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Table of Contents

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Wooden Rockers Were Open Mould for Mudbrick or Concrete Ones

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Abstract

The true purpose of a wooden "rocker" from a foundation deposit in the tomb of Queen Hatshepsut at Dier el-Bahri is proposed that it was an open mould for a mudbrick or concrete rocker. The solid rockers produced by such a mould have grooves that act as rope channels so that they can be attached to a stone (or sledge under the stone) by ropes to roll or turn the stone easily. We proposed how the wooden rocker could be used to produce solid rockers, then tested this method experimentally to get mudbrick or concrete rockers with grooves.

Keywords

Rocker, Mould, Mudbrick

1. Introduction

It has been long wondered about the true purpose of a wooden appliance called "rocker" or "cradle" (Figure 1) excavated from a foundation deposit (Figure 2) in the tomb of Queen Hatshepsut at Dier el-Bahri (the New Kingdom, circa 1550 to circa 1069 BC). We here propose its new feasible purpose that it was an open mould for a mudbrick or concrete rocker, and the solid rockers produced by this mould would be used in maneuvering heavy stones.

It was assumed hitherto that the excavated rockers as in Figure 1 and Figure 2 are "models" of some masonry tools because they are small and look too fragile to support any heavy stone. But our opinion is that they are full-size, usable tools, not models. Note that a usable brick mould of Figure 3 was also excavated from a foundation deposit in the tomb of Queen Hatshepsut, and this brick mould is almost the same size as a rocker in Figure 1, as can be well observed in Figure 4. These tools were votive objects placed in pits for foundation ceremony so that tools of small size would be chosen in particular, and it would be sincere to select usable tools (rather than "models") as votive objects. Note that our observation does not deny bigger wooden rockers. It is known that big bricks of dimensions about 40 cm × 20 cm × 15 cm were made during the New Kingdom (Hassaan, 2017) so that there must be the corresponding brick moulds much bigger than **Figure 3**. Similarly, it would be quite natural to assume that there were wooden rocker moulds bigger than the ones in **Figure 1** or **Figure 2**.

Figure 1. Rocker from a foundation deposit in the tomb of Queen Hatshepsut at Dier el-Bahri, with dimensions: L. 23.6 cm; W. 10.5 cm; H. 5.1 cm. (https://www.metmuseum.org/art/collection/search/547563).

Figure 2. Votive objects from a foundation deposit in the tomb of Queen Hatshepsut at Dier el-Bahri. (https://www.louvre.fr/en/oeuvre-notices/foundation-deposit-temple-deir-el-bahri).

Figure 3. Rectangular wooden mould for mudbrick from a foundation deposit in the tomb of Queen Hatshepsut at Dier el-Bahri. The longest edge with the handle is of length 28 cm. (https://www.metmuseum.org/art/collection/search/547576).

Figure 4. Various tools from a foundation deposit in the tomb of Queen Hatshepsut at Dier el-Bahri. (https://www.metmuseum.org/art/collection/search/547563).

The rocker of Figure 1 has the structure as illustrated in Figure 5 which is compounded of a couple of wooden boards with curved bottom edges, AEB and DFC, interconnected with several round wooden bars. The top ABCD is wide open, and this feature strongly supports our view that such a hollowed rocker would be an "open" mould for a solid rocker. Observe that the wooden rocker Figure 5 can mould a solid rocker as in Figure 6, like a plano-convex brick, with grooves on its convex side. Details about how to produce such a solid rocker using clay or concrete will be explained in §3.

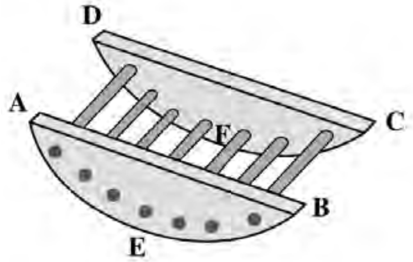

Figure 5. Illustration of a rocker.

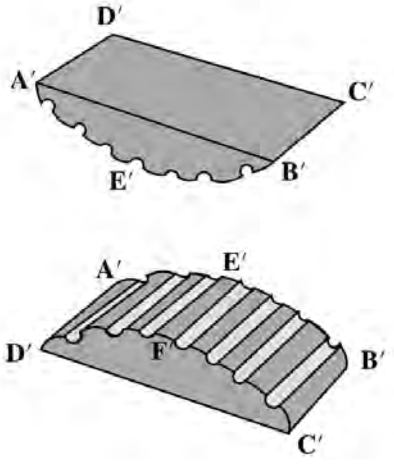

Figure 6. Solid rocker to be produced by the mould of Figure 5.

2. Solid Rockers with Grooves as an Intermediate Device between a Heavy Stone and Ropes

In our former papers, (Kato, 2020) and (Kato, 2021), we have already introduced "rocker made of stone" like **Figure 7** which we assumed to be obtained by chamfering a stone of cuboid. In (Kato, 2020) we described it as "trapezoidal prism" and showed how such a trapezoidal prism can be used in rotating or in turning a heavy stone (Kato, 2020). Further, in (Kato, 2021) we employed such rocker as one of principal means to maneuver heavy long obelisks (Kato, 2021). We note Fonte (Fonte, 1998) called such a rocker of semicylinder "quarter circle" and showed how it could be used in rotating a heavy stone by placing its flat side on the ground. Our usage is an upside down version of Fonte's, that is, we place its convex side on the ground so that its flat side can touch the stone as illustrated in **Figure 8**.

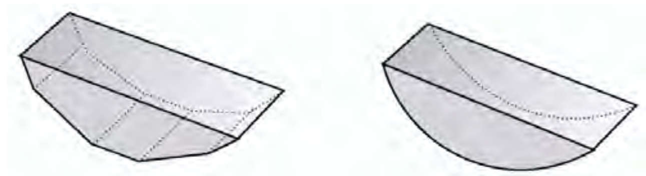

Figure 7. Rockers made from stones of cuboid by chamfer.

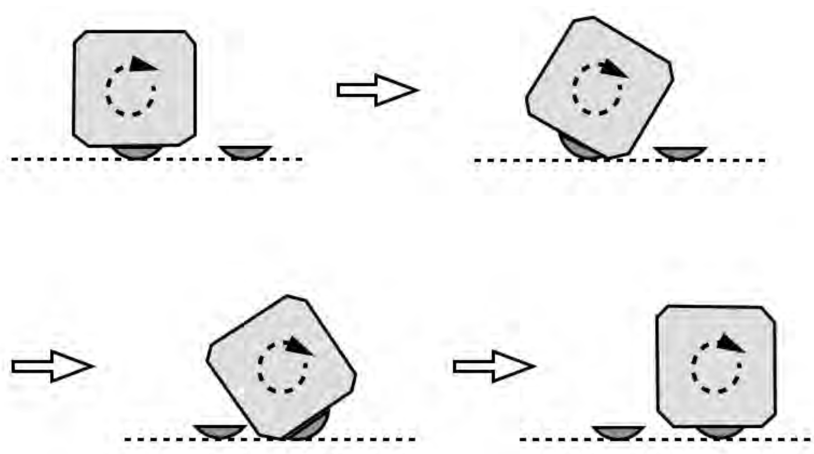

Figure 8. How to use rockers of stone in rotating a heavy stone.

Now we show how the solid rocker of **Figure 6** can be employed in maneuvering a heavy stone. A distinct advantage of the moulded rocker **Figure 6** over the stone one **Figure 7** is that the former has the grooves, thanks to the wooden bars of the mould. These grooves are quite useful as they can act as rope channels, and a rope would not be crushed between the rocker and the ground if it is engaged in the groove cf. (Pierattini, 2019). **Figure 9** and **Figure 11** illustrate examples how the rockers could be attached to a stone in order to roll it like **Figure 10**. (There would be many other ways of setting rockers and ropes around the stone.) What is important here is that we "can" attach rockers to a stone thanks to grooves. Observe additionally that these attached rockers protect the surfaces of the stone during rotation, and this fact would be quite important and necessary in particular when the stone was already decorated with inscriptions and colors. Note further that ropes (not deeply embedded) in the groove would act somewhat as a cushion like a rubber of wheel to protect the rocker. Thus, ropes protect rockers protect the stone. The illustration of Figure 11 shows the case of an octagonal column, and many of such columns would be produced as predecessors of cylindrical columns in temples. The rocker can be fastened also to a timber like Figure 12. And this way of attaching rocker can be applied for example as in Figure 13 and Figure 14. The two rockers in Figure 13 make the bottom of sledge convex, and the one rocker in Figure 14 makes it easy to turn a heavy stone. In the foundation deposit of Figure 2, we can see many very short wooden rockers which would have produced solid rockers of length about 10 cm, portable. Such small rockers would be used as in Figure 14. It is explained in (Isler, 2001) that: "A block of stone that is difficult to turn which is lying on a flat surface can readily be turned when imbalanced by having a small square of hardwood placed under its flat bedding face." The role of the small rocker in Figure 14 is the same as such a small square of hardwood. Note that the top of such a small rocker is almost a square. Of course, another use of such short rockers of half cylinder could be like in Figure 8 or Figure 10 to roll a cubic stone of side length about half a meter or less. Note that a cubic stone of side length half a meter looks small but weighs about 300 kg, very heavy!

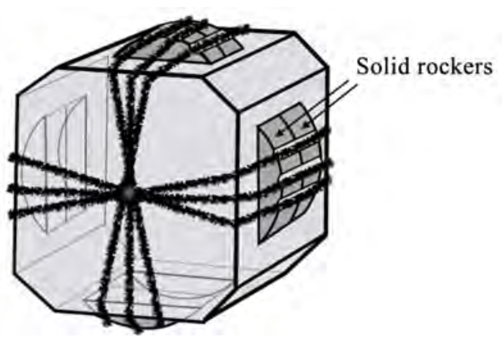

Figure 9. Example of attachment of solid rockers by ropes: Eight rockers in total with two on each of four sides.

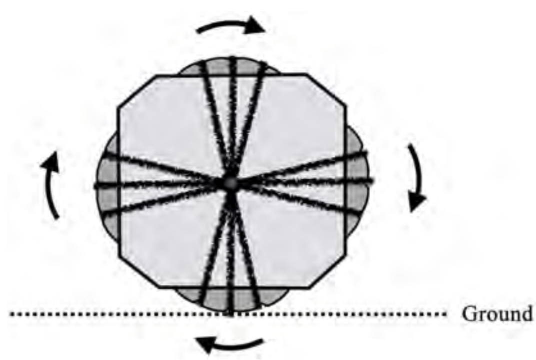

Figure 10. Stone of Figure 9 can be rolled easily.

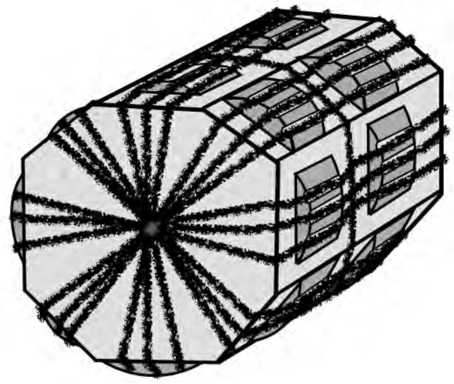

Figure 11. Example of attachment of solid rockers to an octagonal column by ropes.

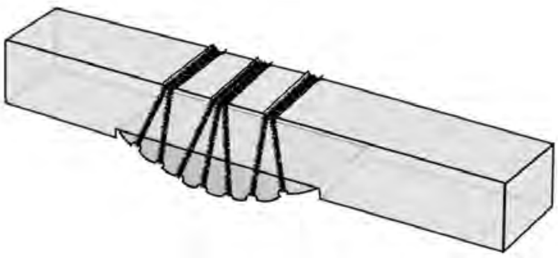

Figure 12. How to attach the rocker under a timber.

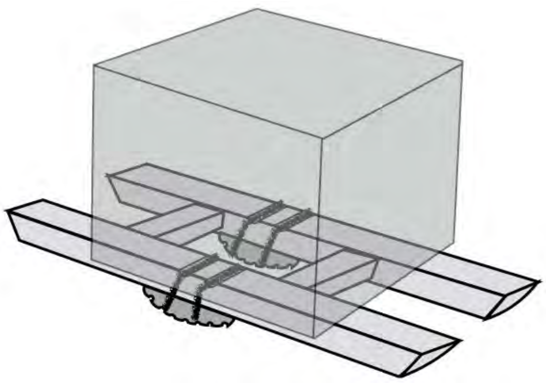

Figure 13. Affixing rockers under a sledge to make its bottom convex.

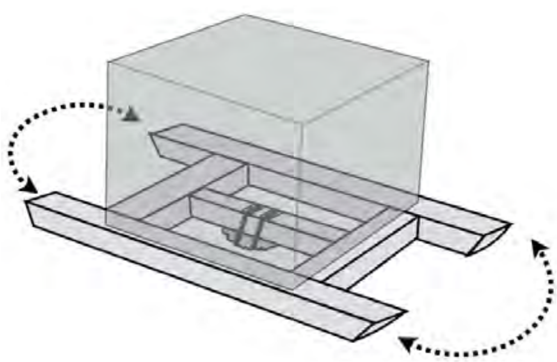

Figure 14. Use of a small rocker to turn a stone.

3. How to Make Solid Rocker

Let us show how the wooden rocker can be used as a mould to produce a solid rocker, made of clay or concrete. First, let us consider the case of viscous clay to make a mudbrick rocker. Prepare a loaf of well-compressed clay of almost the same size as the wooden rocker. (Quite incidentally, we may use the wooden brick mould like Figure 3 in order to make such a well-compressed clay clot.) Press the loaf of clay into the wooden rocker as (1) in Figure 15, where some thin cloth is laid in order to shape the clay. Using a flat piece of wood, scrape the excess clay off of the rocker. Sun-dry the clay on the board as (2) in Figure 15 for some time until it is dried somewhat. Then remove carefully the wooden rocker by lifting it as in (3) of Figure 16. The laid cloth would help to separate the clay from the wooden rocker. Finally sun-dry well the moulded clay, placing it in the form of (4) of Figure 16 in order to be sun-dried effectively. This process of Figure 15 and Figure 16 is what we believe to be a standard one, and there would be many variants. We note that the mudbrick rocker could be very strong when good clay was used like the soil of Egypt: (Maspero, 1895). "The soil of Egypt, periodically washed by the inundation, is a black, compact, homogeneous clay, which becomes of stony hardness when dry". It is also well known that adding plant straw strengthens clay products (Hassaan, 2017).

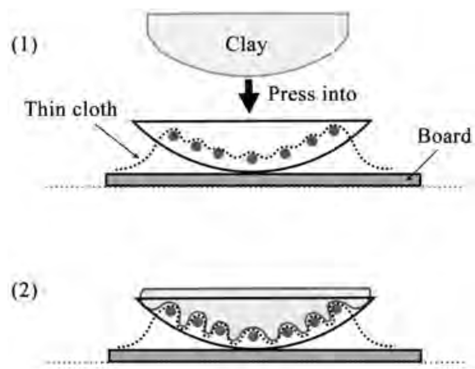

Figure 15. Pressing the loaf of well-compressed clay into the wooden rocker (Side view).

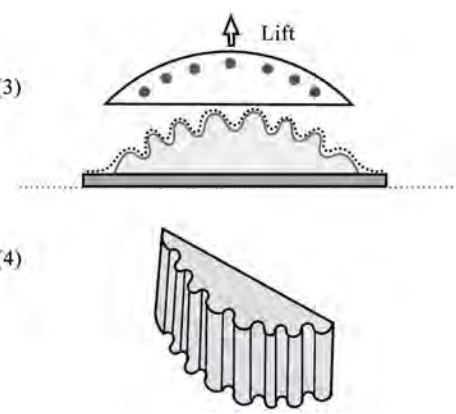

Figure 16. Sun-dry.

We remark that the shape of the solid rocker thus obtained has vulnerable thin spots near the two acute edges as shown in Figure 17, but it can survive even if the two edges were chipped, and the shortened rocker with flat ends as in Figure 17 could be stronger than the original one. This vulnerability is due to the shape, not the material, and it is easy to modify the shape of mud-brick rocker. Moreover, the length of the mud-brick rocker can be adjusted by cutting off acute ends, and the flat ends work effectively in connecting rockers as shown in Figure 18. So, we may conclude that it would be better to aim at making mud-brick rockers with flat ends rather than acute ends.

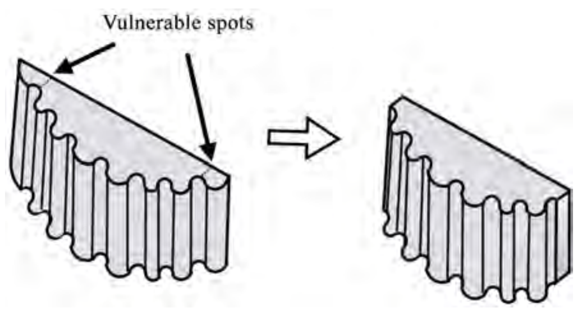

Figure 17. The solid rocker in (4) of Figure 16 can survive even if the two edges were chipped.

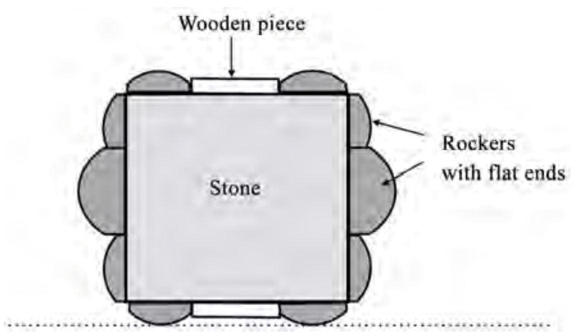

Figure 18. How to connect rockers (Side view).

The case of concrete would be almost the same as that of clay if we replace "pressing clay into the wooden rocker" in Figure 15 with "pouring concrete into the wooden rocker." Since concrete is not so viscous as clay, we propose to insert some bendable thin wooden plate (or some bark), instead of "thin cloth," as illustrated in Figure 19. Recall that solid rockers moulded by the wooden rocker are to be affixed on the faces of a heavy stone as explained in §2. Hence they should be light enough to be portable. For such purpose, it would be preferable to produce an "arched" type of rockers, and this can be done easily by pressing a short wooden cylinder onto the center of the surface of the poured concrete, as shown in Figure 20. Then we can get an arched concrete rocker like Figure 21. Of course, this is lighter than the non-arched one, yet it remains to be strong because of its arch structure. Though we have used the general term "concrete", the concrete the ancient Egyptian used seems to be gypsum mortars or mortars of lime and mud, which is a bit different from our modern Portland cement with sand. So, precisely speaking, we better replace our term "concrete" with "mortars of lime and mud," and the resultant is a "mud-concrete" rocker. See (Arooz & Halwatuna, 2018) about the strength of "mud-concrete".

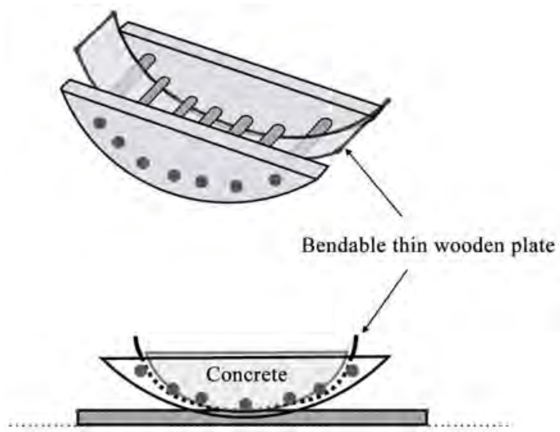

Figure 19. Mould to produce a concrete rocker.

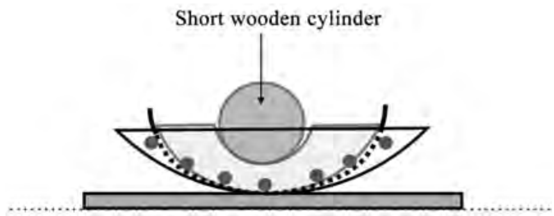

Figure 20. How to produce an arched rocker.

Figure 21. Arched rocker produced by the method of **Figure 20**.

4. Experiments

We have tested our theory of producing solid rockers by experiment, though we had no experience even of making homemade bricks. First, we made a wooden rocker almost of the same size as the excavated one **Figure 1** and produced mudbrick rockers following the procedure of **Figure 15** and **Figure 16** using clay. The result is **Figure 22** and **Figure 23**. (In producing the mudbrick rocker of **Figure 22** we could dispense with the supplementary cloth described in **Figure 15** as we could use a good clay clot well compressed.) Next, following the procedure of **Figure 19** and **Figure 20** we used Portland cement with sand to make the arched concrete rockers of **Figure 24**. We experimentally made also the concrete rocker Figure 25 with holes instead of grooves applying the method similar to Figure 19, a bit lowering the bendable wooden plate. But, we can see that rockers with grooves rather than holes are much easier to be handled with, mainly because a rope thicker than the width of the groove can be used for the groove, but this is not the case for the hole. So, we may conclude that rockers with holes would not be used actually, though they could be made theoretically. We also experimented how our rockers can be attached to timbers by ropes, as exhibited in Figure 26 and Figure 27.

