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Cisterns, Wells and Use of Water in the Mining and Quarrying Sites of the Egyptian Eastern Desert: A Special Focus on the Central Myos Hormos Road

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Introduction

The Eastern Desert has no oases except "Laqeita", so there are no permanent settlements and no agriculture, but wells can be sunk in most places, the fossil water-reserves under the Eastern Desert are not renewed, so the water-table has been sinking ever since desertification.[2]

Potable water would have been more easily located farther from the Red Sea and this must have been a major reason for placement of the road, where possible, some distance from the coast. Sometimes, deviations occurred in the road course such as the sharp turn inland for some distance in the case of the fort of Wadi Safaga due to the level of potable water.[3]

Journeys would not have presented insurmountable problems, as late as the New Kingdom and beyond, depictions of a range of desert animals indicate that during the pharaonic period considerable hunting activity could have continued. Indeed, it is notable that there have always been sufficient water resources to travel across the "desert" and that is true even today.[4]

Pictorial evidence for the central section which runs through Wadi Hammamat, with its quarries, cisterns and other features was attested in the Turin papyrus map of the 12th century B.C. [5]

Inscriptions record traders in the Roman early imperial period and the Roman road through the desert to Berenice on the coast. There are several wells which still give water along this route. Game and forage would have been available, so carrying large amounts of rations should not have been necessary. With the probable absence of large carnivores, and with water available, the only dangers would have been from the heat and any hostile nomadic inhabitants. All this suggests that movement through and even life in the Central Eastern Desert has been possible for small groups of people for many thousands of years. [6]

An inscription in Greek dated to 137 A.D. described the Via Hadriana as safe, level and supplied with stations or lodgings, watch posts and Hydreumata (fortified water points). [7] These *hydreumata* represent "Well" stops that existed along the northern route and they are discovered with huge piles of sand and other detritus. [8]

Pliny described the journey from Coptos to Berenice by camel passing by watering points placed at intervals along the route and an old *hydreuma*, called "Troglodyticum", where there is a fort which accommodates 2,000 people. He added that the greater part of the journey used to be made at night because of the heat and the days are spent at these stations.[9] An ostracon from Mons Claudianus recorded water distribution to no less than 920 people present on the site on a given day, the number includes at least 60 (and possibly more) who were certainly soldiers. [10]

Along the Eastern Desert trade routes, the army can be perceived as manning the fortified watering stations, patrolling the roads, and providing escorts for the caravans themselves. Large numbers of merchants, camels, donkeys and their handlers cannot have been permanently based at Quseir as there was no suitable infrastructure to support them. It is probable that the army presence too was removed, or, at the very least, thinned down between sailings whether a more permanent presence was required to guard the watering-places and thus deny them to those who travelled the routes for nefarious purposes — raiders heading towards the wealth of the Nile Valley — depends on the perceived likelihood of such an eventuality (the existence of a threat is apparent from the later 3rd century A.D. but it is considerably less clear earlier on.[11]

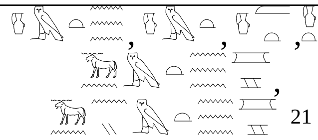
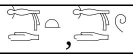
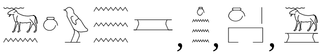
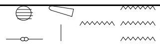
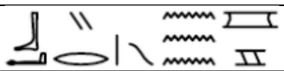
The Qift – Quseir road is the only area within the Eastern Desert where it is possible to see a degree of overall consistency in site planning, of the 9 intermediate stations identified along this route, 5 share the same general design and are of very similar size to one another. They are small *quadriburgia*, roughly square, single-entranced enclosures with projecting external corner and gate towers and with the internal buildings concentrating around the exterior walls. This leaves the interior space open and in most cases, it accommodates a well.

Water, wells and cisterns in the Ancient Egyptian Language

Water was referred to as mw (miw) , , , , (Greek: νερόν "*neron*") [12], (Coptic: moou, mwou, mau) [13] or nt , , . [14] It was also written as nnw , , , (Greek: Νουν, Νογn, "*noun*"). [15] The sign mw was used as a determinative to refer to the flowing boundless water. On the other hand, the hieroglyphic sign mr was used as a determinative to refer to the limited water regions such as pools, lakes, and rivers. [16]

The wells of the desert were the main water sources as they are away from the River Nile. Moreover, finding a well in ancient Egypt was considered as some sort of a miracle. For instance, Neb-Taui-Re was sent by the 11th Dynasty king Mentohotep IV (1997-1991 B.C.) to Wadi Hammamat. [17] He found there a well. According to the inscriptions of Wadi Hammamat, this discovery was described to be a miraculous event. Therefore, the ancient Egyptian was keen in recording the wells he discovered either in the western or the eastern desert of Egypt. [18]

Five terms were used to indicate wells, cisterns and water – stations since the Old Kingdom till the Late Period. [19]

	Term	Transliteration	Translation
1	 [20] [21]	Xnm.t	Well, cistern, desert well, well – station.
2	 [22]	Sd.t	Well, Cistern, Waterhole.
3	 [23]	Xnw.t	Waters, desert well, Well – station.
4	 [24]	xs n mw	Well.
5		Bar	Well, Bir (in Arabic)

Water and Supplies on the Myos Hormos Road

The primary need along the route was potable water that used to be secured by the *hydreumata* (watering stations) either from wells—often within the enclosures—or cisterns to which water could be carried. The Eastern Desert is a very arid region in which a typical rainfall, although infrequent, can be very intense causing a powerful flash flood (seil). The size of waterborne stones in wadi beds attests to the tremendous energy potential of these floods.

Examples of these damages can be attested after the 1979 flood that damaged and destroyed houses and caused loss of life in Quseir. Moreover, sections of road to Mons Claudianus were washed out and, in other sections, covered by stones weighing about 30 kg or by sand and gravel about one metre deep in 1986. Therefore, it should have been intense, infrequent rains such as these which supplied some of the water for the Eastern Desert *hydreumata*.

Natural catchment basins (qalts) in the mountains retain surface water, but these are unreliable due to the infrequent rains and few are conveniently located on the central desert route. Groundwater reserves are the most dependable source even though most groundwater is either very saline or brackish. During the Roman period, many water points were available. Digging through wadi sands in the Eastern Desert today, one can usually find water at a relatively shallow depth.[25]

Pharaonic inscriptions at Wadi Hammamat indicate that Egyptians dug numerous wells in the region.[26] A habit that continued during the Roman period but most of the Roman wells are probably not evident today due to obliteration by flash floods. Each station probably had its own well and it is possible that numerous other temporary small wells existed along the route disassociated from any major population centres. At many *hydreumata* the well was large, in some cases as much as 30 m in diameter. The free water surface of the aquifer may have been at the bottom of the large diameter excavation or there could have been a smaller diameter well at the bottom of this tapping the aquifer.

