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RESEARCH

Late Pleistocene to Early Holocene Technological Traditions at Boila Rockshelter in Epirus, Northwestern Greece

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Abstract

Boila Rockshelter is located on the south bank of the Voidomatis River in Epirus, northwestern Greece. It is one of a series of three shelters that were occupied soon after the Last Glacial Maximum, all of which suggest the use of novel areas and diversification in subsistence. Dominated by backed tools, the chipped stone assemblage points to a continuum from the Gravettian to the Epigravettian, and in the case of Boila, into the early part of the Mesolithic. During the final phase of its use, the internal organisation of the shelter also appears to have changed, with a single large hearth beyond the dripline, in contrast to multiple smaller patches of burning along the back wall during its earlier use. This would have freed up space beneath the roof, while the deposits within the ash-rich feature suggest that it was also used for discarding knapping waste. The use of Boila appears to cease during the Early Holocene, suggesting that niche upland environments such as the Vikos Gorge became less important as conditions improved after the Younger Dryas. Our study included 35,901 pieces of chipped stone, estimated to represent around two-thirds of the complete assemblage. We focus on raw materials and the *chaîne opératoire*, with the results pointing to both continuity and change in lithic technology during the Final Upper Palaeolithic and into the Early Mesolithic in this part of the Balkans.

Keywords Epirus · Upper Palaeolithic · Mesolithic · Backed Artefacts · Sauveterrian · Microburins

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Introduction

The post-glacial archaeological record in Greece consists of a small number of excavated sites (Elefanti & Marshall, 2015) and many more surface scatters identified during surveys in Epirus (Forsén & Galanidou, 2016; Kourtessi-Philippakis et al., 2019; Runnels & van Andel, 2003; Tourloukis & Palli, 2009), western Macedonia (Efstratiou et al., 2006), the Peloponnese (Runnels et al., 2005), and the Ionian (Galanidou, 2011, 2014) and Aegean Sea regions (Galanidou, 2011; Kaczanowska et al., 2010; Efstratiou et al., 2014; 2022; Carter et al., 2019). Of the excavated sites, ten are dated caves and rock shelters. In the Peloponnese, these include Franchthi Cave (Perlès, 1999), Klissoura Cave 1 (Kaczanowska et al., 2010; Koumouzelis et al., 2004), and Kephalari Cave (Reisch, 1976; Marshall & Elefanti, forthcoming). In central Greece, there are Sarakeno (Kaczanowska et al., 2016; Sampson et al., 2009), Schisto (Papadea et al., 2020), and Kouvaras caves (Mavridis et al., 2021), along with Theopetra Cave in Thessaly (Kyparissi-Apostolika, 2021). In Epirus, they include Kastritsa Cave (Adam, 1997), Klithi (Bailey, 1997; Gowlett et al., 1997), Megalakkos (Sinclair, 1997), Boila (Kotjabopoulou et al., 1999), and Asprochaliko rockshelters (Galanidou, 2003), along with Grava Cave on Corfu (Gowlett et al., 1997; Sordinas, 1969; Marshall & Elefanti, forthcoming), and Cyclope Cave on Youra (Sampson et al., 2008; Sampson, 2014). The list also includes two dated open-air sites, Maroulas on Kythnos (Sampson et al., 2010), and Ouriakos on Lemnos (Efstratiou et al., 2014). Other undated Late Upper Palaeolithic sites include Zaimis and Ulbrich caves (Galanidou, 2003 and references therein).

The late Pleistocene and early Holocene coincided with the onset of the Bølling/Ållerød (14,700 BP) and Pre-Boreal warming (11,700 BP) phases, both of which led to a significant sea-level rise within just a few centuries (Naughton et al., 2023a; Weaver et al., 2003). These two phases were interrupted by cooling during the Younger Dryas, from 12.9 to 11.6 ka BP (Cheng et al., 2020; Naughton et al., 2023b). These events had a significant impact on the sea level, coastal landscapes, and the development of forest-steppe vegetation in Greece (Asouti et al., 2018; Lambeck, 1996; Lambeck et al., 2014; Panagiotopoulos et al., 2013), although local-scale landscape attributes, bedrock type, soil properties, relief, and tectonics also played a significant role in the development and composition of plant communities (Ntinou & Kotjabopoulou, 2002). These factors, together with the suggested increase in populations at the time (Stiner & Munro, 2011), led to the adoption of a wider set of subsistence strategies. In Epirus, Klithi, Megalakkos, and Boila point to expansion into novel uplands areas, as part of a system of diversification in which a wider range of seasonal resources were exploited (Bailey, 1997; Elefanti, 2003; Gamble, 1997). In other areas, tentative use of marine resources took place, along with the inclusion of smaller but more predictable species in the diet, at sites such as Klissoura, Franchthi, and Kephalari caves (Starkovich, 2012; Starkovich & Ntinou, 2017; Starkovich et al., 2018; Stiner & Munro, 2011). The archaeobotanical evidence from the first half of the 10th millennium at Franchthi also suggests the exploitation of a broad range of plant resources, including wild barley, oats, and lentils, with various Leguminosae taxa, along with fruit and nuts, including pear, caper, almond, and pistachio (Asouti et al., 2018, figure 12). A similar picture is repeated at Theopetra Cave in Thessaly, with the exploitation of wild plants, fruit and nuts, and resources available in the mountainous and wooded surroundings of the site (Kotzamani & Livarda, 2018). The sites of Ouriakos, Peristereònas, and Agia Marina on the island of Lemnos (Efstratiou et al., 2014, 2022), along with Maroulas on Kythnos (Sampson et al., 2010), point to seafaring during the terminal Pleistocene, a trend which continued into the Mesolithic, incorporating more distant Aegean islands, including Youra, Naxos, Ikaria, Astypalaia, and Chalki (Carter et al., 2019; Galanidou, 2014; Kaczanowska & Kozłowski, 2014, 2018; Sampson, 2014). Evidence for seafaring in the form of obsidian from Melos and Yali is found on several islands in the Cycladic and Dodecanese, as well as mainland coastal sites (Carter et al., 2019; Kaczanowska & Kozłowski, 2014, 2018; Perlès, 1999; Reingruber, 2017), indicating an extended network within which well-connected and skilled maritime communities on both sides of the Aegean were interacting (Çilingiroğlu, 2017; Gemici et al., 2022; Horejs, 2019; Horejs et al., 2015; Reingruber, 2018).

Technologically, the final phases of the Palaeolithic were dominated by backed bladelets and points, along with a ratcheting up of the microburin technique at some sites (Papadea et al., 2020; Perlès, 1999) and the continuation of the splintered technique at others (Kaczanowska et al., 2010, Marshall & Elefanti forthcoming). On the other hand, the Mesolithic has been interpreted as local and lacking archetypical traits (Galanidou, 2011). As has been suggested, continental Mesolithic chipped stone tool production was more strongly linked with the preceding Epigravettian (Kaczanowska & Kozłowski, 2014, 2018), while the Aegean Basin seemed to have followed a different trajectory characterised technologically by notch/denticulates as well as amorphous tools (Carter et al., 2017; Kaczanowska & Kozłowski, 2008, 2014). In some cases, they may even suggest connections with Cyprus and the pebble-flake industry from Nissi Beach (Kaczanowska & Kozłowski, 2014).

With all this variability in mind, we present the results of recent work on the chipped stone material from Boila Rockshelter in Epirus. We aim to contribute to the discussion regarding continuity and discontinuity in technology during the Late Pleistocene and Early Holocene. Gorming part of a larger project entitled ‘From hunter-gatherers to early farmers in Greece’ which involved the investigation of key late Pleistocene to Early Holocene sites in Greece (Elefanti & Marshall forthcoming), our study set out to contribute to our understanding of two issues, the degree of continuity in technology during the Pleistocene to Holocene transition and, secondly, the extent to which differences in technology can be attributed to the location of sites, or whether factors such as raw materials or terrain play a more important role.

Location, Environment, and Chronology

Boila is located on the western edge of the Tymphi Massif in the northern Pindus Mountains of Epirus, approximately 32 km north of the city of Ioannina. At an elevation of 420 masl, it lies just meters from the Voidomatis River which drains the central part of the massif, before flowing out onto the Konitsa Plain (Fig. 1). The

Voidomatis then flows north before joining with the Aoos, the major river system which drains the central Pindus Mountains, before flowing in a north-westerly direction through Greece and Albania and into the Adriatic near the city of Vlorë.

The shelter itself is wide but shallow, with the dripline located just 3 m from the back wall (Fig. 2). The truncated talus falls away steeply down to the narrow floodplain of the river around 11 m below. The initial gravel floor of the shelter was tentatively occupied shortly before around 18 ka cal. BP as the level of the Voidomatis fell, due to downcutting (Woodward et al., 2001) and probably increasing aridity following the Last Glacial Maximum (Hughes et al., 2022).

Although undated, this initial use of the shelter was sealed by alluvial slackwater silts deposited during flood events soon after (see Table 1 and Fig. 3). Once the flooding had abated, more continuous use of the shelter began after around 17 ka cal. BP, initially on the alluvial sediments and then during a long period of very gradual accumulation of terrestrial scree and fine sand and silt deposits blown or washed in. The scarce evidence from animal teeth suggests that this mainly took place during the warmer months of the year, possibly late spring and mid-summer. The desiccated and brittle state of the bones suggests intermittent use, with long periods of exposure to the elements (Kotjabopoulou, 2001, 2008). The fauna points to the hunting of caprine, ibex and chamois along the craggy slopes above the Voidomatis, with some red deer, probably on the nearby plain of Konitsa, along with rare smaller animals and fish. The wood charcoal evidence points to a diverse tree community along the river, with more open conditions and pioneer woodland dominated by birch on the adjacent Konitsa Plain (Ntinou & Kotjabopoulou, 2002).

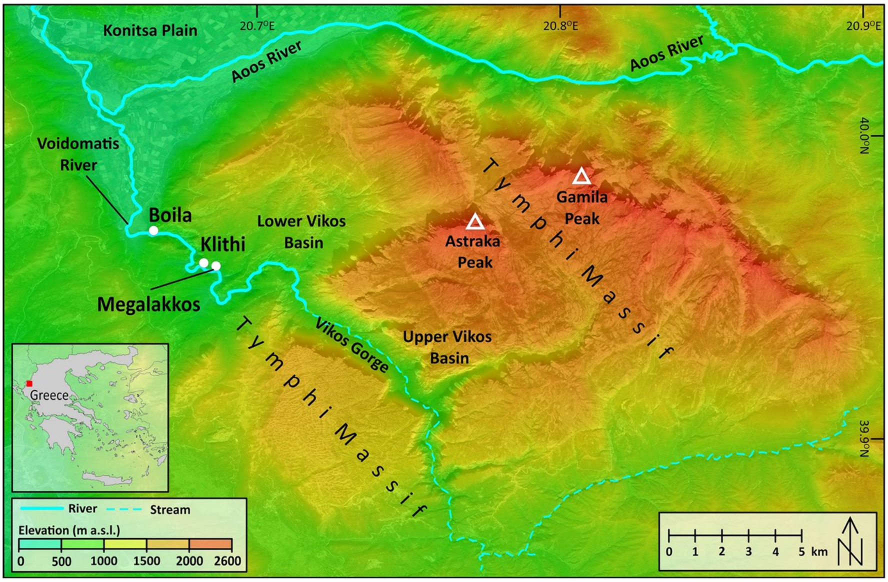


Fig. 1 Shaded relief map of the Tymphi Massif in Epirus, showing the locations of Boila, Klithi, and Megalakkos rock shelters (by C. Stergiou)

Fig. 2 **a** Boila from the west (G. Marshall). **b** From the east after the excavations. The grey deposits of units III and II can be seen to the left, with unit IV to the right (E. Kotjabopoulou)

Also recovered during the excavations were a few simple bone tools, perforated marine shells and a single perforated deer tooth, along with unmodified marine shells and a tiny stone bead (Kotjabopoulou & Adam, 2004). Unit III is the most thoroughly dated and thickest part of the sequence at around 70 cm (see Table 1 and Figs. 3 and 4). The eight dates range between approximately 16.7 and 12 ka cal. BP, pointing to very gradual accumulation over an extended period of 4.7 ka, equating to an average of around 1.5 cm per 100 years. This estimate compares with 6.7 cm for Klithi and 8.3 cm for Kastritsa (Bailey & Woodward, 1997, 83), or 4–7 cm per 100 years for Franchthi Cave before around 12 ka cal. BP (Farrand, 2001).

The excavations identified five stratigraphic units in which chipped stone and other anthropogenic-related material was present, Ia–IV from the bottom up (Fig. 4). Unit Ia consisted of the Aristi fluvial gravels, deposited as the river flowed through the shelter. Slightly downstream, carbonates from deep within these produced U-series, ESR and TL age estimates of between 24 and 28 thousand years ago (see Table 1). As the level of the river fell, the top surface of the gravels was exposed, and the site tentatively occupied, producing a relatively small chipped stone assemblage of debitage and tools. But the bank of the river would still have been nearby, and shelter was prone to flooding. Soon after the initial use of the site, the gravel floor and small chipped stone assemblage were sealed by a series of alluvial slackwater deposits (unit Ib). A date of 14,310 ± 200 BP (18,108–16,971 cal. BP, 2σ) from the lower contact with the underlying gravels provides a date for the initial use of the shelter. All radiocarbon dates presented in this paper were calibrated using OxCal online 4.4 (152) and the IntCal20 curve (Bronk Ramsey, 2021; Reimer et al., 2020). The flooding events point to

Table 1 Boila dates arranged by age per stratigraphic unit (Facorellis, 2013, 50; Gowlett et al., 1997; Hamlin et al., 2000**, Kotjabopoulou et al., 1997, 1999; Kotjabopoulou, 2001, 220; Macklin et al., 1997, 352*; Woodward et al., 2001, 510), presented following Millard (2014) and calibrated to 1σ and 2σ using OxCal online 4.4 (152) and the IntCal20 curve (Bronk Ramsey, 2021; Reimer et al., 2020). Note that the three radiocarbon dates obtained recently are underlined. The dates from the Aristi gravels are not associated with human occupation of the shelter. *Beta*, Beta Analytic, USA; *DEM*, NCSR Demokritos, Greece; *OxA*, Oxford Radiocarbon Accelerator Unit, UK; *RTA*, The Helen and Martin Kimmel Center for Archaeological Science, Weizmann Institute of Science, Israel

