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RESEARCH ARTICLE

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Geoarchaeological characterisation of a Younger Dryas site in the Alpine uplands: Cornafessa rock shelter (Italy)

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Abstract

The effects of the Younger Dryas (YD) fluctuation on Late Pleistocene hunter-gatherers' settlement and subsistence systems in the southern Alps are poorly known. This is primarily due to the scarcity of archaeological sites dating from the YD, in contrast with the extensive evidence available from the lateglacial interstadial and the early Holocene. Here, we present the initial stratigraphic, chronologic and geoarchaeological data collected from Cornafessa rock shelter, a new site located in the Lessini massif of the Italian Alps, at an elevation of 1240 m. The site was occupied during both the YD and the early Holocene. The YD archaeological deposit is clearly recognisable within the fairly uniform lateglacial and Holocene clastic succession. Geoarchaeological data indicate that the YD deposit corresponds to an occupation surface, which was formed during short visits to the site by late Epigravettian hunter-gatherer groups, who settled in the sheltered area and performed distinct activities.

KEYWORDS

Alps, archaeological micromorphology, geoarchaeology, Lessini, rock shelter, Younger Dryas

1 | INTRODUCTION

The Younger Dryas event (hereafter YD) triggered a major crisis within biological communities, including human ones, and fostered their adaptation. The effects of the YD were particularly relevant for communities occupying marginal areas, as they were more exposed to the consequences of climate and environmental change (see, e.g., Ammann & Oldfield, 2000; Straus & Goebel, 2011).

The YD represents the last fluctuation of the lateglacial and was marked by environmental instability (see Broecker et al., 2010; Renssen et al., 2018). At present, the YD abrupt climate event is dated from *c.* 12.9–12.8 to 11.7–11.6 ka B.P. in the North Atlantic region (Cheng et al., 2020), matching the Greenland Stadial 1 (GS1) of the INTIMATE event stratigraphy (Rasmussen et al., 2014). In Southern Europe, after the overall temperature increase and the expansion of vegetation and forest environments in the lateglacial interstadial (former Bølling-Allerød interstadial), a drastic descent in temperature and moisture levels is recorded at the onset of the YD, with relevant consequences for biological communities (Ravazzi et al., 2007; Ravazzi, 2005; Vescovi et al., 2007).

Today, the environmental context of the lateglacial in the Southern Alps is well understood. Alpine glaciers reached their maximum extent during the Alpine Last Glacial Maximum (ALGM, *c.* 26–23 ka B.P., see Monegato et al., 2017) and retreated rapidly during the lateglacial interstadial. The surface area of the Southern Alpine glaciers was somewhat reduced at the onset of the YD (Angelucci & Bassetti, 2009), and phases of glacial advance are detected in some sectors of the Alpine chain during the YD

(Baroni et al., 2017, 2021; Ivy-Ochs et al., 2009). During the lateglacial interstadial, the treeline reached an elevation higher than 1500 m asl (above present sea level) in the Southern Alps (Tinner & Vescovi, 2005; Vescovi et al., 2007), and the land experienced general geomorphological stability (Angelucci & Bassetti, 2009). In the subsequent YD, the air temperature in the Alps decreased by about 4°C over a few decades (von Grafenstein et al., 1999; Heiri et al., 2014; Lotter et al., 2000), with the development of drier conditions and negative winter precipitation anomalies (Baroni et al., 2021; Ivy-Ochs et al., 2009), causing synchronous and rapid vegetation shifts. An altitudinal decrease in the treeline altitude of *c.* 200–300 m is observed, while plant species that are typical of grassland and steppe environments expanded at the expense of trees, as registered by pollen records and other proxies (Frisia, Borsato, et al., 2005; Frisia, Filippi, et al., 2005; Ravazzi, 2005; Ravazzi et al., 2007; Vescovi et al., 2007).

The abrupt environmental shift at the YD onset also impacted the settlement and subsistence strategies of end-Pleistocene hunter-gatherers. Archaeologically, the eastern part of the Southern Alpine belt is one of the regions featuring the highest number of lateglacial and early Holocene sites and off-site evidence (Angelucci & Bassetti, 2009). As Mussi and Peresani (2011) point out, large stretches of Italian territory seem devoid of any YD sites, including the central and western Alpine foothills. The eastern sector of the Southern Alps is thus a key area for understanding the adaptation patterns of hunter-gatherers across lateglacial and early postglacial times.

During the lateglacial, the Southern Alps were peopled by Epigravettian groups. The Epigravettian technocomplexes originated from the Gravettian during the ALGM (Bietti, 1985; Broglio, 1997; Palma di Cesnola, 2001) and lasted until the Pleistocene–Holocene termination, showing changes in lithic technology, as well as in the mobility strategies and settlement pattern of their producers (Bertola et al., 2007; Duches et al., 2018; Mussi & Peresani, 2011; Naudinot et al., 2017; Peresani et al., 2021; Tomasso et al., 2018, 2020). As far as the settlement system is concerned, the peopling of ALGM-glaciated land by the Epigravettian bands was a gradual process, with an early phase restricted to valley bottoms and plateaux around 500 m elevation and a later stage of upland occupation reaching altitudes of *c.* 1500 m asl, with development of a logistical occupation network based on seasonal mobility patterns (Angelucci, 1998; Duches et al., 2019; Fontana et al., 2018). In the YD, significant changes in the density and characteristics of sites are observed, compared with the preceding lateglacial interstadial (Angelucci & Bassetti, 2009; Duches et al., 2014). Mussi and Peresani (2011) consider that the distribution of sites in the area may indicate that the uplands were seasonally exploited and that, despite its impact on vegetation, the YD cooling had a 'limited effect on the exploitation of hunting grounds at a middle altitude and on settlement patterns' (Mussi & Peresani, 2011, p. 367). Still, the consequences of the YD on human settlement involved other factors, such as the size of camps and the characteristics of lithic assemblages, which suggest 'a trend towards an increasing simplification of the settlement, a diminishing surface of flint scatters and a reduction in the set of procedures involved in chipping, supplying and manufacturing food and other materials' (Mussi & Peresani, 2011, p. 368). This suggests that the YD environment was quite demanding for final Epigravettian humans because they 'continued to exploit [the land], but at a smaller scale than before' (Mussi & Peresani, 2011; p. 368). This is also detected in the eastern Southern Alps since few lateglacial interstadials sites were seldom reoccupied during the YD (an example being Riparo Dalmeri, Angelucci et al., 2011), while YD sites are novel with respect to the Bølling-Allerød settlement system and smaller than previous ones. This evidence has been interpreted as reflecting shorter visits to this area, within a continuous but distinct use of resources related to a higher mobility pattern (Duches et al., 2014, 2018), which could be 'indicative of a remarkable resilience to climatic change' by lateglacial hunter-gatherers (Mussi & Peresani, 2011, p. 369).

Present knowledge of YD settlement in the eastern Southern Alps is based on a total of 15 open-air and rock-shelter sites (Figure 1). Since YD archaeological evidence in the area is scarce, new data are of paramount importance to give further clues as to how environmental change and cultural patterns interacted during lateglacial times, fostering the emergence of differences in human behaviour.

We present here a recently discovered YD site, the excavation of which is ongoing: Cornafessa rock shelter (hereafter referred to as RCF, see Figure 2). A recent international paper introduced the site (Duches et al., 2019) but, besides articles in local journals, no information on the site's stratigraphy and formation has been published so far. This paper deals with these points, emphasising the importance of RCF for understanding the effects of the YD in the Alps and the strategies adopted by foragers at the very end of the Pleistocene. Fieldwork at the site was interrupted in 2020 and 2021 and will possibly resume in 2022, which means that the data presented are partial and will be updated.

2 | SITE PRESENTATION

2.1 | Cornafessa rock shelter: History of research

Cornafessa rock shelter (RCF) is located at the north-western edge of the Lessini plateau, under a limestone face, at *c.* 1240 m asl (Figures 1 and 2).

The Lessini massif and its surroundings are an exceptionally rich area for Southern European prehistory and archaeology, of both the number of sites detected (Margaritora et al., 2020) and their importance (e.g., among Palaeolithic sites: Grotta di Fumane, Riparo Tagliente, Ponte di Veia: see Broglio, 2002 ; Broglio et al., 1963; Fontana et al., 2009; Peresani, 2012; Peresani et al., 2008). For this reason, the Lessini uplands, the valleys dissecting the plateau and their piedmont belt have been extensively surveyed since the 19th century (see Salzani, 1981). Nonetheless, the area can still provide archaeological surprises.

In 2014, Christian Fracchetti found archaeological remains on the surface of the rock shelter and informed the region's archaeological

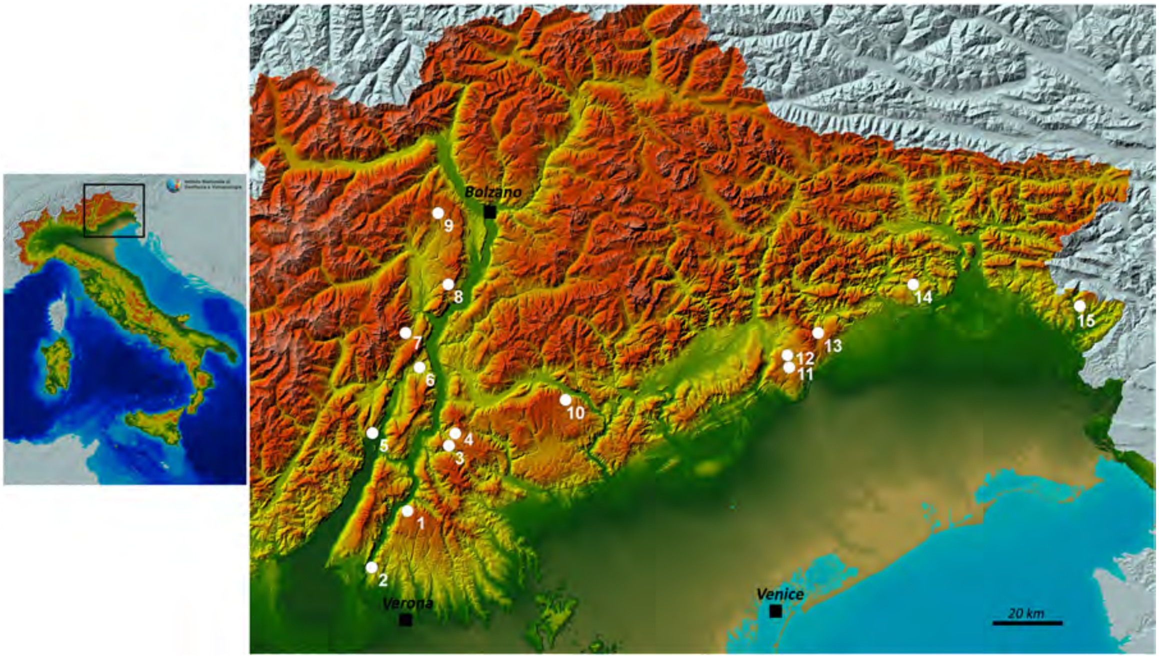

FIGURE 1 Location of Cornafessa rock shelter and other sites radiocarbon-dated to the Younger Dryas or attributed to the Younger Dryas on the basis of the techno-typological characteristics of lithic assemblages collected, in the eastern sector of the Southern Alps. Relief map: Digital elevation model from TINITALY DEM (CC BY 4.0, see Tarquini et al., 2007, 2012). 1, Cornafessa rock shelter*; 2, Riparo Soman*; 3, Riparo la Cogola*; 4, Palù Echen; 5, Arco via Serafini; 6, Terlago; 7, Andalo; 8, Laget; 9, Laghetto delle Regole; 10, Riparo Dalmeri*; 11, Bus de La Lum; 12, Palughetto; 13, Piancavallo; 14, Grotte Verdi di Pradis*; 15, Riparo Biarzo*. Asterisk (*) indicates rock-shelter and cave sites (elaboration by R. Duches); see also Table 8. [Color figure can be viewed at wileyonlinelibrary.com]

FIGURE 2 View of Cornafessa rock shelter at the end of the 2016 field campaign (picture by D. Angelucci). [Color figure can be viewed at wileyonlinelibrary.com]

service. A 'phone-booth-shaped' pit was then dug at the site, bringing to light the archaeological deposit, which systematic excavation campaigns have explored since 2015 under the direction of Giampaolo Dalmeri (2015 and 2016) and one of the authors (R.D., since 2017). Archaeological fieldwork revealed a YD occupation floor featuring abundant finds, the analysis of which has produced evidence of bear hunting and processing at the site (Duches et al., 2019). Field campaigns between 2017 and 2019 (Figure 3) extended the explored archaeological surface and conducted a geoarchaeological analysis of the deposit to understand site formation processes. The results are discussed below.

2.2 | Cornafessa rock shelter: Location and context

The Lessini massif exhibits a distinctive geological structure compared with that of the surrounding southern Alpine chain. The Southern Alps constitute a compressional, strongly deformed, tectonically active mountain belt (Castellarin et al., 2006), in which rock masses display a wide range of tectonic processes (faulting, folding, thrusting…). In this context, the Lessini sector is undeformed foreland (Pola et al., 2014); the Meso-Cenozoic succession mostly outcrops as subhorizontal tabular layers and is only dissected by normal faults, often with limited displacements (Castellarin et al., 1968).

