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THE MIDDLE PALAEOLITHIC SITE OF VAJO SALSONE IN THE MONTI LESSINI, ITALIAN ALPS. FIRST REPORT ON THE ARCHAEOFAUNA AND LITHIC ASSEMBLAGE WITH FOLIATE TOOLS.

Marco Peresani [1,2], Davide Delpiano [1], Ursula Thun Hohenstein [1],Gianluca Arnetta [1], Hugues-Alexandre Blain [3,4], Vittoriana Espedito [1], Juan Manuel López-García [3,4], Alessandro Poti [1], Ugo Sauro [5], Davide Visentin [1,6], Giorgio Chelidonio [1], Davide Margaritora [1], Yvonne Tafelmaier [7]
with the collaboration of: **Lorena Beltrame [1], Cristina Failla [1], Federico Pellegrini [8], Paolo Pellegrini [8]**

[1] Università di Ferrara, Dipartimento di Studi Umanistici, Sezione di Scienze Preistoriche e Antropologiche, Ferrara, Italy.
[2] IGAG - CNR, Milano, Italy.
[3] IPHES, Tarragona, Spain.
[4] Universitat Rovira i Virgili, Departament d'Història i Història de l'Art, Tarragona, Spain.
[5] Ethnografic Museum, La Lessinia, l'uomo e l'ambiente, Boscochiesanuova (VR), Italy.
[6] Archaeology of Social Dynamics Group, IMF-CSIC, Barcelona, Spain.
[7] Regierungspräsidium Stuttgart, Landesamt für Denkmalpflege, Referentin für Paläolithikum & Mesolithikum, Esslingen, Germany.
[8] Via Vagiol 44, 37020, Fane di Negrar, Verona, Italy.

Corresponding author: Marco Peresani <marco.peresani@unife.it>

ABSTRACT: This first report aims to illustrate the Middle Palaeolithic site of Vajo Salsone in the Monti Lessini plateau in the eastern Italian Alps, its geological and geomorphological context, the conditions leading to its discovery occurred after a road cutting, and the archaeological excavation of a karst structure where the sediments, faunal and cultural remains were still preserved. The karst infill is a massive clast-supported breccia with abundant animal bones and lithic artifacts coated of carbonate encrustations. The first analysis of the samples of small and large mammal assemblages recovered in the karst deposits has revealed the abundance of *Microtus arvalis*, a rodent currently reported to live in open environments and in relatively drier regions of northern Italy. Still, mosaic habitats with the presence of stony areas and scattered low scrubs are suggested by the presence of *H. viridiflavus* among the herpetofauna. Amongst the abundant faunal assemblage, the most common represented species are *Cervus elaphus*, *Capreolus capreolus* and *Rupicapra rupicapra* along with few carnivores.
At the present state, only red deer bones showed taphonomic evidence ascribable to hunting and exploitation, similarly to other Middle Palaeolihic sites of the region. The lithic industry consists of a huge number of chert artifacts produced using Levallois as the main knapping method together with an ephemeral use of discoid and volumetric blade exploitation. No appreciable difference in the taphonomic layout has been observed between the by- and end-products of these technologies. Predetermined blanks, cores and numberless of flat, elongated, cortical flakes attest the integrity of the Levallois reduction sequences. Retouched tools are mostly simple, double, often converging and, occasionally, transverse scrapers, and retouched points. In addition to these typical Mousterian tools, the distinguishing feature of Vajo Salsone is the presence of foliate tools made through invasive bifacial shaping, an already known model in Central Europe. Based on what resulted from our preliminary data, we have provisionally reconstructed the morphogenesis of the site in accordance with the following hypothesis: 1) in the basal part of a wall, inside a large natural niche evolved by weathering and karst processes, groups of Neanderthals settled, leading to the deposition of anthropogenic sediments; 2) following phenomena of rockfall and toppling of large blocks, retreat of the wall and dismantling of the large niche occurred, together with the erosion of the sediments of the shelter. These sediments were transported down-valley and partly trapped in a small karst shaft. Even though most of the evidence from the Vajo Salsone lithic assemblage is comparable with the one of other sites in the region and the northern Mediterranean area, it does however provide new details about the Late Pleistocene cultural scenario, thus contributing to enrich the Middle Palaeolithic picture.

Keywords: Mousterian, Foliate tool, Fauna, Prealps, Italy.

1. INTRODUCTION

Monti Lessini, in the central Southern Italian Pre-Alps (Fig. 1), is a mountainous area closely surveyed for the reconstruction of the Middle Palaeolithic settlement system and Neanderthal culture. Within the framework of multidisciplinary projects led by the Natural History Museum of Verona, the University of Ferrara, the Superintendence for Archaeological Heritage of Veneto and local societies, surface prospections and excavations have been carried on from the end of the 19th century, and they are still ongoing (see contributions in Aspes, 2003). Monti Lessini count the highest number of Mousterian sites within the North of Italy. A considerable bulk of data was obtained from deposits in caves, rock shelters and open air sites, becoming even more significant when compared to other Italian mountain ranges (Margaritora et al., 2020). However, despite the remarkable information acquired through the study of these sites, our knowledge about the variability of Neanderthal

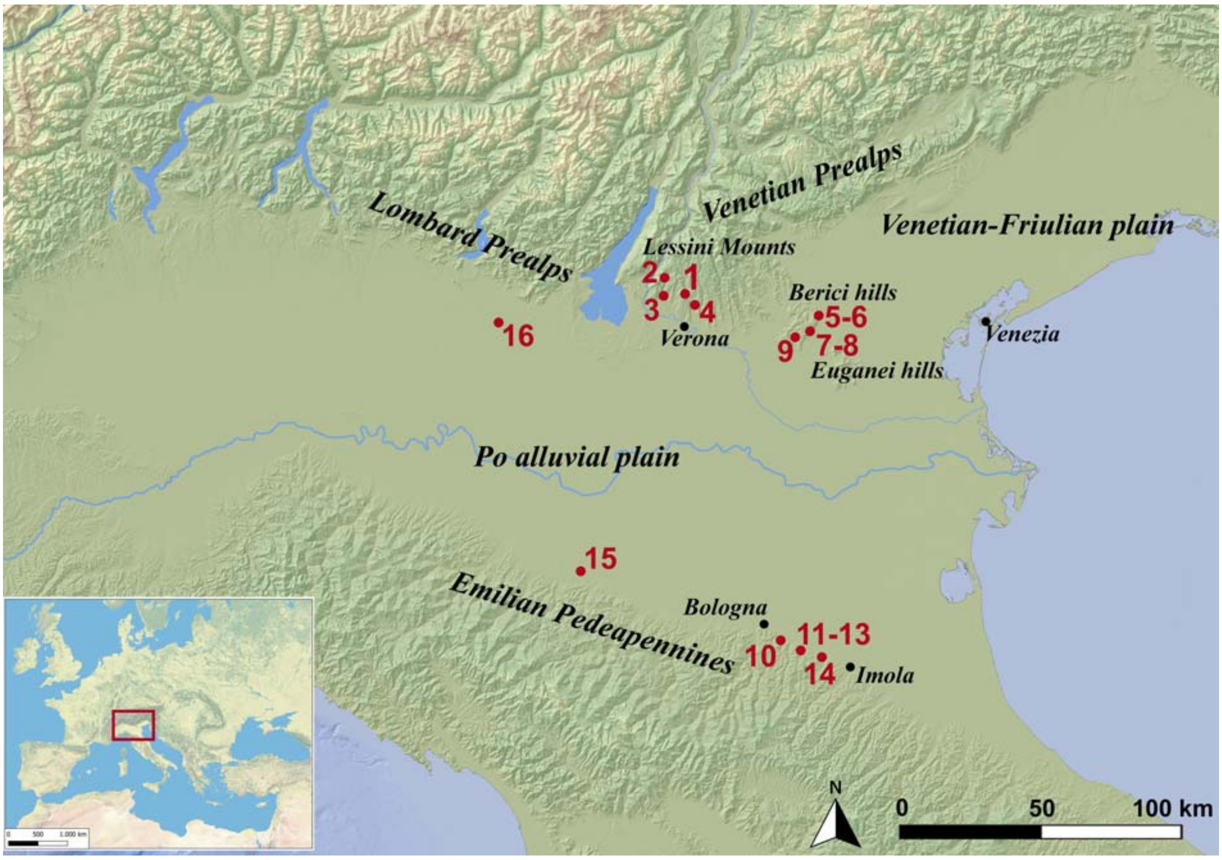

Fig.1 - North-eastern Italy showing the geographical location of Vajo salsone and of the Middle Palaeolithic sites mentioned in the text: 1) Vajo Salsone; 2) Fumane cave; 3) Ghiacciaia cave; 4) Tagliente rockshelter; 5-6) Broion cave, Broion rockshelter; 7-8) San Bernardino cave, Paina cave; 9) De Nadale cave; 10) Podere due Pozzi; 11-13) Palazzone-Ca Roma, Peverella, Ca' San Carlo; 14) Brusaida; 15) Ghiardo; 16) Monte Netto. Coordinate system ETRS89 / UTM zone 32N (EPSG 25832); Digital Elevation Model (base topography – Copernicus Land Monitoring Service (CLMS), 2019 and General Bathymetric Chart of the Oceans (GEBCO), 2019; Rivers and lakes (http://www.sinanet.isprambiente.it/it/sia-ispra/download-mais/reticolo-idrografico).

material culture is still unexpectedly far from being considered exhaustive. A factor of bias is the decreasing of the archaeological record as consequence of destructive post-depositional processes, which affect the degree of preservation and therefore the information value of the finds coming from open-air and stratified sites.

Stratigraphic deposits preserved in atrial cavities and under rock shelters, indeed act as geological archives, preserving key information about chronology, evolution of natural environments and expressions of human behavior. Among the contexts that had been systematically explored, it is worth to mention Riparo Zampieri, Riparo Mezzena, the "cave A" of Veja, Riparo Tagliente, Grotta della Ghiacciaia and Grotta di Fumane. In particular, the latter is a crucial site for the understanding of the Middle and Upper Palaeolithic transition, bearing the oldest cultural attestations ascribable to Anatomically Modern Humans (Peresani, 2012; Peresani et al., 2016; Broglio et al., 2006). Despite the dating of some stratigraphic sequences still need to be confirmed, according to the material culture found at these sites it appeared that human groups settled in the area roughly during the Late Pleistocene. Older lithic assemblages are represented by thick flakes sometimes retouched or by Levallois industries, both associated with some bifaces. Still, the Quinzano quarries remain the most important site, also because of the recovery of faunal remains of deer, elephant, fallow deer, and roe deer (Zorzi & Pasa, 1944-45).

In north-eastern Italy, it is commonly assumed that the Levallois technology, with its recurrent unidirectional and centripetal modalities, dominates the lithic industries of the sites of this region and of Monti Lessini as well (Peresani, 2001, 2011). Flexibility in flake-making resulting from the application of these different recurrent modalities has been observed both at open-air and at multilayered sites. Technological similarities amongst the lithic industries have been recognized within the tool -sets, mostly composed of side, transverse, converging scrapers, retouched points, and, to a much lesser extent, of denticulates. Conversely, none of these assemblages specifically aimed at a Levallois points production. Yet, a core volumetric concept related to the Quina sphere was undoubtedly identified at two sites (Peresani, 2012; Jéquier et al., 2015). Discoid technology was recorded as well. It becomes more frequent during the Marine Isotope Stage 3 and participates to a more complex cultural phenomena which highlights an increase in the variability at the end of the Middle Palaeolithic (Peresani, 2011). Discoid industries are typically represented by a range of flakes and pseudo-Levallois points, scrapers, points and denticulates, and purposedly modified backed tools (Delpiano et al., 2019a).

