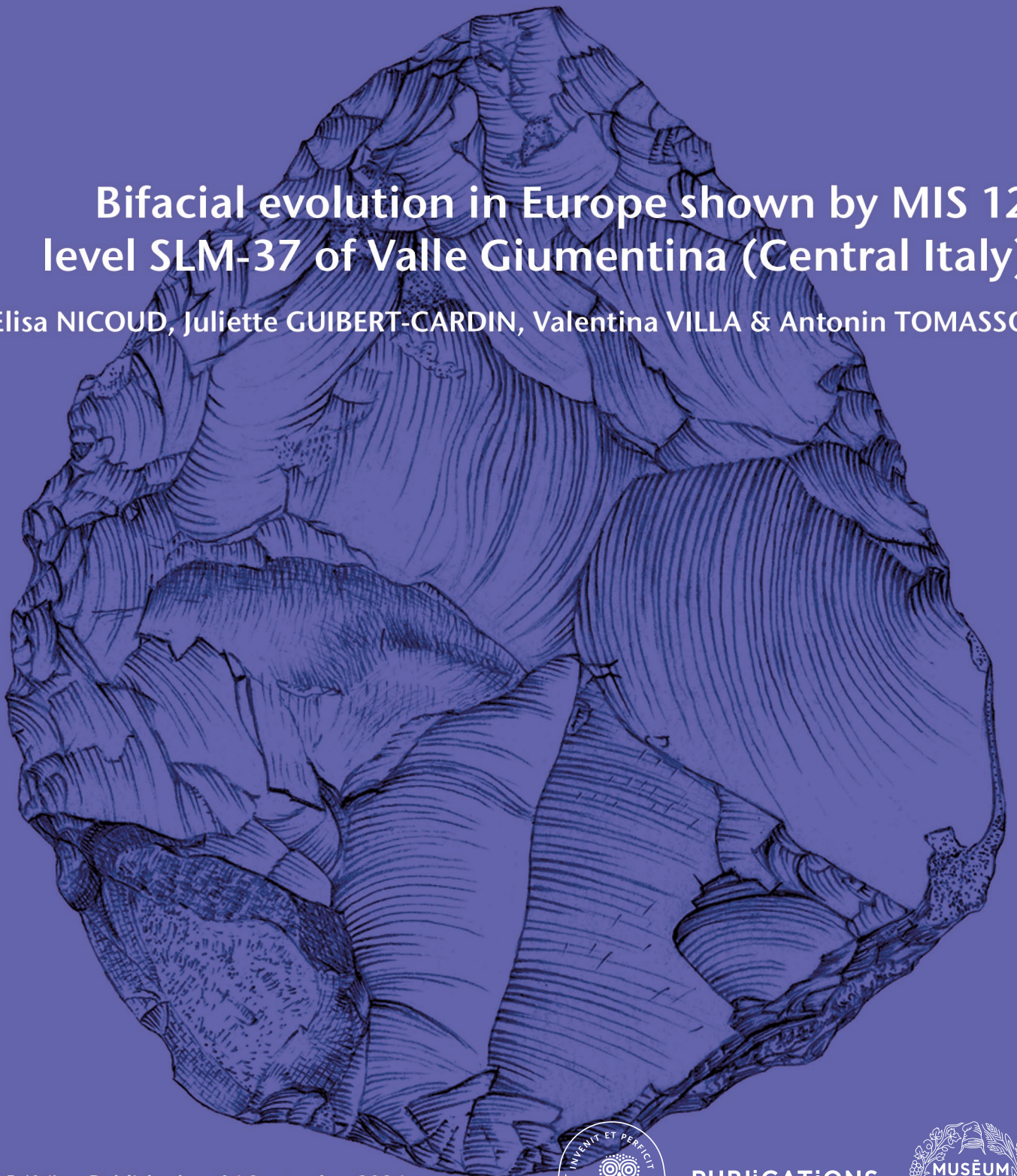


Bifacial evolution in Europe shown by MIS 12 level SLM-37 of Valle Giumentina (Central Italy)

Elisa NICOUD, Juliette GUIBERT-CARDIN, Valentina VILLA & Antonin TOMASSO



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Valle Giumentina SLM-37: biface VV1 I11 3. Credits: drawing by Michel Grenet/EFR.

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Elisa NICOUD
Juliette GUIBERT-CARDIN
Valentina VILLA
Antonin TOMASSO

Cultures et Environnements. Préhistoire, Antiquité, Moyen Âge (CEPAM),
CNRS Université Côte d'Azur, 24 avenue des Diables bleus, 06300 Nice (France)
elisa.nicoud@cnrs.fr (corresponding author)
juliette.guibert-cardin@univ-cotedazur.fr
valentina.villa@cnrs.fr
antonin.tomasso@cnrs.fr

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ABSTRACT

Valle Giumentina (Abruzzo, Italy) comprises 12 archaeological levels dating from MIS 15 to MIS 12, four of which contain bifacial industries. Level SLM-37, excavated between 2015 and 2017 in two areas, reflects a steppic environment and is attributed to MIS 12c. It yielded a bifacial industry made on local cherts (1 471 artefacts, including one biface). Post-depositional modifications only slightly affected the assemblage, and numerous refits were identified. Faunal remains are scarce (*Cervus elaphus* Linnaeus, 1758 and possibly *Dama dama* (Linnaeus, 1758)). Flaking activities occurred at the site, which appears to have been occupied briefly but repeatedly. A shift in biface structure is observed between level SLM-37 and the subsequent MIS 12b level LABM-40, from “biface as a blank for tools” to “biface as a tool.” This structural change coincides with the emergence of core-and-flake production, absent in SLM-37. Valle Giumentina is one of the very few sites associated with the glacial event of MIS 12. The feasibility of detailed and reliable chronostratigraphic and palaeoenvironmental reconstructions for the Middle Pleistocene is demonstrated here. This allows us to identify a previously unknown, local, and rapid evolution of bifacial industries, and to propose multiple reinventions and developments of the biface within the European Lower Palaeolithic. Notably, owing to the exceptional state of preservation of the site, the LABM-40 biface exhibits some of the earliest identified use-wear traces on a biface until now.

KEY WORDS

Lower Palaeolithic,
biface,
Middle Pleistocene,
lithic technology,
techno-economy,
traceology,
palaeoenvironments,
Europe,
Valle Giumentina,
Acheulian,
micromorphology,
taphonomy.

RÉSUMÉ

L'évolution du biface en Europe illustrée par le niveau SLM-37 du MIS 12 à Valle Giumentina (Italie centrale).

Valle Giumentina (Abruzzes, Italie) comprend 12 niveaux archéologiques datés du MIS 15 au MIS 12, dont quatre présentent des industries bifaciales. Le niveau SLM-37, fouillé entre 2015 et 2017 dans deux aires, reflète un environnement steppique et est attribué au MIS 12c. Il a livré une industrie bifaciale réalisée sur des silex locaux (1 471 artefacts, dont un biface). Les modifications post-dépositionnelles n'ont que légèrement affecté l'assemblage et de nombreux remontages lithiques ont été identifiés. Les restes fauniques sont rares (*Cervus elaphus* Linnaeus, 1758 et possiblement *Dama dama* (Linnaeus, 1758)). Des activités de débitage ont eu lieu sur le site, qui semble avoir été occupé brièvement mais de manière répétée. Une évolution dans la structure des bifaces est observée entre le niveau SLM-37 et le niveau suivant, LABM-40 du MIS 12 b, qui passe de « pièce bifaciale-support d'outil(s) » à « pièce bifaciale-outil ». Ce changement structurel coïncide avec l'apparition d'une production d'outils sur éclats issus de débitages, absente du niveau SLM-37. Valle Giumentina est l'un des très rares sites associés à l'événement glaciaire du MIS 12. La faisabilité de reconstitutions chronostratigraphiques et paléoenvironnementales détaillées et fiables pour le Pléistocène moyen est ici démontrée. C'est grâce à cela que l'on peut identifier une évolution locale et rapide, jusque-là insoupçonnée, des industries bifaciales et proposer de multiples réinventions et évolutions du biface au sein du Paléolithique inférieur européen. En outre, grâce à l'état de conservation exceptionnel du site, le biface de LABM-40 présente les traces d'utilisation parmi les plus anciennes identifiées sur un biface à ce jour.

MOTS CLÉS
Paléolithique inférieur,
biface,
Pléistocène moyen,
technologie lithique,
techno-économie,
tracéologie,
paléoenvironnements,
Europe,
Valle Giumentina,
Acheuléen,
micromorphologie,
taphonomie.

INTRODUCTION

The European Lower Palaeolithic is partly defined by the presence of bifaces in lithic industries, which gave rise to the Acheulean culture (Mortillet 1872). The cultural significance and diversity of these artefacts, as well as of the Acheulean itself, are widely debated (e.g., Mortillet 1875; D'Acy *in* Bordes 1961; Piperno 1982; Shipton & White 2020). At the European scale, a structural evolution of the biface has been observed around MIS 10, alongside changes in the rest of lithic production through flaking (Boëda 1997; Nicoud 2013a, b). At Valle Giumentina (Abbateggio, Maiella, Abruzzo), the first excavations were carried out by A. M. Radmilli in collaboration with the geologist J. Demangeot (Demangeot & Radmilli 1953). Between 2012 and 2019, new excavations took place a hundred metres away (École française de Rome research program; Nicoud *et al.* 2016). Within the 45 m-long sedimentary sequence, which contains 12 archaeological levels spanning from MIS 15 to MIS 12, bifaces appear discreetly at MIS 13a (levels IIG SFL-35 and SFL-36), and again at MIS 12c (SLM-37) then at MIS 12b (LABM-40). This paper focuses on level SLM-37, while the other levels are used for specific comparisons, as their sedimentological features and chronostratigraphic settings have been presented in previous studies (Villa V. *et al.* 2016, 2021, 2024).

The excellent preservation of Pleistocene deposits at Valle Giumentina allows for an accurate reconstruction of the chronology and environment of bifacial occurrences. Following the taphonomic assessment of the occupation, the multidisciplinary analysis addresses the technology of the lithic

series, the techno-economic behaviors, and the possibility of identifying activity areas in level SLM-37. We present the structure and function of bifaces, as well as the composition of the bifacial series at Valle Giumentina. We highlight the value of high-resolution environmental data for determining the timing of short but intense Middle Pleistocene ecosystem changes. Finally, we discuss the cultural significance of this evolutionary shift in the biface structure for settlements dynamics in Europe during Lower Palaeolithic.

MATERIAL AND METHODS

ARCHAEOLOGICAL EXCAVATION AND REMAINS FROM SLM-37 LEVEL

Level SLM-37 was excavated manually in two loci 175 m apart, firstly from 2015 to 2017 in locus VV3, nearly 4.30 m below the surface (c. 732.20 m asl) over a restricted area of 7 m². We exploited a landslide to reach this level. An excavation was also carried out in 2017, in the main locus VV1 over an area of 35 m², almost 6 m below the surface (c. 732.50 m asl; Nicoud *et al.* 2018; Figs 1; 2). In VV1, the manual excavation yielded 252 lithic remains in chert (excluding debris), 45 limestone cobbles and fragments and three faunal remains. The sediments were sieved with water per quarter m², yielding others 498 very small chert debris as well as 15 fragmentary bone remains. In VV3, 338 chert lithic remains were spatially positioned during the excavation and a further 383 very small flakes, fragments of flakes and debris were collected per ¼ m² (n = 208) and

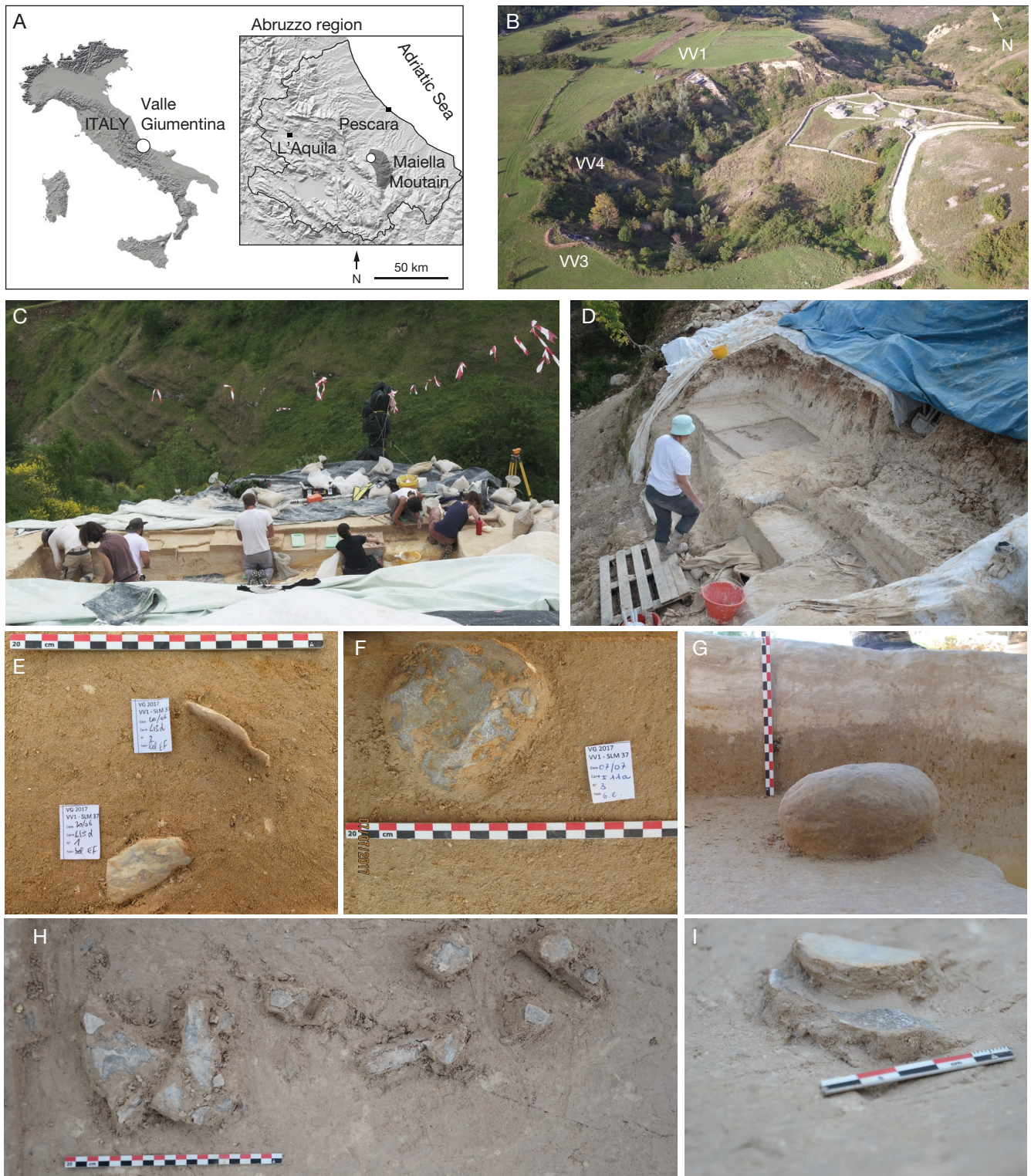


FIG. 1. — Valle Giumentina: location of the archaeological site and of its stratigraphic sequences: **A**, location of the site in the calcareous Maiella mountain range, Abruzzo region, Italy; **B**, location of the stratigraphic sequences studied in this work on the slope of a ravine, in front of the “Ecomuseo del Paleolitico”, 2016; **C**, Excavation in locus VV1, 2017; **D**, Locus VV3, 2015; **E-G**, Locus VV1, 2017; **H, I**, Locus VV3, 2015. Credits: E. Nicoud/EFR.

after sieving ($n = 175$, making a total of 721 chert remains). Five artefacts in limestone and 15 faunal remains also appeared. In VV1 locus, the archaeological level is around 20 cm thick and in VV3 it is 50 cm thick, although most

of the finds were found in the very-upper part of the layer. The layer dip slightly to the north-west. Lithic industry from A.M. Radmilli's excavation in the 1950's is used for comparisons (Radmilli 1965).

SEDIMENTOLOGY, SOIL MICROMORPHOLOGY AND PALAEOENVIRONMENTAL STUDIES

The archaeological level SLM-37 is included in one of the palaeosols that characterise the upper part of the Valle Giumentina sequence, called “stratigraphic unit EN1” (Villa V. *et al.* 2016). It lies between the stratigraphic layers SFL-35/36 and LBL (Fig. 2).

The sedimentological study conducted on the EN1 sequence is based on a set of high-resolution analyses, comprising particle size distribution, calcimetry, total organic carbon, volume magnetic susceptibility and ED-XRF spectrometry measures on palaeosols and sediments. A malacological study was also conducted on the whole VV1 profile and on some complementary samples from the VV3 profile. The chronostratigraphic framework of the whole Valle Giumentina sequence was established using eight $^{40}\text{Ar}/^{39}\text{Ar}$ dates on tephras and one ESR/U-Th dates on a deer mandible, and confirmed by geochemical analyses of the tephras. These data, as well as the palaeoclimatic and palaeoenvironmental reconstructions to which they have contributed, have already been presented in detail in previous papers (Villa V. *et al.* 2016, 2021; Pereira 2017; Villa 2017; Limondin-Lozouet *et al.* 2017; Degeai *et al.* 2018; Nicoud *et al.* 2022).

Here we present new results of the micromorphological study carried out on samples taken from both VV1 and VV3 stratigraphic profiles in SLM-37 layer. Three undisturbed sediments blocks for thin sections (about 6×10 cm in size) were collected, then oven dried and impregnated under vacuum with polyester resin. Thin sections were observed under plane-polarized light (PPL) and cross-polarized light (XPL) using a standard Leica DM petrographic microscope. The descriptions follow the guidelines established by Bullock *et al.* (1985) and Stoops (2003).

PETROARCHAEOLOGY

Petrographic analyses were conducted using mesoscopic observations (i.e., stereomicroscope, magnifications $\times 40$ to $\times 200$) following the classical approach (Fernandes *et al.* 2024). From VV1 locus, all coordinated cherts remains were considered for this study ($n = 252$) and from VV3 locus, all coordinated cherts remains ($n = 338$) plus all the small items recorded per m^2 ($n = 208$) and all debris coming from sieving ($n = 175$) have been taking into account.

Lithic raw materials are described and classified within the rock collection “MPALP” kept at the CEPAM laboratory in Nice. Maiella cherts come from two main calcareous formations. The first one is a Tortonian-Burdigalian formation (M4-2) referenced as MPALP #123. This grey to brown chert has a massive structure with 30-40 % of well-sorted clasts (200-500 μm), with spicules (notably tetraxones) and often foraminifera with a trochospired test and globular to ovate chambers. The second one is an Oligocene-Palaeocene formation (O-PC) named MPALP #124. This chert also has a massive structure but with >50 % of poorly sorted bioclasts. Nummulites up to 5 mm and millimetric discoidal foraminifera with rectangular chambers (Lepidorbitoidae) occur. A proper description is available in Nicoud *et al.* (2022).