The Lessini succession belongs to the Venetian platform and is made up of carbonate sedimentary formations with a variety of rock types (pure limestone, marl, nodular limestone, calcarenite, dolostone… see Castellarin et al., 1968). The massif's geomorphology is strongly controlled by geological factors, in particular lithology and structural configuration (Sauro, 1973). The geological formations of the upper portion of the succession (from top to bottom: *Scaglia Rossa*, *Scaglia Variegata*, *Maiolica* and *Rosso Ammonitico Veronese*, all of them bearing high-quality chert) outcrop in the massif's upland

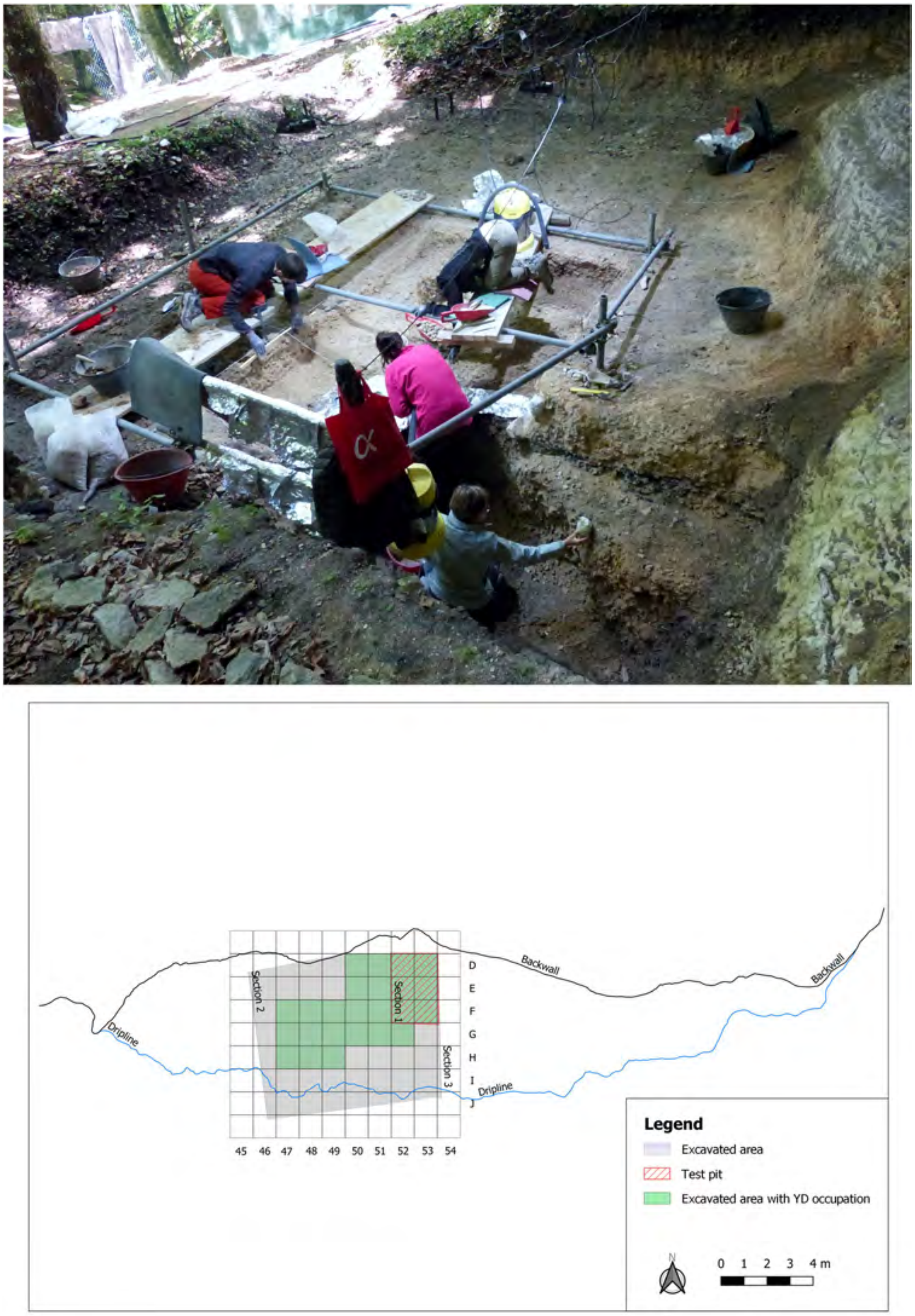

FIGURE 3 Cornafessa rock shelter. Above: view of the site during 2017 fieldwork; in the foreground is one of the authors (E. Patauner), holding sample RCF1701 (picture by D. Angelucci). Below: The plan of the site, with grid squares and excavated area (elaboration by Dennis Zammarchi). [Color figure can be viewed at wileyonlinelibrary.com]

plateau, while the lower Mesozoic succession (*Calcari oolitici di San Vigilio*, *Calcari grigi di Noriglio* and *Dolomia Principale*—Figure 4) is exposed along the slopes of the deeply incised valleys cutting the plateau and along its peripheral escarpment. Surface morphologies are strictly related to the geological stratification (Sauro, 1973). At the same time, the location of rock shelters and karstic features is influenced by lithological boundaries between distinct formations, while the transition from the plateau to its peripheral scarp—usually an abrupt slope break—occurs in correspondence to the *Rosso Ammonitico Veronese* formation. The Mesozoic succession is crossed by Cenozoic volcanic dykes, mostly of basaltic composition (one is located a few hundred metres upslope from RCF).

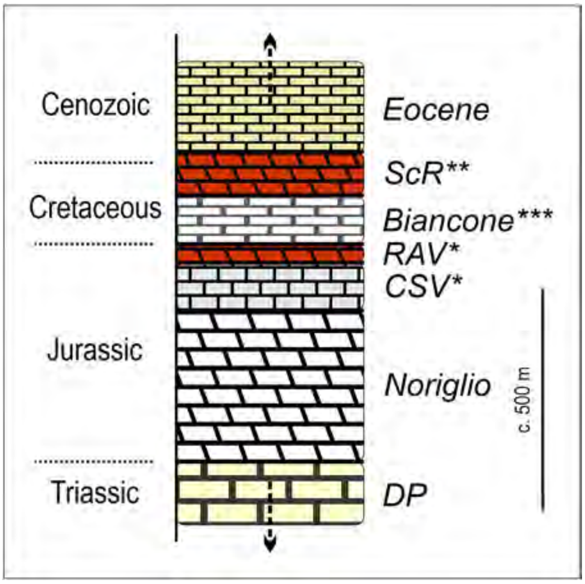

FIGURE 4 Simplified stratigraphic sketch of the Mesozoic succession of the Lessini massif. CSV, Calcari oolitici di San Vigilio; DP, Dolomia Principale; Noriglio, Calcari grigi di Noriglio; RAV, Rosso Ammonitico Veronese; ScR, Scaglia Rossa. The Biancone group includes two formations, Scaglia Variegata and Maiolica; asterisks indicate the quantity and quality of the chert embedded in the rock formations (*moderate quantity, poor quality; **reasonable quantity and good quality; ***abundant and high quality); reported thickness is approximate (elaboration by D. Angelucci; data after Carraro et al., 1969; Castellarin et al., 1968 and unpublished survey data). [Color figure can be viewed at wileyonlinelibrary.com]

During the Pleistocene, the Lessini plateau was not reached by glaciers that occupied the main Alpine valleys (Angelucci & Bassetti, 2009). RCF is located at 1240 m asl, higher than the elevation attained by the Adige\Etsch glacier during the ALGM. Specific survey work during field campaigns at the site has shown that the ALGM moraine is located at *c.* 1 km north of the site, at a maximum elevation of 990–1025 m asl.

Due to the absence of major Pleistocene glacial erosion, thick polycyclic or relict soils developed on the upland Lessini plateau (see Cremaschi, 1990). These are preserved in morphologically protected areas, given that erosion dynamics during the mid-late Holocene—often human-induced—have led to the removal of soil cover and to the subsequent accumulation of thick soil–sediment colluvia at the base of escarpments and in the main valleys (Angelucci, 2002; Cavulli et al., 2002). Soils around the site mainly show A–C profiles. On steep slopes, where the parent material is limestone, soils typically comprise rendzina\Mollisol profiles, while on gentler hillsides, where silty-clay soil–sediment outcrops, they exhibit desaturated profiles, sometimes with incipient, poorly developed B horizons.

The RCF rock shelter opens on the north side of a small valley (Figure 2), a few metres below the outcrop of the *Rosso Ammonitico* limestone that marks the slope break delimiting the Lessini plateau. The valley is fed by a short periglacial *Delle* draining the area upstream; downstream of the rock shelter, the valley becomes a narrow fluviokarstic gorge with a maximum depth of about 20 m. At present, the valley is dry, and no water flow has ever been detected in recent years. No data are available on its latest activity, but it cannot be excluded that water flowed in it at the end of the Pleistocene or in the early Holocene.

The limestone of the *Calcari oolitici di San Vigilio* formation ('St Vigilio's oolitic limestone') forms the rock-shelter wall. The rock mass is cut by three sets of structurally induced joints that cause the limestone to split into cube-like fragments separated by serrated planar voids (Figure 5b). The limestone contains embedded chert nodules of moderate quality; these were not employed for the production of lithic artefacts at the site. Neither was the *Rosso Ammonitico Veronese* chert, which is widespread near the rock shelter, used as a raw material for tool manufacturers. The lithic assemblage is derived from chert belonging to the *Scaglia Rossa*, *Scaglia Variegata* and *Maiolica* formations, which outcrop at distances between a few hundred metres and a few kilometres from RCF.

2.3 | Cornafessa rock shelter: Archaeological background and dating

Since fieldwork at the site is ongoing, the study of the archaeological assemblage is still in progress (preliminary reports were published by Duches et al., 2019 and in master theses by Nannini, 2018–2019; Patauner, 2019–2020; Zammarchi 2019–2020). The faunal assemblage comprises 4255 remains, of which 3698 are from Epigravettian layers (Table 1). The high rate of bone breakage (more than 95% of the bones are smaller than 2 cm) and thermal alteration (19%) make it difficult to determine anatomical parts, and to date, only 112 fragments have been taxonomically identified. The low value of NISP (number of identified specimens) is consistent with data from other late Epigravettian contexts of northeastern Italy (see Bertola et al., 2007; Fiore & Tagliacozzo, 2005). Brown bear (*Ursus arctos*) dominates the YD faunal assemblage with 48 remains (*c.* 43% of identified specimens, while the MNI, minimum number of individuals, is three). Other species mostly include large- and medium-sized mammals from distinct environments (*Cervus elaphus*, *Capreolus capreolus*, *Capra ibex*, *Rupicapra rupicapra*), while remains of carnivores such as wolf/dog or mustelids are rare. The skeletal representation and analysis of bone surfaces indicate that the processing of bear carcasses was carried out at the site. A projectile impact mark has also been recognised on a bear rib, evidence that bears were directly hunted using a bow and lithic composite projectiles (Duches et al., 2016, 2019).

The lithic assemblage consists of 524 artefacts (≥1 cm), 480 of which are from late Epigravettian layers (see Table 2). The raw material used is chert from Cretaceous limestone formations (see above), collected in the form of small nodules and slabs from primary outcrops and slope deposits around the site. More than 100 refitting fragments suggest that they were reduced on-site, while the

