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Importing Clay for Local Pottery Production in the 4th Century B.C. at Tell el-Timai, Egypt

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ABSTRACT
Archaeological evidence of ceramic production most commonly consists of locally procured raw materials. Excavations at Tell el-Timai in Lower Egypt recovered raw fine marl clay from two transport jars in the vicinity of pottery kilns dating to the 4th century B.C. Production wasters of small perfume bottles produced in the same fine marl clay were found inside the kilns. The marl clay inside the jars pointed to an origin outside of Lower Egypt. Samples of the clay and wasters, along with a confirmed locally sourced sample, were subjected to X-Ray Fluourescence (XRF) analysis, revealing significant differences in their chemical compositions. The results of the analysis are compared to published Egyptian data and an Upper Egyptian provenience is suggested because the raw clay is consistent with available comparative XRF data.

KEYWORDS
Pottery production; perfume; clay; XRF; Egypt

In 2010, the University of Hawaii excavations led by Drs. Robert Littman and Jay Silverstein made an extraordinary discovery of two imported amphoras containing raw, fine clay at the site of Tell el-Timai, ancient Thmuis, in the central Nile delta (FIGURE 1). During that same season, the excavation team uncovered evidence for the production of small perfume bottles made of a high-quality, fine-grained clay in kiln contexts dating to the 4th century B.C. (Hudson 2014a, 2014b). Post-excavation analysis suggested a link between the raw clay from the transport jars and the fine perfume bottles. X-Ray Fluorescence (XRF) analysis of both the raw clay and the fine bottles, which was subsequently performed in 2011, revealed a common chemical signature, arguably affirming the link. This article presents the archaeological contexts of the discoveries of the raw clay and the fired fine bottles, and discusses the typological and chemical analyses. Our goal is to identify a possible source for the raw clay that is consistent with marl clays in Upper Egypt. Because Egyptian clays are roughly grouped into two families—Nile silts and desert marls, where Nile silts are confined to the Nile valley and marls are found either at the edges of or beyond the valley—the presence of ceramic production using marls at Tell el-Timai in the central Nile delta may shed light on exotic raw material procurement patterns in the 4th century B.C. This report presents the first archaeological evidence of long-distance transport of raw materials for ceramic production in Egypt.

Globally, the phenomenon of transporting clay over long distances to local pottery workshops is not unique, though it is unusual. Potters typically obtain raw materials for production from easily accessible and nearby sources. Scholars have long agreed that most workshops use locally sourced clay, from clay sources that are seldom further than a few kilometers from workshops and kilns (Arnold 1985: 39–44, 54–55; Rice 1987: 115–118). Bishop and colleagues (1982: 317) identify five possible clay procurement patterns for ceramic production: nondiscriminating (clays procured without concern of origin), discriminating (selective procurement from a preferred source), specializing (different clays procured to suite to vessel function), compounding (mixing clays to achieve desired qualities), and importing (securing clays over long distance) strategies. In ancient contexts, scholars most often assume a discriminating strategy, in which local potters exploit a single clay source for production. An ancient example of this, albeit at a much larger scale than at Tell el-Timai, can be found in the extensive workshops of Roman North Africa, where the enormous quantities of pottery produced at the workshops were exported throughout the Mediterranean. These workshops, essentially confined to the area of modern Tunisia, could each produce fine table ware (African Red Slip Ware), cooking vessels (African Cook Ware), and transport amphoras (such as Africana Piccolo 1). While some workshops specialized in one category or another, other centers could produce two or all three of the functional classes of pottery. In cases where workshops produced different types of ceramic wares, they were still exploiting only a single source of clay. The potters would prepare the clay specifically to achieve the desired physical properties for table, cooking, or transport vessels (Leitch 2011).

An inversion of the multipurpose local clay model is more rarely observed. Potters can make use of exotic clays to make special vessels that differ from the local ceramic repertoire. A modern example of this is the case of the Amphlett Islanders in Melanesia. The Amphlett potters travel long distances to acquire a special, fine-quality clay for the express purpose of making a particular class of vessels. Thus, the Amphlett Islanders follow Bishop and colleagues' (1982) specializing and importing strategies. By cultural convention, the special vessels made by the Amphlett potters can only be made from the fine clay collected from that specific source (Lauer 1970: 165–166). Within Egypt, a modern example of transporting clay is provided by the traditional potters at Aswan who import clay from the Luxor/Esna area, preferring that clay's handling properties over the local kaolinitic clay (Peloschek 2015: 6).

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Archaeological evidence of transporting clay over long distances in pre-modern Egypt, on the other hand, has been lacking to date. John Boardman (1956, 1986) has suggested that raw clay was imported to Naukratis from Chios, though solid proof has yet to surface. To our knowledge, the raw clay and the associated class of fine perfume bottles found in 4th century contexts at Tell el-Timai represent unique evidence of an ancient example of long-distance clay procurement for local ceramic production. Like the Amphlett Islanders, the potters at Tell el-Timai appear to have limited the use of this special clay to a single class of vessel, incorporating Bishop and colleagues' (1982) importing and specializing strategies.

Small, Fine Bottles

Excavations by the University of Hawaii team in the northern spur of the tell in 2009 and 2010 uncovered a series of kilns located in area O7 (FIGURE 1). While the best-preserved examples of the kilns date to the Hellenistic period, excavations exposed remnants of earlier kilns dating to pre-Ptolemaic 4th century B.C. directly beneath the 3rd century Hellenistic kilns. The earliest kiln context produced a small cache of pottery, neatly stacked as if for firing (Hudson 2014a). The shape range of these vessels conforms to Egyptian ceramic types of the 5th–4th centuries B.C. The presence of a small sherd of an Attic Red Figure bell krater helps

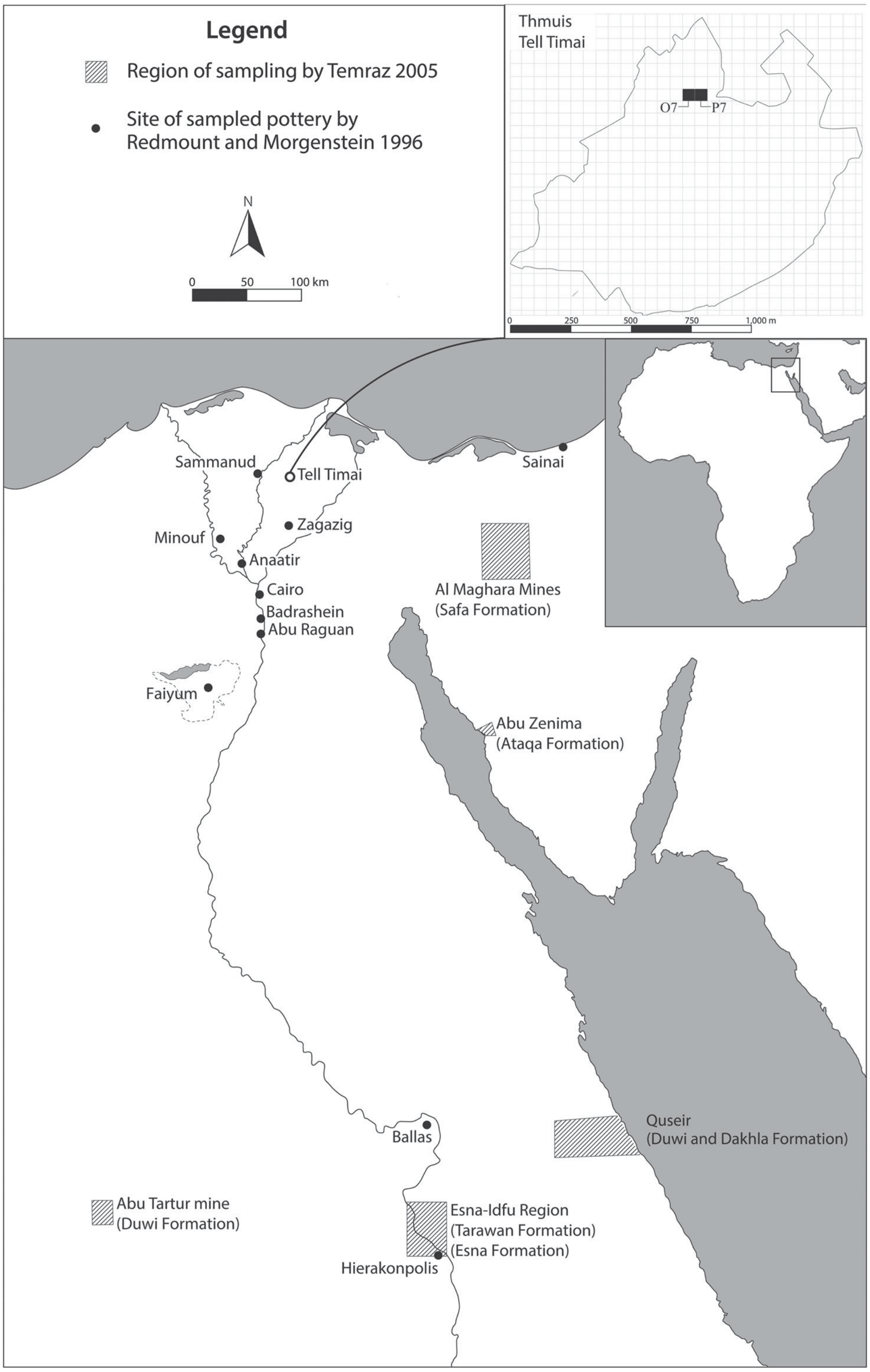


Figure 1. Map of Egypt with names of places and regions referenced in this article. Inset of the site plan of Tell el-Timai with overlay excavation grid.

narrow the date range for the context. Based on the style and composition of the figures that survive, the Attic sherd likely dates to the first half of the 4th century B.C. (Hudson 2014a: catalogue no. 1). The presence of the sherd dates the context firmly to the 4th century B.C. Given the sherd's poor state of preservation, especially in comparison to the rest of the pottery in the context—which includes intact, wholly mendable, and otherwise well-preserved vessels—it is likely that the Attic fragment is residual. This has led Hudson (2014a: 242) to suggest a date for the context in the second half of the 4th century B.C., though a less constricted dating scheme open to the entirety of the 4th century is possible.

