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The Changing Landscape of the Clay Deposits at 'Ayn aṭ-Ṭīnah, Wādī Mūsā

Introduction

In his study of industrial rocks and minerals in Jordan, Khoury (1989: 92ff) showed the main industrial clay minerals to be present at the Māḥiṣ to Ghawr Kabid area, al-Azraq and Baṭn al-Ghūl (with other less important occurrences at ar-Rashādiyya and al-Fujaij). By 1993, another major industrial source of clay was added, at the "Wādī Mūsā - Petra area" (Abu Dayyeh 1993). The clay source was found to be applicable for the industrial manufacture of pottery by modern geological standards (Abu Dayyeh 1993: 141, 143). More surprising was a study indicating its possible application for the treatment of polluted water resulting from modern industrial waste (Baker 1993).

The clay source concerned comprises Jabal aṭ-Ṭīnah (the mountain of clay), located between the town of Wādī Mūsā and Petra (FIG. 1). The section of the site next to a spring ('Ayn aṭ-Ṭīnah, UTM coordinates 737610E-3357730N) was first recognised as an important source of clay by archaeologists in 1981 during a search for possible clays used at the Zurrāba pottery workshop ('Amr 1987: especially 43; first reported by Zayadine 1982: 380), and was brought to the attention of the scientific community in Jordan through personal communications (Khairieh 'Amr with Maha Tutunji and Hani Khoury in 1992), thus being a case of the field archaeologist recognising a geological discovery more than a decade earlier than the field geologist. Of course the local people were aware of the clay in the area and of its use for pottery production much earlier than both the archaeologists and scientists ('Amr 1987: 43; Mason and 'Amr 1990: 288).

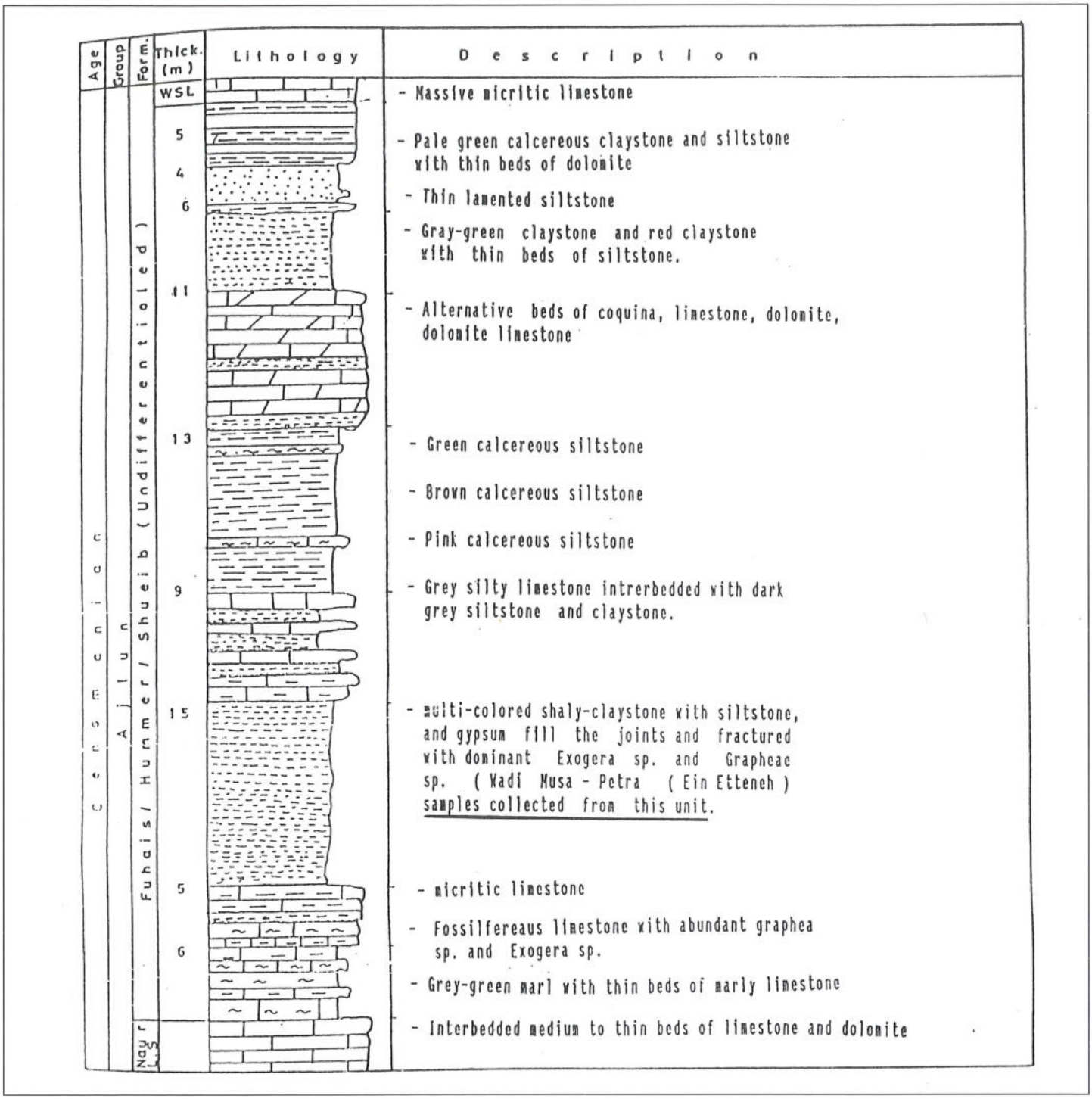
1. Aerial photograph of the Jabal aṭ-Ṭīnah area (IGN-PARIS and Dept. of Antiquities - Amman 1977).