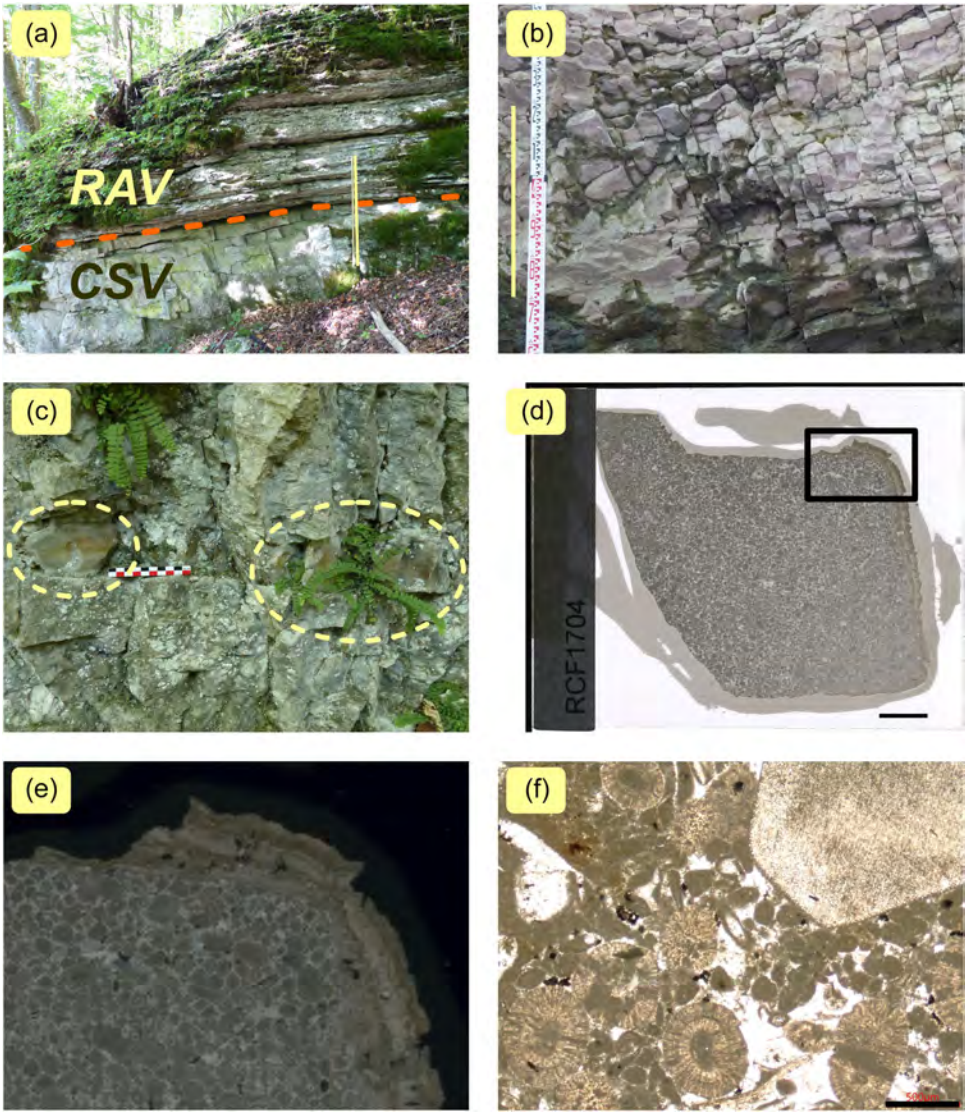

FIGURE 5 Cornafessa rock shelter: Bedrock. (a) Lithological contact (dashed line) between the Rosso Ammonitico Veronese (RAV) and Calcari oolitici di San Vigilio (CSV) formations: notice distinct lithologies and selective erosion; the picture was taken about 50 m east\upslope from the rock shelter (scale: 1 m; picture and elaboration by D. Angelucci). (b) View of the shelter wall: notice discontinuous aspect of rock mass and its partition into 3-to-10-cm-sized elements (approximate scale: 50 cm; picture and elaboration by D. Angelucci). (c) Chert nodules (circles) embedded in the limestone of the rock shelter wall (scale: 10 cm; picture by Stefano Neri). (d) PPL scan of thin section RCF-1704, collected from the shelter wall (scale: 1 cm; the square marks the area depicted in Figure 5e; scan by E. Patauner and Paolo Chistè). (e) Detail of the limestone bedrock and the rock coating on the wall (XPL). (f) Limestone fragments, calcite crystals, single ooids and other calcareous particles from the bedrock embedded in the groundmass of unit 5 (TS RCF1706, PPL, scale: 0.5 mm; picture by E. Patauner). Elaboration by D. Angelucci. PPL, plane-polarised light; XPL, crossed-polarised light. [Color figure can be viewed at wileyonlinelibrary.com]

evidence of raw materials introduced as shaped cores or retouched items is scarce. Tools are scarce and were manufactured on shaping or maintenance flakes.

The radiocarbon dating available is consistent with the archaeological evidence and the chronocultural attribution based on the lithic assemblages collected at the site. Five measurements were obtained from the finds from unit 5 (see Table 3). Four of them fall around the Pleistocene–Holocene boundary; two dates on charcoal from unit 5D are statistically identical (LTL-15976A and LTL-15977A), indicating a 2σ interval of *c.* 12,000–11,300 cal. B.P., which partly overlaps the slightly younger value obtained from layer 303/5 (*c.* 11,700–11,250 cal. B.P., LTL-17865A). Other results are somewhat different, both slightly older (LTL-17867A falls at the end of the lateglacial interstadial) and younger (LTL-14854A, on the bone). Two more samples were collected from layer 301 (see Figure 6), to date the ephemeral Mesolithic occupations recorded at RCF; both dates lie within the 6th millennium B.C.E. (see Table 3).

TABLE 1 Cornafessa rock shelter—Faunal remains

Taxa	Late Epigravettian NISP (nr)	Late Epigravettian NISP (%)	Mesolithic NISP (nr)	Mesolithic NISP (%)
Erinaceus europaeus			2	18.2
Mustela erminea	1	0.9		
Meles meles	1	0.9		
Canis lupus	1	0.9		
Ursus arctos	48	42.9		
Carnivora	24	21.4		
Sus scrofa			2	18.2
Capreolus capreolus	1	0.9		
Cervus elaphus	9	8.0	3	27.3
cfr. *Rupicapra rupicapra*	1	0.9		
Capra ibex	4	3.6	1	9.1
Caprinae	1	0.9		
Ungulata	21	18.7	3	27.3
Total NISP	**112**	**100.00**	**11**	**100.0**
Indeterminate				
Large size	29		7	
Medium–large size	49		6	
Medium size	18		1	
Medium–small size	1			
Small size	2			
Unidentified	3481		534	
Aves	6			
Total remains	**3698**		**559**	

Abbreviations: NISP, number of identified specimens; nr, number.

TABLE 2 Cornafessa rock shelter—Lithic artefacts

	Late Epigravettian nr	Late Epigravettian %	Mesolithic nr	Mesolithic %
Unworked *debitage* products (>1 cm)	**420**	**87.5**	**41**	**93.1**
Retouched *debitage* products	26	5.4	2	4.6
Projectile implements	21	4.4	1	2.3
Backed points	4			
Backed bitruncated bladelets	1			
Undetermined backed fragments	8			
Undetermined implements fragments	3			
Geometric microliths	5		1	
Tools	5	1.0	1	2.3
Burins	2			
End-scrapers	2			
Undetermined fragments	1		1	
Backed piece manufacturing waste	**31**	**6.5**	**1**	**2.3**
Cores	3	0.6	0	0.0
Total	480	100.0	44	100.0

Note: Frequency of the main morphotechnical categories identified among the unworked and retouched *debitage* products of the lithic assemblage. Abbreviation: nr, number.

3 | METHODS

Recent data on the geological and geomorphological setting of this sector of the Lessini massif are rather scarce. For this reason, the collection of geoarchaeological data at RCF included nonsystematic geological, geomorphological and soil surveys around the site, to understand the local geology and the distribution and location of chert-bearing geological formations, to trace possible outcrops of volcanic rocks (some of which were found in the shelter deposit), to locate glacial deposits and forms (as well as the maximum altitude reached by the ALGM glacier) and to understand past and present surface dynamics in the surrounding area. These data have been combined with existing information from literature and are partly integrated into the 'Site Presentation' chapter above.

At the site, an accurate field description of the deposit was undertaken to reconstruct formation processes on the basis of sedimentological, pedological and stratigraphic criteria (Angelucci, 2022). All the units under excavation and the sections exposed were systematically described, considering sedimentary, soil\diagenetic and archaeological characteristics. Colour was determined in moist conditions using the *Munsell Soil Color Book*, while evaluation of the quantity of calcium carbonate in the sediment was based on semiquantitative observation of reaction with 10% HCl. For identification of layers, stratification units (referred to as units or US from now onwards) defined during excavation were used; units showing significant internal variability were further subdivided into subunits or facies.

Archaeological micromorphology was also employed to characterise the shelter deposit. Seven large-format undisturbed samples were collected from the YD deposit at the site (Table 4). Most of these were withdrawn with the help of gypsum bands, due to poor cohesion or high porosity of the sediment (see Figures 7 and 8). Large-sized thin sections (Figure 9) were prepared in the laboratory 'Servizi per la Geologia' (Piombino, Italy), following these stages: impregnation using a mixture of resin, styrene and hardener, curing, cutting into cm-thick slabs and definitive preparation of thin sections 25 µm thick and of variable size (95 mm × 55 mm or 55 mm × 45 mm).

TABLE 3 Cornafessa rock shelter—Radiocarbon dating

Label	Laboratory reference	Coll.	Unit	Material	Result (a ^{14}C bp)	$\delta^{13}C$ (‰)	cal. 2σ (a cal. B.P.)	Remarks
RCF1 (2014)	LTL-14854A	2014	5A	Bone	9651 ± 65	−26.6 ± 0.6	11,203–10,767	
RCF2 (2015)	LTL-15976A	2015	5D	Charcoal	10,080 ± 70	−25.0 ± 0.4	11,926–11,324	(*)
RCF3 (2015)	LTL-15977A	2015	5D	Charcoal	10,171 ± 70	−22.7 ± 0.3	12,094–11,401	(*)
RCF1 (2018)	LTL-17865A	2017	303/5	Charcoal	9966 ± 55	−19.7 ± 0.4	11,691–11,247	
RCF2 (2018)	LTL-17866A	2017	303/5	Charcoal	11,054 ± 80	−25.8 ± 0.3	13,104–12,770	
RCF3 (2018)	LTL-17867A	2017	301	Charcoal	6190 ± 45	−24.4 ± 0.8	7245–6954	
RCF4 (2018)	LTL-17868A	2017	301	Charcoal	6807 ± 45	−20.8 ± 0.4	7575–7721	

Note: Radiocarbon determinations were obtained by AMS (accelerator mass spectrometry) at CEDAD (Centro di Datazione e Diagnostica, University of Salento, Brindisi, Italy); decontamination using the ABA method; calibration by D. Angelucci by means of CALIB 8.2 (Stuiver et al., 2020; accessed 26 August 2020), using the INTCAL13 data set (Reimer et al., 2013).

Abbreviations: coll., year of the collection; (*), after Duches et al. (2019).

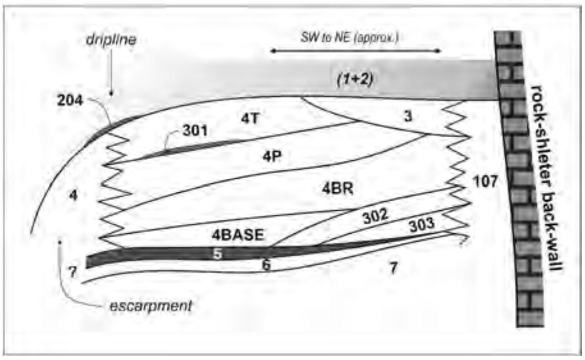

FIGURE 6 Cornafessa rock shelter: A simplified sketch of the stratigraphic layout, showing physical relationships between units excavated up to 2019 (not to the scale, with vertical exaggeration and approximate thickness; elaboration by D. Angelucci and R. Duches).

TABLE 4 Cornafessa rock shelter—List of micromorphological samples

#	Number	Year	Provenance	Unit(s)
1	RCF1701	2017	Cross-Section 1, sq. 52E	7
2	RCF1702	2017	Cross-Section 1, sq. 52E	7
3	RCF1703	2017	Cross-Section 1, sq. 51E	4
4	RCF1704	2017	Rock shelter wall	(bedrock)
5	RCF1706	2017	Excavation surface, sq. 51G	5A + 7
6	RCF1707	2017	Excavation surface, sq. 52G	5A + 7
7	RCF1708	2017	Excavation surface, sq. 51F	5B

Thin sections were observed under polarising microscopes in the LaBAAF (*Laboratorio Bagolini Archeologia, Archeometria, Fotografia*, University of Trento) at magnifications between ×20 and ×1000, using plane-polarised light (PPL), crossed-polarised light (XPL) and oblique incident light (OIL), the last of these for observation in

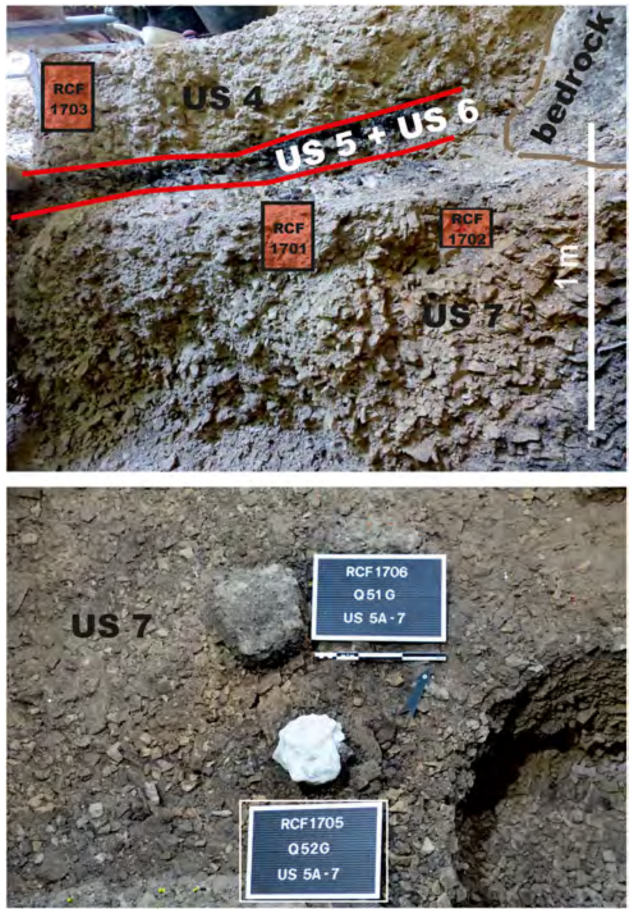

FIGURE 7 Cornafessa rock shelter: Position of undisturbed samples. Above: position of samples RCF1701 (unit 7), RCF1702 (unit 7) and RCF1703 (unit 4), cross-section 1. Below: samples RCF1705 and RCF1706 (units 5A and 7) during collection from the excavation surface; the stony layer below the samples is unit 7. Sample RCF1705 had to be discarded after removal. US, unit of stratification (pictures by D. Angelucci and E. Patauner, elaboration by D. Angelucci). [Color figure can be viewed at wileyonlinelibrary.com]