LITHIC TECHNOLOGY AND TRACEOLOGY

A typo-technological and techno-functional analysis of the artefacts was carried out (excluding very small debris), in order to characterize bifacial shaping techniques and methods. The production *chaîne opératoire* steps illustrated on the site are outlined in a techno-economic perspective.

To document post-depositional modifications (PDM) and use-wear traces, we used a stereomicroscope (Leica Z16 APO – camera Leica DMC 2900; range of magnification from $11.4\times$ to $184\times$) and a metallographic microscope (Leica DM 2700 MH – camera Leica DFC 295; range of magnification from $100\times$ to $200\times$). Except for small fragments (<1 cm), all the chert artefacts were analysed from VV1 locus ($n = 252$) and VV3 ($n = 338$). Use-wear traces were compared to the experimental reference collection available at the CEPAM laboratory.

TAPHONOMY

Sedimentological and micromorphological analyses are used to evaluate the degree of soil formation and its potential impact on archaeological remains. To assess the state of preservation of the lithic series and identify the weathering processes, we used and adapted the third analytical framework for characterizing archaeological cherts developed within the framework of the Research Programme “Réseau de lithothèques en Auvergne-Rhône-Alpes” and the GDR Silex (Fernandes & Raynal 2005). This analytical framework takes into account the PDMs commonly used to determine the state of preservation of artefacts and is based, among other studies, on the work of Rottländer (1975), Stapert (1976), Masson (1981), and Burroni *et al.* (2002). Description criteria are incrustation gradient, patina gradient and polarity, damage marks gradient and type (scars, crushing, impact point on surface), rounding of the ridges and edges, dissolution and soil sheen gradient, other processes (bright spots, striations, recent damage...). For each artefact, we assessed whether the alterations were mainly of mechanical, chemical, biochemical or thermal origin. Finally, according to all PDM, we determined whether the artefact has a slight, medium, or high degree of alteration. We then look for lithic refitting units in order to show any dispersion of the artefacts according technological significance. The condition of the faunal remains is also considered to finally assess the overall integrity of the archaeological layer thereby justifying a socio-economic approach to the occupation.

RESULTS

SOIL AND SEDIMENTARY FEATURES, PALAEOENVIRONMENTAL DATA AND CHRONOLOGICAL CONTEXT OF THE SLM LAYER
At locus VV1, the SLM layer is a light brown horizon (Munsell code 10YR 7/3) 14 cm thick, consisting of massive, compacted silty sand. The voids, which are few and less than a millimetre in size, are often characterised by the presence of slight oxidation marks in the form of rust-coloured flecks. The lower boundary is irregular,

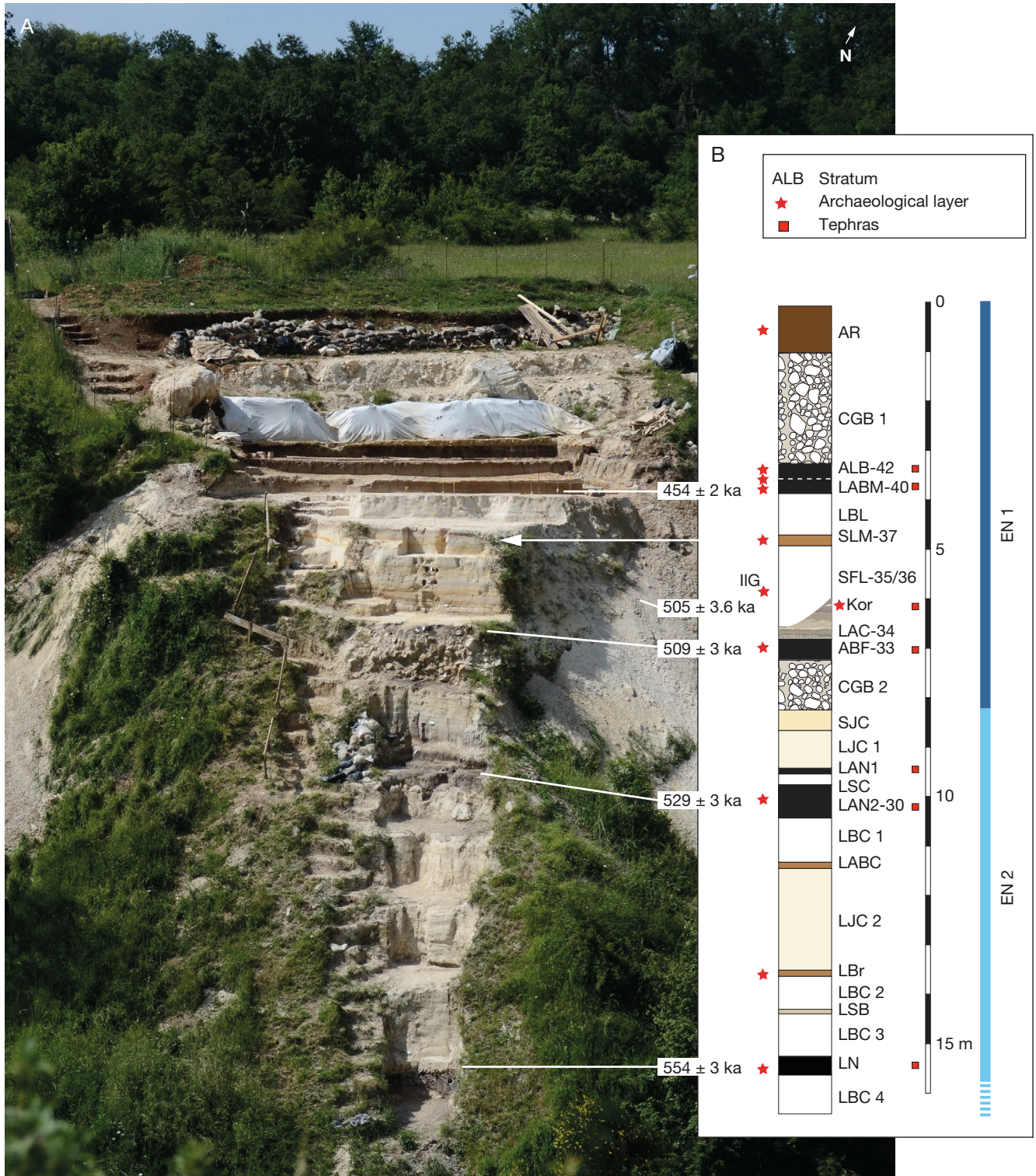


FIG. 2. — Valle Giumentina locus VV1 stratigraphic profile: **A**, picture; **B**, schematic stratigraphy (after Villa 2017 and Villa *et al.* 2021 with $^{40}\text{Ar}/^{39}\text{Ar}$ ages from Pereira 2017). The white arrow indicates the SLM-37 level excavated in 2017. **Red stars** highlight the archaeological levels. Another archaeological level occurs further down at a depth of 24 m. A total of 12 levels span the period from c. 565 to 450 ka (Villa *et al.* 2024). Credits: Photo by P. Gaignard/ EFR 2016; DAO by E. Nicoud.

undulating and gradual. Within the VV3 stratigraphic profile, this same horizon is slightly lighter (10YR 6/3), thicker (approximately 25 cm) and has a very slightly sandy silty texture, finer than in section VV1. Solid and

compacted, it is characterised by clearly visible bioturbation features, highlighted by numerous white flecks corresponding to channel fillings. The lower boundary is very irregular, undulating and gradual.

Calcimetry and TOC measurements carried out on samples taken from locus VV1 reveal a predominantly carbonate composition (97.5 % CaCO_3) and a minimal organic carbon content (0.15 %). Grain size analyses confirm the poorly sorted nature of the layer, which comprises silt and fine sand, with particle sizes ranging from 2 to 200 μm . A sudden change in texture can be observed compared to the underlying deposits. The SFL layer is coarser, well-sorted, consisting mainly of fine and medium sands (mainly between 100 and 400 μm). Conversely, the texture of SLM is more similar to that of the upper layer, LBL, which consists of silt and fine sand (between 2 and 100 μm), with slightly better sorting (Fig. 3A). These results suggest that the formation of SLM corresponds to a change in sedimentation processes.

In thin sections, the SLM layer from locus VV1 appears to consist of detrital calcareous silt and sand grains embedded in a minor micritic matrix, with a close porphyric distribution. The fine fraction is much more significant here than in the underlying SFL unit. In its lower part, the layer is bedded, characterised by a succession of undulated thin laminations with normal grain sorting. A few angular sandy grains of flint are present (Fig. 3B). Clay nodules of detrital origin, resulting from the dismantling and erosion of pre-existing soils, are incorporated into the sediment (Fig. 3C). Their size is approximately 250 μm , which is equivalent to the limestone grains surrounding them. Bioturbation is attested by some channels and by frequent discontinuous fillings made of rounded excrement. The most striking feature of this layer is the presence of numerous molluscs remains. Whole shells are observed throughout the layer, their cavities partially filled with micrite, amorphous organic matter and ferromanganese oxides (Fig. 3D). However, oxidation patterns remain rare; only a few intercalations and impregnations of amorphous iron oxides have been identified around voids. A few rare opaque clay coatings are present in the voids.

The thin sections from cut VV3 confirm the field observations suggesting a finer texture to the deposits in this area. There is a much more abundant micritic matrix and a lower proportion of coarse grains throughout the layer, ranging from 20 % to 50 % (Fig. 3E). Bioturbation is also clearly visible here, as evidenced by the frequent presence of channels filled with coarser materials that disrupt the deposits' weakly bedded structure (Fig. 3F). The presence of a small bone fragment and a few angular flint chips in the thin sections is most likely a relic of human occupation.

The characteristics observed in the field and in thin sections indicate that SLM is a palaeosol, formed on deposits originating from a humid environment, characterised by runoff phenomena of varying intensity, stronger in VV1 and very weak in VV3. It attests to a pause, or at least a decline, in the aeolian and alluvial sedimentation that formed the flanking sedimentary layers (the SFL and LBL layers). It can be defined as an entisol (U.S. Department of Agriculture 1999), as it shows little evolution, characterised mainly by slight oxidation and rare clayey illuviation, and no development or differentiation of soil horizons. Nevertheless, evidence of bioturbation and numerous intact shells, features which are absent in the SFL and LBL layers,

reflect climatic and environmental conditions that were not particularly favourable to soil formation processes, but mild enough to allow vegetation and mollusc fauna to develop. This suggests that it may have formed during a period of improved climate conditions within a glacial period. This is a less significant and/or shorter-lived climate improvement compared to subsequent ones, which enabled the development of the upper LABM and ALB soils. These soils show a much more evolved pedogenesis, characterised by a partially decarbonated sandy-clay matrix, a well-defined prismatic structure, thick clayey coatings, impregnative redox pedofeatures and a cross-striated b-fabric resulting from vertic processes.

Malacological analysis supports this hypothesis. The malacological assemblage preserved in the SLM layer is very rich and comprises 12 different species. They are almost exclusively xerophilic species such as *Truncatellina cylindrica* (Férussac, 1807) and *Vallonia costata* (O. F. Müller, 1774). This indicates an open, dry, steppe-like environment with areas of xerophilous herbaceous vegetation, some shrubs and, elsewhere, an exposed calcareous substrate. The presence of such a variety of species, and the mosaic landscape they attest to, are consistent with the hypothesis of an interstadial phase during a glacial period. (sample M13; 3 858 specimens; Limondin-Lozouet *et al.* 2017). In comparison, the sample located immediately above is characterised by a significantly lower abundance and a reduced diversity (LBL layer, sample M12; 10 specimens, five species), suggesting a shift towards colder, fully glacial climatic conditions. The $^{40}\text{Ar}/^{39}\text{Ar}$ ages obtained from the tephra samples extracted from the Kor (505 ± 3.6 ka) and LABM-40 (454 ± 2 ka) layers, together with tephrostratigraphic data, provide a robust temporal framework for this part of the sedimentary sequence (Villa *et al.* 2021; Nicoud *et al.* 2022), placing it definitively within the MIS 12 (Railsback *et al.* 2015).

By cross-referencing the climate signal and the chronology of the Valle Giumentina sequence with the main Mediterranean archives, it is possible to propose correlations between these records and to refine the age of the SLM soil. Several climate records show that MIS12 is characterised by increasingly cold and dry conditions from MIS 12c through to MIS 12a. The cold peak of MIS 12a, recorded by the Ohrid pollen assemblages between 440 and 426 ka (Koutsodendris *et al.* 2019), is also attested at Tenaghi Philippon (Tzedakis *et al.* 2006) and Sulmona (Regattieri *et al.* 2016). The climate signal and the chronology from Valle Giumentina are consistent with these data, as they indicate that the SLM, LABM and ALB soils developed prior to this phase. Consequently, they must have formed during the rapid interstadial oscillations that characterised the first part of the glacial period, during MIS 12c and MIS 12b. At Lake Ohrid, six phases of vegetation expansion were recorded between 476 and 447 ka, phases which correlate well with the Tenaghi record. The age of the LABM and ALB soils coincides with that of two of these phases (Ohrid LO-12-7e and LO-12-8e), between 460 and 454 ka. It is noteworthy that they are separated by a pronounced and abrupt contraction in vegetation, which can be correlated with the LB layer (section VV3) and with

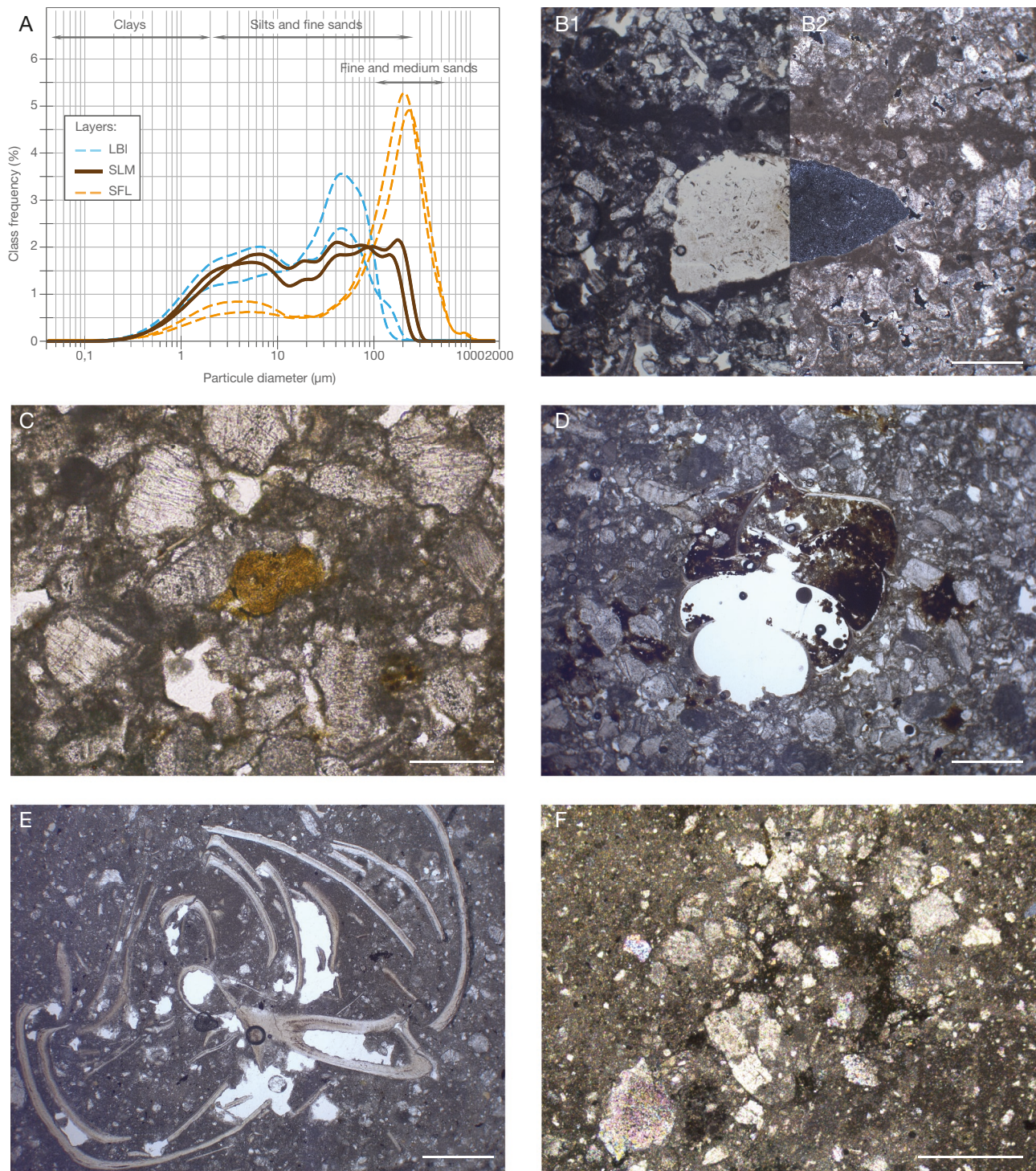


FIG. 3. — Valle Giumentina, layer SLM-37 (VV1 and VV3 stratigraphic profiles): **A**, frequency grain size curves for the SFL, SLM and LBI layers; **B**, VV1: flint fragment in PPL (**B1**) and XPL (**B2**); **C**, VV1: detrital clay nodule embedded in the sandy limestone deposit forming the SLM layer; **D**, mollusc shell filled with micrite and ferromanganese oxides in PPL; **E**, VV3: mollusc shell fragments embedded in the micritic matrix of the SLM layer in PPL; **F**, VV3: filling of a biological void consisting of sandy limestone grains in PPL. Abbreviations: **PPL**, plane polarized light; **XPL**, crossed polarized light. Scale bars: B, D-F, 500 μ m; C, 200 μ m. Credits: V. Villa.

the erosion surface (section VV1) present between these two soils (Nicoud *et al.* 2015). Accordingly, the SLM soil may correspond to one of the earlier phases of climatic improvement (LO-12-4e, LO-12-5e or LO-12-6e), which occurred between 466 and 462 ka.