Among the vessels recovered from the lower kiln contexts was a class of small, thin-walled bottles. The bottles, of a distinct squat shape and made of a very fine clay (FIGURE 2A–R, V), stood out in the assemblage because of their physical qualities. They also drew attention because of how many were found in the small archaeological feature: eighteen sherds representing a minimum of fifteen individual vessels. The initial assumption was that the small bottles were produced elsewhere in Egypt and imported to Tell el-Timai. This was in part because the clay used to make the bottles was a fine, densely packed marl that is markedly different from the local Nile silt used for Tell el-Timai ceramic production (Hudson 2014a, 2014b). The term "Nile silt" is used here because it is the convention in ceramic studies in Egypt. The term refers to the alluvial sediments found throughout the Nile delta and valley (Arnold and Bourriau 1993: ch. 4). In addition to the obvious fabric differences between local Nile silt and the fine marl bottles, the marl bottles are also more carefully finished, with clear indications of tooling and burnishing, which is otherwise absent from the local production traditions at Tell el-Timai. Despite the apparent indicators that the marl bottles were imported to the site, close inspection of the bottles revealed that at least one waster was among the eighteen surviving sherds. The waster consisted of a whole base whose floor had warped and cracked during firing, leaving an open gap. The gap would have

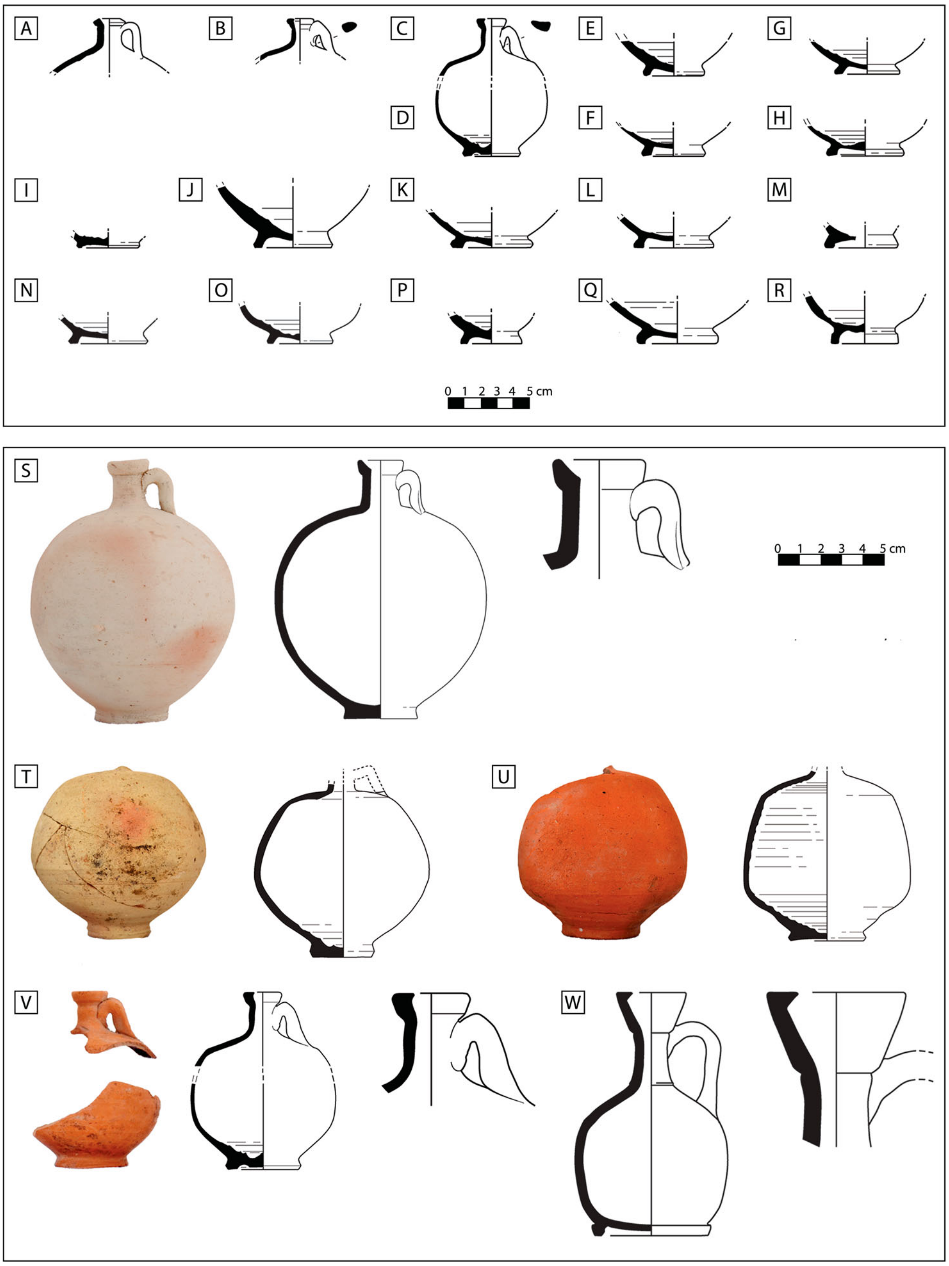


Figure 2. A–R, V) Small fine bottles from kilns in Area O7; S–U) Marl and Nile silt small bottles from Tell el-Timai; W) example of an Attic squat lekythos after Redmount and Friedman (1997: fig. 10).

rendered the bottle useless as a container for liquids. Rather than arriving at Tell el-Timai as an empty bottle, it is more likely that the small bottle belongs to the ceramic production in the kiln context where it was found.

The small, fine bottles also fit within the local ceramic typology. Later 5th and 4th century contexts at Tell el-Timai have yielded both marl and Nile silt versions of the bottles (in more common marl [FIGURE 2S–T] and in local Nile silt [FIGURE 2U]). Local Nile silt versions were found in the same kiln context where the fine versions were found (Hudson 2014a: catalogue nos. 36–43). Due to the differences in their physical characteristics, the relatively coarse Nile silt versions of the bottles cannot be confused with their finer counterparts. The discovery of a high quality version of the small bottles (the marl) produced alongside a lower quality version (the Nile silt) of the same type is worth noting. Different uses or purposes of the small bottles may have been intended, based on the differing qualities made in the single production center. It is clear that the finer version was produced in limited quantities. Only four additional sherds belonging to small bottles in the same fine clay were identified in the approximately eight metric tons of pottery processed between 2010 and 2013. All of the sherds belong to another 4th century B.C. context, suggesting a limited chronological range for the ware (Hudson 2016: assemblage 2). As a point of contrast, local Nile silt versions have proven to be relatively common in 4th and early 3rd century contexts, illustrating the exceptional (and perhaps culturally significant) nature of the fine clay parallel productions at Tell el-Timai. Furthermore, the small bottles are the only shape also produced in the fine clay. The reason why no other types of vessels were made of the fine clay is not immediately obvious, though a possible explanation is offered in our discussion below.

The small bottles are distinct in shape with specific typological features that may be chronological markers. The bottles belong to a class of small bulbous bottles found in the broader Egyptian ceramic assemblage of the 6th through early 4th centuries B.C. Examples of this class of bottles are readily found at Tell el-Timai. Notable examples come from a cache of small cosmetics vessels that included five small bottles dating from the mid-5th to mid-4th century B.C. (Hudson 2016: assemblage 1, nos. 12–16). All the examples in the cache are soft, whitish marl clay that is noticeably coarser and lighter in color than the fine bottles from the kiln context (FIGURE 2S, V). Similar marl perfume bottles are present in the kiln contexts of Area O7 (FIGURE 2T), but are easily distinguished from the fine bottles by ware and typological features. A small, stumpy, string-cut foot is a typological marker for this class of bottle, which has parallels throughout much of Egypt and the southern Levant: for example, Tell el-Herr, generally 4th-1st century B.C. (Gratien and Soulié 1988: fig. 6g); Mendes, "Late Period" (Wilson 1982: fig. XVIII.6); Tell el-Maskhuta, ca. 486 B.C. (Holladay 1982: fig. 27.10); Saqqara, 4th century B.C. (French and Ghaly 1991: catalogue no. 38); Thebes, 4th–2nd centuries B.C. (Schreiber 2003: catalogue nos. 60–65); and Tell el-Hesi, late Persian period (Bennett and Blakely 1989: fig. 161.25). These bottles have a squat, bulbous body that has a tendency to sag in the lower half. A short, narrow neck terminates with a slightly offset rim with an inwardly beveled lip (FIGURE 2S). A small pinched handle is attached just below the rim and connected to the shoulder.

The small bottles from the second half of the 4th century B.C. kiln context include certain typological changes that can be described with reference to Greek pottery. In place of a solid, stumpy, string-cut foot, the base is a carefully pared ring foot that is splayed outward (FIGURE 2E–R). The other significant change is to the rim, which is now cup-like with an inset lip (FIGURE 2B–C, T). One example of the fine clay bottle was observed with an inwardly beveled lip (FIGURE 2A). All other surviving rims have the inset lip. Six examples of Nile silt version with inset lips were found in the same kiln context (Hudson 2014a). If the date for the kiln context can be pushed to the second half of the 4th century B.C., then perhaps rim treatment for the bottles can be seen as a chronological marker. The single example of the beveled rim bottle in the context would be a lingering pre-mid-4th century example of the type and the six inset lip versions represent the post-mid-4th century development.

The changes to the bases and rims of the fine bottles present two typological features that are divergences from the Egyptian models that precede them. The date of the find context for the new versions of the small bottles places their development in a politically and culturally dynamic period of Egyptian history. The second half of the 4th century saw the fall of the 30th Dynasty to the returning Persian forces, which were then ousted by the Greek armies led by Alexander the Great. The historical circumstances of this half-century justify looking to Greek pottery as a possible influence for the changes made to the small perfume bottles. The rim treatment, in particular, is reminiscent of Athenian squat lekythoi (FIGURE 2W), which may well have provided an inspiration for the Thmuisian form.

