Compressed Air Technology in Swedish Archaeology

An Example of the Social Construction of Technology in Practice

Åsa Gillberg & Ola W Jensen

In this paper the authors problematize the relation between technological and social aspects of archaeological fieldwork through a historical case study of the introduction and use of compressed air technology in archaeology. They do this by incorporating aspects of Science and Technology Studies (STS) and Actor Network Theory (ANT) into the history of archaeology. Apart from archive material, fieldwork reports and interviews with colleagues have been the primary sources. The study shows how technology is negotiated and renegotiated, and how the technical and the social form each other. Finally, the authors draw attention to issues of technological development in the present.

Åsa Gillberg & Ola W Jensen, Deptartment of Archaeology, Gothenburg University, Box 200, SE-405 30 Göteborg, Sweden

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In February 1966, the Archaeological Excavations Department (Sw. *Undersökningsverksamheten*, UV) of the National Heritage Board held a weeklong meeting, the so-called digging course, with its area managers and team leaders. The course covered all essential aspects of the Department's enterprise, from the contemporary Law of Antiquities to administration and field techniques. Detailed minutes were kept and filed away at the Archaeological Excavations Department (AED) offices in Stockholm. On the agenda for the third day were two interesting points: "experiments with topsoil removal" and "experiments with compressed air". The minutes revealed an intense discussion, which became the incentive for this paper.[1]

Although compressed air implements started to be systematically used in the archaeological excavations of the AED from the mid-1960s, they have been sparsely discussed in publications. During the '60s the archaeologists involved in the experiments published their results and ambitions (e.g., Ambrosiani 1965;

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Hagberg 1966; Ambrosiani & Hagberg 1967), but only one text has assessed the techniques from a historical point of view. Its author states that the results were varied. The removal of topsoil layers with compressed air was not a success, as not only loose earth but also archaeological finds were blown away, while the mechanical sieve was put to good use (Lagerlöf 2002:47).

It has been suggested that the material and social side of archaeological practice, along with its craft and organisation, is perhaps considered of less importance in relation to results (for a discussion, see Nordbladh 1995:10). Not only has the use of a certain field technique far-reaching implications for what kinds of finds and materials the excavation will generate, but technical changes may also deeply affect the social organisation of labour (Sundin 1996:92), which is an equally important aspect of archaeological practice. The overall purpose of this paper is to problematize the latter, i.e., the relation between technological and social aspects of field practice, through a historical case study. We do this by incorporating aspects of Science and Technology Studies (STS) into the history of archaeology.

THEORETICAL PERSPECTIVES ON TECHNOLOGY

Historical studies of archaeological field techniques in Sweden are hard to come by (but see Trotzig 1990; Jensen 2002, 2004; Lagerlöf 2002; Floderus & Gustawsson 1946; Larsson 2000, 2004; Gansum 2004), but internationally the history of methods and techniques within archaeology has been discussed from several different perspectives. Usually it is described as a progression thanks to either individual genius or some innate progressive development of archaeology itself (see Gustafsson 2001 for a detailed discussion). Some would even argue that the development of excavation techniques is a precondition for the discipline itself, or as Glyn Daniel once put it, "the development of a systematic discipline of excavation is, in one way, the story of the development of the systematic discipline of archaeology" (Daniel 1967:222). Within the history of archaeology this is exemplified in several biographies that ascribe the role of "founding father" of scientific field archaeology to a number of men (Gillberg 2001), from Pitt Rivers to Petrie to Wheeler (Bowden 1991; Drower 1985; Hawkes 1982). Hjalmar Stolpe is perhaps the best Swedish example of this (Floderus & Gustawsson 1946:278). Within technology studies Daniel's position would fall within the materialistic approach, which tends to focus on technology itself, or more precisely the physical artefacts. Technological development is perceived as an autonomous rational and evolutionary process, fermented by some inherent logic and brilliant brains, which more or less determines changes within society and in our case science (Bijker 1995:238-239).

In another approach theory is considered irrelevant to excavation, the latter merely being a technical process, while others would agree that the excavating methods used are the result of a theoretical choice (Collis 2004). Any change in methods and technology is mainly due to changes in what questions are being asked by the excavator (Lucas 2001; Larsson 2000). Trigger, for instance, states that, "The development of the culture-historical approach resulted in a significant elaboration of archaeological methods" (Trigger 1989:196). Trigger considers the culture-historical perspective an archaeological consequence of ideas and political currents in society (Trigger 1989), a statement that lets him combine a certain historiographical internalism with externalism. Archaeological ideas and theories come about as mergers between society and archaeology, while excavation techniques are an internal affair. This approach is comparable to the cognitivistic approach in technology studies. Technology is often thought of in terms of evolutionary progress, but instead of the technological equipment per se, this model emphasises the technological knowledge and the use of technology to solve problems within new frameworks of theory and ideas (Bijker 1995:239-241). From this perspective, technology is seen as nothing more than applied science; the knowledge of technique has to adapt to altered views and theories, in our case about the past and its material culture.

Rather than being moulded by some inherent scientific logic or mere reflecting cognitive processes, a third approach sees technology as mainly the result of different social factors (Bijker 1995:241). This social shaping model is represented by different social constructivist approaches in technology (generally and collectively referred to as Science and Technology Studies – STS), such as Social Construction of Technology (SCOT), originally represented by Wiebe Bijker and Trevor Pinch, Actor Network Theory (ANT), mainly associated with Bruno Latour, Michel Callon and John Law, but also by gender theory. Since we are deeply influenced by these theoretical approaches, our paper will be an attempt to write a piece of the history of archaeology using these perspectives.

