Olga Krzyszkowska

Materials, motifs and mobility in Minoan glyptic

Abstract

Seals are small, easily portable and often travelled far from their place of manufacture. The raw materials used to make them could also travel, some certainly reaching Crete from beyond the Aegean, while others were evidently confined to specific parts of the island. Tracing the *precise* sources of the raw materials — including those of Cretan origin — has so far met with limited success.

This paper presents new research which has identified several rare and/or distinctive materials used for Cretan seals from MM II onwards, including banded jasper, red serpentine, fine-grained limestone, and calcite; spondylus shell is also discussed. Certain materials (or more accurately the seals made from them) *seem* to cluster in eastern Crete — encompassing the sites of Mallia, Mochlos, Petras and Palaikastro. Whether this reflects reality or chance remains to be established. In some cases, clusters are linked not only through material but also through motif and style, suggesting the output of individual workshops, which ultimately may help in the localization of production centres.

The use of these distinctive materials helps to confirm that MM II witnessed considerable experimentation in Cretan glyptic, in which both local and long-distance exchange networks played a significant role. Currently open to question is whether the materials in question were genuinely rare, confined to a specific locale, or were only exploited occasionally, on an "opportunistic" basis. Some materials may have been common enough, but were not much favoured by seal engravers (e.g. because of natural flaws) or by their clientele, who regarded them as insufficiently "attractive". Nevertheless the existence of these small clusters also chimes with the view that only a tiny percentage of original output has been discovered to date.

Keywords: Crete, glyptic, seals, materials, banded jasper, calcite, fine-grained limestone, red serpentine, spondylus shell

Seals are small and easily portable, capable of passing through many hands and travelling long distances before reaching their final resting place. The raw materials used to make them could also travel, some certainly reaching Crete from beyond the Aegean, while others were

* Much of the research presented here was carried out with the support of an INSTAP Fellowship, with further funding from the Institute of Classical Studies (London). For access to material and facilitating study, I am sincerely grateful to the Directors (past and present) and the Staff of the following museums: National Archaeological Museum, Athens; the Archaeological Museums in Chania, Heraklion, Nauplia, Rethymnon and Siteia; the Ashmolean Museum, Oxford; Cabinet des Médailles, Paris; and the Fitzwilliam Museum, Cambridge. I cordially thank the following excavators for permission to study, discuss and illustrate material from their sites: K. Demakopoulou (Midea), J. Maran (Tiryns), J. S. Soles (Mochlos), Y. Tzedakis (Armenoi), M. Tsipopoulou (Petras). The following individuals have helped in numerous ways, through practical help or piercing questions: M. Anastasiadou, K. Athanasaki, T. Brogan, D. Evely, G. Flouda, A. Gize, H. Hughes-Brock, M. Kostoula, G. McGuire, S. Mandalaki, H. Martlew, E. Papadopoulou, K. Paschalides, I. Pini, G. Rethemiotakis and, last but certainly not least, P. M. Warren. To all I express my deepest thanks.

evidently confined to specific parts of the island. Tracing the *precise* sources of the raw materials — including those of Cretan origin — has so far met with limited success.

These twin aspects of mobility — of materials and of finished products — contribute to one of the major challenges in Aegean glyptic, namely the localization of production centres. The scarcity of genuine workshop material and the high proportion of unprovenanced seals underscore the difficulties, which apply to virtually all areas and periods of the Aegean Bronze Age. Thus attempting to define large "style groups" and smaller "clusters" is essential if we are to make sense of the c. 10,000 seal faces at our disposal. The most promising results have focused on distinctive combinations of material, motif and style.[1]

Cretan glyptic received a major boost in MM II with the arrival of the lapidary lathe, evidently introduced from the East, enabling the manufacture of seals from hard semi-precious stones, such as agate, amethyst, blue chalcedony, carnelian, green jasper, and lapis lazuli — imported from overseas.[2] Other semi-precious stones, such as rock crystal, red jasper and haematite, are known to occur on Crete.[3] But whether local sources were exploited in the Bronze Age remains unclear. Moreover, so far the workshops that utilized semi-precious stones in MM II have not been localized. In other words we do not know whether such seals were made in a single workshop (say at Knossos) and dispersed from there, or whether they were made in several centres. During MM II output in soft stone was dominated by steatite, used chiefly but not exclusively for three-sided prisms (Anastasiadou 2011). Roughly 600 are known, including about 125 from the *Atelier des sceaux* at Mallia. So far the source of the raw material has not been identified. It occurs in a wide variety of colours — pale greens and yellows, browns and blacks. Also attested in MM glyptic is chlorite and calcite (see below), but serpentine seems rare until the early Neopalatial.

This then is a very brief summary of our current knowledge regarding materials at the disposal of Cretan seal engravers from MM II onwards. Patterns of distribution undoubtedly changed through space and time. But our ability to document them and our attempts to understand their significance are entirely dependent on accurate identifications. This is not always an easy matter. I have elsewhere highlighted some of the misunderstandings and misidentifications that appeared in volumes of the *Corpus der minoischen und mykenischen Siegel* (CMS) (Krzyszkowska 2010a). While some errors have been corrected in the on-line version of the CMS,[4] there is much more work to be done. First-hand examination supported by colour photography is crucial; frequently diagnostic features are more readily observed on unengraved surfaces.

---

1 For example (Pini 1990) for so-called "white pieces" closely associated with Mesara / Asterousia in the late Prepalatial; Anastasiadou (2011, 120-137) for the Mesara Chlorite prisms of MM IB-II. Also Yule 1981, 206-225 (early Cretan style groups); Krzyszkowska 2005, 324-329 (general survey of attribution studies).

2 Lapis lacedaimonius from Laconia is first used for seals in MM III-LM I: Krzyszkowska 2005, 123.

3 Rock crystal: sample from the White Mountains, formerly displayed in the Natural History Museum of Crete. Red jasper: good sources near Nea Krya Vrysi (northeast of Melambes; visited by the author and the geologist Dr Andrew Gize in 2008). Haematite: source near Ano Valsamonero (west of Armenoi; visited by the author and Dr Gize in 2008). See also Krzyszkowska 2010a, 250.

