INTERDISCIPLINARY EGYPTOLOGY

RESEARCH ARTICLE

Surface Pitting on Predynastic Palettes

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Abstract

Stone palettes are the third most common object type found in Predynastic Egyptian burials (after beads and pottery), but understandings of their use are based on 19th century assumptions that they were used for processing pigments, specifically malachite, for use as eye paint. Though overlooked in previous studies, a significant number of Predynastic palettes display surface pitting that may indicate a specific type of use. This article investigates surface pitting through a statistical analysis of palettes in the Predynastic Palette Database (PPDB), together with reflectance transformation imaging (RTI), microscopy, and experimental archaeological studies to establish if the phenomenon may be related to chronology. This paper suggests that palettes played a more nuanced ritualistic role in elite Predynastic society than has previous been discussed. The possible causes of pitting are also explored, along with possible links to pitting being the product of the deliberate striking of palettes as a component of sonorous ritual.

Keywords: Predynastic, palette, surface pitting, use wear, experimental archaeology

تنقر السطح علي صلايات عصر ما قبل الأسرات

الملخص

تعتبر الصلايات الحجرية هي ثالث أكثر أنواع القطع الأثرية المكتشفة شيوعا في الدفنات الخاصة بعصر ما قبل الأسرات في مصر (بعد الخرز و الفخار)، و لكن يرتكز فهم طريقة استخدامها علي أفتراضات ترجع إلي القرن التاسع عشر، أي وهي أنها كان يتم استخدامها في اعداد الصبغات، خاصة الملاخيت، لكي تستخدم كطلاء للعين. وعلي الرغم من تغاضي الدراسات السابقة عن هذه الظاهرة، إلا أن عددا كبيرا من الصلايات التي ترجع إلي عصر ما قبل الأسرات تظهر تنقر علي السطح، مما قد يشير إلي أنه قد تم استخدمها لغرض معين. و تعمل هذه المقالة علي البحث في تنقر السطح وذلك من خلال التحليل الإحصائي للصلايات المنتمية إلي قاعدة البيانات الخاصة بصلايات عصر ما قبل الأسرات، بالأضافة إلي تصوير تحويل الانعكاس، و الفحص المجهري، والدراسات الأثرية التجريبية وكل ذلك لكي يتم معرفة ما أذا كانت هذه الظاهرة متعلقة بالتسلسل الزمني. كما يشير هذا البحث إلي أن الصلايات لعبت دورا طقوسيا أكثر دقة في مجتمع النخبة خلال عصر ما قبل الأسرات، أكثر مما تم ذكره في الدراسات سابقا. .حيث تم الفصح ايضا عن الأسباب المحتملة للتنقر، بالأضافة إلي ذكر الروابط المحتملة المشيرة إلي أن التنقر هو نتيجة للضرب المتعمد للصلايات كجزء من الطقوس الرنانة.

الكلمات الدالة عصر ما قبل الأسرات، صلايا، تنقير السطح، علم الآثار التجريبي

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1 Introduction

Predynastic palettes are predominately flat stone objects, whose morphology changes over the periods of their use with the dominant shape changing from rhomboid, to zoomorphic, to oval, rectangular and shapeless (CIAŁOWICZ, 1991; HENDRICKX & EYCKERMAN, 2012; PATCH et al., 2011: 137–151; PAYNE, 2000; PETRIE, 1953; PETRIE, 1920, 1921). Since the time of their excavation, chiefly in the 19th Century, palettes have been associated with processing pigments. Pigment staining on palettes is typically green in colour from processing malachite, but red ochre is also found, and galena is extremely rarely found with BADUEL's (2008: 1068) study only finding two palettes with galena residue. Pigment processing is commonly cited as their sole function, typically linking the pigment use with cosmetics (QUIBELL et al., 1900; PETRIE, 1895: 371; PETRIE, 1917b) due to their burial proximity to the head (ADAMS, 1988: 47; PETRIE & MACE, 1901: 20), or as a sun-defence (MURRAY, 1949: 3), or to ward off flies (ADAMS, 1988: 59).

In the 21st Century, scholars have suggested a less utilitarian and more ritualistic use for palettes (STEVENSON, 2007: 152), which were most likely owned and used by the elites of society (BADUEL, 2008: 1065–1067; RIGGS, 2020: 92). BADUEL (2008: 1068, 1083) suggests that palettes were a part of the social structure of the Predynastic eras not solely created for inclusion in burials, and SMOLIK (2019: 186–189) has also suggested that certain palette morphologies may have performed an apotropaic function.

It should be noted that the inclusion of palettes in burials has not been limited to any specific social demographic and palettes have been found in graves of infants and elderly adults, however they do appear to be more frequently included in the burial assemblages of females (STEVENSON, 2007: 154–156). Palettes were not a 'standard' inclusion in burials and whilst several hundred palettes have been documented, they have only been found in 15% of all graves (STEVENSON, 2007: 153). It is difficult to objectively determine the status of a burial, and the best measure available is to use the size and contents – i.e. larger tombs with more grave goods are more 'elite' than smaller and less-provisioned tombs (STEVENSON, 2007: 156). Previous studies have found that palettes are most likely to be found in middle-sized tombs, however it is also true that the larger wealthier tombs have been more attractive targets for tomb robbery that would of course skew this attribution (STEVENSON, 2007: 156). Therefore, despite their relative exclusivity, we cannot conclusively say that palettes are only an elite item.

Descriptions of Predynastic palettes as sometimes being made from slate or schist appears to date back to late 19th Century assumptions such as a those made by PETRIE (1895: 371). This definition is incorrect, and palettes were in fact made from greywacke from the Wadi Hammamat (BLOXAM et al., 2014: 15; STEVENSON, 2007: 150; SZAFRAN, 2020a: 75), or most accurately described as metagreywacke to reflect the presence of chloride and epidote minerals indicating metamorphism (STEVENSON, 2007: 150).

One of the properties of greywacke is that it has an advantageous cleavage which make especially well-suited to producing the relatively thin flat sheets required to produce palettes (STEVENSON, 2007: 150–151). The Predynastic craftspeople created roughly shaped palettes in the quarries of the Wadi Hammamat, with the final processing completed in workshops on the floor of the wadi (BLOXAM et al., 2014: 16).

Many Predynastic palettes feature pitting on their surfaces, which can be defined as the presence of small indentations and flaking on the otherwise smooth surface of the palette (Figures 1 to 3). This pitting is not always present, and where present can vary in frequency with some palettes being more heavily pitted than others (Figure 2).

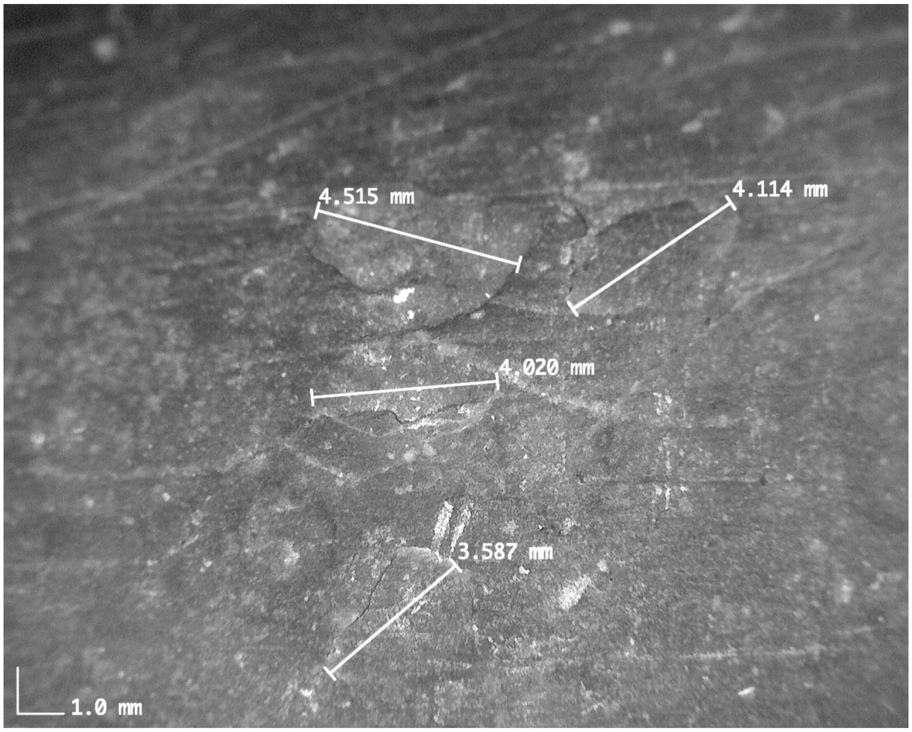


Fig. 1: Surface pitting of rhomboid-shaped palette Bolton LAMS 1909.76.10, viewed at 20x through a Dino-Lite AM4113T digital microscope, with measurements taken in DinoXcope.

