Middle and early upper Pleistocene human occupations in Southern Italy. A reassessment of the assemblages from Cala d'Arconte, Capo Grosso and Cala Bianca

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Middle and early upper Pleistocene human occupations in Southern Italy. A reassessment of the assemblages from Cala d'Arconte, Capo Grosso and Cala Bianca

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ABSTRACT

In southern Italy, the number of Acheulean sites in a secure stratigraphic context is small and sites with control over the age of the deposit and of the artefacts are even less. The open-air sites of Cala d'Arconte, Capo Grosso and Cala Bianca, located along the Italian south-west coastline, represent, in this context, an important source of information for the Lower Paleolithic.

These sites were discovered and preliminarily studied in 1967–70 by A. Palma di Cesnola and P. Gambassini of the University of Siena, who ascribed them to the Acheulean due to the recovery of several handaxes associated with flaking reduction systems part of which attributed to the Levallois technology. A small number of the handaxes was recovered in its stratigraphic position while Levallois artefacts were collected exclusively on surface, leaving the question about the relations between these two groups unsolved.

Here, the sites of Cala d'Arconte, Capo Grosso and Cala Bianca and their lithic collections are reinvestigated by re-evaluating the stratigraphy at each locality and by analyzing the techno-typology of the available artefacts. During a test trench carried out at Cala Bianca, several Levallois artefacts were discovered *in situ* in the uppermost part of the sequence in a layer located above a tephra recently attributed to the X-6 marker of the Monticchio series dated to 108.33 ± 1.08 ka. We suggest that these *in situ* Levallois artefacts belong to a Mousterian layer that must be considered as the most plausible origin for the Levallois assemblage previously collected out of context at this site. In turn, we also suggest that the Levallois and biface components collected from the surface at Cala Bianca and Capo Grosso derive from distinct occupations in time.

1. Introduction

The decline of handaxes and the development of standardized core technology (e.g., Levallois) mark the shift between the Lower and the Middle Palaeolithic in Europe.

Changes in the proportion of bifaces and/or pebble tools alongside standardized flake production were often associated with the transition from the Acheulean phase to the Mousterian one. Even though presence/absence of handaxes in archaeological contexts continue to be considered as an important chrono-cultural marker (e.g., Moncel et al., 2019; 2020; Sharon and Barsky, 2016), the conventional notion of the Acheulean as a homogeneous cultural entity, mainly identifiable by the occurrence of handaxes, has been partially criticized, as a range of specific issues, like, for instance, function, economic behaviour and environmental constraints, should be taken into consideration when tackling the question of Acheulean diversity and the diffusion of bifacial technology in Europe (e.g., Rocca et al., 2016; Santagata, 2016; Nicoud, 2011).

The Italian Peninsula looks extremely rich in evidence of handaxe technology (Fig. 1). However, the number of sites in a secure stratigraphic context is rather low, and sites with control of the age of the deposits and age of the artefacts are even less. Modern geochronological

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Fig. 1. Distribution of handaxe (red dots) and early Levallois (yellow pentagons) sites quoted in the text. 1: Torre in Pietra; 2: Valle Giumentina; 3: Guado San Nicola; 4: Guardia Sanframondi; 5: Castelpagano; 6: Notarchirico; 7: Cimitero di Atella; 8: Quisisana di Capri; 9: Cala d'Arconte; 10: Capo Grosso; 11: Cala Bianca; 12: Grotta di San Bernardino; 13: Cave dall'Olio; 14: Monte delle Gioie; 15: Sedia del Diavolo. Small black dots indicate the position of other sites with handaxes and isolated findings, not quoted in the text. Source of the digital elevation model: European digital elevation model from the Copernicus Land Monitoring Service - EU-DEM (https://www.eea.europa.eu/data-and-maps/data/copernicus-land-monitoring-service-eu-dem). Studied area in the square. (For interpretation of the references to color in this figure legend, the reader is referred to the web version of this article.)

investigations in volcanic deposits of central-southern Italy successions (e.g., Pereira, 2017; Ceruleo et al., 2019) and systematic research at some among the most important sites in Italy (i.e. Valle Giumentina in Abruzzo – Nicoud et al., 2016; Villa et al., 2016a, Cimitero di Atella and Notarchirico in Basilicata – Abruzzese et al., 2016; Moncel et al., 2019; 2020; and Guado San Nicola in Molise – Peretto et al., 2016; Arnaud et al., 2017) contributed to a better understanding of the chrono-cultural evolution of this phenomenon. However, the Italian Acheulean is still today mostly known through research and studies carried out in the 20th century and has not yet been fully defined either chronologically or technologically, especially when we are dealing with the southern part of the Italian Peninsula. This is particularly true for the Campania region, where the Lower Paleolithic is poorly represented and is only known from old excavations/collections (Piperno and Segre, 1984; Palma di Cesnola, 1982, 2001).

Here, we re-investigate three sites located in the southern fringe of the Campania region in the south of Italy: Cala d'Arconte, Capo Grosso and Cala Bianca (Figs. 1, 2).

The choice to concentrate research on these sites was motivated by the fact that they feature the main and most reliable source of information available for the Campanian Lower Paleolithic but also, to a lesser extent, for that of southern Italy (Palma di Cesnola, 1969; Gambassini and Palma di Cesnola, 1972; Gambassini, 1984). In addition to the scientific interest, the renewed attention for these sites was also due to preservation issues, given that erosion has been progressively destroying the deposits.

The archaeological successions of these sites contain important sedimentary archives of paleoenvironmental and cultural data, which have never been systematically explored. Apart from the reconstruction tentatively proposed by Gambassini and Ronchitelli (1998), the only

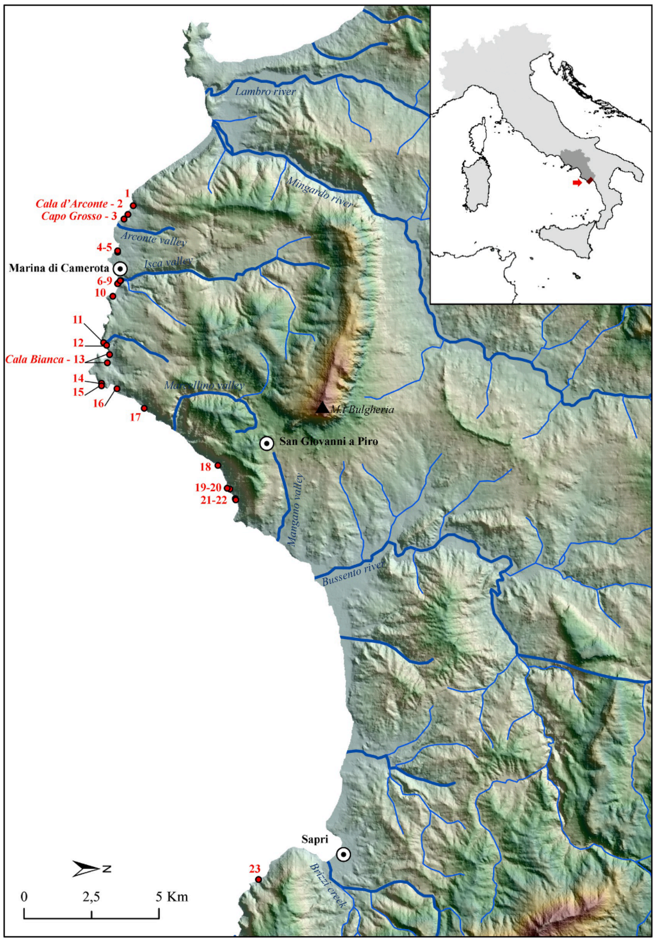

Fig. 2. Location of the main Lower (L), Middle (M) and Upper (U) Palaeolithic sites situated along the costal belt between Palinuro and Sapri. 1: Grotta d'Arconte (M?); 2: Cala d'Arconte (L); 3: Capo Grosso (L); 4: Grotta della Calanca (U); 5: Grotta Taddeo (M); 6: Grotta Tina (M); 7: Riparo Silhar (M); 8: Grotta della Cala (M-U); 9: Grotta-Riparo del Poggio (M-U); 10: Grotta della Serratura (U); 11: Riparo di S. Caterina (M); 12: Pozzallo (M?); 13: Cala Bianca (L-M); 14: Grotta di Santa Maria (M-U); 15: Grotta del Noglio (U); 16: Grotta degli Infreschi (M); 17: Riparo della Difesa (M); 18: Grotta di Cascarella (U); 19: Grotta di Masseta (M); 20: Grotta dell'Acqua (M); 21: Grotta Grande (M); 22: Riparo del Molare (M); 23: Riparo Smaldone (M). Source of the digital elevation model: Environmental Territorial Information System of ISPRA, 20-m resolution DEM (http://www.sinanet.isprambiente.it/it/sia-ispra/download-mais/dem20/view).

reliable chronological indicator is represented by a tephra layer identified in the uppermost part of the sequence at Cala Bianca, dated at 108.33 ± 1.08 ka and attributed to the post-Tyrrhenian X-6 marker of the Monticchio series (Giaccio et al., 2012).