Figure 22. Mudbrick rocker (on the red brick of dimensions 20 cm × 10 cm × 6 cm) produced by our wooden mould (right).

Figure 23. Mudbrick rocker with flat ends.

Figure 24. Arched concrete rockers.

Figure 25. Concrete rocker with holes.

Figure 26. Rockers of **Figure 22** and **Figure 25** attached to timbers by ropes.

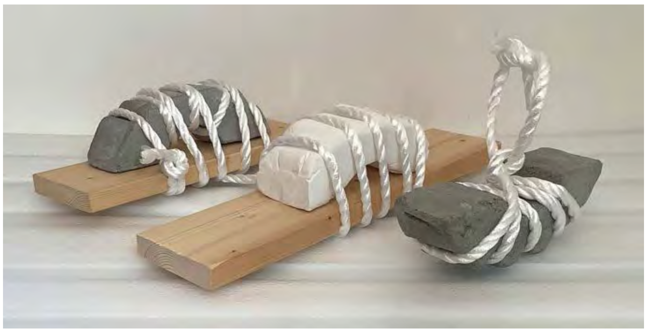

Figure 27. Arched rockers attached to timbers, and an example of passing a rope around the arched rocker (right).

5. Evolution about How to Move Stones

As is well known, Queen Hatshepsut remarkably pioneered architectural techniques, and wooden rockers would be invented during her reign (c.1479-1458 BC). The fact that 36 many wooden rockers as votive objects were excavated from foundation deposits of Hatshepsut (Arnold, 1991) indicates that the wooden rockers played an important role in the construction of building like Hatshepsut's Temple. We pointed out in (Kato, 2020) that, in moving a stone, "rolling" is much easier than "dragging," and proposed various ways to move a heavy stone using ropes. Solid rockers produced by the wooden rocker transform cubic stone or octagonal column into the form of cylinder as in **Figure 10** and **Figure 11**, evolving the way of moving heavy stones. A typical method proposed in (Kato, 2020) is to roll a stone as described in (1) of Figure 28 (see also Figure 8), where one end of each rope is held by some anchoring post and its other end is pulled. (Figure 28 is a side view so that only one thick rope is illustrated in each of (1) and (2), but actually, many ropes would be used.) Here, rockers made of stone as in Figure 7 were used, and we assumed such a method was already employed in the Pyramid Age, a millennium before Hatshepsut. Solid rockers with grooves would have evolved the way (1) into the way (2) of Figure 28, where the lower part of the rope is held by the grooved rocker so that we can dispense with any post as in (1). The rolling of (2) would be quite effective and much smoother than that of (1).

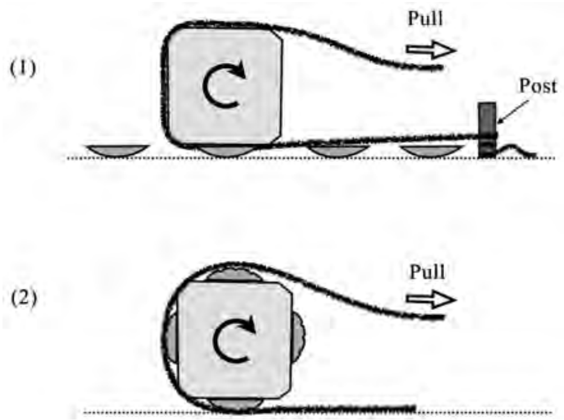

Figure 28. How to roll a heavy stone effectively by ropes: (1) Before Hatshepsut; (2) After Hatshepsut (Side view).

We also want to note about rolling stones of cylinder as we can see many many columns in temples of ancient Egypt, including Hatshepsut's Temple. Of course, physically no problem in rolling such stones, but suppose they were already decorated. Then we need special care to protect their surface. We already showed how to affix rockers to any flat surface of stone or sledge. Here, we want to propose that an arched rocker can be attached also to the stone of cylinder if its concave part (see Figure 21) is made to fit the surface of the cylinder like Figure 29. This way of Figure 29 surely can protect the surface of the cylinder, and so, would be actually employed frequently in rolling decorated columns.

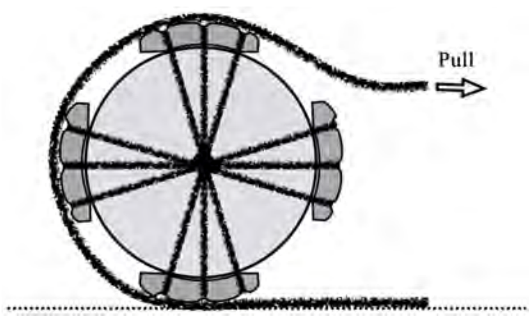

Figure 29. Arched rockers can be attached to a stone of cylinder if their concave parts were made to fit well onto the surface of the stone (Side view).

The above evolution of moving stones, generated by rockers, took place, we believe, during Hatshepsut's reign, but it seems the wooden rockers soon faded into the background of history after Hatshepsut. Why? We do not know yet its true reason. What we can suspect is that:

1) The wooden rocker was kept being a useful tool in producing solid rockers even after Hatshepsut, but later pharaohs were hostile to Queen Hatshepsut so they did not include wooden rockers in their votive objects (Roehrig, 2005).

2) some alternative new device was invented utilizing some kind of "wheel" since the technology about wheel was introduced and developed remarkably during the New Kingdom era (c.1550-c.1069 BC), as symbolized by the "Chariots" of Egypt's military.

6. Conclusions

We proposed our new idea that the excavated wooden rockers are open mould to produce solid rockers, and this idea naturally stemmed from our former papers, (Kato, 2020) and (Kato, 2021), where "rocker made of stone" was introduced as one of important means to maneuver heavy stones. Seeking an alternative way of making it, rather than chamfering from a stone, we got the idea of moulding mudbrick or concrete rocker. In literatures there appeared various theories about how to use the wooden rockers: See (Arnold, 1991): Figure 6.29, Figure 6.30, (Clarke & Engelbach, 1930), (Isler, 2001), (Petrie, 1910). But, it seems none of them meets the fact that the excavated wooden rockers look too fragile to be endured under a heavy stone. Our idea of "mould" obviously resolves this problem of fragility, excluding the idea of "models." And it should be recalled that the ancient Egyptians in the New Kingdom already had rich experience in making mudbricks and in using their concrete so that they had no difficulties in producing solid rockers using clay or concrete.

We hope this article has "excavated" a milestone in the evolution of ancient Egyptian's technique of maneuvering stones.

Conflicts of Interest

The author declares no conflicts of interest regarding the publication of this paper.

References

Arnold, D. (1991). *Building in Egypt: Pharaonic Stone Masonry*. Oxford: Oxford University Press.

Arooz, F. R., & Halwatuna, R. U. (2018). Mud-Concrete Block (MCB): Mix Design and Durability Characteristics. *Case Studies in Construction Materials*, *8,* 39-50. https://doi.org/10.1016/j.cscm.2017.12.004

Clarke, S., & Engelbach, R. (1930). *Ancient Egyptian Mansonry*. London: Oxford University Press.

Fonte, A. (1998). *Building the Great Pyramid in a Year*. London: Professional Engineering Publishing.

Hassaan, G. A. (2017). Mechanical Engineering in Ancient Egypt, Part 52: Mud-Bricks Industry, *International Journal of Advanced Research in Management*, *Architecture*, *Technology and Engineering, 3,* 11-16.

Isler, M. (2001). *Sticks, Stones, and Shadows Building the Egyptian Pyra-Mids*. Norman: University of Oklahoma Press.

Kato, A. (2020). How They Moved and Lifted Heavy Stones to Build the Great Pyramid. *Archaeological Discovery, 8,* 47-62. https://doi.org/10.4236/ad.2020.81003

Kato, A. (2021). How Obelisks Were Constructed, Moved, Shaped, and Erected in the Ancient Egypt. *Archaeological Discovery, 9,* 16-51. https://doi.org/10.4236/ad.2021.91002

Maspero, G., & Edwards, A. B. (1895). *Manual of Egyptian Archaeology and Guide to the Study of Antiquities in Egypt.* New York: G. P. Putnam. http://www.gutenberg.org/ebooks/14400

Petrie, W. M. F. (1910). *Arts and Crafts of Ancient Egypt (The World of Art Series).* Chicago, IL: A.C. McClurg. https://doi.org/10.5479/sil.247614.39088000358044

Pierattini, A. (2019). *Interpreting Rope Channels: Lifting, Setting and the Birth of Greek Monumental Architecture*. https://www.cambridge.org/core/journals/annual-of-the-british-school-at-athens/volume/3E6722E2EC597146C692561286EAB4B0

Roehrig, C. H. (2005). *Hatshepsut from Queen to Pharaoh*. New York: Metropolitan Museum of Art.

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Faydhat Nayif Archaeological Site, AsSubbiyah, Kuwait: A Discovery of an Ancient Blacksmith Village along the North Shore of the Kuwait Bay, Kuwait

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Abstract

This paper is a report on a discovery of an ancient human settlement next to the Faydhat Nayif pond in the AsSubbiyah area, north of Kuwait Bay, Kuwait. It also presents a description of the site and its artefacts. The settlement, named by the author Faydhat Nayif Archaeological Site, is composed of two parts, the main cluster of gallery remains and a small satellite, the Sonna Village. The main site contains foundations of around fifty galleries. The state of preservation of the foundations varies from excellent to weak. The dominant architectural plan for the galleries is a rectangle. Infrastructural components associated with the foundations are iron smelters and iron tools. Artefacts include fabricated iron tools, fishhooks and fishnets, pottery fragments, glass shards, and animal bones. The craft of the inhabitants revolves around iron smelting and tool fabrication, and hence, the "blacksmith" status. The research method followed in the research is simple classical surveying techniques utilizing a Brunton compass and a measuring tape. Imaging of the galleries used digital cameras. The settlement displays three styles of construction. The first style is that of a faint triangle, seen mostly in the southern and western sides of the site. The second style shows as a rectangle, with most galleries containing two rooms and external bathrooms. The third style of construction is similar to the second style, except for the presence of wood vestiges and the gypsum lining of the gallery walls. These differences between the three styles suggest three episodes of occupancy. One of the occupancies was by the AsSubbah tribe. The site served repeatedly as a center of population and pilgrim rest area, as well as cultural exchanges in the last 1500 years.

Keywords

Faydhat Nayif, AsSubbiyah, Kuwait, Archaeology, Settlement

1. Introduction

Kuwait is a country that does not possess extensive archaeological archives. Any discovery of an archaeological settlement or remains adds significantly to this archive, and, by inference, to the country's culture and history. Recently, the country started to address its ancient heritage (Frohlich, 1987; Al-Wohaibi, 1999; Poirier, 2005). In the last two decades, accelerated exploration campaigns located many findings, tagged them and catalogued them; examples are (Al-DuWeesh, 2010) and (Al-Wohaibi, 1987). (Al-AlMutairi, 2008) presented a review of the archaeology of Kuwait. The Department of Antiquities and Museums (Kuwait) published in 2006 a summary of its achievements (Department of Antiquities and Museum, 2006).

Aside from the National Museum of Kuwait and expeditions from several countries (British Team (Carter et al., 1999), the Slovak team (Benedikova, 2007), the French team (Callot, 2008), and the Danish team (Hoilund, 2009)), only a few individuals (like the present author) are involved in the exploration of past archaeological sites scattered in the desert of Kuwait.

Although many of the sites in the Kuwait desert, some of which archaeological, were mentioned in Arabic poetry and ancient chronicles, a very meagre number of sites has been located and described; only the description of a few of these sites found their way to the published literature.

The author discovered the Faydhat Nayif Archaeological Site (FNAS) in 2015, and it has been under investigation by him since. This paper constitutes the first report on the FNAS. Results of mapping and surveying generated a site map and sampled a collection of artefacts. Therefore, the report is only preliminary. Future investigations will follow to unravel all aspects of the FNAS.

2. Location

The location of the FNAS within the regional setting shows in **Figure 1** (inset). The FNAS occupies the land between the high watermark of Kuwait Bay and the Faydhat Nayif Pond (FNP) northeast of it. It hugs the southern shore of the FNP. A narrow and faint dirt car track conveniently splits the FNAS galleries

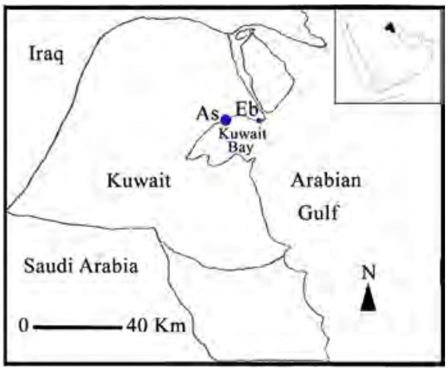

Figure 1. Location of the FNAS in the Ebharah (Eb) area in the AsSubbiyah (As) region in Kuwait (inset).

into two parts, southeastern and northwestern halves. Each half contains approximately an equal number of galleries. Approximately 500 meters separates the main site of the FNAS from the site of the Sonna Village (SV) satellite hamlet to the southeast. The village suffered total destruction, and only some graves testify to its past presence. The low area between the FNAS and SV sites likely contains many gallery foundations, but the sediments of the FNP deposited at high flooding times cover the area. Due to its destruction and consequent loss of information, the Sonna Village will receive only marginal discussion in this paper.

3. Relief

The FNAS stands above a semi-flat surface that slopes faintly to the northeast (2 - 3 degrees slope). This surface is part of the lower foot plain of the Jal AsSubbiyah (Swideg, 2010). The site lies along the southwest shore of the FNP and 200 meters from the high watermark of Kuwait Bay. A well-developed gravel plain separates the FNAS from Kuwait Bay. Surface erosion by rain and sediment transportation in a northeastern direction has preferentially eroded deeper into the southwestern galleries, rendering them difficult to detect and map. The state of preservation of galleries varies from excellent to weak. Recent annual eolian wind episodes have deposited a thin layer of sand sheets and small cross-bedded sand dunes that camouflage the galleries' foundations. Short winter grass (20 cm) grows in the area of the FNAS. It is ephemeral and disappears in summer.

4. General Description

4.1. Main Galleries

Gallery Foundations

The most conspicuous feature of the FNAS is the remains of the foundations of the galleries. These foundation infrastructures form rectangular houses and rooms. Figure 2 shows a map of the gallery foundations in the FNAS.

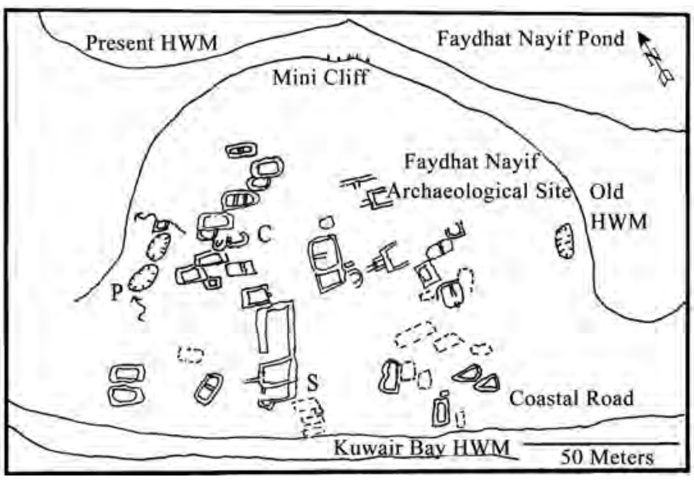

Figure 2. A map of the foundation galleries in the FNAS, AsSubbiyah, Kuwait. (S for smelter, C for corral, and P for animal pond).

The galleries' layout does not follow a systematic plan, and lacks a robust organizational style; the layout is haphazard. Open areas separate the galleries. Streets are few and narrow. The area of the FNAS measures roughly 250 × 250 meters. The average size of the galleries in the FNAS is roughly 10 × 5 meters. No evidence exists for an external wall for the protection of the FNAS site.

Styles of constructions: The FNAS displays three styles of gallery construction. The first style of gallery infrastructure is that of a triangle (**Figure 3**). The length of the base of the triangle is roughly half of its height. Generally, an average dimension of the triangles is 3 meters (base) by 6 meters (length). The walls are thin. No traces of doors are apparent. This style of gallery foundations shows best in the south and west of the FNAS

A very special feature of the first simple style of construction is the absence of associated infrastructure features and artefacts. Interiors of such triangular compartments are barren.

Unlike the other two styles of foundation construction (see below), this first style has a fewer number of preserved galleries.

An interesting facet of this style is the orientation of the triangle base in a roughly N-S direction. The triangle length is oriented roughly E-W, approximately parallel to the path of the sun as it traverses the sky. This is most likely an astronomical sign of celestial significance.

The second style of gallery foundations in the FNAS is the more common geometry for the galleries and the most widespread. It is a rectangular enclosure that contains one to three chambers (**Figure 4**). The southeastern walls have in their middle a door facing mostly southeast, compatible with the dominant northwest wind direction. Dimensions of the galleries are approximately ten by three meters (2 rooms) and five by three meters (1 room).

Figure 3. An image of an example of the first style of triangular galleries in the FNAS, AsSubbiyah, Kuwait, showing the upper half and apex of a triangle (lower end of the cane). Erosion removed the rest of the gallery.

Figure 4. An image of an example of the second style of galleries in the FNAS, the As-Subbiyah, Kuwait. It shows a 3-chamber gallery and an external gypsum-floored bathroom. The FNP is on the upper right corner.

Adjacent to the external short walls of the galleries are 2 × 1 meter areas floored by gypsum and clay. These are interpreted as floors of bathrooms and bathing facilities. Mimicking the external walls of galleries are thirty-centimetres wide adjacent strips of clays derived from the collapse of the gallery clay-brick walls. A room in each gallery functions as a kitchen and smelting workshop. Some of the more complex galleries include central yards, possibly for audience, reception and function halls.

The third style of gallery construction is similar to the second style, except that the walls show plastering internally and externally by a 1 - 2 centimetres of gypsum. Figure 5 shows an example of this style. Gypsum provides constant winter warming and summer cooling inside the confinements. Remains of door wood with nails stuck in them show nearby these galleries. It appears that this third style of building is slightly squarer in dimension than rectangular.

Associated with the second and the third styles of galleries are widespread occurrences of iron smelters and iron tool fabrications. One corner of almost every gallery in these two styles of construction has a rounded smelter measuring about one meter in diameter.

The FNAS displays several circular structures (approximately 1 meter in diameter) attached to the outside of some of the galleries. Such structures are vestiges of water wells, baking ovens, shower rooms, bathrooms and outhouses.

4.2. Minor Infrastructures

4.2.1. Animal Corrals and Water Ponds

Attached to some of the galleries are animal corrals to shelter animals while at home. One of these corrals shows in Figure 6. The corrals are mostly circular,

Figure 5. An image of an example of the third style of galleries in the FNAS, AsSubbiyah, Kuwait. It shows the internal and external gypsum plastering of the walls.

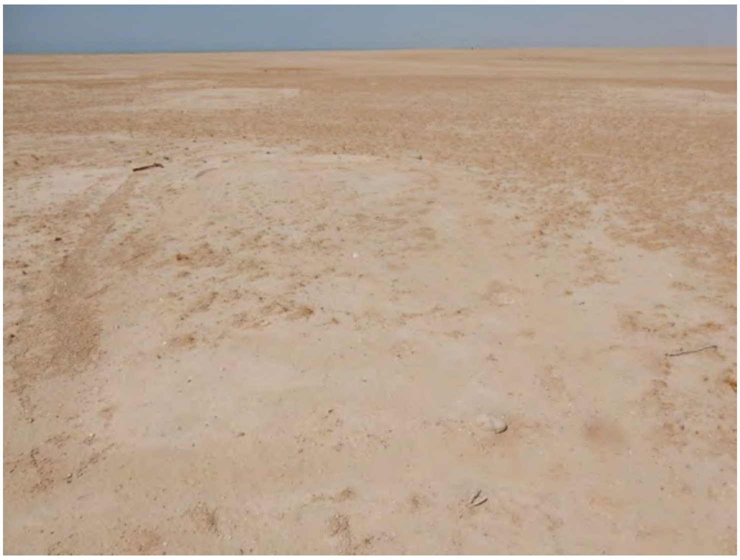

Figure 6. An example of the animal corrals in the FNAS in the AsSubbiyah area, Kuwait.

and one side of the corral lodges against the gallery walls. An outlet door serves as an entrance to the corral. Possibly, as many as fifty heads of livestock found refuge in a corral.

