

## ARCHAEOLOGY IN GREECE 2020–2021

# From tools to production: recent research on textile economies in Greece

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*The aim of this report is to provide a summary of the latest developments in the textile archaeology of Greece and the broader Aegean from the Neolithic through to the Roman period, focusing in particular on recent research on textile tools. Spindle-whorls and loomweights appeared in the Aegean during the Neolithic and by the Early Bronze Age weaving on the warp-weighted loom was well established across the region. Recent methodological advances allow the use of the physical characteristics of tools to estimate the quality of the yarns and textiles produced, even in the absence of extant fabrics. The shapes of spindle-whorls evolved with the introduction of wool fibre, which by the Middle Bronze Age had become the dominant textile raw material in the region. The spread of discoid loomweights from Crete to the wider Aegean has been linked to the wider Minoanization of the area during the Middle Bronze Age, as well as the mobility of weavers. Broader issues discussed in connection with textile production include urbanization, the spread of different textile cultures and the identification of specific practices (sealing) and previously unrecognized technologies (splicing), as well as the value of textiles enhanced by a variety of decorative techniques and purple dyeing.*

### Introduction

The study of archaeological textiles from Greece and the broader Aegean has made tremendous progress over the past two decades, and a recent volume of *AR* presented an overview of textiles excavated in Greece and discussed the challenges of their preservation and conservation (Spantidaki and Margariti 2017). Thanks to the increasing number of textile finds and large-scale tool analyses reviewed below, we are now in a position to move from the study of individual finds to tackling broader questions, as exemplified by the European Research Council-funded projects *PROCON* (2013–2018) and *PENELOPE* (2016–2021), and numerous recent Marie Skłodowska Curie-sponsored and other projects. In this report, we focus on studies of textile tools within their archaeological contexts and broader developments in scholarship of the region based on textile and environmental remains. The large volume of literature published in recent years on the subject makes it impossible to cite all relevant publications but we hope those provided will guide the reader.

### Textile tools

Textile tools allow the study of various aspects of textile production, even when the textiles themselves do not survive (see Grömer 2016: 38–39, fig. 15 for the textile *chaîne opératoire*). Furthermore, unlike textiles, which survive predominantly in funerary contexts, textile tools are ubiquitous at many settlement sites. Not only can they be used to hypothesize about the organization of textile production, but the development of a new functional analysis method by the Centre for Textile Research (CTR) in Copenhagen, based on experimental data (Andersson Strand and Nosch 2015), allows us to calculate the range of textile and thread qualities obtainable from specific tools. Further experiments testing different types of loomweights have been carried out by, for instance, Małgorzata Siennicka and Agata Ulanowska (Siennicka and Ulanowska 2016; Ulanowska 2020a) and *PROCON* (Gleba *et al.* forthcoming). The last ten years have seen an explosion of tool studies in Greece, with many projects in progress or now completed.

### Neolithic

Evidence of textile production in the Neolithic Aegean is rather limited due to an absence of textile remains and the restricted distribution of loomweights to sites in northern Greece and Thessaly (Carington Smith 1975; 2000). This indicates either the absence of loom-weaving technology in the south or that looms other



138. Sesklo and Dimini: Neolithic spindle-whorls (left: pierced pottery sherds; right: purpose-made discoid whorl). © K. Sarri (after Sarri 2018: 98–99, figs 10.6–10.7).

than the warp-weighted type common in later periods were utilized, in particular the horizontal ground loom documented by clay heddle rod jacks (Sarri 2020a; 2020b). An assemblage of about 500 spindle-whorls from Sesklo and Dimini analysed by Kalliope Sarri (<https://cordis.europa.eu/project/id/656848>) includes both earlier pierced pottery sherds and later purpose-made ceramic whorls (Fig. 138). The shape of the latter evolved from discoid to biconical and conical shapes, and this evolution is interpreted as a consequence of the introduction of wool fibre.

This change in the shape of spindle-whorls has been noted more broadly. From 2012 to 2019 the *Textile Revolution* research group of the Excellence Cluster *Topoi* at the Free University of Berlin investigated the archaeological evidence for the introduction of wool in Late Neolithic and Early Copper Age (6500–2000 BC) Europe and the Near East by analysing large datasets of spindle-whorls from Anatolia and the Pannonian plain (Schier 2020). Functional analysis of more than 2,000 spindle-whorls found a change in shape from discoid towards more compact whorls (biconical, conical, spherical). In combination with zooarchaeological data, this development may indicate a shift towards the use of wool during the fifth to fourth millennium BC as part of a more general ‘pastoral turn’, although the shift was much more gradual than expected (Grabundžija and Schoch 2020). An ongoing project led by Sophia Vakirtzi and Aikaterini Papagianni at the University of Athens, *Interdisciplinary Research on Early Wool Production in the Aegean*, combines analyses of textile tools and faunal remains to investigate the early use of sheep and goat fibres in the Aegean.

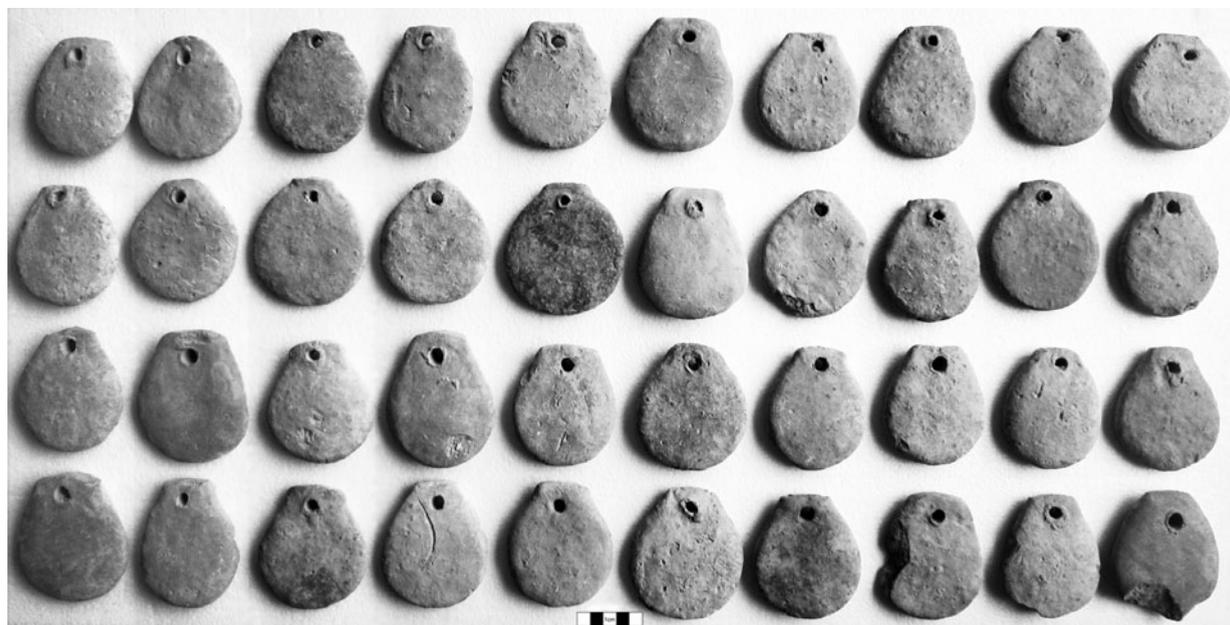
### *Bronze Age*

The gradual integration of wool into the textile production processes of the Aegean islands was investigated in Vakirtzi’s doctoral work. Her PhD documents 442 spindle-whorls from Early Bronze Age Thasos, Samos, Ios, Naxos, Syros, Keos and Lemnos (Vakirtzi 2015; 2018; 2020). In particular, the appearance of ‘Anatolianizing’ whorls in the Early Bronze Age Aegean suggests the arrival of wool.