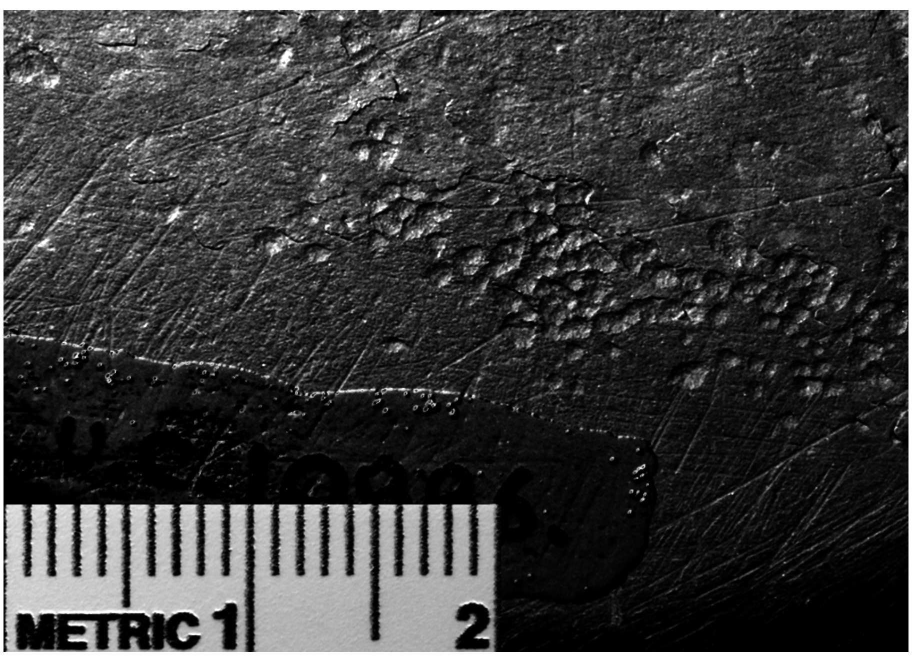


Fig. 2: Close up of 'Specular Enhancement' rendering of RTI of turtle shaped palette, Petrie UC10886, showing flaking and pitting of the palette's surface.

It may be that greywacke's propensity for cleavage is responsible for the surface pitting, as forceful strikes of a hard object against the surface of a palette may cause the stone to spall, resulting in flaking, surface pitting, and possible breakage. To investigate the possible causes of surface pitting this study used a combination of statistical analysis to compare features of a significant number of palettes, a reflectance transformation imaging study of provenanced Predynastic palette, and experimental archaeology to investigate the material properties of siltstone, malachite, and to create a replica fish-shaped palette.

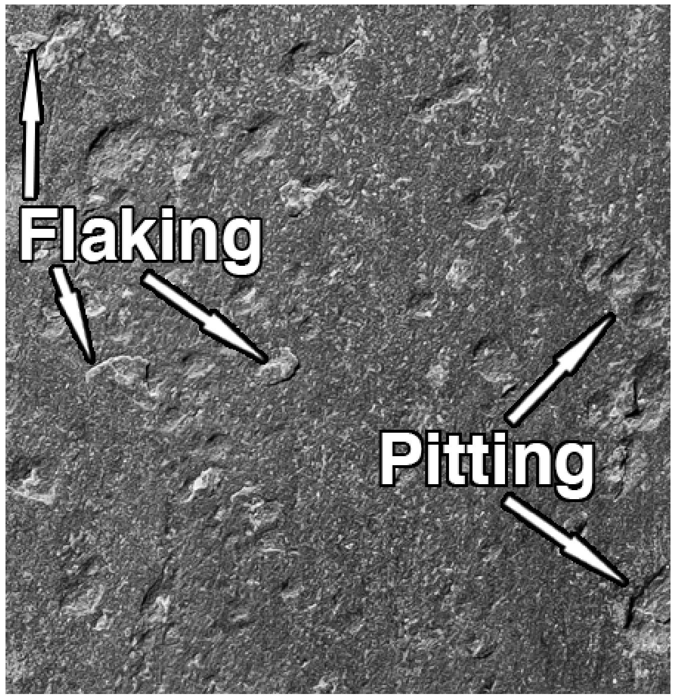


Fig. 3: Close up of surface of Manchester 5476, demonstrating flaking and pitting of the palette's surface.

2 Research Objective

Surface pitting on Predynastic palettes has not previously been discussed, and the primary goal of this analysis was to establish whether it could be evidence of use-wear. The secondary goal of this analysis is to determine what processes may have surface pitting if it is indeed a form of use-wear, and hence to establish what implications this has for understanding the possible function of palettes in the Predynastic cultures that used them.

The first consideration in determining whether surface pitting is a form of use-wear is to establish how frequently it occurs in the corpus of known palettes, and whether it is more or less common for palettes of different periods or morphologies. Queries on the Predynastic Palette Database (PPDB) comparing chronological distribution and different features (e.g., morphology or presence of 'suspension holes') were run to understand the relationship between surface pitting and different groups of palettes.

In order to understand what processes may have caused the pitting, and whether this is likely to be the result of a deliberate use of the palette, multiple experiments were conducted to study how different materials behave.

3 Statistical Analysis

The Predynastic Palette Database (PPDB) was established by the author in 2020, collating data such as size, morphology, presence of pigment staining, and presence of surface pitting of Predynastic palettes from museum and auction house catalogues into a MySQL database. Larger palettes and also so called amuletic palettes have also been catalogued, the latter being labelled with the prefix 'Amulet-' in their morphological description – e.g. 'Amulet-Antelope'. At the time of writing, the PPDB contains information on 1230 palettes from 42 different collections.

The database schema (Table 1) was designed to capture specific features of the different palette morphologies, for example the type of eye found on zoomorphic palettes and the presence of indentations on the surface of some rhomboid-shaped palettes.

Tab. 1: Predynastic Palette Database column schema.

Column	Description	Notes
Accession Number	What is the collection's accession number for the palette?	If no accession number, e.g. auction house, then one was created

When cataloguing palettes, the first image in the collection catalogue was taken to be the 'recto' and the second image as the 'verso', not all collections show both sides and so some entries only have information about their recto recorded in the PPDB.

Where possible the stored values were normalised and reduced to as small a list of options as possible. This then allows for easier and broader comparison between palettes than if they all have slightly different values. This is particularly important with the palette morphology, as individual collections use different terms for what is essentially the same shape. Where the morphology was difficult to determine, it was recorded with a question mark – for example 'Cow?'. If desired, this allows queries to be built which exclude these uncertain morphologies.

A column was included to identify whether the palette is a suspected forgery, thus allowing these palettes to be removed from queries against the dataset so as not to skew the results.