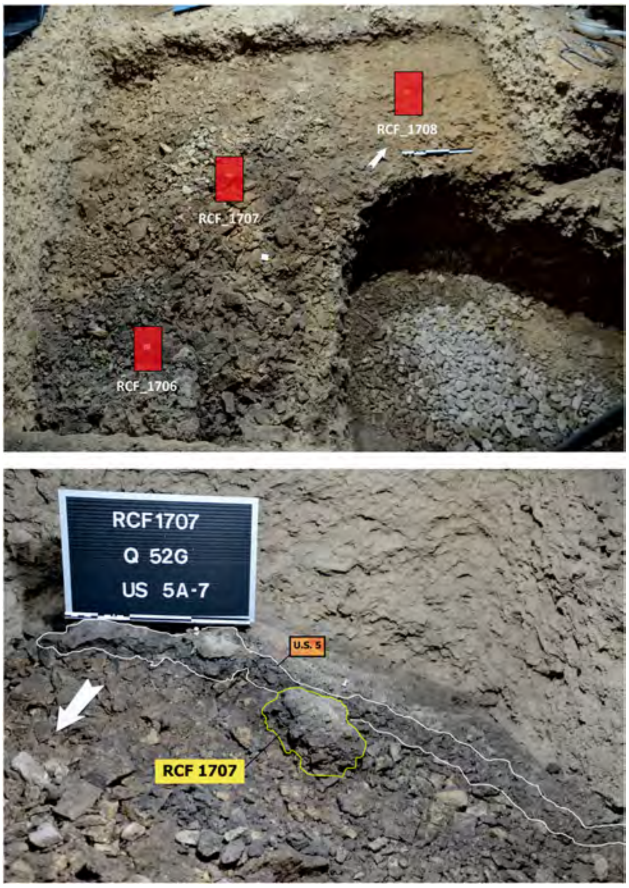

FIGURE 8 Cornafessa rock shelter: Position of undisturbed samples. Above: Position of samples RCF1706, RCF1707 and RCF1708 (the surface in the picture corresponds to the top of unit 7). Below: The detail of sample RCF1707. Q, excavation grid square; US, unit of stratification (pictures by E. Patauner and Stefano Neri, elaboration by D. Angelucci). [Color figure can be viewed at wileyonlinelibrary.com]

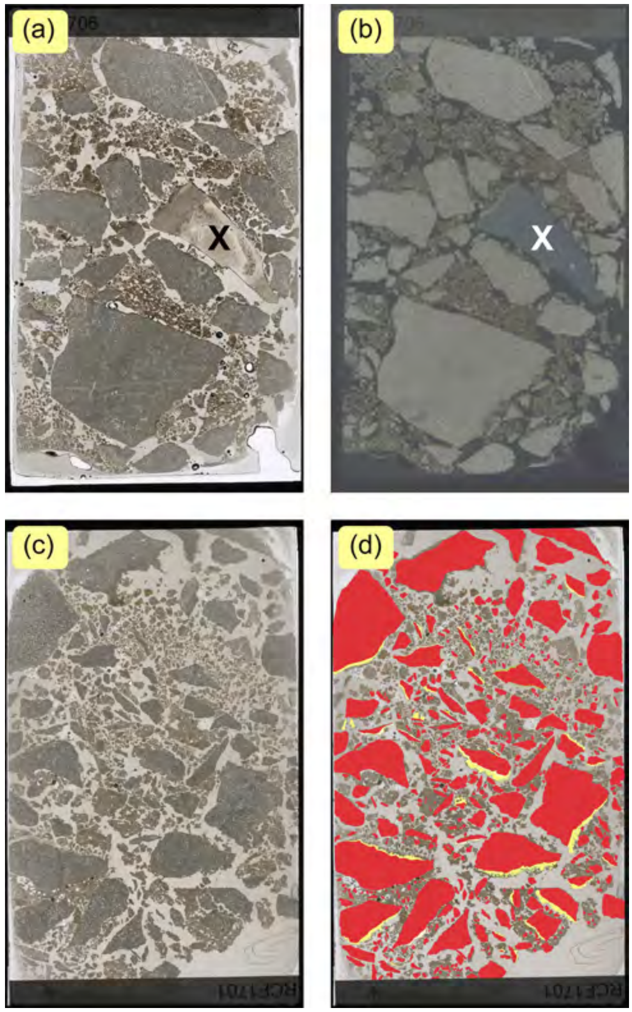

FIGURE 9 Cornafessa rock shelter: Scans of thin sections. (a) PPL scan of thin section RCF1706 (unit 5A). Notice high porosity, the abundance of angular fragments of limestone and a chert artefact ('X'). (b) Same as (a) but XPL (brightened + 25%). (c) PPL scan of thin section RCF1701 (unit 7). (d) Graphical elaboration of RCF1701 thin section; fragments of limestone are in red, while yellow colour indicates calcite pendants. Thin sections measure 9 cm × 5 cm and were scanned following the procedure described by Angelucci et al. (2017); scans by E. Patauner, Paolo Chistè and Maurizio Zambaldi, elaboration by E. Patauner. PPL, plane-polarised light; XPL, crossed-polarised light. [Color figure can be viewed at wileyonlinelibrary.com]

standard light condition and for primary fluorescence. Fluorescence observation was performed using two distinct wideband filter combinations: ultraviolet and blue (super wideband), with excitation filters at 330–335 and 420–480 nm, respectively, and suppression filters at 420 and 520 nm, respectively. Images were captured using a digital camera for polarising microscopy.

The description of the thin sections follows the guidelines proposed by Bullock et al. (1985) and Stoops (2003), with integrations for anthropogenic features from Nicosia and Stoops (2017) and Stoops et al. (2018).

4 | RESULTS

4.1 | Cornafessa rock shelter succession: Stratigraphic layout and main characteristics

The RCF's succession fills the overhang-protected area and shows characteristics matching the clastic infillings of southern European rock shelters (see Angelucci et al., 2019; Woodward & Goldberg, 2001). In this chapter, the main characteristics of the deposit and other aspects of interest (such as the site's morphology and bedrock and rock coatings developed over it) are described.

Seven US (units of stratification) were distinguished in the test sounding dug in 2014 (Figure 10). During the following seasons, further units were identified and labelled with three-digit numbers. The deposit can be divided into three main stratigraphic complexes: (1) the upper complex (US1 to US4) is made up of coarse clastic sediments that contain thin early Holocene archaeological intercalations and is topped by late-Holocene sediment enriched in organic

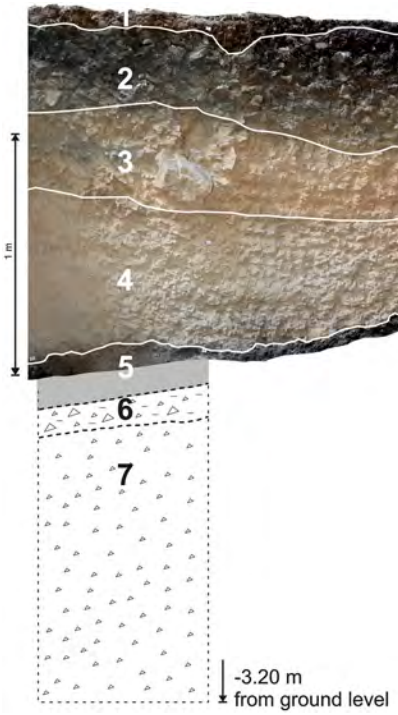

FIGURE 10 Cornafessa rock shelter: Composite cross-section of the 2015 test sounding and pit (elaboration by Stefano Neri and D. Angelucci). [Color figure can be viewed at wileyonlinelibrary.com]

matter, on which the present-day soil has developed; (2) the archaeological sediments accumulated during the YD occupation (US5 and related subunits), which form a complex paleosurface with juxtaposed lateral facies and (3) the lower deposit (US6 and US7), which consists of coarse detrital inputs, mostly from the shelter wall.

All the units show lateral variability, both parallel and perpendicular to the wall. Inward–outward variations of the sheltered area are mainly controlled by the dripline position. An erosive scarp (Figure 6) is found in correspondence to the shelter's dripline; along this line, a slope break was detected in all the units. This suggests that the dripline has been quite stable and has not retreated significantly since end-Pleistocene times. As the shelter's overhang is rather small (maximum distance from the dripline to the wall is *c.* 7 m), the stratification is markedly variable over short distances and dips slightly outwards (i.e., to the geographic SW), on average. At the same time, the deposit displays variations in a longitudinal direction (parallel to the wall), due to inputs coming from the slopes beside the shelter, which have fed the sheltered space with surface sediment through time. Still today, two asymmetrical colluvial fans can be detected at the NW and the SE of the site. This configuration of local microrelief is responsible for variations in the direction and angle of dip of the units on the site plan.

Despite the lateral variations, the succession at RCF is quite monotonous. Most of it consists of coarse detrital inputs from the wall ('*éboulis*', see below), while its vertical variability depends on several factors, namely, (a) the provenance of the coarse material, which may include a certain (usually low) quantity of constituents that do not come from the shelter wall (see below); (b) the shape and size of the coarse material, which is mostly formed of equant fragments but can incorporate platy elements, namely, frost slabs; (c) the surface characteristics of the coarse material, which can include features developed on the limestone while on the wall (such as rock coatings) and post-depositional pedofeatures such as coatings; (d) the quantity of the fine fraction (silt and clay), which may fill voids completely or only partly and (e) the characteristics of the fine fraction, namely, its composition and the relative proportion of distinct components (siliciclastic silt, calcium carbonate and organic matter).

The coarse detrital fraction (meaning the elements larger than 2 mm or 'skeleton') is abundant. All the units contain calcareous stones, mostly from the shelter bedrock, that is, limestone belonging to the geological formation *Calcari oolitici di San Vigilio* (see Figures 4 and 5). This consists mostly of light-to-medium grey calcarenite featuring abundant mm-sized ooids; these are easily recognised under the microscope and in hand samples, with the help of a hand lens.

The control sample collected from the wall (thin section RCF1704, see Figure 5) shows that the local bedrock is an oosparite. It consists of clast-supported, well-sorted calcareous particles, mostly 400–600 µm, embedded in sparite cement and includes oolites showing a layered inner structure, ooids with less-preserved structure (sometimes with microsparite cores wrapped within a micrite envelope, at times more or less elongated), oncoids, intraclasts and occasional fossils (more or less recrystallised). Loose ooids and other calcareous particles are also detected in the groundmass of the Quaternary sediment (Figure 5f).

The limestone fragments found in the deposit are mostly angular and equant, sometimes platy (for description purposes during thin section observation, limestone *éboulis* was labelled as *LST*). A comparison between these and the control sample RCF1704 shows that most limestone fragments come from the shelter wall. Along the dripline and outside of it, subordinate quantities of calcareous fragments derived from the *Rosso Ammonitico Veronese* and *Scaglia Rossa* formations are present. Determining the provenance of limestone clasts is quite straightforward in the Lessini region, due to the variability of the Meso-Cenozoic succession and its tabular setting, which allows easy assessment of the origin of the detrital fraction at archaeological sites. The calcareous formations around the site possess distinct characteristics, which range from white-to-very-light-grey calcilutite and marl (*Biancone* formation) to pink-to-red marly limestone with nodular structure (*Rosso Ammonitico Veronese* and *Scaglia Rossa*).

The limestone wall is covered by a hundred-micron-thick patina made up of micrite layers of bacterial and algal origin. This coating is also visible on the control sample RCF1704, as well as on isolated limestone fragments in the deposit (see below and Figure 11), in particular from units 4 and 5 (see below). Features of this kind are rock coatings related to weathering and surface accretion (Cremaschi et al., 2018), produced by an exo- or endolithic biofilm. Within the rock coatings, few fine (of the order of tens of µm, see Figure 11c,d), angular, opaque, organic particles are observed. Their characteristics allow them to be identified as soot particles trapped within the micrite coating. They are scattered within the rock coating and do not form any continuous black films of sooted concretions such as those reported by Vandevelde et al. (2018).

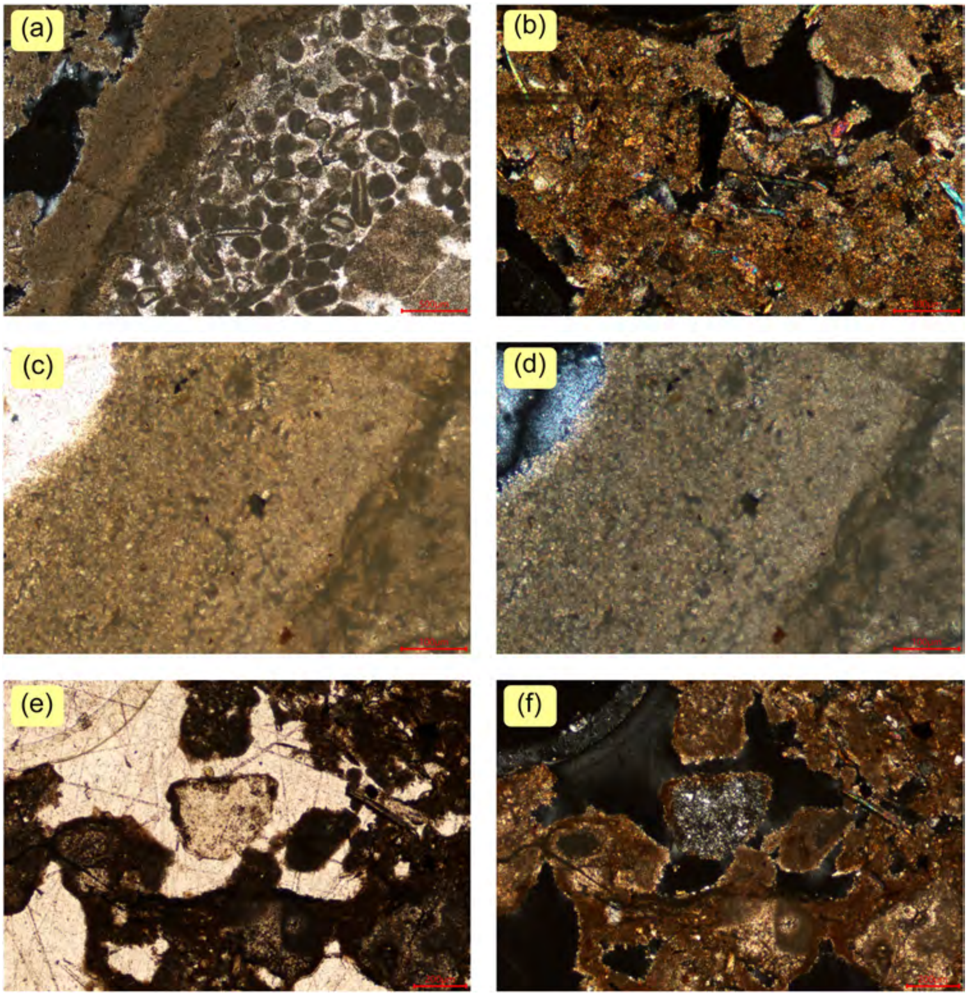

FIGURE 11 Cornafessa rock shelter: Micrographs of components. (a) Limestone fragment ('LST') from unit 4, with rock coating preserved (TS RCF1703, XPL, scale: 500 µm). (b) Groundmass of unit 5B, including siliciclastic ('SIL') components embedded in fine materials (TS RCF1708, XPL, scale: 100 µm). (c) Rock coating on limestone fragments; notice fine opaque angular particles (detail of the micrograph [a], TS RCF1703, PPL, scale: 100 µm). (d) Same as (c), but XPL. (e) Chert fragment (TS RCF1708, PPL, scale: 200 µm). (f) Same as (e) but XPL. Pictures by E. Patauner, elaboration by E. Patauner and D. Angelucci. PPL, plane-polarised light; XPL, crossed-polarised light. [Color figure can be viewed at wileyonlinelibrary.com]