Previous studies ascribed these three sites to the Acheulean due to the recovery of several handaxes. A small number of the bifaces was found in stratigraphic position while the majority were collected on surface in association with flaking reduction systems part of which attributed to Levallois technology. In this study we present an integration of past and new data derived from both the reappraisal of the lithic collections - known so far only from old Italian publications - and the initial results of recent fieldwork.

Recent excavations carried out at Cala Bianca unearthed Levallois artefacts located above the X-6 tephra and we suggest that these *in situ* Levallois artefacts belong to a Mousterian layer that must be considered as the most plausible origin also for the Levallois artefacts previously collected out of context at this site. These results hint that Levallois and biface components collected from the surface at Cala Bianca and Capo Grosso are related to distinct occupations in time, confirming the general trend observed in central-southern Italy where Levallois technology, in a securely dated context, has never been found in association with handaxes (Caramia, 2008; Gambassini and Ronchitelli, 1998; Aureli and Ronchitelli, 2018; Soriano et al., 2017; Villa et al., 2016b).

2. Regional setting, presentation of sites and history of research

The studied sites are located in a historical/natural region of southern Campania known as Cilento (Fig. 2). This territory (especially the coastal belt) is a privileged point of reference for the study of the Palaeolithic, due to the large number of important caves, shelter and open-air sites (Fig. 2), where the different phases of this period are documented by well-articulated stratified deposits.

The whole area has been investigated by the University of Siena since the 1960s. This long-term research activity created a rich record from which a highly informative reconstruction of local Paleolithic evolution has been drawn (Palma di Cesnola, 2001 and references therein). Most of these sites bear evidence of Middle and Upper Palaeolithic occupations and some of them constitute real landmarks for the reconstruction of Neandertal and modern human cultural behaviors on a European scale, as their stratigraphic sequences either cover large time spans or focus on specific periods with great detail (Fig. 2) (e.g., Ronchitelli et al., 2011; Aureli and Ronchitelli, 2018; Martini et al., 2018; Spagnolo et al., 2020).

The open-air sites of Arconte, Capo Grosso and Cala Bianca (Fig. 2) are located along the coastline and correspond to natural cliffs and gullies extending over a large area, with individual outcrops laterally developing even for several tens of meters (Figs. 3, 4 and 5). Geological and archaeological research started in 1968 and went on until 1970 (Gambassini and Palma di Cesnola, 1972). Surface surveys were carried out also in the following years. Unfortunately, no organic remains have been found in either of the three sites.

Geological descriptions of each site were provided by Gambassini and Palma di Cesnola (1972); Gambassini (1984) and Gambassini and Ronchitelli (1998). According to these authors the continental successions of Arconte and Capo Grosso (km 1.5 west and km 2 west-Northwest of Marina di Camerota, respectively) lie, through an unconformity, on a marine conglomerate (layer 1 of Fig. 3). The deposits are composed of (in stratigraphic order): i) aeolian and alluvial reddish deposits (layer 2 of Fig. 3); ii) polyhedrically aggregated sandy clayey paleosol with Fe-Mn accumulations (layer 3 of Fig. 3); iii) brown reddish aeolian sand (layer 4 of Fig. 3) containing a layer of volcanic ash (layer 4a of Fig. 3). Also the series of Cala Bianca (km 3.5 east of Marina di Camerota) (Figs. 4, 5) is described to be composed of four main units (1 to 4 in stratigraphic order): i) Calabrian marine grey-yellowish fossiliferous clayey marl (Sgrosso and Ciampo, 1966) (layer 1 of Figs. 4, 5); ii) coarse-grained aeolian and alluvial red sand, showing pedogenetic features ascribable to a plinthite-type paleosol (layer 2 of Figs. 4, 5); iii) aeolian and alluvial red sand (layer 3 of Figs. 4, 5); and iv) brown aeolian fine-grained sand with limestone concretions (layer 4 of Figs. 4, 5), with an interbedded layer of volcanic ash (layer 4a of Figs. 4, 5). Based on the pedologic study by Ferrari and Magaldi (1979), Gambassini (1984) and Gambassini and Ronchitelli (1998) hypothesized that pedogenesis of paleosol 2 at Cala Bianca occurred during the interglacial isotopic stage 11, whilst the lithic industry inside could date back to MIS 12 (namely to an age of about 450 ka). A different chronology (MIS 9) is, instead, proposed for the formation of paleosol 3 of Arconte and Capo Grosso, where human occupation could have occurred a little before, 360 (MIS 10) ka ago.

The lithic artefacts were mainly collected on surface during surveys. Yet a set of finds, including some handaxes, was recovered from the natural sections of the three successions and from two small test trenches made at Arconte in 1969, thus allowing the identification of the original archaeological layers. Due to the occurrence of several handaxes, the