Like the Athenian squat lekythoi they resemble, the Thmuisian bottles are best suited to be oil containers, likely for oil-based perfumes. Their small size and the inset lip to catch carefully poured oils make the bottles suitable perfume containers. The small capacity of the bottles, ranging from 0.21 to 0.24 liters as measured from well-preserved examples, are comparable to Mendesian perfume vessels described in the mid-3rd century B.C. archive of the correspondences and records of Zenon, the private secretary for Apollonios, advisor to King Ptolemy II of Egypt. Mendes is the parent city of Thmuis, and is located less than 1 km from Tell el-Timai. Correspondences in the archive between Zenon and his agents include a report on the distribution of Mendesian perfume as payment, using the common Greek measure of one *kotyle* (Edgar 1925: fragment CGC 59089), which measures about 0.27 liters (Lang and Crosby 1964). Another correspondence related to Mendisian perfume uses an Egyptian unit of measure, the *hin* (identified in a fragment dating to 256 B.C. [Orrieux 1983: fragment PSI 533]), which is roughly the equivalent of 0.46 liters. Zenon's agent received ten hins of perfume (ca. 4.6 liters) packaged in twenty-one alabastra. Assuming the alabastra were of equal size, they would each have held approximately 0.22 liters, or half a hin, similar to the kotyle, matching the capacities of the small bulbous bottles from Tell el-Timai.

Another physical feature of the bottles that makes them suitable for perfume is the narrow opening of the neck. The opening where the neck joins the body is approximately 0.6 cm. Such a narrow opening for a closed vessel is too narrow to allow water to flow freely, due in part to water's high surface tension. Oils, on the other hand, are more viscous and have a lower surface tension, allowing them to flow more smoothly through such narrow openings of closed vessels.

Similarly, the pronounced inner lip of the rim would serve well to catch and stop the flow of viscous liquids like oils.

Another physical property of the bottles that suits their role as perfume containers is the low-porosity material from which the bottles are made. The clay used to make the bottles is very fine and carefully levigated to produce a densely-packed clay body. After firing at high temperature, the bottles appear to have a low porosity, which may have been a preferred feature for keeping perfume. While we were unable to perform porosity tests in the field, macroscopic observation of vessel breaks indicated a relatively high level of vitrification in the clay body, which would reduce the porosity of the bottles. Reference to non-porous containers for perfume can be found in the writings of Theophrastus. Theophrastus, the successor to Aristotle and leader of the Peripatetic school of philosophy in Athens, wrote many scientific treatises on the natural world, including a lengthy essay on the nature of smells called *Concerning Odors*. In this work, Theophrastus explains the principals of how odors are bound to certain oils to make perfumes and how best to preserve those odors from decay. This is best done, he suggests, by keeping perfumes in sealed, non-porous containers:

> Perfumes are ruined by a hot season or place or by being put in the sun. This is why perfumers seek upper rooms which do not face the sun but are shaded as much as possible. For the sun or a hot place deprives the perfumes of their odor, and in general makes them lose their character more than cold treatment: while cold and frost, even if they make them less odorous by congealing them, yet do not altogether deprive them of their virtue. For the most destructive thing that can happen to them, as to wines and other savors, is that they should be deprived of their proper heat. This is why men put them into vessels of lead and try to secure phials of alabaster—a stone which has the required effect: for lead is cold and of close texture, and stone has the same character, that being the best for keeping perfumes which has it in the highest degree. So that vessels made of these materials keep perfumes well for both reasons, their coolness and their closeness of texture: they neither let the odor pass away through them, nor do they take in anything else. For evaporation destroys the perfume, and so also does any foreign substance which finds its way in: for even draughts of air destroy odors and cause them to waste, as was said, especially those odors which do not belong to a thing's essential nature. (Theophrastus, *Concerning Odors* 40–41; see Hort 1916: 363)

A local concern at Tell el-Timai for hermetic perfume vessels is evident from the references to Mendesian perfume found in Zenon's Archives from the mid-3rd century B.C. Mendesian perfume was famous in the 3rd century B.C. and of high quality. In Zenon's Archives we read that Mendesian perfume was stored and transported in lead containers (de Rodrigo 2002: 455). The physical properties of the Thmuisian fine small bottles easily fit Theophrastus' parameters of appropriate perfume containers. The "closeness of texture" (*tô puknô*, more literally "compactness") that Theophrastus singles out as important characteristics of lead and stone is applicable to the clay body of the fine small bottles.

Macroscopic observations of the fine bottles produce a description of a distinct ceramic ware that fit Theophrastus' specifications well. Here we are using the term "ware" to refer to a production tradition that has a constancy of vessel shapes, raw material use, treatment of clays, and overall preparation of vessels' surfaces, including decoration, within a single production ecosystem. The clay body used to produce the fine small bottles at Tell el-Timai is a fine-grained marl clay with densely-packed particles in the clay body. Visible inclusions are rare. When present, inclusions consist of small sub-angular gray bits that are likely small lumps of the calcareous geological formation from which the marl eroded, rather than a temper added by the potters. All observed examples of bottles were evenly fired in section with clear banding visible in breaks. In section, the core is pale yellowish pink (2.5YR 6/5). The margins of the core are typically fired pale pink (2.5YR 5/6). In the thickest sections, typically the ring foot, the core is fired light grey.

The closest parallel for the ware in the Vienna System, the standardized Egyptian ceramics classification, is Marl A3 (Arnold and Bourriau 1993: 177). An important difference between Marl A3 and the ware found at Tell el-Timai is not physical but chronological. Marl A3, as it is defined in the Vienna System, dates from the early Middle Kingdom into the New Kingdom Periods, making it at least one thousand years earlier than the small, fine bottles found at Tell el-Timai (Arnold and Bourriau 1993: 177). Despite the chronological incongruity, certain similarities between Marl A3 and the Thmuisian fine bottles are strong. The fineness and homogeneity of the clay is similar, though the matrix of the Thmuisian clay body is more densely packed. This is most easily demonstrated by frequent long voids that are present in sections of Marl A3, though no such voids were observed among the examples of fine bottles from Tell el-Timai. Similarly, the incipient vitrification that can occur in Marl A3 extends to more continuous vitrification throughout the clay body in all the Tell el-Timai bottles.

The fine texture of the clay used to make the small bottles was exploited when the vessel surfaces were prepared. The exterior surfaces are carefully smoothed. The lower portion of the body and the entirety of the ring foot are highly burnished. The burnishing, coupled with the vitrification of the clay body, produces a very smooth texture with an overall slightly greasy feel that is similar to soapstone to the touch. The upper portion of the bottles (the cup-rim, neck, handle, and shoulder) is smoothed but not burnished and so lacks the same greasy texture present on the lower portion. While no complete bottles survive, the best-preserved examples suggest that the burnishing stops approximately 5 cm from the base of the ring foot. The color of the exterior surfaces is a soft yellowish red (5YR 6/6) with subtle mottling throughout that results in a rich color that is reminiscent of fine alabaster bottles. It is conceivable this was the desired effect. The overall appearance of the bottles is similar to alabaster. It is possible that the potter attempted to link the bottles visually to the costlier (and better suited for perfume, according to Theophrastus) stone containers.

The interior surfaces of the bottles are left plain, as can be expected of closed vessels. They are, nonetheless, distinctive in appearance and texture. Clearly-defined, sharp, tightly-bound rilling is present on the lower portions of the walls and floors. Though untreated, the texture of the interior surfaces remains soapy-smooth due to both the fine grain of the marl and the partial vitrification. The color of the interior surfaces is a uniform pale pink (7.5YR 7/4).

The exceptional physical properties of the small bottles can be highlighted by contrasting the ware with the local pottery production that made use of a refined version of the coarse Nile silt. Nile silt vessels are characterized by a clay body made of loosely packed large silt particles with occasional small white and gray sub-angular mineral inclusions and few small- to medium-sized lumps of lime. The Nile silt clay body is typically micaceous; the marl bottles are not. Surfaces of the Nile silt vessels are commonly smoothed, but the coarse nature of the clay body yields a markedly different result than the fine marl clay does when smoothed. The surfaces of Nile silt vessels are slightly sandy to the touch. Small cracks are visible across the surfaces due to irregular shrinking, in marked contrast to the burnished, soapy texture of the fine marl bottles. The color of Nile silt vessels is also significantly different, commonly appearing in variations of brownish-red (between 2.5YR 5/6–5/8 and 4/4–4/8).

The Raw Clay Context

Preparations and cleaning for salvage mapping in the northern spur of the tell resulted in the discovery of two imported amphoras during the 2010 season. The amphoras were found inside a series of cellular mudbrick structures located in field grid Unit P7-7 (FIGURE 1). The architectural features, which include domestic cooking areas, date to the Hellenistic period. For reference, the kilns that produced the cache of small bottles lie 35 meters to the northwest in Area O7. It is conceivable the features in P7-7 are the remains of the living spaces of the potters working the nearby kilns. The two imported amphoras that were recovered do not belong to the Hellenistic phase of the mudbrick structures. Both amphoras were found in relation to three archaeological features, Features 2010-2001, -2002, and -2003 (hereafter the prefix 2010- will be omitted). Feature 2001 is a rectangular platform measuring 3.2 × 2.9 m (FIGURE 3). The platform is constructed of one or more courses of mudbrick capped by a single stretcher course of red bricks. Resting on Feature 2001 is Feature 2002, an irregular course of dry-mortared limestone blocks. Feature 2003 partly abuts and rests atop Feature 2002 and consists of one or two courses of dry-mortared limestone blocks as well. Features 2002 and 2003 appear to have been constructed in the same phase. Most of the limestone blocks from the two features had been robbed out before their discovery in 2010. Part of this robbing activity exposed a cavity within Feature 2002, in which the two amphoras were found.

The two imported amphoras were found resting upright on top of Feature 2001, which is likely an ancient floor. Surrounding the amphoras was a dark brown (10YR 2/1), wet, silty clay matrix that was rich with sherds. Both amphoras were missing their rims, necks, and handles. We believe this to be a reflection of the relationship between the amphoras and the architecture with which they were found. By the time limestone Features 2002 and 2003 were built, the amphoras had already been in their archaeological context for some time. The truncation of the amphoras is the result of leveling action in preparation for the construction of the limestone features.

Filling both amphoras were two distinct layers of sediment. The top layer was a dark brown, silty clay matrix identical to the sherd-rich fill surrounding the vessels. Because the top layer inside the amphoras was the same as the material outside the vessels, we conclude that this sediment was intrusive to the original contents, entering the jar only after it became part of the archeological context. The bottom half of one of the amphoras was filled with about 2 kg of pale yellow (2.5YR 7/3, wet) marl clay. The second amphora, which was crushed in situ, had traces of the same clay adhering to its interior walls and a small amount pooled at the interior base. The contents of both amphoras were collected as soil samples. Inspection of the clay revealed a fine-grained marl with many lumps of chalky material of varying sizes (up to approximately 0.5 cm in diameter). These lumps were similar in color and appearance to the marl clay in which they were situated and it is likely that they are preserved bits of the geological formation from which the marl weathered. The presence of many lumps of chalky material mixed with the clay has led us to suggest that the clay was shipped directly from the source, probably inside the amphoras, without first being processed or otherwise cleaned after quarrying. Other than the remnant lumps, the clay matrix was notably fine, as was apparent with the naked eye and with physical inspection by pinching a sample between finger and thumb. Observation of the clay with a small hand loop with 10× magnification confirmed that the matrix was particularly fine-grained.