A general presupposition within social studies of technology is that innovations and implementations of technology cannot be understood in terms of a linear process, explained by some singular force or in neutral, technical terms. On the contrary, technology is rather conditioned by several different heterogeneous factors, such as social, political, economical and cultural elements. In fact, different technologies are always components of bigger societal systems including not just different artefacts but also individuals, organisations, laws and norms, cultural and political values and economical systems in a "seamless web" (Bijker, Hughes & Pinch 1987:3; Bijker & Law 1992).

That technology is socially constructed means that it is in a constant state of being negotiated and renegotiated. What is to become accepted technology and not, how it should be designed, redesigned and even used and reused is therefore a question of debate. Controversies and disagreements between different actors and social groups on how to perceive or create technology are of central interest within this approach (Brey 1997; Bijker, Hughes & Pinch 1987:12-13). The social construction of technology also implies that symbolic and ideological values are written into the technical artefacts, and they are often said to be designed by men for men. Several papers state that archaeological fieldwork as a whole has such male connotations (see Wylie 1993; Diaz-Andreu & Sørensen 1998:8). In feminist and gender studies of technology the androgenic connotation is often highlighted, and central issues are how existing gender constructions influence the development of certain techniques and vice versa (Wajcman 1995; Berner 1997; Nyberg 2001:39-62; Mellström 2001; Trojer 2002; Leonard 2003).

ANT works with the concept of networks to discuss how knowledge and technology are created, accepted and spread (Latour 1987, 1988, 1998, 2005; Callon 1987). The process of creating a network is called 'translation' in ANT terms. It involves defining the problems, persuading other actors to see things your way, designing appropriate artefacts and charging existing technology with new values. In this way, artefacts can be 'enrolled' into the network. The concept of the network can compile very heterogeneous bits and pieces into an analytical whole. Within ANT all nodes in the network are given the same status, whether they consist of humans or non-humans (actors and actants), which is an attempt to avoid social determinism. The analytical equality of actors and actants has been severely criticised, as things do not 'act' of their own accord (see e.g., Amsterdamska 1990; Hallberg 2001:26-30). For an archaeologist, this is of course familiar territory. Within post-processual archaeology and material culture studies, it has long been established that artefacts can have different meanings in different contexts or for different groups, and that objects can be 'activated' in certain circumstances. Material culture is not a mere reflection of society; it is an active component in the human ideological formation and perception of the world. It can be a tool for the powerful but also an oppositional force. Material culture does not simply respond to human activating; it also to a certain extent shapes our perception. Object and subject form each other (Karlsson 2000; Edgeworth 2003; Yarrow 2003). This dialectic between actors and actants implies that the social and the technical are completely integrated.

THE OFFICIAL STORY OF COMPRESSED AIR TECHNOLOGY IN ARCHAEOLOGY

We start by presenting a key text from 1967, where two of the archaeologists involved set the agenda for the work on adapting compressed air techniques for archaeological purposes (Ambrosiani & Hagberg 1967). We will scrutinize the text from the theoretical perspective we have outlined above, and by using archive material and interviews we try to open the 'black box' created in their paper to make a more detailed study of the processes of innovation, implementation and closure.[2]

The authors start their paper by defining the problem that compressed air technology is the solution to. The problem was not perceived as something inherent within archaeology itself, but rather as a consequence of processes in the Swedish society during the 1950s and '60s. There was a great increase in infra-structural construction work and excavations had to be undertaken before any ancient

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[2] We are grateful to our colleagues for sharing their personal experiences with us.

Fig. 1. Demonstration of the use of a blow pipe and 'earth-sucker' (Ambrosiani 1972:61).

monuments were allowed to be destroyed or moved. There were, however, too few trained archaeologists to deal with all the work, and the work itself changed as well. Large-scale land development meant that huge areas had to be excavated, and monuments had to be completely removed. Traditionally, archaeologists would excavate single graves in a grave-field, but now the whole site had to be excavated, including the areas between graves. The Law of Antiquities from 1942 stated that any company wanting to develop the land also had to pay for excavation of any monuments and settlements concerned. For the developers' planning, archaeologists had to come up with budgets and cost estimates as well as time plans. Time pressure became a new component in archaeological work.

The authors state that the true archaeological work of measuring and excavating was only a small part of the total work to be done. Removal of topsoil and rough cleaning of the area were the two heaviest and most time-consuming parts. The solution "had to be" to use technical means to rationalise work, and that compressed air "must be" used (Ambrosiani & Hagberg 1967:4). Previous experiments with compressed air implements to clean cairns and stone settings had been troublesome as the force of the air stream was uncontrollable.

At this stage, in 1962, contacts were established with Atlas Copco.[3] Three of the company's employees were specially mentioned, the engineer Östen Carlsson, assisted by the instructor Carl Åke Pettersson, and the director Pelle Löfström. For several years to come, experiments on a wide range of their standard tools were made in archaeological excavations, with close collaboration between Atlas Copco and the engineer Rolf Näslund of the National Heritage Board. Gradually functioning adaptations were developed, including vacuum cleaners, special nozzles, pneumatic spades, sieves, conveyor belts, brushes and other implements. Two of them seemed more promising than the others, namely a blow pipe and a special vacuum cleaner, very literally called an 'earth-sucker' (ibid:15).

