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1 **Emergence of regional cultural traditions during the Lower Paleolithic: the**  
2 **case of Frosinone-Ceprano basin (Central Italy) at the MIS 11-10 transition**

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13

14 **Abstract**

15 Decades of fieldwork in the Frosinone-Ceprano basin (Latin Valley, Latium, central Italy) have shed  
16 light on numerous open-air Lower Palaeolithic localities, delivering a human fossil calvarium,  
17 thousands of scattered faunal remains and a large collection of lithic industries, including core-and-  
18 flake type lithic series (Mode 1) and Acheulean assemblages (Mode 2).

19 The continuously growing number of available geochronological data (obtained by  $^{40}\text{Ar}/^{39}\text{Ar}$  on  
20 volcanic minerals, ESR/U-series on large mammal teeth and ESR on bleached fluvial quartz) allow  
21 today the construction of a reliable and precise chronological framework for the Lower Palaeolithic  
22 sites of this area of the Latin valley. The archaeological horizons with bifaces all appear to belong to a  
23 relatively short Middle Pleistocene time range, between about 410 and 350 ka, coeval to the end of  
24 the interglacial MIS 11 and to the beginning of the following glacial MIS 10.

25 The Acheulean tools are often associated with cores and flakes. Bifaces are mainly made on  
26 limestone, secondary flint and quartz. The archaeological corpus also yielded tools on fragments of  
27 large herbivore bones. Comparisons between technological strategies and paleo-anthropological  
28 data at the global scale are now meaningful and enable us to decipher hominin behaviour at a more  
29 regional scale. Such careful work is becoming essential in the frame of the recent discoveries showing  
30 that the MIS 11-10 period was a pivotal period characterized by the appearance of several new  
31 archaeological features later associated with the Neanderthal lineage in Western Europe. We present  
32 here the first in-depth technological study of the Acheulean lithic corpus from the major  
33 archaeological sites from the Frosinone-Ceprano basin including the Campogrande localities (CG9  
34 and CG10, intermediate and upper levels), Colle Avarone, Selvotta, Isoletta (level 4), Lademagne  
35 (upper and lower levels) and Masseria Castellone.

1 For this work, we focus on biface shaping strategies and demonstrate technological features  
2 suggesting the existence of networks connecting the different human occupation sites. Technological  
3 data are compared to other penecontemporaneous Italian sites to discuss the hypotheses and  
4 characteristics of such early evidence of regionalization in Europe in this specific area of Central Italy.  
5 It seems indicate that glacial conditions characterized by millennial rapid climatic oscillations could  
6 have been favourable to the development of specific vegetation propitious to human settlement in  
7 South-western Europe. European vegetation, as it drives the biomass availability for large herbivores,  
8 seems hence have played crucial role in the mobility and settlement of human groups.

9

## 10 **Key-words**

11 Italy; Ceprano basin; Acheulean; Marine Isotopic Stages 11-10; bifaces; regionalization

12

## 13 **Introduction**

14 From the hominin evolution perspective, the period ranging between 450 and 350 ka, corresponding  
15 to the interglacial/glacial cycle constituted by Marine Isotopic Stages (MIS) 11 and 10, stands out in  
16 Western Europe as a crucial period. This time threshold, associated in Europe to the Lower  
17 Palaeolithic (and the Acheulean culture) and to the transition towards the Middle Palaeolithic, is still  
18 under-investigated and only few studies discussing the reasons and modes of the appearance and  
19 transmission of Middle Palaeolithic innovations in Western Europe have been published despite the  
20 importance of this period to understand the human settlement of the continent (Moncel et al.,  
21 2020a).

22 The Acheulean culture is commonly linked to the ability to produce bifaces. Other behaviours are  
23 punctually evidenced such as the management of the raw material territory, the production of large  
24 flakes for the LCTs and some innovations such as the independency of the stone shape for the  
25 debitage (*i.e* Moncel et al., 2015, 2020b). Western European archaeological assemblages show that  
26 the MIS 11 interglacial was a threshold period associated with early evidence of regionalization of  
27 cultural traditions after the intense MIS 12 glacial period, considered as a major climatic crisis for  
28 hominins and fauna in this area (Moncel et al., 2017, Pereira et al., 2018). After this glacial phase, we  
29 observe an increase in the number of well-preserved occupation levels and the appearance of new  
30 subsistence behaviours (hunting organization, specialization on one or some species of large  
31 mammals, seasonal occupations depending on the location of the site and land use patterns) and  
32 technical innovations (appearance of core technologies, increase in light-duty tools, fire  
33 domestication) in Western Mediterranean and more especially in Italy (Villa et al., 2016, Pereira et  
34 al., 2017, 2018). These behavioural changes and innovations suggest, by their nature and diversity,  
35 an increase in cognitive capacities of the hominins illustrated by new skills and social interactions

1 with site networks. Furthermore, the beginnings of the control of fire could have contributed to the  
2 development of behavioural abilities and to the extension and organization of territories. However,  
3 the reasons underlying these behavioural changes, pushing back the roots of the Neanderthal world,  
4 have yet to be identified. (1) Was this behavioural evolution rooted in previous traditions? (2) Was it  
5 due to the arrival(s) of new populations or to the on-site evolution of Neanderthals from *Homo*  
6 *heidelbergensis* or another Middle Pleistocene hominin ancestor? (3) Was there a population  
7 increase conducive to early regional networks of sites and the diffusion of innovations? (4) Was it  
8 due to local environmental adaptation to climatic changes? (Moncel et al., 2018).

9 The last hypothesis is supported by the available climatic and environmental reconstructions. Indeed,  
10 MIS 12 is known as one of the most arid glacial periods of the Quaternary (Shackleton, 1987, Tzedakis  
11 et al., 2003, Masson-Delmotte et al., 2010, Rohling et al., 2014). In contrast, the subsequent MIS 11  
12 interglacial was exceptionally long (more than 20 ka, whereas typical interglacial duration is ~13 ka,  
13 Tzedakis et al., 2012). Such a long-lasting interglacial period after a harsh glacial stage could have  
14 been favourable to the development of vegetation propitious to animal and human settlement in  
15 Western Europe. European vegetation, as it drives the biomass availability for large herbivores,  
16 affects the mobility of animal and human groups and it is therefore crucial for this point of view.

17 In order to better understand the impact of the MIS 11-10 period on human settlements in Central  
18 Italy, we have studied lithic assemblages recovered from sites located in the Frosinone-Ceprano  
19 (Pofi) basin (Latin Valley, Latium, Central Italy). This area is renowned for the discovery in 1994 of a  
20 fragmented human calvarium, firstly erroneously attributed to *Homo erectus* and now relied to  
21 *Homo heidelbergensis* (Ascenzi et al. 1996, 2000; Manzi et al., 2001; 2010; Manzi, 2012, 2016; Di  
22 Vincenzo et al., 2017). Initially considered as dated around 900-800 ka, this human fossil was recently  
23 re-dated by a multidisciplinary approach, including magnetostratigraphic and  $^{40}\text{Ar}/^{39}\text{Ar}$  analyses (e.g.,  
24 Nomade et al., 2011; Biddittu et al., 2019). The refined chronology indicates that humans probably  
25 lived in Central Italy during the cold period of marine isotope stage (MIS) 12 and the subsequent  
26 warm period of MIS 11. Despite its archaic morphological features and lack of Neanderthal traits, the  
27 Ceprano calvarium is therefore contemporaneous with derived hominins such as the ancestors of  
28 Neanderthals (Manzi et al. 2010; Manzi, 2016).

29 Decades of surveys in the Frosinone-Ceprano basin have yielded lithic industries in numerous  
30 localities dispersed in a relatively small area. The series are limited in number but sufficient to  
31 compare the technological processes between localities and to discuss possible connections between  
32 sites. The geochronological and palaeo-environmental framework available for Central Italy permits  
33 then to discuss the hypothesis of networks of sites and investigate a possible early cyclic process of  
34 regionalization during prehistoric times, much earlier than those highlighted for late Neanderthals  
35 during MIS 4-3 (*i.e.*, Burke et al, 2008; Deujard and Moncel, 2010; Faivre et al 2017).

- 1 Several issues motivate the analysis of the Frosinone-Ceprano lithic series:
- 2 -What are the modalities of biface production and core technologies during the MIS 11/10 timescale
- 3 in the basin?
- 4 -Are there common technological features and differences in biface production evidenced in all the
- 5 studied localities?
- 6 -Do these technological features provide evidences of traditions and/or regionalization in the Italian
- 7 peninsula and more generally in Southern Europe during the MIS 11/10 timescale?
- 8 -If common technological strategies exist, can we assume that the localities are part of a network of
- 9 nearby sites in a small area?
- 10 -How can we explain the differences in technological strategies and toolkits (presence or not of Large
- 11 Cutting Tools-LCTs)? Could they be due to the location or functions of the sites, or eventually to the
- 12 diversity of traditions inside the basin (palimpsest of networks)?

