Geological Field Trips and Maps

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"Palaeolithic Cave deposits and Karst evolution in the Venetian Pre-Alps",
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Palaeolithic Cave deposits and Karst evolution in the Venetian Pre-Alps

PRE-5 – Pre-congress Field Trip of the XXI Inqua Congress "Palaeolithic Cave deposits and Karst evolution in the Venetian Pre-Alps", Rome 14th-20th July 2023

Marco Peresani[1,2] & Ugo Sauro[3]

[1] Department of Humanities, Section of Prehistoric and Anthropological Sciences, University of Ferrara, Corso Ercole I d'Este, 32, 44100 Ferrara, Italy.
[2] Institute of Environmental Geology and Geoengineering, National Council of Research, Piazza della Scienza 1, 20126 Milano, Italy.
[3] Lessinia, Man and environment Ethnographic Museum, Via Spiazzi 4, 37021 Bosco Chiesanuova, Italy.

Corresponding author e-mail: marco.peresani@unife.it

Cover page Figure: The stratigraphic section at Grotta di Fumane with record of the transition from Middle Palaeolithic (*Homo neanderthalensis*) and Upper Palaeolithic (*Homo sapiens*) (Photo courtesy by A. Leon).

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ABSTRACT

This excursion delves into the themes of human evolution, Palaeolithic caves, and karst landscapes, providing participants with a unique opportunity to explore the Monti Lessini, the Monti Berici, and two Palaeolithic sites in the Eastern Italian Pre-Alps and Alpine foreland. The Monti Lessini are characterised by a unique physical landscape shaped by tectonic evolution and a range of geomorphological processes including fluvial, karstic, glacial, and periglacial dynamics. This pre-alpine zone boasts an abundance of natural archives nestled within karst cavities, serving as invaluable resources for research into the human-ecological dynamics of Neanderthals and early Homo sapiens. At Grotta di Fumane, the deposits represent evidence of paramount significance for understanding the subsistence and spirituality of ancient humanity that thrived in this region of southern Europe for over 50,000 years. The second part of the excursion is dedicated to showcasing the fluviokarstic landscape of the Monti Berici, characterised by a plateau featuring varied topography, including peaks, sinkholes, palaeosols and caves like Grotta San Bernardino. This site is of particular significance as it preserves a Middle and Late Pleistocene stratigraphy, which records a series of climatic cycles and provides evidence of Neanderthal use of the cave and surrounding landscape resources across varying ecologies.

Keywords: cave sediment, karst landscape, morpho-stratigraphic evolution, palaeoecology, prehistory.

PROGRAM SUMMARY

The itinerary for the first day of the excursion is centred around exploring the karstic landscape of the Monti Lessini, a plateau characterised by palaeosols and caves such as Grotta di Fumane. On the second day, excursion will delve into the fluviokarstic terrain of the Monti Berici, another plateau featuring uneven topography with towering walls, sinkholes, palaeosols, and caves, including Grotta San Bernardino.

Table 1 - Summary of number, location, latitude, longitude and altitude of the stops of the field trip.

Stop	Location	Latitude	Longitude	Elevation (m amsl)
Meeting at Verona railway station 8.30-9.00				
FIRST DAY				
1.1	Fumane cave	45° 35’ 33”	10° 54’ 17”	350
Lunch				
1.2A	Monti Lessini 1 from Mount Cornetto	45° 40’ 44”	10° 58’ 04”	1543
1.2B	Monti Lessini 2 Sant’Anna D’Alfaedo Museum	45° 37’ 42”	10° 57’ 14”	925
1.3	Monti Lessini 3: Veja Natural Bridge	45° 36’ 29”	10° 58’ 13”	600
Accomodation Hotel Valpolicella, San Pietro Incariano				
Dinner				

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SECOND DAY				
2.1	Pozzolo dead valley	45° 24' 36"	11° 29' 48"	159
2.2	San Donato: The walls in the limestone cliffs	45° 24' 33"	11° 31' 13"	300
Lunch				
2.3	San Bernardino Cave	45° 25' 38"	11° 33' 25"	135
2.4	Walls in the reef limestone and karst spring in the Lumignano square	45° 27' 35"	11° 35' 13"	30
2.5	Fimon Lake	45° 28' 12"	11° 32' 36"	28
End of the excursion at the railway stations of Verona, Padova or Ferrara				

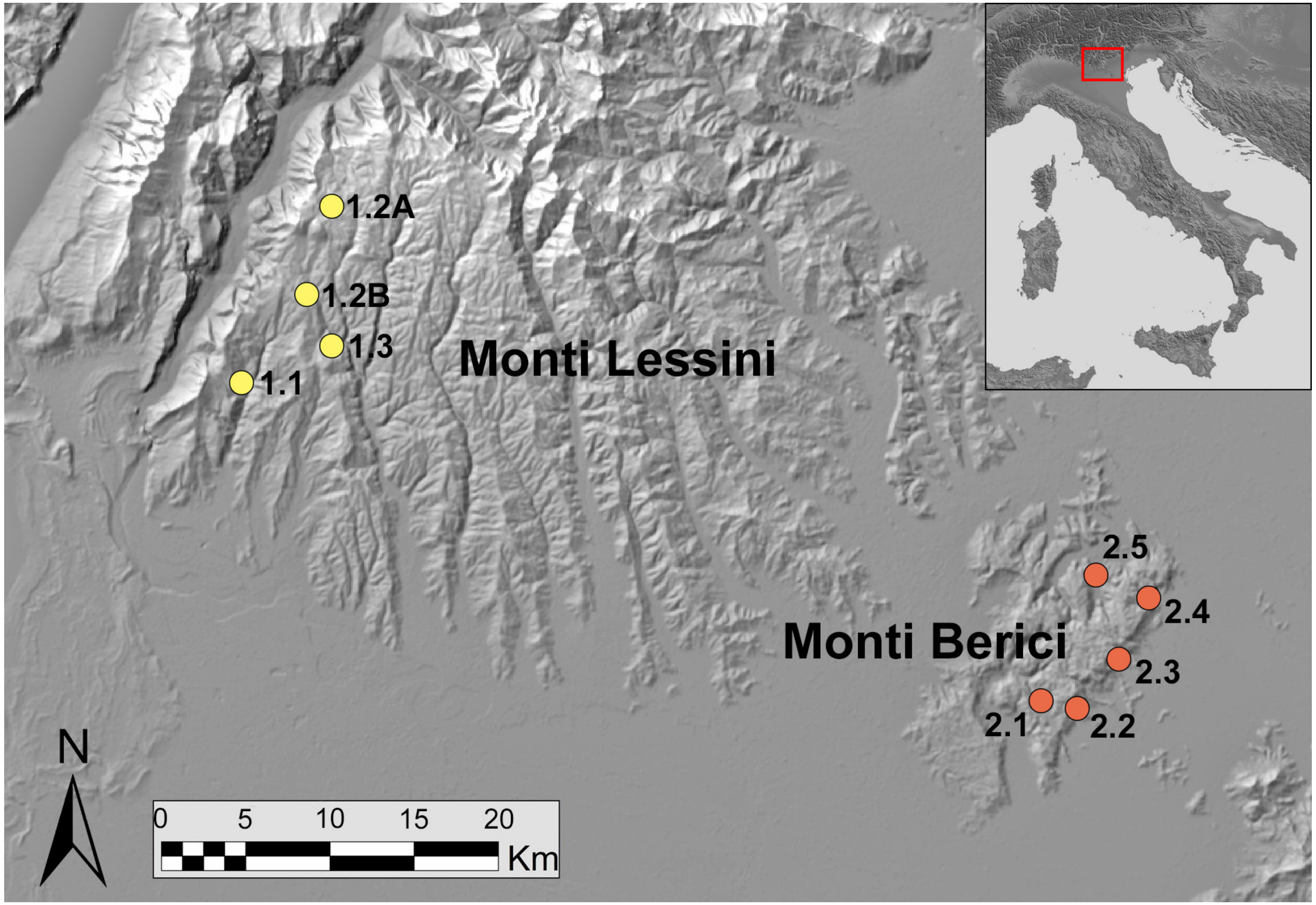

Fig. 1 - Itinerary of the Field trip with steps of the first (yellow) and second days (orange) respectively (DEM elaborated by D. Delpiano).

SAFETY

Access to the outcrops during the excursion is convenient, as they can be reached either by car or through easy walking routes with no significant access challenges. While some stops may be located within forested areas, participants are advised to wear appropriate footwear to ensure comfort and safety during the journey.

HOSPITALS

Sacro Cuore Hospital, Negrar (VR), https://www.sacrocuore.it/
Milani Hospital, Noventa Vicentina (VI), https://www.aulss8.veneto.it/ospedali/ospedale-di-noventa-vicentina/

ACCOMMODATION

Hotel Valpolicella International, San Pietro Incariano (VR), https://www.hotelvalpolicella.net/it

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INTRODUCTION

The Southern Alps comprise a multitude of diverse karst morpho-units, each characterised by a complex history that poses challenges for detailed reconstruction. Although it is relatively straightforward to describe the forms of these karst morpho-units and identify their main geomorphological styles—such as tectokarstic, fluviokarstic, glaciokarstic, and typically karstic (dominated by dolines)—recognising the morphogenetic events and phases preceding the most recent ones poses significant challenges. Additionally, delineating the morphological evolution during the Neogene and the Quaternary periods is particularly difficult.
In this vast region, particularly within the Italian eastern Alps, the prevalence of karst processes has fostered the development of caves and rock shelters. These natural formations served as crucial habitats for past human populations, even during some of the most pivotal phases of human evolution. One extensively studied phases is, the transition from the Middle to the Upper Palaeolithic which represents a crucial bio-cultural shift from Neanderthals to *Homo sapiens* in Western Eurasia. This transition is well documented in numerous archaeological sites, where distinctive traces of cultural diversity and technological innovations in stone and bone tools have been uncovered. These sites also reveal insights into symbolic expressions during this pivotal phase, shedding light on the cognitive abilities of these ancient hominins and prompting a re-evaluation of Pleistocene human diversity.
Since the late 19th century, the Monti Lessini and the Monti Berici, two areas in the central southern Pre-Alps, have been the focus of systematic archaeological investigations. These efforts have been supported by excavations and multidisciplinary projects, particularly in the Monti Lessini region, which boasts the highest concentration of archaeological sites in Veneto. A wealth of data has been generated from deposits found in caves, rock shelters, and open-air sites in this area. Among archaeological contexts, the caves of Fumane and San Bernardino hold significant importance as key sites positioned along the potential trajectory of hominins moving into southern Europe from eastern and southeastern regions. Fumane preserves a finely layered sedimentary sequence, featuring cultural layers attributed to the Mousterian, Uluzzian, Aurignacian and Gravettian. Together with San Bernardino, the caves constitute one of the most comprehensive, detailed, and chronologically well-defined continental stratigraphic series within the Late Pleistocene. Spanning from 50 to 30 ka cal BP, this sequence provides invaluable insights within a cave context in Southern Europe. Analysis of sedimentological and palaeontological records provides valuable insights for contextualizing *Homo neanderthalensis* and early *Homo sapiens* within their respective ecological settings, spanning from the late Middle Pleistocene until the decline of the Neanderthals during MIS3. On-going research is yielding data on human ecological relationships and the interaction with specific natural resources, enriching our understanding of *Homo neanderthalensis* behavioural complexity. Fumane's rich archaeological record, featuring early appearances of *Homo sapiens*, provides valuable insights for comparing life, subsistence, and cultures among Pleistocene hominins. This comprehensive assessment sheds light on the uniqueness of our species.

