Tool Marks and Construction in Ancient Tanis

Olivier Lavigne

Ancient Tanis was a new town created on the Nile delta during the XXth Egyptian dynasty (Brissaud 1998, p. 13). It was an important port on the eastern or Tannic branch of the Nile, and its location made it a departure point for the eastern Mediterranean, particularly Byblos. Smendes (who reigned from 1064 to 1043 B.C.) made Tanis the Egyptian capital (Grimal 1988, p.404). The town seems to have been designed as the Thebes of the north (Brissaud 1998, p.13), and major building works, in particular the temple of Amoun, were started. At that period Egypt was open to the outside world and several dynasties were of foreign descent, the Libyan (XXII dynasty), Ethiopian (XXV dynasty) the “Saites” (XXVI dynasty) and the Persian (XXVII dynasty). With the increase in trade the peoples of many different Greek cities held prominent positions as merchants and mercenaries (Grimal 1988, pp. 457-458 and 465-471).

Tanis, nowadays, lies in ruins. The Nile delta has no good building stone, so if buildings fall into disrepair, all the stones are re-used. The majority of stone-built buildings, including the temples, have completely disappeared because they were built with Torah limestone (a fine-grained limestone, homogenous, half-firm, white-cream in colour and with a cutting coefficient of around 6, De Puter, Karlhausen, 1992). All of these stones have either been reused or turned into lime (Bavay, Bovot, and Lavigne 2000).

The great temple of Amoun, with its east-west orientation, had a sacred lake and four wells within its walls plus the Tanis Royal necropolis. The oldest well, Fougerousse’s well (Fougerousse, 1935) is near to the second pylon. The three other wells are clustered towards the north of the temple courtyard. Nowadays they are known as Petrie’s well to the south, the Square well, the largest, is to the east, and the Round well to the west. These latter two were found in 1946-47 by M. Pierre Montet (Montet 1952, pp. 125-128), whilst Sir William Flinders Petrie discovered the well that bears his name in 1883-85 (Petrie 1886, p.13).

In 1995 M. Philippe Brissaud, the Director of the French Excavations Mission of Tanis became interested in the area around the wells. These wells are some of the few remaining standing structures still in a good state of repair. A survey and a detailed study of the stones had become urgent, because of a rapid deterioration in their condition (Evrard 1990, Lefur 1984).

In order to understand monumental building stones from the point of view of a professional stoneworker, a process for studying and analysing tools marks has been developed (Lavigne 2003). This method has been tested on two of the extant structures at Tanis - the wells known as Petrie's well and the Square well. The research concluded with an architectural analysis, and the results are given in this paper.

The purpose of this study is to understand the different technical methods in use throughout Egyptian history. This subject has been only partially studied, and in little depth. The chronological and geographical influences on tools and their usage have always been neglected. For this research project care was taken to collect more information about tools and tool marks to aid our understanding of development and comparison (Abou Roach 2003, Denderah 2004). The first part of this analysis will deal with this new information and give a context in which it is possible to discover the technical schemes.

AN INTRODUCTION TO THE METHODOLOGY

This method was developed at the instigation of M. Philippe Brissaud. It works towards an understanding of the direction of the marks made during construction. The existing indications, although fragile, are plentiful, and consist of the different marks which distinguish different tools. As with the discovery of a new script, we must find the key to interpretation. This includes an understanding of the surrounding archaeological evidence and the need to avoid looking at the methods of the past through the eyes of current practice, even though this must be the position from which we begin to understand the origin of tool marks.

The method starts with a detailed observation of each face of each stone. It is necessary to discover sufficient information to be able to distinguish the tool used, whether it is sharp, rounded or flat, a chisel, point, stoneaxe (facing hammer), or toothed chisel (claw chisel) (Leroi-Gourhan 1971, pp.58-59; Bessac 1986; Bessac 1999, p.23-35).

This study is concerned primarily with the evolution of tools and equipment. What is even more important than the actual tools is the way in which they were used to work the stone. The slope of the mark, and hence the angle of the tool is revealing in that it enables us to deduce the position of the worker. If the marks are fan-like and go from right to the left, then the centre of the segment so described is the place from which a right-handed worker worked. Of course each example is different, depending on the type of stone face, whether it is a bedding or resting surface, a joint face or an outer face.