Unit	Lithology	U-series, ESR and TL	Conventional and AMS 14C ages (yr BP)	Laboratory reference	14C age (yr cal. BP), 1σ (68.3%)	14C age (yr cal. BP), 2σ (95.4%)	$\delta^{13}C$	Material
IV	Altered ash		9540 ± 75 (A)	(RTA-3529)	11,072–10,694	11,145–10,585	−22.9	Charcoal
			9840 ± 80 (A)	(RTA-3527)	11,397–11,192	11,690–11,114	−27	Charcoal
			9980 ± 80 (A)	(RTA-3530)	11,612–11,269	11,811–11,237	−27.7	Charcoal
			10,690 ± 90 (A)	(RTA-3528)	12,740–12,620	12,767–12,480	−25.2	Charcoal
III	Angular limestone clasts within a silt matrix		10,190 ± 90 (A)	(OxA-5243)	12,042–11,620	12,448–11,400	−21.2	Bone
			10,275 ± 31 (A)	(OxA-40768)	12,092–11,885	12,431–11,826	−24.74	Charcoal
			11,173 ± 453 (C)	(DEM-371)	13,602–12,630	14,224–11.823	−25	Charcoal
			12,233 ± 221 (C)	(DEM-501)	14,822–13,814	15,099–13,614	−25	Charcoal
			12,480 ± 120 (A)	(OxA-5241)	14,974–14,346	15,135–14,170	−21.2	Bone
			12,901 ± 157 (C)	(DEM-502)	15,650–15,206	15,900–14,977	−25	Charcoal
			13,329 ± 36 (A)	(OxA-41032)	16,116–15,955	16,190–15,864	−24.98	Charcoal
			13,758 ± 41 (A)	(OxA-40769)	16,772–16,564	16,898–16,488	−26.16	Charcoal
II	Disturbed alluvial silt		13,709 ± 238 (C)	(DEM-662)	16,974–16,286	17,312–15,943	−25	Charcoal
			13,810 ± 130 (A)	(OxA-5246)	16,972–16,574	17,080–16,338	−20.6	Bone
Ib	Alluvial silt		13,960 ± 260 (A)	(Beta-109162)	17,330–16,585	17,787–16,226	Unknown	Charcoal
			14,310 ± 200 (A)	(Beta-109187)	17,746–17,130	18,108–16,971	Unknown	Charcoal
Ia	Aristi fluvial gravels	24,000 ± 2000 (U series)** 24,300 ± 600 (ESR)* 25,000 ± 2000 (U series)** 28,200 ± 7100 (TL)*						Carbonate

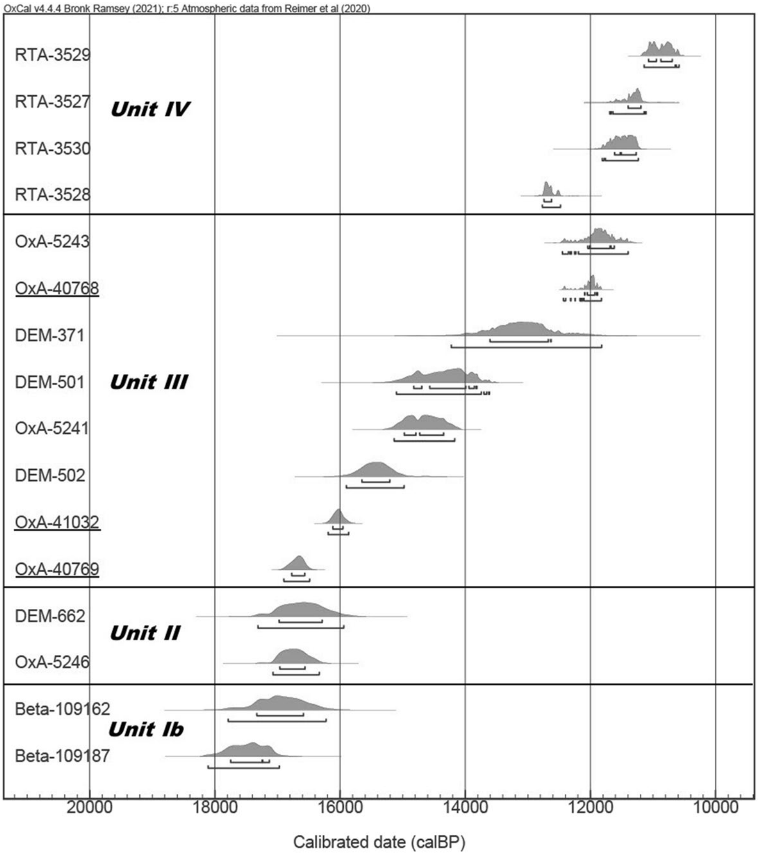


Fig. 3 Probability distribution within one (1σ) and two (2σ), arranged by age per stratigraphic unit. Plotted using Oxcal plot (OxCal online 4.4 (152)) and the IntCal20 curve (Bronk Ramsey, 2021; Reimer et al., 2020). The three radiocarbon dates obtained recently are underlined

periods of increased flow, which in turn would have led to downcutting of the riverbed and eventually to the cessation of such events after around 13,960 ± 260 BP (17,787–16,226 cal. BP, 2σ) (Woodward et al., 2001). The slackwater deposits of unit Ib were followed by a complex series of silts in Unit II, in which clasts were almost completely absent. Unit II produced more substantial evidence for the use of the shelter, with an uppermost date of 13,709 ± 238 BP (17,312–15,943 cal. BP, 2σ). The four dates from units Ib and II suggest rapid accumulation, or perhaps that the silt deposits of unit II were already present as part of the upper component of the slackwater silts of unit Ib, but then disturbed by human activity. Unit III was very different, significantly thicker and rich in angular scree with a silty matrix, along with chipped stone, animal bone and charcoal lenses. The top surface of unit III forms the current floor across much of the shelter within the dripline. The eight dates point to very gradual accumulation between 13,758 ± 41 BP (16,898–16,488 cal. BP, 2σ) and 10,190 ± 90 BP (12,448–11,400 cal. BP, 2σ),

Fig. 4 The excavation trenches from the northwest, with unit boundaries. At the bottom are the Aristi gravels (unit Ia), alluvial silt (unit Ib), disturbed alluvial silt (unit II), and scree with silt (unit III). Unit IV is not visible, located to the left (original image by E. Kotjabopoulou)

or 4.7 ka cal, between around 16.7 and 12 ka cal. BP, ending towards the end of the Younger Dryas (~12.9–11.6 ka) (Cheng et al., 2020).

The deposits of unit IV were different to those of unit III, with much less scree and rich in altered ash. They filled a depression in the central part of the shelter outside the dripline and were truncated by the edge of the talus. Also present was abundant chipped stone, charcoal fragments and rare animal bones (Kotjabopoulou, 2001). The homogenous nature of the deposit and the jumbled arrangement of the larger inclusions suggested to the excavators that unit IV was redeposited (Kotjabopoulou pers. com). The earliest date is slightly early, 10,680 ± 90 BP (12,767–12,480 cal. BP, 2σ), but the subsequent estimates, as well as those from the top of unit III, suggest that unit IV began to develop slightly after 12 ka cal. BP, so towards the end of the Younger Dryas stadial (see Fig. 3).

The most recent date from unit IV points to the use of the shelter until at least 9540 ± 75 (11,145–10,585 cal. BP, 2σ), although the very top is undated. The dates point to the use of Boila over seven millennia between ~18 and 11 ka cal BP.

The Chipped Stone Assemblage

All chipped stone was recorded from 28 squares in the central part of the shelter and grouped within five broad categories. These included small fractions (debitage less than 10 mm), debitage (pieces larger than 10 mm), tools, technical pieces and cores. Small fractions consisted of chips (struck flakes or laminar pieces with ventral surface) and fragments (small chunks). Debitage included flakes, laminar flakes, blades, bladelets, chunks, and untested and tested (with two or less removals) pebbles. Laminar flakes were pieces longer than twice their width, but insufficiently regular to be described as blades or bladelets, while our blade versus bladelet length cut-off was 50 mm. The third category was tools, including backed pieces, retouched pieces, scrapers, notch/denticulates, truncations, burins and piercers. The fourth category was technical pieces, waste associated with the manufacture and maintenance of cores and tools, including crested pieces, change of direction pieces, core tablets, core rejuvenation pieces, burin spalls, scraper resharpening pieces, and microburins. The fifth category was cores, with seven types defined on the basis of shape, including amorphous, conical, sub-conical, broad-fronted, narrow-fronted, elongate, and on flake. Also included within cores was a single splintered piece.

The sample amounted to a total of 35,901 pieces, of which small fractions were abundant throughout the sequence, collectively accounting for 72.1% ($n=25,875$), with chips predominant (Table 2). The quantities of small fractions point to knapping using the rolled pebbles of variability quality collected from the nearby gravels of the Voidomatis. The most abundant was the black flint from the Vigla limestone formations of the Vikos Gorge, accounting for 61.3% of our complete sample, followed by the opaque grey variety (23.7%) from outcrops closer to the site (Table 3). Both were transported down the Voidomatis and are abundant within the gravels below the shelter today as lightly rolled sub-angular pebbles of up to around 6 cm in diameter, although most are much smaller.

Other types were less common, most likely from further afield. For example, the reddish-brown variety that accounted for 3.7% of our sample, which rare earth element analysis has suggested, was collected elsewhere in Epirus (Elefanti et al., 2021).

Also present was a yellowish-brown (4.8%) variety, along with ‘Others’ (6.5%), including burnt or patinated pieces for which colour could not be defined and trace quantities of chalcedony. Although some variability was noted between the units, the Voidomatis black variety was predominant, reflecting its abundance just meters away from the site and its relatively high quality.

The rest of the assemblage consisted of 10,026 pieces, including debitage, tools, technical pieces, cores and the single splintered piece (Table 4).

Debitage (*n* = 8046)

Debitage was abundant throughout the sequence (see Tables 2, 4, and 5). Pieces with cortex were common (28.9%, $n=2325$), including 191 (2.4%) primary flakes. Bladelets and blades in particular were rare (Fig. 5), reflecting the challenges of working small and irregular pebble raw materials, as well as the likelihood that these types of blanks would have been retouched and carried away from site more frequently. Despite being an assemblage with a laminar focus, flakes were the predominant blank form. Broken pieces accounted for around a quarter of all debitage (25.1%, $n=1773$), excluding the 970 chunks and pebbles where breakage could not recorded. Burning was noted on 17.7% ($n=1424$) of all debitage, while the majority of pieces were small (Fig. 6).

Table 2 The chipped stone sample ($n=35{,}901$)

Unit	Small fractions ($n=25{,}875$, 72.1%)		Debitage (%)	Tools (%)	Technical pieces (%)	Cores (%)	Splintered piece (%)
	Chips (%)	Fragments (%)					
IV ($n=14{,}014$)	8410 (60)	1416 (10.1)	3177 (22.7)	325 (2.3)	627 (4.5)	59 (0.4)	-
III ($n=15{,}851$)	8816 (55.6)	2671 (16.9)	3668 (23.1)	468 (3)	175 (1.1)	52 (0.3)	1 (0.006)
II ($n=5415$)	3140 (58)	900 (16.6)	1122 (20.7)	175 (3.2)	57 (1.1)	21 (0.4)	-
Ia ($n=621$)	333 (53.6)	189 (30.4)	79 (12.7)	11 (1.8)	9 (1.4)	-	-
Total ($n=35{,}901$)	20,699 (57.7)	5176 (14.4)	8046 (22.4)	979 (2.7)	868 (2.4)	132 (0.4)	1 (0.003)

Table 3 Raw material varieties

Unit	Voidomatis black (%)	Voidomatis grey (%)	Yellowish-brown (%)	Reddish-brown (%)	Others (%)
IV (*n* = 14,104)	9277 (66.2)	3086 (22)	416 (3)	294 (2.1)	941 (6.1)
III (*n* = 15,851)	9529 (60.1)	3528 (22.3)	1029 (6.5)	689 (4.3)	1076 (6.8)
II (*n* = 5415)	2846 (52.6)	1687 (31.2)	269 (5)	313 (5.8)	300 (5.5)
Ia (*n* = 621)	354 (57)	212 (34.1)	22 (3.5)	19 (3.1)	14 (2.3)
Total (*n* = 35,901)	22,006 (61.3)	8513 (23.7)	1736 (4.8)	1315 (3.7)	2331 (6.5)

Table 4 The sample excluding small fractions ($n = 10{,}026$)

Unit	Debitage (%)	Tools (%)	Technical pieces (%)	Cores (%)	Splintered piece (%)
IV ($n = 4188$)	3177 (75.9)	325 (7.8)	627 (14)	59 (1.4)	-
III ($n = 4364$)	3668 (84.1)	468 (10.7)	175 (4)	52 (1.2)	1 (0.02)
II ($n = 1375$)	1122 (81.6)	175 (12.7)	57 (4.2)	21 (1.5)	-
Ia ($n = 99$)	79 (79.8)	11 (11.1)	9 (9.1)	-	-
Total ($n = 10{,}026$)	8046 (80.3)	979 (9.8)	868 (8.7)	132 (1.3)	1 (0.01)

Tools (*n* = 979)

Tools were present throughout the sequence, typically accounting for between 8 and 13% of the assemblages excluding small fractions (Table 6). Breakage (43.5%, $n = 426$) was common, higher than amongst debitage, while burning was noted on 19.4% ($n = 190$) of pieces, roughly the same as debitage.

Backed pieces were most abundant category, with 765 pieces recorded, including indeterminate backed fragments (Table 7). The majority of backed pieces were relatively small, with 300 of the 317 complete pieces less than 32 mm by 8 mm, a reflection of the small size of the majority of the available raw materials, but also an element of standardisation amongst these types of tools (Fig. 7).

Unilateral Backed Bladelets (*n* = 360, 47.1%)

Unilateral backed bladelets were the predominant category accounting for just less than half of all backed pieces, including indeterminate backed fragments (see Table 7 and Fig. 8a, b). Breakage was common (48.1%, $n = 173$), while burning was noted on 15% ($n = 54$) of pieces. Most were made on bladelet (39.7%, $n = 143$) and laminar flake (35.8%, $n = 129$) blanks. Of the 306 with intact edges, most were straight (88%, $n = 269$), Followed by weakly convex (8.5%, $n = 26$) and weakly concave (3.5%, $n = 11$). Backing was obverse abrupt to semi-abrupt (87.2%, $n = 314$), inverse (8.1%, $n = 29$), or crossed abrupt (7.7%, $n = 18$), the latter always mid-section.

Bilaterally Backed Bladelets (*n* = 19, 2.5%)

Despite being modified along both sides, the primary backed edge was straighter and more strongly modified. Breakage was relatively common (42.1%, $n = 8$), while burning was noted on 15.8% ($n = 3$) of pieces.