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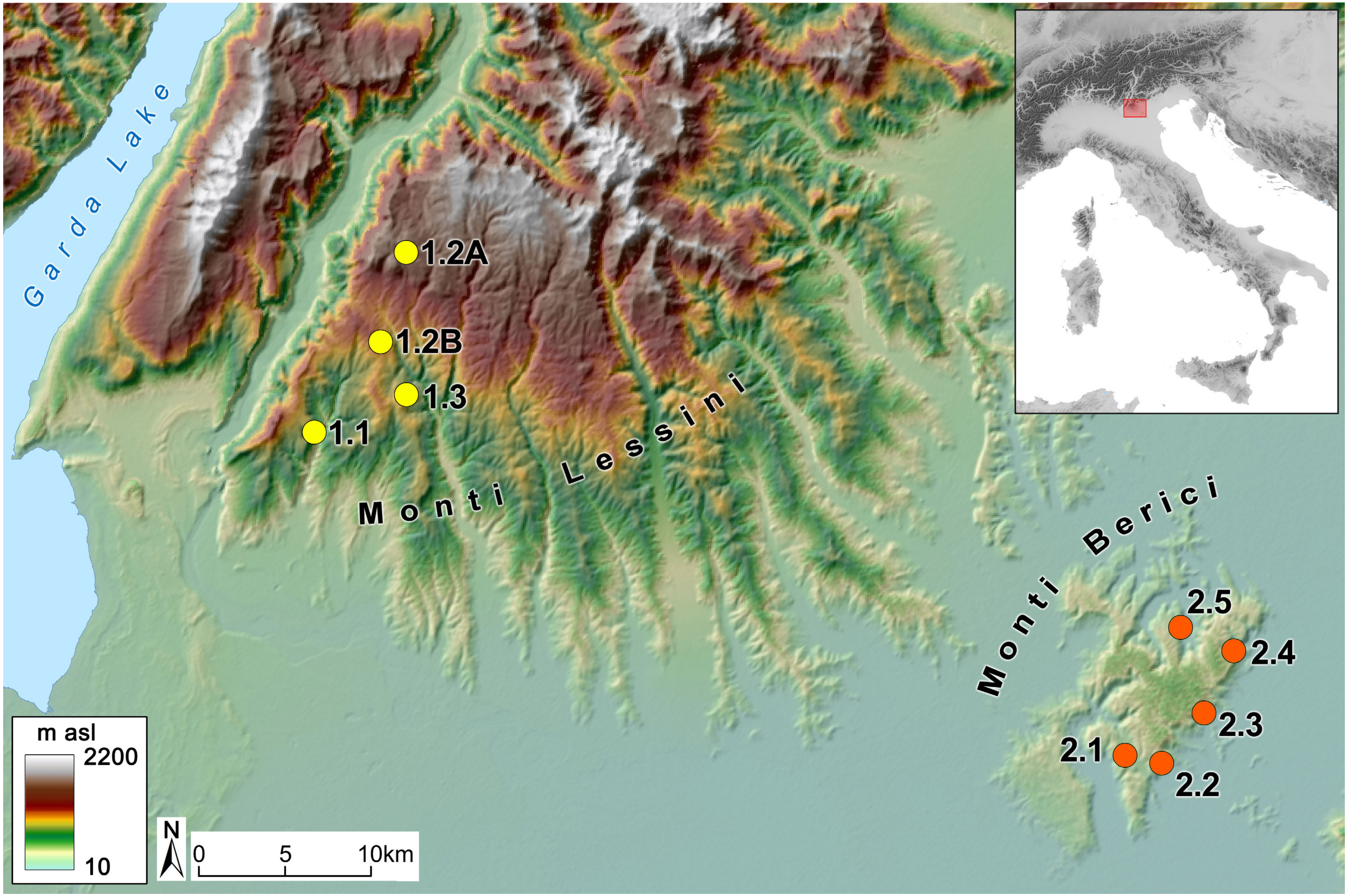

Fig. 2 - Digital elevation model of Monti Lessini and Monti Berici (in the SE corner); note the typical fluviokarstic features. Main steps of the Field trip of the first (yellow) and the second day (orange) are evidenced. (DEM elaborated by F. Ferrarese).

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THE MONTI LESSINI

Geological and geomorphological features

The Monti Lessini extend between the high Venetian plain to the south and the Carega-Pasubio group ("Piccole Dolomiti") to the north, with elevations up to 2260 m a.s.l. They are bordered to the west by the incision of the Adige Valley, and to the east by the high plain of Vicenza. The Monti Lessini are a promontory at the southern edge of the Alpine range, descending with its southern base beneath the alluvial deposits of the Adige basin. From a geometric perspective, the Lessini resemble an inclined plane of trapezoidal shape, dissected by several north-south trending valleys formed along the main tectonic structures. Some of these depressions, known locally as 'vaj', exhibit characteristics reminiscent of canyon-like valleys (Sauro, 2010).

The Monti Lessini morpho-structure is made up mainly of marine sedimentary rocks. The main outcropping geological formations are the Dolomia Principale (upper Carnian-Norian), the Calcari Grigi group (Hettangian-Pliensbachian), the Oolite di San Vigilio (upper Toarcian-Aalenian), the Rosso Ammonitico Veronese (upper Bajocian-Tithonian), the Maiolica (lower Tithonian-

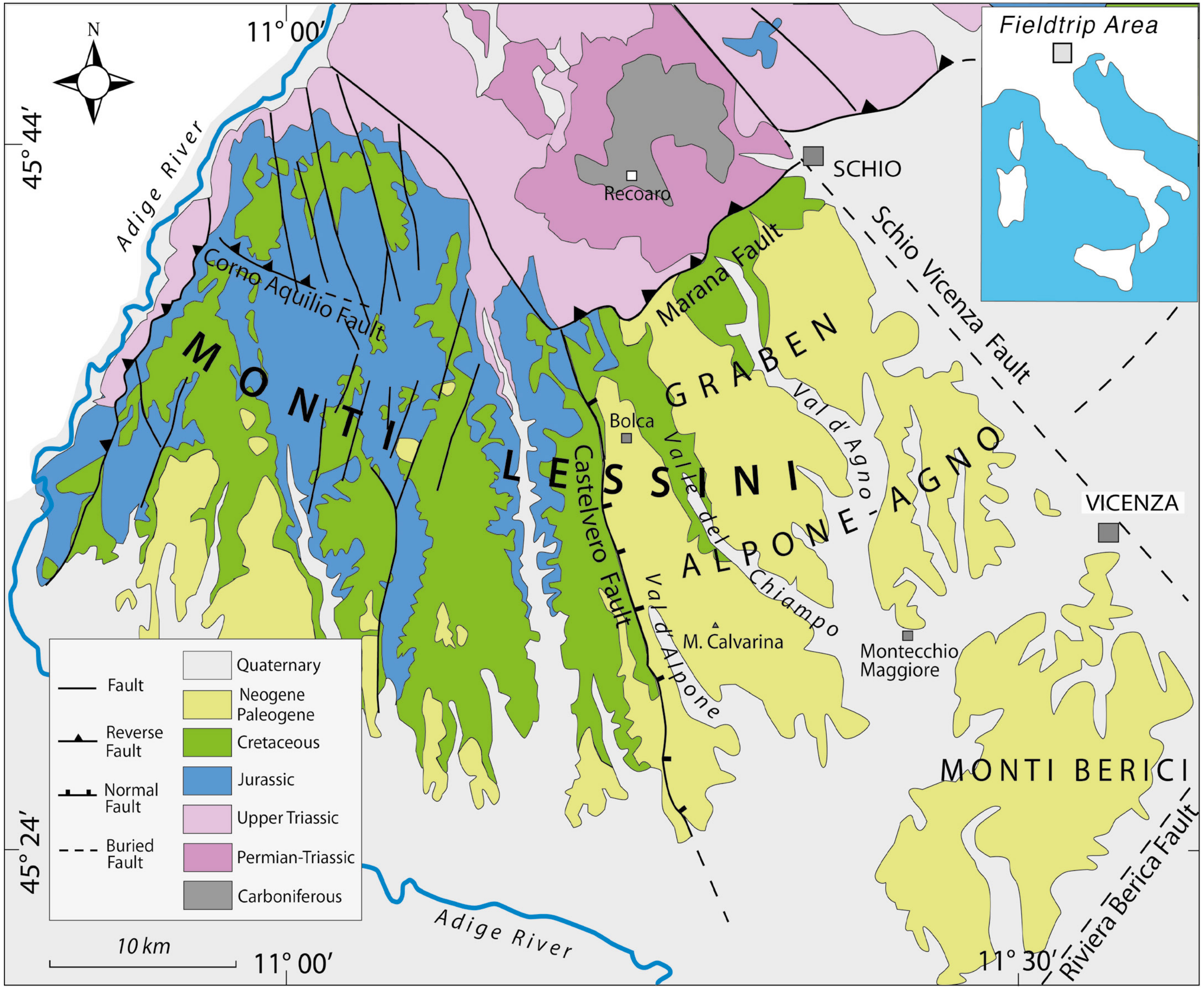

Fig. 3 - Geological sketch of the area of Monti Lessini and Monti Berici (modified from Zampieri, 2022).

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lower Aptian), the Scaglia Rossa (lower Turonian *p.p.*-middle Eocene *p.p.*) and the "Eocene limestones" (Castellarin, 1972; Castellarin and Vai, 1982; Doglioni and Bosellini, 1987; Sauro and Zampieri, 2001; Roghi and Romano, 2009; Masetti et al., 2012).

During the Mesozoic era, the Monti Lessini have shared the evolution of the future tectonic unit of the Southern Alps. These mountains are part of the deformed passive continental margin of the Adria microplate, located to the east of the Ligurian ocean or Alpine Tethys (e.g., Bertotti et al., 1993). They are made up mainly of Upper Triassic to Miocene dolostones and limestones deposited on the Trento Platform Mesozoic unit. Changes in the seabed morphology preceding emergence, coupled with the evolution of life forms, played a pivotal role in shaping the succession of marine environments and landscapes. These processes ultimately influenced the characteristics of the geological formations that constitute the Monti Lessini.

The palaeogeographic structural high of the Trento Platform was influenced at its margins by north-south trending syn-sedimentary normal faults. Within this platform, the Calcari Grigi group represents the typical unit, comprising shallow-water sediments deposited from the Hettangian to the Pliensbachian (Masetti et al., 2012). During the Paleogene basaltic magmas ascended along fractures and resulting in submarine eruptive manifestations characterised by ialoclastites and lava flows, particularly in the eastern Lessini area (Piccoli, 1966; Zampieri, 1995). In contrast, during the Neogene, when contraction affected the Southern Alps, the Lessini, together with the adjoining Berici mountains and the Euganei hills, remained unaffected by thrust faults. In fact, are considered a foreland block of the Alpine chain (Bigi et al., 1990; Zampieri, 2000). This block is one of the three outcropping portions of the "autochthonous" Adria (the others are Istria and Apulia), which at present is mainly submerged by the Adriatic Sea (Márton et al., 2017).

From a morpho-structural perspective, the top surface of the current plateau could be interpreted as a late Cenozoic erosional surface that has been displaced due to tectonic activity. This displacement is particularly evident in correspondence with the NNE fault systems, where erosion has occurred (Zampieri, 2000). Generally, the plateau top and the summits of the ridges were mainly affected by weathering, slope, fluvial and karst processes which led to the development of "terra rossa" type palaeosols (Magaldi and Sauro, 1982; Castiglioni et al., 1990).

The hydrography of the region is strongly influenced by the composition, position, and permeability of the various geological formations, as well as by tectonics and lithology. This influence manifests in a dense network of main valleys, with smaller valleys connecting from the ridges depending on their composition and permeability. Some of the main valleys are rich in surface water, such as the Valle di Fumane, the Val d'Alpone, the Val d'Agno, while others are decidedly dry such as the Vajo dell'Anguilla and Vajo di Squaranto. Some others are narrow gorges or look like canyons; in their distal parts the transverse profiles may have a flat bottom. The ridges between the main valleys initially appear as narrow plateaus, collectively forming a tabular structure that gently slopes towards the plain.

Within the Monti Lessini, distinct landscape areas can be easily distinguished from south to north: A) the southern hills, which exhibit significant variations due to the presence of more linear ridges in the west gradually becoming more branched in the east; B) the middle Monti Lessini, characterised by diversified shapes from west to east. Initially, there is a prevalence of tabular surfaces, which gradually transition into a more articulated and energetic relief; C) the high Monti Lessini situated between the Adige and the Illasi valleys, which merge with the

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Fig. 4 - The Vajo dell'Anguilla, a canyon like valley, a typical vajo of the Monti Lessini (north of the town of Verona, in the municipalities of Erbezzo, Bosco Chiesanuova and Grezzana, VR), is developed along a complex fault angle depression (by U. Sauro).

southern offshoots of the Carega Mountain. These are delimited to the south by a sharp tectonic scarp, particularly pronounced in the western sector (Corno d'Aquilio - Corno Mozzo - Mount Busimo). This area appears as an articulated system of rounded backbones with convex and gentle shapes.

Although the calcareous rocks have similar chemical composition, they exhibit considerable lithological diversity, which can be attributed to the different marine-type sedimentary environments in which they were formed. Within the sedimentary sequence, multiple geological formations contain limestones with distinct characteristics in appearance and behaviour towards degradation and erosion processes. For example, formations such as the Rosso Ammonitico Veronese (upper Bajocian-Tithonian) contribute to the formation of structural forms and rugged landscapes typical of rock cities, characterised by numerous rocky outcroppings. In contrast, formations such as the Maiolica (lower Tithonian-lower Aptian) give rise to rounded ridges devoid of prominent rocky outcrops. This diversity results in a wide range of relief styles throughout the region.

