Documentation and preservation: technical development in Swedish archaeology
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Archaeology is a humanistic science, for it processes its material according to "humanistic methods". These methods have developed during a very long period of time. They are well tried, but, in spite of the help provided by modern computer techniques, they run the risk of stagnating in their development.

The research material of archaeology is extracted by means of the methods of the natural sciences and technology. These, in contrast to the humanistic methods, are developing with accelerating rapidity. Their future possibilities seem boundless. This contradictory state of affairs should give archaeology as a whole the possibility of developing, by its basic material, at the same rate as its auxiliary sciences, in spite of the limitations of the humanistic methods. A consistent, goal-directed and continuous renewal of the technical and laboratory elements of archaeology is therefore a condition for more rapid and more reliable results in research into prehistory.

In Sweden, technical development in archaeology has been very rapid during recent decades, primarily in the sphere of documentation techniques, but also new ways of using machines in the field when prehistoric sites are to be excavated have been tried out successfully. The borderline between work in the field and in the laboratory has become less marked, and a new conception, "laboratory archaeology" has emerged, comprising a co-ordination of all the finer techniques which should make it possible to gain more and new qualities from the archaeological material.

A stricter organization of the total research resources has also begun. At the Central Office of National Antiquities and the Museums of National Antiquities, a research board has been set up, with three consultation groups, representing Sweden's leading experts in archaeology, building research and technical auxiliary sciences. Co-ordination and rational planning of training, research and development in Swedish archaeology seem therefore possible to realize.

Much-needed training in the basic elements common to all branches of archaeology, called "laboratory archaeology" above, has not yet become general in Swedish universities. A docentship in this field has, however, been established at the University of Stockholm. On the other hand, most of the universities have laboratories or conservation institutions, of which the one at Uppsala early performed valuable pioneering work for laboratory archaeology. A large laboratory is being built at the University of Stockholm. It will have special functions relating to laboratory analysis of archaeological material. A similar innovation with the main emphasis on X-ray, documentation and conservation of finds has been introduced in the Central Office of National Antiquities excavations on Gotland (RAGU) at Visby. When fully developed this system of "innovations centres" will provide new impulses continuously to the central technical laboratory, the Technical Institute at the Central Office of National Antiquities and the Museums of National Antiquities in Stockholm. So much for organi-
Every large archaeological research project should include the following items:

A preliminary study or excavation with limited objectives to ensure as exact planning as possible in respect of finance and time for the project, preferably including all phases from planning to the publication or other distribution of the results.

The technical aids to be discussed first in this connection are indicating and documentation from the air—aeroplane or helicopter. The methods developed in conjunction with military activities in particular during the two world wars and later, and also various space projects, will be mentioned only in passing. Here photogrammetry, computer techniques and various kinds of light- and heat-sensitive apparatus have given great possibilities of documentation of human activities not visible above ground. For obvious economic reasons these methods have been tried out in archaeology to only a very small extent. Some attempts have been started by RAGU in collaboration with the cultural-geographical institution of the University of Stockholm to improve the interpretation of the documentation obtained by photography. The basic photographic material used for the economic map of Sweden, scale 1:10000, is stored in archives. A revision of this work is now in progress and new photographs are being taken. Traces of human activity visible in this material—soil marks and crop marks—depend on many factors. Among these, season, locality and weather are of prime importance. A correct interpretation of the aerial photographs requires, therefore, a systematic study of how one and the same indication reacts to changes in these factors. By processing schemata or codes, attempts are being made to achieve more reliable results in the use of aerial pictures in the work of archaeological registration and planning.

Another detail of this is mapping accumulations of stones and pits, hidden below the surface of the ground, with the help of different kinds of technical equipment. Side by side with well-known methods of electrical resistance measurement, a seismographic method, which promises to be of great value in archaeology, has been tried out in collaboration with cultural geographers.

Soil analyses of various kinds have long been made to determine primarily remains found in settlements. Phosphate mapping is one of the most common methods. It has been found, however, to depend on many more factors than was formerly assumed. Soils with different degrees of retentivity or permeability for phosphates have, like secondary conditions such as ploughing and other forms of cultivation, shown that samples taken at different depths may, in some cases, be necessary for a correct interpretation of the material.