With the aim of shedding new light on the Neanderthal cultural variability of this area, the following paper presents the recently discovered (2017) site of Vajo del Salsone (Vajo Salsone). Its archaeological content is represented by a huge amount of lithic artefacts and faunal bones contained in a karst pit developed in oolitic limestones and opened during new road cutting. The cultural value of this site is supported by the unexpected finding of several leaf points which add a touch of originality in the Middle Palaeolithic of this part of Mediterranean Europe.

2. PRESENTATION OF THE VAJO SALSONE SITE

2.1. The site in the morphostructural setting of the Lessini Mountains

The Vajo Salsone site is located in the Monti Lessini, a mountain group belonging to the Venetian Pre-Alps (Fig. 1). The Lessini group can be considered a monocline structure with a trapezoidal shape, where its shortest side faces north. It is radially dissected by several valleys developed along tectonic lines, shaping canyons - locally called vaj - in some sections. The relief is mainly sculptured in the context of a series of carbonate rocks ranging in age between the upper Triassic and the Eocene. This is the so-called “Serie Veneta" which includes the following geological formations: Calcari Grigi, Oolite di San Vigilio, Rosso Ammonitico Veronese, Maiolica, Scaglia Rossa, Eocene limestones, formed in marine environment. Volcanic rocks are equally attested in the upper part of the succession (Bosellini et al., 1967; Carraro et al., 1969). In its medium-high portion, the Serie Veneta is rich in chert. This one can be found both in primary outcrops - as nodules and layered deposits in late Jurassic, Cretaceous and Eocene rocks - and in secondary position in superficial deposits, soils and coarse alluvial deposits (Bertola, 2016).

If the main features of the relief can be explained by the lithological and tectonic characteristics of the different formations, the understanding of the morphostructural building and its evolution requires a summary of the geological history and an analysis of the sort of deposits resulting from the main recent seismic events (Sauro, 2003; Sauro & Zampieri, 2001; Sauro & Ferrarese 2016).

The most significant tectonic events for the history of the morphostructural building began with a relaxing phase, developed during Jurassic and Cretaceous periods, when the sedimentary rock complex was still covered by the sea. The movements of continental masses generated fractures in the crust, with formation of a submarine rift consisting in a sort of plateau elongated in the N-S direction, corresponding to the current Verona-Trentino area (called “Trento platform”). This plateau was bordered on both sides by a stairway of narrow and elongated blocks, which marked the passage towards the bottom of two basins located on the sides: on the west side the “Lombard basin”, and on the east side the “Belluno basin” (Castellarin, 1981). In this phase, the different depths of the seabed influenced the sedimentation processes, and therefore determined the characteristics and thickness of the formations themselves.

The subsequent deformation events were controlled by the fault systems identified in the context of the Mesozoic rift. The ancient faults were reactivated due to different geodynamic conditions, mainly of compressive type. In addition, new fault systems were originated, such as the Schio-Vicenza system (Zampieri, 1995, 2000).

This evolution is explained by the collision of the African craton against the Eurasian one, which, in the Mediterranean, resulted in the formation of the Alps. The directions of maximum tectonic compression have changed over time, rotating counterclockwise, from N 55° direction (between 50 and 35 million years ago), followed by N 25° directions (between 30 and 16 million years), N 340° (between 16 and 6 million years), and N 310° (between 6 and 2 million years) (Castellarin et al., 2006).

Nowadays, compressive mechanisms are still active, as shown by recent earthquakes such as the Friulian one in 1976, or the historical 1117 Verona earthquake, which turns out to be the most famous historical seismic event in the Alps (Guidoboni et al., 1985, 2005; Galadini et al., 2001; Sauro & Zampieri 2001; Sauro, 2003; Poli et al., 2008; Viganò et al., 2008; Sauro & Ferrarese, 2016; Mantovani et al., 2021). The prevailing compression from south to north is due to the advancement of the Apennine front, buried under the alluvial sediments of the Po River. Yet, at the same time, the Brescia Pre-Alps, being hindered in their movement to the north by the Adamello batholith, divert their thrust to the east, investing the Monte Baldo group and the Lessini mountains. Therefore, the compressive forces are exerted both in N-S and in E-W direction due to the anisotropy of the structural building. The result is a progressive fragmentation of the N-S elongated blocks and their deformation, together with vertical shifting and western tilting (Massironi et al., 2009; Sauro & Ferrarese, 2016).

Tectonic activity and its related fault systems (Zampieri, 2000) exert strong influence on erosional phenomena, represented by weathering, karst, and different classes of slope processes which led to the development of the present-day landscape. Karst is one of the most impacting process and together with hydrological activity gives rise to different styles of physical landscape also controlled by the lithological features of the geological formations. These features can be identified through the hydrographic network and from a series of different superficial and underground morphologies, resulted by the numerous faults and fractures that accelerate and facilitate the water flowing through rocks. According to the tectonic evolution and to the main mopho-dynamic processes, the pattern of the present-day landscape may be defined as both fluviokarstic and tectokarstic (Sauro, 1973; Mietto and Sauro, 2000).

In the Valpantena area these movements can be easily detected: surface faulting walls with displacements that locally exceed two meters, folds created at the edges of the blocks, covers of debris and breccias on the slope that can be interpreted as seismites (Zanferrari et al., 1982; Sauro & Zampieri, 2001; Sauro & Ferrarese, 2016). The Vajo Salsone is located right besides an E-W fault that separates two of the blocks constituting the N-S ridge between Valpolicella and Valpantena. This explains the intense fracturing activity in proximity of the fault.

During the Quaternary, the Monti Lessini were partly covered by the Adige glacier or by local glaciers attested on the upper part of the plateau and in the nearby Carega Massif (Sauro, 1973, 2020). Periglacial conditions activated strong erosion of the paleosols, accumulations of colluvial deposits in valley bottoms and dolines, especially in the central part of the plateau. From the Middle Pleistocene onward, the Loess sedimentation affected the entire surface of the plateau (Magaldi & Sauro, 1982; Castiglioni et al., 1990). Deposits in caves and rock shelters along the slopes allowed to estimate that the deepening of gorges and valleys occurred at least from the late Middle Pleistocene (Castiglioni et al., 1990; Cremaschi, 1990). Anthropogenic soil erosion during the Holocene strongly affected the main slopes, especially starting from the Neolithic.

2.2. The Valpantena and the Vajo Salsone

The prehistoric site (5046787.37 N, 655509.97 E, 376m a.s.l) is located on the left (northern) slope of Vajo Salsone, a deep cut in the right slope of the upper Valpantena (Fig. 2). This latter, a large erosional feature located NE of the town of Verona, looks like an inlet of the high venetian plain within the Pre-Alpine relief, including a large alluvial plain that mostly originated during the Middle and Late Pleistocene from the depositional activity of the Adige river and its Monti Lessini tributaries (De Zanche et al., 1977). Valpantena begins at the confluence of three canyon like valleys: Vajo della Marciora, Vajo dei Falconi and Vajo dell'Anguilla. Regarding the tectonic system, the afore-mentioned three fluviokarstic canyons together with Valpantena as their continuation, are set along a bundle of fault lines oriented NNW-SSE and NNE-SSW. The right (western) slopes of these valleys are mainly in-facing slopes, while the left (eastern) ones are predominantly dip-slopes (Sauro, 1978, 2013). This explains the asymmetry of the valley slopes and the presence of high walls only on the right slopes.

The profile of the main valley western slope surrounding the archaeological site is characterized, in its lower part, by a strip inclined 30-35°, modelled in the limestone of the Lower Jurassic (formations of Calcari Grigi and Oolite di San Vigilio). The band is delimited upstream by a frame of Oolite di San Vigilio and Rosso Ammonitico Veronese limestone rock walls. The Rosso Ammonitico, consisting of micritic limestones more resistant to degradation and erosion than the underlying rocks, acts as a "roof" for the more erodible Oolite limestones, thus favouring the conservation of the walls. Above these, the profile develops in a large substructural terrace followed upwards by a sequence of slopes shaped in Cretaceous limestone formations interbedded

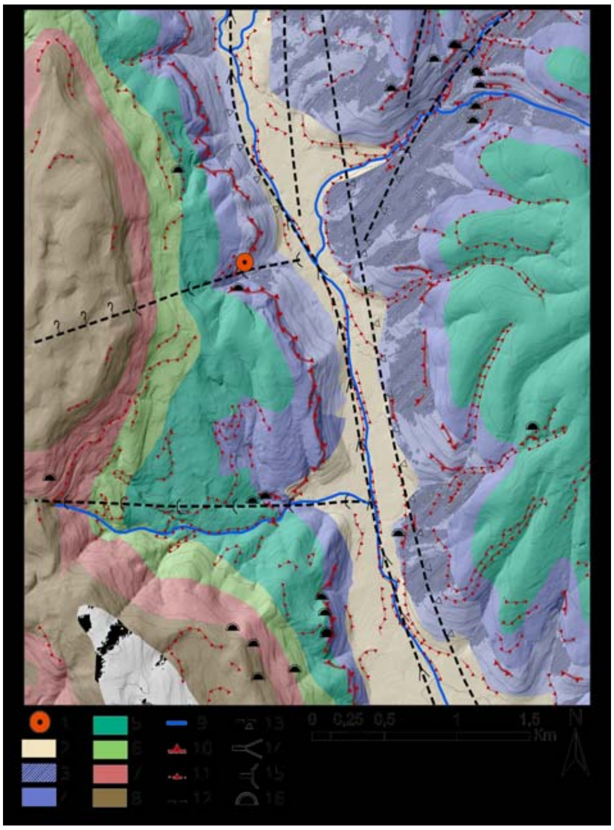

Fig. 2 - Geomorphologic map of Valpantena. Key: 1 - Vajo Salsone site; 2 - alluvional, fluvioglacial, lacustric and palustric deposits; 3 - Oolite di San Vigilio, Calcari Grigi, Encrinite of Fanes; 4 - Rosso Ammonico, Fonzaso formation; 5 - Maiolica, Soccher limestone; 6 - Scaglia Rossa, Scaglia Variegata, Scaglia Cinerea; 7 - Basaltic vulcanite of Euganei; 8 - Calvene formation, Salcedo Formation, Castelgomerto limestone; 9 - streams; 10 - Scarp ≥10 m; 11 - Scarp n.d.; 12 - Fault line; 13 - Flexure scarp; 14 - Fault line valley; 15 - Small valleys along fault line; 16 - Caves. Technical note. Coordinate system WGS84. Digital Elevation Model (base topography DTM 5m - https://idt2.regione.veneto.it/). Geological layers from https://idt2.regione.veneto.it/. Scarp from https://idt2.regione.veneto.it/. Faults from Sauro, 1978.

with volcanites, up to a sub-structural summit plateau in Eocene limestone, which characterizes the ridge between Valpantena and Valpolicella (Monte Comun).

Karst landforms are widely distributed in the whole area either as surface karst (dolines, limestone pavements, natural bridges) and deep karst (caves, shafts, swallowing cavities). South of the confluence of the three valleys, the valley floor, formed by gravelly, sandy and pelitic alluvial and colluvial-detrital deposits at the foot of the steepest slopes, widens from North to South, joining the high Venetian plain after 15 km. The thickness of the sedimentary filling increases towards South, to such an extent that the rocky bottom of the middle and lower Valpantena is situated below the sea level. This can be explained by the Messinian event of "desiccation" of the Mediterranean and, therefore, by the over-excavation of the river due to the lowering of the base level (Bini et al., 1978).

