Work Organisation for Attractive Mining: Lean Mining and the Working Environment

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ABSTRACT
Attractive mining workplaces are good, safe and healthy workplaces. They are also workplaces that the workforce of the future wants to work in. As skilled miners and engineers are already scarce, this is important both for today and for the future. But future of mining will also be subject to increased international competition. In attempting to become more competitive, many mining companies turn to rationalisation, looking to both rationalise their production and organisation, as well as to optimise their processes. Work organisation is important in both rationalisation and providing attractive mining work. Therefore, a Lean Production philosophy is investigated for the organisation of future mines. The aim of this paper is to investigate to what extent Lean Production can be used to organise for attractive mining. To do so, it first need to be defined what attractive mining work is and to what degree it can be influenced by work organisation. A short insight into the production concept that is Lean will be given as well as a review of how Lean Production is discussed and utilised in mining today will be given. In conclusion, a summary of Lean Production’s potential to realise future, attractive mining is given.

INTRODUCTION
Two developments in the mining industry inspired the topic of this paper. The first is that there is a shortage of skilled workers in the mining industry. This shortage is significant because the current workforce is ageing in addition to already being insufficient for the industry’s current needs (Hebblewhite, 2008). It is also predicted that new ore bodies will be found and exploited in locations located far away from major population centres (Abrahamsson, Johansson and Johansson, 2009). This makes attracting a young workforce even harder. Designing work that people want to have and workplaces where people want to work is referred to creating attractive work, workplaces or work environments (these terms are used interchangeably throughout the paper) (Hedlund, 2007). A significant, future challenge for the mining industry, then, is to design attractive workplaces.

The second development is the increased need for and interest in rationalisation (Abrahamsson, Johansson and Johansson, 2009). Due to increasing costs for each tonne mined, mining companies will have to focus on strategies that help them remain competitive (Hancock and Sinclair, 2008). These strategies will often entail increasing productivity and efficiency, i.e. to rationalise both the production and the company. Lean Production (LP) is a management concept that has often been turned to achieve this. The concept has been adapted, firstly, in the automotive industry and, secondly, in the manufacturing industry; however, even sectors such as healthcare have reported successful examples. Recently, the mining industry has also started to adapt the concept.

Although LP has the potential to negatively influence work environments and work tasks, it can have a positive effect. In addition to this, most rationalisations concepts has the potential to improve work environments (see Westgaard and Winkel, 2011 for a review). Since management concepts affect the nature of work, the work environment and the workplace, it is reasonable to assume that the implementation of LP to mining environments (Lean Mining; LM) will affect the attractiveness of mining work (mining work is taken to mean the content of the work, the working environment and so on). The aim of this paper is to investigate in which ways LM can affect the attractiveness of mining work.

ATTRACTIVE WORK
In this paper attractive work is defined as work that a person wants to have (the external view) and that the worker wants to keep (the internal view) (Hedlund, 2007). This definition results in a two dimensional model: if a job is both externally and internally unattractive, the job is unattractive; if external attraction is high but the internal attraction low, the job is idealised; if internal attraction is high but external attraction is low, the job is hidden; and finally, if the job is attractive internally and externally, the job is attractive (Hedlund, 2007). Although more extensive data on the mining industry’s attractiveness is lacking, a quite commonly expressed opinion among managers seem to be that it is hard to recruit the right people. Furthermore, the results from a smaller workshop with engineering students (Bäckblom, 2009) indicate that the mining industry is considered dark, dirty, dangerous and bad for the environment; the mining industry is not being considered as a suitable place of employment. As such, according to the above model, the mining industry is at best hidden and at worst unattractive.

What makes a job attractive is dependent on three categories: working conditions, work content and work satisfaction (Åteg, Hedlund and Pontén, 2004). Together, these three categories encompass 22 dimensions (TABLE 1) It is an extensive model (the 22 dimensions encompass more than 80 qualities) which hints at the complexities of job attractiveness. All these factors will most likely influence the attractiveness of mining
work. However, it is also reasonable to assume that the importance of each dimension and quality differs between sectors and individuals. The question then becomes: what can the mining industry do to move from being unattractive or hidden to become attractive?

There is a lack of data regarding this topic as well. However, the workshop referenced earlier (Bäckblom, 2009) provides some insight into the matter. With regards to the students' requirements for the future mining industry sector and their future working place, focus on research and development and continuous improvements to better working conditions and lessen environmental impact is important. They want to be able to learn the different aspects of the company by rotating between different positions in the company. Workplaces should be gender equal with good leaders, and there should be cooperation between colleagues. Job security is also important and to be able to feel proud to work for the company (making vision and values important).