Other rock types can be found in the sediment. Small (maximum cm-sized) chert fragments, sometimes looking like tiny flakes or *debitage* chips, are sometimes detected during excavation. Careful analysis of their lithology indicates that they do not derive from knapping but come from the chert nodules embedded in bedrock (see Figure 5). Their origin is the same as that of the limestone *éboulis*: fragments freed by wall disintegration, which suffered natural breakage upon hitting the ground, thus producing pseudo-artefacts; it should be noted that no artefact made from chert of the *Calcari oolitici di San Vigilio* has ever been recorded in the archaeological assemblage. Similar fragments of local chert are also detected in thin section, ranging from tens to hundreds of microns (Figure 11e,f).

Occasional small fragments of basalt-like volcanic rock are also found. Volcanic sills and dykes are common around the Lessini massif, and one dyke of basalt (*l.s.*) was detected about 100 m upslope of the rock shelter.

During fieldwork, it was observed that many units contain yellowish-brown silt featuring muscovite, which also outcrops around the rock shelter. Under the microscope, the silty loam fraction appears as siliciclastic materials containing quartz, feldspars, mica (mostly muscovite) and other silicate minerals (amphiboles and pyroxenes), systematically associated with yellowish-brown clay (Figure 11). The siliciclastic fraction (named *SIL* for description purposes) is usually scarce and often mixed with carbonate components from the wall (tiny fragments of limestone, individual ooids or oncoids…), as well as occasional small chert fragments.

The units with higher archaeological content and the horizons at the top of the succession feature abundant organic matter, mostly well-humified, rich in carbonate (according to their reaction with dilute hydrochloric acid), and combustion byproducts. Calcium-carbonate clayey silt similar to moonmilk was also described, in particular in unit 4 (see below).

4.2 | Description of the succession

4.2.1 | Upper complex

The post-YD succession includes units 1, 2, 3 and 4, as well as other units that were defined during excavation in 2018 and 2019 (US 204, 301, 302, 303 and others—see Figure 6).

Units 1 and 2 (see Table 5 for details) are superposed cumulative A horizons. They were formed as a result of continuous input of limestone fragments from the wall and the slope and concurrent accumulation and incorporation of organic matter. The units embed combustion byproducts, in particular charcoal microfragments and ash; although they have not been studied in detail so far, they seem to derive from recent (medieval and modern) charcoal production that took place at the site or nearby.

The bulk of the post-occupational succession at RCF is unit 4. This was identified as a single undifferentiated layer in 2015, but subsequent campaigns have shown that it can be split into subunits, sometimes separated by thin, discontinuous intercalations of archaeological horizons (see Figure 6). The unit is substantially homogeneous as far as its basic

TABLE 5 Cornafessa rock shelter—Field characteristics of excavated units

Unit	Main characteristics
1	Tabular unit, parallel to ground surface; lb clear linear to unit 2. Silty loam with few to common heterometric ang. & subang. lst frs. (from the wall, see text), often planar oriented; **10YR2.5/1; well-dev. fine granular structure**, mod. porosity; **abundant well-humified org. matter**, few roots; mod. calcareous; **cont. coatings of org. matter on lst frs.**; scarce very fine (mm-sized) charcoal frs.
2	Tabular unit, parallel to ground surface; lb clear linear to unit 3 or unit 4. Silty loam, with many stones: heterometric (max. size 80 cm, average 3–4 cm), ang. & subang. lst frs. (from the wall), mostly equant (some platy), sometimes planar-oriented; 10YR3.5/1; mod.-dev. fine granular structure, mod. porosity; mod. org., **no roots**; mod. calcareous; **discont. thin coatings of org. matter on lst frs**.
3	Lenticular unit near wall; lateral boundary gradual, poorly distinct, lb clear linear to unit 4. Silty loam, with many stones: heterometric (average 3–4 cm), ang. & subang. lst frs. (from the wall), **equant & platy**, **weak subhorizontal orientation pattern**; **10YR5/3**; **poorly dev. subangular blocky structure**, porosity low; no org. matter, no roots; weakly calcareous; contains muscovite (see text); **thin (clay?) coating on lst frs.**
4	Thick layer occupying whole overhang space; tabular, weakly dipping to (geographic) SW; lb sharp linear to unit 5; distinct facies (see below and text). Clast-supported calcareous breccia: ang. & subang., mostly equant (sometimes platy) lst frs. (from the wall); fine mat. fills all voids: **clayey silt, 1.25Y8/3, no org. matter, strongly calcareous** (see the text for details); apedal, porosity almost absent; no roots; **frequent calcium carb. pendants** on the lower side of lst frs.
	Subunit 4T. The part of unit 4 is stratigraphically situated over unit 301, showing the same characteristics as unit 4.
	Subunit 4P. The part of unit 4 is stratigraphically situated below unit 301 and above unit 4BR, showing the same characteristics as unit 4.
	*Subunit 4BR. The **lower part of unit 4, showing open-work support** (fine mat. almost absent) and a higher quantity of platy lst frs.*
	*Subunit 4BASE. The **bottom of unit 4**, showing the same characteristics as unit 4.*
5	Few-cm thick layer, thinning inwards and weakly dipping to SW; lb clear, slightly wavy. Unit 5 is the **main archaeological layer** and includes four lateral facies (see below); archaeologically, the richest subunit is facies 5A.
	*Subunit 5A. Lenticular layer with subcircular contour. Silty loam with abundant heterometric (mostly 2–10-cm-sized) ang. & subang., equant & platy (some are frost-slabs) lst frs. (from the wall, with few frs. from RAV formation), mainly random oriented with local planar orientation, some stones show calcite coating (see text); 10YR2/1; weakly dev. fine granular structure, porosity low; abundant org. matter; **thin iron-oxide coatings are common on the lower side of lst frs.;** common to abundant archaeological components: charcoal frs. (mm-to-cm-sized), lithic artefacts, faunal remains and bone tools*
	*Subunit 5B. Outcrops inwards of subunit 5A and was differentiated due to a **lower quantity of org. matter** and **distinct colour (10YR5/4).***
	*Subunit 5C. Outcrops outwards, along dripline, differentiated due to its **loose, partially open-work support***
	*Subunit 5D. Found near the wall, dips to W and closes due to lateral thinning. Same characteristics as unit 5A expect for: **colour** varies between 2.5Y3/1 and 2.5Y5/1; org. matter is common; lithic artefacts are oriented parallel to the upper interface (while stones are randomly oriented)*
6	Thin discont. layer, parallel to unit 5; lb clear, slightly wavy. Silty loam, stones as in unit 7; **colour varies between 7.5YR4/3.5 and 10YR5/2.5**; **weakly dev. fine granular structure**, porosity low; mod. org.
	*Subunit 6B. This is a cm-thin horizon, weakly dipping to geographic SW, found at the boundary between units 4 and 7 (where these units are in contact, due to the absence of layer 5), formed of compact, apedal, **bleached (5Y8/2) silty clay***
7	Bottom of succession; lb not observed; max. thickness 120 cm. Loose **partially open-work breccia**, with lst frs. from local bedrock, mostly ang., equant & platy (some are frost-slabs), orientation of clasts follows the upper interface (almost flat planar inwards, dipping to SW with the moderate angle along dripline and out of it); size of lst frs. increase downwards; apedal, **no org. matter**; **fine mat. is clayey silt, 2.5Y6/4**

Note: All units moist. Bold indicates distinctive or diagnostic characteristics.

Abbreviations: ang., angular; carb., calcium carbonate; cont., continuous; dev., developed; disc., discontinuous; fr(s)., fragment(s); hor., horizon; lb, lower boundary; loc., locally; lst, limestone; mat., material; mod., moderate\moderately; org., organic; RAV, Rosso Ammonitico Veronese limestone.

TABLE 6 Cornafessa rock shelter—Main micromorphological characteristics (I). Microstructure and components.

Unit	Aggr.	Porosity	Coarse components	Fine material
4	Granular mod. dev.	High (20%): common planes; few pvs, channels, chambers & vesicles	LST: heterometric (tens of µm to cm-sized), frequent, ang. & subang. (often with micrite rock coating), include occ. frs. of marly lst. (not from the wall). SIL: occ. (2%–3%). OTHER: occ. chert frs. (from the wall); occ. calcite (spar) crystals (from the wall). DP & OP random	Yellowish-brown (see the text)
5A	Intergrade granular to fine platy, mod. dev.	High (30%): common compound & complex pvs; few channel, chambers, infraggregate vughs	LST: frequent, heterometric, ang. & subang, mostly equant (platy are rare), showing DP in bands, some with micrite rock coating; include occ. frs. of marly lst. (not from the wall) and broken frs. of micrite crusts; SIL subordinate, c. 10%, quartz, feldspars and mica (muscovite); OTHER: frs. of natural chert; common charcoal frs., few shells and frs. of shell, few bones (some thermoaltered), occ. lithic artefacts	Brown to dark brown, with many punctuations
5B	Granular mod. dev.	High (20%): common pvs, channel & chambers; few infraggregate vughs & ice-lenses	LST: frequent, heterometric, ang. & subang, mostly equant (platy are rare), showing DP in bands, some with micrite rock coating; include occ. frs. of marly lst. (not from the wall) and broken frs. of micrite crusts; SIL subordinate, c. 10%, quartz, feldspars and mica (muscovite); OTHER: frs. of natural chert; few charcoal frs., occ. bones (some thermoaltered), occ. lithic artefacts	Yellowish-grey, dotted (punctuations)
7	Granular well dev.	High (25%–30%): common complex & compound pvs; few channels & chambers, ice lenses & vughs	LST: Heterometric (tens of µm to cm-sized), frequent, ang. & subang., both equant & platy, include single ooids, occ. frs. of marly lst. (not from the wall). SIL: few (c. 5%), mica almost absent. OTHER: occ. chert frs. (from the wall); occ. calcite (spar) crystals (from the wall); one single microcharcoal fr. DP & OP random	Yellowish-brown, dotted, with occ. org. punctuations

Note: Data from thin sections are as follows: Unit 4 from TS RCF1703. Unit 5A from TS RCF1706 and 1707. Unit 5B from TS RCF1708. Unit 7 from TS RCF1701 and 1702.

Abbreviations: aggr., aggregation; ang., angular; dev., developed; DP, distribution pattern; fr(s)., fragment(s); mod., moderately; occ.: occasional; OP, orientation pattern; pv(s)., packing void(s). Components (see the text for details): LST, limestone fragments; SIL, siliciclastic fraction.

TABLE 7 Cornafessa rock shelter—Main micromorphological characteristics (II). Groundmass and pedofeatures.

Unit	c/f RlDP	b-fabric	Pedofeatures and sedimentary features
4	Chitonic	cryst.	Common well-dev. pendants below LST; common silty-clay cts., also in form of cappings (on stones, often laminated) and 'rolling pedofeatures' (around stones); occ. very thin dusty-clay cts.
5A	Enaulic	cryst., poorly dev.	Common well-dev. laminated pendants below LST; common silt cappings; few thin discont. clay cts.
5B	Enaulic	cryst.	Common well-dev. laminated pendants below LST; common silt cappings; few thin discont. clay cts.
7	Enaulic	cryst.	Common well-dev. calcite pendants below lst frs., laminated, sometimes mammilated (see the text); few slightly dusty orange-to-red-coloured clay cts. in voids and on lst (in form of cappings); few micrite coating on ped surfaces; occ. fragmented clay cts.

Note: Data from thin sections are as follows: Unit 4 from TS RCF1703. Unit 5A from TS RCF1706 and 1707. Unit 5B from TS RCF1708. Unit 7 from TS RCF1701 and 1702.