The most abundant source of good water along the route is at el-Laqeita, only few metres below the surface of which the agricultural expansion evidence the quality of this source. The Romans knew this source and made Laqeita a stop on both the Berenice and Myos Hormos roads, although the water now comes from very deep wells. [27]

It is evident that water supplies had to be protected; any cisterns in the stations were surely covered. the amount of water required by travellers/residents in the Eastern Desert can be approximated by:

- Drinking needed about 6 L/day per person.

- Cooking, bathing, cleaning, etc. may have raised the daily requirement up to about 20 L/day per person for the residents at the *hydreumata*.

As for the necessary water for those stationed in the *hydreumata*, it can be assumed that many travellers coming from the Nile carried their own water. However, those arriving from Myos Hormos depended on the Eastern Desert wells, as water along the coast was not potable due to high salinity and the source must have been inland. There were several large mining communities on the route which had a constant demand for water and, ergo, a relatively abundant source of drinking water. Water was probably used sparingly for small gardens near some wells. [28]

More important than agricultural use was the requirement for animals which varied with the seasons and the amount of moisture available in the food. A working pack animal-donkey in hot weather requires 10 L/day and about 20 L/day for a pack-camel. However, the camel's better ability to go without water enabled it to journey from the Red Sea to the Nile without chinking. Furthermore, camels can also drink water too saline for human consumption and about five times the salinity tolerated by a donkey, Thus, the camel was probably the preferred pack animal. [29]

Apart from the necessity of water, other alimentary supplies were recorded in the written material discovered along the Quseir – Qift road such as: Two ostraca from Wadi Fawakhir record deliveries made by the wagoners to the garrison at this eastern desert location. In one, the wagoner is not identified as a soldier and has an Egyptian name, which suggest that he is a civilian. [30] The text of this ostraca dates to the 1st or 2nd century AD, and at this early date in the imperial period, it is unlikely that Egyptians would have served in the Roman army, even in auxiliary units, this gradually changed during the late second century A.D when Egyptians were inserted in the Roman military posts.[31]

These facts proved that the *hydreumata* / *praesidia* were resided by both the Roman soldiers who provided protection for caravans travelling from the Red Sea to the Nile valley, the workers in the quarries and mines of the region, and the soldiers who were spent away from the Nile valley in the desert for a long period. Therefore, supplies brought by the civilians were essential. These civilians were involved in a substantial capacity throughout the empire, a phenomenon attested by the texts. Regular supplies to the army garrisons / *hydreumata* in the eastern desert of Egypt were attested through the archive of Nicanor, which concerns the business of Nicanor and his family during the 1st century AD. [32]

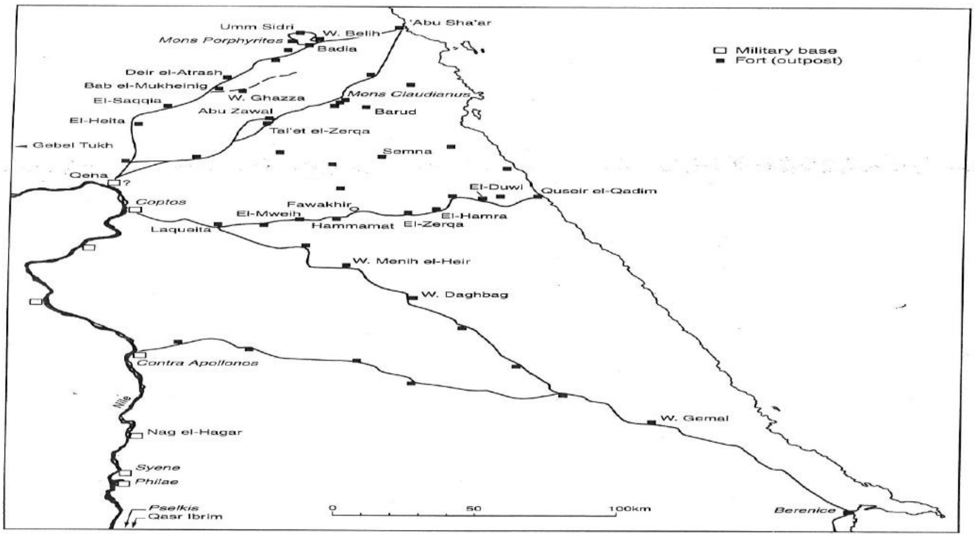


Fig. 1 Map of the *hydreumata* and military bases in the Eastern Desert
After, Maxfield, "The Eastern desert forts", 10, Fig.1.

Water – stations along the Myos Hormos road

The central Eastern Desert Myos Hormos road is supplied by nine square forts (*praesidia*) which can hold both a garrison and visiting caravans (animals and people). These constructions were supposed to contain a well (*hydreuma*). They were erected at a day's walk distance about 15 - 20 km away from one another. Each *praesidium* hosted a garrison of about 50-70 Egyptian auxiliaries and furnished rest and water to travellers, who had to pay a toll to pass through, the garrison also supplied sentinels for the signal towers and escort to travellers. [33]

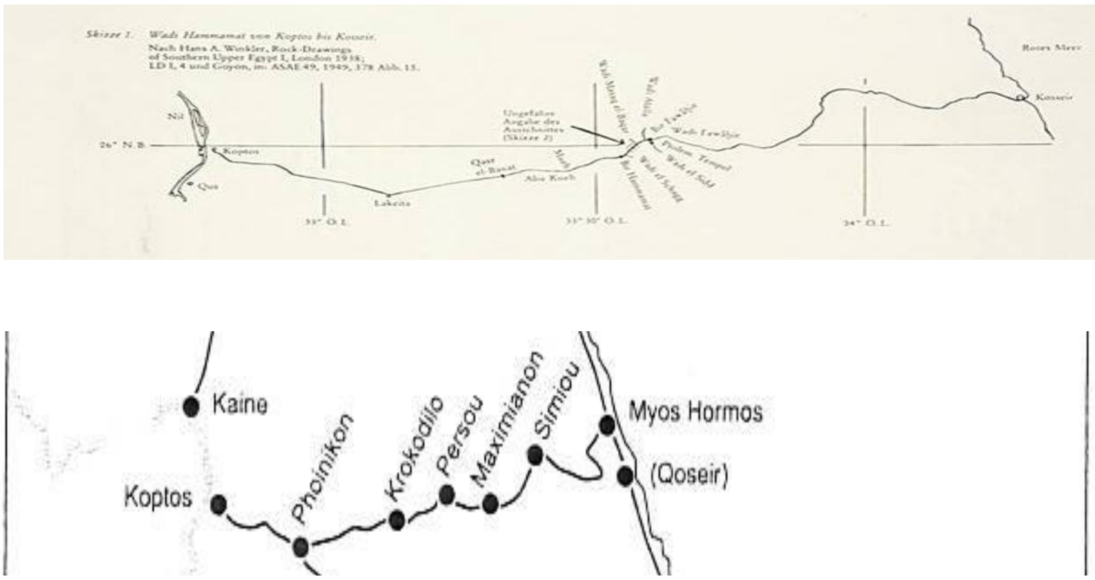


Fig. 2 Map of the *hydreumata* along the Myos Hormos road
After, R. Gundlach, "Wadi Hammamat", col. 1101 – 1102; Adam Bülow – Jacobsen, "Communication, Travel and transportation in Egypt's Eastern Desert during Roman times, 560, fig. 3.