Unfortunately, not all details are recorded and/or displayed in collection databases, for example dimensions and find location or provenance are rarely known/recorded.

3.1 How Common is Surface Pitting?

Palettes with surface pitting represent 32.93% (405/1230) of the corpus of palettes catalogued in the PPDB to date. The pitting may be present on one or both sides of the palette (Table 2).

Not all online collection catalogues include photographs of both the recto and verso of the palettes. As such, the data in the PPDB is biased to the recto and there may be additional pitting on the verso of objects that has not been catalogued.

Tab. 2: Surface pitting distribution between palette surfaces.

Surface Pitting Recto	Surface Pitting Verso	Surface Pitting on Both Recto and Verso	Surface Pitting on Either Recto or Verso
360	131	86	405

3.2 Which Morphologies Demonstrate Surface Pitting?

Surface pitting is present on 54 of the 77 morphologies catalogued in the PPDB. The 23 morphologies (Table 3) which do not display surface pitting are among the less-common types, representing only 2.85% (35/1230) of palettes in the PPDB, with 8 being questionable morphologies and so may possibly be grouped with other pitted forms

(**??**). There does not seem to be any commonality between sizes, with the non-pitted palettes ranging from the smaller 'amulet' sized palettes to the larger rhomboid-shaped palettes.

Tab. 3: Frequencies of palette morphologies not displaying surface pitting.

Morphology	Morphology Frequency
Amulet-DoubleBird?	2
Amulet-Lion	1
Amulet-Rectangle	1
Amulet-Turtle	2
Bird/Boat?	5
Blade	1
Conjoined-Antelopes	1
Cow?	2
Crocodile	1
Cruciform	1
D-Shape	4
DoubleBird?	1
Duck	1
Fragment-Carved	1
Goat?	1
Hedgehog?	2
Jackal	1
Lion?	1
Reed boat	1
Rhomboid-Antelope	2
Rhomboid-Figure	1
Trussed-Ox	1
Turtle?	1

Palettes in all other morphologies display surface pitting, although the frequency of its occurrence varies by morphology (Table 4). If the pitting is the result of a deliberate action, the variation in frequency could imply that the different palette morphologies were used in different ways. However, it is difficult to speculate on exactly what the function and symbolism was for the different morphologies.

Tab. 4: Frequencies and morphologies of surface pitted palettes.

Amulet-Rhomboid	Morphology Frequency	Pitting Frequency	Pitting Percentage
Fish	209	86	41.15%
Rectangle	180	49	27.22%
Rhomboid	146	65	44.52%
Scutiform-Birds	99	38	38.38%
Oval	55	19	34.55%
Bird	53	13	24.53%
Turtle	48	15	31.25%
Fragment	42	7	16.67%
Boat	41	17	41.46%
Scutiform	41	9	21.95%
Shapeless	40	9	22.50%
DoubleBird	37	5	13.51%
Amulet-DoubleBird	32	5	15.63%
Rhomboid-Birds	20	5	25.00%
Amulet-Bird	14	4	28.57%
Carved	13	5	38.46%
Ram	11	5	45.45%
Antelope	8	1	12.50%
Hippopotamus	8	3	37.50%
Elephant	6	4	66.67%
Scutiform-Bird	5	1	20.00%
Animal	4	2	50.00%
Rhomboid-Bird	3	1	33.33%
Amulet-Rhomboid	2	1	50.00%
Amulet-Scutiform	2	1	50.00%
Conjoined-Birds	2	1	50.00%
Conjoined-Fish	2	1	50.00%
Fish/Oval	2	1	50.00%
Hybrid-TurtleAntelopes	2	1	50.00%
Poppy	2	1	50.00%
Amulet-Antelope	1	1	100.00%
Amulet-Gazelle	1	1	100.00%
Amulet-Heads	1	1	100.00%
Bag	1	1	100.00%
Conjoined-Antelope	1	1	100.00%
Conjoined-Turtle	1	1	100.00%
Half-Fish	1	1	100.00%
Lion	1	1	100.00%
Rhomboid-Carved	1	1	100.00%

Tab. 4: (continued)

Amulet-Rhomboid	Morphology Frequency	Pitting Frequency	Pitting Percentage
Rhomboid-Figures	1	1	100.00%
Scutiform-Animal	1	1	100.00%
Scutiform-Heads	1	1	100.00%
Trussed-Duck	1	1	100.00%
Trussed-Sheep	1	1	100.00%

There appears to be an inverse correlation between the frequency of a morphology and the occurrence of surface pitting, namely that the less frequently a morphology occurs, the more likely it will be that it will display surface pitting (Table 4). This includes the conjoined animal palettes which SMOLIK (2019: 190–191) suggests may have been representations of deities with their double nature conferring double the power. This more ritual use could imply that the rituals performed were responsible for the surface pitting. This in turn could imply that these more unusual morphologies were only used for practices that resulted in pitting, with the more common morphologies being used in multiple different ways.

When studying the pitted palette, it must be borne in mind that certain periods had a more limited differentiation of morphologies, for example rhomboid-shaped palettes that occur almost exclusively during the Naqada I period. However, the zoomorphic shapes of the Naqada II palettes potentially gives us an insight into a greater diversity in the symbolism of palettes and the rituals in which they were used (BADUEL, 2008: 1065–1067; SMOLIK, 2019: 186–189).

It has been suggested that many of the fish-shaped palettes represent the Nile tilapia (*Oreochromis niloticus*) (BREWER & FRIEDMAN, 1989: 9; STEVENSON, 2011: 160), which is a maternal mouth-brooding species. This has led to speculation that the young emerging fully developed from the mother's mouth could have been interpreted as a symbol for fertility when represented as palettes and other material culture (PATCH et al., 2011: 26).

BADUEL (2008: 1059–1060) suggests palettes in burial contexts have malachite staining, whist ochre staining is more prevalent for palettes in settlement contexts. However, BADUEL (2008: 1068) also notes that fish-shaped palettes appear to only ever have malachite staining no matter their find context. It has been suggested that the green malachite pigmentation could be a symbol of fertility and new life. Palettes are predominantly found in burial contexts and fish-shaped palettes are the most common morphology of the Naqada II period (CIAŁOWICZ, 1991: 20) and this may imply that their possible links to fertility and new life was important in the funerary ritual. As surface pitting is present on 41.15% of the fish-shaped palettes catalogued in the PPDB, this may then imply that this was the result of use in these fertility and new life rituals. (Table 4).

Other contemporaneous morphologies do not display the same frequency of pitting as fish-shaped palettes, such as bird-shaped palettes of which only 24.53% are pitted (Table 4), and this may imply that they were used in different ways than fish-shaped palettes.

3.3 Is Surface Pitting Restricted to Palettes with 'Suspension Holes'?

A feature commonly found on zoomorphic palettes of the Naqada II period, but not typically on other forms, is a hole drilled through the centre of the top edge – the use of which is unknown but may have provided a means by which to hang the palette (BROVARSKI, 2015: 49–51; ROY, 2011: 88; HAWASS, 2010: 46). Alternatively, the palette may have been attached to the body (CAPART, 1905: 85; PATENAUDE & SHAW, 2011: 1), whereas other suggestions are that the perforation permitted storage – perhaps hung on a wall as suggested by MENDOZA (2017: 54), PATENAUDE and SHAW (2011: 1), PODZORSKI (1994: 373) and SHAW (2015).

Surface pitting appears equally frequently on palettes with (51.6%) and without (48.4%) suspension holes. It is also present on palettes from all periods, and not just on those from Naqada II. Even though there are more palettes from Naqada II than other periods, there are still non-pierced palettes with surface pitting. There is also variation amongst similar palettes with, for example, not every fish-shaped palette displaying a 'suspension hole'.