Such an investigation can only be undertaken when specific conditions are met. The marks must still be legible, and this depends on the type of stone and the effects of weathering and pollution. The state of preservation of the building may make study impossible, for if the building is a total ruin the stones are generally unusable, and this is also the case if a building has been recently restored (Bessac 1999, p.21).

All this information, laborious as it is to collect, becomes fruitful when cross-checked with a detailed architectural analysis of the building. It includes a stone by stone analysis, which allows the comparison of tools marks with information on the action of the tools and the handling direction. This helps us to understand the organisation of the building yard. Often the work was done on site and a thorough examination of tool marks reveals this. Working postures become clearer and may throw unexpected light on building yard organisation, the number of workers on the site, the geographical origin of the stones and the use of scaffolding.

From the remains of the marks we are able to study tool handling directions which by combining the different directions in which links are made will give us more information, and allow us to understand the technical logic of schemes. (Amouretti 2003, pp.41-42).

AN ANALYSIS OF PETRIE'S WELL

Petrie's well is of the same type as the other wells in Tanis. There is access to its lower parts by stairs. When the well was discovered the building was described as having a straight flight of stairs covered with stone lintels (Petrie 1886, p.13). There is a landing inside the well leading to a spiral staircase which follows the walls of the well allowing water to be drawn even during dry periods.

The building has several different types of stonework: big and irregular stonework with joggle joints for the stair walls, although the north and south walls have different stonework. In the well, units of irregular big or middle-sized stonework may be observed, with both joggles and skew joints. A third type of stone between the big and small stones has been used for stairwell construction. The well was ruthlessly quarried immediately after the departure of the discoverer and the resultant damage has revealed the heterogeneous nature of the construction with its three main types of building work.

It is easy to see that the well cylinder is the oldest part of the structure. During latest excavations a walled-up lower door was found, a discovery which is completely unprecedented. This door is connected to the very first stairs, originally surveyed by Sir Flinders Petrie, and are on the same axis. There is therefore have a way down, which has been extensively modified, and it is not known if these stairs have one or two flights. Meanwhile it is apparent that stairs going straight to the Square well must have been hidden when this last staircase was built.

The second trench shows a radical modification to the access. When the lower door was walled up, the upper door was formed by breaking through the existing masonry, and a new outdoor staircase was built. This new staircase had two straight flights with a landing. Today the first flight, with a north-south orientation is in ruins. The second flight is still partly visible because it lay under more recent work. Instead of completing this access (the straight stair does not go down the well in the opposite direction to the original, an architectural trick so as not to have to dig down so far), a spiral staircase was built in the well. This latter way down stops at the bottom and it uses the very first steps of the original stairs, in order to have access to the lower parts.

From these final modifications it seems that the ancient Egyptians tried to get more space on the surface of the courtyard. To do this the spiral staircase was heightened, and that is what Petrie saw along the well cylinder, rather than the earlier arrangements. The landing and the outer stair go from two flights to a single steeper flight with the first step just down from the upper door. This step is jammed with a "torpedo" crock (from the XXIVth dynasty to Ptolemaïc times). The outer face of the stair walls was resurfaced and hollowed out so it could receive the new steps. The same walls were lengthened in an easterly direction where they joined the back wall, which was built at the same time.

The results from the three working trenches will be compared. Those from the first and second trenches are similar and will be compared with those from the third trench which differs in a number of ways.

The quarry

Stone blocks are squared in the quarry. This work is done with stone picks or sharp points. The point work is often done in two opposite direction, thus digging some deep grooves. It looks as if all the six faces were worked without reference points, which could happen in rough working. All the raw faces had been worked.

Preparatory cutting, or workshop cutting

The very first cutting work consists in defining the plane of the resting face which is used as a reference (Golvin Larronde 1982; Noël 1994; Bessac 1999, p.48; Golvin, Goyon, Simon-Boidot, Martinet 2004, pp.285-289). These were very well worked. To get a flatter face, points and chisels with round edges were used and the work was finished with a facing hammer, or sometimes a big chisel. The use of these finishing tools erased many of the marks, the only ones remaining are those under the plane. These marks are regular and clearly describe a fan as in the example of facing hammer work. The problem is with the levelled face: it must not be irregular or it will be difficult to finish. The ancient Egyptians checked the levels of the stone face using diagonals. This method is illustrated in the Rekhmire tomb's drawings (Newberry 1900, pl. XX), and it is still used today, especially for final dressing work.