Undoubtedly, the primary erosion process at work in the Monti Lessini is karst erosion. Consequently, runoff in the Monti Lessini primarily occurs underground, as the karst erosion has widened a network of voids, some of which are explored by cavers. These caves provide pathways through which water can penetrate and flow (Mietto and Sauro, 2000). In this way the average daily chemical erosion, estimated for each km^2, is of the order of 300-500 kg of dissolved rock transported in solution. The resultant landscape does not exhibit the typical features of a karst

Fig. 5 - A rock city in Rosso Ammonitico Veronese in the high Lessini (in the area of Malga Costeggioli di Sotto, municipality of Bosco Chiesanuova, VR). It is characterised by large parallelepiped blocks separated by karst corridors developed along the fractures (by U. Sauro).

Fig. 6 - The most known rock city in Rosso Ammonitico Veronese, called 'Valle delle Sfingi', is characterised by selective weathering due to karstic and cryoclastic processes (in municipality of Velo Veronese, VR) (by U. Sauro).

landscape, akin to the Karst of Trieste. Instead, it takes the form of a fluvial karst, distinguished by a network of dry valleys, predominantly devoid of watercourses at their bottoms. Additionally, the influence of tectonics is profound, shaping the landscape of the Monti Lessini into what can be defined as a "tecto-fluvial karst" terrain. This designation is evident in the surface features, such as dolines, which are predominantly found along fracture lines or in correspondence with inter-bedding discontinuities characterised by changes in hydraulic conductivity, particularly between the Maiolica and the underlying Jurassic limestone layers.

In terms of the karst phenomenon's development, the Monti Lessini boast a notable number of surveyed and registered cavities by the "Catasto Speleologico del Veneto" — over 1600 out of a total of approximately 8800 in the entire Veneto region. Nevertheless, it is worth of note that the majority of these cavities are primarily vertically developed, comprising karst shafts or interconnected systems of shafts. Consequently, most of these cavities are not easily accessible to humans.

During the Quaternary, the area was partially covered by the Adige glacier or by local glaciers documented on the upper part of the Monti Lessini, the Carega Massif, the summit of the Monte Baldo chain (Sauro, 1973, 2020). Periglacial conditions during the Quaternary period led

Fig. 7 - Fluviokarstic relief in the marly limestone called Maiolica in the high Lessini plateau. The absence of rocky outcrops is the consequence of the high sensivity to gelifraction (by U. Sauro).

Fig. 8 - A karst dry valley in the Maiolica formation of high Lessini. There is no evidence of recent fluvial activity (mostly in the area of Malga Brol, municipality of Bosco Chiesanuova, VR) (by U. Sauro).

to intense erosion of the palaeosols, accumulation of slope deposits, particularly notable in the central part of the plateau, and widespread loess sedimentation throughout the relief from the Middle Pleistocene onward (Magaldi and Sauro, 1982; Castiglioni et al., 1990; Cremaschi, 1990). Deposits found in caves and rock shelters along the slopes offer valuable data indicating that the deepening of gorges and valleys occurred, at the very least, from the late Middle Pleistocene (Castiglioni et al., 1988). Anthropogenic erosion during the Holocene strongly affected the main slopes especially starting from the Neolithic (Sauro, 1993).

The bottoms of the valleys are occupied by sediments several metres thick, composed mainly of gravelly, sandy, and pelitic materials. Additionally, colluvial detrital deposits are frequent at the foot of the steepest slopes, predominantly comprising fragments of limestone. The Lessini and Baldo foreland encompass a vast alluvial plain, largely formed during the Middle and Late Pleistocene period from the Adige River and its tributaries originating from the central and eastern Monti Lessini. Particularly, the western sector is situated where the Adige fans out from its long and deeply incised valley, which dissects the mountain range up to the alpine watershed.

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The recent geological evolution of the Monti Lessini has been punctuated by numerous earthquakes. These seismic events, documented in historical records and discernible in the flowstone deposits of caves, provide datable evidence of the region's seismic activity. Additionally, they have left behind geomorphological and sedimentological evidence, including surface faulting and deposits interpreted as seismites (Sauro and Zampieri, 2001; Sauro and Ferrarese, 2016). Among the most renowned historical earthquakes is the "Verona earthquake of January 3, 1117," which stands as one of the most well-known historical seismic events in the Alps. The compressive tectonic forces, currently active in this geological phase are evident in the evolution of the thrust-type morpho-structures, manifesting primarily in two directions: south-north and west-east. The south-north direction is influenced by the advancement of the Apennine front, while the west-east by the eastward movement of the Brescian Prealps and Mount Baldo.

Brief summary of the past human frequentations and settlements

It is noteworthy to emphasize that the intricate relief, particularly the network of valleys, has facilitated human movement and provided "refuge-niches" since prehistoric times (Margaritora et al., 2020). Moreover, due to the structured relief, allowed adept hunters in prehistoric times to exploit various hunting territories in the vicinity of the site. Additionally, the abundance of chert in specific geological formations, notably the high-quality vitreous flint found

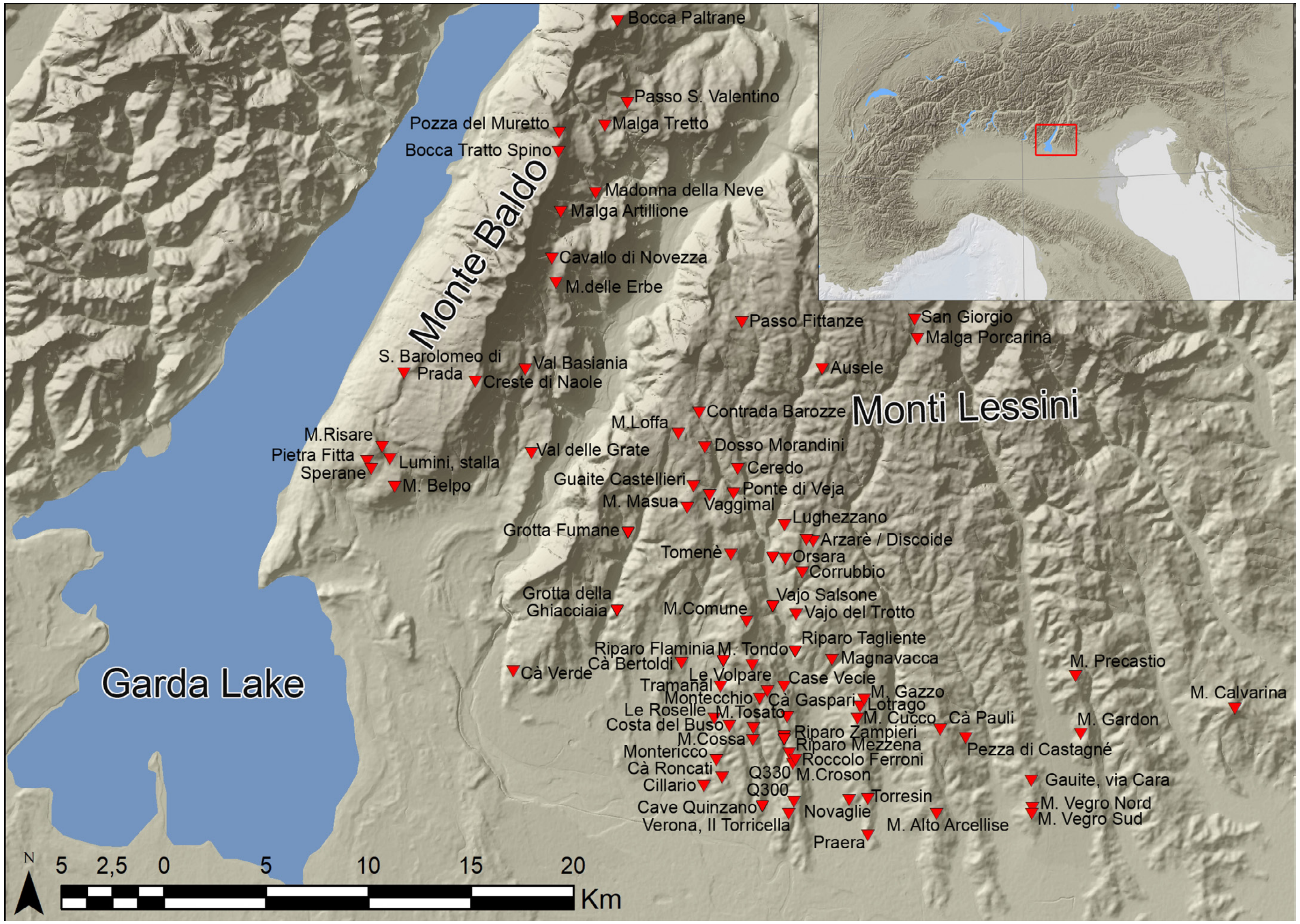

Fig. 9 - Map of Monte Baldo and Monti Lessini showing the location of Palaeolithic sites analysed. Technical notes: Coordinate system: Monte Mario/ Italy Zone 2 (fuso E) – Datum: Roma 40 – Projection: Gauss-Boaga – Fuso: Est – EPSG: 3004; Digital Elevation Model (base topography – Veneto Region DTM 5 m, http://www.regione.veneto.it/web/ambiente-e-territorio/geoportale), Garda Lake (http://www.sinanet.isprambiente.it/it/sia-ispra/download-mais/).

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Fig. 10 - Chert nodule inside the cherty limestone of Maiolica (thickness = 13 cm; by U. Sauro).

in the Cretaceous Maiolica formation, has played a significant role. From the Lower Palaeolithic through the Middle and Upper Palaeolithic, this resource has encouraged both human presence and settlement in these mountains.

Among the countless human adaptations observed in karst areas, some are emblematic and worth mentioning. Neanderthals and early *Homo sapiens* settled caves and rockshelters from river valleys up to the mid mountain regions. During the final phase of the Pleistocene, during the GI-1 and GS-1 periods, hunter-gatherers returned to colonize the valleys following the cold phase of the Last Glacial Maximum. Hunter groups established camps in high-altitude prairies, which were free of local glaciers. They strategically chose locations near snowfields or small lakes within depressions on the moraine, many of which have since dried up. Exemplary in some respects is the story of the arrival and settlement of a tribe of Neolithic shepherds and farmers in Campagna di Lugo. In protohistory and ancient history, settlements proliferated, typically associated with sites featuring water availability, such as small springs or streams.

THE FUMANE CAVE

Fumane cave is part of a non-active karst system formed during the Neogene. It opens in micritic and calcarenitic limestones at the base of a carbonate cliff (Oolite di San Vigilio, upper Toarcian-Aalenian), extensively dolomitised. It originates from a former pit that was filled with residual dolomitic sands at the base of the currently explored deposits. Over time, geomorphic processes along the stream valley partially eroded the pit walls and the sedimentary deposits preserved within it during the Pleistocene epoch. These deposits were unearthed during

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road construction works in 1950. In the same year, the first explorations were conducted by the Natural History Museum of Verona (1964 and 1982) at the bottom of the sequence exposed by the road cutting. Subsequently, a new series of investigations commenced in 1988 under the auspices of the Superintendence for the Archaeological Heritage of Veneto, and these efforts continue annually to this day.

Three karst galleries open at the upper levels of the karst system. The main (B) and secondary (C) galleries form the major rock-shelter, while a third western (A) gallery connects with B forming a vault at the present-day cave entrance in the calcarenitic bank. However, this entrance remains unstable due to several fractures running roughly parallel along the overhung rock wall. The cracks visible in the cave are the consequence of numerous collapse events, primarily induced by repeated frost actions during the late Pleistocene. These events resulted in the closure of the cave entrance and the accumulation of significant blocks and slabs. During previous excavation campaigns spanning from 1988 to 1996, these large blocks and slabs were systematically cleared away. Hence, the original cave entrance was situated a few metres south of its current position (Bartolomei et al., 1992). Owing to the successive rock collapses, the current sheltered entrance has expanded to approximately 30 m^2.

Fig. 11 - View of Fumane cave with galleries A (left) and B (centre) (by M. Dalla Pegorara).

THE MONTI BERICI

The Monti Berici morpho-unit resembles a limestone island amidst the alluvial deposits of the high Venetian Plain. It is a karst plateau marked by a combination of fluvial and karstic forms with an area of about 200 km^2 extended to the SE of the Monti Lessini. The highest point (Monte Alto) is 444 m a.s.l. The uppermost plateau area, only 2-4 km wide and about 10 km long, is located on the east side. A south-western lower plateau is gently sloping to the western alluvial plain. Systems of branched ridges originate from these plateaus, some with characteristics of narrow plateaus or gently rounded hills. The eastern scarp of the upper plateau is higher and steeper than the western side. This asymmetry is influenced by the varying competence of the rocks.