3.4 Chronological Distribution of Surface Pitting

Surface pitting has been present on palettes from their origins in the Badarian period through to the Naqada III period (Figure 4, Table 5). The practice appears to have continued into the Early Dynastic period, with carved palettes such as the Narmer Palette displaying surface pitting on different carvings – for example on the cow/Bat/Hathor symbols at the top of the palette. This implies that the actions performed with the palettes resulting in surface pitting were present from the inception of palettes through their fall from favour in the Early Dynastic period.

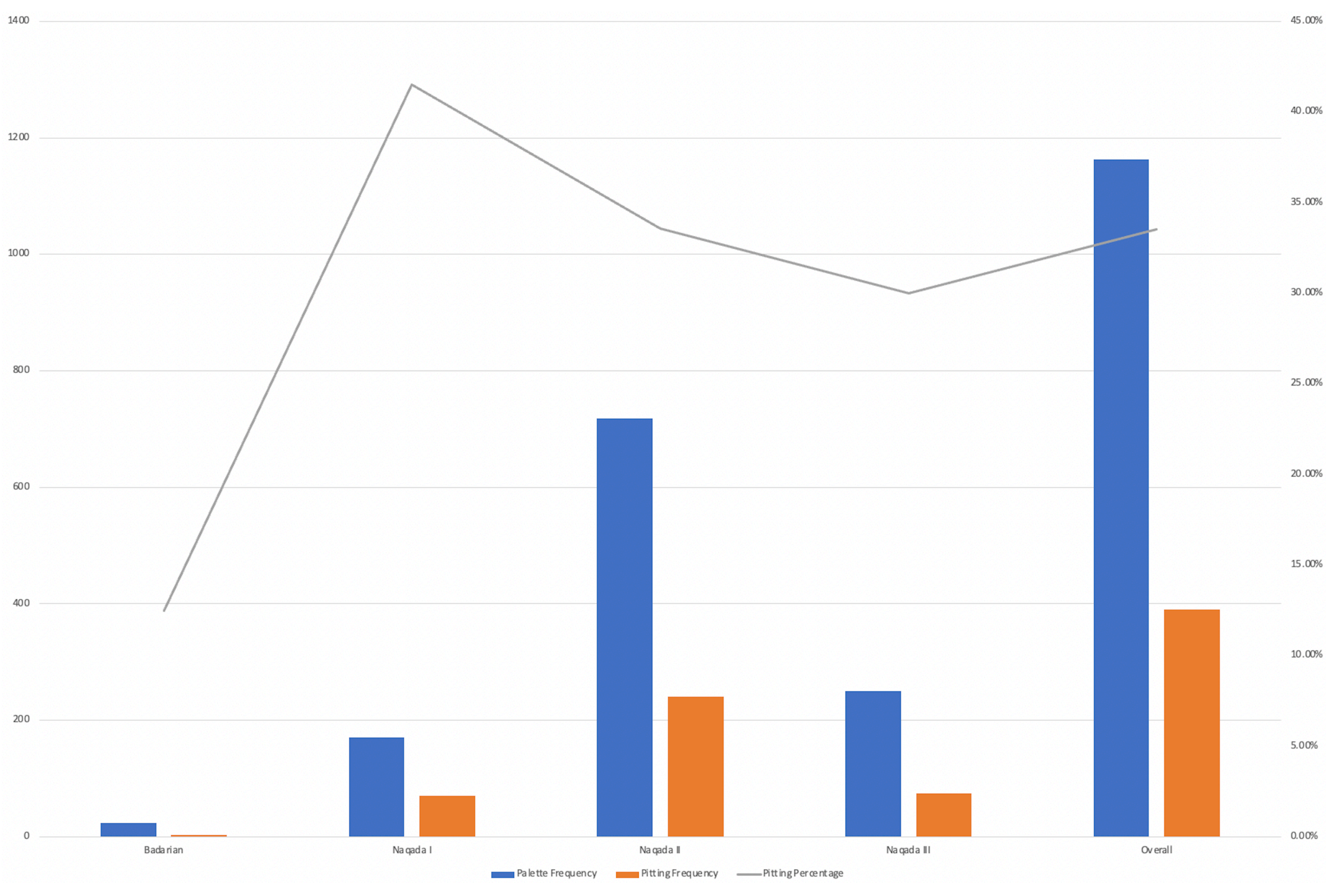


Fig. 4: Predynastic palette surface pitting frequency by period. Note: This is data represents palettes that could be securely dated and excludes those which could not, for example fragmentary palettes.

Tab. 5: Predynastic palette surface pitting frequency by period. Note: This is data represents palettes that could be securely dated and excludes those which could not, for example fragmentary palettes.

Period	Palette Frequency	Pitting Frequency	Pitting Percentage
Badarian	24	3	12.50%
Naqada I	171	71	41.52%
Naqada II	718	241	33.57%
Naqada III	250	75	30.00%
Overall	1163	390	33.53%

A chi-square test of independence was performed (Table 6) to examine the relationship between period of manufacture and the presence of surface pitting using a 5% significance level. The relationship between these variables was significant, χ^2 (3,N=1163)=11.06,p= .11413. This strongly suggests that the presence of surface pitting on Predynastic palettes may be linked to the period of their manufacture.

Tab. 6: Chi-square test of independence of surface pitting on Predynastic palettes by period.

Period	Badarian	Naqada I	Naqada II	Naqada III	All
Pitted	3	71	241	75	390
	8.048	57.343	240.774	83.835	
	3.166	3.253	0.000	0.931	
Non-Pitted	21	100	477	175	773
	15.952	113.657	477.226	166.165	
	1.598	1.641	0.000	0.470	
All	24	171	718	250	1163

Cell contents:

- Count
- Expected Count
- Contribution to Chi-square

Surface pitting appears on only 12.50% of palettes in the Badarian period, however this then rises to 41.52% in the Naqada I period before becoming slightly less prevalent in the Naqada II and Naqada III periods with 33.57% and 30.00% respectively. It is possible that the significantly increased number of palettes in the Naqada II period may explain the dip in the percentage compared to the Naqada I period.

There are significantly fewer palettes from the Naqada III period compared to Naqada II, most likely caused by the increasing restriction of materials and craftspeople as the Egyptian state began to form (BADUEL, 2008: 1063–1064; WENGROW et al., 2006: 151–175). However, the percentage of pitted palettes only decreased by 3.57% between the Naqada II and Naqada III periods. This would imply that whilst there were less palettes in use between these two periods, they continued to be used proportionally in rituals that resulted in surface pitting.

3.5 How Common is Pigment Staining?

The discussion of the uses of Predynastic palettes should always consider their role in pigment production and use. Crushed malachite has been found alongside palettes in pouches, pots, or shells (AYRTON & LOAT, 1911; PETRIE & MACE, 1901: 20; QUIBELL & GREEN, 1902: 42), held between the hands of the deceased in leather pouches, reed baskets, or simply as loose crystals (STEVENSON, 2011: 160). Malachite paste has also been found in ivory vases (BRUNTON & CATON-THOMPSON, 1928: 28).