TAPHONOMIC CONSIDERATIONS

Impacts of deposition dynamics and pedogenesis processes

The variations in depositional dynamics and, consequently, in the texture of the SLM layer observed in the two stratigraphic profiles, VV1 and VV3, may have had different

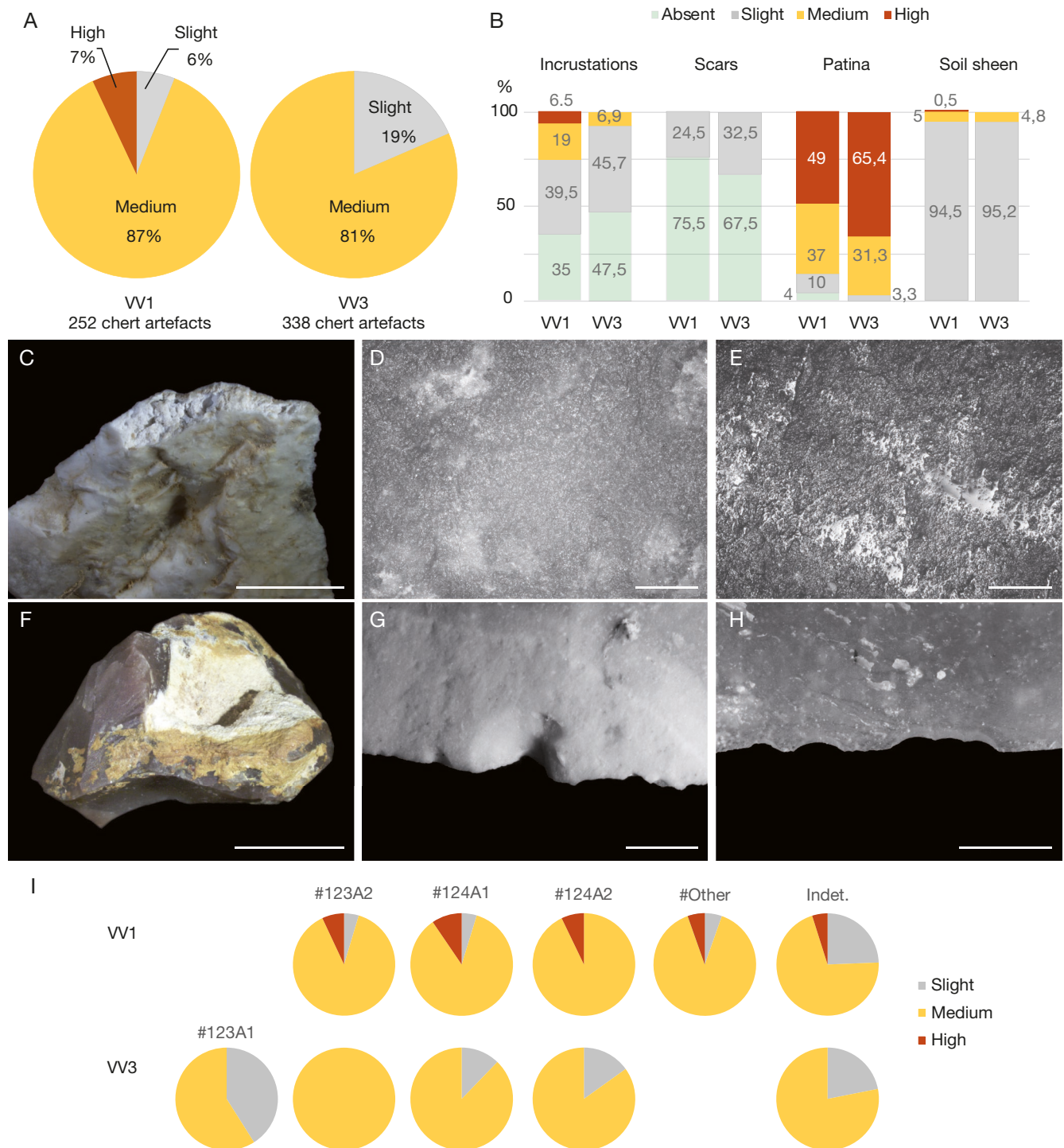


FIG. 4. — Valle Giumentina SLM-37: **A**, chert artefacts alteration; **B**, main post-depositionnal modifications intensity. One piece can present several types of post-depositional modifications (PDMs); **C**, recent fracture with a sugary aspect due to a highly developed white patina; **D**, soil sheen; **E**, large bright spots; **F**, calcareous incrustations; **G**, notch-like taphonomic scar with a crush at initiation; **H**, aligned, crescent-shaped and transverse taphonomic scars; **I**, PDMs intensity by chert types. Scale bars: C, F, 5 mm; D, E, 200 µm; G, H, 2 mm. Credits: J. Guibert-Cardin.

impacts on the preservation of archaeological levels and lithic remains. The presence of multiple undulating sandy bedding planes within VV1 suggests the occurrence of both runoff phenomena and irregularities in the topographic surface. These two factors may have resulted in a slight

rearrangement of the lithic remains, which could have been displaced and/or repositioned in a vertical or on-edge orientation. Furthermore, the transport and deposition of sandy grains covering the remains may have had an abrasive effect, potentially affecting the preservation of use-wear traces.

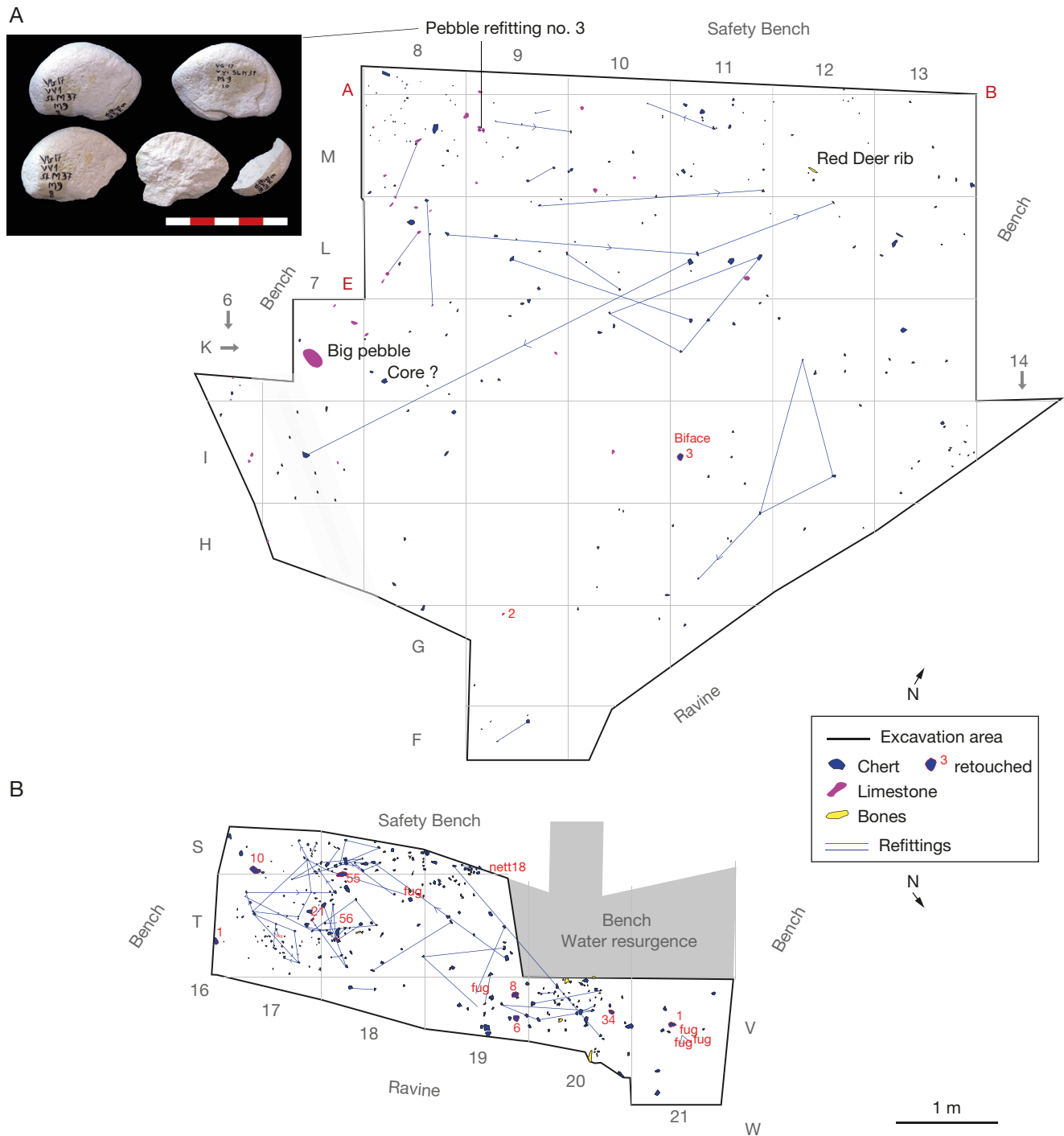


FIG. 5. — Valle Giumentina SLM-37: spatial distribution of the remains in: **A**, locus VV1 with a limestone pebble shattered by frost (refitting no. 3); **B**, locus VV3. Scale bar: A, 5 cm. Credits: E. Nicoud.

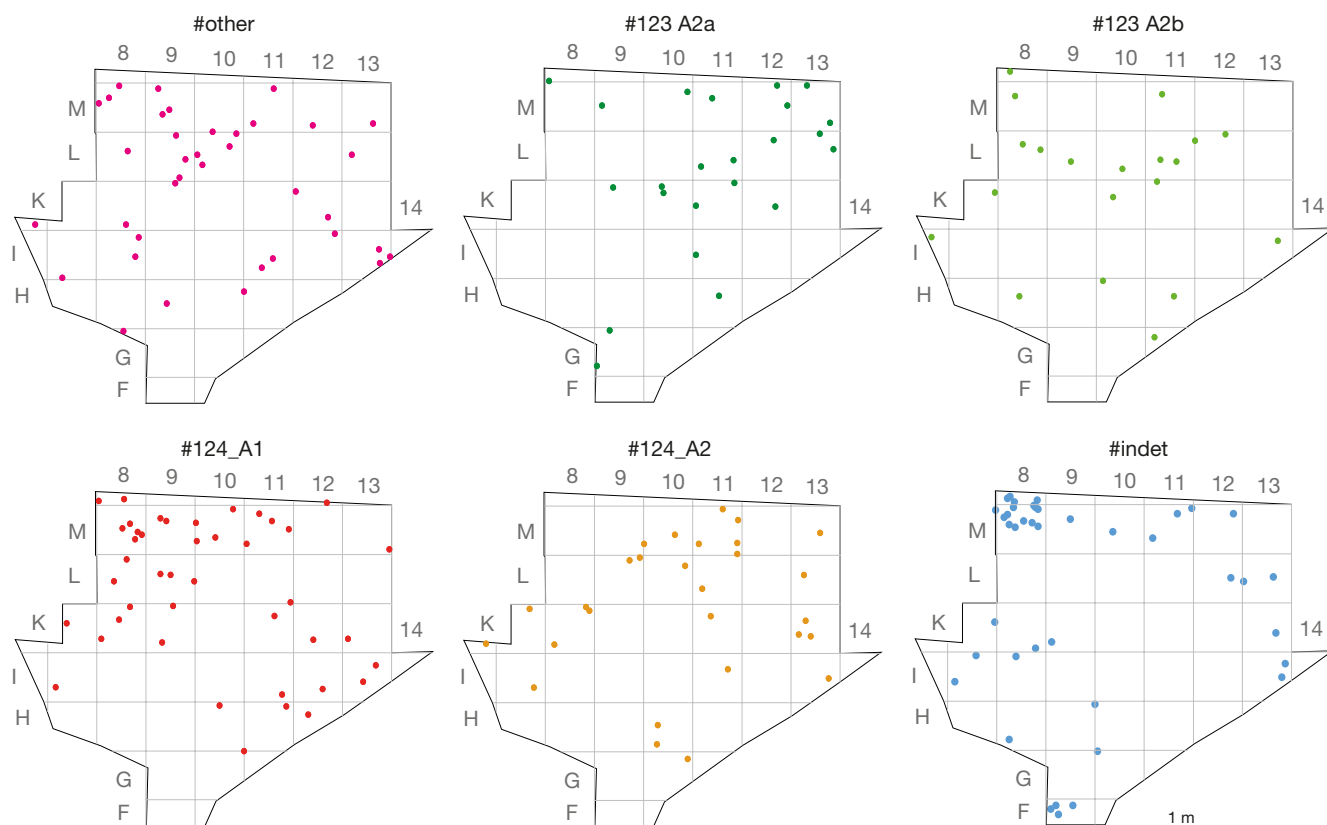
In contrast, the clayey-silty (micritic) sediments embedding the remains in VV3 suggest a calm depositional environment, which would have favoured the *in situ* preservation of the remains and allowed for better surface conservation. Finally, the bioturbation features observed in both soil horizons, particularly the centimetre-wide channels filled with coarse sediments derived from the upper layers, indicate that slight displacement of the smallest remains may have

occurred. The faunal remains are altered and fragmented, and root traces are visible on a humerus fragment, attesting to the development of the palaeosol.

Traceology and chert alterations

Artefacts are globally moderately altered (Fig. 4A). The PDMs are the same in nature in both areas, but are slightly more intense in VV1 (Fig. 4B) and are affecting every type

A



B

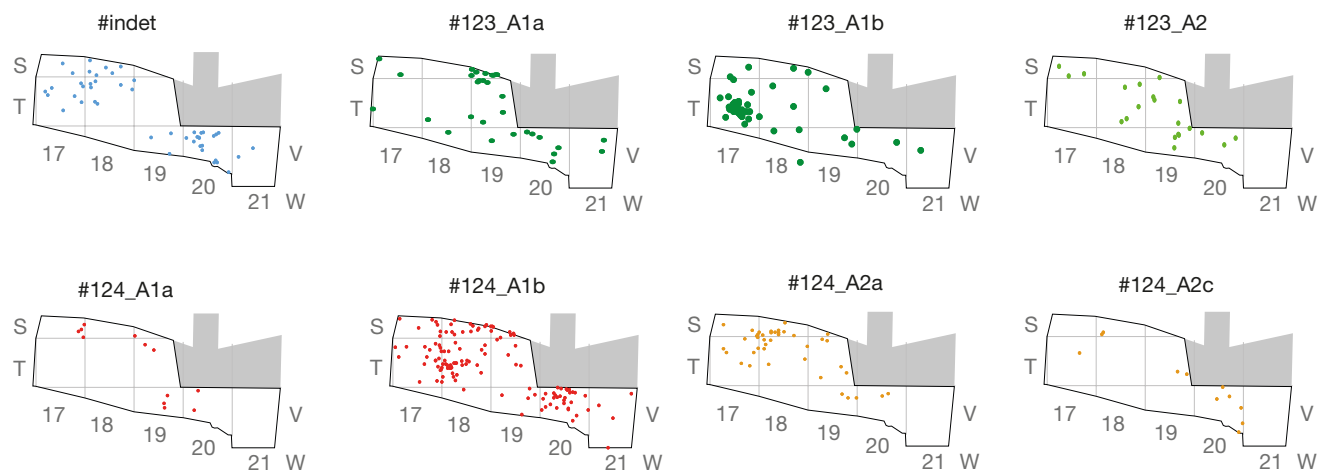


FIG. 6. — Valle Giumentina SLM-37. Spatial distribution of the remains according to their raw material unit (RMU) in: **A**, locus VV1; **B**, locus VV3 (without debris). Credits: E. Nicoud.

of cherts (Fig. 4I). They are due to mechanical processes (soil sheen and scars) and chemical processes (white patina, incrustations, and soil sheen). Apart from occasional edge damage, PDMs mainly affect artefact surfaces rather than cutting edges, allowing functional analysis of the lithic series.

Half of the series shows slight to moderate calcareous and ferro-manganic incrustations (Fig. 4F). They are more developed in VV1. Taphonomic scars affect one third of the

remains. They are either crescent-shaped, transversal and aligned (Fig. 4H) or isolated and notch-like with a crush at initiation (Fig. 4G). White patina deeply affects all the pieces except eight remains in VV1 and is highly to moderately developed (Fig. 4B). The artefacts become brittle and recent damages occur on the edges. These damages always have a so-called sugary aspect (Schmalz 1960), which differentiates them from functional scars. They are either small, localised



FIG. 7. — Valle Giumentina SLM-37. Fragmented faunal remains: **A**, *Cervus elaphus* Linnaeus, 1758 rib (VV1 M12 8); **B**, Metatarsal dorsal fragment of *Cervus elaphus* (VV3 V20 40); **C**, Distal part of a diaphysis of a right humerus (caudal face), possibly *Dama dama* (Linnaeus, 1758) (VV3 V20 12). Scale bar: 3 cm. Credits: E. Nicoud.

fracture or take away a large part of the cutting edge and potential use-wear traces (Fig. 4C). A slight soil sheen gives the whole series surfaces a glossy appearance (Fig. 4D). It is continuous, affects the entire surface of the artefacts and has a rough texture. It does not interfere with functional analysis as rounding and scars are still visible. Some bright spots also occur (Fig. 4E). They are randomly distributed, leaving no doubt about their taphonomic origin.

A positive taphonomic assessment

The first considerations based on sedimentology and traceology show the development of a paleosoil during a phase of climatic improvement at the beginning of MIS 12 with weak perturbation of the layers and of the lithic remains. Faunal remains are more altered. If small limestone pebbles seem to have suffered from frost, their fragments show only a low dispersion (Fig. 5). This alteration may have occurred when the pebbles were still exposed, prior to their burial. Indeed, we observe today this phenomenon on limestone pebbles exposed in the section (CGB2) from one year to the next, probably resulting from the bedded structure of the local limestone. Several chert refittings were carried out, suggesting limited reworking of the pieces, particularly in VV3 (Fig. 5).

Some concentrations by Raw Material Units support this view (Fig. 6). These results allow us to compete the techno-economic and functional analyses and to propose a paleo-anthropological view of this MIS 12c occupation.

FAUNAL REMAINS

In VV1, three faunal remains were discovered, including a rib of *Cervus elaphus* (Fig. 7A). In VV3, 15 fragments appeared, two of which are identifiable, a portion of a metatarsal of *Cervus elaphus* (Fig. 7B) and the distal part of a diaphysis of a right humerus, attributed without certainty to *Dama dama* (Fig. 7C). The presence of Red Deer, a ubiquitous species, and possibly Fallow Deer, is coherent with a phase of improved climate conditions within a glacial period (Nicoud *et al.* 2018).

PETROGRAPHIC CHARACTERISTICS OF THE LITHIC INDUSTRIES

The industry is made of Maiella chert (Table 1). The two main local formations are well represented (#123 and #124). Due to the high patina development, many pieces could not be identified. Five raw material unit (RMU) were recognized in VV1. They relate to the four facies known from the conglomerates in the upper levels of the site. Only one RMU differs from the references established to this point (#other).