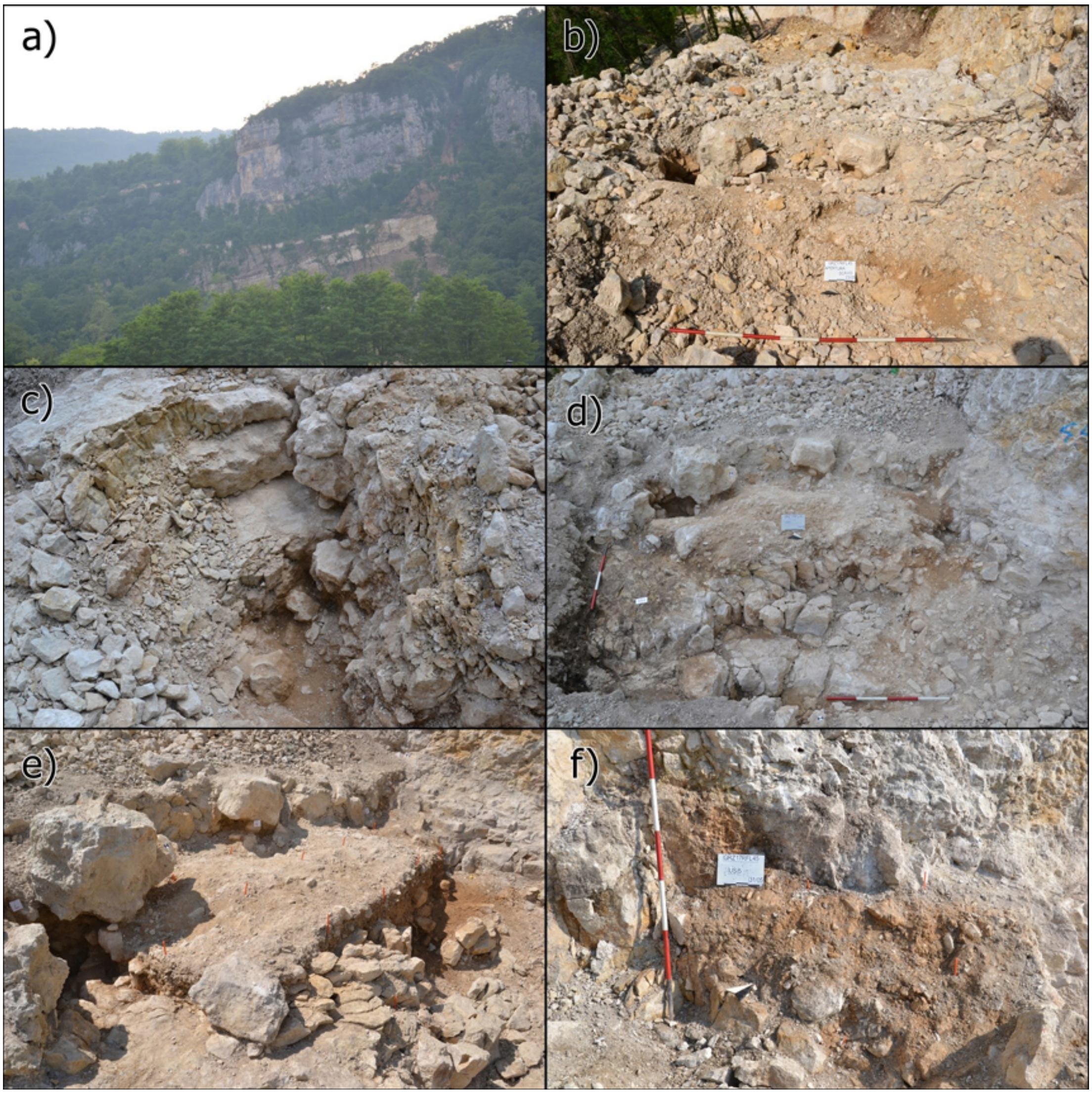

Fig.3 - Slope and road between Stallavena and Coda where the archaeological deposit was found (3a); the study area before any archaeological interventions (3b); detail of the terraced S-E side of the cavity (3c); eastern view of SU 5 once recent layers were removed (3d); south-eastern view of US 5. Red nails delimitate the square-grid used for the excavation of US 5 (3e); South-western view of a portion of SU 5 preserved beside the karst chimney (3f).

2.3. Discovery of the site, rescue excavation and processing of materials

The site was found during the construction of a truckable road between Stallavena (zona Revolto) and Coda (Fig. 1). On May 1st 2016, two of us (F.P. and P.P.) were walking on the fresh road cut at mid elevation along the eastern slope of Comun Mount, collecting bones and flint artifacts from the mined brecciated bedrock between the fourth and the fifth harpin turn of the road, at 376 m a.s.l. (Fig. 3a and 3b). Thanks to this discovery a rescue excavation campaign (Excavation code: GRZ17RFL45) was conducted by two of us (D.V. and A.P.) from May 23rd to June 3rd 2017, led by the Archaeological Superintendence and the University of Ferrara.

At first the excavations for the construction of the truckable road revealed covers of diamicton with a thickness of between a few decimeters and about 2 m, poor in matrix, formed by angular fragments of limestone, mostly small in size but including some big blocks. There was little or no cementation. Inside the covers there were also soil sediments, both in the form of bodies trapped inside cavities with irregular shapes and mixed with rock clasts. The artificial sections of the deposit allowed to recognize some cavities inside it, in form of small conduits, probably caused by piping processes.

The site is a small and narrow karst cavity filled by Pleistocene sediments yielding abundant Middle Paleolithic artefacts and faunal remains. The finds were gathered in a context located two meters below the original ground-level, the Vajo slope. During the excavation the reworked upper stratigraphic units (SUs 1-2-3) were removed as a whole, whereas the main layer (SU 5)

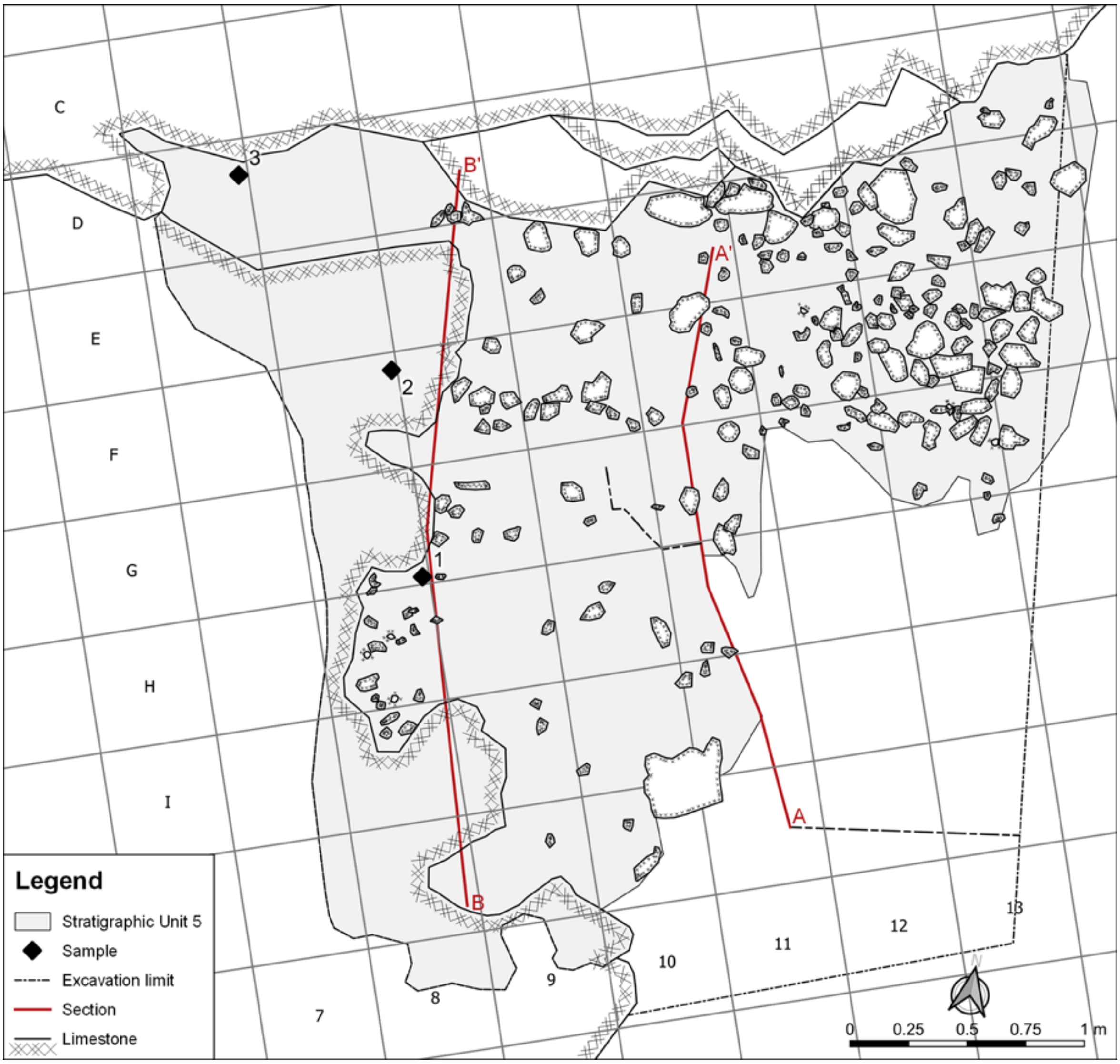

Fig. 4 - General plan of the excavated area with extention of SU 5 (drawing by D.V. and A.P.).

with its palaeontological and archaeological content was manually excavated through a 50 cm grid system and artificial spits of different depths (Fig. 3c, 3d and 3e; Fig. 4). Due to mines activity, the rock wall was highly unstable. For this reason, it was not possible to entirely investigate the archaeological deposit since part of the cavity extended beside the road cut (Fig. 3f). In addition to loose sediment samples, three columns of soil and abundant speleothems samples were collected for micromorphological analyses. Sediments were wet sieved through superimposed meshes ranging from 5 to 0.5 mm. Lithic artifacts and faunal remains were systematically recovered in situ during the excavation process and after wet sieving the sediments.

2.4. Sedimentary context

Morphology of the karst structure. The site consists in a narrow vertical shaft -a feature locally called "arso"- formed by the chemical dissolution and water erosion of a discontinuity in the geological bedrock, where two faults (respectively oriented WNW-ESE and NE-SW) meet (Fig. 5a). There were no traces of active water erosion. The eastern and southern sides of the cavity are terraced and consistent with the stratification of the bedrock, forming a sort of underground room. Due to the explosions and the removal of the reworked material the top of the cavity was taken off, thus showing the central and lowest parts of the underground room. Despite this partial loss, it was possible to infer the presence of a second karst system. This latter is sub-horizontal, developing N-S, and it might have contributed to the formation of the aforementioned underground room. On the southern side of the excavation the filling deposits directly expose on the slope. The remaining of the vertical chimney was identified at the NW of the deposit on the side of the road cut (Fig. 5b).

Fig. 5 - The karst fissure exposed at the end of the excavation (5a) with portion of SU 5 deepening below the rockwall left unexcavated because of the instability of the rock. As shown by the picture 5b, the deposit extends inside the rockwall on the northern side of the excavation. The sediment within the karst chimney only partially fills the latter.

Nevertheless, this was not enough to allow to infer the original size and shape of the cavity. Once the archaeological layers were removed, it was clear that these last ones occupied only a small portion of the chimney, which deepens far below the excavated area without any filling.

Sediments, distribution, and composition. Below the reworked layers (RIM) resulted by the construction works it lays the archaeological deposit. This filling is bounded by the cliff and the slope on its northern and southern sides, respectively. Overall, the volume of the deposit spread over a 4x4 m surface, and it was thick more than 2 m (without considering the chimney). During the archaeological excavation six Stratigraphic Units (SU) were identified, including a negative one:

SU1: reworked layer located in the northern part of the excavation besides the rock wall. It contained faunal remains, lithics and modern glazed pottery.

SU2: resulted by the digging of an artificial pit (SU6) in the southern part of the excavation. The filling was located E or NE of the pit and it was characterized by abundant lithic artefacts, faunal remains and limestone clasts ranging in size from cm to dm. The artificial pit was realized in the framework of the first surveys carried on once the deposit was discovered but before any archaeological intervention. It deepens until SU5.

