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Mehit's Stump: Unmasking the Great Sphinx of Giza

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Abstract

The current mainstream model of history proposes that 4th Dynasty King Khafre had the Great Sphinx carved from the bedrock of the Giza Plateau in approximately 2500 B.C.E., and that the entire statue including its head, neck, and body was sculpted from the three raw substrate limestone layers of the Mokattam Formation *de novo* at the same time. However, a growing body of evidence suggests that the Great Sphinx is older than the date commonly ascribed to its construction, and that the head and neck were merely remodeled from a prior sculpture to create the face of the Great Sphinx sometime during the Old Kingdom. The following archaeo-sculptural analysis of the Great Sphinx subjects the monument to a detailed reconstructive examination to demonstrate the existence of a previously unreported contour signature, which suggests a modification to a prior sculpted structure that was partly removed and/or altered. This discovery provides a basis for an empirical method, which may aid in the relative dating of the stone layers belonging to the neck and body of the Great Sphinx to determine if they were indeed created at the same time or in different eras.

Keywords

Great Sphinx, Giza, Lioness, Mehit, 4th Dynasty, Khafre

1. Introduction

Despite circumstantial archeological and Egyptological evidence dating the creation of the Great Sphinx to the Fourth Dynasty (Lehner & Hawass, 2017: pp. 240-241), there is no unequivocally conclusive evidence when or by whom it was carved. Based on geological and astronomical evidence, some researchers have proposed that the monument was carved at an earlier date, and its head was merely re-carved in dynastic times (Dobecki & Schoch, 1992; Schoch, 1992; Schoch & Bauval, 2017). Textual evidence suggests that the monument was originally a lioness (Seyfzadeh et al., 2017; Seyfzadeh & Schoch, 2018; **Figure 1**). An analysis and discussion of this evidence, *pro* and *con*, is outside the scope of this paper. However, it makes a testable prediction: if the head of the Great Sphinx was indeed re-carved from the head of an older, original lioness statue as proposed, a plausible sculptural reconstruction of the original monument must in principle demonstrate that all known sculptural elements present throughout its history, even if no longer existing, can be contained inside the original head and neck of the reconstructed lioness simulated in sculpture (**Figure 2**).

Figure 1. The tandem dual title mentioning Mehit as seen on the pedestal of Hemiunu, the slab stele of Wepemnefret, and the wooden tomb panels of Hesy-Ra: Overseer of the Scribes to the King and Master of the Key to the Lioness. Or: "*The King's Chief Librarian and Guardian of the Royal Archives of Mehit*." Image by permission of Catherine Ulissey and Robert Schoch.

Figure 2. Reconstruction of the hypothetical lioness statue in sculpture. Sculpture and photo by R.S.N., May 2019.

Using historical and contemporary references (Lehner, 1991), photographs and descriptions from history (Hassan, 1953: pp. 234-268; **Figure 3**), photographs and visual inspections made in person when touring the site in May 2019, this is the purpose of the study I here present. My contribution to the debate about the age and construction of the Great Sphinx rests on a reconstructive analysis and interpretation of weathering and sculptural aspects of the shape-changing process which created it from its proposed origin as a lioness statue. This process involves the subtractive reduction of a multi-ton dense and brittle bedrock medium, i.e. the three-layered Mokattam Limestone Formation, into a desired sculptural result using only hand tools, which I here simulate.

Figure 3. 1925 view of the Great Sphinx pre-restoration, before concrete repairs applied during Émile Baraize's excavation. The Major Fissure at hips of the statue is still visible, in addition to the crack directly behind the head. The front fissure possibly was created during the same impact which caused the royal Nemes tail to break off.
https://1drv.ms/u/s!AjLfhylwf90ogZcp8ENFEIN6aw81VQ

If the Great Sphinx we know today was indeed carved from an earlier lioness monument as proposed (Schoch, 2012: pp. 24-37; Seyfzadeh et al., 2017), the original "block" would be the lioness head into which everything sculpted later must fit. The lioness head, if it existed and unlike the current Sphinx head, must also be proportional with the original core body of the lioness monument. We must be able to work backwards to reconstructively incorporate all subsequent components of the Sphinx head. This does not just include the appearance of the currently existing head, but also known historical elements such as Nemes headdress and tail, the Sphinx's beard, and the breast lappets (**Figure 4**).

Figure 4. A reconstructive head must be able to include all known presented historical elements: royal Nemes headdress, tail, beard, breast lappets and a nose. From Lehner (1991). The Archeology of an Image: The Great Sphinx of Giza. Zenodo.
https://zenodo.org/record/1203621

By contrast, the Great Sphinx's core body was carved directly from the two lower strata of the Mokattam Formation of the Giza Plateau, and so the original "block" as it pertains to the Sphinx core body are the middle and lowermost Members II and I, respectively.

There is no evidence today that other stony images of naturally wild or fable creatures ever existed over the currently known monument. Instead, geological evidence points to the Third Member (Member III) stratum's lone promontory from which the head was fashioned. "*The Sphinx head layers are found nowhere else on the Giza Plateau*." (Lehner, 1991: p. 16).

The first two forensic archaeo-sculptural aspects that present themselves are: 1) the existing head is clearly too small for the monument (e.g. Lehner, 1991: p. 347); and 2) the existing head is the least eroded and deteriorated component of the monument. It is still exhibiting crisply cut lines of the Nemes headdress, and devoid of the vertical and horizontal erosion striations characteristic of the rest of the monument's core body (**Figure 5**).

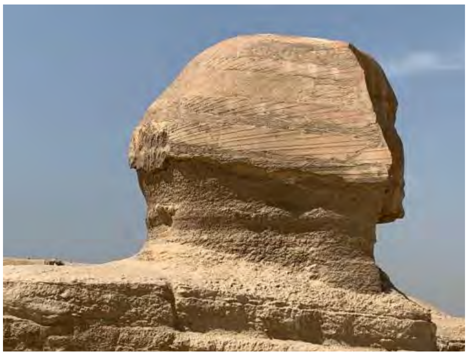


Figure 5. Converging Nemes headdress lines are still distinctly evident. Softer strata were filled in with concrete in 1926, during Émile Baraize excavation. The breakage scar at rear of head is clearly visible. Photo by R.S.N., June 2019.

Even though the head is comprised of the harder and denser Member III strata (Hawass & Lehner, 1994a: pp. 47), it has been exposed to the elements since its creation, presumed to be in circa 2500 B.C.E., while the body has been largely buried in sand for millennia interrupted only by comparatively short periods of restorative excavations both in ancient and modern times (e.g. Thutmose IV, Roman era, Giovanni Caviglia, Auguste Mariette, Gaston Maspero, Emile Baraize and Selim Hassan) (**Figure 6**).

Figure 6. The Great Sphinx. Pre-reconstruction photo dated to 1925. From Lehner (1991). The Archeology of an Image: The Great Sphinx of Giza. Zenodo. https://zenodo.org/record/1203621

2. Methodology

Various images of lioness heads available on the worldwide web were studied; these included photos of live animals as well as ancient iconography from Egyptian temples and the array of lion imagery which I observed displayed in the Cairo Museum (Figures 7-9). In order to demonstrate that all elements could fit inside a lioness statue's head and neck which was proportional with the body of the Great Sphinx, the existing monument had to be recreated first. Oil-based sculptor's clay, clay working tools, a sculptor's hands and eyes, the Internet, and a personal dawn visit to the Sphinx Enclosure were the tools utilized.

Figure 7. Mehit carving, with bent rod key in back from the wooden panels found inside Third Dynasty official Hesy-Ra's tomb at Saqqara, Egypt. The use of this image associated with the lion goddess Mehit extends back to early dynastic times. Cairo Museum. Photo by R.S.N., June 2019.

Figure 8. Couchant lioness statue discovered at "Lion Hill", Saqqara, Egypt. While some lion images appear to have a male's mane, often it is a representation of the gathered skin on lioness neck. Cairo Museum. Photo by R.S.N., June 2019.

Figure 9. Split Lioness iconography. Cairo Museum. Photo by R.S.N., June 2019.

There is no shortage of images of the Great Sphinx online, and I reviewed hundreds of them in every aspect to establish proportion, and to observe the cracks and erosion impacts. The multiple strata of the Giza bedrock presented rather like a layer cake, with each stratum taking on its own outline. As such, vertical top down images were most informative and helpful. The body layers and paws were sculpted first, followed by sculpting the existing undersized head. Then the cladding of the different historical "repair" areas was added all around the Sphinx body (**Figure 10**).

Figure 10. "Restoration" cladding added to Sphinx sculpture. Sculpture and photo by R.S.N., May 2019.

Once the current existing Sphinx was created, the lioness head was sculpted. The concept was to make the head much like a Godiva chocolatier: Mold the head to the desired configuration, slice it in half and hollow out the interior. Install the head pieces like a clamshell over the existing, undersized Sphinx head and examine the fit (**Figure 11**).

Figure 11. Clamshell head opening, like a chocolate truffle. The lioness head was sculpted last, then cut in half and hollowed out. Everything must fit inside. Sculpture and photo by R.S.N., May 2019.

The key aspect of the lioness head was the front to back placement upon the body. Studying scores of side views, front views and the few available, legible top views, I sought the correct proportions to the frontal chest, and the placement in relation to front elbows and rear paws. Specifically, my aim was to identify where the neck must have originally landed on the back of the monument to be correctly proportional. It should be noted that this sculpture does not purport to be an exact scale model in every detail; it is a study of proportion to demonstrate the concept of sculptural reduction.

3. Results

In a sculptural moment of coordinated tactile and visual observations, my hands and eyes arrived at the front-to-back landing area on my model which seemed to locate the proportionally correct place on the statue. There is a physical correlate on the Great Sphinx; it can be seen in an aerial photo as a faintly defined hump and the remnant of an eroded rock layer whose semi-elliptical shape and position on the back matches where one might expect a proportional lioness neck to once have landed on the back of the hypothetically remodeled Sphinx (**Figure 12**). Barely visible from the ground and in most views of the Great Sphinx, it appears only from above in the extreme late sunset light. What appears as silhouette of an elevated rock contour, is in fact a stratigraphic rise detailed in Lehner's topographic drawing (Lehner, 1991: Fig. 5.1; reproduced here as **Figure 13**). In that drawing it is shown as simply another contour line making up the lowest layer of the Member III stratum that comprises the Sphinx head. This was previously identified as Bed 7a in Lal Gauri's nomenclature applied to the substrata of the Member layers; in this scheme Bed 7a marks the thin, eroded boundary layer between the Sphinx's back and its head. Member II beds are numbered 1-6, with the softer beds labeled "i" and the harder beds labeled "ii". Gauri designates Bed 6ii as the top of Member II from which the body of the Sphinx was carved (Gauri, 1984: pp. 30-31; Lehner, 1991: pp. 198-200; **Figure 14**). Consequently, the Sphinx's head and neck belong to the limestone layers of the upper Member III, a limestone bed distinct from that of Member II (Lehner, 1991: p. 183).

Figure 12. Aerial photo of the Great Sphinx taken during late sunset. The semi-elliptical stratigraphic rise is faintly visible only from the air in these extreme long-lighted conditions. Photo by Marcello Bertinetti, licensed use through Alamy.com #IY01273732. February 2015.

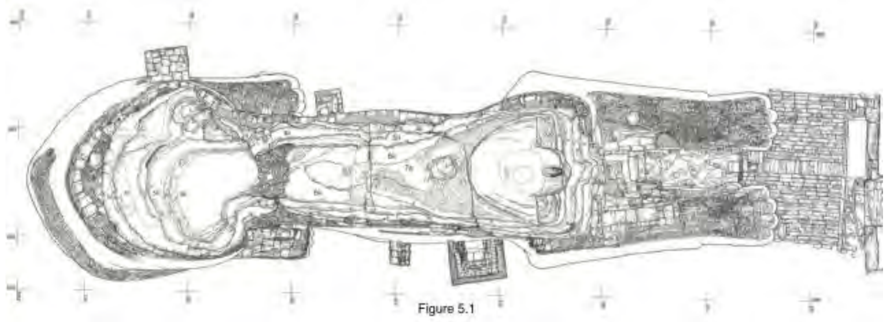


Figure 13. Illustration showing the location of Bed 7a. Courtesy of Mark Lehner. "Drawing d-ss-011 from Egypt/Giza/Sphinx Amphitheater/Sphinx Ditch/Sphinx Statue" (2017). In ARCE Sphinx Project 1979-1983 Archive. Mark Lehner, Megan Flowers, Rebekah Miracle (Eds.). Released: 2017-12-23. Open Context.
http://opencontext.org/media/b16d0723-802c-4141-97d0-b1b077678d2f

Figure 14. Member II Beds are numbered 1-6, with the softer Beds labeled "i", and the harder Beds labeled "ii". Gauri designates Bed 6ii as the top of Member II in the Sphinx body, and Bed 7a as the boundary layer between the Sphinx body and the neck. From Lehner (1991). The Archeology of an Image: The Great Sphinx of Giza. Zenodo.
https://zenodo.org/record/1203621

This topographic feature labeled 7a is consistent in size, shape, aspect and location with the remnant of a stump from the lioness neck's root. The cut-off stump constitutes an archaeo-sculptural signature (or "neck-print") left by the original sculpture from which a head and neck can be reconstructed that is proportional to the rest of the lion's body.

Lehner's contour drawings also show the location of the three major cracks/fissures that transect the monument, particularly one which runs directly behind the head. This fissure was possibly caused by the same event which broke the ceremonial Nemes headdress tail (Schoch, 2012: pp. 173-179). This breakage event left a telltale scar on the rear of the Sphinx's head (**Figure 15**).

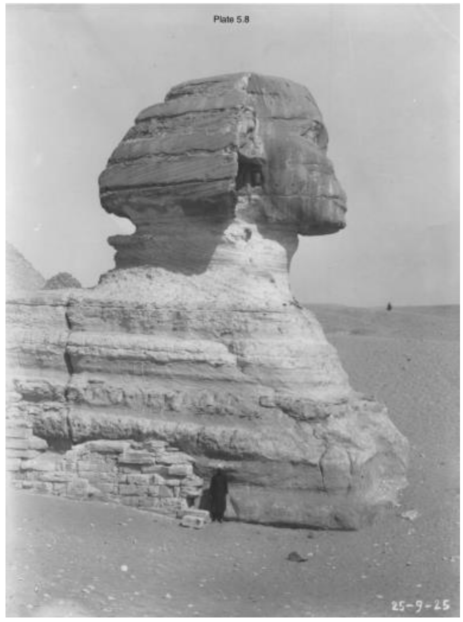


Figure 15. Pre-reconstruction photo from 1925 showing the frontal fissure vertically extending into the body of the Great Sphinx. From Lehner (1991). The Archeology of an Image: The Great Sphinx of Giza. Zenodo. https://zenodo.org/record/1203621

4. Predictive Modelling

Under the assumption that the lioness head was re-carved, trace sculptural remnants of prior versions can be reasonably expected, and these distinctions can be measured. This can be seen, for example, in the remnant lion ears and mane of the sphinx discovered at Abu Roash depicting Djedefre's sister-wife Hetepheres II (**Figure 16**).

Figure 16. Sphinx statue of Djedefre's sister-wife Hetepheres II. https://en.wikipedia.org/wiki/Hetepheres_II#/media/File:Sphinx_of_Hetepheres_II_-_fourth_dynasty_of_Egypt.jpg

Corroborating the remnant signatures of prior sculpted elements can allow predictive modelling to compare different rates and degrees of surface exposure, thermoluminescence, and weathering. If the current head was carved later than the core body, then the hump left from a previous neck described here would have been exposed to the elements for far less time than the back and rump of the Sphinx. This area identified as Bed 7a was not exposed as a surface until c. 2500 B.C.E., when it was re-carved, and the old neck removed.

This "neck-print", or contour as shown by Lehner (**Figure 17**) provides a map that can precisely plot data points in proximity to adjacent Beds 7a and 6ii. One should be able to look for measurable difference in surface (or subsurface) exposure/weathering at these points in order to test the theory that the Great Sphinx's head and core body were not carved contemporaneously. The advantage of measuring relative weathering (not just erosion) of adjacent rock layers is that absolute dating is not required to draw a definitive conclusion, only differential weathering/surface exposure comparing one layer to the next. While the exact testing protocols likely remain to be identified, this archaeo-sculptural analysis provides a roadmap to predict such differences.

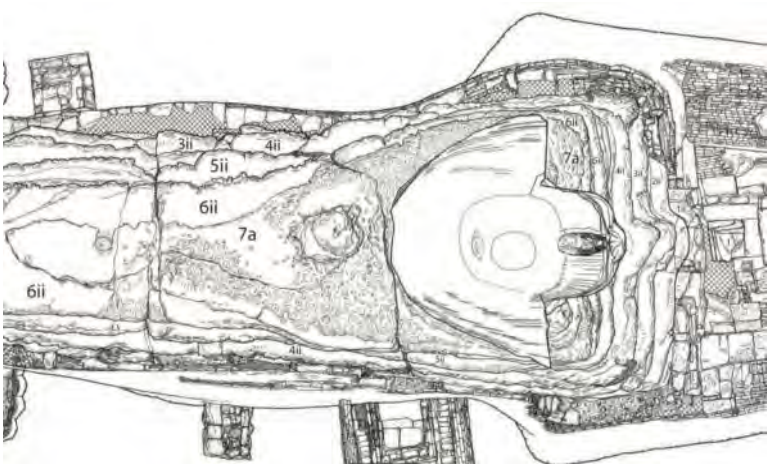


Figure 17. Illustration showing the limestone rock layer elevation contours as viewed from above. Layer 7a is sharply demarcated from layer 6ii defining the border between the head and neck of the Great Sphinx on the one hand and its body on the other. From Lehner (1991). The Archeology of an Image: The Great Sphinx of Giza. Zenodo. https://zenodo.org/record/1203621

5. Discussion

The initial objective of this sculptural examination was to demonstrate that if the head of the Great Sphinx was indeed fashioned from a prior image such as a lioness' head, then all the former's elements must be contained by the proposed lioness head under the assumption the original lioness body and head were created proportionally. I approached this strictly with the discipline imposed by the process of subtractive sculpture, using a sculptor's eye and reviewing hundreds of Sphinx images to gain a sense of this sculpture's proportions. The resulting sculptured model was not created to be an exact scale replica; instead, it served as a demonstration of concept. It was to be a work unbiased by observations and interpretations previously made by other researchers. Fortuitously, while creating the sculpture, I observed a hump which can in fact be seen in an aerial photo of the Sphinx taken at sunset (**Figure 12**). In order to assess the significance of this observation, I would like to first establish a context based on prior work.

Geology. "*The Sphinx is cut from the lowest layers of the Mokattam Formation, those layers lying directly on the hard, petrified reef. Most of the lion body and south wall and the upper part of the ditch were carved in Member II, seven layers that are soft near the bottom and becoming progressively harder near the top. The neck is carved in the base of Member III, which is softer than the upper part from which the head is sculpted.*" (Hawass & Lehner, 1994b: pp. 33-34; **Figure 18**).

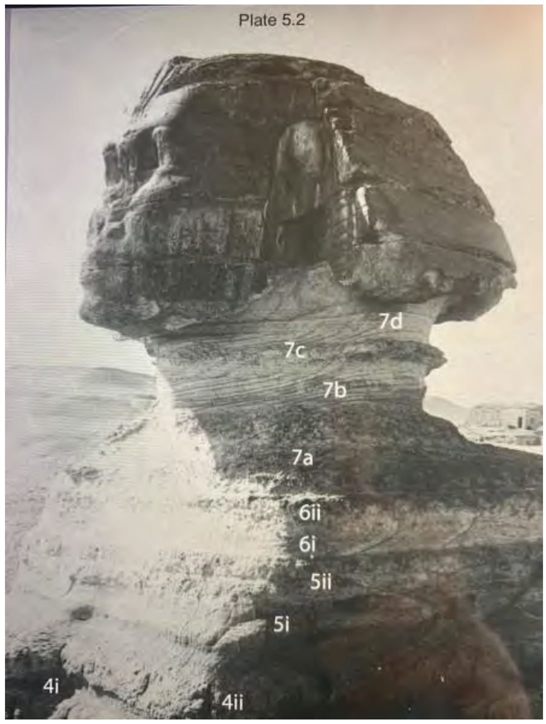


Figure 18. Gauri's nomenclature labelling the individual substrata of the Upper and Middle Members (III and II) of the Mokattam Formation as they contribute to the head, neck, and body of the Great Sphinx. From Lehner (1991). The Archeology of an Image: The Great Sphinx of Giza. Zenodo. https://zenodo.org/record/1203621

Member II beds are numbered 1-6 with the softer beds labeled "i" and the harder beds labeled "ii" (Gauri, 1984: pp. 30-31, Figures 3a-b). Lal Gauri designates bed 6ii as the top of Member II in the Sphinx body. Lehner further notes that Sphinx head layers are found nowhere else on the Giza Plateau (Lehner, 1991: p. 16).

No Prior References. No consensus exists on the conclusive date and sculptor of the Giza Sphinx as we know it:

"*We are left to speculate about the meaning of the Sphinx for its builders because there are no known Old Kingdom texts that refer to it or its temple.*"

(Hawass & Lehner, 1994b: p. 35).

"*Although we are certain that the Sphinx dates to the* 4*th* *Dynasty, we are confronted by a complete absence of texts mentioning the Sphinx in the Old Kingdom.*" (Lehner, 1991: p. 95).

"*None of the materials unearthed at Giza or anywhere else in Egypt make any mention of the statue's construction; it is referenced as though it had always existed when it is mentioned at all. It seems odd that so large and obviously significant a structure would not be mentioned anywhere by anyone at the time it was supposedly built.*" (Mark, 2016).

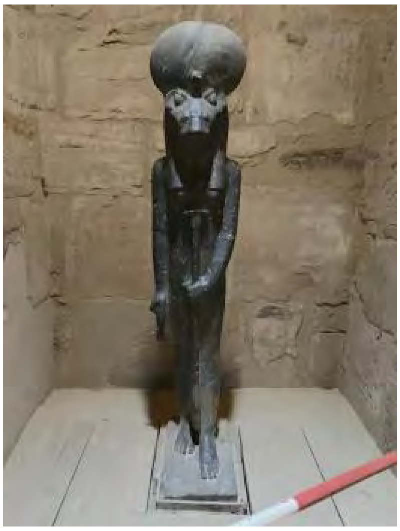
(*Thutmose Stela*) … "*This is the only text that makes a historical connection between Khafre and the Sphinx and here the connection, if any, is problematic…*" (Lehner, 1991: p. 104). It would seem quite possible that the reason there is no mention of the Great Sphinx in Old Kingdom texts (see however Bauval's contention that its celestial counterpart was the Horakhty mentioned in the Pyramid Texts; Schoch & Bauval, 2017: Chapter 6) is because it did not exist as a cultural image prior to the king carving his likeness into the head of a preexisting statue during the 4th Dynasty, though this has been challenged recently (Seyfzadeh et al., 2017; Seyfzadeh & Schoch, 2019). Certainly, there are 2500 years of Sphinx-styled iconography after that time, but as Lehner observes: "*Except for the Louvre head of Djedefre, no Nemes-coifed sphinx earlier than the Great Sphinx are known.*" (Lehner, 1991: p. 352; **Figure 19**). It should be noted here that the Djedefre head is conjectured to have been a part lion, part man sphinx image, although the altered image of his wife Heterphenes II may present the first appearance of recumbent lion with a human face.

Figure 19. Quartzite sphinx head depicting King Djedefre, son of Khufu, Fourth Dynasty; Louvre, Paris, France. The familiar features of the Great Sphinx can be seen here: The Nemes headdress (unplaited here), the uraeus cobra head, and the intense stare. https://www.louvre.fr/en/oeuvre-notices/head-sphinx-king-djedefre

The sphinx design of an animal body and a human head with royal and divine features appears to be a later concept and was without precedent at the time of Khafre as noted by Lehner. It was not even called a Sphinx until 2000 years later when the name was applied by the Greeks. However, lion, lion goddess and couchant lioness imagery are profuse throughout Egyptian iconography dating well back to pre-dynastic times (**Figures 20(a)-(c)**), and these powerful female icons helped shape early culture (Seyfzadeh & Schoch, 2019: pp. 12-13).

(a)

(b)



(c)

Figure 20. (a) Lioness symbol Saqqara, Pyramid of Unas, sarcophagus chamber, north wall. Photo by R.S.N., May 2019. (b) Lioness symbol inscribed into the Temple of Khnum at Esna. Photo by R.S.N., May 2019. (c) Statue of Sekhmet in a chapel of the Temple of Ptah at Karnak Temple, Luxor, Egypt. Photo by R.S.N., May 2019.

Disproportionality. Much has been written of the disproportionate sizing of the Sphinx head relative to the lion body. It is variously attributed to miscalculation, structural constraints, material limitations, or the major fissures. Opinion varies widely on whether the head was carved first and then the body, or if the body was quarried first and the head articulated after.

From a sculptor's planning standpoint, if the head was carved from its promontory first, the quarrymen could have easily sized the body accordingly, and even would have the opportunity to move the body position forwards or backwards to accommodate the stone layers beneath. If the body was relieved from the Sphinx ditch first, then the head could easily be sized properly from the promontory material available. In short, if the head was first, they could have made the body smaller. If the body was first, they could have made the head larger when initially blocking the sculpture in. This combined with Lehner's insight that Khafre was a prolific statue builder, make the blunder scenario unlikely:

"*It has not been appreciated the extent to which Khafre was the statue builder par excellence in the Old Kingdom. His reign is unequalled in terms of numbers and the great size of his statues until well into New Kingdom times*." (Lehner, 1991: p. 107).

Geologist Colin Reader, likewise, rejects the blunder argument, and notes that the ancient Egyptians were masters in stonework and could not possibly have miscalculated in carving the Sphinx nor would they have shrunk the head out of proportion with the body for the sake of stability. There are plenty of other monuments, he notes, in perfect proportion, which have stood the test of time (Reader, 2001: pp. 149-159). Lehner concluded that Egyptians were carving smaller scale lions in the round since the First Dynasty, and in relief since the predynastic times, some of them reasonably accurate in their proportions (Lehner, 1991: p. 352).

Original Block? Lehner describes the original block of material that was sculpted into the Great Sphinx head as follows:

"*The head itself must have been sculpted from a reserved block of limestone almost exactly* 20 × 20 *royal cubits square*. Figure 9.1, *in which the grid squares are each one royal cubit illustrates this point. In plan, the head is symmetrical with a fair degree of accuracy. The division of the face and the head into cubits corresponds remarkably with the upper hard layers of Member III bedrock, and even with the distinct beds into which Member II is subdivided*." (Lehner, 1991: p. 348).

However, in Lehner's model of such an original block from which the head was carved, no allowances are made for other structures extending from the basic head design. While one can put a convenient grid box over a plan view of the current Sphinx's head as seen in his Figure 9.1 (Lehner, 1991: Figure 9.1; reproduced here as **Figure 21**), it omits all substrate material for the Nemes tail structure, the breast lappets, the uraeus, or the divine beard … all of which must be incorporated into the head. Otherwise, those known elements would be "out of the block". That cannot be correct, except in the case of the divine beard, which may have been attached later.

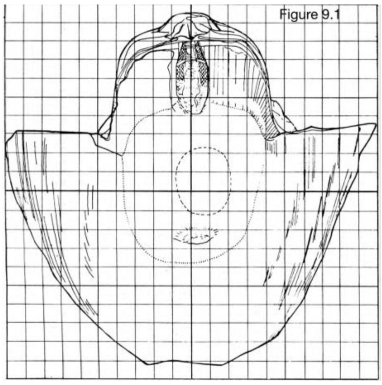


Figure 21. Hypothetical block from which the Sphinx head was carved according to Mark Lehner with superimposed grid. Each square is one royal cubit on the side. Image courtesy of Mark Lehner. "Drawing d-h-011 from Egypt/Giza/Sphinx Amphitheater/Sphinx Ditch/Sphinx Statue" (2017). In ARCE Sphinx Project 1979-1983 Archive. Mark Lehner, Megan Flowers, Rebekah Miracle (Eds.). Released: 2017-12-23. Open Context: http://opencontext.org/media/f21bca31-c2aa-4195-ad61-daa7ac19974c
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Lehner states that in sum, the head and the body are individually symmetrical, "*and the front elevation is fairly well proportioned between head and body*" (Lehner, 1991: p. 349). However, Lehner's Figure 9.4 shows an overlay of Khafre's head that does not align (Lehner, 1991: Figure 9.4; reproduced here as **Figure 22**). By contrast, the proposed lioness head brings proportionality to the statue and incorporates all the known historical elements of the head (**Figure 23**). This analysis allows the linking of the King to a 4th Dynasty creation of the Sphinx. By carving his likeness into the head of the preexisting lioness monument, Khafre arguably created a previously unknown image which only after many centuries became known as the Sphinx.

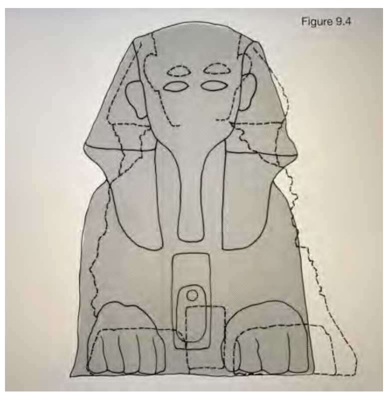

Figure 22. A hypothetical overlay. Lehner is seeking here to demonstrate that there is a reasonable match in proportion to the frontal contours of the existing Sphinx (dotted line) and the more traditionally proportioned Sphinx images of the 18th Dynasty. Image courtesy of Mark Lehner. "Drawing d-ss-035 from Egypt/Giza/Sphinx Amphitheater/Sphinx Ditch/Sphinx Statue" (2017). In ARCE Sphinx Project 1979-1983 Archive. Mark Lehner, Megan Flowers, Rebekah Miracle (Eds.). Released: 2017-12-23. Open Context: http://opencontext.org/media/b03a6756-ad35-456b-978e-9546026a5e4f
ARK (Archive): https://n2t.net/ark:/28722/k2sj1q92b

Figure 23. The proposed lioness head contains all historical elements within the boundaries of its contour. Sculpture and photo by R.S.N., August 2019.

Nemes Tail and Breast Lappets. As previously noted, the royal plaited Nemes headdress-clad sphinx is not known prior to the Great Sphinx. Certainly, there are over two millennia of Nemes-coifed sphinx images subsequent to the conventional creation date of the Great Sphinx. Any reconstruction of the historical Great Sphinx head must incorporate these essential elements of kingship, both the Nemes tail and the breast lappets (**Figure 24**). The crisply carved lines on the Sphinx head clearly gather at a convergence point at the rear of the head, although the height of this point is problematic for Lehner:

Figure 24. Modern visage of the Great Sphinx. The squared off shoulders Gauri described, which are thought to reflect bedrock remnants of breast lappets are visible on the near (south) side, as are the horizontal connectors where the lappets attached to the ceremonial headdress. Photo by R.S.N., June 2019.

"*The tail of the Sphinx Nemes presents a puzzle, because the relief-carved pleating appears to be headed toward a knot that would have been* 2.5 *to* 3 *m above the top of the back … but the break at the back of the head makes it likely that they carved the tail of the Nemes at least partly from the natural rock.*" (Lehner, 1991: pp. 357-358).

In the reconstructed model proposed here, the Nemes tail is gathered tight and low to acknowledge the breakage scar at the back of head (**Figure 25**).

Figure 25. The original Nemes headdress lines are distinctly visible, note the lines converging low behind head. The telltale breakage scar is present at rear of head (see red circle). The softer, eroded strata of the head have been filled in with concrete during the 1925-36 Baraize restoration. Photo by R.S.N., June 2019.

Nemes Tail. Is the humped stratum behind the Sphinx head a connecting structure for the Nemes tail? While possible, the indicated convergence point for the carved lines on the Nemes headdress suggests an impractically elevated tail structure; almost 9 feet off the Sphinx back. From the sculptural planning and blocking standpoint, the Nemes tail either must be elevated on a substantial structure or lay along the back (as it does with virtually all other Sphinx images).

With the tail laying down along the back, there are only a few ways to visually elevate the tail. One is to make the gathered tail thicker to give the impression of height off the back. The other way is to elevate the entire surface beneath the tail. The difficulty with this approach is that it creates a giant visual structure to solve a small visual problem, creating a situation where the tail would take over the entire sculpture as the dominant visual element. Using the entire rock layer of Bed 7a spanning the width of the Sphinx back just to prop up the trailing Nemes tail a foot or so is not the kind of amateur planning mistake that the King's master quarrymen and sculptors would make in this monumental undertaking.

Given the problematic sizing of the King's head to lion body, either a larger, thicker Nemes tail or one that was raised on some elevated bridging would highlight and accentuate the disproportion, and possibly make a grotesque caricature out of the King's head. It would look like a small head with an over-sized stony blimp attached behind.

It is unlikely that its creators would use the entire breadth of the Sphinx back, and portions of strata 7*a*, 7*b* and 7*c* only for the purpose of bridging for the Nemes tail, and that all evidence of this has eroded away. The Egyptians routinely carved in high relief, (such as arms, legs and beards) with solid bridging to the body, and this would be a more likely solution to which his sculptors would have turned.

These hypothetical scenarios suggest that the Great Sphinx as we see it today is the result of a series of blunders and miscalculations. That seems an inadequate assessment, given the extraordinary and timeless engineering and stonework performed all around the statue on the Giza Plateau (Reader, 2005: p. 54).

The breakage of the Nemes tail structure may well have been associated with the eastern most fissure that transects the Sphinx directly behind the head. However, it may also have been vandalized or mutilated (perhaps along with the other symbols of divine kingship; beard, breast lappets).

Divine Beard. Fragments of a long, braided beard attributed to the Great Sphinx were found, and are displayed in the British Museum and Cairo Museum (**Figure 26**). Hawass and Lehner explain:

Figure 26. Remnant of the beard of the Great Sphinx, British Museum. https://danderma.files.wordpress.com/2010/12/ttdilvttbm24.jpg?w=570.

"*The Sphinx Beard is relevant to this question. Captain Giovanni Battista Caviglia found several fragments of the beard at the base of the chest in* 1817, *the earliest recorded modern excavation of the Sphinx. The fragments were part of a long braided* '*divine beard*', *curled at the end, that gods and deified kings wore. Statues of living kings sported short, square beard.*" (Hawass & Lehner, 1994b: p. 37; **Figure 27**).

Figure 27. Khafre statue with royal beard, Cairo Museum. Photo by R.S.N., June 2019.

Evidence indicates that the beard was carved originally into the bedrock as a divine beard, not a royal beard:

"*The long curled divine beard of the Sphinx appears to be the same stone as* *the layers of the Sphinx neck and chest where it once was positioned*." (Lehner, 1991: p. 410).

Ricke maintains that the fragments show no evidence that the divine beard was adapted from a straight square royal beard (Ricke, 1970: p. 33).

Thus, the 4th Dynasty carving created a Sphinx sculpture which began its life as a deified image, not simply an image of kingship. This raises the question if the king would have had his master quarrymen and sculptors create for the first time in history a unique image that was divine but diminutive? This seems unlikely. More likely is that the head became smaller because it had been re-carved from the weathered remains of a larger original. Even the braided, curled beard of divinity fits neatly into the modelled predynastic lioness head (**Figure 28**).

Figure 28. Divine beard fits into proposed lioness head. Sculpture and photo by R.S.N., August 2019.

Bed 7a. Lehner writes of the quarrymen who relieved the Sphinx from the bedrock:

"*Their skill is evident in the way they fit their sculpture to the bedrock layers. They reserved the uppermost layers of the SE part of the Giza Plateau, Member III for the Sphinx's head* …" (Lehner, 1991: p. 408).

Bed 7a is one of the least discussed layers of the Sphinx structure, characterized mostly as a residual boundary layer between prominent strata, if mentioned at all.

As Lehner states:

"*The neck consists of stone from geological beds 7b, 7c, and 7d. Bed 7c is slightly harder and was left protruding by the weathering away of 7b and 7d*." (Lehner, 1991: p. 198).

According to Gauri's distinction, the division between Members II and III occurs as a thin separation line passing through the upper, squared corners of the shoulders, about 3.5 m below the chin. Gauri designated Bed 7a as the beginning of Member III (Gauri, 1984: p. 31, Fig 3B; **Figure 29**).