13

## 14 **The archaeological data**

### 15 ***General archaeological and geological context***

16 The archaeological sites investigated in our study are located in the Latin Valley (Latium, Central

17 Apennines), on the Tyrrhenian side of the Apennines chain (**Fig. 1**). This valley is geographically

18 enclosed between mountains to the northeast (Simbruini-Ernici mounts) and southwest (Lepini-

19 Ausoni-Aurunci carbonatic mounts), and volcanic complexes to the west (Colli Albani) and southeast

20 (Roccamonfina) (Marra et al., 2009; Rouchon et al., 2008). The tectonic depression of the Latin Valley

21 consists of several extensional basins formed because of the evolution of the Late Pliocene-Middle

22 Pleistocene Apennines normal fault system (Carrara et al., 1995; Boari et al., 2009). The Frosinone-

23 Ceprano basin, in which all the archaeological sites investigated in this study (Campogrande, Colle

24 Avarone, Selvotta, Isoletta, Lademagne and Masseria Castellone) are located, represent along with

25 the Anagni basin the main sedimentary basins of the valley. Due to the intense volcanic activity

26 occurred during the Middle Pleistocene along the Tyrrhenian marge, volcanic effluents (tephra layers

27 or free volcanic minerals) were regularly deposited in the sedimentary sequences recorded in these

28 basins, including archaeological ones. The main volcanic sources of these effluents are mainly located

29 along the Tyrrhenian marge (Colli Albani, Roccamonfina, Sabatini and Vico volcanic districts), but

30 include also the local Middle Latin valley volcanic field complex (MLVVF), sometimes called

31 Ernici/Volschi cones, located in the heart of the Latin Valley (Civetta et al., 1979; Karner and Renne,

32 1998; Giannetti, 2001; Rouchon et al., 2008; Marra et al., 2009, Pereira et al., submitted). This

33 complex consists of about twenty monogenetic cones, the most active of which being the Pofi and

34 Ceccano edifices (Basilone et Civetta, 1975; Civetta et al., 1979, see **Fig. 1**). All these volcanic edifices

1 were very active during MIS 11 and MIS 10, causing direct impacts on the various environments  
2 bearing the Frosinone-Ceprano basin human occupations. All the archaeological sites presented in  
3 this contribution are coeval with this local volcanic activity from a narrow time range of about 50 ka  
4 (c.a. 410-350 ka), spanning from the MIS 11 optimum to the MIS 10 glacial onset (see **Fig. 2**, Manzi,  
5 2016; Pereira et al., 2018).

6 From a climatic point of view, the MIS 11- MIS 10 period was, in Central Italy and more largely in the  
7 Mediterranean basin, suitable to the development and subsistence of hominin populations. Indeed,  
8 the MIS 11 was one of the warmest and longest (20-30 kyrs) Quaternary interglacials (Karner and  
9 Marra, 2003) and the MIS 10 Glacial stage was characterized in the Mediterranean basin by  
10 mild/temperate conditions followed at the end by a brief period more drought. Several  
11 palaeoclimatic and palaeoenvironmental records of the Mediterranean area (e.g. sea surface  
12 temperature records, Girone et al., 2013; Lake Ohrid and Tenaghi Philippon pollen diagrams, Tzedakis  
13 et al., 2006, Sadori et al., 2016, Wagner et al., 2019) suggest indeed rather favourable climatic  
14 conditions during MIS 10 with no significant reduction of the arboreal taxa. In the neighbour Boiano  
15 basin (Molise), pollen's assemblage studies led by Orain et al., (2013) have demonstrated the  
16 persistence of high edaphic humidity during the MIS 11-10 period. In this study the authors  
17 suggested that these specific conditions may have privileged the existence of refuge area for arboreal  
18 taxa and thus could have provided subsistence resources and had a significant effect on the  
19 demography of human populations (Orain et al., 2013, Moncel and Schreve in 2016). It is also worth  
20 noticing that palynological analyses of the sedimentary unit stratigraphically located just below the  
21 layer where was found the Ceprano calvarium in the Campogrande archaeological area have been  
22 recently provided (Margari et al., 2018). These two sedimentary layers are separated by an erosional  
23 surface attributed by the authors to the glacial stage MIS 12. The pollen assemblage of this layer is  
24 dominated by the arboreal species *Corylus*, *Carpinus betulus*, deciduous *Quercus* and *Abies*. These  
25 analyses have allowed the authors to identify two forested phases. Based on biostratigraphical and  
26 sedimentological data this sequence has been attributed to the MIS 13 interglacial and by analogy  
27 the authors encouraged a MIS 11 age for the archaeological levels of Campogrande. All these climatic  
28 specific conditions of the Mediterranean basin may also have contributed to the good preservation  
29 of archaeological sites in Central Italy during this period. This time range is also coeval to a significant  
30 renewal of the faunal groups takes. The post- MIS 10 period corresponds to the transition between  
31 the Galerian and Aurelian Large Mammal's periods (Milli and Palombo, 2005, Marra et al., 2018). It  
32 should be noticed that the most part of the paleontological assemblages of the sites investigated in  
33 this study are all attributed to the final Galerian.

34

35 ***Campogrande, Colle Avarone and Selvotta localities***

1 The stratigraphic sequence of the Frosinone-Ceprano basin comprises an extensive lacustrine  
2 formation, called the Lirino lake sequence, mainly recorded in the South-eastern part of the basin  
3 (Devoto, 1965; Carrara et al., 1995; Centamore et al., 2007). This lacustrine formation is oriented  
4 NW-SE (from Ceprano to Cassino-Pignataro Interamna) and reached its maximum extension (35 km)  
5 during the Middle Pleistocene.

6 The deposits are characterized by a total maximum thickness of about 100 m and were divided into  
7 two main geological units, LR1 at the base and LR2 at the top (Devoto, 1965; Carrara et al., 1995;  
8 Centamore et al., 2007, Centamore and Dramis, 2010, Manzi et al., 2010). Most of the Lirino  
9 formation is made up of fluvio-lacustrine and volcanic derived deposits. The final phase of the Lirino  
10 basin infilling (top of LR2), associated to lacustrine facies, was dated by Nomade et al. (2011) to  
11 about  $353 \pm 4$  ka ( $2\sigma$  analytical uncertainties). This final phase of the Lirino sequence (LR2) was  
12 identified in the sequences of the investigated sites.

13 Similar stratigraphic contexts have been evidenced by I. Biddittu in 1974 on the Campogrande, Colle  
14 Avarone and Selvotta outcrops that are mainly constituted by gravels, sands and sandy-clays.  
15 Quaternary deposits present a thickness of about twenty meters in these three localities (between  
16 125 and 102 m a.s.l.) and lay in unconformity above Messinian fluvio-lacustrine deposits (Biddittu,  
17 1974). Regarding the function of the sites where fauna and artefacts are found are generally at a  
18 comparable altitude and in levels of sand and small gravels, which suggest the presence of vast  
19 territories close to fluvial and peri-lacustrine formations. These areas seem to have been explored by  
20 hominins periodically, particularly along rivers. These hominines would thus have carried out  
21 different types of activities related to the exploitation of plant and animal resources.

22

23

24 *Campogrande localities \_ CG 9 (CG9A = 41°31'48.6" 13°28' 54.1" and CG9B = 41°31'49.9" 13°28'*  
25 *54.0") and CG 10 (CG10A = 41°31'32.2" 13°28' 54.5", CG10B = 41°31'31.1" 13°28' 53.3" and CG10C =*  
26 *41°31'29.7" 13°28' 57.1")*

27 The Campogrande archaeological area (120-115 m a.s.l.) is located 3 km SE of the city of Ceprano (see  
28 **Fig. 1**). Palaeontological and archaeological remains were found in twelve localities of this area,  
29 named from CG 1 to CG 12 (CG for Campogrande), some of which containing more than one  
30 archaeological level. CG 1 corresponds to the pioneering site, where the Ceprano calvarium was  
31 found (Ascenzi et al., 1996, 2000; Manzi et al., 2001, 2010; Manzi, 2012, 2016; Di Vincenzo et al.,  
32 2017).

33 Two excavations were carried out at CG9 between 2001 and 2006 (Biddittu et al., 2019). They started  
34 from a surface located about 3 m deep with respect to the ancient excavating level associated to a

1 paleo-channel constituted by gravels and sands. In this excavating area were found fauna fossils and  
2 Acheulean pieces. All the materials studied in this contribution were yielded from both these  
3 excavation campaigns and previous surveys. This level attests to the presence of waterways that  
4 have drained paleo-surfaces that contained both the remains of faunas and the lithic artefact.  
5 According to these new excavations data and previous ones, it appears that the all archaeological  
6 levels identified at Campogrande are restricted into the end of the Lirino paleo-lacustrine sequence,  
7 in the northern part of this paleolake (Manzi, 2016).

8 The geological layers at Campogrande are rich in volcanic material originating from neighbouring  
9 volcanoes and in 2011, Nomade et al. obtained an  $^{40}\text{Ar}/^{39}\text{Ar}$  age of  $353 \pm 4$  ka ( $2\sigma$  analytical  
10 uncertainties) for a clayey geological layer rich in K-feldspars, stratigraphically located above the  
11 palaeo-anthropological horizon. This chronological constraint thus providing a *terminus ante quem*  
12 age to the human fossil (see **Fig. 1, 2**). Among the twelve Campogrande archaeological localities, two  
13 have delivered an abundant archaeological assemblage: CG 9 and CG 10 (Manzi et al., 2016). Most of  
14 the archaeological material recovered at CG 9 and CG 10 is on display at the Pietro Fedele Museum  
15 at Pofi (Frosinone province, Latium) (Biddittu et al., 2019). The simplified stratigraphic log of  
16 Campogrande sequence, with the positions of the CG 9 and CG 10 archaeological levels, is shown in  
17 **Fig. 2** (modified from Pereira et al., 2018). At CG 9, only one significant archaeological level was  
18 found in the upper part of the section (CG 9 upper), whereas at CG 10, three different human  
19 occupations levels were identified (CG 10 lower, CG 10 intermediate and CG 10 upper). Between  
20 2001 and 2006, fieldwork investigations were conducted at CG 9, resulting in the enrichment of the  
21 upper CG 9 archaeological corpus (Margari et al., 2018). Acheulean industries are recovered in level  
22 CG 9 upper, CG 10 intermediate and CG 10 upper. Few lithic tools were found in intermediate CG 10  
23 and lower CG 10 is only associated with core-and-flake industries. These archaeological horizons  
24 (excepted lower CG 10) are stratigraphically located above the layer dated in Nomade et al., 2011,  
25 suggesting a maximum age of  $353 \pm 4$  ka ( $2\sigma$  analytical uncertainties) for the archaeo-surfaces.