The joint faces are only worked near to the outer face. The worker in this way forms a crude anathyrosic band that helps the blocks juxtaposing. The rising joints, as can be seen in the outer face, are no more than two millimetres in breadth in contrast to the back of the wall which while they have a greater breadth, are irregular and rough, but they were not made to be visible. This space, which is wedge shaped for the circular parts and oval for the straight walls, is filled stone chips and mortar on which we still can see the drift done by the stone layer's hand when he try to salvage the excess mortar. It looks as if in this construction trench and the next, that only one joint face is worked during preparatory cutting and that the other face is worked once the stone is in place.

Having examined the resting surface and joint face, the work on the outer face can now be considered. This begins with an examination of the common edge between the two faces, one for the resting surface the other for the joint face. A square is set transversely on the resting surface so the plane of the outer face can be drawn to determine the amount that must be removed during the final dressing. This plane will have these edges because the margin is bevelled and neatly worked with a facing hammer used parallel to the edge. The surface is finally dressed at the very end of the work. This avoids splintering whilst the block is being handled. The resting bed, one joint face and the outer face's down and lateral edges are completed and the stone is ready to be laid.

The block is upside down and the putting bed is therefore the upper surface. If it is transported to the building yard and left like this until it is incorporated into the wall thus protecting the work that has already been done and making for ease of handling. The block will be laid by tilting it over and up, a method which allows for easy control. This way is also easier as the plaster and limestone dust mortar hardens quickly, and helps the use of the transverse and lengthwise wedging system which will be examined later in this paper. Before moving on to a discussion of this, we must first look at work on the bedding face of the lower stone course.

Cutting in place

This operation is the one that left the most tool marks. Technically, this work looks like the resting surface. It is done with the same tools with the exception of the facing hammer, which is used more frequently. It is clear that this work is done in situ as tool marks overlap stones and mortared joints. The tool handling shows the work was done from the inside of the construction. The joggle on the bedding surface may be used for three reasons: the first is to use materials with the maximum efficiency and least waste, the second is to make a kind of horizontal quoining and the third is to have a similar method of working for each unit in an era before standardisation or prefabrication.

Work must be done when the joint face is in place. This is undertaken by the same method as used previously. Adjustments are made to the wall so new blocks can be incorporated. Each stone has a unique position measured out for it. This might help explain the number of joggles seen in all pharaonic construction.

On the bedding surface two kinds of cavity are hollowed out that will help with laying. The first one is either rectangular or half oval. They are placed in the middle of the breadth of the block near to the joggle. With the help of a lever or a crow bar it allows the length of the stone to be wedged correctly. The second kind of cavity is rectangular with rounded corners. The larger side goes inside the block, flush with the outer face and near to the joggle. The same kind of tools are used to lay two stones sideways, one at the top the other at the bottom. If the hypothesis of tilting over and up for laying stones is accurate, these cavities play an essential part in carrying this into effect, because the process of laying stones must be very fast, as discussed earlier. These cavities must therefore be in exactly the right place, and they are used for a very short time.

The construction trench (from before the XXVIth dynasty, that is before the middle of the 7th century B.C.}, offers a magnificent example of work done jointly by an experienced worker and an apprentice, with recognisable tools. On the well bedding surface the posture of the workers shows that less than half of the work is done by a right-handed worker at the north, and that most of the work has been performed by a craftsman working left-handed, although this soon returns to right-handed work. The laying cavities show that the work is carried out from east to west. In this situation right-handed men can work on the northern wall, but work on the southern wall must be done left-handed otherwise the facing hammer handle will be impeded by the stone on his left hand. The point at which the work meets is worked with different tools, proving that the workers were between the two stones which were in place. The work on both sides of this bedding surface has been done with flat facing hammers of 60 mm for the finishing work, and 29 to 33 mm breadth chisels with a round active part of 1 to 3 mm for roughing out and stick stitching. The forehead cutting has been done with big chisels (49 to 54 mm breadth for 1 to 4 mm round) and smaller tools of, between 28-29 mm. We have here a insight into a complete set of ancient equipment. Finally, it is apparent that the work was undertaken by two right-handed workers, one of whom also worked left-handed and completed more of the job than the other. This is typical of an apprentice learning his craft, while his skilled and experienced master works faster and more accurately.

