Bifaces or not bifaces? Role of raw materials in the Middle Pleistocene. The example of levels E-E1, B and F (610-670 ka) at Notarchirico (Italy).

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Abstract

Notarchirico is the earliest Acheulean Italian site. On account of the wide variety of artefacts (cores, flakes, pebble tools and bifaces for some levels) and raw materials, it is also a key site for analysing behavioural variability in the Acheulean record before 600 ka, and for investigating the significance of occupation levels with and without bifaces. In this paper, we focus on the upper part of the sequence, which was excavated by M. Piperno in the 1980s and recently securely dated between 610 and 670 ka by 40Ar/39Ar. The deposits of Notarchirico consist of a superimposition of sandy and silty sediments, with more or less intense occupation levels interspersed with sterile layers. Here we present the technological analysis of the lithic assemblages of three paleosurfaces, F, E/E1 and B. The lithic corpus from levels F and B yielded some bifaces, whereas no bifaces were found in levels E/E1, where artefacts are mainly on small flint nodules and small limestone pebbles. Technological strategies are described in the three levels, in particular previously unpublished core technologies, and compared to the rest of the site sequence and to comparable Southern European sites. We present the different hominin strategies, their modes of adaptation to diverse types and geometries of raw materials and the concomitant cultural shifts and discussed by this way the role of activities and traditions.

Key-words: Acheulean, Italy, Notarchirico, core technology, Large Cutting Tools, raw materials

1.Introduction

In the south of Western Europe, between at least 700 and 500 ka (from MIS 16 to MIS 12), *Homo heidelbergensis* and Middle Pleistocene populations are associated with the earliest evidence of biface production (Acheulean or Mode 2) and climatic and environmental changes (end of Mid-Pleistocene Transition) (Wagner et al., 2010; Abbate and Sagri, 2012; Stringer, 2012; Schreve et al., 2015; Voinchet et al., 2015). This behaviour occurs shortly after and at the same time as core-and-flake assemblages without bifaces, with a heavy-duty component of diversified pebble tools made on local

stones. Many authors have questioned whether these assemblages represent continuity over time or shifts between local traditions (Dennel et al., 2011; Bermúdez de Castro et al., 2013; Gallotti and Peretto, 2015; Moncel et al., 2013, 2015; Martínez and Garriga, 2016; Moncel and Ashton, 2018; Antoine et al., 2019).

The early site of Notarchirico is a perfect case for examining the variability of technological behaviour in Southern Europe, and assessing the presence of shifts over a long sequence excavated by M. Piperno, and recently securely dated between 610 and 670 ka by 40Ar/39Ar (Piperno ed., 1999; Pereira et al., 2015). Furthermore, new excavations outside the building revealed the hitherto unknown bottom of the sequence below deposits found during M. Piperno's excavations (levels A to F), calling for a revision of the archaeological lithic series from former excavations. Here, we will focus on three key archaeological levels, level F (lithostratigraphic unit 3), at the bottom of the sequence and dated to 670 ka, level E/E1 (lithostratigraphic unit 2.5) and level B (lithostratigraphic unit 2.10) at the top (Lefèvre et al., 2010). We aim to compare these three phases of occupation, two of which include bifaces (levels F and B), and one without bifaces (level E/E1). Moreover, levels F and B are pebble "floors", while level E is a sandy level.

The presence of bifaces in some levels and not in others (if not due to the location of the excavations) raises questions concerning: (1) cultural entities or traditions with common core technologies but with bifaces in some due to specific activities, or (2) different traditions, or (3) the impact of available raw materials, level E/E1 being a sandy level without large cobbles-pebbles, whereas levels F and B are cobble floors.

At some more recent sites in Central Italy (MIS 11-9), for instance in the Latium, hominins found solutions to compensate for the lack of large stones by collecting fragments of elephant bones to make Large Cutting Tools-LCTs (i.e. Boschian and Saccà, 2015). However, at Notarchirico, despite the presence of elephant remains (Piperno ed., 1999), there is no evidence of bone collecting to make LCTs and strategies to overcome the scarcity of large cobbles-pebbles on some levels, apart perhaps with some large quartzite flakes introduced on the site (Moncel et al., 2019). There are no more links between the presence of large stone tools and the mammal bones (no cut marks preserved). In Piperno (ed, 1999), no evidence confirms the association of the dispersed faunal remains with the hominin tool kit. However, we can assume that the location of the site near water shores with remains of large mammal carcasses would have attracted hominin groups to take advantage of abandoned meat and bones, as observed at the penecontemporaneous site of Isernia-la-Pineta (590 ka, Peretto et al., 2004, 2015; Lugli et al., 2017; Pereira, 2017).

Here, we compare the three archaeological levels to identify (1) the type of management of the different raw materials (limestone, flint and quartzite), (2) the core technologies and reduction processes, (3) the shaping processes with a special focus on biface production, when it existed, and the small tool kit. Questions regarding the role of the availability and types of raw materials on

technological features are discussed and compared to broadly contemporaneous South European lithic assemblages.

2.The site of Notarchirico

The site of Notarchirico is located in the Basilicata region, in the Venosa Basin in the South of Italy. The Monte Vulture volcano is located just 10 km northwest of the archaeological site. This volcano was active and numerous short-lived eruptions were recorded, which help to date the archaeological sequence. These eruptions also contributed to the good conservation of the archaeological deposits. The stratigraphy of the Venosa Basin is mainly composed of volcanoclastic sediments deposited and reworked in an alluvial environment (Lefevre et al., 2010) (**Fig. 1)**.

The site was first investigated in the 1970s and 1980s by V. Segre and then M. Piperno. The archaeological stratigraphy is composed of thick cobblestone pavements (A, A1, B, C, D and F) alternating with sandy levels in relation to the slightly sloping eastward channel bottom (E/E1 and alfa), with the occasional presence of small and medium-sized pebbles. The cobblestone levels are dense and, in some of them, bone remains of *Elephas antiquus* were preserved in anatomical connection.