26 *Colle Avarone (41° 32' 10.44"N 3° 28' 38.22"E)*

27 Concerning both Colle Avarone and Selvotta it is worth noticing that findings made over the years  
28 came for most of them, from archaeological excavations, while others were collected in a small  
29 agricultural plot where the archaeological surface constituted by sands and gravels layer was clearly  
30 evidenced. Colle Avarone archaeological site (about 120 m a.s.l.), very close to the Campogrande  
31 localities, is located in the lower valley of the Sacco River, a few kilometres upstream of the  
32 confluence with the Liri River (Biddittu, 1974, see **Fig. 1**). The locality was discovered in 1973 by Italo  
33 Biddittu in a quarry ("pozzolana cava") which no longer exists.

34 A small excavating area conducted in a sedimentary level constituted by sands and gravels have been  
35 opened in 1975 by I. Biddittu. This level was identified on a small gravel pit exploited at that time at



1 the base of a section of about 4 m high in front of an older quarry (Colle Avarone in the original  
2 definition was perhaps Colle Cavarone for the presence of quarries). From this small essay came out  
3 a bone "dagger" made from an elephant rib whose length was determined by an intentional fracture  
4 facilitated by a notch performed transversely in the bone. This essay is about 15 m from the point  
5 where the recent sampling was done on the levels alongside the road.

6 One main archaeological level, containing Acheulean and bone industries, was identified (Biddittu,  
7 1974). From a sedimentological and geological point of view, the archaeological remains were  
8 discovered into fluvio-lacustrine deposits rich in gravels and K-rich volcanic minerals (leucites and  
9 potassium feldspars) corresponding to the final infilling of the Lirino paleolake basin. A simplified  
10 stratigraphic log of Colle Avarone is presented in **Fig. 2** and further stratigraphic information can be  
11 found in Biddittu, 1974 and Biddittu and Segre, 1984. The archaeological level found below a  
12 paleosol, is mainly constituted by gravels and altered leucites. Biface tools, usually symmetric, are  
13 dominant in the lithic assemblage (Biddittu and Segre, 1984). The palaeontological assemblage  
14 mainly comprises Middle Pleistocene large mammal species (or taxa) (*Palaeoloxodon antiquus*, *Sus*  
15 *scrofa*, *Equus caballus*, *Bos primigenius*, *Cervus elaphus*), avifauna (*Stercorarius longicaudatus*, *Anser*  
16 *brachyrhynchus*) and turtles (*Testudo* sp.). The birds and the occurrence of *Cuon* sp. remains suggest,  
17 according to Biddittu and Segre (1984), a cold environment during the human occupation level.

18

19 *Selvotta* ( $41^{\circ} 32' 10.44''N$   $3^{\circ} 28' 38.22''E$ )

20 Selvotta locality is directly adjoined to the section of Colle Avarone (about 120 m a.s.l., Biddittu,  
21 1974, see **Fig. 1**). So far, no scientific publication has been devoted to this archaeological locality.  
22 Only one Acheulean archaeological level has been brought to light and the most part of the lithic  
23 tools were surface collected. Both lithic and bone tools were recovered at this site. Italo Biddittu  
24 proposed a geological correlation between the archaeological level of Selvotta and the  
25 archaeological level of Colle Avarone (CA and the archaeological levels CG 9 and CG 10 upper from  
26 the Campogrande localities (see Fig. 2). All these levels are characteristic fluvio-lacustrine deposits,  
27 with gravels and volcanic minerals, of the Lirino paleo-lake that occurred during the MIS 11/MIS 10  
28 transition period (Nomade et al., 2011; Biddittu et al., 2019).

29

30  $^{40}\text{Ar}/^{39}\text{Ar}$  dating on single K-feldspar crystals extracted from Selvotta and Colle Avarone sandstones  
31 are currently in progress to confirm or infirm the stratigraphic attributions and correlations.

32

33 ***Isoletta, Lademagne and Masseria Castellone localities***

34 *Isoletta* ( $41^{\circ}31'44.86''N$ ,  $13^{\circ}34'0.16''E$ )

1 The Isoletta archaeological site (~105 m a.s.l., Biddittu, 1974, 2004; Pereira et al., 2018), discovered  
2 in the 1970s, is located at the confluence between the Sacco and Liri rivers only a few kilometres SE  
3 of Ceprano city. A large excavating area was conducted in 1998 and 1999 and was focused on the  
4 Acheulean level (Isoletta L4) and the inferior sedimentary levels only. The stratigraphic description of  
5 the site was established during this excavation following the high-speed train railway construction,  
6 which that helped exposed a 30-m-thick section (Biddittu, 2004). The sequence, which is no longer  
7 accessible, is mainly composed of alluvial deposits including sands, gravels and volcanic material  
8 related to the final lacustrine phase of the Lirino basin infilling (see **Fig. 2**). Two archaeological levels  
9 were evidenced in the Isoletta sequence but only the uppermost level presents Acheulean industries  
10 (Level 4, labelled GA6Z in Pereira et al., 2018 (Biddittu, 2004)). Palaeontological remains found in  
11 level 4 are associated with the Galerian large mammal assemblage (Biddittu, 1974; Milli and  
12 Palombo, 2005).

13 Rare mode 1 artefacts and remains of mammals, birds, amphibians and fish were found in the lowest  
14 archaeological level (Pereira et al., 2018). A tibia of elephant was found in this level, it was  
15 intentionally fractured by the hominids. The lower part of the sequence is more lacustrine, very rich  
16 in silt, and has delivered abundant molluscs and vegetation debris.

17

18 *Lademagne (41°31'16.68"N, 13°35'0.72"E)*

19 The Lademagne site, discovered in 1965 (105 m a.s.l.), was found in a very active tectonic area in the  
20 North-West part of the Lirino lake sedimentary basin. It is only located 5 km west of Isoletta near the  
21 city of San Giovanni Incarico (Biddittu et al., 2012, see **Fig. 1**). Most of the Lademagne sequence is  
22 made up of clays, sands, silts, gravels and reworked volcanic deposits corresponding to an alluvial  
23 terrace. Gastropods found in level 3 (*Planorbis* sp., *Valvata cristata*, *Pisidium* sp.) indicate a lacustrine  
24 habitat (Comerci et al., 2015). At Lademagne, two archaeological layers separated by 5 m of  
25 thickness of sediments were identified with very similar archaeological and palaeontological  
26 assemblages (Biddittu et al., 2012). They are comprised in gravels and sands sedimentary levels  
27 (Biddittu et al., 2012). Unlike at Isoletta, Acheulean and bone tools were found in both levels. The  
28 Lademagne palaeontological assemblage is associated with the Galerian Large Mammal Age (Milli  
29 and Palombo, 2005; Biddittu et al., 2012) and the upper level assemblage includes *Palaeoloxodon*  
30 *antiquus*, *Hippopotamus* sp., *Dicerorhinus* sp., *Dama clactoniana*, *Equus ferus*, *Cervus elaphus*,  
31 *Castor* sp. and some remains of *Bos* sp., *Equus* sp. and *Ursus* sp. (Biddittu et al., 2012).

32

33 *Masseria Castellone locality (41°31'12.69"N, 13°35'28.87"E)*

34 Masseria Castellone is located at 400 m from the Lademagne archaeological site (see **Fig. 1**) and only  
35 a river ditch separates the two sites. The lithic tools (only a few bifaces in limestone) were discovered

1 in a geological horizon similar to the “Lademagne upper” archaeological layer, rich in sands and  
2 gravels (**Fig. 2**) and found at the same altitude (i.e., 105 m a.s.l.). It could suggest that they belong to  
3 the same sedimentary unit and are therefore of the same age. So far, no data have been published  
4 on this archaeological horizon.

5 From a general point of view, the overall areas where fauna and artefacts were found in the studied  
6 zone are generally at a comparable altitude and in levels of sand and small gravels, which suggest the  
7 presence of vast territories close to fluvial and peri-lacustrine formations during a period of intense  
8 volcanic activity between 410 and 340 ka according to all available  $^{40}\text{Ar}/^{39}\text{Ar}$  constraints. These areas  
9 seem to have been explored by hominins periodically, particularly along rivers. These hominines  
10 would thus have carried out different types of activities related to the exploitation of plant and  
11 animal resources. Traces of human activity on faunal remains are mainly represented by the  
12 presence of frequent bone artefacts that are for some of them not straightforward. Bone tools were  
13 recognized both in the upper level (Selvotta, Colle Avarone, Campogrande 9A, Isoletta L4,  
14 Lademagne Upper level) and in the lower level (Isoletta ESR1, Lademagne Lower Level). The faunal  
15 remains are characterized by alteration surfaces due to exposure and in rare cases fluctuation  
16 especially in the smallest fragments (common aspect also observed in in situ levels with slow water  
17 circulation). The presence of artefacts on bone is a characteristic of all the Acheulean sites of  
18 southern Lazio from Fontana Ranuccio to Pontecorvo- Aquino

## 19 **Material and method**

20

### 21 **Material**

22 The aforementioned geochronological multi-method study ( $^{40}\text{Ar}/^{39}\text{Ar}$  on single grains, ESR on  
23 bleached quartz and ESR/U-series) at Isoletta and Lademagne (Pereira et al., 2018, Voinchet et al.,  
24 2019) and the stratigraphic correlations proposed considering the geological similarities between the  
25 deposits (facies, altitude of the levels, proximity) to link these two localities with the other studied  
26 sites in the Frosinone-Ceprano basin constrained the age of the Acheulean archaeological levels of  
27 these localities between 410 and 370 ka, *i.e.* as contemporaneous of the period ranging from MIS 11  
28 interglacial optimum to the MIS 10 glacial onset.

29 Two groups of localities with artefacts can be distinguished: (1) the localities on which were  
30 evidenced flakes, cores and pebble-tools (for instance Campogrande CG 10 lower, or Isoletta lower)  
31 (**Fig. 3**), and (2) the localities demonstrating a core technology and some Large Cutting Tools (LCTs)  
32 including bifaces (Campogrande 10 intermediate, Campogrande 10 upper, Campogrande 9  
33 intermediate and upper, Colle Avarone, Selvotta, Isoletta L4, Lademagne lower and upper and  
34 Masseria Castellone) (**Table 1**).