In their paper the authors state initial problems and common questions from colleagues. One frequent objection was that not only earth but also finds and bones would be blown away. This was countered by the new nozzle that allowed

[3] Atlas Copco is a Swedish company that produces such tools for an international market.

the archaeologist to determine the force of the air stream and by changes in excavation strategy – the blow pipe should be used for rough cleaning work on graves of stone and not on layers with find material.

In their conclusion they define the value of their experiments as well as the overall benefit to every actor involved: the individual archaeologist, who will get more and better work done with the same input as before; the land developers, who get efficient work for their money; and finally, the government and funding agencies who pay for research (it is not clearly stated, but we assume the improved excavation work is their benefit). Further experiments would give rise to even better techniques and increase the possibilities of a really efficient excavation method that gives good results (ibid).

It should be noted that most of the work with compressed air implements was focused on graves, not settlements.[4] The whole purpose of cleaning graves was to make their structures and the stones they were made of clearly visible before they were documented by vertical photography with a turret. The blow pipe replaced the older method of cleaning with brooms. The conveyor belt, though, came to be used on settlement sites.

In ANT terms, we note how the authors define the problem as well as the main actors and actants. As they put it, the network consisted of the archaeologists within AED, developers (bringing with them the concept of economy), government authorities (deciding on huge infrastructure investments), the Law of Antiquities (with the judicial system), Atlas Copco engineers (bringing technology, inventions, and special skills), the archaeological sites, and finally the compressed air implements (the earth-sucker and the blow pipe).

The authors' text gives a rather closed or finished picture of the processes involved in bringing compressed air technology into archaeological fieldwork. The arguments put forward were based on a notion of rationality and technicality and presented the chain of events in the same way. Certain elements of negotiation and attempts at translation are visible, as in objections from colleagues or in the collaboration with Atlas Copco, but the text does not reveal how the implementation was made or how the cooperation with Atlas came about.

By means of archival material and interviews, we aim to open up these arenas for a more detailed study.

THE INNOVATION PHASE

The text referred to above was written towards the end of the innovation phase, which started in 1962 and ended around 1968, when the techniques were described as fully implemented (Ambrosiani 1968).

In earlier texts another range of arguments had been used. It was pointed out that compressed air had been used in archaeology before, already in the 1940s

[4] In the geographical area most affected by developments, Iron Age grave-field was a common feature, more so than in western Sweden, for example.

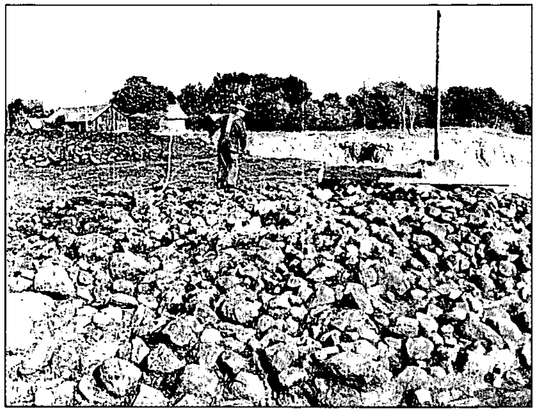

Fig. 2. The use of a blow pipe for cleaning a cairn in Våmb, Västergötland in 1959 (ATA, Vg, Våmbs sn, Persberg).

by Erik Nylén of the Department of Archaeology at Uppsala University. At that time it was used for rough cleaning of graves in Lekarehed on Gotland. Another prehistoric context was the cleaning of cairns in Våmb near Skövde in 1957-59. Medieval archaeologists had used compressed air to work pumps and as blow pipes to clean renaissance floors (*Arkeologisk grävningsmetodik* 1964; Hagberg 1966). In later texts such historical legitimisation was not emphasised.

As mentioned above, contacts between the AED and Atlas Copco were established in 1962, and their standard equipment was tried out in excavations over the next two years. A 'vacuum cleaner' was tested the first year, and a blow pipe, which was originally intended for removal of ice and snow from the railways, was the next to be tested (Ambrosiani & Hagberg 1967; ATA Up Skepptuna sn). It became obvious that the tools had to be adapted to suit archaeological work, and the first evaluations discuss possible improvements (ATA Sö Nacka sn Sickla). At this stage, it seems Atlas was willing to lend their standard equipment, but not to engage in anything further (ibid).

The cooperation was intensified in 1965, when the AED undertook an excavation on the Atlas Copco premises. A small grave-field was removed to make way for a new warehouse. The Atlas Copco information director, Pelle Löfström, approached Björn Ambrosiani (head of AED) with a suggestion for cooperation with a specific purpose, namely to design an archaeological excavation tool to be presented to the Swedish king Gustav VI Adolf as a birthday gift (Ambrosiani, in press). The king was trained in archaeology, had participated in several excavations, and took an active interest in archaeology in general. This argument united the two actors and provided them with a common goal, which resulted in an increased investment from Atlas and the establishment of a 'compressed air group' within AED (Damell pers. comm.). In theoretical terms this would be an excellent example of translation between two otherwise heterogeneous organisations.

