ATTACHMENT METHODS AND ASPECTS OF TECHNOLOGY IN LATE BRONZE AGE WORKSHOPS; THE CASE OF IVORY[1].

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ΑΡΧΑΙΟΛΟΓΟΣ

Ivory working, an elite craft at the best of times, basically on account of the scarcity and the imported status of the raw material, is a prime candidate, not only for the study of Bronze Age technology, but also for the study of cultural/technological differences between various human groups. The Late Bronze Age witnessed an unprecedented peak in ivory production. From the period of the 2nd palaces on Crete (LM IB) and the LH III period on the Mainland and related areas, ivory working was relegated to the level of a palace industry, although ivory finds were not confined to palace sites (Spata, Menidi, Thorikos, Archanes, Palaikastro).

Despite the huge gaps in the archaeological record, the most intriguing and instructive aspects of ivory technology are still to be found in the surviving workshop contexts, unfortunately few and far apart. The selected sites at Mycenae, Delos and Knossos, are not an exhaustive[2] , but a more or less representative cross section of the state of the industry in the Late Bronze Age. At *Mycenae,* the only published workshop sites, involve two of the four LH IIIB1 houses, S of Grave Circle B, the *House of Shields* and the *House of Sphinxes,* secondary workshops and joining establishments, including well over 18.000 pieces of worked ivory (Tournavitou, 1995). The possible workshop in the vicinity of the *Sacred Centre* (Krzyszkowska forhcoming) and the *House of the Artisans* (Mylonas, 1965, 85-96; 1966, 419-26), part of the E wing of the palace, secondary and primary workshops respectively, are unfortunately still unpublished. The *Delos* material, a total of 2.533 pieces, of LH III A2-B1 date, from the foundation deposit of the *Artemision* (Vallois, 1929, 184-315; 1944; Gallet de Santerre-Treheux, 1947-8, 148-254; Poursat 1973, 415-25), represents a probably local workshop assemblage, combining both primary and secondary working of ivory, whichever the ultimate context of the finished objects may have been (Tournavitou, 1996). Finally, the *Knossos* material, several thousand pieces of elephant and hippopotamus ivory, comes from the *Royal Road workshop*[3] (Hood, 1957-1962), one of the two surviving Late Bronze Age workshop sites in Crete (Zakros), dated in the LM IB period[4].

The three basic attachment methods employed by Late Bronze Age ivory carvers, whether they were working with inlays, applique ornaments, or freestanding objects in the round, consisted of glue, pegs and the tenon-mortise system, or as was mostly the case, combinations of the above.

Late Bronze Age *glues* have not survived in the archaeological record, with one possible exception, a yellowish substance found among the workshop debris of the House of the Artisans (Mylonas, 1965, 93-4), which is believed to have been such an agent. The only hard evidence for the existence of this method is the total lack of other attachment devices and the state of the underside of the piece involved (Evely, 1993, 238). Glue, for reasons of better adhesion, is even nowadays, preferably, but not exclusively, applied on a specially prepared, or as we say, a scored, surface (Fig 1). Scoring is basically used as a term for deliberately incised patterns on the underside of an object (blade tip), as for example a series of parallel lines, oblique or vertical to

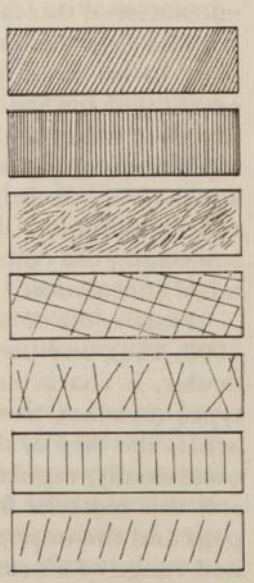


FIG. 1 Types of scoring (Mycenae, Delos)