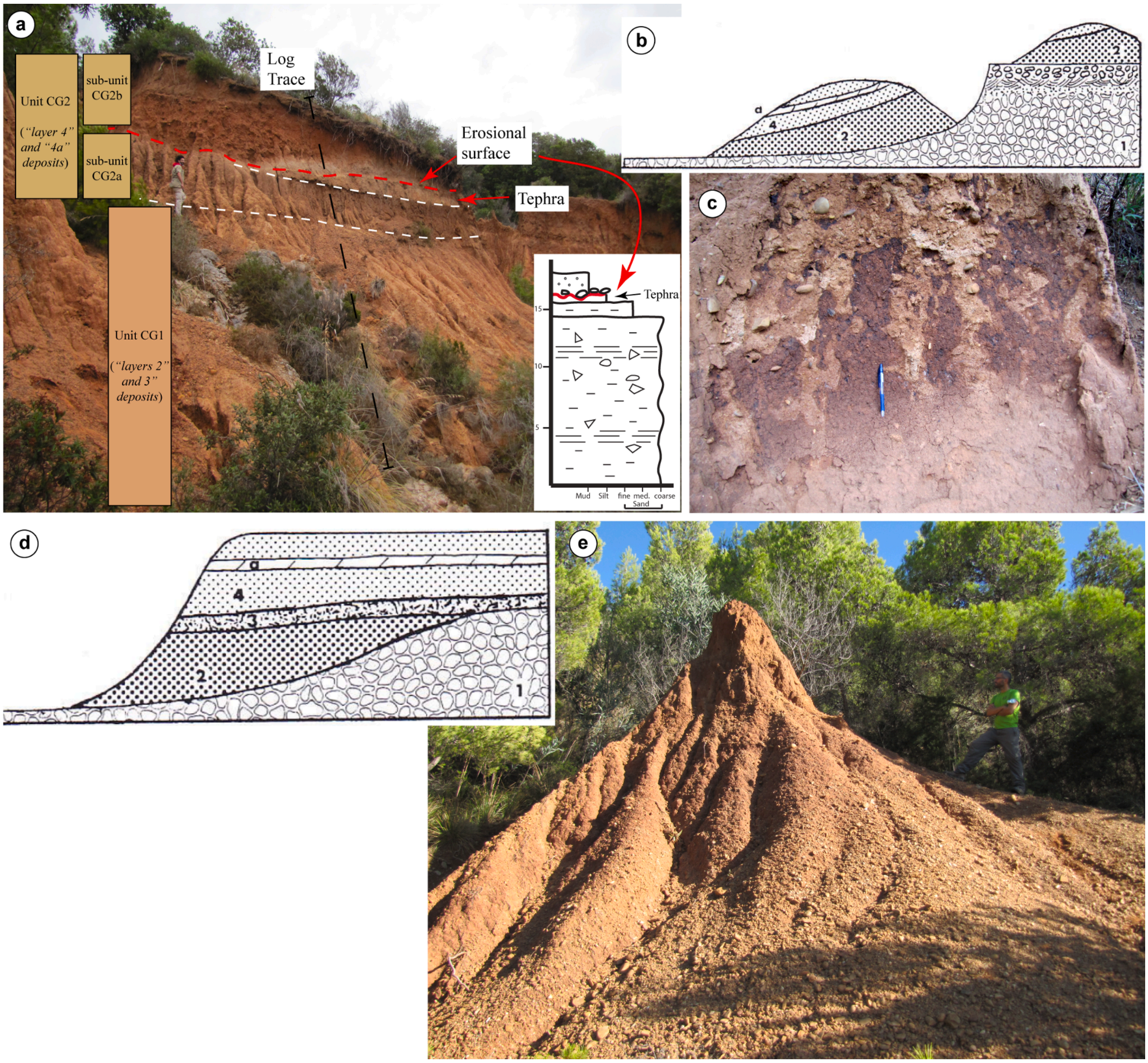

Fig. 3. (a) Panoramic view of the Capo Grosso succession with highlighted the recognized depositional units and the erosional surface at the top of the tephra layer. A stratigraphic log is presented in the right corner of the figure. (b) Original scheme of the Capo Grosso succession proposed by Gambassini and Palma di Cesnola in 1972) (1- bedrock, marine conglomerates; 2–3 aeolian red dune with pebble and Fe-Mg accumulations s; 4- brown-reddish aeolian sand; a- volcanic tuff). (c) Close-up view of the sedimentological features of the pedogenized sandy deposits; note the common occurrence of gravels and debris. (d) Original scheme of the Arconte succession as proposed by Gambassini and Palma di Cesnola in 1972 (1- bedrock, marine clay; 2- aeolian red dune with pebbles; 3- paleosol with localized Fe-Mg accumulations; 4- brown-reddish aeolian sand; a- volcanic tuff Present-day exposure of the Arconte succession. (e) Present-day exposure of the Arconte succession. Original scheme of the Arconte succession as proposed by Gambassini and Palma di Cesnola in 1972 (1- bedrock, marine clay; 2- aeolian red dune with pebbles; 3- paleosol with localized Fe-Mg accumulations; 4- brown-reddish aeolian sand; a- volcanic tuff). (For interpretation of the references to color in this figure legend, the reader is referred to the web version of this article.)

newly discovered sites were automatically attributed to the Acheulean. Based on typological features and the physical aspect, two different phases (A and B) of this cultural entity were recognized at Cala Bianca (Gambassini and Ronchitelli, 1998). The most ancient phase (A) was characterized by worn and, sometimes, "corroded" artefacts of "archaic typology" found in layer 2. Conversely phase B was represented by a set of fresh and more curated handaxes, exclusively found out of context and possibly coming from a more recent Acheulean occupation located somewhere in the upper part of the succession. Since layer 2 of Cala Bianca is missing at Arconte and Capo Grosso (Fig. 3), and the lithic materials (including handaxes), recovered both in the archaeological layers and on surface, appear to be fresher and typologically more "evolved", they were ascribed to the most recent phase (B) (Gambassini and Ronchitelli, 1998).

3. Materials and methods

3.1. Geology

Geological observations were made on the present-day exposures of the three sites. The descriptive sedimentological and stratigraphic terminology used is from Harms et al. (1975, 1982) and Collinson et al. (2006).

3.2. Fieldwork

Fieldwork consisting of surface surveys in the three sites and a brief excavation campaign at Cala Bianca was organized in 2018, with the main aim of i) evaluating the state of preservation of the deposits; ii) testing their current stratigraphic and archaeological potential; iii)

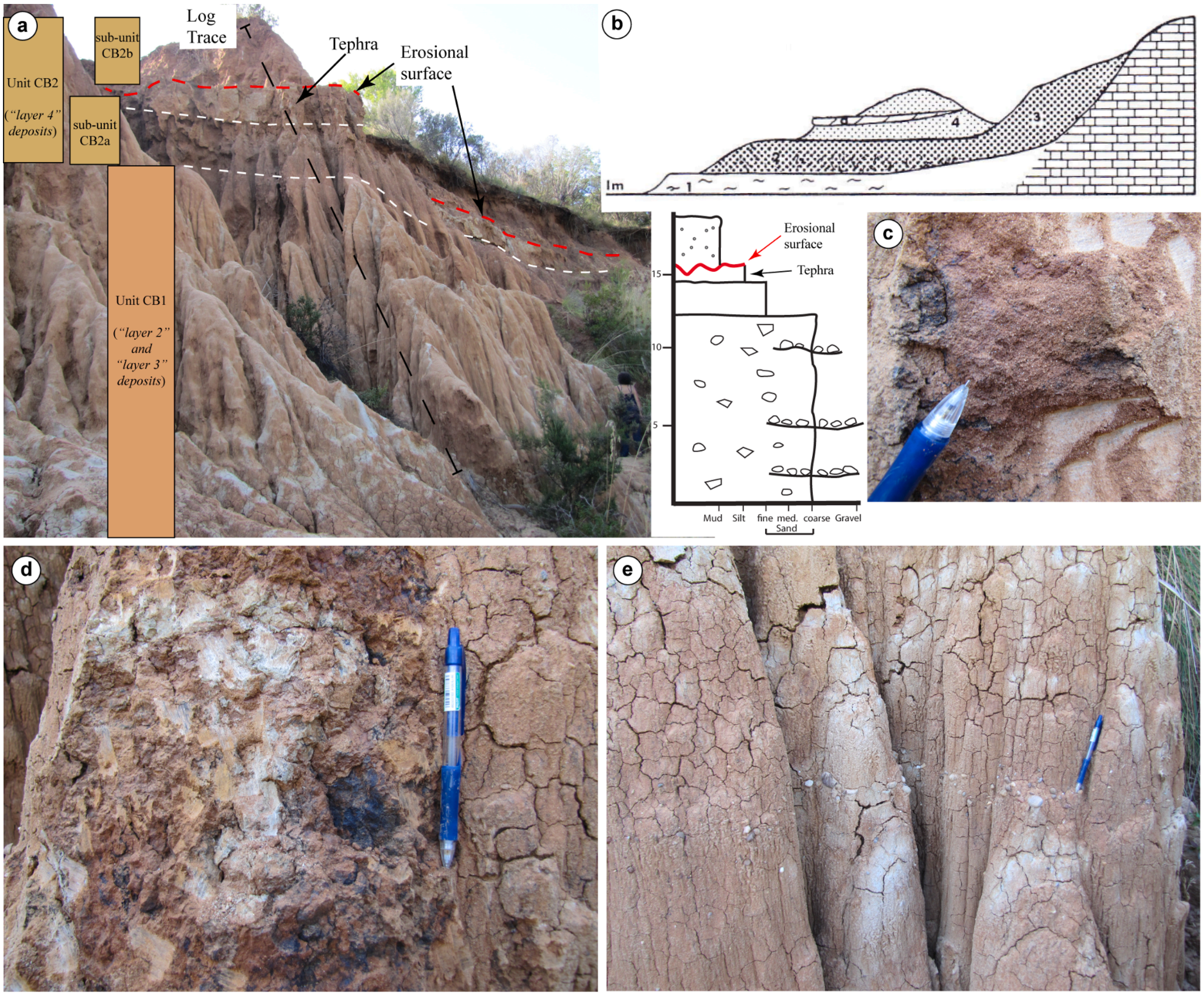

Fig. 4. (a) View of the Cala Bianca succession with highlighted the recognized depositional units and the erosional surface at the top of the tephra layer. A stratigraphic log is presented in the right corner of the figure. (b) Original scheme of the Cala Bianca succession proposed by Gambassini and Palma di Cesnola in 1972 (1- bedrock, marine conglomerates; 2- aeolian red dune; 3- aeolian bright red sand; 4- brown aeolian fine-grained sand; a- volcanic tuff.) (d) Close-up view of the sedimentological features of the reddish sandy deposits. (d) Close-up view of pedogenized features. (e) String of clasts within a sandy dominated interval. (For interpretation of the references to color in this figure legend, the reader is referred to the web version of this article.)

identifying the archaeological layers recognized in 1968–70. Two small test trenches were made at Cala Bianca (Fig. 5) at the base and top of the same 15 m thick section. The first one, named "SondC1" (Sondaggio Calanchi 1), was opened in the lower part of the succession and was 3x1 m wide × 1 m deep. The second trench, named "Sond P1" (Sondaggio Pianoro 1), was dug at the top and was 1x2 m wide × 20 cm deep (for information on the excavation methods see SM1).

3.3. Stone tools

The study of the lithic assemblage includes both artefacts coming from new investigations and from past research. Most of the lithic artefacts are housed in the Department of Physical Science, Earth and Environment of the University of Siena. Few artefacts directly collected from the original archaeological layers by Gambassini and Palma di Cesnola at Capo Grosso and few objects from Cala Bianca and Arconte (2 handaxes and a core from Cala Bianca; a core, 5 flakes and 2 retouched tools from Arconte) are presently stored at the Soprintendenza Archeologia, Belle Arti e Paesaggio of Salerno and at the Naples Museum. These objects are not included in the present study, even if they were described by Gambassini and Palma di Cesnola (1972).

Due to the small number of pieces found *in situ* our study is mainly based on qualitative analyses based on technological and typological attributes. For the artefacts collected on surface we separated heavy-duty tools (handaxes, choppers, chopping tools), cores, formal tools, and flakes. The sorting procedures excluded from a detailed study flake fragments, flakes < 20 mm and chunks. These materials have been counted and bagged by large categories and are available for specific studies. We excluded from the analysis also the few deeply patinated pieces, which are impossible to determine.