The third construction trench is partly composed of the building of the stair well supporting the spiral stair, and the arrangement of one straight stair. Not many marks are to be found in this trench. There were a number of marks on the re-cut stone from the preceding trench, but they are evidence of a different technology. These works have several peculiarities, the first being the equipment and handle link. The most important part is the slanting cut of the joint face drafted margin, especially those done with the facing hammer, (in other examples they were perpendicular). As they were done either on site or at the workshop, this means not only a different technique than that used for the rest of the building, but also different equipment, a good quality stone axe that allows a job to be half roughed out. These different tools lead to several unexpected consequences. Firstly, the relationship between the craftsmen and his equipment changes. From a finishing tool that produces finished work of a quality demonstrated by the thinness of the hatching and the straightness of the plane, a rougher tool leads to a rougher job, removing more material, but eventually producing work as accurate. This way of working allows an easier working position, the strokes are more emphatic and working time is reduced as this method is faster. Finally, this is a new phase for the stone cutter because the facing hammer may be used to work vertically. The bulk of the tool is no longer a restraint, and a new type of stone working is permitted. This has an effect on the shape of tools, as a level-headed tool shape is better suited to this working method.

The drafted margins of the joint faces have been done. The face rest is roughly worked, with some little chisels, from 13 to 28 mm breadth. The joint faces are quite level and no longer concave, they have big jags which helps the adhesion of the mortar. The stones, just behind the steps which are still in place today, have roughly radiant joints opposite to the well bedding surface. These two joint faces look as if they have been worked during the preparatory cutting. Bedding surfaces are less characteristic, nevertheless, they are distinguished by a deeper stitching on the entire plane, with the same tools as the joint faces. The stones are frequently ones that are being re-used.

The same equipment is used, whatever the surface worked, whether bedding or resting surfaces, joints or outer faces. This is the only location where this has been observed. It could mean either that this work was done by a single team who completed the entire job, or alternatively that there was less work organisation compared with the earlier work. This is confirmed by the tools and the way in which they are handled. The evolution of equipment is different for different crafts such as quarrymen or stone cutters. This is clearly shown in the use of the sharp point. This evolution can be found in several construction trenches and some are close together in time. (The lack of wear on the steps in the second trench could be due to the third trench being worked soon after). Different tools are seen such as the flat chisel (third trench), the flat toothed chisel (third trench) or the sharp point (first trench for the quarrymen, third for the stone cutters). It is more than likely that they reveal a new kind of metal being used to make the equipment, in particular the change from bronze to iron. However these transformations seem to have been slow, and new and old tools are often used together (third trench). At the top of the outer stair walls, a new stone cutting tool, the flat toothed chisel used for re-cutting the back middle wall, appears. These are in common use today and are used as much for scraping as for finishing work. The one being used here is a crude tool, a kind of prototype. It is a round-ended chisel, the same kind of tool frequently used during the second trench, but the active part has been cut in two. It was exclusively used for roughing out and is an adaptation of an old tool.

There are also new ways of handling the tools, and facing hammers in particular are used in many different ways, especially for roughing out. But perhaps the specialisation of facing hammers covers all aspects from finishing to roughing out. This is remarkable because all other tools change in the other direction by become specialised, especially flat toothed chisels and small or big chisels.

Even though there are not many objects for comparison, the facing hammers are used in a way that looks more Greek than Egyptian. But they are also close to those studied at Abou Roach in a much earlier period.

This comparison leads to questions about the way in which the joint faces are worked. It is clear that at Abou Roach that one of these surfaces is worked in situ to the measurements of the stone that is to be placed next to it. It looks as if the same thing happened in Petrie's well, possibly on the first, but definitely on the second trench construction, at a more recent period (before the XXVIth dynasty), and it disappears with the third trench. An understanding of the working of joint faces is key.

THE FINAL DRESSING OF THE SQUARE WELL

This building, unlike Petrie's well, is almost undamaged, with the exception of the top of the well. Its interest consists mostly in the final dressing which remains unfinished. Built at a later date, it stands comparison with other Egyptian buildings in the south. Access to the bottom of the well is by stairs at the north. These consist of two straight flights separated by a landing, the second flight being covered with nine stone flags. On the west pavement, two metres above the water, there is a small opening placed on a support. One course down, two brackets hold this opening.