The workshop also concerned the students’ vision regarding the future of the mining industry. The students want to see less energy used, smaller environmental impact and higher safety. Technology – such as remote operation and automation – seem to be regarded as a possible way to improve safety, for example.

Lastly, the students’ idea concerning technology and organisation were investigated, and furthermore how their expectations could be met. Flexibility in working hours and workplace (including the possibility to work off-site); they want individual agreements. They, furthermore, expect more remote operation and automation.

The accounts from the workshop correlate to some of the categories of the model (TABLE 1). However, they leave much to be desired in term of what the mining industry practically can do to become more attractive. Johansson, Johansson and Abrahamsson (2010) compiled 26 statements (TABLE 2) for the attractive mine of the future. These statements give guidance on what the mining industry can do to become more attractive. (It is also possible to identify some of the students’ “requests” in this model.) However, not all of these statements are directly affected by work organisational measure (which is what this paper is concerned with).

LEAN PRODUCTION

LP is known by several different names (e.g. Toyota Production System, Lean Thinking/Manufacturing and World-Class Manufacturing). Although these concepts may have the same core, their application in practice differs; practices considered the essence of the concept by one party might not even be a part of the other party’s interpretation of the concept. Different industries will also require adaptations or modification of the concept for it to “fit” the industry in question. These facts – and other still – make it hard to arrive at one widely accepted definition. The fact that this paper is concerned with LP in a somewhat unusual setting renders traditional models for LP unsuitable. To describe LP (and subsequently LM) a bottom-up model by Lyons et al. (2013) is used. Instead of being one normative, prescriptive model, it is a result of summarising the descriptions LP made by the most prominent “lean literature”.

The model describes LP as consisting of four principles. These principles, in turn, consist of a number of practices. The principles are alignment of production with demand (e.g. pull systems, one-piece flow), elimination of waste (e.g. 5S, TPM), integration of suppliers (e.g. supplier development activities, just-in-time deliveries), and creative involvement of the workforce (e.g. kaizen, team-based organisation). The principles are not exclusive, however, and there is some overlap (i.e. one practice might be considered to be part of two or more principles). The remainder of this section further explains these principles to the extent that they are relevant to this paper. The descriptions of the principles are based on Lyons et al. (2013) while the descriptions of the selected practices are based on Liker (2004) and Womack and Jones (2003).

The alignment of production with demand is the principle that deals directly with production. The idea is that products should be manufactured on demand instead of being “pushed” through the production. This means production is “pulled” based on the demand of downstream customers. Customer can be internal (e.g. other workstations) and external (e.g. people or companies buying the product). Production is started at signals sent from a downstream customer. Another way to express the idea is that production should be “make-to-order” as opposed to “make-to-stock”. The demand of the customer sets the rate at which products are produced. The principle of production alignment requires the ability to vary production rates and that production is flexible. The concept of flexibility involves the ability for machines and processes to be used for several different products (non-specialised equipment), and for changes in volume and product mix to be accounted for.

The elimination of waste is probably the most recognisable LP principles. In LP there are eight different kinds of waste: (1) overproduction; (2) waiting times; (3) unnecessary transportation; (4) unnecessary processing or reworking; (5) inventories (e.g. intermediate storage); (6) useless motions; (7) scrap, repairs and inspections; and (8) unused employee creativity. LP is concerned with eliminating – or reducing – these
should be to develop long-term contracts and relations between the supplying and ordering company. The workforce, as well as improving the working environment. Work should be organised in multi-functional teams with no one worker assigned to a single task. Instead, each member of the team should be capable of doing the tasks of the other team members. This not only makes the teams less sensitive to disruptions, but also allows workers to rotate between different tasks and develop their competences. Workforce problem solving is another part of creative workforce involvement. Problem solving should also be team-based. The practice ties into the concept of kaizen, or continuous improvements, which is the idea that organisations should continuously strive to improve on ever last detail (e.g. to develop existing, stable and standardised processes in small steps). This has to be worker-driven; it is the workers who possess the knowledge of the manufacturing process and its shortcomings.