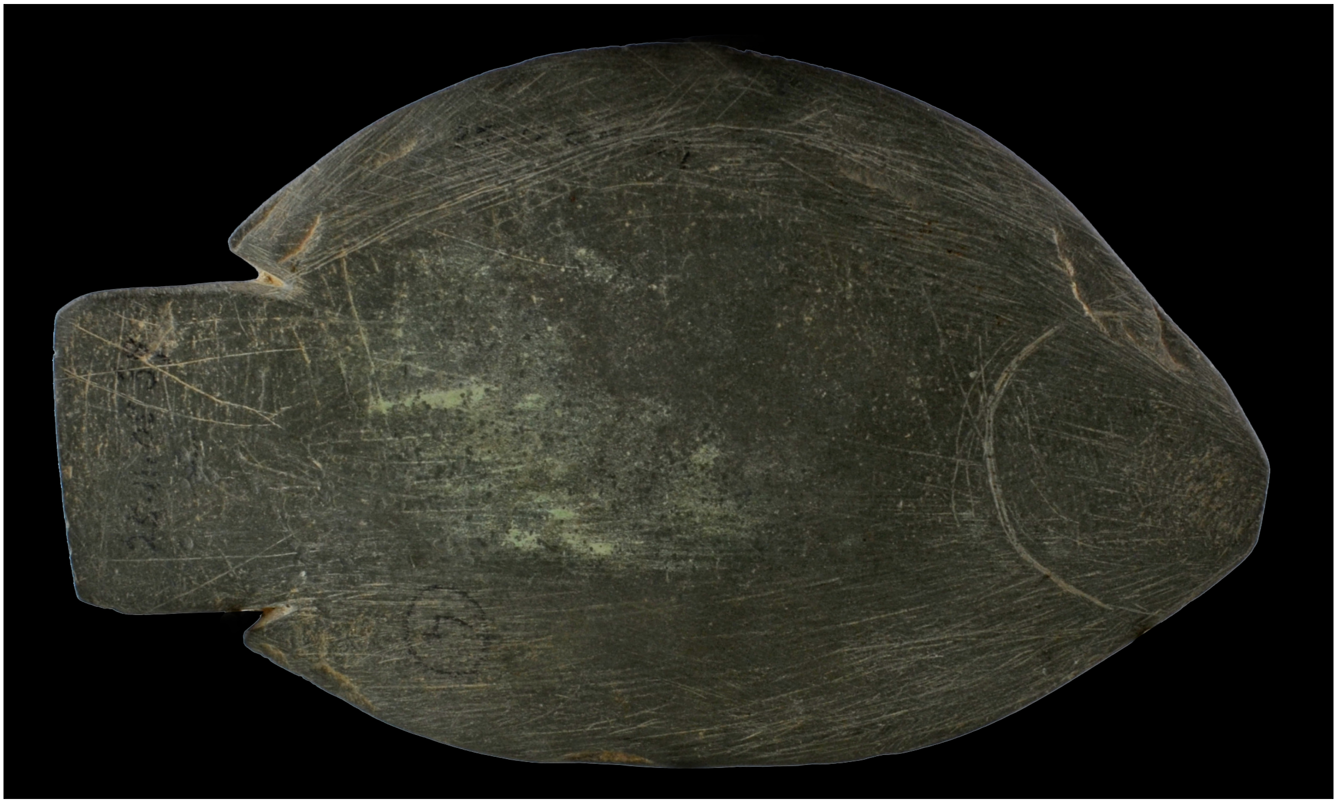


Fig. 5: Fish-shaped Predynastic palette with green pigment staining on its surface, World Museum 25.11.05.39

However, only 4.80% (59/1230) of the palettes in the PPDB show traces of pigment staining (Figure 5). Pigment traces have less permanence than physical changes to a palette, and so it is likely that other palettes had pigment traces which have disappeared over time. Curatorial conservational practice has also changed over time, and it is possible that palettes have been cleaned, with pigment traces being deliberately removed on discovery or upon entry into a collection for display in a museum.

Surface pitting and pigment staining are not mutually exclusive with 25 out of 59 (42.37%) of the pigment stained palettes also having surface pitting, which implies some crossover in terms of of their use. This also suggests that surface pitting is unlikely to be related to the processing of pigment, as it does not feature on all palettes with pigment staining and vice versa.

4 Experimental Archaeology

The use of experimental archaeology allows studies into material behaviour and possible use which are not possible by simply examining ancient artefacts, for example by forcibly striking the surface of a palette with a stone. The results of these experiments can then be compared with Predynastic palettes to determine if the process was likely to have produced surface pitting.

4.1 Malachite Processing

Malachite is a relatively soft (Mohs 3.5-4) bright green ore of copper (ASTON et al., 2000: 43). Palettes are typically described as being used for the 'grinding' of malachite (PETRIE, 1895: 371), however this appears to be incorrect as experimentation using a section of polished British greywacke to grind malachite only succeeded in scratching the malachite and producing a fractional amount of powdered malachite.

To effectively process malachite, it first needs to be smashed into small crystalline shards that can then be crushed into a fine powder. When smashed, malachite fractures easily in extremely small particles that can easy be blown away unless they are contained. Experimentation has shown that wrapping the malachite in a piece of textile, such as linen, contained the friable shards (Figure 6 and SZAFRAN (2020b)), which could then be crushed into a fine powder. This crushing process could utilise either handheld hammerstones or mauls comprising a stone hammer head on a wooden shaft, against an anvil stone. STOCKS (2003: 46–47) argues that the majority of hammering in the Dynastic era was performed with handheld hammerstones rather than mauls. Experimentation showed that hammerstones afford a greater control of both impact location and striking power over mauls, allowing use of the same tool for both the initial heavy crushing and also for the significantly softer crushing to powder.

Fig. 6: Malachite crushed by the author on a sandstone anvil using a limestone hand hammer.

Figure 7 shows the results of crushing a piece of malachite, approximately 110 x 55 x 40 mm in size, against a sandstone anvil stone using a limestone hammer. This process was also captured in a video, demonstrating the force required to break the large malachite section into shards (SZAFRAN, 2022). The required force to initially crush malachite would undoubtedly break a palette.

Wrapping the malachite in linen serves to retain much of the friable granules. A linen sheet was also placed underneath the anvil stone, assisting in capturing any crystals lost through the linen wrapping. This process produced a small amount of powder along with sub 5 mm granules, which can easily be crushed against a smooth surface to produce a fine powder for use as a pigment. The smooth surface of a palette would be ideal for further processing into a fine powder. The powder could also be mixed with a base on a palette's surface to produce a pigment, which could then be utilised for application in a similar way to a modern artist's palette.

Figure 7 illustrates that the powder resulting from this process contains microscopic fibres transferred from the linen wrapping, with diameters ranging from 8μm to 23μm, and with an average diameter of 14.72μm. Once mixed with a base, these microfibres will help to reinforce the resulting pigment helping reduce shrinkage and cracking; analogous to the reinforcement of mudbricks with straw.

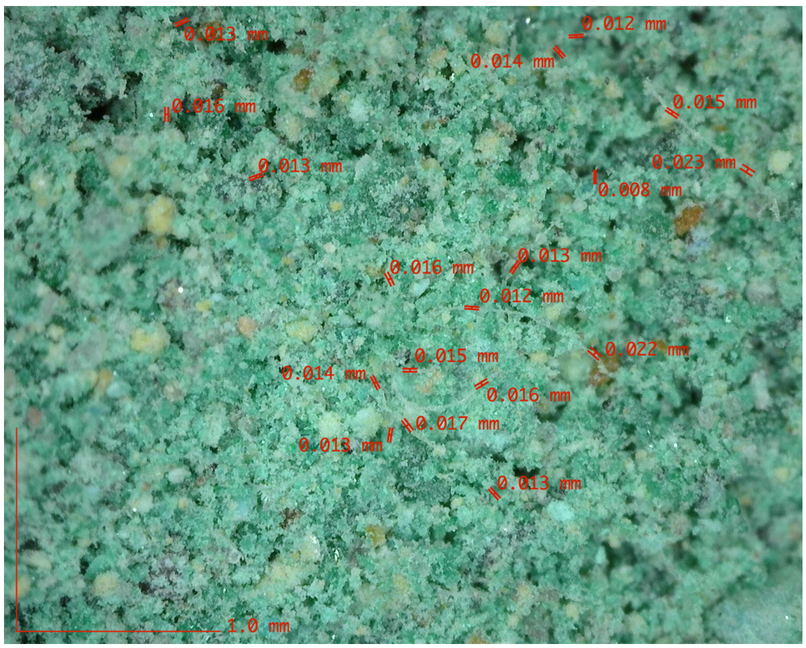


Fig. 7: Powdered malachite viewed at 100x through a Dino-Lite AM4113T, with measurements taken in DinoXcope.