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The stratigraphic sequence is defined by Upper Cretaceous to Miocene sedimentary rocks with featuring subhorizontal or gently dipping beds along with basaltic rocks associated with the Paleogene Lessini-Berici-Euganean volcanic cycle (Mietto, 1988). The articulated morphology of the Monti Berici is influenced by the litho-stratigraphic asset, contributing to a complex geomorphological evolution.

In the western sector, the landscape is shaped by a highly erodible limestone-marly complex, consisting of the middle Eocene "Nummulitic limestone" and upper Eocene "Marne di Priabona" formations. Conversely, the eastern sector is defined by massive limestones belonging to the platform margin of the lower Oligocene, known as the "Castelgomberto formation". These formations give rise to spectacular cliffs adorned with various weathering forms and caves. Among the numerous caves in the Monti Berici, the "covoli" (shallow caves), also locally referred to as "grottoni," were selected as shelters and refuges by hunters, hermits, and friars, both in prehistoric and historical times (Mietto and Sauro, 2000). The landscape is rocky, characterised by large walls. Due to this rugged terrain, despite their modest altitude above sea level, the Berici are often considered "mountains" rather than hills (Mietto, 2003).

On the NE side the Berici morpho-structure is delimited by the regional Schio-Vicenza fault (Zampieri et al., 2021). The SE slope is controlled by the buried Riviera Berica fault, which separate the "mountains" from the complex morpho-structure of the Euganei hills.

On the plateau, alongside the marine sedimentary rocks, there are also outcrops of volcanic rocks and discontinuous covers of continental deposits. Pebbles and boulders of exotic rocks are widespread inside depressions or karst traps. Some former authors have considered these pebbles as relics of old glacial deposits (Dal Piaz, 1947). However, in reality, they are the remnants of the fluvial planation of the top surface (Sauro, 2002, 2005).

Some zones of the plateau feature typical doline areas, while others display combinations of dry valleys, uvalas, and dolines. Additionally, pockmarked and canyon-like valleys are entrenched in the outer belt of the plateau. Pocket valleys, also known as "reculé karstique" in French, are valleys with steep heads characterised by the presence of a karst spring. They originate from the retreat of the valley heads due to under-excavation by water. At the heads of some pocket valleys, the springs feed small creeks that were utilised in the past to power chains of mills.

This plateau embodies a distinct type of karst, as noted by Castiglioni et al. (1988) and Sauro (2002, 2005). Through the analysis of topography and geology, alongside the identification of planation surfaces, various fluvial forms, and select chronologically significant elements, a "morpho-stratigraphic framework" emerges, providing a preliminary model for the geomorphological evolution of this mountain group. The primary features are predominantly of fluvial origin and have been shaped not only by climatic changes but also by tectonic uplifting and/or alterations in the base level. Karst landforms have largely evolved atop relict fluvial forms, with the age of the main features spanning a significant timespan, likely around 15 million years.

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According to Sauro (2002, 2005), the "morpho-chronological" sequence of the main erosional features, identified through a morphographical analysis and organised from the oldest to the youngest is as follows:

1. The summit plateau, interpreted as a planation surface partly influenced by the bedding of the sedimentary formations;
2. The top-surfaces of the northern ridges, ranging in elevation between 150 e 180 m a.s.l., likely remnants of a planation surface;
3. Traces of large meanders entrenched in the relief, such as those of Pozzolo-Val Liona and the Brendola imprints, hanging more than 100 m above the level of the plain;
4. The canyon like valleys, excavated below the present-day sea level;
5. Relicts of planation surface corresponding to the tops of some eastern ridges extending from the foots of the large eastern scarp;
6. Alluvial sediments found of the outer sectors of the canyon like valleys, which now converge into wide-flat bottomed, gulfs opening towards the surrounding alluvial plain.

The morphogenetical events organised in a chronological sequence based on the interrelations between the main erosional forms and the terrigenous sedimentary units (Fig. 12) could be outlined as follows:

I) Uplifting and emersion of the Berici morpho-structure; after the marine regression, a planation surface corresponding to the main plateau and the southwestern ridges (surfaces 1a, 1b) developed, likely through river abrasion (Middle Miocene?);
II) Slow uplifting phase with development of a lower planation surface - the northern ridges system - (surface 3), and entrenchment of the meanders of a large river in the plateau (forms 2a and 2b); so, the meanders of Pozzolo-Val Liona and Brendola formed (Middle-Late Miocene?);

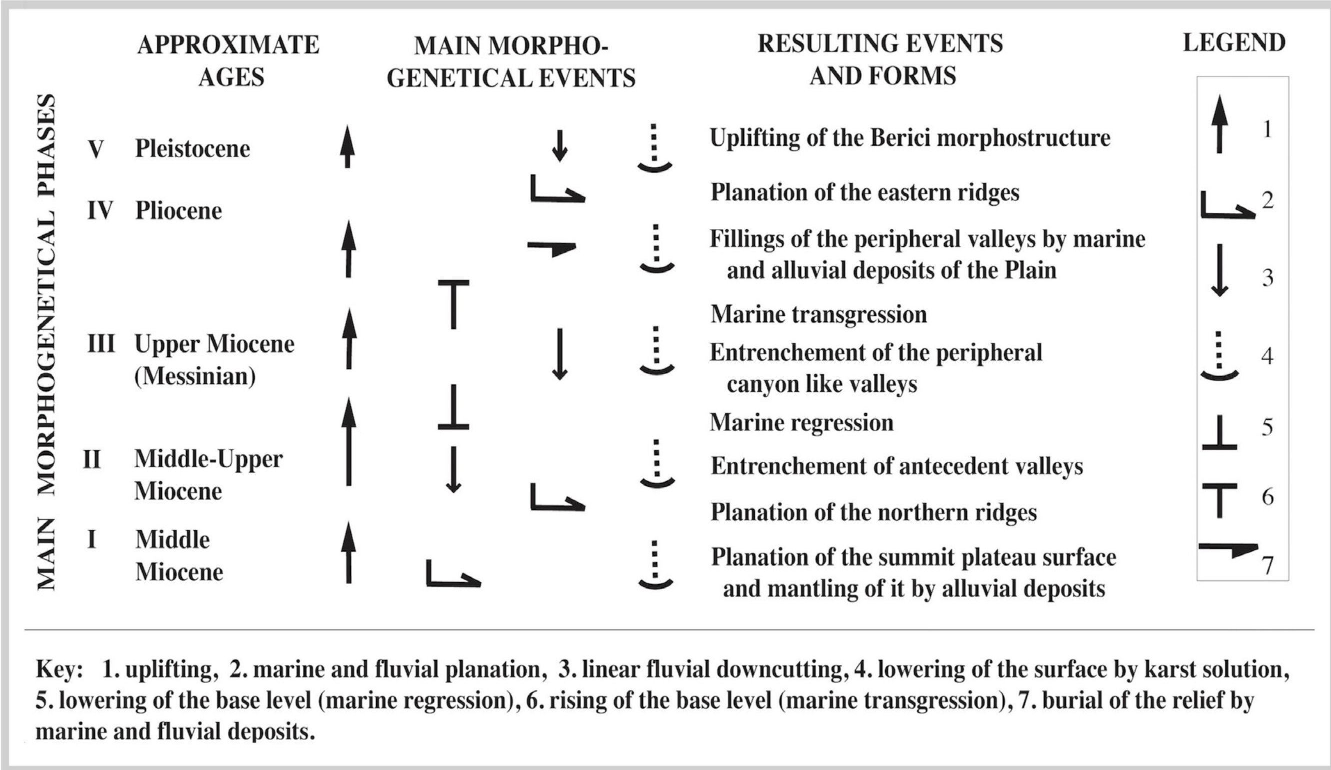

Fig. 12 - Sketch of the main morphogenetical events and of the resulting forms of Monti Berici (after Sauro, 2002, 2005).

III) Subsequent uplifting phase and/or a lowering of the base level led to the abandonment of the Berici morpho-unit by the large river. Local creeks excavated peripheral canyon-like valleys (forms 4a and 4b) with rocky bottoms extending below present-day sea level (Messinian stage, between 6 and 5 million years ago?).

IV) Marine transgression occurred inside the depression corresponding to the Po'-Venetian plain (Early Pliocene) following the reopening of the communication between the Mediterranean and the Atlantic; the planation surface of the eastern ridges (n. 5) might represent the relict of a wide marine terrace linked with the level of the Pliocene Sea.

V) The depression corresponding to the Po-Venetian plain was filled with alluvial deposits. Outer segments of the canyon-like valleys filled with alluvial material, forming gulfs of the alluvial plain within the relief (present-day forms 4a and 4b): uplifting of the Berici morpho-structure, and modification, by different weathering processes of the relict forms, as the plateau surface and the entrenched meanders; in particular the plateau surface has been firstly interested by local fluvial morphogenesis, with the development of a network of small valleys, and later by karst morphogenesis with the evolution, in correspondence with the fluvial segments, of uvalas and dolines, mostly of the type "cover doline" (Pliocene-Pleistocene).

Ecological conditions during the first half of MIS3, as reconstructed from the Fimon Lake pollen core, unveil the presence of open birch-conifer forests, xerophytic scrubs, and steppe environments (Pini et al., 2010; Monegato et al., 2011). The pollen record documents episodes

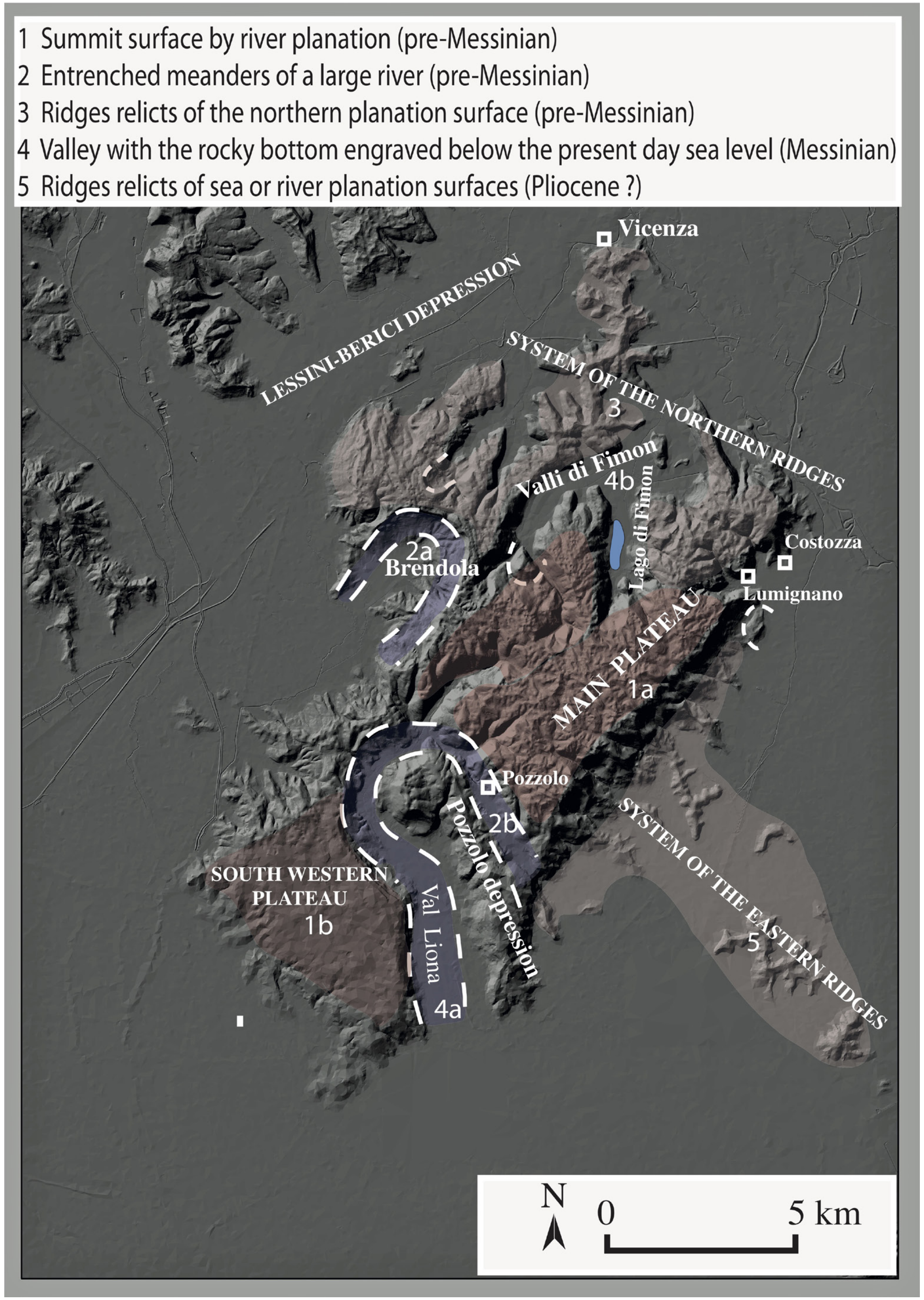

Fig. 13 - A morpho-stratigraphic model of the Monti Berici (after Sauro, 2002, 2005).