4 Available at: http://arachne.uni-koeln.de/drupal/?q=en/node/196. This complements and to some extent supersedes the original print volumes, since it contains much corrected data and many new illustrations.

Plate 1. Seals made of spondylus shell, EB I/II-MM II: (a) CMS IS no. 67, Poliochni; (b) PTSK06.66, Petras House Tomb 3; (c) CMS II.1 no. 478, Mochlos Tomb II; (d) HM 2232, Mochlos surface find; (e) PTSK12.602, Petras House Tomb 10. Not to scale. Photographs © O. Krzyszkowska.

In the limited space available here my aim is to present several distinctive materials which hitherto have gone unrecognized in the glyptic repertoire. All are first attested in MM II and, in some cases, examples seem to cluster in eastern Crete, though I must stress the sample remains small.

I begin not with stone but spondylus shell. So far I have managed to identify five Cretan seals made of this material, plus another from Poliochni (Plate 1a; CMS IS no. 67). In the past the material has been mistaken for marble and even ivory, as was true of a straight-sided cylinder

from Mochlos (Plate 1c; CMS II.1 no. 481). Because the shell is formed in layers it can mimic the laminations found in ivory (Krzyszkowska 1990, pl. 32a-b). There is, however, a crucial difference. Whereas ivory is a soft material, registering c. 2 on the Mohs scale, spondylus can reach Mohs 7-8, comparable to or even surpassing the hardness of rock crystal. This helps to explain why it was seemingly used for seals so infrequently in the EBA. At Petras there are two unengraved examples: a pear-shaped seal or "bottle" (Plate 1b; Krzyszkowska 2012, 147-148, fig. 3) and a foot amulet (Krzyszkowska 2017, 144-145, fig. 1). The so-called "telephone receiver" (Plate 1d; HM 2232) from Mochlos in part exploits the natural shape of the shell, while the engraving on the seal faces counts as little more than random scratching.[5] Thus a new *Petschaft* (loop signet) from Petras, depicting a lion *regardant*, is all the more extraordinary (Plate 1e; Krzyszkowska 2017, 151-152, fig. 6). It is a true masterpiece in the technical and aesthetic sense. But it is the only MM II seal so far identified in spondylus shell, and I know of none later. By this time the hardness was not necessarily an obstacle, but faced with the huge variety of vibrantly-coloured stones now available, the creamy white colour may have found little favour (cf. Hughes-Brock 1995, 108).

Next we turn to a very distinctive and extremely attractive opaque stone, with yellow or yellowish-orange and deep red or reddish-purple banding. However, the precise identity of the stone is currently open to question, though it has usually been seen as jasper.[6] Jasper is a form of micro-crystalline quartz and hence belongs to the silicate group; being impregnated with impurities it invariably has an opaque appearance and dense coloration. As previously noted, red jasper is known to occur on Crete; green jasper — especially favoured in MM II-LM I — is likely to have been imported. In addition to solid colours, banded and variegated jaspers also occur and were certainly used in Aegean glyptic, albeit occasionally. Whatever the colour, jasper counts as a hard semi-precious stone, registering c. 7 on the Mohs scale of hardness. For the purposes of macroscopic identifications conchoidal fracturing is diagnostic, though all too often seals presumed to be jasper are intact. This applies to the examples under discussion here.

During the presentation of this paper, Peter Warren observed that the stone in question resembled a banded limestone, embedded in a breccia matrix, known to him from the Kakon Oros (Warren 1969, 134). Subsequently he kindly showed me a specimen in his collection, which in terms of opacity, coloration and banding closely resembles the banded "jasper" discussed here. However, generally speaking limestones count as soft (Mohs 3-4) whereas the engraving on our seals points to a hard stone (Mohs 7, as is jasper). In future, non-destructive testing

5 A surface find from the cemetery area, see Hughes-Brock 1995, 109-110, figs. 1a-b, where considered to be "white (?)steatite – Cretan or imported?". Two examples of this shape exist in bone: CMS III no. 6 from "Lasithi, cave" and PTSU06.116 from the Petras Rock Shelter (Krzyszkowska 2012, 146, fig. 1).

6 Examples published as jasper include: CMS II.2 no. 75; II.3 no. 340 (in the CMS on-line); IV no. 132; VII no. 221; IX no. 33; and the new examples from Petras, PTSK05.291 (Krzyszkowska 2012, 152-153, fig. 7) and PTSK11.38 (Krzyszkowska 2017, 152, fig. 7). CMS X nos. 50 and 82 were originally identified by Betts as "agate, banded pink and cream-yellow, burnt opaque", but subsequently "corrected" by him to "banded tufa (calcite)" in *The Erlenmeyer Collection of Cretan Seals* (Christie's London, Sale Catalogue, 5 June 1989) 29, 32, cat. nos. 48, 62. The whereabouts of CMS X no. 82 is unknown; X no. 50 is now in the Getty Museum (2001.14.32); colour image at http://www.getty.edu/art/collection/objects/130716/unknown-maker-block-engraved-seal-greek-minoan-about-1850-bc-1550-bc/.

(e.g. by XRF) might help determine whether the material is indeed jasper (a silicate, SiO_2) or limestone (essentially a calcium carbonate, $CaCO_3$).

While *we* may find it frustrating to be unable to identify this stone and ascertain its precise chemical constituents, these issues would not have troubled Minoan engravers. Rather they would have been concerned with more fundamental properties. Consistency would have been a key factor: e.g. fine-or coarse-grained, compact or inclined to split, presence or absence of inclusions or natural flaws. Hardness was also crucial, since soft stones (2-4 Mohs) could be engraved with hand-held tools, whereas hard stones (6-7 Mohs) required rotary tools mounted on the lapidary lathe. Stones that were especially "attractive", distinctive or unusual may also have been favoured; there is even some evidence that specific colours came to be associated with certain style groups or even particular motifs (Krzyszkowska 2010b, 176 for the association of water-birds with dark green or blue-black stones).