The most recent archaeosurface of the site, level alpha, yielded a *Homo heilderbergensis* femur and was recently securely dated to 610 ka by 40Ar / 39Ar (Pereira et al., 2015). The faunal assemblage was attributed to the Ponte Galeria facies (PG2) and is characterized by *Elephas antiquus*, *Dama clactoniana, Bos primigenius* and *Bison schoetensacki* (Cattani, in Piperno ed., 1999). The faunal association reflects an open environment, with prevalent grasslands and limited forest cover, characterized by the presence of bison, rhinoceros and *Arvicola cantianus*. Cervids and, in particular, *Dama clactoniana,* in archaeosurfaces A and alpha suggests a more humid and forested environment.

Level F is a natural cobble-pebble pavement excavated over a surface of 19 m². Level E was excavated over a total of 40 m^2. The archaeological material is incorporated in a thin layer of sand and covered by a thin crust of concretion. Two sub-levels were identified. Level E1 was excavated over around 20 m^2 and lies immediately below level E. The two sub-levels belong to the same lithostratigraphic unit, made up of light-grey volcanic sands with pyroxenes in the bottom of a small excavated channel. As it was difficult to distinguish the two sub-levels everywhere and as the two lithic series are very similar, the material from E and E1 was studied together (named level E/E1). The excavated area of level B totals 133 m^2 in distinct sectors. Cobble-pebbles densely pave this surface. Large Cutting Tools (LCTs) and artefacts were found in clusters in some sectors or dispersed over the excavated areas.

3.Material and method

3.1.Corpus of material

The lithic corpus from the three levels totals 829 artefacts, and is composed of cores, flakes, pebble tools and LCTs made on flint, limestone and rare quartzite (**Tables 1, 2**). After our revision of the material, the number of artefacts in each level differs from M. Piperno's counts (Piperno ed, 1999). The material is either *in situ* on the site (some pieces were left on the archeosurfaces preserved in the Museum of site and sometimes inaccessible) or stored at the Venosa Museum.

3.2.Method

Flint and limestone raw materials were determined by macro-petrographic analysis, apart from some bifaces in limestone from level B, which were differentiated macroscopically by G. Vernet (in Santagata, 2012, 2016), with a magnifying glass X 10.

The technological analysis was performed using the "chaîne opératoire" approach (*i.e.* Boëda et al., 1990; Geneste, 1991; Texier and Roche, 1995; Soressi and Geneste, 2011), in order to understand the technical objectives through the analysis and description of each object. The following characteristics of LCTs, including pebble tools, bifaces, unifaces and partial bifacial tools, were analysed: general morphology, raw material and blank (if recognizable), size, number and characteristics of removals, symmetry (bifacial and bilateral), processing sequence for the general volume and the tip, presence of cortical residue and retouch. The pebble tools are characterized by limited shaping intended to create a linear or pointed cutting edge by unifacial or bifacial removals. The biface was described in terms of the extension of the removals and the general management of volume/geometry. The uniface is a tool with invasive unifacial removals (Bordes, 1961). The flake cleaver is characterized by a transversal cutting edge and one or two lateral retouched edges. We consider all these tools as belonging to a shaping process in order to manage a cobble, a pebble or a large flake to produce a large tool, in contrary to the core technology devoted to the production of flakes and end-products. It is why we have distinguished the small nodules on flint directly used for retouching and included them in the process of shaping.

Core technologies are identified on cores and flakes by studying the reduction processes: size of cores and end-products, type of cores (discoid, unifacial, bifacial, orthogonal and polyhedral), organization of removals on cores and flakes, extension of cortex, platform and retouch. Face to the difficulties to distinguish in these kind of early lithic assemblages some cores from pebble tools by the location, organization and the angle of the removals, we decided to maintain the term of chopper-cores. These pieces could be both a core and/or a tool with shape active edges. For cobbles/pebbles with one removal, the usual definition was remains of hammerstones with isolated detachment due to the percussion. We maintain these few pieces in the list of cores despite their problematic attribution by the sharp feature of the detachment that could be due to a voluntary debitage of a single flake. The analysis of the small tool kit focused on broad categories of tools (scrapers, denticulates and notches): size, location, extension, type and continuity of retouch, and final morphology of the tool.

4.Results: Technological strategies in levels F, B and E/E1.

4.1.Raw materials

Different raw materials were used, mainly in the form of pebbles and limestone blocks of varied sizes, and small rounded or cubic nodules of flint. We use the term flint for convenience to encompass the large diversity of flint and chert types available *in situ*. Quartzite was rarely collected, perhaps because it is rare on the site, whereas limestone and flint are abundant. Some selection is apparent as large limestone cobble-pebbles were collected for the heavy-duty component, whereas small nodules of flint (20-40 mm long) were predominantly used for debitage. In some cases, hominids used large flint nodules to make LCTs. All the stones are available *in situ*, even in the sandy level E/E1.

4.2.Core technologies

4.2.1.Cores

Cores were only found in levels E/E1 and B (**Table 2**).

-Level E/E1

A total of 22 cores on limestone and 56 on flint (**Table 3**) were counted in this level. The limestone cores are mainly unifacial and rarely bifacial. The flint cores are unifacial, bifacial, multifacial and include some cores on flakes **(Fig. 2**).

-Limestone

Unifacial cores (n = 10) are largely cortical with a limited number of removals. One surface is worked by a short series (3-4) of medium-sized and small-sized, unipolar or crossed removals, without preparation of the striking platform. They mainly measure between 30 and 90 mm long, 20 and 60 mm wide, and 10 and 30 thick (**Fig. 3**). Only two cores are larger (108-110 mm) .

On the bifacial cores (n = 4), a small number of abrupt and not very invasive removals (3-4) is also produced on two pebble surfaces. A large cortical zone subsists on one surface. Dimensions vary between 30-50 mm long and 45 mm wide. Thickness oscillates between 20 and 30 mm. Only one core is larger (112 mm long).