TABLE 1. — Valle Giumentina SLM-37: Raw material assignments of the chert artefacts. Most of the material comes from the local Maiella Mountain (#123 and 124). “Other” refers to an undetermined, but most probably local, chert’s source. “Undetermined” refers to remains that cannot be associated with a specific raw material due to their weathering or other limitations (notably of small size).

Geology	Locus VV1			Locus VV3		
	RMU	nb	%	RMU	nb	%
Maiella Tortonian-Burdigalian formation, M4-2	—	—	—	#123_A1a	37	5.13
	—	—	—	#123_A1b	49	6.80
	#123_A2a	28	11.11	#123_A2	26	3.61
	#123_A2b	28	11.11	—	—	—
Maiella Oligocene-Palaeocene formation, O-PC	#124_A1	51	20.24	#124_A1a	12	1.66
	—	—	—	#124_A1b	258	35.78
	#124_A2	31	12.30	#124_A2a	77	10.68
	—	—	—	#124_A2b	2	0.28
	—	—	—	#124_A2c	13	1.80
Maiella	#other	43	17.06	—	—	—
Undetermined	—	71	28.17	—	247	34.26
Undetermined débris	—	498	—	—	—	—
Total	n = 5	750	100 %	n = 8	721	100 %

TABLE 2. — Valle Giumentina SLM-37. Typo-technical counting of lithic industries in chert, limestone pebbles and faunal remains in excavations areas VV1 and VV3.

SLM-37	Cherts		Lime-stone		Fauna	
	VV1	VV3	VV1	VV3	VV1	VV3
Bifacial shaping flakes and fragments of flakes	250	543	2	30	3	12
Flakes and fragments of flakes						
of which entire > 1 cm ²	80	127	1	30	—	—
of which entire < 1 cm ²	24	151	0	0	—	—
of which proximal fgt	61	77	0	0	—	—
of which mesial and distal fgt	85	178	1	0	—	—
of which Siret fgt	0	10	—	0	—	—
of which retouched flake	1	10	—	0	—	—
of which totally cortical	16	15	—	—	—	—
of which semi-cortical	48	38	—	—	—	—
of which without cortex	186	473	—	—	—	—
Pebbles	0	0	2	15	—	—
Core/hammerstone	1	1	0	0	—	—
Biface	1	0	1	0	—	—
Undetermined fragment	—	2	—	—	—	—
Sub-total	252	546	5	45	3	12
Débris after sieving	498	175	—	4	15	3
Total	750	721	5	49	18	15

Eight RMU appear in VV3. Here the raw material appears to be single-sourced and strictly local. This brings us with a minimum number of RMU of 13 in level SLM-37.

The Tortonian-Burdigalian formation (M4-2) is represented by two Facies #123A1 and #123A2 (Fig. 8A). The first RMU (#123_A1a) is a massive pale yellow-grey chert with a bioclastic fraction (20-30 %) fine and well sorted (elements sizes *c.* 200 µm). It includes large monoaxonal spicules and diversified foraminifera (trochospirals with angular chambers; biserials; biloculates with spherical chambers and trochospirals with quadrangular chambers). We also observe very small angular particles representing 1-5 %. The second RMU is a massive brown shiny and opaque chert with large, diffuse light-grey patches and a light-grey patina that varies

from diffuse to covering depending on the area. The fairly abundant bioclastic content (5-10 %) is mainly composed of grey monoaxonal spicules and foraminifera (trochospiral with spherical chambers and spiral with quadrangular chambers). The sorting is good to moderate with a dominant around 200 µm and rarer elements reaching 500 µm. Facies #123A2 counts three RMU (Fig. 8B). The first one from VV1 (#123_A2a) corresponds to a massive, homogeneous chert with a high bioclastic fraction (10-20 %: trochospiral foraminifera with spherical chambers and small monoaxonal spicules) and moderate sorting (100 to 500 µm). The second RMU (#123_A2b) is distinguished by the marked diversity of foraminifera: uniserial with quadrangular or spherical chambers, biserial with ovoid chambers, biloculate with

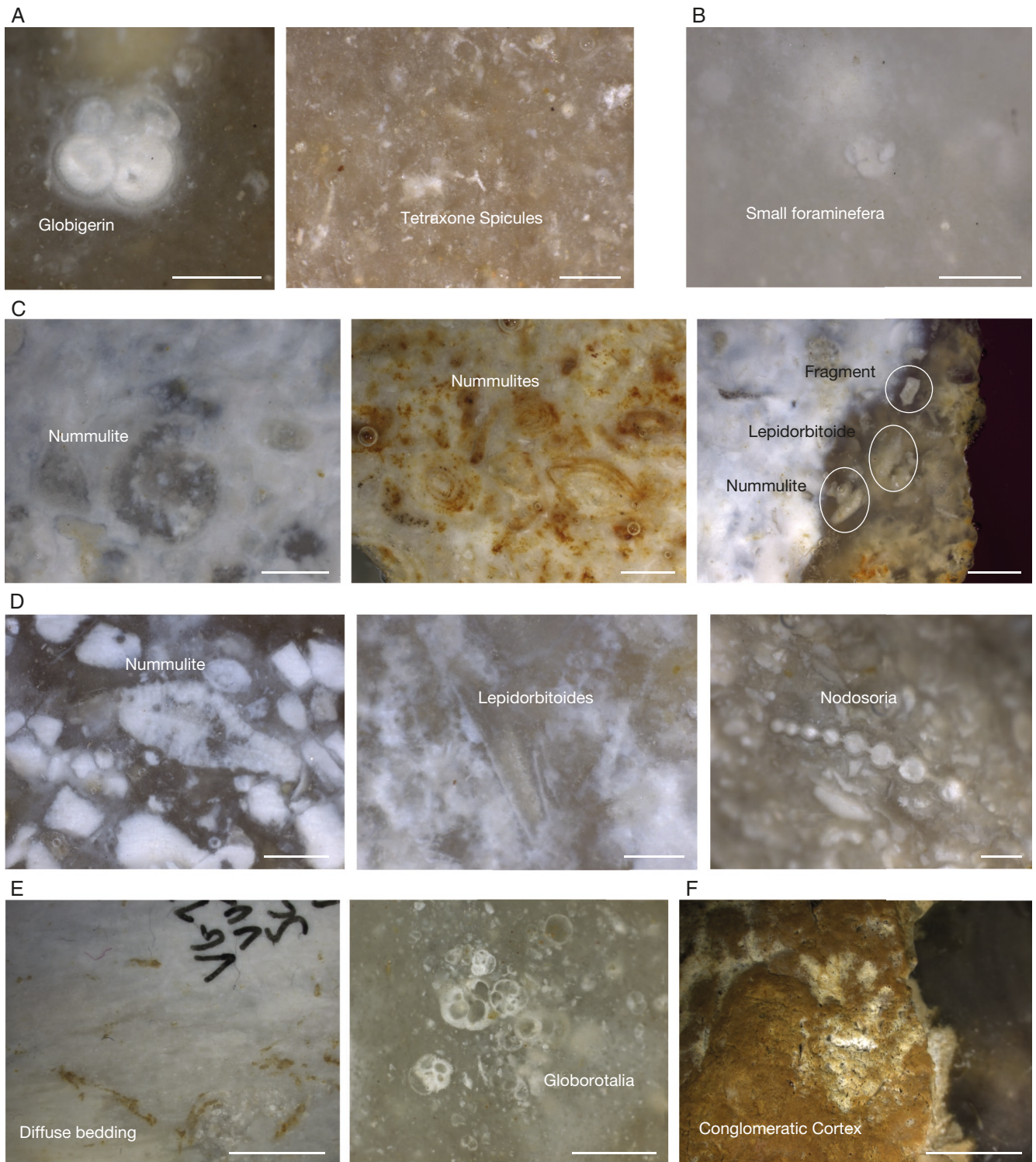


FIG. 8. — Valle Giumentina SLM-37 – Pictures of the cherts lithotypes identified in archaeological samples (stereomicroscope, reflected light) with their main fossils (A-E): **A**, #123_A1 M4-2 Tortonian-Burdigalian: **A1**, T18-50; **A2**, T17-40; **B**, #123_A2 M4-2 Tortonian-Burdigalian, T18-7; **C**, #124_A1 O-PC Oligocene-Palaeocene: **C1**, M11-4; **C2**, K11-1; **C3**, M9-5; **D**, #124_A2 O-PC Oligocene-Palaeocene: **D1**, T19-2; **D2**, V20-24; **D3**, K11-4; **E**, #other Maiella: **E1**, L13-1; **E2**, K3-1; **F**, view of the conglomeratic cortex, S21-1. Scale bars: A1, B, C1, D1, E2, 500 μ m; A2, D2, D3, 200 μ m; C2, C3, 1 mm; E1, E3, 5 mm. Credits: A. Tomasso.

spherical chambers and spiral with trapezoidal chambers. The third RMU, from VV3, is a grey translucent chert, with trochospiral foraminifera with quadrangular lodges and grey monoaxonal spicules.

Both in VV1 and VV3 we identified highly altered pieces from the Oligocene-Palaeocene formation (O-PC; facies #124A1) with a covering white patina (Fig. 8C). The structure is massive and the detrital component is significant

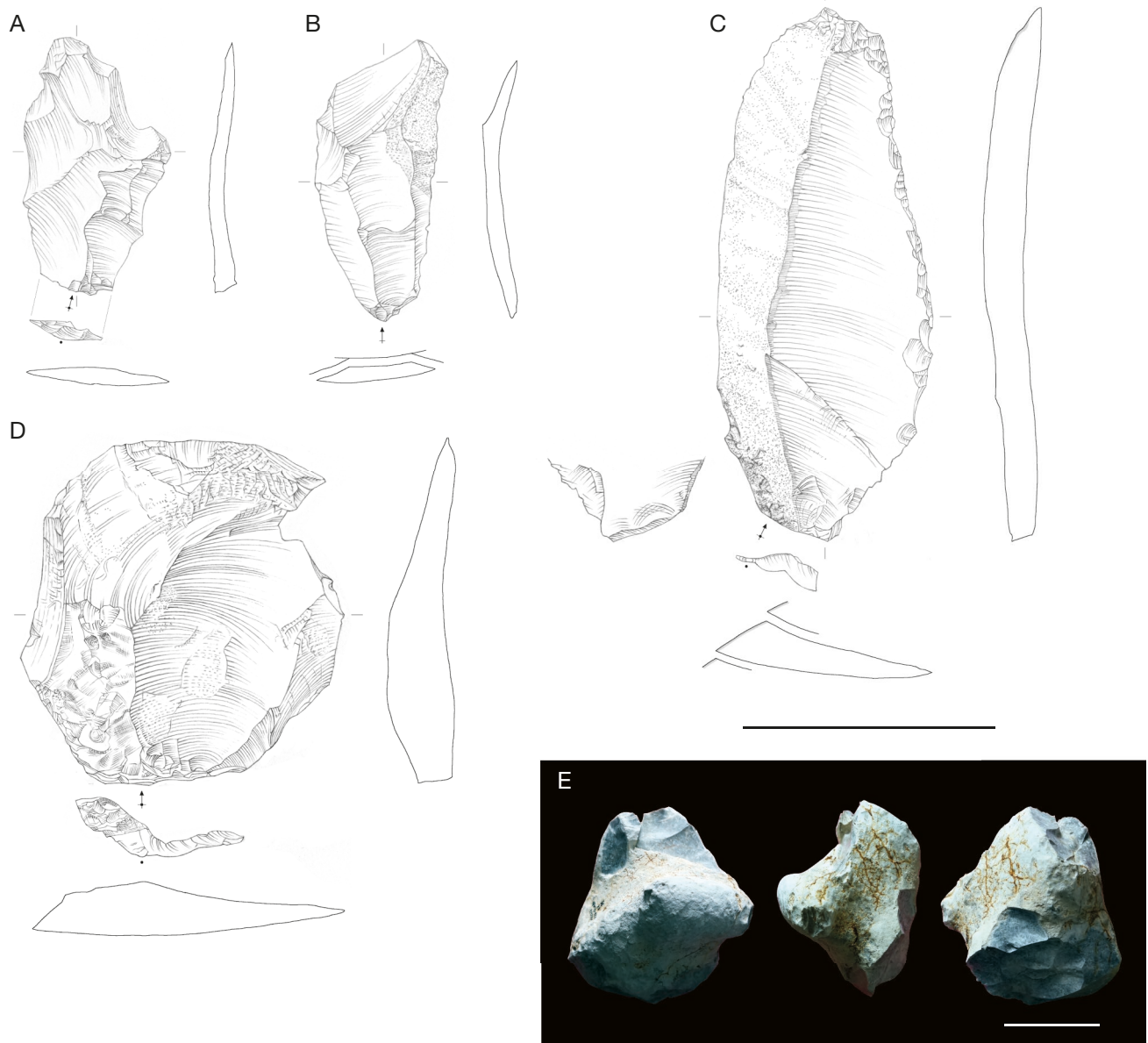


FIG. 9. — Valle Giumentina SLM-37 locus VV1. Thin, curved bifacial shaping flakes: **A**, H8 2 #Ind; **B**, H10 3 #123_A2; **C**, backed knife L12 2 #Ind, this piece is heavily desilicified and the retouch on the right edge is post-depositional; **D**, L13 2 #124-A2; **E**, block of chert supposedly used as a hammerstone (VV1 K8 11). Scale bars: 5 cm. Credits: A-D, drawings by M. Grenet; E and DAO, E. Nicoud.

(10-15 %) with large benthic foraminifera (Lepidorbitoids and Nummulites). The cortex is compact and millimeter-thick. Sorting is moderate to poor. Aspect varies from the peripheral to the core areas of the blocks. Facies #124A2 shows an orange neocortex of conglomerate type (Fig. 8D-F). This homogeneous massive chert shows a dominant bioclastic fraction (>50 %) with unidentifiable angular elements (mainly 100-200µm) and numerous foraminifera (Lepidorbitoides; Nummulites and *Miliolidae*). In VV3, three RMU are associated with this facies. They differ on their aspect: pale yellow semi-translucent and shiny, light grey with a diffuse thin rhythmic bedding or pale yellow to white opaque and matt with manganese dendrites. They also show variations in visibility of clasts and foraminifera.

The last facies (#other), only in VV1, does not correspond to a known type in the current reference system (Fig. 8E). This is a bedded chert with diffuse bedding. Trochospiral foraminifera with triangular chambers grouped in clusters occur. They are very homogeneous, even in size (around 200 µm). These bioclasts are associated with small white and black angular minerals.

BIFACIAL SHAPING: TECHNIQUES AND METHODS

Level SLM-37 only shows bifacial shaping products (Table 2); in the absence of significant differences between the RMU, we present a general count here, with details available in the Appendices 1; 2. Many flakes show the stigmata of a tangential gesture: crushing occurs on the proximal part; the flakes are

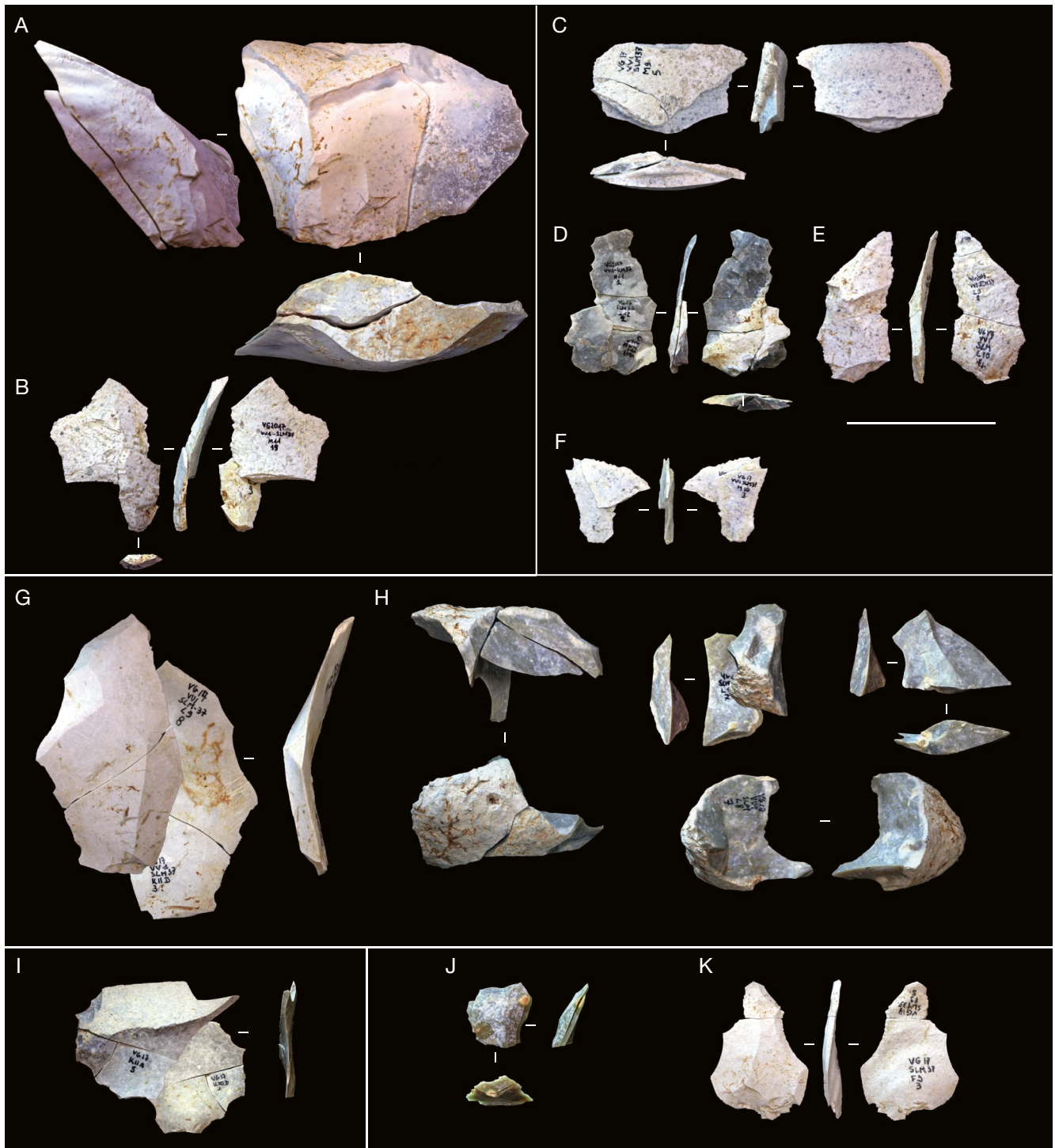


FIG. 10. — Valle Giumentina SLM-37 locus VV1. Refittings of flakes from different stages of bifacial shaping in different types of chert: **A**, first flakes obtained with a hard hammerstone (#124_A2, Refit 6, I7 berme, L11 2); **B**, typical shaping flakes (#124_A2, Refit 8, L9 3, M11 19); **C**, distal fragment of a cortical hinged flake and a cortex fragment (#124_A1, Refit 5, M9 5, M10 4); **D**, partially cortical flakes fragments (#124_A1, Refit 2, H11 1, H11a fug, I12 2, K12 2); **E**, typical shaping flake (#124_A1, Refit 10, L10 4, L10c fug, L9 9); **F**, typical flakes (#124_A1, Refit 7, M10 3-6); **G**, typical flake without butt (#123_A2b, Refit 4, K11 3, L9 8); **H**, Cortical flakes (#123_A2b, Refit 1, L11 7, L12 1, L8 7); **I**, partial cortical flake (#123_A2a, Refit 3, K11 5, K10 1, L11 4); **J**, small flakes from the end of shaping (#indet, Refit 12, M9 4, M9cd); **K**, shaping flake (#indet, Refit 11, F9 3-5). Scale bar: 5 cm. Credits: E. Nicoud.