SU3: present day soil preserved only in the SE area of the excavation and laying on slope deposits, lays on SU4 and partially on SU5. It was cut by construction works - which did not affect B and C horizons - and its thickness measures about 15-40 cm. It is a loamy sand soil characterized by abundant and heterometric clasts (<30 cm) randomly oriented. The layer is dark brown, homogeneous, friable, with roots, organic matter, lithic artifacts and faunal remains scattered in proximity of the boundary with SU 5.

SU5: loamy sand and clast supported layer, slightly hard, yellowish brown (10YR 6/6 Munsell Soil Color Charts®, 2001) with increasing content of clay in the lowest part. It contains monolithologic blocks of the size of decimeters, rare, smoothed blocks, fragmented speleothems, abundant lithic artefacts, and faunal remains showing fresh and not abraded edges. Two are the most frequent carbonate deposits: A) fragments of speleothems dispersed in the sediment grading > 30-40 cm; B) withish, polylobed and millimetric spots/stains. The layer covers a 4x4 m surface and its thickness spans from few centimetres to more than two meters in relation to the topography of the karst structure (Fig. 6).

SU4: Carbonate bedrock exposed over the whole excavated area.

Flowstone and fragments. In the deepest part of the karst chimney which contained the archaeological layers it was identified a calcite deposit, 3-4 cm thick. It develops besides the bedrock and it preceded the blockage of the cavity.

3. THE FAUNAL BONE ASSEMBLAGE

3.1. Small vertebrates

3.1.1. Materials and methods

Small vertebrates were identified following the general criteria given by Berto (2013) and López-García (2011) for insectivores and rodents, and Szyndlar (1984, 1991) for snakes. The specific attribution of this material is mainly based on the best diagnostic elements, mandible, maxilla and isolate teeth for small mammals, and trunk vertebrae for snakes. Fossils from SU5 were grouped using the minimum number of individuals (MNI) method, by means of which we determined the sample (i.e. from each level) through the counting of the most represented diagnostic elements. In the case of snakes, MNI has been approached taking into account size categories.

3.1.2. Results

Although the number of identified specimens (NISP) and the MNI of small vertebrates are low in Vajo Salsone SU5, the number of the species represented is relatively high (Tab. 1). As a matter of fact, small mammals are represented at least by nine different taxa, one insectivore (*Sorex* sp.) and eight rodent species (*Arvicola amphibius*, *Dinaromys bogdanovi*, *Clerthrionomys glareolus*, *Microtus arvalis*, *M. agrestis*, *M.*

Fig. 6 - Stratigraphic sections of SU 5 (see figure 4 for position; drawing by D.V. and A.P.).

(*Terricola*) *multiplex-subterraneus*, *Apodemus* (*Sylvaemus*) sp. and *Glis glis*, whereas the herpetofauna is only represented by snakes. Green whip snake (*Hierophis viridiflavus*) is probably represented by two individuals, an adult (one cervical vertebra, and 20 trunk vertebrae) and a juvenile (two cervical vertebrae, and nine trunk vertebrae), while a viper (*Vipera aspis*) is documented by two fragmentary trunk vertebrae. The relative abundance of *M. arvalis*, being the most abundant species and the presence of the Balkan vole (*D. bogdanovi*) indicate a Late Pleistocene age for this assemblage. On the contrary, the Holocene in this area (according to Berto et al., 2019) from the Bølling-Allerød interstadial is characterized by a strong decrease of *M. arvalis* and the disappearance of *D. bogdanovi*.

From a quantitative point of view, among the small mammals the common vole (*M. arvalis*) is the most abundant species, representing 39.3% of the total MNI. Such a high rate of *M. arvalis* is relatively common in late Pleistocene sites of north-eastern Italy, as attested during MIS 5 of Grotta Maggiore di San Bernardino (López-García et al., 2017), MIS 3 of Grotta del Broion (Colamussi, 2002), and Grotta Minore di San Bernardino (López-García et al., 2019) in the Berici Hills, together with MIS 3 of Fumane cave (López-García et al., 2015) and MIS 2 of Riparo Tagliente (Berto et al., 2018) in Lessini Mounts. The abundance of *M. arvalis* is currently reported to be higher in open areas and in relatively drier regions of northern Italy (Amori et al., 2008). Still *H. viridiflavus* prefers open, mosaic habitats with the presence of stony areas and scattered low scrubs. These conditions allowed both species to find open areas for thermoregulation, optimal shelters and hunting zones. On the other hand, they tend to avoid uniform environments such as extensive forest or large grasslands (Scali et al., 2008). Nowadays, in the region of Vajo Salsone, only two vipers are present: *Vipera aspis* and *Vipera berus* (Sindaco et al., 2006; Sillero et al., 2014). *V. aspis* occupies a wide variety of environments, however, its thermal requirements oblige it to exploit habitats provided with stony substrate, relatively sunny and south-facing dry soils, and with some vegetation cover. In a similar way, *V. berus* requires a certain habitat complexity. In southern France and northern

	NISP	MNI	%
Hierophis viridiflavus	32	2	7.1
Vipera sp.	2	1	3.6
Sorex sp.	1	1	3.6
Arvicola amphibius	1	1	3.6
Dinaromys bogdanovi	2	2	7.1
Clethrionomys glareolus	2	2	7.1
Microtus arvalis	21	11	39.3
Microtus agrestis	3	2	7.1
Micrtous arvalis-agrestis	1	1	3.6
M. (*Terricola*) *multiplex-subterraneus*	1	1	3.6
Apodemus (*Sylvaemus*) sp.	6	3	10.7
Glis glis	3	1	3.6
Total	**75**	**28**	**100.0**

Tab. 1 - Representation of the Number of Identified Specimens (NISP), minimum number of individuals (MNI) and percentage of MNI (%) for small vertebrates of Vajo Salsone US 5 archaeofauna assemblage.

Italy, it is found in either low lying wetlands (if dry soils are available) or at high altitudes (Mallow et al., 2003).

Among the aforementioned sites - which are geographically close to each other, and cautiously taking in account data from Vajo Salsone SU 5 due to the small sample of remains, it resulted that this latter mammal assemblage is similar to Fumane cave's one (Lopez-García et al., 2015), spanning between 50-35 ka BP (Peresani et al., 2008; Higham et al., 2009).

3.2. Large vertebrates
3.2.1. Materials and methods

Our analysis concerned a sample of bone assemblage coming from the upper part of SU 5 (spits I, II and III). Overall, 26,360 faunal remains were examined for this study. The analyzed sample consists of unidentified bone elements and shows a high degree of fragmentation on 85.9% of the finds (22,631) smaller than 2 cm, while only 3,729 remains are longer than 2 cm. Considering a total sample of 3.729 TNR selected both for archaeozoological and taphonomic analyses, only 89.8% was scrutinized because 10.2% of the remains (380) is covered by concretions (Tab. 2). Taxonomic identifications were carried on with the help of reference collections of the Laboratory of Archaeozoology and Taphonomy (LAT) and of the Large Vertebrates of the Department of Humanities, University of Ferrara. Anatomy atlases (Schmidt, 1972; Barone, 1980; Pales & Lambert, 1971; Pales & Garcia, 1981) were employed for skeletal and anatomical nomenclature. Unidentified remains have been classified according to bone morphology (long, flat, and articular/compact bones), as well as animal groups by weight.

We quantified the identified elements using the following indices: NR (Number of Remains); NISP (Grayson, 1984); MNE (minimum number of elements) - it has been counted considering side, body size and ontogeny (Klein & Cruz-Uribe, 1984); MNI (Klein & Cruz -Uribe, 1984; Grayson, 1984; Lyman, 1994) and MAU (minimum animal units) (Binford, 1984). Fragmentation indexes (MNE/NISP) and skeletal survival rate, obtained by comparing the minimum number of elements (MNE) with the number of elements expected (eNE) on the basis of the MNI, were calculated to estimate the skeletal representation of the most represented taxa (Binford, 1981; Brain, 1981; Lyman, 1994). We assessed age at death mainly through the state of ossification of the long bones and the study of deciduos and permanent isolated teeth, although in some instances teeth eruption degree, dental wear, and the stage of epiphysis fusion on long bones were used as well (Habermehl, 1961; Mariezkurrena, 1983).

In order to distinguish the edaphic and anthropic modifications, we scrutinized all the selected specimens at both macroscopic and microscopic level. When necessary, microscopic analyses of bone surfaces were carried out using a Leica S6D Greenough stereomicroscope with 0.75-70X magnification range, also employed for capturing images. We distinguished taphonomic modifications according to the criteria established by Behrensmeyer (1978), Binford (1981), Lyman (1994), Fernández-Jalvo & Andrews (2016). We classified carnivore marks as follows: pits, scores, punctures, furrowing, gnawing and corrosion by gastric acid (Fisher, 1995; Domínguez-Rodrigo & Piqueras, 2003). Burnt modifications were recorded too (Bennett, 1999). Trampling marks were distinguished from butchering

SU 5						
Taxa	**NISP**	**%NISP**	**MNI**	**%MNI**	**MNE**	**MAU**
Canis lupus	76	6.9	4	14.8	8	4
Vulpes vulpes	14	1.3	2	7.4	3	1.5
Canidae	12	1.1				
Total Carnivora	102	9.3	6	22.2		
Alces alces	2	0.2	1	3.7	1	0.5
Cervus elaphus	680	62.0	18	66.7	29	14.5
Capreolus capreolus	6	0.5	1	3.7	1	0.5
Cervidae	283	25.7				
Cervidae large size	15	1.4				
Rupicapra rupicapra	4	0.4	1	3.7	1	0.5
Caprinae	5	0.5				
Total Ungulata	995	90.7	21	77.8		
Total identified	**1.097**	**100.0**	**27**	**100**		
Mammals	82					
Large size mammals	1					
Small size mammals	12					
Aves	5					
Total	**1.197**					
Unidentified > 2 cm	2.532					
Total remains > 2 cm	**3.729**					
Unidentified < 2 cm	22.631					
Total remains	**26.360**					

Tab. 2 - Composition of a sample of Vajo Salsone US 5 archaeofauna assemblage with number of identified specimens (NISP), minimum number of individuals (MNI) and minimum animal units (MAU). Minimal Number of Elements (MNE) is referred to the most represented element useful to estimate both the MNI and MAU, except for red deer for which MNI has been estimated on teeth and MAU on astragalus (see Table 3).