Several artificial animal water ponds occur southeast and northwest of the FNAS. An example of these miniature ponds appears in Figure 7. These watering basins measure about 10 meters by 20 meters. Inhabitants of the FNAS carried fresh water from the FNP to these small animal ponds. These basins were used for watering of the FNAS livestock and other herds. They cordoned off the animals from contaminating the FNP by animal urine, dung and faces. This ensured the quality of the FNP, which provides the main source of drinking, washing, and potable water.

Figure 7. One example of the animal water ponds in the FNAS in the AsSubbiyah area, Kuwait. The 30-meter long basin is presently filled by sand and desert shrubs.

4.2.2. Refuse Dumps

The FNAS shows a few refuse dumps of different sizes. **Figure 8** displays one of these dumps. The dumps are rounded to lobate and subdued mounds (approximately 20 cm high). Their colour is a distinctive grey colour that distinguishes them from the FNAS landscape. The grey tone results from the abundance of fine-grained fire ash that dominates the dumps. Refuse dumps contain all material leftover by the FNAS daily activities. Types of refuse include broken glass, pottery shards and by-products from the cooking hearths. Other material in the dumps are small and white animal bones, shattered ceramic cups, fragments of domestic and various iron tools. Natural erosive processes have lowered dumps heights and spread them horizontally. Dumps are communal.

4.2.3. Graves

Anomalously, graves are missing from the FNAS. For such a good size settlement, with evidence suggesting long-term longevity (*i.e.* one and a half millennia), graves and other types of burial should be encountered (Uerpmann et al., 2006). However, the search failed to detect the presence of graves or burial mounds. It is possible that dead bodies were transported and buried elsewhere, as practiced by the ancient Dilmun culture (Barta et al., 2008). Alternatively, cremation of dead bodies was the order of the FNAS. Muslims practice neither of these rituals.

Nonetheless, some graves show up in the SV. Mughyairah, to the west of the FNAS, contained some human remains (Soltysiak, 2007). (Parker, 1999) gives a review of death and burial in ancient societies. (Jarman, 1977) described the first millennium BC human remains from Bahrain.

The near total lack of coins in the FNAS suggests the absence of a financial center (*i.e.* bank). This is surprising and may not argue for the FNAS being an

Figure 8. An example of a refuse dump in the FNAS in the AsSubbiyah area, Kuwait.

exchange pit stop for pilgrims and commercial caravans passing through the settlement.

4.3. Iron Smelting and Fabrication

Beside galleries, iron smelting is the second most characteristic feature of the FNAS. Iron smelting, presence of smelters, and iron tools are widespread. Figure 9 illustrates one of the smelters. Such manufacturing practices are plentiful throughout the settlement. The numerous iron smelters are indicative of the "blacksmith" nature of the FNAS.

Smelting of iron for the production of various tools gives the FNAS its importance for itself and the local and far markets. Nearly every gallery has its own smelter, and a community smelter is available for members of the blacksmiths who do not own their own smelters. These smelter factories appear as low-elevation (3 centimetres) mounds of smelted iron pieces, usually in a corner of the gallery. The pieces measure approximately two to four centimetres.

5. Artefacts

A large assortment of artefacts litters the FNAS, but some of these artefact types are meagre. Most abundant, however, are remains of iron smelters and tools, pottery and glass shards. What follows is a brief description of each type of artefact, and where possible, illustrated by a field image.

5.1. Iron Tools

By far, the most abundant artefacts in the FNAS are those related to iron smelting and fabrication (Figure 10). Situated on the Arabian Gulf, fishing tools necessarily formed a large component of the smelting ensemble (Al-Thani, 1997). The site shows fishing hooks, nets and spears. It also contains parts of knives,

Figure 9. Remains of a rounded iron smelter in the FNAS in the AsSubbiyah area, Kuwait.

Figure 10. An outline of a partially-buried fabricated iron container tank produced by the smelting and fabrication activities in the FNAS in the AsSubbiyah area, Kuwait.

swords, pots and other items. Other iron tools include rectangular cans and nails of different sizes. Smelters are essential to cast such tools. Most fabricated tools are presently fragile and disintegrating, and cannot be retrieved intact.

5.2. Pottery Shards, Glass Shards and Ceramics

Pottery shards are common features in archaeological sites globally, and the FNAS is no exception. (Wilkinson, 1973) wrote on the pottery of the Early Islamic period and (Hannestad, 1983) described pottery shards from Failaka, a nearby island. A large number of pottery shards ornament the FNAS site (**Figure 11**). The shards differ in colour, size, thickness, generation and ornamentation.

Figure 11. A cluster of pottery shards in the FNAS in the AsSubbiyah area, Kuwait.

They are mostly light in colour. White, beige, grey, pink and light green varieties are common in the FNAS. The shards are mostly fragments of jars. Many of the jars came from afar, but some were produced locally. Many shards cluster around smelting dumps and refuse dumps. Ornamentations appear on necks and rims of some jar fragments.

Glass shards and bottles are widespread in the FNAS (**Figure 12**). Most of the glass shards are fragments of bottles. The shards have different colors. The most common color is green, but blue, dark green and colourless glass shards are also abundant. Some large pieces lack mixing and casting sophistication.

Ceramics appear in the FNAS. Most of the ceramics are small drinking cups. They are mostly white and ornamented on the outside. Many ceramic cups show glazing, and several styles of glazing were applied. Some of these ceramic remains resemble those in the Sabah collection (Watson, 2004). Sometimes, it is difficult to distinguish between ancient and modern glass shards and bottles.

5.3. Home Utensils

The FNAS has a few scattered house utensils (like knives). Many of these tools lost their sharpness and shiny appearance with time. These tools were vital for the daily livelihood in the galleries. Departing settlers removed these necessities from the FNAS when they abandoned it. Utensils lagging behind in the FNAS were probably forgotten.

5.4. Fishhooks, Fishnets, and Animal Bones

The FNAS contains fishing hooks and fishnets (**Figure 13**), but does not contain fish bones. Shell midden and shell mounds are absent; in particular, they are absent from the refuse dumps, where they are expected. (Beech, 2010) discussed the significance of these remains in archaeological sites.

Figure 12. Shattered green glass shards in the FNAS in the AsSubbiyah area, Kuwait.

Figure 13. An example of fishing hooks in the FNAS in the AsSubbiyah area, Kuwait.

The FNAS settlement displays many small (1 - 5 cm) scattered animal bone fragments, especially in and near refuse dumps (Figure 14). Due to their small size, it is difficult to ascertain the identity of animals from which the bones came. (Beech, 2010) discussed animal bone remains in the H3 site in the AsSubbiyah area. Transportation processes have relocated the bone fragments in many directions. The bone fragments are fragile and disintegrate readily.

A very peculiar intact animal skeleton appears in the FNAS. Most likely, it belongs to a member of the canine family. The bones are shiny white. This suggests that the skeleton is a recent addition to the FNAS archive of artefacts.

5.5. Hearth Rocks and Rock Hammers

Almost every gallery in the FNAS, particularly big galleries with more than one room, has a room dedicated to the kitchen. A pile of classical hearth triple rocks construction occupies a central location in kitchens (Figure 15). The three rocks

Figure 14. Pieces of animal bones in the FNAS in the AsSubbiyah area, Kuwait.

Figure 15. An example of hearth triple stones in the FNAS in the AsSubbiyah area, Kuwait.

support cooking pots during cooking sessions. The local shallow bedrock supplied the necessary rocks.

Rock hammers utilized for crushing and milling are abundant in the FNAS. Figure 16 shows some of the rock hammers. Several rock types, mostly felsic fine-grained rhyolites and intermediate rock types constitute the rock hammers. The size of the lithic hammers varies from six to twelve centimetres. They are always rounded. Their colours range from reddish to dark green-black tones. Inhabitants collected the hammers from the Pleistocene Dibdibah Formation exposed in the area of the FNAS.

Related to the rock hammers are faceted lithic fragments with sharp corners and edges, used for butchering and skinning of animals. Several such skinning stones occur in the settlement.

Figure 16. A cluster of rock hammers with different colours and approximately the same size in the FNAS in the AsSubbiyah area, Kuwait.

6. Missing Features

Despite the good appearance and the clear remains of the foundations of galleries, and their robust traces on the ground, many construction materials are absent from the FNAS. Not a single wall remains standing in the site; natural surface processes bevelled galleries flush with the ground. During the abandonment of the site, inhabitants carried with them palm reeds and other ceiling material. Doors and wooden support columns for doors and windows faced the same fate and are no longer present in the site, except for galleries belonging to the third style of foundations. In addition, traces of water skin bags that are necessary for water transportation and supply from the FNP no longer appear in the site. The FNAS remains lack out-house and cesspool facilities.

7. Repeated Occupancy

Like many archaeological sites elsewhere, the FNAS galleries display signs of repeated occupancy. Differences in the design characteristics suggest three episodes of occupation. They also suggest three different cultural groups resided in the FNAS at different times.

8. State of Preservation

The state of preservations of the different galleries in the FNAS is variable It is a direct function of the natural erosional processes and anthropogenic activities. Natural processes, such as running water, produce vertical and horizontal transportation and relocation of infrastructural components in galleries. These processes cause the removal of the gallery components and artefacts from their original positions.

Potentially, this material redistribution can confuse interpretations. Wind and other aeolian activities also contribute to the reduced quality of the appearance of the gallery foundations and artefacts. Anthropogenic destructive processes (**Figure 17**) include digging of falconer holes for trapping of migrating hawks and other migratory birds in their annual migration corridor in the area. In addition, holes dug by desert lizards (dubs) invite people who consider these animals as delicacy to enlarge the holes to catch them.

Desert tent campers also add to the decimation effects of the FNAS, by discarding behind them litter and debris upon their departure from the galleries. Heavy road vehicles took their toll on the FNAS and the accessory Sonna Village. In particular, this was very detrimental for the village.

9. People

Who are the people that settled in the FNAS? Did they belong to one cultural group or did they represent more than one cultural group (Whittle, 2003). Currently, the second interval of occupancy seems to belong to the AsSubbah tribe. The tribe may have also populated the third interval; both intervals are close in architectural design of galleries and similar in the ensemble of artefacts and iron smelting products. The first style of settlement reflects a very different engineering layout. It suggests an older cultural group of people, probably of less refined engineering capabilities.

10. Sonna Village

The Sonna Village is a small community located about half a kilometer southeast of the FNAS. It is an associated satellite hamlet that served the FNAS needs and supplied it with labour, work force and crafts. Unfortunately, the village underwent irreversible damage; it no longer exists. The SV contained a mosque and a graveyard, enforcing the notion of an Islamic character of the village.

Figure 17. Anthropogenic destruction of galleries in the FNAS in the AsSubbiyah area, Kuwait.

11. Discussion

General, this paper describes the discovery of the FNAS ancient settlement in the AsSubbiyah area north of Kuwait Bay, Kuwait. It also displays a comprehensive field illustration of the various gallery structures and their artefacts.

The FNAS contains gallery foundations of three architectural styles which represent three cultural groups that inhabited the site. The foundations contain ample evidence for a blacksmith community, as shown by the preponderance of smelters and manufactured iron tools.

The tight clustering of the FNAS galleries, as well as its community smelters, reflect the tight social compassion and solidarity, and assistance of the needy members of the society.

11.1. People

The identity of the people who inhabited the FNAS site is unknown, and more than one generation of people may have dwelled in the site. Potentially, three different groups settled in the site, each corresponding to one of the three occupation intervals. The AsSubbah culture settled in the FNAS in the third (and possibly second) occupation interval. Similarities between the galleries of the second and third intervals support this conclusion, but this is uncertain. The first episode of occupation gives no hints to the identity of the occupiers. May be the inhabitants of the first occupation were celestially motivated people following an ancient faith.

The size of the settlement and the well-designed structures are indications that occupancy was continuous for short terms, before the settlement was re-populated. A period of unknown length elapsed between the successive residences. Moreover, the close proximity of the FNAS to a fresh-water source, that probably became inundated semi-continuously, helped in the stability of the site and its people. There are no signs of strictly seasonal (winter or summer) living in the site.

Nations that resided in the FNAS galleries are environmentally sensitive and conscious. The fact that the gallery foundations do not possess redundant construction material, among other evidence, testifies to the awareness of recycling of the natural resources by the FNAS residents. The inhabitants may have likely suffered from shortages of building material and food, and barely had self-sufficiency.

Situated on an ancient pre-Islamic route network made the FNAS a gathering point of cultures. People from central Asia, Persia, Asia Minor, east Africa and the Arabian Peninsula mingled in the FNAS. It is likely that people belonging to the multiple occupations of the FNAS descended from these exotic cultures. Interactions between the different cultures are commercial, faith preaching, political, linguistics, cultural and scientific. For example, (Potts, 1986) discussed the connection between the Dilmun culture in the Arabian Gulf and the Syro-Anatolian nations to the northwest. The present area of Kuwait (e.g. FNAS) played a significant central role in this connection. (Kepinski, 2007) elaborated on the tribal links between Arabia and the Middle Euphrates at the beginning of the second millennium BC. (Kennet et al., 2011) investigated Early Islamic settlements along Kuwait Bay.

11.2. Diet

Insufficient information about the diet of the residents that inhabited the FNAS prevents the assessment of their diet habits. Generally, the FNAS does not provide sufficient diet evidence. Refuse dumps, likely surplus collection centers, contain meagre remains of fish bones and skeletons. The site lacks shell midden, a sure sign for non-sea diet. Presence of fishhooks and nets contradicts this interpretation. This shortage of the evidence for remains of sea resources is surprising, due to the proximity of the FNAS to Kuwait Bay. Consumption of fish and shells constituted only a minor part of the diet of the FNAS inhabitants.

Remains of animal bones do not fare better than sea-derived food. Although many small bones of vertebrate animals are common in the FNAS (**Figure 14**), larger bones are missing. This suggests that the main provider of meat is small desert animals, and not large animals like sheep and camels.

Staple grains and other organic components of the diet also do not appear in refuse dumps and other places in the FNAS likely to contain such remains. This observation, however, may be a function of the instability of this type of food material with time. The desert sun heat is another reason causing deterioration and disappearance of such organic stuff (Misak et al., 2003). Aside from the animal and fish bones, evidences for much consumption of other types of diets are absent.

11.3. Age

The age of the FNAS is unknown. Neither are the ages of the different repeated occupations. Currently, no physical or numerical ages are available for the FNAS.

Speculations on the numerical age are based on the Holy Gurran. Three verses in the Holy Gurraan mention the name AsSabeen (pre-Islamic name for the modern AsSubbah people). The Holy Gurraan mentions the name in Verse number 62 in Chapter 2 (Al-Bagarah), Verse number 69 in Chapter 5 (Al-Maeedah), and in Verse number 17 in Chapter 22 (Al-Hajj).

God revealed the Holy Gurraan 1442 years ago. This places a lower limit of age for the FNAS. It is unknown how far back in antiquity the AsSubbah tribe existed. It is reasonable to declare a general age of more than 1500 years as the age of the settlement, until an accurate age is determined. Animal bones and charcoal found in the FNAS will facilitate the age determinations. Such determinations of the age of the FNAS by radiometric methods are vital for the assignment of time intervals for the occupations in the FNAS. Around it revolves the chronology of the site. The determination of the age of the FNAS will be paramount among all future investigations.

Coins constitute an exceptionally informative artefact in any archaeological site. Excruciating attempts failed to find coins in the FNAS. Inscriptions on coins provide the age of the minting of the coins and the name of the ruling dynasties. In addition, coins are the repositories of numerical benchmark ages of settlements.

Excavations in the Kathemah area to the west of the FNAS revealed Islamic remains (Skinner & Fitton, 2010), supporting an Islamic age for at least a part of the FNAS site.

11.4. Pilgrim Routes

From ancient times, the Arabian Peninsula has been the criss-crossing of commercial and pilgrim caravans (Karlovsky, 1972; Al-Farhan, 2008). The northeastern part of the peninsula has several well-known routes that intensified after the advent of the Islamic faith. (Potts, 1986) outlined most of these caravan routes.

I have constructed an additional subsidiary route that extends along the northwestern Arabian Gulf and the western border of Kuwait. It travels from southern Iraq to the holy cities in western Arabia (**Figure 18**). This additional route passes through the FNAS, Dhlay Emsayeed Khan (Al-Mishwat, in preparation), Emhazool Khan (Al-Mishwat, 2005, 2007), and Hafr Abu Mosa (Hafr El-Batin), Saudi Arabia.

The FNAS acted as a rest area, supply center, and pit stop for exchange of goods carried by commercial caravans and pilgrimages travelling this route. The route also served as a path for ancient military campaigns through this part of the Arabian Peninsula.

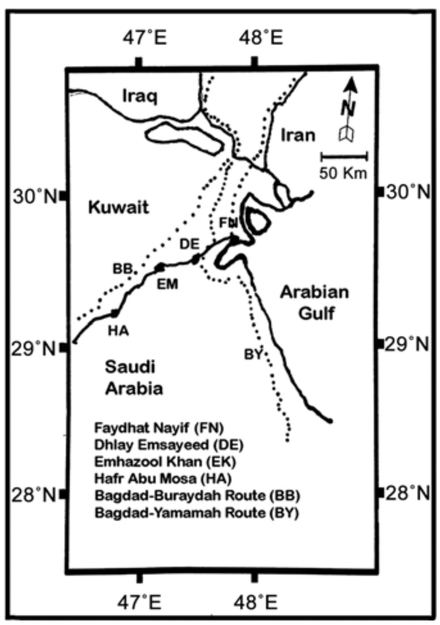

Figure 18. The established pilgrim and commercial routes in the northeastern part of Arabian Peninsula (Potts, 1986) (dotted line) and the subsidiary route constructed by the author in this study (solid line). The new route passes through the FNAS in the AsSubbiyah area, Kuwait and the DE, the EK, and the HA, in its way to BB in Saudi Arabia.

12. Conclusions

I conclude this research paper by summarizing the most salient aspects of the FNAS, an archaeological site discovered recently by the author north of Kuwait Bay, Kuwait. The site shows gallery foundations that display three distinct structural styles. Each style potentially belongs to a different group of site inhabitants. Inhabitants of the site were involved in iron smelting and fabrication. Many iron tools, pottery shards, and glass shards comprise the FNAS artefacts, among other remains. The FNAS served as a blacksmith community along the pilgrim's route to the Holy places in western Arabia.

Inhabitants of the FNAS likely belong to the different nations of the Middle East. The younger (*i.e.*, third) style of galleries was settled by the AsSubbah wandering tribe of Arabia. Indirect evidence from the Holy Gurraan places 1442 years as a minimum age for the FNAS.

Much research will ensue in the future. It will explore the many facets of the FNAS. It also will address many of the contradictions posed by the present state of knowledge on the site.

13. Future Investigations

Being a discovery, the FNAS (and the Sonna Village) do not have references in the literature. Future research will follow to address the various aspects of the FNAS. Among the facets targeted for investigations are the age of the site, the identity of cultures that occupied it, inspection of the iron smelting profession, diets of the people, ethnicity and faith of the people, and comparison with other sites in the region. Scouting for other archaeological settlements will intensify. The grave burial aspect of the FNAS is presently enigmatic, and awaits investigations.

Currently, technically oriented investigations of the FNAS are under consideration. Paramount among the lines of studies is age dating of the FNAS by the C14 radiocarbon method, and delineation of the age of different episodes of settlements. Future research involves also AUTOCAD mapping of the gallery structures to create an accurate map of the site. GPR studies on a highly sophisticated ground plan will help unravel the shallow subsurface beneath the FNAS.

An anthropological investigation of the site will provide additional information that will enrich the history of the area.

This paper serves as a basis for future studies on the FNAS multitude of aspects. A team of specialized researchers, supported by requisite funds, working according to a long-term plan, will lead investigations to a satisfying wealth of information.

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Conflicts of Interest

The author declares that the research has no conflict of interests.

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References

Al-Duweesh, S. (2010). *Sabbiyah Graves in the State of Kuwait: Archaeological Study.* Unpublished MA Dissertation. Zagazeg: Zagazeq University.

Al-Farhan, F. (2008). Historical Routes in Kuwait's History. *Alqabas Newspaper*, 12600, 30.

Al-Mishwat, A. (2005). Emhazool Archaeological Site: A New Discovery of Remains of an Ancient Settlement in the Emhazool Area in Southwest Kuwait. *Developing International Geoarchaeology Conference (DIG 2005)*, 21-23 October 2005, Saint John, Newfoundland, Canada.

Al-Mishwat, A. (2007). Ancient Water Cisterns in the Emhazool Area, Southwest Kuwait: A New Discovery. *Developing International Geoarchaeology Conference (DIG 2007)*, 19-21 April 2000, Cambridge.