The application of the method at this location gives unique results. It is possible to observe all the tools used and by examining the handling, it is also obvious that the resurfacing work was done with scaffolding, and from these observations the measurements and characteristics of the scaffolding may be calculated (20 centimetres for the scaffolds-poles) (Newberry 1900, pl. XXI; Clarke and Engelbach, fig 83, 1930; Goyon, 2001, p.9). This work brings up questions about its use during building construction, especially for the door's lintel. These levels are definite from the workers' postures. If we imagine a wall section, the position of the tray will be characterised by a kind of "pad" (*bourrelet*) loosely angular, softly sloped at the top and more sharply angled further down. The uncarved stone behind the scaffold pole, indicates the thickness and breadth of these pieces of scaffolding, which were almost certainly made of wood. There is a height of 1 m 70 between each platform in the well, and 2 m 10 in the staircase. From this latter measurement it looks as if the workers had an intermediate stage.

It was difficult to work behind the scaffolding poles so the areas of wall behind it were not resurfaced. These areas should have been completed whilst the scaffolding was being taken down. The shape of a pole can be seen on the west wall of the well plumb to the first stone lintels where some of the outer face could not have been worked easily. The shape of another scaffold is on the west wall of the well between the bracket and the south jamb of the opening.

It is remarkable that the walls around the first stair form three distinct areas of work. Three metres up from the water, (seven courses) there are no rough surfaces. Three courses up, half of these faces have been more or less worked, and all the rough surfaces are under the lintels. On the three last courses there are many more rough faces and particularly on the east wall where no faces have been worked. It looks as if, contrary to preconceptions, that resurfacing work was not necessarily done from the top to the bottom.

The final dressing, of about ten to fifteen centimetres, is done in several steps (Bessac 1999, p.51), sometimes by the same craftsmen. The drawn margin bevels are used as references. The work starts with a sketch, done with some little chisels used as points. It looks rough pointed, hits are not done in chains (*enchained*), and the tools breadths are from 9 to 12 mm. They are often present in the well. The purpose of this operation is to weaken the material so the next one can be easier and flatter. This first operation is less well known because there are so few of them. There is very little evidence of the use of flat toothed chisels, with two or three teeth. These are only down the well and the stairs case walls.

A large amount of roughing out work is done afterwards consisting in rough leveling out, with few reference points. The tools used are wider, between 24 and 52mm, and generously rounded, between 2 to 4mm. The use of this kind equipment can be observed as having been used on the staircase walls as the well walls. The work is done stone by stone.

The resurfacing finishing work is done in two steps, but before, we must cut out references. We call it "window witness" (Saner 1999, p.349), and they are approximatively square (we have taken measurement, on two windows witnesses serial one is perfectly line up). They are done a stickler on rising joints and are horizontal. They stopped at the drafted margin bevels angles.

After the references, there is a first passage that covers all the worker posture, and no more stone by stone like before. That is the reason to carve references. This time the work is fitter (*convenable*) and they hit less the tools because it is a more precise job. Before the ultimate step, they do a new references work by connecting all the windows witness. So craftsmen do a drafted margin (called "reference band" in Greek architecture, Saner 1999, p.348-349) in the plan and half on both sides of stones. The marks are slant (oblique). The last step is to work the surface levelling at the reference band and even erase these one. This work is done with chisels of 24 to 52mm breadth, but the 30 to 32mm group is very much more present. We got a remarkable equipment unity. Their active parts are flats or sometimes with a very small round, no more than 1 mm. These tools are used only for the last two steps of finishing work and for the references carving.

This work has been done by experienced craftsmen and their handling is very sure. Resurfacing work is a hard job, because the working position is difficult. Unfortunately, it is not possible to determine, even approximately, the number of workers, because the equipment is too standardised. However it is interesting to observe that a large number of the stonecutters were able to work with either hand. This can be seen by the working position of workers in the returning angles, and it looks as if most, if not all the workers were able to work with both hands.

These three different steps can be seen in Greek architecture (Bessac 1999, p.50-51). The made link looks the same as at Denderah's temple, on all the inside walls of the terrace. There too, the resurfacing is done with scaffolding made of wood too, but thinner than that used at the Square. Here also, we found the same resurfacing references schemes but this time they can be horizontal or vertical, as in Ionia. Resurfacing seems to have a long history. Similar things may be found at Abou Roach, but we do not have references, with few tools polyvalent like points, pickaxes, and few copper chisels. This can still be seen on Djoser's funeral complex, at Saqqara, on hard limestones, but we have seen exclusively chisels marks yet.

CONCLUSION

The made links studies, and comparison with other sites, allows a chronological sketch. It seems that the Greeks are the direct heirs (Martin) of this technology that took Egypt several centuries to develop. Greek technology and equipment are well known (Orlando 1968; Bessac 1986; Hellman 2002) because it is also a part of our inheritance.