The following characteristics were taken into consideration for defining handaxe production: (a) the extension of shaping related to volume management, (b) the presence and the specific management of the tip (convergent or transversal cutting edge), (c) the bifacial and bilateral equilibrium.

Flaking systems were defined taking into consideration the volumetric concept, methods and technique that underlie the reduction process. The definition of Levallois is based on the criteria originally proposed by Boëda (1993, 1994, 1995).

A preliminary study of lithic raw materials was carried out (more extended data on raw materials are available in SM2). A large sample of the lithic assemblage of Cala Bianca, comprising all the heavy-duty tools and a quantitatively representative sample of the débitage elements (cores and flakes), was divided into general groups based on macroscopic characteristics and further divided into lithotypes by means of microscopy observation of microfacies (see SM2). Also, the natural

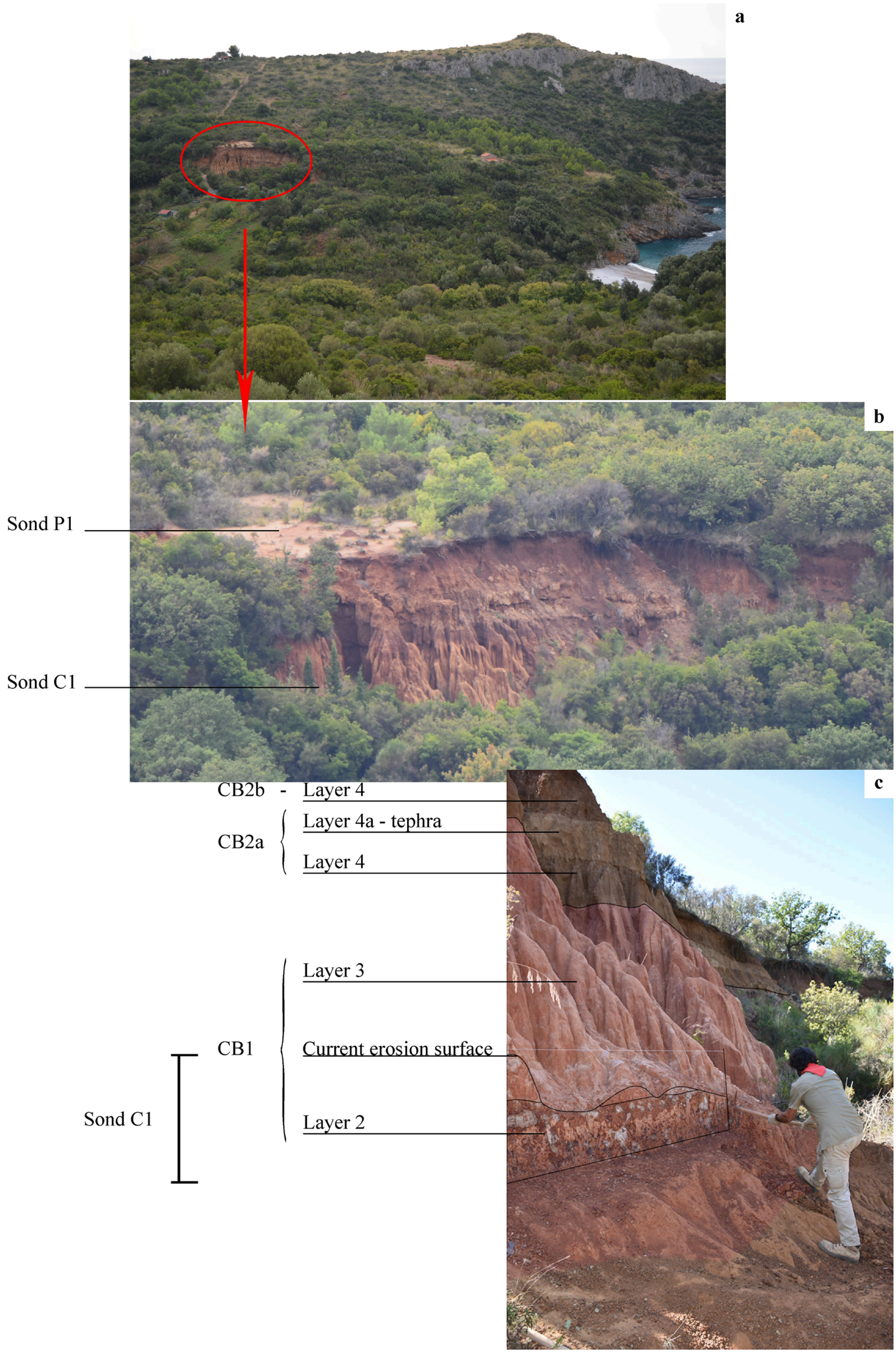

Fig. 5. (a) Panoramic view of the area surrounding Cala Bianca (White Bay). The beach made of white pebbles which gave the name to the Lower Palaeolithic site is clearly visible on the right. (b) Location of SondC1 and SondP1. (c) Stratigraphy viewed from SondC1. Quoted layers are those identified in the last century, correlated to the ones described from sedimentological fieldwork. In the current investigations layers 2–3 correspond to the CB1 unit and layer 4 corresponds to CB2a and b sub-units. Layer 4a corresponds to tephra embedded in unit CB2.

surfaces present on the artefacts were observed in order to determine the source of the raw material blocks. The raw materials of the rest of the assemblage from Cala Bianca and those of the two other sites were compared in a qualitative way to the analyzed sample.

In order to verify the observations made in the past on alterations of the artefacts and compare them with the results of the new investigation, all the heavy-duty tools from the three sites were divided into four main categories according to their surface status (see SM2).

4. Results

4.1. Stratigraphy of Arconte, Capo Grosso and Cala Bianca successions

The successions of Capo Grosso (Fig. 3 A, B, C) and Arconte (Fig. 3 D, E) are presented together due to their stratigraphic similarities and geographic proximity. Observations were made on the succession exposed at Capo Grosso because the Arconte succession has been deeply eroded by natural processes in the last years. Both the successions overlay marine conglomerates (labelled 1 in the original scheme reported in Fig. 3 B) through an unconformity. Even if the present-day conditions do not allow us to appreciate this boundary, such conglomerates are exposed close to the successions (i.e., at Arconte promontory).

The succession exposed at Capo Grosso (Fig. 3) has been subdivided into two main stratigraphic units based on stratigraphic and sedimentological features. They are labelled CG1 and CG2 in stratigraphic order (i.e., from bottom to top, see Fig. 3 A). Unit CG1 starts with some m-thick poorly sorted sand, rich in silt-sized materials, gravels and debris (pebble to cobble in size). These deposits are structureless and only occasionally show a weak plane-parallel stratification. Evidence of an intense pedogenesis is widespread throughout the deposits. Deposits of unit CG1 correspond to “layers 2 and 3” of Gambassini and Palma di Cesnola (1972) and are sharply overlayed by finer-grained sediments of unit CG2. These deposits correspond to “layer 4” in the original scheme. The deposits of unit CG2 can be subdivided into two sub-units (labelled CG2a and CG2b in stratigraphic order) thanks to the identification of an important erosional surface (highlighted in Fig. 3 A). Sub-unit CG2a deposited directly on CG1 sediments and consists of: i) brownish fine - to medium-grained sand about 1.5 m-thick with abundant silty matrix, passing upward to ii) about 0.5 m-thick yellowish tephra deposits. The erosional surface at the top of sub-unit CG2a partially eroded the tephra layer, although at places the erosion reached the sand below with the total loss of the tephra deposits. The erosional surface is locally paved by rounded clasts, up to cobble in size, and is overlaid by sediments of sub-units CG2b, consisting of about 2 m-thick structureless reddish muddy sand, sharply overlaid by some m-thick sand with a less amount of fine-grained matrix.

The deposits of Cala Bianca (Fig. 4 A) are exposed in the two flanks of a valley, while in the central portion of it they are eroded by an ephemeral river. The succession has been subdivided into two main stratigraphic units based on stratigraphic and sedimentological features, labelled CB1 and CB2 in stratigraphic order. Unit CB1 starts with some m-thick poorly sorted and structureless coarse-grained sand (Fig. 4 C), with the common occurrence of gravels, often concentrated to form thin beds or strings (Fig. 4 E). Evidence of an intense pedogenesis is widespread throughout the deposits (Fig. 4 D) and includes: i) Fe-Mn oxides in the form of patinas over clasts, ii) a marked reddish color of the sediments, and iii) vertical white veins. Unit CB1 corresponds to “layer 2 and 3” of Gambassini and Palma di Cesnola (1972) and is sharply overlaid by deposits of unit CB2, that in turn correspond to “layer 4” of the original scheme. Unit CB2 can be subdivided into two sub-units (labelled CB2a and CB2b in stratigraphic order) thanks to the recognition of an erosional surface (highlighted in Fig. 4A). Sub-unit CB2a starts with about 1 m-thick brownish fine-grained sand over which about 0.5 m of tephra deposits occur (“layer 4a” in the original scheme). The tephra layer is overlaid by the aforementioned erosional surface, over which some m-thick reddish muddy sands occur up to the top of the succession (sub-unit CB2b).