The thought of a potential archaeological arena was not new to Atlas, though. Their equipment was used in the raising of the flagship Wasa (1956-61). The divers used a blow pipe to loosen the mud in shafts beneath the ship, and a suction apparatus for its removal (Lundström 1968). They created an adapted blow pipe nozzle to suit their purposes (Clason & Franzén 1959). All the equipment was delivered by Atlas Copco (Munthe 1966). The company also provided some of the equipment for the Abu Simbel project.

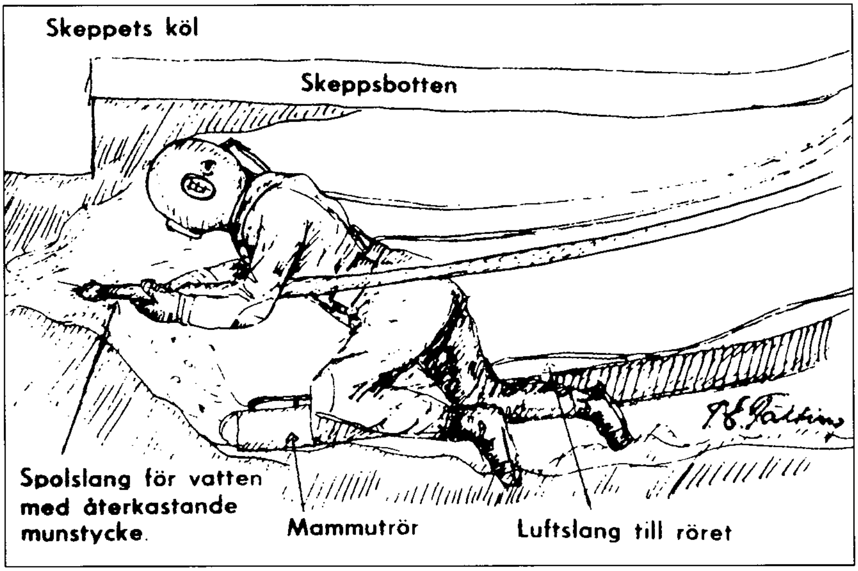

Fig.3. A drawing illustrating the use of a blow pipe and a suction apparatus in the raising of the flagship Wasa (Clason & Franzén 1959:24).

Apart from the specific use and PR in working with media-covered projects, there was a more symbolic aspect to be gained for their trademark. In a short history of the company, the many uses of compressed air were listed. Not only was it used to cut rock, but also to fly jet planes, thaw snow, run respirators, and drill teeth. To all these was added its use in science, "yes even in romantic scientific contexts", by which is meant archaeology (Munthe 1966:95). A "romantic" birthday gift to the king from a large industrial corporation would be a materialisation of their ambitions.

During the 1950s and '60s the company had an active strategy of research and development, with a special branch for this purpose. Existing technology and tools were improved and redesigned in close cooperation with ergonomic experts and with the clients. The aim was to widen the field of application for compressed air technology and ultimately to open new markets (www.atlascopco.se).

Fig. 4. The use of a blow pipe during excavations at Acquarossa, with King Gustaf VI Adolf on the right (Wetter, Östenberg & Moretti 1972:165).

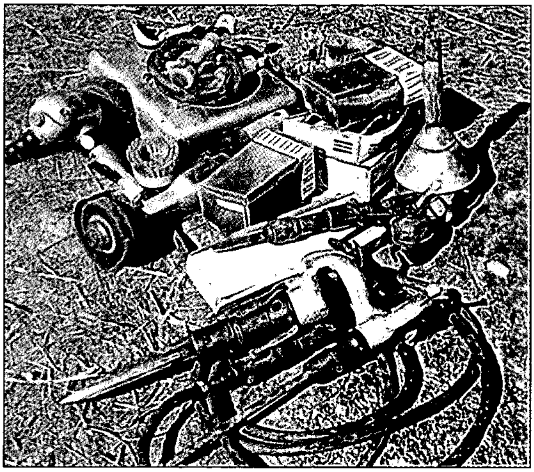

Fig. 5. Some of the pneumatic tools used during the excavations at Acquarossa (Östenberg 1968:19).

With the organisational expansion of the AED and the systematic incorporation of archaeology in urban planning and infrastructure development, Atlas saw a future market there (Ambrosiani pers. comm.).

The official arguments for the use of compressed air technology by the archaeologists themselves were based on rationality and economy, and the cooperation with Atlas could be seen as enhancing this aspect. Archaeology appeared as a well-integrated, modern and efficient service in society (Lagerlöf pers. comm.); "organizations as well as physical artifacts have to be invented for systems and actor worlds. If existing organizations of artifacts are to be used, then they must be translated" (Bijker, Hughes & Pinch 1987:14). Two rather heterogeneous actors could in this way benefit each other and join in a more stabilized network, where the next step would be to design (translate, inscript) the archaeological tool.

