1867. Letter from Ramsay to his friends, Nainital, 2 October 1862, Ramsay’s papers, E1:1.04, and letter from Sir Charles Wingfield, acting as the chairman of a committee of the shareholders of the company residing in England, to the Secretary to the Government, NWP, 18 December 1867, Home Correspondence 1871–1879, L/PWD/2/29. Also in Atkinson, The Himalayan Gazetteer, 1, p. 263. On the ensuing discussions between the Company and Julius Ramsay, see letters from Ramsay to his friends, Kumaon Ironworks, 15 March 1865, Nainital, July 14, 1865 and Nainital, 19 September 1865, Ramsay’s papers, E1:1.24.

58 W. Ness (1880, February), “Report from a visit to the Kumaon Ironworks, especially from those pig iron at the blast furnace plant at Dechauri”, in Public Works Departmental Papers 1882, 1018, Collections to despatches (1882), L/PWD/6/55, OIOC, p. 9.

59 Calcutta Gazette, 19 August 1863, p. 2358–2359.


62 "The Tools of Empire", signed W. T. T., India Office 28 November 1866, in L/PWD/2/32, OIOC. See also letter from Colonel Alexander Fraser, Secretary to the Public Works Department of the North-Western Provinces, Letter 1664A, from the Government of the NWP to the Secretary to the Government of India, in the PWD, 6 August 1872, in L/PWD/5/384, OIOC.
64 E. H. Salomon, Protection for Indian Steel, (Calcutta 1924), p. 16.
65 Question 3739, British Parliamentary Papers, Colonies, East India 18, p. 20–21.
66 Oldham (1865, May), p. 27.
67 Question 3783, British Parliamentary Papers, Colonies, East India 18, p. 20–21.
69 See Ian Inkster, ‘The ‘Manchester School’ in Yorkshire: Economic Relations between India and Sheffield in the Mid-Nineteenth Century”, in Indian Economic and Social History Review, 23 (1), (New Delhi 1986), p. 317–318. The petition from “the Master Cutler, and the Cutlers’ Company, of Sheffield and Hallamshire, in Meeting Assembled” (Sheffield 13 April 1853) is given in full on pp. 119–22.
70 British Parliamentary Papers (1859), Colonies, East India, 18, with evidence on iron given by Mr. George Fenwick (17 February); Charles Atkinson, Mayor of Sheffield, and Robert Jackson, Master Cutler of Sheffield (24 March); Dr. Ralph Moore (28 March); and Captain Felix Haig (4 April). Hardy Wells used some of the minutes of 24 March in his report on the Kumaon Iron Works to emphasise the high quality of Indian iron. He quoted pts. 1777–1782, 3824 and part of 3784, (Wells (1859, December), p. 2–3. However Wells confused the testimony given by the two witnesses called to London from Sheffield. The answers he quoted were given by the Master Cutler, not by the Mayor. Other examples of evidence on iron taken by select committees are found in British Parliamentary Papers (1857–58), Colonies East India, vol. 17 and British Parliamentary Papers (1871), Colonies East India, 19.
71 Question 3783, Reports from the Select Committee on Colonisation and Settlement in India With Proceedings, Minutes of Evidence, Appendices and Indices 1859, reprint in Irish University Press series of British Parliamentary Papers, Colonies, East India, 18, (Shannon 1968–)
72 Sowerby (1858, August), p. v.
73 Questions nos. 3733 and 3746, British Parliamentary Papers, Colonies, East India 18.
74 Question 3777–3783, British Parliamentary Papers, Colonies, East India 18. These comments were also quoted in Wells (1859, December), p. 3–4.
75 Question 3739, British Parliamentary Papers, Colonies, East India 18.
76 British Parliamentary Papers, Colonies, East India 18, p. 466–467 and 472.
78 Cooke, “Mineral Products – India”, p. 72–73. As earlier noted iron and steel from India was exhibited in London in 1862.
81 The minutes, letters and notification are collected in “Burwai Ironworks, Central India”, Public Works Proceedings, August 1863, P 196/76, OIOC. They are also to be found in “Burwai Ironworks”, Collection to Public Works despatches to India, Letter 11 January 1861, 3, Collections to the Public Works Despatches to India (1864), L/PWD/3/136, OIOC, p. 20–21.
83 Sir C. E. Trevelyan referred to changes in 1865. These changes were part of a series of decisions to lower duties generally, under pressure from British tradesmen and the British business community. Dutt, The Economic History of India, p. 316–317.
84 Italics as in original.
90 Nasir Tyabji, British Imperialism, 1688–2000, p. 112.
92 Letter 1964A, from the Government of the NWP to the Secretary to the Government of India, in the PWD, 6 August 1872, India Public Works, Collections to Despatches (1872), L/PWD/3/1384, OIOC.
93 In a case of technological development Mats Fridlund has analysed co-operation between state agencies and private companies as “development pairs” (Mats Fridlund Den gemensamma utvecklingen: staten, storföretaget och samarbetet kring den svenska elkrafttekniken [The Mutual Development. The State, Big Industry and Cooperation on Swedish Electric Power Technology], (Eslöv, 1999).
94 This could be one of very few surviving shareholders’ lists from this period in India. According to A. K. Bagchi’s investigations in the Office of the Registrar of Companies in Calcutta there are few shareholders’ lists surviving even from the first decades of the twentieth century. Amiya Kumar Bagchi, Private Investment in India, 1900–1939, Cambridge South Asian Studies 10 (London 1972), p. 193.
95 Ramsay’s report, p. 16.
At the same time as the Kumaon Ironworks were finally closed, the project of the coke-based ironmaking at the Bengal Ironworks was under way, beginning to use India’s large resources of mineral coal. Primary material on this issue is extensive. Two collections should be noted: “Manu-
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95 Ramsay’s letters to his friends, Nainital and Dechauri, 14 January 1862, Ramsay’s papers, E1:1.24.
96 “List of ‘shareholders’ in the North of India Kumaon Iron Company Limited on the 31st December 1862”, Ramsay’s papers, F1:1.14. According to a letter from Ramsay while in London on his way out to India, “a Colonel Ramsay, who is one of the foremost civil servants in Nainital” was one of the shareholders (Letter from Ramsay to his friends, London 15 October 1861, Ramsay’s papers, E1:1.24). This might be a mistake, although two shareholders in fact were Ramsay’s (General L. Ramsay, London, and Colonel R. Ramsay, England). It is not unreasonable to assume that these two were relatives of the Commissioner, Henry Ramsay.
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109 Fryar, “Iron Production in India”.
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3 Becket (1856, January), p. 28.


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In the early 1860s, British colonial interests commissioned three young Swedish metallurgists to plan and lead the construction of two ironworks in India, one in the foothills of the Himalayas, the other in the Narmada Valley. In their Indian setting, both enterprises were pioneering enterprises, based on the most modern European ironmaking technology. Neither ironworks ever went into full and continuous production and the Swedes had to return to Sweden. In spite of this lack of success, or maybe because of it, the history of the ironworks and the contexts in which they operated provide a narrative. And it is of wide relevance, not only in explaining the workings and effects of administration, but also as a description of the complex processes influencing a transfer of technology.

Landscapes of Technology Transfer is a wide-ranging empirical study. From a local and individual perspective it traces lines of connection across boundaries of time and geography. The historical landscapes of technology transfer are described in their cultural, social, economic, and political dimensions and the remains of the ironworks and their local landscapes in present-day India are used as a central source for writing their histories. The book is illustrated with more than 170 photographs and drawings, both nineteenth-century and modern.

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