4.2 Siltstone Striking

Pebbles are often found in burial contexts alongside palettes, which have been linked with pigment processing (STEVENSON, 2009: 2), however they may also have been used for the deliberate striking of palettes. To test this hypothesis, a small (45 x 36 x 6 mm) sample of British siltstone was smoothed and then struck with a smooth jasper river pebble (Figure 8).

British siltstone was used for this test as it was more easily available to the author than Wadi Hammamat series siltstone or greywacke. The sample was more coarsely grained and more friable than Hammamat siltstone but did still demonstrate similar cleavage.

The results of this striking caused the creation of surface pitting and ultimately breakage of siltstone sample (Figures 8 and 9).

Fig. 8: British siltstone sample after striking with jasper pebble.

It should be noted that if two hard objects are hit together, both can incur damage. This damage may be immediate, or alternatively accumulated over time. When striking the siltstone sample with the jasper pebble, the siltstone was immediately damaged and each strike cause pitting, flaking, and ultimately breakage. The jasper pebble also appears to have incurred damage and after approximately 20 strikes a section of the stone spalled away (Figure 10). This may explain why some of the pebbles found in burial contexts with palettes also display surface pitting.

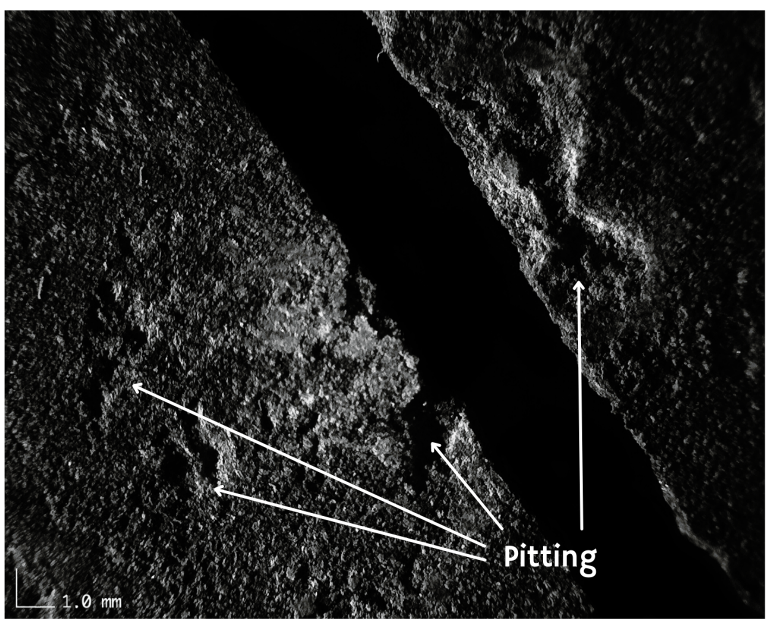


Fig. 9: Surface pitting of British siltstone sample viewed at 20x through a Dino-Lite AM4113T.

Fig. 10: Jasper pebble used to strike British siltstone sample, displaying damage incurred during experiment.

4.3 Replica Fish-Shaped Palette

The author created a replica fish-shaped palette (Figure 11) from slate as it is more freely available to a UK-based researcher than Wadi Hammamat series siltstone or greywacke, however all the tools and techniques (Figure 12 a–j) would be applicable to working with siltstone or greywacke.

The palette was created using replica tools (Petrie, 1917a: 46–47, 49, 63–64); flint denticulated saws, burins (Pitzer, 1977), drills, and blades along with small handheld pieces of sandstone (Bomann, 1995: 15) and smooth river-pebbles (Figure 12 a). Flint tools require regular maintenance during use to keep their edges sharp, which was achieved through pressure flaking using either an antler tine (Bomann, 1995: 15; Krzyszkowska, 1992) or copper tipped pressure flaking tools (Figure 12 a).

Coarse shaping was achieved through sawing (Figure 12 b) part way through either side of the palette and then fracturing with an antler (Figure 12 c) as an analogue for horns found in workshop contexts (Bomann, 1995: 15). Grinding can either be achieved with handheld stones against the palette, or by grinding the palette itself against a larger stone. The replica palette (Figure 11) was wet-ground with a handheld sandstone abrader against the palette (Figure 12 d–e). Dry-working causes removed material to be lost as a fine dust, however wet-working will produce a slurry which has abrasive and polishing properties and assists the grinding process. To enhance the cutting capacity, sand (crushed quartz) can be mixed with this abrasive slurry, as is seen used with copper drills and saws (Stocks, 2003: 120). Wet-working also prevents the grinding tools from clogging as frequently as when dry-worked, however regular rinses are still required to maintain the effectiveness of the tools.

Once the outer perimeter of the palette had been shaped, the detail of the fins was added with a flint burin (Figure 12 f). The ‘suspension hole’ and eye indentation were drilled using flint drills (Figure 12 g). After this, the palette was given a final surface polish (Figure 12 h) using a smooth pebble. Multiple different pebbles are required for a smooth finish, as different pebbles have differing coarseness (akin to modern sandpaper having varied ‘grits’). It is therefore likely that a Predynastic craftsperson would have had multiple pebbles in their toolkit to perform different levels of polishing.

The shaped inlay (Figure 12 i–j) was then affixed in place using an organic adhesive. The original adhesive used to hold inlays in place would most likely be made from plant resin or possibly beeswax (LUCAS & HARRIS, 2000: 2–3; NEWMAN & SERPICO, 2000). The eye inlay on the replica palette (Figure 11) was affixed with adhesive made from beeswax and charcoal powder (mixed in a ratio of roughly 2 parts beeswax to 1 part charcoal). Charcoal inclusion reduces the stickiness of the adhesive, and is required for all resin and wax based adhesives.

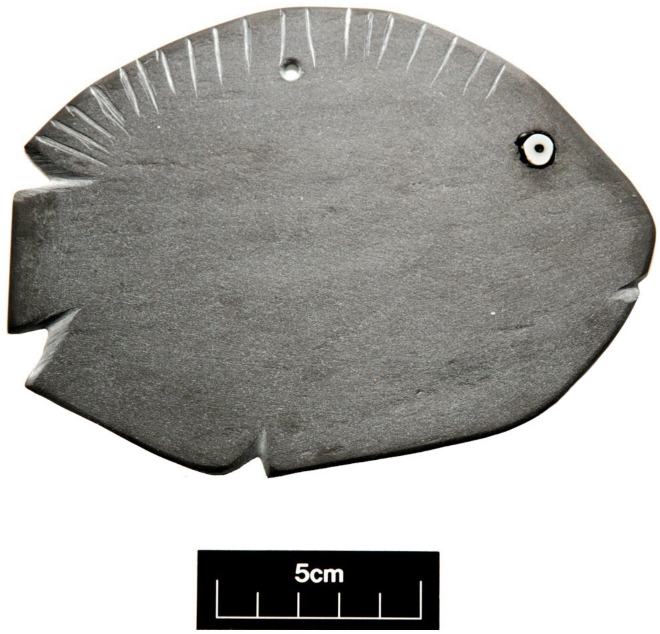


Fig. 11: Slate replica Petrie type 45A (Petrie 1920) fish-shaped palette created by the author.