It can be seen that technology in pharaonic Egypt was evolving, but this was frequently slow, and sometimes a little faster. Anyway, we don't believe in antic technology jamming (Vernant 1955 and 1957, Jockey 2003, pp.57-58). Equipment transformations, of material and even in the shape, the made link modifications (joint faces, windows witness) won't carry along technical revolution. This evolution, not revolution, will allow organisation structure to stay on (Valbelle 1985, Aufrère 1991) but it disappears in the Graeco-Roman world, which is not the case for the technology.

We should also consider another way of organisation, which was the origin of the preceding things. Egyptology calls them "sculptors", but they are not sculptors in the sense that we define the word today. Their work is confined to stone ornamentation and they generally worked on hardest stones, which were the most prestigious. They had very high level of knowledge about working out and geometry and we hope to be able to display when these things will be more known (Lavigne, making a palmiform column, in preparation). These craftsmen are the key to the Egyptian knowledge of geometry.

As we can see, all this breaks fresh ground in our technical knowledge of construction in pharonic Egypt. This area requires much more research, but we are always coming up against a lack of interest in such studies which are off the beaten track.

Figure 1. The sanctuary of Amon in front of the Psousenes' monumental door

Figure 2. Tool Marks

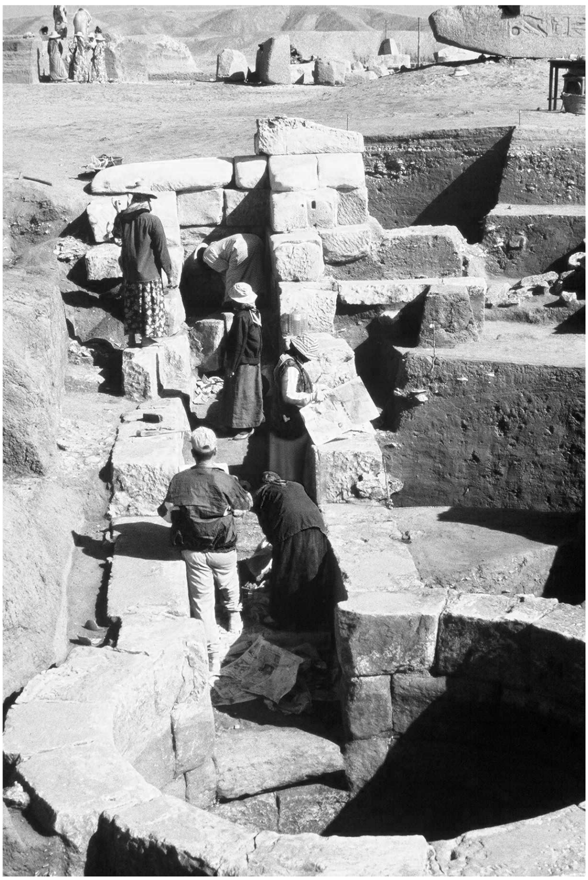


Figure 3. Excavation of Petrie's well

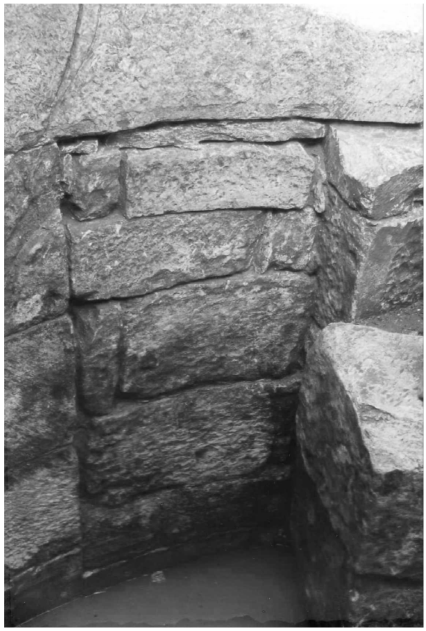
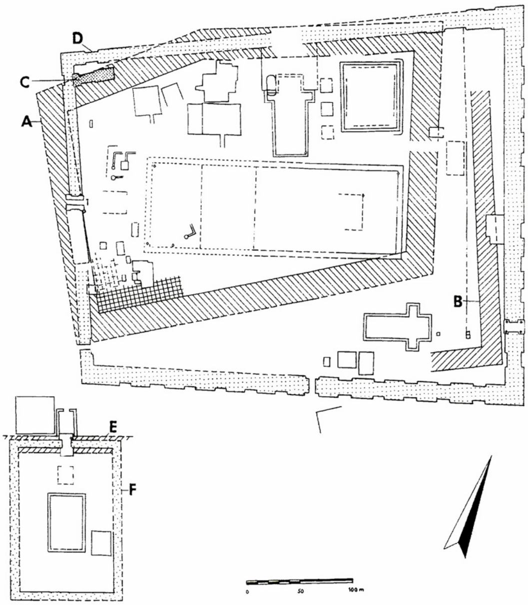