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of contraction in conifer forests and expansion of steppe communities, alternating with periods of mixed conifer (Pinus and Picea) – Betula forests, as well as a reduced warm-temperate component (Tilia). These conditions persisted up to approximately 40,000 years ago (Pini et al., 2010, 2010; Badino et al., 2020). Additionally, rainfall and humid conditions in the southeastern Alpine foreland supported by the glaciated Alps have also been confirmed by micromammal assemblages in the Monti Berici at Broion Cave and San Bernardino Cave and in the Monti Lessini area at Fumane Cave (López-García et al., 2015, 2017, 2019).

THE SAN BERNARDINO CAVE

San Bernardino Cave is situated on the eastern slope of the Berici at 135 m above sea-level, facing the alluvial plain of Bacchiglione river and the western side of the Euganean Hills (Fig. 1). Besides San Bernardino, other Middle Palaeolithic caves and shelters open in the same area: Broion Cave and Broion Rockshelter (Peresani et al., 2019), De Nadale Cave (Livraghi et al., 2021), Paina Cave (Bartolomei et al., 1985). San Bernardino Cave is 41 m long, 7 m wide and 9 m high and originated from the widening of deep, SE-NW oriented fractures produced by thermoclastic processes and chemical dissolution. The natural morphology of San Bernardino has undergone significant modifications over time. Initially used as a hermitage since Medieval times and inhabited by members of the Franciscan Order, the cave saw alterations during the Late Middle Ages or later periods, where prehistoric deposits were partly dismantled to construct a wall sealing the cave entrance. Throughout the Modern Age, the inner cavity was extensively emptied through quarrying activities to extract infill material. Following the discovery of Pleistocene bones by Ramiro Fabiani at the beginning of the last century (Fabiani, 1902-03), the first phase of archaeological investigations occurred in the 1960s under the coordination of P. Leonardi, focusing on the medieval wall facing area. These excavations uncovered a Pleistocene sequence containing faunal remains and lithic industries (Leonardi, 1958–1959). Subsequently, a second phase of excavation was conducted between 1986 and 1995, coordinated by A. Broglio and M. Peresani, which allowed for a re-examination of the stratigraphic series from both the inner and outer zones of the cave.

Fig. 14 - View of San Bernardino cave (by. M. Peresani).

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ITINERARY

After assembling at the Verona Railway station, the excursion begins with a visit to Fumane cave, located 20 kilometres west of Verona. This leg of the journey traverses the western Monti Lessini area, offering panoramic views of the distinctive landscape, karst formations, and the remarkable rock bridge of Veja. On the second day, the itinerary includes a visit to the Monti Berici region, with five stops planned to explore various aspects of this karst landscape. The excursion culminates at San Bernardino cave, marking the conclusion of the journey.

FIRST DAY

Fumane cave

The Grotta di Fumane, located in a hydrographic basin characterised by many gorges engraved by watercourses with waterfalls. This region stands out as one of the most abundant in surface water within the central-western Monti Lessini, where springs nourished by aquifers suspended within the Cretaceous and Eocene formations contribute to the flow of streams. The presence of active hydrography has facilitated the establishment of mills, giving rise to the name of the village of Molina.

Stop 1.1 - Fumane cave

Coordinates: Lat. 45° 35’ 33”N, Long. 10° 54’ 17’’E

The sedimentary sequence, brief cultural and chronological layout.
The entire karst complex of Fumane cave preserves a sedimentary body estimated to be approximately 220 m^3 (Abu-Zeid et al., 2019), based on the geometry of the visible sections and 12 m thick as measured from the present-day ground to the top above the cave entrance (Fig. 15). Four macro-units, S, BR, A and D have been delineated based on lithological characteristics and archaeological evidence (Cremaschi et al., 2005). Within macro-unit S, evidence of repeated human habitation is evident, while macro-unit BR, aside from the dense concentration of cultural remains in BR11, suggests short-term occupations characterised by scattered lithic artifacts and faunal remains, or hearths with disorganised tools and bones. Traces of significantly intense human occupation have been identified from the macro-unit A record, while they are less intense within macro-unit D. The Paleolithic sequence includes the Mousterian, Uluzzian, Aurignacian and Gravettian cultural periods.
Above the residual yellow massive dolomite sandy plug, the macro-unit S comprises layers of dolomite sand, angular stones, surface weathered boulders, and traces of Neanderthals’ use of the cave spanning from units S10 to S1, with a total thickness of 1.4m. This differentiation is

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predicated on the extent of anthropogenic influence rather than on the lithological content. Macroscopic features, grain size, heavy minerals contents, micromorphology, and magnetic properties collectively suggests that pedogenesis affected the bedrock in conditions of climatic instability, followed by moderate roof degradation and hydrological redistribution of the dolomite sands. The overlying macro-unit BR comprises a substantial sedimentary mass consisting of stones and aeolian dust (Cremaschi et al., 2005). Within this unit, BR11 is a dense accumulation, measuring 0.4 metres thick, containing cultural material such as articulated ungulate bones, knapped stones, charcoal, and associated combustion features. The sedimentary body continues

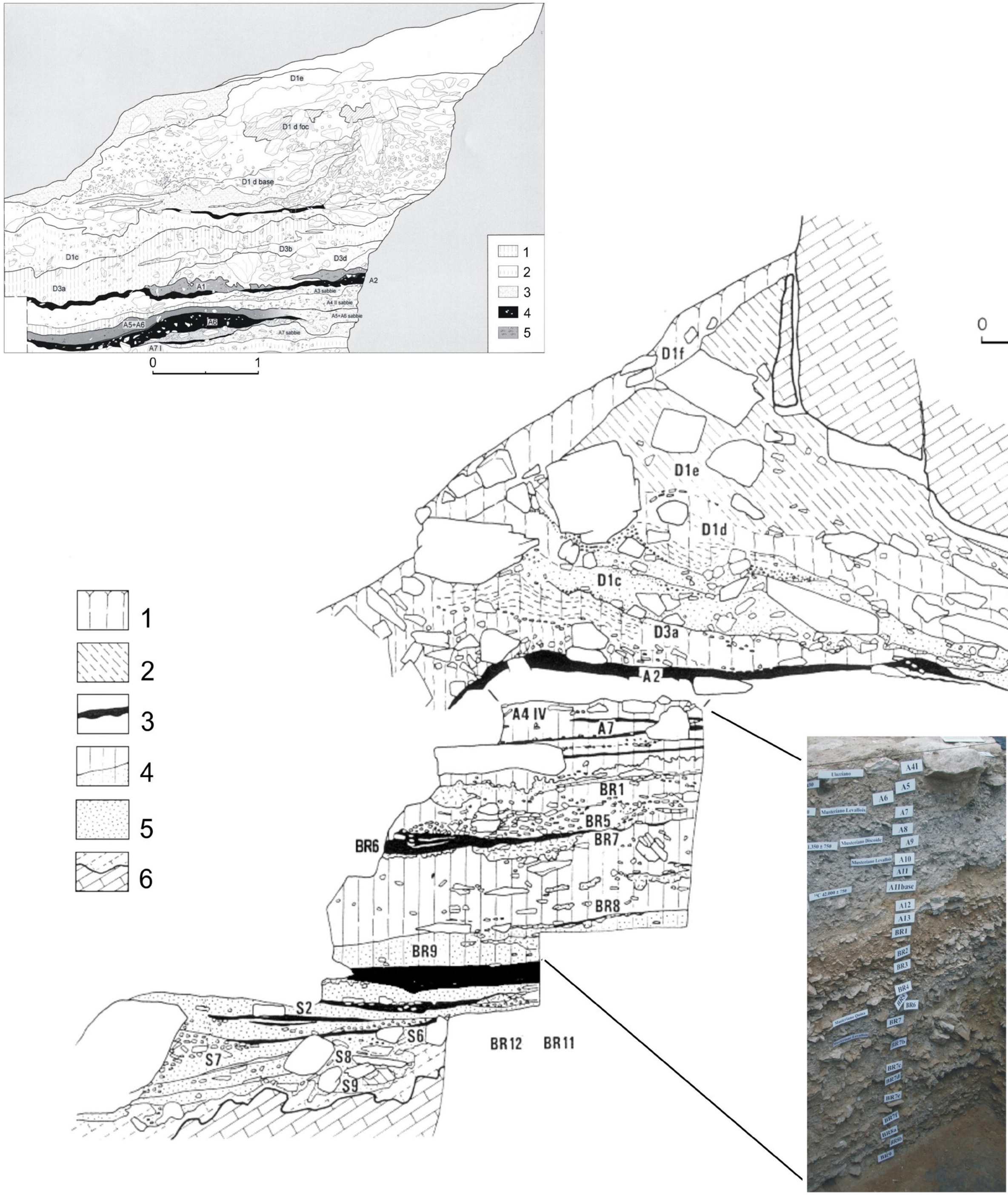

Fig. 15 - Stratigraphic sequence of Fumane Cave observed on the main sagittal section running from outside to the inner cave. The lithological features of the most significant units within macro-units S, BR, A and D are shown. Key: 1 - rendzina, upper soil; 2 – slope deposits with boulders; 3 – living floors; 4 - loess and sandy loess; 5 - CaCO3 cemented layers; 5 – sandy sediments; 6 – unweathered and weathered bedrock (drawn by M. Cremaschi). Above left: stratigraphy at the entrance of tunnel A with evidence of late Mousterian (A6-A5), Uluzzian (A4-A3) and Aurignacian layers (A2-D3): 1 - loess and sandy loess; 2 – loess; 3 – sand; 4 – archaeological layer with dense concentration of organic matter and charcoal; 5 – archaeological layer with organic matter and charcoal (after Peresani et al., 2011).

with units from BR10 up to BR7a, totalling thickness of 1.6 m. Above, units from BR6 to BR4 lie in para-concordance with BR7. These coarse open-work frost breccia seal scattered Mousterian fireplaces and associated material evidence (Cremaschi et al., 2002). Sediments from BR3 to BR1 exhibit an increased content in the fine fraction and are covered by a clear para-concordance by the macro-unit A.

Macro-unit A is characterised by numerous thin to very thin parallel levels and lenses, grouped into stratigraphic units labelled A13 to A1 from bottom to top. While A13 and A12 consist of flat angular stones embedded in yellow residual dolomite sands and silts, the other units are comprised of angular fine to medium-sized stone layers resulting from frost-shattering. These layers exhibit variable percentages of sand and aeolian dust, with the latter becoming almost exclusive from the sheltered area to the exterior. Sediments within macro-unit A are generally loose or densely packed but are never intensively cemented. Macro-unit A contains varying amounts of organic and cultural material associated to traces of intense and repeated human uses of the cave. Mousterian living floors are documented in A11, A10, A9, A6-A5 and A4, Uluzzians in A3 and proto-Aurignacians in A2 and A1. All these have been extensively explored at the cave entrance until unit A9. However, units A13, A12 and A7 are archaeologically sterile, although A12 contains portions of the overlying anthropogenic unit A11, displaced by post-depositional deformations. Unit A11 is composed of loamy dark-brown sediment, with stones associated with abundant lithic artefacts and faunal remains. Above this, unit A10 yielded anthropogenic lenses and levels embedded in various stone-lines and levels of stones resulting from frost-shattering. Unit A9 comprises several layers showing a succession of thin, dark, anthropogenic levels alternating with loose, stone-supported layers or thin sandy levels. Unit A7 is a stony layer between A9 and A6, with A6 consisting of dark sediment with high content of cultural anthropogenic remains. Units A5 and A4 contain fewer archaeological remains than A6 and are composed of frost-shattered slabs with variable sand content and aeolian dust, which becomes more prevalent towards the outermost part of the cave. The early Upper Palaeolithic sequence is recorded in units labelled from A3 to A1, along with D6 and D3, where A3 is composed of slabs, loose stones and loamy fine fraction, A2 and A1 are thin Aurignacian cultural layers alongside with D6 and D3, which are part of the Macro-unit D at the top of the sequence.

The cave entrance and the main tunnels were sealed by Macro-unit D, mostly composed of boulders resulting from rock falls and stones, sands and varying amount of aeolian dust accumulated during MIS2. The thickness of the layers gradually decreases moving towards the cave-opening where post-depositional deformations occurred under the influence of periglacial conditions at the onset and during MIS2. Within macro-unit D, evidence of Aurignacian human presence is found in D3d, D3b and D3a, becoming scarce in D1c and is eventually replaced in the last anthropic level, D1d, by Gravettian cultural evidence in the last anthropic level, D1d (Falcucci and Peresani, 2022).