Here, too, systematic research may be needed to produce schemata as aids for an effective utilization of the method.

A preparatory pilot investigation to make possible a desired, tenable detail planning of an archaeological research project often includes digging trial trenches or excavations within the appropriate sites. Although this may seem uncomplicated, it has been found in practice that effectivity can be increased considerably by the application of a carefully prepared technique in order to achieve the best results with a minimum of work. Digging trial trenches with an excavating machine or more usually manually has been performed in a planned system, where the marked trenches have been limited in the first place to trial pits worked into the system only large enough to facilitate extreme stratification indication. The system is concentrated, or may become a continuous trench where positive results are obtained. The find strata are studied with the
greatest care. Quantitative and qualitative analyses and comparisons in immediate connection with the field work contribute to an effective “steering” of the investigations. Hitherto unknown settlements have been determined surprisingly rapidly in this way with very little labour.

The principles for total planning should also include, in addition to the demand for economic guarantees for each phase of the investigation, a consistent steering of the work so that it can be concluded at any time, and still provide possibilities for meaningful, scientific processing. Further, excavated finds that are not to be taken away should be replaced and protected immediately. When prehistoric remains are exposed, and particularly stone settings in graves, experiments have been made in consultation with Swedish industrial enterprises resulting in compressed air apparatus, which may greatly facilitate certain kinds of work.

Various types of mechanical revolving brushes, which can be regulated in respect of pressure and speed, are being tried out. The brushes may be of different materials with varying elasticity and stiffness. The method may be combined with suction on the vacuum-cleaner principle. One advantage of this method seems to be that the superficial root system of the turf is disintegrated without disturbing underlying stones. In some excavations, conveyer belts in combination with automatic riddles have been used. In conjunction with the investigation of H.M.S. Wasa, water screening (jets of water of varying pressure and the dissolution of appropriate types of soil in water) gave strikingly good results. Extremely accurate recovery of objects is facilitated in this way.

As far as field documentation is concerned, photography has replaced drawing as far as possible. With the help of a tower construction of steel tubing, plane pictures by means of so-called vertical photography are now taken consistently at most Swedish excavations. The method has also been used in Swedish archaeological expeditions to Greece, Italy, Africa and other places. The greatly improved rapidity, the greater objectivity and the possibilities of detailed studies of strata during the excavation are advantages which have been confirmed during the 25 or so years the method has been used. Certain disadvantages—cloud shadows and relatively high costs of photography and the mounting of plans and maps—may, judging by experiments now in progress where demands on precision allow, be largely eliminated by the construction of apparatus for drawing directly from negatives.

One unsatisfactory item in archaeological field work is the production of section drawings. Most of the methods and principles give misleading or erroneous results, due to necessary generalization. By means of a method developed by the Institute of Cultural Geography at the University of Stockholm, most of these sources of error have been eliminated. The section is not depicted as a plane section, but has depth, within which all material (stones, for example) is shown to its total extent. In this way the representation is scientifically exact, although somewhat difficult to interpret, and is perhaps best as an alternative to conventional section drawings when a very high degree of exactness is required.

The main objective of the experimental work performed by RAGU is the conservation of finds and find strata from field investigations. One absolute demand has been not to treat excavations in the field and work in the laboratory as separate entities. This demand has been met by roofing over the find strata and moving the laboratory to the field or by transporting the whole complex of finds and strata to the laboratory for further processing and documentation under the supervision and with the collaboration of the leader of the excavation. The apparatus used is very similar to that used in a hospital operating theatre. Special adjustable “operation tables” with access to stereomicroscope, micro-photography and X-rays of dif-
Fig. 1. Report on method of documentation and attempted reconstruction by the help of advanced X-ray.

A. Object as taken from the earth. B. X-ray pictures of the object, taken from different angles, combined. C. The object in drawings: present appearance and reconstructed.

In principle the objects need not be freed from their surrounding coatings or conserved, but may in this way be recorded and reconstructed for scientific treatment, publication and demonstration for the public. The object may, in anticipation of better methods in conservation, be stored indefinitely in a freezer or refrigerator.