Abbreviations: c/f RlDP, coarse/fine related distribution pattern; cont., continuous; cryst., crystallitic; ct(s)., coating(s); dev., developed; disc., discontinuous; fr(s)., fragment(s).

components are concerned (Table 5): it is clast-supported breccia, sometimes partially open-work, with angular, few-cm-sized, mostly equant fragments of local limestone, often showing the size and shape identical to the cleavage of the bedrock (see Figure 5b).

Under the microscope (see Tables 6 and 7 for details), the fragments of local bedrock (labelled *LST* during micromorphological observation) are easily recognised, and other occasional coarse components are also detected: the *SIL* fraction (see above) is rare (2%–3%), few splinters of chert from site bedrock and occasional crystals of the spar are present, as well as rare angular fragments of marl or marly limestone that do not come from the shelter. No coarse components that could be related to human inputs have been recognised in thin sections.

The fine material of unit 4 is bleached, very pale brown, clayey silt to silty clay, strongly calcareous (according to its reaction with dilute hydrochloric acid, which is strong and persistent), plastic when moist, sticky, often adhering to calcareous stones. Under the microscope, the fine material appears as a micro- to crypto-crystalline mass of calcite (*aka* micrite), showing yellowish-brown colour and well-developed crystallitic b-fabric (Figure 12a,b). This fine material corresponds to the so-called moonmilk (see Borsato et al., 2000 and references therein).

Secondary accumulation of calcium carbonate is detected throughout the unit, mostly as micrite pendants below calcareous stones, sometimes laminated, already visible to the naked eye in the field. Among pedofeatures, silty-clay coatings are also detected, often in form of thick capping or similar to so-called 'rolling-pedofeatures' (Angelucci & Zilhão, 2009; see Figure 12c,d).

Near the shelter wall, unit 3 is found, partly heteropic to US4. Unit 3 is mainly differentiated due to its poorly developed structure and the brown colour of fine materials (see Table 5 for description), which suggest that the unit has been slightly affected by soil formation as a B horizon during the Holocene.

4.2.2 | Epigravettian (YD) occupation layers

The Epigravettian occupation complex, unit 5, is composed of a set of usually thin, laterally heteropic layers, squeezed between the clastic breccias of units 4 and 7. Unit 5 is clearly dated to the YD (see above), and all its facies contain abundant anthropogenic components.

In 2014, unit 5 was originally identified as a black, strongly organic layer featuring lithic and bone artefacts, faunal remains and abundant charcoal fragments (see Table 5 for details). This corresponds to what was later labelled as subunit 5A, as further fieldwork showed that the deposit related to the YD occupation at RCF included distinct facies. Although the whole sheltered area has not been fully explored yet, it is clear that unit 5A forms a spatially restricted convex-shaped lens, which thins laterally and covers the outer escarpment of the site. Around unit 5A, other facies are found; they share the same abundance of remains but do not share the same characteristics. Three subunits have been distinguished: (a) US5B outcrops near the wall and contains less organic matter, thus being lighter in colour; (b) US5C is found outwards and is partially open-work, due to a lower quantity of fine material and (c) US5D is detected along the wall and shows mottling of fine material. The nature of these lateral variations is not known yet—more excavation and analyses are needed—but seems to depend on the human use of space.

Charcoal fragments and burnt remains are mostly concentrated in facies 5A and 5D, probably as a result of the scattering of hitherto undocumented primary hearths. The distribution of lithic artefacts and refitting suggest that the central inner area of the shelter was used for knapping and tool manufacturing, while bear remains are clustered within a restricted area (*c.* 1 m^2), interpreted as an accumulation of butchering waste (Zammarchi 2019–2020).

Micromorphological samples come from facies 5A and 5B. Both display granular aggregation that intergrades platy structure, high porosity and rather a loose aspect (Figure 9). Coarse components of the *LST* and *SIL* groups are common; the limestone fragments are often platy or covered by rock coatings (see above), and also include broken fragments of the coatings; the *SIL* fraction, while subordinate, is more common than in other units, reaching *c.* 10% of the groundmass (see Figure 11). Samples from these facies include a range of components that are absent in other units, such as few shells and fragments of shells (Figure 13a,b); few bones (Figure 13c,d), some of them heat-altered or with Fe–Mn coatings; occasional lithic artefacts (Figure 13e,f, see Angelucci, 2010);

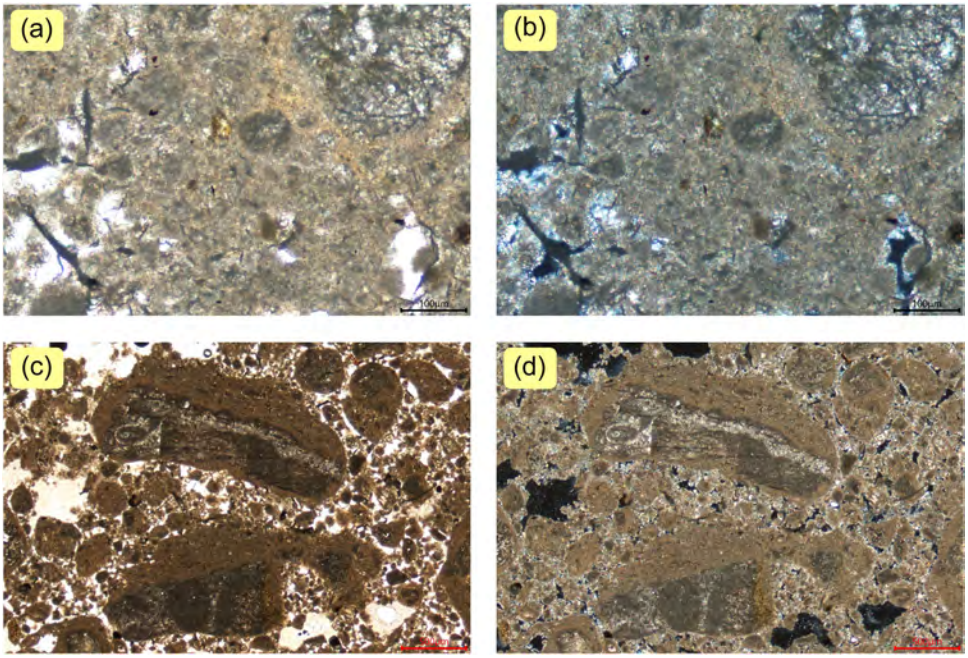

FIGURE 12 Cornafessa rock shelter: Micrographs from unit 4. (a) Fine material of the unit (TS RCF1703, PPL, scale: 100 µm). (b) Same as (a) but XPL. (c) Silt cappings on limestone fragments (TS RCF1703, PPL, scale: 500 µm). (d) Same as (c), but XPL. Pictures by E. Pateuner, elaboration by E. Patauner and D. Angelucci. PPL, plane-polarised light; XPL, crossed-polarised light. [Color figure can be viewed at wileyonlinelibrary.com]

common charcoal fragments, of variable size (Figure 14a) and possible residues of fat-derived char (Figure 14b, see Mallol, Mentzer, & Miller, 2017). The fine material in US5A is distinct from the other units (Figure 14c): it is brown to dark brown, with many organic punctuations giving a cloudy aspect. Under the microscope, unit 5B shows the same characteristics as 5A as far as its microstructure and components are concerned but exhibits a yellowish-grey fine material, with much less punctuations than unit 5A (see Table 6). Among pedofeatures, calcite pendants, silt cappings (Figure 14d) and thin clay coatings are found in both 5A and 5B.

4.2.3 | Lower succession

The lower part of the succession includes unit 6, a transitional layer and unit 7, a massive layer of calcareous breccia.

Unit 6 is a thin, silty loam horizon intercalated between units 5 and 7. Its characteristics (in particular its clear lower boundary, brown colour and poorly developed structure—see Table 5 for details) point to its genesis as a horizon, which was affected by slight, short-lived soil formation. In the positions where unit 5A is missing, US6 is absent as well, and units 4 and 7 lie in direct contact, making them almost undistinguishable due to their similar sedimentary characteristics. Still, careful field observation has shown that the contact between these units is marked by a thin horizon of bleached, pale yellow silty clay (unit 6B). Further information on this unit will be collected once the fieldwork at the site is resumed.

Unit 7 is partially open-work breccia (Figure 9), with limestone fragments mostly from local bedrock, angular, equant and platy (some of them are clearly frost-slabs), with scarce fine materials consisting of light-yellowish brown clayey silt. This layer is more than 1 m thick, does not show any major vertical variation, and its characteristics are quite similar to those of unit 4. Two thin sections were collected from unit 7 (see Tables 6 and 7). Under the microscope, other coarse components besides limestone *éboulis* were detected: occasional pieces of local chert and spar crystals, while the *SIL* fraction is very scarce (*c*. 5%). Only one single fragment of charcoal was observed. Among pedofeatures, calcite pendants are common and well formed: they show laminated structure, often with mammilated shape (see Figure 9). Other pedofeatures are scarce (clay coatings, some of them fragmented, and micrite coatings).

5 | DISCUSSION

5.1 | Formation processes at Cornafessa rock shelter

The first data collected from the succession at Riparo Cornafessa are of interest for reconstructing the climatic and environmental conditions of the Alps at the Pleistocene–Holocene transition and for understanding late Epigravettian hunter-gatherers' adaptation patterns.

The RCF's succession shows characteristics that are typical of southern European rock-shelter infillings formed in fluctuating,

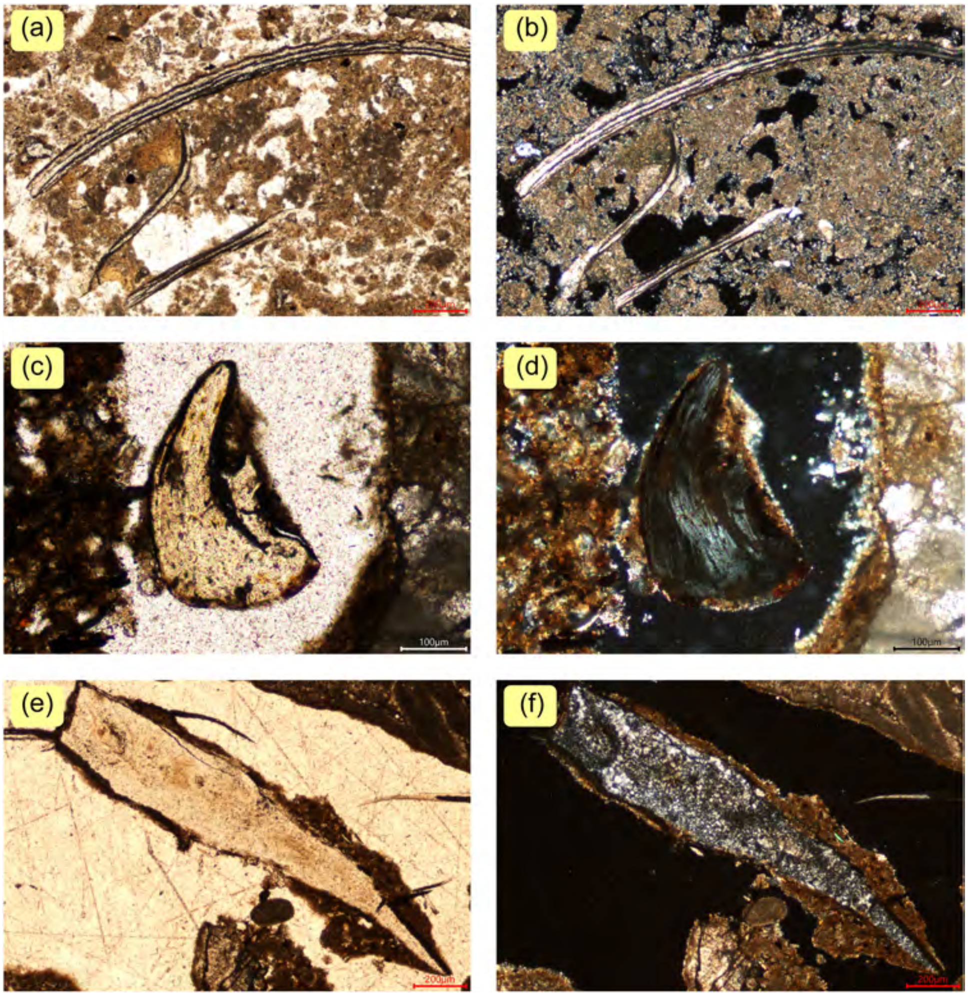

FIGURE 13 Cornafessa rock shelter: Micrographs of components from units 5A and 5B. 2. (a) Shell fragments from unit 5A (TS RCF1707, PPL, scale: 200 µm). (b) Same as (a) but XPL. (c) Bone fragment from unit 5A (TS RCF1706, PPL, scale: 100 µm). (d) Same as (c), but XPL. (e) Lithic artefact from unit 5B (TS RCF1708, PPL, scale: 200 µm). (f) Same as (e) but XPL. Pictures by E. Patauner, elaboration by E. Patauner and D. Angelucci. PPL, plane-polarised light; XPL, crossed-polarised light. [Color figure can be viewed at wileyonlinelibrary.com]

humid-temperate climatic contexts: crude stratification, the predominance of a coarse angular fraction with a variable quantity of fine interstitial material and poor textural sorting (see Angelucci et al., 2019; Mallol & Goldberg, 2017; Woodward & Goldberg, 2001).

Natural sedimentary inputs are mostly detrital and come from the shelter wall, while secondary carbonate precipitation is significant; these features make anthropic inputs easily recognisable both in the field and under the microscope. The sedimentary characteristics of the clastic units are quite uniform, as a result of the homogeneity of inputs and sources. Units 7 and 4, respectively, deposited before and after the main phase of site occupation, are clastic breccias composed of fragments from the roof and wall, with occasional splinters of local chert (see Figure 5). The size and shape of the *éboulis* are strikingly similar to the discontinuities in the bedrock (as shown above), which is an indicator of rapid degradation of the wall and a subsequent high rate of sedimentary accumulation within the shelter. Frost slabs are only occasionally present, despite the occurrence of other frost-related traces, especially in US7 (see below).