I. Bir Al Nakhil

The site was largely destroyed in the 1950s. By 1978, it was thoroughly explored by the team of the University of Chicago led by Martha Prickett.[34] Then, the French expedition re-examined the field and drew the plan of the fort remains in 1998.[35]

The presence of easy to reach water, in a sector where it is so rare, attracted travelers and nomads. Therefore, it is legitimate to include the site between those who have played a role along the Myos Hormos road. Bir al-Nakhil is marked by some groves of palm trees and tamarisk growing on the northeastern foothills of the Jabal Dawwi. Several wells of modern times with a very close water table (average 1 m. depth), explains the presence of trees. There are also several dry sources nearby, that should have been important in the ancient times such as Ain Ghazal, known as Bir al-Ambaji, 10 km southeast of Nakhil. [36]

The water of Bir al-Nakhil is brackish, but the salt content is low enough to allow human consumption. A modern well is roughly dug in the center of the fort and another one, now partially filled, is located about 20 meters to the west. Bir Al Nakhil is different than the other *hydreumata* on the road as the well in the middle does not exist due to the proximity of the water, therefore, it was not necessary to drill large diameter wells, however, one or even more wells could have existed inside the *hydreuma* and disappeared after the course of landslides and destructions.

II. Dawwi
The well of Dawwi

It is possible that the digging of wells and the construction of *hydreumata - praesidia* show a tendency to rationalize the route, as before the construction of Dawwi, caravans should have gone directly from Bir Sayyala to Myos Hormos, which is 41 km, or to step in the *praesidium* of Bir al-Nakhil located at 35 km, which required a detour of about 10 km. However, it seems that the attempt to create a new station had not gained the expected success (most probably for the lack of water).[37] Piles of rubble lie on either sides of the southern entrance and continue along the east and west sides. These piles represent the digging rubble of a well that once occupied an almost central place within the enclosure. The Well has collapsed, taking all the surroundings and now, the excavation measures 15 to 20 m in diameter. A diverticulum sloping emerging northwest certainly indicates the remains of a staircase, as Maximianon, that should have provided access to the water table. [38]

III. Bir Sayyala

Before the French excavations, the *praesidium* was composed of an accumulated mass of ancient ruins around a modern well. Until the 19th century, the modern well was not yet constructed, however, its location was occupied by a circular depression indicating the existence of an ancient well. The existing well, built in 1832 by the English, is still used and seems to have been built of ancient structures that had been discovered during the cleaning of the collapsed Roman well. [39]

Fig. 3 The modern well.
After, photography of the researcher.

Now, the water level is at a shallow depth of about 10 meters. On the northern side of the fort, there is about one meter of rubbles from the digging of the well. The water level is shallow and the existing well appears to have an ancient origin that measures only 3.50 m of diameter for which the efforts paid to build the deployment should not have been compared to those required for large deep wells, such as those of Maximianon (diameter: 16 m) and Dawwi (estimated diameter more than 15 m).

The Cisterns

Three cisterns were dug in front of the northern barracks. They are constructed of lime and coated with an average of 4 cm thick lime mortar deposited in three layers. The western cistern is isolated, and it measures 6 m x 3.90 m, whereas the other two cisterns are connected, and they measure respectively 4.80 m x 3.85 m and 4.50 m x 3.55 m. [40]

Fig. 4 The Cisterns of Bir Sayyala
After, Brun, and Redde, “Bir Sayyala”, 181, fig. 165.

IV. Al-Zarqa (Maximianon)

The eastern curtain of Maximianon is traversed in the middle by another very carefully bricked rectangular pipe, located at 1.14 m height. A (0.27 x 0.27 m) section. It is internally coated with lime mortar and covered with squared stone lintels. There can be no doubt that this conduit was used to channel a liquid towards the exterior, that could have been either the water of the well for the animals staying outside the fort, or the evacuation of the sewerage. Moreover, excavations were executed under the curtain to discover the remains of either a cistern or a pit.

Fig 5. The pipe that passed through the eastern curtain After, Adam, Brun, and Redde, “Al Zarqa (Maximianon)”, Fig. 90.

Maximianon (Al Zarqa) has two pipes but it is hard to imagine that it has two latrines. if one of the two pipes (or even both) have been used to bring water from the well, it is possible that the eastern curtain belonged to an unfinished device that might have been an external trough. [41]

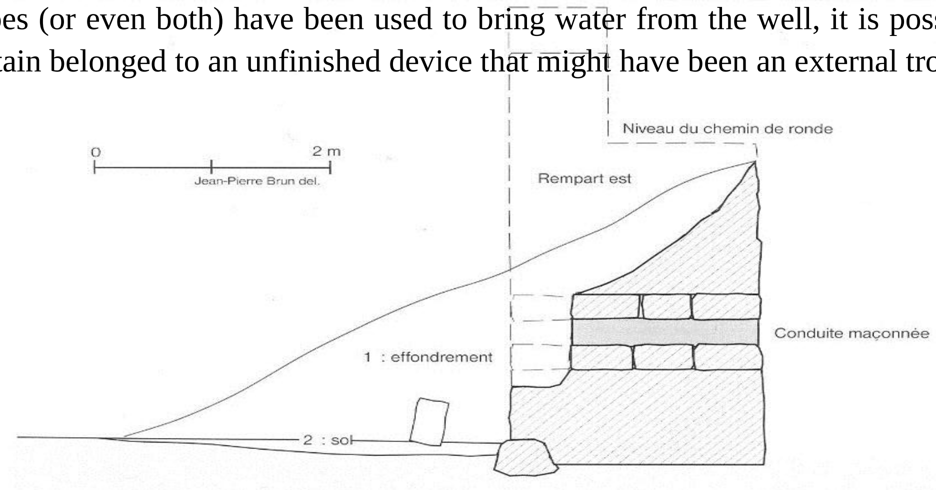


Fig. 6 A plan of the piping system through the eastern curtain
After, Adam, Brun, and Redde, “Al Zarqa (Maximianon)”, Fig. 89.

The Spa

A small bath complex existed in the northeast corner of the fort, positioned in a secondary level to the original soil. After the construction of two thermal rooms, the basin used to be entered by a small 0.68 m wide door, along the north curtain wall and it leaded to a 4 x 3.15 m room containing two tubs carefully built of coated and baked bricks of lime, measuring about 1.78 x 0.68 m, of which only the northern one is quite well retained.