Upon discovery, an immediate association was hypothesized with the small fine bottles found in the kilns in area O7 just 35 m away. Both the raw clay and the fired bottles share common characteristics in the fine-grained matrices of their clay bodies, the smoothness of their texture, and even aspects of their color. These same qualities made it apparent that the raw clay was not of the local Nile floodplain sediment, which constitutes the overlying sediment layer in the amphoras.

The amphoras are an early Knidian type (FIGURE 3). Because the amphoras are missing necks, rims, and handles, positive identification is difficult. However, the sandy fabric with some small white and grey mineral inclusions and with a clay body that is fully fired light grey (10YR 7/2) is within the range of Knidian production. Without the surviving necks, rims, or stamp-bearing handles, it is not possible to

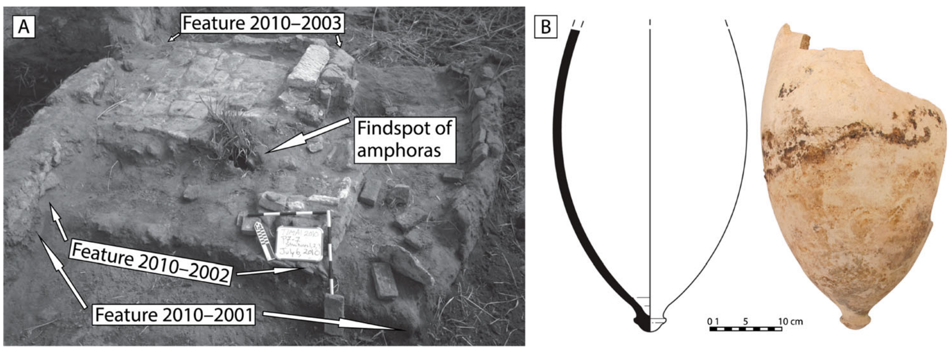


Figure 3. A) Find context of the raw clay; B) one of the amphoras containing the clay.

confidently place the Knidian amphoras in their broader production history. The general characteristics that are present are typical of Knidian amphoras of the 4th and 3rd centuries B.C. However, the large capacity, the pithoid shape, and the small, rounded, slightly-banded toe of examples containing the raw clay fit well within the parameters of Monakhov's Knidian type I-B (mid- to third quarter of the 4th century B.C.) or type I-D (mid-4th century B.C.) (Monakhov 1999). If the amphoras do indeed belong to these 4th century types, this would mean that the raw clay belongs to the same phase as the fired fine marl bottles in the nearby kiln context, making a tentative connection between the raw clay and fired vessels all the more possible.

XRF Analyses and Results

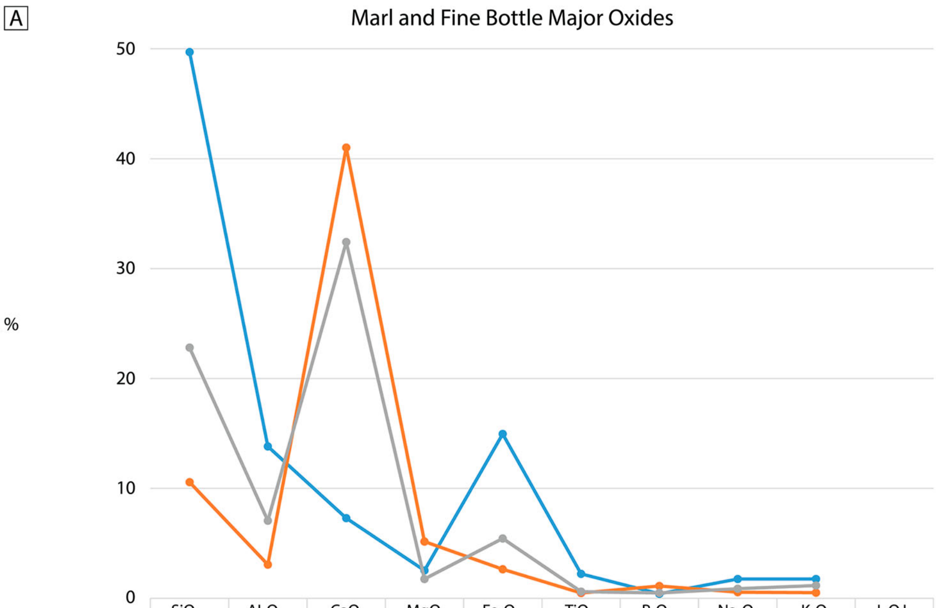
Ideally, our analysis of the raw and fired fine bottles would have included several samples of each specimen to be subjected to two separate analytical processes. In addition to performing XRF chemical analysis, we would have liked to prepare thin sections of the samples for petrographic analysis. Doing so would have provided a geological counterpart to the chemical fingerprints provided by XRF. Unfortunately, because of the circumstances of the field season, it was only possible to send a limited number of samples for XRF analysis. Subsequent political circumstances in Egypt have not allowed further access to and study of the material for petrographic analysis of the material.

Three samples were selected for XRF analysis. These consisted of one sample of the raw clay found in the amphoras, one sample of the fine small perfume bottles from the kilns, and one sample of a small bottle produced in the local Nile silt. The Nile silt sample (FIGURE 2U) was sent to act as a control sample of local material to observe against the presumed imported or non-local samples of raw clay and fine bottle. The samples were collected in the field and sent to the laboratories of the Housing and Building National Research Center in Cairo for analysis. The laboratories crushed the samples into homogenous powders that were then pressed into pellets for analysis. American Society for Testing and Materials (ASTM) standard C114 was used to calibrate the instrument and allow for quantitative results.

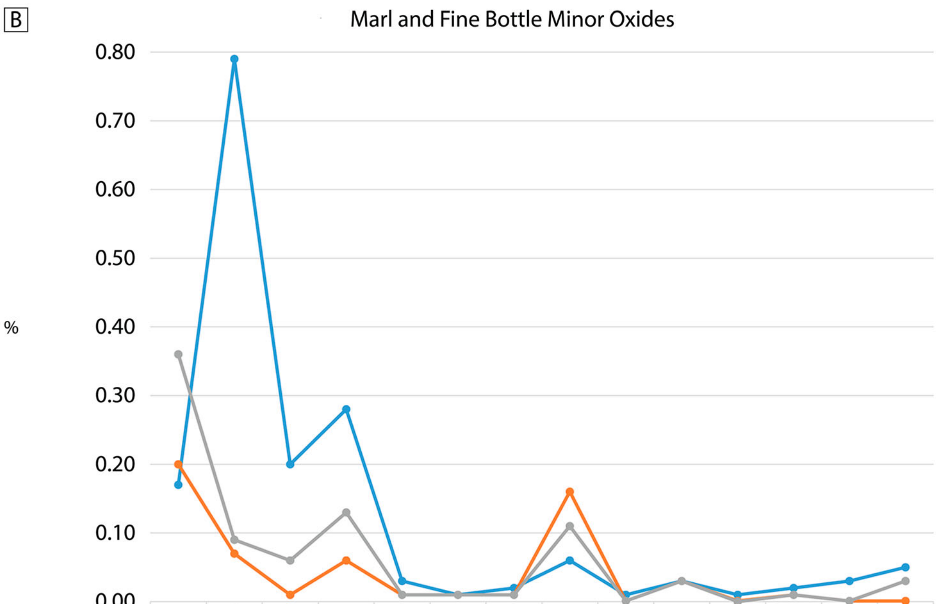
The purpose of subjecting our samples to XRF analysis was twofold: to determine if the fine bottles have the same chemical signature as the raw clay and to create data that could lead to the identification of the provenience of the raw clay. The problem with the second goal is a dearth of comparative data. Subjecting archaeological ceramics to XRF analysis has become increasingly common in recent years. This is especially true since the advent of hand-held XRF devices that make collecting data in the field more feasible. The dissemination of raw data generated in the field has yet to find an open platform, creating problems for comparative studies. As such, the datasets used in this study to suggest provenience for the raw clay are limited to two studies that produced similar major and trace elemental compositions, presented as percentages of oxides. The largest dataset comes from an unpublished geology master's thesis from the Technischen Universität Berlin by Mostafa Gouda Mohamed Attia Temraz (2005). Temraz provides the XRF results from 55 samples of carbonaceous shale deposits gathered from five separate regions in Egypt (FIGURE 1). These geological samples were used as comparanda for the XRF results of the raw clay recovered from the amphoras. Our decision to limit comparison of the raw clay to geological samples was based on our decision to treat the contents of the amphoras as geological material. This decision was reached following an assessment of the physical properties of the clay (see description above). We believe the clay was untreated (and so chemically unaltered) before it was packed in the amphoras, justifying classifying it as geological material. On the other hand, the XRF results of the fired bottles are compared with data published by Carol Redmount and Maury Morgenstein (1996). The data provided by Redmount and Morgenstein consists of the XRF results of 24 fired vessels from eleven modern pottery producers from as many different locations in Egypt (FIGURE 1). Thus, within the scope of the overall comparative analysis, there are two categories of samples: geological and fired ceramic; each was compared with appropriate datasets. Only the nine major oxides detected for all samples across the studies were used to establish consistency and comparability in the analysis. Data for these nine oxides were then normalized to equal 100% for each sample to allow for effective comparison.

Subsequent statistical analysis consisted of factor analysis to identify the oxides that were most indicative of the separation of subpopulations within the datasets. Factor analysis detects analytes (those chemical components that have been identified and measured in the original XRF analysis) that most account for variability between samples made up of many analytes. These variables are then converged into two factors, to enable the samples to be plotted in two dimensions. Next, discriminant analysis was performed, whereby the data of the two unprovenienced samples from Tell el-Timai (the raw clay and the fired fine bottle) were entered to predict likely origin based on the identified subpopulations. Hierarchical clustering was then applied to generate dendrograms of both the geological and ceramic samples.