Figure 29. Pre-reconstruction photo from 1925 showing Gauri's designation of layers comprising the body, neck, and head of the Great Sphinx. The boundary layer between beds 6ii and 7a is sharply defined. From Lehner (1991). The Archeology of an Image: The Great Sphinx of Giza. Zenodo. DOI 10.5281/zenodo. 1203620.

Lehner describes the strata thus:

"*The top of the Sphinx's back is mostly made from Bed 6ii (Member II) except for a residue of bed 7a (Member III), thinning out behind the head. Bed 7a is easily distinguished by the way it weathers, forming a dark crusty surface, as opposed to the smoother, more homogenous white and yellow beds of Member II. Bed 7a (Member III) can be traced from the top of the Sphinx's chest around the back of the head to phase out* 15.0 *m behind the neck.*" (Lehner, 1991: pp. 199-201; **Figure 30**).

Figure 30. Bed 7a is a "residual eroded layer that thins out behind the head." Image courtesy of Mark Lehner. From Lehner (1991). The Archeology of an Image: The Great Sphinx of Giza. Zenodo. https://zenodo.org/record/1203621

The presence of Bed 7a is delineated as a contour profile in Lehner's careful drawings of the topography of the Sphinx and is repeatedly described as the boundary layer between the Sphinx back and neck. All these descriptions and characterizations of Bed 7a appear correct. Geologically, it is the boundary layer between Member II and Member III. Sculpturally, the semi-elliptical mounded shape behind the Sphinx's head formed by Bed 7a is the boundary between the Sphinx's back and the root of the original lioness' neck. The "thinned out, residual layer" corresponds precisely in size, shape, aspect and location to where the root of the lioness' neck would have originated (Figure 31). Thus, while Bed 7a was described, it was incompletely interpreted. Bed 7a, arguably, is the key feature which identifies the substrate statue from which the Great Sphinx was made; this key feature was the root of the stony lioness's neck, which can incorporate all the subsequent historical sculptured elements of the Great Sphinx: Nemes tail, divine beard and breast lappets (Figure 32). Further, the reconstructed head of the monumental lioness incorporating all these elements makes the entire monument a proportional statue without the need to invoke the other explanations offered which rest on presumed mistakes, miscalculations and oversights by its creators (Figure 33).

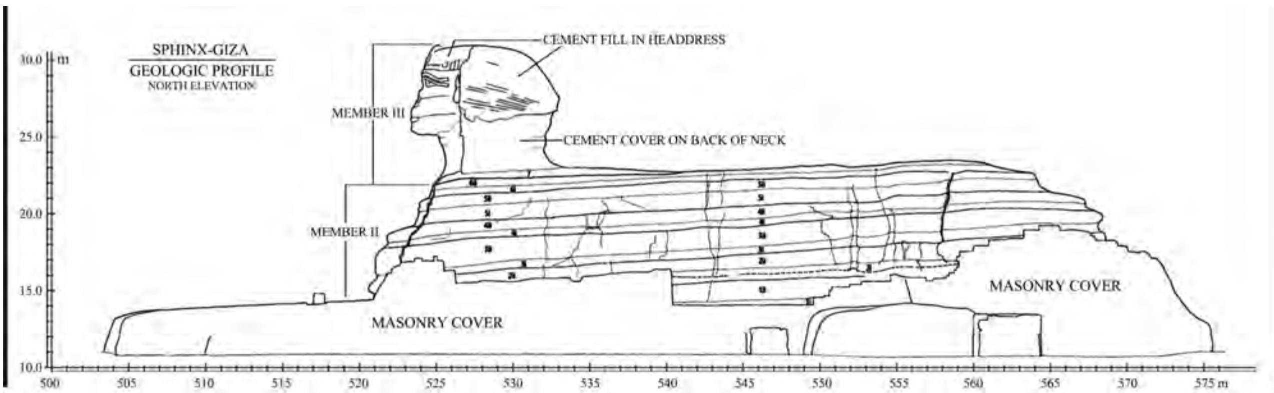

Figure 31. Bed 7a shown, but not interpreted. Image courtesy Mark Lehner. "Drawing d-ss-029 from Egypt/Giza/Sphinx Amphitheater/Sphinx Ditch/Sphinx Statue" (2017). In ARCE Sphinx Project 1979-1983 Archive. Mark Lehner, Megan Flowers, Rebekah Miracle (Eds.). Released: 2017-12-23. Open Context: http://opencontext.org/media/d1d1f1e6-87bd-4fc7-9f82-19d3d35eb47a ARK (Archive): https://n2t.net/ark:/28722/k2vm4gg5k

Figure 32. All Historical elements fit inside the proposed original lioness head. Sculpture and photo by R.S.N., August 2019.

Figure 33. The proposed original sculpture of Mehit before losing her head. Sculpture and Photo by R.S.N., May 2019.

The model presented here makes a testable prediction. The boundary division between Bed 6ii and Bed 7a is well-mapped and provides a reliable guide for adjacent data points used to measure differential exposure/weathering. The exposure differential postulated here is by design more than a comparison of erosional weathering. Certainly, different layers of Member II and Member III comprise strata with varying hardness as has been well documented, and differing rates of simple erosion could be expected. Exposure sensitive markers must be identified which will reliably indicate differing degrees of cumulative surface and subsurface effects. Such markers are likely to present as accumulative of a molecular process, radiometric decay of certain isotopes or compounds, or the physiochemical transformation of isotopes which can provide a basis for comparison of similar stone surfaces independent of simple erosion.

All this natural stone material is photoreactive to some degree; witness the descriptions of the "natural patina" that forms on Member III. Not unlike a radiation dosimeter, there will be a cumulative difference in exposure demonstrated between the exposed surface of Bed 6ii and the much more recently revealed surface of Bed 7a. This surface was exposed circa 2500 B.C.E. when the neck was carved away by Khafre's sculptors as the head was re-carved to its current likeness. These quantifiable measurements may provide evidence that the Great Sphinx body and head are not contemporaneous. The hump could be a stump!

6. Conclusion

The preceding archaeo-sculptural analysis provides a roadmap to predict and establish an empirical method to confirm prior sculptural elements on the Great Sphinx of Giza and demonstrates that:

1) A proportional lioness head can spatially contain all subsequent sculptural elements historically displayed by the Great Sphinx.

2) There is a previously unreported "forensic neck-print" which is the contour signature of an alteration which reduced the lioness' neck at the time of re-carving, possibly to fashion the Nemes tail. If the hump was indeed the root of the original neck, the entire statue would have been proportional. Thus, the

hump could be a remnant stump!

3) This new model of the evolution of the disproportionate Great Sphinx from a preexisting proportional lioness statue predicts that the original neck area (Bed 7a) and the contiguous back and rump (Bed 6ii) have been exposed to different time-dependent degrees of weathering due to sun, radiation, wind, sand, and rain; and these differences may be measurable to put the model to the test.

Sculpture is a primary modality of sub-verbal communication for cultures that generally predates written symbology. As a vehicle for expressing the cosmology and aspirations of ancient peoples, it can provide a unique window to learning about their beliefs. This is especially true when the effects of reuse, repurposing or appropriation can be identified as markers of the change and evolution of cultures. Archaeo-sculptural analysis may provide a useful tool for looking at other monuments in antiquity through the lens of sculpture and stone working. Examples include the adjacent Sphinx Temple and Valley Temple of Khafre, ostensibly comprised of stone quarried from the Sphinx Enclosure.

The conclusions presented here indicate that the existing head and core body of the Great Sphinx were not carved at the same time. Confirmation of this prediction through exposure sensitive markers will mean that the creation of this iconic statue must be ascribed to a different author, and to a different era than is commonly accepted. This in turn will require a re-examination of our understanding of the chronology and sequencing for the unfolding of the entire Giza Plateau. It impacts the Who, What, When, How and Why of the complex, with rippling implications for the advent of predynastic civilization in Egypt.

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About the Author

My qualifications in this regard are unique; having competed around the world as part of the United States Snow Sculpture Team. Over the past 30 years I have been World Champion, US Champion, and have won numerous Gold and Silver Medals in international competition including Finland, Moscow, Sapporo Japan, and Breckenridge Colorado. These international competitions involve rendering a 25-ton frozen block into a finished sculpture in four days using only hand tools (**Figures 34-36**). As such, I am keenly aware of the dynamics of the subtractive process and working within the confines of the original "block" of material to achieve the desired sculptured result where extra material cannot be added back on.

Figure 34. Early on Day 2 of "*The Dance*". 25-ton block, during four days, more than half will be removed by hand. The inner form is just beginning to emerge. Photo by D. Neyland, January 1998.

Figure 35. Hand Tools. They haven't changed much over the millennia: saw, chisel, scraper, tined fork … except that today we can enjoy the magnificence of Japanese tool steel for the blades. Photo by R.S.N., January 2019.

Figure 36. *The Dance* completed. 14 feet tall, hands not touching, completely self-supporting. Sculpture and photo by R.S.N., 1998.

Conflicts of Interest

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

References

Dobecki, T. L., & Schoch, R. M. (1992). Seismic Investigations in the Vicinity of the Great Sphinx of Giza, Egypt. *Geoarchaeology: An International Journal, 7,* 527-544. https://doi.org/10.1002/gea.3340070603

Gauri, K. L. (1984). Geologic Study of the Sphinx. *NARCE, 127,* 24-43.

Hassan, S. (1953). *The Great Sphinx and Its Secrets. Historical Studies in the Light of Recent Excavations*. Cairo: Government Press.

Hawass, Z., & Lehner, M. (1994a). Remnant of a Lost Civilization? *Archeology, 47,* 44-47. http://www.jstor.org/stable/41766475

Hawass, Z., & Lehner, M. (1994b). The SPHINX: Who Built It, and Why? *Archeology, 47,* 30-41. http://www.jstor.org/stable/41766473

Lehner, M. E. (1991). *Archaeology of an Image: The Great Sphinx of Giza*. PhD Thesis, Volume 1 (Text), New Haven, CT: Graduate School of Yale University.

Lehner, M., & Hawass, Z. (2017). *Giza and the Pyramids. The Definitive History*. Chicago, IL: University of Chicago Press.

Mark, J. J. (2016). *The Great Sphinx of Giza*. Ancient History Encyclopedia. https://www.ancient.eu/Great_Sphinx_of_Giza/

Reader, C. (2001). A Geomorphological Study of the Giza Necropolis with Implications for the Development of the Site. *Archeometry, 43,* 149-159. https://doi.org/10.1111/1475-4754.00009

Reader, C. (2005). A Reconciliation of the Geological and Archaeological Evidence for the Age of the Sphinx and a Revised Sequence of Development for the Giza Necropolis. In A. Cooke, & F. C. Simpson (Eds.), *Current Research in Egyptology II* (pp. 47-56). Liverpool, Dublin: Bar International Series 1380.

Ricke, H. (1970). *Der Harmarchistempel des Chefren in Giseh* (pp. 31-33). Beiträge BF 10. Mainz: Rheingold Druckerei.

Schoch, R. (1992). Redating the Great Sphinx of Giza. *KMT, a Modern Journal of Ancient Egypt, 3,* 52-59, 66-70.

Schoch, R. M. (2012). *Forgotten Civilization: The Role of Solar Outbursts in Our Past and Future*. Rochester, VT: Inner Traditions.

Schoch, R. M., & Bauval, R. (2017). *Origins of the Sphinx: Celestial Guardian of Pre-Pharaonic Civilization*. Rochester, VT: Inner Traditions.

Seyfzadeh, M., & Schoch, R. M. (2018). The Inventory Stele: More Fact than Fiction. *Archaeological Discovery, 6,* 103-161. https://doi.org/10.4236/ad.2018.62007

Seyfzadeh, M., & Schoch, R. M. (2019). Major Geological Fissure through Prehistoric Lion Monument at Giza Inspired Split Lion Hieroglyphs and Ancient Egypt's Creation Myth. *Archaeological Discovery, 7,* 211-256. https://doi.org/10.4236/ad.2019.74011

Seyfzadeh, M., Schoch, R. M., & Bauval, R. (2017). A New Interpretation of a Rare Old Kingdom Dual Title: The King's Chief Librarian and Guardian of the Royal Archives of Mehit. *Archaeological Discovery, 5,* 163-177. https://doi.org/10.4236/ad.2017.53010

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Using of GIS Technology for Conservation of the Ottoman Bathroom and Its Urban Surrounding in Qena—Egypt

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Abstract

The Bathroom area in Qena city is suffering from urban, social and economic problems, which affects negatively on one of the most important Islamic buildings (the Ottoman Bathroom). In the present study, Geographic Information Systems (GIS) technique has been chosen for evaluating the current state of the Ottoman Bathroom and its urban surrounding that is situated within Qena city. Three categories of the evaluating were carried out, the urban, economic, and social status of the environment urban of the Bathroom. Monitoring and analysis of spatial and descriptive data were carried on the surrounding of the Bathroom through design the spatial database; the results of the study indicated that the residential buildings have been suffering from severe damage. The samples were collected from different places of the Bathroom, investigated by Scanning Electron Microscopy (SEM) with EDX analytical methods, and X-Ray Diffraction (XRD). The previous results were indicated that there is a crystallized salt in bricks pores, micro-cracks, and loss in the internal structure of the building materials. The conservation plan included on many steps: 1) documentation of the building and its urban surrounding; 2) monitoring of deterioration symptoms of the building, urban deterioration symptoms of the surrounding; 3) the conservation plan and adaptive reuse of the Ottoman Bathroom.

Keywords

GIS Technology, The Current State, The Ottoman Bathroom in Qena, Conservation, Rehabilitation, Adaptive Reuse, Intervention Suggestions

1. Introduction

The conservation of the local architectural heritage is one of the most important factors to conserve the local identity. These buildings are considered mind of the nation and the link between the past and the present which reflects the communication and continuity in civilization which is the best evidence of the cultural heritage and civilization through the different ages. The ottoman bathroom in Qena city is considered one of the important Islamic service facilities, as a necessity for people's health in their daily lives. Moreover, it represents a symbol of Islamic civilization in Qena city. GIS applications have spread widely throughout the world as an important technique, which use to support decision making in the development and management of archaeological sites, that require an inventory of natural and human resources, in order to develop appropriate plans and achieve optimum utilization and compatibility between the multiple uses of land and their representation and drawing (Chang, 2008; Lock, 2001; National Center for Geographic Information and Analysis, 1989). Geographic Information Systems (GIS) are considered an important tool used to evaluate the current state of archaeological sites, this technique has a high ability on monitoring, documentation, analysis, and other capabilities, that used in the evaluation, it has the ability in the creation of an integrated electronic database for the archaeological site (Aldenderfer & Carolyn, 2000; Elphinstone & Wickham-Jones, 2012), that allows more than user to access data and modify it simultaneously, saving a lot of time, effort, cost in the medium and long term, the studies related to using GIS techniques in the documentation and rehabilitation of the archaeological sites are still few (Wheatley & Gillings, 2013; Rajani, 2016). the interrelationship between GIS and the documentation of archaeological sites is represented of the influence of each part to the other, showing the features of this effect either as a source for providing the scientific material or as an applied method or another, to contribute to the development of assumptions or future predictions that may arise on the natural and human phenomena represented by archaeological sites (Mekni, 2013). It is known that the most of the developed countries technically have become dependent on the basis of their work on GIS, especially in the providers of public services, this technique has been used in several fields, such as road planning, construction, and maintenance, identification of services types, villages, and towns (El Adnani et al., 2019; Ramsay, 2011), which have archaeological sites requirement access to various necessary information to determine traffic directions, control and regulation of traffic lights and the establishment of security patrol centers and points (Godchild et al., 1992; Moustafa, 2000; Meaden & Aguilar-Manjarrez, 2013; El Adnani et al., 2019). GIS techniques are used in design of geometric vision through aerial photographs and maps to identify neglected heritage buildings, and how to reuse them, integrate them and use them in tourism activity, in addition, to find economic sources for financing, conservation of ancient buildings, so as not to lose the area value, specifically in the Ottoman Bathroom zone and its surrounding, so, it should be developed, rehabilitate and preserve. The digital maps of cultural heritage sites are represented, by layers, which are used to manage and develop the archaeological and tourist sites, and these layers contain all the information and natural and human components (Güney, 2001; Openshaw, 1991). In geographic information systems, the following steps are taken: Data Collection & Correction. Spatial data include all forms of data for archaeological sites, that are associated with specific coordinates, the site is defined in a specific way in the form of coordinates (X-Y) or three dimensions (X. Y. Z.), the spatial data are divided into three sets of phenomena when represented in maps: Point features, Line features, and areal features (Lake, 1993; Akhter, 2018; Pickles, 2008). According to (Benavente et al., 2004), the experimental study, which carried on the stone samples affected by crystallization of sodium sulphate and sodium chloride showed that halite resort to deposit on the surface of the stone with a similar distribution in all samples. The present research has been oriented by the following hypothesis: In order to determine the values of the monument and its conservation, it must address the conservation of archeological buildings from an integrated holistic perspective of all means and principles.

- The archeological building and its built environment are an organic unit that should be dealt with from this point of view when thinking about its restoration or maintenance.
- There is an inverse relevance between the continuation of the archaeological building and damage factors affecting it. Whenever the risks increased the archaeological building, becomes more damaged and destroyed.
- Dealing with the laws of monuments, buildings and urban planning must be from an integrated holistic perspective that takes into account the unity and entity of the architectural heritage of the region.
- Strategies, policies, and objectives that achieve conservation of the buildings as a historical and archaeological value should be preceded by the study and identification of problems and risks that threaten these buildings and the urban environment.
- Adaptive reuse is the best way to the conservation of historic buildings, particularly a case of the Ottoman Bathroom.

The study deals with the conservation and reuse of the Ottoman Bathroom situated in Qena by using GIS technique to monitoring the current state of the building and its surrounding, which helps in visualize of the conservation and rehabilitation plan.

2. The Ottoman Bathroom

The Ottoman Bathroom is situated within scope of the second section of Qena city (**Figure 1**); this zone represents the old residential block of Qena city that existed at the beginning of 19th century AD.

2.1. The Historical, Architectural and Functional Values

The Ottoman Bathroom in Qena dating back to the late 18th century and the beginning of 19th century AD. It was registered as archeological building according to the decree of Council of Ministers no. (332) of 2002 A.D. From the construction date of the building shows that it has a historical value represents in its age, which is more than 200 years, in addition to it is represented one of three Bathrooms remains in Upper Egypt (Osman, 2001). Function of the building is considered as a test that determines validity of the building design, where the building value is increased whenever; the building was suitable for its purposes. If we look at the architectural value of the Bathroom, we observe that its horizontal design is oriented to the interior, taking into consideration the privacy of the building, it has a diversity of the height of the architectural elements based on the function of each it, in addition to different of domes and vaulted roofing. The Ottoman Bathroom's layout principles are summarized in the following points: it has an entrance similar to the entrances of public buildings in the Mamluk period; it contained a strip room, and a durqac covered by a wooden skylight, iwans are covered by a wooden roof. The first house was to prepare the bather to receive heat, before and after use. In addition to the heat, it is contained the washbasin, spaces, a furnace, and facilities.

2.2. Architectural Description of the Ottoman Bathroom

The area of the Bathroom's architectural units is 29 m from north to south, 23.30 m from east to west. The building's borders are Street of the Bathroom in the north, the Qaysariya Street in the west, Grand Mosque Street in the south and Grand Mosque in the west (**Figure 2** & **Figure 3**).

2.2.1. Facades

The façades of the build are characterized by simplicity; the main facade is located in the northern side of the Bathroom where there is the main entrance in the eastern side, this face has two windows. The western façade has three windows similar to those on the northern façade. The southern façade has another entrance is located in the western side, its width less than the main entrance; this façade extends to a space where the furnace was located (**Figures 4-7**).

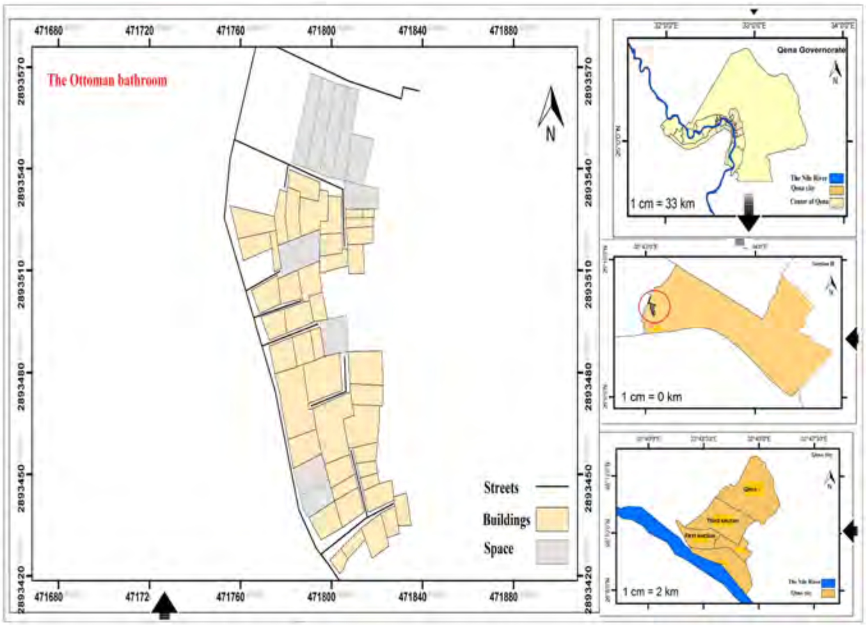


Figure 1. Site of the Ottoman Bathroom in Qena city.

Figure 2. Geographic boundaries of the Ottoman Bathroom.

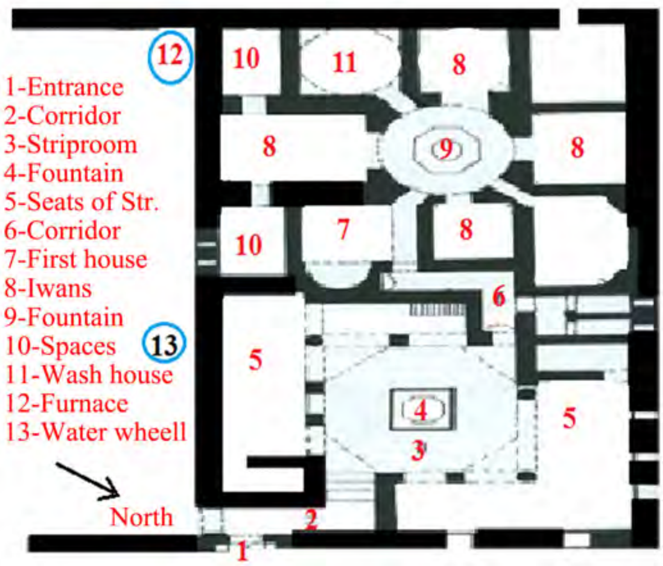


Figure 3. The horizontal design of the Ottoman Bathroom.

2.2.2. Interior Design of the Bathroom

The building layout included curved corridor has a wooden roof leading to a strip room covered with a wooden roof and a skylight; it occupies an area approaching to half of the Bathroom, it has a square courtyard with a fountain located in the center, the area of the courtyard is (47.61) m^2, it has iwans from the four sides rise (60) cm from the ground, in south of the courtyard there is a stairway leading to roof of the Bathroom, and in western side there is a door leading to the second corridor, which its length is (4.8) m, it connects between the strip room and first house. The first house opens on the heat house, and a fountain in the center, it contains four iwans that have the same size, from the heat house we get to the wash house (Figure 3).

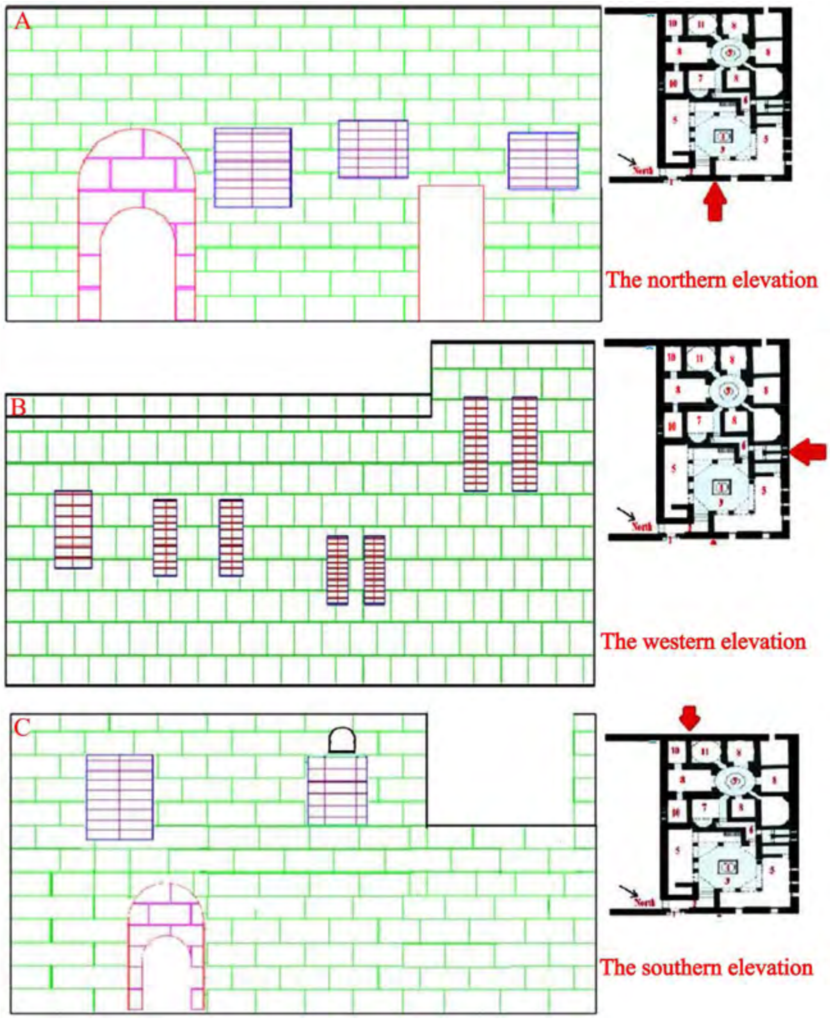


Figure 4. A. The main facade of the Bathroom B. The western façade C. The southern façade.

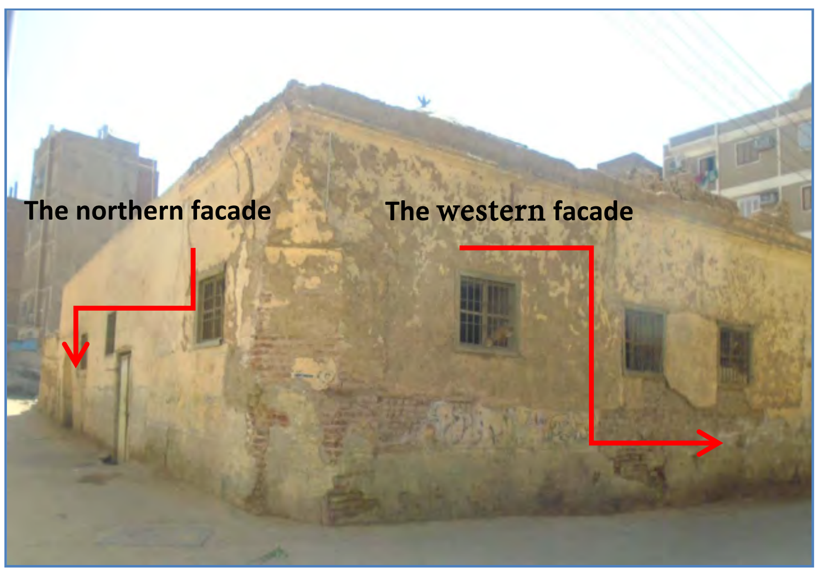


Figure 5. The northern, western facades of the Ottoman Bathroom.

Figure 6. The southern façade of the Ottoman Bathroom.

Figure 7. The eastern side of the Ottoman Bathroom.

2.3. Deterioration Aspects of the Ottoman Bathroom and Its Surrounding

2.3.1. Deterioration Aspects of the Building

The Bathroom site is surrounded by urban growth which represents a source of visual distortion and physical damage due to rising groundwater level under foundation of the building, this as well as the partial loss of the components of the building in addition to partial loss of the architectural units themselves, so it has been in bad physical condition and there is a possibility of further deterioration, damage and failure, due to that the building has been suffering damage factors and causes since far times because of the destructive reuse, floods in Qena in 1954 and effect of saturated soil with contaminated water, it is also suffering damage factors and causes at the moment such as moisture, housing ,urban trespasses and man-made destruction, ground water raised, pollution and infection of ground water beneath the Bathroom foundation.

Red bricks and mortars are the essential building materials that have been used for the construction of the Ottoman Bathroom, in addition to marble, stucco windows, mosaics, wood, and metals, etc. as secondary construction materials. Different types of weathering forms were observed in building materials of case study, such as the efflorescence of salts, due to effect groundwater. The ground water containing various kinds of mineral salts, in which they are the most important physiochemical weathering and damage processes that affect building materials (Hemeda et al., 2018; Binda, 2006), when water rise to the brick pores by capillary the salts will penetrate the pores, if the water dries the salts will crystallize. The salts generate internal pressure could lead to cracks in the fabric of red bricks, which turn it into a powder on long term (Lourenço et al., 2014). The Bathroom is in bad condition due to misuse and effect of different deterioration factors, such as, rising groundwater level, settlement of soil, frequency between temperature and relative humidity, in addition to lack of attention to restoration and maintenance of the building, we are observed that there are various deterioration symptoms in building material, such as, loss of building materials (red bricks and mortars), flaking and crumbling of plaster layer, accumulation of dust and salt particles on materials surface, different sizes of cracks in walls, loss of parts from the internal walls, loss of mortar layers, rise of groundwater level, efflorescence salts on building materials, loss and deterioration of wooden elements, addition to the misuse and accumulation the dust and garbage inside of the Bathroom, loss of most of the mosaic floor of the fountain, and partial loss of the roof (**Figure 8**).

2.3.2. The Urban Zone of Ottoman Bathroom

In beginning of the 19th century Qena has gained a great position among the cities of Egypt because of its geographical location, which linking Egypt and its ports on the Red Sea; in beginning of the 20th century the city has significantly grown, as a result to several factors that the city was a major center for commercial and administrative activities in that period. Therefore, the residential block increased from 0.17 km to 0.52 km by the end of the twentieth century. During the 20th century the urban growth of case study were in four periods, as the following: the 1st period was from 1903 to 1954, the 2nd period was from 1954 to 1955 which the city was hit by floods, the 3th period from 1955 to 1978, and the 4th period from 1979 to 1999 (**Table 1** & **Figure 9**).

The site of Ottoman Bathroom lacked to sewage network a long-term, so the soil contaminated with sewage water that affected on the building materials of the Bathroom and other physical and chemical properties, the urban deterioration aspects were shown the following:

- Non-commitment with standards of the build, according to the standards of Nation Organization for Urban Harmony;
- The urban surrounding is suffering from an irregularity of the region texture and non-compliance with building requirements, addition to that the buildings are bad condition;
- The urban surrounding is characterized by interlaced texture, and narrow streets;
- Lack of awareness of the historical value of the Bathroom between area residents, as well as the spread of environmental pollutants and collection of the garbage close to the monument.

3. Methods and Materials

3.1. Construction of the Study Database Subsystem

Software programs were used in construction of the database, in the following: Terra incognita program was used to loading of Satellite photos, Arc Map 10.3 was used to drawing, linking, classification, query, analysis, and output of the spatial data, ERDAS Imagine program was used in the classification of land uses, Google Earth Program, Microsoft Excel, and Microsoft Access was used in Design and link databases. The ottoman bathroom built with fired bricks, mortars, and wooden roofs (Wheatley, 2000; Perttula et al., 2011).

Figure 8. Deterioration aspects of the Bathroom: A) Erosion of bricks surface due to effect of groundwater and damage of the fountain. B) Cracks in the upper parts of the northern façade. C) Loss of mortar layer in the southern and the western façades. D) Shows neglect and misuse in Iwan of The Striproom. E) Salt efflorescence and cracks in walls with thick layers dropping off and accumaltion of dust in the basin. F) Splitting in wooden roof and the paint flakes with thick layers dropping off in big particles. G) Partial loss of Plaster layer in skylight. H) Shows rise of the level of the street about the level of the entrance. I) Use of electricity network with bad shape. J) partial loss of the vaulted roof of the corridor. K) Damage of fountain of the striproom partial. L) Loss of plaster layer, and salt efflorescence on wall surface.

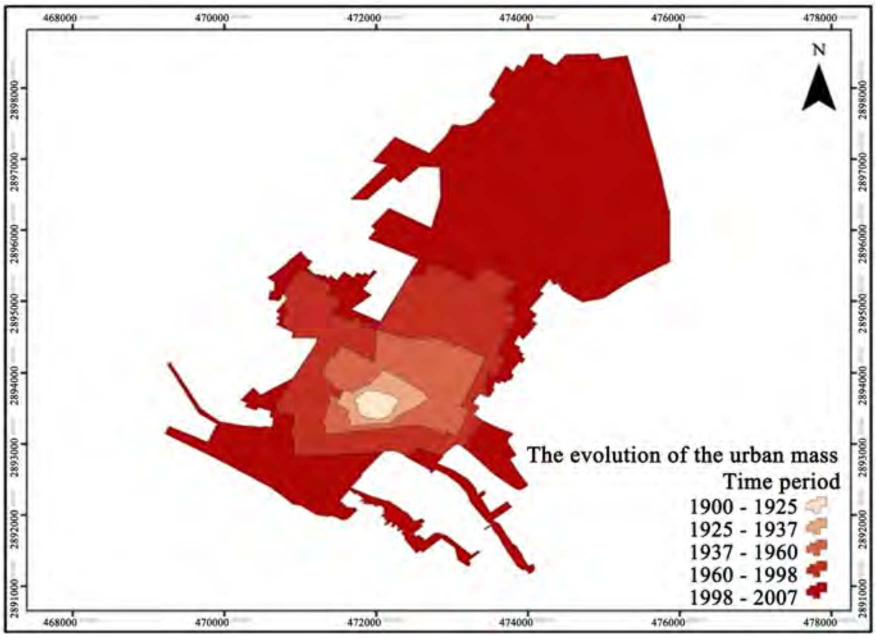


Figure 9. Directions of the urban growth of Qena city.

Table 1. Urban growth rate in the Ottoman Bathroom zone from 1800 to 1999.

Year	North %	East %	South %	West %
1800	-			
1898	51.8	21.4	3.6	23.2
1954	61.7	13.5	18.3	6.5
1979	29.3	20.6	16.8	33.3
1999	49.4	4.1	17.7	28.8

Data collection and correction

This step is included the spatial data, all forms of data of case study, when it represents as maps, spatial data are classified into three groups of features, in the following: point features, line features, and areal features.

The geographical data input and the construction of the database

In this step, the data input that collected about the case study was carried out, where all information is transferred from the paper format to the digital format that can be handled by the computer through geographic information systems.

Data storage and retrieval subsystem

This step is included the storage of geographical data from different sources, like maps, digital data and descriptive in different styles: points, lines, closed spaces and spreadsheets, which are linked together to make it easy to call them as a layer or layers when needed.

Data manipulation and analysis subsystem

In this step change the style, level of data, remove input errors and update the data, in addition to procedure some computations, such as determination of spaces, distances and the urban zones.

Data display and reporting subsystem

This step is represented in presentation of all or some of the original data in the database with different ways, such as mapping, display, modified data, graphs, images, video movies, reports, composites reports and tables, as well as the definition of features, dimensions, the calculation of distances, spaces and spatial research (Aghasi, 2019).

3.2. Investigation Methods

The red bricks and mortar samples were collected from different places in the Ottoman Bathroom; the samples represented walls, mortar, and plaster layers. They generally consisted of damage layers.

Scanning Electron Microscope

The deteriorated samples were investigated by SEM JEOL JSM 5500 LV to identify the morphology of the bricks and used to examine the micro deterioration in the internal structure of building materials, samples were coated with gold.

X-Ray Diffraction (XRD)

X-ray diffraction method was carried out on deteriorated building materials samples; to study the changes in chemical composition of the samples was performed in Micro Analytical Unit, faculty of archaeology, Cairo university, and was carried by X-ray diffraction patterns, using a Philips X-ray PW 1840 diffractometer with Cu-Kα radiation generated at 40 kV and 40 mA. It covers 2^{Θ} from 50 to 500.