thin, curved, often fractured; the bulb is diffuse and a lip is present (Figs 9-11). A soft hammer percussion often seems to be used. Only a few flakes show an inward percussion, probably using a hard hammer (well-marked bulbs, well-defined point

of percussion). They are thick, cortical or partially cortical. In the absence of matching cores, and thanks to the refitting units, we consider these thick flakes to result from the early phases of shaping (Fig. 10A). The use of a block of chert cannot be

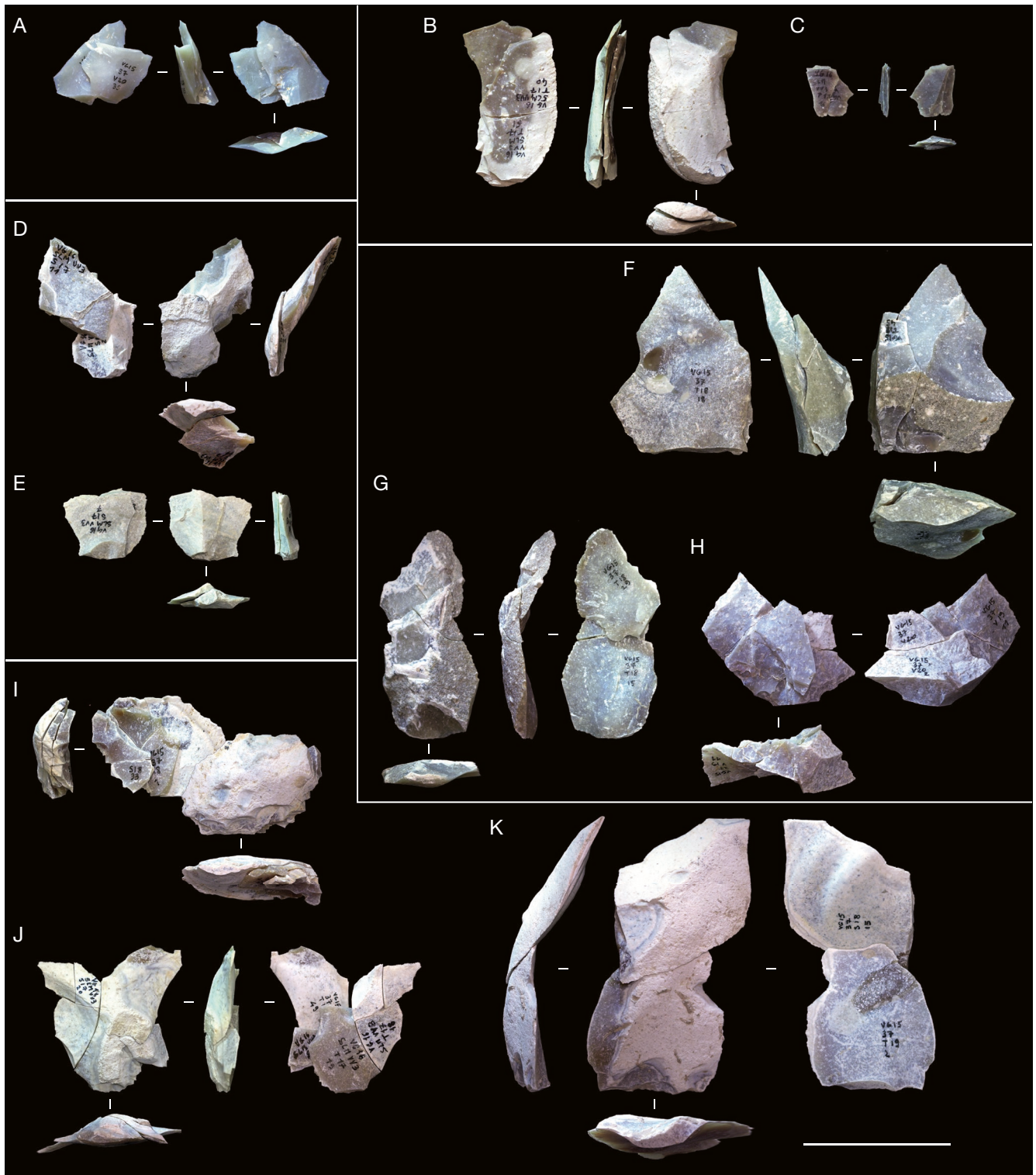


FIG. 11. — Valle Giumentina SLM-37 locus VV3. Lithic industry examples: **A**, two small shaping flakes (#123_A1a, Refit 14, V20 35, S19 6); **B**, two long and partially cortical shaping flakes (#123_A1b, Refit 32, T17 42-5-40-60); **C**, two small and thin shaping flakes (#123_A1b, Refit 18, T17 16-25). **B** and **C** illustrates the whole bifacial shaping *chaîne opératoire* occurred on the spot; **D**, two cortical and semi-cortical unipolar flakes (#124_A1a, Refit 34, S17 11-23); **E**, two small unipolar plain-shaping flakes (#124_A1a, Refit 31, S17 7-8); **F**, thick semi cortical flakes (#124_A1b, Refit 8, T18 18-55-45); **G**, two cortical centripetal shaping flakes (#124_A1b, Refit 20, T18 14-15-29); **H**, two irregular or twisted flakes showing a centripetal flaking (#124_A1b, Refit 3, V20 2-25, V19 11, V20 fug); **I**, cortex removal flake and successive ones for a progressive thinning (#124_A2a, Refit 27, S18 13-1-11); **J**, Idem. (#124_A2a, Refit 33, S17 18-20, T17 18-19, T18 49); **K**, Idem (#124_A2a, Refit 37, T19 2, S18 15). Scale bar: 5 cm. Credits: E. Nicoud.

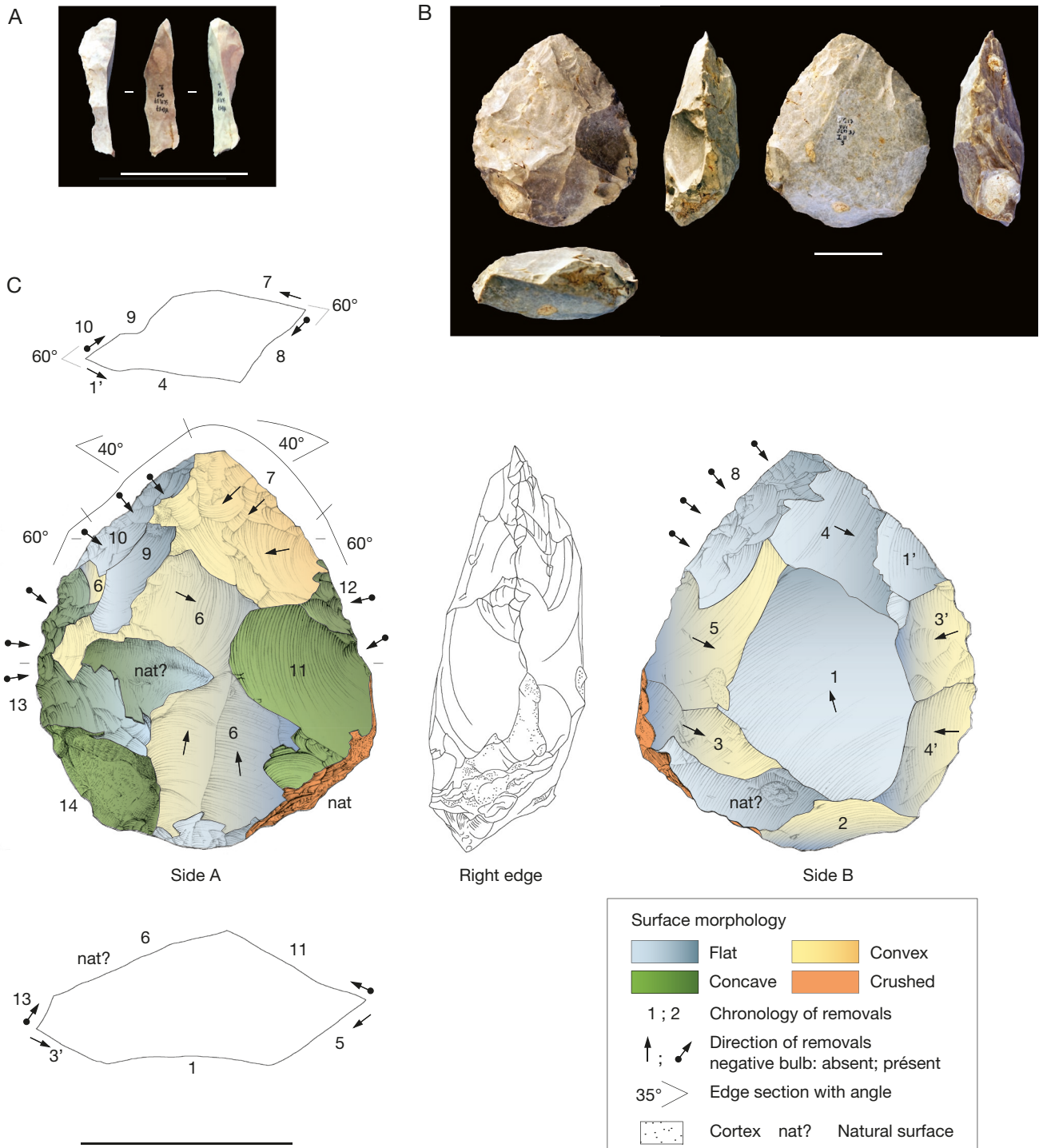


FIG. 12. — Valle Giumentina SLM-37: **A**, tranchet blow (#123_A2a, G9.2); **B**, biface VV1 I11 3 (#123_A2a), picture; **C**, drawing, diacritical and morpho-functional sketches. Scale bars: A, B, 3cm; C, 5 cm. Credits: E. Nicoud; C, drawing by M. Grenet.

excluded, both as a soft hammer and a hard one. Such a block was found in VV1 (Fig. 9F) with crushing and shattering on its prominent parts. Its use as a hammer rather than a core is favored due to the scarcity of flakes with classic debitage scars in the series. VV1 and VV3 series share similar technics (Fig. 11). As we did not see significant differences according each RMU, we regroup by locus the typo-technic description on Table 2 (see Appendices 1; 2 for details by RMU).

TECHNO-FUNCTIONAL AND USE-WEAR DATA

A biface was discovered in VV1. It is of small size ($97 \times 81 \times 33$ mm; Fig. 12B). The initial volume appears to be close to the finished shape, particularly in thickness as indicated by the residual cortex and pre-existing more patinated surfaces (Fig. 12C). One face is summarily shaped by large invasive (no. 1) or centripetal, long and oblique removals (nos 2 to 5). This surface serves as a striking platform for

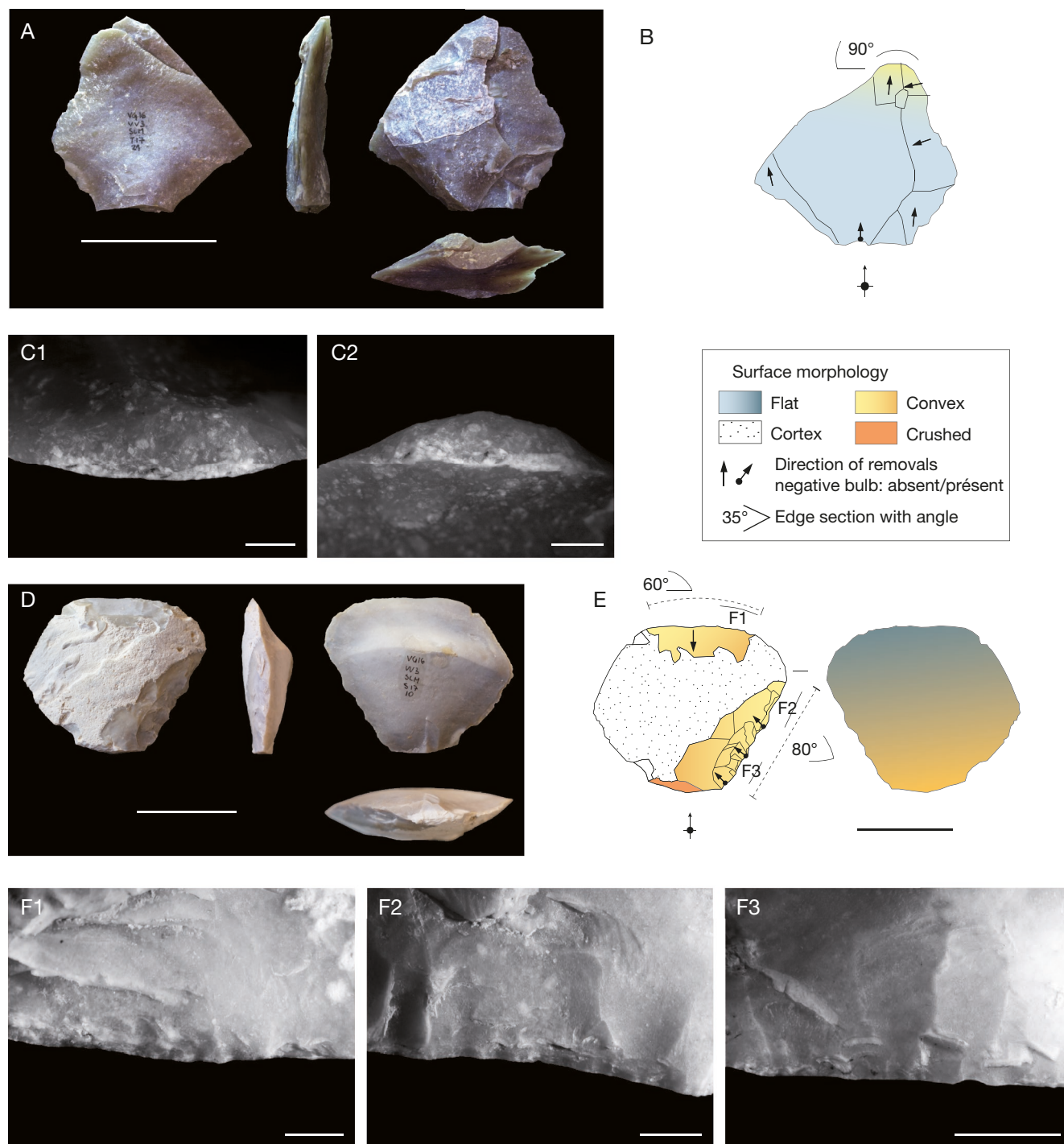


FIG. 13. — Valle Giumentina SLM-37: **A-C**, tool VV3 T17 21 used with a transversal unidirectional motion on a hard material. It is part of a refitting unit with: **A**, T18 2-43 (Refitting 9 #123 A1); **B**, techno-functional sketch; **C**, numerous and overlapped scars on the distal edge; **D-F**, tool VV3 S17 10 used with a transversal unidirectional motion to process a hard material; **D**, picture; **E**, techno-functional sketch; **F**, crushing and numerous overlapped scars. Scale bars: A, B, D, E, 5 cm; C1, C2, F1, F2, 2 mm; F3, 5 mm. Credits: J. Guibert-Cardin.

the shaping of the second face. Centripetal invasive removals (no. 6) create a slightly convex surface. The right edge is shaped in the distal part, first by several rows of thin convex removals on this face (no. 7), then by short removals on the other face (no. 8). This creates an edge-point cutting edge, with an angle ranging from 40° towards the point to 60° on the upper third of the piece. The distal left edge is then

asymmetrically shaped in the continuity of this cutting edge (nos 8, 9 and 10). This second cutting edge, biplane in section, is not as deep. The mesial part of the biface is transformed by concave removals, which stop the regularity of the cutting edges (nos 11 to 13). This structure is similar to that of the “biface as a blank for tools” (*“biface support d’outils”*, Soriano 2000; Boëda 1997, 2013). Also, a small twisted flake

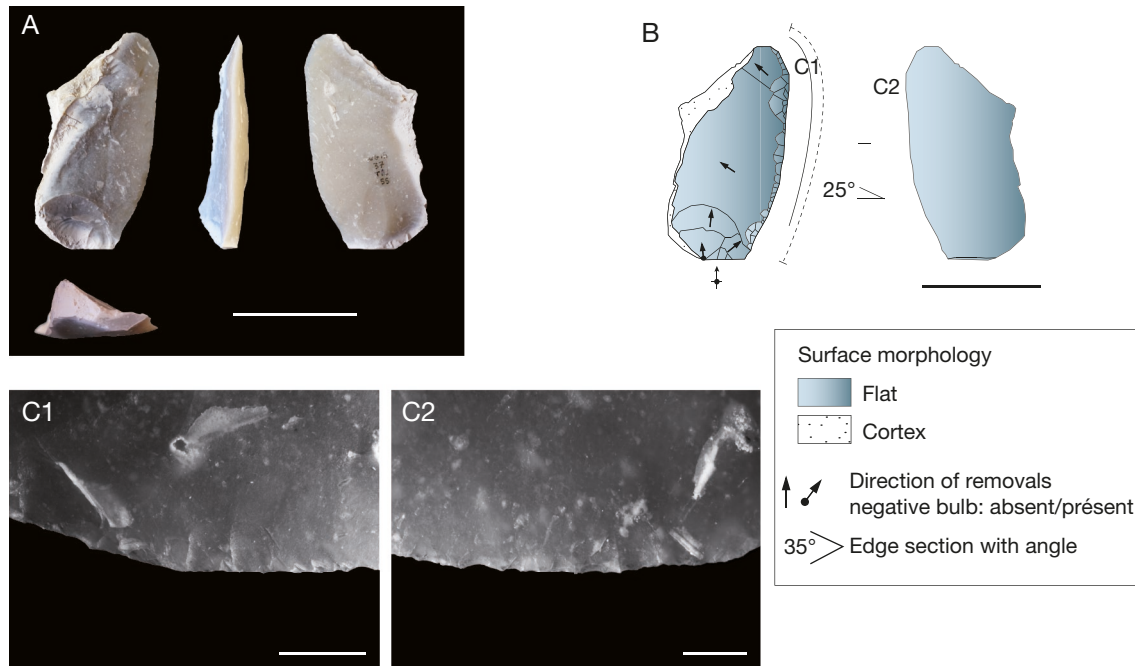


FIG. 14. — Valle Giumentina SLM-37. Tool VV3 T18 55 used with a longitudinal motion, possibly for butchery activities without contact with the hard parts of the carcass: **A**, picture; **B**, techno-functional sketch; **C**, small scars with angular shapes and step or feather termination. Scale bars: A, B, 5 cm; C1, 2 mm; C2, 1 mm. Credits : J. Guibert-Cardin

TABLE 3. — Valle Giumentina SLM-37. Techno-morpho-functional data for tools with use-wear traces. Abbreviations: **cvx**, convex; **dent.**, denticulated; **Transv.**, Transverse; **L**, length; **Longit.**, Longitudinal; **Th**, thickness; **Undet.**, Undetermined; **Unidir.**, Unidirectional; **W**, width.