Cervus elaphus										
Skeletal element		NISP	%NISP	MNE	MNI	MAU	eNE	MNE/NISP	MNE/eNE	Note (Element for the calculation of MNE, MNI e MAU)
Antler		2	0.3	2	2	1	36	1	0.06	
Mandible		27	4.0	4	2	2	36	0.15	0.11	
Teeth		181								
	Deciduous	17	2.5	5	**4**	2.5	36		0.14	**dP4**
	Upper	54	7,9	13	4	6.5	36		0.36	P^3
	Lower	110	16.2	19	**14**	9.5	36		0.53	**M3**
Vertebra		10	1.5							
Scapula		6	0.9	6	4	3	36	1	0.17	
Humerus		21	3.1	11	6	5.5	36	0.52	0.31	
Radius		9	1.3	7	5	3.5	36	0.78	0.19	
Ulna		16	2.4	15	11	7.5	36	0.94	0.42	
Carpals										
	Scaphoid	8	1.2	8	7	4	36	1	0.22	
	Lunate	15	2.2	15	8	7.5	36	1	0.42	
	Cuneiform	5	0.7	5	3	2.5	36	1	0.14	
	Trapezoid-magnum	10	1.5	10	5	5	36	1	0.28	
	Uncinatum	11	1.6	11	6	5.5	36	1	0.30	
	Pisiform	4	0.6	4	3	2	36	1	0.11	
Metacarpal		10	1.5	3	2	1.5	36	0.30	0.08	
Coxal		15	2.2	8	8	4	36	0.93	0.39	
Sacrum		2	0.3	2	2	2	18	1	0.11	
Femur		17	2.5	2	2	1	36	0.12	0.06	
Tibia		36	5.3	12	7	6	36	0.33	0.33	
Malleolus		17	2.5	17	9	8.5	36	1	0.47	
Astragalus		29	4.3	**29**	15	**14.5**	36	0.97	0.78	
Calcaneum		16	2.4	12	10	6	36	0.75	0.33	
Tarsals										
	Navicular-cuboid	22	3.2	19	10	9.5	36	0.86	0.53	
	Medial cuneiform	14	2.1	14	8	7	36	1	0.39	
Metatarsal		31	4.6	7	6	3.5	36	0.23	0.19	
Metapodial		29	4.3							
Phalanx										
	I	26	3.8	15		1.9	144	0.58	0.10	
	II	40	5.9	19		2.4	144	0.48	0.13	
	III	12	1.8	12		1.7	144	1	0.09	
	Vestigial	22	3.2	14						
Sesamoid		17	2.5	13						
Total		**680**	**100.0**							

Tab. 3 - Skeletal elements of *Cervus elaphus* with estimation of minimum animal unit (MAU), fragmentation index (MNE/NISP) and skeletal survival rate (MNE/eNE-expected number of elements) of a sample of Vajo Salsone US 5 archaeofauna assemblage. The highlighted values are referred to the elements utilised for estimating MNI and MNE-MAU of red deer for Table 2. (Grey and light grey respectively).

marks using the works of Blasco et al. (2008) and Domínguez-Rodrigo et al. (2009). Evidence of anthropic modification observed on faunal remains include butchery marks (Binford, 1981; Potts & Shipman, 1981; Shipman, 1981; Galán et al., 2009) and bone retouchers (Mallye et al., 2012).

3.2.2. Results: composition and taphonomy

Among the 3,729 selected remains longer than 2 cm, a taxonomic determination was only possible for 1,097 remains representing 29.4% of the sample (Tab. 2). Isolated teeth and phalanges predominate among the identified elements, followed by tarsal bones, metatarsals and metapodials. However, other skeletal elements belonging to both the axial and appendicular skeletons are present although very fragmented.

The faunal composition (Tab. 2) consists almost entirely of mammals and for a small percentage of birds,

Bone surface modifications NR > 2 cm	TNR 3729	
	NR	% TNR
Concretion	380	10.04
Rodent marks	11	0.29
Carnivore marks	3	0.08
Anthropic modification		
Burned	39	1.05
Cutmarks	26	0.70
Scraping marks	3	0.08
Percussion marks	38	1.02
Retoucher	2	0.05

Tab. 4 - Percentage distribution of the different typologies of bone surface modifications in a sample of Vajo Salsone US 5 archaeofauna assemblage.

at the moment not yet identified at the species level. On the basis of NISP and MNI, the most represented species among ungulates is red deer (*Cervus elaphus*) with 62.0%. Roe deer (*Capreolus capreolus*) and chamois (*Rupicapra rupicapra*) are rare: 0.5% and 0.4% respectively. The presence of elk (*Alces alces*) is attested by only two remains (0.2%). Among carnivores, wolf (*Canis lupus*) prevails with 6.9%, while red fox (*Vulpes vulpes*) reaches only 1.3%. Several remains were classified as Caprinae, Cervidae, large Cervidae, Canidae in cases when it was not possible to identify them at species or genus level because of the lack of diagnostic morphological elements and the high degree of fragmentation.

Considering the age at death, estimated on the basis of the degree of dental eruption and wear, and on the state of ossification of long bones, most taxa belong to adults, while some young and sub-adults individuals have been recognized only for red deer.

The estimation of minimum animal unit (MAU) vs the MNI suggests that more than a half of red deer carcasses were introduced complete into the site (Tab. 2) and at least half carcasses for the other ungulates. However, only for *Cervus elaphus* it is possible to propose some preliminary considerations about their exploitation and fragmentation of anatomical elements. Red deer is represented by 18 individuals: distributed over 4 juvenile/ sub-adults and 14 adults, based on the presence of lower deciduous (dp4) and permanent isolated lower teeth (M3). With regard to the distribution of anatomical elements there are both parts of the axial skeleton and skull with high percentage of teeth (30.6%), and parts of the appendicular skeleton with prevalence of phalanges (14.7%) and tarsals (12%), followed by carpals (7.8%), tibia (5.3%) and metatarsals (4.6%) (Tab. 3). Estimation of the skeletal survival index (MNE/eNE) shows that the more represented anatomical elements are astragals (0.78). The other elements belonging to appendicular skeleton are instead poorly represented, showing greater fragmentation (MNE/NISP) of hind limb than forelimb bones. This could indicate a possible selection in the hunting area of elements introduced into the site. The marked representation of teeth, upper (0.58) and lower (0.53), could suggest a transport to the site not only of appendicular parts, but also of complete carcasses in agreement with the results of the comparison between MAU and MNI (Tab. 3).

3.2.3. Results: taphonomy

All bones and teeth have the same preservation characteristics and uniform surface features pointing for a common sedimentary context and exclude any type of evidence ascribable to mixing with material of Holocene or very recent origin. The faunal remains are in a good state of preservation, their color is very homogenous and ranges from whitish to light yellow (10YR8/6 Munsell Soil Color Charts®, 2001), with presence of scattered manganese oxides. 27% of the remains (NR 329) is completely covered by concretions that are present on the lithic assemblage too and did not allow to observe the bone surfaces. Weathering is light although the remains present post-depositional fractures.

Of the whole ensemble of taphonomic traces, those ascribable to carnivore actions are rare, identified on only 0.08% of the sample and classified primarily as scores and scarce presence of digested bones. Rodent marks were found on a small percentage as well (0.29%), mainly on lateral phalanges and tarsals.

Traces of anthropic modifications have been observed in higher number than those of carnivores and rodents (Tab. 4). The remains bearing butchering marks are 1.7% of the sample and were recognized on bones of medium and large sized cervids: 17 remains belong to red deer, and one to elk. Considering red deer's anatomical elements, traces of butchery are mostly present on segments of the appendicular skeleton, exploited not only for the removal of the meat but also for the consumption of marrow. Still, the attested cut-marks suggest skinning and disarticulation (Fig. 7) operations, identified respectively on the tarsals and at the level of the articular heads of the long bones, and those relative to defleshing activites localized on the diaphyseal surface of the metapodials. Impacts on long bones fragments aimed to collect marrow were also recognized. Some thick fragments of long bones like the metapodials bear notches testifying the use of bones as retoucher of stone artifacts. Burning traces were found primarily on remains smaller than 2 cm, while only 1.05% of the selected sample showed color changes due to exposure to heating; these included a tooth fragment, a phalanx of roe deer, two diaphyseal fragments of metapodial and a tarsus of red deer.

4. LITHIC INDUSTRY

4.1. Materials and methods

The lithic industry consists of a huge number of chert artifacts picked up as single items during the excavation and after screening of wet sieved sediment. All artifacts are affected by extensive and deep whitish opaque patinae regardless the texture of the chert. Nevertheless, the sandy textured chert artifacts of the Jurassic San Vigilio Group were so intensively weathered that ended up disaggregating. However, we did not observe the presence of either the yellowish to dark reddish or bright alteration and patinae which usually affect the paleolithic artifacts contained in clayey pal-

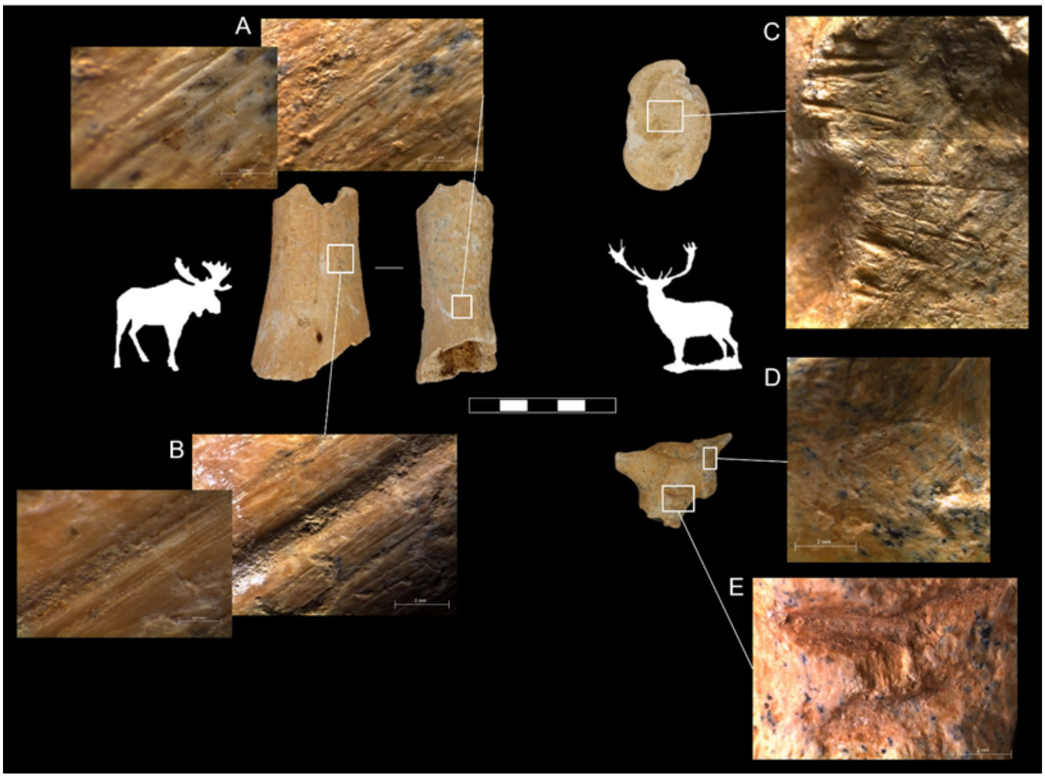

Fig. 7 - Metacarpal of *Alces alces* with linear butchering marks produced during the recovery of the meat mass (A) and scrapings, referable to the periosteum removing phase, associated to cupules produced by flint retouching (B). Astragalus of *Cervus elaphus* with a series of short and repeated cut-marks probably due to skinning (C). Fragment of coxal bone ascribed to *Cervus elaphus* showing a series of insistent cutmarks (D) and chopmarks (E) in proximity of the acetabulum associated to the disarticulation of the femur.

aeosoils surveyed in this region and the whitish surface patinae frequently developed on the Neolithic - Bronze Age lithic artifacts (Magaldi et al., 1981; Chelidonio & Stocchiero, 1991; Chelidonio & Sommaruga, 2011). All artifacts are variably coated of carbonatic concretions.

Wet sieved sediments were carefully scrutinized in order to exclude any recent contamination of the Vajo Salsone lithic assemblage. We examined each artefact of module (length + width) greater than 4 cm in order to determine the main technological and typological features for an approximate total number of >10,000 items. The technological outlines of the major lithic production, together with the main typological and typometric features of retouched blanks and leaf points are described below in the results section. The conceptual and analytical approach to this preliminary inspection is inspired by several authors according to the main volumetric concepts in use during the Middle Palaeolithic (Boëda, 1994; Delagnes, 1992). Moreover, it has been enriched with broader criteria for the definition of Levallois predetermined products (Grimaldi, 1995; Guette, 2002) and with insights on the variability of the Discoid core technology (Peresani ed., 2003). Volumetric blade technological features are consistent to what was assessed by Inizan et al. (1999). We referred typological taxonomy to F. Bordes, 1961.

To provide a first reconstruction of the reduction sequences, we conducted morpho-technical and morphometric observations on cores, the complete Levallois and other predetermined blanks, as well as certain by-products deemed to have had a significant role in the production, including the phase of the reduction sequence from which they were obtained. We did not conduct any systematic refitting of artifacts. Technological outlines of the major lithic productions, together with the key typological features of the retouched blanks, are shown in the paragraphs below.