The increased investment by Atlas meant that they delegated personnel to the cooperation. This included Löfström and the engineer Carlsson as well as designers and technical experts. They were all willing to engage in the solving of the problems that the archaeologists had already defined. Many suggestions for new tools were made especially from the Atlas Copco employees. Among the things that never got beyond the brainstorming stage were the inflatable photography tower and a "pressure chamber" (ATA Sö Nacka sn Sickla), but Löfström also suggested things like a pneumatic sieve, a reel and a conveyor belt for removal of large amounts of soil. The archives show that these discussions were lively and took place at meetings between Atlas Copco directors and archaeologists, especially the management at the AED, but also internally between directors, designers and engineers at Atlas Copco (ATA Sö Nacka sn Sickla). These tools were first drawn and designed, then built in the Atlas Copco workshops and finally tested in actual excavations. The archaeologists in the field made their own evaluations and tried certain adjustments (see e.g., Nilsson 1972). The experiments also attracted some attention from archaeologists abroad (Joëlsson 1968; Lagerlöf 2002:49). The intended users were not, however, the archaeologists themselves; instead the relevant social group was the unskilled labourers present on most excavations during this period (Damell pers. comm.; re. relevant social group see Pinch & Bijker 1987).

THE IMPLEMENTATION

How was the implementation of compressed air done in practice within the AED enterprise?[5]

Fig. 6. Demonstration of a pneumatic spade during the excavation at Sickla in Nacka County (Hagberg 1966:42).

In the negotiation within the core set of archaeologists, i.e., area managers and team leaders within the AED, there was no agreement. This can be seen in the filed protocols of the digging courses mentioned in the introduction to this paper. The content of the courses was of course decided by those organising it, and contained their definition of what was to be seen as relevant problems. Excavation costs were high, and the financier had the right to expect the most efficient archaeological work. The answer to the problems was also already provided – rationalisation. As a background for this, especially time-consuming aspects were identified through careful studies of time management, and solutions were suggested. The clearance of the excavation area along with topsoil removal was estimated to 30% of the total excavation time. Further cleaning was another 30%, while vertical photography using a turret counted as 10%. The last 30% was described as "the proper archaeological part" (AED Protokoll fört vid grävningskurs 1967).

Although we concern ourselves with compressed air in this paper, the rationalisation covered almost all aspects of excavation, including photography, drawing and tents for year-round excavations. There was special focus, however, on the stages preceding what was considered the proper archaeological work. That meant clearing and cleaning work, i.e., those operations performed by the unskilled labourers. The calculation of costs operated with two variables: the extent of the excavation area, and the amount of labour hours. This resulted in a specified sum for each square metre (AED Protokoll grävningskurs 1968).

The discussions at the digging courses were sometimes lively, but generally kept within the frames already provided by the management (AED Protokoll grävningskurs 1966, 1968). The process of design continued to some extent. Some of the archaeologists experimented with compressed air implements in their excavations and reported on results, positive or negative. Most implements

[5] We have to point out that the AED was only one of many actors within Swedish archaeology. Most university archaeologists were doing something else entirely, and in some regions archaeologists were busy with other kinds of technical experiments. When we refer to 'the archaeologists' in this study, we mean those working within the AED of the National Heritage Board.

were, as we have seen, quickly discarded. This was true for the "reel" (Sw. *haspel*), which was designed to cut straight lines through the turf to enable faster removal of the topsoil. It consisted of a cutting tool attached to a wire and a compressor, which reeled in the cutting tool. The arguments for abandoning this implement were primarily functional. Every time the tool touched stones, roots or tree stumps, it jumped around too much to be of any practical use (AED Protokoll grävningskurs 1968).

Over time the discussion focused on the two implements which came to more extensive use, the blow pipe and the earth-sucker, and opinions were both negative and positive. Sometimes differences in regional conditions, such as heavier soil or different kinds of graves, were put forward as arguments for not using compressed air in certain circumstances. Moist conditions were no good either, as the earth then clogged up within the hose (sometimes resulting in strange "ceramic" shards with corrugated "decorations", as the earth within the hose dried up, cracked and came out in the sieve). This was countered by using special cleansing needles (Ambrosiani & Hagberg 1967:11). The argument of finds being scattered by too forceful air streams was countered by adapting the nozzle so the force could be manually regulated.

As we have shown, the negotiation within the core set comprised both verbal discussions and practical experiments. The courses themselves can be seen as arguments in the negotiation but also as a means to implement the technique in question.

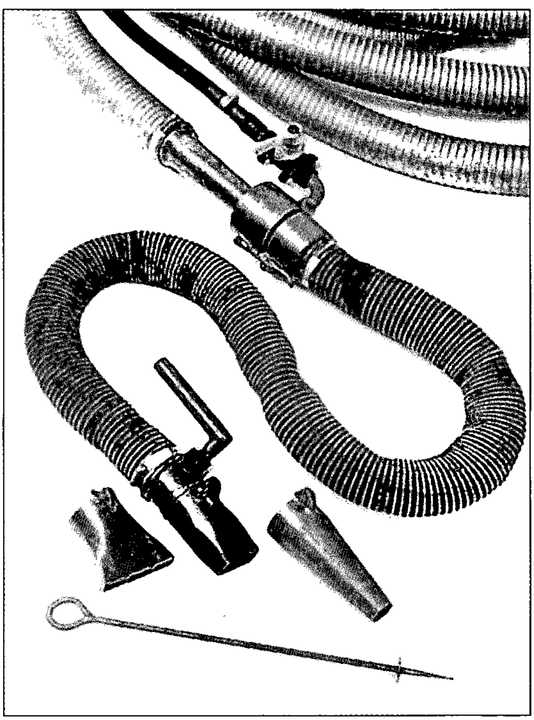

Fig. 7. An 'earth-sucker' with different types of nozzles and a cleansing needle (Ambrosiani & Hagberg 1967:11).