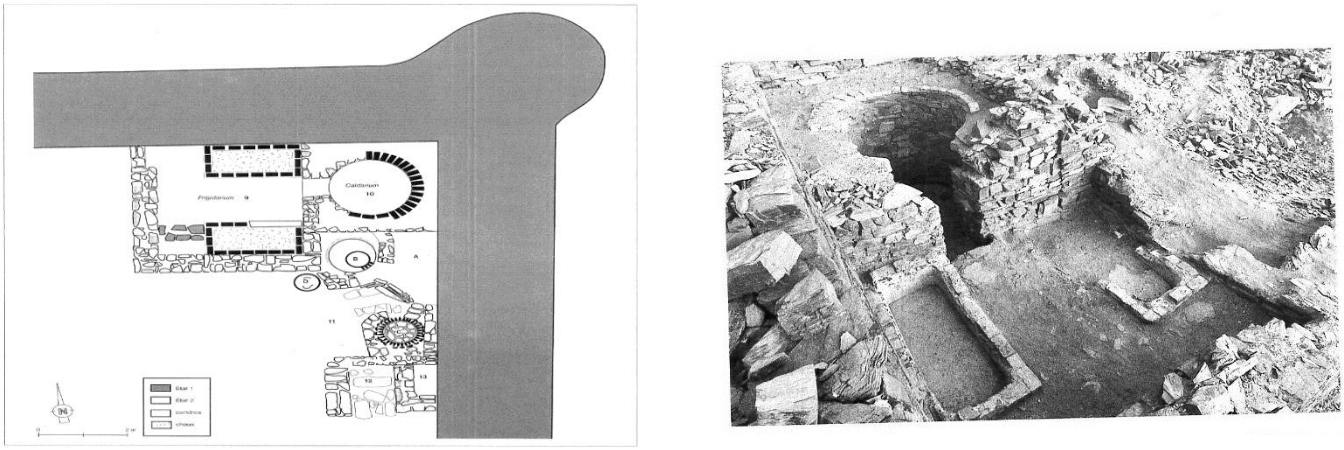


Fig. 7 The bath and basin of Maximianon.
After, J. P. Adam, J. P. Brun, and M. Redde, "Al Zarqa (Maximianon)", Figs. 103 – 104.

The inside of the door wall reaches the height of 0.60 m while a small ocher lime coating marks the upper limit of the bath. Below, the remains of white plaster are identical to those sealing the installation of the basin. Two successive floors were observed at the base of the baths:

I. A first schist pavement that should have covered the leveling course of a wall dated back to the first phase and its soil. This pavement included few furniture of mainly fragments of an amphora AE3 and a bowl. In addition to, a layer of ash that revealed some furniture (gourd, bottle, bowl, pot and amphora AE3).

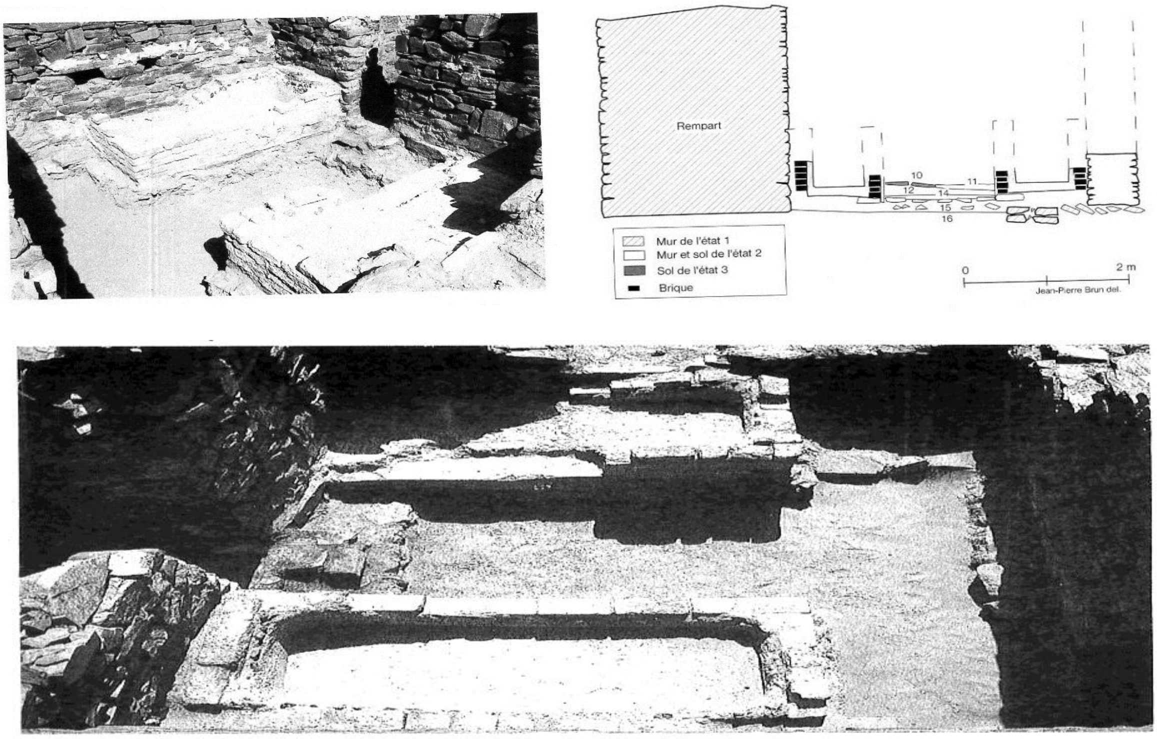


Fig. 8 Top left: The *Frigidarium*.
Top right: Stratigraphy of the bath.
Down: The schist pavement.
After, Adam, Brun, and Redde, "Al Zarqa (Maximianon)", Figs. 105 – 107.

II. The second slab was based on two levels of embankments formed of rubble and sand containing abundant furniture (10 gourdes, vases, cooking pot, Pompeian and AE3 amphorae and an apparent glass tumbler. This cold room opened on a hot circular room of about 1.80 m diameter. This stove, built of schist, was probably surmounted by a dome of baked bricks, of which only the single lower row remains. The floor of the (hot room) is situated in its southern half, in the form of schist slabs that rested on a sterile embankment down to the substrate.

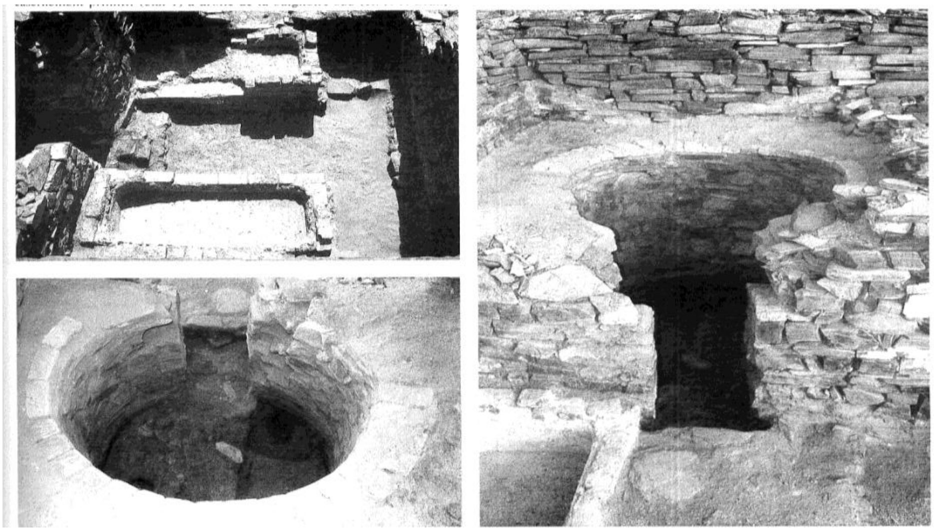


Fig. 9 The caldarium in the bath of Maximianon.
After: Adam, Brun, and Redde, “Al Zarqa (Maximianon)”, Figs. 108 – 109.