The chopper-cores (n = 5) measure 43 and 111 mm. A short series (2-5) of unipolar, flat and marginal or invasive removals are located on one side of rectangular pebbles. Finally, three oval pebbles only bear one removal, but are nonetheless considered as cores on account of the shape and angle of the scars, which do not look like results from percussion. The dimensions are 40/50 mm long (one of 143 mm), 30/40 mm wide and 18/30 mm thick.

-Flint

The unifacial cores (n = 9) are managed by a short series of generally three invasive, unipolar or bipolar removals (**Fig. 2**). The cores are small (16-49 mm long, 20-47 mm wide and 10-26 mm thick) (**Fig. 3**).

Most of the bifacial cores (n = 15) are also on small pebbles or cubic nodules between 10 and 40 mm long, 10-30 mm wide and 10-20 mm thick, with a majority between 21-27 mm long. They are exhausted and, in some cases, broken. The cortex is preserved on one surface or side. For the whole cores, we observe unipolar or centripetal abrupt removals (3-6 each). At the end of the debitage sequence, removals become flatter and hinged sometimes and the debitage can continue in some cases after the breakage of the core. The multifacial core on a nodule is small (36 mm) (**Fig.2, n°3**). The category of indeterminate cores (n=29) is composed of cores on pebbles or nodules and they are small (20-27 mm long, 13-22 wide, 10-18 thick).

-Level B

The 30 cores are in limestone and flint (**Fig. 4)**, on cobbles-pebbles or flakes (**Table 4**). The limestone cores (n = 15) are only on cobbles-pebbles of varying quality. The series is mainly composed of chopper-cores, unifacial and bifacial cores. The cores on flint nodules (n = 15) are mainly unifacial and secondarily bifacial.

-Limestone

The unifacial cores (n = 3) are flaked on the larger face or the side of the pebble. In most cases, they present 5 or 6 invasive and convergent removals. Dimensions are between 70 - 100 mm long, 66 - 96 mm wide and 48 - 73 mm thick (**Fig. 5**).

Bifacial cores (n = 3) are the largest cores of the series and two cores are more than 100 mm long. They bear 4-7 marginal, abrupt and convergent removals on the periphery, producing asymmetrical pieces. Debitage is alternate and not prioritized.

On the single multifacial core (96 mm long), the removals are convergent and frequently hinged.

The chopper-cores (n = 6) are medium-sized (60-140 mm long) and highly cortical with one flaking surface located on the pebble edge. They bear 2-6 unipolar, marginal and flat removals. In three cases, flaking takes place after a fracture. There is one piece with one removal (79 mm) on a pebble fragment.

-Flint

The unifacial cores (n = 6) bear between 3 and 6 marginal unipolar or centripetal removals and are mostly small (38-65 mm long, 33-49 mm wide and 20-39 mm thick). Only two cores are smaller (24 mm long) or larger (80 mm long) (**Fig. 5**).

The bifacial cores (n = 3) present between 3 and 5 marginal and steep centripetal removals for each face (from 38 to 81 mm long).

The multifacial core is fragmented (22 mm). The chopper core (77 mm) presents 6 bipolar and marginal removals.

4.2.2.Unretouched and retouched flakes

-Level F

The number of flakes is limited. Most of them are in flint and only two flakes are in limestone.

The unretouched products in limestone (n=2) are non-cortical but with a cortical platform (more than 65 mm in length) (**Fig. 6**). They could be related to the shaping of pebble tools or to the first stages of flaking. Most of the flint unretouched flakes (n=10) are cortical with one or two unipolar removals while the non-cortical flakes bear centripetal removals (**Table 5**).

Among the flint products, flake tools are selected from different phases of the reduction processes (**Table 5).** They consist of three main categories: points, scrapers and notches, regardless of flake types. The scrapers (n=3) are located on one edge, the extremity of two cortical backed flakes, or on a cortical flake. They measure 26 to 59 mm. Retouch is generally abrupt and invasive, on the distal part, or opposite the back (**Fig. 6**). The three notches are retouched, on cortical and non-cortical flakes measuring from 15 to 43 mm in length with thicknesses between 11 and 13 mm.

-Level E/E1

Flakes are in flint (n = 43) and limestone (n = 14) but lake tools are mostly in flint (**Table 6, Fig. 7**). The unretouched products in limestone consist of both cortical and non-cortical flakes. The cortical flakes are a bit larger (18-45 mm long, 19-44 mm wide and 7-24 mm thick), with a cortical or punctiform, rarely facetted platform than the nonthe non-cortical flakes (27-41 mm long, 17-36 mm wide and 6-20 mm thick) with 1-3 unipolar removals. The scars are mainly bipolar or centripetal.

The unretouched products in flint (n = 43) comprise small cortical flakes with punctiform butts , with lengths ranging between 17 to 34 mm. The non-cortical flakes (n = 52) measure 10-38 mm long, 9-46 mm wide and 3-21 mm thick with bipolar or centripetal removals (**Fig. 8**).

Only one limestone cortical flake is retouched (47x60x22 mm) with a distal notch. Most of the flint tools on cortical flakes (n = 15) are denticulates (n 7) and scrapers (n = 2) and are small (20-32 mm long, 19-28 wide and 5-15 mm thick). The non-cortical flint products (n = 14) are scrapers (n = 5) and denticulates (n = 6), with lateral, direct and abrupt retouch. There is also one notch and a borer on a non-cortical flake. No differences in size between flake tools and unretouched flakes were observed They measure 12-34 mm long, 15-40 mm wide and 4-14 mm thick.

-Level B

The number of flakes is low (n = 9) in comparison to the quantity of pebble tools and cores. These flakes in flint (n = 7) and limestone (n = 2) present disparate sizes and generally comprise a large cortical area. The flakes derive from the initial phases of production and no morphological and dimensional standardization was observed.

The two unretouched limestone flakes consist of a large flake (87 mm). The smaller flake (43 mm) presents a cortical butt and unipolar and abrupt removals. The flint flakes measure 30-40 mm long, 27-44 mm wide, 12-21 mm thick, with cortical residues and a generally flat platform.
The large cortical retouched flint flakes (58 and 64 mm) are notches (n = 2) and denticulated scrapers (n = 2)**.**

4.2.3. Large Cutting Tools and the modes of shaping

This category consists of various LCTs, including bifaces, unifaces and cleavers, and pebble tools on limestone cobbles or pebbles and flint nodules (**Table 7**). The technological analysis of the bifaces being published elsewhere (Moncel et al., 2019), we present additional data on the pebble tools and retouched nodules.