SOCIAL REORGANISATION AND IMPLICATIONS

Large-scale excavations and the increased use of technical implements implied that fieldwork had to be reorganised. Well-defined groups or task forces appeared: the archaeologists (with a certain hierarchical order), technicians and unskilled labourers. All aspects of fieldwork were assigned to either of these groups, so that the 'true' archaeological work was documentation and excavation of special features, while topsoil removal and cleaning were detailed to the unskilled labourers. This was a heterogeneous group, which could include men from the unemployment agency, the financiers' own work force, or local handymen. In practice, they were often the ones using the new technical implements (Svedberg pers. comm.; Särlvik pers. comm.).

For the archaeologists, leading such a work force on a professional basis was a new, and not unproblematic, task. The Atlas Copco manager Pelle Löfström suggested that special foremen should be employed to supervise the labour force to get the most out of them, as the archaeologists seemed unable to keep them up to speed (ATA Sö Nacka sn Sickla). The problem had been noted among the archaeologists too (Ambrosiani pers. comm.), and was put on the agenda of the digging courses (AED Protokoll grävningskurser 1966-69). Ambrosiani in his turn suggested that the labourers should be experienced with the kind of work required (ATA Sö Nacka sn Sickla). By 1969, it was proposed that a team leader should have no more than 3-4 students and 6 labourers, and that the technicians should be put in charge of measurements and establishment of systems of coordinates in the field. In the personnel lists, the technician Rolf Näslund was listed as "compressed air engineer" (Ambrosiani 1969:4). In some areas, specialised groups of labourers had emerged that were accustomed to archaeological work and which were employed regularly (Ambrosiani pers. comm.; AED Protokoll grävningskurs 1967).

Gradually, an ideal procedure was modelled, which comprised six steps. Firstly, the ground had to be cleared of trees and bushes. Secondly, a system of coordinates was established by the technician, who also made a plan of trenches in cooperation with the area manager. A photographer or the area manager photographed the site as well as the individual features. In the third stage, a system of sections covering all features and spaces between them was laid out by the area manager in cooperation with the technician. All sections were then measured and drawn. The archaeologist made notes on all features before starting to excavate them. The section trenches were dug down to bottom, and were again measured and drawn. The removal of the topsoil was the fourth step. This could be done manually or with a backhoe, bulldozer or excavator depending on the situation. The labourers and the area manager all had to be involved in this. The cleaning with compressed air was the fifth stage and was performed by the labourers. In the sixth and final step, an archaeological team under a team leader dealt with the excavation of graves and the registration of finds (ATA Sö Nacka sn Sickla). In the evaluation of cost efficiency and strategy, the Täby excavation comprising an area of 8000 m2 was used as an example. It was estimated that 1,200 labour hours had been saved using the new technology, i.e., 1.5 months' work (AED Protokoll grävningskurs 1966).

This idealization of excavation strategy and use of the compressed air tools had been designed into the implements right from the start. This could perhaps be compared to what Madeleine Akrich calls the script, where ideals and expectations are built into the artefacts in the design process (Akrich 1992). "In technological design, constituencies inscribe a vision of the world into the designs. Designs consequently embody a script: They harbour expectations about the characteristics of users, social relations, the use environment, and so forth, and stimulate or even demand conformity to this vision" (Brey 1997:8-9). The use of compressed air 'demanded' changes in excavation strategies and was a factor in changing the social formations in fieldwork.

Different groups within the organisation experienced the technology in different ways. The management recognised one group of romantics, who were hostile towards technology in general and compressed air in particular (Ambrosiani pers.comm.; see also Joëlsson 1968 and Östenberg 1968). For some, it had too heavy industrial connotations that diminished the craft of excavation (Browall pers. comm.). The noise of the machines was one part of the archaeologists' objections (Östenberg 1968). Others approved and saw the opportunity to spend more time on the excavation of finds than on the cleaning of structures. In some cases it was also used to improve the social relations between archaeologists and labourers. It gave the latter group the opportunity to acquire special skills which resulted in an increase in both self-confidence and status (Särlvik pers. comm.). In some instances it was the archaeologists themselves who used these implements. You were expected to handle the technology as a professional, and it did not matter whether you were male or female (Hårdh pers. comm.). This could give rise to situations of negotiation of social roles in the field, as when two young female archaeologists were encouraged by their team leader to use the blow pipe to clean stone settings. They tried without success to start the compressor, all the time watched by a group of older labourers, until finally one of them relented and gallantly came to the 'rescue' of the young women. The situation contains a complex web of gender aspects, age and status differences (through education), which could be consciously manoeuvred by any one of the individuals involved (ibid).