Table 5 Debitage

Unit	Flakes (%)	Laminar flakes (%)	Chunks (%)	Bladelets (%)	Blades (%)	Tested pebbles (%)	Untested pebbles (%)
IV ($n=3177$)	2129 (67)	474 (14.9)	352 (11.1)	214 (6.7)	-	7 (0.2)	1 (0.03)
III ($n=3668$)	2296 (62.6)	504 (13.7)	476 (13)	369 (10.1)	18 (0.5)	4 (0.1)	1 (0.03)
II ($n=1122$)	712 (63.5)	171 (15.2)	101 (9)	130 (11.6)	7 (0.6)	1 (0.09)	-
Ia ($n=79$)	35 (44.3)	17 (21.5)	23 (29.1)	-	-	-	4 (5.1)
Total ($n=8046$)	5172 (64.3)	1166 (14.5)	952 (11.8)	713 (8.9)	25 (0.3)	12 (0.2)	6 (0.08)

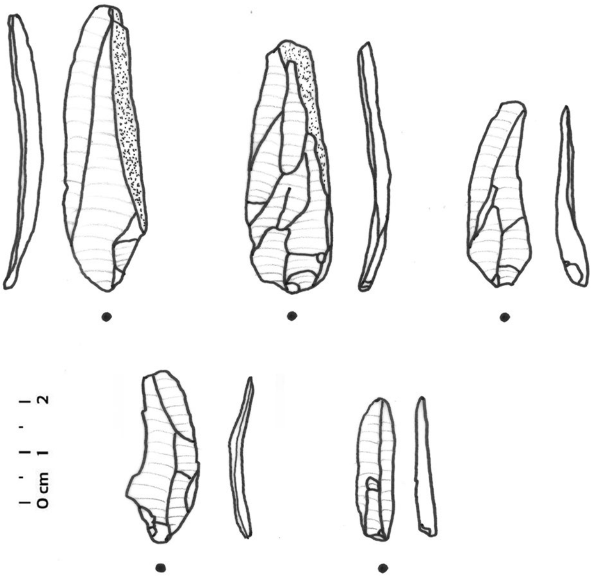


Fig. 5 Blades and bladelets from units II, III, II, II, and III, respectively. All illustrations by Gilbert Marshall

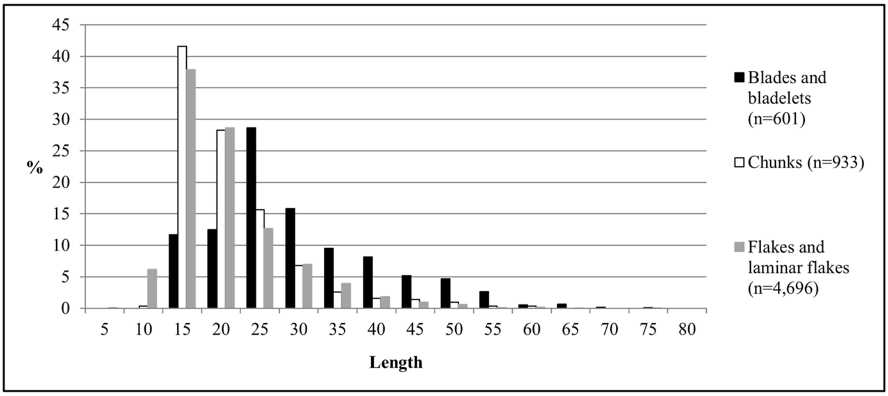


Fig. 6 Length frequency histogram for complete pieces of debitage, including flakes and laminar flakes combined, blades and bladelets combined, and chunks ($n=6230$). All measurements in millimetres to one decimal place

Table 6 Tools from all four units ($n=979$)

Unit	Backed pieces (including indeterminate fragments) (%)	Retouched pieces (%)	Scrapers (%)	Notch/denticulates (%)	Perforators (%)	Burins (%)	Truncations (%)
IV ($n=325$)	256 (78.8)	32 (9.8)	14 (4.3)	15 (4.6)	4 (1.2)	4 (1.2)	-
III ($n=468$)	362 (77.4)	54 (11.5)	23 (4.9)	14 (3)	9 (1.9)	4 (0.9)	2 (0.4)
II ($n=175$)	139 (79.4)	13 (7.4)	11 (6.3)	-	2 (1.1)	3 (1.7)	7 (4)
Ia ($n=11$)	8 (72.7)	2 (18.2)	1 (9.1)	-	-	-	-
Total ($n=979$)	765 (78.1)	101 (10.3)	49 (5)	29 (3)	15 (1.5)	11 (1.1)	9 (0.9)

Table 7 Backed tools ($n = 765$)

Unit	Unilateral backed blade-lets (%)	Bilateral backed blade-lets (%)	Backed flakes (%)	Unilateral backed points (%)	Bilateral backed points (%)	Double backed needle points (%)	Shouldered points (%)	Geometric microliths (%)	Indeterminate backed fragments (%)
IV ($n = 256$)	32 (12.5)	6 (2.3)	2 (0.8)	23 (9)	44 (17.2)	75 (29.3)	2 (0.8)	24 (9.4)	48 (18.8)
III ($n = 362$)	227 (62.7)	7 (1.9)	7 (1.9)	84 (23.2)	8 (2.2)	8 (2.2)	1 (0.3)	4 (1.1)	16 (4.4)
II ($n = 139$)	95 (68.3)	5 (3.6)	-	25 (18)	2 (1.4)	1 (0.7)	-	1 (0.7)	10 (7.2)
Ia ($n = 8$)	6 (75)	1 (12.5)	-	-	-	-	-	-	1 (12.5)
Total ($n = 765$)	360 (47.1)	19 (2.5)	9 (1.2)	132 (17.3)	54 (7.1)	84 (11)	3 (0.4)	29 (3.8)	75 (9.8)

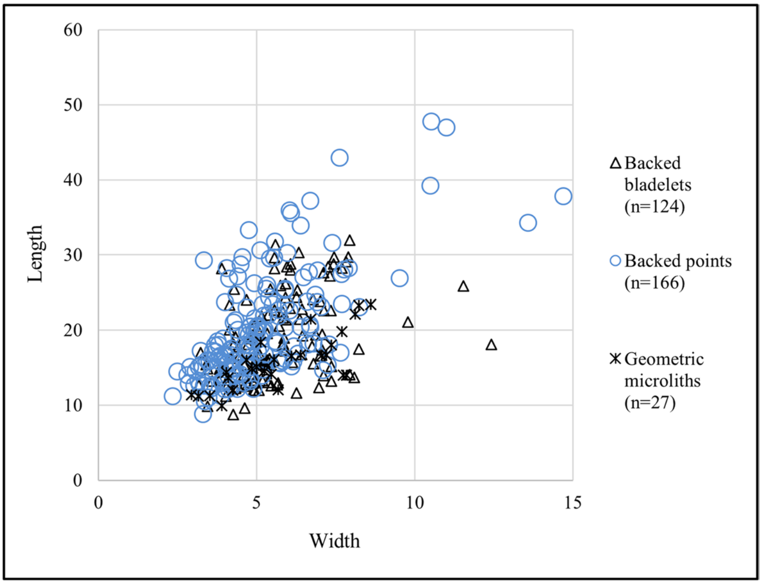


Fig. 7 Length plotted against width for complete backed bladelets, backed points, and geometric microliths (*n* = 317). All measurements in millimetres to one decimal place

Backed Flakes (*n* = 9, 1.2%)

Breakage was common (55.6%, *n* = 5), along with one burnt piece (11.1%).

Unilaterally Backed Points (*n* = 132, 17.3%)

Unilaterally backed points were most abundant in units III and II (see Table 7 and Fig. 9a, b). Breakage was less frequent (39.4%, *n* = 52) compared to unilaterally backed bladelets, while 15.2% (*n* = 20) of pieces were burnt. The backing itself was obverse abrupt to semi-abrupt (79.8% *n* = 105), inverse (4.6% *n* = 6), or crossed (16.1%, *n* = 21). In almost half of all cases (47.7%, *n* = 63), the point was formed by the backed edge and the unmodified adjacent edge, the rest (52.3%, *n* = 69) with a short section of weak backing along the adjacent edge. In 42.4% (*n* = 56) and 9.8% (*n* = 13) of these cases respectively, the backing was obverse or inverse, always just a few millimetres in extent, probably just to strengthen the tip. Distal points were predominant (79.5%, *n* = 105).

Bilaterally Backed Points (*n* = 54, 7.1%)

These were most abundant in unit IV (*n* = 44), with smaller quantities in III and II (see Table 7 and also Fig. 9). Breakage was slightly more common (46.3%, *n* = 25) compared to unilaterally backed points, while burning was also significantly more

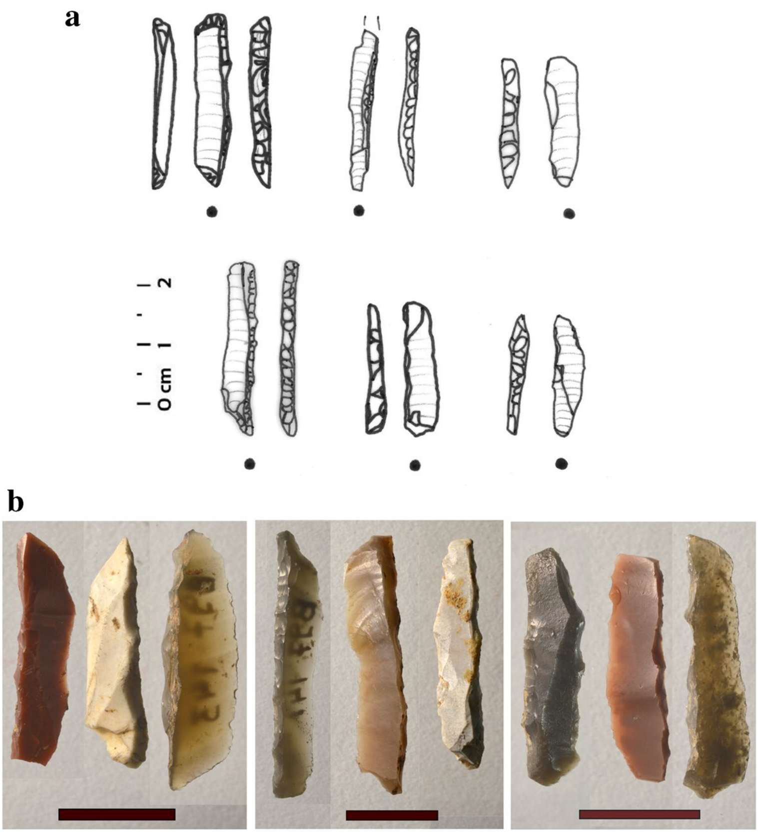


Fig. 8 **a** Unilaterally backed bladelets from units III, II, IV, III, III and II, respectively. **b** Representative examples of unilaterally backed bladelets. The scale is 10 mm in all cases

abundant 31.8% ($n=17$), all from the altered ash deposits of unit IV. The primary backed edge was typically straight or slightly convex. The backing itself was obverse abrupt to semi-abrupt (88.8%, $n=48$), inverse (7.4%, $n=4$), or crossed (3.7%, $n=2$). In two cases, there was a change in the direction of the backing between the main and adjacent edges, both shifting from obverse to inverse. Distal points were predominant (74.1%, $n=40$).

Double Backed Points ($n=84$, 11%)

These were abundant in unit IV, with trace quantities in units III and II (see Table 7). Two types were identified, with 48 needle-like points and the second group of 36 broader examples (see Fig. 10a, b).

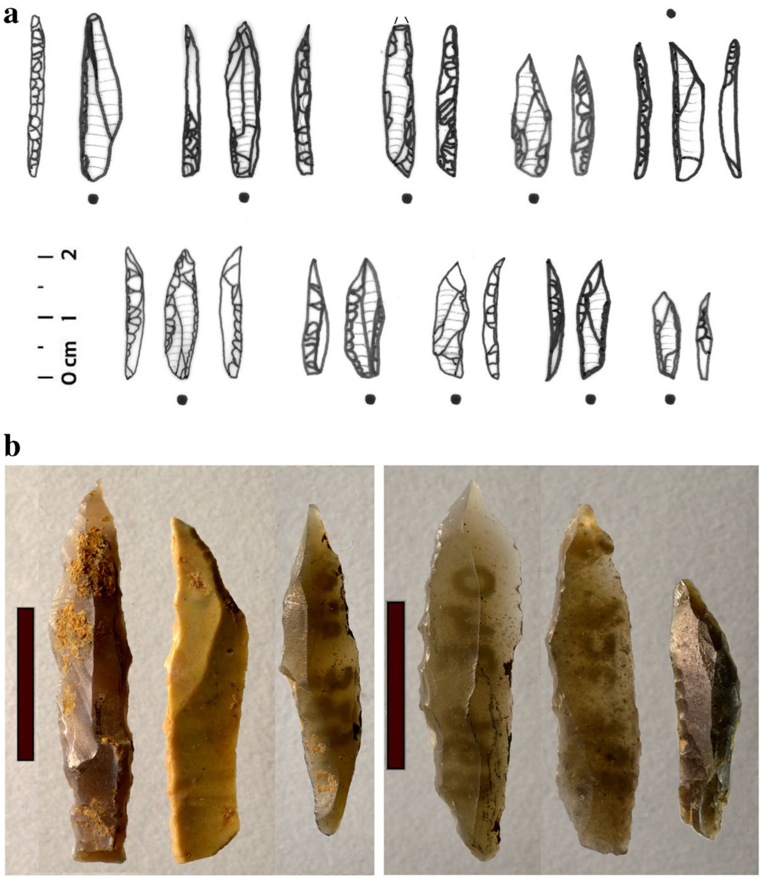


Fig. 9 **a** Backed points with stratigraphic units in parenthesis. (a) unilaterally backed (III), (b) unilaterally backed (III), (c) unilaterally backed (II), (d) bilaterally backed (IV), (e) unilaterally backed (III), (f) bilaterally backed (IV), (g) bilaterally backed (IV), (h) unilaterally backed (III), (i) bilaterally backed (IV), and (j) bilaterally backed. **b** Representative examples of unilaterally backed points from Boila. Both scales are 10 mm

The needle-like points were typically narrow, with steep backing along both edges and no preference for one side or the other. Breakage was common (50%, $n=24$), while burning was noted on just over a quarter (27%, $n=13$) of pieces. The point was on the proximal (37.5%, $n=18$) and distal (35.4%, $n=17$), with two (4.2%) equally pointed on the proximal and distal and 11 where the ends could not be determined due to the intensity of the backing. The backing itself was obverse steep (81.3%, $n=39$), with short sections of steep inverse backing in nine (18.7%) cases. Seven were made on bladelet blanks, four on laminar flakes and the remaining 37 unknown due to their small size and the intensity of the backing. Of the 24 complete pieces, most were small, with 21 ranging from 8.8 to 18 mm in length and less than 5 mm in width (Fig. 11). Also present were two large outliers, the longest from unit IV and the slightly shorter one from unit III.