4. Results

4.1. Evaluation of Urban, Social, and Economic Characteristics

The geographic database of the Ottoman Bathroom and its surrounding included geographic maps about of the construction state of the buildings, land uses, the construction method, sewage and drinking water networks.

Through analytical study for the urban surrounding and assessment of the current state of the land uses, the results revealed the following:

- From the evaluation of the structural state of the buildings in surrounding of the Bathroom, show that 37% of the buildings are cracked, 34% are good, 18% are bad, and 11% are ruined (**Figure 10**). The height of the buildings is ranging from one to five of the floors (**Figure 11** & **Figure 12**).
- From the assessment of structural style of buildings, show that 27.77% were built of walls and concert roofs, 27.77% were built of mud bricks, 20.37% were built of walls and wooden roofs, and 5.55% were built of concrete buildings (**Table 2**, **Table 3** & **Figure 13** & **Figure 14**).
- 74.07% of the buildings are residential buildings, 18.51% are space lands, 1.85% are commercial buildings, 1.85% are administrative buildings, and 1.85% are mixed residential buildings (**Figure 14**).
- From social statistics which were performed on population, we were observed that 54.8% of the population have a free activity, and 31.7% are working in the government sector, from the analytical studies of economic statis-

tics were indicated the urban surroundings haven't any economic development, although the high price of the land.

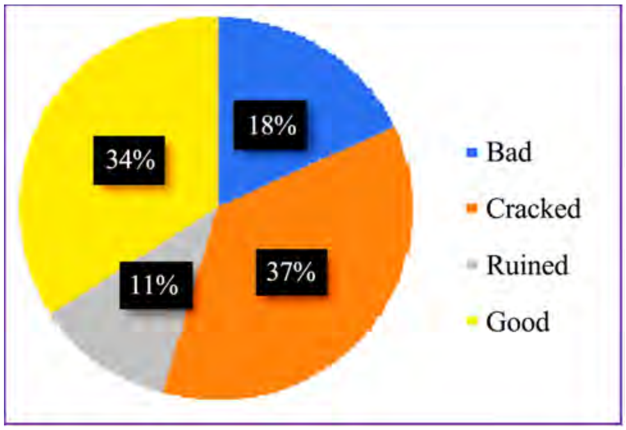


Figure 10. Diagram of thestructural state of buildings.

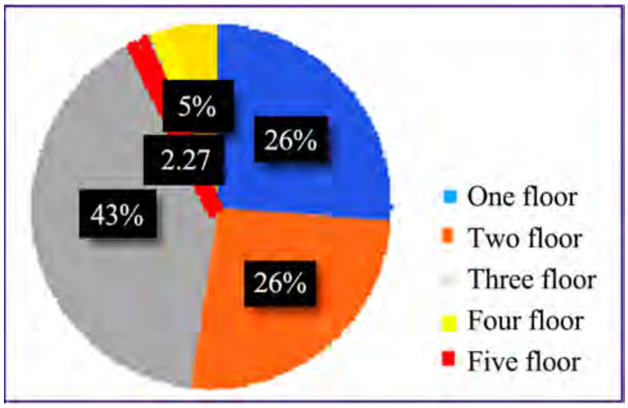
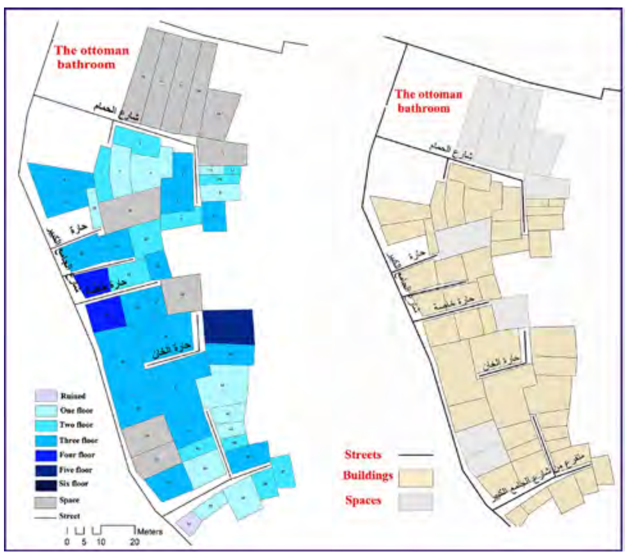


Figure 11. Diagram of the height rating of buildings.

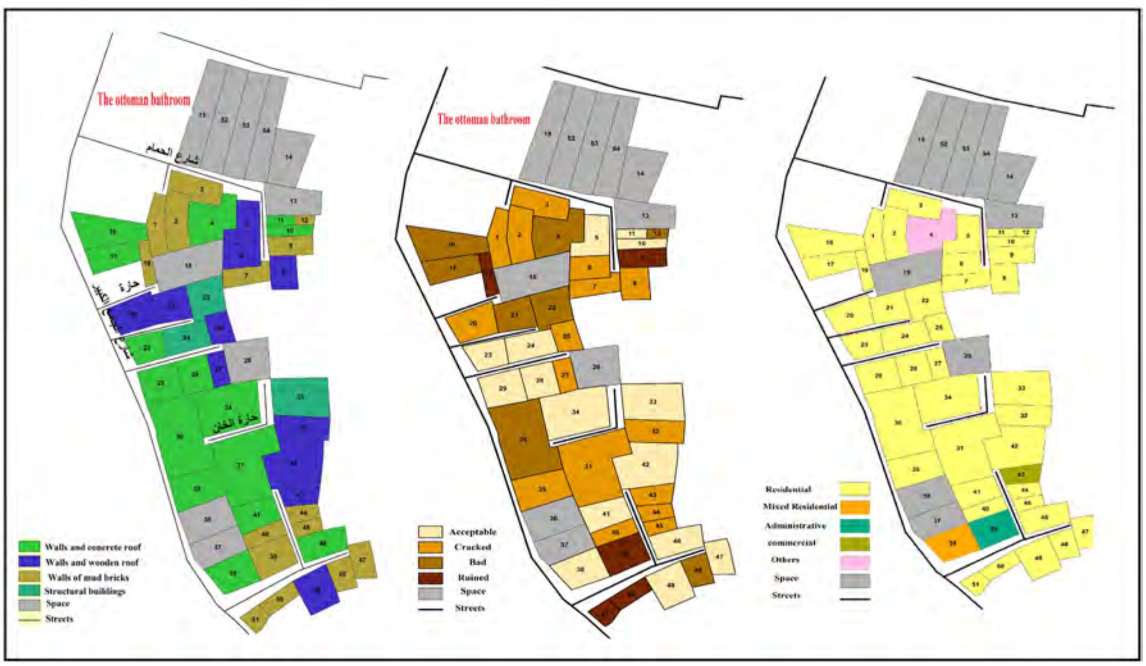


A B

Figure 12. A. Shows height of the buildings. B. Shows a map of streets in Bathroom site.

A B C

Figure 13. A. Shows the buildings were built by walls and concert roofs. B. Shows the buildings were built by mud bricks. C. Shows the buildings were built by walls and wooden roofs.



A B C

Figure 14. A. Database by GIS is shown construction style of the buildings. B. Database by GIS is shown construction state of buildings. C. Database by GIS is shown land uses.

Table 2. The land uses of surrounding of the Bathroom.

Cat.	Number	per. %
Residential	40	74.07
Mixed Residential	1	1.85
Administrative	1	1.85
Commercial	1	1.85
Space	10	18.51

Table 3. The structural style of the buildings.

Cat.	Number	per. %
Walls and concert roofs	15	27.77
Walls and wooden roofs	11	20.37
Walls of mud bricks	15	27.77
Structural buildings	3	5.55
Space	10	18.51

4.2. The Current State of Building Materials of the Bathroom

4.2.1. SEM Investigation

SEM image of red bricks samples are presented the deterioration places in the Ottoman Bathroom. The examination is shown weakness and cracks in bricks fiber and also shows no cohesion and interdependence with the presence of crystallized salt in the internal structure of the bricks. Deterioration, corrosion, voids and loss of binding materials observed in bricks structure. From the investigation, we observed intensive of sodium chloride between pores of bricks (**Figure 15**).

4.2.2. X-Ray Diffraction (XRD)

The red bricks samples analyses were carried out by XRD for defining the chemical components of samples. All results are shown in **Table 4** and **Figure 16**. The results of the study show that the deteriorated bricks samples consists of Quartz (SiO_2), Feldspar, Hematite (Fe_2O_3) as a major components, in addition to Halite (NaCl) and Gypsum ($CaSO_4 \cdot 2H_2O$), in which accelerated of red bricks weathering, the salts increase the moisture content within the building materials, which dissolves the salts in the pores, and when water is evaporation occurs crystallization and recrystallization of salts causing mechanical damage to the bricks due to crystallization and recrystallization pressure.

The summary: From evaluation of the urban environment of the Bathroom by GIS technique, the results indicated that the residential buildings are represented 74.07% of the total buildings, 37% of the buildings are cracked, 34% are good and 11.5% are ruins. From the investigation study was carried by scientific techniques on building materials, indicated that there is a crystallized salt in bricks pores, such as sodium chloride and calcium sulphate, micro-cracks, loss in the internal structure of building materials, the examination is shown weakness and cracks in bricks fiber and also shows no cohesion and interdependence, the previous results contributed to evaluating the physical condition of the bathroom that shows his condition is critical and needs urgent intervention to restore.

5. Restoration and Rehabilitation Suggestions

5.1. Suggestions for Restoration and Rehabilitation of the Bathroom

- **Procedures of restoration of the Ottoman Bathroom were summarized in the following.** From observation of various deterioration forms of the exterior facades of the Bathroom; the restoration steps can be defined as follows: 1) Restoration of cracks will be carried out with wooden bars method; in this method Cutting is done in bricks course with 50 cm length on both sides of the crack. It is possible to make a full belt around the building (Figure 17). The application of this technique is in accordance with the principles and rules of international restoration, especially the provisions of Article (10) of the Venice Charter in 1964, and Article (11) of the Lahore Charter in 1980. 2) A mortar made of lime, sand and kaolin is used to fill cracks after laying of wooden bars. 3) Replacement of damaged bricks with red bricks having the same chemical and physical properties. 4) Compensation the missing plaster layer of the facades. 5) Repair of the skylight of Ottoman Bathroom.

Table 4. X-ray diffraction analysis results.

Sample tite	Quartz	Calcite	Feldspar	Hema	Halite	Gypsum
RB1	50	20	-	10	12	8
RB2	45	18	22	15	-	-
RB3	44	10	26	20	-	-
RB4	78	10	-	-	-	12

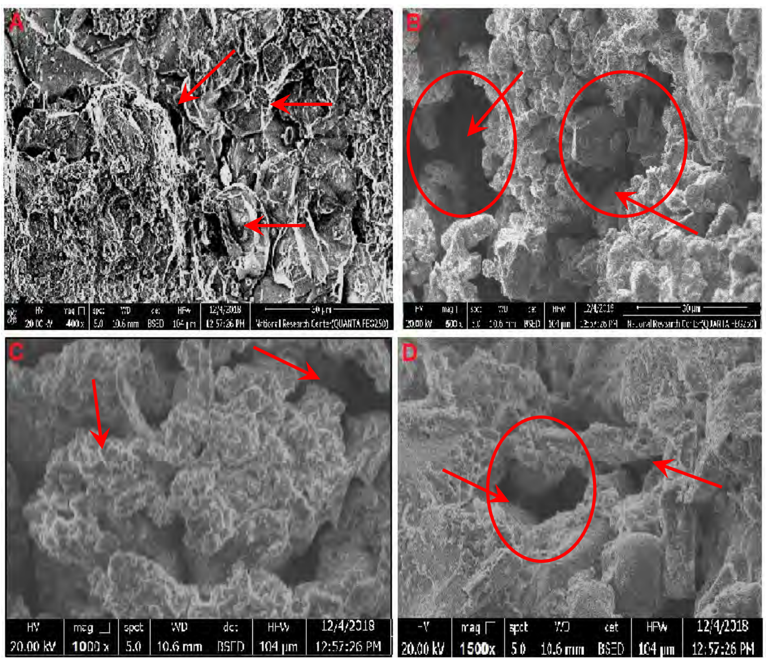


Figure 15. SEM Photographs of red bricks. A. Showing corrosion of quartz and presence voids in bricks structure. B. Showing loss of binding materials and presence of crystallized salt. C. Showing dense of crystallized salt between pores of bricks. D. Presence of voids and salts in bricks structure.

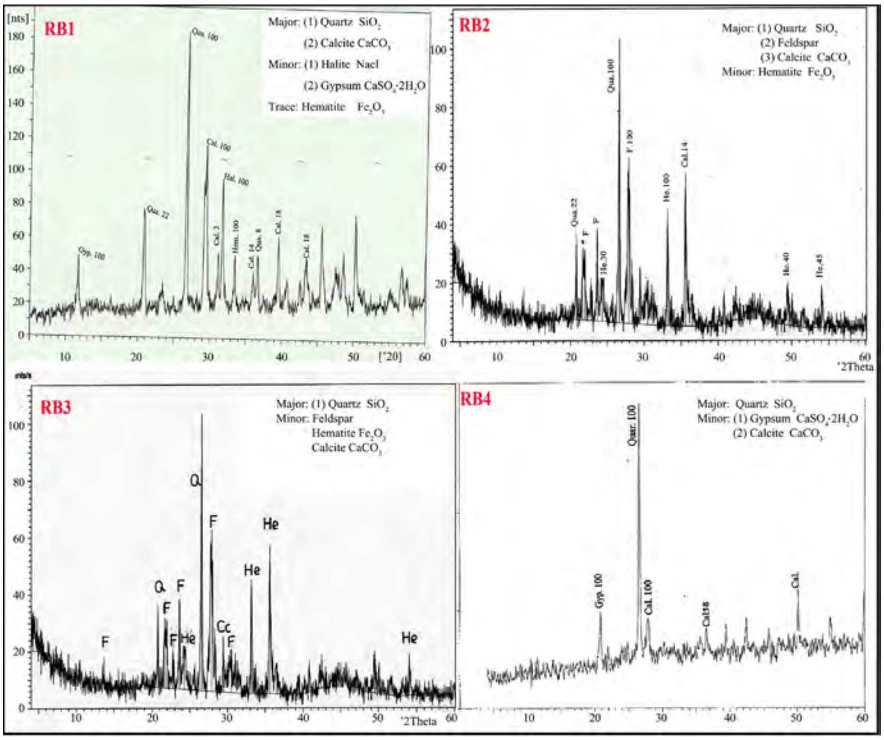


Figure 16. XRD pattern of the red bricks samples presented case study.

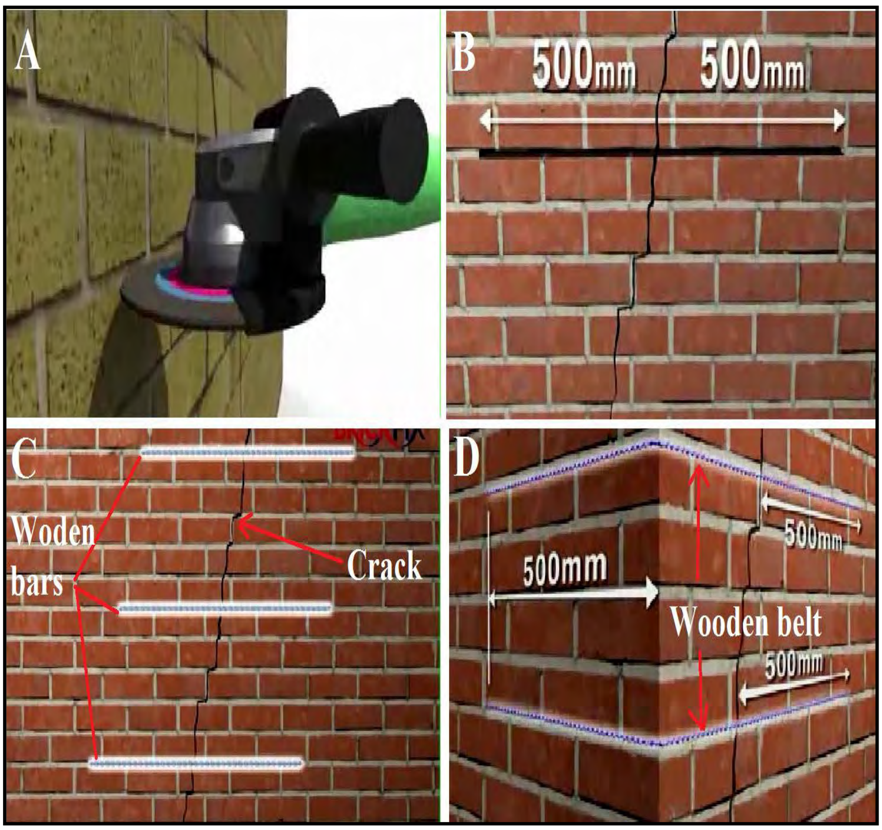


Figure 17. Showing stages of cracks Stitching. (A) Cutting in bricks course. (B) Cleaning the cutting in the course. (C) Install wood bars in the cutting on sides of the cracks. (D) Install wooden belt in corners of the build.

- **From monitoring of deterioration symptoms in the interior of the Bathroom**, the restoration steps can be defined as follows: 1) Removing dust and debris inside the Bathroom rooms. 2) For the walls, the damaged plaster layers will be removed, the salts will be extracted, replacement of damaged bricks, then the walls will be consolidated, and put the plaster layers. 3) For the floor of the Bathroom, the floor slabs are disassembled and the floor is consolidated, then reassembly the floor slabs and completes the missing ones with the same materials used in the past. 4) Repair windows and doors and replacement damaged ones. 5) Reconstruction of destroyed Bathroom annexes with the same design used in the past. Renovation of the infrastructure of the Bathroom while preserving the ancient archaeological appearance. 6) Repairing and restoration any damage to artworks such as stucco windows and mosaic floors.
- **Adaptive reuse**: In accordance the article (5) of the Venice Charter of 1964, article (5) of the Convention for the Protection of the World Cultural and Natural Heritage of the 1972 General Conference of UNESCO, and article (8) of the Charter for the Preservation of Cities and Historic Sites, Washington, 1987. We will show the policy of the Bathroom reuse in the following: 1) The Bathroom will be reuse in the same old function, as physiotherapy center. 2) Determine the rehabilitation of the building in its current form to perform its old functions, which the architectural elements of the building are designed according to their role. 3) The policy of reuse of the building is one of the most important steps to the preservation, and provides self-financing for urban and social development projects in the area of the Bathroom. 4) The re-employment of the Bathroom leads to the development of the surrounding community through the services that the building can provide it, and the involvement of the population in the conservation works 5) The building reuse is work to increase the tourist attraction of the Bathroom area.

5.2. Rehabilitation of the Bathroom Surrounding

Proposals of the upgrading of the urban surrounding of the Ottoman Bathroom were carried in the following: 1) Determine the borders of macro and micro context of the old Qena city, addition to determine of the major streets for reaching to the area (**Figure 18**). 2) Design a database by GIS for the road, sewerage, drinking water, electricity distribution, and communication lines networks (**Figure 19**). 3) Modernization of infrastructure in the Bathroom surrounding. 4) Removing collapsed houses and replacement it with houses compatible with the region's historical style. 5) Conceptualize for services areas in the surrounding of the bathroom (**Figure 20**).

6. Conclusion

This research paper constitutes an integrated approach to illustrate the role of Geographic Information Systems (GIS) in the conservation of historic buildings

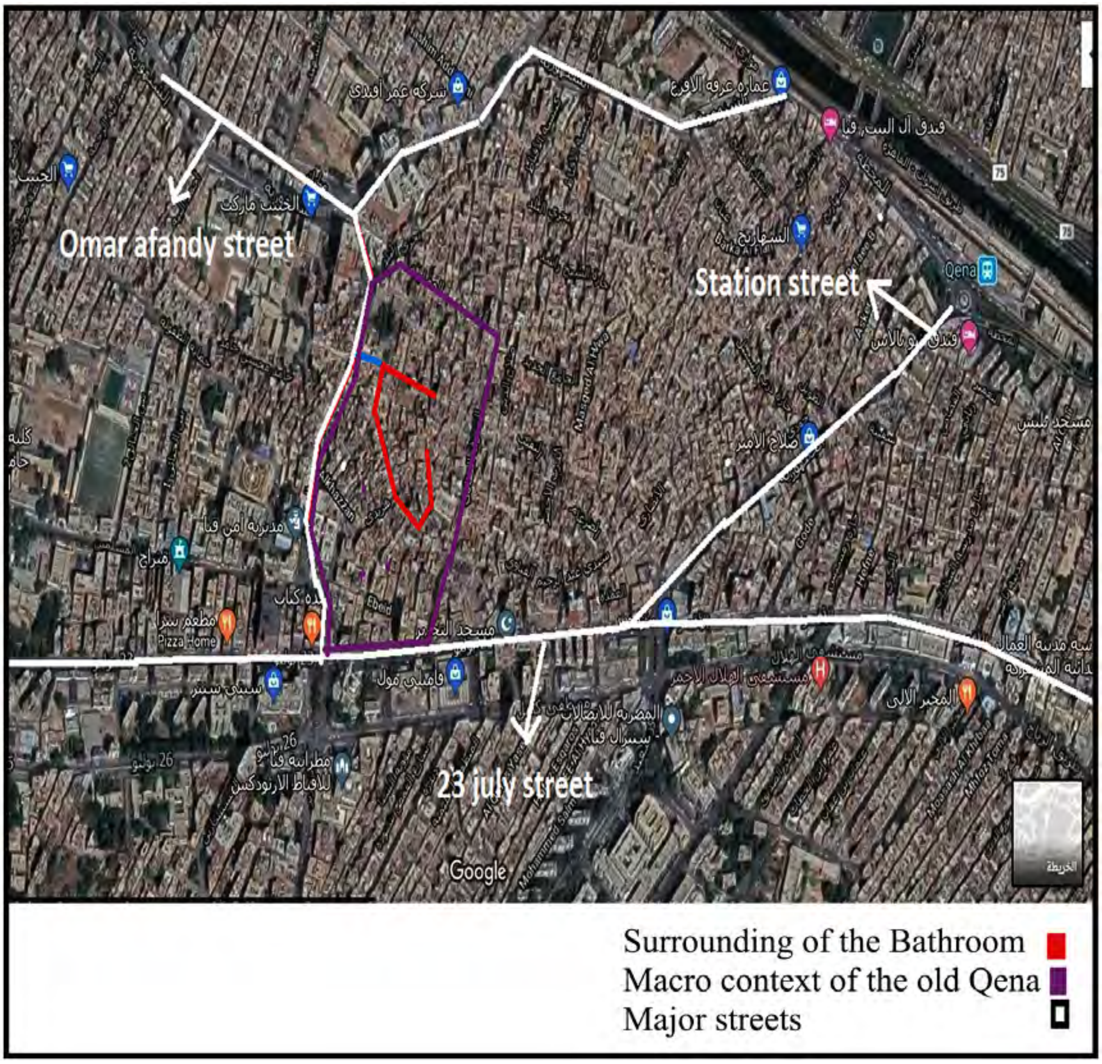


Figure 18. Shows site of the Ottoman Bathroom and its surrounding (Goog earth).

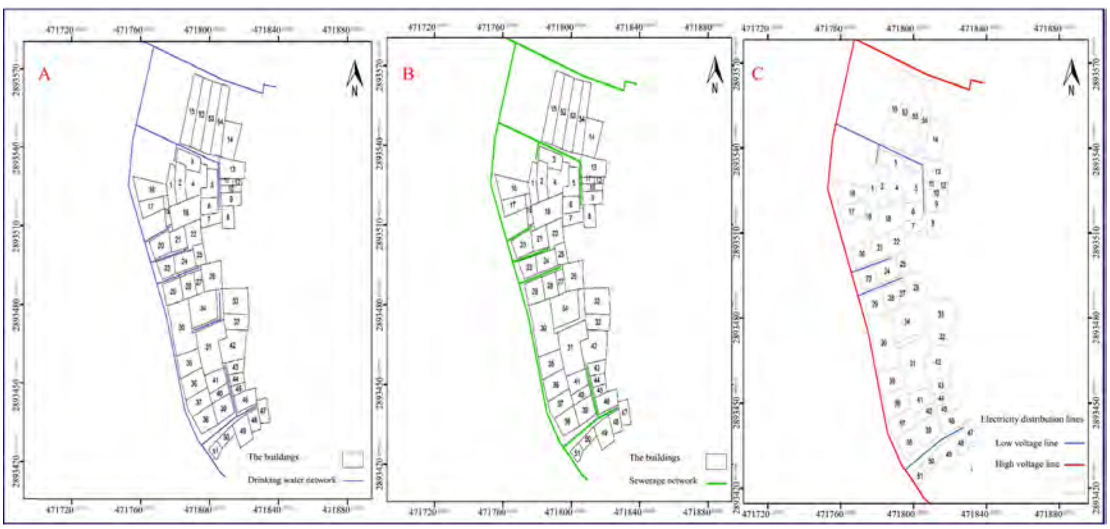


Figure 19. Shows A. Database by GIS is shown drinking water network. B. Database by GIS is shown sewerage network. C. Database by GIS is shown electricity distribution network.

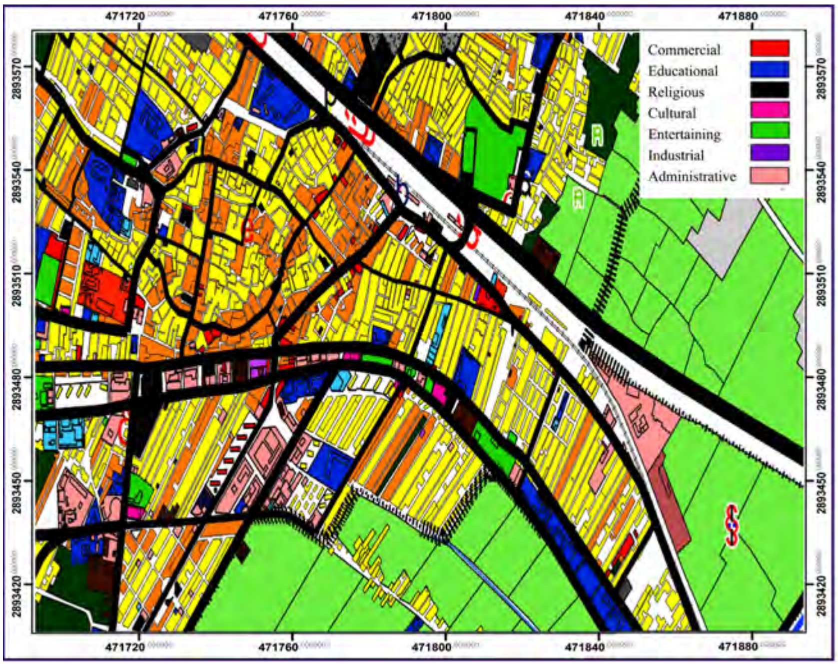


Figure 20. Shows a vision for upgrading of the services in the surrounding of the Bathroom.

through providing an integrated database of the monument, which is useful in evaluating the current state of the Ottoman Bathroom and its urban surrounding in Qena city, which will be used to support the decision in the conservation and reuse of the Bathroom. The results of the study indicated that the urban surrounding of the Ottoman Bathroom area has compact texture, and suffering from an irregularity of the region texture, it is concluded that the current state of the buildings in the Bathroom area represents 37% of the buildings are cracked, 11.5% are ruined. We observed that the Ottoman Bathroom in bad physical condition and there is a possibility of further deterioration damage and failure, due to that the building has been suffering damage factors and causes since far times because of the destructive reuse; this confirmed with the investigation and analysis that carried out on building materials. The paper is concluded that GIS technique is a suitable method for the rehabilitation of the Ottoman Bathroom and surrounding environment, with necessity to reuse of the Bathroom in the same old function to preserve, revitalize and benefit it in the tourism development of Qena city. Where GIS technique is used in determing the borders of macro and micro context of the old Qena city, in addition to determining of the major streets for reaching the area, design maps of sewerage, drinking water, electricity distribution, and communication lines networks, in addition to design of database for modernization of infrastructure and conceptualize for services areas, which will perform in the surrounding of the bathroom.

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Conflicts of Interest

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

References

Aghasi, N. H. M. (2019). Application of GIS for Urban Traffic Accidents: A Critical Review. *Journal of Geographic Information System, 11,* 82-96. https://doi.org/10.4236/ad.2018.64017

Akhter, H. (2018). The Methods and Recent Invented Tools and Techniques Used in Archaeology for Delicately Preserving the Past for the Future. *Archaeological Discovery, 6,* 338-354. http://creativecommons.org/licenses/by/4.0/ https://doi.org/10.4236/ad.2018.64017

Aldenderfer, M.S., & Carolyn, A. H. (2000). The Small-Scale Archaeological Survey Revisited. *American Archeology, 4,* 4-5.

Benavente, D., del Cura, M. G., Garcıa-Guinea, J., Sánchez-Moral, S., & Ordóñez, S. (2004). Role of Pore Structure in Salt Crystallization in Unsaturated Porous Stone. *Journal of Crystal Growth, 260,* 532-544. https://doi.org/10.1016/j.jcrysgro.2003.09.004

Binda, L. (2006). The Difficult Choice of Materials Used for the Repair of Brick and Stone Masonry Walls. In *1st International Conference on Restoration of Heritage Masonry Structures* (pp. 1-16). http://hdl.handle.net/11311/242096

Chang, K. T. (2008). *Introduction to Geographic Information Systems* (Vol. 4). Boston, MA: McGraw-Hill.

El Adnani, A., Habib, A., El khalidi, K., & Zourarah, B. (2019). Spatio-Temporal Dynamics and Evolution of Land Use Land Cover Using Remote Sensing and GIS in Sebou Estuary, Morocco. *Journal of Geographic Information System, 11,* 551-566. https://doi.org/10.4236/jgis.2019.115034

Elphinstone, M., & Wickham-Jones, C. (2012). Archaeology and Fiction. *Antiquity, 86,* 532-537. https://doi.org/10.1017/S0003598X0006292X

Godchild, M. F., Haining, R., & Wise, S. (1992). Integrating GIS and Spatial Data Analysis: Problems and Possibilities. *International Journal of Geographical Information Systems, 6,* 407-423. https://doi.org/10.1080/02693799208901923

Güney, C. (2001). Multimedia Supported GIS Application: Ottoman Castles Information Systems. *Magazine of "Sanal Gazete", 6,* 13.

Hemeda, S., Khalil, M., Shoeb, A., & EL Aziz, A. A. (2018). The Effectiveness of Nano Materials and Nanomodified Polymers for Preservation of Historic Brick Masonry in Rashid, Egypt. *International Journal of Conservation Science, 9.*

Lake, R. W. (1993). Planning and Applied Geography: Positivism, Ethics, and Geographic Information Systems. *Progress in Human Geography, 17,* 404-413. https://doi.org/10.1177/030913259301700309

Lock, G. (2001). Theorising the Practice or Practicing the Theory: Archaeology and GIS. *Archaeologia Polona, 39,* 153-164.

Lourenço, P. B., van Hees, R., Fernandes, F., & Lubelli, B. (2014). Characterization and Damage of Brick Masonry. In *Structural Rehabilitation of Old Buildings* (pp. 109-130). Berlin, Heidelberg: Springer. https://doi.org/10.1007/978-3-642-39686-1_4

Meaden, G. J., & Aguilar-Manjarrez, J. (2013). *Advances in Geographic Information Sys-*

tems and Remote Sensing for Fisheries and Aquaculture. FAO Fisheries and Aquaculture Technical Paper. https://search.proquest.com/openview/aa858b06ca6d54c16d52f39e0c6a48f7/1?pq-origsite=gscholar&cbl=237320

Mekni, M. (2013). Using GIS Data to Build Informed Virtual Geographic Environments (IVGE). *Journal of Geographic Information System, 5,* 548-558. https://doi.org/10.4236/jgis.2013.56052

Moustafa, M. M. (2000). *Geographical Information Infrastructure (GII) to Support Decision-making in Urban Development in Egypt.* Doctoral Dissertation, Enschede, The Netherlands: The International Institute for Aerospace Survey and Earth Sciences, Department of Urban Planning and Management, ITC.

National Center for Geographic Information and Analysis. (1989). The Research Plan of the National Center for Geographic Information and Analysis. *International Journal of Geographical Information Systems, 3,* 117-136. https://doi.org/10.1080/02693798908941502

Openshaw, S. (1991). A View on the GIS Crisis in Geography, or Using GIS to Put Humpty Dumpty Back Together again. *Environment and Planning A, 23,* 621-628. https://doi.org/10.1068/a230621

Osman, A. M. (2001). *Jurisprudence of Architecture of Bathrooms in the Ottoman Period, European Influences on Ottoman Architecture and Mechanism of Conservation* (p. 314). The 4th International Conference for Ottoman Archeology Code.

Perttula, T. K., Nelson, B., & Lohse, J. C. (2011). Archeological Survey Investigations at Martin Creek Lake State Park, Rusk County, Texas. *Index of Texas Archaeology: Open Access Gray Literature from the Lone Star State, 2011,* 11. https://doi.org/10.21112/ita.2011.1.11

Pickles, J. (2008). *Representations in an Electronic Age: Geography, GIS, and democracy.* Praxis(e)Press. https://atrium.lib.uoguelph.ca/xmlui/bitstream/handle/10214/1827/33-Pickles.pdf?sequence=1

Rajani, M. B. (2016). *Cultural Heritage of Karnataka: A Remote Sensing and GIS Perspective.* Bangalore: National Institute of Advanced Studies (NIAS) IISc Campus.

Ramsay, S. (2011). *Secret Rock Art in the Caderbarg. Year in the Wild Blog.* http://www.yearinthewild.com/secret-rock-art-in-the-cederberg/

Wheatley, D. (2000). Spatial Technology and Archaeological Theory Revisited. *Bar International Series, 845,* 123-132.

Wheatley, D., & Gillings, M. (2013). *Spatial Technology and Archaeology: The Archaeological Applications of GIS.* London: CRC Press. https://doi.org/10.1201/b12806

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How They Moved and Lifted Heavy Stones to Build the Great Pyramid

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Abstract

We present a new feasible theory about how the ancient Egyptians moved and lifted heavy stones and how they built the Great Pyramid of Giza around 2500 BC, from the viewpoint of energy management taking account of the vast quantity of the stones needed for the Pyramid. We give our solutions to the following three mysteries of the Pyramid: 1) How they could overcome the difficulty in making the four straight edges of the Pyramid meet in one point, high up in the sky? 2) Why all of chambers and passages (the King's and the Queen's chambers, the Grand Gallery and other passages), except the Subterranean chamber, are away from the central axis about seven meters eastwards? 3) For what purpose they dug the Subterranean Chamber, thirty meters deep?

Keywords

Great Pyramid, Nucleus, Statics, Energy Efficiency

1. Introduction

We present a new feasible theory about how the ancient Egyptians moved and lifted heavy stones and how they built the Great Pyramid of Giza, around 2500 B.C. The first thing we should do when we want to build something big is the "geotechnical investigation" of the construction site. Therefore, our theory starts that: First of all, they examined and confirmed that "the bedrock at the construction site on the Giza Plateau has dimensions big enough to sustain the planned Pyramid" by digging it, which explains why the Subterranean Chamber locates thirty meters deep below the surface (Remark 3.1). Then the construction of the Pyramid began, but this embraced a big famous problem with the precise shape of the Pyramid (Isler, 2001: pp. 204-211): How they could overcome the difficulty in making the four straight edges of the Pyramid converge to the apex, in spite of the fact that the right spot of the apex always stayed high in the air during the construction? Our solution in Section 3 is new but simple: They utilized a chimney-like central well made "vertical" by "gravity." And this resulted in the presence of void spine, which explains why all of chambers and passages (the King's and the Queen's chambers, the Grand Gallery and other passages), except the Subterranean chamber, are away from the central axis about seven meters eastwards. We further propose in Section 4 and Section 5, from the viewpoint of energy management, how they could move and raise the vast amount of heavy stones. Our idea of moving stones is to "roll" stones using "ropes" only, and is quite practical because "rolling" is much easier than "dragging with sledge." To raise stones, we propose an example of simple ancient lift which may coincide with what Herodotus described as the "machine made of short wooden lengths".