The geology of the area is discussed in Abu Dayyeh 1993 (14-23, after Barjous; FIG. 2). It suffices here to say that the clays under discussion come from a 15m thick band in the lower part the "Fuhais-Hummer-Shueib" (undifferentiated) Formation (as compared to the 4.2m thickness of the Māḥiṣ clay layer and 2.8m thickness of the Ghawr Kabid clay layer, Bender 1974: 168). The clay at 'Ayn aṭ-Ṭīnah directly overlies outcropping limestone of the same formation.

The claystone at Jabal/'Ayn aṭ-Ṭīnah is intensely fractured by the "Wādī Mūsā Fault" and is characterised by massive landslides due to the nature of the deposits, and notably due to the deposition of secondary gypsum in the fractures (Abu Dayyeh 1993: esp. 128, 142). This threat to buildings there has been brought to the attention of the Wādī Mūsā municipality and currently no building permits are issued in the area (personal communication with the former mayor of Wādī Mūsā in 1993, who also said that owners of land there are offered alternative municipal land for building). Unfortunately, some houses were built, without permission, at the southwestern edge of this dangerous zone. The residents report difficulty in getting home during the rainy season and one fortunate house was abandoned due to substantial cracking during the initial building stage. It is gravely feared now — due to the recent building boom in Wādī Mūsā — that this municipal decision will be overruled and lives will be endangered.

The Raw Material for the Nabataean Ceramic Industry

The accidental discovery of the Zurrāba pottery workshop in the outskirts of Petra in 1979 opened a whole new horizon for the study of the most common archaeological artifact of the Nabataean culture, which chronologically went even beyond the limits of the Nabataean Kingdom as defined by history. This workshop, which is much humbled by the nearby magnificent capital of Nabataea, manu-



2. Columnar section for the "Fuhais-Hummer-Shueib" Formation at Wādī Mūsā (after Abu Dayyeh 1993: FIG. 2.5).

factured Nabataean products from the first up to the sixth century AD, making it the longest operating industrial area known in Jordan ('Amr 1991).