Size (L × W × Th) in mm	Edge	Retouch	L	W	Angle	Plan	Profile	Section	Gesture	Direction	Material
VV3 S17 10 Retouched flake 75 × 85 × 27	Right Distal	Yes No	59 44	10 10	70 to 80° 60	Straight Slightly dent.	Straight Straight	Bicvx Plano-cvx	Transv. Transv.	Unidir. Unidir.	Hard Hard
VV3 T17 21 Unretouched flake 67 × 74 × 9	Distal	No	12	9	90	Cvx	Straight	Plano-cvx	Transv.	Unidir.	Hard
VV3 T8 55 Retouched flake 86 × 44 × 17	Right	Yes	84	9	30	Straight	Straight	Biplane	Longit.	Undet.	Butchery?

wearing part of a biface edge has been found (Fig. 12A). It may be associated with the shaping of the tip of this biface, as the RMU is the same, but no corresponding negative is present. It may have been removed by subsequent removals.

Like most other retouched or unretouched artefacts, the biface bears no use-wear traces. The biface is in a medium state of preservation and has undergone both mechanical and chemical taphonomical processes. It is affected by a few scars randomly distributed along the edges, by a slight and continuous rounding, a slight soil sheen, rare bright spots, and a highly developed white patina.

Of the 590 pieces analysed, three flakes, retouched or not, exhibit use-wear traces. They come from locus VV3 (Table 3). Two flakes (three active parts) indicate the working of a hard material with a unidirectional transversal motion and an open working angle (Fig. 13). One other flake was used with a longitudinal motion for butchery activities (Fig. 14). The dimensions, angles and delineations in plan and section of the active parts are varied, even for the same activity.

Therefore, the morphological characteristics of the edges do not seem to be linked to the motion or the processed material. The active part is always opposite a non-sharp edge (cortical, abrupt, or thick butt).

The unretouched flake T17 21 (Fig. 13A-C) has a distal edge with convex delineation, plano-convex in 90° angle section. The dorsal face bears numerous, large, continuous and overlapped scars, with feather or step termination. The ventral face exhibits an altered and indeterminable polish. It is discontinuous, with a smooth texture and unclear boundaries. These asymmetrical use-wear stigmata, with scars on one face and polish on the opposite face, indicate a unidirectional transversal motion with an open working angle. The numerous and overlapped scars are due to the processing of a hard material.

The flake S17 10 (Fig. 13D-F) is large, thick and cortical. The unretouched distal edge and the retouched right edge are convergent. The flake has two active parts. One is located on the transversal cutting-edge. Its dorsal face bears crushing and numerous, continuous, and overlapped scars.

They are large to small, perpendicular to the edge, trapezoidal or quadrangular shaped, with a step, hinge or, more rarely, feather termination and with a cone or bending initiation (Fig. 13F). The ventral face bears a single scar. It is small, trapezoidal in shape, with a feather termination and a bending initiation. These well-developed and asymmetrical use-wear traces indicate a unidirectional transverse motion with an open working angle to process a hard material. The second active part is on the right cutting-edge, which has a direct retouch. The dorsal face exhibits crushing and scars. They are perpendicular to the cutting-edge, small to medium-sized, semi-circular or trapezoidal in shape, and with a step termination (Fig. 13F). Prominent areas bear a slightly developed rounding. The opposite face shows a single, small and irregular scar. This association of use-wear traces indicates the processing of a hard material with a transverse unidirectional motion.

The T18 55 backed knife (Fig. 14) has a continuous, short and direct retouch on the right edge. Some scars are superposed on the retouch. They are bifacially distributed, discontinuous, small to medium-sized, trapezoidal, triangular or quadrangular in shape, oblique to the cutting edge and with a feather or step termination and a bending initiation (Fig. 14C). Crushing appear locally on the cutting-edge. These use-wear traces, bifacial and oblique to the cutting edge, are indicative of a longitudinal motion. The direction of the motion and the material processed are difficult to assess. The material could be soft, as the scars are small and with a bending initiation. Their characteristics are similar to the scars that occur during butchery activities without contact with hard parts of the carcass (cartilage or bone).

DISCUSSION

TECHNO-ECONOMIC BEHAVIORS IN SLM-37 LEVEL AND SITE FUNCTION

Raw materials units and refittings indicate that at least five blocks were shaped in locus VV1 and eight in VV3 (82 artefacts in 35 refitting units, from two to five pieces in each unit; see details in Appendices 3-6). In VV3, cortical flakes and shaping flakes are well represented within the refitting units (Fig. 11). It shows us that the first step of bifacial shaping have been made on the spot. This implies that chert nodules, available in conglomerates from the Maiella Massif, were brought to the site. The rest of the flakes that we couldn't insert in refitting units are often fragmented (255 fragments), fitting well with the successive phases of shaping by progressive thinning of the handaxe. Small retouch flakes are also present. No biface appears in this locus excavated only on 7 m². The -at least- eight bifaces that should result from these shaping processes, corresponding to the eight recognized RMU, were either used in the vicinity or carried away for a later activity, or even both. Among the few industries from A.M. Radmilli's excavations, notable is a refitting of a flake on a biface. The presence of three functional tools on flakes in locus VV3, may suggest also an on-site use of the missing

bifaces, before possible removal. In VV1, the refitting units are less numerous (Fig. 10) but the ratio of cortical flakes are similar. Plain shaping flakes are more frequent regardless of the raw material or the RMU. The only biface found shows no refitting, indicating it was brought onto the site, at least onto this locus. This reminds the case of Soucy 3P where an area for shaping the bifacial piece is spatially distinct from a sharpening area and a discard area as also seen at Boxgrove and in Suffolk sites (Ashton & McNabb 1994; Roberts & Parfitt 1999; Lhomme *et al.* 2004).

Three flakes have use-wear traces in level SLM-37. The function of Lower Palaeolithic tools are still poorly understood (for a detailed review of traceological data, see Guibert-Cardin 2022). Post-depositional processes may have erased some functional traces, but they alone are not sufficient to explain the low number of pieces with use-wear traces. The absence of functional polish may be linked to white patina and soil sheen, but macrotraces should be preserved because taphonomic scars and rounding are limited. Thus, the processing of soft materials (meat without contact with bone, fresh skin, graminæ, etc.) may have gone unnoticed because these materials generally produce slight use-wear traces that can easily be hidden or erased by weathering processes (Plisson 1983). In the contrary, the exploitation of abrasive or harder materials should have been more identified if it had taken place (certain plants, meat with contact with bone, bone, dry skin, antler, etc.). The site's function may explain this scarcity of use-wear traces. In VV3, one tool has certainly been used for butchery activities and the herbivore bones show anthropic breaks. Also, a manuport, a large limestone pebble was found in VV1 (K7 4193 × 115 × 81 mm, 1.4 kg; Fig. 1G). Its outer surface is rough, with no clearly visible percussion marks or other traces such as striations that would suggest its use as a hammerstone or a cutting board. Small limestone pebbles are numerous in VV3 but their significance remains uncertain.

The small number of retouched flakes (n = 11) and bifacial pieces (n = 1) and the presence of numerous wastes show that the site has been mainly dedicated to the production of tools for later consumption outside the excavation areas. This also supports the idea of short-term occupations of the area. Bifacial flaking spots and butchery activities appear to be distinct as seen, e.g., at Cagny-l'Épinette, Boxgrove or Barnham (Roberts & Parfitt 1999; Ashton *et al.* 1994; Peudon 2021). The excavation areas VV1 and VV3 are 175 m apart, suggesting repeated occupations at different spots across the entire Valle Giumentina area. SLM-37 reflects the circulation of bifaces frequently observed in the European Lower Palaeolithic (e.g., Hallos 2005; Lhomme 2007; Tuffreau *et al.* 2008; Nicoud 2013a). The moving tools and manuports and the in-situ shaping of absent biface fit quite well with the idea of a "veil" of artefacts found in most open air Lower and Early Middle Palaeolithic sites which is "a palimpsest of a countless number of individual events involving tool use, resharpening, limited flake production for cutting tasks and tool discard" (Langbroek 2012: 12, after the idea of Roebroeks *et al.* 1992). Here the artifact

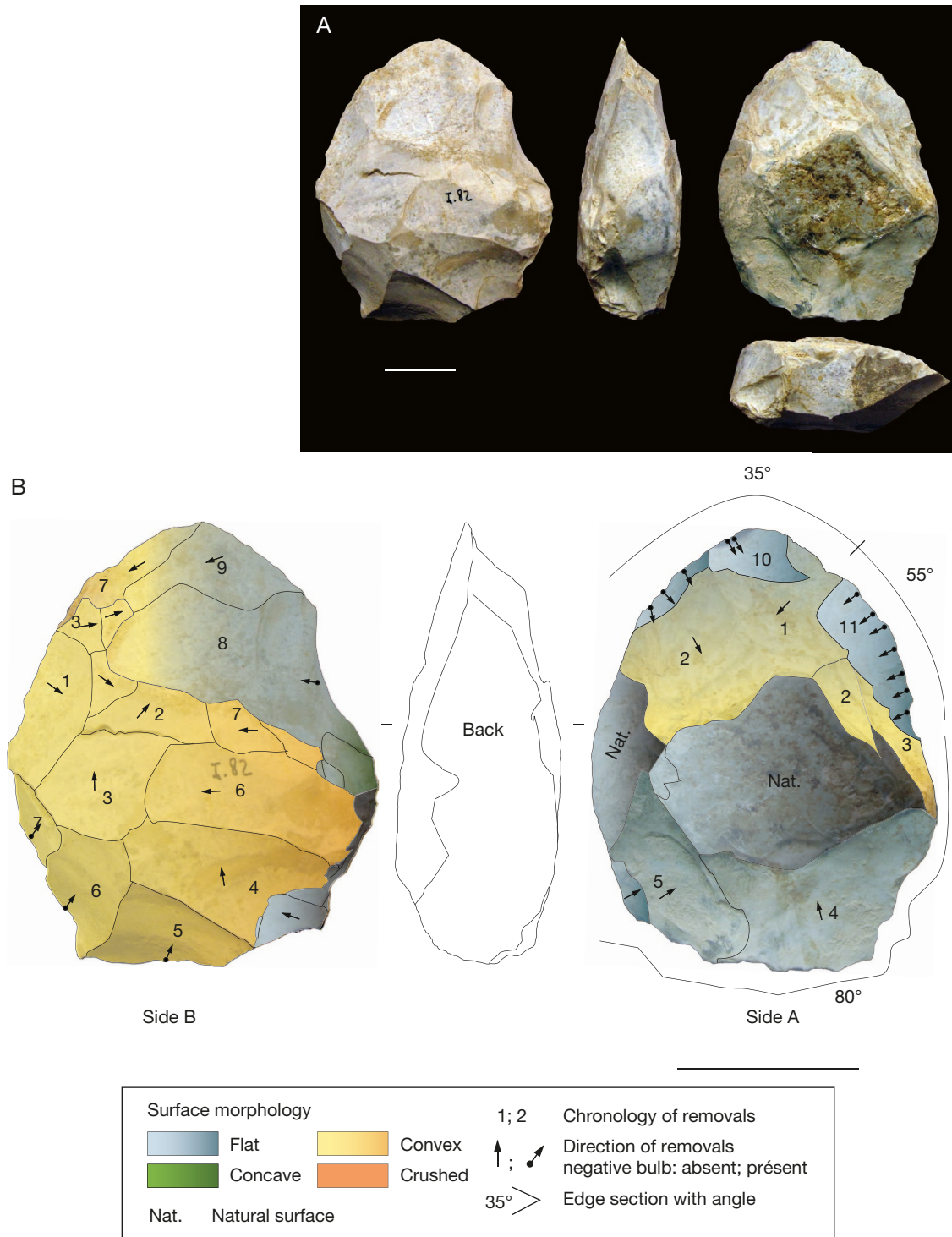


FIG. 15. — Valle Giumentina SLM-37. “Biface as a blank for tools” (*Pièce bifaciale-support d’outils*) from 1950’s A.M. Radmilli excavation (VG37-19): **A**, picture; **B**, picture and techno-functional sketches. The center of side A is covered with the glue that held it in place on display windows at the University of Pisa. Scale bars: A, 3 cm; B, 5 cm. Credits: E. Nicoud.

density is low, allowing us to still see areas of emptiness and areas of concentration or “scatters and patches” (Langbroek 2012), as “snapshots” of many occupations (Hallos 2005 after Conard & Adler 1997). Prehistoric groups most likely visited the site on several occasions, anticipating their need for raw material by carrying with them small flint blocks

from a nearby conglomerate, or pre-prepared tools such as bifaces. The use-wear traces are limited in intensity, suggesting short-term tasks at Valle Giumentina. This provides new evidence for territory partition during the Lower Palaeolithic, as already shown for level ALB-42 (MIS 12b; Nicoud *et al.* 2022; see also for Aridos 1 in Spain, Santonja & Querrol

TABLE 4. — Valle Giumentina. Archaeological series, correlation with the isotopic chronology, age and main technological features of the lithic industries.

Archeological Level n = 14	Series/Locus n = 20	MIS	Age (ka)	Lithic
46 - AR	46 Radmilli	< MIS 12	< 400	Core-and-flake, Bifaces, Levallois, Laminar
45	45 Radmilli	< MIS 12	< 400	Core-and-flake, Bifaces, Levallois, Laminar
42 - ALB	ALB-42	12b	454 ± 2	Core-and-flake
	42 Radmilli	12b	454 ± 2	Core-and-flake
41 - LDP	LDP-41	12b	c. 454 ka	Core-and-flake
40 - LABM	LABM-40	12b	454 ± 2	Bifacial shaping + Core-and-flake (one biface, tools on flakes)
	40 Radmilli	12b	454 ± 2	Core-and-flake
37 - SLM	SLM-37 VV1	12c	> 454 ± 2	Bifacial shaping (one biface, flakes)
	SLM-37 VV3	12c	> 454 ± 2	Bifacial shaping (flakes)
	37 Radmilli	12c	> 454 ± 2	Bifacial shaping (three bifaces)
36 - SFL	SFL-36 VV3	13a	> 454 ± 2	Bifacial shaping (flakes and a hammerstone)
34-35 IIG	LAC 34-35/IIG	13a	c. 500	Bifacial shaping (flakes)
34 Kor	LAC 34-9/Kor	13b/a	c. 505 ± 3.6	Core-and-flake
33 - ABF	ABF-33	13b	509 ± 3	Core-and-flake
	33 Radmilli	13b	509 ± 3	Core-and-flake
30	30 Radmilli	13c	529 ± 3	Core-and-flake
LBr	LBr (VV1)	Transition 14c-14b	c. 545	Core-and-flake
24	24 Radmilli	14d	554 ± 3	Core-and-flake
20 - AO1	20 Radmilli	Transition 15a-14d	c. 565	Core-and-flake
	AO1 (VG1)	Transition 15a-14d	c. 565	Core-and-flake

1980 or Agam & Finkel 2024 about specific lithic raw material procurement). SLM-37 discovery reinforces the idea that *Homo heidelbergensis* Schoetensack, 1908 had high mobility, organized sites functionally, and repeatedly used the same landscape.

BIFACIAL CONSIDERATIONS AT VALLE GIUMENTINA AND IN EUROPE

Different lithic industries at Valle Giumentina and in Italy

At Valle Giumentina, the bifacial industry appears in the middle of the sequence (MIS 13a to MIS 12c, c. 500–455 ka; Table 4) and is framed by levels devoid of bifacial products, with neither bifaces nor flakes from bifacial production (Nicoud *et al.* 2022; Villa *et al.* 2024).

There are as many technical differences in the lithic industries of the various Valle Giumentina levels as there are between two distant sites attributed to MIS 12 (Nicoud *et al.* 2022) or between the Italian Lower Palaeolithic sites. One element of continuity in the sequence is the use of good quality and abundant local raw materials. When A.M. Radmilli named the flake industry from Valle Giumentina a “Clactonian”, he referred to the English production made on good quality and large size flint (Demangeot & Radmilli 1966). We think the raw material availability in the Maiella mountain explains the still ongoing original aspect of the Valle Giumentina industry within the Italian panorama (recent synthesis in Mutillo *et al.* 2021). The closest stratified Lower Paleolithic site with renewed research is located 67 km SSW at Isernia La Pineta (Molise Region, MIS 15 to 13, Peretto *et al.* 2015). Isernia levels 3c, 3a, 3coll from Unit 4 (travertine) are contemporaneous of Valle Giumentina paleosol AO1-20 (MIS 15a). The typo-technological differences are obvious. In AO1-20, big flakes are produced with SSDA methods on cherts blocks (Villa *et al.* 2024) whereas silicite tablets and limestone cobbles, collected in secondary position, have been knapped by bipolar exploitation to produce

small or medium flakes at Isernia (Peretto *et al.* 2015). The closest handaxes in time and space must be found 90 km SW at Fontana Ranuccio (Latium, MIS 11 interglacial, Segre Naldini *et al.* 2009). The older site in Italy with handaxes is Notarchirico (MIS 16, Basilicata Region), but only Valle Giumentina provide handaxes at MIS 12. They appear later, for example at Torre in Pietra where they are mainly made on limestone pebbles (Latium, MIS 10-9; Villa P. *et al.* 2016). On all these sites, the faunal remains are numerous. Carcass processing is often documented. It is still unclear if the difference in tools (bifaces vs flakes) is due to different or more diverse activities. It is still a possibility, but more techno-functional studies are required.