the long axis, a series of X marks, or a series of crossed lines (###), often on a smoothed, or even polished background; this is called distinctive scoring. Scoring could also involve random lines. Finally, as was the case in many examples, scoring could be also broadly used to describe regular, radiating or oblique toolmarks, deliberately left on the underside, as a remnant of earlier cutting/trimming processes, mostly sawcuts or abrasion marks that were not obliterated by polishing, in order to provide a better keying surface for the application of the glue. Regular toolcuts were often encountered on one or more of the vertical edges, which, like the underside, would not be visible, when in position. The frequency and/or intensity of these toolmarks varies from one workshop site to the other, and was probably not only a matter of local workshop practices, but also possibly a consequence of two factors: the kind of ivory used (elephant or hippopotamus), and the extent to which gluing was relied upon as an exclusive method of attachment. The latter is again not only a matter of local tradition; it is often a technical issue, involving the potential of the gluing agent, which should be compatible with the size and weight of the object concerned. This implies that larger and heavier objects, especially applique ornaments with no sockets to receive them, would normally be provided with other additional means of attachment. The type of scoring applied was also probably related to the size of the available area, that is, distinctive or even random scoring would only be attempted on a reasonably large surface.

The extent to which gluing alone or even in combination with other methods was employed for the attachment of ivory objects, varies from one area to the other. The evidence from the extant workshop sites suggests that gluing, as an independent means of attachment was one of the characteristic features of the "Mycenaean", as opposed to the "Minoan" corpus, both on the Mainland and in the Cyclades. This becomes most evident in the class of *plain rectangular strips and squares, common* to all three areas. The *Mycenae strips* were in their vast majority (90%), true inlays, with flat, rough or smooth undersides, mostly provided with a scored surface. The *square inlays* (Fig 2), preserved no traces of other means of attachment except scoring, and especially the type of scoring involving toolcuts from the cutting stage; no distinctive or even random scoring has been encountered this far.

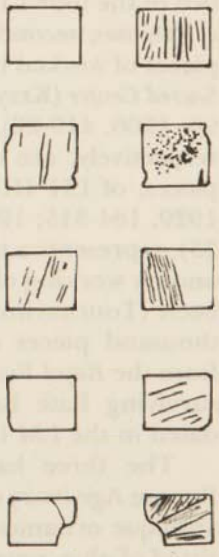


FIG. 2 Square inlays, scoring, underside, Mycenae (53-278a-d, f)

The *Delos* material conforms to the same general principles, to an even greater degree (99.99%). Although the extant toolcuts are of the same type as those observed in the Mycenae material (Pl 1), they are on the whole less intense, a phenomenon perhaps related to the greater significance attached to distinctive scoring. Whether or not this also reflects technical differences, including a preference for smoothing old cutmarks over before attachment, it is a matter of speculation.

Finally, the *Royal Road* material, all hippo ivory (Evely, 1993, 234), and the class of the *plain rectangular strips* in particular, is characterised by regular toolmarks of the usual types (sawcuts, abrasives), as well as distinctive scoring of the oblique kind, running across the face of the area (///); overlapping and radiating toolmarks also occur, while occasionally, regular toolcuts also appear on one of the vertical edges. What differentiates this material from the Mainland and Cycladic corpuses, is first the preference for pegs and the unpopularity of gluing as an exclusive means of attachment, the more limited range of scoring patterns (only one pattern) and finally, the apparent faintness of the extant toolcuts. The latter could be possibly related to the kind of ivory used, but it could equally well be related to a difference in workshop practices, i.e. less reliance on gluing in principle. As regards the *square inlays* (Pl 2), of noticeably larger size than the

Mainland examples, the technical differences become even more apparent. Not only were the extant toolmarks less intense on the whole, but scoring and the use of glue is encountered only in a small minority of the material.

Glue was the only attachment method used for the entire range of small inlays, whether geometric or cutout, as for example triangles, discs, ivies, lilies, etc. Within this broader class of objects, the vast majority of the Delos material, in direct contrast to the Mycenae corpus, included pieces with smoothed or polished undersides, and a curious lack of cutmarks on the vertical edges. This suggests, apart from the obvious conclusions about differences in workshop practices and/or standards, that although a scored underside may have been technically preferable, it was not obligatory. The markedly eneven undersides of otherwise perfectly finished inlays at Mycenae (Pl 3-4), on the other hand, like plain discs, rosettes, lilies and triangles, reveal a number of technical issues. *Firstly*, stepped undersides, and/or a slightly faceted circumference, with toolmarks on all preserved levels, reflect a secondary and possibly ongoing thinning or trimming process. *Secondly*, that trimming of the underside and/or the circumference was an activity which at Mycenae at least, was in some cases left for last, after the final polishing or incising of the top surface, possibly part of the final adjustments before attachment. *Thirdly*, the rarity or complete absence of this phenomenon from the other two workshop sites, and the dramatic differences in output between them, suggest that this procedure was conceivably symptomatic of mass production, when certain types were ordered in bulk, at two or more set sizes and were then adjusted according to the current needs.