The results of the XRF analysis performed in the Housing and Building National Research Center in Cairo are presented in their entirety (FIGURE 4). The results were provided by the laboratory as percentages of oxides, except for chlorine. The report included both major and minor/trace elements. The laboratory rounded the percentages to the nearest one-hundredth of a percent for most of the reported oxides. The few instances where the results were rounded to the nearest one-thousandth of a percent may be points where the analysis identified the presence of an oxide but the sensitivity was not calibrated to record exact measurements. The precise reason remains unknown. Attempts to contact the laboratory for clarification were left unanswered. These instances are limited to the minor elements, which serves to highlight the limitations of XRF results presented as percentages rather than as parts per million (ppm), which would allow for a more precise documentation of the minor elements in the clay body. However, the lack of precision is perhaps balanced by the fact that the most readily available comparative XRF data for Egypt were also published as percentages of major oxides (Redmount and Morgenstein 1996: table 2; Temraz 2005: table 4), making the comparison far simpler. These same studies offer a more precise record of trace elements in ppm and were our data for trace elements comparable, so that we would be better equipped to identify likely sources for the raw clay at Tell el-Timai. Rather than lament the limitations of our existing data, and given that it is not likely that new XRF analyses of the same materials will be forthcoming



	SiO_2	Al_2O_3	CaO	MgO	Fe_2O_3	TiO_2	P_2O_5	Na_2O	K_2O	L.O.I
NS bottle	49.71	13.81	7.30	2.54	14.96	2.23	0.41	1.76	1.75	3.81
Raw marl clay	10.57	3.06	41.01	5.17	2.64	0.48	1.12	0.56	0.51	34.310
Fine marl bottle	22.82	7.06	32.41	1.76	5.44	0.61	0.49	0.87	1.16	26.50



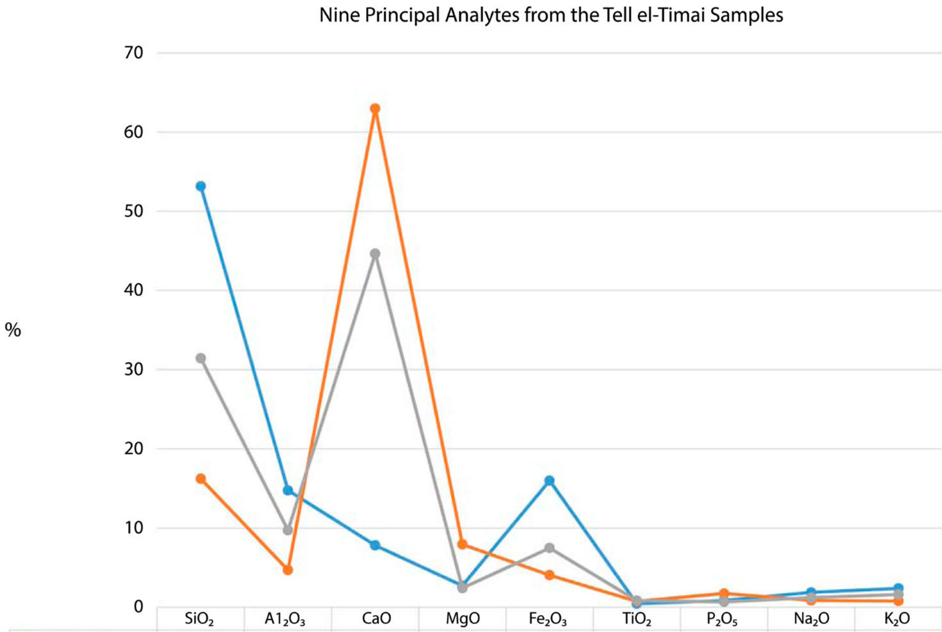
	SO_3	Cl	Cr_2O_3	MnO	NiO	CuO	ZnO	SrO	Y_2O_3	BaO	PbO	As_2O_3	Co_3O_4	ZrO_2
NS bottle	0.17	0.79	0.20	0.28	0.03	0.01	0.02	0.06	0.01	0.03	0.01	0.02	0.03	0.05
Raw marl clay	0.20	0.07	0.01	0.06	0.01	0.01	0.01	0.16	0.001	0.03	0.001	0.01	0.001	0.001
Fine marl bottle	0.36	0.09	0.06	0.13	0.01	0.01	0.01	0.11	0.001	0.03	0.00	0.01	0.001	0.03

Figure 4. Results of XRF reported as percentages of oxides, both major (A) and minor (B).

anytime soon, we present this paper as a tentative working hypothesis for the origin of the materials found at Tell el-Timai. For the purposes of comparative statistical analysis and following the results of the factor analysis, the trace oxides were not considered as part of the normalization (adjustments of the percentages to equal 100%) of the available comparable data presented in the studies by Temraz and by Redmount and Morgenstein (FIGURE 5). The normalization process involved removing the Loss on Ignition (LOI) from the percentage of the whole. The reason for this is that the XRF analyses were of both fired and raw samples of clay, which will necessarily have large differences in LOI due to being fired or not fired.

Initial interpretation of the XRF results divided the three Tell el-Timai samples into two distinct categories based on relative proportions of calcium and ferric oxides. Both the raw clay and the fine bottle contain similar proportions of major and minor elemental oxides, with similar spikes of calcium oxide and low proportions of ferric oxide (FIGURES 4, 5). These contrast with the Nile silt bottle, which is distinguished by low calcium oxide content and a comparatively high ferric oxide proportion. This fits well within our expectations that, based on macroscopic observations, the raw clay and fine bottle belong to a separate geological source from the Nile silt sample. With the Nile silt sample having performed its role as a control to the two marl samples, the Nile silt sample will be set aside for the remaining analysis of the XRF results, which will instead focus entirely on the raw clay and fired fine bottle.

Factor analysis of data from the Tell el-Timai samples and similar data from samples of previously published



	SiO_2	$A1_2O_3$	CaO	MgO	Fe_2O_3	TiO_2	P_2O_5	Na_2O	K_2O
NS bottle	53.16	14.77	7.81	2.72	16	0.44	0.84	1.88	2.38
Raw marl clay	16.23	4.7	62.98	7.94	4.05	0.74	1.72	0.86	0.78
FInemarl bottle	31.42	9.72	44.64	2.42	7.49	0.84	0.67	1.2	1.6

Figure 5. Percentages of the nine principal analytes from the three samples from Tell el-Timai after normalization of the XRF results once the Loss on Ignition (LOI) percentages have been removed.

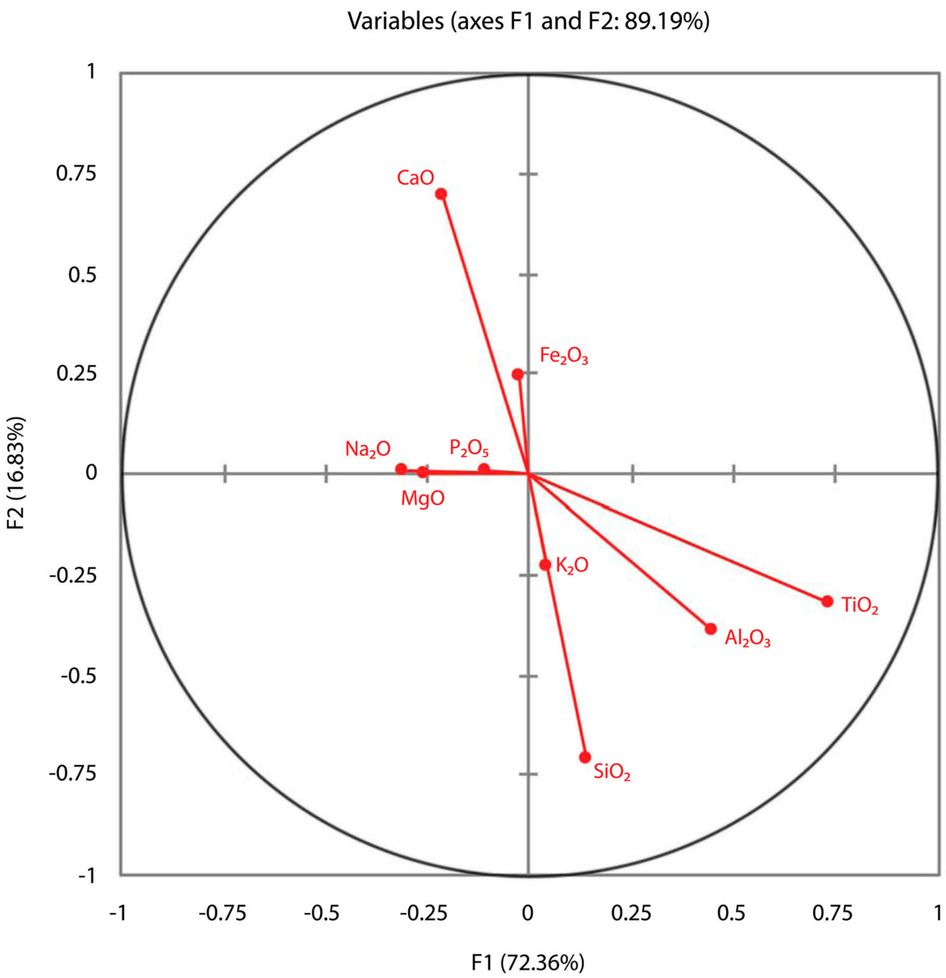


Figure 6. Factors that correlate most with subpopulation separation within the dataset.

studies reveals the component oxides that best separate the samples into identifiable subpopulations (FIGURE 6). In this case, subpopulations are synonymous with where the clay originated. Factor analysis is particularly useful in identifying latent variables, that is, those variables that correlate with the separation of subpopulations within a dataset, specifically the underlying variables that give an overview of the dataset and its subpopulations and are not immediately apparent. Figure 6 graphically represents the oxides that were identified as being most indicative of different populations. The components are linear combinations of the variables, with the length of each vector correlating with how much influence that variable has on population separation. F1 represents factor 1: this factor describes the greatest amount of variation between the samples accounting for 72.36% the variance between samples. F2 represents factor 2, the second factor with the next greatest variation, accounting for 16.83%.