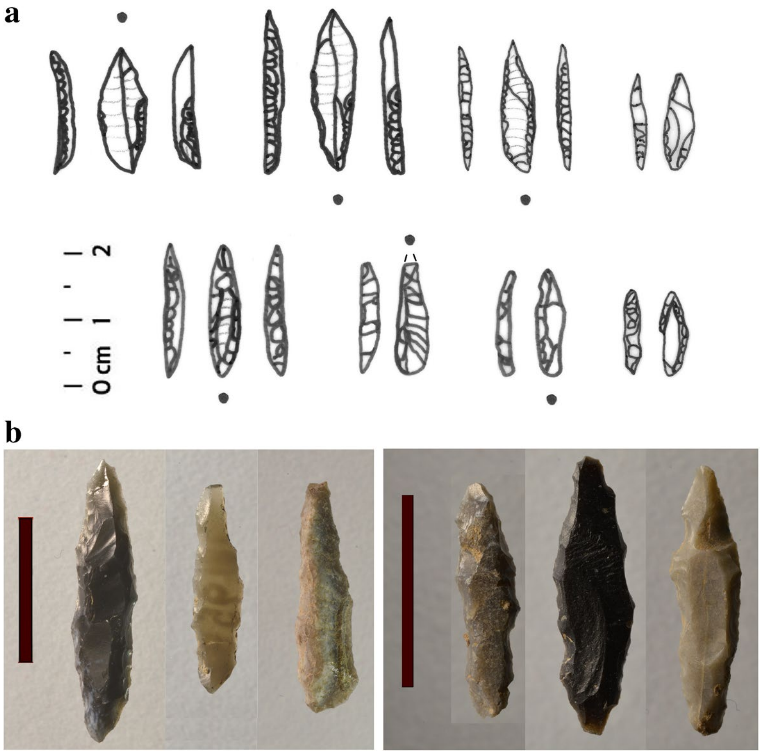


Fig. 10 **a** Needle-like and Sauveterroid points with stratigraphic units in parenthesis. (a) needle-like point (IV), (b) Sauveterroid point (IV), (c) Sauveterroid point (IV), (d) Sauveterroid point (IV), (e) Sauveterroid point (IV), (f) needle-like point (IV), (g) needle-like point (IV), and (h) needle-like point (IV). **b** Characteristic needle-like points from Boila. The scale is 10 mm in both cases

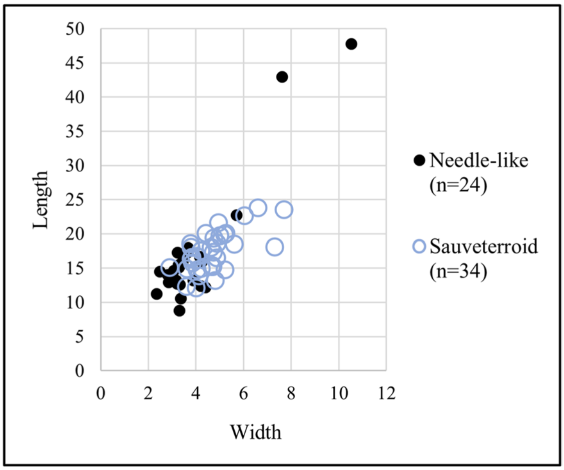


Fig. 11 Complete needle-like and Sauveterroid points ($n=58$). All measurements in millimetres to one decimal place

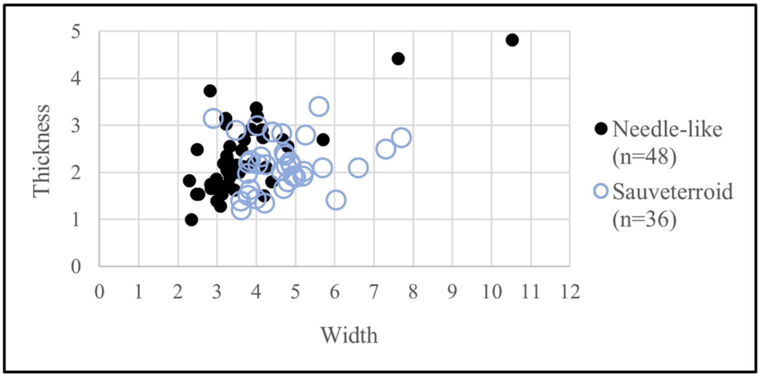


Fig. 12 Width plotted against thickness for all 84 complete needle-like and Sauveterroid points. Width and thickness could be measured in all cases, including broken pieces. All measurements in millimetres to one decimal place

For a comparable example from Klissoura, see Kaczanowska et al., (2010, plate 75:28), although those from Boila lacked ventral thinning.

The second group of Sauveterroid points ($n=34$) included slightly wider and longer pieces (see also Fig. 11). The majority were from unit IV (94.4%, $n=34$), with just two from unit III. Although wider, they were not thinner than the needle-like points (Fig. 12), suggesting either that they were less intensively backed or perhaps that wider blanks were selected to begin with. The backing was obverse abrupt to semi-abrupt bilateral, much weaker and less high than the needle-like points. Just two (5.6%) pieces were broken, and five (13.9%) were burnt. Those made on bladelet blanks were common (38.9%, $n=14$), followed by laminar flakes (16.7%, $n=6$) and unknown (38.8%, $n=14$). The 34 complete pieces were small, ranging from 12.2 to 23.8 mm in length and mostly less than around 5.5 mm in width (see Fig. 7). Of the 32 pieces where the orientation of the blank could be determined, the point was on the proximal ($n=16$) and distal ($n=16$) in equal numbers. Two had piquant trièdre, one each on the proximal and distal. Similar examples referred to as 'Sauveterroidal' have been reported from Klissoura Cave sequence A (Kaczanowska et al., 2010, 195, plate 83:11, 12).

Table 8 Geometric microliths

Unit	Convex back (%)	Angulated back (%)	Isosceles triangles (%)	Scalene triangles (%)	Trapezes (%)	Rhomboids (%)
IV ($n=24$)	11 (45.8)	4 (16.7)	2 (8.3)	4 (16.7)	2 (8.3)	1 (4.2)
III ($n=4$)	-	2 (50)	1 (25)	-	-	1 (25)
II ($n=1$)	-	-	-	1 (100)	-	-
Ia	-	-	-	-	-	-
Total ($n=29$)	11 (37.9)	6 (20.7)	3 (10.3)	5 (17.2)	2 (6.9)	2 (6.9)

Shouldered Points ($n = 3$, 0.4%)

Three possible shouldered points were recorded, two from unit IV and one from unit III. All were broken with the points missing, one of which would have been on the proximal and two distal. The possible shoulders were weak in all three cases.

Geometric Microliths ($n = 29$, 3.8%)

Most geometric microliths were recovered from unit IV ($n = 24$), with four from unit III and one possible scalene triangle from unit II (Table 8). Convex and angulated back pieces were predominant ($n = 17$), two with proximal *piquant trièdre*. All microliths were mostly complete; in one case, just the tip was missing, and in three, some of the backed edges may have been missing. One example had a strongly convex backed edge, almost a half-circle. Other forms included isosceles triangles, scalene triangles, trapezes, and rhomboids (Fig. 13a, b).

Retouched Tools ($n = 101$)

Retouched tools with low angle edge modification, in contrast to those with backed edges, accounted for 10.3% of all tools. The incidence of breakage was high (42.6%, $n = 43$), while burnt examples accounted for 19.8% ($n = 20$) of all pieces. They were made on both flake (63.4%, $n = 64$) and laminar (36.6%, $n = 37$) blanks.

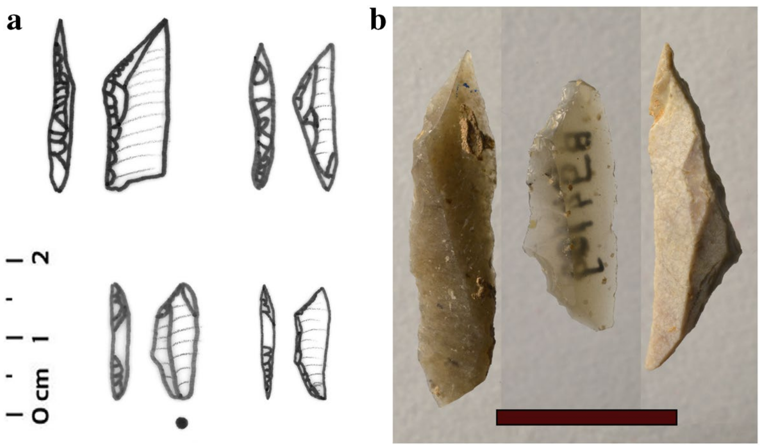


Fig. 13 **a** Geometric microliths with stratigraphic units in parenthesis. (a) scalene triangle (IV), (b) isosceles triangle (III), (c) trapeze (IV), and (d) trapeze (IV). **b** Characteristic geometric microliths from Boila, the first with proximal *piquant trièdre*. The scale is 10 mm

Scrapers ($n=49$)

Scrapers accounted for 5% of all tools and were most numerous in units III and IV (Table 6), including 36 end and 13 side (Fig. 14a, b). The incidence of breakage was relatively low for tools (20.4%, $n=10$), seven end, and three side, a result of the more robust nature of these pieces.

End scrapers were mostly made on flakes ($n=28$), with two on laminar flakes, three on bladelets, one on a blade, and two on chunks. Eight (22.2%) were burnt, while the worked edge was on the distal in 25 cases, the rest on the proximal. Five had weakly stepped retouch, suggesting resharpening and more intense use, mostly, the few larger examples between 30 and 50 mm. The rest appear to have been only lightly used, if at all, while most were less than 40 mm in length (Fig. 15). Of the 13 side scrapers, seven were made on flakes, with two on blades, two on laminar flakes, and one each on a chunk and a core. Three were broken (23.1%), while five (38.5%) were burnt.

The Rest of the Tool Assemblage ($n=64$)

Notch/denticulates included 27 notches and 2 denticulates. The incidence of breakage was low for tools (17.2%, $n=5$), while two were burnt. Of the 15 perforators, two had edge damage suggesting rotational use. Two (13.3%) were broken, and two were burnt. The 11 burins were mostly atypical, including two single-angle examples on truncations, possibly end scrapers, one each on the proximal or distal of a flake and laminar flake, respectively. There was one with a single burin blow on a possible distal snap on a small flake. The remaining six pieces had single ($n=4$) or multiple burin blows ($n=2$), down either one ($n=5$) or both edges ($n=1$). All six were on flake blanks, and all were struck from the proximal, which in two cases was missing. Single-blow burins were also recorded on two chunks. Several of these pieces may have served as flake cores rather than burins or were core fragments or larger flakes with ventral scars, rather than burins. The nine complete examples ranged in length from 19.8 to 39.3 mm. Nine truncations were recorded, four broken and one burnt. Four were proximal and five distal, while most were oblique to the axis ($n=8$), with one perpendicular. The five complete pieces ranged in length from 14.9 to 34.5 mm.

Technical Pieces ($n=868$)

Technical pieces included core setup and maintenance pieces, burin spalls, scraper resharpening pieces, and microburins (Table 9). The latter were the most abundant and distinctive category, accounting for almost 84% of all technical pieces (Fig. 16a, b).

Apart from a single Krukowski, the rest were typical. Several of these types were reported at Klithi and Kastritsa (Adam, 1997; Roubet, 1997). Unless the modified edge had been extended beyond the notch and the snap was perpendicular, we defined microburins as typical, irrespective of their overall length. The single Krukowski example from Boila measured 11.9 by 4.7 mm.

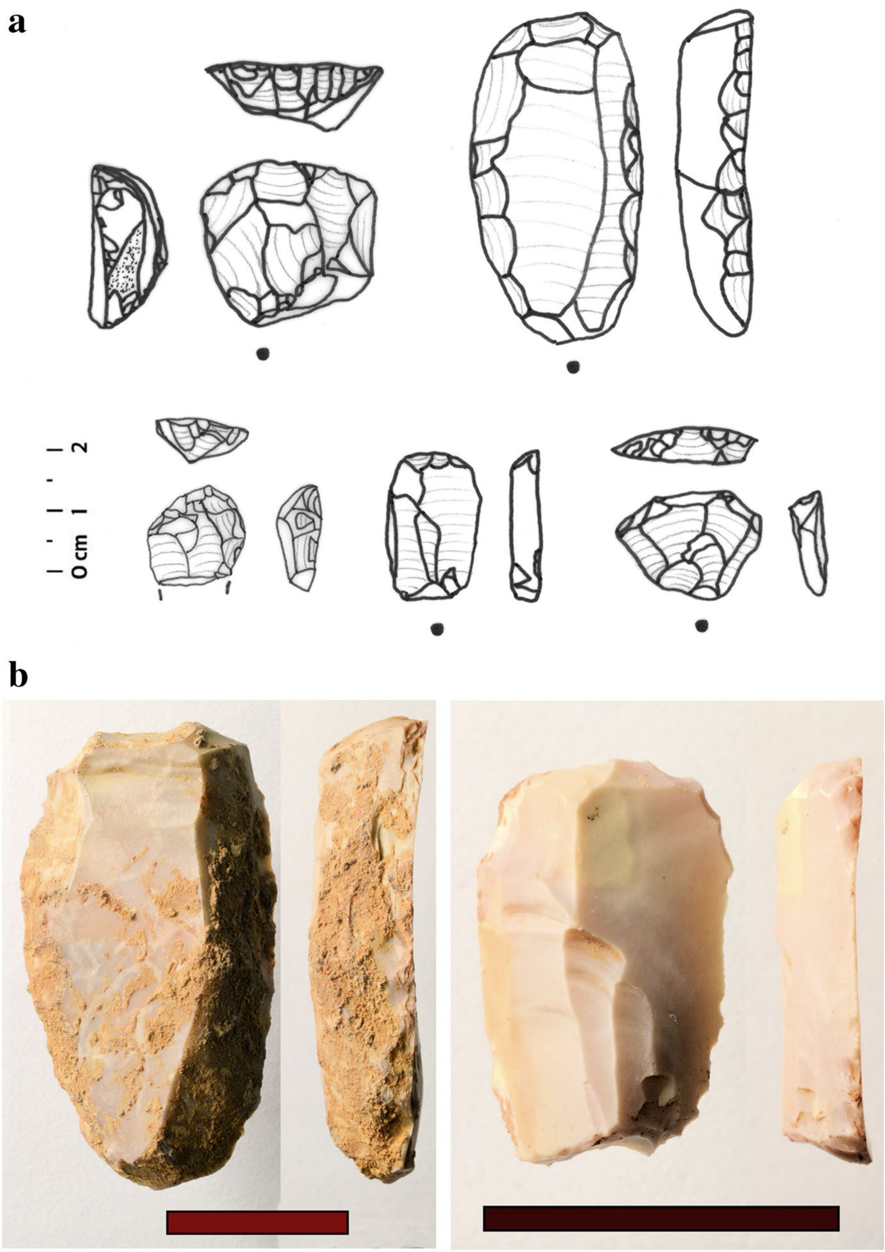
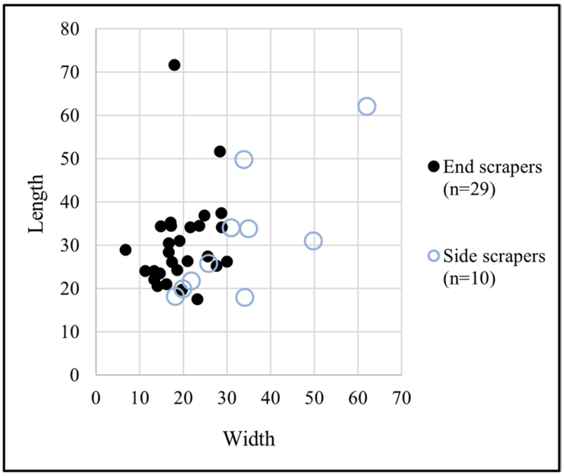


Fig. 14 **a** Scrapers with stratigraphic units in parenthesis. (a) end (IV), (b) end and side (III), (c) end and side (IV), (d) end (III), and (e) end (IV). **b** Scrapers from unit III. The scale in both cases is 20 mm

Fig. 15 Length plotted against width for complete end and side scrapers ($n=39$). All measurements in millimetres to one decimal place



The quantities of microburins in unit IV in particular point to a significant ratcheting up of the technique during the later occupation at Boila, with a microburin to backed tool ratio (including indeterminate backed fragments) of 2.3:1, compared to 0.3:1 and 0.2:1 in units III and II, respectively. Burning was noted on 18.6% ($n=135$) of all microburins, although all were sufficiently intact to be measured. Distal microburins were slightly more common (53%, $n=385$) than proximal (47%, $n=341$). The largest proportions were between 8 and 10 mm long (see Figs. 17 and 18). Laminar examples accounted for 21.5% ($n=156$), and these were four times as common amongst distal ($n=125$) than proximal ($n=31$) examples. There was no evidence for any subsequent modification or use of microburins as tools.

The convention chosen for describing microburins was dorsal facing, proximal down, or distal up. The position of the notch, specifically for those microburins with obverse retouch, was recorded in 682 cases. The remaining 44 had either inverse retouch, or the location of the notch could not be determined with respect to either the dorsal or ventral surface. In the contingency table, the location of the notch for proximal ($n=325$) and distal ($n=357$) microburins is recorded (Table 10). The results point to a predominance of distal microburins with the notch on the left and proximal examples with the notch on the right.