Natural clastic inputs mostly come from the shelter itself. Other inputs, both coarse and fine (respectively, the *Rosso Ammonitico Veronese* and *Scaglia Rossa* fragments and the *SIL* fraction, see above), were transported from a relatively short distance. The aforementioned rock formations outcrop upslope of the site, while the *SIL* fraction contains a mineralogical assemblage (quartz, feldspars, micas and other silicate minerals) that is virtually absent in the rocks of the Lessini massif. These minerals are commonly reported as components of soils and surface sediments of the southern Prealps' calcareous plateaux and were originally derived from aeolian inputs related to loess accumulation throughout the Pleistocene along the southern margin of the Alps (see Cremaschi, 1990). In this region, they are often detected as constituents of lateglacial and early Holocene archaeological stratifications in rock shelters (for instance, at Riparo Dalmeri and Riparo Cogola, see Angelucci et al., 2011; Angelucci & Bassetti, 2009). In such contexts, quartz and silicate minerals may even be affected by residual concentration, due to preferential

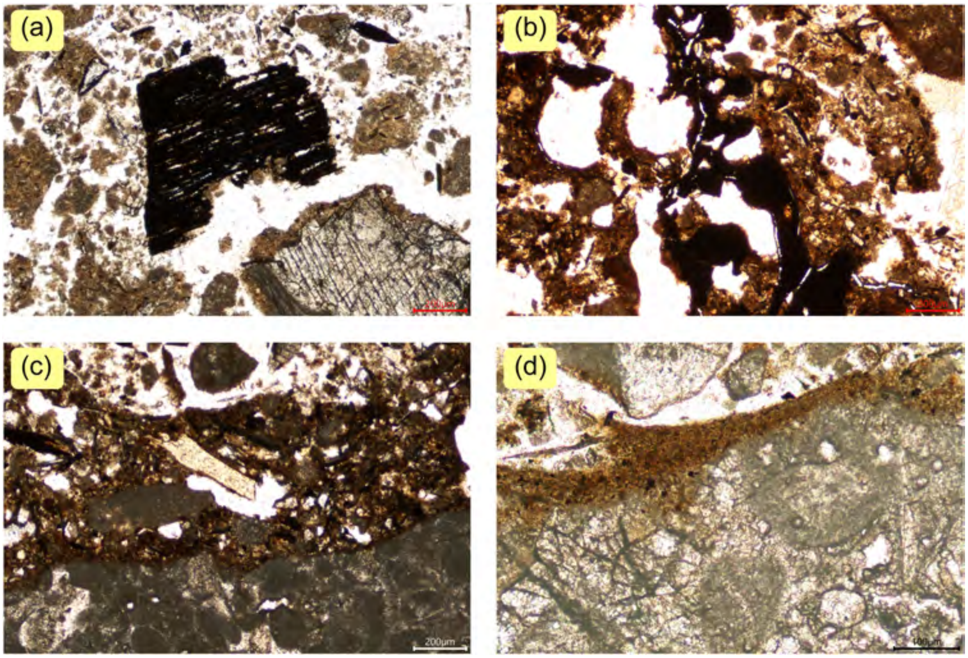

FIGURE 14 Cornafessa rock shelter: Micrographs from unit 5. (a) Charcoal fragment (TS RCF1707, PPL, scale: 200 µm). (b) Possible fat-derived char (TS RCF1706, PPL, scale: 200 µm). (c) Groundmass of unit 5 A (TS RCF1706, PPL, scale: 200 µm). (d) Silt capping on limestone fragments, containing many organic punctuations (TS RCF1706, PPL, scale: 100 µm). Pictures by E. Patauner, elaboration by E. Patauner and D. Angelucci. PPL, plane-polarised light; XPL, crossed-polarised light. [Color figure can be viewed at wileyonlinelibrary.com]

accumulation in rock shelters and cave entrances and their greater resistance to weathering dynamics compared with carbonate minerals. Both kinds of external clastic inputs point to phases during which the sedimentary sources of the RCF deposit were the surrounding slopes, thus indicating episodes of erosion and environmental instability—as usual, the rock shelter functioned as a 'sedimentary trap' with regard to the erosion taking place around it.

Unit 7 represents the scenario before human occupation at the site. Its age is unknown, although it can be supposed that it may date from the ALGM or the early lateglacial. The unit is made up of local constituents indicating the fast degradation of the shelter's wall and roof, with only occasional inputs from the surroundings (the *SIL* fraction is almost absent). As the main dynamic of sediment inwash into the shelter is runoff or surface flow, the lack of external inputs may depend on the absence of surface running water, thus reinforcing the possible attribution of this unit to the ALGM, during which the Lessini plateau suffered harsh climate conditions with the occurrence of permafrost (see Cremaschi, 1990).

An episode of surface stabilisation is probably recorded by unit 6, which has not been analysed yet. Future studies may clarify the nature of this unit that could perhaps date to the lateglacial interstadial and be associated with radiocarbon date LTL-17866A; the calendar age of which is about 13 ka cal. B.P. (see Table 3).

Unit 5 was identified in the field as an occupation surface, on the basis of its geometry and characteristics (in particular the abundance of organic matter, combustion byproducts and archaeological remains—both artefacts and ecofacts) and the preliminary results of the study of the archaeological assemblage, of refitting of lithic artefacts, spatial analysis and taphonomy on bones (see above). Under the microscope, constituents related to human activity such as lithic artefacts and charcoal fragments are detected in all thin sections of this unit. Other components of biological origin (bones, for instance) are most probably due to human inputs as well. At present, micromorphological information is only available for units 5A and 5B, and the nature of the lateral variations observed in the field to facies 5C and 5D has not yet been explained. Nonetheless, micromorphological data clearly indicate that units 5A and 5B are anthropogenic, while field evidence suggests that the lateral variability could be related to the use of space and the existence of distinct activity areas at the site. The data collected at present show that late Epigravettian people settled in the sheltered area, performed distinct activities (knapping and processing animal residues, for instance), organised the inner space, added phosphate, organic matter, artefacts and ecofacts and made use of fire (see also Duches et al., 2019).

According to the (geo)archaeological evidence, it is likely that human occupation at RCF was rather ephemeral during the YD. Unit 5A is thin and laterally discontinuous; at the same time, indirect traces, such as the soot trapped in the rock coatings, do not suggest intense use of fire at the site. Soot particles are found on the present-day wall and on limestone *éboulis* detached from the wall, and

TABLE 8 Younger Dryas sites in north-eastern Italy

nr.	Name of site	Type	Position	Elevation (m asl)	Dating	Reference
1	Cornafessa	Rock shelter	Edge of calc. plateau	1240	Yes	This paper
2	Riparo Soman	Rock shelter	Main valley	95	Yes	Battaglia et al. (1992)
3	Riparo la Cogola	Rock shelter	Calc. plateau	1070	Yes	Bassetti et al. (2008)
4	Palù Echen	Open air	Lake\wetland shore on calc. plateau	1260	Yes	Duches et al. (2014)
5	Arco via Serafini	Open air	Alluvial fan, main valley	80	Yes	Mottes et al. (2014)
6	Terlago	Open air	Calc. plateau	450	-	Dalmeri (1992)
7	Andalo	Open air	Lake shore, calc. plateau	1000	-	Guerreschi (1984)
8	Laget di Predaia	Open air	Calc. plateau	1430	-	Dalmeri et al. (2013)
9	Laghetto delle Regole	Open air	Lake\wetland shore	1236-9	Yes	Dalmeri et al. (2002)
10	Riparo Dalmeri	Rock shelter	Edge of calc. plateau	1240	Yes	Dalmeri et al. (2006)
11	Bus de la Lum	Open air	Calc. plateau	995	Yes	Peresani et al. (1999–2000)
12	Palughetto	Open air	Lake\wetland shore	1040	-	Peresani et al. (2011)
13	Piancavallo	Open air	Calc. plateau	1280		Guerreschi (1975)
14	Grotte Verdi di Pradis	Rock shelter	Calc. plateau	515	Yes	Nannini et al. (2022)
15	Riparo Biarzo	Rock shelter	Main valley	160	Yes	Bertolini et al. (2016)

Note: nr.: number (same as Figure 1); position: a short description of geomorphological context (calc.: calcareous); dating: indicates if radiocarbon dating is available and confirms Younger Dryas age (age of other sites is based on characteristics of lithic assemblages).

incorporated within the sediment (especially in units 4 and 5). The particles are scarce and scattered within the micrite matrix (see above). It is not possible, therefore, to draw a parallel with other cases reported in the literature, such as Grotte Mandrin or Balma de la Margineda (Vandevelde et al., 2018), where well-developed films of sooted concretions are recognised; this supports the evidence that human occupation at RCF was somewhat ephemeral. This hypothesis is also backed by data from the lithic and faunal assemblages; the small number of artefacts, the high rate of lithic refitting and the low MNI suggest, indeed, that the site was visited few times and briefly (Duches et al., 2019; Zammarchi 2019–2020).

The sedimentary characteristics of unit 5, in particular the abundance of *éboulis* deriving from rapid degradation of the shelter wall, which commonly includes frost slabs, and the pedofeatures detected under the microscope, such as the silt cappings on coarse components, point to an environmental context with significant frost action. Thus the YD occupation at RCF must have taken place in a relatively cold, moist climatic context.

The YD occupation surface is sealed by unit 4, which is similar to US7: a detrital layer of *éboulis* fallen from the wall, pointing to fast bedrock degradation. The accumulation of such a thick layer has favoured the preservation of the YD archaeological evidence of the underlying unit 5. The unit locally features thin intercalations of archaeological sediments that yielded Mesolithic assemblages and early Holocene radiocarbon dates (see Table 3). The coarse fraction of this unit indicates a relatively cold climatic context, as also suggested by the evidence of frost action (capping, in particular). The fine material of unit 4, most probably deposited as interstitial accumulation once the *éboulis* was already in place, is moonmilk (see above). According to Borsato et al. (2000, pp. 1177–1178), who analysed caves from similar geological contexts in the same region, moonmilk formation occurs with a mean annual temperature below 8°C, preferentially below the present-day timberline, with 100% relative humidity and is not active today. These data suggest that the occurrence of moonmilk in unit 4 may date from the mid-Holocene optimum, probably as a result of higher temperature (or even moisture levels) at the site.

The upper units of the succession (units 3, 2 and 1) attest to the stabilisation of the shelter's surface in later times, with soil formation and accumulation of human inputs during historical times.

6 | CONCLUDING REMARKS

Archaeological sites featuring evidence of YD human occupation are rather scarce in the Southern Alps. For this reason, the data from Cornafessa rock shelter, even if partial and awaiting expansion through future fieldwork and further analyses, may help to shed light on the settlement and behavioural patterns of late Epigravettian hunter-gatherers and on the Pleistocene–Holocene transition in the Alps.

In the eastern sector of the Southern Alps, 15 YD sites, scattered over an area of *c.* 30,000 km^2, are presently known (Figure 1). The relative scarcity of sites with evidence of YD\late Epigravettian occupation is in contrast with the abundant record available for both the lateglacial interstadial and the early Holocene in the same region (Angelucci & Bassetti, 2009).

In this sector of the Alps, YD sites are found in distinct geomorphological and environmental contexts and at different elevations (see Table 8). Three sites are located at low elevation, along three of the main valleys in the Alpine foothills, not far from the southern Alpine margin (namely, Riparo Soman, in the Adige\Etsch Valley, nr. 2; Arco via Serafini, in the Sarca Valley, nr. 5; and Riparo Biarzo, in the Natisone Valley, nr. 15). Two of these are set at relatively low altitudes, on calcareous plateaux (Terlago, at 450 m asl, nr. 6; Grotte Verdi di Pradis, at 515 m, nr. 14). Ten sites were established between *c.* 1000 and 1400 m, most probably to explore resources of the ecotone between forest and grassland ecosystems, close to the YD treeline (see above). Most of the upland sites are on gently sloping or flat ground, more often on limestone plateaux and sometimes on lake shores or in nearby wetlands (Table 8). Among the sites at a higher elevation, two show striking similarities to RCF with regard to their geomorphological context and ecological situation: Riparo Dalmeri (1240 m asl) and Riparo Cogola (1070 m asl). Riparo Dalmeri (1240 m, see Angelucci & Peresani, 2001; Dalmeri et al., 2006) yielded an impressive lateglacial interstadial record, which includes occupation surfaces covering the whole sheltered area. Evidence of YD occupation is restricted to a narrow strip along the shelter's dripline, with relatively few remains (Angelucci et al., 2011). Together with Riparo Soman (see Figure 1), Riparo Dalmeri is one of the very few sites that record both lateglacial interstadial and YD occupations in this sector of the Alps. Riparo Cogola (1070 m, see Bassetti et al., 2008) features a late-Epigravettian living floor, as well as evidence of early Mesolithic occupation, which is rather unusual across the Pleistocene–Holocene transition in this region because early Mesolithic groups seldom occupied the same places as their Epigravettian forebears. The three sites of Riparo Cornafessa, Riparo Dalmeri and Riparo Cogola are situated on calcareous plateaux, not far from their edges, near outcrops of good-quality chert, and take the form of large rock shelters with wide entrances that are relatively restricted in depth. In addition, they were occupied in the YD during short, ephemeral visits, on rather small surface areas, measuring *c.* 20 m² (see also Mussi & Peresani, 2011; Table 3).