Almutairi, M. (2008). *The History of Kuwait Archaeology and the Future Possibilities.* Unpublished MA Dissertation. Cardiff: Cardiff University.

Al-Thani, H. (1997). *The Arabian Gulf in the Prehistory Ages.* Cairo: Book Centre Press.

Al-Wohaibi, F. (1987). *Survey of Umm an-Namel Island, State of Kuwait.* Unpublished PhD Dissertation, Bloomington: Indiana University.

Al-Wohaibi, F. (1999). *Preliminary Report of Kuwaiti Archaeological Team Excavations in Sabbiyah Area.* Kuwait: Kuwait National Museum, Antiquity Department.

Barta, P., Benediková, L., Hajnalová, M., Miliková, Z., Belanová, T., & Shehab, A. (2008). Al-Khidr on Failaka Island: Preliminary Result of the Fieldworks at a Dilmun Culture Settlement in Kuwait, Turkish. *Turkish Academy of Sciences Journal of Archaeology, 11,* 121-134. https://doi.org/10.22520/tubaar.2008.0007

Beech, M. (2010). The Animal and Fish Bones. In R. Carter, & H. Crawford (Eds.), *Maritime Interactions in the Arabian Neolithic: The Evidence from H3, As-Sabiyah, an Ubaid-Related Site in Kuwait* (pp. 129-156). Boston, MA: Leiden.

Benedikovà, L. (2007). *Final Report on the Third Excavation Season of Kuwaiti-Slovak Team, February 2007.* Unpublished Report. Kuwait: Kuwait National Museum.

Callot, O. (2008). *Kuwaiti-French Archaeological Mission in Kuwait, Failaka.* Kuwait: Antiquity Department.

Carter, R., Crawford, H., Mellalieu, S., & Barrett, D. (1999). The Kuwait-British Archaeological Expedition to As-Sabbiyah: Report on the First Season's Work. *Iraq, 61,* 43-58. https://doi.org/10.2307/4200466

Department of Antiquities and Museum (2006). *The Summary of Achievements of the Department of Antiquities and Museum 2001-2005.* Kuwait: The National Council for Culture, Art and Letters.

Frohlich, B. (1987). *Kuwait Archaeological Survey.* Kuwait: Kuwait National Museum.

Hannestad, L. (1983). *The Hellenistic Pottery from Failaka*. Aarhus: Jysk arkaeologisk selskab. 16, 7-128.

Hoilund, F. (2009). *The Danish Archaeological Mission in Kuwait 1958-1963.* Kuwait: National Council for Culture, Arts and Letters.

Jarman, S. (1977). Bahrain Island: Human Skeletal Material from the First Millennium BC. *Bulletin of the Asia Institute Quarterly, 2,* 19-40.

Kennet, D., Blair, A., Ulrich, B., & Al-Duweesh, S. (2011). The Kadima Project: Investigating an Early Islamic Settlement and Landscape on Kuwait Bay. *Proceedings of the Seminar for Arabian Studies, 41,* 161-172.

Kepinski, C. (2007). Tribal Links between the Arabian Peninsula and the Middle Euphrates at the Beginning of the Second Millennium BC. *Proceedings of the Seminar for Arabian Studies, 37,* 125-134.

Lamberg-Karlovsky, C. C. (1972). Trade Mechanisms in Indus-Mesopotamian Interrelations. *Journal of the American Oriental Society, 92,* 222-229. https://doi.org/10.2307/600649

Misak, R., Mahfud, S., & Al-Asfur, T. (2003). *Kuwait Desert Environment: Its Features, Degradation Causes and the Ways to Rehabilitate it.* Kuwait: Centre for Research and Studies on Kuwait.

Parker, P. M. (1999). *The Archaeology of Death and Burial* (pp. 66). Stroud: Sutton.

Poirier, F. (2005). *Preliminary Investigations into Kuwait's Prehistory.* Columbus, OH: The Ohio State University.

Potts, D. T. (1986). Dilmun's Further Relations: The Syro-Anatolian Evidence from the Third and Second Millennia BC. In S. H. A. Al Khalifa, & M. Rice (Eds.), *Bahrain Through The Ages-Archa* (pp. 389-398). London: Routledge.

Skinner, T., & Fitton, T. (2010). *The Kadima Project: Archaeological Survey and Excavation of an Early Islamic landscape on Kuwait Bay.* Kuwait: National Council for Culture, Arts and Letters.

Soltysiak, A. (2007). *Preliminary Report on Human Remains from Mughyairah, Radha, Sabbiyah and Khuwaisat Areas.* Kuwait: Kuwait National Museum.

Swideg, S. (2010). *Jal al-Zur geomorphology.* http://swideg.jeeran.com/geography/archive/2010/8/1201214.html

Uerpmann, H., Uerpmann, M., & Jassim, S. (2006). *Funeral Monuments and Human Remains from Jebel-Buhais.* United Arab Emirates: Sharjah Government.

Watson, O. (2004). *Ceramics from the Islamic Land, the Al-Sabah Collection.* London: Thames and Hudson.

Whittle, A. (2003). *The Archaeology of People: Dimensions of Neolithic Life.* London: Routledge. https://doi.org/10.4324/9780203403532

Wilkinson, C. (1973). *Nishapur: Pottery of the Early Islamic Period.* New York, NY: Metropolitan Museum of Art.

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Sumerian Arsenic Copper and Tin Bronze Metallurgy (5300-1500 BC): The Archaeological and Cuneiform Textual Evidence

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Abstract

Copper was one of the first metals to be utilized since 8000 BC. Arsenic copper became popular due to its lower melting point and decreased metal porosity, allowing for the creation of longer metal blades. Tin bronze began appearing around 3500 BC, and its superior recyclability and malleability made it the favorite metal alloy until the prevalence of iron. Bronze alloy was limited by its requirement of tin, which was more difficult to acquire than copper in ancient Mesopotamia. This manuscript describes the ancient trade of copper and tin based on the cuneiform texts. The paper will also list the cuneiform texts that described steps of metallurgy, including the tools, furnaces, and crucibles utilized in Sumerian metallurgy. This paper reports the analysis of the metallurgy techniques described by cuneiform to the chemical analysis of copper artifacts in order to provide a better understanding of the meaning of Sumerian metallurgy cuneiform texts.

Keywords

Copper, Bronze, Cuneiform, Metallurgy, Mesopotamia

1. Introduction

Copper was one of the first metals to be utilized worldwide due to ubiquitous ore deposits, its low smelting temperature, and its coveted lustered appearance (Patterson, 1971; Moorey, 1988; Oudbashi et al., 2020; Radivojević, 2010; Garfinel et al., 2010). There has been long-standing debate as to whether metallurgy technology arose spontaneously across the globe, or whether it represents a process of knowledge diffusion (Wertime et al., 1973; Killick, 2009; Thornton, 2009). Whichever model is more reflective of metal history, it is important to remember that the metallurgy technology in each region developed its own local characteristics and methodologies; each area of the world has its unique geography, natural resources, and history of innovation. For example, what kind of copper ore is available: pure copper, copper oxide, or copper sulfide? What kind of fuel is available: wood, dried grass, or charcoal? What can be used to enhance fire temperature: forced air flow through reed straws, hand fans, or bellows? What material is available to create casting molds: open sand, clay, or lost wax (Helwing, 2017; Wischnewski, 2017)?

This paper will explore the development of arsenic copper and tin bronze metallurgy technology from 6th millennium BC Sumer, when arsenic copper was utilized, until around 1500 BC when the rise of iron metallurgy required different sets of technology and tools to purify and cast metal with a much higher melting temperature. It will illustrate some of the cuneiform textual evidence, including texts that describe the steps of copper metallurgy.

2. Background: Sumer's Copper History

Copper metallurgy has been associated with some of the earliest complex civilizations of the world (Golden, 2014). Cold annealing of native copper was found as early as the 8th millennium BC in Southwest Asia (Roberts, 2009; Matthews & Fazeli, 2004; Raymond, 1986). Early copper metalwork was found in 5th millennium BC Varna, Bulgaria, which showed evidence of metal casting (Svend, 2017). Copper smelting specialization has also been documented on the Levantine coast in the 6th millennium BC (Borschel-Dan, 2000; Garfinkel et al., 2014).

Ancient Sumer and southwestern Iran were unique in that they showed the first evidence of arsenic copper utilization, found, for example, from 5300 BC in Susa (Ryck et al., 2005). While pure copper annealing was documented in Northern Mesopotamia before 6000 BC (Levey, 1959), arsenic copper first became prevalent in Southern Mesopotamia in the second half of the 6th millennium BC (Svend, 2017).

There is debate as to whether arsenic copper was the result of deliberate addition of arsenic to copper during the smelting process or whether arsenic was a carry-over compound during the smelting process (Wischnewski, 2017; Ryck et al., 2005). While natural copper ores, especially those from Anatolia, may possess some naturally occurring arsenic, it is generally believed that arsenic content over 5% is evidence of deliberate addition (Ryck et al., 2005). During copper smelting, arsenic sulfide can be added via either orpiment or realgar, two pigments well known from ancient Egypt (Daniels & Leach, 2013; Levey, 1959; Stech, 1999). Copper comprised of greater than 2% arsenic possesses useful chemical properties (Raymond, 1986; Moorey, 1999). Instead of the reddish copper appearance, arsenic copper exhibits a silvery luster and was valued as a luxury item (Svend, 2017). Arsenic copper alloy demonstrates greater elasticity and structural durability, and thus, could be fashioned into ornaments more easily (Allen et al., 1951).

Arsenic copper also increased the range of weapons Sumerians were able to construct. Arsenic added to copper reduces metal porosity, thus creating a stronger alloy (Junk, 1973). While battle axes and maces could withstand metal porosity, daggers could not. The absence of porosity prevents pitting of the metal, thus allowing casting of a longer metal blade. It was observed that, with the invention of arsenic copper, average Sumerian daggers increased from an average length of 34 cm to 60 cm (Svend, 2017).

Additionally, with a lower melting temperature and decreased porosity, arsenic copper could be cast more easily (Junk, 1973). Instead of being limited to open sand molds where castings had to be more carefully monitored, metalsmiths could pour melted arsenic copper into lost-wax molds without having to worry about uneven filling or undetected bubbles (Zettler & Lee, 1999). With lost-wax casting using pre-formed clay or pottery molds, a coppersmith could create more complex objects such as crowns, scepters, or the spokes of wheels, thus fostering innovations in metallurgy (Svend, 2017).

Arsenic copper represented the height of copper metallurgy until the arrival of bronze, an alloy of copper and tin. Sumer was also the birthplace of bronze technology, most likely owing to the area's long history of copper working knowledge and its flourishing copper smelting centers (Lopez, 2009). Tin bronze was introduced around the middle of the 3rd millennium BC, whereas the first true evidence of bronze is known from around 3000 BC at Ur in Mesopotamia (Pollock, 1999).

Tin bronze provided several advantages: while copper has a melting temperature of 1084˚C, the addition of tin lowers the melting point to 950˚C (Raymond, 1986). The lower melting temperature was easier to achieve and maintain, thus making the pouring and casting of metal even more manageable. The ease of casting increased the rate of production and thus accelerated the bronze industry.

Tin bronze also had the additional advantage over arsenic copper in its ability to be recycled and reused. Due to their precious nature, copper artifacts were continuously recycled and repurposed (Moorey, 1982). In "Laws of Eshnunna", a bilingual (Sumerian and Akkadian) composition which may have originally been composed in the late 3rd millennium BC but is known from Old Babylonian Akkadian (early 2nd millennium BC), one clause stipulated that workmen issued copper tools for the harvest must return metals of the same weight at the end of the season, even if in scraps (Roth, 1995). Metalware and scraps were melted down and recast, but arsenic is a volatile element and can evaporate during the smelting process (Crawford, 2004; Shibayama et al., 2010). Repeated hot annealing of arsenic copper would gradually see a decline of the arsenic content and thus lead to degradation of the alloy (Greenfield, 2017; Mödlinger et al., 2017). The evaporated arsenic gas was most likely also toxic to the coppersmith; recent bone analysis of ancient metal workers at Chalcolithic Levant showed elevated levels of arsenic (Oakberg et al., 2000). Tin bronze, however, was superior in that it did not suffer from metal degradation with metal recycling nor give off toxic fumes, and this may have contributed to its gain in popularity among coppersmiths.

Tin copper compounds had additional advantages over arsenic copper. Like arsenic, tin could also reduce the amount of bubble formation in the copper cast. However, tin bronze provides much more structural strength than is found in arsenic copper. While arsenic copper was strong enough to make tools and weapons, its limited tensile strength restricted the length of arsenic copper weapons to be no longer than daggers (Lopez, 2009). With the availability of bronze, metalsmiths were able to create longer weapons such as sabers, larger constructs such as statues, or sturdier tools such as hoes, via casting (Crawford, 2004).

Through trial-and-error over the years, Sumerian metalsmiths defaulted to creating copper alloys with approximately 10% tin (Raymond, 1986). This ratio most likely represents a balance between better properties of tin bronze vs the high cost of tin metal due to difficulty of procurement. The limited supply of tin was one of the major reasons why, despite the superior performance of tin bronze, it did not supplant arsenic copper until 1500 BC (Greenfield, 2017). Here it is important to examine the supply of copper and tin during the Bronze Age, as Mesopotamia lacked natural metal ores.

3. Results

1) Sumerian Copper Trade

Mesopotamia in the 3rd millennium BC received copper through both land and sea routes. Traders were able to bring copper over land from the Zagros (present day Iran) and Taurus (present day Turkey) mountains (Muhly, 1973; Morr et al., 2013). Anatolian copper mines produced copper sulfides, which had to first be roasted into copper oxide before it could be smelted (Levey, 1959). It is thought that Anatolian copper was smelted in Tishmurna and Durhumit (near the mines of Boghazkeui and Kültepe) before being exported to Sumer (Collins, 2016). An extensive network of trading posts, based on the Old Assyrian trade route via Assur, was established such that the amount of copper imported increased over time (Leick, 2001). By the 2nd millennium BC, the annual import of copper from Anatolia to northern Mesopotamia via donkey caravan was estimated to be 10 tons (Mieroop, 2016).

In addition to the overland copper routes, Sumer also had a robust copper sea trade to three regions (Begemann et al., 2010): Dilmun, Magan, and Meluhha. Dilmun (present day Bahrain) was a major trading post connecting Mesopotamia, Oman, Iran and the Indus Valley (Giardino, 2019). Magan is present day Oman, a major source of copper ores. Meluhha refers to the present-day Indus Valley (Muhly, 1973), where the Harappan Civilization flourished from 2500-1700 BC.

There are records of many copper purchases from Tilmun by Ur during the Larsa period 2025-1763 BC (Muhly, 1973). It is estimated that several hundred kilograms of copper arrived annually from Tilmun to Southern Mesopotamia during the 3rd millennium BC (Giardino, 2019). Trades were carried out by “Tilmun boats” (má tilmun-naki). That Tilmun traders played a dominant role in the copper trade might be inferred by the fact that copper transactions were conducted using the weight standard of Tilmun, the "Tilmun standard" (na4 tilmunki) (Muhly, 1973).

One of the texts from Ur during the Lara period (2025-1753 BC) showed details of a copper trade with Tilmun:

2 ma-na kù-babbar;
5 Ì-gÌš gur;
30 túg-hi-a;
Kaskal tilmunki-šè;
Nam urudu sa10-sa10-dè;
"2 minas of silver
5 kur of sesame oil
30 garments
For an expedition to Tilmun
To buy copper there" (Muhly, 1973).

Tilmun was first mentioned in the Uruk IV period (4000-3100 BC), but its name appeared much more frequently in Early Dynastic period texts (2900-2350 BC) (Mieroop, 2016). By the end of the third dynasty of Ur, however, copper trade from Tilmun apparently declined. Instead, Magan appeared to have replaced Tilmun as the source of copper during the reign of Ibbī-Sîn (2029-2006 BC). The title of the office in charge of trade with Tilmun, the Alik Tilmun, no longer appeared in texts (Falkenstein, 1966). Instead, the title of ĝa-eš8 a-ab-ba, with connection to Magan, was used in association with trade:

"níg-šám-ma urudu má-ganki";
"merchandise for buying copper of Magan".

The texts from 2000 BC referred to the quantity of wool and textile that were traded for copper (Leemans, 1960). With the shift in trade, Magan boats were increasingly described. They were characterized by their large size, with each able to carry 15 metric tons of material, and by their coating of water-proof black bitumen tar (Giardino, 2019).

As opposed to Tilmun, which was most likely a trading post, Magan was an actual site of copper production. Magan was referred to as KUR URUDU   (mountain of copper) (Muhly, 1973). The importance of Magan copper can be determined by chemical analysis, since copper mined from Magan ores contained characteristic high nickel content. It has been determined that, among Sumerian copper artifacts from the 2nd to the 3rd millennium BC, about half possessed the characteristic high nickel content, averaging 0.05% - 3.34% (Giardino, 2019).

Copper trade with Meluhha, on the other hand, was not as well documented. It is thought that Mesopotamian cuneiform texts actually described two Meluhhas, one to the west (now generally believed to be located in present day Nubia and Ethiopia), while the other one was to the east and thought to be in present day west Pakistan in the Indus Valley (Dhavalikar, 1997). The Meluhha in the Indus Valley is believed to be the copper trading partner described in a Sargon I text by someone described as "Su-i-li-su, Meluhha interpreter" on a Mesopotamian seal (Kanika, 2021). Meluhha was located near two major copper deposits, the copper oxide ores in the Saindak, and malachite and azurite carbonate ores in the Raskoh Range (Muhly, 1973).

Trade with Meluhha was better documented during the second half of the 3rd millennium BC. The reliance of the sea trade route to the Indus Valley most likely accelerated during the Sargonic period when overland trade routes to the Zagros mountains were disrupted. The empire of Ur III, however, collapsed around 2000 BC. With the concomitant decline of Magan, the sea copper trade route was largely discontinued in favor of northern overland routes as new and cheaper sources of copper became available from Anatolia and Cyprus (Steinkeller, 2014).

As opposed to copper, the source of tin for Mesopotamia during the Bronze Age is not as well defined (Cuénod et al., 2015; Yener, 1993). First of all, tin and lead both have similar grayish-white appearances and were described interchangeably in Sumerian texts (Muhly, 1973). In Sumerian, the word an-na is actually used to describe both tin and lead (ePSD, 2021). The confusion persisted even to the Classical period, as tin was actually called plumbum candidum in Latin, or "white lead".

2) Sumerian Metallurgy Technology

Having reviewed the sources of Mesopotamian copper and tin bronze in Bronze Age Sumer, I turn to the cuneiform texts that provide evidence for the steps in the process of copper metallurgy. Copper in Sumerian was referred to as urud , while bronze was referred to as zabar .

Copper ore exists in rock form and needs to be pulverized into pellets to allow for metal extraction during the smelting process. Copper ores were referred to as Urud hašum (urud ha-šum) (Levey et al., 1959). Mortars (naĝa) or pestles (ĝešgana) were already in existence during the Early Bronze age to grind grains into flour and it is believed that the same tools were used to process copper ores.

First, mortars and pestles were utilized to crush (gum) and to grind (guru) ores into pellets of manageable size (Levey et al., 1959). Next, the crushed copper pellets were washed to remove soil impurities and were recollected via a sieve (sim, "to sieve"). A text from 2200 BC shows that clay colanders with pores were covered with hair or wool to strain and isolate materials (Levey et al., 1959).

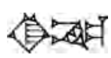
Processed ore pellets were next smelted in order to extract copper. Copper metallurgy arose after the development of pottery, and many believe that copper smelting initially occurred as an accidental pottery byproduct when copper in pottery glazing became congealed in the furnace and was extruded as small copper nuggets (Tylecote, 1992).

Furnaces used for copper smelting also evolved over time. Small furnaces were found dating as far back as 4000 BC in Assur, in northern Mesopotamia, a region which at the time exhibited cultural connections with the south (the so-called "Uruk culture") (Levey et al., 1959). The initial furnaces were constructed with clay and were of a circular design. The furnaces had openings at the bottom where fuel could be added, and had multiple side vents to allow for air drafts and thus, higher burning temperatures. Furnaces from the 3rd millennium BC became taller (total height up to 100 cm), and were now in the shape of a house. Fuel was kept inside the rectangular base of the furnace, and air vents in the shape of windows were added to the sides of the house-shaped furnaces in order to enhance air flow. Larger furnaces started appearing in Susa at the beginning of the 3rd millennium (Levey et al., 1959). These were of a circular design and were topped with a dome. The furnaces were over 200 cm tall and are estimated to have reached temperatures up to 1100˚C. Deposits of calcium carbonate found inside a furnace in Khafaje in the Diyala region of central Mesopotamia are evidence that this type of furnace was used for smelting, rather than for pottery making. Calcium carbonate was an often-used flux agent, in the form of limestone, utilized in copper smelting to facilitate the isolation of copper, and its existence within the slag inside this furnace suggests its usage for copper metallurgy (Patterson, 1971).