Through these long-term contracts, both parties can develop. The waste elimination-principle also includes establishing systems that prevent faulty products from continuing in the production process; each worker is trained to recognise and control potential defects. Quality is also further ensured by adapting the concept of poka-yoke (meaning “mistake proofing”). This entails designing technology and tools in such a way that it is literally impossible to make mistakes in positioning, number of operations, operations sequence, and so on. Another tool included in the principle of eliminating waste is Total Productive Maintenance (TPM). The purpose of TPM is to create disruption-free production by encouraging all employees to get involved and continuously making small improvements and preventative maintenance; everyone learns how to clean, inspect and maintain equipment. There is also 5S, which is a tool with the objective of engaging every employee in all aspects of production and, with orderliness, create an efficient and conducive workplace. The aim is also to gain an overview and to make production, flow and any shortcomings visible so that improvements can be made.

The integration of suppliers entails actively supporting suppliers in their effort in adapting LP. This means assisting in solving problems and improving performance. One goal of this is for deliveries to be just-in-time, i.e. deliveries should arrive exactly as they are needed in the production. The suppliers, like the ordering company, have to be flexible, with the ability to quickly respond to changing demands. Furthermore, the aim should be to develop long-term contracts and relations between the supplying and ordering company. Through these long-term contracts, both parties can develop.

The last principle is the creative involvement of the workforce. In many respects, this principle concerns avoiding the eighth waste: unused employee creativity. However, it also deals with developing and training the workforce, as well as improving the working environment. Work should be organised in multi-functional teams with no one worker assigned to a single task. Instead, each member of the team should be capable of doing the tasks of the other team members. This not only makes the teams less sensitive to disruptions, but also allows workers to rotate between different tasks and develop their competences. Workforce problem solving is another part of creative workforce involvement. Problem solving should also be team-based. The practice ties into the concept of kaizen, or continuous improvements, which is the idea that organisations should continuously strive to improve on ever last detail (e.g. to develop existing, stable and standardised processes in small steps). This has to be worker-driven; it is the workers who possess the knowledge of the manufacturing process and its short-comings.

**LEAN MINING**

The implementation and actualisation of LP differs between different companies and industries. In this paper the concern is how the characteristics of the mining industry (including the mining environment) change the LP concept (i.e. what is the difference between LP and LM). The differences between the automotive industry and mining industry are summarised below (TABLE 3). What then follows is an account for LM: what it is, how it is used today, and how it is different from LP.

The topic of value is central to LP and so too in LM. In fact, it is expanded beyond simply being defined as value for direct customers (as is usually done). Wijaya, Kumar and Kumar (2009) argue that mining companies have several indirect customers. These are stakeholders such as society, government and media. The values and opinions of these stakeholders should influence the mining company's definition of value. An example of this would be taking into consideration society's "green" values by ensuring the ore is produced with as little environmental impact as possible. It is because a mines potential impact on society, environment, and so on, is much bigger than that of an automotive factory that this broadened view on value is necessary.

Similar to LP, standardised work is also desirable for LM (Dunstan, Lavin and Sanford, 2006; Hattingh and Keys, 2010; Wijaya, Kumar and Kumar, 2009; Yingling, Detty and Sottile, 2000). However, standardised work is more difficult to apply to mining than to traditional manufacturing (Haugen, 2013; Wijaya, Kumar and Kumar, 2009; Yingling, Detty and Sottile, 2000). This is because of the previously mentioned variations inherent in the mining environment; standards usually require predictability and stability. Thus, standards intended for mining activities have to be more flexible than "traditional" standards (Hattingh and Keys, 2010; Yingling, Detty and Sottile, 2000). Wijaya, Kumar and Kumar (2009) provide a theoretical example of the possibility to standardise one activity of the mining cycle: rock bolting. The number of bolts used and the
pattern utilised is based on worse rock conditions. This would increase material used and time taken, but would reduce variation in process time and improve quality.

TPM can be useful for mining and is important in LM. Because of the long distances involved in mining and expensive machines, downtime can be very costly. Furthermore, some mines suffer from quite extensive machine downtime (Haugen, 2013). The utilisation of TPM could decrease machine downtime. Furthermore, it also means that the operator is taught additional skills which in turn create broader work roles. The training is essential in TPM; if the operators (i.e. those who are supposed to perform the maintenance) do not know how to perform the maintenance, more uncertainty and variations would result from faulty repairs and inadequate maintenance (Wijaya, Kumar and Kumar, 2009).