Table 9 Technical pieces ($n=868$)

Unit	Microburins (%)	Core setup and maintenance pieces (%)	Burin spalls (%)	Scraper resharpening pieces (%)
IV ($n=627$)	587 (93.6)	32 (5.1)	8 (1.3)	-
III ($n=175$)	103 (58.9)	56 (32)	14 (8)	2 (1.1)
II ($n=57$)	28 (49.1)	22 (38.6)	7 (12.3)	-
Ia ($n=9$)	8 (88.9)	1 (11.1)	-	-
Total ($n=868$)	726 (83.6)	111 (12.8)	29 (3.3)	2 (0.2)

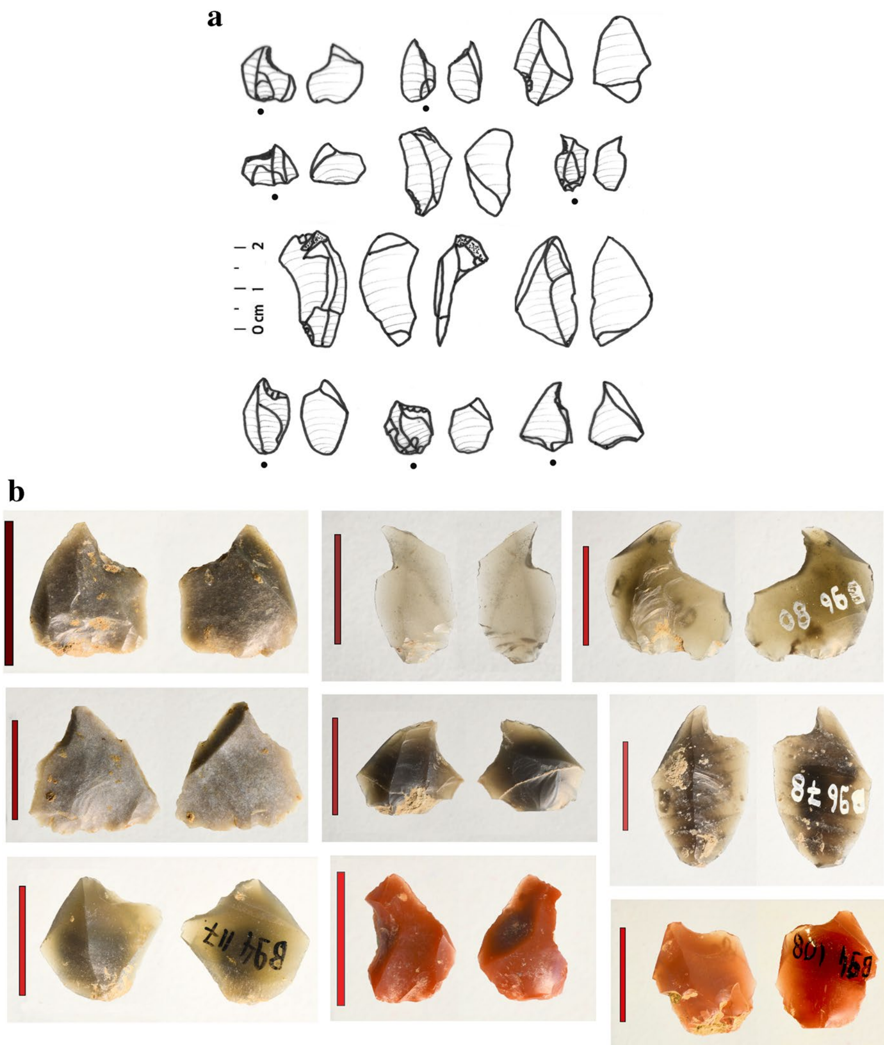


Fig. 16 **a** Microburins with stratigraphic units in parenthesis. (a) proximal (IV), (b) proximal (IV), (c) distal (IV), (d) proximal (IV), (e) distal (IV), (f) proximal (IV), (g) distal plunging (IV), (h) distal (IV), (i) proximal (IV), (j) proximal (IV), (k) proximal (IV). **b** Typical microburins from Boila, all from unit IV and proximal. The first seven made of Voidomatis black chert, with numbers eight and nine of red chert. The scales are all 10 mm

We suggest that one possible explanation may be related to handedness, with the notch produced using an implement held in the preferred hand. Although the results are some way off the modern right to left hand ratio of around 9:1, the microburins from Boila do suggest an element of repetition in the way in which these pieces were made. Further work on this possible relationship is ongoing.

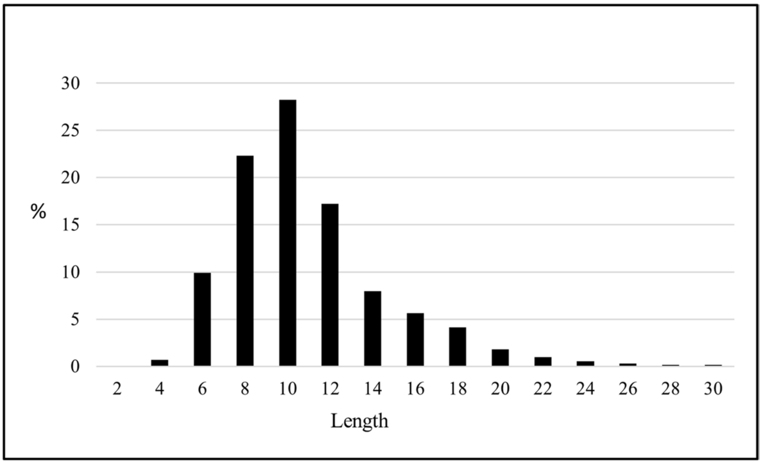


Fig. 17 Length frequency histogram for all 726 microburins. All measurements in millimetres to one decimal place

Fig. 18 Length plotted against width for all 726 microburins. The diagonal line represents the laminar/flake divide. All measurements in millimetres to one decimal place

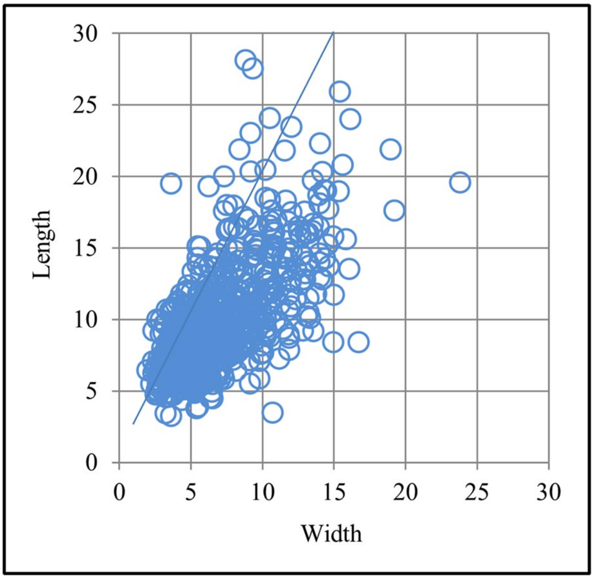


Table 10 Notch location for microburins with obverse retouch, dorsal facing, proximal down, or distal up

Microburin type ($n=682$)	Left notch (%)	Right notch (%)
Distal ($n=357$)	256 (71.7)	101 (28.3)
Proximal ($n=325$)	121 (37.2)	204 (62.8)

Cores ($n=133$)

Cores were present in the upper three units, although they were most abundant in III ($n=53$) and IV ($n=59$). Cortex was present on almost three-quarters (73.7%, $n=98$), while the incidence of burning was relatively low (13.5%, $n=18$). The platform was modified on just over a third of all cores (35.3%, $n=47$), with weak trimming of the edge perpendicular to the platform ($n=46$) and one with weak faceting parallel to the platform. Almost half (48.1%, $n=64$) were discarded in a residual state, with 21.8% ($n=29$) initial and 24.1% ($n=32$) advanced, while eight of the 14 fragments could not be defined in terms of working stage.

The largest shape category was amorphous (45.9%, $n=61$), followed by conical/sub-conical (24.8%, $n=33$) and broad-fronted (16.5%, $n=22$). There were two narrow-fronted cores made on large flakes, like burins, but on balance probably cores, along with 14 fragments (Table 11 and Fig. 19a, b). The size of most cores, with a mean length of just 32 mm, reflects the small size of raw materials and their many flaws (see Fig. 20). Also present in our sample was a splintered piece, measuring 21.9 mm long by 7.5 mm wide. The rarity of such pieces at Boila and other nearby sites contrasts with the Peloponnese where they are abundant, for example at Kephalari Cave (Marshall and Elefanti, forthcoming) and Klissoura Cave (Kaczanowska et al., 2010).

In the following discussion, units I to IV are compared, highlighting continuity between the first three, followed by change in unit IV. These included a shift towards backed points, a decline in their size and a major ratchetting up of the microburin technique. It is argued that these changes mirror those which occurred elsewhere in southern and western Europe during the Early Holocene and that they were also accompanied by a shift in the organisation of space within the shelter.

Unit Ia ($n=621$)

Unit Ia produced an assemblage of 621 pieces, accounting for 1.7% of our complete sample. Small fractions collectively amounted to 522 pieces (84%), with the rest of the assemblage consisting of just 99 pieces of debitage (79.8%, $n=79$), tools (11.1%, $n=11$), and technical pieces (9.1%, $n=9$). No cores were present in our sample. Debitage with cortex accounted for a quarter of all pieces (25.3%, $n=20$), including one primary flake, while broken pieces made up around a fifth (19.2%, $n=10$), excluding the 27 chunks and untested pebbles. Nine pieces were burnt (11.4%), six patinated (7.6%), and 12 (15.2%) abraded. Tools included eight backed pieces, two with low angle retouch, and a single side scraper. The incidence of breakage was very high amongst tools (81.8%, $n=9$). Of the seven backed tools, all but one was broken. Eight microburins were recorded, accounting for 8.1% of the assemblage excluding small fractions and equating to a backed tool to microburin ratio of 1:1.1. It was only in unit IV that even higher ratios were observed.

Table 11 All cores ($n=133$), including the single splintered piece

Type	Amorphous ($n=61$)				Conical ($n=5$)		Sub-conical ($n=28$)				Broad-fronted ($n=22$)			Fragments ($n=14$)				On flake ($n=2$)	Splintered piece ($n=1$)
Platform number and arrangement	Single (%)	Double opposed (%)	Double adjacent (%)	Triple adjacent (%)	Single (%)	Double opposed (%)	Single (%)	Double opposed (%)	Double adjacent (%)	Triple adjacent (%)	Single (%)	Double opposed (%)	Double adjacent (%)	Single (%)	Double opposed (%)	Double adjacent (%)	Unknown (%)	Single (%)	Double opposed (%)
Unit IV ($n=59$)	12 (20)	1 (1.7)	3 (5.1)	4 (6.8)	1 (1.7)	-	11 (18.6)	2 (3.4)	2 (3.4)	1 (1.7)	10 (16.9)	4 (6.8)	1 (1.7)	4 (6.8)	1 (1.7)	1 (1.7)	1 (1.7)	-	-
Unit III ($n=53$)	16 (30)	4 (7.5)	7 (13.2)	4 (7.5)	1 (1.9)	-	8 (15.1)	-	-	-	-	5 (9.4)	1 (1.9)	1 (1.9)	1 (1.9)	-	3 (5.7)	1 (1.9)	1 (1.9)
Unit II ($n=21$)	5 (24)	3 (14.3)	2 (9.5)	-	2 (9.5)	1 (4.8)	1 (4.8)	1 (4.8)	2 (9.5)	-	-	1 (4.8)	-	1 (4.8)	-	-	1 (4.8)	1 (4.8)	-
Unit Ia	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Total ($n=133$)	33 (25)	8 (6)	12 (9)	8 (6)	4 (3)	1 (0.8)	20 (15)	3 (2.3)	4 (3)	1 (0.8)	10 (7.5)	10 (7.5)	2 (1.5)	6 (4.5)	2 (1.5)	1 (0.8)	5 (3.8)	2 (1.5)	1 (0.8)

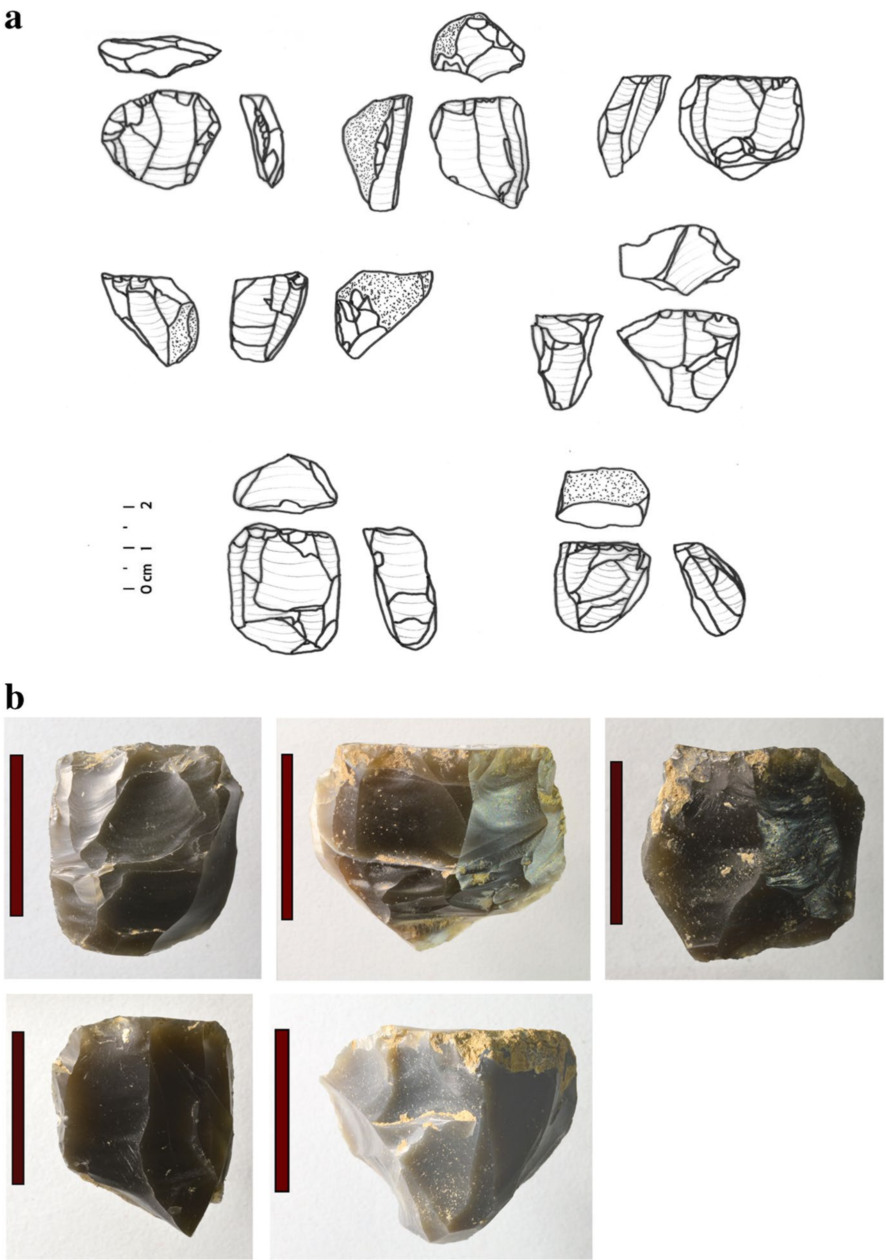


Fig. 19 **a** Cores from Boila with stratigraphic units in parenthesis. (a) broad-fronted (IV), (b) sub-conical (IV), (c) broad-fronted (IV), (d) sub-conical (IV), (e) sub-conical (III), (f) broad-fronted (IV), and (g) broad-fronted (IV). **b** Representative examples of cores from Boila, all made of the local Voidomatis black chert. The scales are all 20 mm

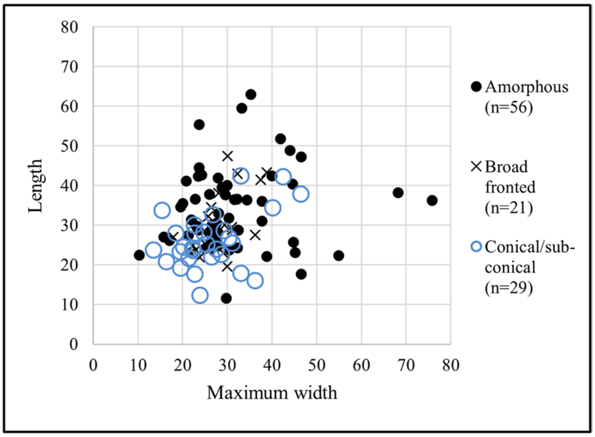


Fig. 20 Length plotted against width for amorphous, broad-fronted, and conical/sub-conical cores. All measurements in millimetres to one decimal place

Unit II (*n* = 5415)

Unit II accounted for 15.1% (*n* = 5415) of our sample, with small fractions accounting for 74.6% (*n* = 4040), less than unit Ia (84%). The rest of the assemblage amounted to 1375 pieces, with debitage proportions close to that seen in unit Ia. Tools were similar, technical pieces halved, and while 21 cores were recorded, with none in unit Ia (Table 12).