The Petra area — with its major pottery production centre at Zurrāba — was proven to be the main producer of fine Nabataean ceramics through two Neutron Activation Analysis studies ('Amr 1987; Gunneweg *et al.* 1988). The results of the first study indicated that the same clay source in the Petra area was utilised from around the beginning of the second century BC up to the sixth century AD for manufacturing a wide variety of wares ('Amr 1987: 199); while the second study arrived at two closely related composition groups, of chronological significance, dated from circa 50 BC to the end of the second century AD (Gunneweg *et al.* 1988: 342-343). The Neutron Activation Analysis studies failed to pin-point the clay source(s) in the Petra area, but the composition of clay samples from 'Ayn aṭ-Ṭīnah (presented in 'Amr

1987) came closer to the composition of the "local Petra Group" (in the same study) than any other clay samples from the Wādī Mūsā area (TABLE 1, based on 'Amr 1987; also compare to Gunneweg *et al.* 1988: 324 Table 4). This failure to relate the pottery to its clay source is thought to be mainly due to the processing of clay prior to manufacturing the pots, especially the extensive levigation needed for the production of fine wares which results in the removal of the heavier particles.

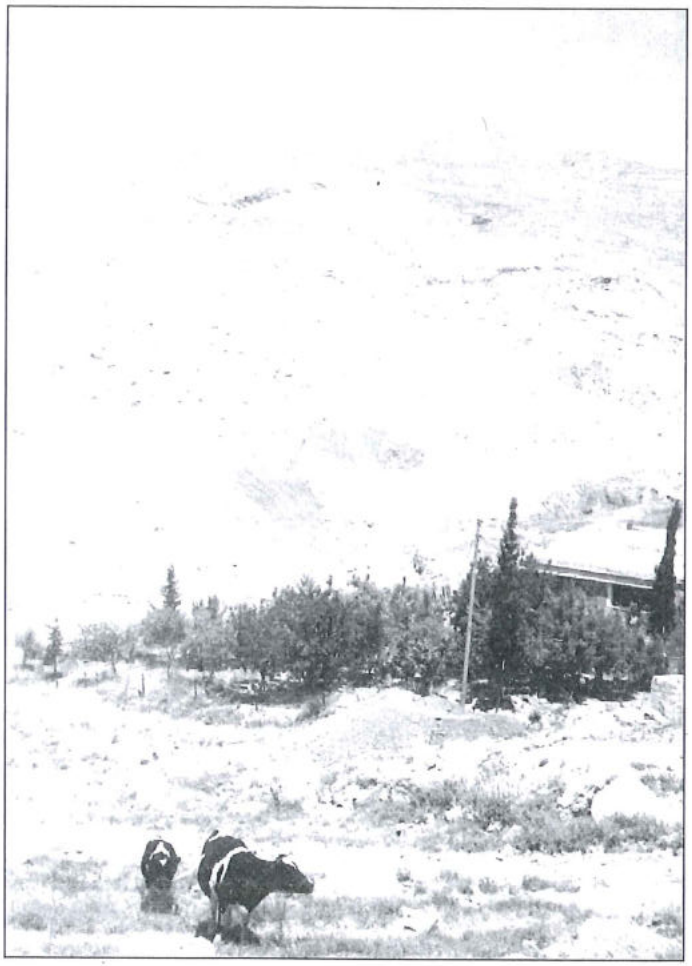
In their search for clays used in ancient ceramic industries, several researchers have concentrated their efforts on wadi beds, this being a natural choice as the secondary transported clays found there are usually well sorted due to the action of water, thus reducing the effort needed in processing. For example, an experimental firing of a dried sample of 'flood clay' deposited in Petra after the floods of March 1991 — with no post-field treatment — resulted in an appearance which is very similar to the finest of the Classical Nabataean fine wares (Mason and 'Amr 1993: 207), although all the primary clay deposits in the area would necessarily require much levigation before they can even get close to the finesse of the Nabataean wares.

Unless dealing with alluvial flood plains or deltas, it is difficult to conceive that the small amounts of clays usually found in the wadi beds of Jordan could support anything larger than a small-scale household industry. Mining of dependable clay deposits, despite the extra effort needed in the processing, would be the answer for a commercial pottery industry. An extreme (modern) example can be seen at the Tunisian island of Jarba, where the clay has to be quarried underground "a practice which is dangerous and has claimed many lives" (Peacock 1982: 42).