The Kitchen

The kitchen dates to the same time as the baths, after the construction of the fort. it contains a thermal room that dates to a second transformed short phase, it was established using fragments of jar and amphora bottoms and it must have been destroyed by a late refection.

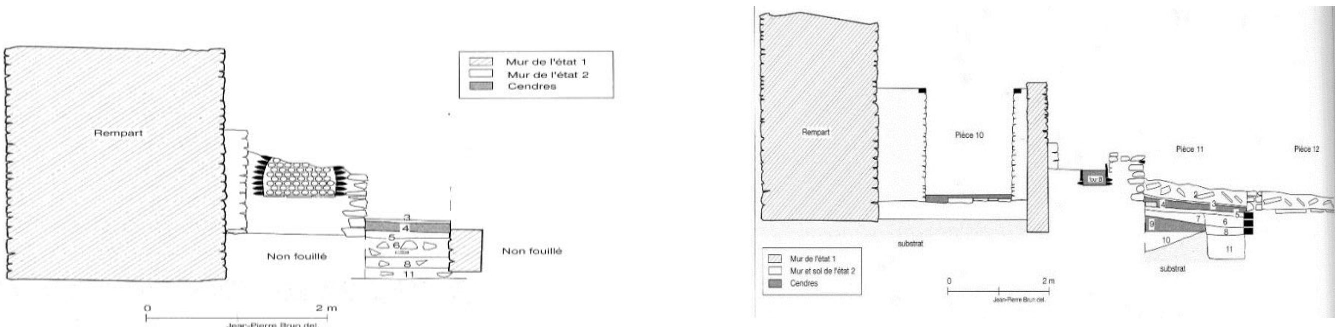


Fig. 10 Plan of the kitchen.
After: Adam, Brun, and Redde, “Al Zarqa (Maximianon)”, Figs. 110 – 111.

Fig. 11 The fireplace and the thermal room
After: Adam, Brun, and Redde, "Al Zarqa (Maximianon)", Fig. 112.

It presents a diameter of about 1 m, with a 15 centimeters' crown of amphorae bottoms around the masonry. A jar hole, of which base measures 0.36 m in diameter, is filed immediately southwest of the thermal room. The thermal room area was backfilled with stones after a period of use and a new layer of ash produced by the firehouse and the oven that was accumulated on the floor. The oven is particularly well preserved on the ash layer, with a diameter of 0.75 m. It represents a schist paved hearth whose elevation is made of tips of amphorae AE3, carefully recut and assembled in successive crowns.

The upper part collapsed, but the height of the oven till about 0.80 m can be restored. There had to be a large opening at the dome for fading and flat bread plating. A new soil was then laid out at the base of the ovens and the firehouse. Two depressions were built at the same time as the thermal room, one of these depressions may have been used as tightening or silo, but it was quickly filled by an embankment, while the second depression represents a schist paving.

During the using phase, the space between the furnaces and the firehouse has gradually filled with alternate beds of earth and ash until it reached the level of the firehouse. The furniture of these layers includes fifty amphorae bottoms, a handle of an amphora of Cilicia, a bottle and three gourds resized as cooking pots. In the final phase, the firehouse was filled with ash and detritus (burnet bones, sherds) and the oven was reduced. The proximity of the thermal spot brings also to consideration the use of these firehouses to heat water and possibly to prepare the coals used to heat the hot – steam room, which is a weak hypothesis.

The function of this set of houses is not clear, however, the presence of burnt bones, numerous pots, a jar and a stone mortar found in the rubble indicated that the kitchen was in that location. [42]

Fig. 12 The oven before and after the French excavation clearance.
After: Adam, Brun, and Redde, “Al Zarqa (Maximianon)”, Figs. 113 – 114.

V. Al-Muwayh (Krokodilo)

The barracks in the north side of the fort have almost completely disappeared. In the southeast corner, barracks give way to a large cistern constructed of lime. In the third construction phase, after an abandoning marked by a sandy deposit, the door was partially blocked by a wall. This wall was built with baked bricks, recovered in a building located inside the fort forming probably the cover of the cistern.

Fig. 13
The late wall that blocked the entrance
After: Brun, “Al -Muwayh (Krokodilo)”, Figs. 40 – 41.

The Cistern of Krokodilo

Despite the cistern is covered by a thick layer of rubble and sand, the leveling courses of the few walls were released. The walls are built of lime and covered with a fine white layer of lime and sand that covers the bottom. Two construction phases are visible. Initially, the basin measured 7.4 m (25 feet) x 8.5 meters (about 29 feet) to a depth of 3.35 or (11 feet) with a capacity of about 200.000 liters. In a second phase, a compartment measuring 4 m x 3.6 m (approx. 12 x 14 feet) with a height of 2.66 m was built in the northwest corner of the previous cistern walls. It cannot be determined if there is a settling basin or a reduction in the storage capacity at 37.000 liters. Both phases have left traces in the dump including a gravel deposit that could correspond to digging cuttings and a layer of lime wasted discharges associated with the construction of the large cistern. White washed stone and lime remains were also found, they could possibly correspond to the renovation phase, which would be placed in the (B2 phase) of the dump. The filling of the cistern is made of alternating layers of windblown sand and fine clay slurry, which show a long process of natural alluvial deposit after the abandonment of the *hydreuma*. In the bottom, some stones materialize an abandoned level. while no dating evidence has been revealed.