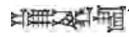
There was another type of large furnace found dating to around 3000 BC, the "floor of eye" furnace, known from Levant and Northern Mesopotamia. This furnace was constructed on the floor of the shop, with a large central pit or "eye." While this type of furnace was easier to construct, its open-air design would not be able to achieve a high enough temperature for copper smelting. This type of furnace was most likely used for copper hot annealing, rather than for smelting.

In order to achieve the higher temperatures required for copper smelting, another design, the stacking furnace, also emerged (Levey, 1959). Multiple furnace elements were stacked vertically atop each other, achieving the height of a house. The utilization of these furnaces for copper smelting was confirmed by cuprite and malachite copper deposits found at the bottom of a furnace excavated in Khirbet el-Jariyeh.

The stacking furnace also utilized bellows at the bottom to fan flames and achieve high temperatures. The use of bellows was documented as early as the second millennium BC, when a Larsa coppersmith received two goats "for the leather of the bellow" of the furnace (Faust, 1941). Another tablet reveals that reed pipes ^{GI}KA IM  were connected to the bellows in order to direct flames into the furnace (Cros, 1910).

Within the furnaces, copper pellets were smelted inside crucibles, Sumerian abni$_2$  (ePSD, 2021). Crucibles were made of fired clay in order to endure the high furnace temperatures, and were found as early as 3000 BC at Amouq in Syria, near the northern extent of the Uruk culture and trade networks. During copper smelting, impurities were separated as floating slags and tapped off, with molten copper remaining in the crucible to be recovered (Hauptmann, 2014).

Copper metallurgy requires sustained and controlled flames, and the importance of fire and temperature were recorded in some of the earliest cuneiform texts: "Fire is kindled, it should be a good fire, not a smoky or a fierce fire" (Levey, 1959); the text also mentions that the furnace fire needed to be kept going for four to ten days (Thompson, 1936).

Fuel was a critical component of fire, and cuneiform texts recorded different types of fuel used in the copper extracting process. Fires from 2000 BC in Palestine and Northern Mesopotamia mostly used dried shrubs and bushes (Levey et al., 1959). There is text showing the usage of styrax, mulberry or willow wood, Sumerian $^{\text{ĝeš}}$šag$_4$-kal  in Sumer in the 7$^{\text{th}}$ century BC (Levey et al., 1959). There are discussions as to whether charcoal $^{\text{ĝeš}}$u$_2$-bil$_2$-la ($^{\text{ĝeš}}$u$_2$-bil$_2$-la) [46] were used as fuel, as the archaeological evidence is ambiguous; it is difficult to differentiate between charcoal and accidentally charred firewood (Levey et al., 1959).

The combination of tin and copper to create bronze was a technological advancement known at an early time, as a 3$^{\text{rd}}$ millennium BC hymn praised the god of fire, Gibil, for mixing copper and tin (Figulla & Martin, 1953). A tablet from the 2$^{\text{nd}}$ millennium BC showed a formula for bronze, namely "10 minas of glittering copper and 2 minas of tin" and "900 shekels of copper and 70 of tin" (Wiseman, 1953). Similarly, a Sumerian text from the 3$^{\text{rd}}$ millennium BC reads:

"1/2 talent, 5 minas and 1/3 shekel of copper plus 4 minas, 5 shekels of tin to make bronze (Strassmaier, 1889)."

For modern day calculations:

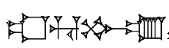
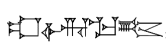
1 talent = 75 lbs or 60 minas

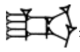
1 mina = 1.25 lbs or 50 shekels

1 shekel = 0.4 ounce

Smelted copper alloys were cast into molds for the final products. The earliest mold system was the open cast, in which a mold was created either in a sand tray or chiseled into the floor of the workshop (Lopez, 2009). The pattern on the shop floor for bronze casting was described as a "crevice" or ki-i-dar or *nigissu*  from a second millennium BC text from Sumer (Levey et al., 1959). The lost wax method of casting was already developed by 2800 BC, in which a wax model of the final object was first created and wrapped with clay (Levey, 1959). Wax dissolved with heating, and the empty space left behind in the clay could be used to mold bronze. Molds used in bronze casting were called niĝdea in Sumerian, written $^{\text{urud}}\text{niĝ}_2\text{-de}_2\text{-a}$ .

The wax method was mentioned in a first millennium BC text: "20 minas of wax were given to the smith to make a *ni-bi-ri*", which is associated with the Sumerian god Marduk .

$^{\text{d}}\text{AMAR.UTU}$ (Strassmaier, 1889). The lost wax method was also documented in the 3rd Dynasty of Ur, when a hubum ($^{\text{urud}}\text{hu-bu-um}$) , which forms part of a chariot, was made with one minas of copper (Limet, 1955). In addition, a chariot door part, armatum ($^{\text{urud}}\text{ar-ma-tum}$) , was made with 2 minas and 16-1/2 shekels of copper. Additionally, it was noted that sheep fat, flour and oil were used as early as the end of the 3rd millennium BC to coat the molds for easier extraction (Wischnewski, 2017).

There were multiple classes of metal workers in 3rd millennium Sumer. Simug , was a metalsmith who worked with all kinds of metals (Wischnewski, 2017).

Simug urudu worked primarily on copper , and Simug zabar , specialized in bronze. There were also metal specialists, with tibira focused on hammering metals into shape, and kù-dím was a luxury smith who only worked with gold and silver.

4. Discussion

As compared to other ancient civilizations who underwent the Bronze Age transformation, the history of copper metallurgy is especially well documented in ancient Sumer due to the availability of cuneiform tablets. This paper outlines some of the known evidence of arsenic copper and tin bronze metallurgy, from copper and tin mineral acquisition, mostly achieved through trade, to ore processing, smelting, and casting. Unique aspects of Sumerian metallurgical tradition include their set of local fuels for smelting fires and their particular crucible and furnace designs.

The study of metallurgy history is hampered by the complicated history of copper artifacts, where each piece invariably underwent repeated cycles of salvage and re-tooling. Since each cycle of metal annealing adds new chemical signatures to the alloy, understanding the provenance of each ancient metal object via chemical or atomic analysis is complicated. The study of the history of metallurgy is thus substantially improved by a careful examination of the textual evidence, as this overview has shown. With up to 90% of the 500,000 cuneiform tablets available yet unanalyzed, there is a large treasure trove of potential metallurgy history yet to be discovered (Hardach, 2018). The interpretation of metallurgy cuneiform can be improved when cuneiform texts could be analyzed in the context of modern day chemistry in order to better understand the chemistry described by cuneiform. With digital cuneiform analysis becoming available, it is possible more information can be shed on the origin of metallurgy in ancient Sumer.

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Conflicts of Interest

The author declares no conflicts of interest regarding the publication of this paper.

References

Allen, N. P., Schofield, T. H. et al. (1951). Mechanical Properties of α-Solid Solutions of Copper, with Zinc, Gallium, Germanium and Arsenic. *Nature, 168,* 378-379. https://doi.org/10.1038/168378a0

Begemann, F., Hauptmann, A. et al. (2010). Lead Isotope and Chemical Signature of Copper from Oman and its Occurrence in Mesopotamia and Sites on the Arabian Gulf coast. *Arabian Archaeology and Epigraphy, 21,* 135-169. https://doi.org/10.1111/j.1600-0471.2010.00327.x

Borschel-Dan, A. (2000). 6,500-Year-Old Metalworkers: Humanity's 1st Smelting Furnaces Found in Israel? *The Times of Israel,* October 4

Collins, P. (2016). *Mountains and Lowlands: Ancient Iran and Mesopotamia*. Oxford: University of Oxford.

Crawford, H. (2004). *Sumer and the Sumerians*. Cambridge: Cambridge University Press. https://doi.org/10.1017/CBO9780511816208

Cros, G. (1910). *Nouvelles Fouilles de Tello*. Paris: Leroux.

Cuénod, A., Bray, P. et al. (2015). The "Tin Problem" in the Prehistoric Near East: Further Insights from a Study of Chemical Datasets on Copper Alloys from Iran and Mesopotamia. *Journal of the British Institute of Persian Studies, 53,* 29-48. https://doi.org/10.1080/05786967.2015.11834749

Daniels, V., & Leach, B. (2013). The Occurrence and Alteration of Realgar on Ancient Egyptian Papyri. *Studies in Conservation, 49,* 73-84. https://doi.org/10.1179/sic.2004.49.2.73

Dhavalikar, M. K. (1997). Meluhha—The Land of Copper. *South Asian Studies, 13,* 275-279. https://doi.org/10.1080/02666030.1997.9628541

ePSD (2021). *The Pennsylvania Sumerian Dictionary*. http://psd.museum.upenn.edu/nepsd-frame.html

Falkenstein, A. (1966). *Die Inschriften Gudea von Lagaš, 30*. Rome: Einleitung.

Faust, D. E. (1941). *Contracts from Larsa Dated in the Reign of Rim-Sin*. New Haven: Yale.

Figulla, H. H., & Martin, W. J. (1953). *Ur Excavations Texts: Letters and Documents of the Old-Babylonian Period* (Volume 5). London: British Museum.

Garfinkel, Y. et al. (2014). The Beginning of Metallurgy in the Southern Levant: A Late 6th Millennium CalBC Copper Awl from Tel Tsaf, Israel. *PLoS ONE, 9,* e96882. https://doi.org/10.1371/journal.pone.0092591

Giardino, C. (2019). *Magan—The Land of Copper: Prehistoric Metallurgy of Oman*. Oxford: Archaeopress Publishing, Ltd. https://doi.org/10.2307/j.ctvndv6cp

Golden, J. M. (2014). *Dawn of the Metal Age: Technology and Society during the Levantine Chalcolithic*. New York: Routledge.

Greenfield, H. J. (2017). *The Spread of Productive and Technological Innovations in Europe and the Near East: An Integrated Zooarchaeological Perspective on Secondary Animal Products and Bronze Utilitarian Metallurgy. Appropriating Innovations: Entangled Knowledge in Eurasia, 5000-1500 BCE*. Oxford: Oxbow Books.

Hardach, S. (2018). *The Key to Cracking Long-Dead Languages*? BBC. https://www.bbc.com/future/article/20181207-how-ai-could-help-us-with-ancient-languag-es-like-sumerian#:~:text=An%20estimated%20half%20a%20million,of%20cuneiform%20texts%20remain%20untranslated

Hauptmann, A. (2014). The Investigation of Archaeometallurgical Slag. In *Archaeometallurgy in Global Perspective* (pp. 91-105). New York: Springer. https://doi.org/10.1007/978-1-4614-9017-3_5

Helwing, B. (2017). *A Comparative View on Metallurgical Innovations in South-Western Asia: What Came First? Appropriating Innovations: Entangled Knowledge in Eurasia, 5000-1500 BCE*. Oxford: Oxbow Books.

Junk, M. (1973). *Material Properties of Copper Alloy Containing Arsenic, Antimony, and Bismuth*. Work Submitted as Doctorate Dissertation, Freiberg: Technischen Universität Bergakademie. https://tubaf.qucosa.de/api/qucosa%3A22426/attachment/ATT-0

Kanika, B. (2021). *Early Indus Civilization and Its Trade Relations*. History Discussions. https://www.historydiscussion.net/history-of-india/indus-valley-civilisation/early-indus-civilization-and-its-trade-relations-india-history/7058

Killick, D. (2009). Cairo to Cape: The Spread of Metallurgy through Eastern and Southern Africa. *Journal of World Prehistory, 22,* 399-414. https://doi.org/10.1007/s10963-009-9025-3

Leemans, W. F. (1960). *Foreign Trade in the Old Babylonian Period, VI*. Leiden: Studia et Documenta ad iura Orientis Antique Pertinentia.

Leick, G. (2001). *Mesopotamia: The Invention of the City*. London: Penguin Books.

Levey et al. (1959). A Study of Ancient Mesopotamian Bronze. *Chymia, 5,* 37-50. https://doi.org/10.2307/27757175

Levey, M. (1959). *Chemistry and Chemical Technology in Ancient Mesopotamia*. New York: Elsevier. https://doi.org/10.1111/j.1600-0498.1959.tb00254.x

Limet, H. (1955). Documents Économiques de la III e Dynastie D'Ur. *Revue d'Assyriologie et d'Archéologie Orientale, 49,* 69-93.

Lopez, A. M. (2009). *Metalworking through History: An Encyclopedia*. London: Greenwood Press.

Matthews, R., & Fazeli, H. (2004). Copper and Complexity: Iran and Mesopotamia in the Fourth Millennium B.C. *Journal of the British Institute of Persian Studies, 42,* 61-75. https://doi.org/10.2307/4300663

Mieroop, M. (2016). *A History of the Ancient near East: Ca. 3000-323 BC*. Oxford: Wiley Blackwell.

Mödlinger, M. et al. (2017). Arsenic Loss during Metallurgical Processing of Arsenical Bronze. *Archaeological and Anthropological Sciences, 11,* 133-140. https://doi.org/10.1007/s12520-017-0534-1

Moorey, P. R. S. (1982). The Archaeological Evidence for Metallurgy and Related Technologies in Mesopotamia, c. 5500-2100 B.C. *Iraq, 44,* 13-38. https://doi.org/10.2307/4200150

Moorey, P. R. S. (1988). The Chalcolithic Hoard from Nahal Mishmar, Israel, in Context. *World Archaeology, 20,* 171-189. https://doi.org/10.1080/00438243.1988.9980066

Moorey, P. R. S. (1999). *Ancient Mesopotamian Materials and Industries: The Archaeological Evidence* (p. 251). University Park, PA: Pennsylvania State University Press.

Morr, Z., Cattin, F. et al. (2013). Copper Quality and Provenance in Middle Bronze Age I Byblos and Tell Arqa (Lebanon). *Journal of Archaeological Science, 40,* 4291-4305. https://doi.org/10.1016/j.jas.2013.05.025

Muhly, J. D. (1973). *Copper and Tin*. Hamden, CT: The Connecticut Academy of Arts and Sciences.

Oakberg, K. et al. (2000). A Method for Skeletal Arsenic Analysis, Applied to the Chalcolithic Copper Smelting Site of Shiqmim, Israel. *Journal of Archaeological Science, 27,* 895-901. https://doi.org/10.1006/jasc.1999.0505

Oudbashi, O. et al. (2020). Arsenical Copper and Bronze Metallurgy during Late Bronze Age of North-Eastern Iran: Evidences from Shahrak-e Firouzeh Archaeological Site. *Archaeological and Anthropological Sciences, 12,* 231. https://doi.org/10.1007/s12520-020-01182-3

Patterson, C. C. (1971). Native Copper, Silver, and Gold Accessible to Early Metallurgists. *American Antiquity, 36,* 286-321. https://doi.org/10.2307/277716

Pollock, S. (1999). *Ancient Mesopotamia: The Eden That Never Was*. Cambridge: Cambridge University Press.

Radivojević, M. et al. (2010). On the Origins of Extractive Metallurgy: New Evidence from Europe. *Journal of Archaeological Science, 37,* 2775-2787. https://doi.org/10.1016/j.jas.2010.06.012

Raymond, R. (1986). *Out of the Fiery Furnace: The Impact of Metals on the History of Mankind*. University Park, PA: Pennsylvania State University Press.

Roberts, B. W. (2009). Development of Metallurgy in Eurasia. *Antiquity, 83,* 1012-1022. https://doi.org/10.1017/S0003598X00099312

Roth, M. T. (1995). Laws of Eshnunna. In *Law Collections from Mesopotamia and Asia Minor* (pp. 57-70). Atlanta, GA: Scholarship Press.

Ryck, I., Adriaens, A. et al. (2005). An Overview of Mesopotamian Bronze Metallurgy during the 3rd Millennium BC. *Journal of Cultural Heritage, 6,* 261-268.

Shibayama, A. et al. (2010). Treatment of Smelting Residue for Arsenic Removal and Recovery of Copper Using Pyro-Hydrometallurgical Process. *Journal of Hazardous Material, 181,* 1016-1023. https://doi.org/10.1016/j.jhazmat.2010.05.116

Stech, T. (1999). Aspects of Early Metallurgy in Mesopotamia and Anatolia. In *The Archaeometallurgy of the Asian Old World* (pp. 59-67). Ann Arbor: University of Michigan Press.

Steinkeller, P. (2014). The Role of Iran in the Inter-Regional Exchange of Metals: Tin, Copper, Silver and Gold in the Second Half of the Third Millennium BC. Ancient Iran: New Perspectives from Archaeology and Cuneiform Studies. *Proceedings of the International Colloquium,* Kyoto, 6-7 December 2014, 127-150.

Strassmaier, J. N. (1889). *Inschriften von Nabonidus*. Leipzig: Verlag von Eduard Pfeiffer.

Svend, H. (2017). Key Techniques in the Production of Metals in the 6th and 5th Millennia BCE: Prerequisites, Preconditions and Consequences. In *Appropriating Innovations: Entangled Knowledge in Eurasia, 5000-1500 BCE* (pp. 136-149). Oxford: Oxbow Books. https://doi.org/10.2307/j.ctt1vgw6v1.14

Thompson, R. C. (1936). *A Dictionary of Assyrian Chemistry and Geology*. London: Oxford Press.

Thornton, C. P. (2009). The Emergence of Complex Metallurgy on the Iranian Plateau: Escaping the Levantine Paradigm. *Journal of World Prehistory, 22,* 301-327.

Tylecote, R. F. (1992). *A History of Metallurgy*. London: The Institute of Materials.

Wertime, T. et al. (1973). The Beginnings of Metallurgy: A New Look. *Science, 30,* 875-887. https://doi.org/10.1126/science.182.4115.875

Wischnewski, U. (2017). Appropriation of Tin-Bronze Technology: A Regional Study of the History of Metallurgy in Early Bronze Age Southern Mesopotamia. In *Appropriat-*

ing Innovations: Entangled Knowledge in Eurasia, 5000-1500 BCE (pp. 211-219). Oxford: Oxbow Books: Oxford. https://doi.org/10.2307/j.ctt1vgw6v1.19

Wiseman, D. J. (1953). *The Alalakh Tablets*. London: British Institute of Archaeology.

Yener, K. A. et al. (1993). Tin Processing at Göltepe, an Early Bronze Age Site in Anatolia. *American Journal of Archaeology, 97,* 207-238. https://doi.org/10.2307/505657

Zettler, R. L., & Lee, H. (1999). *Treasures from the Royal Tombs of Ur*. Philadelphia, PA: University of Pennsylvania.

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The German Radar Stations at the Pointe Du Raz (FR)

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Abstract

Because of its extension in the Atlantic Ocean, the Pointe du Raz, at the extremity of Brittany, was always an ideal place for signalisation and surveillance. For this reason, lighthouses and semaphores were activated. In the thirties of the last century, the Pointe experienced a period of prosperity that led to the construction of several hotels. It was because of the rapid German occupation of France in 1940 that the situation at the Pointe changed radically. A 2 km^2 surface from the Pointe to Lescoff was requisitioned for the construction of the *Stp*s *QU 300*, *QU 500* and *QU 13* hosting sophisticated radar stations. Various German units took turns ensuring the defence and the operations at the Pointe. On 8th August 1944, the garrison evacuated after having set on fire and destroyed military and civilian installations. The visits on 3rd January 2005 and 14th August 2020 permitted to identify many *Stp* components and to determine their preservation state at about 75 years after the conclusion of WWII.

Keywords

WW II, Brittany, Pointe Du Raz, Radar Stations, *QU 300*, *QU 500*, Renntier, *QU 13*, Radar *Mammut*

1. Introduction

Because of its extension in the Atlantic Ocean, the Pointe du Raz, at the extremity of Brittany, was always an ideal place for signalisation and surveillance. For this reason, on 1838-1839 a lighthouse was erected and from 15th May 1839, it delivered a first order white light. In 1881 the lighthouse was completed with guardian lodgements and on 15 September 1887, it was deactivated to let place on the sea to La Vieille lighthouse. In October 1892, it was adapted to semaphore for optical signalisation operated by the French Marine Nationale (C'Est en

France, 2020).

In the thirties of the last century, the Pointe experienced a period of prosperity that led to the construction of several hotels to lodge multitudes of visitors fascinated by its wild nature and superb panoramic visions.

It was because of the rapid German occupation of France in 1940 that the peaceful situation at the Pointe changed radically.

2. History

From 15 August 1940 up to January 1941, the semaphore was occupied by a detachment of a battery of the 12th Artillery Observation Group, followed up to February 1941 by a detachment of the *6./Bataillon 151* of the *Infanterie-Division 61*.