4.2. Results: main technological outline

The lithic industry does not contain any diagnostic artefact belonging to any of the Upper Palaeolithic blade-bladelet techno-typologically featured industries known in the area, like the Uluzzian with the backed knives and splintered pieces (Peresani et al., 2016; 2019), the Aurignacian and Proto-Auignacian with the end-scrapers, retouched blades and bladelets, and bone industry (Broglio, 1993; Aleo et al., 2021), the Early Epigravettian with shouldered points (Peresani et al., 2021) and the Late Epigravettian with the backed points, short endscrapers and microliths (Broglio, 1992; Montoya et al., 2018). The same holds for the Mesolithic to Bronze age technologically and typologically featured industries (Broglio, 1992).

The assemblage is mostly based on the use of the Levallois method, as attested by predetermined blanks, abundant flat, elongated, cortical flakes and 50 Levallois

Fig. 8 - Selection of cores and artefacts representative of Vajo Salsone lithic assemblage: bifacial Levallois cores exploited in the recurrent centripetal variant (1); unidirectional Levallois core (2); centripetal core (3); overshot blade (4); Mousterian point on a Levallois blade (5); Levallois centripetal flake (6); simple scraper on a laminar flake showing a burin-like detachment on the left edge (7).

cores (Tab.5). The set of finds ascribable to Levallois core maintenance includes a wide range of items suggesting the use of various knapping strategies, such as the trimming of striking platforms, predetermination, the repair of flaking faces and the ablation of flaking accidents. All chert types were exploited: Scaglia Rossa, Maiolica and San Vigilio Group.

The Levallois production consists of different reduction sequences based on recurrent unidirectional and centripete exploitation (Fig. 8, nn. 1 and 2). These ones, at the same time, involve the application of technical variants related to the unidirectional modality. The initialization mostly concerned cortical nodules rather than plates and blocks, that were already naturally suitable for the predetermination of lateral and distal convexities. The blank was then processed, once that striking platforms were prepared while lateral convexities were shaped by means of detaching blades along the longest edges of the solid. The same procedure was used for distal convexities, which were either naturally shaped or improved with oblique or orthogonal removals to the core axis.

The evidence related to unidirectional flakes reflects the intent of optimizing the exploitation of the volumes consistently with the technical criteria adopted during the main production phase, right up to deactivation. Thanks to this optimisation strategy, the decortication and initial shaping of the core convexities were avoided. The striking platforms were faceted in an almost systematic manner, whereas the lateral convexities were created and maintained by means of ordinary and Levallois core-edge removal flakes and the distal convexity was modelled with the removal of one or a series of moderately invasive flakes or from the ridges left by previous Levallois removals. Cores were exploited also by multidirectional Levallois series from the very first stages of the reduction, and sometimes on both the faces of the core. Centripetal modality had different roles in flake-making: it became active since both the first steps of core reduction and in the middle and final steps of the unidirectional sequence. This observation requires further confirmation, although several reasons might be already envisaged: hinged sensu lato unidirectional removals leading to the activation of new flaking axes for repair purposes; core reduction, with the consequent contraction in size to the detriment of the morpho-technical features of the predetermined blanks; routinary turning from unidirectional to orthogonal orientation of flake detachments with the core exploitation approaching the centripetal pattern with minimal modifications of the extenction of the striking platform. Thus, flakes acquired variable edges showing either polygonal or fan-shaped outlines.

Except hinged or plunged flakes, or when the further re-shaping of the convexities is considered economically deficitary, the production ends with the reduction of the core volume. Only few discards attributable to incipient fissurations, voids or other phenomena pinpointing to a poor selection of lithic raw materials have been observed.

Several flakes and some cores attest the exploitation of the lower faces of flake-cores obtained from

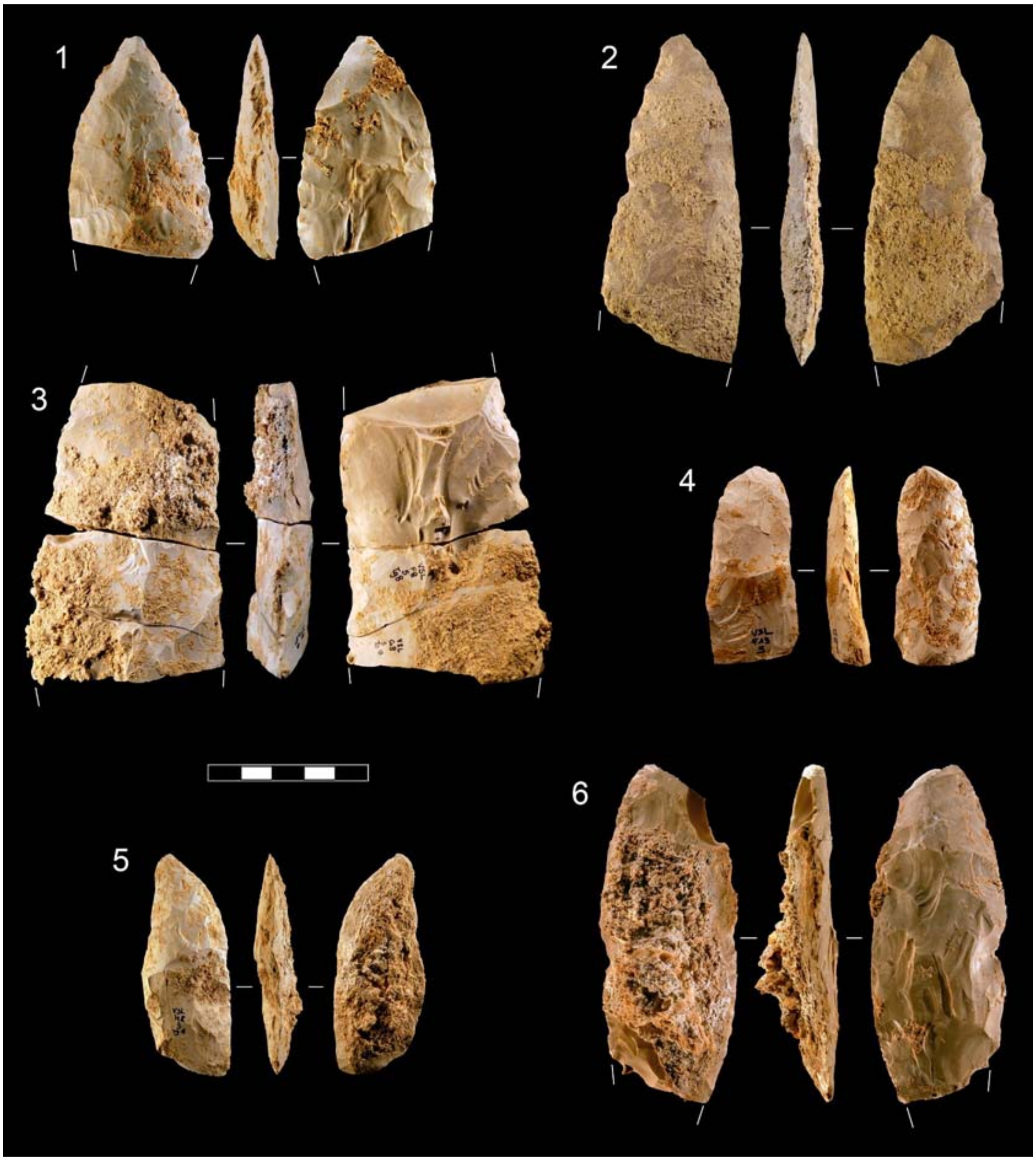

Fig. 9 - Selection of leaf-shaped tools from Vajo Salsone: fragmented leaf points (1-2); fragmented and partially refitted leaf-shaped tool/preform (3); bifacially leaf-shaped scraper (4); asymmetrical leaf knife (5); fragmented leaf point/knife (6).

large cortical flakes. In these instances, knapping operations varied and they mostly involved the proximal zone, where the bulb could be directly removed once convexities were prepared. Flakes are thin and invasive and the edges relatively long and regular, sometimes with the partial removal of the core-edge.

Discoid production is attested by very few centripete cores exploited on both surfaces for obtaining pseudo-Levallois points, core-edge removal flakes and some centripete flakes. All these blanks were not retouched. Cores display the typical biconvex outline with very limited remnants of cortical surface on one of the two faces and do not show any valuable evidence for reconstructing the origin of their reduction sequence.

Tool type	n
Simple scraper	79
Double scraper	71
Convergent scraper	74
Transversal scraper	14
Retouched point	16
Notched/denticulated tool	8
Foliate	23
Undetermined/Other retouched tool	41
Total	**326**

Tab. 5 - Composition of Vajo Salsone retouched lithic assemblage according to the main tool types.

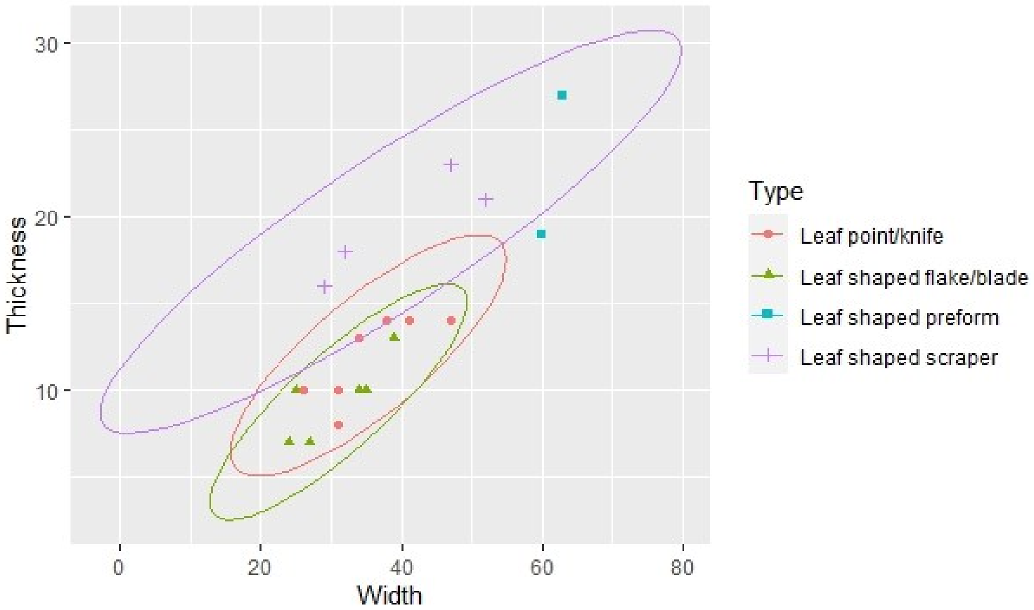

Fig. 10 - Dimensional scatter-plot of leaf-shaped tools from Vajo Salsone, grouped by tool sub-types.

Volumetric blade technology is mainly attested by laminar products and maintainance pieces, while blade cores are less abundant. The production of elongated artefacts is thus based both on Levallois and laminar technologies: the latter can be recognized by thick blades characterized by curved profile, unidirectional or convergent scars and unprepared butt. Blade production began when a natural edge was exploited on a major axis of the raw block. Blade cores management was carried out through the detachments of lateral, partially-crested blades and overshot blades (Fig. 8, n. 4). Together with thick and wide blades, a production of thin bladelets is also attested, although not yet framed in their technological trajectories. Bladelets could be obtained both from unipolar cores and from the burin-like reduction of flake blanks (Fig. 8, n. 7).

4.3. Results: retouched tools and bifacial tools

Retouched tools are mostly scrapers, followed by few points, notches and denticulates (Fig. 8, nn. 5 and 6). Scrapers are simple, double, often converging and occasionally transverse (Tab. 5). Marginally retouched flakes are rare. Cortical and partially semicortical flakes were employed as well. We did not observe any evidence related to the utilization of flakes affected by accidents, fragmented flakes, recycled tools and cores. Regarding scrapers, these tools were mostly shaped on unidirectional Levallois flakes rather than centripete flakes, discoid flakes and blades. On the other hand, flakes and denticulates tended to be manufactured on cortical and flakes affected by imperfections, whereas points were made on Levallois flakes. Several scrapers, cortical flakes and Levallois flakes were also thinned on the ventral face.