From the chronological point of view, these deposits contain datable furniture from the reign of Trajan. Moreover, the construction of the door and the digging of the cistern are dated to the period after 110 A.D. which is datable to the second half of the reign of Trajan. Therefore, this work campaign occurred between 110 and 115 A.D. [43]

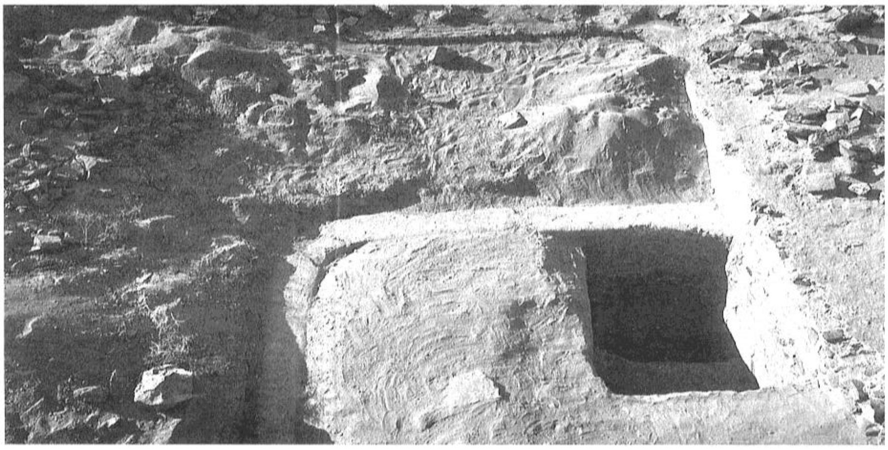


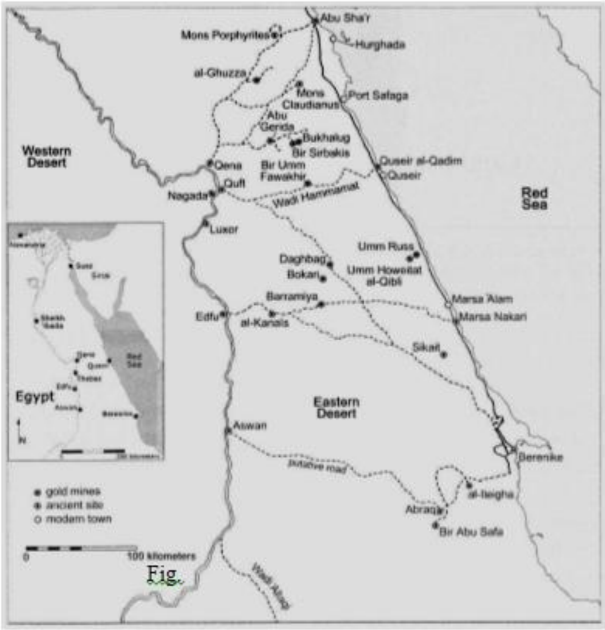
Fig. 14 The cistern of Krokodilo.
After: Brun, "Al -Muwayh (Krokodilo)", 145, fig. 44.

Water in the Gold Mining Sites

Egypt has a long history of gold mining dating back to Pharaonic times, an activity that continued by the Greeks, Romans and Arabs attested by the existence of worn waste piles and ruins at old mines that vary in character and suggest multiple periods of operation.

There are more than 95 known gold deposits and occurrences in Egypt, mainly associated with the Precambrian Basement Complex of the Eastern Desert. The last gold mine (Bir Umm

Fawakhir) was closed in 1958. It is worth mentioning that estimated 1,710 tons of gold has been produced from alluvial/colluvial and hard rock deposits.[44]



A B

Geographic positions:	
Fawakhir mine:	26°00′48″ N, 33°36′10″ E
Centre of the Roman/ Byzantine settlement:	26°00′36″ N, 33°36′27″E
El-Sid mine, administrative building:	25°59′15″ N, 33°36′23″ E
New Kingdom settlement in Wadi el-Sid:	25°58′47″ N, 33°37′04″ E

Fig. 15 A. The gold – mines of the central eastern desert. After: Sidebotham, et al. *The Red Land*, 214, fig. 9.1.

B. Bir Umm Fawakhir and Wadi El Sid area with the various ancient sites (Google Earth Image). After, Rosmarie Klemm, and Dietrich Klemm, *Gold and Gold Mining in Ancient Egypt and Nubia*, (Berlin, 2013),133, fig. 5.78.

The use of water in Fawakhir gold mine and settlement

Bir Umm Fawakhir is one of the characterized large, well-preserved and exceptionally complete sites along the Quseir – Qift road. The occupation of this area is attested from the Old Kingdom. During the New Kingdom, the most noticed evidence for the ancient Egyptian Bir Umm Fawakhir is the Turin Papyrus (20th Dynasty) that functioned once as a map of the “Bekhen” stone quarries in Wadi Hammamat and the gold mines of Bir Umm Fawakhir. [45]

The most obvious remains are dated to the Graeco-Roman and Byzantine eras, during the 5th and 6th c. and perhaps into the 7th century AD. in Jabal Shahimiyya (south of the current cafeteria) that was the most densely occupied. Bir Umm Fawakhir settlement is the largest ancient town in the Eastern Desert that used to be inhabited by more than 1000 miners who were inserted in a general organization of mining activities. It implied a whole chain of organized staff: many slaves who were either prisoners of war or convicts (“*damnata ad metalla*”), but also paupers, often with their entire families (for the rough excavation and transport work and for milling and washing the ore), guardians, few skilled free workers to maintain control, choose the rock and melt the gold, officials, and at least a *probator* (geologist) for managing the mines and the gold transport. Therefore, the organization of the operations was apparently complex and shows a certain degree of professionalism.

In later times, the walls of the huts would have been built of unhewn and non - mortared stacked stone (the locally available pebbles and cobbles of granite) with the roofs and perhaps also the upper walls constructed of thatch, the Ptolemaic and Roman workers would certainly have cannibalized these earlier structures when they built their huts. This continuous use of the site should have necessitated the existence of water resources either for human daily use or for the mining process. The actual existing ruins in the settlement site of Bir Umm Fawakhir which are preserved in the form of the grouped houses date back to the Graeco – Roman period. However, no doubt that an earlier and probably smaller New Kingdom settlement occupied the same site. [46] Estimating the size of the population, the total figure for all houses mapped in Bir Umm Fawakhir settlement (During the Oriental Institute first two seasons) was 5422 m square that accommodated more than 1000 people. [47]
The ruined houses of the Fawakhir settlement revealed several elements that indicated a certain use of water such as:

Benches

They are usually made of a row of slabs set upright and apparently filled with sand and stones. The benches are either back up against a wall or are built into a corner. Sometimes, boulders were used as benches and several buildings have outside benches too. The bench is a characteristic feature of the Egyptian houses of all ages, and in such case, they were also used as water jars' holders.

Walls

Walls might have been plastered, however, water is a prime commodity in the desert to be used in plastering. [48] The texts of Turin Papyrus describe a cistern that was probably built to hold water drawn from the well. The water would have been used to separate the gold from the pulverized vein quartz by a process of gravity separation. Perhaps the brown area surrounding the cistern and nearby stela of Seti I was where the gold ore was brought for crushing and washing. The colour of the area matches the brown bands on the adjacent pink hill and so many denote an accumulation of discarded tailings. [49]

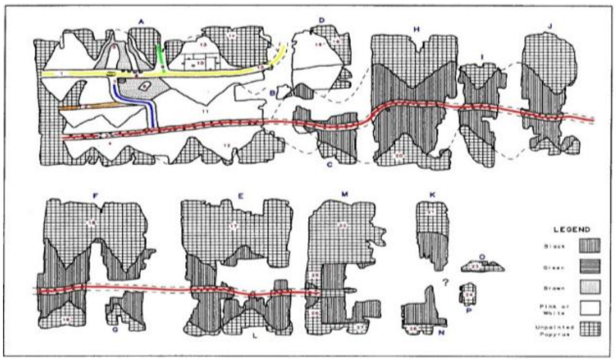


Fig. 16 The reconstruction of Harrell to the Turin Papyrus map indicating a cistern or "water reservoir".