Failure to find evidence for the extraction of clay, other than the occasional relatively small clay pits in the immediate vicinities of kilns, has been assumed to be due to very little material being required for making a pot "and the extraction of raw materials can have a relatively slight impact on the landscape" (Peacock 1982: 52). In the case of the Nabataean ceramic industry, it is difficult to conceive that a material which was probably extracted for almost eight centuries would not have impacted the landscape. The area of 'Ayn aṭ-Ṭīnah presents evidence for exactly this sort of impact, where part of the eastern edge of Jabal aṭ-Ṭīnah seems to be gouged in the form of a huge, open edged, ovoid "pit". The orientation of the long axis of this "pit" is at around 20° west of North, and it measures just under 80m in length by 45m in width with a maximum depth of around 15m (the full thickness of the natural clay deposit layer; FIGS. 3, 4). The "pit" is cut on the northeastern side by Wādī Qrāra (Ghrāra), a tributary of Wādī Ḥamāṭat Ḥammād. The overall form of this "pit", evident in the centre of FIG. 1, is a prime candidate for the location of an ancient mine, although the dimensions may not be exact due to landslides which are especially evident

Table 1. Compositions of "local Petra group" compared to green clay samples from 'Ayn aṭ-Ṭīnah. Concentrations in ppm except for K and Fe, which are in % (based on 'Amr 1987).[1]

	Petra pottery (211 spls)		'Ayn aṭ-Ṭīnah Clay (4 spls)	
	Mean	σ	Mean	σ
K	002.34	00.35	001.96	00.17
Fe	004.71	00.59	005.54	00.71
Cs	003.32	00.48	003.56	00.28
Sc	021.1	02.4	022.1	04.7
La	027.9	03.0	025.8	03.6
Ce	067.8	12.3	049.6	07.2
Lu	000.414	00.056	000.355	00.026
Th	009.03	01.07	008.67	00.78
Cr	128.	20.	113.	11.
Co	019.8	03.0	025.7	10.
Sm	005.70	00.68	004.40	01.17



3. General view of the clay deposits at 'Ayn aṭ-Ṭīnah (view from the south-east).

[1] Only the green coloured clay samples from 'Ayn aṭ-Ṭīnah are considered in this table as the green clay forms the bulk of the deposit in the area, with the other clays being present in only small amounts.

4. The northwestern edge of the ovoid "pit" at 'Ayn aṭ-Ṭīnah where the concave form is evident (view from the south).

at the southern end of the western slope (FIG. 5). However, this pit form cannot be caused by landsliding.

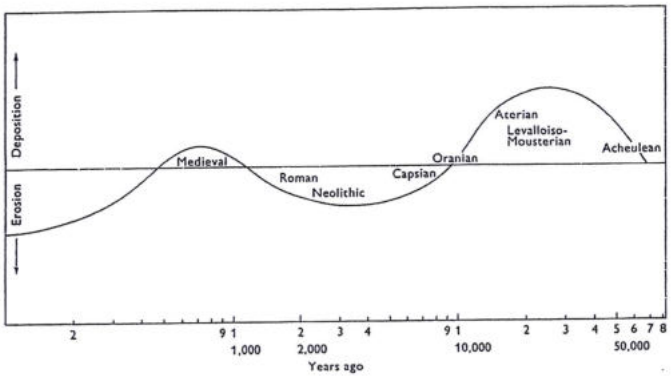
Further indications for the clays at 'Ayn aṭ-Ṭīnah having been used by the Zurrāba potters are given in Mason and 'Amr 1990; 1995. The strongest evidence is presented by the suitability of the clay for manufacturing fine wares very similar to those produced at Zurrāba due to its special mineralogical composition, more specifically its high illite/smectite content (see Baker 1993 for comparisons between the mineralogical contents of various clay sources in Jordan).