2. Holes and the Central Well

In this article we mainly concern about the nucleus of the Pyramid, the essential part from the statics viewpoint. Consider a stone of cuboid. Then it is quite natural to chamfer it slightly in order to prevent damage to its edges and also to allow the introduction of a lever. If we chamfer it somewhat deeply, we can get an octagonal prism like **Figure 1**, and such extra labor of carving would be traded for the following advantages:

1) Lightens the stone; for example, suppose in **Figure 1** that the length $\overline{A'D'} = \overline{B'C'}$ is half of $\overline{AD} = \overline{BC}$, then the stone loses one eighth of its weight, more than 12%.

2) An octagonal prism can be moved easily by rolling, not dragging, and this is quite an energy saving (see Section 4).

Note also that newly-appeared faces (dotted in **Figure 1**) need no polishing as they do not touch other stones in the arrangement of stones. Therefore, the extra carving can be rough not to consume much energy in careful carving. Practically, cube-shaped stones would be chamfered into various modified forms of octagonal prism, not so symmetric like **Figure 1**. It seems in most pyramids the invisible innermost masonry is not so fine compared with the outermost part (Isler, 2001: p. 202, p. 203), and it is even possible to guess that most of the nucleus is made of rough boulders. Nevertheless, we believe that both (unchamfered) cubic stones and chamfered octagonal-like prisms were used in some parts of the nucleus, including some basic lower courses, where the structural stability is exclusively needed. Let us now show that chamfered octagonal-like prisms are indeed quite useful materials for the construction of the nucleus. Observe first that octagonal columns generate holes, for example, four neighboring octagonal columns automatically make a square hole (a hole of rectangular prism) as can be seen in **Figure 2**, and such a hole is quite strong against external pressure. If we connect this kind of square holes, we can make passages or wells. Another type of wider octagonal hole can be made by eight neighboring octagonal columns and four subsidiary small stones of square prism or cube as in **Figure 2**, and such octagonal hole is also strong due to its arch structure. (Note that the subsidiary stones need not be as high as the surrounding octagonal columns so that they can even be cubes.) Then a vertical well can be made by piling up such square holes and octagonal holes alternately as in Figure 3. There could be various arrangements of stones for a well, other than Figure 3. Even, a well can be made using only cube-shaped stones so that the use of stones of octagonal prism is not crucial in making a well. For our theory the existence of vertical well itself is more important than the shape of its material. We strongly believe that there existed such a well surrounding the central axis of the Great Pyramid from the center of the base to the apex in order to make the shape of Pyramid precise so that the four lateral edges meet in one point, the apex. We will call such a well "the Central Well" assuming its existence.

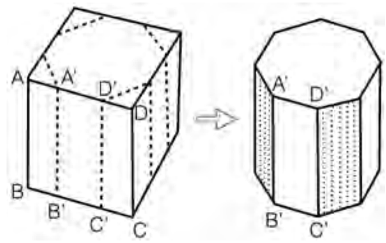

Figure 1. Chamfer a cuboid into an octagonal prism.

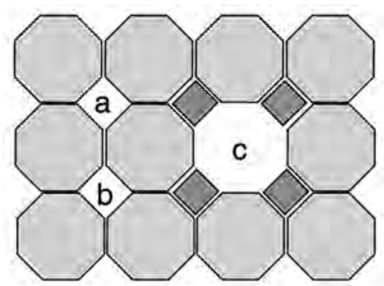

Figure 2. Square holes (a), (b), and octagonal hole (c) (top view).

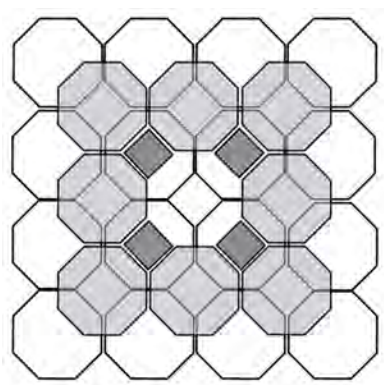

Figure 3. An octagonal hole (made by gray stones) on a square hole (made by white stones) (top view).

3. Construction of the Pyramid

Assumption 1: *The whole construction of the Pyramid was led by the vertical well with the central axis.*

Let us explain the details of this assumption. Our term "well" stands for an empty column surrounded by a wall of stones so that a "well" need not be underground but rather above the ground like a chimney. Though we have already used the term "vertical well," its precise meaning is that the well has an imaginary axis, vertical to the ground, passing through the centers of all horizontal cross sections of the well (in our case, such cross section is either a square or octagon). First, let us observe that it is always possible to make a vertical well of any height (or depth). Indeed, suppose we have already made a vertical well of some height; then we can increase its height in the following way. Mount some simple framework on the top of the well as shown in **Figure 4**, and hang a plumb from some point P of the framework down to the base of the well. Adjusting A, B, C, D in **Figure 4**, find the right spot of P such that the plumb barely touches to the center O of the base of the well as in **Figure 5**. Then, thanks to the gravity, the plumb line is vertical to the ground and identical to the axis of the well. Guided by this visible axis of plumb line, put new stones of the same height (described as white stones in **Figure 5**) on the top circumference of the well in such a way that all of them are equidistant from the plumb line. Then we can get a new higher well vertical to the ground, with the axis PO as seen in **Figure 5**.

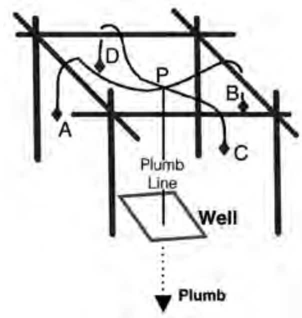

Figure 4. Framework to control the position of the plumb.

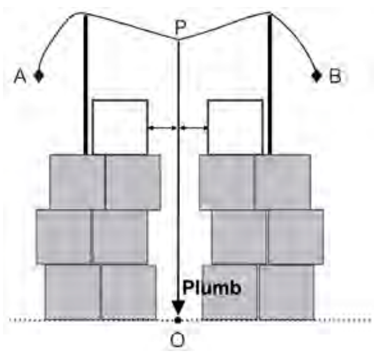

Figure 5. The plumb line PO guides in making a vertical well higher (Vertical section).

Now, suppose we aim for the final square pyramid $ABCDT$ with the base $ABCD$ and the apex T as in **Figure 7**. Of course the construction starts with the base $ABCD$. The problem is that the apex T stays always in the sky during the construction, and there is no easy way to identify the exact spot of the apex T to which the four straight edges from A, B, C, D must converge. We can overcome this difficulty by utilizing the vertical well as follows. First, build a vertical well of some height h, with its axis OO', from the center O of the base $ABCD$ to some point O'. The height h can be measured precisely as the length of the plumb line $\overline{OO'}$; see **Figure 6**. Next, around this chimney-like well construct the square frustum $ABCDA'B'C'D'$ such that O' is the center of the top base $A'B'C'D'$ as in **Figure 7**. Let us show how to find the exact positions of A', B', C', D'. We already know exact positions of A, B, C, D, O, O' as well as the directions $\overrightarrow{OA}, \overrightarrow{OB}, \overrightarrow{OC}, \overrightarrow{OD}$. Let us assume that $\overrightarrow{OA}$ directs to North-East, and the height of the apex T is planned to be $\overline{OT} = 146.7$ meters. Then, for example, the desired position of A' is at the horizontal distance $\overline{OA} \times \left(\overline{OT} - \overline{OO'}\right) / \overline{OT}$ from O' toward North-East, and similarly we can find desired positions of B', C', D'. To find precise orientation it would be helpful to mount a sighting target on the top of the well, e.g., an easy-to-see sign T' reflecting the sun as shown in **Figure 6** (which would be replaced by the Pyramidion T at the final stage), and no problem in finding precise orientation as the ancient Egyptians were noted astronomers (No problem also in the mathematical ability of the Egyptians in the Old Kingdom, which we can believe in through the fact that the Egyptian in the Middle Kingdom even knew the correct formula for the volume of a square frustum (Gillings, 1972)). Thus, we can obtain the square frustum $ABCDA'B'C'D'$ of height h satisfying the strict condition that the extensions of five lines AA', BB', CC', DD', OO' meet at the imaginary point T in the sky. Next, make the vertical well heigher $h' > h$, with its axis OO'', and do the similar construction as above to add a new square frustum $A'B'C'D'A''B''C''D''$ on the old one $ABCDA'B'C'D'$. Repeating similar constructions, may be more than ten times, we will be able to pile up frustums to get the final square pyramid $ABCDT$ along with the vertical Central Well OT. Thus we have explained the details of Assumption 1. To sum up, the whole process resembles how a volcanic eruption creates a pyramidal mountain with the central vent (note that what makes the central vent of a valcano almost vertical is the "gravity" by which the extremely hot gases, lighter than the air, go up straight into the sky from the underground). The Central Well or Vent would have completed its role just when the Pyramidion was set on the top of Pyramid, and its top entrance would have been covered with stones. Therefore, we believe that the Central Well remains as a void column up to some height.

There exists another convincing evidence to support the presence of such spinal cavity. That is the fact that all of chambers and passages (the King's and the Queen's chambers, the Grand Gallery and other passages), except the Subterranean chamber, are away (eastward) from the central axis about seven meters. This is because they needed to avoid the Central Well!

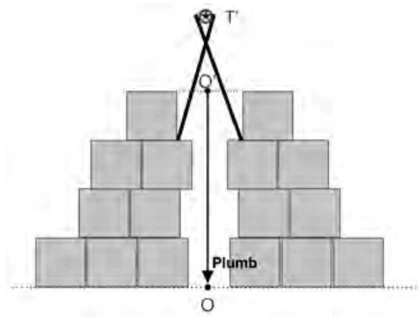

Figure 6. Vertical well mounting a sighting target (Vertical section).

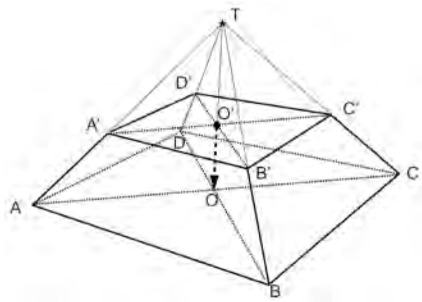

Figure 7. Square frustum with a vertical well *OO'*.

Besides the Central Well, we believe there were many vertical wells in order to lift stones (see Section 5) as well as to measure the heights of some tiers. For example, when we want to examine if the plateau $A'B'C'D'$ in **Figure 7** is horizontal or not, it would be preferable to have vertical wells near the four points A', B', C', D' to measure their precise heights. We believe also that square holes were used in setting poles. For example, if we are on the plateau $A'B'C'D'$ in **Figure 7** and insert poles into all holes there, then we can get an easy-to-see Cartesian coordinate system, which would have worked quite efficiently for supervisors and workmen. Such poles would have helped also in moving and lifting stones as will be explained later in Section 4 and Section 5.

Remark 3.1. Since the Central Well is above the ground, the Subterranean Chamber need not be away from the central axis of the Pyramid. Indeed, it is located just under the center of the base of the Pyramid. One of the mysteries of the Great Pyramid is: For what purpose they dug the Subterranean Chamber, 30 meters deep? We believe the purpose was, as stated in Section 1, the "geotechnical investigation" to examine if the bedrock had the dimensions big enough to sustain the whole Pyramid, which explains also the fact that the Subterranean Chamber looks "left unfinished". They dug two tunnels (see **Figure 8**) the underground parts of "the Descending Passage" BD and "the Well Shaft" BC, down to the Subterranean Chamber, and then the short tunnel AB toward the south from the Chamber. This digging confirmed them that the bedrock extended at least to the gray part of **Figure 8**. Since the Giza Plateau appears to extend from north to south and the site in question is the northern corner of the Plateau, we believe they carefully checked the northern part of the bedrock by digging BD and BC, while just AB for the southern part. Theoretically speaking, the least bedrock needed to sustain the biggest pyramid they were going to build would be the gray part of **Figure 9**, of the form of upside-down pyramid, 30 meters deep from the center of the base, which is included in that of **Figure 8**. Thus, this geotechnical investigation gave them the green light for the construction of the Pyramid. And, being supported by such a big enough bedrock, the Great Pyramid has withstood earthquakes until now, for 4500 long years. Remind and compare with the historical fact that the Lighthouse of Alexandria, constructed in the 3rd century BC, was destroyed mainly by earthquakes in the late 10th century and the early 14th century AD, so it could survive about 1500 years, only one third of 4500 years. See (Badawy, 1999) about the earthquakes in Egypt.

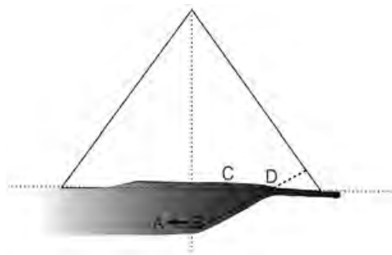

Figure 8. The confirmed dimensions of the bedrock.

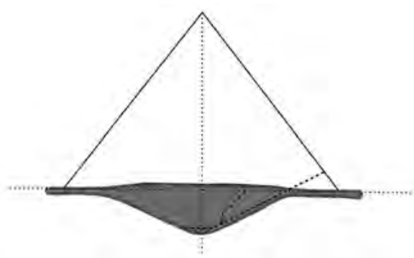

Figure 9. The least bedrock needed to sustain the pyramid.

4. How to Use Ropes to Move Stones

We now propose how they moved heavy stones. Note the simple practical fact that, in moving a heavy stone, "rolling" if possible is usually much easier than "dragging." In other words, "rolling friction" is extremely smaller than "sliding friction". We consider two types of stones, a cubic stone and a stone of octagonal prism. Let us first consider the latter. An octagonal prism can be easily moved by "rolling" since it is almost a cylinder. Though, of course, one can push directly or utilize levers to roll such a cylindrical stone, here we show how to use ropes to roll a stone, quite an efficient and simple way with no need of burdensome device like a sledge. Wrap ropes around a stone of octagonal prism as in **Figure 10** and pull one end of each rope holding another end. Then the stone will rotate and move. Since the reason to hold one end of each rope is lest the rope slips,

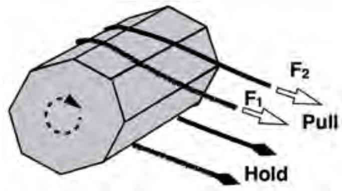

Figure 10. Using ropes to roll a stone.

various alternative ways are possible. For example:

1) Fix one end of each rope to some post (Figure 11);

2) Tie knots in the ropes; if we further join two ends of each rope, we can get a very simple way which looks like a "belt drive" (Figure 12);

3) Lay logs on the ground (Figure 13);

4) Loop each rope around the stone a few times (Figure 14); looping just once is enough if one end of each rope is hold slightly by someone (see also Figure 19);

5) One who pulls a rope stamps on the other end of the rope (this practical way seems to be well known nowadays among Japanese landscape gardeners who need to arrange big natural stones in creating a Japanese Garden)[1].

General Caution: Most of our figures are simplified to illustrate "force diagram" rather than the actual way. Practically, many strong ropes and thick poles or posts would be necessary.

On a ramp it would be better to use turning posts or well-greased posts as in Figure 15 in order to redirect the pulling force and to utilize our bodies' weight or counterweight effectively. Such a turning post can be considered as a primitive simple pulley; see Section 5. The chocks described in Figure 15 can be stones of triangular prism produced abundantly as a by-product when cubic stones were chamfered.

Remark 4.1. When we pull a stone of octagonal prism $A_1A_2\cdots A_8$ of weight W using ropes with the horizontal force F, on level ground, the force diagram can be like Figure 16. Let us estimate the size of F. The effort F is applied to the point A_2, and the pivoting point is A_6. Let d and h be the (perpendicular) distances from the pivoting point A_6 to the vectors W and F, respectively. Then the strength of F needed to rotate the stone is $F = W \cdot d/h$. Let $0 \le \theta \le \pi/8$ be the angle of inclination, i.e., $\theta = \angle A_5A_6B$, and assume the regularity of the octagon. Then we get

$$d/h = \frac{1}{2}\tan\left(\frac{\pi}{8}-\theta\right)$$

$$\left(\approx \frac{1}{2}\left(\frac{\pi}{8}-\theta\right) \text{ with the error} < 0.011\right),$$

which, starting with the value $0.2071\cdots \approx 1/5$ ($\theta = 0$), decreases to 0 ($\theta = \pi/8$), and takes the intermediate value $0.0994\cdots \approx 1/10$ ($\theta = \pi/16$). So, the force F necessary to start rolling is almost $W/5$, and then $W/10$ at the angle $\theta = \pi/16$. Almost no power will be needed to keep the stone rolling after the line A_2A_6 stands vertical ($\theta = \pi/8$), thanks to gravity. Note that when we push the stone,

[1]https://jflc.or.jp/media/niwa_navi/20120330_1246_33_0706.pdf

the effort will be applied to some point about the height $h/2$ (between A_3 and A_4) and then we need the power twice the case of pulling. Thus, pulling is better than pushing. Suppose a stone of weight 2.5 tons was chamfered to lose 10% of its weight, and assume $W = 2.5 \times 0.9 = 2.25$ tons. Then $W/5 = 450$ kg which amounts to nine men's power, assuming one man's pulling force is 50 kg. Precisely speaking, we should take account of the energy loss due to the friction between the ropes and the stone. So, practically, in any of Figures 10-14, about ten men will be needed at the beginning (and four ropes provided each rope is pulled by a few men), and about five men at the inclination $\theta = \pi/16$. Thus, many men are needed at the beginning, but, once the stone starts moving, only a few men would be able to keep it rolling. This is quite an energy saving compared with dragging which needs constant application of power, consuming a lot of energy. We may conclude that, practically, it would be better to be assisted by a lever at the beginning to incline a stone a bit so that only several men can start the roll, and when we suspend rolling the stone, we better use chocks to hold it like Figure 17 which makes easy to resume rolling.

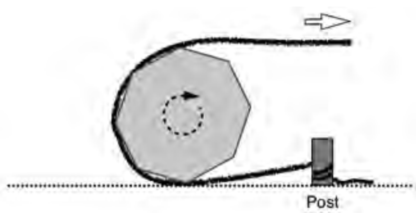

Figure 11. Use posts.

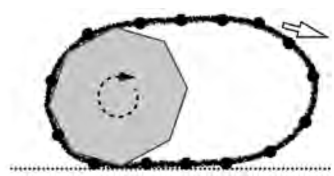

Figure 12. Tie knots.

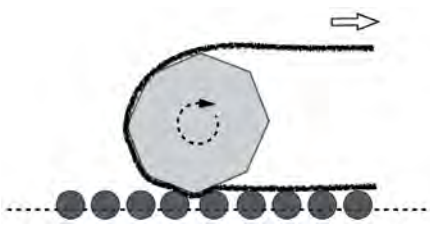

Figure 13. Lay logs.

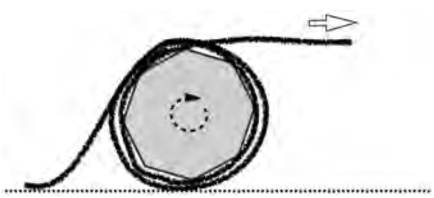

Figure 14. Loop ropes.

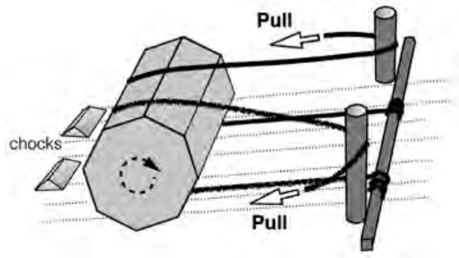

Figure 15. Using turning posts on a ramp.

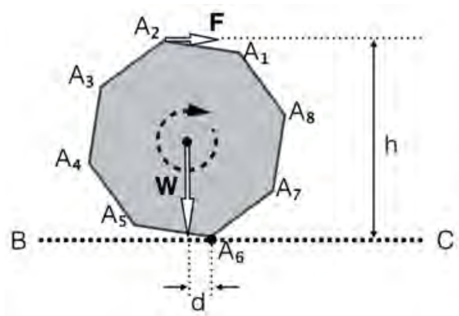

Figure 16. Force diagram when a stone of octagonal prism is pulled by ropes.

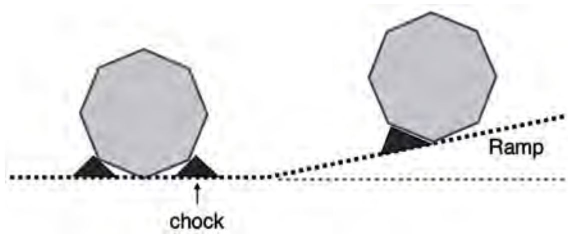

Figure 17. Use of chocks to suspend and resume rolling.

Next, let us consider the case of cube-shaped stone. Of course such a stone might be dragged using a sledge, here we point out that even such a cubic stone can be rolled using ropes only. First of all, note that we can get an octagon by attaching four obtuse triangles to sides of a square. Therefore, if we place stones of triangular prism on the ground like Figure 18 (upside down version of chocks in Figure 15 or Figure 17), rolling a cubic stone is essentially the same as rolling an octagonal prism. Note that such triangular stones can be replaced by any stones of almost the same height as shown in Figure 19, and this simple way could be applied wherever one can find suitable stones. Figure 19 shows also an advantage of using ropes that we can control the speed of rotation, lest the roll damage the stone, by pulling both ends of each rope to adjust the force F-G. Instead of stones, logs can be placed on the ground or ramp at regular intervals as in Figure 20, where each interval should be almost the side length of the stone.

Remark 4.2. By chamfering the right edge of a right triangular prism we can get a trapezoidal prism, and such prisms can be used like Figure 21 (similar to Figure 18) which also shows that a stone on such a trapezoidal short prism can be turned easily. One can see in (Fonte, 1998) a kind of semicylinder called "quarter circle" placed with "the flat side on the ground," which looks like an upside down version of our case of **Figure 21**. An amazing mathematical fact was discovered by (Robison, 1960) that a square wheel can roll horizontally on a road made up of inverted *catenaries* as in **Figure 22** (where "catenary" is the mathematical name of the curve describing a rope or chain hanging loosely between two supports, and an inverted catenary means the curve upside down). This means that such catenary-abutted road can "completely" suppress the vertical movement of the center of the square. Likewise, in **Figure 19** and **Figure 21**, the laid stones suppress "somewhat" the vertical movement of the center of mass of the cubic stone. We can learn from the Khufu first and second Solar Ships found at the foot of the Pyramid that the ancient Egyptians had outstanding knowledge and skill about ropes. They made ropes from the strong materials (e.g., "flax"), and used long enough ropes to hold the ship's timbers together (Jenkins, 1980). Though being strong against strain, ropes would be somewhat easy to be crushed between a heavy stone and the ground. To avoid such a crush, it will be important to suppress the vertical movement of the center of mass of the stone.

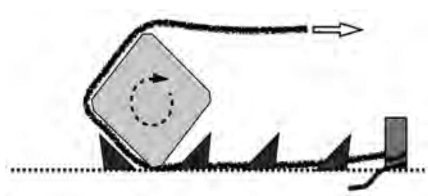

Figure 18. Stones of triangular prism laid regularly on the ground (side view).

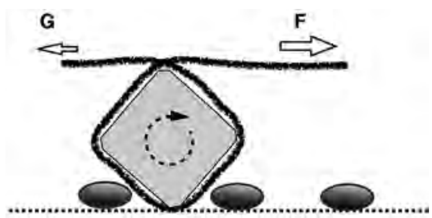

Figure 19. Use of any stones of proper height, and the control of the speed of rotation by the force *F*-*G* (side view).

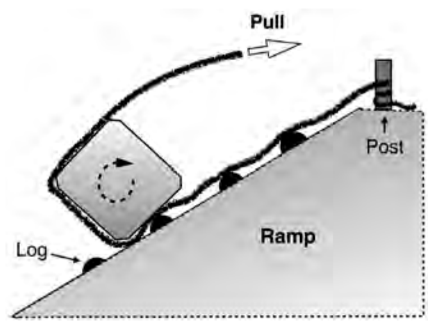

Figure 20. Logs laid regularly on a ramp (side view).

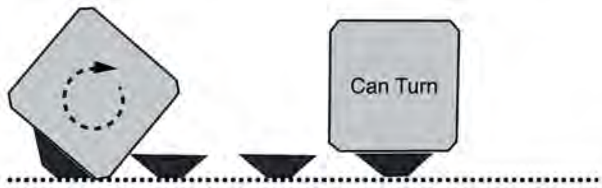

Figure 21. Use of stones of trapezoidal prism.

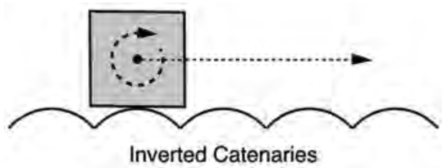

Figure 22. The square can roll on the curve of inverted Catenaries moving its center Horizontally.

5. Ancient Lift

We next propose how they lifted stones. From the viewpoint of energy efficiency we assume some low ramps were made to build the lower courses of the nucleus, but large inefficient ramps were not made. So, in order to lift many heavy stones to upper courses, some device was surely needed, and such device we propose is a simple wooden lift illustrated in Figure 23. Here we assume that:

Assumption 2: *Forerunners of simple pulley were used with ropes in moving and lifting stones.*

This would be quite a reasonable assumption since some devices, believed to be simple pulleys, have been found from the 4th Dynasty on the Giza Plateau, and as noted before, the turning posts in Figure 15 can be considered as "forerunner" of simple pulley (Isler, 2001: p. 262, p. 302). In Figure 23 ropes are fixed at the poles A, B of the platform, and the rotatable poles C, D are "forerunner" of simple pulley. In order to protect poles and ropes from wearing down it would be better if the poles C, D were well greased, and much better if some wooden or bronze tubes were inserted between the poles C, D and ropes. Note that the vertical thick posts in this figure can be replaced by any wooden towers as in Figure 24, where two such towers support a rotatable pole. Of course, Figure 23 essentially shows the force diagram, and actually many stronger ropes as well as thicker poles and posts would be necessary. Notice that: the crossed pole C or D turns stronger as the span between the two vertical posts becomes shorter.

Let us estimate the number of men needed to raise a stone using this lift. Noteworthy in lifting is that we can use counterweights effectively as illustrated on the right side of Figure 23 to decrease the number of men in labor. It would be even possible to hold a stone in the air using only counterweights. In particular, we can disregard the weight of the platform of the lift since it is always possible to balance the platform by counterweight. Suppose we are going to lift a stone of weight 2.25 tons (as in Remark 4.1) without any additional counterbalance. One man's "pulling down" force would be much stronger than his horizontal pulling force 50 kg assumed in Remark 4.1 since one can use his weight quite effectively by almost hanging on the rope. So, let us assume that one man's pulling down force is about 70 kg or 80 kg. Then, we may need about 2250/75 = 30 men, and about ten ropes, five on each side, if each rope is pulled by three men. This is quite a number. Though we can decrease this number using counterbalance, in general many men would be needed to lift such a big stone. But this is not the case of smaller stones. For example, a cubic stone of side length half a meter is about 300 kg (≈2.5/8 tons), and to lift such a stone, we need only four or six men, quite a reasonable number (in case of a stone of side length 0.7 meters, weighing 850 kg, we need about twelve men). The stability of the nucleus would not change at all even if every cubic stone of side length bigger than one meter were replaced by eight stones of half size, and needless to say, smaller stones are much easier to handle with in many respects. Therefore, from the viewpoint of energy management we believe that:

Assumption 3: *Smaller stones of side length about a half meter would be used a lot for upper courses of the nucleus*.

To raise stone to upper courses, each lift would be set and used like Figure 25 so that a lifted stone would roll onto the upper tier if the platform of the lift was inclined by pulling the ropes on the end. Since the quantity of the stones was vast, we believe various alternative ways were also employed simultaneously to raise stones. One of such ways would be to make vertical wells and set some simple lifts on their tops. An example of such a well with a lift is illustrated in Figure 26, by which smaller stones could be raised efficiently. Though mechanically the same as Figure 26, it would be possible to use two wells like Figure 27. A combination of a stairway and a well would also work as Figure 28, where the "white" stone can roll up the face of a stairway when the "black" stone, a counterweight, goes down in the well, while the "black" stone can go up in the well when the "white" stone, a counterweight, rolls down the face of a stairway (this looks somewhat like a modern escalator). See (Isler, 2001) about stairways. Vertical wells would be used also to lift other things, e.g., tools, foods, water or even men, like a modern elevator, concluding that vertical wells were quite indispensable from the viewpoint of energy management. And we believe most of such wells would be made on the west side of the Pyramid, since the east side was for important spaces such as the King's chamber, the Queen's chamber, the Grand Gallery and other passages. In short, the west side was a scaffold for the construction of the east side.

Obviously, every well, including the Central Well, needs a tunnel connecting its base to the outside. Such tunnels belong to the lower courses of the nucleus and note that it was possible to set bigger stones in the lower courses using low ramps. So, they could be made wide enough at least in dealing with the smaller stones as in Assumption 3. For the structural stability and for the protection against invaders such tunnels would be filled with stones when they completed their role, and so, they do not remain as empty spaces nowadays, we believe.

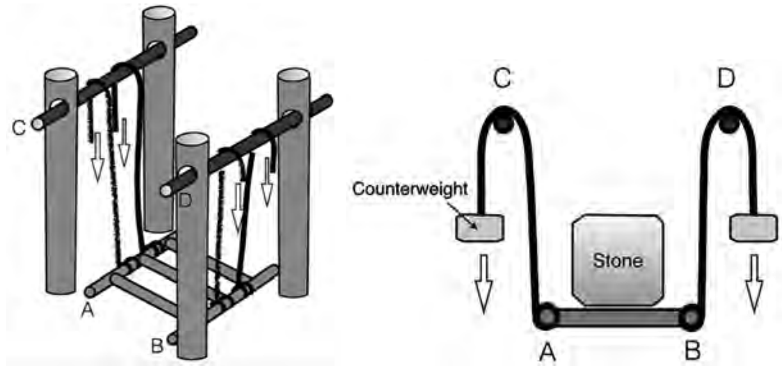

Figure 23. Ancient lift, and its usage.

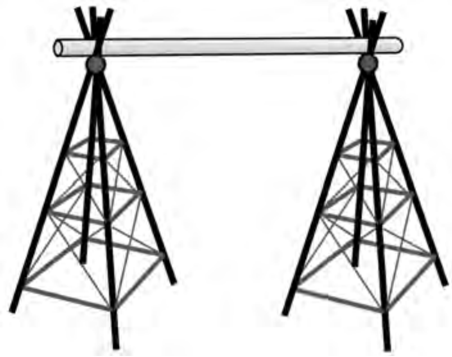

Figure 24. Two wooden towers supporting a rotatable pole.

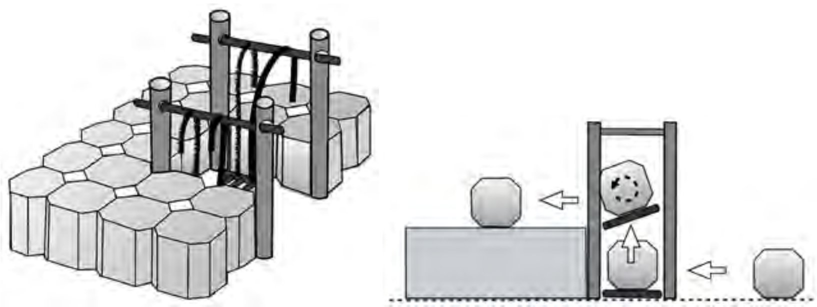

Figure 25. Setting of a lift, and its usage.

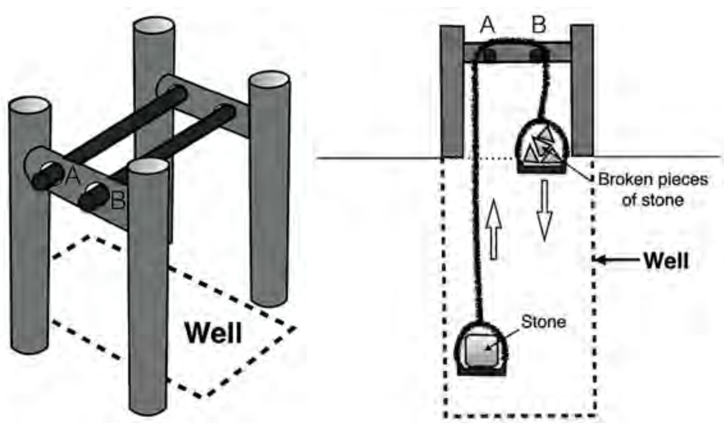

Figure 26. A simple lift on the top of a well, and its usage.

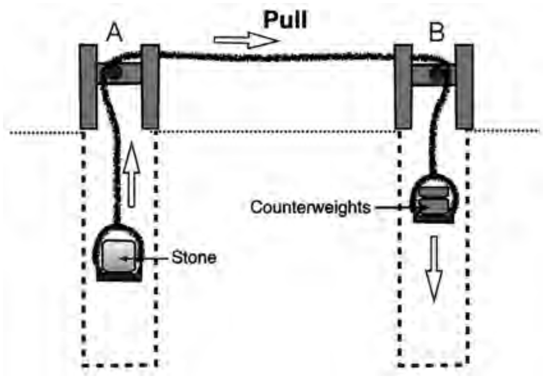

Figure 27. Use of two wells.

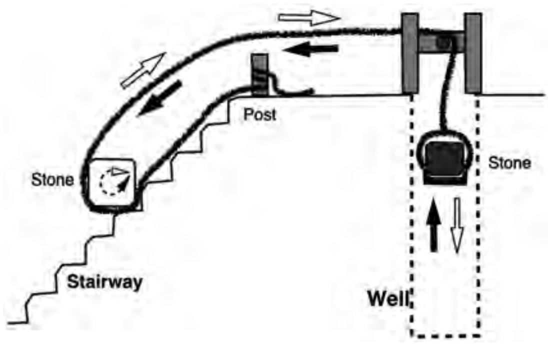

Figure 28. Combination of a stairway and a well.

Remark 5.1. It is feasible that the Ancient Lifts proposed in this section coincide with the "machines made of short wooden lengths" described by Herodotus "The Stories II, 125" (written about 500 BC, i.e., two millennia after the Pyramid Age) as follows:

"… This pyramid was built like this: tier after tier … they raised the stones … with machines made of short wooden lengths, lifting the stones from the ground up to the first tier of steps. When a stone had been raised on the first (tier) it was placed above another machine made of short wooden lengths, that was on the first tier, and from this it was lifted to the second tier and placed onto another machine, many were the steps so many were the machines, that (could be) only one, so easy to carry, from tier to tier."

Since the lift of Figure 23 is made of just poles, posts and a platform with ropes, it can be easily taken apart and assembled again, and hence, "so easy to carry, from tier to tier".

6. Concluding Remarks

We have presented our idea, from the viewpoints of statics and energy efficiency, about how the ancient Egyptians succeeded in moving and lifting the vast quantity of heavy stones to build the Great Pyramid, setting reasonable Assumptions 1, 2 and 3. Let us add the following remarks:

1) Quite recently, in 2018, there was a remarkable discovery, which would

support our theory about moving stones in Section 4, that is, the finding[2] of the ancient ramp system at site in Egypt's eastern desert slope. This ramp system is lined with two staircases and wooden posts, into which our **Figure 15** and **Figure 20** can fit very well.

2) About the Central Well, we now strongly hope to get some direct evidence for the presence of void column for the Central Well, and we wonder if it is possible to confirm such presence, somehow without destroying any parts of the Pyramid, recalling the recent discovery of a big void in the Pyramid (Morishima et al., 2017).

Since the author is a mathematician[3] working on "Topology", a branch of modern geometry, this article took somewhat a mathematical style setting some "Assumptions" to get some conclusions.

Conflicts of Interest

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

References

Badawy, A. (1999). Historical Seismicity of Egypt. *Acta Geodaetica et Geophysica Hungarica, 34,* 119-135.

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

Gillings, R. J. (1972). *Mathematics in the Time of the Pharaohs*. Cambridge, MA: MIT Press.

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

Jenkins, N. (1980). *The Boat beneath the Pyramid*. Holt, New York, NY: Rinehart and Winston.