Quality is hard to influence in main mining activities. LP’s focus on quality is therefore not as applicable to mining. However, quality in supporting or auxiliary functions seems possible (Haugen, 2013; Wijaya, Kumar and Kumar, 2009; Yingling, Detty and Sottile, 2000). Haugen (2013) talks about “internal quality”. This is, for example, the quality of ramps, where low quality results in uneven ramps; or pillars, where low quality results in unstable pillars. Safety is also considered part of the quality of supporting functions (Wijaya, Kumar and Kumar, 2009; Yingling, Detty and Sottile, 2000). Focusing on the quality in supporting functions could, for example, ensure that rock bolts are installed correctly, that shotcreting is done right, or that faces are only being worked under safe conditions (Yingling, Detty and Sottile, 2000).

As in LP, work in LM is recommended to be organised in teams (Yingling, Detty and Sottile, 2000). Today, this can be complicated. This is because the utilised machines in mining tend to be designed for one person. Furthermore, an operator is usually assigned to only one machine (at least for each shift). Although a case study was able to show the potential of organising work in teams (Klippel, Petter and Antunes Jr., 2008), this was done in a mine with a low level of mechanisation. Group-work in modern mining does seem to be practiced in some tunnelling and development projects. These activities can be found to be organised in small teams with a supporting team leader (Haugen, 2013). Historical accounts also serve to illustrate the adaption potential: previously, mines were split into production levels with small, three to four man teams with dedicated production equipment being assigned to them (Haugen, 2013). This team was responsible for all production activities on that level, including maintenance. This seems to indicate that teamwork in mines with a high level of mechanisation will be a question of what level control is exercised towards. Team-based organisation in LM would mean that control is exercised towards a group level rather than an individual level; a group might be assigned a face to work and requested to deliver a certain amount of ore. Which worker is assigned which machines and for how long, for example, is left entirely to the group.

The topic of multi-skilled workers is important to LM (Haugen, 2013; Helman, 2012; Klippel, Petter and Antunes Jr., 2008; Yingling, Detty and Sottile, 2000) and LP. Mining still involves a lot of work with machines designed for one person. Therefore, even if work is not organised for teams, multi-skilling is still important because LM requires a flexible workforce capable of operating several different machines (as opposed to only one or two, as is often the case today) (Yingling, Detty and Sottile, 2000). To some extent, this appears to already be the case. Operators in some mines are multi-skilled (including having knowledge about maintenance), at times to the extent that it is not possible to trace which operator performed a certain task at a given time (Haugen, 2013). Furthermore, because of this skillset, the operators can rotate to get variation in their work and reduce stress. There are times when an operator does not know what task he or she is to perform during the shift, before the shift starts (Haugen, 2013). This combines well team-based organisation of work. The competence and training of operators, in general, is important (Dunstan, Lavin and Sanford, 2006; Haugen, 2013; Helman, 2012; Steinberg and De Tomi, 2010; Yingling, Detty and Sottile, 2000). At the very least this is something that is required for operators to become multi-skilled (see above). Operators should be trained and educated to know the basics of time studies and ergonomics as well as being able to utilise basic analysis principles (Yingling et al., 2000). It is even suggested that operator training could replace work standardisation (Haugen, 2013); with operators sufficiently trained, standards become redundant as the operator would know the best course of action in most situation.

Because the integration of supplier would happen at a high level of the organisation, the type of industry concerned is not as important. Thus, supplier integration would happen the same way in LM as it does in LP. This concept should, however, have one addition. Though normally not related to contractors, they should be included in this practice. They are important in LM because some mining companies are already dependant on contractors (Elgstrand and Vingård, 2013), and contractors’ working environment and accident rate is worse than those of regular employees (Blank et al., 1995; Muzaffar et al., 2013). LM has been used to solve problems that were associated with contractors (Castillo, Alarcón and González, 2014) or increase their performance (Dunstan, Lavin and Sanford, 2006). However, Wijaya, Kumar and Kumar (2009) note that engagement from contractors in practices such as 5S and continuous improvements might be hard, as the contractors do not necessarily share the same values and investment as ordinary employees.
The biggest difference between LP and LM is the inability to directly apply flow-based principle to main mining activities (Haugen, 2013; Mottola, Scoble and Lipsett, 2011). These practices require much modification before they can be utilised in the mining industry (Maier, Kuhlmann and Thiele, 2014). Some of the reasons for the incompatibility include the “tradition” of constantly pushing production (Haugen, 2013; Yingling, Detty and Sottile, 2000); the practice of manning expensive machines at all times to justify the investment (Haugen, 2013); long distances and tendency for large batch operations (Wijaya, Kumar and Kumar, 2009); and the variation in the production process (Haugen, 2013). However, supporting function should be capable of adapting these practices.