Apart from inlays, glue was at Delos, in contrast to the other two workshops, chosen as the chief means of attachment for larger and heavier pieces, like plain, incised or relief plaques. It is worth noting that the majority of the 73 extant relief plaques, some of considerable thickness (1.10cm), including the well known Warrior plaque, were only provided with a smooth underside, lightly and randomly scored, or with a series of heavy oblique or regular cutmarks over fainter toolmarks, probably the remnants of an earlier process. Seven examples preserved no toolmarks or scoring whatsoever.

Pegging, one of the commonest attachment methods, was employed both for inlays and applique ornaments. The working principles of this method involved the use of the drill, mostly the solid version, for the opening of holes, and the manufacture of small cylindrical ivory pegs. Pegholes could be drilled or in a few cases bored right through, or part way, the latter being the minority. The choice depended primarily on the size (thickness) of the object involved, and the manner in which it was meant to be attached onto the backing surface. Pegs, of various sizes have been recorded in all three workshop sites. They are small cylindrical often tapering pieces of ivory (Pl 5), with a polished top section, and the other end sawn and/or broken off. The more strongly faceted examples (Pl 6-7), recorded in all three sites, with distinct toolmarks on the body and a more elongated than circular section, were obviously part of an ongoing trimming or paring process, two or three stages removed from the initial stage. As regards that first stage, the evidence is still inconclusive. Whether they were initially drilled from a blanc with a hollow drill, at a set diameter and then trimmed down to size, or they were worked individually out of offcuts, without the help of the drill, starting off as thick rectangular sticks, is still a matter of speculation. It is possible that both practices were valid, depending on the number of pegs required, especially considering how time consuming the second option is (Evely, 1993, 238; Tournavitou, 1995, 183-4).

The popularity of this method for different types of objects varied widely. In the class of plain rectangular strips for example, it was only a 10% at Mycenae and a mere 0.01% at Delos that preserved pegholes, mostly drilled right through. These holes were ranged at irregular intervals along the central axis. The use of pegging was in most cases combined with a rough or scored surface (///, XXX, or toolmarks), i.e. a combination of pegs and glue. The situation in the Knossos material on the other hand, was almost diametrically different. Here it was the majority of the pieces that were provided with pegholes for attachment (Pl 8), both drilled right through and part way. The positioning of the holes was similar to that encountered at Mycenae and Delos. It is also worth noting that

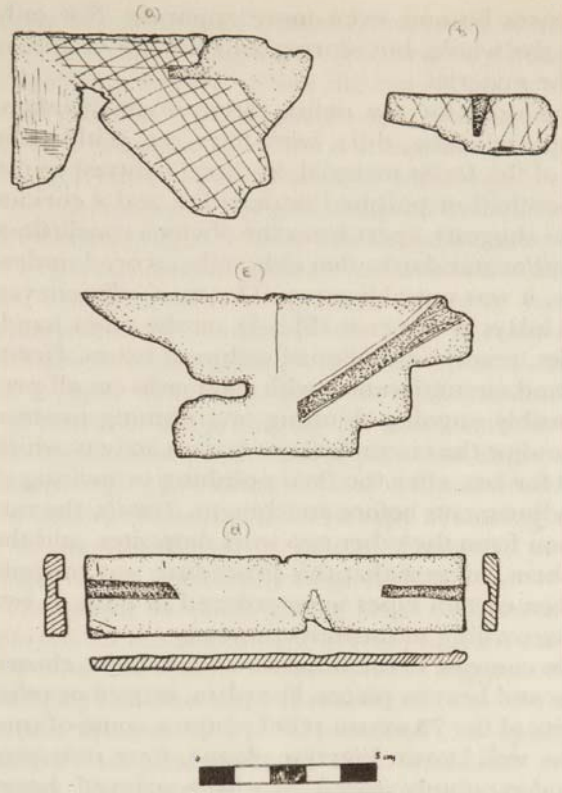


FIG. 3 Plaques, mortises, underside, Mycenae, Delos (a: B7078, b: 54-442, c: B7073, d: B70910)