In practice, area managers and team leaders had the freedom to choose not to use compressed air, and in the excavation reports of the late 1960s and '70s such exceptions are visible. The arguments put forward are usually those already mentioned, like too heavy soil,

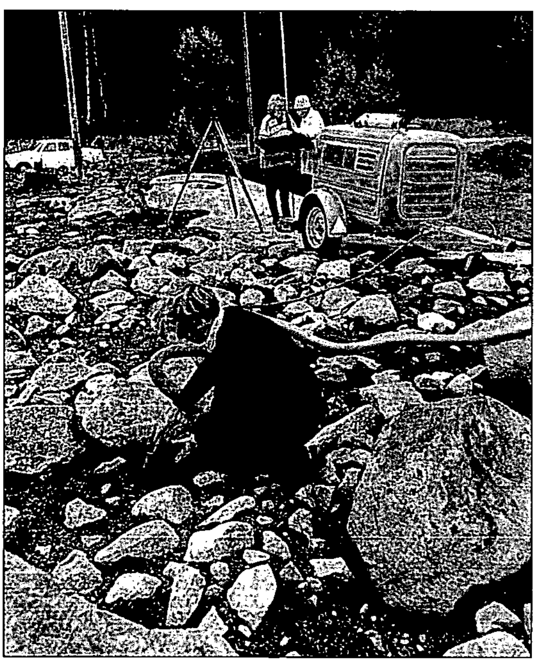

Fig. 8. An Atlas Copco compressor in use on the excavation in Täby, Uppland (Joëlsson 1968:23).

moist conditions, or graves not suited to such treatment. Otherwise, most reports either state that the excavators have used the "normal" or "standard" methods, or do not mention the method at all. That compressed air was used in such excavations is evidenced by the photographs, where the occasional compressor or blow pipe can be seen (e.g., Hedman 1982; Nagmér 1982). "When the social groups involved in designing and using technology decide that a problem is solved, they stabilize the technology. The result is closure" (Bijker, Hughes & Pinch 1987:12). Such closure does not necessarily imply any final solutions, but rather the temporary end of some disagreement or controversy. The interpretative flexibility decreases over time (Pinch & Bijker 1987), or seems to do so from a rhetorical perspective. "The use of compressed air in archaeological excavations can be considered a permanent application and is now part of the normal method of archaeology" (Ambrosiani 1970:3, our transl.). Due to the increasing number of excavations, the management had declared a couple of years earlier that it was no longer possible to spare any personnel for further development of new tools (Ambrosiani 1968:3).

RENEGOTIATION AND OBSOLETENESS – OR...?

> Fieldwork has been more rationalised through a number of technical methods; topsoil removal by machines, cleaning using compressed air, a mechanical sieve, vertical photography using a turret etc. We dig faster than we did in 1968, but do we dig better? To rationalise the methods we already use has been easier than to develop new ones. We have not questioned our "standard procedure" enough. To a certain extent we have let ourselves be duped by the technical aids (for instance cleaning with compressed air is to be used even on types of grave-fields where this is clearly inappropriate). (AED Fältarbetsmetoder. Kritik och diskussion 1978, our transl.)

This was submitted as a basis for a discussion held at an area manager meeting in Stockholm in 1978. It is a sign that the use of compressed air was about to become obsolete within the AED.

Several converging threads led to this. The network promoting compressed air had started to fall apart. Atlas Copco disappeared from the scene having realised there was no future market within Swedish archaeology (Damell pers. comm.), the AED could not afford to assign personnel to the technical development, and later changes in the AED organisation scattered key figures. Without their interest the technical aspects of the AED enterprise became unfocused for a while, and later it changed direction. At the same time, the education of archaeologists changed, too. The number of archaeologists increased (Welinder 2003:45-47), and during their studies they took excavation jobs to get the necessary experience. The composition of the excavation work force gradually changed, with more educated archaeologists and fewer unskilled labourers (Hedman pers. comm.; Damell pers. comm.). This implied that the archaeologists themselves became the main users of the compressed air implements, and they had a different perspective on it than the labourers. The scattering of finds meant something else to the archaeologists than to the labourers. This became one of the aspects of the internal critique of the technique. A new argument put forward was that it was considered filthy, heavy, noisy and even dangerous. The compressed air technique was hence redefined; the earlier closure was mere rhetoric since the interpretive flexibility never ceased.

Another thread was a changed awareness among archaeologists of what kind of sites they were dealing with. Up until the start of the large-scale developments, archaeologists had to a great extent chosen what objects to excavate and how to do it. The change to a formal organisation and to new excavation strategies (like topsoil removal between graves, etc.) revealed new aspects of the sites in a systematic way. It became more common to find settlements beneath the graves, and to realise how little was known of their extent. To remedy this, it became more frequent to remove topsoil with machines outside the grave-field. The ideal strategies mentioned earlier were developed for an archaeology of graves and had no settlement equivalent, and gradually we can see a shift in the focus of the organisation from graves to settlements (Damell pers. comm.). The internal conferences focused on all aspects of settlements, and the methodological work concentrated on excavation strategies. Other regions and archaeologists had been busy with such questions for a longer time, and their competence was now sought after (Moberg 1963; Cullberg 1973, 1975; Hägglund & Andersson 1979; Kaelas 1999:117-120). The regional AED office in western Sweden worked together with Chalmers University of Technology to try out geophysical methods for surveying constructions under ground (Andersson, Sandberg, Wigforss *et al.* 1979). One obvious difference in strategy concerned the vertical photography with a turret, which did not fill the same documentary purpose at a settlement excavation (Damell pers. comm.). This implied that the area did not need to be cleaned in the same manner as graves, and that compressed air implements became obsolete at such sites. During the 1980s the use of compressed air quietly petered out.[6]

Here the story of compressed air technology within Swedish prehistoric archaeology could end,[7] but instead we have found a new beginning. In her first year at the AED's western office in 1989, Anna-Lena Gerdin used this technology in cleaning a cairn. She had never previously used this method herself, but had heard of it during her work on Gotland (Gerdin pers. comm.). Other archaeologists at this office followed suit, and compressed air was thus used a couple of times in the 1990s. The excavator in charge found it of good use, and would use it again where appropriate (Munkenberg pers. comm.).