It was during the Early Bronze Age that loomweights became common across the Aegean, heralding the introduction of the warp-weighted loom (Siennicka 2020). Loomweights from Tiryns, Lerna, Korakou and Kolonna have been investigated by Małgorzata Siennicka (<https://cordis.europa.eu/project/id/329910>). They are of various shapes (conical, cylindrical, crescent-shaped and spool-shaped) and are generally heavy (400–500g). Experiments have shown that heavy spools can be used as loomweights (Siennicka and Ulanowska 2016).

From 2005 to 2010, the large-scale *Tools and Textiles Texts and Contexts* project (Centre for Textile Research, Copenhagen) investigated the growth of textile economies in the central and eastern Mediterranean in the third and second millennia BC (<https://ctr.hum.ku.dk/research-programmes-and-projects/previous-programmes-and-projects/tools/>). The programme recorded approximately 4,000 spindle-whorls (including ‘conuli’, beads, kylix stems and pierced sherds, which were likely used also for spinning) and over 4,000 loomweights of diverse shapes, with spherical, pyramidal and discoid being the most distinct and common types. Textile tools were analysed from the sites of Chania, Agia Triada, Phaistos and Malia on Crete, Akrotiri on Thera, Midea, Mycenae, Tiryns and Thebes in mainland Greece, Archontiko and Sitagroi in northern Greece, Troy in western Turkey, Apliki and Kition on Cyprus and Tel Kabri in Israel (Andersson Strand and Nosch 2015). The Bronze Age examples range in weight from 50g to over 1kg, indicating that a wide repertoire of textiles was produced during this period on the warp-weighted loom and that certain sites specialized in the production of textiles with particular qualities. For example, the fabrics woven with the discoid loomweights were denser and required finer threads than those made with thicker-shaped weights.

The warp-weighted loom was not, however, uniformly adopted across the Aegean. As part of her doctoral research, Joanne Cutler examined the evidence for, and the implications of, the adoption of Cretan-style discoid loomweights at a number of settlements across the southern Aegean by the early Late Bronze Age (**Fig. 139**; Cutler 2011; 2021). She carried out functional and contextual analyses of about 5,600 textile tools from 12 sites on Crete (Knossos, Phaistos, Agia Triada, Kommos, Myrtos Pyrgos, Malia, Sissi, Pseira, Mochlos, Petras, Palaikastro and Chania) and six sites in the wider southern Aegean (Agia Irini, Phylakopi, Akrotiri, Miletos, Iasos and Kythera). The adoption of the new type of loomweight in many cases represents the introduction of a new weaving technology, the use of the warp-weighted loom, since only the discoid form of loomweight was present at the southern Aegean settlements, in contrast to the wider range of loomweight types found on Crete itself. This process, as Cutler has argued, occurred at different paces and to various degrees across the sites studied. On the southern Greek mainland, cylindrical loomweights were present in Early Bronze Age contexts, but disappeared at the end of this period. Identifiable loomweights of any type did not appear again until the Late Bronze Age, except for a few Cretan-style discoid weights from early Middle Bronze Age contexts in Lerna (Cutler 2012: 147).



139. Knossos: discoid loomweights from the Loom-Weight Basement. © J. Cutler (after Cutler 2021: 74, fig. 6.17).

Much of this recent work on textile tools in the Bronze Age Aegean has addressed questions regarding the economic significance of textile production, particularly in light of the Linear B administrative records, which provide abundant evidence of the importance of textile production and consumption in the formation of the political systems synonymous with urbanization. Organization of textile production in the Bronze Age Aegean always involved a domestic mode of manufacture. However, more complex modes of production appear to have developed during the Late Bronze Age (Ulanowska and Siennicka 2018).

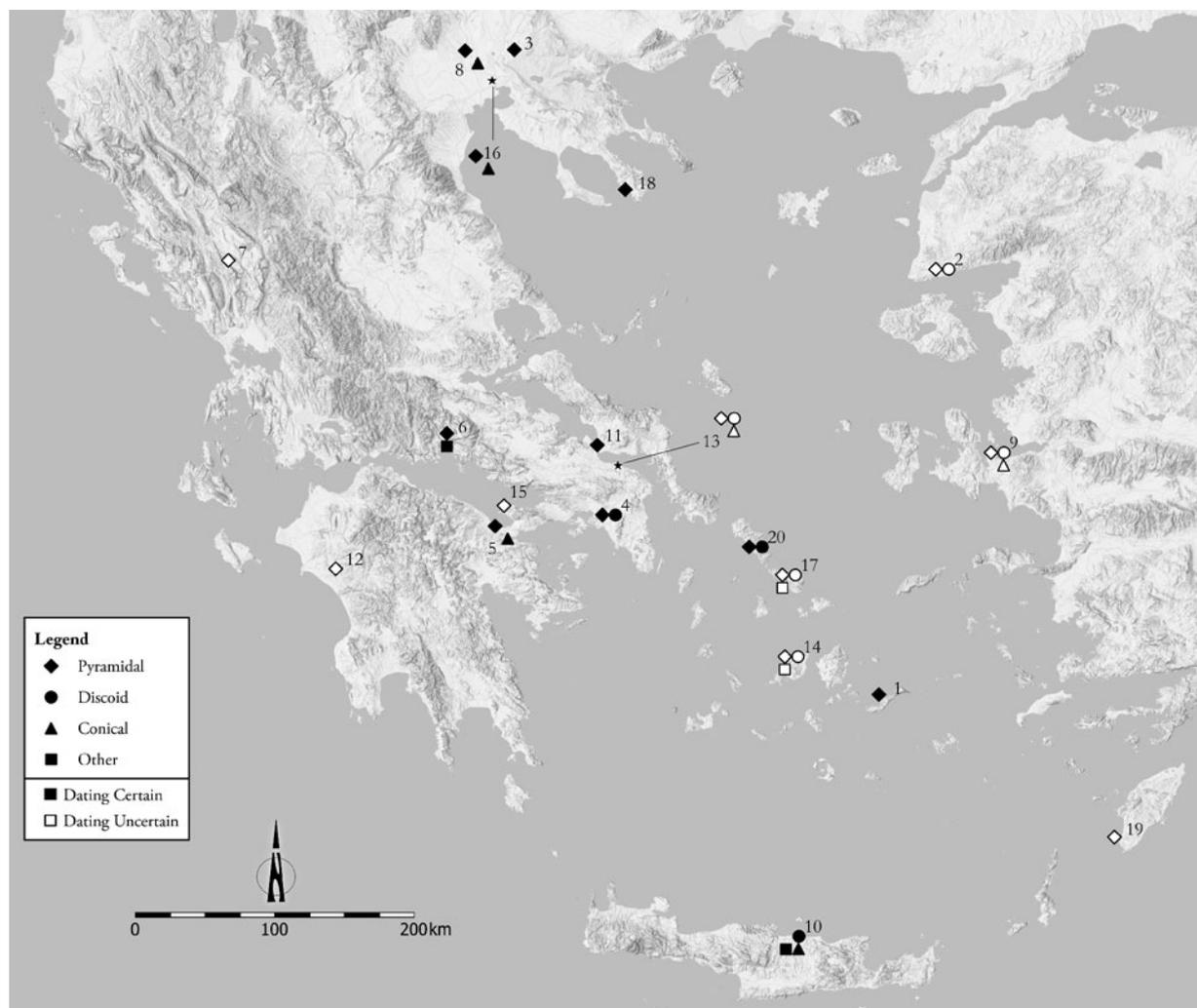
The relevance of textile production during the Bronze Age is clearly underscored by the fact that site reports now regularly include chapters analysing textile tools: for example, Tiryns (Rahmstorf 2008), Petras (Cutler 2016), Alatzomouri Rock Shelter (Brogan and Cutler 2017), Alatzomouri Pefka (Cutler and Brogan 2021), Akrotiri (Vakirtzi 2019), Pseira (Cutler *et al.* 2021), Phylakopi (Cutler *et al.* forthcoming) and Markiani Amorgos and Dhaskalio on Keros (Gavalas 2018). In addition, there are separate publications of textile tools: for example, on those from Maydos Kilisetepe in Gallipoli, Turkey (Yılmaz 2016a).