Artefacts yielding flat and invasive bifacial shaping represent one of the most distinctive features of Vajo Salsone lithic assemblage (Fig. 9). At least 23 tools bear this type of retouch, characterized by a certain diversity in typology and raw material, chosen from those available locally: high quality, fine-grained cherts obtained from Cretaceous limestone formations (Maiolica, Scaglia Variegata Alpina, Scaglia Rossa) represent the majority, while a couple of artefacts are manufactured on the coarse-grained chert from Jurassic Oolitic limestones.

The foliate tools assemblage is almost exclusively composed by fragmented pieces (Fig. 9), presumably abandoned on site as a result of the supervening fractures, characterized by the same heavy patinas affecting the knapping surfaces. A couple of rejoints of fragmented elements show the existence of very large-sized, bifacially shaped tools with symmetrical lense-like sections, which presumably reached 15 cm in length when complete (Fig. 9, n.3). A second rejoint allowed to reconstruct a preform 16 cm long, with large bifacial detachments and irregular edges, including a thick lateral portion used as striking platform. The manufacture of leaf-points from the further reduction of bifacial backed knives is a known model in Central Europe (Nerudova & Neruda, 2017), although in this instance the thick back might be hint of an unintentional residual due to the premature discharge of the tool.

Among the “finished” tools, only one is bearing a regular, thick back opposed to the bifacially-shaped edge (a leaf-knife), while the others are generally characterized by a bilateral techno-functional affinity as suggested by the two opposed cutting edges. These lateral edges are often symmetrical, ending in a pointed tip shaped by bilateral and bifacial flat retouching (Fig. 9, n.1-2). When at least one end is present, the leaf-point tool-type can be often recognized. However, in some cases a light asymmetry between the two edges is attested. Moreover, the tip could be curved or convex (Fig. 9, n.5), maybe corresponding to the base of the

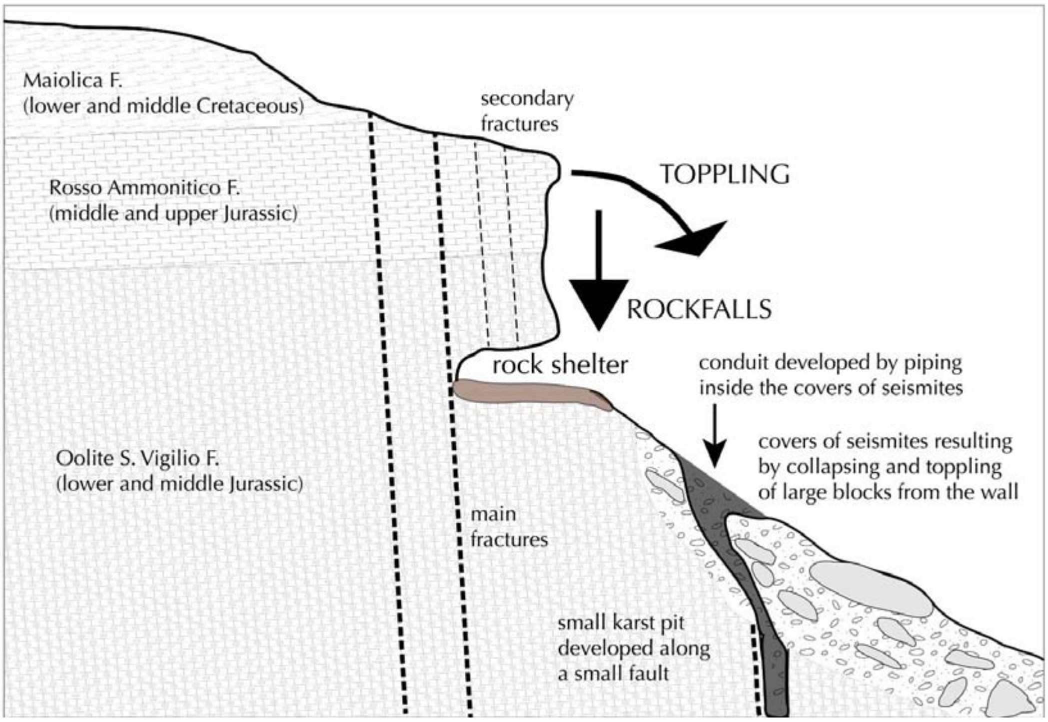

Fig. 11 - Reconstruction of the morfo-dynamic evolution of the Vajo Salsone slope with indication of the main formation process of the karst infill.

tool, or rounded as a consequence of the loss of functionality of the point.

The edges of finished tools are extremely regular, with slightly convex sagittal profile; the sinuous edges belong to large-sized preforms, not yet subjected to the last refinement. In fact, the retouching stages are manifold. At the beginning, large and deep flakes are alternatively detached (presumably with the organic hammer) on both surfaces from the periphery of the tool. The next step is to regularize the thickness of the blank with invasive and flat detachments, prior to the refinement of the edges both in the longitudinal and sagittal views through scaled and more marginal detachments.

Bifacial symmetry can be observed on about half artefacts, while others have one surface flatter than the other. This feature is directly related to the initial blanks of the tools, which in several cases were recognized to be flakes or blades (Fig. 9, n.4). In these cases, the retouching could range from partial to totally covering and therefore different than the retouching recorded on the leaf-points and leaf-knives. Very few pieces (mainly preforms) seem to be shaped directly from raw blocks or plaquettes, while in most of the tools the raw blank is unrecognizable. Moreover, some tools present a strong bifacial asymmetry and flat-convex transversal section, with scalar retouching on the upper face: these tools might be classified as bifacial or leaf-shaped scrapers (Fig. 9, nn. 4-6).

Since these are almost exclusively fragmented tools, a dimensional plot showing width and thickness has been produced (Fig. 10). According to it, leaf-points and knives clearly overlap leaf-shaped flakes and blades, taking in account that the latter are less bifacially symmetrical. Leaf-shaped scrapers are significantly thicker, implying different tool-types both in functionality and manufacturing stages. Preforms record larger sizes, although already defined in a bifacial and bilateral symmetry.

5. DISCUSSION

5.1. A model of the morfo-dynamic evolution of the slope and the genesis of the karst infill

The geomorphological environment in which the site is located is characterized by a rock wall and a belt of the slope immediately below it. The wall is affected by the formation of large niches rockshelter-like, and locally also by the development of karst caves and pits. Niche formation is explained by the slow circulation of water within the fractures and pores of the rock with consequent processes of clastic weathering and chemical erosion. Niches originate where the rock is most porous and / or fractured. The wall is also affected by collapse and toppling phenomena of large blocks of rock, favored by chemical erosion and often triggered by seismotectonic events, such as high intensity earthquakes.

The slope immediately below the wall is affected by these rockfall events with consequent crushing of the rock into both minute and coarse fragments, to constitute discontinuous coverings of diamicton, interpretable as seismites, which can contribute to the filling of karst cavities such as pits or relict portions of caves. Seismites are hardly or not at all cemented, due to the slope processes and the repetition of the collapse events. Inside the diamicton covers, conduits attributable to piping-type processes were observed, resulting from the flow of water and the removal of the finest rock fragments.

Therefore, given this geomorphological context, the following hypothesis concerning the genesis of the site may be suggested: 1) the basal part of the wall presents a large shelter under the rock in which groups of Neanderthals settled depositing anthropogenic sediments containing both flint tools and animal bones; 2) following phenomena of rockfall and toppling of large blocks occurred, with consequent retreat of the wall and dismantling of the large shelter-niche; 3) the sediments of the shelter, in addition to calcite flowstones fragments, have been exposed to the process of washout and transported along a suffusion conduit inside the diamicton cover, up to their accumulation place: a small karst pit interested by the formation of calcite flowstones below the diamicton cover. This pit functioned as a sedimentary trap.

It follows that, if seismic events of strong intensity (see, for example, the Verona earthquake of 1117) have occurred, in the most fragile areas, such as those located in proximity of the faults with E-W orientation, crossing the N-S elongated tectonic blocks, repeated collapses occurred, with the formation of covers of seismites.

The formation of the archaeological deposit inside the sedimentary trap is contextual to the sedimentation of clasts resulted by the overlying diamicton and of fragmented speleothemes, as the finds were found both in the interstitial spaces between the blocks and crushed between each others (Fig. 11). The arrangement of all these elements appears chaotic, indicating a massive sedimentary process, a fact that seems to confirm an important event of collapse of an overlying structure (cave or shelter?) which was the primary location of the archaeological record. The state of conservation of the artifacts, mostly damaged by very fresh mechanical fractures, linked to the action of mines but without traces of floating and prolonged transport suggests that the primary deposition site should not have been very far from the one of the discovery.

This sedimentary evolution hinders the possibility of discriminating any frequentations distributed over a chronological interval which, however, remains to be determined. The only possible approximation would lead to consider a limited range: a broad stratification would be expressed by a greater variety in the faunal spectrum, by possible taphonomic differences between the artifacts, as well as by a greater variability in the techno-typological characteristics of the lithic industry, as instead is detected by cultural sequences that include well distinct levels of Mousterian industries with Quina, Discoid and Levallois technology, the latter declined in a series of techno-economic and typometric aspects (eg Fumane cave: Peresani, 2012; San Bernardino cave: Peresani, 1996).

5.2. Mammal fauna, ecology, and possible chronological range

According to preliminary results obtained from the study, the faunal spectrum is mainly composed of medium and large sized ungulates, with a clear prevalence of red deer and few remains of roe deer, chamois and elk. Regarding the ecological context, this faunal assemblage is representative of close and open forests with transitive and discontinuous Alpine grasslands or sparse vegetation on carbonate rocks (an environment vital to ibex), completed by humid environments and watercourses. The dominance of red deer and roe deer may suggests that forests were commonly the Neanderthals' most exploited hunting environment. However, caution is needed in declaring this assumption given the ecological plasticity of these kind of cervids, which can live in different ecosystems, although the roe deer primary habitat is forest clearings, hedges, and woodland edge (Danilkin, 1996; Geist, 1999). Nevertheless, the low number of remains attributed to elk suggests the presence of humid areas presumably in the valley bottom, as attested by currently available evidence from Fumane cave (Cassoli & Tagliacozzo, 1994; Peresani et al., 2011; Romandini et al., 2014), Tagliente Rockshelter (Thun Hohenstein & Peretto, 2005) and San Bernardino cave (Terlato et al., 2019). The high incidence of cervids is consistent with the faunal records from the late Middle Palaeolithic stratigraphic sequence of Fumane which, from units A11-A10 shows a progressive increase of these species to the detriment of those favoring open environments (Fiore et al., 2004; Romandini et al., 2020). Dominance of cervids is also recorded at Tagliente (Thun-Hohenstein & Peretto, 2005) and San Bernardino in layers of comparable age (Terlato et al., 2021). Moreover, the absence of large bovids at Vajo Salsone despite their representativeness of ecological conditions diversity, spanning from dense forests with wetlands and small streams, to hilly grasslands and plains, disagrees with the presence, although ephemeral, of these ungulates at both Fumane and Tagliente (Terlato et al., 2019) and, above all, at De Nadale cave in the Berici Hills, where the higher frequency of bovids has also been related to the MIS 4 age of this site (Livraghi et al., 2021).