A 2 km^2 surface from the Pointe to Lescoff was requisitioned for the construction of radar stations (Blanchard, 2014, 2021, 2021a). The works were directed by the Organization Todt (O.T.) and the *Luftwaffefeldbauamt 7*. A Decauville line and trucks through the Route Nationale transported materials, sand and Ero Vili pebbles (Tomezzoli & Marzin, 2015) for its construction. 250 - 300 French workers were daily in service at the Pointe.

On 17th mars 1941 a *Focke Wulf 200 Condor* of the *2./Kampfgeswader 40*, in the fog, crashed on a hamlet of Lescoff causing no civilian victims but killing three of its five crew members (Floch, 2012).

On 1st May 1941, the semaphore was reactivated by the *01 512G* unit of the Brest Admiralty Transmission Service.

At the end of 1941 the *25./Luftgau-Nachrichten-Regiment 12* operated a *Freya* and a *Würzburg 39T* near Lescoff, in provisional, non-concrete emplacements (Blanchard, 2021a).

In 1942 the semaphore was occupied by the *01 512W* unit of the *Marine-Wetterwarte* Brest.

The *Stp. QU 300*, unit *01 512F*, near the semaphore, *Kriegsmarine* operated, was equipped initially by 1 × *Würzburg 39G* (Blanchard, 2021a; Le Berre, 2020), replaced on 1942 by 1 × *Freya SeeTakt G41g 310 FuMO 2 Calais B* and 1 × *FuMO 214 Würzburg-See-Riese* (Blanchard, 2021a; Lippmann, 2021; Danzé et al., 2017) operated by a detachment of the *1.Komp.* and parts of the *31.Komp.* of the *Marine-Funkmeß-Abteilung 3*, and by four *Flak* emplacements for light machine guns.

The *Stp. QU 500* coded *Renntier* (Reindeer), at Roz-Bestrée in the middle of the Pointe, *Luftwaffe* operated, was equipped with 2 × *FuSE 65 Würzburg-Riese* and 1 × *FuSE 80 Freya* (Blanchard, 2021a; Lippmann, 2021; Danzé et al., 2017), this last replaced later by 1 × *FuMG-401 Freya-LZ* and 1 × *FuSE 62D* (Lippmann, 2021). Initially, *QU 500* was operated by a detachment of the 16./*Luftgau-Nachrichten-Regiment 7*, unit *L38 089*, up to December 1940. During 1941, it was operated by a detachment of the 8./34 *Luftnachrichten-Regiment*, unit *L08 470*.

On the spring 1943, the *Stp. QU 13*, at Men Tan near Lescoff, *Luftwaffe* operated, was equipped with 1 × *Mammut Frederich FuMG* 41/42 (Danzé et al., 2017) or 1 × *Mammut Caesar FuMG 41 G* (*cF*) (Lippmann, 2021), 1 × *FuSE 62A* on mobile carriage (Danzé et al., 2017) (Lippmann, 2021) and 1 × *FuMG 450 Freya* (Lippmann, 2021).

QU 500 and *QU 13* were operated by a detachment of the *25./Luftgau-Nachtricht-Regiment 12*, unit *L42 432*. On April 1943 the *Regiment* became the *Flugmelde-Leit-Kompanie 54* and its 12.*Komp*., unit *L55 178*, was at the Pointe.

The security of the *Stp*s was assured by *2. Artillerie-Batterie* of the *Flak-Gruppe 752*, unit *L31 782*, the *Landesschützen-Zug der Luftwaffe 66/IV*, unit *L08 889*, as well as by mine fields.

An electrical factory, a water reservoir, shacks, canteens, an infirmary and a cinema projecting a new film each week were in exercise at the Pointe.

A section of the 6./*Regiment 894*, unit *58,135C*, assumed the Pointe defence from July to October 1943. In June 1944 the defence of the coast comprising the Pointe was assumed by the *343. Infanterie Division*. The 4./*Regiment 898*, unit *59,130E*, assumed the Pointe defence from 5th July 1944. A section of the 3./*II. Ostbataillon* (*Mitte*), unit *36,989*, was at the Pointe. The *9./Festung-Stammtruppen XXV* was at the Pointe coastal sector.

On 8th August 1944, the garrison evacuated the Pointe after having set on fire and destroyed military and civilian installations and ended up encircled in the pouch of Lezongar until it surrendered on 20th September 1944 (Floch, 2012).

3. The Visits

The visits on 3rd January 2005 and 14th August 2020 permitted to identify many components of *Qu 300*, *Qu 500* and *Qu 13* (**Figure 1**).

3.1. *Qu 300*

The *Qu 300* identified components (**Figure 2** and **Figure 3**) were the following.

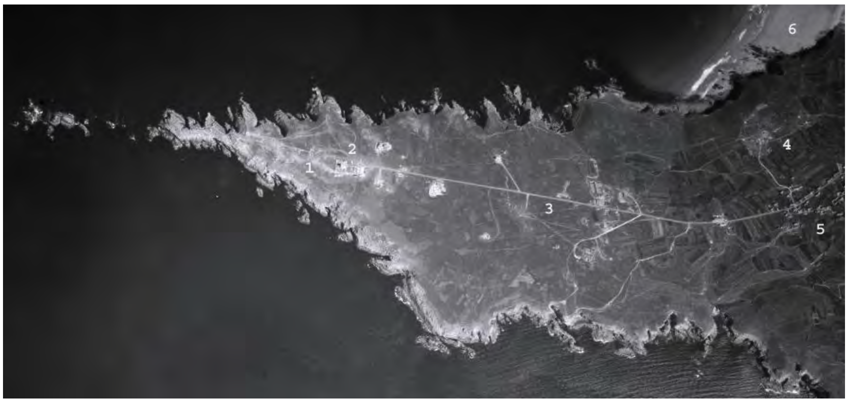

Figure 1. *Stp*s at the Pointe du Raz—1 *Qu 300*; 2 semaphore; 3 *Qu 500*—Roz Bestrée; 4 *Qu 13*—Men Tan; 5 Lescoff; 6 Baie des Trépassés. [Geoportail] Image C0319-0061_1952_F0319-0819_0074, n˚74, 1/26347, Argentique, 24/05/1952.

Figure 2. *Qu 300*—1 semaphore; 2 *Würzburg* and *Freya* emplacements; 3 Notre Dame des Naufragés monument; 4 gun emplacement; 5 shacks; 6 possible Flak emplacement; 7 hotels; 8 shacks; 9 reservoir/pool; 10 possible *R622*; 11 - 12 shacks; 13 heap of debris; 14 access road. [Geoportail] Image C0319-0061_1952_F0319-0819_0074, n˚74, 1/26347, Argentique, 24/05/1952.

(a)

(b)

(c)

Figure 3. (a) Semaphore (1); (b) Details of the base of the 1875 headlight; (c) Gun emplacement.

The semaphore (48˚2'11.31"N, 4˚44'16.38"W, height 69.45 m) (1). Its 44 × 44 m stone enclosure, the quadrangular tower and the building leaning against, destroyed by the garrison, were well reconstructed. The *Flak* emplacement at the top of the tower disappeared replaced by a modern white structure equipped with antennas. Recent constructions replaced ancient constructions at the sides of the stone enclosure. The semaphore is still operated by the Marine Nationale.

The base of a metal sheet 1875 headlight (48˚2'20.65"N, 4˚44'9.82"W, h. 30.63 m) (3) 200 m west from the semaphore, used as 37 mm Flak gun emplacement (Danzé et al., 2017). Formed by two converging stone walls and a circular emplacement filled with stones. Its reconstructed structure was in good preservation state.

The hotels (6), near the semaphore used as garrison lodgements, the antenna and buildings of the French Marine Nationale transmission station north of the semaphore, two French 95 mm 1888 Lahitolle guns and their supports installed west of the semaphore, the chapel near the Notre Dame des Naufragés monument (2), the shacks (7 - 8, 10 - 12), the water reservoir/pool (9), the heap of debris (13), the *FuMO 214 Würzburg-See-Riese* and its support, installed west to the semaphore, on a round stone platform, probably built by the Marine Nationale (Blanchart, 2021), dynamited by the garrison (Danzé et al., 2017) and the square, brick shelter of the *Freya SeeTakt G 41g 310 FuMO 2 Calais B*, dynamited by the garrison (Danzé et al., 2017), disappeared because of after war interventions devoted to restoring the Pointe wild nature.

3.2. *Qu 500*

The *Qu 500* identified components (**Figures 4-9**) were the following.

An *L 479 Anton* (48˚2'18.24"N, 4˚43'5.86"W, h. 69.16 m) (1) (**Appendix Figure A1** and **Figure A2**) for night-fighter control, similar to those of *LA 318*

Figure 4. *Qu 500*—1 *L 479 Anton*; 2 *L 486*, 3 *Vf 61a*; 4 - 5 shack ditches; 6 square bunker; 7 shacks; 8 *V 229*; 8a square excavation; 9 possible bunker; 10 *Flak* emplacement and *R 655*; 11 *V 229*; 12 *R 622*; 13 excavation; 14 shack ditch; 15 infirmary shack ditch; 16 possible *Flak* emplacement; 17 *L 410 A*; 18-19 shack ditches; 20 *Freya* emplacement; 21 shack ditch; 22 *L 409 A*; 23 *RS 58c*; 24 open cistern; 25 buried bunker. [Geoportail] Image C0319-0061_1952_ F0319-0819_0074, n˚74, 1/26347, Argentique, 24/05/1952.

(a) (b)

Figure 5. *V 229* (8): (a) General view; (b) Upper side and interior, on the right fixation point for *Würzburg-Riese*.

(a)

(b) (c)

Figure 6. (a) Octagonal Flak emplacement (10); (b) *R 655*, observation post; (c) Observation post interior.

Frosch at Cap Fréhel (Tomezzoli & Moser, 2021), of *Re 510 Pinguin* at Saint-Pabu-Le Bous (Tomezzoli & Colliou, 2017, 2018) and of Saint-Jacques de la Lande (Dupont et al., 2007). The terrain and vegetation coverage precluded access to the entrances and the interior. The emerging portion appeared in good preservation state.

A 9 × 9 m square bunker (48˚2' 16.55"N, 4˚43' 54.24"W, h. 66.7 m) (6) buried in the terrain, for energy production (Danzé et al., 2017). The concrete coverage, emerging from the terrain, was in good preservation state.

(a)

(b)

(c)

(d)

Figure 7. *R 622* (12): (a) Façade, access trench and personnel entrances; (b) Access trench and external observation post; (c) Entrance ladder with close combat room louver; (d) Gaslock.

(a)

(b)

Figure 8. *L 410 A* (17): (a) Gun emplacement, on the background *Freya* emplacement; (b) Concrete gun support with intrusions.

A 16 × 13 m ditch (48˚2'14.06"N, 4˚43'10.31"W, h. 67.15 m) (15) now part of the Maison de la Pointe du Raz et du Cap Sizun, hosting the rests of an infirmary shack used nowadays as exhibition centre. Its east side was provided with two

(a)

(b) (c)

Figure 9. Cylindrical stone construction (20): (a) Labyrinth personnel entrance; (b) Material entrance and double protection wall; (c) Loopholes and collapsed portions of the protection wall on the terrain.

access ladders. Its concrete structure was in good preservation state. The ditch entrance was closed so that the preservation state of the shack was not be ascertained.

A *V 229* (48˚2'22.15"N, 4˚43'26.61"W, h. 69.26 m) (8). The interior was invaded by vegetation. On the upper side were the traces of the *Würzburg-Riese* supporting elements. The concrete structure was in good preservation state.

A square 6 × 6 m degraded excavation (48˚2'24.51"N, 4˚43'26.46"W, h. 59.33 m) (8a), 0.5 m deep, 70 m north of the *V 229*, for a *Flak* gun.

An octagonal, 6 m in diam. *Flak* emplacement (48˚2'15.46"N, 4˚43'24.02"N, h. 74.2 m) (10), 0.5 m deep for a 2.0/3.7 cm *Flak* gun. Wooden boards covered the floor. The concrete structure was in good preservation state. It was leaning against an *R 655* buried in the terrain, with external observation post filled with stones. Its emerging concrete structure was in good preservation state.

A *V 229* (48˚2'14.35"N, 4˚43'22"W, h. 73.83 m) (11). The internal floor was filled with stones. On the internal walls two recesses for shelves or equipments. On the upper side metallic fixation bolts and the traces of the corresponding *Würzburg-Riese* supporting elements. On the walls, pebbles of the EroVili (Tomezzoli & Marzin, 2015) mixed with concrete. The concrete structure was in good preservation state.

An *R 622* (48˚2'12.76"N, 4˚43'20.76"W, h. 73.18 m) (12) (**Appendix Figure A7**) with observation post and access trench. The two entrances gave access to ladders and to the interior which preserved the original wall white painting and rusted ceilings. All the internal furniture disappeared. The concrete structure was in good preservation state.

A degraded excavation (48˚2'11.71"N, 4˚43'27.13"W, h. 66.35 m) (13) probably for one or more shacks, formed by a 15 × 10 m portion joined to a 27 × 12 m portion, about 2 m deep.

An *L 410 A* (48˚2'10.57"N, 4˚43'8.29"W, h. 70.27 m) (17) (**Appendix Figure A3**) (Tomezzoli & Colliou, 2017) buried in the terrain, only the external octagonal *Flak* emplacement emerged. At the access, in the concrete, the vertical grooves for the wood closure, on the sidewalls, ammunition niches, at the centre a 3.5 m in diam. circular support for a 2.0/3.7 cm *Flak* gun. On the support the Ero Vili pebbles, around its centre a circular alignment of eight square intrusions and near the circumference four other rectangular disposed intrusions. On one external side the rests of a 30 cm in diam. chimney. The entrances buried in the terrain prevented the inspection of the interior. The *Flak* emplacement was in good preservation state.

A 6.20 in diam., 2.40 m high (Blanchard, 2021), cylindrical stone construction (48˚2'19.78"N, 4˚43'8.32"W, h. 69.03 m) (20) as a Middle Ages one, for *Freya*, similar to that of *LA 318* (Tomezzoli & Moser, 2021). It comprised a double external wall provided with personnel, labyrinth entrance and a material entrance. The *Freya* cabin and its antenna were inside and because no lodgement was foreseen, the personnel lodged in the nearby shacks. Recently restored, its structure was in good preservation state, although some portions of the external wall collapsed perhaps because of the explosion of an English bomb on 9th July 1944 (Danzé et al., 2017).

An *L 409 A* (48˚2'9.27"N, 4˚43'5.14"W, h. 67.06 m) (22) (**Appendix Figure A4**) buried in the terrain, only the octagonal emplacement for a 2.0/3.7 cm *Flak* gun emerged. The dense vegetation prevented access to the personnel entrances for the interior inspection and to the gun emplacement. The visible portions were in good preservation state, notwithstanding a minor damage at the entrance of the emplacement letting visible Ero Vili pebbles mixed with the concrete.

An *RS 58c* (48˚2'10.26"N, 4˚43'6.17"W, h. 67.19) (23) at the south west corner of the modern parking, at 35 m from the *L 409 A* (22) connected to it by an access trench. The portion emerging from the vegetation was in good preservation state.

A 2 × 1 m open cistern (48˚2'19.78"N, 4˚43'54.24"W, h. 69.32 m) (24) at the south west corner of the parking, at 50 m from the *L 409 A* (22) and at 15 m from the *RS 58c* (23), similar to those observed at *Be-2* at Mont Saint Michel de Braspart (Tomezzoli & Dupont, 2011) and at *La 318* (Tomezzoli & Moser, 2021). The dense vegetation prevented to reach it for determining its preservation state.

A 7 × 9 bunker (48˚2'8.49"N, 4˚43'8.15"W, h. 67.93) (25) buried in the terrain. The emerging coverage was in good preservation state. The entrances buried in the terrain prevented the inspection of the interior.

An *L 486* (48˚2'17.62"N, 4˚43'4.43"W, h. 69.46) (2) was completely buried in the terrain, a *Vf 61a* (48˚2'17.79"N, 4˚43'1.92"W, h. 70.75) (3) for a mortar was still visible, the shack ditches (4 - 5, 7, 14, 18 - 19, 21) disappeared; a possible bunker (9) was buried in the terrain; a possible *Flak* emplacement (16) was not identified.

3.3. *Qu 13*

The *Qu 13* identified components (**Figures 10-16**) were the following.

Figure 10. *Qu 13*—1 *L 485*(*1*); 2 *R 667*; 3 *Vf 2a*; 4 *R 622*; 5 kitchen and canteen ditch; 6 *Vf 1b*; 7 possible bunker; 8 *Vf 1b* "abri tolle metro"; 9 *Vf 2a*; 10 *RS 58c*; 11 Lescoff. [Geoportail] Image C0319-0041_1961_F0319-0519P_0055, n˚55, 1/25710, Argentique, 21/06/1961.

(a)

(b) (c)

Figure 11. *L 485* (*1*) (1): (a) General view, on the left the pylons and the west antenna support, on the right the chimney; (b) West antenna support; (c) Emergency exit pit.

Figure 12. *L 485* (*1*) (1): (a) Inclined concrete ramp; (b) Entrances, on the left loophole of the close combat room; (c) Gaslock; (d) Close combat room with loophole metallic plate; (e) Compensator room and workshop, left and right entrances to the antenna rooms, rusted ceiling.

An *L 485* (*1*) (48˚2'26.01"N, 4˚42'40.16"W, h. 76.47 m) (1) (**Appendix** Figure A5 and Figure A6) for *Mammut* radar, oriented north-west south-east, partly buried in the terrain. Mainly built in concrete, some portions were in bricks or stones. Rests of a bitumen layer on the coverage, indicated that it was provided with an insulation system. Two 3 × 2 m rectangular pylons for the descent of antenna cables, disfigured by modern graffiti, but in good preservation state and a 1 × 1 m chimney protruded from the coverage. The antenna supports between the pylons were buried in the terrain. An east and west 3 × 2 m antenna support,

Figure 13. (a) *R 667* (2) inclined rear side; (b) *R 667* (2) front side, combat room opening and protective wing; (c) *Vf 2a* (3), coverage with protective wall.

Figure 14. (a) Second 3 × 3 m constructions; (b) Third 3 × 3 m construction (c) Possible *Flak* emplacement.

 

(a) (b)

Figure 15. (a) *Vf 1b*, in the background second and third 3 × 3 m constructions; (b) *RS 58c* near *Vf 1b*, circular opening of the combat room.

(a)

 

(b) (c)

Figure 16. (a) *Vf 1b* "abri tôle de metro" general view (11); (b) Internal room with window and rusted curved ceiling; (c) *RS 58c* (10).

at the exterior of the pylons, emerged from the terrain, letting visible bricks, the bitumen layer, four metallic antenna portions fixed to a rectangular metallic fixing frame embedded in the concrete. On the north side, a 2 × 1 m open cistern covered by vegetation and on the east side a 2 × 2 stone pit of an emergency exit. On the west side, a concrete inclined ramp led to the entrances protected by the loophole of a close combat room. The internal rooms preserved the original white wall painting, somewhere disfigured by modern graffiti, and severely rusted ceilings. All the internal furniture disappeared and the floors were cluttered by terrain and stones not collapsed from the walls. The close combat room preserved the metallic plate of its loophole. The workshop and compensator rooms formed a unique room. On its floor were traces of the compensator support. All the metallic doors, cables, technical instrumentations and furniture disappeared. After war images show that the *Mammut* antenna disappeared before 1948, after its fall to the ground.

A *R 667* (48˚2'25.31"N, 4˚40.35"W, h. 75.41 m) (2) (**Appendix Figure A8**) for a 5 cm KwK (*Kampfwagenkanone*) gun. The entrance, in the inclined rear side, introduced in the combat room which preserved walls disfigured by contemporary graffiti, an ammunition niche on the floor and a rusted ceiling. All the internal furniture disappeared and on the floor, the gun emplacement was covered by stones. The front side hosted the combat room front aperture and a protective wing. The concrete structure was in good preservation state, letting visible Ero-Vili pebbles mixed with concrete and formwork element traces.

A *Vf 2a* (48˚2'27.67"N, 4˚42'41.85"W, h. 71.96 m) (3) for a projector (Danzé et al., 2017). The coverage, emerging from the terrain, was limited by a protection wall formed by stones and concrete. On the west side, two pits were covered by vegetation. Terrain and vegetation covering the access trench and the entrance prevented the inspection of the interior. The coverage and the protective wall were in good preservation state.

An *R 622* (48˚2'27.26"N, 4˚42'37.02"W, h. 77.42 m) (4) (**Appendix Figure A7**) for two groups of ten soldiers (Rudi, 1988) 32 m north-east from the *L 485*(*1*). Dense vegetation invaded the coverage, the access trench and obstructed the entrances; therefore its preservation state was not ascertained.

A first 3 × 3 m construction (48˚2'26.43"N, 4˚42'37.32"W, h. 77.59 m) provided with access trench. Completely covered by vegetation, its purpose and preservation state was not ascertained.