Morishima, K., Kuno, M., Nishio, A., Kitagawa, N., Manabe, Y., Moto, M. et al. (2017). Discovery of a Big Void in Khufu's Pyramid by Observation of Cosmic-Ray Muons. *Nature, 552,* 386-390. https://doi.org/10.1038/nature24647

Robison, G. B. (1960). Rockers and Rollers. *Mathematics Magazine, 33,* 139-144. https://doi.org/10.2307/3029034

[2]https://www.dailymail.co.uk/sciencetech/article-6359375/Ancient-Egyptian-ramp-used-drag-huge-stone-blocks-uncovered-4-500-year-old-quarry.html

[3]retired from the National Defense Academy, Japan, in 2015.

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Scientific Consequentialism: Potential Problems with an Outcome-Driven Form of Indigenous Archaeology

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Abstract

"Scientific consequentialism" is the position that the rightness and wrongness of scientific research and reporting is determined by its effects on individuals or groups, rather than by its adherence to the ideals of the scientific method. Indigenous archaeology asserts that archaeology ought to be performed "with, by, and for" indigenous peoples, and in its reasonable form, Indigenous archaeology is important to making Western science more respectful of Indigenous concerns and more applicable to studying peoples with metaphysically inclusive worldviews. However, some proponents advocate for an extreme, consequentialist form of "for" which seeks to limit scientists to research and results that serve and benefit Indigenous peoples' social and political interests. This may include suppressing undesirable research or results, manipulating scientists or the scientific process, and avoiding research into certain subjects, all of which are presented as morally required efforts toward "the good" of decolonization. This extreme, outcome-driven form of Indigenous archaeology is irreconcilable with and even antithetical to the ideals of Western science, risks unintended negative consequences over the long term, and is no more appropriate now to support decolonial agendas than were consequentialist efforts in the past to support colonial agendas.

Keywords

Scientific Consequentialism, Archaeology, Indigenous Archaeology, Decolonize

1. Introduction

Ethical consequentialism asserts that the rightness and wrongness of actions are determined by their effects with regard to achieving some standard of "the good" (e.g., happiness). Scientific research is an action and is therefore subject to consequentialist evaluation based on its effects on individuals or groups. Deontology is the primary alternative to consequentialism, and it asserts that actions are right insofar as actors (e.g., scientists) adhere to their duty to some ideal and wrong otherwise, regardless of the consequences. Most scientists follow a deontological paradigm in that they attempt to adhere as much as possible to the ideals of the scientific method and accept the results without regard to the potential effects.

In Western culture, science and scientists are highly respected and the ethical foundation of the modern scientific endeavor is largely unquestioned. In at least some social science disciplines, however, there is a growing push for scientific consequentialism. In archaeology, for example, there is growing support for "Indigenous archaeology" which asserts that archaeology ought to be performed "with, by, and for" Indigenous peoples in order to do less harm and provide greater benefits. The limits of "with, by, and for" are still evolving, and while the literature includes "win-win" examples in which Indigenous peoples work closely with scientists and willingly contribute to, greatly enhance, and benefit from research, there is little discussion of more problematic situations in which Indigenous peoples reject research or results which may negatively affect their social or political interests.

On the one hand, we agree that the scientific process far too often ignores the concerns of and effects on its subjects and other stakeholders, and would be improved by increased communication and collaboration. Elsewhere, we have discussed the limitations of the Western scientific worldview for the study of metaphysically inclusive peoples, and identified Indigenous archaeology as a useful approach for overcoming at least some of those limitations (Shipley & Williams, 2019). On the other hand, we believe that these efforts can be taken too far. Some proponents of Indigenous archaeology seem to advocate for an extreme, consequentialist form of "for" which seeks to limit scientists to research and results that serve and benefit Indigenous peoples' social and political interests. This may include suppressing undesirable research or results, manipulating scientists or the scientific process, and avoiding research into certain subjects, all of which are presented as morally required efforts toward "the good" of decolonization. While well-intended, such an outcome-driven paradigm to further Indigenous interests is ethically indistinguishable from past efforts to manipulate scientific research and results to further colonial interests and "the (then) good" of colonization.

This paper examines the rise of scientific consequentialism and potential problems with this extreme, outcome-driven form of Indigenous archaeology. Our presentation necessarily includes a number of problematic quotes from the literature which gave rise to our concern. To the obvious criticism that we have taken these quotes out of context to make our case, we respond that no context can make them reasonable and the writers should have been more thoughtful in crafting the language they used to express their positions. In its extreme form, Indigenous archaeology is irreconcilable with and even antithetical to the ideals of Western science, and we conclude that such manipulation risks unintended negative consequences over the long term and is no more appropriate now to support decolonial agendas than it was in the past to support colonial agendas.

2. Archaeology as a Colonial Endeavor

Archaeology emerged as an aspect of a larger colonial desire to conquer unknown worlds (Smith & Jackson, 2006). Artifacts provided proof of conquest, and the subjugation of Indigenous cultures through research and representation was a manifestation of colonial control (Smith & Jackson, 2006). Modern archaeology inherited this deeply colonial legacy (Atalay, 2006; Smith & Jackson, 2006). Indigenous peoples have often been at odds with archaeologists over their relationship and about who should have control over research questions and designs, how data should be interpreted and used, and how ancestors and their communities should be represented (Watkins, 2003). Due to Western society's emphasis on formal education and the authority of scientists, archaeologists are considered to have knowledge that is somehow beyond the understanding of nonscientists, and so they assume final authority with regard to the archaeological record (Watkins, 2003). As a result, "members of descendant communities often feel powerless about what happens to their ancestors and the archaeological sites associated with them", and they perceive archaeologists to be arrogant and insensitive, even as archaeologists perceive them to be antagonistic toward research (Watkins, 2003: p. 273).

An example of the ongoing colonial perspective in archaeology is the pervasive negative characterization and treatment of the oral histories of Indigenous peoples. Many archaeologists are reluctant to share power and authority over how the past is studied and represented (Watkins, 2003), and this is manifested in their dismissal of Indigenous knowledge (Steeves, 2015). Written histories are viewed as detached, objective, and reliable, while oral histories are viewed as changeable, subjective, and unreliable and have little or no value in the Western scientific worldview (Smith & Jackson, 2006). This scientific colonialism—this failure to include Indigenous peoples as equals in the stewardship of their own past—excludes them from discourse that is ultimately about them (Watkins, 2003).

As long as Indigenous peoples are treated not as research partners but as "objects" of scientific inquiry under policies that privilege Western ontology and epistemology, the scientific study of Indigenous peoples will continue to be a colonial and conflict-laden endeavor. "[F]undamental differences in epistemology must be acknowledged in order to truly understand the conflicts between scientists and indigenous peoples" (Tsosie, 2015: p. 1140). Western science and Native American spirituality must be balanced in a way that recognizes the validity of both, and in order to achieve that balance, "archaeology must accept the validity of Native American spiritual beliefs and practices, particularly with regard to burials and sacred objects" (White Deer, 1998: p. 336). However, archaeology has never seriously considered the spirituality of Indigenous peoples as relevant to its own concepts and practices (White Deer, 1998). As a result, Western scholarship has been characterized as "simply another kind of imperialism that re-inscribes existing structures of power" (Lee, 2010: p. 33), and "science … [which] is the dominant discourse of archaeology … simultaneously reinforces the authority of the academy and the subservient positioning of Indigenous peoples" (Smith & Jackson, 2006: p. 314).

3. Indigenous Archaeology

By the mid-twentieth century, Indigenous people's protests over the excavation, collection, and display of their cultural and ancestral remains by archaeologists and their demands to have more control over their own heritage could no longer be ignored, and archaeology was forced to begin examining its interactions and relationships with Indigenous peoples (Atalay, 2006). Increasing self-reflection along with the influence of postmodernism led to the recognition that archaeology, like most human endeavors, is strongly shaped by the social and political contexts in which it is practiced (Atalay, 2006). Today, debate continues over the injustices of research practices that do not benefit Indigenous peoples and that exploit these remains, and over the larger question of who should have the power to speak for and write the stories of the past (Atalay, 2006). Because archaeology supported or, at least, was used to support many of the stereotypes of colonialism, "Indigenous peoples have a right to expect archaeologists to assist with the decolonization of archaeology" (Smith & Jackson, 2006: p. 312). Just as colonialism violently transformed and erased the identities of Indigenous peoples, decolonizing knowledge production must work to un-erase them (Steeves, 2015). In that light, "[t]he trajectory of Indigenist research is clearly focused on directions of decolonizing, re-writing, re-claiming, and self-determination along paths of 'post-colonial' healing in a 'neo-colonial' world" (Steeves, 2015: p. v). This includes finding ways to create counter-discourses that challenge the colonialist and imperialist interpretations of the past (Atalay, 2006).

Indigenous archaeology arose and continues to evolve as a response to postcolonial critiques of archaeological practices, particularly the privileging of Western perspectives (McNiven, 2016). It has emerged as a new form of archaeology that is informed by Indigenous values and agendas (Wobst, 2010) and that "is in synch with and contributes to the goals, aims, hopes, and curiosities of the communities whose past and heritage are under study, using methods and practices that are harmonious with their own worldviews, traditional knowledges, and lifeways" (Atalay, 2006: p. 284; see also Nicholas, 2008). In actual practice, Indigenous archaeology can mean different things, and what is considered Indigenous archaeology in one region might not be applicable to other regions (Watkins, 2010). Thus, because Indigenous archaeology is a broad approach that can be applied in different ways, it may be better conceived of as Indigenous archaeologies (Colwell-Chanthaphonh et al., 2010).

According to Nicholas (2008), Indigenous archaeology has the goals of making archaeology more representative of, responsible to, and relevant for Indigenous communities; redressing real and perceived inequalities in the practice of archaeology; and informing and broadening the understanding and interpretation of the archaeological record through the incorporation of Indigenous worldviews, histories, and science. This may be accomplished by any of the following: The active participation or consultation of Indigenous peoples in archaeology; *a political statement concerned with issues of Indigenous self-government, sovereignty, land rights, identity, and heritage;* a postcolonial exercise to decolonize the discipline; a manifestation of Indigenous epistemology; a basis for alternative models of cultural heritage management or stewardship; the product of choices and actions by individual archaeologists; *a means of* empowerment and cultural revitalization or *political resistance*; and an extension, evaluation, critique, or application of current archaeological theory.

Atalay (2006: p. 301) characterized Indigenous archaeology as "a collaborative approach that blends the strengths of Western archaeological science with the knowledge and epistemologies of Indigenous peoples to create a set of theories and practices for an ethically informed study of the past, history, and heritage". Unlike mere consultation, collaboration allows Indigenous peoples to play an active role in the entire research process, including research design, grant writing and funding processes, results analysis and interpretation, and report production. Silliman (2008) similarly called for collaboration in which archaeologists consider Indigenous perspectives throughout their projects, from project formulation, development, initiation, data recovery, laboratory analysis, data evaluation and interpretation, and report writing, to project shutdown. Cipolla, Quinn, and Levy (2019) also espoused co-authorship of publications, and expressly categorized each of its co-authors as either settler-colonist or Indigenous. For Croes (2010: p. 211), collaboration is "a 50/50 partnership between the archaeological scientist and the native people", which "means, and allows, joint ownership that can only expand the scientific description and the cultural explanation through an Indigenous archaeology". For McNiven (2016: p. 28), quoting George (2010: p. 105), collaboration often begins with archaeologists asking Indigenous leaders "what sort of research, if any, they would be interested in hosting and 'what they would like others to know about their community and culture", so that Indigenous archaeology is archaeology *for* and not simply *about* Indigenous people. Thus, Indigenous archaeology includes an element of "mutuality" in fieldwork and in the interpretation and presentation of results, "and co-accommodation of Western and Indigenous [worldviews]" (McNiven, 2016: p. 28).

"With, By, and For"

Perhaps the most accepted characterization of Indigenous archaeology is as a decolonized archaeological paradigm that is "with, by, and for" Indigenous peoples (see, e.g., Atalay, 2006; Colwell-Chanthaphonh et al., 2010; Nicholas, 2001; Nicholas & Andrews, 1997; Silliman, 2010 citing Nicholas, 2008). Archaeology "with" Indigenous peoples involves close collaboration, and gives Indigenous stakeholders a voice in how the work is performed (Silliman, 2010). Archaeology "by" Indigenous peoples introduces much needed diversity into the discipline by encouraging participation, providing support for educational and career paths, recognizing sovereignty, prioritizing community, and respecting their knowledge and concerns about history (Silliman, 2010). Archaeology "by" Indigenous scholars and communities is research in which they have power and are in control of the design and interpretations, and in which "research is a ceremony" with the purpose of raising consciousness and developing insight into the world (Wilson, 2008: p. 11). Archaeology "for" Indigenous peoples ensures that research projects acknowledge and address the troubled history of archaeology's treatment of Indigenous peoples, including by telling useful, respectful, and peopled histories that resonate with communities' senses of themselves and their particular needs (Silliman, 2010).

Decolonizing archaeology involves accepting alternative ways of viewing the past as equally valuable and legitimate ways of knowing (Atalay, 2006). Further, Indigenous discourse challenges academic hegemony and its privileging of non-Indigenous written sources in knowledge production of the Indigenous past to accept oral histories as valid data (Steeves, 2015). Adding Indigenous perspectives to our understanding of the past is essential to decolonizing narratives and minds (Steeves, 2015) and creating a more representative past (Nicholas, 2001). So for many Indigenous scholars, methodology begins with a study of relevant oral traditions (Steeves, 2015). "This need not undermine archaeology's commitments to studying parts of the past in rigorous and scientific ways, nor must it produce 'proprietary histories', particularly when done collaboratively" (Silliman, 2010: p. 218). In this manner, Indigenous archaeology seeks to achieve a more respectful dialogue between various stakeholders, of which archaeologists are only one (Silliman, 2010).

Watkins (2010) discussed the positive impact of Indigenous archaeology on several areas of archaeological practice. Indigenous archaeology can provide relational benefits in that it allows archaeologists to improve relationships with stakeholders, because "the more we include local and Indigenous perspectives within our research, the more we create support for what we do" (Watkins, 2010: pp. 54-55). Indigenous archaeology can also have an operational impact in that as archaeologists include more stakeholders they relinquish some control over the way in which archaeology is practiced. While the process will be changed, the sharing of information and the gathering of alternative perspectives will expand and benefit archaeology rather than harm it:

> Generally speaking, we will give up portions of our control over the archaeological record. We will sometimes be forced to ask permission to operate within arenas that previously we took as our own. We will have personality

conflicts and programmatic lapses. We will shake our heads at interpretations and representations, but I believe archaeology will survive and become stronger (Watkins, 2010: p. 58).

In response to archaeologists who argue that the discipline should try to remain more objective, Watkins noted that archaeology never has been and never can be completely apolitical or neutral. If archaeologists continue to insulate themselves from stakeholders who see themselves as the social, political, or cultural stewards of the archaeological record or cultural heritage, then archaeology will continue to be a sterile act serving only the needs of one group of people as a handmaiden of colonialism (Watkins, 2010). Having said that, Indigenous archaeology is not meant to replace scientific archaeology but to add to archaeology's interpretative power (Watkins, 2010). For example, archaeologists tend to focus on the physical, technological, and esoteric attributes of artifacts, while Indigenous peoples are often more interested in the ceremonial and social importance of the same artifacts, so Indigenous archaeology attempts to consider all of these aspects of artifacts and thereby serve the needs of all stakeholders (Watkins, 2005).

4. Critical Debate of Indigenous Archaeology

McGhee (2008) raised the concern that Indigenous archaeology is based on Aboriginal essentialism ("Aboriginalism") and the notion that Indigenous peoples possess fundamentally different qualities from non-Indigenous peoples. McGhee (2008: p. 581) also asserted that some proponents seek "to appease Indigenous opposition by incorporating non-Western values and perspectives as sources and methods of investigation, or by explicitly aligning their efforts with the historical interests of specific communities or groups". Such efforts are not only theoretically unsound, but can be harmful both to archaeology and to Indigenous communities, and they allow Indigenous peoples to assert exclusive rights over knowledge that are not available to non-Indigenous peoples (McGhee, 2008).

McGhee (2008: p. 582) characterized proponents as viewing archaeology as being "an instrument of a coercive state", and as serving "to deprive Indigenous peoples of their right to define their own place in the modern world, and [as] an effective weapon of assimilation to mainstream cultures". For example, Custer (2005: p. 3) asserted that "archaeologists have created a thought world which serves to support their own power and privilege, harms the interests of American Indian people, and aids the ongoing cultural genocide focused on Native Americans". Because traditional archaeology is characterized in such extreme terms, anyone attempting to question the concept of Indigenous archaeology is by implication unethical or even criminal (McGhee, 2008). The proposed solution is to "depart radically from the practice of archaeology as an academic and heritage management discipline" (McGhee, 2008: p. 591). For example:

Some (Custer, 2005) argue that archaeology can be practiced with a clear con-science only if it is carried out at the request of, and under the direction and control of, an Indigenous community. Others simply assume that "Indigenous rights should always trump scientific inquiry" as Gillespie (2004: p. 174) notes of the papers collected by Zimmerman[, Vitelli, & Hollowell-Zimmer] (2003) … McNiven & Russell (2005: p. 239) see the claims of archaeologists to academic freedom as no more than "part of the colonial fantasy of naturalized superiority and hegemonic control." … McNiven & Russell (2005: p. 236) propose that archaeologists accept a "host/guest" relationship with Indigenous communities, which "*have every right to control archaeological research in whatever way they wish*" (McGhee, 2008: pp. 591-594, emphasis added).

McGhee is not alone in questioning such extreme positions. Kuper (2003: p. 400) noted that if anthropologists become "the academic wing of the indigenous rights movement" then their works will be worthless except as propaganda. Trigger (1997: p. x) warned that "[f]or archaeologists to take sides in political issues of this sort risks interference in Native life that may be scarcely less patronizing than the interference of Indian agents and missionaries was in the past". Smith (2004) noted that Indigenous archaeology inserts the discipline into political negotiations between Indigenous and colonial peoples. In particular, Indigenous peoples' historical assertions are part of wider negotiations with governments about the legitimacy of Indigenous claims to specific rights, not least of which are rights to land. The consequences of supporting statements and perspectives which are consistent with the beliefs of Indigenous peoples but not with scientific evidence and of "accommodating a scientific discipline to the desires of a specific nonscientific community are not at all clear" (McGhee, 2008: p. 592).

Croes (2010: p. 215) acknowledged the potential problems identified by McGhee, but asserted that archaeologists should "approach this work as a true 50/50 partnership with tribes, to the mutual benefit of both sides in the shared objectives". Croes gave examples of cooperative efforts, but all were "win-win" scenarios that did not involve difficult questions. For example, Croes asserted that the applied aspect of archaeology needs to be part of the process of improving the quality of lives of stakeholders, and told a story of how archaeological research helped a particular Indigenous group to more beneficially define its treaty rights regarding harvesting shellfish in their traditional area. However, Croes did not discuss the possibility that research might have shown their traditional area to be significantly smaller than the group was asserting. It is unclear whether or how Croes's respectful and facilitative partnership approach would work in cases in which results are not beneficial or flattering or in which they contradict oral histories or spiritual beliefs.

Colwell-Chanthaphonh et al. (2010) rejected McGhee's charge of essentialism, and argued that McGhee was simply pitting science as a pure objective positivist pursuit against Indigenous peoples as eco-spiritual subjectivists. Wilcox (2010) also argued against the dichotomization of scientific and Indigenous archaeologies. Silliman (2010: p. 219) similarly rejected McGhee's position as "[working] against the postcolonial aims supported by most Indigenous archaeologists who seek to interrogate, repair, and hopefully move beyond the colonial origins of the discipline and its treatment of Native people". Silliman asserted that Indigenous archaeology attempts to mitigate the negative effects of archaeological practice on the living descendants of subject communities and also attempts to benefit from those descendants' contributions to knowledge of the past. It does this "simultaneously, successfully, and rigorously without 'strip[ping] archaeology of the scientific attributes that make it a particularly powerful narrator of the past'" (Silliman, 2010: p. 218, quoting McGhee, 2008: p. 591).

5. The Extreme Form of "For"

We disagree with those who reject even the more reasonable form and positive aspects of Indigenous archaeology, and we disagree with those who reject the fact that the Indigenous worldview differs from the Western scientific worldview. Our criticism is not of Indigenous archaeology in general, the benefits of which we think are obvious, but of an extreme, outcome-driven form which seems to involve not the integration of views or equalization of power but merely a transfer of privilege and power:

> If colonialism has meant Indigenous peoples living within a framework of non-Indigenous control, *the decolonization of archaeology has to involve archaeologists working within a framework of Indigenous control* … Given that differential access to power is at the core of colonial relations, it follows that the decolonization of Indigenous archaeology involves a rethinking of power relations between archaeologists and Indigenous peoples. It must involve a movement from the colonial assumption of a right to acquire knowledge to recognition of Indigenous peoples' rights to protect their cultural and intellectual property and to share knowledge on their own terms (Smith & Jackson, 2006: p. 341, emphasis added).

In its more reasonable form, Indigenous archaeology prioritizes research that is relevant to Indigenous peoples, but in its more extreme form, it requires that research "benefit" them. For example, Steeves (2015: p. 29) claimed that "[m]any Indigenous people believe that knowledge gathered as a practice of gathering is a waste of time", which reflects the notion of relevance, but Louis (2007) went further and asserted that research that does not benefit the community and extend the quality of life of its members should not be done. The requirement to benefit already implicates scientific consequentialism, but some have argued that scientific research that is "for" Indigenous peoples should have the consequence of furthering the social and political interests of Indigenous peoples. For example, Ucko (2001: p. 1) noted a lack of awareness in the discipline "of the socio-political contexts of the practice and nature of archaeology in all parts of the world". In particular:

> [Archaeologists] bring *consequences* to the societies involved which may be far removed from that initially assumed by the archaeologist … [I]t behooves

> archaeologists to understand how knowledge of the past, and of the present of "Others", not only plays a part in the social, political, and economic relations of people in the present, but will undoubtedly also do so in the future (Ucko, 2001: pp. 8-9, emphasis added).

Ucko (2001) did not expressly call for avoiding certain consequences or pursuing others, but it is implicit in his call to understand that research has consequences that some action should follow based on that understanding.

According to Nicholas (2001), Australian archaeologists who wish to perform research on the lands of Indigenous peoples must not only obtain permission but may have to relinquish certain rights to their research results. "While the initial reactions of prospective researchers are often negative, the reality is that the provisions are ones that most can abide, with little if any real restrictions on what they would have done otherwise" (Nicholas, 2001: p. 36). Nicholas gave no discussion of why these restrictions are needed if they have "little if any real" effect on archaeologists' work. Nicholas also suggested that the "for" aspect encompasses how science approaches research which contradicts the Indigenous worldview: The Western scientific worldview "threatens the integrity of the [Indigenou] worldview and beliefs", and "many [Indigenous] peoples are satisfied with their knowledge of the past as it is now; they don't need archaeology to tell them what they already know; to challenge this may be tantamount to dismissing their religious beliefs" (Nicholas, 2001: p. 30). Nicholas (2001: p. 31) did admit that "[t]here is a strong desire by some [Indigenous] peoples to use the archaeological record to document cultural continuity, and to identify the material culture of specific cultural groups to support land claims", but did not discuss whether or how to accommodate them. So again, while this is not an express call to manipulate science to achieve particular ends, it begs the question of why archaeologists should be aware of such issues and the related "strong desires" of Indigenous peoples if not to do something to support them, and the question of what happens when research results disappoint. If Indigenous peoples control the rights to results, then it is at least possible that adverse results would be suppressed, in which case researchers would be tempted to either avoid such research altogether or ensure that the results are not adverse.

Steeves (2015) made an appeal to archaeologists and other scientists to actively use science to heal what Duran (2006: pp. 15-16) referred to as the "soul-wounds" (i.e., intergenerational traumas) of Indigenous peoples, including "identity erasure, created in part through archaeologically cleaved links to ancestral places and times due to colonization". Rigney (1999: pp. 117-118, emphasis added) brazenly asserted that research should "*serve and inform the political liberation struggle*", and "*it must be overtly political*". Even Atalay (2006: p. 296, emphasis added) seemed to accept that the extreme form of Indigenous archaeology involves transferring power from one stakeholder to another:

> *If in working to de-center some of the problematic aspects of Western archaeological practice, are we then advocating for destroying one power struc-*

> *ture (a Western one) to simply replace it with another, Indigenous-centered one?* I ask this question because of a recent dialogue I had on this topic in which by suggesting the de-centering of Western concepts in order to center Indigenous views, *I was labeled a "colonist", someone who was doing nothing different than what Western scholars had done before me* (i.e., forcing my Indigenous worldview onto others) … *[W]e must sometimes use the master's tools … to create a counter-discourse to Western approaches* that have consistently worked to destroy or silence our Indigenous ways of knowing.

If "archaeological and historical data are not merely neutral pieces of information [and are] fundamentally fouled with political and neocolonial views and ideas" (Steeves, 2015: p. 48), then the question becomes whose political and neocolonial ideas will it reflect: Colonial or Indigenous? According to Steeves (2015: p 45, p. 85, emphasis added), "Indigenous archaeology … *is a political act* focused on reclaiming control of the Indigenous past in the present … [it is] carried out with and for Indigenous people … *Political control of cultural information is critical to the survival and protection of Indigenous peoples rights and sovereignty*".

6. Examples of Potential Problems with Scientific Consequentialism

The extreme, outcome-driven form of Indigenous archaeology seems to require that scientific research and results have the effect of furthering Indigenous peoples' social and political interests. Of course, it would be difficult or impossible to know of research that has actually been suppressed, manipulated, or avoided, but the following examples show how strong the pressure of scientific consequentialism can be in at least attempting to suppress undesirable research or results, manipulate scientists and the scientific process, and altogether avoid research into certain subjects.

6.1. Suppressing Undesirable Research or Results

It seems unlikely that many Native Americans desire to know whether their ancestors practiced cannibalism, and the knowledge is unlikely to benefit them and could undermine their interests. Therefore, presumably either such research would not be pursued or, if it is, positive results would be suppressed under the extreme, consequentialist form of Indigenous archaeology. In fact, cannibalism has emerged as one of the most controversial issues in the archaeology of the American southwest. Billman, Lambert, & Leonard (2000) reported on the remains of seven individuals exhibiting butchering marks and exposure to high heat, associated tools with blood residue, and a human coprolite containing human myoglobin which provide strong evidence of the preparation and consumption of human flesh. This and a number of similar finds in the region indicate a sharp increase in cannibalism around 1150 A.D., which corresponds with drought and the collapse of the Chaco system. Billman, Lambert, and Leonard hypothesized that faced with severe environmental stress, food scarcity, and sociopolitical upheaval, some groups used violence to terrorize or even eliminate others, and cannibalism was part of this violence. In reporting this research, their expressed goal was "to move the debate from the issue of whether or not cannibalism occurred … to questions of broader anthropological significance", including the causes of cannibalism (Billman, Lambert, & Leonard, 2000: p. 146).

However, some associate the assertion of cannibalism with the charge of "savagery", which historically was used to differentiate the uncivilized "other" and legitimize treating "them" as inferior (Arens, 1979). Dongoske, Martin, and Ferguson (2000: p. 180) asserted that the word "cannibalism" "carries some very heavy historical and emotional baggage", including helping "to ideologically pave the way for the eventual campaign of conquest, Christianization, and genocide that followed" (citing Barreiro, 1992: p. 35, but failing to acknowledge that Barreiro admitted that cannibalism did occur). Kilgour (1998: p. 240) similarly asserted that cannibalism was a symbol of the tools of oppression used by a guilty imperial past, "be it the British empire or the empire of anthropology", and Arens (1979) claimed that much of the literature on cannibalism is a meta-myth created as a means of boundary definition in the construction of Western identity. "These matters are not merely historical or theoretical: Indians must contend with negative stereotypes every day, in every arena of their lives. So … claims for cannibalism must seem like one more attempt to denigrate Indians" (Morrow & Lekson, 1999: p. 6). Even if the assertions are made by disinterested scientists based on objective evidence, they may be picked up and used by others to support racist positions (Morrow & Lekson, 1999). Thus, "any characterization of Indians as 'cannibals' dredges up a long history of oppression and racism, and we have to realize that this may generate ill-will and negative emotions about archaeology in many descendant communities" (Dongoske, Martin, & Ferguson, 2000: p. 180).

Dongoske, Martin, & Ferguson (2000: pp. 180-181, emphasis added) did allow that "this does not mean that [cannibalism] is a forbidden subject for investigation but that its investigation must meet the most rigorous scientific standards possible … *our research must be unassailable* … *there should be incontrovertible archaeological evidence of its existence*". However, developing evidence and consensus requires open debate across multiple studies, so requiring that there be no open discussion of cannibalism until and unless it can be supported by unassailable and incontrovertible evidence is an impractical if not impossible standard, the result of which would be to effectively suppress research on the issue altogether. Further, Dongoske, Martin, and Ferguson criticized Billman, Lambert, and Leonard for not using ethnographic and ethnohistoric evidence to either support their conclusion of cannibalism or propose alternative explanations for the data, but provided no discussion of how such evidence might have resulted in a different interpretation of the data. They did attempt to fabricate an example alternative interpretation that does not involve cannibalism, but in doing so they distorted or outright ignored much of the evidence. Ironically, they argued that "[i]f archaeology is to be taken seriously by other scientists, rigorous adherence to scientific protocol is needed", but then claimed that they do "*a different kind of science*, one that is inclusive of a number of different points of views and perspectives" (Dongoske, Martin, & Ferguson, 2000: p. 189, emphasis added). Ultimately, their concern was not whether past peoples actually engaged in cannibalism, but rather the potential consequences to modern peoples and their interests of openly acknowledging it:

> Needless to say, the appropriation of the Cowboy Wash study by the popular press in complete disregard of the descendant communities was a damaging set back to all of us working in the Southwest. We know because many of our Native American colleagues have told us so … We also are concerned with how allegations of cannibalism in the popular press affect contemporary Native Americans … Historically, science and archaeology have been used to denigrate and dehumanize Native Americans, justifying the taking of land and the perception of Native American cultures as static and destined for extinction … We think the sensationalistic approach to reporting claims of cannibalism inadvertently encourage racist views in American society (Dongoske, Martin, & Ferguson, 2000: p. 188).

6.2. Manipulating the Scientific Process

Origin is a key qualitative distinction between the Indigenous and the colonial, and is often argued as a basis for the former's claims against the latter. Therefore, Indigenous peoples' assertions of originating in the Americas, or, at least, arriving much earlier than Europeans, presumably would be supported under the extreme, consequentialist form of Indigenous archaeology. For example, Deloria (1995: p. 84, emphasis in original) claimed that "[b]y making us immigrants to North America, [scientists] are able to deny the fact that we were the full, complete, and total owners of this continent … and therefore throw back at us the accusation that we had simply *found* North America a little earlier than they had". Deloria (1992: p. 597, emphasis added) further argued that Native Americans will never be accorded full humanity until and unless they "are in some way connected with world history as early peoples, perhaps even as refugees from Old World turmoils and persecutions. *We cannot be primitive peoples who were suddenly discovered half a millennium ago. The image and interpretation are all wrong* … " Thus, accepting that Indigenous peoples have been in the Western Hemisphere for over 60,000 years and possibly over 100,000 years puts them on equal footing with other peoples (Steeves, 2015). Establishing such a long tenure is important because it "impacts the social and political lives of contemporary people" (Steeves, 2015: p. 4, citing Gnecco, 2011) by solidifying their claims to Indigeneity and supporting Indigenous ownership of their past, their culture, and their lands (McNiven & Russell, 2005; Steeves, 2015).

With that in mind, Steeves (2015) argued for a pre-Clovis, deep-time entry or outright origin of Natives in the Americas based on a number of controversial sites. Steeves (2015: pp. 76-77) referred to the Clovis First hypothesis, which was, at the time, the consensus hypothesis for the peopling of the Americas, as "the greatest myth ever told". Adovasio and Page (2002: p. xviii) similarly characterized it as "not logical" and "more like religious dogma". Steeves asserted that this myth was only able to become so deeply embedded in the dominant discourse because archaeologists delegitimized and erased the true Indigenous histories. Steeves (2015: p. 27) embraced Deloria's politicized approach to the issue and suggested that the claim of a more recent origin is nothing more than a deliberate attempt "to erase or marginalize the historical identities or even the historical presence of various groups whose historical consciousness may lead to claims to land, resources, and distinctive identities, all substantive challenges to colonial ownership, privilege, and production of historical knowledge". In an open attempt to coerce researchers, Steeves (2015: p. iv, emphasis added) argued that *to deny an ancient tenure in the Americas is to commit a violence against Native Americans*, and that "archaeology has an ethical and moral duty to un-erase histories and identities that its academic predecessors erased through violent discursive processes of knowledge production". Ironically, Clovis First is no longer the consensus hypothesis as somewhat older sites are now generally accepted (see, e.g., Waters & Stafford, 2014), but this shift occurred because science stayed true to its ideals and worked properly to self-correct by continually considering new and reconsidering old evidence, not because Steeves had successfully coerced them into accepting an unsupported position (and, importantly, the now generally accepted pre-Clovis sites are still nowhere near the age required to support Steeves' position).

6.3. Avoiding Research into Certain Subjects

As discussed, long tenure would strengthen arguments for claims to the Western hemisphere as well as for more specific claims to tribal lands. Evidence of a shorter tenure or, alternatively, the long-term presence of non-Native Americans could weaken those claims. Therefore, Indigenous peoples' demands not to conduct research which might produce such undesirable evidence presumably would be respected under the extreme, consequentialist form of Indigenous archaeology. The case of "Kennewick Man" illustrates how adversarial the conflict between scientists and Indigenous peoples can become and both why a reasonable form of Indigenous archaeology is needed and why an extreme form must be avoided.

Human remains were discovered on federal land, and nearby tribes claimed a relationship with the individual, which they referred to as the "Ancient One", and demanded that the remains be reburied without being studied. Agreeing with the tribes and applying the Native American Graves Protection and Repatriation Act (NAGPRA), the U.S. Army Corps of Engineers seized the remains and halted all testing. Scientists claimed the right to study the remains, which they referred to as "Kennewick Man", under the Archaeological Resources Protection Act (ARPA), and brought suit challenging the Corps' legal conclusion that the remains qualified as Native American. The U.S. District Court found that the Corps had done inadequate analysis of difficult legal and factual issues, and remanded the matter for further consideration. The issue was transferred from the Corps to the Department of the Interior which also concluded that the remains were Native American within NAGPRA's meaning. The scientists returned to court, and the district court ruled in their favor to allow scientific study. The U.S. Court of Appeals affirmed, ruling that the remains were not Native American under NAGPRA, which requires that remains be "of, or relating to, a tribe, people, or culture that is indigenous to the United States". The court stressed that the relevant text is written in the present tense, and therefore the law requires that human remains bear a relationship to a presently existing tribe, people, or culture in order to be considered Native American, and there was insufficient evidence that the remains at issue were related to any current tribe. The court concluded that the remains should be transferred to the scientists who could proceed to study them under ARPA. Genetic testing failed to show that the remains belonged to a non-Native American, and the remains were ultimately transferred to and reburied by the tribes.

According to the Committee on Repatriation (1998) of the Society for American Archaeology (SAA), NAGPRA was intended to balance conflicting scientific and tribal interests. Goold & Fanelli (2000; 2001), attorneys for the SAA, characterized this during litigation as "NAGPRA was intended to reasonably balance Native American interests in human remains and cultural items with those of the scientific community and the broader public", which goes even further in aligning the scientific and general public's interests against those of Native Americans. Barran & Schneider (2001), attorneys for the scientists, made a number of incendiary legal arguments, including, for example, that the Wanapum tribe, which was part of the coalition, was not properly an "Indian tribe" because it was not federally recognized. They also argued for standards of affiliation which Native Americans would never be able to meet, including that determining "group identity" would require knowing the language, religious practices and customs, and interactions between groups thousands of years ago. They also argued that oral histories "are unstable over time and are not inherently reliable explanations of distant past events", and that the tribes "improperly used religious beliefs as proof of prehistoric events, and as a basis for denying [scientists] access to the skeleton, the discovery site, and government-held information" (Barran & Schneider, 2001: p. 1, p. 12). They even went so far as to assert that oral histories that have metaphysical content cannot be used as evidence of past events without violating the U.S. Constitution, arguing:

> Defendants hopelessly confused cultural information with religious beliefs … Defendants repeatedly link religious stories with historical events, all in an effort to show that those religious beliefs point to a prehistory that is "true" for

purposes of cultural affiliation. To use religious belief for such purposes violates the Establishment Clause (Barran & Schneider, 2001: pp. 25-26).