-Level F

Pebble tools and LCTs on limestone (n=4)

The corpus is composed of two tools with a transversal cutting edge a flat and elongated pebble (78-98 mm) and removals on one or two edges, one unifacial pebble tool and one point on a fragment of pebble.

Bifaces on limestone (n=7)

A total of 7 bifaces (and 1 broken biface extremity) were identified in this layer. Three of them are badly preserved. The others are shaped by large or short removals, depending on the face. The well-preserved bifaces are worked by peripheral or invasive removals. The tool is asymmetrical in shape with a symmetrical cross-section. The edges are sinuous and rarely retouched. One biface is symmetrical; elongated and pointed, shaped by abrupt and invasive removals. The tip is worked by series of small and unipolar removals.

Bifaces on quartzite (n = 2)

One symmetrical tool (110 mm) is totally worked by flat and invasive removals. The edges present peripheral retouch, with notches at the base and the tip. The second tool (148 mm) looks like a large scraper on a flake. Removals are marginal, flat and peripheral on one face, and invasive on the opposite face, with abrupt and marginal retouch on the base and the tip. This tool

-Level E/E1

Retouched nodules on flint (n = 5)

Small and thin cubic nodules (12-25 mm long; 15-36 mm wide; 4-16 mm thick) were selected for direct retouch. Retouch is abrupt peripheral, unilateral or bilateral and slightly modifies the edges. They are similar in form to the flakes, but thicker.

Pebble tools (n=20)

The pebble tools on limestone are made by a short series of invasive bifacial removals. Sometimes, they were broken after shaping or during the use process. Others are on flat and elongated pebbles with flat and abrupt removals on the face and the edges. Three small pebbles on flint are retouched in the same way.

-Level B

Pebble tools (n=60)

The pebble tools on limestone include 57 tools with a convex cutting edge and 3 with a convergent/pointed extremity. In both cases, the cutting edge is managed by a small number of unifacial or bifacial unipolar removals (**Fig. 9**). The tools measure between 50 and 130 mm long and between 30 and 130 mm wide. Most of them are made by direct percussion and some could have been worked on an anvil. For the pointed tools, the shaping is finished by retouch on the extremity (**Fig. 10).**

Bifaces and bifacial tools (n= 14)

Five types of limestone were identified on this corpus. The first type (type 1) is the main one used, probably on account of its fine texture. It includes magnesian limestones, dolomitic limestones and pure dolomites. There are three rarer other types: silicified limestones or dolomite (type 2); silicified arenites and calcarenites (type 3), some being also determined as quartzite; and siliceous accidents in limestone layers (type 4).

The symmetrical bifaces in limestone (n = 2) have a large cortical surface at the base, while the tip and the lateral edges are shaped by invasive removals and the edges are retouched. The crude bifacial tools on limestone (n = 6) are partially cortical, backed, on a pebble or half-pebble, with some retouch on the cutting edges. The unifaces in limestone (n=2) are worked by marginal removals on one face. One bears a notch and retouch on the whole cutting edge. The only cleaver-like biface was found in this level, on a limestone pebble. The transversal cutting edge is worked by marginal and abrupt removals.

The bifaces on flint (n=3) are possibly on pebbles or nodules. The largest tool measures 220-120-48 mm. Shaping is face by face with more or less abrupt and invasive removals. In one case, manufacture modifies the original geometry by invasive removals and retouch (131-90-45 mm). The cross-section is generally biconvex. One biface (149-100-45 mm) is made on a natural or Kombewa flake, minimally modified by marginal, peripheral retouch on one surface. The tip is finished by marginal and unifacial abrupt retouch.

5.Technical variability at Notarchirico and in Southern Europe

5.1.Comparison of the technological strategies between levels F and B with bifaces and level E/E1 without biface

-Raw materials

In levels F and B, related to a dense cobble-pebble pavement, the limestone cobbles-pebbles collected for the LCTs show diversified petrography and sizes (more than 50-100 mm). Flint was only available as small (<50 mm) nodules/pebbles and mainly used for debitage or direct retouch. Conversely, level E/E1 is a sandy level with small limestone pebbles (less than 50-100 mm, on average) or flint nodules (10-60 mm) were used. This could explain the large quantity of flint cores and the lack of some categories of LCTs such as bifaces . If this is the case, the *in situ* availability of large-sized raw materials would explain the presence of bifaces in certain levels of the site (if the size of excavated area is significant).

-Core technology

Flaking is attested in the three levels by cores and flakes, except for level F, which only comprises flakes. No major differences were observed in the core technology of the three levels, and variations appear to be adapted to the geometry of the raw materials. No significant technical differences can be observed between the three levels (**Table 8**).

Unifacial cores are prevalent and are generally larger in limestone than flint. Cores in level B are larger than cores in level E/E1, but this difference is not significant given the small number of pieces. Flaking technology is similar, generally with unipolar removals, with some exceptions (more bipolar removals in level E/E1 and convergent removals in level B). The striking platform is generally not prepared. Frequent hinged scars indicate the limited management of the core surface.

Bifacial cores are managed by a short series of centripetal removals with no preparation or with limited preparation of the platform in level B, or unipolar removals in level E/E1. The blank is generally a small pebble (in limestone) or nodule (in flint).

Multifacial cores are present in two levels in both limestone and flint. Level E/E1 comprises two cores on a flint flake.

-Flakes and flake tools

Flakes indicate unipolar and centripetal core technologies in the three levels. Flake tools consist of points, notches and scrapers on various flakes.

Flakes on limestone mainly show unipolar scars. Some are retouched. On flint flakes, the debitage starts with bipolar and centripetal removals and the striking platform only seems to be occasionally prepared during debitage. Only the largest flint flakes are retouched.