The dataset was further interrogated using linear discriminant analysis (LDA). LDA allows the samples to be plotted in two dimensions according to their elemental composition (FIGURE 7). Following the factor analysis and subsequent LDA, the samples are translated into a two dimensional scatter plot on axes *x* and *y*, plotted according to their individual composition by being pulled in the direction of the elemental oxides which they are mostly composed. Each axis represents how much of the separation between subpopulations is accounted for by the oxides identified in Figure 6. In this case, the *x* axis accounts for 72.36% of separation, and the *y* axis 16.83%. The total, 89.19%, corresponds with the confidence that samples will be correctly placed in their assigned population. This confidence is tested by taking known samples out of the algorithm and treating them as unknowns, to determine how many will be correctly assigned to their known population based on their composition. By plotting in this manner, it is possible to identify subpopulations, as their similar elemental composition will necessitate their being plotted in the same area of the graph. It is also possible to identify unidentified samples by analyzing which subpopulation they are plotted with. To test the model with the available dataset, a scatter plot was produced with known validation samples removed from the procedure that were then re-entered as predictions, resulting in an accuracy of 89.19%, demonstrating the robustness of the dataset and its reliability to deal with prediction samples.

Figure 7 details the distribution of all published samples included in the study, identified by their place of origin. The two samples of unknown origin (the raw clay and the fired small, fine bottle) from Tell el-Timai have been predicted to be part of the Tarawan subpopulation using LDA and appear in the plot as "Timai Raw Clay." The Tell el-Timai samples were assigned to the Tarawan group with 98.48% confidence for the raw clay, and 77% confidence for the fine bottle (TABLE 1).

Agglomerative Hierarchical Clustering (AHC) of the compositional data (percentages of the nine principal oxides normalized to equal 100%) was applied to create a dendrogram of the geological samples with known provenience from Temraz's dataset (2005). The unprovenienced clay from Tell el-Timai was included in the AHC and resulting dendrogram (FIGURE 8). A similar dendrogram was created for the fired pottery data from Redmount and Morgenstein (1996) with the fired bottles from Tell el-Timai placed with respect to the emergent subpopulations (FIGURE 9).

As seen in the geological dendrogram (FIGURE 8), the samples cluster into three groups based on common chemical signatures. The signature of each group can be expressed as average percentages of the nine principal chemical components common to all datasets used in the analysis (see

Table 1. Confidence levels of relating the finds from Tell el-Timai to geological formations in Egypt.

	Ataqa Formation	Duwi and Dakhla Formations	Esna Formation	Safa Formation	Tarawan Formation
Timai Raw Clay	0%	1.46%	0%	0%	98.48%
Timai Fine Bottle	0%	22.20%	0.80%	0%	77.00%

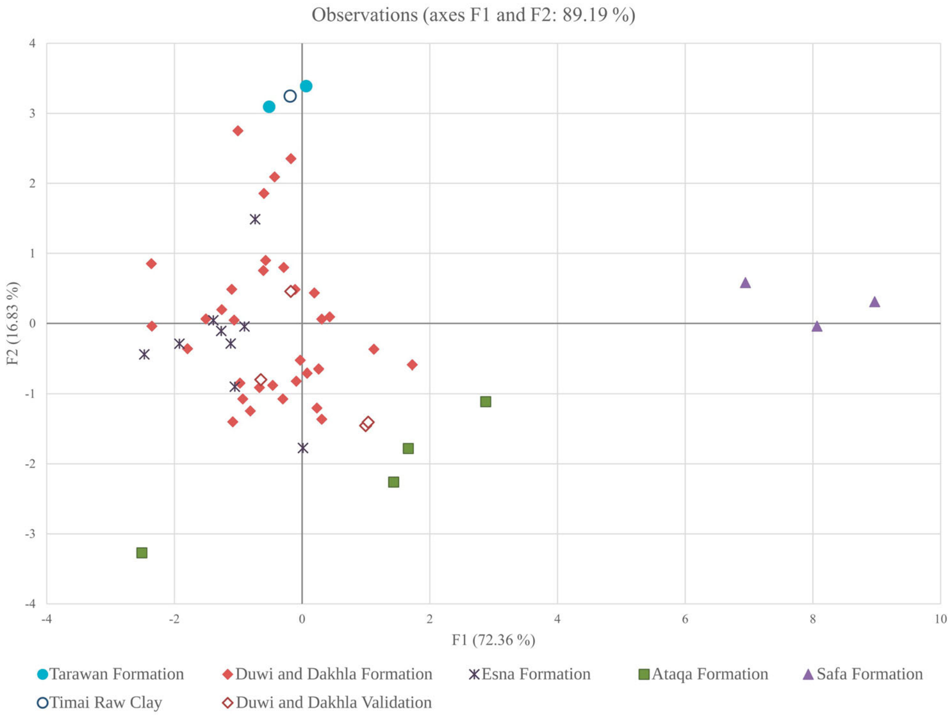


Figure 7. Scatter plot of samples of known provenience with the unknown raw marl clay found at Tell el-Timai.

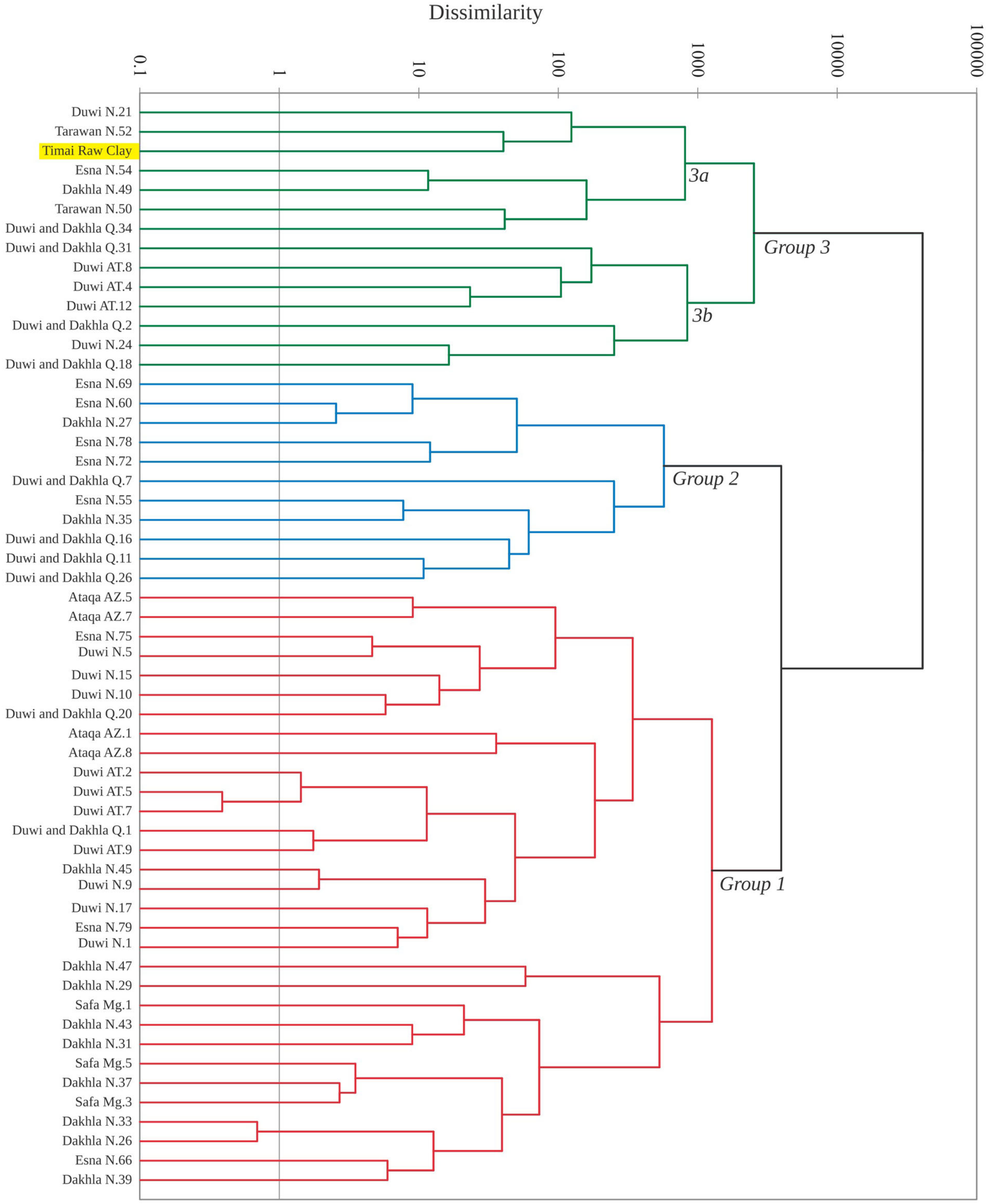


Figure 8. Dendrogram of similarities between the geological samples from the XRF data provided by Temraz (2005) and the raw marl clay found at Tell el-Timai.

above). The signatures are presented as a plot (FIGURE 10) that illustrates divergences in key oxides that help define the three groups. The notable points of oxide that separate the dataset into groups are silica, aluminum, calcium, and phosphorus. Notable divergences in composition are here considered to be a difference of at least 10% of the total. Groups 1 and 2 share similar overall compositions of the nine principal components with the exception of the calcium oxide content. Both Groups 1 and 2 have high SiO2 content, between 50% and 63% of the clay body, and moderate Al_2O_3 content, between 16% and 23%. The principal diverging point is with CaO, which only makes up approximately 1% of the clay body of Group 1, but about 17% of Group 2. Group 3, on the other hand, is markedly different in compositional ratio from both Group 1 and 2 in respect to these oxides. Group 3 has low SiO_2 and Al_2O_3 contents (ca. 22% and 6% respectively) and a high CaO content (ca. 51%).