In critiquing the case, Tsosie (2015) noted that the process was fraught with epistemic injustice. The courts were reluctant to acknowledge the harms asserted by the tribes but were fully accepting of the harms to scientific discovery and the public interest asserted by the scientists. The evidence offered by the tribes was discarded as religious mythology while the evidence offered by the scientists was fully respected, which "effectively reduces the Indigenous peoples to the status of religious zealots" (Tsosie, 2015: p. 1186). Writing on the broader issue of establishing cultural affiliation as a requirement for repatriation, Dumont (2011: p. 6) rejected the argument that Native American claims interfere with scientists' ability to represent "American interests" (and the implicit assertion that Native Americans are not Americans), and noted that "Native peoples continue to struggle with an entrenched assumption of colonial prerogative among American physical anthropologists and archaeologists". Thus, the Kennewick case illustrates the need for Indigenous archaeology and better relations between scientists and Indigenous peoples.

However, although the tribes' actual arguments were based largely on avoiding the desecration of remains belonging to an individual they believed to be their ancestor, the social and political issues of origins and claims to land were clearly present (Goldberg, 2006). As mentioned, Nicholas (2001) has admitted that there is a strong desire by some Indigenous peoples to use the archaeological record to support land claims. At least one commentator speculated that "the tribes fight against further testing of Kennewick Man is based largely on fear, fear that if someone else was here before they were, their status as sovereign nations and all that comes with it—treaty rights and lucrative casinos, like this one on the Umatilla Reservation—could be at risk" (Stahl, 2012, characterizing the position of James Chatters).

7. Conclusion

Certainly, the scientific endeavor would be greatly improved by increased communication and collaboration with and, perhaps most importantly, respect for all of its stakeholders. We support the goals of Indigenous archaeology to perform research that is "with", "by", and (in its reasonable form) "for" Indigenous peoples. However, there is great danger in extreme efforts to manipulate scientists and science to further social and political agendas and "the good" of decolonization. While well-intended, such an outcome-driven paradigm to further Indigenous interests is antithetical to and irreconcilable with the ideals of Western science, and is no more appropriate now to support counter-colonial agendas than it was in the past to support colonial agendas. Many of the historical examples relied upon by those attacking archaeology and other anthropological disciplines were ultimately rectified not by abandoning the ideals of Western science as unachievable but by intensifying efforts to more faithfully achieve them. Certainly, individual scientists are fallible and introduce bias, ignorance, and subjectivity into their research at every stage, but, over time, the consensus-seeking process works to correct much that results from individual weakness.

The misuse of science by colonials in the past should not become a justification for misusing it by or on behalf of Indigenous peoples in the present. Nevertheless, for Smith & Jackson (2006: p. 341, emphasis added), the solution involves not an equalization but merely a transfer of control of the research process: "If colonialism has meant Indigenous peoples living within a framework of non-Indigenous control, *the decolonization of archaeology has to involve archaeologists working within a framework of Indigenous control*". So too for Custer (2005), and for McNiven & Russell (2005: p. 236, emphasis added), who asserted that *Indigenous communities* "*have every right to control archaeological research in whatever way they wish*". For Steeves (2015: p 45, p. 85, emphasis added), "*Political control of cultural information is critical to the survival and protection of Indigenous peoples' rights and sovereignty*". For Smith & Jackson (2006: p. 339) this means that *Indigenous peoples* "*own*" *and have the exclusive right to determine how it is researched and reported*, *without regard to their motivations for exercising such control*. For Nicholas (2001: p. 30), it seems to mean avoiding or suppressing research that "threatens the integrity of the [Indigenous] worldview and beliefs".

The slippery slope of scientific consequentialism is further manifested by a new extreme form of public archaeology which seeks to "make archaeology political again" (Gonzalez-Ruibal, Gonzalez, & Criado-Boado, 2018: p. 513). This new paradigm seems to seek to transform archaeology into a tool of social critique to fight "reactionary populism" driven by nationalism, racism, and anti-intellectualism with the goal of reclaiming the privileges of an earlier, "better" time. What Gonzalez-Ruibal, Gonzalez, & Criado-Boado (2018) have proposed arguably can be characterized as a left-wing archaeology to fight a right-wing movement. Their solution is "to go back to the roots of politics—radical dissent, conflict, inequality—and reconstruct archaeology as a public-engaged practice" (Gonzalez-Ruibal, Gonzalez, & Criado-Boado, 2018: p. 514) to achieve broad consequentialist goals of serving what they perceive to be the social and political interests of all peoples.

Archaeology, being a human endeavor, will always suffer from imperfect objectivity. The response of extreme consequentialists is to abandon objectivity altogether and openly embrace subjectivity, but this response reflects the logical fallacy of the perfect solution (i.e., if we cannot achieve perfect objectivity, then there is no point in pursuing objectivity at all). Using archaeology to promote preferred agendas or ideologies has emotional appeal, but will only undermine overall respect for the discipline and trust in its results. While scientists can be advocates for positions derived from their research and results, they cannot let their personal preferences dictate their research or results or else they stop being scientists and become something else. We agree with McGhee's (2008) point that if archaeologists and other scientists are repentant for and concerned about being the unwitting pawns of colonial governments and their agendas, the solution is not to become the willing pawns of Indigenous governments and their agendas. The scientific study of Indigenous peoples can and should be improved by greater collaboration with its subjects and other stakeholders, but this can be achieved without abandoning the deontological ideals of the scientific method.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

References

Adovasio, J. M., & Page, J. (2002). *The First Americans: In Pursuit of Archaeology's Greatest Mystery*. New York: Random House.

Arens, W. (1979). *The Man-Eating Myth: Anthropology and Anthrophagy*. New York: Oxford University Press.

Atalay, S. L. (2006). Indigenous Archaeology as Decolonizing Practice. *American Indian Quarterly, 30,* 280-310. https://doi.org/10.1353/aiq.2006.0015

Barran, P. A., & Schneider, A. L. (2001). *Memorandum in Support of Motion to Vacate Second Administrative Action*. Bonnichsen et al. v. United States et al., United States District Court for the District of Oregon, April 16.

Barreiro, J. (1992). A Note on the Tainos. In J. Yewell, C. Dodge, & J. DeSirey (Eds.), *Confronting Columbus* (pp. 30-47). Jefferson, NC: McFarland.

Billman, B. R., Lambert, P. M., & Leonard, B. L. (2000). Cannibalism, Warfare, and Drought in the Mesa Verde Region during the Twelfth Century AD. *American Antiquity, 65,* 145-178. https://doi.org/10.2307/2694812

Cipolla, C. N., Quinn, J., & Levy, J. (2019). Theory in Collaborative Indigenous Archaeology: Insights from Mohegan. *American Antiquity, 84,* 127-142. https://doi.org/10.1017/aaq.2018.69

Colwell-Chanthaphonh, C. et al. (2010). The Premise and Promise of Indigenous Archaeology. *American Antiquity, 75,* 228-238. https://doi.org/10.7183/0002-7316.75.2.228

Committee on Repatriation (1998). *SAA Position on the Kennewick Man Controversy*. Washington DC: Society for American Archaeology, March 20.

Croes, D. R. (2010). Courage and Thoughtful Scholarship = Indigenous Archaeology Partnerships. *American Antiquity, 75,* 211-216. https://doi.org/10.7183/0002-7316.75.2.211

Custer, J. F. (2005). Ethics and the Hyperreality of the Archaeological Thought World. *North American Archaeologist, 26,* 3-27. https://doi.org/10.2190/E0Y2-L9N8-43W0-RLT2

Deloria Jr., V. (1992). Indians, Archaeologists, and the Future. *American Antiquity, 57,* 595-598. https://doi.org/10.2307/280822

Deloria Jr., V. (1995). *Red Earth, White Lies: Native Americans and the Myth of Scientific Fact*. New York: Scribner.

Dongoske, K. E., Martin, D. L., & Ferguson, T. J. (2000). Critique of the Claim of Cannibalism at Cowboy Wash. *American Antiquity, 65,* 179-190.

https://doi.org/10.2307/2694813

Dumont, C. W. (2011). Contesting Scientists' Narrations of NAGPRA's Legislative History Rule 10.11 and the Recovery of "Culturally Unidentifiable" Ancestors. *Wicazo Sa Review, 26,* 5-41. https://doi.org/10.1353/wic.2011.0009

Duran, E. (2006). *Healing the Soulwound: Counseling with American Indians and Other Native Peoples*. New York: Teachers College Press.

George, B. E. (2010). Who Am I and How Did I Get Here? In G. P. Nicholas (Ed.), *Being and Becoming Indigenous Archaeologists* (pp. 101-106). Walnut Creek, CA: Left Coast Press.

Gillespie, J. D. (2004). Review of Zimmerman, Larry J., Karen D. Vitelli and Julie Hollowell-Zimmer (2003). *Canadian Journal of Archaeology, 28,* 172-175.

Gnecco, C. (2011). Native Histories and Archaeologists. In C. Gnecco, & P. Ayala (Eds.), *Indigenous Peoples and Archaeology in Latin America* (pp. 53-66). Walnut Creek, CA: Left Coast Press.

Goldberg, S. (2006). *Kennewick Man and the Meaning of Life* (pp. 275-288). Chicago, IL: University of Chicago Legal Forum.

Gonzalez-Ruibal, A., Gonzalez, P. A., & Criado-Boado, F. (2018). Against Reactionary Populism: Towards a New Public Archaeology. *Antiquity, 92,* 507-515. https://doi.org/10.15184/aqy.2017.227

Goold, J. A., & Fanelli, M. J. (2000). *Memorandum in Support of Society for American Archaeology's Motion for Leave to Appear as Amicus Curiae*. Bonnichsen et al. v. United States et al., United States District Court for the District of Oregon, December 11.

Goold, J. A., & Fanelli, M. J. (2001). *Memorandum of Law in Support of the Society for American Archaeology's Amicus Curiae Submission*. Bonnichsen et al. v. United States et al., United States District Court for the District of Oregon, June 1.

Kilgour, M. (1998). The Function of Cannibalism at the Present Time. In F. Barker, P. Hulme, & M. Iverson (Eds.), *Cannibalism and the Colonial World* (pp. 238-259). Cambridge: Cambridge University Press.

Kuper, A. (2003). The Return of the Native. *Current Anthropology, 44,* 389-402. https://doi.org/10.1086/368120

Lee, L. L. (2010). Navajo Transformative Scholarship in the Twenty-First Century. *Wicazo Sa Review, 25,* 35-45. https://doi.org/10.1353/wic.0.0055

Louis, R. P. (2007). Can You Hear Us Now? Voices from the Margin, Using Indigenous Methodologies in Geographic Research. *Geographical Research, 45,* 130-139. https://doi.org/10.1111/j.1745-5871.2007.00443.x

McGhee, R. (2008). Aboriginalism and the Problems of Indigenous Archaeology. *American Antiquity, 73,* 579-597. https://doi.org/10.1017/S0002731600047314

McNiven, I. J. (2016). Theoretical Challenges of Indigenous Archaeology: Setting an Agenda. *American Antiquity, 81,* 27-41. https://doi.org/10.7183/0002-7316.81.1.27

McNiven, I. J., & Russell, L. (2005). *Appropriated Pasts: Indigenous Peoples and the Colonial Culture of Archaeology*. Lanham, MD: AltaMira.

Morrow, D. C., & Lekson, S. (1999). Ancestral Guilt. *Archaeology, 53,* 5-6.

Nicholas, G. P. (2001). The Past and Future of Indigenous Archaeology: Global Challenges, North American Perspectives, Australian Prospects. *Australian Archaeology, 52,* 29-40. https://doi.org/10.1080/03122417.2001.11681703

Nicholas, G. P. (2008). Native Peoples and Archaeology. In D. M. Pearsall (Ed.), *Encyc-*

lopedia of Archaeology (Volume 3, pp. 1660-1669). New York: Elsevier. https://doi.org/10.1016/B978-012373962-9.00203-X

Nicholas, G. P., & Andrews, T. D. (1997). *At a Crossroads: Archaeology and First Peoples in Canada*. Burnaby: Archaeology Press.

Rigney, L.-I. (1999). Internationalization of an Indigenous Anticolonial Cultural Critique of Research Methodologies: A Guide to Indigenist Research Methodology and Its Principles. *Wicazo Sa Review, 14,* 109-121. https://doi.org/10.2307/1409555

Shipley, G. P., & Williams, D. H. (2019). Limitations of the Western Scientific Worldview for the Study of Metaphysically Inclusive Peoples. *Open Journal of Philosophy, 9,* 295-317. https://doi.org/10.4236/ojpp.2019.93020

Silliman, S. W. (2008). *Collaborating at the Trowel's Edge: Teaching and Learning in Indigenous Archaeology*. Tucson, AZ: University of Arizona Press.

Silliman, S. W. (2010). The Value and Diversity of Indigenous Archaeology: A Response to McGhee. *American Antiquity, 75,* 217-220. https://doi.org/10.7183/0002-7316.75.2.217

Smith, C., & Jackson, G. (2006). Decolonizing Indigenous Archaeology. *American Indian Quarterly, 30,* 311-349. https://doi.org/10.1353/aiq.2006.0032

Smith, L. (2004). *Archaeological Theory and the Politics of Cultural Heritage*. London: Routledge. https://doi.org/10.4324/9780203307991

Stahl, L. (2012). *Kennewick Man*. 60 Minutes. CBS, September 25.

Steeves, P. F. (2015). *Decolonizing Indigenous Histories*, *Pleistocene Archaeology Sites of the Western Hemisphere*. PhD Dissertation, Binghamton, NY: Department of Anthropology, State University of New York.

Trigger, B. G. (1997). Foreword. In G. P. Nicholas, & T. D. Andrews (Eds.), *At a Crossroads: Archaeology and First Peoples in Canada* (pp. 7-13). Burnaby: Archaeology Press.

Tsosie, R. (2015). Indigenous Peoples and Epistemic Justice: Science, Ethics, and Human Rights. *Washington Law Review, 87,* 1133-1201.

Ucko, P. J. (2001). Indigenous Archaeology at the Institute of Archaeology. *Papers from the Institute of Archaeology, 12,* 1-11. https://doi.org/10.5334/pia.168

Waters, M. R., & Stafford Jr., T. W. (2014). The First Americans: A Review of the Evidence for the Late-Pleistocene Peopling of the Americas. In K. E. Graf, C. V. Ketron, & M. R. Waters (Eds.), *Paleoamerican Odyssey* (pp. 541-560). College Station, TX: Texas A&M University Press.

Watkins, J. E. (2003). Beyond the Margin: American Indians, First Nations, and Archaeology in North America. *American Antiquity, 68,* 273-285. https://doi.org/10.2307/3557080

Watkins, J. E. (2005). Artefacts, Archaeologists and American Indians. *Public Archaeology, 4,* 187-191. https://doi.org/10.1179/146551805793156211

Watkins, J. E. (2010). Indigenous Archaeology as Complement to, Not Separate From, Scientific Archaeology. *Jangwa Pana, 10,* 46-62.

White Deer, G. (1998). Return of the Sacred: Spirituality and the Scientific Imperative. In D. S. Whitely (Ed.), *Reader in Archaeological Theory: Post-Processual and Cognitive Approaches* (pp. 331-338). New York: Routledge.

Wilcox, M. (2010). Saving Indigenous Peoples from Ourselves: Separate But Equal Archaeology Is Not Scientific Archaeology. *American Antiquity, 75,* 221-227. https://doi.org/10.7183/0002-7316.75.2.221

Wilson, S. (2008). *Research Is Ceremony: Indigenous Research Methods*. Halifax: Fernwood Publishing.

Wobst, M. H. (2010). Power to the Indigenous Past and Present! Or: The Theory and Method behind Archaeological Theory and Method. In M. Burchac, S. M. Hart, & H. M. Wobst (Eds.), *Indigenous Archaeologies: A Reader on Decolonization* (pp. 76-78). Walnut Creek, CA: Left Coast Press.

Zimmerman, L. J., Vitelli, K. D., & Hollowell-Zimmer, J. (2003). *Ethical Issues in Archaeology*. Walnut Creek, CA: AltaMira.

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The Pliska Inscription

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Abstract

In this article, the strong resemblance of Linear A, Linear B characters with the Proto-Bulgarian characters of the Pliska inscription is used for identifying the phonetic value of each Proto-Bulgarian character. Because said characters are on rays of a rosette, several inscription readings are possible. The selection of the valid reading, its separation in words and its deciphering were made on the basis of similarities between the inscription words and corresponding words in the surviving Slavic languages. The resulting deciphering is: the massacre of the Romans drink glum, but resist at, which can be loosely deciphered as: drink the bitter cup of the Roman massacre glum, but hold on together. The massacre mentioned in the inscription was certainly that that occurred during the war between the Bulgarians of khan Krum and the Byzantines of emperor Nikephoros, when this last on 20th July 811 sieged Pliska, capital of the First Bulgarian Empire, plundered its treasures and burned it to ground.

Keywords

Pliska, Rosette, Inscription, Proto-Bulgarian, Linear A, Linear B

1. Introduction

The rosette, on which the inscription is engraved, is numbered 38 in the Catalogue of archaeological finds from Pliska (Henning, 2007) and is laconically described as: Rosette; Large water storage; 9th cen.; Bronze; cast; Engraving. Around a raised round center part there are grouped seven trapezoidal rays. On one side at the center part the engraved character IYI. On the other side, a hanger loop. Two characters on each ray blade. Diam.: 3.9 cm. Nat. Arch. Mus. Sofia, Inv. 5257.

2. The Inscription Studies

The rosette attracted the attention of the experts because of its beautiful seven rays shape and its obscure meaning.

An inscription deciphering attempt was based on Semitic scripts, the ancient Turk and Chuvasian languages. The character group IYI was interpreted as "yuvi" i.e. them, a title brought only by the khan. The deducted inscription meaning was: this for horse riding should be known, carries the seal at home. The inscription and the rosette shape indicated then the rosette as a connection of chest straps in horse equipment (Sachev, 1977).

A Proto-Bulgarian (P-Blg.) character comparative analysis confirmed the characters as forming a P-Blg. inscription and revealed analogies between its P-Blg. characters and other characters engraved on artefacts found in nearby regions of today Bulgaria. Some reading issues were raised:

1) In which sequence the rays should be considered?

2) Which is the first character in each ray: the internal one or the external?

3) How the characters should be seen, as they appear or overturned?

4) If the characters should be read in circular mode, should be read first the characters on the external circumference or those of the internal circumference?

5) How the characters should be read, by rotating the rosette leftward or rightwards?

The inscription meaning was not determined; however, the rosette was considered either a warrior emblem or part of horse equipment, destined to be attached to a perishable material. In use, only the character group IYI was visible to other peoples, while the inscription on the hanger loop side (**Figure 1**) was not visible. The inscription was then considered either a pray, or an oath, or a war call (Vaklinov, 1978).

A study conjectured the character group IYI, found also on many stones and artefacts in Bulgaria, having seven endpoints as the number of the rosette rays, to represent the heaven or sky and the characters on the rays to represent the Sun, Moon, Mars, Mercury, Jupiter, Venus and Saturn. The rosette was then considered a divination tool. It had to be put in rotation on the hanger loop and, at the end of the rotation, the characters of the ray on which it remained supported indicated what was to be done that day and whether it have to be successful or not (Beshevliev, 1981).

Another study was based on similarities between the P-Blg. inscription words and corresponding Elam, Acadian, Sumer, Assyrian-Babylonian words. IYI was assumed to indicate the Sun and according to the above conjecture, the characters on the rays were assumed to indicate the Moon, Mars, Mercury, Jupiter, Venus and Saturn. The union of the characters gave the reading УОНОНКХЕ ШАР САНЪЭХЭ which referred to khan Vonont and its title (Dobrev, 1992; Dobrev, 1994).

Other studies assumed that the characters were rune-like characters (Mihailov, 1995; Ovcharov, 1995).

A further study raised the issue of inconsistencies in different publications, concerning wrong orientations of the hanger loop and of the ray characters. IYI was assumed to be a religious symbol indicating the Sun. The characters on the rays indicated the Sun and the positive gods Venus, Moon, Jupiter and the negative gods Mars, Saturn and Mercury. The correct inscription reading was indicated to be from left to right (Ivanov, 2019).

An attempt to date the rosette, assumed that it was a divination tool. The correspondence characters/zodiacal constellations found was: 1 Sagittarius, 3 Aries, 5 Pisces, 7 Taurus, 9 Scorpius, 11 Virgo, 13 Aquarius and the correspondence characters/planets found was: 2 Mars (red horse), 4 Moon, 6 Sun, 8 Venus, 10 Saturn, 12 Jupiter, 14 Mercury (black horse) (**Figure 1**). The consequent celestial configuration was: Sun in Pisces, Mercury in Aquarius, Venus in Taurus, Mars in Sagittarius, Jupiter in Virgo and Saturn in Scorpius corresponding to the time interval 29th March 1104-13th April 1104 AD or, in relaxed conditions, 10th April 867-15th May 867 AD and three other intervals (Sidorov, 1997; Sidorov & Kelevedzhiev, 2000).

3. The Inscription Reading

The above studies are all very interesting, but no one considered the surprising correspondence between the P-Blg. inscription characters and Linear A (LA), Linear B (LB) characters (Serafimov, 2008). **Figure 1** shows the side of the rosette hosting the hanger loop and the inscription.

In the light of the issues 1), 3) (Vaklinov, 1978), we assumed that:

- The reading starting point is the ray approximately indicated by a straight line crossing the hole in the hanger loop (**Figure 1**). The possible starting point indicated by the upper portion of the character Y of the character IYI, adopted in some of said studies, appears not convincing because said upper portion is located on the rosette side opposed to the inscription side and thus invisible for a reader of the inscription.
- The P-Blg. characters should be seen as the corresponding LA, LB characters are normally seen.

The correspondence between the P-Blg. characters and LA, LB characters has been identified by means of LA, LB grids (Younger, 2017) (**Table 1**). The fact that each one of the 14 P-Blg. characters finds a unique and sure corresponding LA or LB character in said grids confirms that a link existed between the P-Blg. writing and the LA, LB writings.

Because the phonetic value of each corresponding LA, LB character in said grids is known and assuming that each P-Blg. character preserved the same or a similar phonetic value of the corresponding LA, LB character, the phonetic value of each P-Blg. character has been determined (**Table 1**).

In the light of the issues 2), 4), 5) (Vaklinov, 1978), we assumed the following possible reading modes:

1) Clockwise, from the exterior to the interior:

re pi sa a ro no mi di mpu ra pe ti su pi (1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14).

Figure 1. Pliska rosette—P-Blg. inscription characters on the hanger loop side; hanger loop at the centre of the rosette; hanger loop hole indicated in green; IYI character group invisible because on the rosette opposite side; P-Blg. inscription characters; character numbering.

Table 1. Phonetic value identification: P-Blg. Ch N = P-Blg. character numbering; Ph. Value = Phonetic Value; AB 1-92 = AB 1-92 grid identified LB characters, Lin. A Syl. = LA Syllabary grid identified LA characters, Lyn. B Syl. = Conventional LB Syllabary grid identified LB characters, Mel. Syl. = Melena's Full LB Syllabary grid identified LB characters.

P-Blg. Ch N	Ph. Value	AB 1-92	Lin.A Syl.	Lin. B Syl	Mel. Syl.
1	**re**	col. 7, ln2	RE 27??	RE 27	re *27
2	**pi**	col. 9, ln3	PI 39	PI 39	pi *39
3	**sa**	col. 1, ln3	SA 31??		sa *31
4	**a**	col. 4, ln3		*34 unk.	$a_5^{??}$*34/ai/
5	**ro**	col. 2, ln0	RO 2	RO 2	ro *02
6	**no**	col. 2, ln5		NO 52	no *52
7	**mi**	col. 3, ln7		MI 73	
8	**di**		318 DI_2??		
9	**mpu**		$^{m}PU_2$29??		
10	**ra**		RA 60		ra *60
11	**pe**	col. 7, ln2		PE 72	pe *72
12	**ti**	col. 7, ln3		TI 37	ti *37
13	**su**	col. 8, ln5	SU 58	SU 58	su *58
14	**pi**	col. 9, ln3	PI 39	PI 39	pi *39

2) Counter clockwise, from the exterior to the interior:

re pi su pi pe ti mpu ra mi di ro no sa a (1, 2, 13, 14, 11, 12, 9, 10, 7, 8, 5, 6, 3, 4).

3) Clockwise, from the interior to the exterior:

pi re a sa no ro di mi ra mpu ti pe pi su (2, 1, 4, 3, 6, 5, 8, 7, 10, 9, 12, 11, 14, 13).

4) Counter clockwise, from the interior to the exterior:

pi re pi su ti pe ra mpu di mi no ro a sa (2, 1, 14, 13, 12, 11, 10, 9, 8, 7, 6, 5, 4, 3).

5) Clockwise, zigzag:

re pi a sa ro no di mi mpu ra ti pe pi su (1, 2, 4, 3, 5, 6, 8, 7, 9, 10, 12, 11, 13, 14).

6) Counter clockwise, zigzag:

re pi pi su pe ti ra mpu mi di no ro sa a (1, 2, 14, 13, 11, 12, 10, 9, 7, 8, 6, 5, 3, 4).

7) Clockwise, inverted zigzag:

pi re sa a no ro mi di ra mpu pe ti pi su (2, 1, 3, 4, 6, 5, 7, 8, 10, 9, 11, 12, 14, 13).

8) Counter clockwise, inverted zigzag:

pi re pi su ti pe mpu ra di mi ro no a sa (2, 1, 13, 14, 12, 11, 9, 10, 8, 7, 5, 6, 4, 3).

9) Clockwise, ext. circumf. + int. circumf.:

re sa ro mi mpu pe su pi a no di ra ti pi (1, 3, 5, 7, 9, 11, 13, 2, 4, 6, 8, 10, 12, 14).

10) Counter clockwise, ext. circumf. + int. circumf.:

re su pe mpu mi ro sa pi pi ti ra di no a (1, 13, 11, 9, 7, 5, 3, 2, 14, 12, 10, 8, 6, 4).

11) Clockwise, int. circumf. + ext. circumf.:

pi a no di ra ti pi re sa ro mi mpu pe su (2, 4, 6, 8, 10, 12, 14, 1, 3, 5, 7, 9, 11, 13).

12) Counter clockwise, int. circumf + ext. circumf.:

pi pi ti ra di no a re su pe mpu mi ro sa (2, 14, 12, 10, 8, 6, 4, 1, 13, 11, 9, 7, 5, 3).

4. The Inscription Deciphering

The reading mode 9), containing the character groups **resa**, **romi**, **supi**, **dirati**, **pi** having clear substantival and verbal similarities in the today surviving Slavic languages, attracted immediately our attention. Said groups helped to subdivide the inscription in words as follows:

resa romi mpupe supi a no dirati pi

and to decipher the words as follows:

resa: massacre, Bel.: разня, Rus.: резня, Ukr.: різанина;

romi: Romans, Bel. рымляні, Blg. римски, Pol. rzymski, Rus.: римляни, Ser.: римски, Ukr.: римляни;

mpupe: drink, Bel. піць, Mac. Blg. питие, Mac. пијат, Russ.: питьё, Ser.: пиће, Slo. pijača, Slv. pitie, Ukr.: питво;

supi: glum, Bel. супити, Rus. супити, Ser. супити, Ukr. супить,

a no: but, Blg.: но, Mac.: но, Rus.: а, но;

dirati: to resist, to maintain, Blg. да държа, Cro. držati/drži se, Rus. держать/держатся, Ser. держать/држи се, Slo. držati/drži se, Slv. držať;

pi: in, at, Blg.: при, Russ. При.

Wherein: Bel. Belarussian, Blg. Bulgarian, Mac. Macedonian, Pol. Polish, Rus.

Russian, Ukr. Ukrainian, Cro. Croatian, Ser. Serbian, Slo. Slovenian, Slv. Slovakian.

Consequently, the complete inscription deciphering is:

the massacre of the Romans drink glum, but resist at.

Or in loose deciphering:

drink the bitter cup of the Roman massacre glum, but hold on together.

The deciphered words permit to appreciate the archaism of the P-Blg. with respect to the present surviving Slavic languages. The other reading modes do not appears to contain character groups suitable for deciphering.

5. Discussion

At first glance, the strong similarity between LA, LB and P-Blg. characters appears rather strange. In fact, according to the current vision, either LB was created on the Greek Mainland and brought to Crete during the Mycenaean conquest or was adapted from LA on Crete and then brought to the Greek Mainland (Thebe, Mycenae, Miletus), both, however, for use in palace economies in administrative communications. The collapse of the Mycenaean centres (1300-1100 BC) led to the disappearance of LB documents both literary and administrative (Melena, 2014).

However, the similarity of the LA, LB and the inscription writings suggests that LA, LB were known not only in the Aegean Islands and the Greek Mainland but in general also in the Balkans and the Black Sea coasts, and the knowledge survived the influences of Greeks, Romans and Byzantines.

The settlement of the Aegean Islands, the Balkans and Black Sea coasts is complex and not well known. Recently, some authors (Serafimov & Tomezzoli, 2011; Serafimov & Tomezzoli, 2012; Tomezzoli & Serafimov, 2013) challenged the current VI cen. AD theory of the late Slavs arrival in East Europe and highlighted the more ancient Slavs East Europe presence. Therefore, also Slavic populations became aware of the LA, LB characters and evidently adopted them for their languages.

Apparently, there is no attested continuation between LA, LB (18^{th}-12^{th} cen. BC) and P-Blg. (4^{th}-8^{th} cen. AD). In the long period 11^{th} cen. BC-4^{th} cen. AD there is, at least until now, no attested written documents in LA, LB and P-Blg. This absence can be easily explained by observing that said documents were normally current documents not intended for lasting a long time, perhaps, few days, few weeks, some months or some year (Serafimov, 2008). Therefore, perishable support materials like unbacked clay, wood, wood bark and animal hides were largely used by the Mycenaeans and ancient Balkans and the Black Sea Slavs for writing their current documents. Due to the perishable materials limited duration no such document survived. Rarely and in case of relevant information, were the documents written on non-perishable materials like stones and metal objects (Serafimov, 2008).

Note also that it was only by chance, i.e. because of unintentional expositions of their unbaked clay tablets to flames which fire-hardened them and because the inscription was engraved in the rosette bronze which preserved it, that the strong similarity between LA, LB and P-Blg. characters has been revealed.

It could also be possible that LA, LB, Glagolitic and P-Blg. and may be LA, LB characters developed from the much older Vinca characters (Serafimov, 2008). It is also noted that the oldest appearance of the character group IYI is in the 5th millennium BC on Vinca culture potteries (Михайлов, 1987).

The rosette was probably part of a fibula destined, by means of a pin or a brooch to close a mantel, letting in vision the IYI character group on one side but masking the inscription on the side of the hanger loop.

The Romans, mentioned in the inscription, were surely the Byzantines and the massacre, mentioned in the inscription, certainly occurred during the war between the Bulgarians of prince Krum (796/803-814 AD) and the Byzantines of emperor Nikephoros I (802-811 AD), when this last on 20th July 811 sieged Pliska, capital of the First Bulgarian Empire, plundered its treasures and burned it to ground (Wikipedia, 2019). The rosette and the inscription mentioning the massacre would therefore be manufactured after July 811 AD. The inscription asking peoples to resist Byzantines confirms the hypothesis (Vaklinov, 1978) that it was a war call.

6. Conclusion

In our opinion, the relatively easy deciphering and the adherence of the inscription message with a real historical event support also the *a posteriori* hypothesis that a link existed between LA, LB and P-Blg. writings. A further confirmation could arrive from a rosette datation based on radiometric dating methods.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

References

Beshevliev, V. (1981). *Prabylgarski epigrafski pametnici* (p. 23). Sofia. (In Bulgarian)

Dobrev, P. (1992). *Kamennata kniga na prabylgarite* (pp. 91-95). Sofia. (In Bulgarian)

Dobrev, P. (1994). *Svetyt na prabylgarite* (pp. 104-105). Sofia. (In Bulgarian)

Henning, J. (2007). *Catalogue of Archaeological Finds from Pliska*. In *Millennium Studies in the Culture and History of the First Millennium C.E. Post-Roman Towns, Trade and Settlement in Europe and Byzantium* (Vol. 2). Berlin, New York: Walter de Gruyter. https://books.google.de/books?id=3oCI8BVxcB8C&pg=PA671&lpg=PA671&dq=Teofilov+2000;+Ra%C5%A1ev+2003,+165+pliska+rosette&source=bl&ots=MBBO5SBy8v&sig=ACfU3U0M4DTTGLe7OkW2Wussr-sCESlDiw&hl=en&sa=X&ved=2ahUKEwidqITrktPkAhXD2aQKHU0yBXUQ6AEwCnoECAgQAQ#v=onepage&q=Teofilov%202000%3B%20Ra%C5%A1ev%202003%2C%20165%20pliska%20rosette&f=false https://doi.org/10.1515/9783110218831.3.661

Ivanov, I. T. (2019). *Космологични представи на древните българи съгласно бронзовата Розета от Плиска.*

http://сувары.рф/ru/content/kosmologichni-predstavi-na-drevnite-blgari-sglasno-bronzovata-rozeta-ot-pliska

Melena, J. L. (2014). Mycenaean Writing. A Companion to Linear B. Mycenaean Greek Textes and Their World. In D. Dououx, & M. Davies (Ed.), *Bibliothèque des Cahiers de l'Institut de Linguistique de Louvain* (Vol. 3). Peeters: Louvain-la-Neuve.

Михайлов, С. (1987). Към тълкуването на сложния знак IYI и на израза Медното Гумно, Известия на Народния Музей във Варна 23 (28). Книгоиздателство "Георги Бакалов". Варна. (In Bulgarian)

Mihajlov, S. (1995). Kym tylkuvaneto na bronzovata sedmolychna rozeta ot Pliska. *Starobylgaristika, No. 2,* 94-101. (In Bulgarian)

Ovcharov, D. (1995). Otnovo za bronzovata sedmolychna rozeta ot Pliska. *Starobylgaristika, No. 4,* 114-115. (In Bulgarian)

Sachev, E. (1977). Nadpisyt vyrhu bronzovata rozeta ot Pliska. *Vekove, No. 6,* 78-81. (In Bulgarian)

Serafimov, P. (2008). The Origin of the Glagolithic Alphabet. In *Proceedings of the Sixth International Topical Conference on Origin of Europeans* (pp. 99-117). Ljubljana. http://www.korenine.si/zborniki/zbornik08/glagolitic.pdf

Serafimov, P., & Tomezzoli, G. (2011). Evidence of Early Slavic Presence in Minoan Crete. In *Proceedings of the Ninth International Topical Conference on Origin of Europeans* (p. 219). Ljubljana.

Serafimov, P., & Tomezzoli, G. (2012). New Reading of the Linear a Inscription on the Golden Pin CR-ZF-1 from Crete. In *Proceedings of the Tenth International Topical Conference on Origin of Europeans* (p. 83). Ljubljana.

Sidorov, M. (1997). *Blygarianstvoto-religijata na Sedemte* (pp. 97-104). Sofia. (In Bulgarian)

Sidorov, M., & Kelevedzhiev, E. (2000). *An Approach to Dating the Pliska Rosette.* Institute of Mathematics and Informatics at Bulgarian Academy of Sciences. Sofia. http://www.math.bas.bg/~keleved/dplisros

Tomezzoli, G., & Serafimov, P. (2013). The Linear A Inscriptions II.1, II.2 from the Palace of Knossos. In *Proceedings of the Eleventh International Topical Conference on Origin of Europeans* (p. 105). Ljubljana.

Vaklinov, S. (1978). Ein Denkmal Runischen Schrifttums Pliskas. In *Studia in honorem veselin besevliev* (pp. 245-254). Sofia.