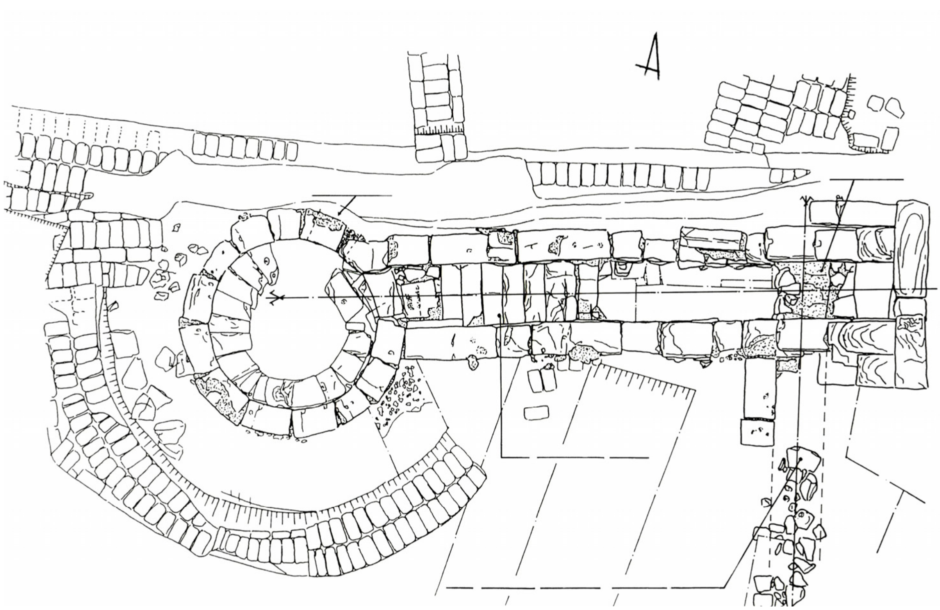
Figure 4. The walled up door in Petrie's well

Figure 5. Unfinished outer face seen down the second straight flight of stairs of the Square well