Table 1
Lithotype frequencies of a sample of 682 artefacts from Cala Bianca divided between heavy-duty tools and débitage (cores and flakes).

Lithotype	Heavy-duty n.	Heavy-duty %	Débitage n.	Débitage %
Lt1-sandstone (fine grained, light coloured)	21	33.3	23	3.7
Lt2-quartz-arenite (coarse grained, varicoloured)	33	52.4	121	19.5
Lt3-radiolarite (fine grained, greenish-gray)	2	3.2	71	11.4
Lt4-radiolarite (fine grained, brownish-red)	1	1.6	154	24.8
Lt8-radiolarite (fine grained, dark coloured)	0	0	55	8.9
Lt5-chert: silicified calcarenite (grey, coarse grained)	3	4.8	82	13.2
Lt7-chert: silicified calcarenite (grey, fine grained)	2	3.2	72	11.6
Lt11-chert: silicified calcarenite (light grey, fine grained)	0	0	10	1.6
Lt12-metamorphosed chert (fine grained)	0	0	3	0.5
Lt13-chert: silicified mudstone (fine grained, whitish)	0	0	4	0.6
Lt9-chert: silicified limestone (fine grained, grey)	0	0	22	3.4
Lt6-porphyric volcanic rock	1	1.6	0	0
Total	63		619	

4.2. Fieldwork

In SondC1 of Cala Bianca (Fig. 5 b, c) the following succession was identified (in stratigraphic order): a) red sand with white veins and abundance of Mn oxides; b) red clayey sand. According to the recognized pedological alterations this part of the sequence corresponds to the transition between layers 2 and 3 of Gambassini and Palma di Cesnola (1972) and to the lower part of Unit CB1 of recent investigations. No archaeological material was found during the excavation of SondC1. Yet, given the considerable extent of the deposit, this was somehow expected.

In SondP1 (Fig. 5 b) two artificial spits 10 cm each were made in the reddish muddy sands (upper part of layer 4; sub-unit CB2b). The uppermost spit (spit 1) yielded lithic artefacts with sharp and fresh edges, including several Levallois items whereas spit 2 was completely devoid of archaeological materials.

4.3. Stone tools

4.3.1. The lithic sample collected on surface

Lithic artefacts at the three sites were collected in different times in

Table 2
Lithic findings collected on surface.

	Arconte		Capo Grosso		Cala Bianca	
	Num	%	Num	%	Num	%
Handaxes	2	13.3	3	0.5	21	1
Choppers	6	40	10	1.7	28	1.3
Rabots	–	0		0	13	0.6
Cores	3	20	9	1.5	54	2.6
Blades	–	0	7	1.2	29	1.4
Flakes > 20 mm	–	0	108	18.3	335	15.9
Flakes < 20 mm	–	0	275	46.6	176	8.3
Cortical flakes	4	26.7	47	8	61	2.9
Retouched tool on flakes	–	0	5	0.8	171	8.1
Debris	–	0	126	21.4	1223	57.9
Total	15		590		2111	

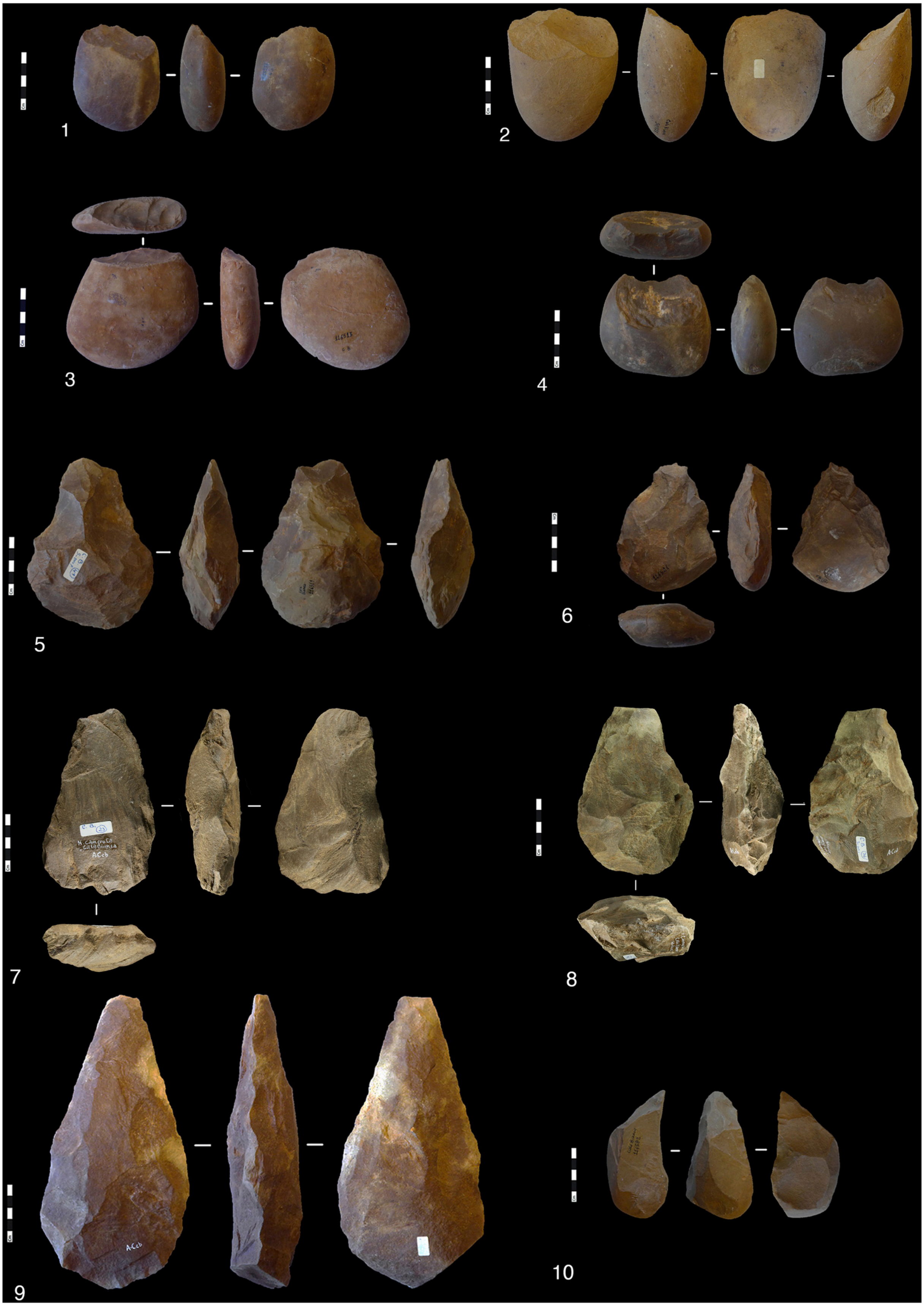

Fig. 6. Heavy-duty tools collected at Cala Bianca. *(Lithotypes, 1, 4–10: Lt2. 2–3: Lt1)*.