With all these factors in mind we may now return to the opaque "jasper" with its attractive banding, ranging from claret-red to burgundy and yellow to ochre in colour. Whatever its precise identity the stone is hard and hence had to be engraved using the lapidary lathe, powered by a bow; onto the free-turning spindle cutting wheels and drills of varying sizes were attached (Krzyszkowska 2005, 83-85, fig. 5.1). To facilitate engraving, these would be "charged" with an abrasive: an obvious candidate would be emery from Naxos, which at Mohs 8 is (crucially) harder than the stones being worked. The technology itself evidently reached Crete during the Protopalatial period, being introduced from the East where there is contemporary evidence for its use in the Old Babylonian Period, c. 1750-1595 BC (Krzyszkowska 2005, 30-31, 85-85).

Unfortunately, we have insufficient evidence at present to identify the earliest use of the lapidary lathe in Crete: simplicity versus complexity of design are not in itself firm criteria for dating. However, we can observe that already in MM II the detail achieved by a master engraver is nothing short of remarkable, as demonstrated by the magnificent four-sided prism from Petras measuring just under 2 cm long (Plate 2a; Krzyszkowska 2012, 152-153, fig. 7). A three-sided prism, said to be from "Elounda" (CMS IV no. 132), can also be firmly dated to MM II on grounds of shape and motif (Plate 2b; Krzyszkowska 2015, 102, fig. 2a). The same applies to a two-sided rectangular bar (CMS X no. 50; see n. 6). Further examples made from the same banded "jasper" include a cushion from Petras with simple chevron decoration (Plate 2c; Krzyszkowska 2017 152-153, fig. 7) and another from Palaikastro with lattice pattern (Plate 2d; CMS VII no. 221), both datable to MM II.

A more complex lattice appears on a fine amygdaloid from Episkopi Pediados (Plate 2f; CMS II.2 no. 75): here the individual lozenges are filled with fine hatching, allowing us to identify this as a so-called "architectural" motif (Pini 2007, 229-230, fig. 2). The discoid in Paris (Plate 2e; CMS IX no. 33) also belongs to this group. "Architectural" motifs are first attested in MM II Phaistos (CMS II.5 nos. 242-244) and continue into MM III. A MM II-III date also seems appropriate for a superb discoid depicting a recumbent goat, sadly without provenance (Plate 2g; CMS II.3 no. 340). So far I have found no later examples made of this lovely banded stone, with the possible exception of CMS X no. 82 (above n. 6). And the source of the material remains unknown: conceivably the stone was imported, but a Cretan source (even an East Cretan source) cannot be ruled out.

Plate 2. Seals made of banded "jasper", MM II/III: (a) PTSK05.291a-d, Petras House Tomb 2, Room 3; (b) CMS IV no. 132a-c, "Elounda"; (c) PTSK11.38, Petras cemetery; (d) CMS VII no. 221, Palaikastro, "Iarnax burial"; (e) CMS IX no. 33, unknown provenance; (f) CMS II.2 no. 75, Episkopi Pediados, LM III chamber tomb; (g) CMS II.3 no. 340, unknown provenance. Photographs © O. Krzyszkowska.

Our next distinctive material is certainly an off-island import, namely obsidian from Giali in the Dodecanese (Plate 3a). Several partly-worked blocks were found in MM II Mallia, the largest measuring some 18 cm high (Carter *et al*. 2016, 23). Two waste flakes were also found in the