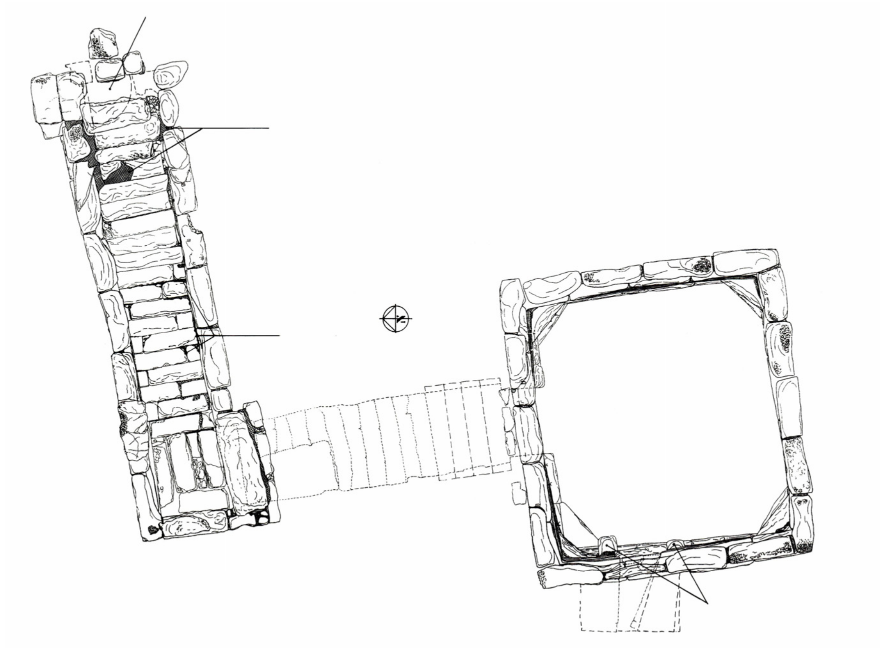


A. Psounenes I
B. XXth dynasty
C. XXXth dynasty
D. XXXth dynasty beguining ptolemaïc
E. Siamon
F. Late period

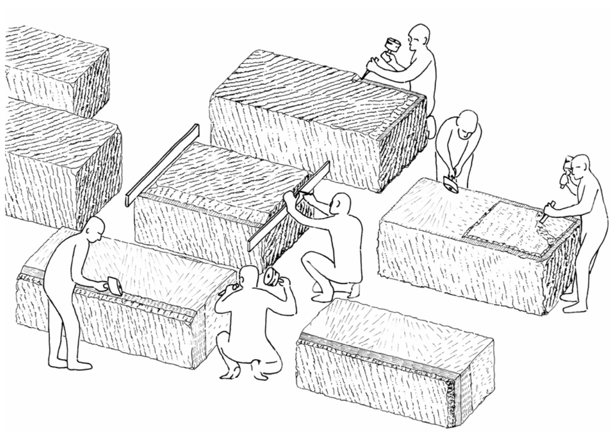
Drawing 1. Great Walls



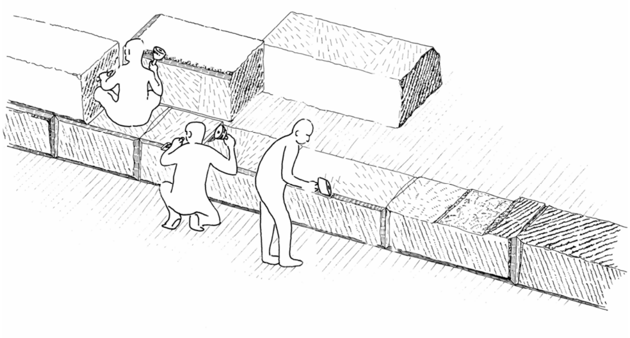
Drawing 2. Plan of Petrie’s Well (O. Lavigne)



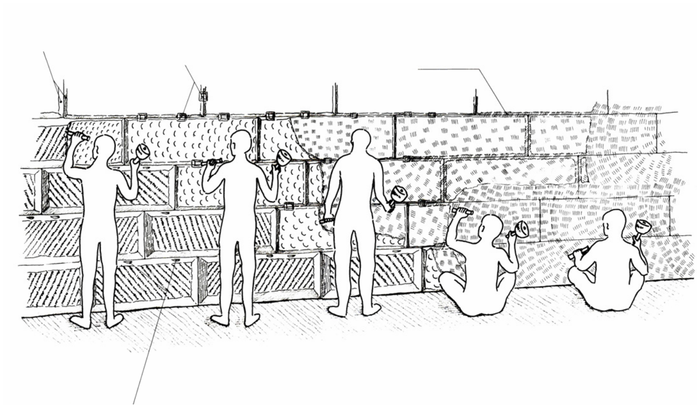
Drawing 3. Plan of the Square well (O. Lavigne)



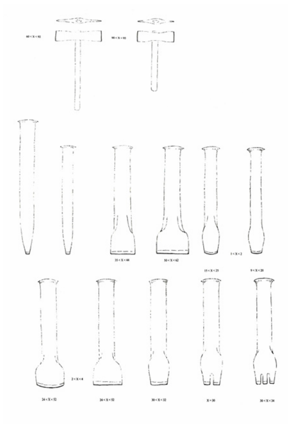
Drawing 4. View of cutting in the workshop (right handed working only: rough stone from quarries; drafted margins on the resting face; jevelled measurement [it is uncertain if work was carried out as illustrated in Rehkmira's tomb]; rough out; finishing resting face; dressing on joint face; cutting one bevel drafted margin of the outer face; stone ready to be laid)



Drawing 5. Cutting on site



Drawing 6. Final dressing of the Square well



Drawing 7. Tools used in the Square well (facing hammer for bevelled edge; facing hammer for cutting the stairs; quarry point; point marks visible on steps; little chisel for recutting steps; big chisel for recutting steps; chisel for the first rough out of the final dressing; chisel for the second rough final dressing; chisel for finishing the final dressing; the most useful chisel for finishing; flat toothed chisel with two teeth; flat toothed chisel with three teeth; chisel used only for the final rough dressing)

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