The raw clay from Tell el-Timai clusters with Group 3 of the geological dendrogram (FIGURE 8). In turn, Group 3 is made up of two broad subpopulations (3a and 3b) that separate at roughly the same level of dissimilarity as Groups 1 and 2. Subpopulations 3a and 3b are similar within their ratios of oxides except for P_2O_5. Whereas Group 3a has an

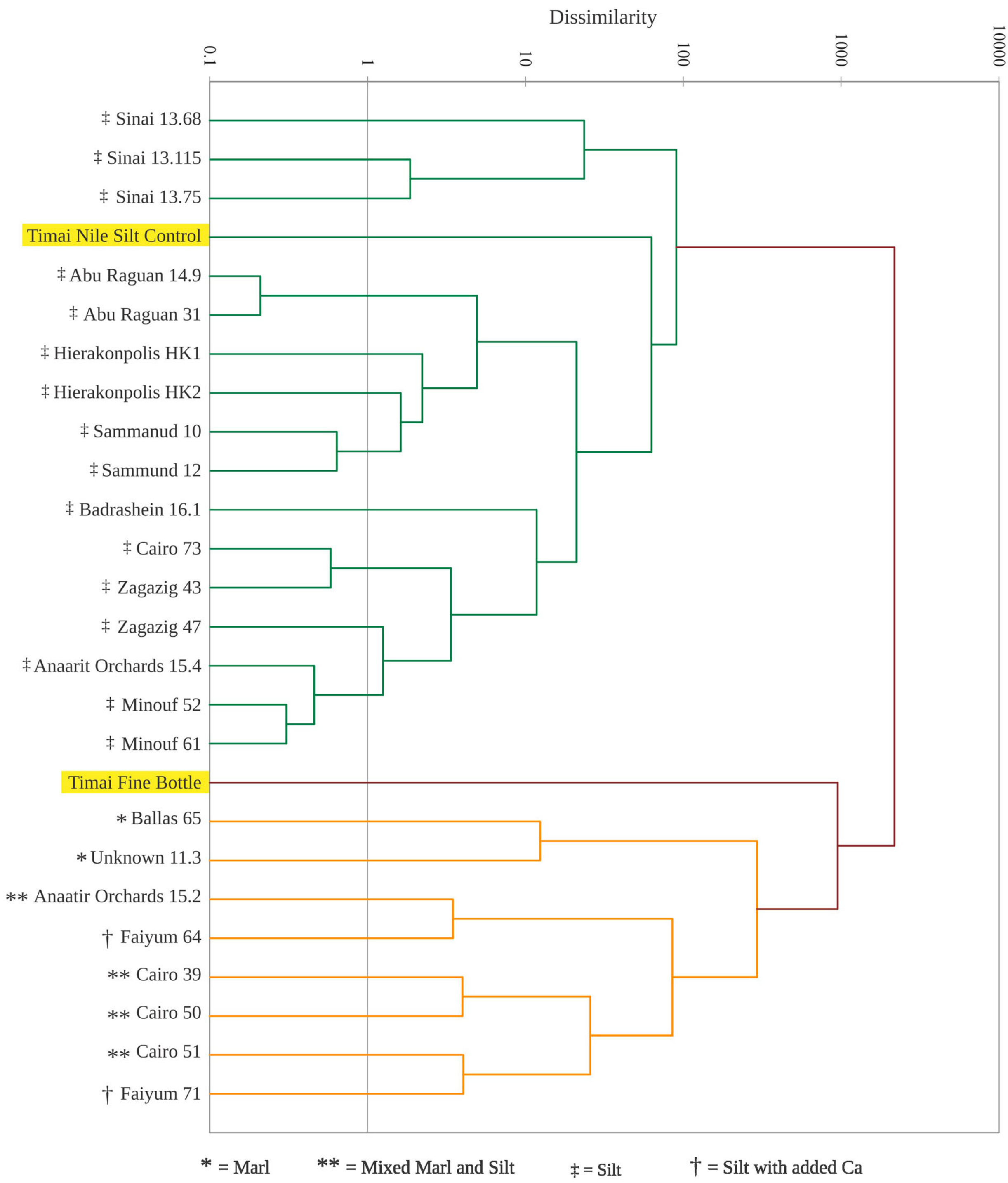


Figure 9. Dendrogram of similarities between the ceramic samples from the XRF data provided by Redmount and Morgenstein (1996) and the fired fine marl bottle from Tell el-Timai.

average composition with only 0.55% P_2O_5, Group 3b samples have a high ratio of P_2O_5, 24% on average. The raw clay sample from Tell el-Timai clusters with Group 3a, which consists of various limestones from the Nile Valley, with the exception of sample Q.34, which is an outlying shale.

Direct comparison of the percentages of oxides across the samples in Group 3a suggests that the most similar geological sample to the raw clay sample is N.52 from the Tarawan Formation, as should be expected following the results of factor analysis and Linear Discriminant Analysis that also grouped the unprovenienced clay with the subpopulation of Tarawan samples with a 98.48% confidence rate. In contrast, the dendrogram of fired vessels (FIGURE 9) isolates the fine bottle from Tell el-Timai, highlighting the fact that it does not belong to any of the identified subpopulations within Redmount and Morgenstein's dataset (1996). Though the dendrogram places the fine bottle in the second tier cluster generally made up of Ca-rich marls (and two examples of Nile silt with added Ca), even among these marls the bottle from Tell el-Timai stands alone, emphasizing the unusual nature of the clay body within the sample selection of modern pottery producers in Egypt. The Tell el-Timai control example of coarse Nile silt, on the other hand, clusters predictably with the Nile silt vessels.

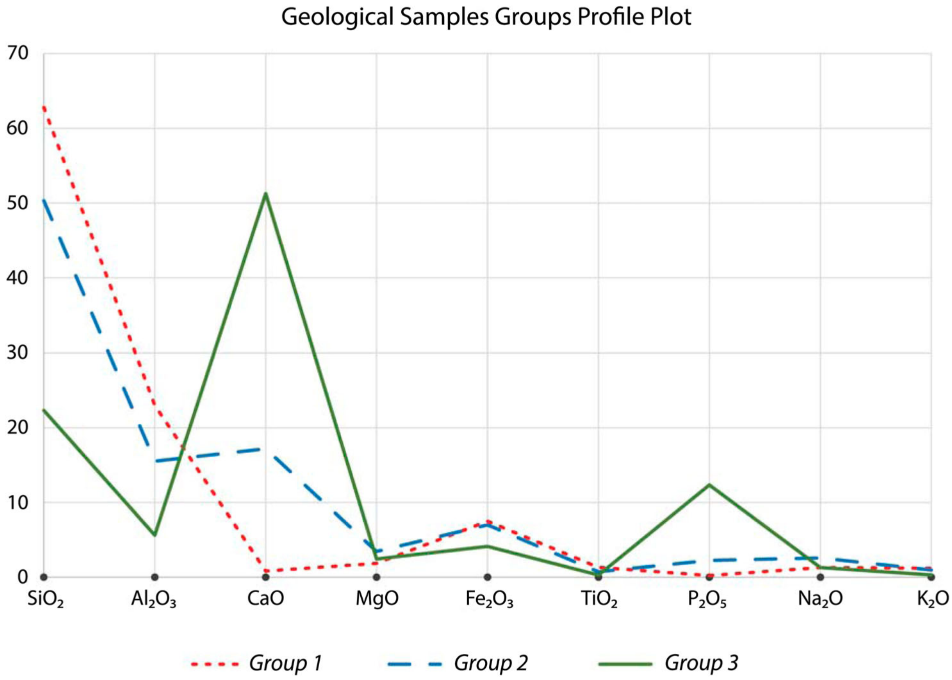


Figure 10. Median percentages of the nine principal analytes of the three major groups identified in the geological dendrogram (figure 8).

Discussion

Our discussion begins from the position that the fine bottles from the kiln context in area O7 are made of the type of clay found in the amphoras in area P7. This position can be approached from three avenues of reasoning. The first avenue follows the observation that the raw clay and the clay body of the fired bottles are macroscopically similar. Also, the wasters of the fine bottles in the kiln strongly suggest a local production, but in a clay dramatically different from the Nile silt that is chiefly used in the Thmuisian workshops. The coincidental discovery within the vicinity of the kilns of raw clay with similar physical properties as those of the bottles naturally leads to a hypothesized connection between the two artifacts.

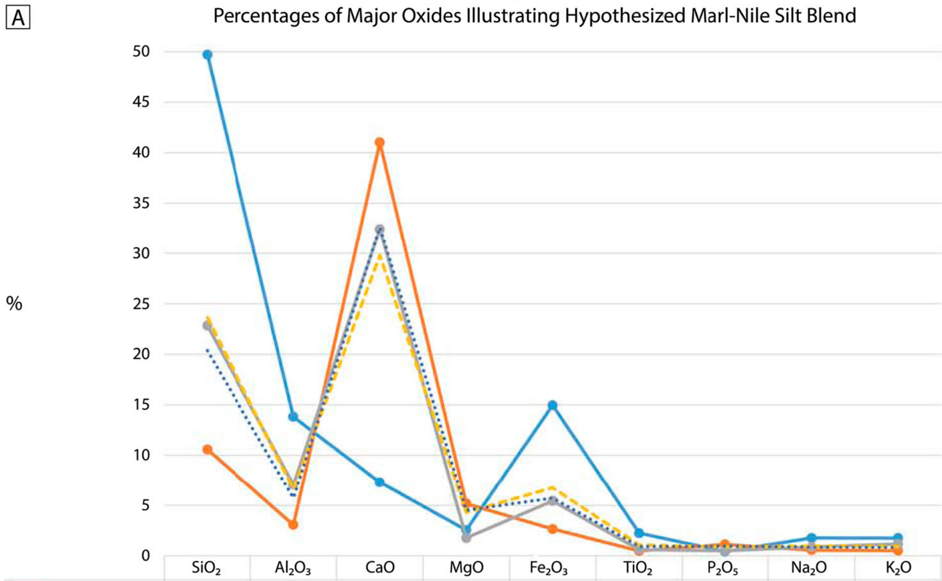
The second avenue of reasoning for linking the raw and fired clay concerns the XRF results of the two samples. The ratios of the chemical compositions of the raw clay and fired fine bottle are very similar to one another, but they are not identical (FIGURES 4, 5). Most notably, the two most common elements, silicon and calcium, which make up just over half of the mass for each sample, differ significantly between samples. Silicon makes up 11.95% more of the body mass of the fired bottle than it does of the raw clay. Conversely, calcium constitutes 8.6% less of the body mass of the fired bottle than it does of the raw clay. In general, though, the ratios of the nine major oxides in both raw and fired clay samples yield similar peaks and troughs when expressed as line graphs (FIGURES 4, 5). There are two feasible explanations for the differences between compositional ratios.

One possibility is that the differences in the ratios are the result of the process of production. The combined effects of preparing the clay for ceramic production may have altered the chemical composition of the final product. Preparations of clay for production likely would have included washing the clay to remove its impurities, including the larger inclusions of limestone that are present in the raw clay from the amphoras. Next, the firing process could further alter the compositional ratios. However, the effects of cleaning and firing the clay on the chemical composition of clays may be negligible. This is especially true of the ratio of the principal components in the clay, such as silicon and calcium in our samples (Rice 1987: 422–423).