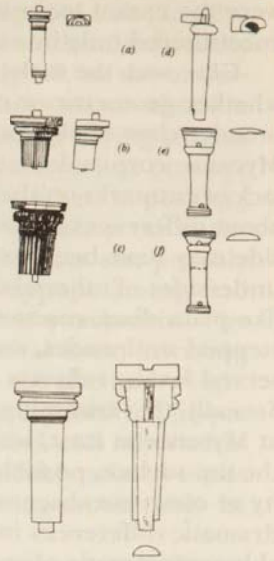
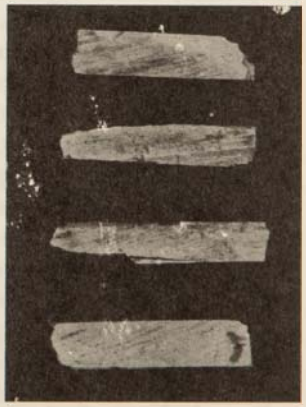
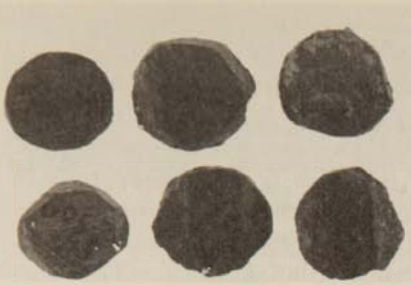


FIG.4 Types of columns, mortise-tenon system, Mycenae (Tournavitou 1995, Fig 29.1, 7)

PL. 1 Strips, scoring, underside, Delos (BCH 119, 1995, Fig 8a)

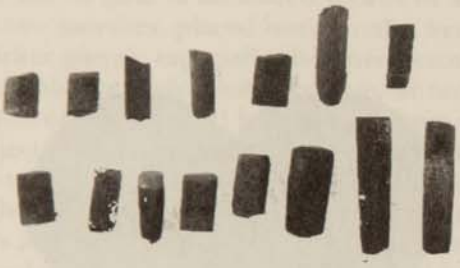


PL. 2 Square inlay, scoring, underside, Knossos

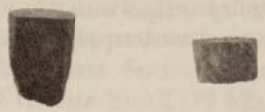


PL. 3 Inlays, uneven surface, underside, Mycenae (54-309)

PL. 4 Inlays, uneven surface, underside, Mycenae (54-309)

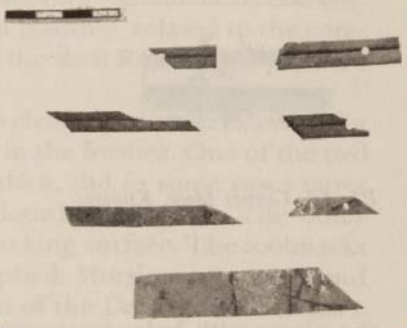


PL. 5 Pegs, Mycenae (53-654)



PL. 6 Faceted pegs, Mycenae (53-239)

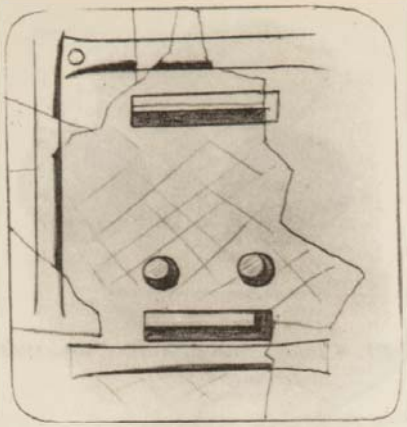
PL. 7 Faceted pegs, Mycenae (53-240)