5 Reflectance Transformation Imaging

The Highlight RTI (H-RTI) process was used for the RTI in this investigation. The H-RTI process was selected as it has certain benefits over dome-based RTI, namely that it is much more portable, and it can easily be employed on objects of varying sizes, unlike the dome method which is restricted to objects that will fit inside it. The H-RTI process uses a camera that is set perpendicular to the object, black reflective spheres are placed in frame (which must be >250 pixels), and multiple photographs are taken with lighting manually positioned at varying angles around the object (MUDGE et al., 2006). Photographs were taken with a hand-held flashgun held at 65, 45, 25, and 15 degree angles to the surface, along 12 equidistant 'ribs' around the object. The distance between the light source and the object is calculated as 3-4 times the diagonal measurement of the object, i.e. the light would be held 300-400 mm for an object 100 mm along its diagonal. A fabric tape measure was attached to the flashgun to ensure a consistent distance for each photograph, a white plastic tip is used on the end of the tape to aid visibility in low light (Figure 13). The resulting 48 photographs were then combined using the RTIBuilder software developed by Cultural Heritage Imaging (CHI) to produce an RTI file (CHI, 2022).

(a) Toolkit: Polishing/smoothing pebbles, grinding stones, antler tine, flint drills, copper point, denticulated flint saw and flint burins.

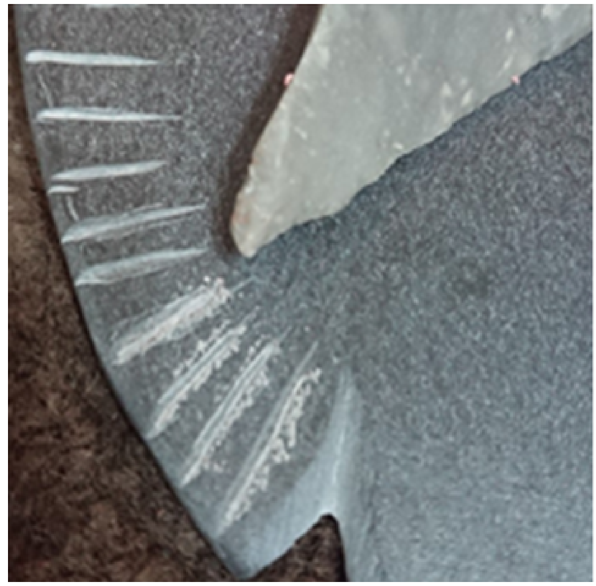
(b) Flatten surface, scribe outline and saw perimeter shape.

(c) Saw both sides and use antler to break spoil away.

(d) Use grinding stones to round corners, refine perimeter shape and chamfer edges.

Fig. 12: Steps in the experimental process of producing a replica fish-shaped palette

(e) Use right angle corner of sandstone abrader to grind fin, tail and mouth detail.



(f) Incise fin detail with flint burin.

(g) Drill 'suspension' hole and eye hole with flint drills.

(h) Polish surface with smooth pebbles.

Fig. 12: continued

(i) Shape bone for eye inlay

(j) Drill eye inlay with very fine flint burin.

Fig. 12: continued

Fig. 13: Flashgun used for H-RTI, with remote trigger, handle, and tape measure with white plastic tip.

This RTI software combines the photographs and creates a Polynomial Texture Map (PTM). The PTM is a digital image format that, rather than conventional image formats, does not record fixed colour values for each pixel, instead storing a two dimensional representation of the object's three dimensional surface geometry. This surface geometry is calculated from the known position of the light source and the incident light reflection to produce a surface normal value which is stored in the PTM (Malzbender et al., 2001: 521). This does not create a 3D model, in the same way as techniques such as 3D scanning or photogrammetry do, instead the RTI process captures 3D surface geometry and stores this in a 2D PTM file. This PTM is then used by the RTI viewing software to calculate and display the image based on in-software view settings, such as the incident light angle. One of the main benefits of RTI is that unlike a standard photograph, the viewing software allows the operator to move the location of the light source and digitally relight the object from different angles. This feature is especially useful as projects develop and it can help to reinvestigate objects with new research questions without the need for additional in-person studies of the object.

RTI is particularly well suited to revealing tool marks and enhancing other surface detail on stone objects as well as other materials (Piquette, 2011; Piquette, 2016; Brand, 2019; de Souza & Trognitz, 2021). For this reason, RTI has been used in this investigation to highlight manufacturing marks, surface scratching, and surface pitting on palettes (Figures 2, 14 and 15). The RTI viewing software allows for different 'rendering modes', each of which offer a different form of enhancement (Malzbender et al., 2001: 525–526). The 'specular enhancement' rendering mode was found to be the most useful for highlighting manufacturing marks and other surface detail on palettes, in part as it allows for desaturation of the image which allows for clearer observation of surface detail than colourised rendering modes.

6 Possible Causes of Surface Pitting

6.1 Malachite Processing

Pre-crushed malachite crystals could be crushed on the surface of a palette, perhaps using the pebbles found in burial contexts with palettes. However, it takes very little force to crush small crystals to powder and this force is extremely unlikely to be sufficient to cause surface pitting.

6.2 Product of Manufacturing Process

Surface pitting is unlikely to be related to the polishing of greywacke, as polishing does not require the percussive force necessary to cause the stone to spall. Surface pitting can also be observed on top of the polishing scratches on palettes (Figure 2), indicating that the polishing process happened first and was followed by whatever process caused the pitting.

When the replica fish-shaped palette (Figure 14) is compared to a provenanced Predynastic palette (Figure 15), they both demonstrate similar manufacturing marks—i.e. scratching from the smoothing and polishing phases.

6.3 Deliberate Striking

Striking the surface of a palette with sufficient force will cause pitting and flaking. It is therefore possible that palettes were deliberately struck with a sufficiently hard object and enough force, and this resulted in the pitting of their surfaces.

This striking may have been to produce sound as a part of ritual practice. There is an importance to the spoken word in Dynastic magic ritual, and it is here hypothesised that the root of this practice started in the Predynastic era with the use of sonorous rituals using palettes (Andrews et al., 2008: 145; Pinch, 2006: 24, 68, 93; Riggs, 2020: 17, 38; Ritner, 1993: 35, 48).

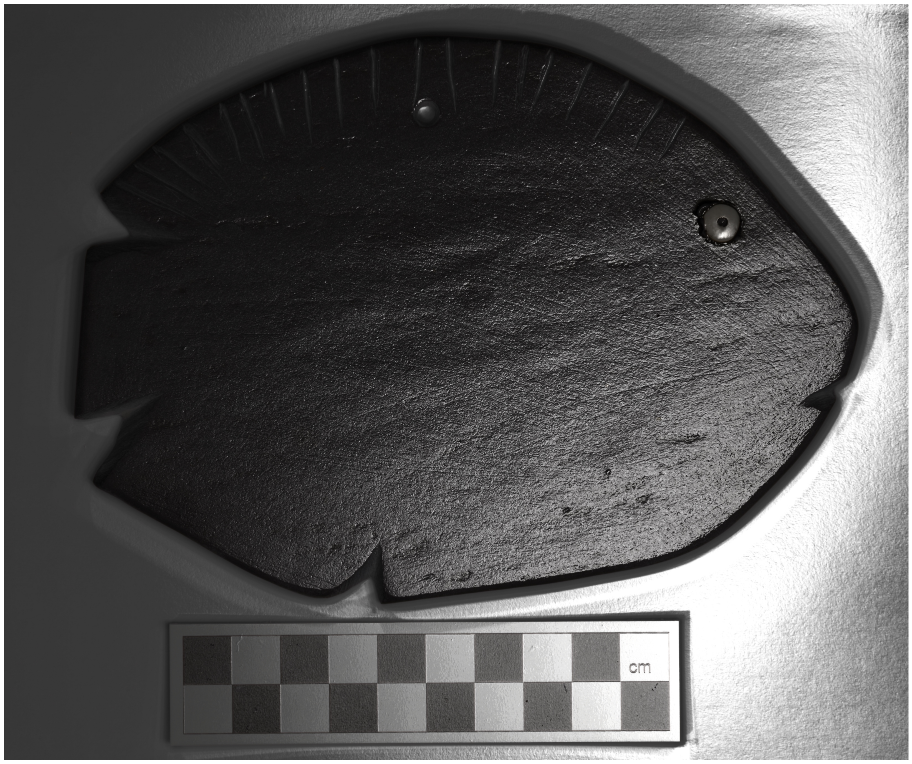


Fig. 14: 'Specular Enhancement' rendering of RTI of slate replica Petrie type 45A (PETRIE, 1920) fish-shaped palette created by the author.