The Historical Wadi Terrace at 'Ayn aṭ-Ṭīnah

The phenomenon of a "historical wadi terrace" — notably where ancient remains that had been buried are re-exposed in wadi cuts — is not uncommon, although this useful indicator seems to be utilised more by "pre-historic" archaeologists (and geologists) than by archaeologists dealing with the later "historic" periods (a random survey of *ADAJ* volumes produced the following examples: Edwards 1984: 56; 1993; Petocz and Villiers 1984: 78-80; Macumber 1984: 83-86; 1993; Besançon *et al.* 1984; Byrd and Rollefson 1984: 143; Gilbertson and Kennedy 1984: 156; Mabry and Palumbo 1988: esp. 277, 296; Palumbo *et al.* 1993: 316).

Vita-Finzi (1969) has beautifully and simply illustrated and explained the formation of the present configurations of valleys in the Mediterranean area, including Jordan. The noted "historical" terraces are due to cycles of erosion and deposition (FIG. 6). Quite simply, soils accumulated *in the valleys* between around 60,000-10,000 years ago, then were eroded away or cut down up until just over a thousand years ago, during which time the floor level (and the cultural material deposited on it) got lower, then again deposition of soils occurred (covering the cultural material) in a process that lasted up till around 500 years ago. Finally, erosion set in again, currently even undercutting the lowest of the previously deposited material and exposing the Capsian-through to-Roman remains that were deposited in the previous erosional cycle.

5. Landslide at the southern edge of the "pit" at 'Ayn aṭ-Ṭīnah (view from the north west). The spring can be seen just below the house on the upper terrace of Wādī Qrāra.



6. Chronology of erosion and deposition in the Mediterranean area (after Vita-Finzi 1969: 92, FIG. 42).

This other form of changing landscape is evident in Wādī Qrāra beneath and just to the northwest of the spring of 'Ayn aṭ-Ṭīnah, opposite the "clay mine", where walls can be seen along the wadi cut (FIG. 7). The walls form a structure of several rooms and are built with mostly unhewn limestone chunks and a few dressed blocks (FIG. 8; it

should be noted that the limestone underlying the clay in the area tends to fracture at right angles). The section below the walls is of wadi cobbles with little silt, from which two probable Neolithic sherds and one flint arrow head were recovered, while the fill at the level of the walls is composed mostly of silt with less cobbles (FIG. 8). One Classical Nabataean body sherd was recovered (by Henry Cleare) from one of the walls and a second century AD cooking pot sherd was found in the fill nearby. These findings are another illustration of Vita-Finzi's study.

The two sides of Wādī Qrāra differ markedly from each other, with the opposite southwestern cut showing the lower (natural) strata of the "Fuhais-Hummer-Shueib" (undifferentiated) Formation. However, around 50m further up the wadi, one wall could be seen next to the northern edge of the "mine pit". This wall could be traced with

7. Stone walls in the northeastern cut of the lower terrace of Wādī Qrāra (view from the south-east, below the spring of 'Ayn aṭ-

8. Section of a wall in the northeastern cut of Wādī Qrāra.

difficulty for approximately 5m on the surface in the only area with an abundance of Nabataean sherds. Still further up the wadi, more walls preserved to higher heights corresponding with the deeper cut were found. However, none on the side of Jabal aṭ-Ṭīnah .

Currently it is difficult to say what the function of the structures near 'Ayn aṭ-Ṭīnah may have been. A purpose related to clay processing is a possibility due to their position next to a "clay mine" and running water. The pottery workshop at Zurrāba is on a slope with several wadis but no dependable water source in the immediate vicinity. Although the Zurrāba cistern and the channel carrying water from 'Ayn Mūsā to fill it are near the pottery workshop, this water would have been too precious to use for clay processing, like the juniper trees on the surrounding hills would have been too precious for kiln fuel. Clay processing installations at 'Ayn aṭ-Ṭīnah would save hauling both water and heavy, unprocessed clay. To date, no levigation set-up was confirmed at the Zurrāba workshop (see Mason and 'Amr 1990: 298). However, only a small part of the Zurrāba site is excavated and much of it has been lost forever due to modern building at the site.

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