DISCUSSION
Attractive mining should be safe. This is reflected in the 26 statements. LM also focuses on safety, although not in the manner stated in the 26 statements; the focus is not on safety through non-entry but rather through quality. Safety in LM is mainly a question of quality (see, for example, Haugen, 2013; Wijaya, Kumar and Kumar, 2009; Yingling, Detty and Sottile, 2000). This is because of one of the unique characteristics of mining: workplaces are “constructed” in order to produce ore (and even as ore is produced). This means, for example, that a focus on quality could ensure all drifts and tunnels are sufficiently rock-bolted and shotcreted. As such, LM is less dependent on technology for safety. The 26 statements dictate that risks are minimised through systematic proactive work. This could be satisfied with continuous improvements and related activities included in LM. Additionally, regarding LM and safety, it is important to consider the negative aspects of LP that has been reported. LP has shown to increase stress and contribute to work-related illnesses. Furthermore, stress increases the risk of accidents. For LM to be viable for attractive work organisation (and work organisation in general), rationalisation efforts cannot come at the cost of increased stress.

Even though work organisation can affect physical factors (Carayon and Smith, 2000), the type or level of work organisation covered by this paper is unable to influence the factors included in the statements on physical work environment (see TABLE 2, second column).

The statements state that management has to be supportive and appreciated by their personnel, and that there is cooperation between these two parties. LM does not only allow for, but requires, cooperation between management and personnel. Successful implementation of LM requires managers to act like coaches rather than bosses. There is, however, always the risk that efforts such as continuous improvements and the engagement of the workforce remains talk only, that the voice of the worker is never really heard. Furthermore, there is also the risk that these kinds of practices solely become a way of accessing worker knowledge. This can lead to management no longer seeing their true value as problem solvers. Therefore, future mining under a LM philosophy has to be built on agreement, consent and cooperation between management and personnel. Management clears obstacles for the workforce who continuously improves their work, workplace and the business. The operators are the true experts on the process.

The statements on attractive mining and the LM concept both advocate group-based production. As mentioned, the current levels of mechanisation do not lend itself to this practice. Future technological development might facilitate or hinder this practice. If machines get more and more advanced it might only be economically (and/or practically) viable to train a few operators. This would hinder group-based work. Technology might also develop in such a way that cooperation between different “functions” is required for optimal operation. In this case, this would help facilitate group work. Alternatively, reiterating a previous point, a solution might be to exercise control towards the group-level rather than the individual one. Even though the work might remain individual it is organised on a group level. In either case, group-based production requires a skilled and authorised workforce that can go beyond the relatively narrow framework that most work organisation offers. The mining industry do not lack experience in teamwork but to succeed in developing and implementing LM these must be further development. Mining production is a complex activity and requires a skilled workforce that is able to resolve the big variety of problems that may occur. LM must be based on a workforce of autonomous goal-oriented work units with a high level of competence. This principle has to be adhered to even in cases where individual work might be easier or preferred.

The statements on attractive mining make clear that learning and flexibility are important. Learning – especially generic theoretical learning – will create flexibility. This is consistent with LM. Under LM, every team can operate every machine. Each team is also capable of repairing and maintaining the machines with they operate. However, it is not enough to just to give the teams these responsibilities. Operators have to be given formal training – both for operating and repairing the machines. Resources are also required that allow the operator to take the required responsibility. Failing to provide the training and sufficient responsibility, productivity can be lost, downtime worsened, and the operator forced to inaction. On the other hand,
succeeding in this, future production can be more flexible and productive. The future operator will also be granted broad work roles, new challenges and be given a holistic perspective of the production process (all which are state requirements of the future, attractive mine). The future mine worker will be employed simply as an operators, instead of a truck driver, repairman, and so on.

The focus on learning is essential. In LM, every team and operator is capable of developing new work procedures and analysing the effects (both ergonomic effects and economic ones). To realise this, sufficient training and opportunity has to be given. If there is only a requirement for operators to have this knowledge but with no possibility to fulfil the demand within the line of work, the whole organisation will suffer. Furthermore, workers have to be given sufficient time to apply their knowledge. In future mining, then, every operator's job include learning consisting of theoretic and practical knowledge. This investment in operators makes them vital to production. This provides them with job security.