[6] Ulf-Erik Hagberg used compressed air technique during his time at UV-Öland and Skara Museum in the 1980s (Hagberg pers. comm.).

[7] Compressed air is still used in marine archaeology and in certain contexts within medieval archaeology.

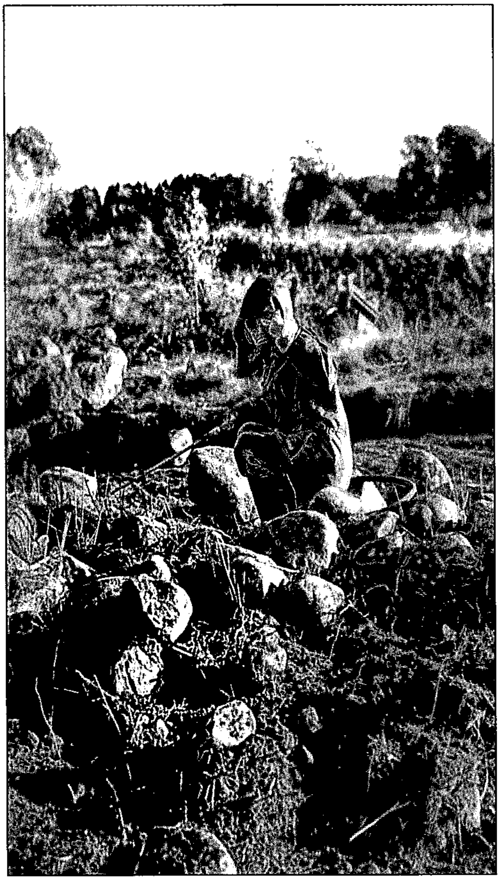

Fig. 9. The archaeologist Louise Olsson cleaning a cairn in Stenstorp County (RAÄ 41) in Southern Halland, photo B. Westergaard (Strömberg 2000).

Since then compressed air has been used by others as well. The arguments regarding its advantages are similar to those put forward in the 1960s: using compressed air is effective and improves the quality of documentation by photo, whereas the cleaning of stone structures by hand is considered hard and time-consuming (Berglund & Sjölin 2005:30-31). With a trained eye and by using the right air pressure, the risk of blowing away smaller items is minimal (ibid). Hence, the quality of the compressed air technique, its drawbacks and advantages, has once again been renegotiated.

CONCLUSIONS AND BEYOND

In this paper we have presented an alternative perspective on the history of archaeology in general and its field techniques in particular. One ambition has been to illustrate the complexity of the innovation and implementation of new techniques, with special focus on the social and material aspects. In this particular case, we have shown how the technical arena consists not only of technology, but also of economical, political, judicial and social aspects. The social organisation of fieldwork is one aspect of the discipline's knowledge production, which has to be empirically described before attempts are made to evaluate its relation to results.

Our results, although primarily historical, also have implications for issues in the present and in the future. Firstly, we want to emphasise the importance of considering not only the economical, ergonomic and 'practical' aspects when developing or introducing new techniques in field archaeology, but also the social aspects. By using historical studies we can learn that new techniques most certainly will have effects on the social structure in the field in various degrees. Initially it is therefore important to deliberate how and for whom it will be designed and implemented, and what social effects it might have on certain groups (women, men, those who are technically inclined and those who are not, different generations and groups with different status within the archaeological community).

Interpretative flexibility means that archaeological field techniques will always be under negotiation, which means they ought to be regularly evaluated.

Secondly we want to highlight the issue of power and control on the development of and the right to use any newly developed technique (cf. Bijker 1995:279-290). In 2004 the Swedish government appointed a committee to evaluate the future role of the AED of the National Heritage Board. One conclusion put forward was that an increased competition in the market of rescue archaeology would probably stimulate 'good quality' and be more cost-effective (SOU 2005:80, p. 136-137), and in consequence it is suggested that the AED should be cut loose from the Board to become a free agent on such a market. Yet another suggestion is that, although the Board would have a supervising role, "the development of methods and technology should primarily be left to the 'market'" (SOU 2005:80, p. 132, our transl.).

As our study has shown, the negotiation surrounding any implementation of new methods or techniques is a complex process, with actors both inside and outside of archaeology (developers, state organs, etc.). It is usually expensive and time-consuming to begin with, and any actor on the 'market' will probably carefully guard such investments. One scenario is that many actors will hesitate to make any investments at all, another that several actors will develop their own new way of doing excavations. We will not argue about whether there is any intrinsic value in developing new techniques or not, or whether a pluralistic situation with several contemporary ideals of technical and methodological solutions is a bad thing. As a matter of fact our study shows that there have always been, and will probably always be, geographical differences when it comes to archaeological practice. Instead the important questions are who will take care of the scientific evaluation if new techniques turn into business secrets? What will happen when different social groups have different opinions on what is good or bad technology? Who will have the power to decide what is good and what is bad archaeological practice?

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