Flakes from level E/E1 are generally smaller than flakes from levels F and B (smaller flint nodules?), except for flake tools. There is a clear selection of the largest blanks for retouch.

-Large Cutting Tools

Level B yielded the highest quantity and diversity of pebble tools. Conversely, pebble tools are rare in level E/E1, possibly on account of the rarity of cobbles-pebbles *in situ*, and there are no bifaces or bifacial tools, only tools on small limestone pebbles or flint nodules.

In the three levels, we observe unifacial (level B) or bifacial pebble tools (all levels) with diversified sizes**.** Some of the pebble tools are pointed and display minimal shaping. One cleaver-like tool and crude bifacial tools on limestone are present in level B. Unifaces and bifaces on various stones are only present in levels F and B. Bifaces generally indicate management of the volume and the geometry of the tool. The only clear difference between levels is the presence/absence of bifaces.

5.2. Elements of variability in the sequence of Notarchirico

5.2.1.Main features of the phases of occupation

As for level E/E1, level alpha is a layer comprising a few small and medium-sized pebbles in a sandy deposit (Piperno ed., 1999), whereas levels D, C and A are dense beds of cobbles-pebbles (**Table 8**).

Level D was excavated over a surface of 25 m². The industry is composed of artefacts on limestone pebbles (n = 256) and flint nodules (n = 44). The limestone cores measure less than 100 mm in length. They consist of chopper-cores, unifacial and bifacial cores with some centripetal removals. Limestone flakes are abundant and larger than flint flakes. The striking platform of these flakes is cortical or flat. Removals are unipolar or crossed. Limestone and flint flakes were transformed into tools (scrapers, denticulates, points and flakes with some retouch). LCTs include pointed unifacial or bifacial pebble tools in limestone, made by a small number or several series of removals. A single trihedral tool made by flat and invasive removals with a rounded tip was observed. The two bifaces are lanceolate, shaped by invasive removals and discontinuous bifacial retouch. Crude bifacial tools also exist. There are also small (less than 70 mm long) tools on nodules/pebbles with a denticulate edge or a point.

Level C was excavated over 20 m² and only yielded 78 artefacts, including four in flint. Flint and limestone flakes were produced by centripetal flaking and flake tools consist exclusively of denticulates in flint. Pebble tools in limestone and flint are mainly unifacial and bifacial and no bifaces were recorded as in level E/E1 despite available cobbles-pebbles. Flint tools are similar in size to tools in level E. Unifacial pebble tools are shaped by one or two series of unipolar removals, sometimes followed by retouch.

Level A1 is known as the “Elephant area”, as it contained a skull of *Elephas antiquus*. It consists of a bed of cobbles/pebbles, in which 41 artefacts were found, made up of several bifacial and limestone pebble tools. The few flint pieces generally include small scrapers, denticulates and a core. Flakes

show a high number of centripetal removals. The striking platform is sometimes facetted. Retouch is peripheral, abrupt or bifacial. Some unifacial or bifacial pebble tools and some bifaces display volume management. Some bifacial tools show a pointed tip shaped by invasive removals, and secondarily a notch or a denticulate. The crude bifacial tools are made by sparse removals and are asymmetrical (**Fig. 11, 12**).

Level A was excavated over 120 m² and yielded 316 artefacts, mainly on limestone pebbles (n = 283) and flint (n = 33). Most of the limestone artefacts are unifacial pebble tools, mainly pointed tools made by marginal removals, sometimes with a final notch and final retouch on one edge. One polyhedral was identified. The flint artefacts are flaking products (n =24) and five are scrapers. Level A1 contains two bifaces in limestone (**Fig. 11**).

The lithic corpus of level alpha is made up of pebble tools (n = 436 for a total of 950), on limestone (55.94%), siliceous limestone (27.29%) and flint (17.43%). Several types of limestone cores were observed. Chopper-cores are produced by several flat and invasive removals. Several peripheral and globular cores were identified, as well as some cores on flint flakes. This level contains abundant flakes (n = 514) in flint (73.73%). Limestone flakes are the largest products and show unipolar or crossed removal scars. A small number of limestone flakes were transformed into scrapers (n = 105, 30-100 mm), borers (20 mm) and denticulates (n = 127). Retouch is located on one or several sides, and is generally invasive or marginal. A small number of denticulates were also produced on quartzite flakes. The limestone artefacts include unifacial pebble tools, some of which are double (70-120 mm long, 40-60 mm wide, 30-70 mm thick). The pointed tools (50 mm) in flint are small pebbles shaped by bifacial, abrupt and more or less invasive removals. The bifacial pebble tools measure 20-60 mm long, 10-40 mm wide and 10-40 mm thick.

5.2.2. Comparison between levels with and without bifaces at Notarchirico

Levels F, D, C, B, A1 and A on beds of cobbles-pebbles present some similarities and some differences in comparison to levels E/E1 and level alpha in a sandy layer (**Table 8**) (Piperno ed., 1999).

Limestone is more widely used than flint and is the main raw material in levels E/E1 and alpha, despite similar *in situ* availability.

Differences were recorded in the number, raw material and technology of core categories between the archaeological levels. However, the methods applied in each category do not differ between levels. Levels F, A1 and A contained no cores, while levels D and C only yielded limestone cores. Level C only contained chopper cores while level D yielded chopper cores and bifacial cores. Chopper cores in flint are only present in levels E/E1, B and alpha.

In levels E/E1 and alpha, limestone and flint cores do not present any different technical specificities related to the raw material, although they differ in size (flint: 20-60 mm long, limestone: 70-120 mm long). Level E/E1 comprised unifacial cores in limestone and flint while level B only contained unifacial cores in limestone. For both raw materials, the cores present unipolar and centripetal removals, and the flint cores also show bipolar removals.

Bifacial cores in limestone were observed in levels E/E1, D and B, flint bifacial cores in limestone and flint were recorded in level E/E1. Multifacial flint cores are only present in level E/E1 and multifacial limestone cores were observed in level B. Some rare cores on flint flakes were only found in level E/E1.