1 Regarding the series for which no bifaces were found, the heavy-duty component is composed of  
2 pebble-tools or chopper-cores, convergent or not, on thick limestone, quartz and quartzite  
3 pebbles/cobbles. Flakes may come from biface production or flaking. Cores are on thick and large  
4 quadrangular limestone pebbles, but also on small flint pebbles/nodules. The debitage is not  
5 intensive. These cores bear a few short, deep and hinged removal scars, on orthogonal or multiple  
6 surfaces adapted to the shape of the blank. There are also some unifacial or bifacial cores with  
7 asymmetrical flaking surfaces.

8 Eleven lithic series containing LCTs were also studied. Part of them corresponds to incomplete  
9 archaeological series recovered from excavations and from surface collecting and therefore  
10 submitted to taphonomic processes (as is usual for open-air Palaeolithic sites), but these series were  
11 nonetheless located quite precisely in the same stratigraphic sequence and considered relevant for a  
12 comparative study of reduction processes (Biddittu et al., 2019). The cutting edges of the artefacts do  
13 not show any signs of damage due to high-level disturbances. When the pieces are partially covered  
14 by breccia or when the scars are smoothed by chemical processes, the technological study provided  
15 was only partial (**Table 1**). The artefacts in flint are better preserved than the ones in limestone. The  
16 cutting edges are usually fresh suggesting that the lithic tools were not much transported. The  
17 alteration on limestone tools seems post-depositional and *in situ*. Small tools, for which flint was  
18 preferably used, are rare because the drainage of running water tends to disperse small objects. The  
19 larger bifaces remain more concentrated.

20

## 21 **Method**

22 In this work, we studied (according to Kleindienst, 1961; Leakey, 1971; Boëda et al., 1990; Geneste,  
23 1991; Texier and Roche, 1995; Roche, 2005; Goren-Inbar and Sharon, 2006; McPherron, 2006; Key et  
24 al., 2016; Lycett et al., 2016; McNabb et al., 2018; Torre de la and Mora, 2018):

25 (1) The mode of debitage on cores by analysing the organization and management of the blank and  
26 the technological characteristics of the end-products (including types of retouch) ;

27 (2) The different modalities of biface production at the final shaping phase for the LCTs: we focused  
28 our work on studying the geometry and identification of the blank and determining when possible,  
29 the number, size and organization of the removals as well as the number of series of the removals,  
30 extension and organization of shaping on both faces, secondary retouch and location, shape of  
31 cutting edges, type of tip management.

32

33 We applied classical statistical methods including box-plots to compare the tool sizes between the  
34 investigated localities. To estimate the internal variability between lithic assemblages, we used the  
35 Multiple Correspondence Analysis with the SYSTAT software based on a list of quantitative and

1 qualitative parameters. A list of relevant parameters was selected (length, width and thickness in  
2 mm, raw materials, extension of removals on each face, number of series of removals, retouch on  
3 the edges, tip shaping and bilateral and bifacial symmetry). All the tables and graphs represent 80%  
4 of the variability of the data with two components.

5

## 6 **Results: technological analyses of the lithic component for each locality**

7

### 8 ***Campogrande (CG) 9 intermediate (or B)***

9

10 In this series three bifaces were identified (see **Table 1**). These tools in flint and limestone may  
11 possibly be on flakes (with the platform residue as a proximal back) (**Fig. 4**). Shaping covers a large  
12 part of one surface and the periphery, with more removals on the extremity.

13

### 14 ***Campogrande (CG) 9 upper (or A)***

15 This series consists of one bifacial and thick core and 11 limestone bifaces characterised by varied  
16 lengths (80 to 180 mm long) (see **Table. 1**):

17 Two bifaces are short completely or partially worked, with a symmetrical cross-section, made by  
18 series of large and short removals. The tip of one of them is curved. The blank may be a flake. Three  
19 tools are plano-convex bifaces shaped on half of the piece, sometimes with a back (on a flake?), with  
20 a pointed or round tip and retouch on the two cutting edges.

21 Then six tools are plano-convex bifacial tools. The flatter surface is shaped by large removals which  
22 thin the whole face, while the opposite convex face is managed by series of removals limited to the  
23 upper half and the periphery of the tool.

24

### 25 ***Campogrande (CG) 10 intermediate (or B).***

26 Apart from some cores on small flint nodules (less than 50 mm long) for the production of a few  
27 small flakes, this series is composed of a heavy-duty and a light-duty component.

28 The light-duty component consists of a micro-biface on a limestone pebble, a micro convergent  
29 pebble-tool and a point on a micro-flint nodule (30 to 50 mm long). They are minimally shaped by a  
30 few unifacial and bifacial removals, which do not really modify the form of the blank.

31 The heavy-duty tools are composed of a “rabot”, a thick scraper on a limestone split pebble, and  
32 three limestone bifaces. One of these bifaces is minimally shaped with a thick base. Shaping covers  
33 the whole volume with numerous and abrupt removals. The cutting edges are sinuous with no final  
34 retouch. Another one is an asymmetrical elongated biface in limestone, with shaping covering most

1 of the surfaces and with final retouch on the edges. Finally, the last one that is in limestone is  
2 symmetric and made on a half-pebble. Shaping is not very invasive.

3

#### 4 ***Campogrande (CG) 10 upper (or A)***

5 A dozen pieces are cores and/or chopper-cores (**Fig. 5**). They are made on small oval and  
6 quadrangular pebbles (in flint and limestone) of poor-quality (50 mm long) (50-100 mm). The  
7 debitage systematically follows the natural morphology of the blank. It is orthogonal or unifacial  
8 unipolar (on the largest face or on the core edge). The number of removals is limited and the  
9 products are irregular and frequently hinged. We did not evidence any preliminary preparation of the  
10 core. The platforms are usually cortical or use previous removals.

11 The series totals 22 heavy-duty tools on limestone. Flint nodules are too small to make heavy-duty  
12 tools. Three categories of heavy-duty tools are described:

13 -The first one corresponds to a thick pointed scraper (rabot-type) made by deep and large removals  
14 on a small part of the periphery of a broken limestone pebble.

15 -The second category is composed of five elongated plano-convex bifaces on badly preserved  
16 limestone (**Fig. 6**). The mean length of these bifaces is around 200 mm, making them among the  
17 longest of the series. Some cortical residues suggest that the blank could be a flat and elongated  
18 cobble. The bifacial volume is globally managed by one series of invasive removals on both faces.  
19 Some removals are hinged. The shaping is alternate or done face by face when visible. The sinuous  
20 edges are not rectified by retouch. The base of the tool is shaped by convergent removals (forming a  
21 thin cutting edge), or left unworked (back or natural round cortical base). The tip is always thin, and  
22 the shaping of the tip by small removals is part of general shaping. The maximum thickness of the  
23 tool is on the proximal or the middle part of the biface.

24 -The third category is constituted by sixteen partial bifacial tools in limestone. This category is more  
25 diversified than the previous ones, and includes short and elongated pieces (from 110 to 210 mm).  
26 The blank is a flake for most of the tools (**Fig. 7, 8**) and the shaping mainly concerns the upper part of  
27 the tool, covering the entire surface or only the periphery. The flatter face is either covered by large  
28 removals or short removals. The opposite surface indicates series of semi-abrupt frequently hinged  
29 removals, rarely rectified by final series of short removals and retouch. In some cases, only one edge  
30 is worked, and the tip and cutting edge are opposite a back or a cortical side. The cutting edges are  
31 consequently sinuous. The pointed or round tip is made by small or large removals related to the  
32 shaping process of the lateral cutting edge(s). The base is always cortical, with or without a back. The  
33 cross-section is plano-convex. One piece shows a longitudinal "coup de tranchet" while another piece  
34 shows some transversal removals on the transversal tip (due to use or resharpening?).

35

1 Most of the tools are asymmetrical bifacial tools on limestone for which the blank appears to play a  
2 major role, with minimal shaping on flakes and more invasive shaping on elongated pebbles. All the  
3 tools are made by a single series of removals with no final retouch, producing sinuous edges. The  
4 main feature is the presence of a back on some pieces, for elongated bifacial pointed tools and  
5 backed bifacial tools.

6

### 7 ***Colle Avarone***

8 This locality yielded 11 cores in flint and limestone (see Table. 1) made on small nodules or pebbles.  
9 The cores are bifacial centripetal, orthogonal, unipolar or unifacial or bifacial chopper-cores with  
10 abrupt removals. There is no preparation of the core. One core is attributed to the Levallois core  
11 technology by the organization of the removals (see Moncel et al., 2020).

12 Regarding the LCTs, Colle Avarone yielded the largest series (n = 87). These tools in limestone,  
13 excepting one on flint, were more or less well-preserved.

14 One LCT was partial and irregular on a flake, made by some removals on the edges and the apical  
15 extremity. Its tip is pointed.

16 Three short bifaces were evidenced. Their bases are thick and large and their cross-section are  
17 symmetrical. Shaping covers the total volume with series of large and short frequently hinged  
18 removals. Final retouch is punctual on cutting edges more or less sinuous. . The tip is round or  
19 quadrangular and the base is shaped by abrupt removals.

20 Nine elongated asymmetrical (plano-convex) and totally shaped biface (n = 9) were found. Shaping  
21 manages the general volume with large removals on both faces, shorter removals on the base and  
22 the round tip. Cortical patches are preserved on the thick base. On the tip, removals are frequently  
23 transversal. For one piece, the tip is nose-shaped. Final retouch often finishes working the periphery  
24 of the tool and does not modify the sinusoidal edges. The thickest part of the tool is in the middle of  
25 the elongated bifaces.