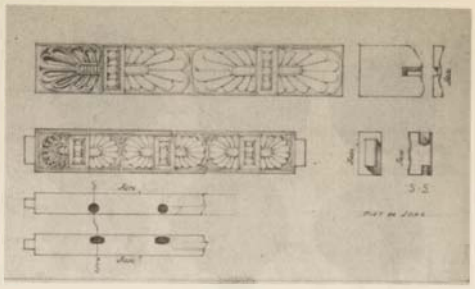
PL. 8 Strips with pegholes, top, Knossos

PL. 9 Square inlays, pegholes, top, Knossos

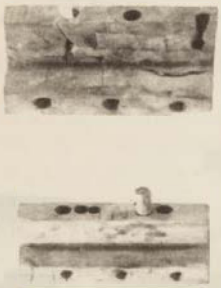
PL. 10 Warrior Head, Mycenae (53-405)



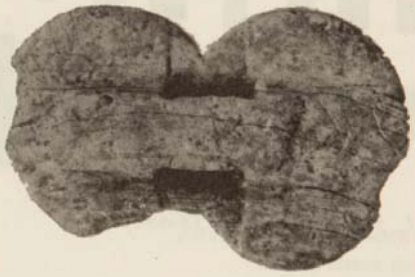
PL. 11 *Plaque with Fig of 8 Shield, underside, mortises, Mycenae (53-410)*



PL. 12 *Triglyph Plaque, with tenons and mortises, Mycenae (54-450)*



PL. 13 *Corner piece, Knossos*



PL. 14 *Figure of 8 Shield, strap device, Mycenae (Prehistoric Cemetery East; 50-2)*

the pieces with holes were apparently less scored on the underside.

In the class of *plain square inlays,* the differences are even more pronounced. Whereas the Mycenae corpus does not include any examples with pegholes whatsoever, in the Royal Road collection, perhaps on account of the much larger size of the pieces, the majority were provided with a distinctive system of pegholes (Pl 9), not encountered anywhere else (two-three). The scoring on the underside and thus the application of the glue was clearly of secondary importance and often missing altogether.

In the class of large rectangular plain or incised plaques, the Mainland preference for gluing prevailed both at Mycenae and Delos. In the *relief plaques* the practice is reversed only at Mycenae, where the chief means of attachment involved pegholes drilled right through, or part way, on a scored surface. At Delos, only on two occasions were through pegholes used[5]. Pegs were almost the only means of attachment used for other more bulky applique ornaments, like fig of 8 shields in relief, where the number of holes depended on the size of the object[6], cockleshells, warrior heads in relief (Pl 10), and half columns. In all these cases, with the exception of the half columns, the holes were only drilled part way.

The *third method,* i.e. *mortises* and their corresponding projecting *tenons,* is the most elaborate form of jointing device encountered in the Bronze Age corpus. It is only rarely that both connecting elements are found in the same context, as was the case with model

columns at Mycenae; in most cases the only element preserved is the mortise. It should be noted at this point that mortises/tenons were seldomly used on their own; they are usually combined with other means of attachment, like pegs and/or scoring. This method was reserved for the bulkier, heavier and/or more complicated objects, applique or free-standing, which includes large plaques, blocks and model columns.

Mortises have been encountered in two basic forms: the open version, a rectangular cutting extending across the surface of an object, and the closed version, a sloping, tapering form, with the corresponding tenon being slotted into it, instead of being simply pressed in (Evely, 1993, 239). *Tenons* were simply designed to fit their respective mortises, and in all the surviving examples they were carved out of the same piece of ivory as the object involved. True tenons have been only preserved in the Mycenae corpus.