Level alpha differs from the other levels by the presence of peripheral cores in limestone and bipolar and globular cores in flint. In sum, level E/E1 and alpha present a higher diversity in terms of core technologies and raw materials.

All the archaeological levels contain varied quantities of flakes and flake tools in diverse raw materials. Unretouched flakes in limestone are often larger than those in flint. Limestone pebbles show unipolar or crossed removals (levels D, B, alpha), various directions (levels E/E1, alpha) or centripetal removals (levels C, A1). Flint flakes platforms are only facetted in level A1. Flaking is centripetal (levels C, A1) or varied (levels F, E/E1, alpha) (**Fig. 11, 12)**.

Retouched flakes in limestone are rare and larger than their flint counterparts. Flake tools are not made on specific flake types. Tool types are composed of denticulates, scrapers and notches and do not differ throughout the sequence. Only levels F and alpha yielded more diversity (more points and borers), exclusively in flint.

Pebble tools are in all levels but in different proportions and sizes. Pebble tools are unifacial or bifacial. In most cases, they are in limestone, except in levels D and alpha, where there are also flint specimens. Tools are small in level E/E1, probably because of the small size of available pebbles. Pointed pebble tools exist throughout the sequence, mainly in limestone, except for levels D and alpha, where some small pointed pebble tools are in flint. None of these tools were recorded in level C. They are made by short series of bifacial, invasive and abrupt removals. Final retouch was only used in levels A and A1 for limestone, and in levels E/E1, D and alpha for flint.

In levels D, B and A1, some crude bifacial tools in flint and in limestone were observed. They are asymmetrical and never retouched except for one flint tool in level D. Bifaces and unifaces showing overall volume management are in various raw materials, mainly flint and limestone. There are no bifaces in levels E/E1, C and alpha. In levels E/E1 and alpha, some small flint retouched nodules with abrupt and denticulate retouch were recorded.

5.3.What Notarchirico provides on the technological variability in the Southern European context

The period between 700 and 500 ka in Southern Europe is a key period for understanding the characteristics of the earliest biface production (management of bifacial volume), as attested for instance at la Noira (MIS17/16), Moulin Quignon (MIS 16) or Caune de l'Arago (MIS 14) in France and compared to the technological strategies of sites without bifaces, as at TD6 Atapuerca (800 ka) in Spain, Isernia-la-Pineta (MIS 15/14), Cimiteri di Atella (MIS 15-14) and Loreto-Venosa (MIS 14/13) in Italy (Crovetto, 1993; Longo et al., 1997; Barsky and Lumley, 2010; Ollé et al., 2013; Gallotti and Peretto et al., 2015; Abruzzese et al, 2016; Mosquera et al., 2018; Antoine et al., 2019; Moncel et al., 2020). Notarchirico is thus an ideal site for describing this variability and questioning the possible impact of raw materials, as there are levels with and without bifaces in different contexts of deposits and raw material *in situ* availability. We selected some key and well-dated sites with or without bifaces (considering a biface as a tool with a bifacial volume management and equilibrium of the two faces) in order to describe the diversity of strategies performed and contribute discussing why bifaces are present only in some occupations. The raw materials used in these sites are moreover diverse in types and forms.

5.3.1. Some key-assemblages with and without bifaces in Southwestern Europe

-Assemblages with bifaces

At la Noira in France (700 ka; Moncel et al., 2013, 2020), hominids used local millstone slabs on the banks of the river. Bifacial discoid cores are predominant, associated with different types of cores with flaking sequences dependent on slab geometry. Core sizes are highly variable (50-180 mm or > 200 mm). Some cores indicate opportunistic and immediate flaking to produce cortical flakes, while others indicate higher productivity with the production of small flakes. Flaking produces both small and large flakes (> 100 mm). Only 7% of the flakes are retouched (simple or double scrapers, notches and convergent scrapers). The LCTs are composed of bifacial tools with limited shaping, more intensively worked bifaces by several series of removals and final retouch, some bifacial cleavers, two cleavers on a flake and a large diversity of crudely-made heavy-duty tools.

The archaeological assemblage recently discovered at Moulin Quignon in a sequence of fluvial sands and gravels is dated to the MIS 16-15 (670 ka) glacial-interglacial cycle of the Somme River (Antoine et al., 2019). More than 260 flint artefacts were recovered, including large flakes, cores (including one with flaking independent of the geometry of the flint nodule) and five bifaces with overall management of the geometry and the shape (diversity of final forms).

The site of Cimiteri di Atella in Italy (MIS 15-14; Abruzzese et al, 2016) yielded elephant remains with a scant lithic assemblage. The raw materials consist of different kinds of flint, quartzite and porous radiolarite. Flint is used for flake tools and radiolarite for the few large tools (1%). The corpus is composed of cores (2%), flakes (47%) and flake tools (25%). Some cores are SSDA type with some orthogonal unipolar flakes (Forestier, 1993), whereas others are discoid-type cores. Flake tools are on natural thick fragments where the flat face was used as a percussion surface for retouch (points,

denticulates, end-scrapers and indeterminate). The *spina* tools (Aureli et al 2016) total 30%, made up of two adjacent notches. The few bifacial tools are on large flakes in radiolarite. They are plano-convex tools with shaping by invasive removals on one asymmetrical face.

At la Caune de l'Arago in France, the sequence extends from MIS 14 to MIS 12, with 14 archaeological levels (Barsky and Lumley, 2010; Barsky, 2013; Falguères et al., 2015). The diversified raw materials include quartz, flint, quartzite, sandstone, limestone, and lava, among others. Most of them were procured around the site but a long-distance perimeter of 30 km is also observed for some good-quality stones (flint for instance). In the early levels P and Q (550 ka), the LCTs include diversified types of bifaces and cleavers on flakes in various raw materials. Some of them show a high level of standardization and are symmetrical. Quartz pebble tools are relatively abundant. The main core technology is discoid. Bipolar percussion on an anvil was also used on quartz pebbles. The flake tools include notches and Tayac and Quinson points. Levels L and K are characterized by very few flake tools, no handaxes and frequent pebble tools. Levels J to H (unit II) are characterized by a selective use of raw materials, only one poorly standardized biface, numerous flake tools and pebble tools. In levels G and D, at the top of the sequence, the industry is on local poor-quality raw materials, mainly quartz. The ratio of flint decreases. Flakes in level D are microlithic (Barsky et al., 2019).