The macro-units A and D represent one of the most complete and detailed continental stratigraphic series from the Late Pleistocene (ca. 50-30 ka BP) within a cave context in the Adriatic region and the Italian Peninsula. Sedimentological, pedological and palaeontological assessments based on these records have been documented elsewhere (Cassoli and Tagliacozzo, 1991; Cremaschi et al., 2005; López-García et al., 2015). Ecological indicators are derived from the studies of small mammals, mammals and avifaunal associations, which represents of a rich and diversified association of animals consumed by humans, carnivores and birds.

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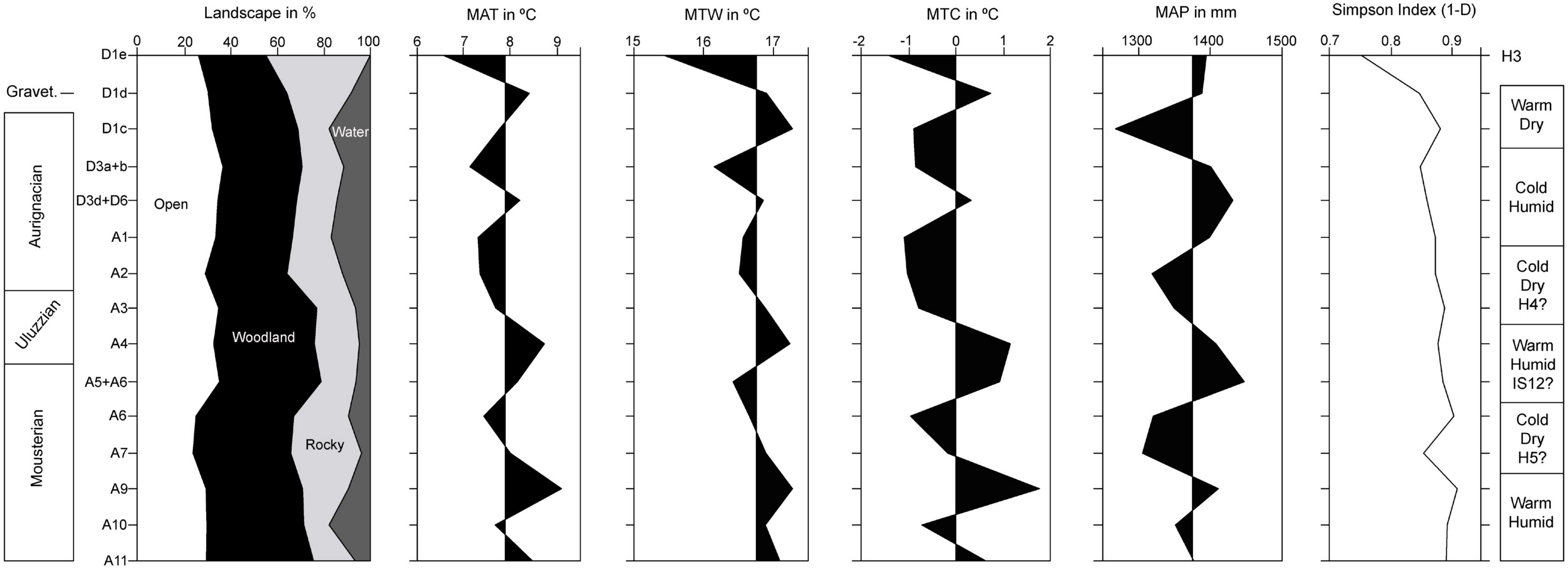

Fig. 16 - Fumane cave. Representation of landscape percentages, mean annual temperature (MAT), mean temperature of the warmest month (MTW), mean temperature of the coldest month (MTC), mean annual precipitation (MAP) and the small-mammal Simpson diversity Index (1-D), from the Fumane cave sequence (after López-García et al., 2015).

Despite the ongoing chronological uncertainty affecting the middle-lower part of the sedimentary sequence due to controversial dates (U/Th on bone teeth and TL on burnt chert artefacts and sediments), a substantial body of radiocarbon dates confirms that the late Mousterian, the Uluzzian, the Aurignacian and the Gravettian phases fall in the MIS3 up to the onset of MIS2. The time range of unit A9 is delimited by the minimum radiocarbon age at 47.6 ky cal BP and the lower chronological boundary of layer A5+A6 at 44.8ky cal BP (Peresani et al., 2008; Higham et al., 2009), which also serves as the upper boundary of layers A6 and A7. To provide chronological resolution from A6 down to A11, a new set of radiocarbon dates is necessary. The final Mousterian phase from A5+A6 to A4 dates to between 44.8 and 42.2 ka cal BP, followed by the Uluzzian up to 40.4 ka cal BP and the Protoaurignacian in A2 and A1 to 41.2–40.4 ky cal BP (Douka et al., 2014; Higham et al., 2009). Layers D3, D6, D3+D6 document the late Protoaurignacian at 38.9–37.7 ky cal BP (Higham et al., 2009), while D1d represents the Gravettian to 35 ky cal BP as maximum age (see discussion in Falcucci and Peresani, 2019).

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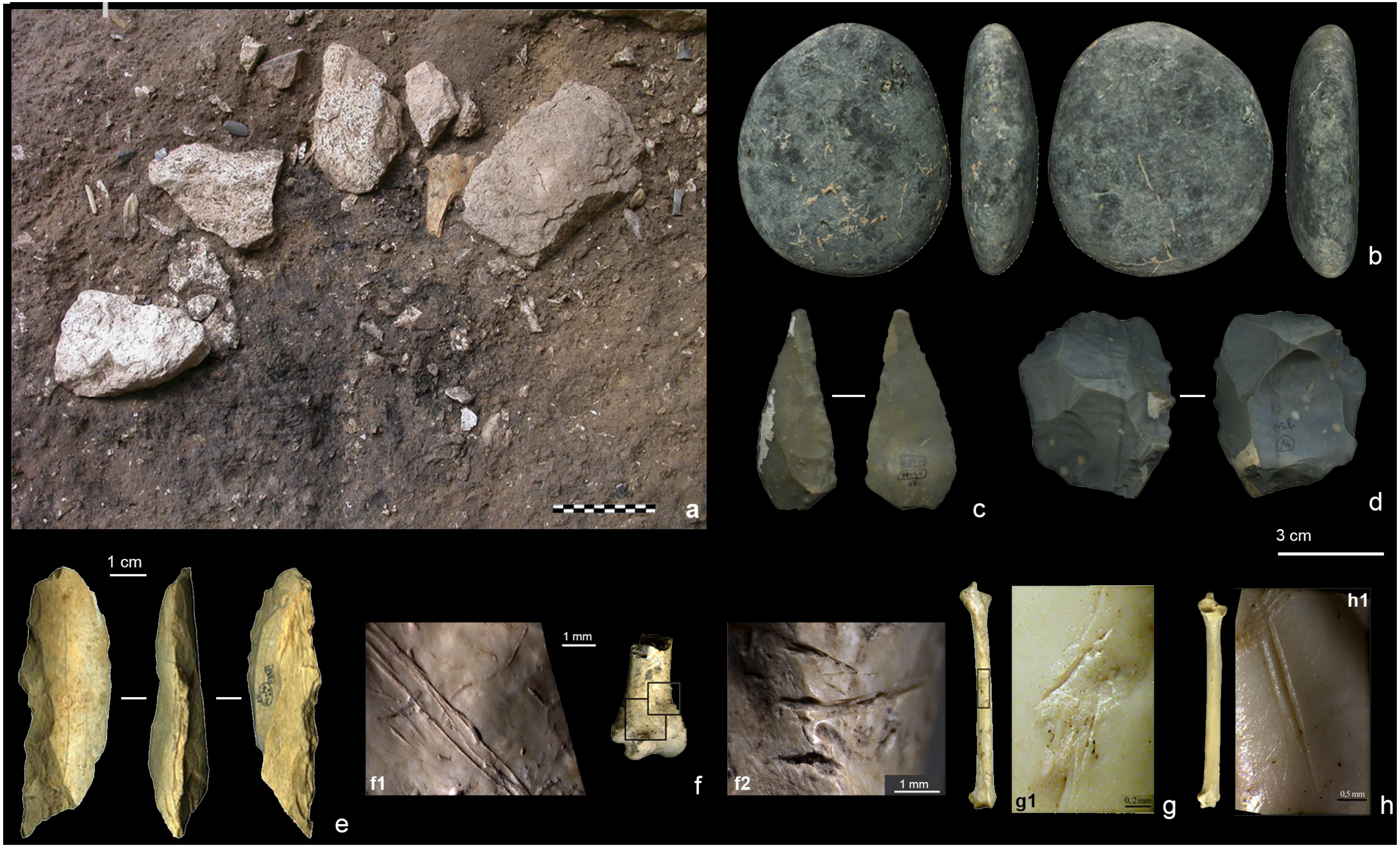

Fig. 17 - The Mousterian "package" of unit A5-A6: a - view from the inner cave of fireplace A5_SIII (scale = 10 cm); b - serpentinite pebble from layer A6; c - side scraper on Levallois blade; d - Levallois core; e - bone scraper from layer A5+A6; f - cut-marked distal end of right ulna of lammergeier (*Gypaetus barbatus*) with close-ups (f1, f2); gh - cut-marked right (7) and left (8) ulnae of Alpine chough (*Pyrrocorax graculus*) with close-ups (after Peresani, 2022, modified).

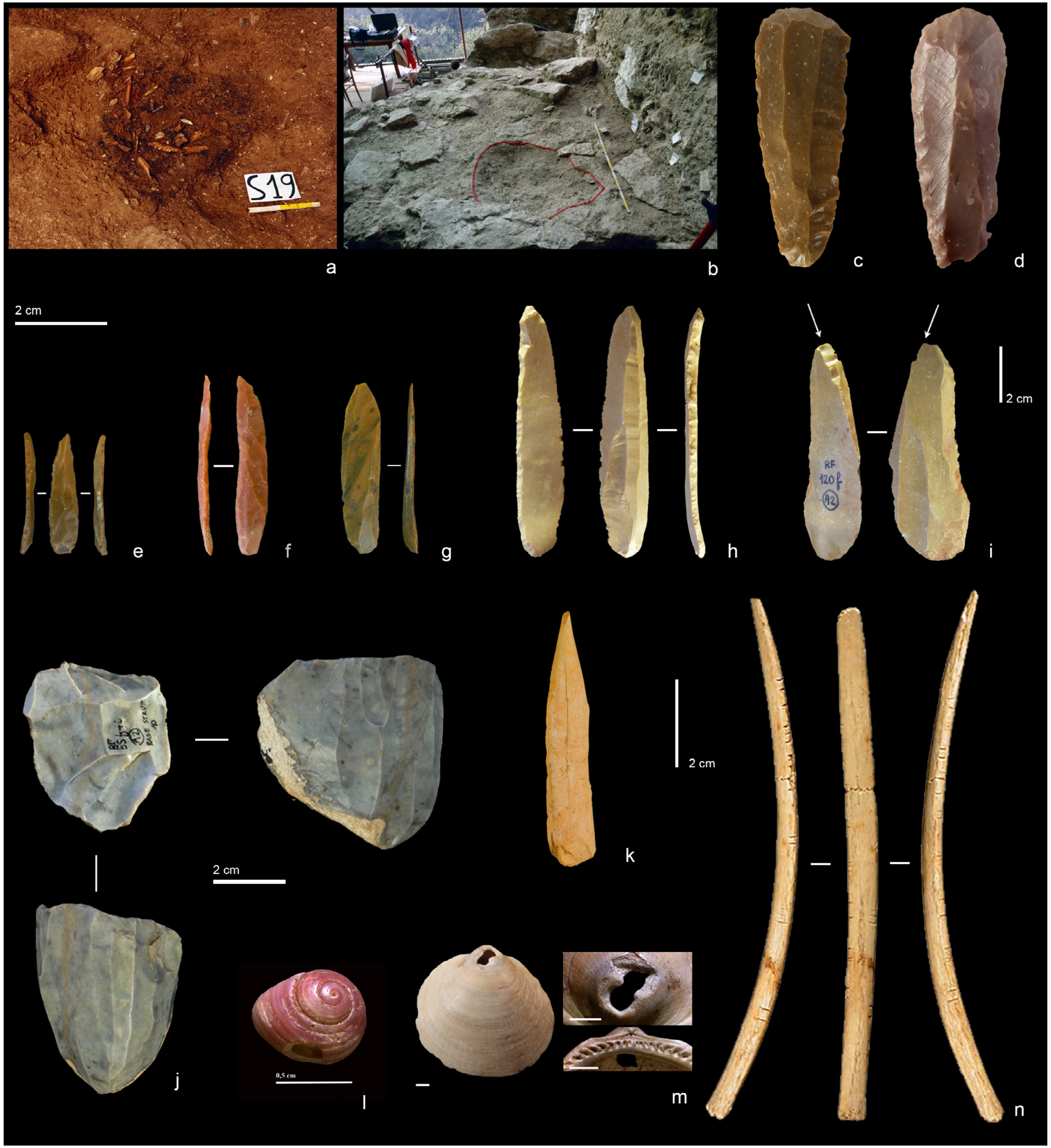

Fig. 18 - The Protoaurignacian “package” of unit A2: a - structure A2_S19, a toss zone isolated at the present-day entrance of the cave; b - a sector of the dwelling outside the present-day entrance of the cave limited by stones and with the large fireplace A2_S10 surrounded by slabs emerging from the ground; c-d - endscrapers made on blade; e-h - dorsal, sagittal and ventral views of retouched bladelets; i - burin; j - bladelet core; k - awl made on an undeterminable fragmentary shaft; l-m - *Homalopoma sanguineum* (l) and *Glycymeris nummaria* (m) perforated shells; n - herbivore rib modified with spaced notches on the sides (after Peresani, 2022, modified).