Although both versions of mortises were used for incised or relief plaques at Mycenae and Delos (Fig 3; Pl 11), it should be always remembered that they were only a small minority as far as attachment methods go. The *Mycenae* material is undoubtedly more varied. Mortises were cut parallel, vertical or at an angle to the long axis of the object, on a smoothed, polished and in most cases a distinctively scored surface, which implies the use of glue as an added means of attachment. Each plaque was equipped with one or two mortises, placed horizontally, vertically or obliquely to the long axis. Some of the thicker pieces, especially the ones decorated with the triglyph/half rosette motif (Pl 12), were also provided with rectangular tenons projecting from the short ends, and with a series of holes drilled horizontally from the long vertical edges, through the width of the object. The concentration of so many attachment devices on this type of objects, can only be related to the way they were meant to be assembled/attached. In the *Delos* material, although the plaques bearing mortises constitute an even smaller minority, the particulars are almost identical. It is worth noting that the more elaborate combinations encountered at Mycenae, were not witnessed here, a phenomenon possibly related to the complexity of the objects produced. The two pierced tenons on the Roal Road D-plaques, are described as flanges (Evely, 1993, 237-8).

The tenon and mortise system is best exemplified in the class of the *model columns* (Fig 4), attested at both Mycenae and Delos, but best illustrated in the former. One of the two tenons projecting from both ends as an extention of the shaft, did in some cases taper upwards, probably in agreement with the mortise of a detachable capital. The other tenon was probably intended to secure the shaft onto the backing surface. The toolmarks on the underside of the shafts suggest that glue was also applied. Mortises are only found on the back of detachable capitals. The only differentiation of the Delos columns, was a hole drilled part way, obliquely or vertically, from the upper surface of the capital.

Finally, two other means of attachment recorded only in the Royal Road workshop and at Mycenae[7] respectively, were the *corner* (Pl 13), an independent unit, designed to facilitate the jointing of two or three quite separate elements (Evely, 1993, 239), from different angles, and the *strap* (Pl 14), as an attachment device for figure of 8 shields. The strap has been also encountered at Tiryns[8].

On the whole, it would be fair to say, that despite the assumed uniformity in the basic manufacturing methods, a uniformity dictated by the nature of the material, the available tools and the range of objects produced, which by the LH III period were more or less standardised, most workshops developed and retained their own routines. The issue of political/economical domination influencing/affecting typology and techniques, is still open and should be handled with caution.

NOTES

1. This is a very abbreviated version of a much larger project, including a more complete range of data.
2. Workshop material has been also discovered at various locations in Thebes, as for example the Kortanzis plot site (Symeonoglou, 1973).

3. I would like to express my thanks to Don Evely for providing the illustrations and for allowing me to present and discuss this material.
4. The material has been studied and will be published by R.D.G. Evely. A certain amount of information appears in Evely, 1993, ch. XVI.
5. Some of the decorated plaques from Delos have been assigned to Cypriot/N Eastern workshops (Poursat, 1973, 425).
6. At the workshop in the vicinity of the Kortanzis plot, it seems that the shields were provided only with scoring on the underside (Symeonoglou, 1973, 53), while at Archanes, part way attachment holes were the rule, both for the shields and the warrior heads (Sakellarakis, 1967, 253-4).
7. 50-2; Prehistoric Cemetery East.
8. Kilian, 1988, 120, Abb. 18