### *Early Iron Age to Archaic*

In contrast to the Bronze Age, the Early Iron Age and Archaic period lack comparable written sources and evidence of textile economies, and our knowledge relies primarily on archaeological material. A total of 3,487 loomweights and 1,097 spindle-whorls from 12 first-millennium BC sites across Greece have recently been analysed within the European Research Council-funded project *PROCON (Production and Consumption: Textile Economy and Urbanisation in Mediterranean Europe 1000–500 BCE)*: <https://cordis.europa.eu/project/id/312603>, including examples from Argilos, Karabournaki, Eretria, Lefkandi, Oropos, Kalapodi, Athens, Corinth, Argos, Zagora, Knossos and Samos. The resulting data and recent publications allow us to update Mark Lawall's (2015) review of regional loomweight types and, in some cases, to discuss functional characteristics over time (**Maps 5, 6**).

For the Early Iron Age, relatively few loomweights have been published, and these are sparsely distributed. Large, heavy (*ca.* 800–1,200g) and roughly shaped pyramidal and conical weights appear in some quantity at Early Iron Age tell sites in Macedonia, such as Assiros (Wardle and Wardle 2007: 473–75), Kastanas (Mauel 2009) and Sindos (Gimatidis 2010). Two large pyramidal and six torus loomweights from Lefkandi have been published (Evely 2006: 297), but they are outliers in the context of the other weaving equipment found at the site, which is mainly concentrated in Late Helladic IIIC layers.

In some regions, the large, heavy weights of the Geometric period gave way to small, lighter weights in the Archaic period, as documented by finds from the northeast Aegean (for example, Argilos and Karabournaki: *PROCON* data) and eastern Crete (Haggis *et al.* 2004: 371–72). At Kavousi Kastro the Geometric pyramidal examples weigh 555–645g, while most of those from Azoria are below 80g. Archaic Prinias in central Crete, inhabited down to the mid-sixth century BC, also has small weights, up to 5–6cm high and in a variety of shapes: pyramidal, parallelepipedal, discoid, biconical, bell-shaped, conical (Rizza 2008). As Donald Haggis notes, this shift points to changes in the use of the warp-weighted loom and a move towards the production of finer cloth (though not necessarily twill, as he suggests; there is currently no evidence for twill in the Aegean). A similar contrast between sparse, heavy Early Iron Age weights and more numerous, lighter Classical weights exists in inner Thrace, though here the smaller weights appear in the fifth century BC (Dimova 2016; Petrova 2016). It is as yet unclear if there is a hiatus between the use of heavy weights and the appearance of the lighter examples. At Sindos, which offers a long-term perspective, roughly made weights appear in Late Protogeometric IIa (Phase 9) contexts; a well-fired pyramidal weight appears in Late Geometric Ia (Phase 7) and small pyramidal, conical and piriform weights are recorded from Archaic deposits; parallel to these shapes, spools are found from phase 8 or 7 onwards (Late Protogeometric IIIb to Late Geometric Ia) (Gimatidis 2010: 295–96). The use of small weights (*ca.* 50–100g) began earlier, from the eighth century BC, in other parts of Greece, including Athens and Corinth, Oropos, Zagora on Andros (*PROCON* data) and Xombourgo on Tinos (Vlachou 2019: 238, fig. 3a). Experimental and contextual evidence confirms that spools were used as weights on the warp-weighted loom in the Aegean, sometimes alongside other shapes (Olofsson *et al.* 2015: 92–95; also Siennicka and Ulanowska 2016). Note, however, that Aegean spools tend to be larger and heavier than