Cortical pieces accounted for 24.9% (*n* = 342) of debitage, the same as in unit Ia (25.3%), but with 25 primary flakes, compared to one in unit Ia. The incidence of burning 12.7% (*n* = 175) was similar in unit Ia (11.1%, *n* = 11), while pieces in fresh condition (72.8%, *n* = 1001) were also the same (72.7%, *n* = 72). Mindful of the significant differences in the size of the assemblages, unit II included many more larger pieces of debitage (Fig. 21), particularly those above 25 mm in length. Unit II produced 21 cores, around three-quarters of which (76.2%, *n* = 16) were discarded in a residual state. No cores were present in our sample from unit Ia.

Tools accounted for 12.7% (*n* = 175) of the assemblage excluding small fractions (*n* = 1375), slightly up on unit Ia (11.1%). Backed tools (including indeterminate fragments) were predominant (79.4%, *n* = 139), increasing from unit Ia (72.7%, *n* = 8). Of the recognisable backed tools in unit II (*n* = 129), backed bladelets were abundant (77.5%, *n* = 100), followed by backed points (21.7%, *n* = 28). Little more can be said regarding the rest of the tool assemblage given the small numbers of pieces in unit Ia. Microburins accounted for 2% of the assemblage excluding small fractions, compared to 8% in unit Ia. Breakage was still common amongst tools (60%, *n* = 57), although slightly down on unit Ia (63.6%). The lack of angular scree and the silty nature of the deposits suggests a complex occupational history, possibly the result of human disturbance of the top of the existing alluvial deposits. More of the *chaîne opératoire* was present than in unit Ia, along with broken tools, suggesting maintenance and replacement. The presence of microburins points to the importance of backed tools, along with a wider variety of other types suggesting broader ranges of processing activities compared to unit Ia.

Table 12 Units II and Ia, excluding small fractions

Unit	Debitage (%)	Tools (%)	Technical pieces (%)	Cores (%)
II (*n* = 1375)	1122 (81.6)	175 (12.7)	57 (4.2)	21 (1.5)
Ia (*n* = 99)	79 (79.8)	11 (11.1)	9 (9.1)	-

Unit III

Unit III accounted for 44.2% (*n* = 15,851) of our sample, with small fractions (72.5%, *n* = 11,487) slightly down on unit II (74.6%). The rest of the assemblage (*n* = 4364) was dominated by debitage (84.1%, *n* = 3668), up compared to unit II (81.6%), while the proportions of tools, technical pieces, and cores were also broadly similar (Table 13).

Cortical pieces accounted for a quarter of all debitage (25%, *n* = 1088), as in unit II (24.9%), of which 7.5% (*n* = 82) were primary flakes, compared to 7.3% in unit II. The incidence of burning (10.7%, *n* = 393) was slightly down on unit II (12.8%), while broken debitage (23.3%), excluding chunks and pebbles, was down on unit II (31.5%). Flakes and laminar flakes combined (76.3%, *n* = 2800) were slightly reduced compared to unit II (78.7%), as were blades and bladelets (10.6%, *n* = 387), compared to 12.2%. The dimensions of complete pieces of debitage were also broadly similar in units III and II (Fig. 22).

Recorded in unit III was a centripetal Levallois flake made of non-local yellowish flint. Indicated by an X (see Figs. 22 and 23), it had a strongly facetted striking platform and pronounced bulb of percussion. The colour of the raw material and the lack of rolling suggest that it was carried into the shelter from further afield, perhaps as a curiosity or source of raw material, although it was not subsequently utilised or modified.

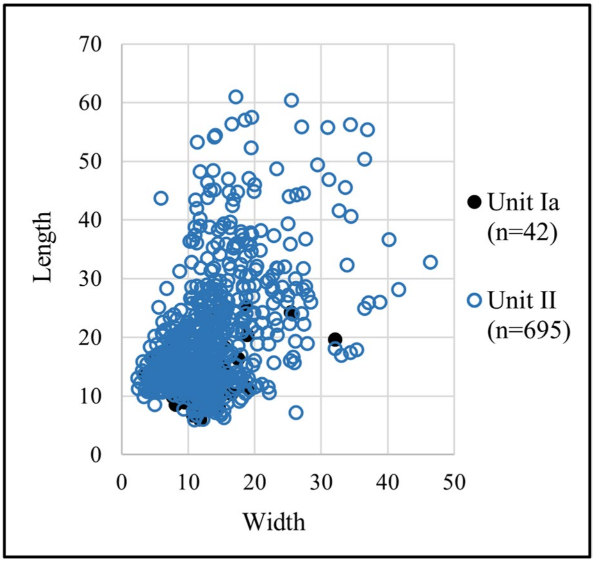


Fig. 21 Length plotted against width for complete flakes, laminar flakes, blades, and bladelets from units II and Ia (*n* = 737). All measurements in millimetres to one decimal place

Table 13 Assemblage breakdown from units III and II, excluding small fractions

Unit	Debitage (%)	Tools (%)	Technical pieces (%)	Cores (%)	Splintered piece (%)
III (*n*=4364)	3668 (84.1)	468 (10.7)	175 (4)	52 (1.2)	1 (0.02)
II (*n*=1375)	1122 (81.6)	175 (12.7)	57 (4.2)	21 (1.5)	-

Cores were rare (1.2%, *n*=53), slightly down on unit II (1.5%). They were similar in size to those from unit II, although with a small number of larger examples (Fig. 24). The single splintered piece is indicated by an X. Cores discarded in a residual state (41.5%, *n*=22) were significantly down on unit II (76.2%).

As a proportion of the assemblage excluding small fractions, microburins increased slightly (2.4%, *n*=103) compared to 2% (*n*=28) in unit II. In addition, the proportion of proximal microburins increased in unit III (42.7%, *n*=44), compared to 32.1% in unit II. Mindful of the difference in assemblage sizes, larger microburins were more common in unit III, particularly those over 10 mm in length and width (Fig. 25).

Tools

Tools (10.7%, *n*=468) were slightly less abundant than in unit II (12.6%), while backed pieces collectively accounted for 77.4% (*n*=362) of all tools (including indeterminate fragments), compared to 79.4% in unit II. The rest of the tool assemblage consisted of retouched pieces, scrapers, truncations, perforators, notch/denticulates, and burins (Table 14).

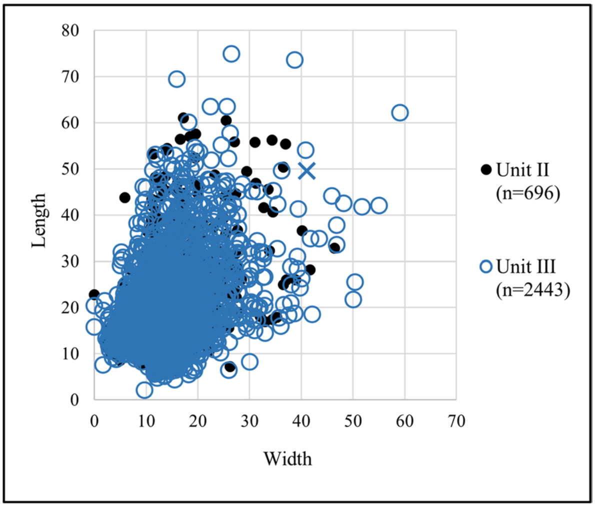


Fig. 22 Length and width for complete pieces of debitage from units III and II (*n*=3139), including flakes (*n*=2155), laminar flakes (*n*=675), blades (*n*=25), and bladelets (*n*=383). The Levallois flake from unit III is indicated by an X. All measurements in millimetres to one decimal place

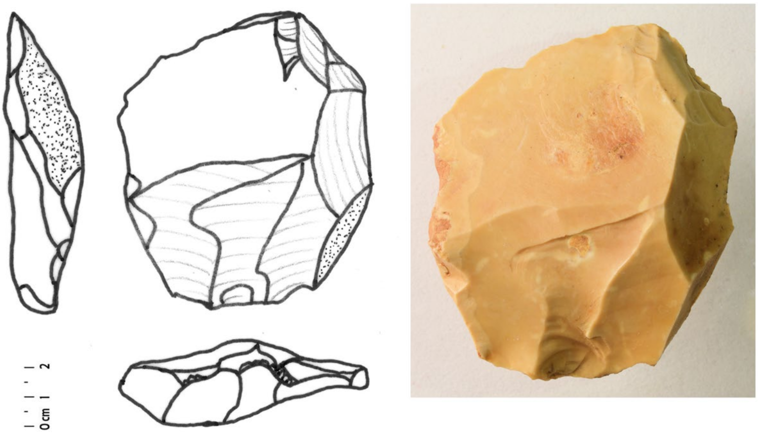


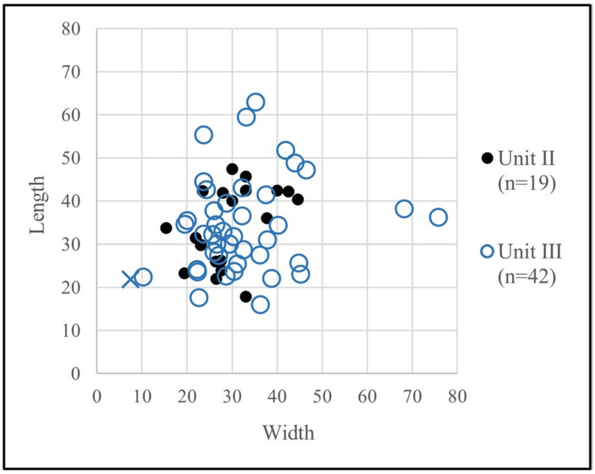
Fig. 23 Levallois flake from unit III

Backed bladelets (50%, $n=234$) were down on unit II (57.1%), while backed points (21.8%, $n=102$) were up (16%). Bearing in mind the differences in assemblage sizes, unit III included more larger examples of both backed bladelets and backed points (see Figs. 26 and 27).

Geometric microliths accounted for 0.9% ($n=4$) of all tools, including two angulated back pieces, an isosceles triangle, and a possible broken trapeze. The two angulated back pieces were similar in size, both around 15 mm in length and 5 mm in width. The proximal of the isosceles triangle had a piquant trièdre.

Unit III produced the largest chipped stone assemblage in our sample ($n=15{,}851$), roughly three times that of unit II (5451), although the dates point to extremely gradual accumulation over 4.7 ka. In contrast, the age estimates suggest just hundreds of years for unit II. Despite this chronological disparity, the assemblages from

Fig. 24 Core length plotted against width ($n=61$) from units III and II. The single splintered piece is indicated by an X. All measurements in millimetres to one decimal place



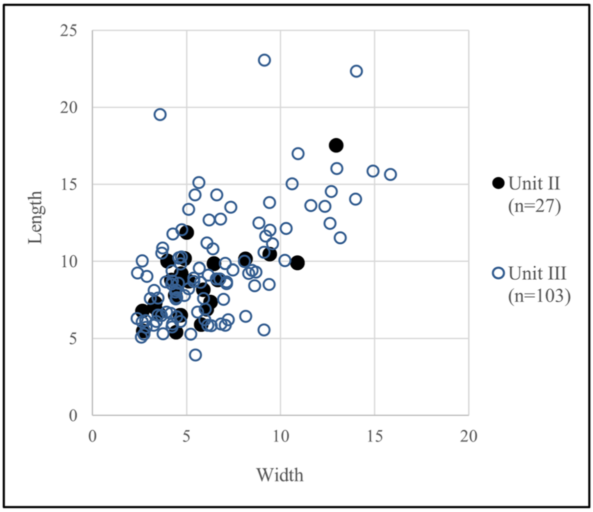


Fig. 25 Length plotted against width for complete microburins ($n=130$) from units III and II. All measurements in millimetres to one decimal place

both units were very similar. Debitage remained virtually unchanged, with extensive use of local black flint pebbles, although fewer cores were discarded in a residual state in unit III. Proportionally, microburins were slightly more abundant, along with an increase in proximal pieces and the contribution of larger examples. There was a drop in backed bladelet proportions and an increase in backed points, along with a decline in unilateral backing and corresponding increase in bilateral amongst both categories, but particularly points. There was also an increase in the proportions of longer examples amongst both backed bladelets and backed points.

Unit IV (*n* = 14,014)

Unit IV accounted for 39% (14,014) of our complete sample. Small fractions were slightly down (70.1%, $n=9826$) compared to unit III (72.5%), with the rest of the assemblage consisting of 4188 pieces (Table 15). Debitage (75.8%, $n=3177$) was down compared to unit III (84.1%). Cortical pieces were up (31.3%, $n=993$) compared to unit III (25%), of which 8.3% ($n=82$) were primary flakes, compared to 7.5% in unit III. The incidence of burning (27.6%, $n=878$) was almost three times that was seen in unit III (10.7%), while breakage (24.6%, $n=694$), excluding chunks and tested pebbles, was similar to unit III (23.3%).

Dimensionally, flakes, laminar flakes, blades, and bladelets were broadly similar in both units (see Fig. 28), although with fewer larger pieces in unit IV, particularly those longer than around 50 mm. No blades were recorded in unit IV, just bladelets.