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ΠΕΡΙΛΗΨΗ

ΜΕΘΟΔΟΙ ΣΥΝΔΕΣΗΣ ΚΑΙ ΟΨΕΙΣ ΤΗΣ ΤΕΧΝΟΛΟΓΙΑΣ ΣΤΗΝ ΥΣΤΕΡΗ ΕΠΟΧΗ ΤΟΥ ΧΑΛΚΟΥ: Η ΠΕΡΙΠΤΩΣΗ ΤΟΥ ΕΛΕΦΑΝΤΟΣΤΟΥ

Ι. ΤΟΥΡΝΑΒΙΤΟΥ

Η ανακοίνωση αυτή επιχειρεί να ανακεφαλαιώσει με κατανοητό τρόπο την τεχνολογία του ελεφαντοστού, και σ' αυτήν την περίπτωση τις μεθόδους σύνδεσης, καθώς και λεπτομέρειες της τεχνολογικής διαδικασίας. Όλα αυτά δίνονται για να αποτελέσουν επιστημονική εκδοχή για την αξία αυτού του τύπου δεδομένων ως κριτηρίου πολιτισμικής/πολιτικής διαφοροποίησης μεταξύ των διαφόρων ανθρώπινων ομάδων στο Αιγαίο της Ύστερης εποχής του Χαλκού. Τα δείγματα που επιλέχτηκαν (Μυκήνες: Οικία των Ασπίδων, Οικία των Σφιγγών, Δήλος: Αποθέτης του Αρτεμισίου, Κνωσός: Εργαστήριο της Βασιλικής Οδού), όλα τους σαφώς αναγνωρισμένα ως εργαστηριακές θέσεις, καλύπτουν τις τρείς κύριες πολιτισμικές περιοχές, δηλ.την Κυρίως Ελλάδα, τις Κυκλάδες και την Κρήτη.

Οι τρείς βασικές μέθοδοι σύνδεσης που εφαρμόζονταν απο τους τεχνίτες του ελεφαντοστού κατά την Ύστερη εποχή του Χαλκού, ήταν η κόλλα, καβίλιες (καρφί) και το σύστημα τενόντων-υποδοχών. Οι μέθοδοι αυτές, καθώς χρησιμοποιούνταν σε διαφορετικές περιοχές και στις ποικίλες κατηγορίες των αντικειμένων που τις αφορούσαν, αποκαλύπτουν σαφείς και πιθανόν σημαντικές διαφορές μεταξύ των εργαστηριακών θέσεων.

Φαίνεται πως η έντονη προτίμηση της Κυρίως Ελλάδας για τη συγκόλληση, στην περίπτωση των ένθετων και κάποιων επίθετων διακοσμητικών στοιχείων (πινακίδων), σε συνδυασμό περιστασιακά και με καβίλιες, είχε επίσης υιοθετηθεί σε μεγάλη έκταση και απο το Κυκλαδίτικο εργαστήριο. Αντίθετα, οι τεχνίτες του ελεφαντοστού απο την Κνωσσό χρησιμοποιούσαν καβίλιες, ως αποκλειστικά μέσα σύνδεσης για τον ίδιο τύπο αντικειμένων. Η κατηγορία των επίπεδων τετράγωνων ένθετων είναι ένα αντιπροσωπευτικό παράδειγμα της τάσης αυτής. Η κατασκευή καβίλιων, απο την άλλη μεριά, φαίνεται ότι αφορούσε κοινές μέθόδους και για τις τρείς αυτές περιοχές.

Το σύστημα τένοντος και υποδοχής, ο πιο πολύπλοκος τρόπος σύνδεσης που συναντάται στο σύνολο της Εποχής του Χαλκού, έμενε και στις τρείς περιοχές αποκλειστικά για τα πιο σύνθετα αντικείμενα ή συστήματα σύνδεσης (κίονες, ολόγλυφα αντικείμενα κτλ.). Φαίνεται ότι τα πιο επαρχιακά εργαστήρια, όπως η Δήλος, με πιο περιορισμένη γκάμα προϊόντων, όντως χρησιμοποίησαν την επινόηση αυτή σε μικρότερο βαθμό. Μερικοί τύποι αντικειμένων, όπως οι μικρογραφίες κιόνων, εμφανίστηκαν με τα ίδια μέσα σύνδεσης σε όλες τις εργαστηριακές θέσεις.

Συνολικά, φαίνεται ότι, παρά τη γενικότερη ομοιογένεια σε βασικές μεθόδους,σε πολλές περιπτώσεις οι οποίες υπαγορεύονται απο το ίδιο το υλικό, η τεχνολογία του ελεφαντοστού όντως υποδεικνύει την ύπαρξη ισχυρών τοπικών παραδόσεων. Οι παραδόσεις αυτές στην περίπτωση μικρότερων επαρχιακών εργαστηρίων μπορούν εύκολα να αναχθούν σε ένα ή περισσότερα μεγάλα κέντρα. Το κατά πόσον το εν λόγω φαινόμενο μπορεί ή πρέπει να συσχετιστεί με πολιτική/οικονομική επιρροή, ή ήταν απλώς ζήτημα περιοδευόντων τεχνιτών, αποτελεί ακόμη αντικείμενο συζήτησης.