Fig. 15: 'Specular Enhancement' rendering of RTI of fish-shaped palette, Manchester 1373.

Fig. 16: A replica fish-shaped palette, made from slate, being struck with a pebble to produce a sound.

Pebbles are commonly found in burial contexts either on top of, or very close, palettes (Brunton & Caton-Thompson, 1928) and rather than being for pigment processing as has been previously suggested (Stevenson, 2009: 2), it is here proposed that these may instead have been used to strike the palette to produce a sound.

Experimentation (Szafran, 2020b and Figure 16) found that when the cord is looped through the suspension hole, the palette will move and bounce as it is struck, and that it was necessary to lightly support the top edge of the palette with the fingertips. it was also found that supporting the palette any lower altered and deadened the tone produced from striking the palette. Further experimentation also found that attaching the cord with a girth hitch added more stability than when the cord was simply looped through the suspension hole.

Palettes such as Manchester Museum 9478 (Figure 17) demonstrate pitting in distinct vertical lines, appearing almost as stripes, on the palette's recto. This is perhaps to produce different notes, as the sound produced would deepen the further away from the suspension point, as was confirmed through experimentation (Szafran, 2020b and Figure 16).

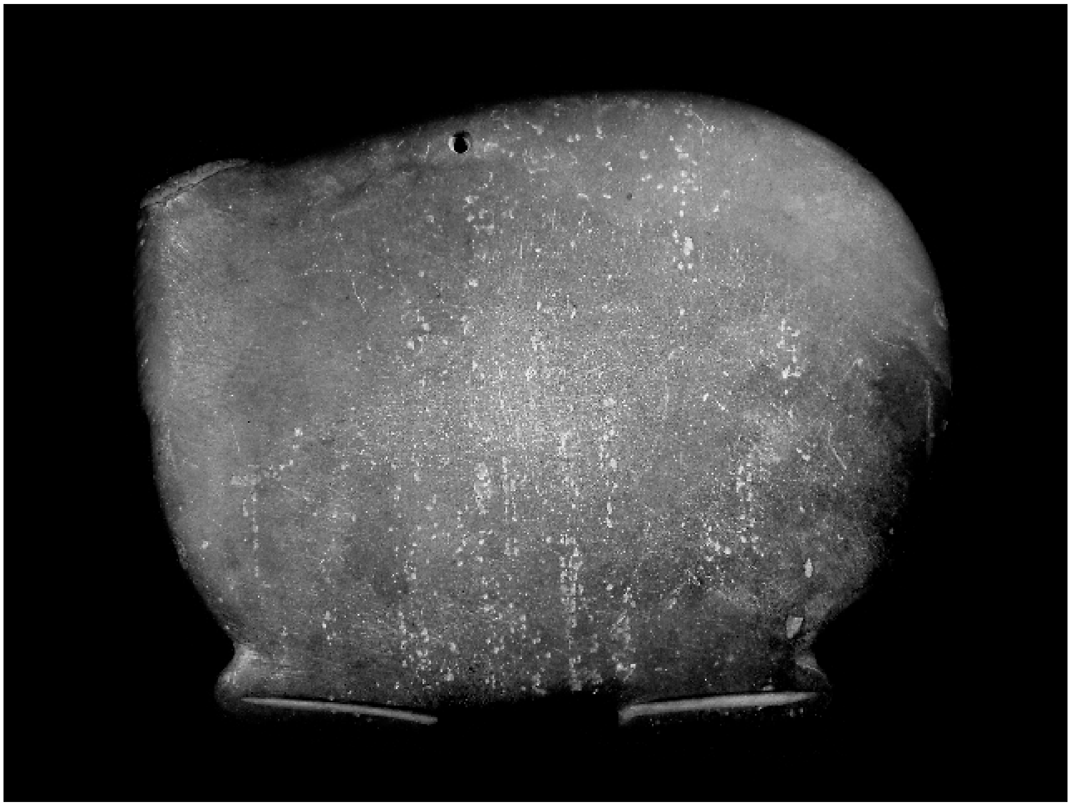


Fig. 17: Linear surface pitting on ram-shaped palette, Manchester Museum 9478.

7 Conclusion

Pigment processing undoubtedly played a role in the usage of palettes. The impermanence of pigment staining, and possible 'cleaning' of objects in modern collections, means that we do not have a full view of how frequently this occurred. It is also interesting to note that both pigment staining and surface pitting occur on the surface of some palettes, indicating that these are not two mutually exclusive types of use-wear.

The use of Predynastic palettes was complex and nuanced, and we need to carefully consider different aspects of their function and meaning throughout the period of their use. We should be mindful when trying to assign a single function for any object which was used by various groups and cultures over an approximately 1500 year period. It is highly likely that opinions and uses would vary from culture to culture and also change and evolve through time.

Producing pitting on the surface of greywacke would require forceful impact of a hard object, such as another stone. Therefore, the presence of surface pitting on a greywacke object may be evidence of deliberate or non-deliberate striking of the surface of the object. Predynastic palettes were created several thousand years ago and have been used, buried, excavated, and transported to new collections and as such may have experienced damage during this time.

However, there is clear evidence of deliberate striking which cannot be explained as damage from use or post-depositional processes. This is typically located in the centre of the palette, and palettes can display extremely heavy amounts of pitting, e.g. UC10886 in the Petrie Museum collection (Figure 17). Whilst we can hypothesise that pitting was in some cases deliberate, it is extremely difficult to hypothesise why they were deliberately pitted. The experiments presented above have demonstrated that pitting could be caused by striking a palette with a stone to produce sound as part of a ritual practice, however this hypothesis is preliminary and conjectural.

Palettes may represent a certain role in society, they do not always represent a wealth item, and instead they may have conveyed multiple social roles and not had a single meaning (STEVENSON, 2007: 156). If we assume that surface pitting is created by ritualistic uses, possibly to control the natural and supernatural worlds, then this may represent one of these meanings and uses of palettes. This would also fit with pitting only being found on 32.93% of palettes catalogued in the PPDB.

We see examples such as Manchester Museum 9478 (Figure 17) with vertical striping, which could have been created by varying the impact location, and therefore the tone produced. Many of the carved palettes (sometimes referred to as 'ceremonial palettes') display surface pitting, which it is often concentrated in certain locations on the palettes' recto and verso. For example, the 'Two Dogs' palette (Ashmolean Museum AN1896-1908 E.3924) features pitting on the dogs, perhaps explaining how one of the heads was broken away, and also on one of the antelope animals. It has been suggested that palettes could be used in rituals to control the natural world (BADUEL, 2008: 1065–1067; RIGGS, 2020: 92), and so perhaps this localised striking was a way to 'activate' the various symbols on the palette, for example by striking the dogs and prey animals for success in the hunt.

There are also links to the prevalence of pitting based on palette morphology. For example, 41.15% of fish-shaped palettes in the PPDB display pitting. Fish-shaped palettes are linked with the idea of fertility and rebirth, implying that these rituals commonly resulted in surface pitting.

Surface pitting also appears to be related to chronology, suggesting that the the use and function of palettes changed over time. This is an indication that palettes played a much more significant role in Predynastic society than typically discussed, and that they likely held multiple different uses.

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