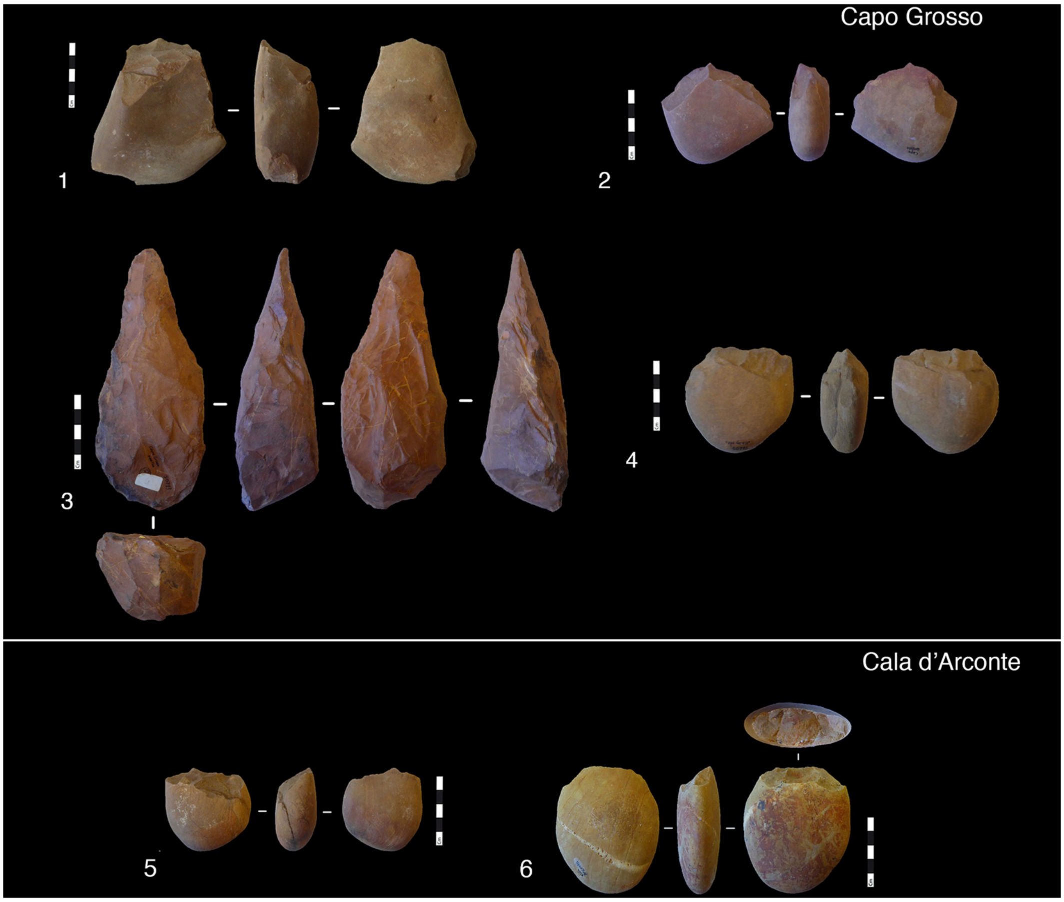

Fig. 7. Heavy-duty tools collected at Capo Grosso and Arconte. *(Lithotypes, 1–2,4–5: Lt2. 3: Lt4. 6: Lt1).*

the surroundings of the exposed sections and found in talus deposits that derived in most cases from the erosion of Pleistocene deposits The lithic raw materials individuated in the broadly representative sample from Cala Bianca comprise quartz-arenite, sandstone, radiolarite and chert even if, within these general categories, several different lithotypes were recognized (Table 1). As shown by preserved natural surfaces, these lithotypes were mostly collected from a secondary source in the form of pebbles and cobbles. The main sources are hypothesized to have been fluvial and marine deposits in the close surroundings of the sites. The qualitative comparison with the rest of the assemblages, both surface and *in situ,* shows a uniform raw material spectrum for the three sites considered.

The presence of numerous small flakes < 20 mm and a conspicuous amount of debris indicates that during the collecting bias based on dimension or techno-types did not occur (Table 2). These features allow us to consider the sampling as reliable and representative.

The three sites attest to repeated occupations through time and in different period. Few unretouched blades collected at Capo Grosso and Cala Bianca show specific technological features that can be correlated to a soft hammer percussion characterized by small, plain, lipped platforms with diffuse bulbs. In absence of more detailed chronological information these elements can be generally correlated to the Upper Palaeolithic or even to Holocene occupations occurred in the area after the erosion of Pleistocene deposits, as attested by the recovery of pottery and dwelling remains referable to the Metal ages close to the present coastline. However, despite these minor occurrences that attest sporadic more recent occupations, the vast majority of the lithic artefacts collected are technologically and typologically ascribable to the Lower and Middle Palaeolithic.

The three sites share the presence of handaxes and choppers. Cala Bianca provided the richest collection and counts 28 choppers and 21 handaxes (Table 2). The choppers of Cala Bianca do not have extended working edges. Two series of detachments shape the cutting edge of the pebble. The shaping is unifacial and more rarely bifacial. The first series of detachments creates a plan-convex or plan-rectilinear cutting cross section. The second series of detachment occurs to regularize the last 2–3 mm of the cutting edge overlapping the first series of detachments (Fig. 6, ns 1 to 4; SM3 Fig. 7).

The working edges have a relatively standardized morphological profile mainly sub-convex or sub-rectilinear. Handaxes of Cala Bianca show heterogeneous features; 11 have asymmetric structures and removals alternate from one surface to the other without a hierarchical organization. As a result of this procedure the handaxes show varying profiles (Fig. 6, n. 5 to 7). In some cases (n. 3) removals partially cover the surfaces, leaving the proximal part of the volume unworked (Fig. 6, n. 6).

Two handaxes show a different volumetric construction. The two faces are similarly shaped giving a symmetric cross section to the volume. (Fig. 6, ns 8, 9). At Cala Bianca 13 tools are partially shaped into a rostrum (or carenoide) shape and can be defined as rabot type (Fig. 6, n. 10). These types of tools were not found at Arconte and Capo Grosso.

Heavy-duty tools at Arconte and Capo Grosso show little divergence compared to what observed at Cala Bianca (Fig. 7).

The choppers have similar features although at Capo Grosso the morphology of the pebbles is more variable including few elements (3 pieces) with a pointed-angulated working edge (Fig. 7, n. 2). The bifacial component falls within the same variability observed at Cala Bianca. Concerning the flaking activities, cores collected on surface in the three sites show diversified patterns that are not easy to attribute to a specific chronological timespan and/or techno-complex. Furthermore, the

Table 3
Core techno-types collected on surface.

	Arconte	Capo Grosso	Cala Bianca
Centripetal cores on secant plan exploitation	3	5	19
Unidirectional cores	0	1	11
Centripetal cores on surface exploitation	0	3	17
Levallois centripetal cores	0	0	6
Levallois lineal cores	0	0	1
Total	3	9	54

Fig. 8. Cala Bianca and Arconte cores and flakes: n.1 core with centripetal secant plan removals from Cala Bianca, n.2 core with centripetal sub-parallel plan removals from Cala Bianca, n.3 core with unidirectional removals from Arconte, n.4 core with unidirectional removals from Cala Bianca, n.5 and 6 Levallois centripetal cores from Cala Bianca, n.7 to 10 Levallois flakes from Cala Bianca. *(Lithotypes, 1–2,4–7: Lr2. 3: Lt1. 8–9: Lt4. 10: Lt3).*

impossibility of reconstructing the complete chaîne opératoire makes it difficult to interpret the reduction process in detail, as well as to identify the objectives of production. For these reasons we classified the cores into broad categories to describe the main technological features.

There are 54 cores at Cala Bianca, 9 at Capo Grosso and 3 at Arconte (Table 3). We identified four main categories of cores. The most common cores refer to a centripetal recurrent exploitation with two sub-variants: a parallel plan exploitation and a secant plan exploitation.

In the parallel centripetal plan exploitation, the angle between the flaking surface and the striking platform of the cores is between 85° and 70° (Fig. 8 n. 2). There are not traces of preparation of the distal or lateral convexity of the flaking surface. Percussion platform is unprepared. These cores were found exclusively at Cala Bianca (n = 17) and Capo Grosso (n = 3) (see Table 3).

The secant plane exploitation systems are present in all the three sites. The débitage starts without preparation, by a series of secant removals (Fig. 8, n.1). Removals can be struck around the core's entire periphery or can be limited to a more or less extended portion of the core periphery, leaving the other part of the volume unexploited. The exploitation is carried out on one surface of the volume and more rarely on both surfaces. In this latter cases cores assume a discoidal morphology. This reduction system is present in all the three sites.

A second group of cores is based on a simple unidirectional exploitation. Removals are directly struck on the core without preparation taking advantage of the natural convexity of the raw material blocks (Fig. 8, n. 4; SM3 Fig. 9 n.2). The lack of preparation of the lateral and distal convexity is a frequent cause of the abandonment of the core after the first series of removals, due to hinged fractures (Fig. 8, ns 3, 4).

The third group of cores was found only at Cala Bianca (n = 7) and according to the parameters defined by Boëda (1993, 1994, 1995) these cores can be fully ascribed to a Levallois volumetric concept (Fig. 8 ns 5, 6). Reduction methods used are centripetal (n. 6) and lineal (n. 1) (Table 3). 77 flakes at Cala Bianca and 23 at Capo Grosso were also found which can be related to this system (Fig. 8, ns 7 to 10).

4.3.2. *The in situ lithic sample*

The lithic sample found *in situ* include artefacts coming from both new and past research (Table 4). Artefact from past research counts 7 pieces, 5 from layers 3 and 2 of Arconte (2 handaxes, 2 retouched tools and one cortical flake) and 2 from layer 2 (CB1 unit) of Cala Bianca (1 large tool "cleaver" and a distal fragment of biface – Fig. 9 A n. 1, 2). The new investigation carried out at Cala Bianca yielded 16 artefacts (from SondP1 – sub-unit CB2b) characterized by fresh edges (Table 4) Among them it is noteworthy the presence of a preferential Levallois core (Fig. 9 n. 3; SM3 Fig. 9, n.1) and three Levallois blanks; one complete flake and two proximal flake fragments (Fig. 9 B, ns 3 to 6).