Therefore, despite being so preliminar, these first data of the Vajo Salsone faunal assemblage agree with ecological contexts existing at the regional scale during MIS 4 and MIS 3, thus supporting this chronological position for the site. The main reference vegetation data in the alpine foreland are provided from the Fimon pollen core, where persistent afforestation (eventually limited during millennial scale cold events) is recorded throughout the entire early and middle part of the last glaciation (Early to Middle Würm; Pini et al., 2010). MIS 3 records clear evidence of afforestation persisting at a long-term scale south of the Alps, although forest withdrawals with expansion of grasslands and dry shrublands occurred as a consequence of colder climatic conditions (Badino et al., 2020) which reinforced the presence of Alpine ibex, chamois, and marmot at low altitudes, as well as the presence of micromammals in steppic environments, and the diffusion of birds in open environments (Romandini et al., 2020). However, these conditions are not recorded at Vajo Salone. Concerning carnivores, the presence of wolf at Vajo Salsone and other sites in the region confirms the existence of open spaces and an abundant ungulate biomass, whereas, red fox is suited to a predominantly forested landscape.

5.3. A first insight on the origin of the zooarchaeological assemblage

According to the taphonomic data, anthropic modifications such as cutmarks, scraping marks and impacts have been recognized on cervid bones (red deer, elk), showing that during this phase of occupation of the Vajo Salsone site, hunting activity was mainly focused on this ungulate.

Hunting and related activities of this ungulate are largely recorded in the Pre-Alpine belt, where taphonomic data indicate that the predominant association of game is consistent with the ecological conditions in the proximity of each specific site and shows shifts correlated with the most relevant climatic oscillations. De Nadale cave in the Berici hills was frequented by hunters of giant deer, red deer, bison and auroch during MIS 4 (Livraghi et al., 2021). San Bernardino Cave, Fumane Cave and Tagliente Rockshelter during MIS 3 share similar exploitation models consisting of the selection of young adult and adult prey and of primary butchering. The main hunted ungulates during the final Mousterian were thus mostly red deer, roe deer and giant deer with lesser amounts of chamois and ibex (Fiore et al., 2004; Thun Hohenstein & Peretto, 2005; Peresani et al., 2011; Romandini et al., 2014; Terlato et al., 2021) and limited exploitation of elk, wild boar and Bos/Bison (Terlato et al., 2019). The exploitation of marmots, beavers (Romandini et al., 2018a) and of some carnivores like bear, wolf and fox (Romandini et al., 2018b) is also documented and suggests recovery for meat, marrow and fur.

5.4. The cultural outline of Vajo Salsone in the North-eastern Italy

Even though most of the evidence from the Vajo Salsone assemblage is comparable with that of other sites in the region and the northern Mediterranean area, it does provide new details of the Late Pleistocene cultural scenario and contributes in making the Middle Paleolithic picture more complex. Not surprisingly, as it occurred in almost all sites around the North-Adriatic region, Levallois technology is largely prevalent in the lithic industries. This flaking method either forms the substrate or contributes to cultural complexes traditionally labelled as Typical Mousterian rich in scrapers, Eastern Charentian Mousterian, Pontinian, in a large area from the Rhône valley to the western Balkans along the Alpine arch and Apennine ridge, displaying variations in each different facies in relation to the frequence of retouched tools and other aspects (Palma di Cesnola, 1996; Peretto, 1992). Nevertheless, none of these industries had the specific target of producing neither points nor converging scrapers at a so relevant number like at Vajo Salsone.

Although it is still lacking of a precise chronological position, the Levallois technology of Vajo Salsone is as much variable as other sites even in the Alpine footbelt (Peresani, 2001) and subalpine area like Monte Versa on the Euganean hills (attributed to the last interglacial; Peresani, 2000-2001), Monticello (undated, Duches & Peresani, 2009) and Cavaso del Tomba (undated: De Stefani et al., 1999-2001), among others. At Vajo Salsone, this system mostly focused on longer-than-wide blanks using the unidirectional recurrent modality and, to a lesser extent, by means of centripetal flake-making as it has been observed in the alpine foreland at sites dated to MIS 3 (Peresani, 2011; Delpiano et al., 2019b), and along the northern slope of the Apennines (Lenzi & Nenzioni, 1996; Fontana et al., 2018). Furthermore, at the present state we cannot confirm whether the different modalities (unidirectional and centripetal) expressed by the Levallois variability at Vajo Salsone relate to different core surface maintenance strategies aimed at the setting of specific predetermination parameters for each lithic material exploited (coarsely vs finely texture chert). As a matter of fact, locally available resources were employed for flake-making, with a subtle prevalence of Maiolica and Scaglia Rossa over the coarser materials catched in the carbonatic sandstones along the Vajo Salsone slope. As the provisioning of nodules, blocks and plates appears to be unconstrained in the site surroundings - we did not observe the use of stream pebbles -, then preferences in relation to the main flaking modalities employed might be related to specific technical economical requirements. Further analyses are needed to verify whether mechanical aptitude of the chert types or economic reasons shall be considered forcing agents in the design of tool sets. Nonetheless, these latter were produced through the exploitation of all kinds of raw material.

Moreover, throughout the observation of the examined assemblage we did not record the presence of the same Levallois reduction patterns already attested in certain stratified sequences, where the unidirectional exploitation systematically turned to the centripetal one when approaching the end of core reduction (Peresani, 1996; 2012). On the contrary, in our instance unidirectional exploitation was applied until almost the end of the reduction sequence, as the presence of elongated flakes with thin and regular edges selected for the side and converging scrapers suggests. These patterns show that the above goals were achieved constantly, without caring for the optimization of the available resources, which may have not been subject to deficiencies in terms of either quality or quantity.

On a regional scale, at open-air sites the Levallois reduction stops at an intermediate grade of the potential exploitation. Conversely, in shelters the exploitation was more exhaustive and affected structural and typometric arrangements, to such an extent that microlithism was observed in some assemblages (Peresani, 1996). Settlement dynamics were thus responsible both for fractionation in reduction sequences and for variations in the grade of retouching of the predetermined blanks and by-products, these latter being left unretouched at Vajo Salsone.

Still, although preliminary, the data presented here express one further element of lithic variability which consists in the co-presence of the Discoid and Laminar volumetric concepts, whereas we do not exclude other more expeditious productions. Discoid industries have been described at Fumane and Rio Secco caves, where a high resolution in Neanderthal occupations within the first part of MIS 3 shows diachronic variability framed in cultural and behavioural contexts. At Fumane, the Discoid concept substitutes the Levallois along a densely stratified sequence (Peresani, 2012; Delpiano et al., 2018), while at Rio Secco it is found in the same context with the Levallois (Peresani et al., 2014). Concerning volumetric laminar production, it is ephemeral in the area and only represented by bladelet making at Fumane unit A5-A6 (Peresani et al., 2013) or remains poorly known and undated as at Tagliente (Carmignani, 2021).

5.5. Foliate tools: comparing evidence in Italy and behind the Alps

The foliate tools of Vajo Salsone, including leaf points, knives and leaf-shaped flakes, are a unique evidence for the Northern Adriatic region. Nonetheless, in the southern margin of the Po plain, where tens of open-air Lower and Middle Palaeolithic sites are preserved on the Pleistocene terraces of the lower Apennines of Emilia-Romagna, five sites located between Bologna and Imola (Fig. 1) contain isolated and sometimes fragmented leaf-points, found in assemblages characterized by developed laminar tendency achieved with the Levallois method. These sites are generally related to the Bellaria/San Biagio stratigraphic unit that is supposed to be framed in MIS 7 and covered by MIS 6 loess (Fontana et al., 2010; 2018). However, lack of absolute dating raised questions and issues: indeed, there would be a chronological divergence between these and other regional Levallois complexes that recently yielded MIS 4 (Ghiardo) or early MIS 3 (Monte Netto) dates (Cremaschi et al., 2015; Delpiano et al., 2019b).

Outside the boundaries of the Great Adriatic Po Region, archaeological sites yielding Middle Palaeolithic leaf-points are mainly situated in the southern part of Germany, spreading along the Danube and its tributaries in an E-W direction. Most of the sites are located in the Swabian and Franconian Jura, preserved in caves and rock-shelters, but also in open air sites resulting from surface collections of isolated leaf-points. The highest number of leaf-points has been found in Bavaria, decreasing towards West and North. Assemblages of southern Germany containing leaf-points attracted scientific attention very early in the 20th century. Except for a few examples, these sites have been excavated within the first half of the last century and, due to this reason, they are affected by lacking documentation, unreliable chronology and poor contextual information (Uthmeier, 2004; Richter, 2009). Since the pioneering work of G. Freund, and later T. Uthmeier (2004) and M. Bolus (2004), no comprehensive research study focused exclusively on leaf-points and their role in the late Middle Palaeolithic of southern Central Europe. Both Uthmeier (2004) and Bolus (2004), as well as Richter (2009), hypothesized that leaf-point assemblages in southern Germany are part of the regional Middle Palaeolithic (Richter, 1997) and should not be interpreted as an innovative behaviour of late Neanderthals. Rather, leaf-points might be related to specific task activities, probably hunting, within the context of a larger settlement system.

Nonetheless, leaf points are often considered as cultural expressions of Late Pleistocene Neanderthals in Europe. Particularly relevant to this issue is the so-called Szeletian (Allsworth-Jones, 1986), an archaeological leaf-points complex distributed in Poland, Hungary and Moravia, although it is still far from being clearly defined in time, space and technological characteristics of stone tool production (Mester, 2018). To the West, in southern Germany, the outshoot of the Szeletian should be considered the so-called Altmühlian (Bohmers, 1939, 1951) - despite the significance of this complex as transitional industry has been recently discussed (Richter, 1997; Bolus, 2004; Uthmeier, 2004) - being lately considered as the last phase of Keilmessergruppen/M.M.O. complex, which is the main cultural expression of central european Neanderthals (Richter, 2016; Delpiano & Uthmeier, 2020). For Bavaria, only the so-called Lincombian-Ranisian-Jerzmanovician (LRJ) (Flas, 2011) is accepted as a potential transitional complex leading from the Middle to the Upper Palaeolithic. Further east, the Bohunician complex is widespread in Moravia, where it is characterized by Levallois alongside blade technology, with the presence of bifacial leaf-points in some sites (Tostevin & Skrdla, 2006); however, doubts have been raised on the links between Bohunician and the neighboring transitional technocomplexes (Neruda, 2009). Incertitude thus concerns the chronology and geographic distribution of complexes in Central and Eastern Europe containing bifacially worked leaf-points. Furthermore, foliates do not seem to be constrained to the phase immediately before the Upper Palaeolithic, but may appear discontinuously and selectively from possibly as early as MIS 7 to MIS 3. Sites bearing leaf-shaped tools in the Balkans and in northern Germany appear to belong to MIS 5 or MIS 7, even though bifacial reshaping and rejuvenation may have had heavily modified tools initially manufactured with a totally different conception (Kot, 2017). In Vajo Salsone, both leaf-points, leaf-knives and other leaf-shaped flake tools are attested, abandoned at different manufacturing stages. These data suggest that they were possibly produced directly according to this mental template, rather than representing a consequence of the reduction of unifacial tools or other bifacial tools.

6. CONCLUSIONS

The discovery of the site of Vajo Salsone contributes to shed new lights on the complexity of the Middle Palaeolithic in the North of Italy, where Mousterian industries are mostly based on the application of the Levallois technology, as recorded from cave and open air sites dated from MIS 7 to early MIS 3. This cultural scenario is not static. In fact, Quina and Discoid technologically related industries are documented as well, except for few contexts. Furthermore, the discovery of leaf points, knives and leaf-shaped flakes in the alpine footbelt reinforces our view about the variability of the Neanderthal world, thus providing a unique evidence not only for the North of Italy but also for the whole Adriatic region. It confirms the reliability of previous findings reported at open-air sites on the northern slope of the Apennines, although isolated from their originary pedostratigraphic contexts. Dating the Apennine and Vajo Salsone evidence using biostratigraphic and geochronological methods, whenever these can be applied, is needed for assessing the values of affinities or differences between the foliate tools featured industries at the South and the North of the Alpine range, in terms of biological and cultural population dynamics.

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