-Series without bifaces

In the TD6 level at Gran Dolina in Spain (Atapuerca, 800 ka, Falgueres et al., 1999; Parés et al., 2013), hominids used large blocks and flakes of local Neogene flint collected 2-5 km from the site, while quartzite, sandstone, quartz and limestone were collected in an area 1 km from the site. Neogene flint was collected as large pebbles, and used for the production of large flakes. These blanks are sometimes not completely depleted. Debitage is multidirectional and orthogonal with no preparation of the striking platform. Flake tools are scrapers and denticulates. Cretaceous flint was collected in small nodules. All the phases of debitage are present. Quartzite is represented on the site as cobbles less than 120 mm long. They are hammers or cubic cores for debitage with orthogonal and centripetal removals. Thick and large flakes were retouched. Quartz was mainly worked with bipolar flaking on an anvil (Carbonell et al., 1999; Ollé et al., 2013; Mosquera et al., 2018).

The recent study of level 3c of the site of Isernia la Pineta (590 ka, Coltorti et al., 2005; Gallotti and Peretto et al., 2004, 2015; Pereira, 2017) shows that production there was partly independent of blank morphology (unifacial and bifacial discoid-type). Most of the series consists of small cores (19.4%) and flakes (49%). Flake tools total 34%. Most of the cores were intensively flaked. The larger flakes are retouched (44 mm long and 45 mm wide). Large pebble tools on limestone coexist with small flint fragments and flakes (Crovetto et al., 1994; Longo et al., 1997; Peretto et al., 2004).

Near Notarchirico, the site of Loreto-Venosa in Italy (Crovetto, 1993) is an open-air site dated to around MIS 13 (Pereira, 2017). The industry from level A consists mainly of unifacial pebble tools on

limestone and other types of stones, and flake tools. Flakes (n = 303) are short and thick, mainly in flint, limestone, siliceous shale and jasper pebbles or slabs. There are 18 small cores with a small number of removals on one face with different organization. Flaking is not standardized. The striking platform is sometimes minimally prepared. Flake tools total 46% of the series of flakes (various scrapers, notches and Upper Palaeolithic type tools (end scrapers, burins, borers and composite tools). Pebble tools total 27% of the total industry, made of whole pebbles and broken pebbles in quartz, quartzite and microquarzite. 11% are pebbles with a single removal by percussion. These are rounded or pointed unifacial tools.

5.3.2. Notarchirico and the Southern European sites

The comparison of data from the different levels of Notarchirico does not reveal clear differences between the lithic corpuses in terms of core technologies, regardless of the presence or absence of LCTs, including bifaces. Pebble tools are present throughout the sequence, including pointed pebble tools. The availability of large-sized raw materials (numerous cobbles/pebbles in limestone and few nodules in flint) cannot account for the presence/absence of LCTs, and in particular bifaces. The behavioural strategies observed for level E/E1 seem to be related to the available stones in the poor sandy deposit (small limestone pebbles and flint nodules). However, in level alpha, despite available cobbles and pebbles, bifaces and LCTs are lacking.

At Notarchirico, core technology is mainly on small flint nodules while pebble tools are on limestone cobble-pebbles. All the stones could have been collected *in situ.* The sample of identified limestone indicates that thin-grained limestone was preferentially selected. However, in levels E/E1 and alpha, the selected limestone is of rather poor quality and the selected pebbles are small in size. The availability of raw materials seems consequently to have played a limited role on the size and perhaps the diversity of artefacts as layer alpha did not yield bifaces despite the fact that occupations were installed on a pavement of cobble-pebbles.

In the same way as for most other sites, data show that hominins selected and used local stones (even directly retouched small flint nodules) without introducing other large raw materials to the site, except the younger site of the Caune de l'Arago (MIS14), or found an alternative solution, as observed on some of the younger sites, with the use of large fragments of elephant bones (i.e., Boschian and Saccà, 2015). Core technology at Notarchirico consists of short reduction sequences, often adapted to the geometry of the stones (small nodules on flint or limestone cobbles-pebbles). The raw material geometry partially explains the technological differences observed between the cores. The limestone cores on pebbles are larger than the flint cores. Bifacial cores are smaller than unifacial cores, indicating perhaps a higher productivity of bifacial flaking surfaces. This trend is similar at most of the sites, except la Noira and Isernia-la-Pineta, where flaking is independent of stone geometry for some cores.

The small size of flint flakes at Notarchirico is also observed at Isernia-la-Pineta, where small quartz pebbles or small fragments of flint were used for debitage, associated with large limestone pebble tools. The exception seems to be TD6 at Atapuerca, with no distinction between raw materials for flaking and shaping. The technological diversity of the categories of flint flakes at Notarchirico indicates that flaking took place *in situ*. A high ratio of cortical flakes indicates the low productivity of cores with a single series of removals, especially unifacial cores. Most of the cores seem to be expedient cores for the rapid production of small and backed flakes. This behaviour is consistent with the opportunistic use of small directly retouched flint nodules in some levels. The only exception seems to be some large quartzite and limestone flakes which could come from large cores that do not exist in the excavated areas (fragmentation of the "chaîne opératoire") (Moncel et al., 2019). These giant cores exist at la Noira *in situ*, producing large flakes, rarely used for shaping.