The cleaver found in layer 2 at Cala Bianca shows highly smoothed edges and a brownish patina. These surface alterations make it difficult to observe the shaping chronology (Fig. 9 A, n.1). However, the tool displays a sub-symmetrical transversal cross-section which is composed by one face shaped through large removals and the opposite face still preserving the rounded cortical surface of the pebble. A second series of retouch scars is present at the tip of the cleaver creating a sub-rectilinear transversal cutting edge of 4 cm (Fig. 9 A, n.1). A second artefact found in the same layer is clearly recognizable as a distal fragment of handaxe with bilateral shaping (Fig. 9 A, n 2).

The two handaxes found at Arconte show a fresher aspect of the cutting edge compared to the cleaver found at Cala Bianca. Shaping removals modified just a portion of the pebble volume (Fig. 10) The remaining part of the volume opposed to the convergence was left unaltered (SM3 Fig. 8).

The first handaxe (reddish-brown quartz-arenite – SM2 Fig. 4) has asymmetrical transverse section (Fig. 10, n.1). Removals are irregular and difficult to read due to the coarse raw material texture. The proximal part on both the bifaces is left unworked. This practice was already observed for some bifaces collected on surface at Cala Bianca (Fig. 6, n. 6). The second handaxe has sub-symmetrical transverse section (Fig. 10, n. 2). Removals partially cover the surfaces and are limited to the distal part and the lateral edges to create a sub-convergent morphology.

Concerning the flaking activities, just two retouched tools and one cortical flake were found in layers 2 and 3 of Arconte (Fig. 10, ns 3 to 5). One element found in layer 3 is a retouched tool on small pebble (greenish-grey radiolarite – SM2 Fig. 5), <5 cm long (Fig. 10, n. 4). One face of the small pebble shows a single flat and large scar with no evidence of conchoidal fracture. These features are comparable with a variant of the splitting procedure which consists in striking the pebble

Table 4
In situ lithic findings.

	Past research (Gambassini and Palma di Cesnola, 1972)		New research
	Arconte layer 2 and 3	Cala Bianca layer 2	Cala Bianca layer 4 (Sond P1)
Handaxes	2	1	0
Cleavers	0	1	0
Retouched tools on flakes	2	0	1
Levallois cores	0	0	1
Levallois-type flakes	0	0	3
Flakes	0	0	2
Flake fragments	0	0	6
Cortical flakes	1	0	3
Total	5	2	16

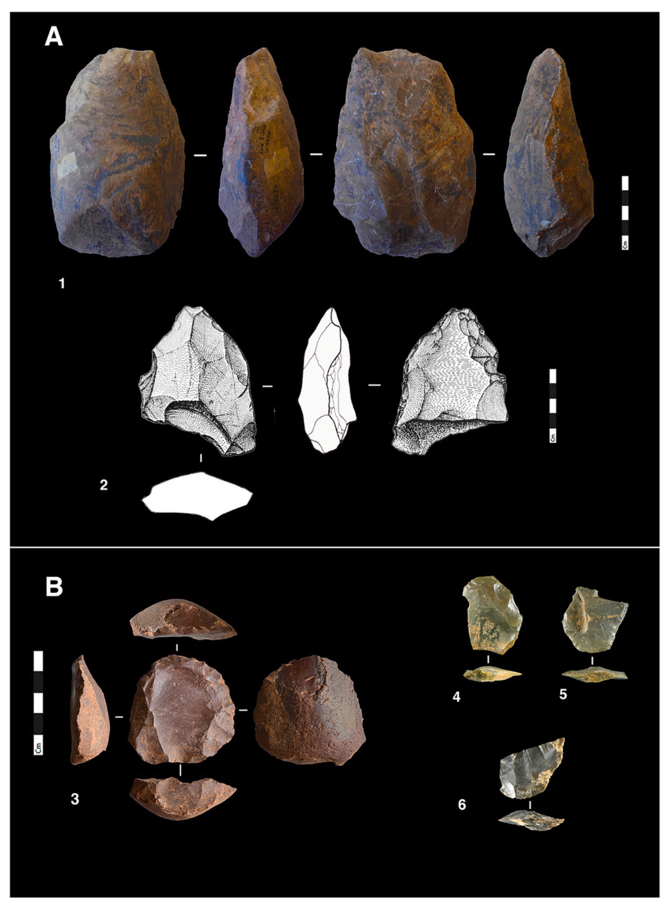

Fig. 9. In situ lithic findings from Cala Bianca. A: Heavy-duty tool from layer 2/unit CB1 (Gambassini and Palma di Cesnola, 1972); B: Levallois pieces from SondP1, layer 4/sub-unit CB2b (new research findings). *(Lithotypes. 1–2: Lt2. 3: Lt4. 4–5: Lt3. 6: Lt7).*

resting on a soft anvil or on the ground (Faivre et al., 2010). The flat surface is used as a striking platform for the retouch that gives a denticulate morphology to the cutting edge. The second tool is a small flake where the retouch creates a convergence (Fig. 10, n. 5).

5. Discussion

According to earlier reconstructions the features recognized in the three investigated successions led to identify a sequence of depositional and paleoclimatic events which can be summarized as follows (Gambassini and Palma di Cesnola, 1972; Gambassini and Ronchitelli, 1998): i) deposition of sandy dunes in arid climate setting (“layers 2 and 3” of Arconte and Capo Grosso, Fig. 3 B, D, and “layers 2 and 3” of Cala Bianca, Fig. 4 B). ii) a subsequent period of warm and humid climate setting that gave rise to a phase of alteration, causing the rubefaction of the sandy deposits and the formation of Fe-Mn oxides. iii) erosion of the previously deposited sediments followed by the accumulation of a new dune (“layer 4”) accompanied by the deposition of tephra (layer 4a dated at Cala Bianca to 108.33 ± 1.08 ka) all over the area.

During new investigations, the identification of an erosional surface located above the tephra layers both at Cala Bianca and Capo Grosso allowed the stratigraphic correlation of these successions. The origin of such erosional surface could be connected to flowing waters in a stream setting as suggested by the rounded clast that paved the surface. According to allostratigraphic principles this surface and the similar features of the depositional units below in both the investigated successions, allow the attribution of the tephra layers exposed in the two sites to the same event.

Regarding the recognized sedimentary facies, their features make the attribution to an aeolian depositional environment doubtful, even admitting an influence by fluvial or marine activity as suggested by Gambassini (1984). The features of the observed sediments, including the general lack of sedimentary structures, the sorting, the average grain size, the occurrence of strings of gravels and the pedogenetic evidence suggest a deposition in a colluvial/alluvial environment (Bull, 1972) instead of an aeolian one. In this view, the vertical variations in grain-size and matrix content observed in all the successions reflect variations in sedimentation rates. Concerning the succession exposed at Cala Bianca, this hypothesis is supported also by the fact that these deposits occur on the flanks of a small paleo-valley. However, their modest preservation and the lack of coeval successions in the axial portion of the paleo-valley prevent the recognition of the feeder system and consequently a definite paleo-environmental attribution.

As a consequence, stratigraphic and sedimentological data record similar depositional settings in all the investigated successions and do not suggest differences in the chronological attribution of the lower portion of the successions. A future specific pedological study of these paleosol complexes can help clarify this aspect.

The recovery of several handaxes confirms the occurrence of Lower Paleolithic occupations characterised by the use of this technology. However, the study of lithic artefacts cannot fully clarify the chronological position of the three assemblages, given the lack of a precise contextualization of most of the finds. The wide typological variability of heavy-duty tools (choppers and handaxes) recorded at Cala Bianca, Arconte and Capo Grosso allows us only to generally place them within the well-known variability attested in the handaxe tradition of the Italian Peninsula. The fresher aspect previously observed by Palma di Cesnola and Gambassini for the artefacts found *in situ* at Cala Bianca and Arconte is, for the latter, confirmed. However, in contrast to what was argued by the same authors, a strict correlation between different types of surface status and specific tool forms (e.g., symmetrical versus asymmetrical handaxes) or core types, collected on the surface, was not found. Large parts of the flaking reduction systems identified cannot be ascribed to a specific chrono-cultural phase. The unidirectional exploitation and the centripetal secant and parallel plan exploitation can be found both in Lower and Middle Palaeolithic contexts.

A major novelty resulting from ongoing investigations is the discovery of Mousterian lithic artefacts in SondP1. The tephra layer (ca. 108 ka), located below, represents a *terminus post quem* for the overlying Mousterian occupation. Such chronological position is consistent with the technological attributes of some lithic artefacts found in SondP1, which are emblematic of a Levallois production.