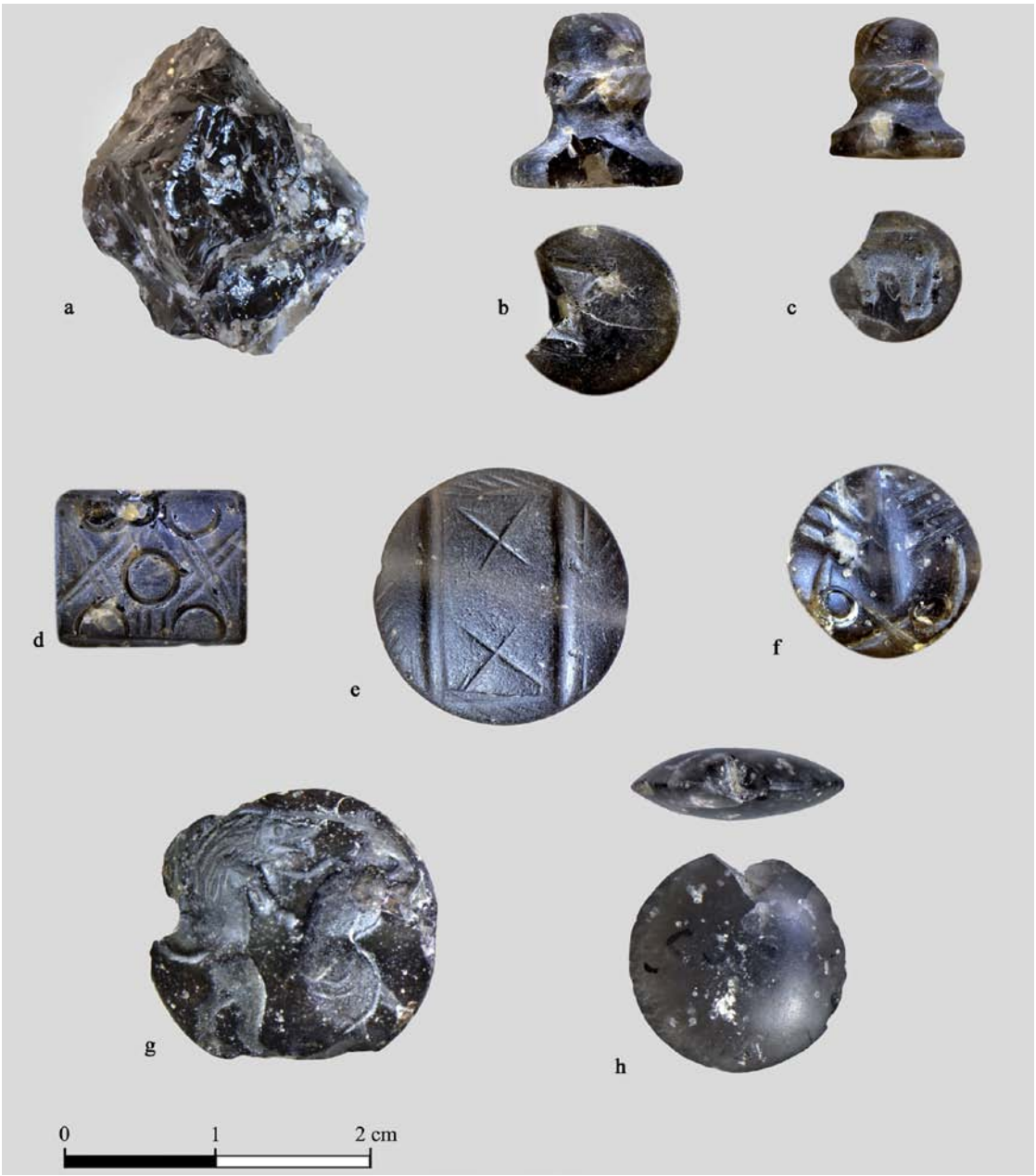

Plate 3. Giali obsidian: (a) unworked specimen (modern). Seals, MM II-LM I/II: (b) CMS II.2 no. 129, Mallia Atelier des sceaux; (c) CMS II.2 no. 130, Mallia Atelier des sceaux; (d) HM 2237, Mochlos surface find; (e) CMS IV no. 157, "Mesara"; (f) CMS IV no. 195, "Lastros"; (g) CMS I no. 228, Vapheio tholos tomb, main chamber; (h) Knossos Stratigraphical Museum SMS 3141, Unexplored Mansion, North Corridor, LM IA/II on floor slabs. Photographs © O. Krzyszkowska.

Atelier des sceaux, as were the two unfinished *Petschafte* illustrated here (Plate 3b-c).[7] Both are discards, broken during manufacture. This is perhaps not surprising since Giali obsidian is very friable and is a medium-hard stone (Mohs 5-5.5). By contrast virtually all the seals produced in the workshop were made of soft steatite (Poursat 1996, 109).

7 CMS II.2 nos. 129-130, originally described in the CMS as "brauner Obsidian"; subsequently "corrected" in CMS online to "Pseudojaspis" (see below). Seen as "agate" in Poursat 1996, 109.

The following examples are somewhat later in date. The cushion bears motifs that are close to the MM II-III "architectural" group, though in addition to linear motifs it also makes use of the tubular drill; it was picked up on the surface at Mochlos between Tombs I-VI and the town site (Plate 3d; Hughes and Warren 1963, 352-354, pl. ΙΘ'; Krzyszkowska forthcoming). Of similar date are a discoid without provenance, now in Oxford (CMS VI no. 169) and another, said to be from the "Mesara" (Plate 3e; CMS IV no. 157); both bear "architectural" motifs. A lentoid, said to come from "Lastros" near Neapolis, can be assigned to the MM III-LM I "talismanic" style (Plate 3f; CMS IV no. 195). Another lentoid, found in the Vapheio tholos but arguably of Cretan manufacture, is datable to LB I-II (Plate 3g; CMS I no. 228), as is an unfinished example from the Unexplored Mansion at Knossos, damaged when drilling the string hole (Plate 3h).[8] During the LBA, seal engravers seem largely to have ignored this material, because of its inherent difficulties. That said, some of the finest ritual vases of the Neopalatial period are made of Giali obsidian and unworked segments are attested from several sites in central and eastern Crete in LM I (Warren 1969, 135-136).

Our fourth unusual material is red serpentine, which hitherto has been virtually unrecognized in Aegean glyptic. The material is highly distinctive: the matrix is very deep red with dark purple or black veining, and sometimes whitish crystalline inclusions (Plate 4a). The red colour comes from the presence of haematite, as do the rusty patches to be seen in the engraved surfaces of a four-sided prism from Vrysinas (Plate 4c).[9] In fact the engraving here is crudely executed, and one suspects the engraver had some difficulty, since red serpentine counts as a medium-hard stone. This might also explain why a discoid from Mochlos remained unfinished (Plate 4d; Krzyszkowska forthcoming). The source(s) on Crete for this stone remain enigmatic. The find-spot of the Vrysinas prism provides no definitive clues: it bears Hieroglyphic signs on all faces, suggesting East Cretan manufacture. It is worth noting that red and the more usual green serpentine can occur in close proximity, as demonstrated by outcrops at Kynance Cove on the Lizard Peninsula in Cornwall, southwest England (Plate 4b).

Red serpentine was never recognized by the CMS, and the seals shown in Plate 5a-e were variously published as red jasper or "pseudo-jasper", a name given by the CMS team to a wide variety of stones, which resemble red jasper in colour, but which seem to be softer (see below). The seals illustrated in Plate 5 range in date from Neopalatial to LB II-III. Three belong to the MM III-LM I "talismanic" style (Plate 5a-c; CMS III no. 280; IV no. 173; IX no. 58) and two can be assigned to the LM I-II(?) Cut Style (Plate 5d-e; CMS II.4 no. 183; IX no. 61). Later examples include an unusual three-sided prism from "Mallia" (Plate 5f; CMS III no. 505) and a stray find from the Knossos area, hitherto unpublished (Plate 5g; HM 2076). From these examples it becomes clear that medium-hard red serpentine not only *can* be engraved with rotary tools, but these produce far more satisfactory results (e.g. Plate 5c-e) than hand-held knives or burins (e.g. Plate 5g). Initially there seemed to be an East Cretan bias for the use of this stone — a possible clue

8 Popham 1984, 92, 240, pl. 219.3 NC 30. The Vapheio lentoid, originally published as "Hämatit" in CMS I, is now described as "Obsidian?" in the CMS on-line.