Wikipedia (2019). https://en.wikipedia.org/wiki/Krum

Younger, J. (2017). *Linear A & Linear B Grids.* http://www.people.ku.edu/~jyounger/LinearA/ABgrids.html

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The Geochemistry of Intrusive Sediment Sampled from the 1st Century CE Inscribed Ossuaries of James and the Talpiot Tomb, Jerusalem

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Abstract

In 2002 an ossuary of unknown provenance was revealed to the public during a press conference; it is inscribed "*James son of Joseph brother of Jesus*". Because its inscription seems to refer to a member of the Jesus of Nazareth's family, it is natural to wonder what relationship this ossuary could have to the Talpiot tomb. Discovered in 1980 during construction operations in SE Jerusalem, the tomb contained several ossuaries inscribed with names from the Jesus family. In pursuit of physical evidence regarding such a relationship, we investigated the geochemistry of the James ossuary's sediment which accumulated through millennia in its interior. For comparison, we similarly investigated samples of material from ossuaries taken from the Talpiot tomb, and also from a wide sample of ossuaries from other tombs in the Jerusalem area. Our purpose was to answer, if possible, two questions. First, is the chemistry of the inorganic materials (soils) which were flushed into the Talpiot tomb and ossuaries therein distinct from other ossuaries removed from tombs in the Jerusalem area? Second, presuming such a distinction exists, does the geochemistry of the materials from the James ossuary resemble either grouping? While we recognize the controversies surrounding both the origin and inscription of the James ossuary and the interpretation of the Talpiot tomb inscriptions, this geochemical evidence is worth investigation and discussion on its own merits. Employing chemical (ICP, SEM and Pb isotope) analyses we have found, based on chemical data alone, that the ossuary of James is far more similar to ossuaries removed from the Talpiot tomb than it is to any other group of ossuaries we sampled.

Keywords

Jerusalem, Talpiot Tomb, James Ossuary, Eastern Hilltop Tombs, Rendzina Soil, Aluminosilicates, Chrome-Nickel (CrNi), CuPbZn-Heavy Metals, Anthropogenic Pb Contamination, Scatterplots, Pb Isotopes, Statistical Analyses

1. Introduction

Ancient artifacts of unknown provenance are legion, they can be found in museums, private collections and in artifact markets. If not derived from a recorded excavation identifying their provenance can often be problematic. An ossuary inscribed with "*James son of Joseph brother of Jesus*" (**Figure 1**) hereafter referred to as the James ossuary, is just such an artifact. It was revealed to the public at a press conference in 2002. The inscribed ossuary, owned by an antiquities collector, was (ostensibly) purchased in the 1970s from a well known dealer in archaeological artifacts in Jerusalem's Old City. The inscription was authenticated by paleographers Professors Andre Lemaire of the Sorbonne, Paris and Ada Yardeni of the Hebrew University, Jerusalem. Soon after the ossuary's disclosure and while on display from November, 2002 to January 2003 at the Royal Ontario Museum in Toronto, a number of researchers (Ayalon et al., 2004; Silberman & Goren, 2003) announced that the inscription is a forgery. The accusation was later narrowed down to the second "brother of Jesus" portion of the inscription leaving the first "*James son of Joseph*" segment potentially authentic. After a seven year trial and over a hundred testimonies the case was thrown out of court for insufficient evidence to support the claim of a forged inscription and the ossuary was soon returned to its owner.

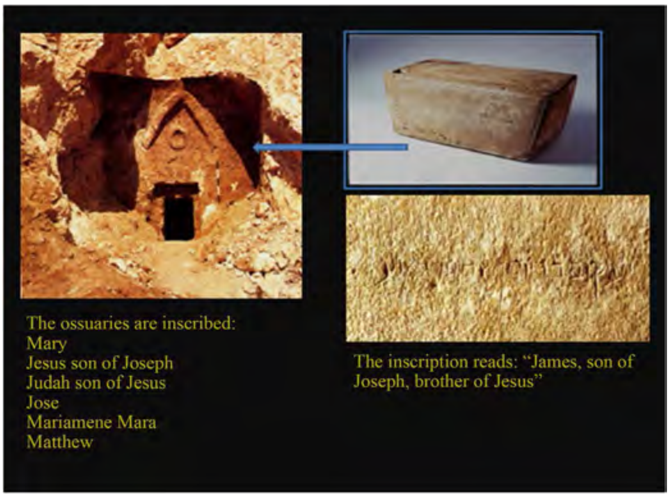
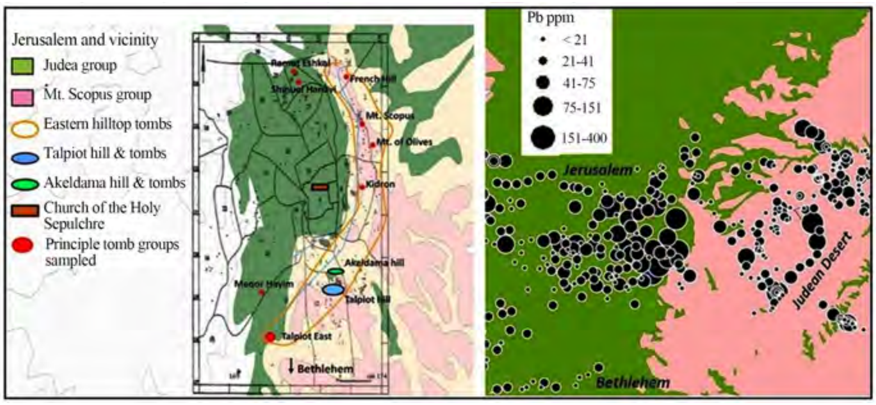


Figure 1. The vestibule and entrance gate leading into the Talpiot tomb after its discovery by construction workers. The blocking stone was missing and the tomb was flooded by over 1/2 m depth of soil. Beneath are names (in English) inscribed on 6 of the 10 ossuaries. The unprovenanced inscribed ossuary of James, and its inscription, are on the right.

The Talpiot tomb was rapidly excavated soon after discovery by the Israel Antiquities Authority (IAA) and "apparently" ten ossuaries were deposited in the IAA collection in the Rockefeller Museum, Jerusalem. The names on the six inscribed ossuaries, five in Aramaic one in Greek, are, in English: Mary, Jesus son of Joseph, Judah son of Jesus, Jose (a brother of Jesus), Mariamene Mara (arguably Maria Magdalena) and Matthew. The first published data on the ossuaries was by Rahmani (Rahmani, 1994) and Kloner (Kloner, 1996), the inscribed names were viewed by the excavators (Kloner & Gibson, 2013) as typical for Roman period Palestine, consequently no attention was paid to the possible significance of the cluster of these names within what is, without any doubt, a 1st century CE tomb located about half way between Jerusalem and Bethlehem.

A Discovery Channel film "The Lost Tomb of Jesus" (Jacobovici, 2007) first suggested a link between the James ossuary and the group of inscribed ossuaries excavated from the Talpiot tomb. Although unprovenanced, the film maker reasoned that the ossuary, inscribed with the name of the oldest brother of Jesus and having made its appearance in a Jerusalem artifact dealer's shop, is the missing 10th ossuary excavated from the Talpiot tomb. The latter disappeared from the IAA collection at some unknown date and under rather mysterious circumstances (Kloner & Gibson, 2013: p. 45). Since the inscription alone does not provide unequivocal evidence of an ossuary's provenance we have sought another means to test this remarkable claim. For this purpose we embarked on a geochemical program of sampling and chemical analyses of soils flushed into the James and Talpiot tomb ossuaries, in addition we sampled a group of random ossuaries from tombs throughout Jerusalem (**Figure 2a**, **Table 1**). We reasoned that the Talpiot tomb ossuaries would produce a chemically identifiable population because a landslide, linked to a major earthquake that struck Jerusalem in 363 CE, dislodged the stone blocking the entrance into the tomb allowing soil and mud to flood the tomb. The excavators reported that when found the ossuaries were covered to a depth of over 0.5 m of soil (Kloner & Gibson, 2013). The absence of stratification in the sediment flooding the tomb and position of the ossuaries in their niches with lids on indicate that flooding occurred in a single short-lived event (Shimron & Shirav, 2015). Unlike the neighboring Patio and other tombs (Tabor & Jacobovici, 2012; **Table 1**) which missed the soil onslaught, the Talpiot tomb, like Pompeii covered with volcanic ash, became almost instantaneously sealed from most additional geological and geochemical processes. The latter affect most tombs by the addition of moisture carrying organic materials, soil, windblown dust and anthropogenic contaminants. Consequently the Talpiot tomb ossuaries were sent on an evolutionary path which differed from ossuaries in other tombs.

A review of the appearance, intrigues and eventually disappearance from most public discourse of the James ossuary can be seen in an article titled "CASHBOX" by journalist Jonathon Gatehouse in MACLEAN'S magazine (dated March 28, 2005). Tabor and Jacobovici (Tabor & Jacobovici, 2012) with considerably more tact and scholarly detail deal with the many challenging and indeed potentially monumental issues regarding the discovery and significance of both the Talpiot and Patio tombs and inscriptions on the ossuaries uncovered therein. We refer the interested readers to articles in the James H. Charlesworth volume titled The Tomb of Jesus and His Family? (Charlesworth, 2013). Here we in particular recommend articles by: 1) J. H. Charlesworth (Introduction: Jerusalem's Tombs during the Time of Jesus, pp. 1-26); 2) C. Pellegrino (The Potential Role of Patina History in Discerning the Removal of Specific Artifacts, pp. 233-243); 3) A. Rosenfeld et al. (On the Authenticity of the James Ossuary and Its Possible Link to the Jesus Family Tomb, pp. 334-352) and 4) M. Elliott and K. Kilty (Who is in the Talpiot Tomb? A Statistical Approach, pp. 355-374). With the exception of the semi-quantitative (SEM) analyses of patina collected from tombs by Pellegrino and Rosenfeld (above) no scientific work has been carried out, before or since the present effort, on the ossuary of James and those removed from the Talpiot tomb. The tomb entrace has for decades been sealed by concrete.



(a) (b)

Figure 2. **(a)** Overview of Jerusalem geology, major sites and tombs sampled. In West Jerusalem the Cretaceous Judea Gp. rocks consist mostly of limestone with lesser amounts of dolomite. In East Jerusalem the overlying Senonian Mt. Scopus Gp. is constructed of chalk with intercallations of flint with rare marl and phosphorite in the upper segment. **(b)** Urban Pb-pollution map. High concentrations of Pb are based on a GSI regional soil sampling program, in addition to Cr and Ni the anomalous area also contains high concentrations of other base and precious metals.

Table 1. List of ossuaries sampled, Israel Antiquities Authority (IAA) ossuary number, materials sampled, name of tomb (where available), Jerusalem city quarter or site.

Specimen (annal.) no.	IAA ossuary no.	Material sampled	Tomb-ossuary inscription	Location Jer. Quarter
Talpiot tomb ossuaries	*inscribed ossuary		Talpiot tomb	Armon Hanatziv
AS 2c	80 - 503*	soil fill	Jesus son of Joseph	"
AS 3c	80 - 504*	soil fill	Jose	"
AS 4c	80 - 502*	soil fill	Matthew	"
AS 5c	80 - 500*	soil fill	Mariamene Mara	"
AS 8c	80 - 508	soil fill		"

Continued

AS 20c	80 - 501*	soil fill	Judah son of Jesus	"
AS 21c	80 - 505*	soil fill	Mary	"
AS 51	James ossuary	soil fill	James son of Joseph brother of Jesus (not provenanced)	
Random ossuaries				
AS 31A	Ossuary 6*	soil fill	Caiaphas tomb	Armon Hanatziv
AS 45	Ossuary 1*	soil fill	"	"
AS 47	Ossuary 7	soil fill	"	"
AS 48	Ossuary 7	int. floor crust	"	"
AS 6c	80 - 512	soil fill		"
AS 11c	69 - 125	int. floor crust		"
AS 13b	69 - 691	dust veneer		Meqor Hayim
AS 18c	68 - 688	int. floor crust		Ramat Eshkol
AS 22a		tomb soil	Shroud tomb	Akeldama hill
AS 22c		hill-slope soil		Akeldama hill
AS 23a		hill-slope soil		Talpiot hill
AS 24a		Composite (int.) sample	Shroud tomb	Akeldama hill
AS 24b		Composite (int.) sample	Shroud tomb	Akeldama hill
AS 25c		soil fill	Patio tomb	Armon Hanatziv
AS 26c		ossuary int. bottom crust	Shroud tomb	Akeldama hill
AS 1a		tomb interior soil	Shroud tomb	Akeldama hill
AS 1b		"	Shroud tomb	Akeldama hill
AS 1c		tomb exterior soil	Shroud tomb	Akeldama hill
***Eastern hilltop tombs*—EHT's**				
	S2576	soil fill		Mt. of Olives
	S2577	soil fill		Mt. of Olives
	S876	soil fill		Kidron valley
	69 - 153	soil fill		Mt. of Offence
	69 - 195	soil fill		Mount Scopus
	69 - 686	soil fill		French Hill
	71 - 429	soil fill		Mount Scopus
	74 - 1502	soil fill		Mount Scopus
	75 - 689	soil fill		Mount Scopus
	80 - 515	soil fill		East Talpiot
	80 - 522	soil fill		East Talpiot
Pt 1		tomb soil	Patio tomb	Armon Hanatziv
L9/2/15		airborne dust-loess		West Jerusalem

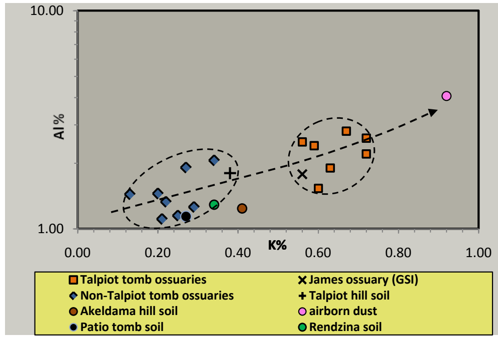
2. Materials and Methods

Table 1 lists the location of tombs and materials sampled and analyzed for the purpose of this study. These include samples of sediment (refered to as soil fill) sampled from ossuaries from the Talpiot tomb, from Random tombs (most from west Jerusalem) and ossuaries removed from tombs excavated into the hills bordering the eastern part of the city (the Eastern hilltop tombs). In addition, for comparison purposes, samples of soil were collected where feasible from the interiors of some tombs in addition from Talpiot and Akeldama hills (details below).

Burial tombs are cave-like features and the ossuaries within potentially act as small caves. Both provide access to water carrying soil and atmospheric pollution consequently, through millennia they are subject to continually varying geological and geochemical change. However ossuaries, such as those recovered from the Talpiot tomb for example, which lay buried beneath a thick layer of soil for ca. 1600 years of their history, will in major part, be sealed from such processes and instead follow a geochemical evolution related to their encapsulating soil. In our attempt at identifying and quantifying a chemical signature that can possibly be linked with the Talpiot, the James and other-random ossuaries we have sampled and studied the chemistry of the sediment flushed into the interior of the nine remaining Talpiot tomb ossuaries and, after its release from the Israeli courts, we sampled the remains of sediment which infiltrated the inscribed ossuary of James. For comparison purposes, ossuaries from some 25 additional tombs throughout Jerusalem were sampled and studied in an identical manner. We refer to the latter two groups of ossuaries as the Random and Eastern hilltop tombs ossuaries (EHT's, Table 1).

Equipped with this chemical data we focus on the following tasks: 1) determining the major and trace element (including Pb-isotopic) chemical composition of materials which invaded the Talpiot tomb ossuaries during almost two millennia of burial; 2) comparing and evaluating these data with chemical data obtained from the Random and EHT ossuaries removed from tombs throughout Jerusalem; and 3) documenting any chemical characteristics (major and chosen trace elements) distinguishing one group from another.

Due to technical issues, sampling of ossuaries and chemical analyses was carried out in three stages between March 2009 and December 2014. Sampling of ossuaries from the EHT group (including tombs from French hill, Mt. of Olives, Mt. Scopus and Talpiot hill in south Jerusalem (also referred to as Hill of Evil Counsel or Armon Hanatziv, Table 1, Figure 2a) was carried out last, it was done especially to compare chemical data from the latter with the data from the Talpiot tomb and Random ossuaries. The above data is finally compared with chemical data from soil sampled from the James ossuary (Figure 3, Figure 4). Samples of representative soils were collected from Talpiot hill (Mt. Scopus group-Pale Rendzina soil, some 100 meters distal from the Talpiot tomb) and from near the Akeldama monastery in East Jerusalem (Akeldama hill, Figure 2a) where numerous burial



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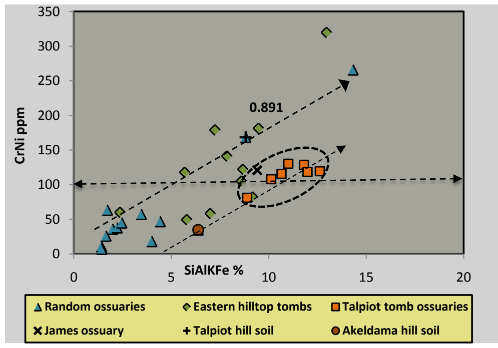

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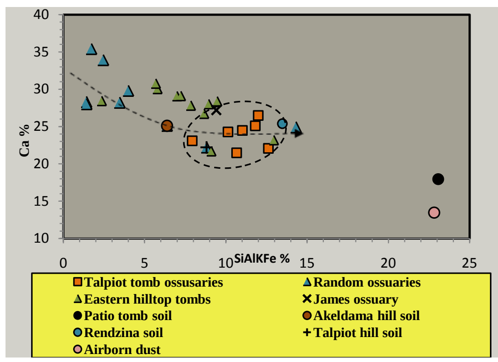
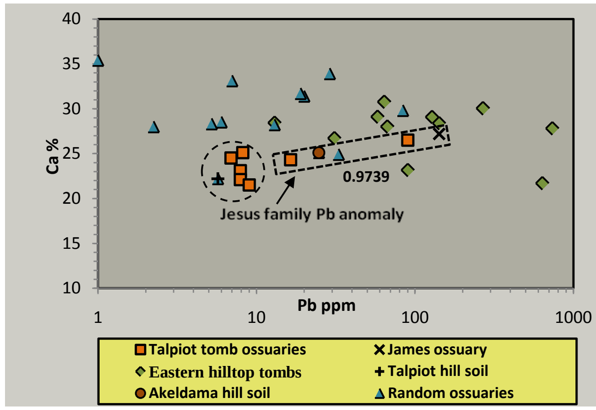


(c)

Figure 3. **(a)** Scatterplot of Al vs. K. The James ossuary, although peripheral (due to its higher Ca content) falls into the well defined TT ossuaries cluster. Soils of the non-Talpiot tomb ossuaries including the Talpiot hill soil and average for Rendzina soils all fit well within a different (lower Al and K) compositional cluster. The chemistry of the airborn dust is entirely outside both these concentrations thus implying foreign sources. **(b)** Scatterplot of CrNi vs. SiAlKFe. A strong positive correlation (R = 0.891) between the two groups of collective variables CrNi and SiAlKFe is seen. The Talpiot hill Pale Rendzina soil is in major part derived directly from, and thus reflects, the underlying chalk-flint bedrock, it contains more Cr and Ni then most other ossuaries we examined. The chemistry of the James ossuary fits well into the TT ossuaries cluster. **(c)** Scatterplot Ca vs. SiAlKFe (combined). The TT ossuaries cluster is well defined on this scatterplot although a few peripherial values from other tombs are also included. There is a very good negative correlation between Ca and the aluminosillicates. The James ossuary is peripheral but within the TT cluster, we can attribute this to the high concentration of bone Ca (see P values in Figure 4c) in the latter. With respect to the aluminosilicates the James and TT ossuaries, the Talpiot hill soil and average for Rendzina soil all fall into the same compositional cluster.

tombs (e.g. the Shroud tomb, Table 1) were excavated into Judea Group limestone. The latter are covered mostly by Brown Rendzina and Terra Rossa soils (Dan et al., 1971; Arkin et al., 1976; Singer, 2007). Talpiot hill was until the 1970's mostly isolated from vehicular traffic and thus petrol Pb contamination, Akeldama hill, on the other hand, was for decades near abundant vehicular traffic and therefore subject to urban contamination.



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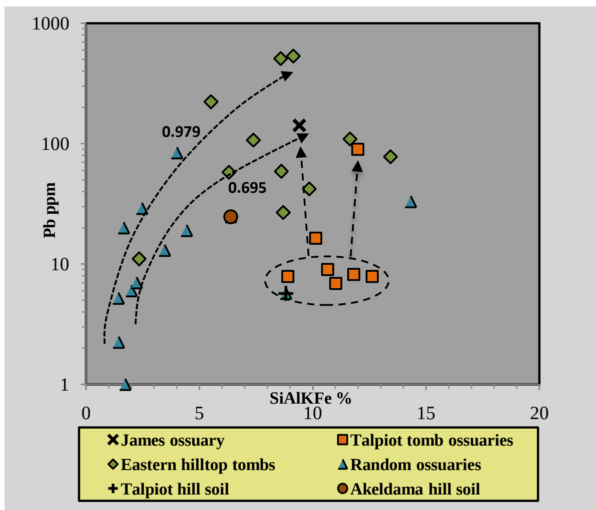

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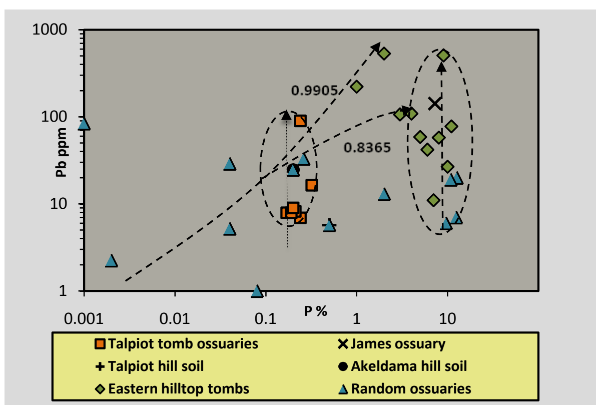

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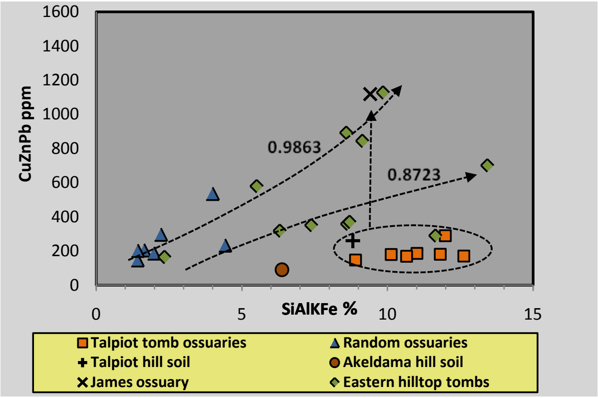


(d)

Figure 4. **(a)** Scatterplot of Ca vs. Pb. The soils inside most of the Talpiot tomb ossuaries (including the Talpiot hill soil), are well characterized by their lower Ca and Pb concentrations from most ossuaries of other tombs. An exceptions is the cluster containing the soil values from the Jesus, Mary and James ossuaries (Pb =16 - 142 ppm) and also including the polluted Akeldama hill soil. The positive correlation between Ca and Pb for the cluster values is defined by Pearson's correlation coefficient (R = 0.9739), such a correlation implies the influence of bone apatite (see Figure 4c). **(b)** Scatterplot of Pb vs. SiAlKFe. The plot exhibits a strong to moderate positive correlation between Pb with SiAlKFe in the Random and EHT ossuaries (two best fit curves R = 0.979 and R = 0.695). Such is not the case for the TT ossuaries. The Pb values for the James, Mary and Jesus ossuaries are probably an exception as they seem to record a different, more complicated story (Figure 4a, Figure 5 and Figure 6). A concentration of 1 ppm Pb in bone is viewed by the WHO as a level of concern, 10 ppm and above as severe poisoning, and in normal soils a Pb concentration above 20 ppm (horizontal arrow above) is viewed as anomalous. It is noteworthy that virtually all soils sampled from the EHT ossuaries carry anomalous concentrations of lead. **(c)** Scatterplot of Pb vs. P. Two best fit trendlines (the lower includes the James ossuary) define two possible positive correlation trends linking Pb with P. Two clusters, one for the TT (including Akeldama hill) soils and the other in the high P range (5% - 12% P) for some Random and most EHT ossuaries, do not show any correlation between Pb and P (bone). The latter values can be attributed to urban polution (Figure 2b). **(d)** Scatterplot for the elements groups CuPbZn vs. SiAlKFe. Two best fit trendlines connecting most Random and EHT values reveal very good positive correlation (R = 0.9863 and R = 0.8723) between the contaminating metals and the aluminosilicates where the metals are concentrated. The Talpiot tomb ossuaries group are an exception as they do not record such a correlation between the polluting metals and soil chemistry (Figure 4b). We emphasise that w*ithout its unique metal contaminants* (1119 *ppm combined metals*) *the James ossuary would fit well within the TT ossuaries group.*

For GSI and Bactochem data major element, and also Sr, Ba and Zr concentrations, were determined by ICP-OES (Perkin Elmer, OPTIMA 3300) after lithium metaborate ($LiBO_2$) fusion using Sc as internal standard. Each analysis run included repeated determinations of four of the international standards NBS-88A, JB-1, SO-3, SCO-1, BHVO-1, and BCR-32. Trace element, including rare earth elements (REE) were determined by ICP-MS (Perkin Elmer, NextION 300D) after sintering with sodium peroxide (Na_2O_2) and dissolution by acid (HNO_3) using Rb and Re as internal standards. Each analysis run included repeated determinations of international standards NBS-88A, JB-1, SO-3 and SCO-1.

The isotopic compositions of Pb were measured using a Nu Plasma MC-ICP-MS instrument. The isotopic mass discriminations of the MC-ICP-MS were corrected by the usage of $^{205/203}$TI ratio and repeated measurements of the SRM-98 standard. The long-term precision of isotopic ratio determinations (2α, relative standard error) was ~0.02‰ for both 206 Pb/204Pb and 207 Pb/204Pb rations, and 0.05‰ for the 208 Pb/204Pb.

For the EHT (Bergen) group of samples between 1 and 4 g of soil was powdered using a ring mill. For loss on ignition (LOI) ca. 3 grams of the powered samples were accurately weighed, transfered into crucible and heated to 1000˚C for two hours in an oven, and then weighed again. During this procedure all volatile components present in the samples (H_2O and CO_2) were removed, and the loss-on-ignition (LOI) was thus calculated. For the major element oxides and trace elements 200 milligram of powder of each of the heated samples was subsequently dissolved in concentrated hydrofluoric acid (HF) in a Teflon beaker. All the major oxides (except SiO_2) and Li were analyzed on an optical ICP instrument (Thermo Scientific ICAP 7600). When dissolving the samples in hydrofluoric acid silicon is lost in the process, hence for determining the SiO_2 concentration glass beads were prepared for XRF-analyses. Each sample (0.96 grams) was mixed with 6.72 grams of lithium tetraborate (Li_2 B_4O_7) as a flux and melted. Glass beads were thus made using a fusion furnace (Claisse, model Fluxy) that was running at around 1000 degrees Celsius for 30 minutes, while steering the samples automatically. The samples were then XRF-analyzed for SiO_2 on a S4 PIONER X-ray spectrometer. Pb-isotopes, the REEs and all the other trace elements (except Li) were analyzed on an ICP-MS instrument (Thermo Scientific Element XR). The international standard BCR-2 was used to calibrate the results, and a solution of Scandium was used as an internal standard. The chemical processing was carried out in a clean-room environment with reagents purified in two-bottle Teflon stills. Samples were dissolved in a mixture of HF and HNO 3. Strontium was separated from the other elements using a Sr-specific ion exchange resin.

SEM examinations were carried out at the Hebrew University Nanolaboratory (The XPS Laboratory Unit for Nanocharacterization, The Harvey M. Krueger Center for Nanoscience and Nanotechnology) in Jerusalem by Dr. Vitaly Gutkin (supervisor of the unit) and AES. Technological analysis was conducted using both a stereomicroscope (magnification: 10 - 40 x) and a scanning electron microscope. The scanning electron microscopy images were obtained using an FEI Quanta 200 ESEM in low-vacuum mode without any preliminary treatment and with a chamber pressure of 0.38 Torr and acceleration voltages of 15 - 20 kV.

Sampling of sediment flushed into the Talpiot and Random tombs ossuaries was carried out by technician Oded Reviv of the IAA and sampling of the James and EHT ossuaries by AES, done in an identical manner. Material was collected using a stainess steel spatula from the little sediment that still remained inside most ossuaries, this was not always possible as many were entirely cleaned out and emptied of all materials in the interior. Occasionally, the little soil remaining on the ossuary floor formed a 1 - 2 cm crust of sediment rubble mixed with degraded bone cemented by carbonate flowstone.

3. Analyses and Findings

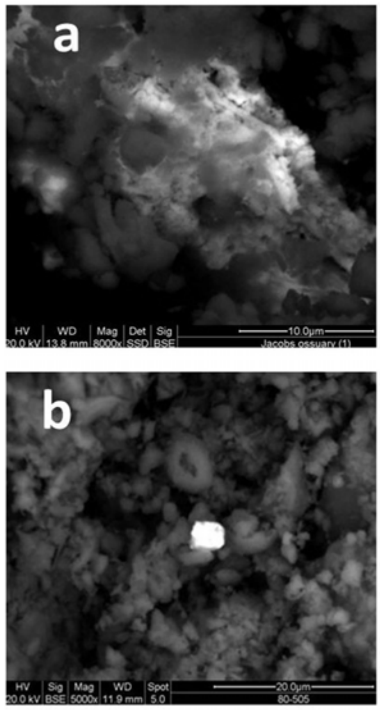
We have studied our chemical analyses (Table 2) and present the data in four ways. First we show a series of chemical element scatterplots (Figures 3a-c) intended to convey the chemical evolution of the major and some minor (Cr, Ni) elements in the three (the Random, the EHT's and Talpiot tomb) groups of ossuaries versus the James ossuary. Second, we focus on lead (Pb, Figures 4a-c) whereby we try to understand its relationship to the chemistry of the host rock followed by examination of anomalous Pb values in the Jesus, Mary and the James ossuaries and try to understand their significance, if such exists. We then focus on the heavy metals Cu, Pb and Zn (Figure 4d, Figure 5a, Figure 5b) and finaly discuss the significance of our Pb isotope data (Figure 6). Next we apply a *likelihood analysis* to some chosen major elements (Figure 7) and finaly perform a factor analysis where, besides the major elements, we pay attention also to some of the trace and rare earth elements (REE's, Figure 8). For technical reasons, we could not obtain chemical data using all methods for every sample for each ossuary.

Table 2. Chemical data from all sources (five Talpiot tomb inscriptions are in Aramaic, the Mariamene Mara in Greek).

BACTOCHEM																				
Talpiot tomb ossuaries			Si	Al	Fe	K	Na	Ca	Mg	Ti	P	Ba	Co	Cr	Cu	Mn	Ni	Pb	Sr	Zn
Sample	Oss. no.	Inscription-location	%	%	%	%	%	%	%	ppm	%	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm
AS 2c	80 - 503	Yeshua bar Yehosef	5.4	2.4	1.74	0.59	0.2	24.3	0.72	1005	0.32	130	7.7	74.9	34.9	206	33	16.4	340	129
AS 3c	80 - 504	Yoseh	4.6	1.53	1.2	0.6	0.21	23.1	0.49	1380	0.17	143	7.4	56	26	223	25	7.9	1180	114
AS 4c	80 - 502	Matyah (Matytyahu)	6.1	2.5	1.85	0.56	0.1	24.5	0.76	661	0.24	115	7.4	87.7	36.5	228	42.5	6.9	359	143
AS 5c	80 - 500	Mariamene Mara	6.34	2.8	2	0.67	0.16	25.1	0.8	956	0.21	143	8.5	88	30	244	40.6	8.2	332	143
AS 8c	80 - 508	no inscription	7.5	2.6	1.8	0.72	0.183	22.1	0.78	946	0.19	172	8.4	79.5	28	241	40	7.9	325	135
AS 20c	80 - 501	Yehuda bar Yeshua	6	2.2	1.74	0.72	0.19	21.5	0.58	858	0.2	151	8.5	78.6	31.4	222	37	9	305	130
AS 21c	80 - 505	Marya	8.24	1.9	1.22	0.63	0.16	26.5	0.4	668	0.24	139	8.2	78	30.7	207	40.5	90	425	170
Random ossuaries																				
AS 6c	80 - 512	Armon Hanatsiv	1	0.2	0.143	0.079	0.69	28.3	0.71	104	0.04	128	1.2	17.8	20.7	26	10.9	5.2	923	121
AS 11c	69 - 125	prob. Jerusalem	2.86	0.55	0.36	0.23	0.2	29.8	0.13	226	0.001	209	2.89	37	31.6	53.6	18.2	84	423	420
AS 18c	68 - 688	Ramat Eshkol	0.98	0.21	0.13	0.11	0.413	28	0.08	76.6	0.002	33	1.1	28	24	16.6	7.21	2.24	308	176
GSI																				
AS 51		James son of Joseph brother of Jesus	5.93	1.78	1.14	0.56	0.49	27.2	0.5	1400	7.24	350	11	100	1119	300	21	142	534	425

Continued

Random ossuaries			Si	Al	Fe	K	Na	Ca	Mg	Ti	P	Ba	Co	Cr	Cu	Mn	Ni	Pb	Sr	Zn		
			%	%	%	%	%	%	%	ppm	%	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm		
AS 31A	Oss. 6	Caiaphas tomb	1.3	0,2	0.15	nd	nd	31.4	0.12	200	12.6	70	1	14	28	25	26	20	386	157		
AS 45	Oss. 1	"	1.58	0.12	0.29	nd	nd	28.5	0.12	200	9.6	160	2	43	1	25	36	6	557	144		
AS 47	Oss. 7	"	3.1	0.84	0.49	nd	nd	31.7	0.18	700	10.8	250	3	61	80	63	47	19	554	134		
AS 48	Oss. 7	"	1.54	0.47	0.21	nd	nd	33.1	0.12	300	12.4	330	2	48	107	24	38	7	629	183		
AS 25c		Patio tomb	8.44	3.36	2.16	0.36	<0.1	24.9	0.6	2600	0.26	215	14	155	74	300	111	33	378	310		
AS 26c		Shroud tomb	1.59	0.49	0.29	0.09	0.21	33.9	0.5	400	0.04	102	2.8	44	39	100	<1	29	410	182		
AS 24a		"	2	0.67	0.46	0.34	0.12	28.2	0.3	325	2.00	69.6	4.3	35	32	84	22.4	13	391	100		
AS 24b		"	1.2	0.21	0.13	0.184	0.067	35.4	0.14	71.8	0.08	20.7	0.7	44.4	11	15	19	1	747	49		
AS 22c		Akeldama hill soil	3.95	1.24	0.78	0.41	0.07	25.1	0.26	309	0.2	58	3.6	23	20	141	12	24.7	132	45.7		
AS 23a		Talpiot hill soil	5.5	1.8	1.13	0.38	0.08	22.2	0.43	354	0.5	92	4.4	118	37.4	125	50.6	5.7	309	217		
BERGEN																					LOI	Total
EHT ossuaries		Location																			%	%
	S 2576	Mt. of Olives	4.08	0.83	0.69	0.19	1.72	30.04	0.60	1000.00	8.59	135	5	33.9	41.3	123.4	15.7	222.3	291.7	316.5	21.62	98.39
	S 2577	Mt. of Olives	5.70	1.11	0.83	0.21	0.01	27.82	1.11	1100.00	0.64	236	10	97.1	73.9	140	44.2	533.3	580.4	237	37.82	96.02
	S 876	Kidron Valley	4.76	1.15	0.84	0.25	0.08	29.08	0.54	1300.00	8.89	199	6	40.8	36.7	137.5	17.5	106.7	330.8	207.5	20.07	96.25
	69 - 153	Mt. of Offence	6.16	1.91	1.13	0.27	0.01	28.39	0.52	1500.00	2.76	159	5	121.5	43.1	163.8	60	109.2	584.6	137.7	30.81	96.76
	69 - 195	Mt. Scopus	6.93	0.90	0.60	0.16	0.08	28.02	0.18	900.00	11.15	66	4	70.2	55.3	49.1	35.1	58.8	337.7	244.7	13.60	96.53
	69 - 686	French Hill	4.63	1.45	0.96	0.20	nd	29.11	0.49	1400.00	0.47	138	13	122.5	34.1	216.6	56.5	42	477.5	1051	37.80	94.93
	71 - 429	Mt. Scopus	1.66	0.35	0.29	0.07	0.22	28.44	0.37	10000.00	12.54	99	2	46.6	26.3	32.2	13.6	11	478	127.1	18.42	92.75
	74 - 1502	Mt. Scopus	3.21	1.44	0.91	0.13	0.09	30.77	0.19	1100.00	13.44	68	5	72	39.6	102.7	45.9	57.7	182	221.6	11.30	96.87
	75 - 689	Mt. Scopus	6.58	1.26	0.98	0.29	0.03	21.70	0.71	1600.00	5.64	276	8	55.2	68.8	148	27.2	508.8	296.8	315.2	25.03	95.07
	80 - 500	Talpiot tomb	8.74	2.48	1.89	0.37	0.01	20.53	0.63	2500.00	0.36	205	19	129	43.6	306.1	58	9.16	387.8	174.8		
	80 - 503	Talpiot tomb	10.54	2.66	1.77	0.39	0.39	23.09	0.71	1400.00	0.5	199	18	106.9	32	296.2	48.9	8.4	401.5	137.4		
	80 - 505	Talpiot tomb	7.63	1.74	1.37	0.31	0.11	22.61	0.45	2000.00	0.22	218	17	112.9	38.3	251.1	48.9	72.2	508.5	191.7		
	80 - 515	East Talpiot	6.15	1.33	0.97	0.22	nd	26.73	0.52	2600.00	10.2	159	6	79.1	69.8	91.4	43.1	26.7	729.3	273.3	15.85	95.51
	80 - 522	East Talpiot	9.13	2.06	1.43	0.34	0.10	23.17	0.72	2500.00	8.59	167	10	206.9	74.1	136.2	112.9	77.6	399.1	550	16.22	95.95
	L 9/2/15	Airborn dust	17.70	4.07	2.94	0.92	0.50	13.48	2.15	4600.00	0.1	445	25	108	46	666	37	16	528	189	23.5	98.47
	Pt 1	Patio tomb soil	20.82	1.14	0.78	0.27	0.02	17.95	0.24	1100.00	0.07	nd	nd	nd	nd	nd	nd	nd	nd	nd	22.32	96.4
	Soil A	Rendzina on chalk	9.37	1.29	2.48	0.34	0.19	25.39	1.56	nd.	0.41	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
	Soil B	Rendzina on marl	18.80	5.94	8.41	1.05	0.63	10.60	1.89	nd.	0.83	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
	Soil C	Terra Rosa-Judea	29.30	9.00	6.08	1.25	0.23	1.23	1.33	0.85	0.05	0.04	31.00	187	32	nd	66	18	129	104	nd	nd



Elem	Wt %	At %
C K	5.48	19.00
O K	12.78	33.25
MgK	0.15	0.26
AlK	1.35	2.08
SiK	3.66	5.42
P K	5.19	6.98
ClK	1.32	1.55
K K	0.69	0.74
CaK	18.95	19.68
FeK	1.67	1.24
PbL	48.75	9.79
Total	100.00	100.00

Elem	Wt %	At %
C K	3.57	19.29
O K	8.41	34.10
MgK	0.18	0.49
AlK	1.03	2.48
SiK	1.66	3.83
CaK	9.55	15.47
FeK	0.78	0.91
PbL	74.81	23.43
Total	100.0	100.00

Figure 5. **(a)** Scanning Electron Microscope (SEM) photograph illustrating James ossuary soil fill contaminated by metallic (white). The lead appears to be assimilated and spread within bone tissue. Bone tissue is indicated by the high P and Ca content. **(b)** SEM photograph showing an isolated fragment of Pb in the soil fill from the Mary ossuary. The lead chip is an isolated, clearly late foreign intrusion, it is detached from the soil matrix. Note that in contrast to (a) there is no detectable P and little Ca in this chemical analysis.