Contractors are prominent in some mining operations. Even though there are two examples of contractors being involved in LM efforts (Castillo, Alarcón and González, 2014; Dunstan, Lavin and Sanford, 2006), their role in “making or braking” such an effort remains unclear. Contractors’ dedication to LM efforts is one issue (Wijaya, Kumar and Kumar, 2009). The bigger issue is related to learning and skills and job security (this issue is raised in part by Yingling, Detty and Sottile, 2000); developing theoretical knowledge and a multi-skilled workforce can be hard if the (ordering) company is not in charge of these processes. In this, there seems to be two viable options. Either contractor companies too are involved in the LM efforts; the contractors companies would also become LM companies. Those who are successful in this should be rewarded with long-term contracts. In this, when establishing supplier relationships, it is important to look beyond monetary factors. Areas such as safety records should carry heavy weight when choosing the most appropriate contractor. The alternative is that the utilisation of contractors is discouraged. In this, mining companies should maintain and possess necessary knowledge and a sufficient workforce, and this workforce should be developed and essentially offered permanent work security (Yingling, Detty and Sottile, 2000).

It has been shown that LP can support in achieving sustainable production systems that include environmental care (Kurdve, 2014). Furthermore, Wijaya, Kumar and Kumar (2009) argue that all stakeholders’ values and opinions should be considered for the company’s own definition of value. This way, the “green” values of the society can be considered under LM. The incorporation of societal, and similar, values into the company could both help minimise environmental impact and make employee fell proud to work for the company. However, the question is if this enough effort to achieve this.

Future technological developments will probably make the production process of mining more stable and predictable. In this, many barriers to introducing LP in mining might be removed. This is especially true for those practices that relate to aligning production to demand. However, this probably has little effect on the attractiveness of the work.

CONCLUSIONS

LM is does not entirely fulfil the statements and requirements for attractive jobs. While LM might be a step in the right direction towards attractive mining, parts of the concept is not sufficient for organising for attractive mining. In fact, at times LP and LM may result a development opposite to what is desired. Issues regarding gender, for example, are not handled satisfactorily in current LM practices. Furthermore, LM does not ensure that working hours are flexible and based on social needs. However, the concept does not actively hinder this either. Finally, some statements for attractive mining are not something that can be influenced by the work organisation.

With this in mind, LM can still be considered important for the design of future mines and mining work. Designing with a LM philosophy in mind would, for example, mean that:

- when new equipment is procured, the choice should be the machine that best allows for work in team (all other factors being equal);
- when mining method is chosen, the one which allows for most flexibility and are most in line with the company’s values (which by extension also is the society’s values) is selected; and
- when new technology is introduced, whole production teams are instructed in its operation so that flexibility and learning is assured.

It is important, though, that focus is on the positive aspects of LM while efforts are spent on negating the negative ones. This leads to the topic of further research, where this paper provides two recommendations:
1. The LM concept needs to be explored further in practical settings. Which practices and principles do actually work and what are the effects? It is also important that the positive and negative parts of LM (mainly with regards to attractive mining work) are identified. This can help shape the concept into a better tool for creating attractive mining work.

2. The lack of data regarding attractive work in the mining industry has to be addressed. Here, studies about what makes the current mining industry hidden or unattractive, and what can make mining attractive have to be conducted.

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**TABLE CAPTIONS**

**TABLE 1**
The 3 categories and 22 dimensions that make up attractive work (based on Åteg, Hedlund and Pontén, 2004).

**TABLE 2**
The 26 statements for future, attractive mining divided in four themes (based on Johansson, Johansson and Abrahamsson, 2010).

**TABLE 3**
A comparison between the mining industry and the automotive industry (based on Dunstan, Lavin and Sanford, 2006; Helman, 2012).
**TABLE 1**
The 3 categories and 22 dimensions that make up attractive work (based on Åteg, Hedlund and Pontén, 2004).