The advantages of this method are that scientifically “delicate” material can long be “saved” from the “destruction” that every total conservation implies, however carefully it is performed. This phase of an excavation is often the most costly, and the method should therefore be the most preferable one also from the financial point of view.

Methods in the documentation and rekonstruktionsförsök med hjälp av avancerad röntgen.

A. Outgrävt (ej frampreparerat) preparat. B. I olika vinklar tagna röntgenbilder av preparatet hopmonterade. C. Föremålet i teckning: nuv. utseende och rekonstruerat.

Föremålen behöver i princip ej utgrävas eller frampreparerats utan kan på detta sätt dokumenteras och rekonstrueras för vetenskaplig bearbetning, publicering och publikdemonstration. Det utgrävda preparatet kan i avvaktan på bättre frampreparerings- och konserveringsmetoder i obegränsad tid förvaras i frysfack eller kylskåp.

Fördelarna med denna metod är att vetenskapligt "känsligt" material i det längsta kan "skonas" från den "destruktion" som varje total frampreparering, trots all tänkbar noggrannhet dock utgör. Denna del av utgrävningen är också ofta den mest kostnadskrävande varför metoden ur ekonomisk synpunkt även bör vara att föredra. Foto RAGU.

Figs. 2–4. Right. A knife treated according to the method described in Fig. 1. Only a selection of the "basic material", from differently exposed X-ray pictures (mainly of the ornamentation), is reported. (The object was later completely conserved.) — Huggkniv behandlad enligt samma metodik som fig. 1. Blott ett urval av "basmaterialet" ifråga om olika exponerade röntgenbilder (främst av ornamentiken) redovisat. (Föremålet senare totalt frampreparerat.) Foto RAGU.

different kinds have proved to be eminently suitable for this work. The experiments reported will be of decisive importance for a future complete revision of objectives and financial investments for field work in archaeology and laboratory archaeology. On the financial side, a rapid shift is now taking place from investments in field work—excavation and illustration—towards laboratory work in the field and conservation institutes. The investigation has then reached a stage where the extraction of the maximum amount of information depends almost entirely on the technical resources available and the ability to use them efficiently. One method might be designated documentation or preservation, whereby is meant that a complete documentation often demands a total disintegration of the artifact in question as is done with prehistoric remains in the field. In practice this usually implies that the value of the object as a specimen—a demonstration piece to show the results of the scientific investigation—is impaired or disappears completely. This radical and destructive method is both expensive and final.

The other way, the practicability of which is now being tested, mainly by experiments in advanced X-ray photogra-
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Phy, may be called documentation and preservation. Its purpose is to obtain, mainly by means of X-ray photography, basic material for a perfectly reliable reconstruction drawing of the object without removing it from the surrounding crust. Since only a very small part of the material found during an excavation is required for exhibition and since we know that approximately 75 per cent of the cost of the "total excavation" of an object is for cleaning, removing incrustation, and conserving, it should—from the economical point of view—be an extremely suitable measure to avoid or postpone these two processes. Of decisive importance from the scientific aspect is that material and such details as can be traced in X-ray photographs, but for the conservation of which no safe methods exist, can be saved for the future, when more advanced technical methods may be available.

Figs. 5–6. Advanced X-ray documentation of plaited silver braid from a hood in a Viking horseman's grave. — Avancerad röntgendokumentation av flätat silverband från huva i vikingatida ryttargrav. Foto RAGU.

Fig. 5. X-ray apparatus (in the background "bound", in the foreground "free X-ray") in use on a find (skull with remains of silver braid attached to the hood). The braid is not cleaned. — Röntgenapparat (i bakgrunden »bunden«, i förgrunden »fri röntgen«) under användning på preparatet (skalle med fastsittande rester av silverbanden till huvan). Banden ej rengjorda. Foto RAGU.