Stop 1.2A - Monti Lessini 1: Alti Lessini from Monte Cornetto

Coordinates: Lat. 45° 40' 44''N, Long. 10° 58' 04''E

After ascending by car and taking a brief walk up to Monte Cornetto, visitors can behold the captivating landscape of the upper part of the Lessini plateau, distinguished by its structural, fluviokarstic, and karstic formations. The diverse geological formations give rise to a variety of relief styles, featuring convex or angular shapes, as well as areas adorned with ruderal landscapes and more.

Stop 1.2B - Monti Lessini 2: Sant'Anna D'Alfaedo Museum

Coordinates: Lat. 45° 37' 42"N, Long. 10° 57' 14"E

Sant'Anna D'Alfaedo Museum (tel. 347-2510121, 388-1791285, infomuseosantannadalfaedo@gmail.com) (alternative to the previous stop in case of bad weather)
The museum provides a comprehensive overview of the area's geology and prehistory. Of particular interest are the fossils from the Scaglia Rossa Veneta, featuring skeletons of large sharks and turtles. Additionally, the exhibits offer illustrated insights into prehistoric and protohistoric human activities in the region.

Fig. 19 - Sunrise view of the natural bridge of Ponte di Veja at the head of a spring valley, where a system of caves is present (by U. Sauro).

Stop 1.3 - Monti Lessini 3: Veja Natural Bridge

Coordinates: Lat. 45° 36' 29"N, Long. 10° 58' 13"E

The Ponte di Veja is a natural monument located on the right side of a canyon-type valley, the Vajo della Marciora (municipality of Sant'Anna D'Alfaedo). This remarkable formation resembles a pocket valley attirbuted to the retreat of a spring head. The bridge itself, resembling a natural architrave, represents the vestige of a grand cavern

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that has partially collapsed over time, resulting from the convergence of several caves. Remarkably, these caves have been frequented since the lower Paleolithic. The speleogenesis of this intricate karst system dates back approximately 40 million years, with its genesis initially attributed to the circulation of hypogenic waters—originating from hydrothermal sources, possibly heated by volcanic magmas—and later to the circulation of epigenic waters (Rossi and Zorzin, 1990). Within the cave deposits lie significant palaeontological and archaeological remnants, offering valuable insights into prehistoric period.

Fig. 20 - A view of the Ponte di Veja as seen from the downvalley side. The roof of the main arch is in Rosso Ammonitico Veronese and is 40 m long, 20 m large and 9 m thick (by U. Sauro).

SECOND DAY

Stop 2.1 - Pozzolo dead valley

Coordinates: Lat. 45° 24’ 36”N, Long. 11° 29’ 48”E

Pozzolo village sits within the relict segment of a dormant valley, deeply entrenched within the Berici plateau and extending across both sides. This segment represents the residual portion of a sizable palaeo-meander that extends further into the Val Liona depression. Towards the western end of the Pozzolo segment, it overlooks the head of the pocked valley, known as Calto, where the water from karst springs historically powered mills in the area.

From Stop 2.1 to Stop 2.2 - Monti Berici main plateau

The main plateau of the Berici is characterised by extensive karst depressions, diverse sizes of dolines, and dry valleys. It is evident that most of the karst forms have evolved as “cover type forms”, resulting by the karstification of limestone beneath layers of alluvial sediments. Relicts of such covers are exotic pebbles scattered all over the plateau.

Fig. 21 - The pocket valley of Calto, west of Pozzolo, in the Monti Berici (municipality of Villaga, VI) (by U. Sauro).

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Fig. 22 - Some karst dolines in Monti Berici (SW of Villabalzana, municipality of Arcugnano, VI) (by U. Sauro).

Fig. 23 - A blind valley in Monto Berici (SE of Villabalzana, municipality of Arcugnano, VI) (by U. Sauro).

Stop 2.2 - San Donato: The walls in the limestone cliffs

Coordinates: Lat. 45° 24’ 33”N, Long. 11° 31’ 13”E

The walls of the eastern slope of Monti Berici offer a captivating array of geomorphological features, owing to the diverse forms observable there. Comprised of compact, whitish limestones from the geological formation known as the “calcareniti di Castelgomberto” (i.e., “Castelgomberto formation”), these rocks deposited during the Oligocene in coral reef environments. Characterised by their solidity and limited fracturing, they possess a primary porosity that facilitates water circulation. These walls, which crown the uppermost belt of the slope facing ESE, vary in height from a few metres to around 200 metres. At their base lie nearly impermeable marly limestones belonging to the “Priabona” formation from the upper Eocene period.

Fig. 24 - The entrance of the San Donato cave developed in the reef limestone of the Castelgomberto formation (municipality of Villaga, VI). The photo has been taken during the fieldtrip of the INQUA Congress of Rome (by U. Sauro).

Fig. 25 - The Euganean Hills seen from the inner of the San Donato cave (municipality of Villaga, VI) (by U. Sauro).

The walls exhibit the solid structure of limestone, adorned with numerous niches, cavities of varying sizes, and various concretionary forms. Among these distinctive features are the "covoli" (shallow caves), degradation patterns, biological incrustations, and shelves at the base of the walls. The surfaces, adorned with mottled colours reminiscent of palettes, enhance the allure of these vertical landscapes.

Of particular note are the large cavities that punctuate these walls, each with its unique characteristics. These range from shallow caves (known locally as "covoli") to more extensive caverns, showcasing a diversity of voids and shelters formed within different limestone types. These cavities, often several metres deep and exhibiting rounded internal chambers in approximately 50% of cases, owe their shapes not only to karstification processes but also to exfoliation phenomena. As a result, they resemble "tafoni" or formations resulting from speleogenesis within massive rocks, rather than conventional karst caves. In many Monti Berici caves, the bottom is either solid rock or covered by a thin layer of terrigenous sediments. However, on the walls, remnants of ancient fill levels are often discernible, suggesting that clastic materials may have been intentionally removed by humans to enlarge the cavities. While concretions on the ceiling, walls, and floor are generally sparse, a few caves boast stalactites, stalagmites, and columns, some of which are quite sizable.

A distinctive feature of cliff limestones is the presence of sub-vertical or even overhanging walls, often accompanied by large niches, caves, and wide rock shelves at their base. These formations bear a striking resemblance to coastal cliffs and their associated marine abrasion platforms. One notable example of such complex formations can be found at the hermitage of San Donato, where the rock shelf served as the foundation for medieval housing structures. The evolution of these intricate formations can be understood as a result of limestone walls undergoing karstification and retreat, while the shelves, resembling abrasion platforms, represent the topmost massive and waterproof limestone layers.

Stop 2.3 - San Bernardino Cave

Coordinates: Lat. 45° 25' 38"N, Long. 11° 33' 25"E

The sedimentary deposit within San Bernardino cave forms a complex body shaped as an elongated prism, extending from inside to partly outside the cave. It is representative of the lower portion of the original sediment within the cave. Currently measuring 4.5 metres in thickness, the sedimentary sequence comprises eight primary stratigraphic units with sub-horizontal bedding, gradually curving outward beyond the cave entrance. These units document the succession of three primary palaeoclimatic cycles, transitioning from temperate to dry/cold conditions: cycle 1 (MIS 7c/b – MIS 6, Units VIII to VII); cycle 2 (MIS 5d and b – MIS 4, Units V to IV) and cycle 3 (MIS 3 – MIS 2? Units III to I) (López-García et al., 2017; Picin et al., 2013). U/Th and ESR dates indicate ages ranging from the Middle/Late Pleistocene (Units VIII-VII, ca. 214 and 154 ka) to the Late Pleistocene for Unit II (57-33 ka BP). Moreover, new radiocarbon dates obtained from bones with anthropogenic marks in Unit II confirm ages exceeding >48.6 ka BP and 45.9±2900 ka BP, indicating that the archaeological content predates the first half of MIS 3 (Terlato et al., 2021).

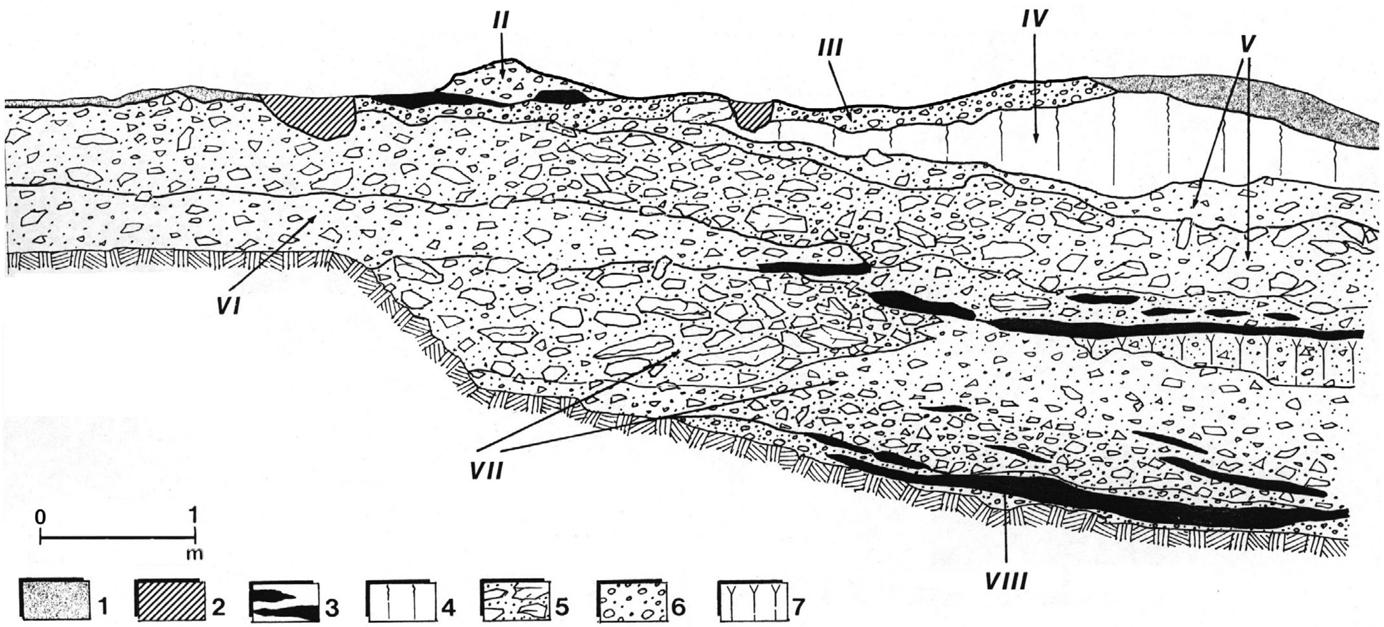

Fig. 26 - San Bernardino cave stratigraphic section with indication of macro-units from II to VIII. Key: 1 - disturbed deposit with medieval finds; 2 - bioturbation; 3 - main palaeo-living floors; 4 - loess; 5 - thermoclastic breccia; 6 - limestone gravel; 7 – palaeosoil (by M. Peresani).