In the Campania region and more in general in southern Italy, the Levallois is not recorded earlier than MIS 5 (e.g., Gambassini and Ronchitelli, 1998; Aureli and Ronchitelli, 2018). The post-Tyrrhenian position of the Mousterian industry found at Cala Bianca is in accordance with the chronometric data obtained at other sites located along the same coast. All together these data are, indeed, in favor of a recent introduction of the Levallois in the region, if compared to what happens in central-northern Italy (e.g., Torre in Pietra, Monte delle Gioie and Sedia del Diavolo – Soriano and Villa, 2017; Villa et al., 2016b; Grotta di San Bernardino – Picin et al., 2013; Cave dall’Olio – Fontana et al., 2009, 2010, 2013). Riparo and Grotta del Poggio (Fig. 2) contain a 20 m deep Middle Paleolithic sequence lying on a marine conglomerate possibly MIS 7 in age. At this site, a TL date of 111.800 ± 9.500 has been obtained for the onset of the Levallois production in layer 17 (Boscato et al., 2009). In the nearby shelter site of Santa Caterina (Fig. 2), the stalagmite underlying the first layer with Levallois production yielded a U/Th date of 111.300 + 10/-11 thousand years BP (Caramia, 2008). Along the same coast, at Porto Infreschi (Fig. 2), a Mousterian industry with Levallois items was found in a lithostratigraphic unit (LU7) containing a tephra layer attributed to the X-6 marker (~109 ka in age) in its lower portion (Bini et al. 2020). Finally, the whole series of Riparo del Molare (Fig. 2), which is characterized by the occurrence of Levallois industries, lays over a Tyrrhenian beach (Gambassini and Ronchitelli, 1998). Based on the above, we are inclined to think that the Levallois and biface components collected from the surface at Cala Bianca and Capo Grosso are related to distinct occupations in time. This notion is reinforced by the fact that, according to present knowledge, Levallois and handaxes in central-southern Italy seem to be mutually exclusive, with the only exception of Guado San Nicola, dated between 345 and 400 ka, for which, however, the attribution of the flaking reduction system to a Levallois production does not find unanimous consensus (Arnaud et al., 2017; Soriano and Villa, 2017). Therefore, the newly documented Mousterian layer found at Cala Bianca above the tephra dated to the MIS 5 must be considered as the most plausible origin for the Levallois industry collected out of context at this site. The attribution to the Levallois concept of the Levallois-type flakes found at Capo Grosso is less secure because of the lack of Levallois cores. Closely-related reduction systems such as a simpler exploitation by parallel plans can in fact produce flakes with highly similar features to those produced by means of the Levallois concept (see Soriano and Villa, 2017; Li et al., 2019).

6. Conclusions

The Cilento region appears to be a strategic area for providing new data in the debate regarding the technological variability of the handaxe tradition and the processes which led to the transition to the Middle Paleolithic in southern Italy. The results obtained from new research and studies at Arconte, Capo Grosso and Cala Bianca, besides confirming the occurrence of Lower Paleolithic occupations with handaxe technology possibly extending in time and space, allowed us to identify a post MIS5e Mousterian occupation at the top of the Cala Bianca succession. These data support the notion that Levallois and biface technologies recorded in the lithic assemblage found out of context at Cala Bianca are not coeval. This separation between Levallois technology and handaxe confirms a more general trend which can be seen on a larger scale throughout southern and central Italy and that would deserve further investigation. This paper also raises the issue regarding the presence of the two distinct Lower Palaeolithic phases previously proposed on the basis of the morphology and surface status of the lithic artefacts. At this stage of the research, the analysis of the three assemblages did not

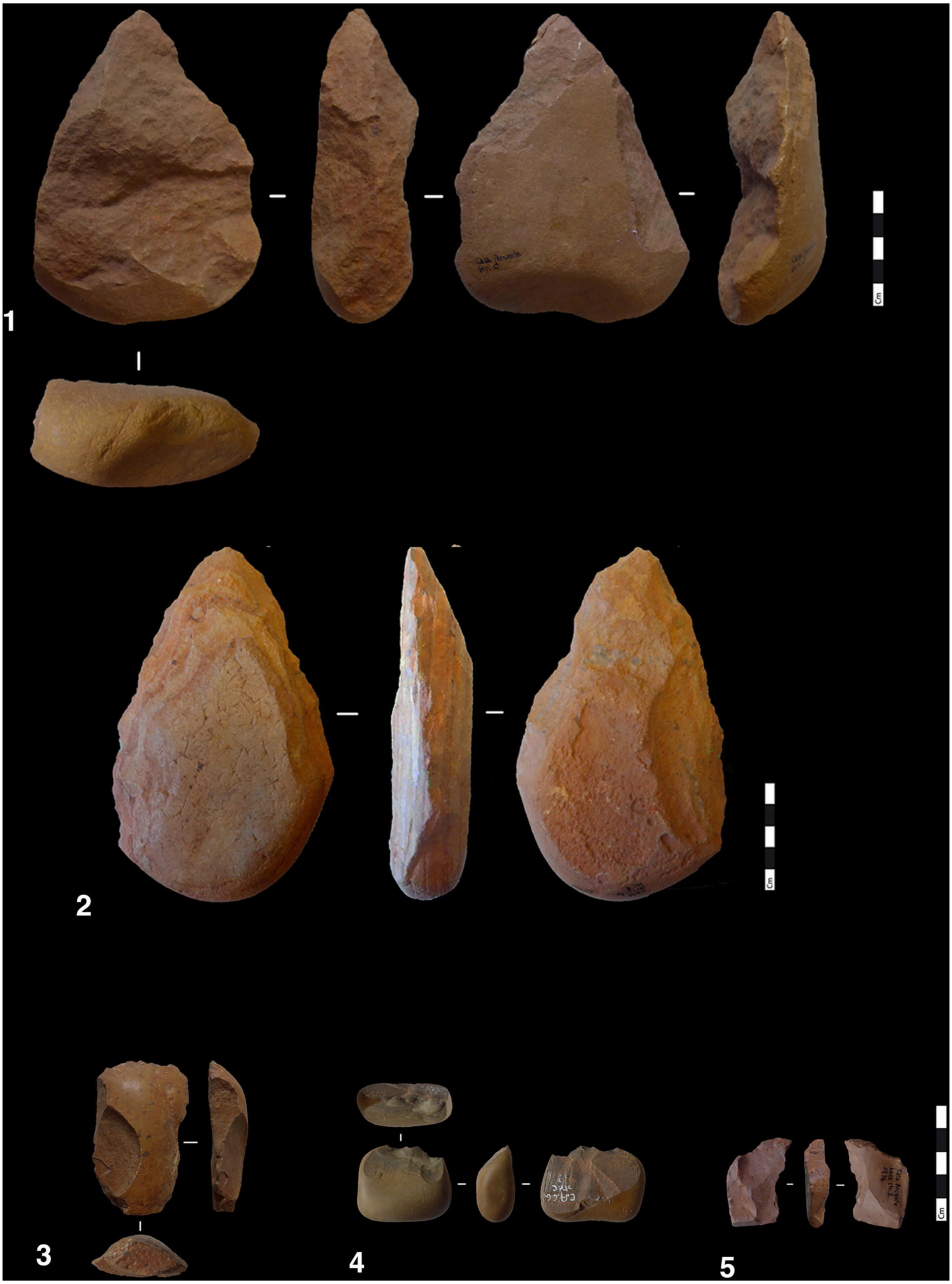

Fig. 10. In situ findings from Arconte layers 2 and 3 (Gambassini and Palma di Cesnola, 1972). *(Lithotypes: 1–3: Lt2. 4: Lt3. 5: Lt4).*

highlight the presence of clearly techno-typologically and chronologically separated phases. Nevertheless, despite the limitations due to the scarce materials found *in situ*, the current study allowed us to better clarify stone tool technology of the lithic assemblages found at Arconte, Capo Grosso and Cala Bianca. Further data from future fieldwork, pedological studies and a radiometric dating program are needed both to verify the actual consistency of the Lower Paleolithic occupation, and to infer reliable and more detailed information on the environmental, chronological and behavioral scenario related to the human groups who lived in the region during the Middle and Early Upper Pleistocene.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Author contributions

A.M. has the scientific responsibility of research in the area of Marina di Camerota for the University of Siena. All the authors conceived and wrote the article. L.C. carried out the technological study of the lithic industry. I.M. provided novel geological results; C.D., M.R. and S.S. performed the study of raw materials; M.R., V.S. and S.S. carried out fieldwork 2018 at Arconte, Capo Grosso and Cala Bianca; V.S., I.M. and L.C. performed Figs. 1, 2 and 5, Figs. 3-4 and Figs. 6-12 respectively.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.jasrep.2021.103256.

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