6.Conclusion

The three lithic corpuses taken as examples at Notarchirico indicate no significant shifts in core technologies throughout the sequence, independently of the presence or absence of bifaces (as observed at Gesher Benot Ya'kov; *i.e.*, Sharon et al., 2011; Goren-Inbar et al., 2018). Hominins selected local raw materials, and adapted processes to the geometry of the stone, even on small flint nodules. Productivity is often limited . This type of site, along water shores, could be both a butchery site (for scavenging?) and a domestic area and other similar sites indicate opportunistic behaviours adapted to activities and hominins used local available stones (Vallverdu et al., 2014). This type of lithic record shows that it is difficult to investigate cognition and skills for early occupations in Western Europe where traditions, adaptations to stone constraints and availability, and the impact of activities and of the climate also interfere, as in East Africa (Rodriguez et al., 2011; Garcia-Medrano et al., 2014; Terradillos-Bernal and Rodríguez-Alvarez, 2014; Carbonell et al., 2016; Hardy et al., 2018; Moncel et al., 2018a, b; Torre et al., 2018).

At Notarchirico, the presence of absence of bifaces and LCTs cannot only discussed through the availability of large size stones *in situ* as we observed in some levels. Even if the role of the activities on the tool kit is still uncertain by few evidence of cut-marks on large herbivores bones on the site, the hypothesis of a strong relationship during the Middle Pleistocene between hominins and megafauna such as Elephants is attractive (i.e. Reshef and Barkai, 2015; Solodenko et al., 2015; Barkai, 2016). Bones are punctually or never used during the early Paleolithic except some evidence in particular the use of small bone fragments for retouchers or large fragments of Elephant bones for making bifaces, in particular from MIS 11-9 (Moigne et al., 2016; Zutovski and Barkai, 2016). Most of the early sites dated to 700-500 ka are often located along water areas and artefacts associated to remains of large herbivores. Cut-marks, when preserved, can be due to the exploitation of carcasses of Elephants and

large bovids. Hunting evidence, even on weak or diseased animals, is not well documented (see traces on bovids at Isernia-la-Pineta; Hohenstein et al., 2009) and scavenging is frequently proposed. Hominins would have taken advantage of numerous and available carcasses along water areas with an easy primary access. Lacking of bifaces and bifacial tools on some levels at Notarchirico raises question on the role of the activities during the occupation(s) that could be not thus systematically devoted to the exploitation of large herbivores. New evidence, provided by new fieldworks on the base of the sequence, indicates through micro-wear analysis that diversified activities took place on the site (Moncel et al., 2020). The sequence of the Caune de l'Arago illustrates the possible functional link between bifaces (LCTs) and remains of megafauna (*i.e.* Elephant), and during cold events (for instance MIS 14), suggesting that these tools could have been efficient and useful for working on carcasses of large herbivores (Lumley et al., 2004; Moigne et al., 2006 ; Barsky and Lumley de, 2010 ; Barsky, 2013), However, for Notarchirico, we have to keep in mind that only a small part of the areas of activities are documented (limited excavated areas) and bifaces could have been taken away by hominins or abandoned elsewhere on the site for some levels. Moreover, pebble tools and pointed pebble tools could have functionally replaced bifaces. The few use wear analyses on pene-contemporaneous sites indicate the diversity of use of the LCTs whatever their techno-morphological features (Hardy et al., 2018).

To conclude, we cannot avoid to think that a part of the diversity in the composition of assemblages of this period can be due to the activities and diverse traditions in relation to the available raw materials opposing Southern Europe where coarse-grained stones were largely used to Northwestern Europe where the dominance of flint and siliceous stones could explain the lack of cleavers on flake for instance. Moreover, between the two big glacial events of the MIS 16 and MIS 12, variability of climatic and ecological conditions could have conducted to successive colonization and depopulation of Western Europe by small groups of hominins with phases of adaptation, some traditions losing or acquiring new tool kits, in an area located at the extremity of Eurasia, east of the Rhine River, functioning as a world apart.

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Captions

Figure 1. Sequence of Notarchirico from the levels F to A with the new 40Ar/39Ar and ESR-Th dates (in italic). The position of the hominin remain and the levels with bifaces are indicated.

Figure 2. Examples of cores on flint of the level E of Notarchirico.
n°1 Unifacial core with some removals on the opposite face (striking platform?), n°2 Centrieptal and bifacial core, n°3 Multidirectional core on a cublic nodule.
The colors indicate the order of the removals on the cores when visible.
(n° 1, 2 drawings C. Santagata, modified, n° 3 photo C. Santagata, n° 4 drawings M. Pennachioni, modified)

Figure 3. Length/width of cores of the level E (in mm). Comparison according to the raw materials and the core technology.

Figure 4. Pebble tools and cores on limestone of the level B of Notarchirico
n°1, 2 Pebble tools, n° 3 Core with centripetal removals,; n°4, 5 Quandrangular peripheral tools or cores. Similar legends for colors than the figure 2.

Figure 5. Length/width of cores of the level E (in mm). Comparison according to the raw materials and the core technology.

Figure 6. Flakes and flake-tools (denticulated and abrupt retouches) on flint (n° 1-5) and limestone (n° 6, 7) of the level F of Notarchirico.

Figure 7. Flakes and flake-tools on flint of the level E of Notarchirico
n° 1, 3, 4, 5, 7, Denticulated and abrupt retouches, n°2, 8 Borers, n° 6, 9 Convergent retouches, n°10 Retouched notch.

Figure 8. Length/width of flakes of the level E (in mm). Comparison according to the raw materials and the extension of the cortex.

Figure 9. Pebble tools (n°1, 2) and crudely-made cleavers-like (n°3) on pebble on limestone of the level B of Notarchirico.

Figure 10. Pointed pebble-tools on limestone of the level B of Notarchirico
Similar legends for colors than the figure 2.

Figure 11. Pebble-tools on limestone of the level A of Notarchirico
n°1, 2, 5, 7, 8, 9 Pebble tools with a limited shaping, n° 3, 4, 6 Pointed pebble tools, n°10 Polyedhral (drawings M. Pennachioni, modified).

Figure 12. “Area dell’Elefante” (upper part of the sequence) at Notarchirico.
n°1, 2, 4, 6. Large bifacial tools and pointed pebble tools on limestone, n°7 Pointed pebble tool on flint, n°3 Biface on limestone, n°5 Biface on flint, n°7, 8, 9 Small simple or double flake-tools on flint (drawings G. Marchesi, modified).