Fig. 6. Right. a. Enlarged photograph of uncleaned silver braid (left). Enlarged X-ray photograph of the same braid (right). Note the possibilities of a detailed study of the plaiting technique. b. X-ray picture, scale 1:1. — a. Förstorat fotografi av ej rengjort silverband (t. v.). Förstorat röntgengrafli av samma band (t. h.). Obs. möjligheterna till detaljstudium av flättekniken. b. Röntgenbilden i skala 1:1. Foto RAGU.
Experiments made in 1974–75 by RAGU have shown the following: Polaroid or conventional X-ray films were applied at right angles to parts of disintegrating weapons in a grave moved into the laboratory. The series of pictures, taken at various exposures, were afterwards combined and detailed reconstruction drawings of the objects could be made. Even the ornamentation was easier to interpret by this method than after complete conservation. After being photographed, the objects were cut out of the coating, packed and stored in a freeze box for future processing.

The importance of this experience cannot be exaggerated. One of the greatest difficulties of archaeology, the decisions that have to be made in the course of conservation—often fateful for the artifacts—is largely eliminated. A logical development would now be for the research to be concerned with the storage of the unconserved, packed artifacts. Freezing at a temperature of \(-20^\circ\text{C}\) is a method now in general use.

Variations in freezing and refrigeration, humidity and chemical conditions in and around the preparation do not seem necessary to achieve a good result. Experimentation in this sphere, and storage space in conjunction with laboratories and storehouses arranged on the basis of the results is a logical development.

Photogrammetric documentation is being tested by us on small objects. It is being used on dug-out artifacts but also on non-prepared objects—hidden in sediment remains—by help of photogrammetric X-ray photography. These methods, which are now fairly inexpensive, will “freeze” and preserve large quantities of basic facts that may be evaluated in the future. In this way, all the dimensions of the object may be secured on microfilm, enabling a complete reconstruction of the “quantitative qualities” of the object. By using X-ray documentation followed by storing of an unexcavated but prepared object, the qualitative analyses may also be postponed.

In closing, mention must be made of collaboration with specialists in the field of medical laser technique to construct apparatus for the irradiation and documentation of prehistoric remains without excavation—a further step in the same direction as that mentioned in the X-ray documentation of artifacts without conservation. This apparatus will act as a combined television transmitter and receiver, to be focused by crossing laser beams at different depths below the surface of the soil. To be able to make an inventory of a prehistoric site would, at one blow, alter all the archaeological field methods and lead to a completely new development in prehistoric research.

Dokumentera och bevara

_Teknisk utveckling inom svensk arkeologi_

Arkeologin är en humanistisk vetenskap, då den bearbetar sitt material med »humanistiska metoder«. Dessa metoder har utvecklats under mycket lång tid. De är väl

I Sverige har den tekniska utvecklingen inom arkeologin under de senaste decennierna gått mycket snabbt. Främst har detta skett inom dokumentationsteknikens område, men även nya maskinella metoder för frampreparation av förlämnningar i fält har med framgång utprövats. Gränsen mellan arbetet i fält och på konserveringsanstalten — laboratoriet — har också allmer utsuddats i en följdriktig utveckling. Ett nytt begrepp, »den laborativa arkeologin«, har härmed tillkommit, innefattande en samordning av all den förfinade teknik, som bör möjliggöra utvinnandet av fler och nya kvalitéer ur det arkeologiska materialet.

En fastare organisation av arkeologins totala forskningsresurser har även börjat genomföras. Vid Riksantikvarieämbetet och Statens Historiska Museer har bildats en forskningsnämnd med tre samrådsgrupper, de senare representerande den främsta sakkunskapen i landet inom arkeologi, byggnadsforskning och tekniska hjälpvetenskaper. Samordning och rationell planering för utbildning, forskning och utvecklingsarbete inom svensk arkeologi syns härmed genomförbar.

Vid Stockholms universitet är ett större laboratorium under uppbyggnad med speciella funktioner, avsedda för laborativ analyS av arkeologiskt material. Ett liknan-
ödande teckning i möjligaste mån ersatts av olika former av fotografering. S. k. loddografering är konsekvent genomförd vid de flesta svenska utgrävningar. Metoden har även kommit till användning vid de svenska expeditionerna i bl.a. Grekland, Italien och Afrika.


Den andra vägen kan kallas dokumentera och bevara. Den syftar till att främst genom röntgendokumentation erhålla basmaterial för en helt tillförlitlig rekonstruktionsritning av föremålet utan att detta framprepareras.

Literature