26 Seven elongated symmetrical totally shaped bifaces (**Fig. 9, 10**) are made by large invasive removals  
27 that shape the global volume, without final retouch, except for one tool on a flake. The edges are  
28 sinusoidal. The round or pointed tip is made by transverse removals except for one tool with a “coup  
29 de tranchet”.

30 Five short bifaces with a thick and cortical base are triangular tools made by total shaping on a flake  
31 by invasive and short removals on one face, shorter on the opposite flat face with final retouch near  
32 the tip. The cross-section is plano-convex or symmetrical.

33 Seven partial bifacial tools on flat and elongated pebbles conducive to minimal management, a  
34 plano-convex cross-section and sinuous edges with hinged removals. Two types of management  
35 were observed: (1) on the upper part and covering the surfaces, (2) peripheral on part of both sides.

1 The thin tip is mainly pointed with series of short removals. Cortical patches are invasive, on the base  
2 and sometimes with a cortical back (pebble side). The maximum thickness is on the middle or  
3 proximal part.

4 Sixteen partial bifacial tools on a flake including 14 in limestone and 2 in flint. In the same way as for  
5 pebbles, shaping is peripheral or covers the upper part. The cross-section depends on the shape of  
6 the flake where the flat surface is more or less covered by flat removals. Removals on the convex  
7 surface are hinged. The base is thick, sometimes with a back. The edges are sinuous. The tip is  
8 pointed or round and formed by short removals and some retouch. The two flint tools show a similar  
9 shaping with many small removals on the tip on the longest tool, one edge is retouched, associating a  
10 bifacial point and a lateral scraper.

11 Eighteen partial elongated bifaces on possible pebble-blocks show an independent shaping on both  
12 edges and the tip, made by alternate, peripheral or partial deep removals, without final retouch. The  
13 thin tip is sometimes shaped by more removals (transversal or lateral). The cross-section is  
14 asymmetrical, sometimes twisted, with a back or a trihedral section.

15 Twenty-nine partial elongated and triangular bifaces on a flake on limestone and one flint (**Fig. 8, 9**)  
16 show a minimal shaping with short removals located on the upper half of the flake with frequent  
17 shaping of the thin tip, retouched or not, and both edges. Invasive removals cover one face more  
18 than the other one. The cross-section is asymmetrical with a proximal thick and cortical back or a  
19 shaped thick base. The edges are rectilinear or sinusoidal. In some cases, final retouch covers one  
20 whole edge, creating what looks like a lateral scraper. The work is thinner on the tip of the single flint  
21 biface.

22 Ten elongated bifaces with total shaping in limestone, asymmetrical ( $n = 7$ ) or symmetrical in cross-  
23 section ( $n = 3$ ) are shaped by series of short and invasive removals. The edges are sinuous or  
24 rectilinear. The cross-section is asymmetrical and some of the bifaces are backed. The tip is round or  
25 pointed, sometimes curved. The middle part of the tool is the thickest.

26 Eight bifacial pieces with a transversal cutting edge are on limestone except for one on flint. They are  
27 on flakes shaped by peripheral and short removals, which are more invasive on one face. The  
28 transversal apical edge is made by transversal and lateral removals without final retouch. One tool  
29 shows a "coup de tranchet". The base is thick, sometimes with a back (the preserved cortical butt of  
30 the flake). The cross-section is asymmetrical.

31

32 If we summarize the series (**Fig. 10**), we can observe three main categories of tools. One is composed  
33 of elongated tools with a cortical back or created by removals, often on flakes, a plano-convex cross-  
34 section, made by large and flat removals on one face and semi-abrupt removals on the opposite face.  
35 The second category is composed of triangular, elongated or short, partial tools with invasive



1 removals and retouch despite sinusoidal edges. Finally, the last category is made of crudely shaped  
2 tools.

3  
4

### 5 ***Selvotta***

6 The series is composed of 38 limestone and quartzite tools, and two flint tools. The heavy-duty tools  
7 are composed of one “rabot” and a thick scraper on a half limestone pebble. A backed biface on a  
8 flake looks like a bifacial scraper. LCTs can be divided into three main groups. Two trihedral pieces  
9 are on limestone and totally shaped by deep and invasive alternate removals with a thick base and a  
10 thin tip. The cutting edges are sinuous with no final retouch. The cross-section is symmetrical or  
11 asymmetrical. Fifteen plano-convex with total management of the tool including two in flint (**Fig. 11**)  
12 are elongated bifaces (150-200 mm long), mostly worked by large then shorter removals, then  
13 retouched on the edges. The tip is pointed or round. The cross-section is plano-convex with a thicker  
14 base. Sixteen plano-convex bifaces in limestone and quartzite show a management of the two cutting  
15 edges and the tip and peripheral and partial shaping of large flakes (cutting edges and tip) (**Fig. 11,**  
16 **12**).

17 To summarize, most of the assemblage is composed of plano-convex bifaces with partial  
18 management of the two cutting edges and the tip, or total management of the volume. For the tools  
19 with a whole management, they are shaped by series of invasive and short face by face removals and  
20 the cutting edges are sometimes rectified by final and partial retouch on the convex face. They are  
21 elongated, triangular or oval. The tip is mainly pointed and thin and is prepared by small removals or  
22 retouch. The thickest part of the tool is the middle part. The two flint tools can be categorized as  
23 whole bifacial tools. They are oval or pointed, elongated, plano-convex, and completely shaped with  
24 general management of the bifacial volume. For the partial tools, when the blank is still visible, half  
25 pebbles, flat pebbles or large flakes are shaped by peripheral removals. The tool base is often left  
26 unworked. The tip is pointed worked by small removals or retouch and its management is an  
27 extension of cutting edge shaping.

28

### 29 ***Isoletta L4 (GA6Z)***

30 The 13 bifaces are in limestone. They are elongated, although partially or totally shaped in different  
31 ways, by deep and large removals and rarely by final retouch (**Fig. 13**). The maximum thickness of the  
32 tool is on the proximal half or in the tool centre.

33 Five technological groups can be distinguished based on asymmetrical or symmetrical cross-sections.  
34 Four tools are made by large removals covering a part of the piece with no final retouch. The tip is  
35 pointed and narrowed by deep removals. The cutting edges are sinusoidal. The maximum thickness is

1 at the base of the tool. Five tools are made by large and short removals on the whole volume with  
2 rare final retouches. The tip is narrowed by removals and the base is also worked and thinned. The  
3 maximum thickness is at the centre of the tool. One asymmetrical tool is made by large removals on  
4 the upper part With a tip thinned and round. Two tool made on a flat pebble are partial with large  
5 removals on the two cutting edges and the tip. Finally, a large flake is partially shaped and some final  
6 retouch.

7

### 8 ***Lademagne lower***

9 The series is composed of a dozen cores (polyhedral cores on large blocks with no preparation and  
10 unifacial cores), some chopper-cores and choppers on limestone and flint. The presence of a flake  
11 that can be described as a Levallois flake is noteworthy (**Fig. 14**). There are also 14 bifacial pieces, 2  
12 with a transversal cutting edge, 5 with partial management and eight with general bifacial  
13 management. The tools are on poor-quality limestone, except for one on flint (**Fig. 15, 16**). The two  
14 tools with a transversal cutting edge are on limestone and are completely bifacial and symmetrical  
15 with invasive removals The partial bifacial tools are mainly on flakes and plano-convex with sinuous  
16 edges. Removals cover either the upper part, or the periphery of the flake. The tip is thin and curved  
17 while the base is thick and generally left unworked or only slightly worked. Bifaces with general  
18 bifacial management are the predominant category. All these tools are in limestone, except for one  
19 in flint. They are elongated or short, made by several series of removals covering the whole surfaces.  
20 The cross-section is plano-convex for the thin tip and sometimes symmetrical for the thick base. Final  
21 retouch is sometimes visible on the whole periphery while the edges remain sinuous. The shorter  
22 bifaces show a round or transversal cutting edge while the longer ones have a carefully worked  
23 pointed tip. The shaping mode seems to be alternate despite a plano-convex cross-section. The flint  
24 biface is the most worked tool of the series and final retouch rectifies the edges.

25

### 26 ***Lademagne upper***

27 Debitage activity is on limestone cores on pebbles. Core technology is unifacial, orthogonal or on  
28 multiple surfaces. Large flakes are the main blanks used for bifacial technology when determinable.  
29 We can mention one *déjeté* flake 15 cm long with limited unifacial shaping of the two convergent  
30 edges.

31 Apart from one flint tool, the bifaces are in limestone of varying quality (accidents occurred during  
32 the production for three pieces). These hinged scars are due to the bad quality of some limestone  
33 but also to technical reasons (too flat face of the tool and bad angles of the cutting edges).

34 Two groups can be distinguished. There thirteen partial bifacial tools , mainly on flakes or broken or  
35 flat pebbles, with preserved cortical backs (**Fig. 17**), which could account for the curved aspect of the

1 longitudinal section of the tool. The tip is managed by some bifacial removals. One or both edges of  
2 the tools are shaped by short removals producing a plano-convex cross-section without final retouch.  
3 Edge angles vary between 75 and 85°. A lateral or proximal back is preserved (butt of the flake?), and  
4 the tools look like backed bifacial scrapers. Twelve elongated or short bifaces show a general  
5 management of the volume and a final retouch. The cross-section is symmetrical (alternate shaping)  
6 or plano-convex (face by face shaping) (**Fig. 17**). The angles of the cutting edges are inferior to those  
7 of the previous group, between 51 and 72°. The shaping mode could be linked to the type of blank  
8 (flake or pebble). The base is sometimes unworked, with a back (part of a flake?) or is part of the  
9 overall bifacial management. The thickest part of the tools is the central area. The tip is pointed or  
10 round, made by general tool management removals, by one large transverse removal or small  
11 retouch.