A second 3 × 3 m construction (48˚2'26.71"N, 4˚42'36.5"W, h. 77.82 m) partially covered by vegetation. It was one of the two stone emerging structures of a kitchen and canteen ditch (5). The visible stone portion was in good preservation state.

A third 3 × 3 m construction (48˚2'27.32"N, 4˚42'35.38"W, h. 78.01 m) covered by vegetation. It was one of the two emerging structures of a kitchen and canteen ditch (5). Completely covered by vegetation, its preservation state was not ascertained.

A 40 × 10 m kitchen and canteen ditch (48˚2'26.86"N, 4˚42'35.78"W, h. 78.12 m) (5) completely filled by terrain and vegetation. It was provided with an access ladder on each short side. Only its rectangular outline was discernible on the terrain.

A *Vf 1b* (48˚2'24.25"N, 4˚42'35.3"W, h. 78.48 m) (6) for servants of two disappeared nearby *Flak* emplacements, buried in the terrain, only its rectangular coverage emerged. The entrance buried in the terrain prevented the inspection of the interior. The coverage was in good preservation state, notwithstanding a 3 cm wide fissure crossing its width, caused by an architectural failure.

A *RS 58c* (48˚2'25.18"N, 4˚42'35.23"W, h. 78.62 m) 5 m south to the *Vf 1b* (6) for the *Q 13* south defence. Covered by terrain and vegetation, only the well preserved circular opening of the combat room was visible.

A possible, 0.5 m deep *Flak* emplacement (48˚2'26.57"N, 4˚42'38.1"W, h. 78.29 m) 12 m south-east from the *L 485*(*1*). Covered by moss and vegetation, appeared in a degraded preservation state.

A bunker (48˚2'25.74"N, 4˚42'31.84"W, h. 79.35 m) (7) 25 m north from the *L 485*(*1*) provided with access trench. Completely covered by terrain and vegetation, its type and preservation state was not ascertained.

A *RS 58c* (48˚2'27.46"N, 4˚42'39.41"W, h. 75.69 m) 10 m west from said bunker, for the *Q 13* north and west defence. The vegetation obstructed its access trench so that its preservation state was not ascertained.

A *Vf 1b* (48˚2'27.86"N, 4˚42'30.78"W, h. 79.13 m) (8) for personnel lodgement, partially covered by vegetation. Rests of a bitumen layer on the coverage, indicated that it was provided with an insulation system. An access trench led to one of the entrances and the internal room was provided with a window, preserving the original white wall painting and a curved rusted ceiling hence the name underground sheet shelter ("abri tôle de metro"). All the internal furniture disappeared. Its structure was in good preservation state.

A *Vf 2a* (48˚2'28.59"N, 4˚42'32.2"W, h. 79.65 m) (9) for personnel lodgment, buried in the terrain, only its rectangular coverage, in good preservation state, emerged. The vegetation covering the access trench and the entrance prevented the inspection of the interior.

A *RS 58c* (48˚2'27.91"N, 4˚42'29.72"W, h. 79.34 m) (10) 10 m south-east from the *Vf 1b*, for the *Q 13* east defence. Partially covered by vegetation, it appeared in good preservation state.

4. Discussion

The Pointe radar stations repeat the same dual organisation of the radar station *LA 318* (Tomezzoli & Moser, 2021) and *RE 510* (Tomezzoli & Colliou, 2017) consisting in separated radar stations operated respectively by the *Kriegsmarine* and the *Luftwaffe*. They repeat also the same architecture of *La 318*, *Re 510*, the radar station *Mandrill* at Monterfil (Dupont et al., 2007) and the radar station *Made* at Les Mées (Tomezzoli & Pottier, 2015) consisting of two *Freya* and two *Würzburg-Riese*. These radars were necessary for assuring continue surveillance also in case of maintenance or malfunctioning of one of them. *Freya* was an early warning phased array radar detecting aircrafts up to 200 km but unable to determine their altitude. *Würzburg-Riese*, often coupled to an IFF (Identification Friend Foe) device, was a near field warning radar detecting aircrafts up to 70 km, their azimuth and their altitude. *Mammut* was a phased array, early warning radar able to detect aircrafts up to 300 km in two directions perpendicular to its rectangular antenna, but blind in a range of 60˚ on the antenna sides, designed to strengthen the surveillance capabilities of the radar stations. The reasons for which the *L 485* (*1*) was selected for the *Mammut* instead of an *L 485* (*2*) as at *La 318* are unknown. Therefore, incoming aircrafts were first intercepted by the *Mammut*, after by the *Freya* and at the end by the *Würzburg-Riese* which, in case of foe aircrafts, provided data for directing the fire of the Flak emplacements. Indicated as unusable on a 1944 map made by an anonymous French informant probably working at the Pointe (Danzé et al., 2017), the *Mammut* was of limited or no surveillance effectiveness.

The eight shack ditches at the Pointe, also of considerable dimensions, offered more personnel safety, with respect to the six at the *Stp* at Menez Hom (Tomezzoli, 2017), the only one at *LA 318* and no one at *RE 500*. All the shacks disappeared before 1948. Probably they were disassembled and rebuilt elsewhere as lodgements for the homeless French population (Tomezzoli, 2019).

The garrison was rather numerous. In 1944, at *Qu 300* and *Q 500* there were 130 soldiers and 3 officers from Austria and Germany and at *Qu 13 70 Luftwaffe* and 20 *Heer* soldiers, between which 7 were from Poland (Danzé et al., 2017).

5. Conclusion

Different after-war interventions on the Pointe have been conducted in order to eliminate hotels, parking, and civilian constructions, and to restore its wild nature so as to elevate it at the rank of Grand Site de France. This is certainly a commendable effort, but up to now no effort at all has been made for documenting and preserving its involved military patrimony.

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Conflicts of Interest

The author declares no conflicts of interest regarding the publication of this paper.

References

Blanchard, Y., & van Genderen, P. (2014). A German Radar Chain facing the British Home Chain during the WWII. *2014 11th European Radar Conference*, Rome, Italy, 8-10 October 2014. https://doi.org/10.1109/EuRAD.2014.6991199

Blanchard, Y. (2021). *Radar allemands de la Seconde Guerre: Les (bonnes) surprises de l'archéologie de terrain*. http://www.bunkers-saint-pabu.fr/wordpress/wp-content/uploads/2016/12/ARTICLE_YVES-BLANCHARD.pdf

Blanchard, Y. (2021a). *Manuscrit YB. Préparé pour l'ouvrage collectif "L'oeil de l'Atlantique"*.

C'Est en France (2020). *Sémaphore de la Pointe du Raz (Phare du bec de Raz)*.

http://www.cestenfrance.fr/semaphore-de-la-pointe-du-raz-phare-du-bec-de-raz/

Danzé, J., Le Berre, A., Le Bour, S., Morvan, J., & Schavsinski, B. (2017). *L'œil de l'Atlantique*. Imprimerie du Commerce.

Dupont, P. H., Fresil, Y., & Tomezzoli, G. (2007). Deutsche Militärbauten bei Rennes. *DAWA Nachrichten, 49, 56-66*.

Farcy, O. (2012) *Intérêt pour les chiroptères des bunkers de la Pointe du Raz à Plogoff.* Bretagne Vivante. SEPNB-Societé Protection Nature Bretagne. https://docplayer.fr/72654806-Interet-pour-les-chiropteres-des-bunkers-de-la-pointe-du-raz-a-plogoff.html

Floch, A. (2012). *L'Occupation Allemande dans les 141 Communes du Sud-Finistère*. Cloitre.

Le Berre, A. (2020). *Les installations radar allemandes de la pointe du Raz et leur environnement historique*. https://polejeanmoulin.com/page27/

Lippmann, H. (2021). *Funkmeß(ortungs)stellungen in Frankreich.* Bretagne West mit Brest. http://www.atlantikwall.info/radar/france/rf_.htm#Bretagne_West

Rudi, R. (1998). *Typologie du Mur de l'Atlantique*. Beetsterzwaag.

Tomezzoli, G., & Dupont, P. H. (2011). Die Drehfunkfeueranlage Bernhard auf dem Mont Saint Michel de Brasparts. *DAWA Nachrichten, 57, 4-15*.

Tomezzoli, G., & Marzin, Y. (2015). The Ero Vili and the Atlantic Wall. *Advances in Anthropology, 5, 183-204*. https://doi.org/10.4236/aa.2015.54018

Tomezzoli, G., & Pottier, L. (2015). Die deutschen militärlogistischen Anlagen westlich von Mamers. *DAWA Nachrichten, 65,* 14-27.

Tomezzoli, G. T. (2017). The WW II German Stützpunkton the Menez-Hom (Finistère-FR). *Archaeological Discovery, 5,* 224-237. https://doi.org/10.4236/ad.2017.54013

Tomezzoli, G. T., & Colliou, S. (2017). The WW II Saint-Pabu German Radar Camp and the Stützpunkte Re 03, Re 04. *Archaeological Discovery, 5,* 142-162. https://doi.org/10.4236/ad.2017.53009

Tomezzoli, G. T., & Colliou, S. (2018). The WW II Saint-Pabu German Radar Camp-2. *Archaeological Discovery, 6,* 88-102. https://doi.org/10.4236/ad.2018.62006

Tomezzoli, G. T. (2019). The BDU West between WWII and Cold War. *Archaeological Discovery, 7,* 1-19. https://doi.org/10.4236/ad.2019.71001

Tomezzoli, G. T., & Moser, J. -L. (2021). The German Radar Station La 318 Frosch. *Archaeological Discovery, 9,* 113-134. https://doi.org/10.4236/ad.2021.92006

Appendices

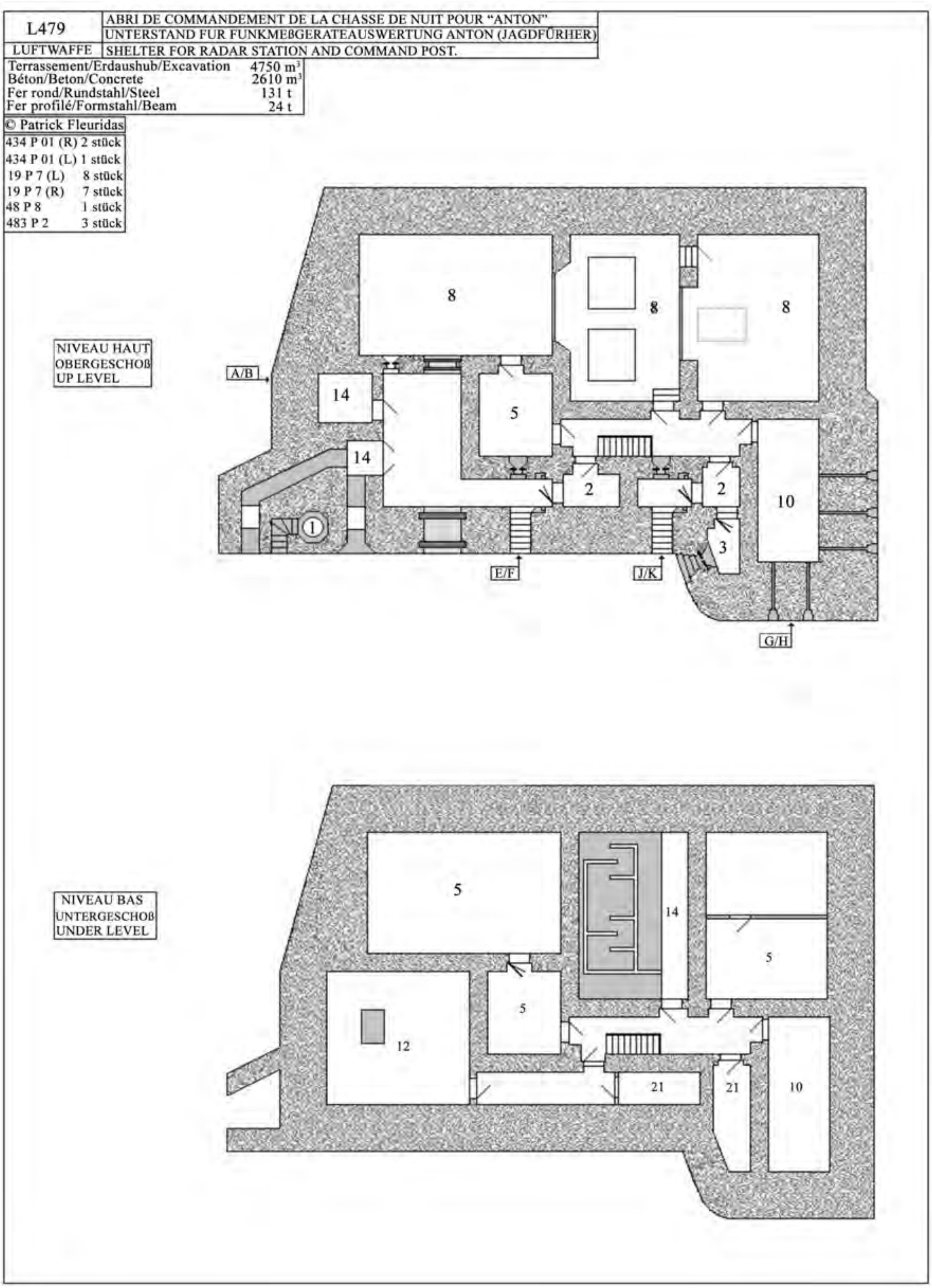

Figure A1. *L 479 Anton* shelter for radar station and command post-plan: 1 observation post; 2 gaslock; 3 close combat defence; 5 crew room; 8 command post; 10 wireless/telephone exchange; 12 ventilation; 14 command post; 21 store (Courtesy Fleuridas P.).

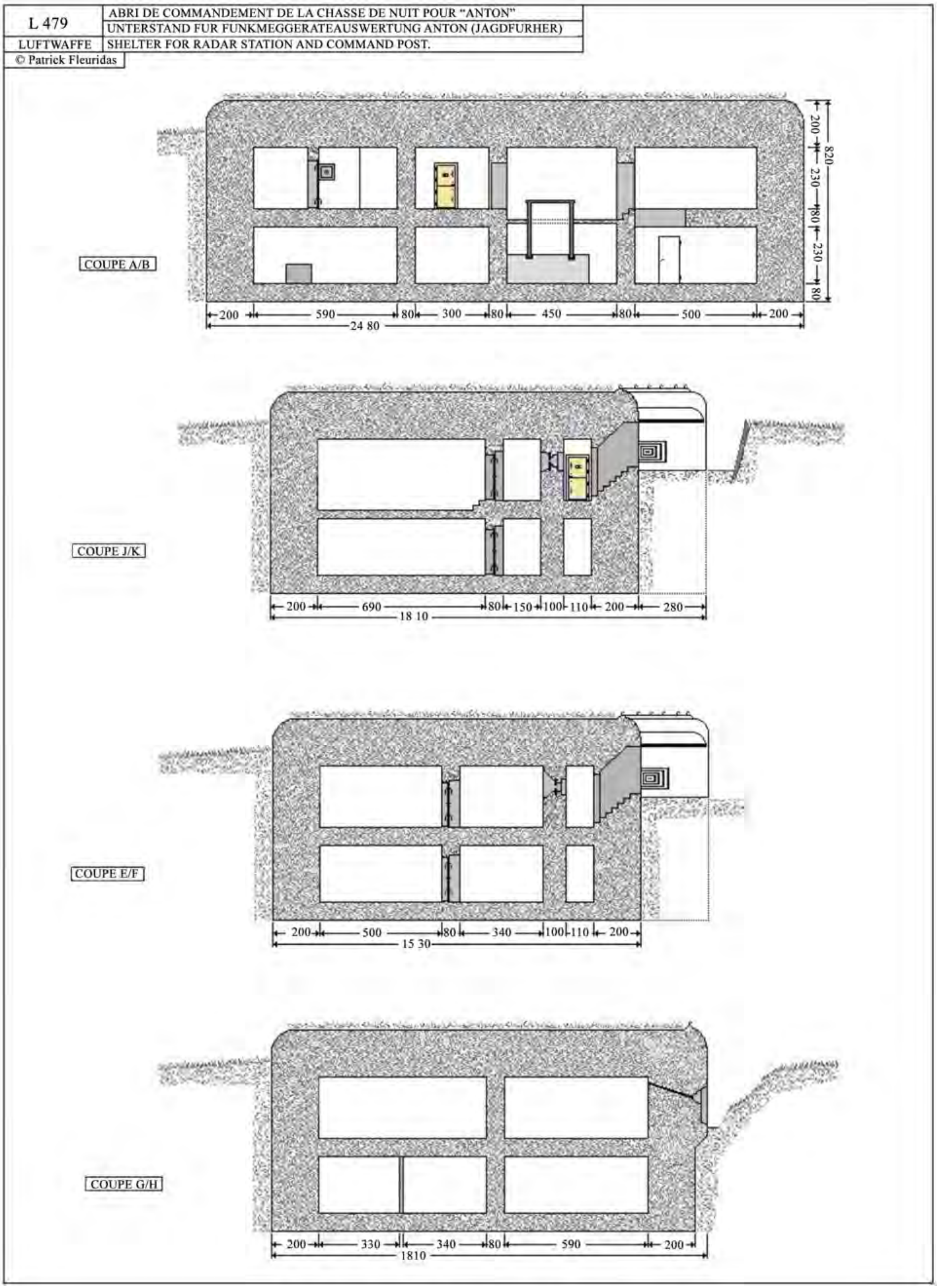

Figure A2. *L 479 Anton* shelter for radar station and command post-plan (Courtesy Fleuridas P.).

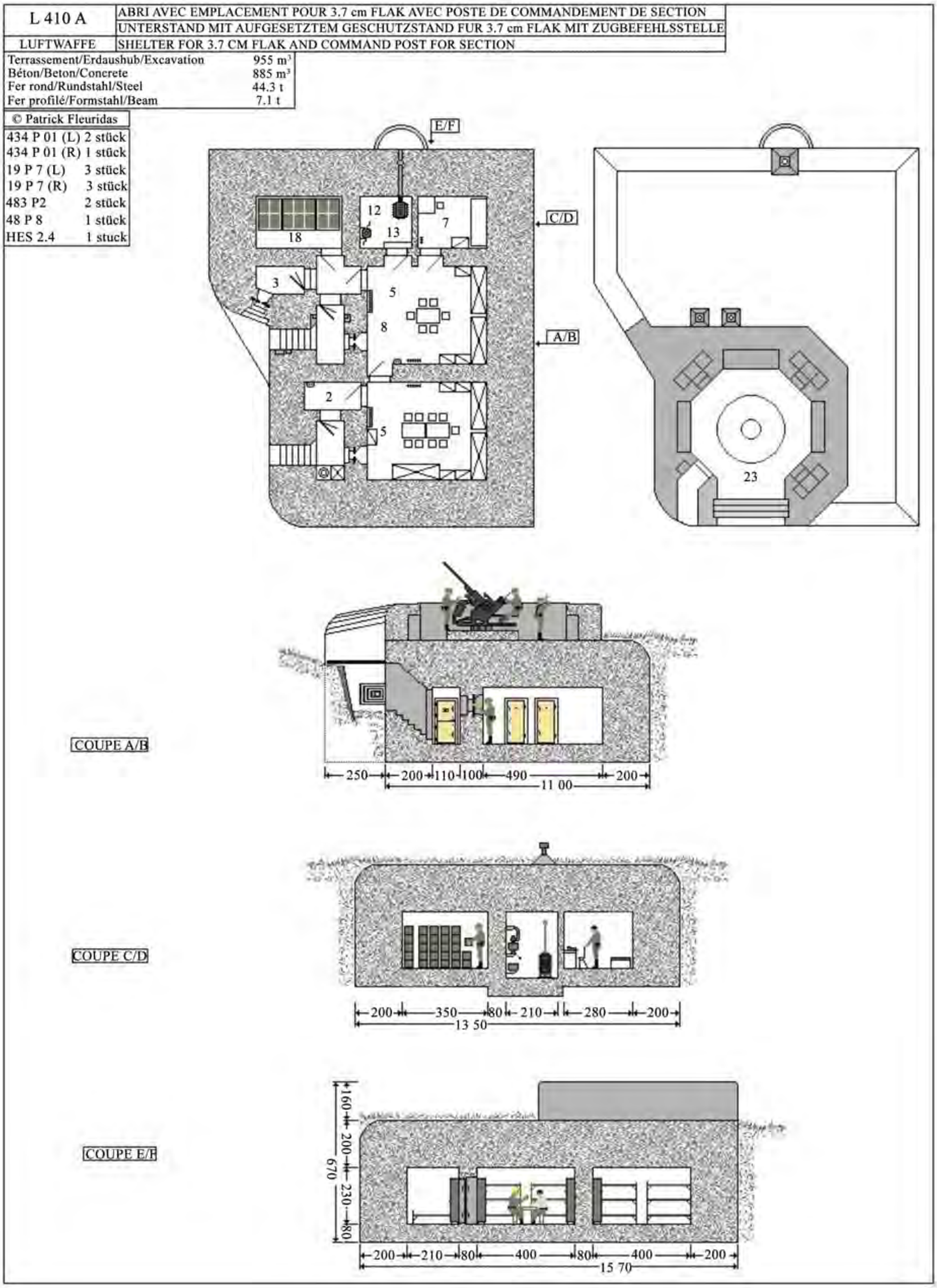

Figure A3. *L 410 A* shelter for 3.7 cm Flak and command section post-plan: 2 gaslock; 3 close combat defence; 5 crew; 7 non-commissioned officer; 8 close combat defence; 12 - 13 ventilation; 18 ammunition; 23 gun emplacement (Courtesy Fleuridas P.).