9 Initially presented as "red jasper" at the 2011 Cretological Congress, but Ingo Pini and I independently concluded that the engraving indicated a much softer stone. On re-examination, Jennifer Moody identified the material as red serpentine (Hallager *et al*., 2011, 65). Following autopsy I can confirm that this is correct.

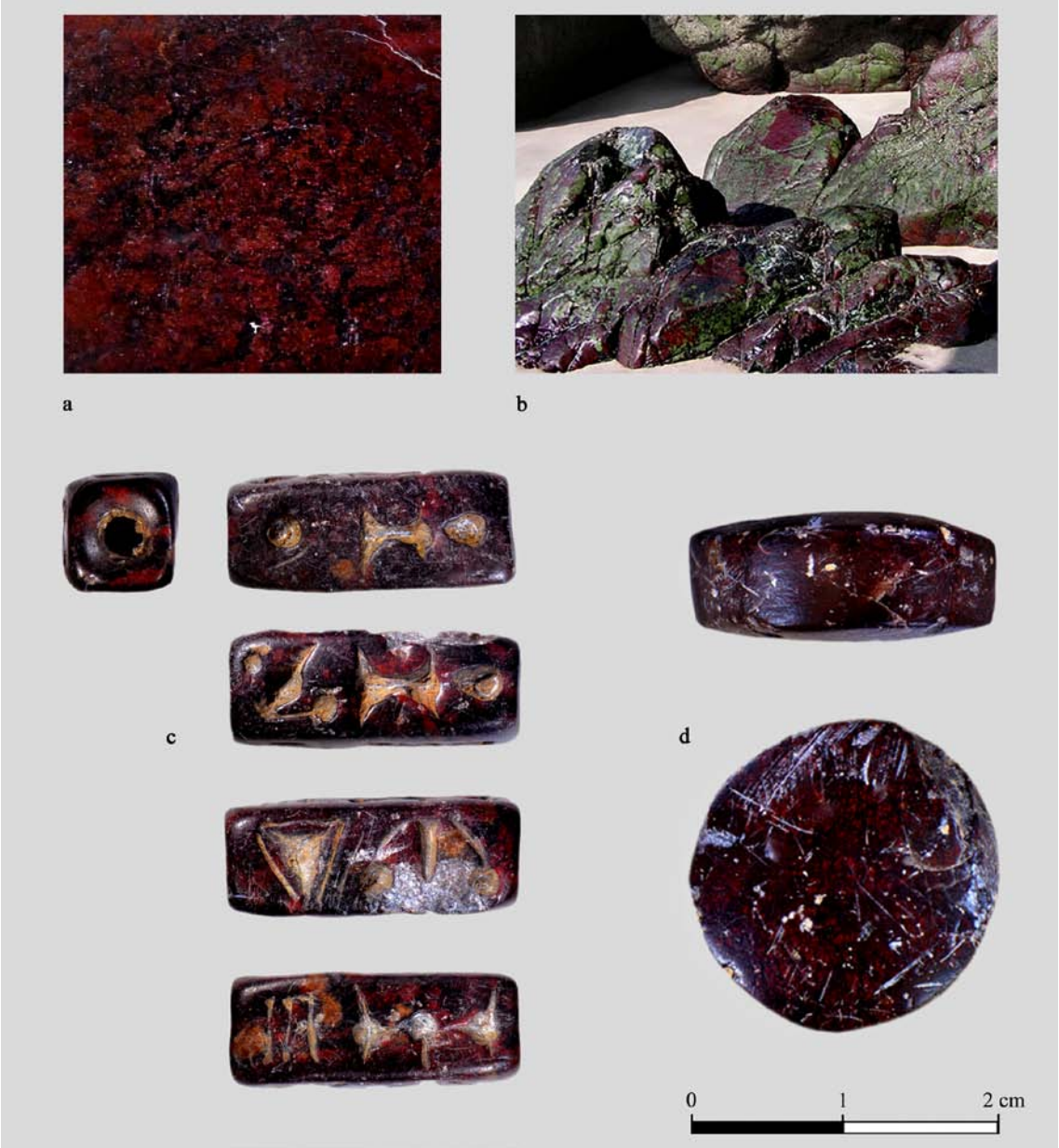

Plate 4. Red serpentine: (a) polished specimen (modern) from the Erzgebirge, southern Germany; (b) Kynance Cove, Lizard Peninsula, Cornwall showing red and green serpentine in close proximity. Seals, MM II/III: (c) VRY S (4/4) 01, four-sided prism, Vrysinas; (d) Mochlos IVA.328, unfinished discoid, House C2. Photograph (b) Cornwall Info; all others © O. Krzyszkowska.

to its source — but subsequently I have identified three examples from Knossos (Plate 5b, d, g). Thus an open mind is essential until we have a much larger sample, and this can only be achieved through targeted re-examination of seals originally published as red or "pseudo-jasper". Finally, I also include here an example from Midea in the Argolid (Plate 5h; CMS VS3 no. 224). Its place of manufacture is impossible to determine with certainty,[10] although it is worth noting that at

10 Pini (2005, 203, pl. XLIh) rightly notes that the motif is widespread both in Crete and the mainland. But he believes this example was manufactured in the Peloponnese, since a comparable "dark-wine red stone similar to steatite"