After: Harrel, and Brown, "The oldest Surviving Topographical Map fromAncient Egypt", 87, Table 1 - Fig. 3.

The use of water in the gold mining process

Inclined gold washing tables constructed of stone fragments, consolidated by primitive clay/sand mortar and with a surface covered by a layer of the same material, can be observed nearby the New Kingdom gold production sites of Bir Umm Fawakhir. The lengths of these washing tables vary between 2.2 and 4 m, and they are 40–60 cm wide and 80–100 cm high, corresponding with an inclination angle of 15–20 grades. The Ramesside Period tomb of Kha'y, the gold washer of the treasury, at Saqqara revealed a scene of gold washing with what appears to be grinding with a sloping washing table. [50]

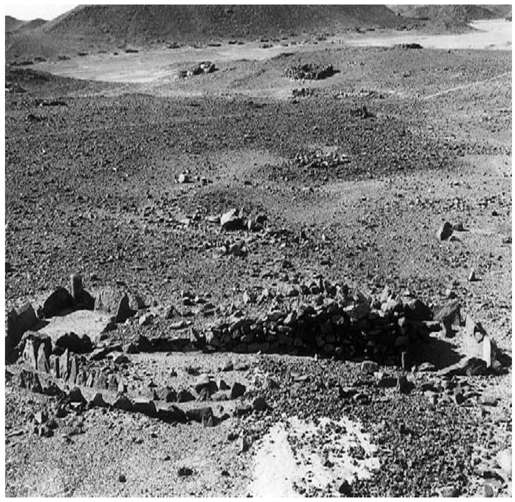


Fig. 17 Left: Gold works in the Tomb of Kha'y at Saqqara.

After, Jack Ogden, "*Metals*", in: P. T. Nicholson and I. Shaw eds., *Ancient Egyptian Materials and Technology*, Cambridge University press, 2000,162, Fig. 6.4.

Right: Inclined Arab period washing table. This type of washing table could be archaeologically assigned in use from New Kingdom times.
After, Dietrich Klemm, and Rosemarie Klemm, et al, "Gold of the Pharaohs – 6000 years of gold mining in Egypt and Nubia", *Journal of African earth science* 33 (2001), 652, Fig. 13.

At the end of this slope, the washing water used to be recovered in a box about 60 cm deep and wide, walled by stone slabs and sealed again with the described mortar. Here also the detritus of the quartz tailings was deposited, from where it was dumped close by, at the tailing heaps, still partly preserved in many cases today. A mortar-sealed and stone slab protected gutter conducted the water back to a large, 80 x 60 cm basin, from where the water was recycled for further gold washing processes, most probably with primitive shadoufs (a scooping bucket conveyor, still in use in Egypt and Nubia today). [51]

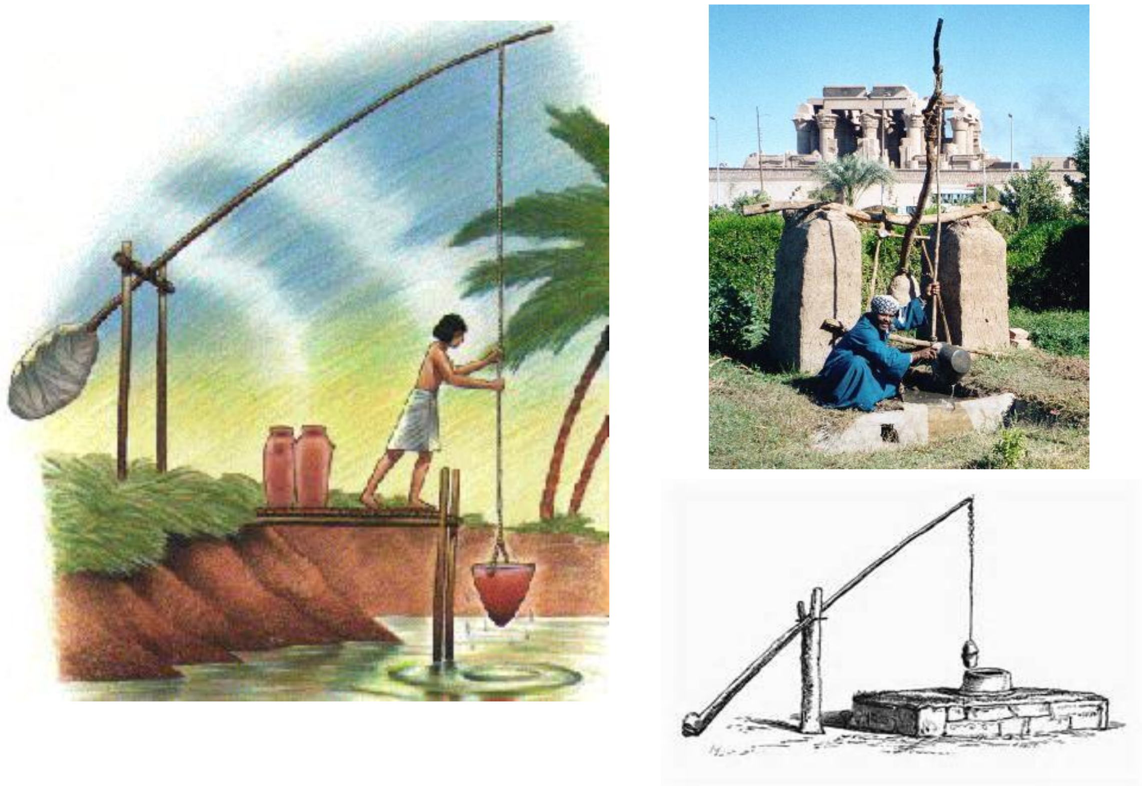


Fig. 18 The Shadouf.
After, http://www.digopaul.com/it/english-word/shaduf.html.