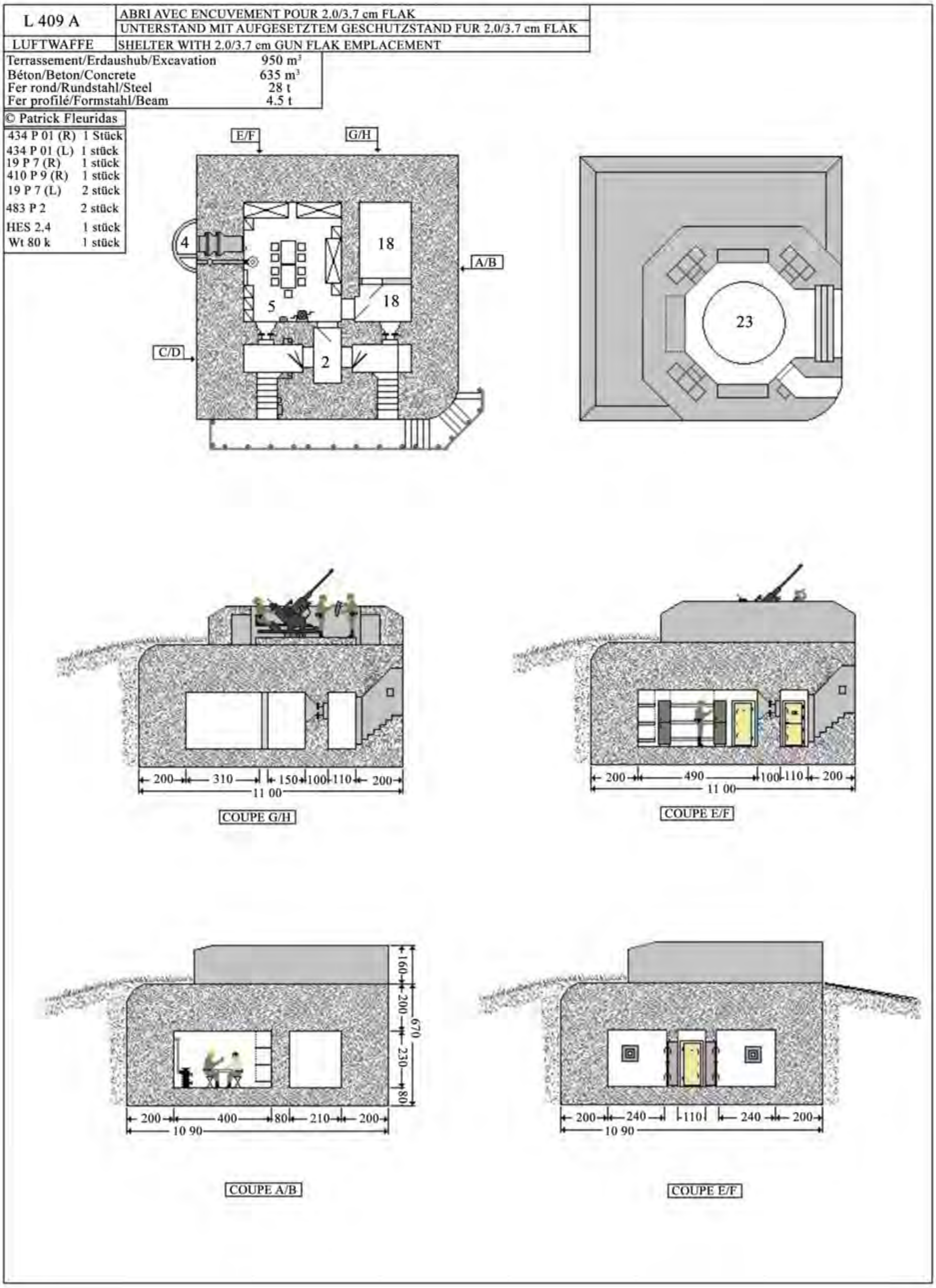

Figure A4. *L 409A* shelter for 2.0/3.7 cm gun *Flak* emplacement, plan: 2 gaslock; 4 emergency exit; 5 crew; 18 ammunition; 23 gun emplacement (Courtesy Fleuridas P.).

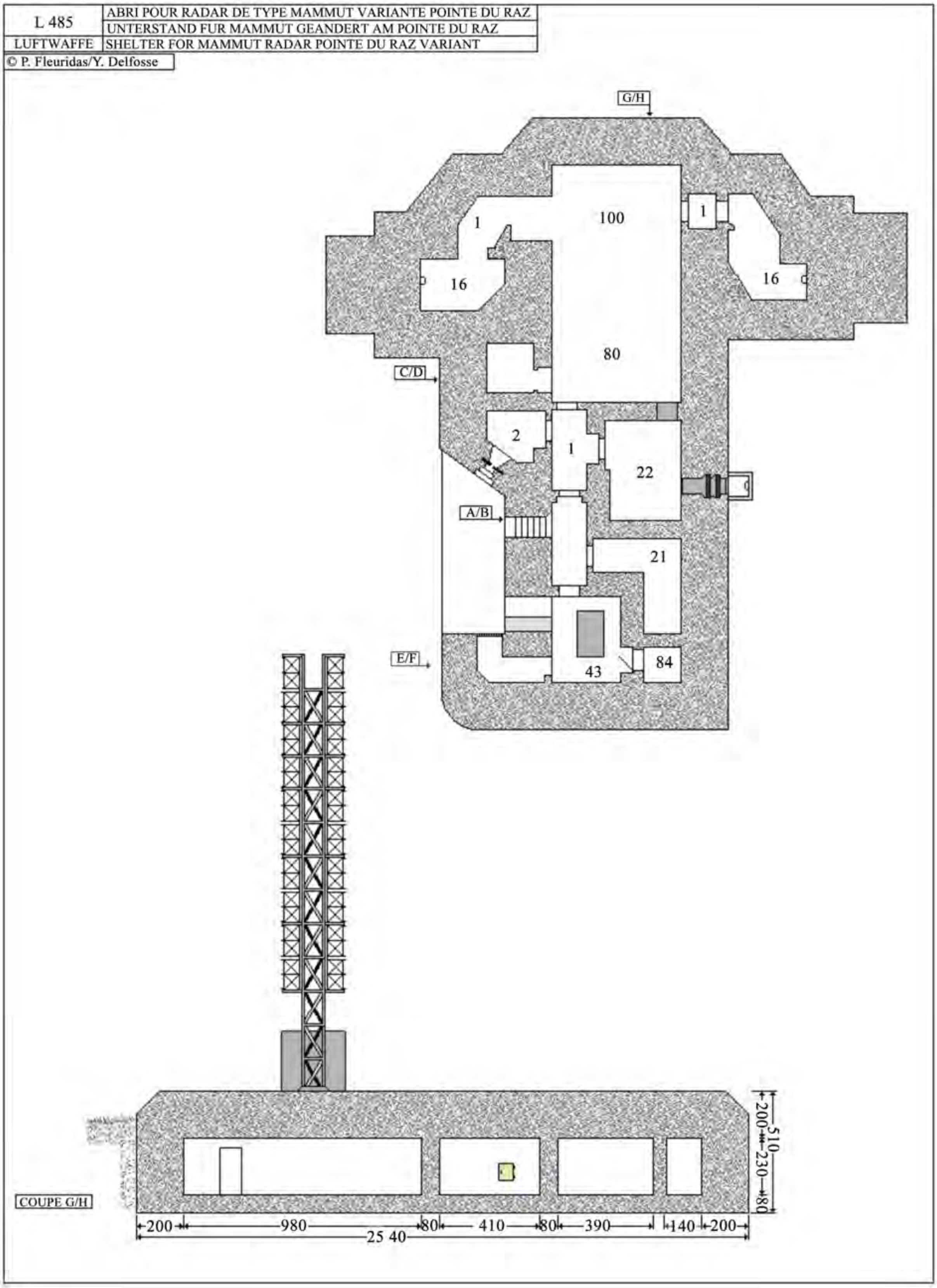

Figure A5. *L 485* shelter for *Mammut* radar, plan: 1 gaslock; 2 close combat room; 16 antenna room; 21 heading; 22 ventilation; 43 engine room; 80 workshop; 84 recooling; 100 compensator (Courtesy Fleuridas P.).

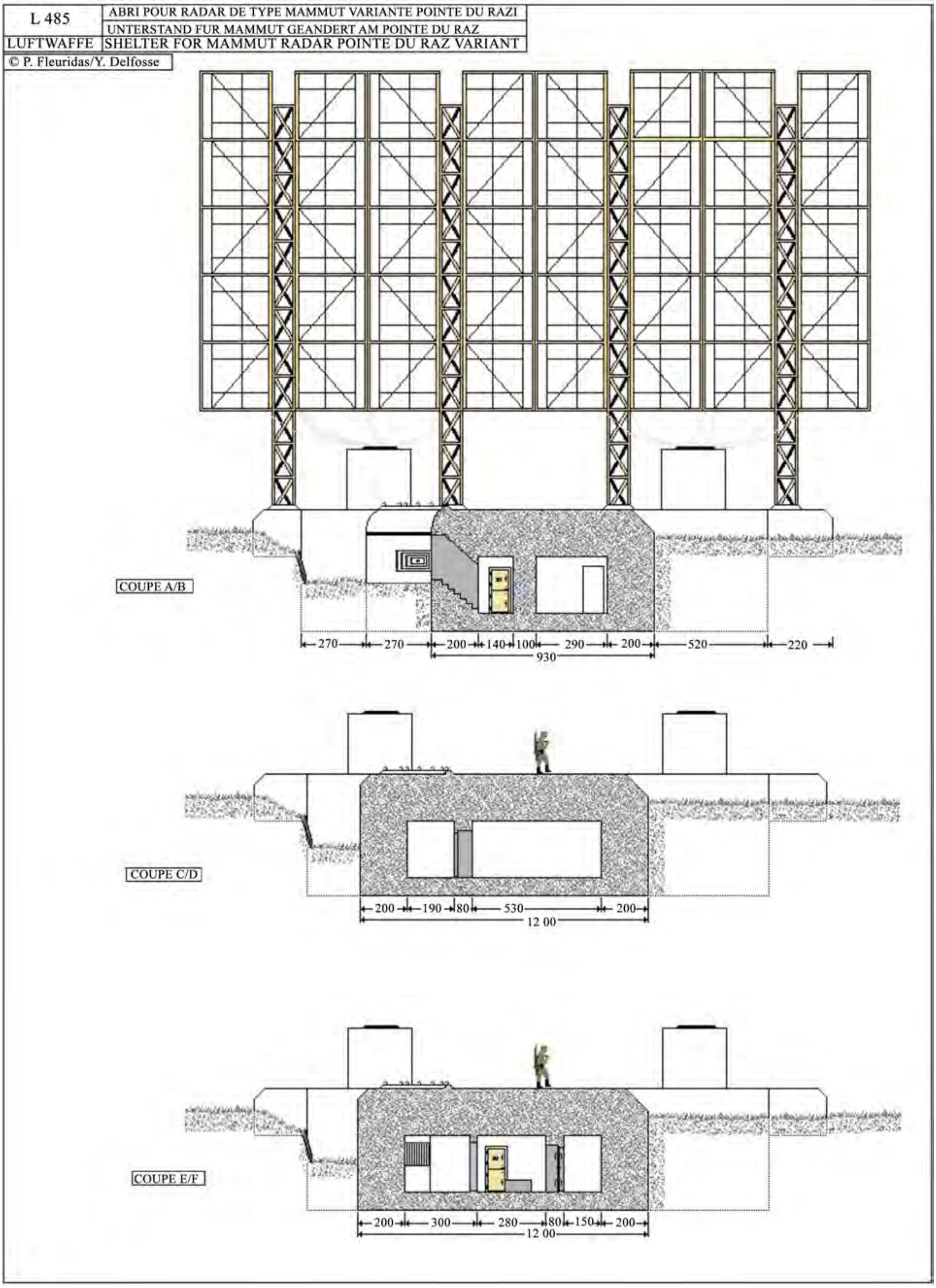

Figure A6. *L 485* shelter for *Mammut* radar, plan (Courtesy Fleuridas P.).

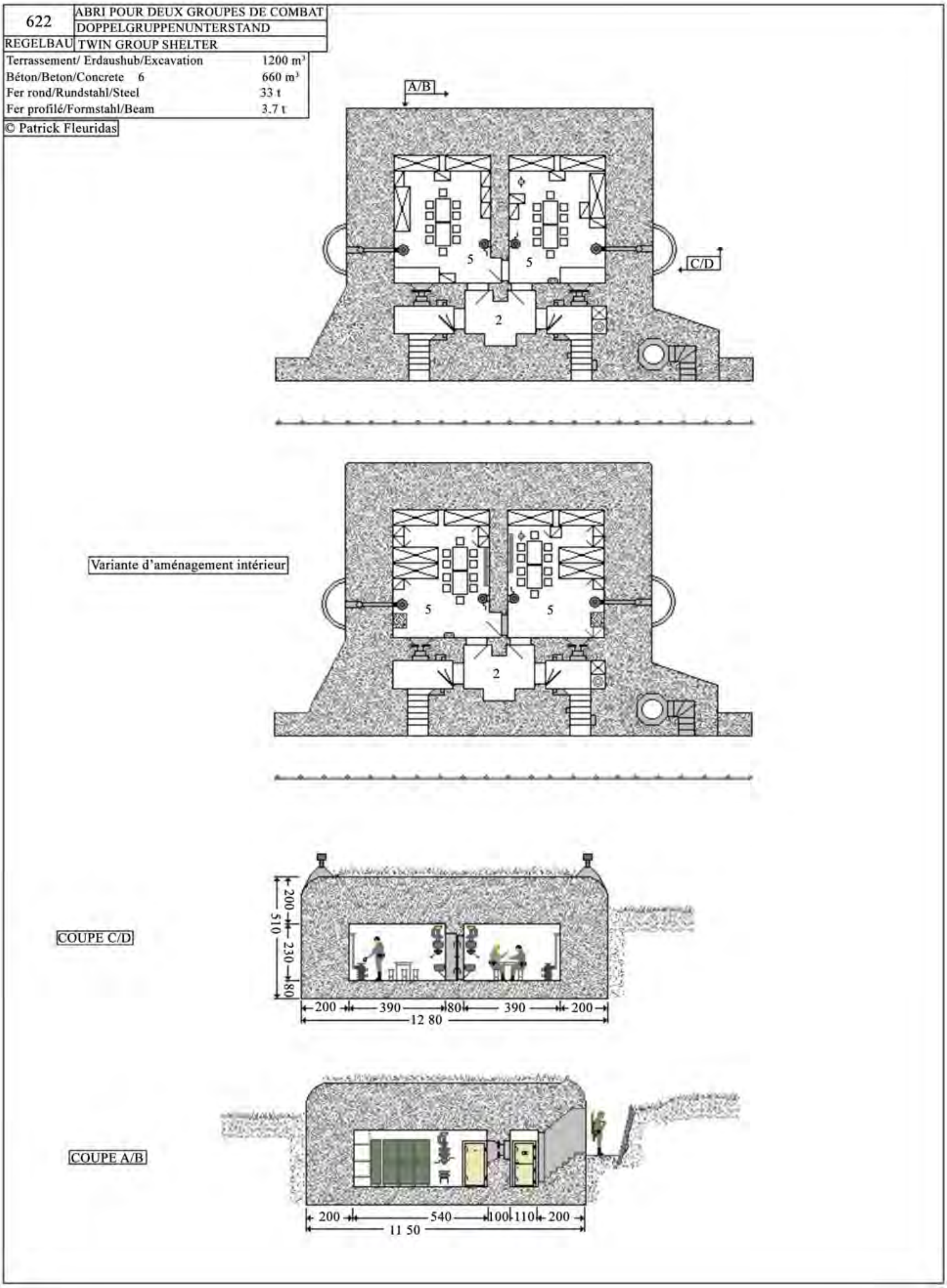

Figure A7. *R 622* twin group shelter, plan: 2 gaslock; 5 - 6 crew (Courtesy Fleuridas P.).

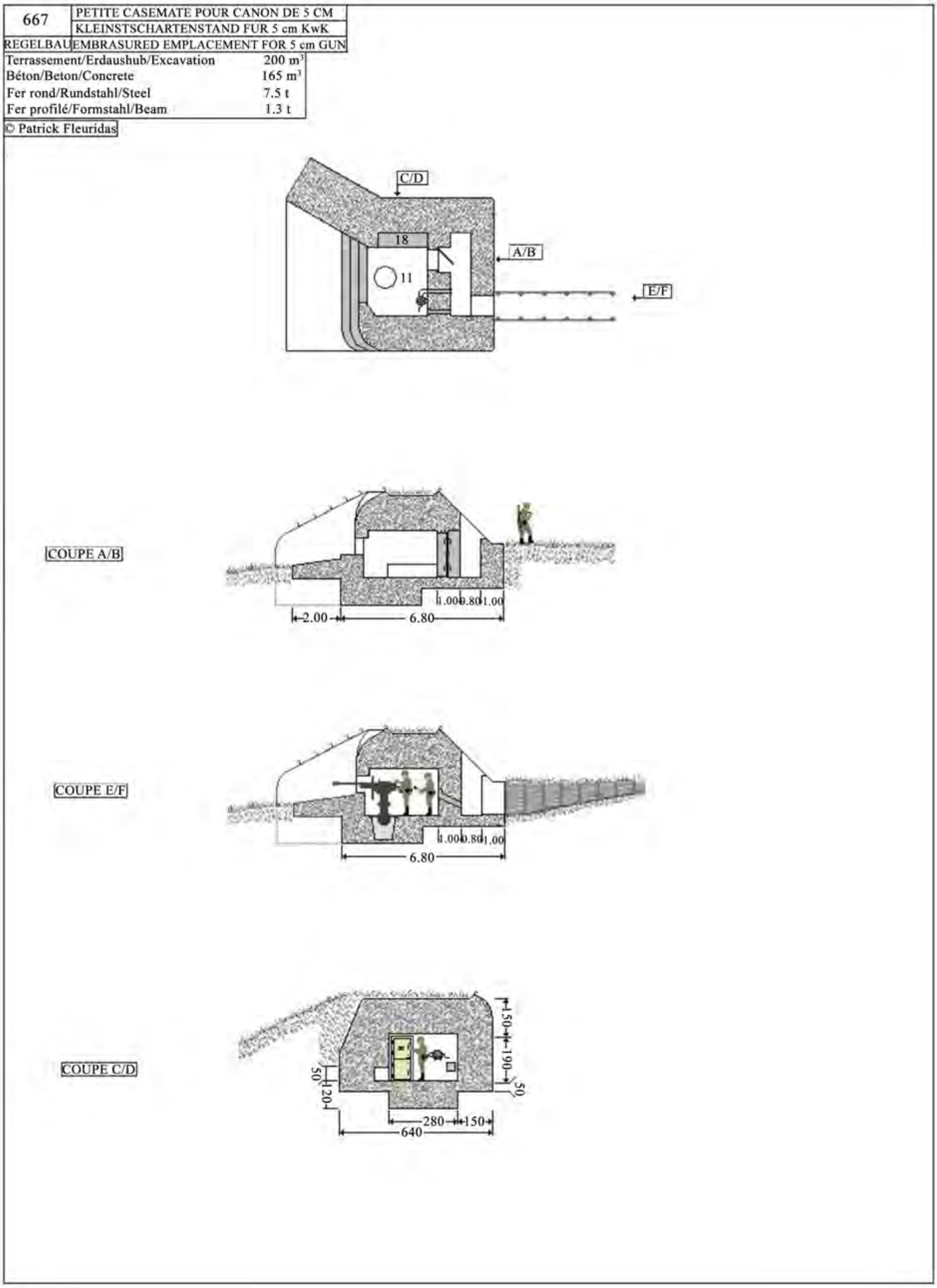

Figure A8. *R 667* embrasured emplacement for 5 cm gun, plan: 11 combat room; 18 ammunition niche (Courtesy Fleuridas P.).