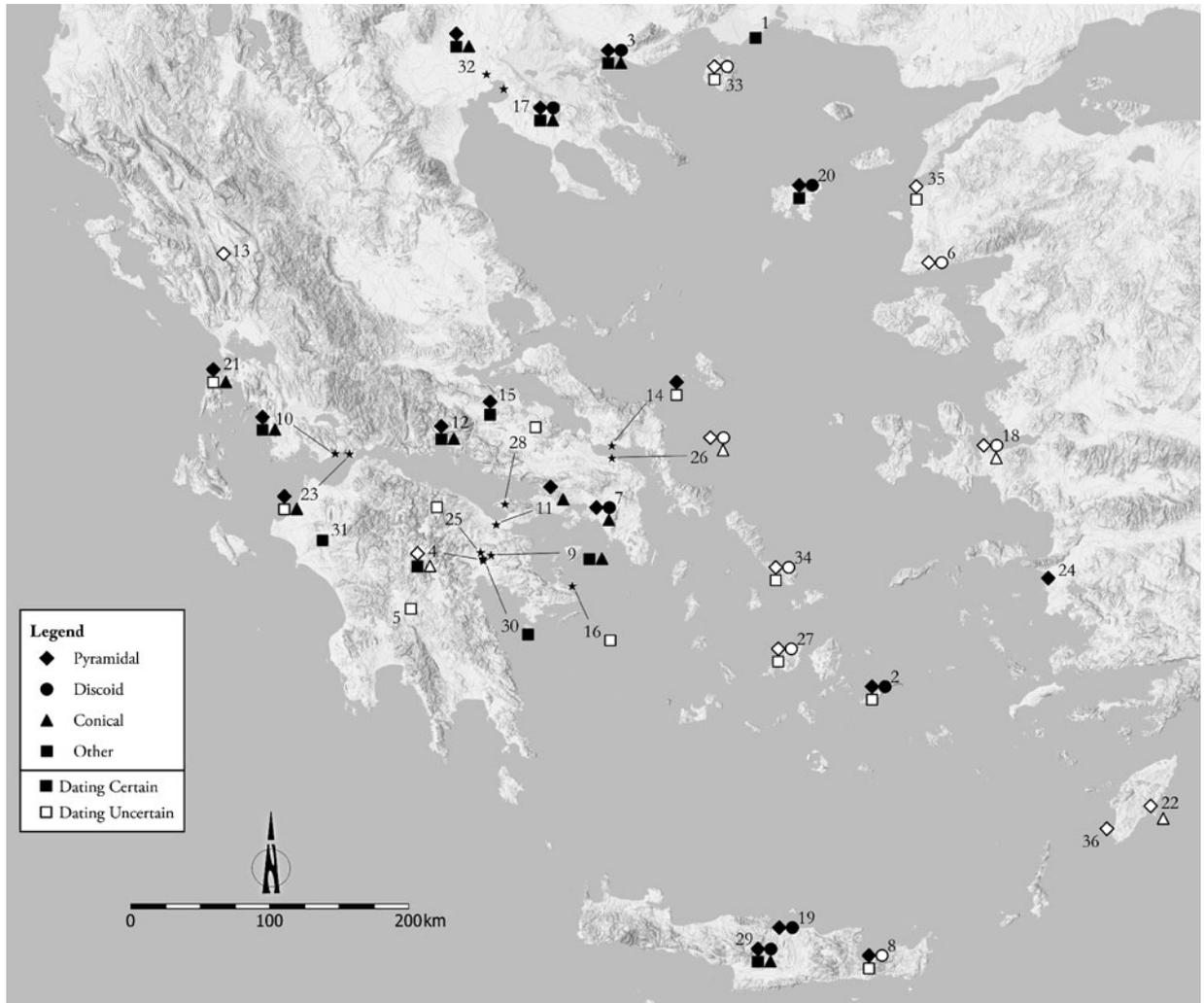


Map 5. Map showing sites that have yielded Early Iron Age loomweights. 1. Amorgos; 2. Assos; 3. Assiros; 4. Athens; 5. Corinth; 6. Delphi; 7. Dodona; 8. Kastanas; 9. Klazomenai; 10. Knossos; 11. Lefkandi; 12. Olympia; 13. Oropos; 14. Paros; 15. Perachora; 16. Sindos; 17. Xombourgo, Tinos; 18. Torone; 19. Vigla, Rhodes; 20. Zagora, Andros. © B. Dimova/BSA.

those from Italy, which are typically under 120g (Cutler *et al.* 2020: 17, fig. 11) and have been linked convincingly to a technique of tablet weaving (Ræder Knudsen 2012). There is so far no evidence for tablet weaving in the pre-Roman Greek textile evidence.

By the Archaic period, the use of the warp-weighted loom was widespread and well established across mainland Greece and the islands (Map 6). Recent publications cover Archaic material from Makyneia and Chalkis (Houby-Nielsen 2020) in Aetolia, Hephaestia on Lemnos (Massa 2020) and Tinos (Vlachou 2019). More material is included in doctoral studies focused on Lefkada (Fiedler 2013) and Amorgos (Gavalas 2014), and in a Master's thesis on weights from Eretria (Martini 2015a; 2015b). While some Archaic sites have a limited range of shapes, often dominated by pyramidal (Athens and Oropos) or conical weights (Corinth and Chalkis Aetolias) or spools (Pylos in Elis), others show greater typological diversity (for example, Argilos, Karabournaki, Xombourgo, Praisos and Knossos). Such typological diversity may reflect the cohabitation of weavers from different traditions, but the different shapes may also be visual aids to distinguish between sets of weights.

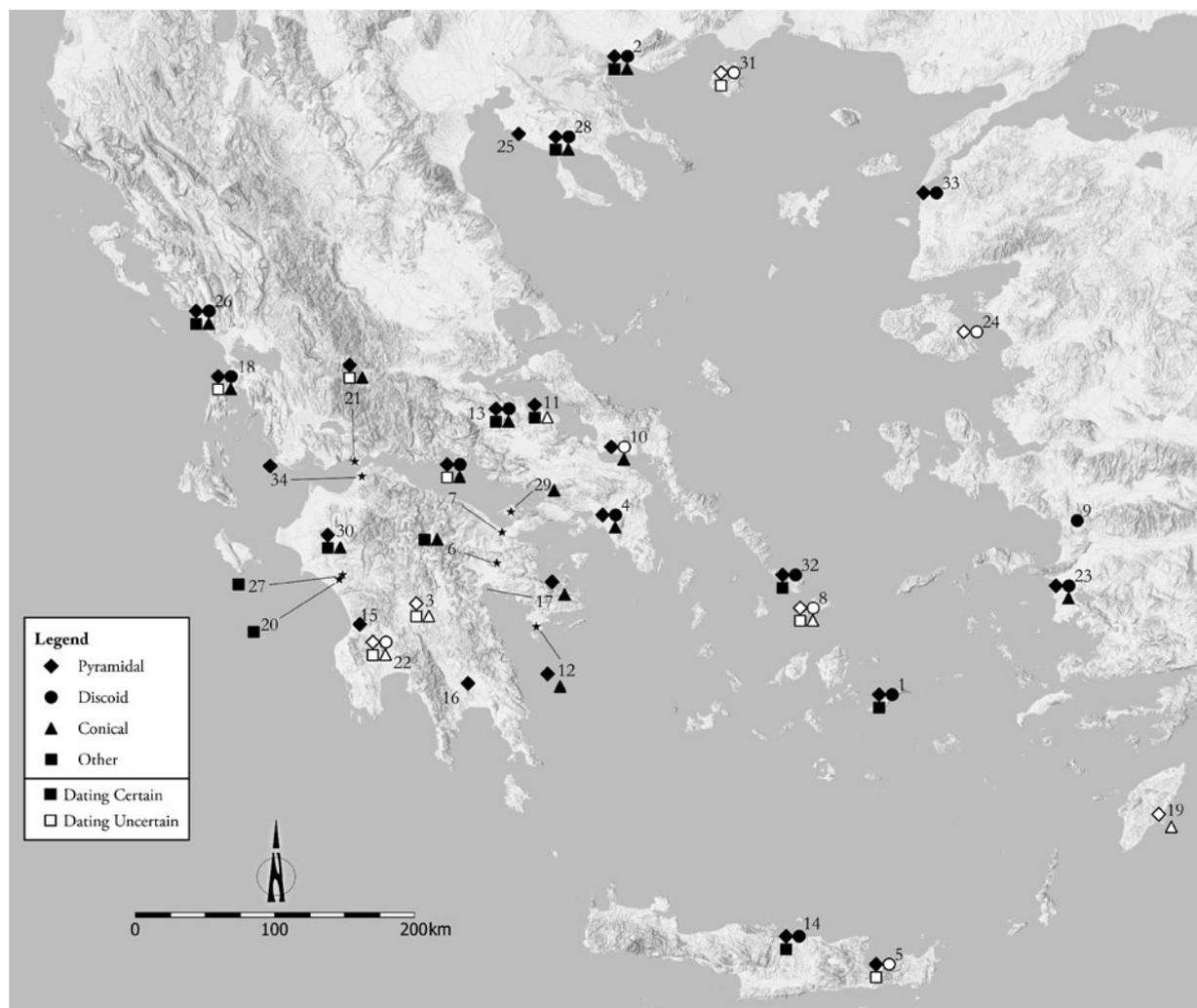
Ceramic spindle-whorls are found more rarely in contexts dating to after the Archaic period, suggesting that spinners preferred spindles without whorls or whorls made of perishable materials. One carbonized wooden whorl displayed at the Brauron Museum lends support to the latter idea.



Map 6. Map showing sites that have yielded Archaic loomweights. 1. Abdera; 2. Amorgos; 3. Argilos; 4. Argos; 5. Asea valley; 6. Assos; 7. Athens; 8. Azoria; 9. Berbati valley; 10. Chalcis Aetolias; 11. Corinth; 12. Delphi; 13. Dodona; 14. Eretria; 15. Kalapodi; 16. Kalaureia; 17. Karabournaki; 18. Klazomenai; 19. Knossos; 20. Hephaestia, Lemnos; 21. Leukas; 22. Lindos, Rhodes; 23. Makyneia; 24. Miletos; 25. Mycenae; 26. Oropos; 27. Paros; 28. Perachora; 29. Prinias; 30. Prosymna; 31. Pylos Armatova; 32. Sindos; 33. Thasos; 34. Xombourgo, Tinos; 35. Troy; 36. Vigla, Rhodes. © B. Dimova/BSA.