Table 14 Retouched tools from units II and III

Unit	Backed bladelets (%)	Backed points (%)	Backed flakes (%)	Indeterminate backed fragments (%)	Geometric microliths (%)	Retouched pieces (%)	Scrapers (%)	Truncations (%)	Perforators (%)	Notch denticulates (%)	Burins (%)
III ($n=468$)	234 (50)	102 (21.8)	6 (1.3)	16 (3.4)	4 (0.9)	54 (11.5)	23 (4.9)	2 (0.4)	9 (1.9)	14 (3)	4 (0.9)
II ($n=175$)	100 (57.1)	28 (16)	-	10 (5.7)	1 (0.6)	13 (7.4)	11 (6.3)	7 (4)	2 (1.1)	-	3 (1.7)

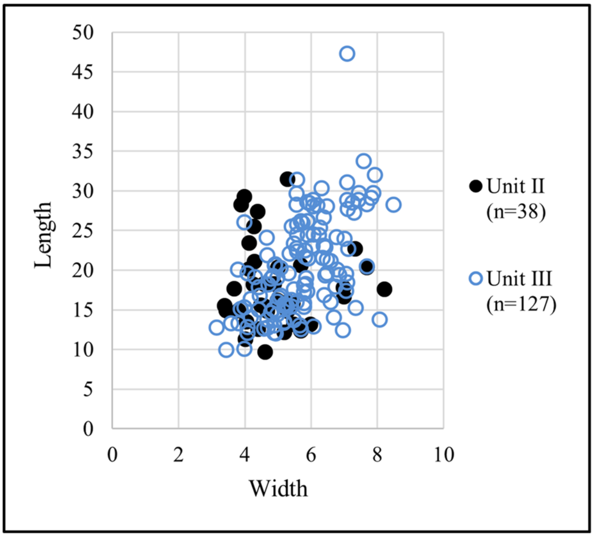


Fig. 26 Length plotted against width for complete backed bladelets ($n=165$) from units III and II. All measurements in millimetres to one decimal place

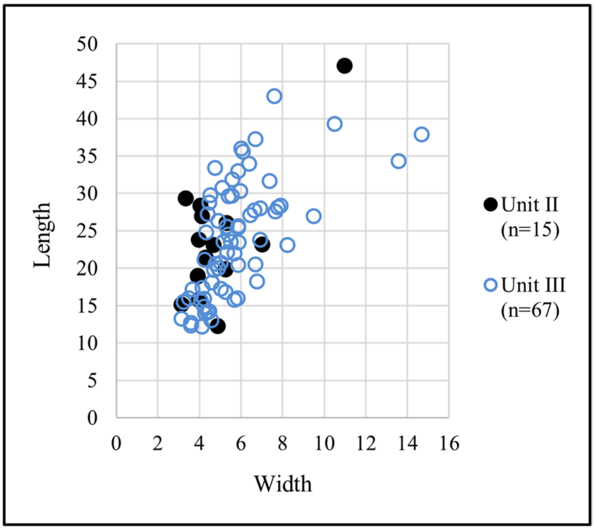


Fig. 27 Length plotted against width for complete backed points ($n=82$) from units III and II. All measurements in millimetres to one decimal place

Cores

Cores were slightly more abundant (1.4%, $n=59$) than in unit III (1.2%). Amorphous types were almost halved compared to unit III, while conical/sub-conical and broad-fronted examples doubled in unit IV (Table 16).

Cores discarded in a residual state (49.2%, $n=29$) increased compared to unit III (41.5%). Most cores were less than 45 mm in length in both units, although with fewer larger examples in unit IV (Fig. 29).

Table 15 Assemblage breakdown from units IV and III, excluding small fractions

Unit	Debitage (%)	Tools (%)	Technical pieces (%)	Cores (%)	Splintered piece (%)
IV (*n* = 4188)	3177 (75.9)	325 (7.8)	627 (14)	59 (1.4)	-
III (*n* = 4364)	3668 (84.1)	468 (10.7)	175 (4)	52 (1.2)	1 (0.02)

One of the most distinctive aspects of unit IV was the significant increase in microburins, accounting for 14% (*n* = 587) of the assemblage excluding small fractions, compared to 2.4% (*n* = 103) in unit III. There was also an increase in proximal examples (48.6%, *n* = 285), compared to 42.7% in unit III. Mindful of the difference in assemblage sizes, larger microburins were more common in unit IV, particularly those over 15 mm in length and width (Fig. 30). Burnt pieces accounted for 22% (*n* = 129) of all microburins in unit IV, compared to just 5% in III.

Tools

Tools 7.8% (*n* = 325) were proportionally less common than in unit III (10.7%), along with a slight increase in backed pieces (78.8%, *n* = 256), compared to 77.4%. The rest of the tool assemblage consisted of scrapers, perforators, notch/denticulates, and burins (Table 17).

As a proportion of tools in unit IV, backed bladelets (11.7%, *n* = 38) declined significantly compared to unit III (50%). In contrast, backed points (44.3%, *n* = 144) were more than doubled compared to unit III (21.8%). In addition, backed bladelets and backed points were both notably smaller in unit IV (see Figs. 31 and 32).

Breakage amongst backed points was more common in unit IV that was 41% (*n* = 59), compared to 33% in unit III (*n* = 33). Unilaterally, backed examples

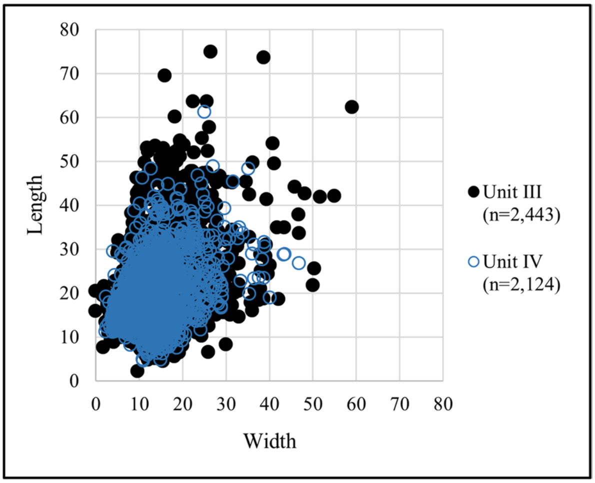


Fig. 28 Length plotted against width for complete debitage from units III and IV (*n* = 4567). Flakes and laminar flakes (*n* = 4061), blades (*n* = 18), and bladelets (*n* = 488). All measurements in millimetres to one decimal place

Table 16 Core counts from units III and IV

Unit	Amorphous (%)	Conical/ sub-conical (%)	Broad-fronted (%)	On flake (%)	Splintered piece (%)	Fragments (%)
IV (*n* = 59)	20 (33.9)	17 (28.8)	15 (25.4)			7 (11.9)
III (*n* = 53)	31 (58.5)	9 (17)	6 (11.3)	1 (1.9)	1 (1.9)	5 (9.4)

accounted for 15.3% (*n* = 22) of all points in unit IV, compared to 83.3% in unit III. In contrast, bilaterally backed points were more common in unit IV (30.6%, *n* = 44), compared to just 5.9% in III. Double backed needle points and Sauveterrian-like points were also more abundant in unit IV, (23.6%, *n* = 34), compared to just 2% in unit III, along with two possible shouldered points (1.4%). In half of all backed points (50%, *n* = 72), the original blank could not be identified, with 30.6% (*n* = 44) made on flakes and laminar flakes and (19.4%, *n* = 28) on bladelets.

Geometric microliths accounted for 7.4% (*n* = 24) of all tools, compared to just 0.9% in unit III. They included convex (50%, *n* = 12) and angulated back pieces (16.7%, *n* = 4), isosceles triangles (8.3%, *n* = 2), scalene triangles (12.5%, *n* = 3), trapezes (8.3%, *n* = 2), and a single rhomboid (4.2%).

Scrapers collectively accounted for 4.3% (*n* = 14) of all tools, including 11 end and 3 side, compared to 4.9% in unit III, 17 end and 6 side. Breakage was common in unit IV (42.9%, *n* = 6), compared to just 8.3% (*n* = 2) in unit III.

Burnt scrapers were also abundant in unit IV (50%, *n* = 7), compared to just 8.3% (*n* = 2) in unit III. Most end and side scrapers (*n* = 24) were less than 40 mm in length and 30 mm in width, with five larger outliers, all from unit III (see Fig. 33).

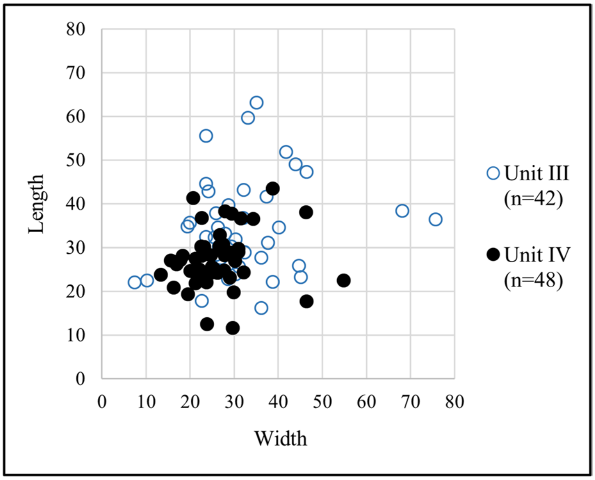


Fig. 29 Length plotted against maximum width for complete cores from units IV and III (*n* = 90). All measurements in millimetres to one decimal place

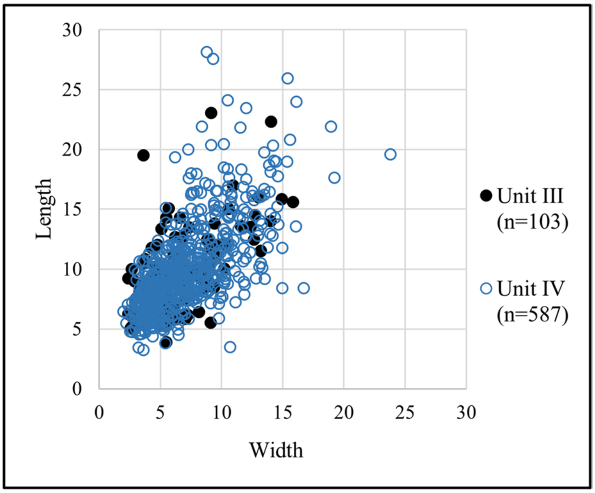


Fig. 30 Microburin dimensions ($n=690$) for units IV and III

Discussion

Boila was initially occupied around 18,000 cal. BP as the level of the Voidomatis River fell. The small chipped stone assemblage from the upper surface of the gravel floor of the shelter was sealed by a sequence of fine grained alluvial slack water flood deposits (Woodward et al., 2001, 510; Woodward et al., 2008, 57). These events were followed by a brief phase during which the alluvial silt floor of the shelter was briefly occupied, between around 17,000 and 16,700 cal. BP. The main occupation phase at Boila began around 16,700 cal BP with deposits consisted of angular limestone scree and fine sandy silt, blown, and washed in, along with animal bones, charcoal lenses, and chipped stone. Approximately 2.5 km up the Vikos Gorge, Klithi Rockshelter was occupied from around 16,500 BP (Bailey & Woodward, 1997, 81) or 20,000 cal. BP, and Megalakkos slightly later at around 19,500 cal. BP (see Gowlett et al., 1997, 31 for the original dates). All three sites have been suggested as part of an increased emphasis on novel environments, part of a wider socio-economic network exploiting the highlands and lowlands of Epirus (Elefanti, 2003 and references therein), with several sites in the wider region (Biagi et al., 2023; Galanidou & Papoulia, 2016; Kourtessi-Philippakis et al., 2019; Runnels et al., 2009a; Tourloukis & Palli, 2009), as well as in Albania with open-air scatters (Gjipali, 2006) and excavated sites such as Konispol (Harrold et al., 2017), Kryegjata B (Runnels et al., 2009b) and Nezir (Hauck et al., 2017a, 2017b). During periods of lower sea level, this network may also have included the islands of the Ionian, for example the site of Grava on Corfu (Sordinas, 2003, Elefanti & Marshall, forthcoming) or other findspots on the islands of Meganisi (Galanidou, 2011).

At Klithi, the dates suggest that by around 13,500 BP (16.3 ka cal. BP), the inner gorge had largely gone out of use (Bailey & Woodward, 1997, 82), but with continued, albeit sporadic and low intensity use of Boila at the edge of the Konitsa Basin. Based on the spread of dates from unit III, the deposit of 70 cm in thickness (see Woodward et al., 2001, 510) accumulated over a substantial period of time, roughly

Table 17 Tools from units III and IV

Unit	Backed bladelets (%)	Backed points (%)	Backed flakes (%)	Indeterminate backed fragments (%)	Geometric microliths (%)	Retouched pieces (%)	Scrapers (%)	Truncations (%)	Perforators (%)	Notch denticulates (%)	Burins (%)
IV ($n=325$)	38 (11.7)	144 (44.3)	2 (0.6)	48 (14.8)	24 (7.4)	32 (9.8)	14 (4.3)		4 (1.2)	15 (4.6)	4 (1.2)
III ($n=468$)	234 (50)	102 (21.8)	6 (1.3)	16 (3.4)	4 (0.9)	54 (11.5)	23 (4.9)	2 (0.4)	9 (1.9)	14 (3)	4 (0.9)

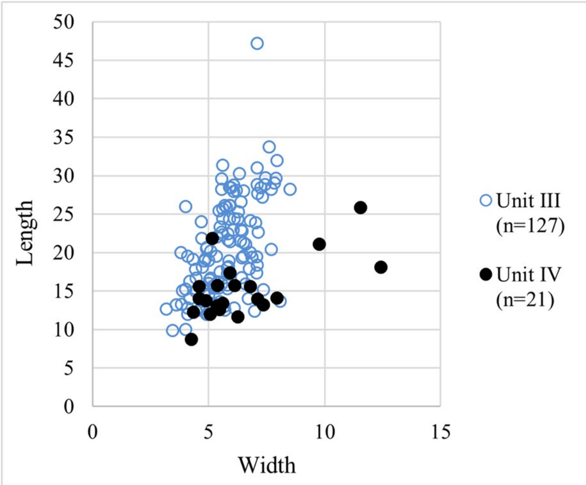


Fig. 31 Length plotted against width for complete backed bladelets (*n* = 148) from units IV and III

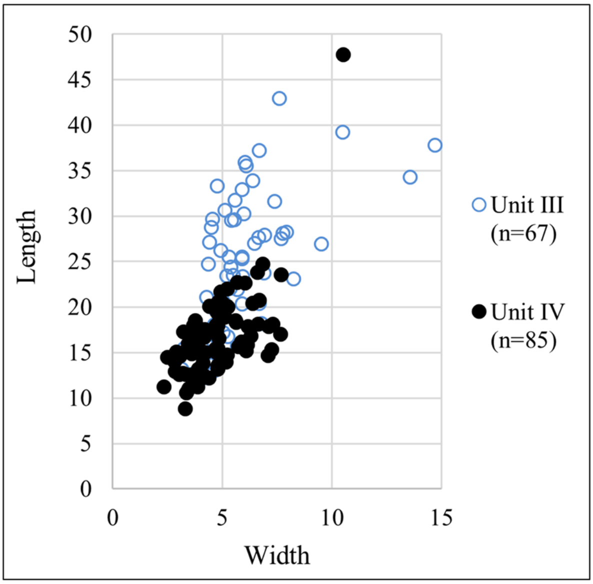


Fig. 32 Length plotted against width for complete backed points (*n* = 152) from units IV and III

4.7 thousand years, with an average accumulation rate estimate of just 1.5 cm per 100 years, significantly less than that suggested for Klithi and Kastritsa of 6.7 and 8.3 cm per 100 years, respectively (Bailey & Woodward, 1997, 83), or the 4 cm suggested for Franchthi Cave (Farrand, 2001). Scree rich unit III forms the current floor of the shelter beneath the overhang. Beyond the dripline, these were overlain by the ash rich deposits of unit IV, which the dates suggest were formed from around 11.7 until 10.9 ka cal. BP.