12

### 13 ***Masseria Castellone***

14 The series is composed of six tools, few more or less elongated in limestone, and of varied  
15 dimensions. They are worked by large and deep and/or short alternate removals limited to the upper  
16 part of the blank and almost all show a symmetrical cross-section. Although only part of the tool is  
17 shaped, we observe general management of the bifacial volume. These tools are one asymmetrical  
18 bifacial “dejeté” scraper, one elongated and symmetrical tool (limande-type), one symmetrical tool  
19 on a flake with a proximal back, one curved and symmetrical tool shaped on the whole periphery by  
20 short removals with a proximal back (**Fig. 18**), one asymmetrical partial tool on a flat pebble, and  
21 finally one symmetrical triangular and partial tool.

22

### 23 **Discussion**

24 Before discussing the tools themselves, it seems essential to give some general information  
25 concerning what we know so far about the origin and nature of raw material used. A constant  
26 characteristic of the various sites is that the stone tools recovered are made on medium-sized and  
27 small limestone gravels. Pebbles are mainly smaller than the mean size of the bifaces. Raw materials  
28 used to elaborate the bifaces were probably collected in adjacent sites to those of the frequentation,  
29 even if no specific selection is evidenced currently. The presence of some types of flakes  
30 demonstrates the probability of the use of the flaking on anvil despite the lack of large pebbles  
31 necessary for this technique. Tests carried using pebbles collected in the bed of current active rivers  
32 in the area has shown that only a very limited number of limestone pebbles have the necessary  
33 compactness and quality require to be used. The field observations also suggest that the bifaces  
34 were made in other unknown neighbouring areas. However, all the raw materials used are products

1 of the erosion of the Cretaceous formations derived from the mountains that surround the Sacco and  
2 Liri valleys.

3

#### 4 ***Common features and differences between the lithic series in the localities of the Ceprano basin***

5 Acheulean culture in the Frosinone area is more frequent than the Middle Paleolithic that is  
6 represented by sporadic objects except for some rare sites. The lithic series of the Ceprano-Frosinone  
7 basin are mainly manufactured on fine-grained, generally of poor-quality limestone that are  
8 sporadically associated with better quality flint, quartzite and quartz. Some bifaces are shaped on  
9 large flakes obtained from cobbles and were rarely abandoned at the localities, excepted in the  
10 upper archaeological level of Lademagne. Raw material types differ for core technology and shaping.  
11 Limestone is the preferred one for the LCTs and heavy-duty component whereas flint and quartz are  
12 mainly used for flaking, although a few LCTs are made on flint and quartzite in the Campogrande and  
13 Lademagne localities. This is probably due to the size of the available nodules and pebbles, as flint is  
14 generally available as small nodules.

15 Core technologies demonstrate common technological rules between the investigated localities.  
16 Small cores on flint nodules are present, excepted at Lademagne where large-sized limestone cores  
17 are also found. The cores are never prepared and are always related to the form of the blank. The  
18 debitage affects one or two faces (unifacial, bifacial or orthogonal) with unipolar removals. Some  
19 round pebbles produced "slices". Cores are never exhausted and the debitage is minimal. The  
20 Levallois core technology is absent, except at Lademagne lower and Colle Avarone where one  
21 "Levallois-type" flake is evidenced.

22 Heavy-duty tools are the main component of the collected lithic series. Three types are common to  
23 the series but in different proportions:

24 (1) Elongated tools, named bifaces, characterized by complete bifacial shaping of the tool volume  
25 and thin tips. When the cross-section is symmetrical, the single series of removals is never rectified  
26 by final retouch. The edges of these tools are sinuous. When the cross-section is asymmetrical the  
27 removals are numerous and a final retouch sometimes rectifies the edges. Series differ between the  
28 localities by the presence/absence of final retouch.

29 (2) Partial tools, named bifacial tools. They are made by successive removals on the upper part of the  
30 tool, of the cutting edges and of the tip. Cross-sections are mainly asymmetric with a preserved back.

31 (3) Heavy "scrapers", "rabots" on pebbles and pebble-tools.

32 The shaping mode is not linked to the type of raw material. The bifaces on flint share common  
33 technological features with the tools on other kinds of stones. However, the mode and intensity of  
34 shaping are consistent with the raw material and the shape of the original pebble. The partial bifacial  
35 tools are mainly made on (easily identifiable) flakes, considered as pre-forms, which do not require

1 extensive management. These categories are not stages in the shaping process but represent clear  
2 distinct tool types with specific purposes (whole volume management, manufacture of the cutting  
3 edges and the tip) and sizes, even if all the tools show an asymmetric cross-section. Some partial  
4 bifacial tools indicate that resharpening would have been possible since a limited area of the upper  
5 part of the tool is shaped by additional series, which can be reworked independently. Conversely,  
6 most of the bifaces with total volume manufacture cannot be resharpened without modifying the  
7 whole volume and reducing the size of the tool. The whole bifaces are symmetrical in form and  
8 elongated while the partial bifacial tools are shorter, not generally elongated and frequently  
9 asymmetrical in form and cross-section. Bifaces are the longest pieces (around 200 mm) (**Fig. 19**).  
10 Although asymmetrical tools with retouch on one side evoke bifacial scrapers rather than bifaces, the  
11 technological study does not indicate strong overall tool reduction. It is important to mention that  
12 each tool category frequently displays the same size and size variation for each locality. This suggests  
13 a mental model or template for making these tools and the flexibility to adapt the model to the blank  
14 (pebble or flake).

15  
16 **Table 2** demonstrates that some technological features of the LCTs may partially distinguish the  
17 series. Internal variability affects above all the shaping mode of the tip and retouch on the edges, and  
18 episodically the presence of a “coup de tranchet”, twisted bifaces and backed tools. Elongated tools  
19 are the most common type of tool, as opposed to the short tools and large flakes that are often used  
20 for shaping. However, the number of tools differs between localities and the quantity can affect the  
21 technological record and picture. We performed a Multiple Correspondence Analysis with a set of  
22 variables characterizing technological features (extension removals along faces A and B, series of  
23 removals, final retouches, tip shaping, presence or absence of cross-sectional and/or lateral  
24 symmetry). Our analysis shows two groups of sites. One group forms a major cluster and one group  
25 isolates the sites CG9 upper, Isoletta 4 and Masseria Castellone, which are visible in **table 2 and fig.**  
26 **20**. These three original series differ by less careful shaping of the tip and edges and more  
27 asymmetrical tools. Number and extension of removals on both faces distinguishes the two groups  
28 along dimension 2 (**Fig. 20**), which calls into question differences in reduction sequence phases by  
29 locality (mobility of tools between sites or longer reduction sequences in some sites as a result of  
30 longer occupations or specific activities). The size of the gravel pebbles is almost always less than the  
31 biface size, suggesting that the bifaces were partially made in other areas than those frequented.

32  
33

34 ***The Ceprano basin: an original case in Italy?***

1 On a broader scale, it is essential to compare the networks of sites studied here with other Italian  
2 Acheulean sites from the same period. Hereafter, the term “Acheulean groups” corresponds to  
3 hominin groups able to perform biface production. However, the fact that some localities do not  
4 yield bifaces and/or LCTs does not mean that hominins occupying these sites were not capable to  
5 produce these kinds of tools. It may mainly depend on the “function” of the site. The quantity of  
6 artefacts collected at Campogrande, Isoletta and Lademagne is higher than in the other studied  
7 localities such as Colle Avarone or Selvotta (~ 600 m from Ceprano) (Biddittu, 1974). Despite the  
8 variable number of artefacts found in these sites, we demonstrate that the technological and  
9 morphological features highlighted share common strategies and specific features that may suggest  
10 regional trends of traditions persisting for about 50 ka (from MIS 11 interglacial toward the MIS 10  
11 glacial inception). For instance, the bifacial tools and bifaces discovered in the Ceprano basin are  
12 generally longer than in other Italian sites studied so far. It could be explained by the dimension and  
13 quality of the available raw materials but also by the types of activities or regional routines of the  
14 knappers of the area.

15 If we integrate our records at a broader scale, the Acheulean layer “m” of the Torre in Pietra (MIS 10)  
16 archaeological site, located 26 km northwest of Rome, is characterized by bifaces similar to the  
17 Ceprano basin ones, characterized with a high proportion of asymmetric tools (Villa et al., 2016). At  
18 Guado San Nicola, located in Molise (Peretto et al., 2016) and also dated to the MIS 10 glacial onset  
19 (Pereira et al., 2016), bifaces represent a total of 3-4% of the series and are mainly made in flint and  
20 rarely in silicified limestone, on slabs and some flakes. The raw material does not seem to influence  
21 the shaping mode and produces asymmetric pieces. We furthermore observe careful shaping of the  
22 tips, including final retouch and limited technical investment. Finally, at Castel di Guido (Boschian and  
23 Saccà, 2015), close to Torre in Pietra, bifacial tools on elephant bones and on pebbles (various  
24 stones) indicate common shaping strategies at this site, regardless of raw materials. Moreover, most  
25 of the LCTs are partial bifacial tools characterized mainly by management of the bifacial tip and a  
26 lateral bifacial scraper.

27 As mentioned above, the core technology of our series is similar to what is observed at Torre in  
28 Pietra (layer m), dated to the MIS 10/MIS 9 transition (Villa et al., 2016; Soriano and Villa, 2017), but  
29 also to the younger butchery site of La Polledrara di Cecanibbio (near Rome) (MIS 9,  $325 \pm 6$  ka,  
30 Pereira et al., 2017). These assemblages without bifaces and on small flint nodules do not show clear  
31 technological changes for more than 100 ka in Latium (i.e. between MIS 11 and MIS 9). The Levallois-  
32 like flake found in the lower archaeological of Lademagne (older than 405 ka, Pereira et al., 2018)  
33 and Colle Avarone could indicate the occasional use of this technology, as also highlighted at the site  
34 of Guado San Nicola (Molise) during the MIS 11/10 transition (Peretto et al., 2016; Pereira et al.,  
35 2016; Moncel et al., 2016, 2020), and in the Acheulean site of Rosaneto in Calabria (Biddittu et al.,

1 1984). The presence of this kind of technology supports the hypothesis of a long transition phase  
2 between the Lower and Middle Palaeolithic and the coexistence of these two entities in Europe, but  
3 also in Asia and Africa during this period for long period (Akhilesh et al., 2018; Deino et al., 2018).