### Classical and Hellenistic

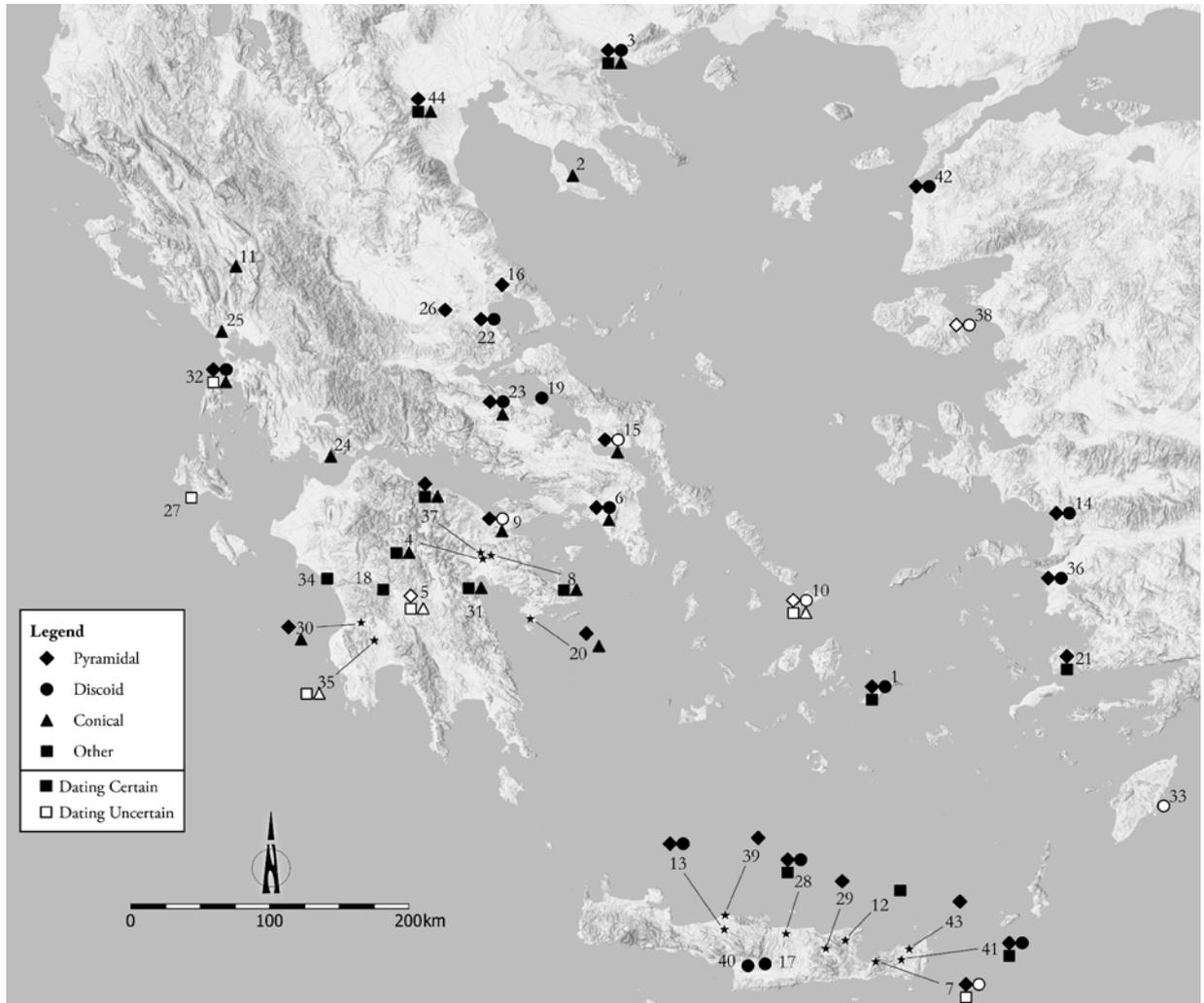
From the Late Archaic and Early Classical periods there is evidence for weaving taking place in workshops; these are archaeologically detectable concentrations of tools. The earliest plausible example comes from Makyneia, with 360 tools found across two buildings burnt *ca.* 480 BC (Saranti and Nikolovieni 2018). Several convincing later examples include a deposit of more than 500 weights from the Athenian Agora, *ca.* 380 BC (Tsakirgis 2016: 174–75), and the well-known clusters from Olynthian houses, *ca.* 350 BC (Cahill 2002: 169–79). Building 10 at Kastro Kallithea, a large second-century BC house, held 122 loomweights as well as a mould for making them (Haagsma *et al.* 2015: 247). Building Z in the Kerameikos (Knigge 2005), the houses at Olynthos and Building 10 at Kastro Kallithea all appear to have been larger-than-average households capable of producing surplus cloth, rather than solely workshops. In contrast, a concentration of over 1,300 loomweights at Hellenistic Vergina has been interpreted as a weaving workshop area, alongside dyeworks (Faklaris 1998; Faklaris and Stamatopoulou 1997).



Map 7. Map showing sites that have yielded Classical loomweights. 1. Amorgos; 2. Argilos; 3. Asea valley; 4. Athens; 5. Azoria; 6. Berbati valley; 7. Corinth; 8. Delos; 9. Ephesos; 10. Eretria; 11. Halai; 12. Halieis; 13. Kalapodi; 14. Knossos; 15. Kopanaki; 16. Laconia; 17. Lerna; 18. Leukas; 19. Lindos, Rhodes; 20. Makrysia; 21. Makyneia; 22. Messene; 23. Miletos; 24. Mytilene; 25. Nea Kallikrateia; 26. Nekromanteion of Acheron; 27. Olympia; 28. Olynthos; 29. Perachora; 30. Pylos Armatova; 31. Thasos; 32. Xombourgo, Tinos; 33. Troy; 34. Voudeni. © B. Dimova/BSA.

In terms of shapes, the Classical period saw a continuation of the trend of the Archaic period: some sites had a dominant shape (Athens and Corinth), while others had a variety (**Map 7**). Some regional patterns include the spread of spools (Iancu 2020 with references) and triangular weights in the Peloponnese (Forsén 2003: 237, n. 23) and piriform weights in the northern Aegean, and the use of biconical weights on Crete; the latter is documented from the Early Iron Age through to the Hellenistic period (at, for example, Knossos, Praisos and Dreros) (**Map 8**). Over time, pyramidal, conical and discoid weights spread and became the main types across the Aegean and wider Mediterranean area. This was likely because these shapes could be produced easily in standardized sizes and large numbers. However, some weavers continued to use a variety of shapes, as in earlier times (for example, at Dreros: Zografaki *et al.* 2020: 173–74).