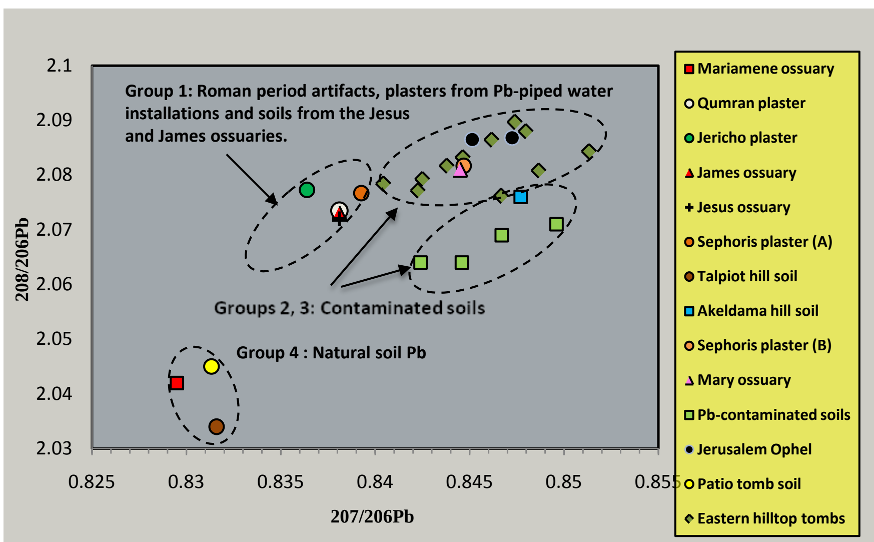


Figure 6. Plot of the isotopes $^{208/206}$Pb vs. $^{207/206}$Pb. Group 1 contains the isotope values for the James and Jesus ossuaries and plasters from Roman period water installations. Group 2 encloses values for soils from the EHT ossuaries, the Mary, one Sepphoris and two Ancient Jerusalem (Ophel) water installations. Group 3 contains values for contaminated soils and Group 4 values for soils from the Mariamene ossuary, Patio tomb and Talpiot hill.

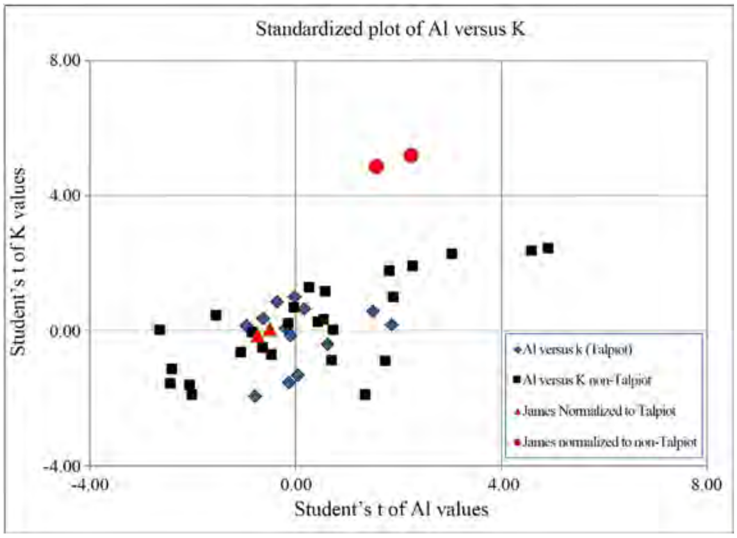


Figure 7. Studentized major element data from all labs. The various symbols represent chemical assays for K and Al from random tombs normalized by their mean and standard deviation; and assays for Talpiot tomb ossuaries normalized similarly. Thus, all plotted data are effectively Student's t deviates—they all plot about the origin and rarely beyond a value of 3.0. The larger symbols represent our two assays from the James ossuary normalized using parameters from these two groups in turn. Note that normalizing by Talpiot tomb mean and standard deviation plots near the center of the diagram, while normalizing by random ossuary mean and standard deviation produces unlikely outliers.

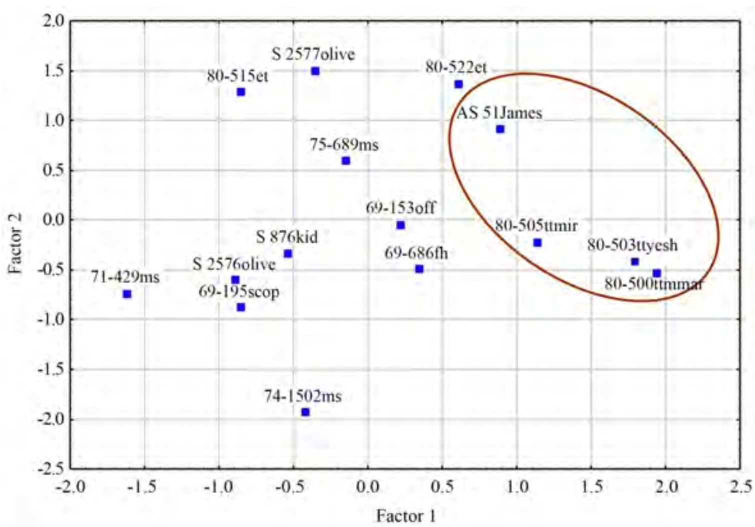


Figure 8. Factor analysis scatterplot. In spite of the wide scatter of points for the TT ossuaries the James ossuary (point AS 51 James) reveals its almost certain affiliation with the Talpiot tomb group. Ossuary 80 - 522 (point 80 - 522 et) was removed from an East Talpiot tomb, it is located about 400 south from the Talpiot tomb in what is an identical geological setting and thus soil of similar compositiom.

3.1. Scatterplots for Selected Major and Trace Element Concentrations

We use scatterplots to display the chemical relationship between two variables each variable representing a set of chemical data (Table 2). Scatterplots demonstrate graphically the presence or absence of a relationship between the variables, correlation between chosen elements may be positive, negative, or null and their strength can be characterized by a best fit trendline and quantified (0 - 1.0) by Pearson's correlation coefficient. For variables we have used either single elements but for some plots we have combined the total concentrations of a number of related elements. For example, we have taken the liberty to combine Cr and Ni and also the heavy metals Cu, Pb and Zn as they collectively manifest important urban pollution characteristics within and around the city of Jerusalem (**Figure 2b**, Shirav et al., 1997). In a similar manner we occasionally use the concentration of the elements Si, Al, K and Fe collectively (refered to as aluminosilicates) since they best represent the clayey and more rarely the siliceous (flinty) soils of Jerusalem.

Jerusalem's geology encompasses the Upper Cretaceous (Cenomanian and Turonian) Judea Gp. limestones with minor dolomite and the Senonian Mt. Scopus Gp. comprised of chalk in the lower and flint with rarely phosphorite in the upper part. The Senonian rocks principally occupy the East Jerusalem hilltops cut along their west margins by the N-S trending Kidron valley (**Figure 2a**, **Figure 2b**). As they are frequently constructed of soft chalk most ancient burial tombs have been carved into these rocks. In West Jerusalem Brown Rendzina and Terra Rossa soils formed above the Judea Gp. limestones whereas covering the East Jerusalem hilltops are mainly Pale Rendzina soils covering the Mt. Scopus chalk and flint units. The former soils are enriched in Mg, Mn, Si and Co, whereas the latter Rendzina soils carry a chemical signature characterized by the elements Zn, Cd, Cr, Ni, U and V among others (Singer, 2007).

In **Figure 3a** we show the relation between the Al and K components in ossuaries' soils. The chemical distinction between the non-Talpiot and Talpiot tomb groups of ossuaries (the latter including the James) is unambiguous. Furthermore, a marked distinction of the TT group of soils (with the James) is shown in the plot for CrNi vs. SiAlKFe (**Figure 3b**). We can probably attribute most of the higher (above the 100 ppm line) concentration of Cr and Ni in most EHT, TT and James ossuaries, including the Talpiot hill soil, to the unique chemical milieu generated by weathering of the Senonian chalk-flint bedrock. **Figure 3c** illustrates the expected negative correlation between Ca (the carbonate fraction of soil) and the combined SiAlKFe (clay) fraction. We note that the James is peripheral, we can attribute this to Ca enrichment attributed to the high bone content of the James ossuary (**Figures 4a-c**).

In **Figure 4a** we show the relationship betwee Ca and Pb. Since the reservoir for natural Pb in soils are the aluminosilicates and Fe-oxides rather than carbonates (Teutsch et al., 2001 and **Figure 4a**, **Figure 4b**) it appears that some of the Pb enrichment can be attributed to other potential lead contributors. One such Pb source is implied by the bone content (note the high P and Ca concentrations in the James) but also anthropogenic contamination caused by urban pollution by petrol Pb, and also metal objects (**Figure 5a**, **Figure 5b**) from workshops and artifacts. Nonetheless, on the basis of published data pertaining to urban contamination of local soils (Teutsch et al., 2001; Erel et al., 1997) we can attribute most of the high Pb concentrations in the EHT's to contamination by anthropogenic Pb contributed to local sediment from leaded petrol fuel. Although the Mary, James and marginally Jesus, ossuaries are enriched in Pb (**Figure 4c**), in contrast, most Talpiot tomb ossuaries, and the Talpiot hill soil, are depleted in the combined metals (**Figure 4d**). We also note that while there is no correlation between the concentration of Pb and P in some Random and most EHT ossuaries (**Figure 4c** vertical arrows) the distribution of data points for some of the Random, EHT and the James ossuaries reveals a moderate to strong positive correlation (R = 0.9905 and R = 0.8365) with P, implying therefore what may be a significant link of Pb with bone.

We studied this rationale further by examining the soil collected from the James ossuary in the Scanning Electron Microscope (SEM). In the photograph (**Figure 5a**) the lead is dispersed throughout bone tissue implying that assimilation of Pb within bone in the James ossuary can be viewed as an ancient phenomenon. In contrast, the Pb fragment (**Figure 5b**) is clearly an isolated, late-introduced contaminant. SEM examination of this and other samples revealed a broad range of such isolated fine chips of metalic Pb, Cu, Fe, PbSnZn (pewter) and Au. Possible sources for Pb contributions into the ossuaries, the James in particular, include: 1) organic lead absorbed by the system ingested as lead acetate with wine and/or 2) Pb introduced as a contaminant in the artifact dealer's shop in Jerusalem's Old City or 3) the home of the artifacts collector where the James resided for some years. Another source 4) may be ceremonial—that is chips detached from jewelry inserted into the ossuary of James, first Bishop of Jerusalem prior to his burial.

3.2. Pb Isotope Analyses

Since the isotopic composition of lead remains unchanged from the original ore into metal during refining, smelting and weathering processes, Pb isotopes are important tools in provenancing ancient materials and artifacts. We determined the Pb isotopes on some of the relevant materials available to us for sampling and study—soil fills from three inscribed Talpiot tomb ossuaries (the Jesus, Mariamene and Mary) and 11 samples from the EHT ossuaries. In addition we analyzed the two samples representing Jerusalem's main soils, the Talpiot hill Pale Rendzina and Akeldama hill Brown Rendzina or Terra Rosa soil. Soil was also collected by a robotic arm from the Patio tomb floor. The latter is located 60 m west of the Talpiot tomb and is an important archaeological site potentially linked to early Christianity (Tabor & Jacobovici, 2012). Because of their relevance we also utilized Pb isotopic values from previous studies, they include data on petrol Pb-contaminated Israeli soils (Teutsch et al., 2001; Erel et al., 1997) and Pb isotope data obtained from hydraulic plasters from installations in ancient Jerusalem, Judean Desert (Qumran), Jericho (Palace of the Kings) and the Sepphoris antiquities site in the Galilee (Shimron, 2003; Shimron, 2018).

A plot of the isotopes $^{208/206}Pb$ vs. $^{207/206}Pb$ (**Table 3** and **Figure 6**) shows a

Table 3. Pb isotope data from all sources.

Bergen (EH tombs)				
Sample	**Area-tomb**	**Material**	**$^{208}Pb/^{207}Pb$**	**$^{207}Pb/^{206}Pb$**
S 2576	Mt. of Olives	ossuary soil	2.0880	0.8480
S 2577	Mt. of Olives	"	2.0897	0.8474
S 876	Wadi Kidron	"	2.0865	0.8462
69 - 153	Mt. of Offence	"	2.0784	0.8404
69 - 195	Mt. Scopus	"	2.0817	0.8438
69 - 686	French Hill	"	2.0808	0.8487
71 - 429	Mt. Scopus	"	2.0762	0.8467
74 - 1502	Mt. Scopus	"	2.0833	0.8446
75 - 689	Mt. Scopus	"	2.0793	0.8425
80 - 515	East Talpiot	"	2.0771	0.8423
80 - 522	East Talpiot	"	2.0843	0.8513
Pt 1	Patio tomb soil	"	2.0450	0.8313
GSI				
Sample	Area-tomb	Material	$^{208}Pb/^{207}Pb$	$^{207}Pb/^{206}Pb$
80 - 500	Talpiot tb.	ossuary soil	2.042	0.8295
80 - 503	Talpiot tb.	"	2.072	0.8381
80 - 505	Talpiot tb.	"	2.081	0.8445
AS 51	James oss.	"	2.073	0.8381
AS 1 - 17	Akeldama soil	hill soil	2.076	0.8477
AS 23	Talpiot hill soil	hill soil	2.034	0.8316
A14a	Jericho	plaster	2.0773	0.83639
Q20a	Qumran	"	2.0735	0.8381
A36a	Sepphoris	"	2.0817	0.84468
A27c	"	"	2.0767	0.83926
Ap6a	Ophel	"	2.0865	0.84514
Ap9b	"	"	2.0868	0.84725
Teutsch (2001)				
Sample		Material	$^{208}Pb/^{207}Pb$	$^{207}Pb/^{206}Pb$
SHO-4-1		humus soil	2.069	0.8467
SHO-4-2		"	2.071	0.8496
SHO-4-3		"	2.064	0.8446
SHO-4-4		"	2.064	0.8424

distribution with four data point concentrations, **Group 1** cluster contains data points for plasters from the Jericho, one of two Sepphoris water installations, it also includes the points for the Jesus and James ossuaries' soils and Qumran water installation. It is remarkable that the soil fills from the Jesus and James ossuaries and plaster from a water installation at the Qumran archaeological site near the Dead Sea (installation No. 49, 85 ppm Pb in plaster (Shimron, 2003) have virtually identical Pb-isotopic values. Such values imply contamination by lead from an (isotopically) identical lead ore and/or an identical Pb-contaminated water source. All these fall well within the field of Pb isotope values obtained from Roman period metal artifacts excavated in Israel (Yahalom Mack et al., 2015) and references therein). **Group 2** cluster contains values for the EHT ossuaries, one of two (an industrial pool) Sepphoris plasters, plasters from two installations in Ancient (Roman period) Jerusalem and values for soil from the Mary ossuary. **Group 3** cluster envelops points for contaminated (including petrol Pb) soils and also values from the Akeldama hill soil (**Figure 4b**, **Figure 4c**). **Group 4** cluster is close to the range of lead from natural soils (Teutsch et al., 2001; Erel et al., 1997). It includes the non-poluted Talpiot hill, the Patio tomb and Mariamene ossuary soils.

3.3. Statistical Analyses of Major Element Assays

A classification problem analogous to provenancing the James ossuary is that of Mosteller and Wallace (Mosteller & Wallace, 1984) determining authorship of the disputed Federalist papers. We have used this analog as guidance in our efforts to use major element assays for classification. Our problem also closely resembles the common forensic problem of identifying the source of a soil or plant residue on a piece of crime evidence. In a recent publication of the Centre for Australian Forensic Soil Science, R. W. Fitzpatrick and M. D. Raven (Fitzpatrick & Raven, 2016) state: "In essence, forensic soil scientists and geologists must determine if there are unique features of soils or geological materials crucial to an investigation that enables these soils to be compared with soils from known locations. To achieve these objectives, there are various approaches, stages and steps for ensuring that this is achieved but there is no 'authoritative scene of crime manual or laboratory methods manual'. The approach and method of each forensic situation has to be taken on its merits according to existing conditions but must involve using standard approaches to record, describe and analysis materials …" Lark and Rawlins (Lark & Rawlins, 2008) have proposed the building of a soils chemical database which would help determine the provenance of soil evidence in a forensic investigation. Specifically they suggested a likelihood function with using elemental profile of the unknown sample compared to known elemental profiles at particular locations.

We have thought about how various groups of ossuaries might become chemically distinct from one another, and then applied methods done in standard ways, to quantify these distinctions. Figure 3 and Figure 4 show that a statistical model should readily distinguish members of the Talpiot group from random ossuaries. The TT ossuaries soil is enriched with Si, Al, Fe, K, Na and Mg when compared to soils taken from our random samples. Using all data from the three laboratories available for the major elements Al, Fe, K, Na and Mg, we first decided on three elements (Al, Fe, and K) exhibiting the largest discriminating factors—statistics indicating the elements having greatest difference between Talpiot and non-Talpiot groups. Using these we built a likelihood model based on a Student's t support function. We calculated parameters of a comprehensive multivariate model which includes estimated correlation among major element assays. We then calculated likelihood ratios of our samples, one each for GSI and Bergen analyses, of James ossuary soil fill material coming from either a Talpiot tomb-like ossuary or an ossuary with chemistry like the random group. Our result is a logarithm (base 10) likelihood of slightly less than to slightly greater than 4 depending on which assays for the James ossuary one chooses for comparison. A likelihood of this magnitude alone suggests our major element assays provide powerful evidence (see Royall, 1997 in regard to likelihood measuring evidence) for a Talpiot classification for the James ossuary. However, a useful example is to illustrate how such evidence should modify one's prior beliefs about membership. In this regard an assumed prior odds of 300:1 in favor of a non-Talpiot classification for the James ossuary, which is approximately the ratio of number of all known ossuaries to Talpiot ossuaries, with a log-likelihood ratio of 4 results in posterior odds above 30:1 favoring a Talpiot designation.

3.4. Factor Analysis

Factor analysis was carried out on log-transformed data of all Bergen University EHT group of soil fill samples analyses (using STATISTICA 12 [Stat soft]), as they are sourced from an identical geological-soil terrain as those from the Talpiot tomb. The analyses focused on the major and trace elements which originate only from the inorganic components of the soil (Si, Al, Fe, K, Na, Ca, Mg, Ti, Ba, Mn, Rb, Y, Zr, Nb, Cs and Hf). The phosphate fraction (bone and rock) and metals (Cu, Pb and Zn), most of which are suspected of having been contributed by pollution, were omitted. The analyses yield 2 factors which account for 89% of the variance. These factors can in major part be explained on the basis of the mineralogy and chemistry of the soil fill samples. They comprise: 1) elements derived from silicates and iron/titanium oxides; and 2) elements sourced by the presence of barite and other heavy minerals. The results, shown in Figure 8 (Table 4), show the plots for the scores of factor I against factor II for the Talpiot tomb samples, samples from the EHT's, three of the Talpiot tomb ossuaries (Jesus, Mary and Mariamene Mara) and the James ossuary. The concentration, although showing a wide scatter, reveals the almost certain affiliation of the James ossuary with the Talpiot tomb.

Table 4. Major, trace element and REE chemical data used for Figure 8.

Sample	Si%	Al%	Fe%	K%	Na%	Ca%	Mg%	Ti%
S 2576 olive	4.08	0.83	0.69	0.19	1.72	30.04	0.60	0.10
S 2577 olive	5.70	1.11	0.83	0.21	0.01	27.82	1.11	0.11
S 876 kid	4.76	1.15	0.84	0.25	0.08	29.08	0.54	0.13
69 - 153 off	6.16	1.91	1.13	0.27	0.01	28.39	0.52	0.15
69 - 195 scop	6.93	0.90	0.60	0.16	0.08	28.02	0.18	0.09
69 - 686 fh	4.63	1.45	0.96	0.20	nd	29.11	0.49	0.14
71 - 429 ms	1.66	0.35	0.29	0.07	0.22	28.44	0.37	1.00
74 - 1502 ms	3.21	1.44	0.91	0.13	0.09	30.77	0.19	0.11
75 - 689 ms	6.58	1.26	0.98	0.29	0.03	21.70	0.71	0.16
80 - 515 et	6.15	1.33	0.97	0.22	nd	26.73	0.52	0.26
80 - 522 et	9.13	2.06	1.43	0.34	0.10	23.17	0.72	0.25
80 - 500 ttmmar	8.74	2.48	1.89	0.37	0.01	20.53	0.63	0.25
80 - 503 ttyesh	10.54	2.66	1.77	0.39	0.39	23.09	0.71	0.14
80 - 505 ttmir	7.63	1.74	1.37	0.31	0.11	22.61	0.45	0.20
AS 51 James	5.93	1.78	1.14	0.56	0.49	27.2	0.5	0.14
Sample	**Bappm**	**Mnppm**	**Rbppm**	**Yppm**	**Zrppm**	**Nbppm**	**Csppm**	**Hfppm**
S 2576 olive	135	104.0	5.50	5.95	17.77	2.50	0.29	0.50
S 2577 olive	236	200.7	12.18	15.14	47.39	6.10	0.69	1.33
S 876 kid	199	171.3	11.32	8.96	nd	4.81	0.57	0.55
69 - 153 off	159	223.1	14.58	17.25	68.94	8.91	0.97	1.91
69 - 195 scop	66	57.46	6.64	11.43	nd	2.59	0.46	0.33
69 - 686 fh	138	257.3	16.71	15.74	77.58	9.15	1.02	2.16
71 - 429 ms	99	38.32	2.23	4.49	nd	1.05	0.20	0.14
74 - 1502 ms	68	116.0	10.07	13.15	32.47	4.48	0.70	0.90
75 - 689 ms	276	193.1	14.10	11.58	36.54	6.07	0.74	1.02
80 - 515 et	159	109.2	8.83	12.42	28.36	4.66	0.46	0.65
80 - 522 et	167	164.7	16.46	27.83	52.68	7.02	1.04	1.43
80 - 500 ttmmar	205	421.4	26.92	25.11	126.4	16.39	1.38	3.49
80 - 503 ttyesh	199	400.6	25.16	24.42	131.8	15.42	0.98	3.66
80 - 505 ttmir	218	345.0	18.38	22.22	104.0	13.14	1.03	2.93
AS 51 James	350	353.1	18.76	11.17	nd	5.63	0.97	0.98

4. Discussion

Prior to discovery the Talpiot tomb ossuaries were completely buried by East Jerusalem's soils for some 1600 years. During this time some of the encapsulating soil invaded the ossuaries. Yet, in spite of being subtly modified by invasive dust, for most elements the chemical composition of the covering soil and that which invaded the ossuaries falls into well-defined compositional clusters implying a common geochemical history. In contrast, soils collected from random ossuaries throughout Jerusalem, including from geological terrain identical to the TT cluster (the EHT group), differ chemically while showing a broad spread in compositional values in addition to extensive anthropogenic contamination. Specifically, Pb-isotopes for soil fills from most EHT, Akeldama hill, and perhaps including the Mary, ossuaries fall into a compositional cluster indicative of lead contributed from what was probably a common anthropogenic (urban and Alkyl-Pb) source. The latter is well exhibited on the Jerusalem soil map; this resembles a mushroom-like shape of toxic fallout with concentrations of Pb (and other metals) in soils frequently in the range 40 - 380 ppm (**Figure 2b**). In addition, Pb-isotopic data (**Figure 6**) also provide evidence that occupants of some of the TT ossuaries may have consumed Pb-polluted water from identical sources such as the Pb-lined plumbing system in Roman-period Sepphoris and/or from Pb-enriched water sources elsewhere (e.g. Qumran).

While **Figure 8** shows especially that various groups of ossuaries form a distinct population based on chemistry, it also shows a substantial scatter around a central measure. What is the source of this scatter? First, the analytical uncertainties of methods and equipment employed in the laboratories (<1%) is miniscule compared to the observed scatter. Thus, we conclude that the major source of uncertainty is that underlying the samples themselves magnified by sampling methods. For example, within the Talpiot tomb the sediment covering its ossuaries was not necessarily homogeneous being as it was a landslide mixed combination of soils, chalk, flint and marl. Each Talpiot tomb ossuary found itself covered by a broadly consistent material with a unique local (Talpiot hill) recipe. Among the Random ossuaries collected from many tombs airborne particles, and even airborne contaminants such as Alkyl-lead, are not necessarily identical from tomb to tomb due to location or construction. Moreover, the chalk and limestone comprising the ossuaries themselves may have come from various unique sources. Finally, when sediment fill had become cemented in some ossuaries, particularly in the Random group, the scraping needed to collect a sample probably contributed to some enrichment in Ca from the chalk, cementing flowstone and P from degrading bone accompanied by a decrease in clay-derived elements from dilution. Nonetheless, we have successfully demonstrated at first identifying physical mechanisms by which artifacts would evolve chemically along unique paths; and, then demonstrating that these expectations were borne out by chemical analyses. Perhaps this combination of broad geological considerations with analytical chemistry is a useful model to employ in the study of artifacts in general.

5. Conclusion

Of our stated objectives we conclude the following: First, the chemistry of the inorganic materials (mostly soils) which were flushed into the Talpiot tomb and ossuaries it held are distinct from other ossuaries removed from tombs in the Jerusalem area. Second, having evidence of the distinct chemistry of these soils, we have shown in several ways—factor analysis, likelihood analysis of major elements assays, isotope analysis, and through analysis of chemistry scatter-plots—a remarkable similarity between chemistry of the James ossuary and the Talpiot tomb group. One obvious conclusion is that the James ossuary is likely a member of the Talpiot group. However, being aware of the controversy surrounding both this tomb and this ossuary, we must suggest other possible explanations for this similarity. Two come to mind, which we can easily address.

The James ossuary may have obtained its chemistry in the courtyard of the antiquities dealer or even home of the antiquities collector, and this chemistry is *by chance* similar to that of the Talpiot tomb. We have no chemical data regarding the chemistry of airborn dusts in the Jerusalem area over the long-term, but we have analyzed a sample of such dust one of us (AES) collected after a major dust storm which struck the country in September 2015 (**Figure 3c**, **Table 2**).

We found that this desert airborn dust is enriched in Si, Al, K, Fe and Mg and much impoverished in Ca relative to the Talpiot tomb, the James, all other ossuaries and most Jerusalem soils in general (**Figure 3c**). Although showing some chemical similarity with the silicic flint-rich soil from the Patio tomb, it bears no resemblance to the chemistry of either the Talpiot tomb or to any soils from the Jerusalem area.

Another possible explanation is that the James ossuary actually belongs to the group of Random ossuaries and simply represents an outlier in their typical chemistry. Putting this possibility to test was our rationale for the *likelihood analysis* above. For this explanation to hold requires not only an outlier status for the James ossuary, but one that happens to map in the heart of the Talpiot group. The likelihood ratio argues strongly against such a coincidental occurrence.

A third possible explanation is more difficult to address. One might speculate that the James ossuary came from some yet unconsidered tomb with a disturbed environment, that is, a tomb breached with soils diluted with marl from the Talpiot hill. We know of no other such tomb except the Talpiot, but of such an alternative we can only conclude that time will tell.

Finally, we have shown that detailed chemical analyses of soils sampled from ossuaries can, within limits, be useful in provenancing such artifacts. Our conclusions are made possible here by the incidental coalescence of a number of geological phenomena: 1) the unique chalk-chert geochemistry of East Jerusalem's bedrock; 2) a powerful earthquake which shook the region in antiquity; and 3) the generation of tectonic slides one of which caused flooding and burial with soil of the Talpiot tomb and ossuaries therein. It is remarkable that the ossuary of James, which must have followed a different evolutionary path for the latter 30 years of its existence, and in spite of the considerable contamination therein with metallic fragments, still manifests a unique geochemical signature consistent with the chemistry of other Talpiot tomb ossuaries.

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Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

References

Arkin, Y. et al. (1976). *Geological Map of Israel: Jerusalem and Vicinity. Geological Survey of Israel.*

Ayalon, A., Bar-Matthews, M., & Goren, Y. (2004). Authenticity Examination of the Inscription on the Ossuary Attributed to James, Brother of Jesus. *Journal of Archaeological Science, 31,* 1185-1189. https://doi.org/10.1016/j.jas.2004.03.001

Charlesworth, J. H. (2013). *Editor: The Tomb of Jesus and His Family? Exploring Ancient Jewish Tombs near Jerusalem's Walls.* Cambridge: William B. Eerdmanns Publishing Co. Grand Rapids Michigan.

Dan, J., Koyumdjisky, Y., Raz, Z., & Yaalon, D. H. (1971). *Map of Israel Soil Associations.* Jerusalem: Carta.

Erel, Y., Veron, A., & Halicz, L. (1997). Tracing the Transport of Anthropogenic Lead in the Atmosphere and in Soils Using Isotopic Data. *Geochimica et Cosmochimica Acta, 61,* 4495-4505. https://doi.org/10.1016/S0016-7037(97)00353-0

Fitzpatrick, R. W., & Raven, M. D. (2016). *Forensic Investigations, Centre for Australian Forensic Soil Science Report CAFSS_076 (Version 10.1) February 1, 2016.*

Jacobovici, S. (2007). *The Lost Tomb of Jesus.* Discovery Channel.

Kloner, A. (1996). A Tomb with Inscribed Ossuaries in East Talpiyot, Jerusalem. *Atiqot, 29,* 15-22.

Kloner, A., & Gibson, S. (2013). The Talpiot Tomb Reconsidered: The Archaeological Facts. In J. H. Charlesworth (Ed.), *The Tomb of Jesus and His Family? Exploring Ancient Jewish Tombs near Jerusalem's Walls* (pp. 29-75). Cambridge: William B. Eerdmanns Publishing Co. Grand Rapids Michigan.

Lark, R. M., & Rawlins, B. G. (2008). Can We Predict the Provenance of a Soil Sample for Forensic Purposes by Reference to a Spatial Database? *European Journal of Soil Science, 59,* 1000-1006. https://doi.org/10.1111/j.1365-2389.2008.01064.x

Mosteller, C. F., & Wallace, D. (1984). *Applied Bayesian and Classical Inference: The Case of the Federalist Papers*. Berlin: Springer-Verlag. https://doi.org/10.1007/978-1-4612-5256-6

Rahmani, L. Y. (1994). *A Catalogue of Jewish Ossuaries in the Collections of the State of Israel* (pp. 222-224). Jerusalem: Israel Antiquities Authority.

Royall, R. (1997). *Statistical Evidence: A Likelihood Paradigm*. London: Chapman and Hall.

Shimron, A. E. (2003). An Archaeometric Study of Plasters from the Qumran Water Installations. In K. Qumran, & A. Feshkha (Eds.), *Studies of Anthropology, Physics and Chemistry* (pp. 321-337). Academic Press Fribourg, Vandenhoeck & Ruprecht Gottingen.

Shimron, A. E. (2018). Geochemical Investigations of Sepphoris Plasters. In E. M. Meyers, C. L. Meyers, & B. D. Gordon (Eds.), *The Architecture, Stratigraphy and Artifacts of the Western Summit of Sepphoris* (Chapter 15, pp. 476-481). Duke University Excavation Reports, University Park, PA: Eisenbraums.

Shimron, A. E., & Shirav, M. (2015). The Armon Hanatziv Tectonic Slide and Some Archaeological Implications. *New Studies on Jerusalem, 20,* 7-16.

Shirav, M., Wolfson, N., Ilani, S., & Halicz, L. (1997). A Tale of Two Cities—Urban Geochemistry of Jerusalem and Haifa. Geochemical Exploration. In *18th International Geochemical Exploration Symposium* (p. 40), Jerusalem, Israel, 25-30 May 1997.

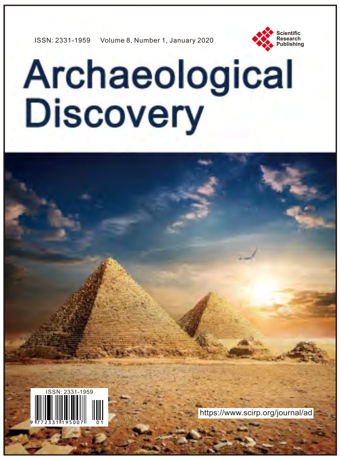
Silberman, N. A., & Goren, Y. (2003). *Faking Biblical History* (pp. 20-30). Archaeology, September/October.

Singer, A. (2007). *The Soils of Israel*. Berlin: Springer Science and Business Media.

Tabor, J. D., & Jacobovici, S. (2012). *The Jesus Discovery*. New York: Simon and Schuster.

Teutsch, N., Erel, Y., Halicz, L., & Banin, A. (2001). Distribution of Natural and Anthropogenic Lead in Mediterranean Soils. *Geochimica et Cosmochimica Acta, 65,* 2853-2863. https://doi.org/10.1016/S0016-7037(01)00607-X

Yahalom Mack, N., Langgut, D., Dvir, O., Tirosh, O., Eliahu-Behar, A., Erel, Y., Langford, B., Frumkin, A., Ullman, A., & Davidovich, U. (2015). The Earliest Lead Object in the Levant. *PLoS ONE, 10,* e0142948. https://doi.org/10.1371/journal.pone.0142948



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