The use of water in the gold mining process can be summarized according to the description of Diodorus as follow:

- Miners made fire to heat and crack the gold – bearing quartz veins then they used to crush the crumbled bits using sledges and further reduced these fragments into smaller pieces using hammers.
- The end of the process involved skilled women who took the fine powder and distribute it on an inclined board then they used to pour water over it.
- The water washed away the unwanted lighter – weight material leaving only the heavier gold behind. That ore was then placed in measured amounts into terracotta jars. [52]

The use of water in Wadi Hammamat greywacke quarries

Wadi Hammamat is well known as a trade route, as well as a region in which key raw materials such as greywacke, gold and granite are found besides the easy accessibility of groundwater, means that this landscape has been travelled since prehistory. [53]

Inscriptions of Wadi Hammamat quarry site indicated how the missions were organized and conducted during the quarrying period. However, these inscriptions should have been inscribed by the quarrymen addressing those who will pass afterwards or the future visitors to the site, particularly the literate leaders of the Expedition to inform them to their predecessors' presence at the site and their achievements there. Socially, some members of the expeditions were mentioned in the inscriptions whereas others were excluded that might have been a reward for excellent work or special assistance during the expedition. These excluded participants left some personal inscriptions of their own, a configuration of commemorative expedition inscriptions and personal inscriptions that occurred especially in the Old Kingdom.[54]

The quarrying expeditions had to travel about 85 km through the desert. therefore, water was a crucial element of concern so, the most important hydrologic resource was the digging of wells along the way to Wadi Hammamat. The inscription of "Henu" during Montuhotep III's reign is a good example of this activity when he stated "ir .n (.i) Xnmt 12" (I made 12 wells). [55]

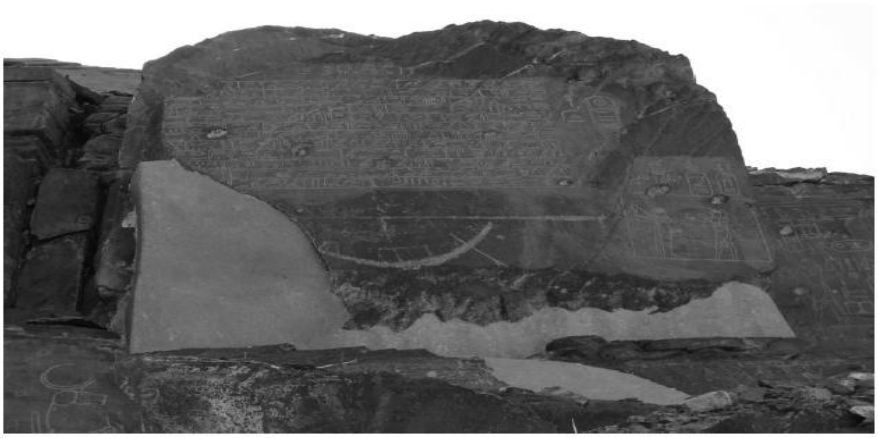


Fig. 19 Cluster of inscriptions covering a time range from the Early Dynastic to the Late Period. After, Bloxam, "A Place Full of Whispers", 806, Fig. 14.

In addition to its importance for drinking, the use of water in the quarrying process is evident in the transportation of the extracted blocks of greywacke. After the block was extracted, it was slid down the hill until it reached the wadi floor, an operation for which the construction of ramps was necessary to facilitate the descent of the blocks. The logistics of transporting large blocks out of the quarries meant that transport infrastructure appeared at the point when objects were no longer finished *in situ*. Ramps constructed from quarry waste, rather than paths, became a new aspect of the transformed landscape, these leading down from some quarries and working platforms where objects were semi-finished into rough outs. [56]

The transport of the stone blocks consisted of three different stages:

1 - Descent of the blocks to the wadi level.

2 - Horizontal overland transport. This phase was performed by using wooden sledges and some of these sledges have been well preserved. [57]

3 - River transport.

The main task of the unskilled workforce was:

1 - Transporting the stone blocks to the Nile Valley.

2 - Building structures such as ramps.

3 - Clearance of debris generated by the extraction works.

These functions were attested by inscription no. 87, in which the term (Ith.w) was used to describe the transportation of the stone blocks.

Fig. 20 Left: Sledge from Lisht South, Complex of Senwosret I, north of pyramid 2, Deposit 4, MMA excavations, 1923–24. After:http://www.metmuseum.org/art/collection/search/545485.
Right: The term (Ith.w). After: Couyat and Montet, *Les Inscriptions Hiéroglyphiques et Hiératiques du Ouâdi Hammâmât*, Inscription no. 87: 64 ff., pl. XX.

Once the Bekhen stone blocks were on the wadi floor, they had to be carried to the Nile valley through a desert route of about 83 km until the expedition reached the town of Coptos and from there, the blocks were embarked on ships and transported to their destination. The roads should be lubricated, therefore, some workers oversaw throwing water to the ground to lubricate it, while other workers had to carry the water jars, the ropes and other tools necessary to ensure the arrival of the blocks to their destination. In addition to, the transportation of quarrying tools, supplies and small pieces of greywacke that were most likely taken. This operation should consider the weight, the terrain slope, the climatic problems, the transport of supplies and the transport across non – lubricated surfaces which would have required more workers in addition to the use of animals which is well attested even if it is not mentioned in the inscriptions. [58]

Final Remarks

Although rainfall has never been extensive over the survey area, sufficient water resources have been available over the millennia to support a range of fauna due to the refilling of aquifers. Even today the water resources available in the Central Eastern Desert are sufficient to support travellers on foot, nomadic populations and desert animals. Despite most wells being located beyond the sandstone zone. therefore, outside the survey area, modern reconstruction and evidence from Bedouin travellers shows that desert travel is perfectly feasible to this day. So long as past travellers had either knowledge of routes or reliable guides.

The question of the water supply seems to have worked on a simple and a relatively equitable scheme, at least from the Old Kingdom until the Roman period. The water supply of the inhabitants was completely managed by the state, through the local administration which was charged to bring the water from rural areas into towns and cities and to redistribute it to the inhabitants even when the settlements were far from a water source. The role played by the institutions in everyday water management is not very well known. Expeditions sent to the desert to reach mines and quarries had sometimes to walk up to several hundred kilometres in the desert, under the hot sun. The lack of water was thus a serious threat and the distribution of water-supply points on the road was essential. In these remote areas, the administration made the choice to use cisterns and wells, technically quite simple at the beginning, but increasingly elaborate with time. Along the Myos Hormos road, Potable water would have been more easily located farther from the Red Sea and this must have been a major reason for placement of the road.

During the pharaonic period, before the construction of the *hydreumata*, temporary wells should have been dug to fulfil the needs of the workers during their mission as attested in several inscriptions. This work might have included the repair of old infrastructures as well as the creation of new ones in addition to the exploitations of wells that could be dug along the way. It is likely that the expeditions carried water in animal skins and jars to the supply stations that could have existed along the way although there is no real evidence of these structures on the route between Coptos and Wadi Hammamat before the Roman Period.

Water was used in the gold mining process to crack the quartz veins as once the rock had been heated, water may have been poured over it to cool it quickly, thereby, cracking it and breaking it up would have facilitated the mining process. Gold washing techniques should have been followed since the Middle Kingdom but due to the scarcity of water in this arid work environment, water was recovered after the washing process in stone boxes to be conducted in basins for future industrial reuse which is regarded as sustainable recycling of the natural resources that took place since the New Kingdom in a systematic way using instruments such as the primitive "Shaduf".

By the Graeco – Roman times, *hydreumata* were constructed along the desert roads containing water cisterns that should have been used to store a supply of water immediately available in case of rain or after an intensive fetching when large caravan passed during the seasonal drying up of wells.

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