DIFFERENT STRUCTURES OF BIFACES AT VALLE GIUMENTINA

The shaping of the biface found in SLM-37 is based on the concept of the “biface as a blank for tools” (*pièce bifaciale support d'outils*). The three bifaces observed in A.M. Radmilli's 1950s collection corroborate this observation. The item presented here (Fig. 15) is morphologically very similar to biface I11 3 though slightly larger (123 × 102 × 42 mm). One side (A), then the other (B), are shaped by invasive centripetal removals. The apical part is then thinned to create a flat surface (nos 8 to 11), which serves as a striking platform for fine retouching on the opposite face. The result is a regular cutting edge on the apical part and on one of the adjacent edges, 80 mm long, biplane in section, with a 30° angle. This way of shaping bifaces has been observed many times across Europe before MIS 10, e.g., at Boxgrove, High Lodge, La Celle or Beeches Pit (Nicoud 2013c; Fig. 17). There is, thought, a slight difference here: a back is preserved, or even created.

Bifacial products also appear in the following Level LABM-40 (MIS 12b, Fig. 16), alongside debitage products, totaling 398 lithic remains (excluding debris), with 137 flakes exhibiting a lip characteristic of tangential gesture (Nicoud *et al.* 2017). One biface occurs too, also of limited size

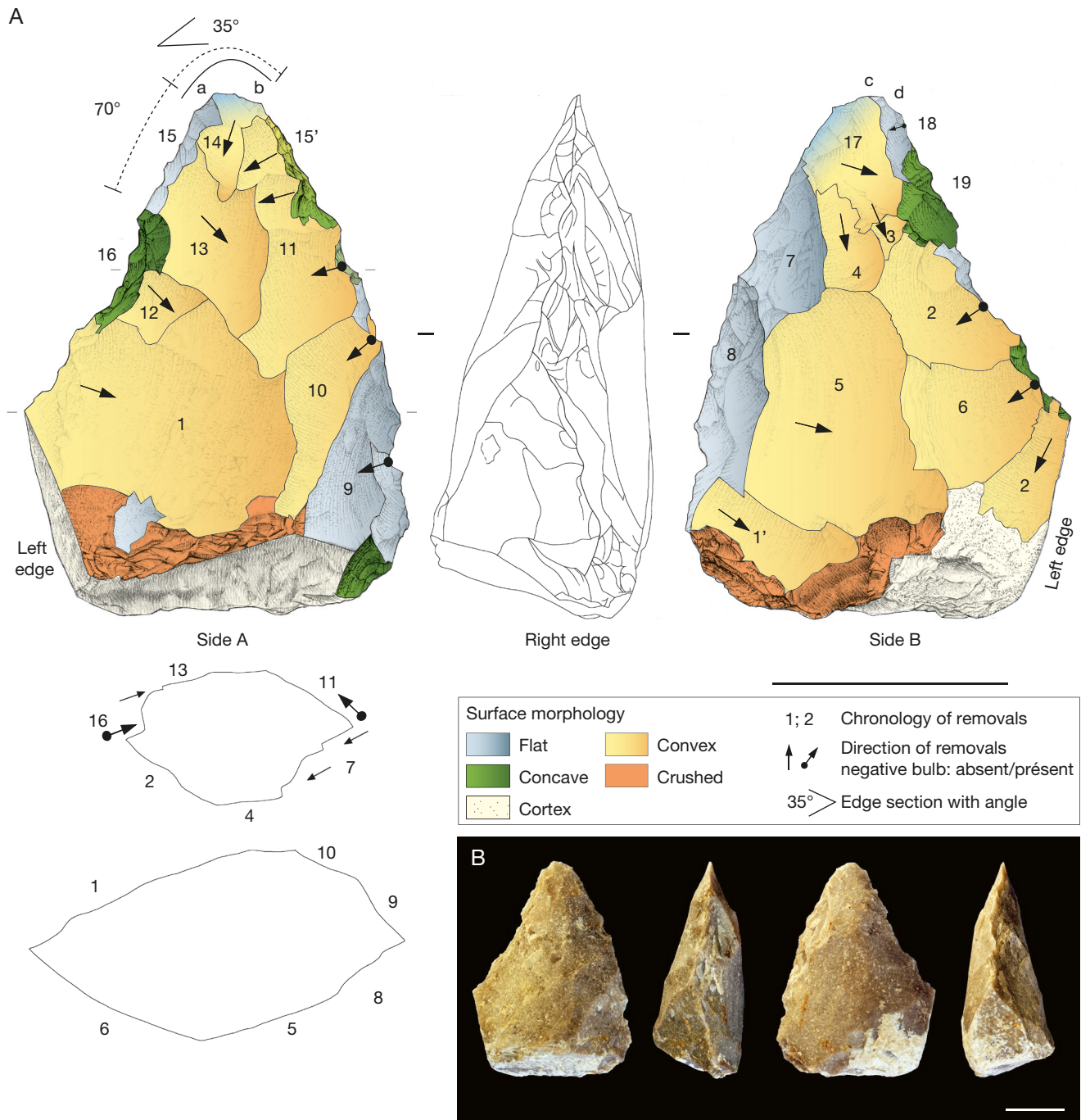
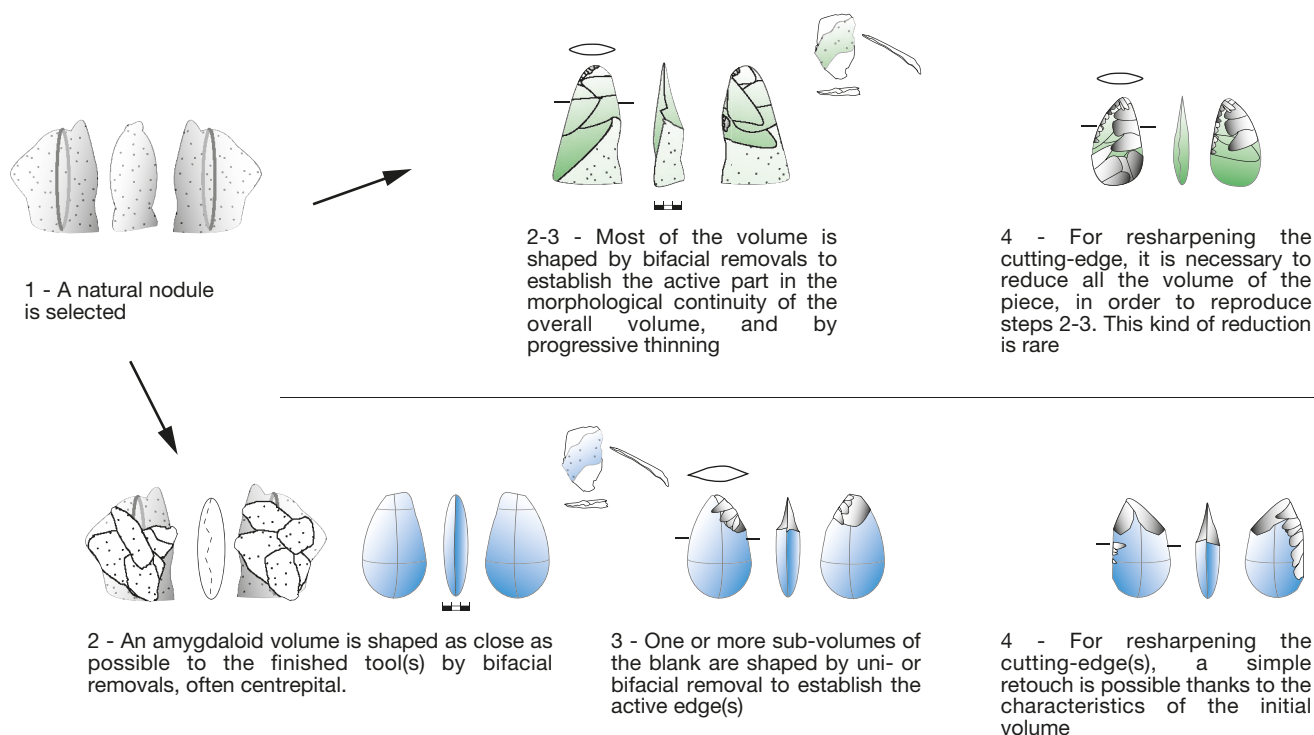


FIG. 16. — Valle Giumentina LABM-40. “Biface as a tool” (*Pièce bifaciale-outil*, VV1 G12 5, #124 A1): **A**, drawing, diacritical and morpho-functional sketches; **B**, picture. Scale bars: A, 5 cm; B, 3 cm. Credits: E. Nicoud.

(108 × 83 × 45 mm) and the base and proximal left edge are natural flat surfaces. Its structure differs from SLM-37 biface. Here, it is tricky to read the chronology of the removals, as they are very thin, creating a regular, homogeneous, biconvex volume. When the counter-bulbs are absent, the convexity of the remaining surface suggests that they were close to the cornice. This indicates a progressive shaping process that alternates face and edge shaping without any techno-morphological discontinuity with the tip. This biface is shaped as follows (Fig. 16). On each face, starting from

the opposite edge, large invasive removals (nos 1 and 1') create a slightly convex surface which is used as a striking platform for the edge finishing. Then, long, thin and convex removals are produced on the right edge of the B side (nos 2 then 6), creating a homogeneous convex surface. This is complemented by long removals emanating from the distal part (nos 3 and 4). A large removal overlaps the first (no. 5) and is followed by short re-entrant removals (nos 7 and 8). The surface created over 1 cm serves as a striking platform for shaping the right edge on the A side

Biface as a tool / “Pièce bifaciale-outil”



Biface as a blank for tool(s) / “Pièce bifaciale support d’outil(s)”

FIG. 17. — Production schemes for a “Biface as a blank for tools” (*Pièce bifaciale-support d’outils*) and a “Biface as a tool” (*Pièce bifaciale-outil*) after Nicoud (2013a). Credits: E. Nicoud.



FIG. 18. — Valle Giumentina VV3 level SFL-36. Detail of the remains during excavation. A cortical chert block is lying on thin shaping flakes and fragments. Credits: E. Nicoud.

(long, flat or convex removals nos 9 to 11). The left edge is then shaped on the A side (nos 12 and 13), maintaining a regular convex surface. The tip is shaped by two very thin tranchet blows on each face (nos 14 and 17) and several rows of very short, thin, flat (no. 15) or convex (no. 18) removals, in morphological continuity with the rest of the

piece. The regularity of the cutting edge seems to be stopped by short notches on each face (nos 16 and 19). The apical part features a 40 mm-long, 6 mm-deep, biplane edge-tip edge, with a 35° angle at the tip that increases rapidly to 70° on the left edge. Percussion is tangential and the negative bulb are well-defined and circumscribed, suggesting the use of a rather hard hammer.

This way of shaping this biface follows the “biface as a tool” concept (Boëda 1997, 2013; *pièce bifaciale-outil*; Fig. 17). It has been identified at several European sites at MIS 9, e.g., Soucy 3P and 5, Torre in Pietra, Ambrona (Nicoud 2013c; Villa P. *et al.* 2016).

In addition to level SLM-37 and LABM-40, a few thin bifacial shaping flakes are also present in locus VV1, within the underlying level IIG-SFL-35/36 (MIS 13a), though they are not diagnostic of a specific techno-type and do not exhibit use-wear traces (Villa *et al.* 2021). The same applies to level SFL-36 in locus VV3, which contains a small series of 20 chert artefacts in a fine silty-sandy matrix beneath SLM-37. These artefacts, made from Maiella Miocene chert (#123_A2), belong to two petrographic sets: one comprising a block and two fragments from it, and another with 17 flakes and fragments. All display typical shaping flake characteristics (thin, convex), and the block appears to have been used as a hammerstone according to the fractures and crushing traces it exhibits (Fig. 18).

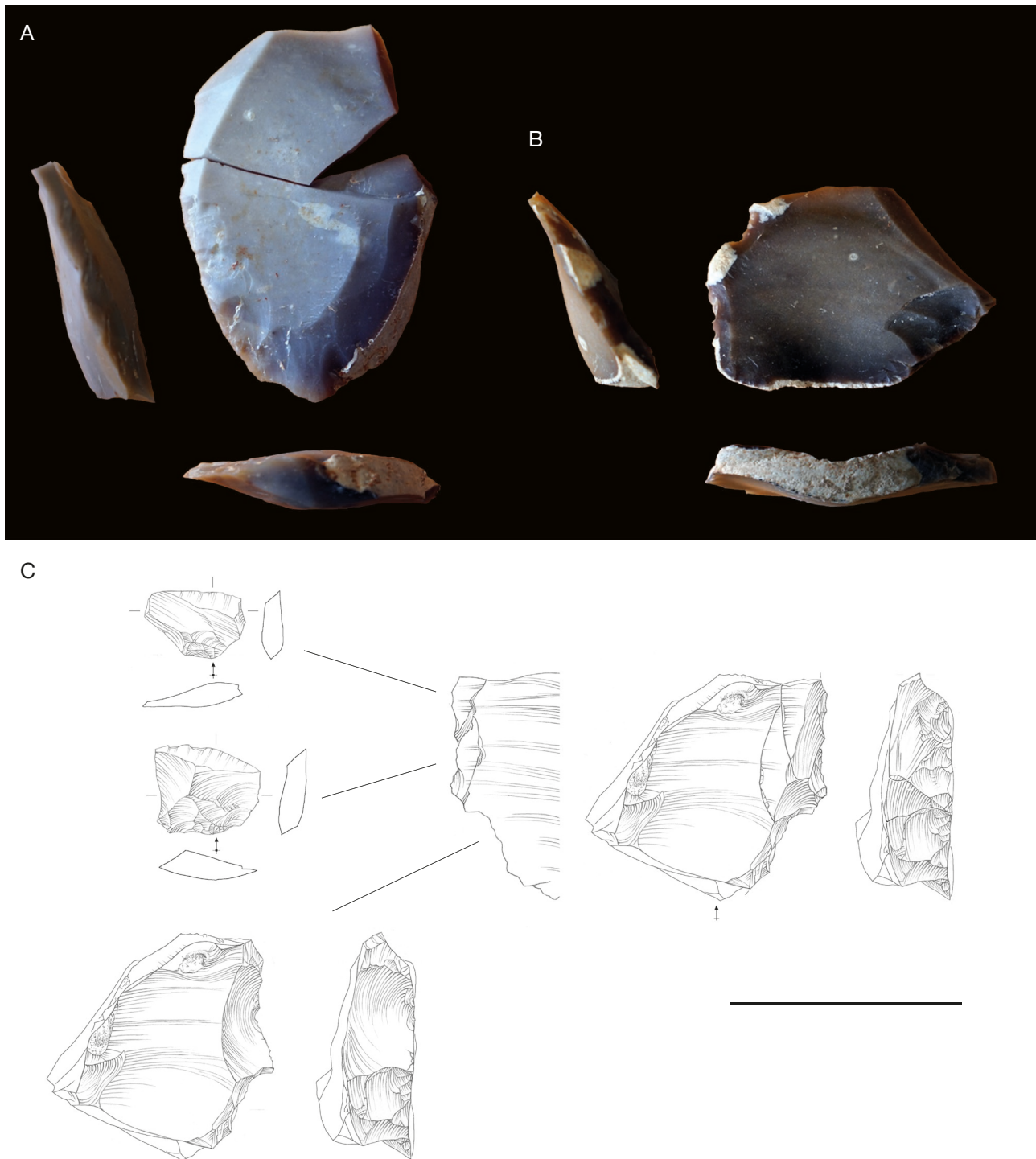


FIG. 19. — Valle Giumentina LABM-40. Retouched tool and refitting unit: **A**, lateral scraper broken *in situ* (K13 4, K13 14); **B**, thick flake with discontinuous retouch on left edge (K10 2); **C**, thick flake (L7 5) with a retouched right edge and two successive small flakes creating notches (L7 4, L6 1). Scale bar: 5 cm. Credits: C, drawings M. Grenet; DAO, E. Nicoud.

A PATTERN FOR THE TECHNICAL EVOLUTION OF BIFACIAL LITHIC SERIES IN EUROPE?

Level SLM-37 exhibits a bifacial shaping production and some rare tools are made on shaping flakes. On the other hand, the successive level LABM-40 shows both shaping and debitage productions. Indeed, some tools are present on flakes produced by debitage (Fig. 19; Nicoud *et al.* 2017).

Although we have only one example of biface in LABM-40, it should be noted that the succession of “biface as a blank for tools” and then “biface as a tool” appears at Valle Giumentina, in line with the chronological order observed at European scale (Nicoud 2013a). The biface, as a technical object, shifts from being an “abstract” object to a “concrete” one (Simondon 1958). The chaîne opératoire stages of volume shaping and

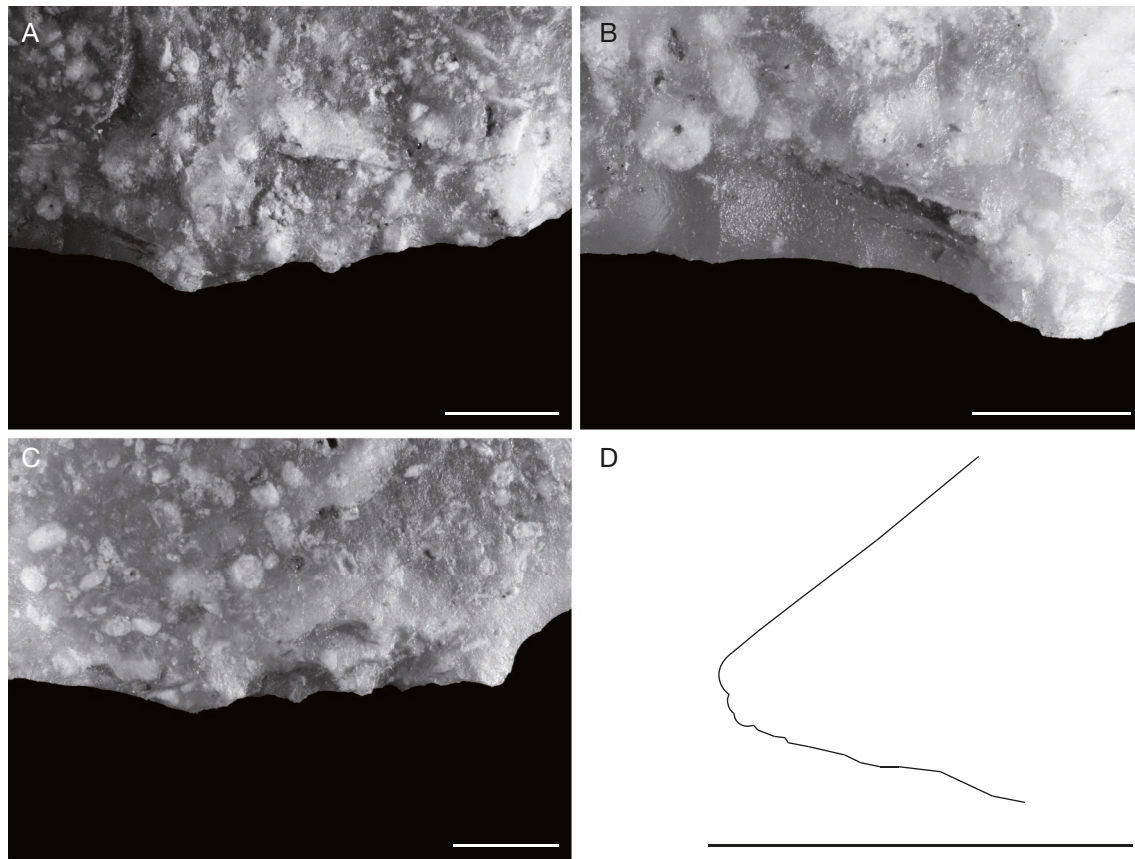


FIG. 20. — Valle Giumentina LABM-40. Use-wear traces on the apex of the biface used for butchery activities (VV1 G12 5, #124 A1): **A**, **B** and **C**, bifacial overlapped scars, oblique to the cutting edge, of irregular, trapezoidal or quadrangular shape and with a step termination; **D**, rounding slightly developed and localized on prominent part of the cutting edge. Letters A, B, C, D refer to a, b, c, d in Figure 16. Scale bars: A, C, 2 mm; B, 1 mm; D, 500 µm. Credits: J. Guibert-Cardin.

cutting-edge production, initially distinct, gradually become integrated and increasingly difficult to differentiate. This structural evolution of the biface is even more significant when accompanied by a change in the rest of the production, characterized by a variety of tools obtained by debitage.