While most loomweights, particularly those deposited in groups, are found in domestic contexts, there are some published examples from sanctuaries and public buildings (for example, Xombourgo on Tinos, Building E of the late sixth and fifth century BC and the Thesmophoreion of the mid-fifth to late fourth



Map 8. Map showing sites that have yielded Hellenistic loomweights. 1. Amorgos; 2. Aphytos; 3. Argilos; 4. Argos; 5. Asea valley; 6. Athens; 7. Azoria; 8. Berbati valley; 9. Corinth; 10. Delos; 11. Dodona; 12. Dreros; 13. Eleutherna; 14. Ephesos; 15. Eretria; 16. Goritsa; 17. Gortyn; 18. Gortys; 19. Halai; 20. Halieis; 21. Halikarnassos; 22. Halos; 23. Kalapodi; 24. Kalydon; 25. Kassope; 26. Kastro Kallithea; 27. Kephallonia; 28. Knossos; 29. Kolonna, Crete; 30. Kopanaki; 31. Lerna; 32. Leukas; 33. Lindos, Rhodes; 34. Makryisia; 35. Messene; 36. Miletos; 37. Mycenae; 38. Mytilene; 39. Panormos; 40. Phaistos; 41. Praisos; 42. Troy; 43. Trypitos; 44. Aigai, Vergina. © B. Dimova/BSA.

century BC: Vlachou 2019: 246, 254). Some tools were used to produce textiles at sanctuaries, as plausibly argued for Stymphalos (Surtees 2014 with references to other examples), but it was more common for textile tools to be used as dedications, and these probably had significant biographical and practical values for their owners (Bookidis 2018). Very rarely, loomweights are found in cemeteries, including those at Lemnos (Massa 2020: 99, n. 900), Archaic Abdera (Skarlatidou 2010: 110) and Xombourgo on Tinos (Vlachou 2019: 257).

### Roman

In the Roman period the warp-weighted loom was gradually abandoned in favour of the two-beam vertical loom, and loomweights, typically heavy pyramids or discs, became rare. Their continued production is documented by discoid moulds at Chalkis from the Roman Imperial period (Sampson 1987: 126–27) and finds inside a kiln at Lete in Macedonia of the mid-first century AD (Tzanavari and Filis 2003). Their use is evidenced in Early Roman levels at Delos, Demetrias (pyramidal, conical and discoid), Miletos, Ephesos

and Olympia (unspecified ‘Roman’ date) (Lawall 2015 with references.). In some areas, their use continued into the Late Roman period, for instance at a farm near Lamia (Psarogianni and Tileli 2010: 246). In inner Thrace, loomweights are recorded even at sites dating up to the sixth century AD (Petrova 2016: 178–83). Several, from unspecified contexts, are displayed in the Byzantine Museum in Athens, suggesting that their late use also extended to Greece.

### *The wider ‘Greek’ world*

In the wider ‘Greek’ world, detailed studies of textile tools have made significant progress in southern Italy: Herakleia, Basilicata (Meo 2015a; 2015b), the Heraion at the mouth of the Sele river (Ferrara and Meo 2017), the Ionian coast of Campania (Luberto and Meo 2017) and Sicily (Enegren 2015; Quercia 2017; Longhitano 2021). In North Africa, where the warp-weighted loom was used from at least the Hellenistic period until the beginning of the second millennium AD, in combination with other types of looms (Bender Jørgensen 2017), some of the early finds in the region are linked with ‘Greek’ cities, such as Naukratis in Egypt (Villing *et al.* 2013) and Cyrene (Warden 1990) and Euesperides in Libya (Tébar Megías and Wilson 2008).

In the Black Sea region, Classical and Hellenistic textile tools appear to follow similar trends to those evidenced in the Aegean. Examples have been published recently from Myrmekion and Chersonessos in Ukraine (Butyagin 2008), Classical and Hellenistic Apollonia Pontica in Bulgaria (Baralis *et al.* 2019; Nedyalkov 2020: 119, 195–96) and Açıç Suat (Caraburun) in Romania (Lungu 2019: 84, fig. 4). Several scholars have dealt with textile tools from a range of periods in Bulgaria (Dimova 2016; Petrova 2016; Hristova 2018), and examples from Turkey dating to the Bronze Age have also been published (Yılmaz 2016b). Lorenz Rahmstorf (2005) and Joanna Smith (2002; 2019; Smith and Tzachili 2012) have tracked the long-term history of the warp-weighted loom on Cyprus, from the Early Bronze Age to the Hellenistic period, with attention paid to the themes of mobility, ethnicity and organization of production; they note major changes at the end of the Bronze Age and in the Classical period.

### **Broader aspects**

The review above demonstrates that the study of textile tools has developed into an important subfield of textile archaeology. These tools are not only important in and of themselves, but also because they allow us to tackle broader questions dealing with, for example, the role of textile production in cultural transfer, mobility and the development of cities.

There is archaeological evidence indicating long-distance movements of loomweights in the Bronze Age Aegean, where small but consistent numbers of non-local discoid loomweights have been noted at several Aegean sites. Cutler (2012; 2019; 2021) has suggested that the presence of non-local loomweights indicates that there was some degree of mobility among women in the Aegean region. Whether the mechanism of this mobility was intermarriage, migration or slavery is impossible to determine, but textile equipment allows us to track women’s movements, as well as the diffusion of Minoan textile technologies and fashions.

Study of archaeological and historical evidence shows that, during the second and first millennia BC in the Aegean, textile workers moved for various reasons and in various ways, including the forced migration of captives of war, refugees and slaves, and the free movement of individuals, families and larger communities across distances large and small (Dimova and Gleba forthcoming). These movements are documented in written sources and by the distribution of certain techniques and tools, such as the spread of Cretan-style weaving with discoid loomweights in the Bronze Age (Cutler 2021) and the introduction of weft-faced tabbies in Italy in areas with greater contact with the Aegean (Gleba 2017). While moving, textile workers played an important role in the transfer of technologies, knowledge, skills and fashions. In addition, written sources document the practice of relying on foreign forced labour for textile production in the Bronze Age and later periods, and that this generated considerable wealth for various beneficiaries: Mycenaean palaces, Classical Athenian households and Roman estate-owners.

The role of textile production and consumption as a significant driving force of the economy and of the creation and perception of wealth in Mediterranean Europe during the period of urbanization and early urbanism (1000–500 BC) has been investigated recently by the *PROCON* project. The archaeological data collected demonstrate that, along with other craft activities, textile production and consumption defined the development of the productive and commercial activities of early urban Mediterranean societies in the Iron Age and had a significant social and symbolic value (Gleba *et al.* 2021; forthcoming).



140. Experimental sail weaving with 40g weights  
© L. Hammarlund.

Sails, essential for the movement of ships carrying goods and people across the Aegean, were a particular type of textile product that was needed in large volumes. Recent work has investigated the production and management of sails in ancient Greece by combining study of textual sources and experimental archaeology (Fig. 140) with analysis of the remains of sails from Roman and later ships (Spantidaki 2018; Dimova *et al.* forthcoming). According to our estimates, equipping a trireme like the reconstructed *Olympias* with its 119m<sup>2</sup> of sails would have taken one and a half years (4,299 hours) of spinning and one year (2,966 hours) of weaving, on top of the labour required to grow the flax and process the fibres. This work could have been distributed across cities, but

managing supplies and reserves of sailcloth would have constituted a significant challenge; this was addressed through a combination of strategies, including trade and taxation, as well as more intensive exploitation of textile workers.

## Textiles

Thanks to the increase in the number of textile finds, and the much greater attention paid to them (Spantidaki and Margariti 2017; Gleba 2017; 2018; Dimova 2018), textiles are beginning to provide sufficiently robust data to reconstruct broader developments in fibre use and textile technologies and uses.