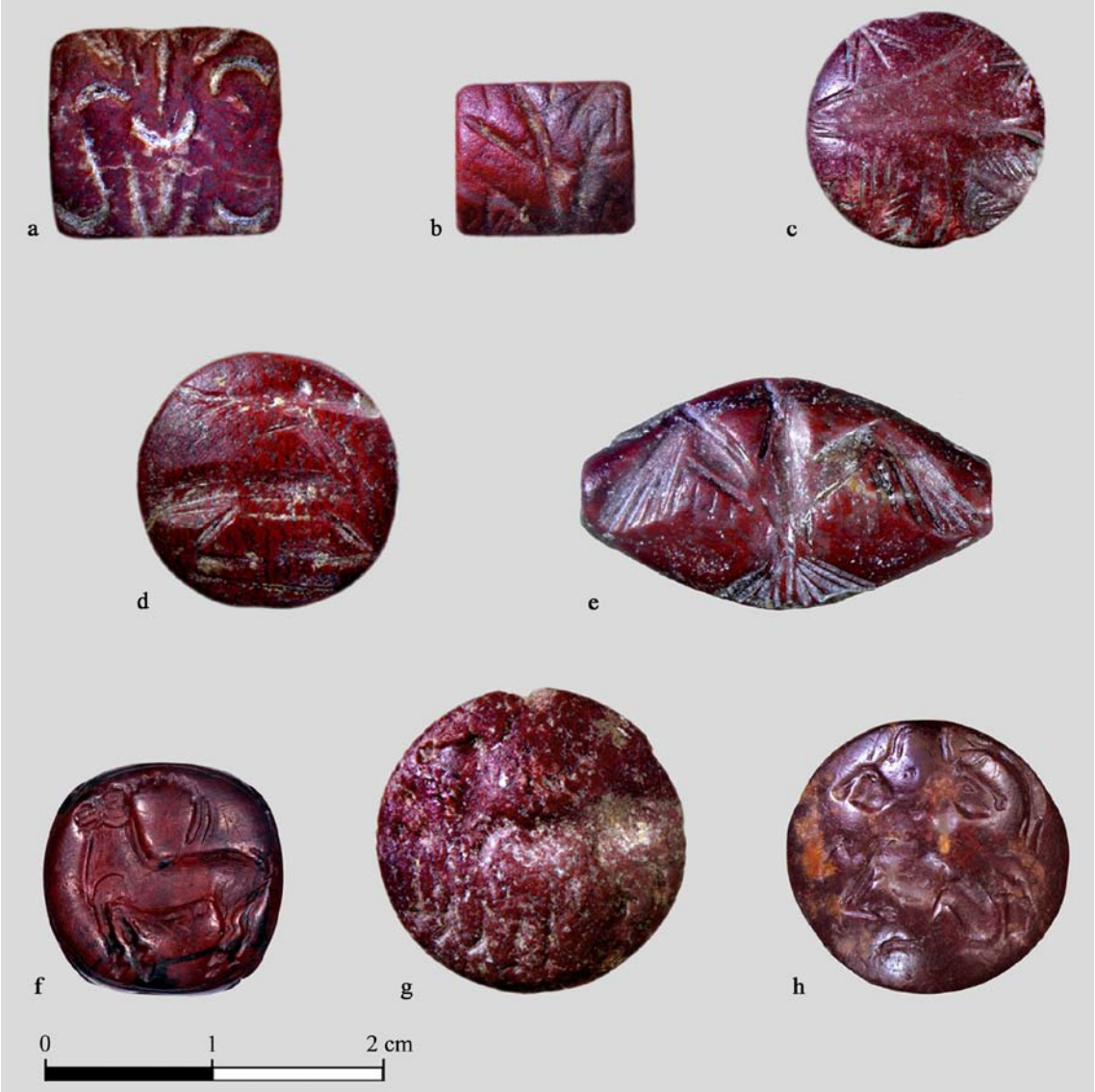

Plate 5. Seals made of red serpentine, MM III/LM I-LM III: (a) CMS III no. 280, "Mallia"; (b) CMS IV no. 173, "Knossos"; (c) CMS IX no. 58, unknown provenance; (d) CMS II.4 no. 183, "Knossos"; (e) CMS IX no. 61, unknown provenance; (f) CMS III no. 505a, "Mallia"; (g) HM 2076, Knossos stray find; (h) CMS VS3 no. 224, Midea, Acropolis West Gate area. Photographs © O. Krzyszkowska.

least one, and possibly three seals from Midea are Cretan in origin (CMS VS3 nos. 222-223 and a haematite lentoid from the West Gate area: Krzyszkowska 2016, 121, pl. XLVh, with references).

Another reddish material first attested in MM II is a fine-grained limestone. This too has gone entirely unrecognized by the CMS; in recent volumes and in the CMS on-line some examples have been identified as "pseudo-jasper", evidently because the material can mimic the colour of (genuine) red jasper but is not hard. The "term", however, should be abandoned forthwith, since it gives a wholly false impression that there are scientific grounds for the identification. In

was utilized there in the LBA and also Geometric-Archaic periods, further commenting that the material is practically unknown in Crete. Based on autopsy I can confirm the Midea seal is undoubtedly made of red serpentine; but the extent to which that material (as opposed to steatite) was used on the mainland remains open.

Plate 6. Seals made of fine-grained limestone, MM II: (a) PTSK10.877a-c, Petras House Tomb 10, Room 1; (b) PTSK13.1485a-c and impression of face a, Petras House Tomb 10, Room 1; (c) HM 2379a-c and impression of face a, Mallia Palace (Pelon 1968). Photographs © O. Krzyszkowska.

fact many of the seals so described prove to be made of fine-grained limestone, often brick-red in colour but sometimes paler.

In common with the other materials under discussion here, this fine-grained limestone is initially attested in MM II glyptic, with an apparent East Cretan bias. Our first examples are a pair of three-sided prisms from House Tomb 10 at Petras (Plate 6a-b; Krzyszkowska 2017, 149-150, fig. 5) and a hitherto unpublished example from Mallia (Plate 6c; HM 2379). The style differs significantly from the popular three-sided prisms of steatite. Instead it relies heavily on rotary tools, although the stone is only medium hard (cf. red serpentine, above). The motifs on the three prisms are very close, with a predilection for jugs, amphorae and pithoi. Especially striking, however, are the animal heads on one of the Petras prisms (Plate 6b; PTSK13.1485) and that from Mallia (Plate 6c) as the impressions make clear. There is no doubt in my mind we are dealing not merely with a single workshop but a single hand. But where they were made remains an open question.