#### 4 5 ***Evidence of regional networks of sites from MIS 11 onwards in Europe?***

6 The small number of known sites in Western Europe anterior to the MIS 12 glacial period suggests  
7 either the bad preservation of the sites or a low population density perhaps reflecting the isolation of  
8 small and mobile hominin groups before 450 ka. The first hypothesis raises the question of the good  
9 preservation of the sites after this arid glacial stage in Central Italy and more generally in Western  
10 Europe. Some studies suggest a good preservation of the sites as well as an increase of the  
11 population densities in Mediterranean due to the suitable climatic conditions of the MIS 11  
12 interglacial, that is one of the warmest and longest (20-30 kyrs) Quaternary interglacials (Karner and  
13 Marra, 2003, Moncel et al., 2018a).

14 We here propose to explore some hypotheses on social behaviours. The hominins groups probably  
15 adapted their behaviours to local constraints, which may explain both the diversity and common  
16 features of toolkit morphology and modes of shaping for this period. Consequently, they were able  
17 to maintain social networks and to permanently occupy some areas. This hypothesis might also  
18 explain the lack of clear regional traditions, either among a metapopulation or disconnected groups  
19 (White and Ashton, 2003; Premo and Hublin, 2009; Premo and Kuhn, 2010; White et al., 2011;  
20 Schreve et al., 2015; Moncel et al., 2015; Moncel and Schreve, 2016; Moncel and Ashton, 2018).  
21 Hominins only occupied marginal areas under favourable environments, especially in the northwest  
22 of the continent. Latitudinal climatic gradients are consistent with the persistence of occupations in  
23 the south during periods of climatic deterioration (Moncel et al., 2016). These climatic oscillations  
24 regularly compelled hominins to retreat and expand or led to their disappearance despite evidence  
25 of occupations at the MIS 16 in the North-West of Europe under cold conditions or during a cooler  
26 period into the glacial event (see *e.g.* Antoine et al., 2019). Even in the Italian peninsula, periodic  
27 contractions and expansions of hominin groups during rapid climatic variations were clearly shown  
28 during MIS 13 and MIS 12 at Valle Giumentina in Abruzzo, for example (Degeai et al., 2017).

29 A large-scale expansion of Acheulean assemblages over Western Europe is discernible after the  
30 glacial period known as MIS 12, and various regional traditions appeared and evolved in both the  
31 north and south of Europe (Ashton et al., 2008; Moncel et al., 2015; Ashton and Scott, 2016). The  
32 long interglacial MIS 11 followed by a short and relatively mild glacial period MIS 10, especially  
33 weakly marked in Southern Europe, seems to have been a crucial period. This period already records  
34 some evidence of behavioural changes towards the early Middle Palaeolithic, such as for instance,  
35 indications of sporadic, more complex and standardized core technologies, organized hunting or

1 changes in land use patterns (Conard et al., 2015; Moigne et al., 2016; Moncel et al., 2016). Early fire  
2 control (Roebroeks and Villa, 2011) could have contributed to new hominin abilities to expand their  
3 territories and modify their behaviour accordingly. After 500 ka, lithic assemblages are characterized  
4 once again by diverse technological behaviours, with or without bifacial tools, but it is possible to  
5 identify regional trends due to the higher quantity of lithic assemblages. We observe the  
6 standardization of technological processes in biface production, despite the persistence of the  
7 diversity of large toolkits. The diversity of biface thickness and shaping intensity are either due to raw  
8 material constraints, site location or traditions. The diversity in the cross-sections of plano-convex or  
9 symmetrical bifaces depends on the shaping mode and the intensity and location of retouch  
10 (unifacial retouch for a scraper on one edge), and also points to varied toolkit purposes and  
11 functions, in the same way as for the early Acheulean (Iovita et al., 2017).

12 The morphological results for LCTs differ between geographical areas suggesting regional trends in or  
13 between regions. For instance, in the UK, ovate bifaces dominate in some sites (Hoxne), while  
14 pointed bifaces are more numerous in other sites (Swanscombe) (Ashton and Lewis, 2012; Moncel et  
15 al., 2015). This suggests the arrival of new population(s) or the diffusion of new traditions, during  
16 periods of low sea levels and/or local evolutions. Pointed bifaces also exist in France at the same  
17 time (*i.e.* Saint-Pierre-les-Elbeuf) (Cliquet et al., 2009; Lamotte and Tuffreau, 1997; Limondin-Lozouet  
18 et al., 2010, 2015).

19 After the MIS 12, core technologies become more complex in Western Europe, with intense  
20 development of debitage and production control, including the first traces of Levallois technology in  
21 Italy, for example (Peretto et al., 2016). Land use management indicates the fragmentation of  
22 reduction processes, an increase in the circulation of long-distance lithic raw materials, despite the  
23 persistent use of predominantly local raw materials (Moncel et al., 2012; Herisson et al., 2016;  
24 Ravon, 2017).

25 Some sites in the Mediterranean region from this time period (*i.e.* MIS 11-10) yielded assemblages  
26 suggesting the widespread diffusion of behaviours over a short period of time beginning during MIS  
27 11, and above all, specificities in each area related to raw materials (Gran Dolina TD 10, Spain  
28 (Atapuerca, García-Medrano et al., 2015). For example, the sites of Terra Amata (South of France, de  
29 Lumley et al., 2008) and Menez Dregan (West of France, Ravon, 2017) demonstrate a high quantity of  
30 pebbles on beach sites, with micro-regional traditions strongly impacted by the local environment  
31 (marine formations) (Ravon, 2017). Equally, large flakes are used more in Southern Europe than in  
32 the northwest, possibly due to an adaptation to raw material availability (flint nodules in the north v.  
33 coarse-grained pebbles and blocks in the south).

34 Of course, changes in climate cycles (after MIS 12 and during the warm and long MIS 11 interglacial),  
35 in demography, and in the density of occupations could have influenced these behavioural changes.



1 They could have encouraged the emergence of regional traditions, a wider system of mobility in the  
2 landscape, demographic expansion and genetic exchanges (growth and regular adaptation without  
3 demographic discontinuities), as well as new skills amplified by more or less rapid processes of  
4 population dynamics and cultural change (Guilfoyle, 2005; Winton, 2005; Bocquet-Appel and  
5 Tuffreau, 2009; Chazan, 2009; Dennell et al., 2011; Jagher, 2011; Richter, 2011; Manzi et al., 2011;  
6 Kleinen et al., 2014; Grove, 2016; Moncel and Schreve, 2016; Moncel et al., 2016; Henry et al., 2017;  
7 Vaesen and Houkes, 2017; Carrión and Walker, 2019). The extension of reliable areas for hominin  
8 occupations and better adaptation to diverse environments could explain a phenomenon of “product  
9 copying” rather than “process copying”, as described by d’Errico et al. (2017) for the Middle Stone  
10 Age in South Africa. This would explain the origin of distinct regional traditions due to the flexible  
11 behaviour of hominin groups with common toolkits but varied manufacturing processes depending  
12 on raw materials.

13

14 In this general frame, the Frosinone-Ceprano basin localities offer the opportunity to observe  
15 technological trends and variability from a regional perspective and to describe lithic series within a  
16 narrow time frame over a small territory. Of course, we cannot certify that the occupations were  
17 contemporaneous and took place at the same time. However, we are working on the “long” time and  
18 the time windows of the ages of the sites is relatively short enough to question and compare the  
19 occupations in a delimited territory. Despite limited variations, the common behaviours identified in  
20 biface production processes and in the morphological results between the localities raise a new  
21 question. How can we explain the high morphological homogeneity (with some types of frequent  
22 homogeneous sizes) of assemblages from this basin and their low technological variability? The  
23 expertise used for making the LCTs suggests the existence of a common mental template and the  
24 flexibility of expert knappers, regardless of the number of pieces and the raw materials (some flint is  
25 shaped in the same way as limestone). This could indicate a sort of “network” of sites with strong  
26 relationships over time between mobile groups occupying a small region in a short window of time,  
27 sharing a micro-regional tradition, possibly with sub-divisions of a metapopulation covering large  
28 areas. Studies of late Neanderthal populations suggest low effective population size and  
29 demographic isolation and some evidence tends to indicate a similar structure for the earlier period  
30 (Ríos et al., 2019). Socio-demographic processes could also affect cognition by the diffusion of new  
31 behaviours in a limited area which could maintain stable behaviours, where efficient, leading to the  
32 isolation of regional populations (Hamilton et al., 2007; Shipton et al., 2009; Hill et al., 2011;  
33 Malinsky-Buller and Hovers, 2019). Slight differences in technology and morphology could be due to  
34 variable parameters such as activities, the duration of occupation or site location, but also to  
35 individual preferences or the adaptation of expert knappers to the available blanks. We can mention

1 for instance some relevant features of bifaces that, unlike core technologies, distinguish localities:  
2 occasional presence of tools with a transverse edge (cleaver-like), intensity of tip-shaping on bifaces,  
3 presence of final retouch on bifaces, ratio of short LCTs that are not due to reduction during the  
4 shaping process, use of a “coup de tranchet”, presence of twisted bifaces and backed bifaces.  
5 LCTs in the Ceprano basin localities are often made on poorly preserved local limestone and are  
6 often covered by patches of breccia, rendering the identification of detailed land-use patterns over  
7 territories difficult (residential camps or occasional habitats). Moreover, most of the limestone and  
8 flint pebbles can be found *in situ*. The topography of the basin could provide an idea of a potential  
9 territory with the efficient management of space in an area rich in available blocks, pebbles, flint  
10 nodules and large game. Moreover, in some localities (Isoletta, Campogrande), retouched fragments  
11 of large mammal bones show the exploitation of elephants and other large herbivore carcasses and  
12 bone fragments and this trend is not an isolated case in Latium (Fontana Ranuccio, Torre in Pietra, La  
13 Polledrara di Cecanibbio and Castel di Guido) (Piperno and Biddutti, 1978; Biddittu et al., 1979;  
14 Ascenzi and Segre, 1997; Radmilli and Boschian, 1996; Segre et al., 2009; Muttoni et al., 2009;  
15 Anzidei et al., 2012; Saccà, 2012; Boschian and Saccà, 2015; Santucci et al., 2016; Villa et al., 2016;  
16 Pereira et al., 2017). Habitat quality and resources (availability of large fragments of bones) could  
17 explain the density of occupations and networks of sites with similar activities, with hominins  
18 circulating between localities depending on seasonal resources.