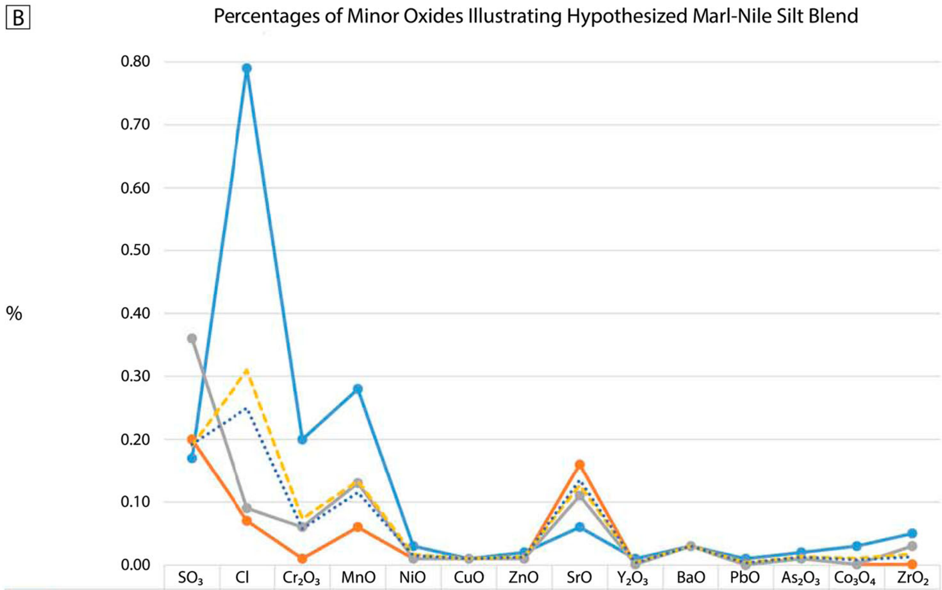
Another explanation for the difference in the compositional ratios between the raw clay and fired fine bottle may be that the bottle is the product of mixing the marl clay with Nile silt. There are multiple possible reasons for blending fine marl clays and Nile silts, including to improve the plasticity of the clay body for throwing. It may also be that without the addition of coarser Nile silt to the fine marl clay, the bottles' thin walls (as thin as 0.2 cm) would have been more likely to slump. Another reason for mixing the clays may have been to improve the rate of success relative to shrinkage due to water loss during the drying period. Especially fine-grained clay bodies suffer from a high level of shrinkage due to water loss that can result in cracking (Rice 1987: 67). Adding the coarser Nile silt to the fine marl clay would have reduced the chances of such damage at that critical stage of production. Alternatively, blending the fine marl clay with Nile silt could have served the simple purpose of extending the productivity of the fine marl clay so more vessels could be produced with the limited quantity imported to Tell el-Timai.

Using the known chemical ratios of the raw clay and the Nile silt control sample (FIGURES 2C, 4), it is possible to suggest a mixture ratio to recreate the chemical ratios of the fine bottle. A mixture ratio between two or three parts marl clay and one part Nile silt produces the closest proximation of the chemical ratios found in the fired bottle (FIGURE 11).

The third avenue of reasoning that leads us to suggest the small fine bottles were produced in the raw clay found in the amphoras involves the XRF data from Temraz's geological survey (2005) and our use of it to identify a possible source for the raw clay. Working with the current dataset, we associate the raw clay found at Tell el-Timai with the chalky and argillaceous limestone samples taken from the Tarawan limestone formation in the Nile Valley within the Idfu-Esna region. The Tarawan Formation is a large Paleocene



	SiO_2	Al_2O_3	CaO	MgO	Fe_2O_3	TiO_2	P_2O_5	Na_2O	K_2O
NS bottle	49.71	13.81	7.30	2.54	14.96	2.23	0.41	1.76	1.75
Raw marl clay	10.57	3.06	41.01	5.17	2.64	0.48	1.12	0.56	0.51
Fine marl bottle	22.82	7.06	32.41	1.76	5.44	0.61	0.49	0.87	1.16
Blend 2:1	23.62	6.64	29.77	4.29	6.75	1.06	0.88	0.96	0.92
Blend 3:1	20.36	5.75	32.58	4.51	5.72	0.92	0.94	0.86	0.82



	SO_3	Cl	Cr_2O_3	MnO	NiO	CuO	ZnO	SrO	Y_2O_3	BaO	PbO	As_2O_3	Co_3O_4	ZrO_2
NS bottle	0.17	0.79	0.20	0.28	0.03	0.01	0.02	0.06	0.01	0.03	0.01	0.02	0.03	0.05
Raw marl clay	0.20	0.07	0.01	0.06	0.01	0.01	0.01	0.16	0.001	0.03	0.001	0.01	0.001	0.001
Fine marl bottle	0.36	0.09	0.06	0.13	0.01	0.01	0.01	0.11	0.001	0.03	0.00	0.01	0.001	0.03
Blend 2:1	0.19	0.31	0.07	0.13	0.02	0.01	0.01	0.13	0.00	0.03	0.004	0.01	0.01	0.02
Blend 3:1	0.19	0.25	0.06	0.12	0.02	0.01	0.01	0.14	0.00	0.03	0.003	0.01	0.01	0.01

Figure 11. Percentages of the nine analytes from the three samples from Tell el-Timai and a hypothesized marl-Nile silt blend.

formation that can be found throughout most of Egypt. It is a heterogeneous limestone formation that is generally chalky, with high carbonate content between 60% and 70%. The formation's upper levels near the boundary of the overlying Esna Shale Formation can have significantly lower carbonate counts, falling below 50% (Dupuis et al. 2003: 44), at which point they become argillaceous rather than chalky limestone (Ouda, Berggren, and Saad 2003: 149). As illustrated by the range of carbonate content found in different sections of the formation, Temraz's samples from the Idfu-Esna region produce ratios that provide a best fit for our raw clay sample. While a confidence of fit between our raw clay sample and the Tarawan samples is high at 98.48% (TABLE 1), it comes with a caveat. The high confidence is limited to the parameters of the dataset, which does not reflect an exhaustive sampling of geochemical signatures in Egypt. Additionally, as highlighted earlier, we are consciously pitting the raw clay data against geological (stone) data, which makes direct association between the two data types problematic. Equally problematic is the issue of sample size for the geological sources that appear most similar to the raw clay found at Tell el-Timai. As collected and reported by Temraz (2005: table 4), the number of samples that are clearly different in their major chemical compositions compared to the rest of the dataset, especially in terms of their CaO content, which is a major marker for our raw clay sample, is very small. The result is that our archaeological raw clay would inevitably have a best fit with the Tawaran Formation samples within the existing dataset. Were the comparable data more robust, with hundreds of chemical signatures from geological samples taken throughout Egypt, the confidence level of associating our raw clay to the Tawaran Formation in the Idfu-Esna region would certainly shrink. Similarly, were the sample size larger, it is likely that many potential sources for the marl clay would become possible based on the major elements. In this case, the analysis would benefit from a more precise measurement of trace elements, which we do not have. In the end, we are confronted with the reality that our data are limited and for the moment unlikely to be improved, at least as far as the marl clay found at Tell el-Timai is concerned. Within this framework, we are suggesting an Upper Egyptian origin for the raw clay and our current data points to a region on the edge of the Nile valley in the area of Idfu and Esna. We are willing to accept this as a working hypothesis while acknowledging the problematic nature of the assumptions the hypothesis relies on.

Connecting the fired fine bottles found at Tell el-Timai to the same source as the clay means looking for a level of confidence of fit between the XRF results of the bottle and the geological samples. We do so acknowledging the obvious methodological problems this presents. We also look to Temraz's geological data because of how different the fine bottles appear to be from the samples in Redmount and Morgenstein's study of modern Egyptian pottery. In the dendrogram of subpopulations generated with Redmount and Morgenstein's data and the fired bottles from Tell el-Timai, the fine bottle is alone, placed in its own subpopulation (FIGURE 9). However, when comparing the fired fine bottle with the geological samples, an association with the Tarawan Formation can be made with a confidence level of 77.00% (TABLE 1). The lower confidence level may be due to the mixing of Nile silt with the fine marl clay. Though the confidence levels do not constitute proof the raw clay from the amphoras was used to produce the fine bottle, we believe that they lend weight to our posited relationship. Furthermore, the confidence levels allow us to posit an origin for raw materials in Upper Egypt, possibly from the Idfu-Esna region. If this is the case, it is strikingly similar to the modern phenomenon, albeit in the opposite direction, of Aswan potters importing clay from Esna (Peloschek 2015: 6).

As is made clear by our frequent use of conditionals and caveats, much work on Egyptian clays remains before effective, confident identification of ancient clay sources can occur. The extraordinary discovery of imported clay stored in transport amphoras and of the fired vessels in a kiln context made of that same clay provides a rich archaeological and cultural context with which to explore the issue of provenience. At the moment, truly comparable data is lacking. The context of discovery at Tell el-Timai makes knowledge of the source for the clay all the more desirable since it leads to many questions. Is there potentially a more nuanced explanation for the particular choice of fine marl clay to produce the perfume bottles at Tell el-Timai? Certainly the clay selected for this purpose could produce vessels with low porosity, but so could other clays that are available closer to Tell el-Timai. The potential source of the raw clay in the Idfu-Esna region is no less than 800 river kilometers from Tell el-Timai. Might there be a culturally meaningful reason for the exploitation of clays from this specific region, similar to the modern phenomenon of the Amphlette Islanders singled out at the beginning? At the moment, any discussion of the cultural, political, or economic implications of Upper Egyptian clay imported to a Lower Egyptian ceramic workshop would be speculative. Certainly, many possible interpretive schemes are readily open and questions of the phenomenon's connection to the Mendesian perfume industry immediately come to mind. Likewise, does the phenomenon shed light more generally on the internal trade networks of Egypt in the 4th century B.C.? Full consideration of questions such as these are well beyond the scope of the current study but will be addressed in a future article to flesh out the historical, political, and economic circumstances in which to understand the unusual discovery. The ability to pinpoint a clay source, potentially to the vicinity of a town, may help make sense of these questions. It is fortunate that new initiatives are underway that aim to provide high resolution mapping of the clay sources of Egypt, such as the French-German project, *Ceramegypt* (Heinzelmann et al. n.d.). We eagerly await the initial round of data dissemination so that more analyses like this one can be performed with greater confidence.

Geolocation Information

Tell el-Timai: Latitude 30°56′35″N; Longitude 31°31′1″E

Acknowledgements

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Disclosure Statement

No potential conflict of interest was reported by the authors.

Notes on Contributors

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