And the next set of prisms does not entirely resolve the matter. Here the limestone is a little paler in colour, rose-pink, rather than brick-red. Again we have two examples from Petras (Plate 7a-b) and one from Mallia (Plate 7c; CMS II.2 no. 79). The Mallia prism is rather battered

Plate 7. Seals made of fine-grained limestone, MM II: (a) PTSK14.2603a-c, Petras cemetery; (b) PTSK14. 2604a-c, Petras cemetery; (c) CMS II.2 no. II.2 no. 79, Mallia, street north of House Δα; (d) Ti-07 L52/63, Tiryns. Photographs © O. Krzyszkowska.

but, more significantly, lacks a string-hole, so is evidently unfinished. Does that mean that all the limestone prisms were produced in Mallia rather than Petras or elsewhere in eastern Crete? Perhaps. But again we should keep an open mind.

A rather surprising addition to the small group of MM II seals made from this fine-grained limestone was found at Tiryns (Plate 7d).[11] There can be no doubt as to its Cretan origin or date, since it is a *Petschaft* with ribbed grip, torsional grooving on the torus, and centred circles on the seal face. Further examples of MM II seals on the mainland are known from Midea (CMS VS3 no. 222) and Kalapodi (Niemeier 2010, 284-285, fig. 2).

11 Full publication is in preparation by the author and Maria Kostoula, with kind permission of the excavator Joseph Maran.

Plate 8. Seals made of fine-grained limestone, MM III/LM I-LM IIIA1: (a) CMS II.3 no. 259, Mochlos; (b) CMS VS3 no. 354, Palaikastro; (c) CMS IX no. 101, unknown provenance; (d) HM 2236, Mochlos surface find; (e) CMS I no. 256, Vapheio tholos tomb, floor cist; (f) CMS III no. 422, unknown provenance; (g) CMS II.3 no. 331, unknown provenance. Photographs © O. Krzyszkowska.

As in previous cases, the source or sources of this attractive limestone remain unknown, although beach pebbles which I have collected at Mochlos are remarkably similar in colour and texture to the finished seals. Two examples of Neopalatial date come from Mochlos itself: one from Seager's excavations (Plate 8a; CMS II.3 no. 259), the other found on the threshold of one of the houses (Plate 8d; HM 2236; Hughes and Warren 1963, 354-355, pl. IΘ'). It is interesting to note that three examples (so far identified) depict goats in the MM III-LM I "talismanic" style, although they are not by the same hand: CMS II.3 no. 259 from Mochlos, CMS VS3 no. 354 from Palaikastro, and CMS IX no. 101 without provenance (Plate 8a-c). This fine-grained limestone

Plate 9. Seals made of calcite, MM II: (a) CMS II.2 no. 128, Mallia Atelier des sceaux; (b) CMS II.2 no. 148, Mallia Atelier des sceaux; (c) CMS II.2 no. 246, Dictaean Cave; (d) PTSK12.1624, Petras House Tomb 10, Room 1. Photographs © O. Krzyszkowska.

continued to be used in LM I, as evidenced by HM 2236 and CMS III no. 422 (Plate 8d, f) and a poorly-preserved lentoid found in the Vapheio floor cist (Plate 8e; CMS I no. 256),[12] while the goat-man depicted on CMS II.3 no. 331 (Plate 8g) indicates a date in LM II-IIIA. But the extent to which this material was used — through time and space — will require further targeted re-examination.

Finally we may turn to calcite. This too was first used by seal engravers in MM II as indicated by several examples from eastern Crete, including a button from the Dictaean Cave (Plate 9c; CMS II.2 no. 246) and a theriomorphic seal from Petras (Plate 9d; PTSK12.1624; Krzyszkowska 2017, 147, fig. 3). Two from the *Atelier des sceaux* at Mallia are unfinished (Plate 9a-b; CMS II.2 nos. 128, 148) and calcite crystals are reported widely on the site (Poursat 1995, 103), although

12 Originally published in CMS I as "Ton" (clay), described as "Pseudojaspis?" in the CMS on-line. The fine-grained limestone suggests a Cretan origin for the seal.

Plate 10. Calcite (a) specimen (modern) from near the Armenoi cemetery. Seals, LM I-III: (b) HM 2505, Knossos Unexplored Mansion, Room M; (b) CMS VS3 no. 322, Armenoi Tomb 223; (c) CMS V no. 277, Armenoi Tomb 59; (d) CMS VI no. 497, Dictaean Cave; (e) CMS VI no. 496, unknown provenance (ex-Evans). Photographs © O. Krzyszkowska.

the material is also likely to occur elsewhere in eastern Crete. It is a relatively soft stone (Mohs 3), hence workable with hand tools. It is usually translucent and milky-white in colour.

Calcite seemingly fell out of favour in the Neopalatial period: an example from the Unexplored Mansion is a rare exception (Plate 10b; HM 2505); there is another from Mochlos (Krzyszkowska forthcoming). Only in LM III did this material see a resurgence, occasionally used for representational motifs as on a broken seal from Armenoi (Plate 10c; CMS VS3 no. 224). More commonly it was employed for small lentoids bearing geometric designs (Plate 10d-f). About 20 have been found at Armenoi, including CMS V nos. 277 (Plate 10d). An excellent source of calcite occurs adjacent to the cemetery, where the large crystal shown in Plate 10a was collected.

In older volumes of the CMS calcite was regularly misidentified as rock crystal, a macrocrystalline quartz, clear and colourless, which counts as a hard semi-precious stone (Mohs 7).

Unfortunately in recent volumes of the CMS and in the CMS on-line, the material has been re-identified as fluorite. While this is likely to be correct for seals from the Greek mainland, for most if not all Cretan examples the identification is certainly false (Krzyszkowska 2010a, 255-256). Calcite and fluorite are similar in appearance, but differ slightly in hardness and, more significantly, in cleavage. As illustrated in Plate 10e-f (CMS VI nos. 496-497) the 60/120° cleavage of calcite is diagnostic (cf. also Plate 10c). By contrast fluorite has perfect octohedral cleavage in all directions (90°). Unfortunately it is not always possible to observe this phenomenon in seals, in which case non-destructive testing (e.g. XRF) would be required for a conclusive verdict. It is, however, worth noting that whereas calcite appears to have been widely available throughout Crete, no firm evidence yet exists for fluorite on the island.