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Units II, VI and VIII are situated at the entrance of the cave extending also below the medieval wall. The palaeoenvironmental and palaeoclimatic reconstruction of the sequence was also based on small-mammal (insectivore, bat and rodent) assemblages. The biochronological record, mostly based on rodents, suggests that units VIII-VII, featuring *Arvicola mosbachensis*, *Dinaromys* cf. *D. bogdanovi* and *Microtus agrestis* type *jansoni*, can be assigned to late Middle Pleistocene. Meanwhile, units V-II, characterised by *Arvicola amphibius*, *Chionomys nivalis*, *Microtus agrestis*, *M. oeconomus*, *Sicista betulina* and *Dryomys nitedula*, belong to the Late Pleistocene. Coupled with biochronological data and absolute dating, along with previous studies on large mammals, birds and other studies on small mammals and pollen from comparable time-spans in Italy, the analyses of these assemblages enable clear identification of distinct climatic periods: i) MIS 7c or 7b in units VIII-VII, associated with a temperate and moist climatic period and a landscape dominated by woodland formations; ii) MIS 5d in unit V, and probably MIS 5b in unit IV, associated with a cool and dry climatic period and a landscape dominated by open meadows; and iii) an indeterminate interstadial from MIS 3 in units III-II, associated with mild and humid conditions, with a landscape dominated by woodland formations (López-García et al., 2017).

Units record a notable increase in the density of anthropogenic evidence – including faunal remains, lithic artefacts, and hearths – in comparison with the underlying Units III, IV and V. Taxonomic studies of the macro mammal associations reveal the presence of a diverse array of mammal species such as roe deer, red deer, moose, wild boar and bovines, with cave bear being the most abundant carnivore.

Middle Palaeolithic lithic industries found in Units II and IV to VIII exhibit intensive exploitation of local resources. Taphonomic analyses suggest that

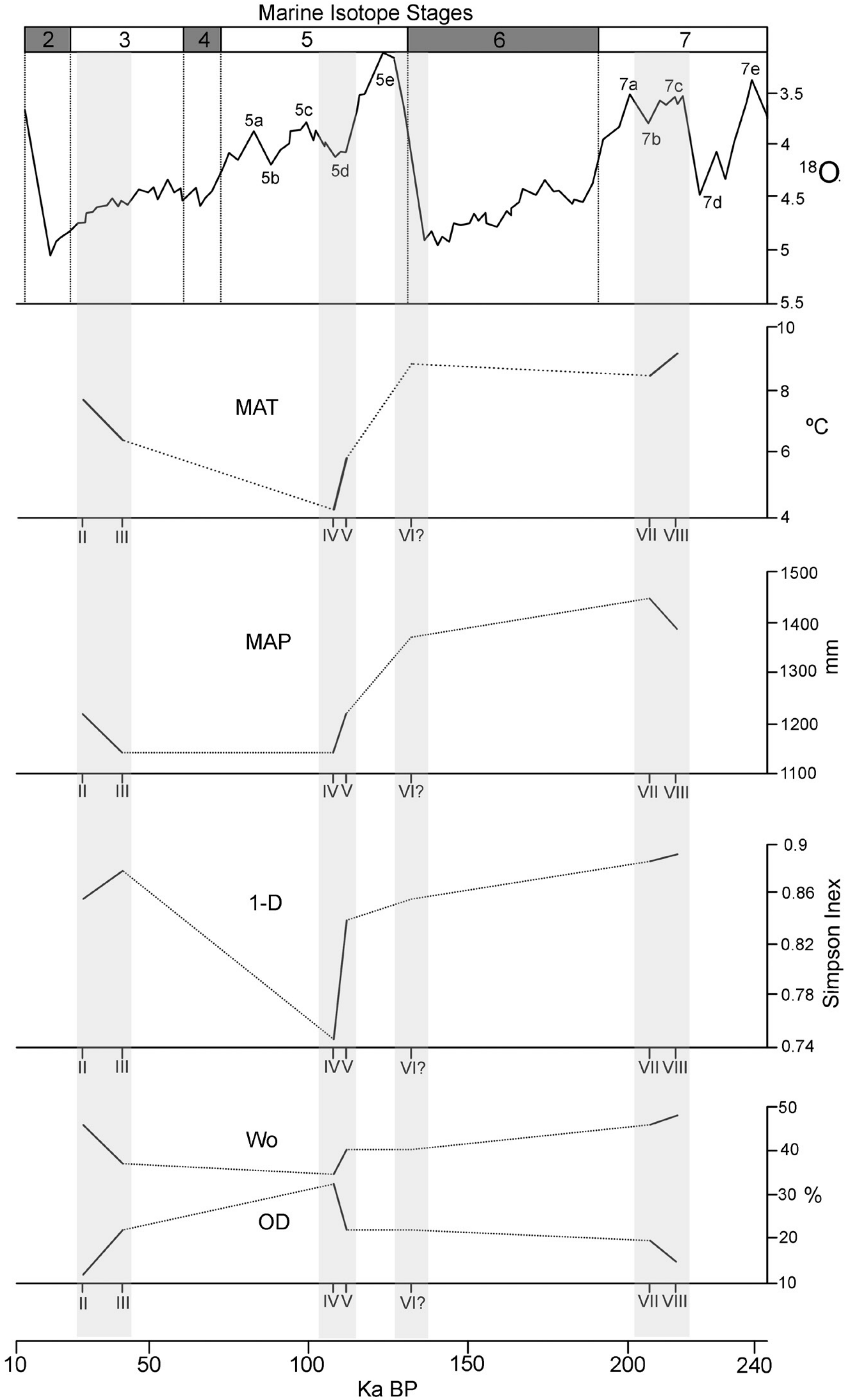

Fig. 27 - San Bernardino cave: representation of mean annual temperature (MAT), mean annual precipitation (MAP), the Simpson small-mammal diversity index (1-D) and the landscape percentages (Wo: woodland + open woodland; OD: open dry + rocky) from the Grotta Maggiore di San Bernardino sequence in relation with the 18O isotope curve (by López-García et al., 2017).

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Neanderthal groups were the primary agents responsible for the accumulation of mammal remains, with hunting mainly focused on ungulates, such as *Cervus elaphus* and *Capreolus capreolus*. The presence of forested environment sustained by mild climatic conditions is inferred from micromammals evidence. Data also indicate a selective transport of the prey – including roe deer – possibly implying long-distance transportation from the site (Terlato et al., 2021). Flake-manufacture predominately utilised Levallois modalities. While many tools were crafted from finely textured chert collected from nearby sources (within 1-5 km), a significant number were manufactured from chert of similar quality obtained from more distant locations (15-20 km away), including the Euganean Hills and central-western Monti Lessini, up to 80 km from the cave, and introduced at different stages of reduction (Peresani, 1996).

Stop 2.4 - Walls in the reef limestone and karst spring in the Lumignano village square

Coordinates: Lat. 45° 27' 35"N, Long. 11° 35' 13"E

The towering scarp above the village of Lumignano boasts the most striking walls of Monti Berici, shaped by the limestone of Castelgomberto formation. This formation, influenced by the unique lithology and rich structure, harbour numerous caves, shelters, and natural niches that have been frequented by humans since prehistoric times.

Several pathways offer access to the main cliffs, which are adorned with entrances to many caves and shelters. These sites contain deposits abundant in archaeological prehistoric remains and have also served as hermitages for monks during the Middle and Modern Ages. In the Lumignano square, a fountain fed by a karstic spring, stands as a testament to the area's geological richness. Along the eastern border of Monti Berici, several similar springs can be found, highlighting the prevalence of these unique hydrological features in the region.

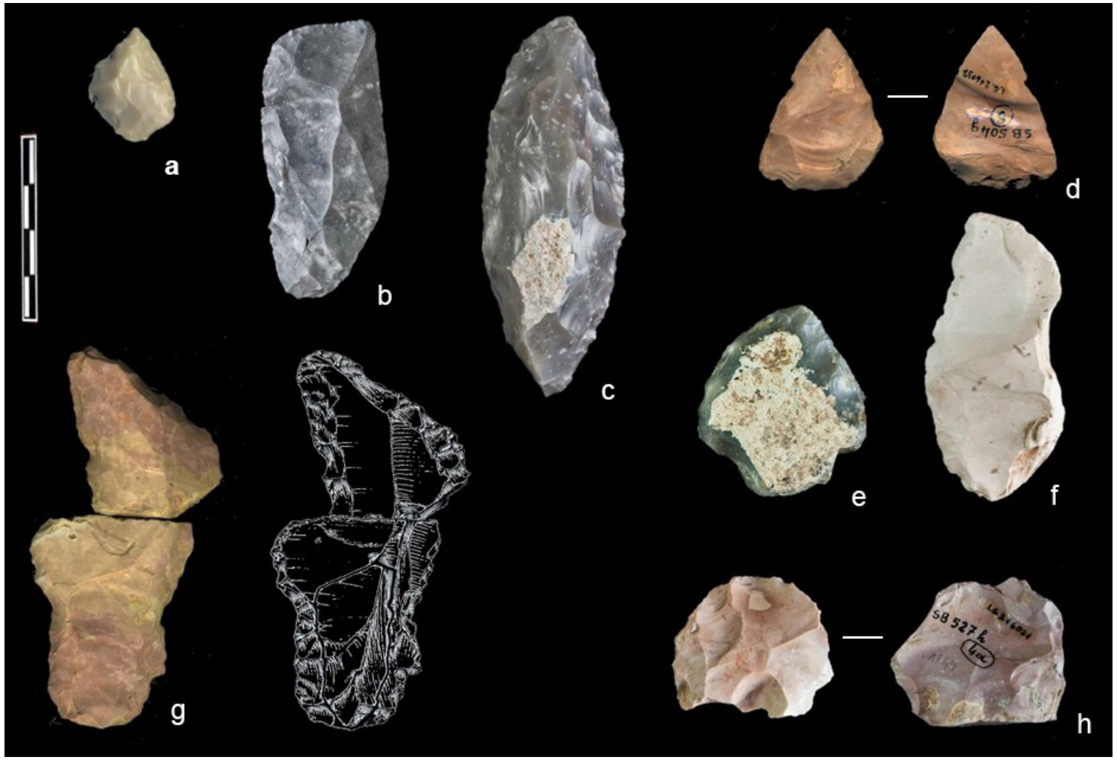

Fig. 28 - San Bernardino cave, Unit II, Middle Palaeolithic artifacts: a, d - retouched points; b,e - scrapers; c - *limace*; f - denticulate; g - recycled scraper; h - Levallois core (scale = 4 cm).

Stop 2.5 - Fimon Lake

Coordinates: Lat. 45° 28' 12"N, Long. 11° 32' 36"E

Fig. 29 - Above the village of Lumignano the eastern scarp of the Monti Berici is crowned by high walls in reef limestone of the Castelgomberto formation (by U. Sauro).

Fimon Lake, nestled within the Fimon Valley system, is a semi-natural lake that bears significant marks of human alteration. Situated within the Berici relief, the lake occupies a unique geographical niche resembling a "fiord-bay" within the alluvial plain. Its formation owes to the damming effect of the rivers that flow through the plain, their alluvial deposits creating a phenomenon known as "over-aggradation." The sediments within Fimon Lake, are an invaluable archive of the Late Pleistocene environmental and climate history of the southern Alpine foreland. A detailed palynological record spanning from Termination II and the Last Glacial Maximum reveals significant correlations with major forest expansion and contraction events recorded in isotopic events in the Greenland Ice core records. The onset of the Last Interglacial period is characterised by a rapid expansion of broad-leaved temperate forests and a sudden rise in water table levels following a phase of treeless steppe conditions at the conclusion of the penultimate glaciation. At the interglacial period, waned mixed oak forests gave way to oceanic mixed forests, which persisted for approximately 7,000 years until the end of the Eemian succession. Following a stadial phase characterised by moderate decline in forest cover, a subsequent expansion of warm broad-leaved forests, known as the north-alpine Saint Germain I phase, was identified.

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Fig. 30 - Fimon Lake extends across the bottom of an inlet, a sort of gulf, of the high alluvial plain within the Berici relief (south of Vicenza, municipality of Arcugnano, VI). The alluvial deposits of the plain have partially buried the offshoots of the Berico relief, following the oscillations of the base level (sea level) (by U. Sauro).

The proliferation of beech trees during the oceanic phase serves a significant circumalpine indicator. The subsequent succession of stadial-interstadial phases aligns closely with evidence from the north-alpine foreland. During the Middle Würmian corresponding to the full glacial stage, mixed forests persisted, primarily dominated by conifers but also featuring significant presence of lime and other broad-leaved species. A significant decrease in Arboreal Pollen is noted around the modelled age of 38.7±0.5 ka, corresponding to Heinrich Event 4 (Pini et al., 2010). The persistent presence of forestation south of the Alps during much of MIS 3 suggests a prevailing southern air circulation. This observation is consistent with palaeoglaciological data from the Alps and is supported by palaeoclimate simulations illustrating patterns of pressure and rainfall. The intensification of continental high pressure during the full glacial period triggered cyclogenesis in the middle latitude eastern Europe, resulting in orographic rainfall in the eastern Alps and the Balkanic mountains. This climatic mechanism facilitated the expansion of forests at elevations equivalent to current sea-level (Pini et al., 2010).

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