### *Plant-splicing technology*

Recent examination of a variety of European and Near Eastern plant bast-fibre textiles across wide chronological and geographical spectra has resulted in the identification of splicing in all of them, including multiple examples dating to the first millennium BC from Greece (Fig. 141; Gleba and Harris 2019). These new data indicate that splicing was the original technology used to make thread across the world and that draft spinning was almost certainly a later technological innovation that was required to



141. Corinth: microphoto of Archaic textile woven in spliced yarn. © M. Gleba.

make thread from short fibres such as sheep wool. The discovery of more widespread evidence for splicing than expected has a number of important implications for how we interpret the archaeological evidence of plant bast-fibre technologies and their role in ancient civilizations. For example, the assumption that during the Neolithic and Early Bronze Age spindle-whorls were used for spinning is no longer tenable. Considering that primarily plant fibres were used during these periods, the spindles would have been used mostly for plying, as spliced fibres need to be plied to form stable yarn. The gradual change of the spindle-whorl shape from discoid, suitable for plying spliced threads, to

biconical/conical/spherical forms better adapted for spinning wool during the introduction of wool fibre across various regions of the Aegean, starting in the Early Bronze Age, is likely explained by the introduction of draft-spinning technology.

In Mediterranean Europe, the splicing of bast fibres and the draft spinning of sheep wool coexisted for several millennia before spinning technology was transferred to flax around the middle of the first millennium BC. This coincided with developing urbanization of the Mediterranean, when trade and transport powered by textile-driven sailing ships demanded intensification of production (Gleba *et al.* forthcoming).

#### *Introduction and importance of wool*

The introduction of wool has been explored by many recent projects in conjunction with the analyses of textile tools outlined above (also see Breniquet and Michel 2014; Sabatini and Bergerbrant 2020). The adoption of wool as a fibre led to the evolution of new textile technologies and uses. Wool fibres have a scaly surface, which accounts for their ability to felt. The kinks along the length of the fibre create air pockets, and this makes wool an excellent insulating material. Wool fibre is also very elastic, making it a highly suitable fibre for weaving textiles in particular bindings, such as twill and weft-faced tabby (the original tapestry weave). Unlike plant fibres, which have a light colour, wool comes in a variety of shades naturally and can be dyed easily and in a multitude of bright colours. All these properties make wool one of the most useful types of fibre available, and its adoption led to a veritable revolution in textile technologies. A recent find from Eleon in Boeotia, dating to *ca.* 1700–1600 BC, is the earliest-known wool textile from Greece, and it shows a well-developed technology of weaving (Fig. 142; Burke and Dimova forthcoming).



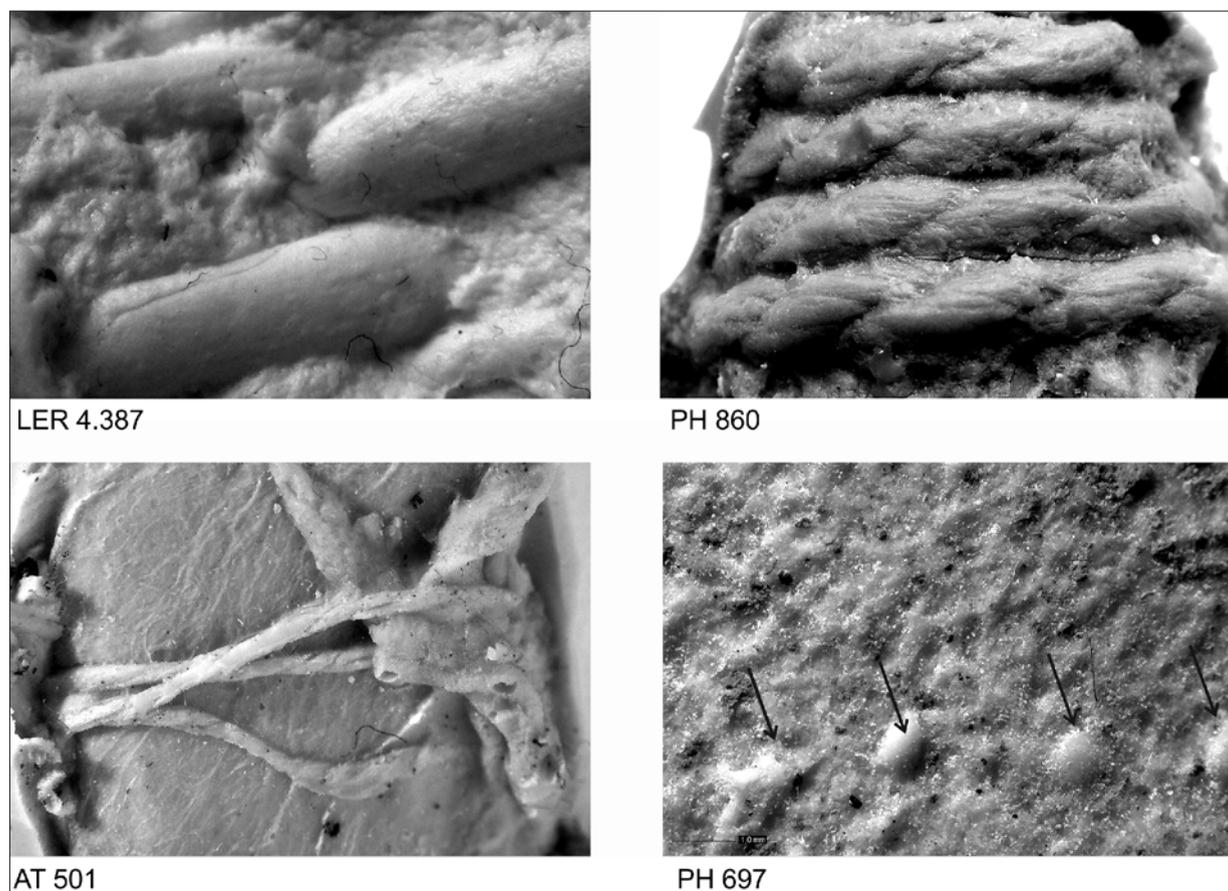
142. Eleon: textile. © Jeff Vanderpool/Eastern Boeotia Archaeological Project.

*Decorative techniques*

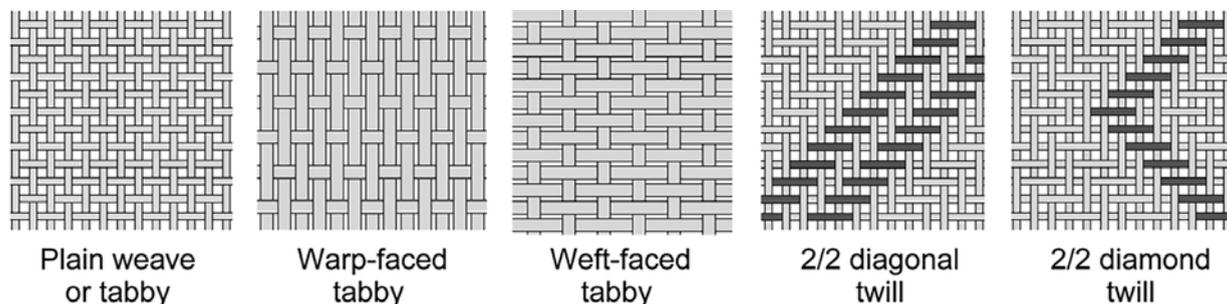
Once wool was introduced, it was combined with familiar plant fibres in creative ways. The Eleon textile was decorated with supplementary plant-fibre thread (now degraded). Combinations of plant- and animal-fibre yarns, as well as different qualities of yarns are attested in other textiles from the second and first millennia BC (Spantidaki and Moulherat 2012). A new analysis of the textiles from Lefkandi, dated to the very end of the Bronze Age, documents the use of various yarns and weaving techniques to produce patterns (Margariti and Spantidaki 2020). Embroidery, however, appeared only in the fifth century BC, as evidenced by a textile from Nikaia in Attica (Margariti 2018). Some decorative techniques familiar in the central Mediterranean area and central Europe seem to have remained unknown in the Aegean region. In the growing body of material, now comprising hundreds of textile fragments, there is no evidence of twills and tablet weaving from Greece. Hence the plaid patterns and borders seen in iconography were likely achieved with other techniques.