Most of the distinctive materials discussed in this paper make their first appearance in Cretan glyptic during MM II. Certain materials (or more accurately the seals made from them) *seem* to cluster in eastern Crete, encompassing the sites of Mallia, Mochlos, Petras and Palaikastro. Whether this reflects reality or chance remains to be established. In some cases there also exist links and cross-links between motifs and styles, which may ultimately help us to localize production centres. But currently open to question is whether these materials were *genuinely* rare, confined to a specific locale, or were only exploited occasionally, on an "opportunistic" basis. Some may have been common enough, but were largely avoided by seal engravers (say, because of natural flaws) or were not favoured by their clientele, who perhaps regarded them as insufficiently "attractive". Nevertheless the existence of these small clusters also chimes with the view that only a tiny percentage of the original output has been discovered to date.

Finally I would ask museum staff, excavators, geologists and indeed all *Κρητολόγοι* to be on the look-out for these distinctive materials — whether in finished objects or especially in natural outcrops. Any information would be most gratefully received.

Abbreviation

CMS *Corpus der minoischen und mykenischen Siegel* (Berlin 1964-2000; Mainz 2002-).

Bibliography

Maria Anastasiadou (2011), *The Middle Minoan Three-sided Soft Stone Prism: A Study of Style and Iconography* (CMS Beiheft 9), Mainz.

Tristan Carter, Daniel A. Contreras, Kathryn Campeau and Kyle Freund (2016), "Spherulites and aspiring elites: the identification, distribution, and consumption of Giali obsidian (Dodecanese, Greece)", *Journal of Mediterranean Archaeology* 29.1, 3-36.

Erik Hallager, Eleni Papadopoulou and Iris Tzachili (2011), "VRS 4/4 01 – The first hieroglyphic inscription from western Crete", *Kadmos* 50, 63-74.

Helen M.C. Hughes and Peter Warren (1963), "Two sealstones from Mochlos", *Kretika Chronika*, 350-355.

Helen Hughes-Brock (1995), "Seals and beads: their shapes and materials compared", Ingo Pini and Jean-Claude Poursat (eds.), *Sceaux minoens et mycéniens* (CMS Beiheft 5), Berlin, 105-116.

Olga Krzyszkowska (1990), *Ivory and Related Materials: An Illustrated Guide* (BICS Suppl. 59), London.

Olga Krzyszkowska (2005), *Aegean Seals: An Introduction* (BICS Suppl. 85), London.

Olga Krzyszkowska (2010a), "Material matters: some challenges past, present and future for Aegean glyptic", Walter Müller (ed.), *Die Bedeutung der minoischen und mykenischen Glyptik* (CMS Beiheft 8), Mainz, 249-257.

Olga Krzyszkowka (2010b), "Impressions of the past: landscape in Aegean glyptic", Olga Krzyszkowska (ed.), *Cretan Offerings Studies in Honour of Peter Warren* (BSA Studies 18), London, 169-187.

Olga Krzyszkowska (2012), "Seals from the cemetery of Petras", Metaxia Tsipopoulou (ed.), *Petras, Siteia: 25 Years of Excavations and Studies* (Monographs of the Danish Institute at Athens 16), Athens, 145-160.

Olga Krzyszkowska (2015), "Why were cats different? Script and symbolism in Middle Minoan II glyptic", Colin F. MacDonald, Eleni Hatzaki and Stelios Andreou (eds.), *The Great Islands. Studies of Crete and Cyprus presented to Gerald Cadogan*, Athens, 100-116.

Olga Krzyszkowska (2016), "Warding off evil: apotropaic practices and imagery in Bronze Age Crete", Eva Alram-Stern, Fritz Blakolmer, Sigrid Deger-Jalkotzy, Robert Laffineur and Jörg Weilhartner (eds.), *METAPHYSIS: Ritual, Myth and Symbolism in the Aegean Bronze Age* (Aegaeum 39), Leuven, 115-121.

Olga Krzyszkowska (2017), "Further seals from the cemetery of Petras, Siteia", Metaxia Tsipopoulou (ed.), *Petras, Siteia. The Pre- and Proto-palatial Cemetery in Context* (Monographs of the Danish Institute at Athens 21), Aarhus, 143-154.

Olga Krzyszkowska (forthcoming), "The seals and clay sealing", Jeffrey S. Soles, *Mochlos IVA: Period III. The House of the Metal Merchant and Other Houses in the Neopalatial Settlement* (Prehistory Monograph).

Ingo Pini (1990), "Eine frühkretische Siegelwerkstatt?", *Πεπραγμένα του ΣΤ' Διεθνούς Κρητολογικού Συνεδρίου*, Chania, A2, 115-127.

Ingo Pini (2005), "Spätbronzezeitliche ägäische Weichsteinsiegel mit ausnahme der ‚Mainland Popular Group' von Fundorten ausserhalb Kretas", Isabelle Bradfer-Burdet, Béatrice Detournay and Robert Laffineur (eds.), *ΚΡΗΣ ΤΕΧΝΙΤΗΣ, L'artisan crétois* (Aegaeum 26), Liège and Austin, 199-208.

Ingo Pini (2007), "Die ‚Architekturmotive' in der MM-Glyptik", Felix Lang, Claus Reinholdt and Jörg Weilhartner (eds.), *ΣΤΕΦΑΝΟΣ ΑΡΙΣΤΕΙΟΣ, Archäologische Forschungen zwischen Nil und Istros. Festschrift für Stefan Hiller zum 65.Geburtstag*, Vienna, 225-233.

Mervyn Popham (1984), *The Minoan Unexplored Mansion at Knossos* (BSA Suppl. 17), London.

Jean-Claude Poursat (1996), *Artisans minoens. Les maisons-ateliers du Quartier Mu. Fouilles Éxecutées à Malia, Le Quartier Mu* III (Études Crétoises 32), Athens and Paris.

Peter Warren (1969), *Minoan Stone Vases*, Cambridge.

Paul Yule (1981), *Early Cretan Seals: A Study of Chronology* (Marburger Studien zur Vor- und Frühgeschichte 4), Mainz.