Similar patterns in bifacial evolution are emerging between the European framework and the new data from Valle Giumentina, although additional evidence would be needed to support or refute this idea. At Valle Giumentina, the appearance of the “biface as a tool” in the LABM-40 level attributed to MIS 12b is precursory, since it is usually observed after MIS 10. We can see here the expression of this technical evolution on a local, ancient and “rapid” scale, rather than on a European scale and over several isotopic stages. According to us, this illustrates successive reinventions of these two techno-types of bifaces in Europe. The inconsistencies in the dating of European sites, sometimes by as much as 100 000 years (Villa V. *et al.* 2016), make it difficult to approach these inventions and innovations with such resolution. Moreover, the scarcity of sites prevents us from perceiving them on a regional scale.

BIFACES USES AND BUTCHERY ACTIVITIES

AT VALLE GIUMENTINA AND ACROSS EUROPE

Butchery is the most frequently recorded activity at European Lower Palaeolithic sites mainly by archeozoological data (e.g.,

Moigne & Barsky 1999; Bemilli 2006). Use-wear traces from butchery activities have been identified at Valle Giumentina on flakes from level ALB-42 (Nicoud *et al.* 2022) and on the biface of level LABM-40 as well as on a retouched flake. Indeed, the tip of the biface from LABM-40 bears a slightly developed rounding, which develops on the prominent areas of the cutting edge (Fig. 20D). It also exhibits numerous bifacial scars: they are localized, alternated, medium-sized, overlapped, oblique to the cutting edge and of irregular, trapezoidal or quadrangular shape (Fig. 20A-C). Terminations are step, and initiations are difficult to identify, but they seem to be mainly cone-shaped. These stigmata have a functional origin, as they are combined and localized on the tool. Scars are bifacial and the rounding is equally distributed on both sides of the cutting-edge indicating longitudinal gesture. The medium-sized and overlapped scars and the rounding found only on the prominent areas indicate the processing of a hard material. Nevertheless, the cutting edge remains only slightly modified by use, and the use-wear traces are similar to those formed experimentally during butchery activities (i.e., slight rounding and scars with angular shapes and cone initiations). This biface is one of the oldest with preserved use-wear traces in Europe.

According to the few traceological data available for the European Lower Palaeolithic, bifaces are generally associated with butchery activities. This is the case for example

in Boxgrove or Hoxne (MIS 13 to 9, United Kingdom; Keeley 1980; Singer *et al.* 1993; Mitchell 1998), Etrécourt-Manancourt and Soucy 3P (MIS 9, France; Hérissou *et al.* 2012; Guibert-Cardin 2022). Butchery activities were not carried out exclusively with bifaces, as use-wear related to this activity are frequently found on flakes. This is the case for example in Marathousa 1 (MIS 12, Greece), La Grande Vallée (MIS 13-10, France), Soucy 1, 5-I and 3P (MIS 9, France), Hoxne (MIS 9, England) or Gran Dolina TD10.1 (MIS 9, Spain; Guibert-Cardin *et al.* 2025 and references within 2021; Keeley 1980; Lhomme *et al.* 2004; Marquez *et al.* 2001; Hérissou *et al.* 2012).

In Soucy 3P, flakes and bifaces sometimes have similar modes of use, raising questions about the necessity of having different kinds of tools (Guibert-Cardin *et al.* 2021). Several experiments with bifacial tools demonstrate their efficiency for butchery activities, particularly in comparison with flakes (Jones 1980; Galán & Domínguez-Rodrigo 2014). These two types of tools could be complementary and used at different stages of carcass processing, as, maybe, in level LABM-40. The main qualities reported for bifacial tools in butchery activities are their good grip, their weight and long, resistant and sharp edges (Jones 1980; Mitchell 1998).

The processing of vegetal materials with bifaces is marginal, given that only bifaces from La Noira (MIS 16, France), Soucy 1 (MIS 9, France) and Gruta da Aroeira (MIS 11, Portugal) exhibit use-wear traces related to vegetal processing (Lhomme *et al.* 2004; Daura *et al.* 2018; Hardy *et al.* 2018).

We can discuss here the hypothesis put forward previously with only a technological point of view that, by evolving into a ‘biface-as-tool’, the biface became a tool with a specific function, complemented by a set of new flake tools (Nicoud 2013a). During Lower Palaeolithic, bifaces are rarely the only tools in lithic industries and are generally less numerous than flake tools or pebble tools (Nicoud 2013a). Use-wear traces indicate that regardless of their structure, bifaces appear to have been used for a more limited range of activities than flaked tools (synthesis in Guibert-Cardin 2022; see references within). This supports the idea that the biface was a highly specialized tool, whereas flake tools -whose morphological variability was broad- were more versatile. As shown by SLM-37 data once again, bifaces are very mobile artefacts. This seems less valid for flake tools, although we observed it in level ALB-42 (Nicoud *et al.* 2022). It is important to emphasize that biface-bearing sites are less common than sites without bifaces. Further functional analyses of lithic industries (both on bifaces and flakes) would help us to better understand whether the role of the biface in the sequence evolves according to its structure, as well as over time and across regions (Claud 2008; Nicoud 2013a; Guibert-Cardin 2022).

IMPLICATIONS OF A BETTER CHRONOENVIRONMENTAL RESOLUTION FOR EUROPEAN SETTLEMENTS

Recognizing isotopic substages during long Glacial events

The multidisciplinary data obtained on the sedimentary succession of Valle Giumentina demonstrate the feasibility of detailed and reliable chronostratigraphic and palaeoenvironmental

reconstructions, even for the Middle Pleistocene. These data enable a better contextualisation of human occupations and enhance the precision of their ages. They also emphasise the capacity of continental archives to document climate change, not only major glacial/interglacial cycles, but also rapid, millennial to centennial-scale, oscillations. The lack of continuous sedimentary records contributes to the underestimation of the impact of these high-frequency variations on continental ecosystems. Combined with the limited material available for dating and the significant standard deviations associated with the geochronological methods employed, this frequently leads to the environmental variations observed in archaeological sequences being incorrectly interpreted as proof of a shift in either the climate cycle or the isotopic stage.

The Valle Giumentina sequence shows that, in favourable geomorphological contexts, sediments and soils can record oscillations within stadial and interstadial phases, and that these oscillations can determine significant landscape changes. At the site, a particular sensitivity to millennial climate oscillations was observed, especially variations in humidity/aridity. This is similar to regions further east, such as the Balkans and Greece (Tzedakis *et al.* 2006; Wagner *et al.* 2008). Unlike Tyrrhenian regions, where a certain stability can be observed with humid conditions being maintained and a less pronounced response from the ecosystem, Adriatic environments are strongly affected by these variations, which cause drastic changes in landscapes (Combourieu-Nebout *et al.* 2015; Villa *et al.* 2021). During MIS 12 in particular (474-427 ka; Lisiecki & Raymo 2005), several climate changes were recorded in Valle Giumentina, with variations between: 1) extremely arid periods, characterised by the deposition of mainly aeolian loess-type deposits (SFL-36 layer); and 2) wetter phases, with a reduced sedimentation rate, which permitted the formation of paleosols (SLM-37, LABM-40 and ALB-42) during the MIS 12b and MIS 12c interstadials. Within them, four archaeological levels have been preserved.

MIS 12, along with MIS 16, is one of the most arid and extended glacial periods of the Quaternary (Rohling *et al.* 2014). The repeated occupations at Valle Giumentina during this glacial phase demonstrate the capacity of human groups to adapt to particularly harsh conditions and the fact that they were “continuously” present in the region. These data are consistent with settlement models that depict the Mediterranean basin as a refuge for Palaeolithic groups during glacial periods (Dennell *et al.* 2011). However, recent discoveries indicate that Northern Europe was not completely unoccupied during the glacial phases (Antoine *et al.* 2019).

Archaeology of MIS 12 in Europe and bifaces occurrences

As presented in a previous paper on the MIS 12b ALB-42 occupation of Valle Giumentina, a comparison with MIS 12 sites in Europe is not very effective. Sites in stratigraphic context with palaeoenvironmental evidence allowing them to be attributed to this long glacial period of MIS 12 are rare: Caune de l'Arago Middle Complex, Visogliano levels 46 to 13, Menez-Dregan level 9a, Cagny-la-Garenne I levels CXV, CXB, LJ and CA, Kärlich H (only 26 artefacts), Korolevo level VI,

and Marathousa 1 (Nicoud *et al.* 2022 and references therein). Bifacial shaping is well represented in the MIS 13, 11 and 9 interglacials but is clearly not predominant during MIS 12 (Cagny-la-Garenne I levels CXV and CXB, Caune de l'Arago mainly in the Lower P-Q levels that can also be attributed to MIS 14 – Lebreton *et al.* 2017; see discussion in Nicoud *et al.* 2022: 410), while the production of cores and flakes is more widespread. Valle Giumentina add two new levels with handaxes during MIS 12 (SLM-37, LABM-40).

CONCLUSION

The biface serves as a marker of technical practices, clearly reflecting the knapper's intentions and, in some cases, providing insights into its use, as observed on the Valle Giumentina LABM-40 biface – one of the oldest known biface bearing use-wear traces (*c.* 455 ka, MIS 12b). This raises the possibility of finding even older similar discoveries, as long as the most favorable geological contexts are targeted. Basins such as Valle Giumentina are particularly valuable for the preservation of Glacial period sediments, likely due to their southern latitude and limited erosion. The fine geochronological and paleoenvironmental context, along with the well-preserved remains highlighted in this study, encourage further investigation. However, it remains necessary to determine the significance and causes of the apparent absence of occupation in certain regions during Middle Pleistocene glacial events. This absence may be linked to intense erosion processes, deep burial of archaeological levels, chronological uncertainties, or simply a lack of research. Valle Giumentina offers another example of what was previously suspected on a larger European scale. The biface, as a technical object, has a potential for structural evolution from a “biface as a blank for tool” to a “biface as a tool”. There is no evidence of external contributions to the technical novelty. Here, thanks to the fine geochronological resolution, we see that this evolution takes place within two levels from MIS 12. This strengthens the hypothesis that the biface may have been reinvented and evolved numerous times across Europe during the Lower Palaeolithic. That is why, in the European context, the biface cannot be considered a marker of human migrations. The scarcity of sites forces us to consider the continental scale, whereas with better regional resolution, it would be possible to refine the appearances and evolutions of both bifaces and core-and-flakes industries. Also, the precise environmental and chronological resolution at Valle Giumentina highlights the ubiquitous nature of Lower Palaeolithic tools, as technical changes are not synchronous with environmental changes.

Acknowledgements

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APPENDICES

APPENDIX 1. — Valle Giumentina SLM-37 locus VV1 and VV3: lithic industry typo-technical counting by raw material units (RMU). Abbreviation: **Undet.**, Undertermined.

SLM-37 VV1		Cherts RMU							
	Total cherts	#123 A2a	#123 A2b	#124 A1	#124 A2	#other	Undet.	Limestone	Fauna
2017 – 35 m²									
Flakes and fragments of flakes	250	27	28	51	30	43	71	30	3
of which entire > 1 cm ²	80	12	13	14	12	12	17	30	–
of which entire < 1 cm ²	24	2	3	4	0	0	15	0	–
of which proximal fgt	61	5	6	12	11	18	9	0	–
of which mesial and distal fgt (no butt)	85	8	6	21	7	13	30	0	–
of which retouched flake	1	1	–	–	–	–	–	–	–
Pebbles	0	–	–	–	–	–	–	15	–
Core/hammerstone	1	–	–	–	1	–	–	–	–
Biface	1	1	–	–	–	–	–	–	–
Sub-total	252	28	28	51	31	43	71	45	3
Débris after sieving	498	–	–	–	–	–	498	4	15
Total	750	28	28	51	31	43	569	49	18

APPENDIX 2. — Valle Giumentina SLM-37 locus VV3: typo-technical counting of lithic industries by raw material units (RMU) and faunal remains (*Cervus elaphus* Linnaeus, 1758). Abbreviations: **Fgt**, fragments; **Undet.**, Undertermined.

SLM-37 VV3	Cherts RMU											
	Total cherts	#123 Tortonian- Burdigalian			#124 Oligocene-Palaeocene					Undet.	Limestone	Fauna
		A1a	A1b	A2	A1a	A1b	A2a	A2b	A2c			
2015-17 – 7 m²												
Flakes and fragments of flakes	543	30	47	21	12	194	38	2	11	188	2	12
of which entire > 1 cm²	127	14	20	12	6	36	14	2	5	18	1	–
of which entire < 1 cm²	151	3	3	1	0	74	0	0	0	70	0	–
of which proximal fgt	77	2	9	2	3	27	6	0	2	26	0	–
of which mesial and distal fgt (no butt)	178	11	14	4	3	53	17	0	4	72	1	–
of which Siret fgt	10	0	1	2	0	4	1	0	0	2	0	–
of which retouched flakes	10	3	3	–	–	2	–	–	–	2	–	–
Pebbles	0	–	–	–	–	–	–	–	–	–	2	–
Core	1	–	–	–	–	–	1	–	–	–	–	–
Undetermined fragment (casson)	2	–	–	–	–	–	2	–	–	–	1	–
Sub-total	546	30	47	21	12	194	41	2	11	188	5	12
Débris after sieving	175	7	2	5	0	64	36	0	2	59	–	3
Total	721	37	49	26	12	258	77	2	13	247	5	15

APPENDIX 3. — Valle Giumentina, SLM-37, Locus VV1: distribution of refitting units by raw material units (RMU). Abbreviations: **nb**, number; **p.**, pieces; **Und.**, Undetermined.

Locus VV1	RMU	Total flakes and fragments	Nb of Refitting units by RMU / nb of pieces involved in refitting units	Refitting unit no. / nb of pieces in each unit	Figures
#123	A2a	27	1 unit/1 p.	no. 3/3 p. (same flake)	Fig. 10I
	A2b	28	2 units/5 p.	nos 1/3 p. – 4/2	Fig. 10G, H
#124	A1	51	5 units/11 p.	nos 2/4 p. – 5/2 – 9/2 – 10/3	Fig. 10C-F
	A2	30	2 units/4 p.	nos 6/2 p. – 8/2	Fig. 10A, B
other		43	–	–	–
Und.		71	2 units/4 p.	Nos 11/2 p. – 12/2 p.	Fig. 10J, K
Total		250	12 units/25 p.		

APPENDIX 4. — Valle Giumentina, SLM-37, Locus VV3: Distribution of refitting units by raw material units (RMU). Abbreviation: **nb**, number; **p.**, pieces; **Und.**, Undetermined.

Locus VV3	RMU	Total flakes and fragments	Nb of Refitting units by RMU / nb of pieces involved in refitting units	Refitting unit no. / nb of pieces in each unit	Figures
#123	A1a	30	3 units/6 p.	no. 5/2 p. - 12/2 - 14/2	Fig. 11A
	A1b	47	2 units/6 p.	no. 18/2 p. - 32/4	Fig. 11B, C
	A2	21	2 units/4 p.	no. 7/2 p. - 13/2	nn
#124	A1a	12	2 units/4 p.	no. 31/2 p. - 34/2	Fig. 11D, E
	A1b	194	10 units/26 p.	nos 1/2 p. - 2/2 - 3/3 - 4/2 - 6/2 - 8/6 - 9/3 - 11/2 - 15/2 - 16/2	Fig. 11F-H
	A2a	38	4 units/11 p.	nos 10/2 p. - 27/2 - 33/5 - 37/2	Fig. 11I-K
	A2b	2	—	—	—
	A2c	11	—	—	—
Und.		188	—	—	—
Total		543	23 units/57 p.		

APPENDIX 5. — Valle Giumentina, SLM-37, Locus VV1: cortex on flakes and fragments sorted by raw material units (RMU). Abbreviation: **Und.**, Undetermined.

Locus VV1	RMU	Total flakes and fragments	Of which		
			Without cortex	Partially cortical	Totally cortical
#123	A2a	27	20	5	2
	A2b	28	18	8	2
#124	A1	51	36	12	3
	A2	30	21	7	2
Other		43	33	8	2
Und.		71	58	8	5
Total		250	186	48	16

APPENDIX 6. — Valle Giumentina, SLM-37, Locus VV3: Cortex on flakes and fragments sorted by raw material units (RMU). Abbreviation: **Und.**, Undetermined.

Locus VV3	RMU	Total flakes and fragments	Of which		
			Without cortex	Partially cortical	Totally cortical
#123	A1a	30	27	1	2
	A1b	47	39	7	1
	A2	21	20	1	—
#124	A1a	12	7	4	1
	A1b	194	171	13	6
	A2a	38	25	10	3
	A2b	2	2	—	—
	A2c	11	9	—	2
Und.		188	188	4	—
Total		543	488	40	15