<table>
<thead>
<tr>
<th>Working conditions</th>
<th>Work content</th>
<th>Work satisfaction</th>
</tr>
</thead>
<tbody>
<tr>
<td>Adequate equipment and tools</td>
<td>Work pace</td>
<td>Coveted</td>
</tr>
<tr>
<td>Working hours</td>
<td>Familiarity</td>
<td>Recognition</td>
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<tr>
<td>Physical work environment</td>
<td>Physical activity</td>
<td>Status</td>
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<tr>
<td>Leadership</td>
<td>Freedom to act</td>
<td>Stimulation</td>
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<tr>
<td>Loyalty</td>
<td>Practical work</td>
<td>Results</td>
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<tr>
<td>Location</td>
<td>Theoretical work</td>
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<tr>
<td>Wage</td>
<td>Variation</td>
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<td>Organisation</td>
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<tr>
<td>Relations</td>
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<td>Social contact</td>
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**TABLE 2**
The 26 statements for future, attractive mining divided in four themes (based on Johansson, Johansson and Abrahamsson, 2010).

<table>
<thead>
<tr>
<th>Safety</th>
<th>Physical work environment</th>
<th>Psychosocial work environment</th>
<th>Social responsibility</th>
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</thead>
<tbody>
<tr>
<td>Safety is maximised through zero entry to the development and production areas, based on automation and remote control technology</td>
<td>Appropriate variation in musculoskeletal workload promotes physical health</td>
<td>Management is supportive to and appreciated by their personnel</td>
<td>The employees feel proud to work in the company</td>
</tr>
<tr>
<td>Risks (especially severe risks) are minimised through systematic work environment management with actions based on systematic and thorough risk assessments</td>
<td>Noise exposure is minimised (no harmful exposure, minimised disturbing noise)</td>
<td>Cooperation between management and personnel is extensive and efficient</td>
<td>The mine site has a living society with broad cultural activities</td>
</tr>
<tr>
<td>Vibration exposure is minimised (no harmful exposure, minimised disturbing vibrations)</td>
<td>Work organisation is based on autonomous production groups</td>
<td>There is a good balance between demands and self-control (for groups and individuals)</td>
<td>Fly-in-Fly-out of personnel and contractors are avoided as far as possible</td>
</tr>
<tr>
<td>Chemical exposure is minimised (no harmful exposure, no motor exhaust fumes)</td>
<td>There is a good balance between demands and self-control (for groups and individuals)</td>
<td>Contractors have the same basic rights and obligations as the companies own personnel</td>
<td></td>
</tr>
<tr>
<td>Physical climate is comfortable (comfortable heat load)</td>
<td>Learning includes generic theoretical knowledge to create flexibility in the</td>
<td>The environmental impact is minimised</td>
<td></td>
</tr>
</tbody>
</table>
Proper lighting is installed (comfortable and task supporting lighting)

The understanding of mining production in a holistic perspective is general and good

Radiation exposure is minimised (radioactive, electromagnetic)

The work continually offers new challenges and meetings with new professions

Premises, machines and vehicles are fit for humans different needs and limits and for efficient performance of tasks.

Underrepresented groups are affirmed and the workplace culture is based on gender equality

The wage systems promote both safety and work motivation

Working hours and schedules are flexible and based on social requirements

Job security is good and based on efficient production

### TABLE 3

A comparison between the mining industry and the automotive industry (based on Dunstan, Lavin and Sanford, 2006; Helman, 2012).

<table>
<thead>
<tr>
<th>Mining industry</th>
<th>Automotive industry</th>
</tr>
</thead>
<tbody>
<tr>
<td>A smelter or refinery cannot be stopped so there is inherent production push in the process</td>
<td>An automotive assembly line can be stopped so there is the possibility to create pull systems</td>
</tr>
<tr>
<td>Production is in continuous units and around the clock</td>
<td>Production is in discrete units and in cycles (often shorter than one day)</td>
</tr>
<tr>
<td>Generates considerable dust</td>
<td>Little dust</td>
</tr>
<tr>
<td>Physically challenging environment</td>
<td>Ambient conditions</td>
</tr>
<tr>
<td>Unstable/variable operating conditions</td>
<td>Stable operating conditions</td>
</tr>
<tr>
<td>Inherently variable work environment</td>
<td>Stable (and permanent) work environment</td>
</tr>
<tr>
<td>Geological hazards can halt the production</td>
<td>No threats to production</td>
</tr>
<tr>
<td>Remote locations</td>
<td>Large centres</td>
</tr>
<tr>
<td>Inherently variable raw materials</td>
<td>Controlled raw materials</td>
</tr>
<tr>
<td>Large dispersion of work</td>
<td>Compact plants</td>
</tr>
<tr>
<td>Customers are other industrial companies or metal exchanges</td>
<td>Sales of products primarily to individual customers</td>
</tr>
</tbody>
</table>