*Sealing practices*

Seals were used in the administrative practices of the Bronze Age Aegean centres, and textiles and cords were utilized in sealing practices. An ongoing project being undertaken by Agata Ulanowska is investigating the impressions of textiles, threads, cords, mats, leather and basketry on Early to Middle Bronze Age clay sealings from Greece (**Fig. 143**), as well as contemporaneous seal impressions on textile tools (*Textiles and Seals. Relations between Textile Production and Seals and Sealing Practices in Bronze Age Greece*: see <https://textileseals.uw.edu.pl/> with an open-access database). This hitherto under-explored



143. Lerna (LER), Phaistos (PH) and Agia Triada (AT): textile impressions on the undersides of clay sealings. LER 4.387: possible textile impression between the wicker sticks; PH 860: bast-like cord wrapped around a peg or knob; AT 501: packet of folded parchment wrapped by a cord; PH 697: impression of a possibly decorated fabric with additional thicker thread marked by arrows (Dino-Lite photos). © A. Ulanowska (with imprints courtesy of the *Corpus der minoischen und mykenischen Siegel*, Heidelberg).



144. Different types of weave structures. © V. Herring and M. Gleba.

source of evidence demonstrates how textiles were used in sealing practices and what types of textile-production-related motifs can be recognized in the imagery of Aegean glyptics appearing on textile tools and other objects (Ulanowska 2020b).

#### *Textile cultures*

The analysis of hundreds of textile fragments dating to the first millennium BC by the *PROCON* project has shown that Italy mostly shared a textile culture with central Europe that was characterized by the use of twill and tablet weaving. Meanwhile, Greece largely followed the Near Eastern traditions of textile production, which produced weft-faced tabbies (Fig. 144; Gleba 2017). These regional differences can be traced back to no later than the Late Bronze Age. The production of different textile types would have had aesthetic but also organizational and labour implications, as the resources, time and labour consumed by the various stages of the *chaîne opératoire* would have differed depending on the type of cloth being produced. These new data help us to understand the technological choices made within particular regions and reveal cultural similarities with other, broader areas, as well as providing a *longue-durée* view of technological developments.

Greek settlements appeared along the littoral of southern Italy from the seventh century BC onwards and, with them, weft-faced tabbies started to appear not only at these sites but also at the indigenous sites that had close connections with them (Gleba and Vanden Berghe forthcoming). Finds from one site, Ripacandida, may indicate development of a new, hybrid textile culture; these are weft-faced tabbies with integral tablet-woven borders, and thus combine a typically ‘Greek’ weave structure with a typically ‘Italic’ border (Gleba *et al.* 2018). Weft-faced tabby eventually spread across Italy, becoming the dominant weave in Roman times. Borders, however, were retained as important markers of status, as seen in the toga, on which the width of the purple-dyed border was indicative of the wearer’s rank.

#### *Textile value*

Textiles were highly valued products in past societies, as Susanna Harris has shown in a recent ground-breaking article that proposes five value principles (Harris 2017). Through complex *chaînes opératoires* of production, distribution and accumulation, some textiles gained status from makers, owners, events, and networks, while others facilitated standardized barter transactions. It is thus hardly surprising that these valuable objects were preserved for many generations. Recent radiocarbon dating of multiple textiles from the Early Iron Age burials at Stamna (Kolonas *et al.* 2017) and Lefkandi (Margariti and Spantidaki 2020) has shown that they are Late Bronze Age heirlooms. These data add to the revision of the ‘Dark Ages’, by demonstrating that textile traditions were passed on through objects and skills, and continued despite the political turmoil of the period.

Furthermore, the European Research Council-funded project *PENELOPE (A Study of Weaving as Technical Mode of Existence)* builds on the hypothesis that there was a significant but tacit contribution of textile technology involved in the advent of science in ancient Greece and focuses on the technological principles of ancient weaving (<https://zenodo.org/communities/penelope/search?page=1&size=20>; <https://cordis.europa.eu/project/id/682711>).

### *Dyeing and purple-dye production*

The processes of societal differentiation and state formation were accompanied by the production of textiles characterized by an increasing added value. In this process of adding value, the investment of time in raw materials and new technologies played a key role. Dyeing was one way of adding value to cloth. Many potential dyeworks and purple-dye production sites (Sanidas 2013; 2016 with references) as well as some fulling workshops (Spantidaki 2016: 15) have been identified. The archaeological evidence, however, seldom allows for certain identification of these activities. Some facilities, like vats, may have been multi-functional (see Ault 2005: 79 with references for revised interpretations; Alberti 2008; Koh *et al.* 2016). In other cases, the finds are not published in sufficient detail (for example, purple-dye extraction requires that the shells be crushed, but not all reports state the quantity of muricid shells found or their state).

Recent specialist studies of mollusc remains have moved the field forward by correcting some enduring misconceptions and generating high-quality data, which allow an appreciation of the *chaîne opératoire*, the scale and the context of purple-dye production (Marín-Aguilera *et al.* 2018; Mylona 2020; 2021: 118–22; Mylona *et al.* forthcoming). Contemporary archaeological work has confirmed the early appearance of purple-dye technology in the Aegean in the Middle Bronze Age, 1800–1700 BC (Apostolakou *et al.* 2016; Brogan *et al.* 2019). The new data support Brendan Burke's suggestion that purple-dyed textiles contributed to the development of the Minoan economy and long-distance trade (Burke 2010). The scale of the production, however, often remained small (Veropoulidou *et al.* 2008).

### **Conclusions**

Over the past 15 years our knowledge about textiles and the textile economy of the ancient Aegean has grown significantly. Integrated research on textile remains and tools has illuminated the history of various techniques, raw materials and traditions, and has included re-evaluation of the evidence for pattern and decoration technologies. The use of the warp-weighted loom and drop spindle varied considerably over time, and their adoption and abandonment were linked to socio-economic shifts, the movement of craftspeople and changing fashions. The evidence for fibres, on the other hand, reveals a remarkably conservative trend: all known archaeological textiles from pre-Roman Greece, for which the fibres have been identified with reliable methods, from the coarsest to the finest, are made primarily of linen and wool.

Recent projects have shown that we need large datasets of textile tools, textiles and environmental evidence in order to detect and interpret patterns of chronological change and geographical difference, and, thus, to address larger historical questions. This in turn requires publications that provide comprehensive quantitative data including key parameters of loomweights (weight, thickness, date) and contextual detail, rather than catalogue descriptions. Experimental archaeology has been fundamental in moving the field forward, and the particular fibres, geography and traditions of Greece prompt new questions for future experimental research.

The growing number of archaeological textile finds, not only in Greece but more widely across the Mediterranean region, allows the comparison and reconstruction of technological developments, textile cultures and value systems of different areas, thereby bringing to light previously unfamiliar aspects of ancient social and economic history in Greece and beyond.

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### Competing interests

Bela Dimova compiled her contribution whilst A.G. Leventis Fellow at the British School at Athens.