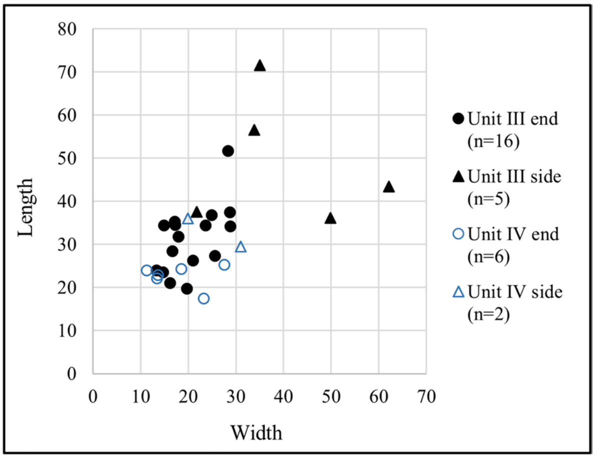


Fig. 33 Length plotted against width for complete scrapers from units IV ($n = 8$) and III ($n = 21$)

Chipped stone was present throughout the sequence from the earliest tentative use of the gravel floor of the shelter as the river subsided. The assemblage was dominated by local black and grey flint that transported the relatively short distance down the Voidomatis from outcrops within the inner gorge. Similar rolled pebbles can be collected along the banks of the river today. Small quantities of other colour varieties suggest that material was also being carried in from elsewhere (Elefanti et al., 2021). The use of these other colour varieties declined through time, albeit from very low levels to begin with. This was most notable amongst the red and yellow, perhaps due to reduced mobility, a pattern suggested for the Late Epigravettian elsewhere in the Balkans (Mihailovic, 1999).

Little can be said in detail about the small assemblage in unit I, with just 621 pieces in total. The abundance of small fractions points to knapping on site, with the rest of the assemblage numbering just 99 pieces, with a quarter of all debitage broken. The 11 tools were dominated by backed pieces, with breakage rates significantly higher than debitage. Microburins were also proportionally abundant, with a microburin to backed tool ratio of 1.1:1. The abundance of backed pieces, incidence of breakage, and the microburins point to an emphasis on gearing up and maintenance of toolkits. All but one of the tools was made using the local black flint, a large side scraper made of distinctive red flint with yellow cortex. One of the eight microburins was also made of red flint.

In unit II, we see more substantial use of the shelter, with our sample consisting of 5415 pieces. Three quarters of the total was made up of small fractions, again pointing to the working of river pebbles on site. Also present were blades, bladelets, and cores, all absent in unit I. Excluding small fractions, the assemblage amounted to 1375 pieces, with slightly higher proportions of cortical pieces compared to unit Ia and almost a third of pieces broken. Backed tools were abundant ($n = 139$), in particular backed bladelets and specifically unilaterally backed pieces. Backed points were predominantly unilaterally backed as well. Also recorded were 28 microburins, with a microburin to backed tool ratio of 0.2:1. Unit II also produced a wider variety of tools, end scrapers, truncations, perforators, and burins. Broken pieces accounted for over half of all tools, roughly twice that seen amongst debitage. Non-local raw materials accounted for 12% of all debitage, but a quarter of all tools and 15% of microburins. The high incidences of backed pieces, breakage, microburins, and non-local raw materials are again indicative of manufacture and repair as an important function of the shelter.

In unit III, we see the first evidence for the accumulation of terrestrial deposits in the form of scree and silt, incorporating occupation debris and discrete charcoal lenses, during an extended period and with very gradual accumulation rates. The abundance of angular limestone scree points to cold weather processes acting on the back wall of the shelter and the cliffs above. Unsurprisingly, given this long interval, unit III produced the largest assemblage in our sample ($n=15,851$), although this equates to an average of just 337 pieces per 100 years from the squares in our sample. Small fractions accounted for just less than three quarters of the assemblage, with the rest numbering 4364 pieces. Cortical debitage was abundant, including primary flakes, while broken pieces accounted for 23% of debitage. Tools accounted for around 11% of pieces excluding small fractions, predominantly backed pieces, mainly unilaterally backed bladelets and backed points. Also present were four geometric microliths. Also recorded were 103 microburins, with a microburin to backed tool ratio of 0.3:1. Broken pieces accounted for 43% of all tools, around twice the rate for debitage, although less than in unit II. Non-local raw materials accounted for 9% of all debitage, but 16% of all tools and 12% ($n=12$) of microburins. Although the assemblage from unit III was very similar to that from II, a decline in backed bladelets was noted, along with an increase in backed points. Also noted in unit III was an increase in the size of both backed bladelets and backed points, as well as microburins, suggesting the selection of larger blanks for backed tool manufacture.

Unit IV was very different and was located exclusively outside of the dripline. Rich in ash and silt with rare scree, it had no discernible features and probably formed within a depression on the edge of the floor, now truncated by the talus. It began forming during the Early Holocene, from around 11.7 ka cal. BP, with an uppermost estimate of around 11 ka cal. BP, although the top of the sequence is undated. The assemblage in our sample amounted to 14,014 pieces, just slightly less than unit III, although it appears to have accumulated much more rapidly. Small fractions accounted for 70% ($n=8826$), with the rest of the assemblage numbering 4188 pieces. The proportions of cortical pieces were indistinguishable from unit III, as were broken pieces which accounted for a quarter (25%) of all debitage. Backed pieces were abundant, accounting for almost 80% of all retouched tools, but with a decline in backed bladelets and an increase in backed points. At the same time, there was also a decline in unilateral backed pieces amongst both the small number of backed bladelets, and the much larger numbers of backed points, the latter dominated by bilaterally backed and double backed needle points. In addition to the shift away from backed bladelets towards backed points, and from unilateral to bilateral backing, there was also a notable decline in the sizes of both backed bladelets and backed points in unit IV. Also recorded were 24 microliths, including convex and angulated back, isosceles triangles, scalene triangles, trapezes, and rhomboids. Breakage amongst tools (44%) was around twice that of debitage, the same as the rates noted in from unit III. Non-local raw materials accounted for 5.5% of debitage, 10% of tools, and 2.8% of microburins.

Amongst the backed tools from unit IV were those recorded as double backed needle points of the Sauveterrian technocomplex. Early excavations at Le Martinet and Le Roc Allan in Sauveterre la-Lémance in southern France produced assemblages containing slender backed bladelets and triangular microliths (Coulonges, 1928, 1930). Excavations carried out during the following decades produced comparable sequences in France and Italy at Romagnano III (Broglio & Kozłowski, 1984; Visentin, 2018, 17), and in north-eastern Spain at Peña 14 (Soto et al., 2020). The French and Italian chronologies have been summarised by Visentin (2018, 37, Appendix A, and references therein), for example, Le Sansonnet in south-eastern France (9995 ± 95 BP, 11,689–10,875 cal. BP, 2σ), Romagnano III in Italy (9,830 ± 90 BP, 11,689–10,875 cal. BP, 2σ), while Peña 14 (level d) is dated to 10,120 ± 40 BP (11,931–11,404 cal. BP, 2σ) (Soto et al., 2020). Two sites in northern Italy near Trento, Galgenbühel 1 and La Cogola (stratigraphic units 18 and 16), are dated to 9265 ± 70 BP (10,648–10,247 cal. BP, 2σ), 9820 ± 60 BP (11,397–11,115 cal. BP, 2σ), and 9430 ± 60 (11,068–10,500 cal. BP, 2σ), respectively (Bassetti et al., 2009, 130).

In Greece, similar points have been reported from Klissoura Cave sequence A, the base of which is dated to 9150 ± 220 BP (11,075–9,676 cal. BP, 2σ) (Kaczanowska et al., 2010, 187). The dates from unit IV at Boila suggest that it began forming from at least 9.980 ± 90 (11,811–11,237 cal. BP, 2σ) until 9540 ± 75 (11,145–10,585 cal. BP, 2σ), although the top of the sequence is not dated. Given the broad similarity in the dating and widespread distribution off these specific tool types, we suggest a similar transition that took place at Boila, representing a continuum from the underlying Epigravettian industries. Although this shift does not appear to have been associated with any changes in the meat component of the diet, with continued hunting of mountain goat and some red deer, the ash-rich deposits of unit IV suggest a change in the organisation of the shelter itself. The placement of what appears to be a large single hearth beyond the dripline would have freed up space within the shelter, perhaps suggesting larger group sizes. The density of chipped stone and the short chronology of unit IV point to much more intense use of the site, with maintenance of toolkits at what would useful stopover point at the southern end of the Konitsa Plain, with abundant raw materials located just meters away. Although north-facing, the improved conditions of the Early Holocene would have probably enabled Boila to be used for more seasons.

Another significant aspect of unit IV was the notable increase in the use of the microburin technique, with 587 recorded, a six-fold increase on unit III and a microburin to backed tool ratio of 2.3:1. Microburins accounted for 14% of the assemblage excluding small fractions in unit IV, compared to 2% and 2.3% in units II and III, respectively. In square Q26 at Klithi, microburins accounted for 0.3% ($n = 8$) of the assemblage excluding chips and debris ($n = 2467$) (Adam, 1997, 491). In the 1000 series contexts from the WX33-30 trench, also at Klithi, microburins accounted for 3.1% ($n = 24$), 0.5% ($n = 5$), and 0.09% ($n = 3$) of the assemblages from contexts 1002, 1003c, and 1003b, respectively (excluding microflakes and microbladelets), at increasing depth (see Roubet, 1997, 128, Table 8.3). A late date of 13,640 ± 100

BP (Gowlett et al., 1997, 28) (16,875–16,190 cal. BP) from layer 7 (Bailey & Woodward, 1997, 69) points towards increasing use of the microburin technique towards the final phases of use of Klithi. Increasing numbers were also reported at Kastritsa Cave in strata 3 and 1, with trace quantities down to stratum 9 (Adam, 1997, 488). No microburins were recorded at either Grava or Sidari on Corfu, although both are incomplete (Elefanti & Marshall, forthcoming). At Konispol Cave in southern Albania, microburins are not reported, although the dates suggest more recent use compared to Boila (Harrold, et al., 2017, 11; Schuldenrein, 1998, 510). No microburins were reported from central Albania at Blazi Cave in the Mat region, dated to between around 18 and 17 ka cal. BP (Hauck et al., 2017a), or nearby Neziri Cave, although it was occupied later than Boila (Hauck et al., 2017b). Microburins have also been reported from Late Glacial sites in Turkey, for example, Öküzini in Antalya Province (Atakuman et al., 2020, 8).

In the Argolid, just north of Nafplio, microburins were essentially absent at Klissoura Cave 1 (Kaczanowska & Kozłowski, 2018, 258; Kaczanowska et al., 2010, 182), although deposits dated to between 15 and 10 ka BP appear to be missing. However, some were reported from nearby Klissoura Cave 4 (Koumouzelis et al., 2004). Microburins were also absent at Kephalari Cave, just north of Nafplio (Marshall & Elefanti, forthcoming). In contrast, both sites produced abundant quantities of splintered pieces.

Unit IV at Boila is broadly contemporary with Franchthi lithic phases IV to VI, with age estimates from the early thirteenth millennium (13,408–12,141 cal. BP) until the late eleventh (10,639–9,459 cal. BP) (Perlès, 1999, 313). After an apparent hiatus, the microburin technique expanded significantly in phase IV, along with an increase in geometric microliths and a decline in unilaterally backed bladelets (Perlès, 1987, 120, 135, 139, 148–149). Microburins and microliths continued into phase V and then VI. Following another hiatus after phase VI (Farrand, 1988), lasting until the first half of the ninth millennium (9,222–8,341 cal. BP), microburins and microliths were absent from lithic phase VII, replaced by notches, end scrapers, and denticulates (Perlès, 1999, 316). The dates and the presence of microburins suggest a broad temporal and technological synchronism between Franchthi lithic phases IV to VI and Boila unit IV. Both correspond broadly with the end of the Younger Dryas; however, occupation at Boila appears to have ceased during the first half of the eleventh millennium, slightly earlier than the beginning of the hiatus following lithic phase VI at Franchthi. After the hiatus, the cave was reoccupied, with microburins and microliths absent in lithic phase VII. In contrast, Boila was not reoccupied, perhaps suggesting a shift away from upland areas. At Franchthi, it has been suggested that the shift away from microburins and backed industries from phase VII onwards marked a cultural discontinuity and that this was accompanied by changes in subsistence and a decline in the importance of hunting, especially during the latter part of the Mesolithic when marine resources gained in importance (Perlès, 1999, 316; Kaczanowska & Kozłowski, 2018).

Conclusions

Boila, along with other sites in the Vikos Gorge, point to an expansion in the resource base following the Last Glacial Maximum, forming a series of hunting locations, providing access to the craggy slopes of the gorge as well as the north open southern end of the Konitsa Basin and floodplain of the Aoos River and beyond. Whether there are more sites within the gorge remains an open question, as does whether sites such as Klithi formed part of a system of movement within the gorge, or an end in itself. Klithi was occupied earlier, when Boila was still underwater. But soon after the level of the river had fallen and flooding had ceased, the shelter began to be more intensively used. Not long after, by around 16.5 ka cal. BP, Klithi had largely gone out of use. Although not conclusive, this may suggest that the deeper parts of the gorge were less frequently visited and that Bola became a focus for groups operating in the area of the Aoos River floodplain. Despite this, the extremely low average accumulation rates, both in deposits and artefacts, suggest very low intensity use throughout the Late Glacial and into the Younger Dryas. During the Early Holocene, there appears to have been a brief phase of more intense use of the site, along with a reorganisation of space beneath the overhang by relocating the hearth to beyond the dripline, perhaps suggesting the need to accommodate larger numbers of people. Despite this, there was no change in the range of animals hunted, and fauna remains were rare. This final phase of use of Boila coincided with several changes in the lithic repertoire and, in particular, a shift away from backed bladelets towards various forms of smaller backed points and geometric microliths, and a significant ratcheting up of the microburin technique. The presence of double backed points and the proposed Sauveterrian connection, also suggested for Klissoura Cave 1, suggests continuity with the underlying Epigravettian, as well as regional scale trends linking the southern Balkans with Italy, France, and Iberia at this time. Further analysis of dated sequences should shed additional light on why certain elements are seen at some sites but not others. For example, the presence of microburins at Klithi, Boila and Franchthi, and their absence at Klissoura and Kephalari caves, and *visa-versa* for splintered pieces. Why Boila was abandoned is also not clear, given its favourable location on the edge of the Aoos River floodplain. But it probably reflects a more general trend away from upland environments towards coastal areas during the early Holocene.

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Author Contribution Both authors wrote the main manuscript text. Gilbert Marshall prepared the figures and tables, apart from Fig. 1, which was prepared by C. Stergiou. Both authors reviewed the manuscript.

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Data Availability The datasets created during our work on the chipped stone assemblage from Boila are to be archived with the Archaeology Data Service at the University of York in the UK, for which we have agreed a 3-year access embargo, to enable the authors to publish additional studies.

Declarations

Ethical Approval Our work at Boila was based exclusively on the chipped stone assemblage. We therefore believe that there are no ethical issues which need to be addressed.

Consent for Publication The excavator of Boila Rockshelter, Dr. Eleni Kotjabopoulou, has granted her consent for us to publish our results on the chipped stone assemblage. Furthermore, we have study and publication permits issued by the Ephorate of Palaeoanthropology and Speleology and the Ephorate of Antiquities in Ioannina.

Competing Interests The authors declare no competing interests.

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