19 The type of mobility and occupations based on current models of mobility (foraging radius and  
20 logistical radius, hierarchical sites) cannot be confidently identified in our corpus (*e.g.*, Binford, 1980,  
21 1982; Kühn, 1992). When data are available, most of the sites of this period are butchery sites and at  
22 the same time record domestic activities, along rivers, lakeshores, and stone outcrops, with or  
23 without a hierarchical structure of occupations (aggregation-dispersal mechanism) and are  
24 dependent on local ecological conditions and seasonal variations (as demonstrated at the Acheulean  
25 site GBY in Israel, by Herlinger and Goren-Inbar, 2019). Each series of our corpus with LCTs could  
26 portray several occupations at favourable spots or one main occupation, and the hypothesis of  
27 catchment in some cases must be considered for the smallest series. Our series contain few flakes  
28 issued from shaping processes and no evidence of *in situ* biface production. However, that does not  
29 mean that bifaces were only mobile tools transported from site to site and introduced to the sites in  
30 a finished state. Due to the lack of extensive excavations at our localities, it is not possible to observe  
31 activity areas. However, it is important to mention that some LCTs occasionally show crushing marks  
32 on their edges, indicating use, and a more or less large quantity of these tools was abandoned.  
33 Perhaps these tools were easily reproducible owing to the widespread availability of large formations  
34 of pebbles. Binford (1980) suggested that environments offering homogeneously distributed resources  
35 would have been exploited by frequent residential mobility, while those supplying heterogeneous

1 resources would be best exploited by low residential mobility and by logistic displacement for  
2 specific resources. Mithen (1994) and Bocquet-Appel and Tuffreau (2009) suggested a possible  
3 higher mobility of small groups during interglacial periods. Grove (2009) demonstrates that habitat  
4 quality is the best predictor of the distance travelled by hunter-gatherers between camps. Likewise,  
5 large groups move often, rather than far (idea of costly strategy and high-mobility when necessary).  
6 We are not capable of identifying group size or social units, or the duration of occupations on the  
7 basis of the size of our lithic series, which may possibly result from recurrent passages and  
8 palimpsests (Powell et al., 2009; Bocquet-Appel and Degioanni, 2013; Collard et al., 2013; Derex et  
9 al., 2013; Vaesen et al., 2016; Dominguez-Rodrigo et al., 2019). Nor do we have any idea of the  
10 original surface area of the occupations. If we admit that the smallest series, if relevant, evidenced  
11 short-term camps or ephemeral passages, while the largest ones indicate large camps or palimpsests  
12 of regular short-term occupations, the technology used everywhere indicates expert knappers and  
13 the smaller lithic series are neither more homogeneous nor heterogeneous than the larger ones. The  
14 quantity of bifaces tends to demonstrate how hominins managed their toolkits in the landscape and  
15 between occupations. Our series attest that LCTs were regularly abandoned while still usable.

16

## 17 **Conclusion**

18 The different localities of the Frosinone-Ceprano basin with lithic artefacts are located in a small-  
19 sized area. Radio-isotopic constraints as well as geological and archaeological information indicate  
20 the contemporaneity or penecontemporaneity of these localities and related series allow for  
21 comparisons of the technological behaviours of hominins during the MIS 11-10 time period in this  
22 region. Core technologies were simple and similar for all localities. Bifaces and bifacial tools were  
23 managed in the same way with minor differences between localities. Tools are generally large in size  
24 (ranging in length from 50 to 260 mm). Common trends in toolkits could indicate networks of  
25 connected sites along fluvial systems in the basin and record the use of locally available raw  
26 materials.

27 Future analyses of bone assemblages will help to understand which types of sites existed and which  
28 subsistence activities were performed and how this network worked in relation to the exploitation of  
29 carcasses of elephants and other large herbivores. This could explain why core technologies show  
30 minimal flaking aimed at rapidly producing flakes in sporadic occupations. A heavy-duty component  
31 is present at some sites, and this cannot be explained by stone availability. The quantity of flakes  
32 indicating an *in situ* shaping process is often small and it is consequently difficult to investigate the  
33 status of these large tools. They could be mobile pieces transported between sites or expedient tools  
34 prepared for the activities performed on the site.

1 Current genetic data and anthropological analyses show that Neanderthal features emerged in the  
2 European population between 600 and 400 ka, and various hominins may have co-existed at that  
3 time (Hublin, 2009; Stringer, 2012). Our analysis supports the hypothesis of early evidence of  
4 regional traditions at the end of this transitional morphological period with an increase in the  
5 number of sites, which cannot solely be attributed to better preservation as a result of tectonic and  
6 climatic factors. This regionalization is not only discernible for the predecessors of Neanderthal  
7 populations, but also for the archaic hominin of Ceprano. This process of regionalization is not  
8 restricted to the Italian Peninsula but is a broader process that is also apparent in the Northwest and  
9 South of Europe (Ashton et al., 2008; Rightmire, 2008; Scott and Ashton, 2011; Ashton and Lewis,  
10 2012; Moncel et al., 2011, 2012, 2018; Fontana et al., 2013; Blain et al., 2014, 2015; Brenet et al.,  
11 2014; Wisniewski, 2014; Garcia-Medrano et al., 2015; Ashton and Scott, 2016).

12

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24

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## 1 **Figure captions**

2 Figure 1: a) Reference map of the Latina Valley with the location of the archaeological sites of  
3 Fontana Ranuccio, Colle Marino, Cava Pompei, Campogrande (CG), Selvotta (Sel), Colle Avarone (CA),  
4 Isoletta, Lademagne, Masseria Castellone and Pignataro Interamna (modified from Pereira et al.,  
5 2018). The main volcanic centres are also shown (triangles). b) Location of the archaeological sites  
6 investigated in the study.

7 Figure 2. Simplified lithostratigraphic columns of the studied sites indicating the sampling position  
8 and stratigraphic correlations between the archaeological levels. Campogrande (composite log from  
9 Manzi et al., 2001; Manzi, 2016), Isoletta (Pereira et al., 2018), and Lademagne (modified from  
10 Biddittu et al., 2012, Comerci et al., 2015) logs are from previous studies (see Pereira et al., 2018 for  
11 more details).

12 Figure 3. Campogrande (CG) 10 lower. Core on a flint nodule with small bifacial removals on a part of  
13 the periphery.

14 Figure 4. Campogrande 9 intermediate. Biface on a limestone flake.

15 Figure 5 Campogrande 10 upper: n°1: unifacial core on a limestone pebble, n°2: chopper core on a  
16 small flint pebble, n°3: chopper or chopper core on limestone pebble, n°4: pointed pebble tool on a  
17 small flint pebble

18 Figure 6. Campogrande 10 upper: asymmetrical elongated bifacial tool on limestone with a general  
19 shaping. The middle part of the tool is the thickest part. Removals cover the surfaces and edges are  
20 sinuous. This piece is an example of the chemical superficial alteration that makes it difficult to read  
21 the shaping process. The organization of the removals is however visible.

22 Figure 7. Campogrande 10 upper: partial bifacial tools on limestone flake. The upper part of the tool  
23 is shaped by small removals, including the tip. The base is left unworked.

24 Figure 8. Campogrande 10 upper: partial bifacial tool on a limestone flake. Some breccia on one face  
25 makes it difficult the reading of the removals.

26 Figure 9. Colle Avarone: n°1: elongated and totally shaped bifaces on limestone, n°2: partial  
27 triangular bifacial tool on a limestone flake, n°3: partial triangular bifacial tool on a flint flake

28 Figure 10. Colle Avarone: one or two series of removals on examples of pointed bifaces and tools  
29 with a transversal cutting edge.

30 Figure 11. Selvotta: n°1: partial bifacial tool on a limestone flake, n°2: plano-convex bifaces on  
31 limestone.

32 Figure 12. Selvotta: n°1, 4: elongated and plano-convex biface on limestone, n°2: partial bifacial tool  
33 on a limestone cortical flake, n°3: biface on flint.

34 Figure 13. Isoletta 4: n°1: elongated bifaces on limestone, n°2: partial bifacial tool on a limestone  
35 flake, n°3: lateral side of a backed biface with partial shaping.

36 Figure 14. Lademagne lower: Levallois or Levallois-like flake



- 1 Figure 15. Lademagne lower: n°1: elongated biface with a global shaping on limestone, n°2: backed  
2 biface on limestone
- 3 Figure 16. Lademagne lower: n°1, 2: elongated biface with a global shaping on limestone, n°3: biface  
4 with a global shaping on flint
- 5 Figure 17. Lademagne upper: n°1: partial backed bifacial tool on a limestone pebble, n°2: elongated  
6 and plano-convex biface with a global shaping on limestone
- 7 Figure 18. Masseria Castellone: backed biface on limestone
- 8 Figure 19. Boxplot of the length of the bifaces and bifacial tools by locality.
- 9 Figure 20. Correspondence analysis of the assemblages (colored dots) and a set of factor states  
10 characterizing technological features (non-colored dots), in particular the presence or absence of  
11 cross-sectional or lateral symmetry (black dots) and the number of removals (grey dots).
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