The data from Cornafessa rock shelter thus support the evidence that late-Epigravettian groups frequented the mid-altitude belt of the Southern Alps during the YD. On a regional scale, Cornafessa is also significant because it is one of the very few sites that was resettled by Mesolithic hunter-gatherers during the early Holocene. Future fieldwork and data will help to clarify the nature and function of both the lateglacial and early Holocene occupation at the site.

AUTHOR CONTRIBUTIONS

Diego E. Angelucci: Conceptualisation, investigation (data collection and elaboration), writing (original draft preparation, review and editing) and supervision (corresponding author). **Erica Pataune**r: Investigation (data collection and elaboration), writing (review and editing). **Rossella Duches**: Investigation (data collection), writing (review and editing) and funding acquisition.

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CONFLICT OF INTEREST

The authors declare no conflict of interest.

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REFERENCES

Ammann, B., & Oldfield, F. (Eds.) (2000). Rapid-warming project. *Palaeogeography, Palaeoclimatology, Palaeoecology*, *159*(3–4), 191–366.

Angelucci, D. E. (1998). Sistemi insediativi e spazi domestici nel Paleolitico superiore e nel Mesolitico: alcune osservazioni sul caso dell'Italia Nord-Orientale. In L. Castelletti, & A. Pessina, A. (Eds.), *Introduzione all'archeologia degli spazi domestici* (pp. 11–34). Museo Civico Archeologico "Giovio".

Angelucci, D. E. (2002). Il sito preistorico di Lugo di Grezzana (VR): Prime osservazioni micromorfologiche. *Preistoria Alpina*, *38*, 109–129.

Angelucci, D. E. (2010). The recognition and description of knapped lithic artifacts in thin section. *Geoarchaeology*, *25*, 220–232.

Angelucci, D. E. (2022). *Elementi di geoarcheologia. Minerali, sedimenti, suoli*. Carocci.

Angelucci, D. E., Anesin, D., Bassetti, M., Bernardo, A., Neri, S., & Dalmeri, G. (2011). La successione esterna del Riparo Dalmeri (Trento, Italia). Prime informazioni geoarcheologiche. *Preistoria Alpina*, *45*, 127–146.

Angelucci, D. E., & Bassetti, M. (2009). Humans and their landscape from the Alpine Last Glacial Maximum to the Middle Holocene in Trentino: Geoarchaeological considerations. *Preistoria Alpina*, *44*, 59–78.

Angelucci, D. E., Chistè, P., Mologni, C., Cappellari, E., Vitti, A., & Zatelli, P. (2017). Automatic segmentation of thin sections with GRASS GIS: First experiments. *Geomatic Workbooks*, *13*(2017), 77–90.

Angelucci, D. E., & Peresani, M. (2001). The sedimentary sequence of Riparo Dalmeri (Grigno, Valsugana, TN): Pedostratighraphic and micromorphological features. *Preistoria Alpina*, *34*(1998), 155–162.

Angelucci, D. E., Zambaldi, M., Tessari, U., Vaccaro, C., Arnaud, J., Berruti, G. L. F., Daffara, S., & Arzarello, M. (2019). New insights on the Monte Fenera Palaeolithic. *Geoarchaeology*, *34*, 413–429.

Angelucci, D. E., & Zilhão, J. (2009). Stratigraphy and formation process of the Upper Pleistocene deposit at Gruta de Oliveira, Almonda karstic system, Torres Novas, Portugal. *Geoarchaeology*, *24*, 277–310.

Baroni, C., Casale, S., Salvatore, M. C., Ivy-Ochs, S., Christl, M., Carturan, L., Seppi, R., & Carton, A. (2017). Double response of glaciers in the Upper Peio Valley (Rhaetian Alps, Italy) to the Younger Dryas climatic deterioration. *Boreas*, *46*, 783–798.

Baroni, C., Gennaro, S., Salvatore, M. C., Ivy-Ochs, S., Christl, M., Cerrato, R., & Orombelli, G. (2021). Last Lateglacial glacier advance in the Gran Paradiso Group reveals relatively drier climatic conditions established in the Western Alps since at least the Younger Dryas. *Quaternary Science Reviews*, *255*, 106815. https://doi.org/10.1016/j.quascirev.2021.106815

Bassetti, M., Ferraro, F., & Peresani, M. (2008). Analisi sedimentologica e micromorfologica delle unità epigravet tiane di Riparo Cogola—Carbonare di Folgaria (Trento). *Preistoria Alpina*, *43*, 25–47.

Battaglia, L., Broglio, A., Castelletti, L., Lanzinger, M., & Maspero, A. (1992). Abri Soman. *Preistoria Alpina*, *28*(2), 291–298.

Bertola, S., Broglio, A., Cassoli, P., Cilli, C., Cusinato, A., Dalmeri, G., De Stefani, M., Fiore, I., Fontana, F., Giacobini, G., Guerreschi, A., Gurioli, F., Lemorini, C., Liagre, J., Malerba, G., Montoya, C., Peresani, M., Rocci Ris, A., Rossetti, P., … Ziggiotti, S. (2007). L'Epigravettiano recente nell'area prealpina e alpina orientale. In F. Martini (Ed.), *L'Italia tra 15.000 e 10.000 anni fa, Cosmopolitismo e regionalità nel Tardoglaciale* (pp. 39–94). Museo Fiorentino di Preistoria "Paolo Graziosi".

Bertolini, M., Cristiani, E., Modolo, M., Visentini, P., & Romandini, M. (2016). Late Epigravettian and Mesolithic foragers of the eastern Alpine region: Animal exploitation and ornamental strategies at Riparo Biarzo (Northern Italy). *Quaternary International*, *423*, 73–91.

Bietti, A. (1985). Analyse des données de l'Epigravettien en Italie, Considération générale sur la classification traditionnelle de l'Epigravettien en Italie continentale. In M. Otte (Ed.), *La signification culturelle des industries lithiques* (pp. 15–38). Actes du colloque de Liège (3–7 of October, 1984), British Archaeological Reports, 239.

Borsato, A., Frisia, S., Jones, B., & van der Borg, K. (2000). Calcite moonmilk: Crystal morphology and environment of formation in caves in the Italian Alps. *Journal of sedimentary research*, *70*(5), 1171–1182.

Broecker, W. S., Denton, G. H., Edwards, R. L., Cheng, H., Alley, R. B., & Putnam, A. E. (2010). Putting the Younger Dryas cold event into context. *Quaternary Science Reviews*, *29*, 1078–1081.

Broglio, A. (1997). Considérations sur l'Epigravettien italien. In J. M. Fullola, & N. Soler (Eds.), *El môn méditerrani desprès del Pleniglacial (18.000–12.000 BP)* (pp. 147–158). Centre d'investigations arqueològiques.

Broglio, A. (2002). Paleolitico e Mesolitico. In A. Aspes (Ed.), *Preistoria Veronese. Contributi e aggiornamenti*. Museo Civico di Storia Naturale di Verona.

Broglio, A., Laplace, G., & Zorzi, F. (1963). I depositi quaternari del Ponte di Veja. Le industrie. *Memorie Museo Civico Storia Naturale di Verona*, *11*, 325–367.

Bullock, P. N., Fedoroff, N., Jongerius, G. J., Stoops, G., Tursina, T., & Babel, U. (Eds.) (1985). *Handbook for soil thin section description*. Waine Research Publishers.

Carraro, F., Malaroda, R., Piccoli, G., Sturani, C., & Venzo, S. (1969). *Note illustrative della Carta geologica d'Italia alla scala 1:100.000. Foglio 48—Peschiera del Garda*. Servizio Geologico d'Italia.

Castellarin, A., Corsi, M., De Vecchi, G. P., Gatto, G. O., Largaiolli, T., Mozzi, G., Piccoli, G., Sassi, F. P., Zanettin, B., & Zirpoli, G. (1968). *Note illustrative della Carta geologica d'Italia alla scala 1:100.000. Foglio 36—Schio*. Servizio Geologico d'Italia.

Castellarin, A., Vai, G. B., & Cantelli, L. (2006). The Alpine evolution of the Southern Alps around the Giudicarie faults: A Late Cretaceous to Early Eocene transfer zone. *Tectonophysics*, *414*, 203–223.

Cavulli, F., Angelucci, D. E., & Pedrotti, A. (2002). La successione stratigrafica di Lugo di Grezzana. *Preistoria Alpina*, *38*, 89–107.

Cheng, H., Zhang, H., Spötl, C., Baker, J., Sinha, A., Li, H., Bartolomé, M., Moreno, A., Kathayat, G., Zhao, J., Dong, X., Li, Y., Ning, Y., Jia, X., Zong, B., Ait Brahim, Y., Pérez-Mejías, C., Cai, Y., Novello, V. F., … Edwards, R. L. (2020). Timing and structure of the Younger Dryas event and its underlying climate dynamics. *Proceedings of the National Academy of Sciences of the United States of America*, *117*, 23408–23417. https://doi.org/10.1073/pnas.2007869117

Cremaschi, M. (Ed.) (1990). *The loess in Northern and Central Italy: A loess basin between the Alps and the Mediterranean region*. Quaderni di Geodinamica Alpina e Quaternaria, 1. Centro di studio per la stratigrafia e petrografia delle Alpi centrali, Consiglio Nazionale delle Ricerche.

Cremaschi, M., Trombino, L., & Zerboni, A. (2018). Palaeosoils and relict soils: A systematic review. In G. Stoops, V. Marcelino, & F. Mees (Eds.), *Interpretation of micromorphological features of soils and regoliths* (2nd ed., pp. 863–894). Elsevier.

Dalmeri, G. (1992). Ricerche nel sito Tardopaleolitico-Mesolitico di Terlago (Trentino). Tracce di strutture di abitato. *Natura Bresciana*, *28*, 433–461.

Dalmeri, G., Bassetti, M., Cusinato, A., Kompatscher, K., & Hrozny Kompatscher, M. (2002). Laghetto della Regola di Castelfondo (Trento). Primi risultati delle ricerche paletnologiche e paleoambientali. *Preistoria Alpina*, *38*, 35–65.

Dalmeri, G., Bassetti, M., Cusinato, A., Kompatscher, M. H., & Kompatscher, K. (2006). Le site Épigravettien de l'Abri Dalmeri: aspects artistiques à la fin du Paléolithique supérieur en Italie du nord. *L'Anthropologie*, *110*(4), 510–529.

Dalmeri, G., Duches, R., Kompatscher, K., Kompatscher, N., Flor, E., & Neri, S. (2013). Laget di Predaia (Tres-TN), primo rapporto sulle campagne di scavi 2011-2012. *Preistoria Alpina*, *47*, 325–328.

Duches, R., Avanzini, M., Bassetti, M., Flor, E., Neri, S., & Dalmeri, G. (2014). Évolution de la mobilité épigravettienne durant le Dryas récent: quelles nouvelles informations pour l'Italie nord-orientale. In M. Langlais, N. Naudinot, & M. Peresani (Eds.), *Les groupes culturels de la transition Pléistocène-Holocène entre Atlantique et Adriatique (24-25 Mai 2012)* (pp. 185–203). Actes de la Séance de la Société Préhistorique Française Bordeaux 3.

Duches, R., Nannini, N., Fontana, A., Boschin, F., Crezzini, J., Bernardini, F., Tuniz, C., & Dalmeri, G. (2019). Archeological bone injuries by lithic backed projectiles: new evidence on bear hunting from the Late Epigravettian site of Cornafessa rock shelter (Italy). *Archaeological and Anthropological Sciences*, *11*(5), 2249–2270.

Duches, R., Nannini, N., Romandini, M., Boschin, F., Crezzini, J., & Peresani, M. (2016). Identification of Late Epigravettian hunting injuries: Descriptive and 3D analysis of experimental projectile impact marks on bone. *Journal of Archaeological Science*, *66*, 88–102.

Duches, R., Peresani, M., & Pasetti, P. (2018). Success of a flexible behavior. Considerations on the manufacture of Late Epigravettian lithic projectile implements according to experimental tests. *Archaeological and Anthropological Sciences*, *10*(7), 1617–1643.

Fiore, I., & Tagliacozzo, A. (2005). Lo sfruttamento delle risorse animali nei siti di altura e di fondovalle nel Tardiglaciale dell'Italia nord-orientale. In G. Malerba, & P. Visentini (Eds.), *Atti del 4° Convegno Nazionale di Archeozoologia* (pp. 97–109). Museo Archeologico del Friuli Occidentale.

Fontana, F., Cilli, C., Cremona, M. G., Giacobini, G., Gurioli, F., Liagre, J., Malerba, G., Rocci Ris, A., Veronese, C., & Guerreschi, A. (2009). Recent data on the Late Epigravettian occupation at Riparo Tagliente, Monti Lessini (Grezzana, Verona): A multidisciplinary perspective. *Preistoria Alpina*, *44*, 1–6.

Fontana, F., Falceri, L., Gajardo, A., Bertola, S., Cremona, M. G., Cavulli, F., Guerreschi, A., & Visentin, D. (2018). Re-colonising the Southern Alpine fringe: Diachronic data on the use of sheltered space in the late Epigravettian site of Riparo Tagliente. In V. Borgia, & E. Cristiani (Eds.), *Palaeolithic Italy. Advanced studies on early human adaptations in the Apennine peninsula* (pp. 287–310). Sidestone Press Academics.

Frisia, S., Borsato, A., Spötl, C., Villa, I. M., & Cucchi, F. (2005). Climate variability in the SE Alps of Italy over the past 17 000 years reconstructed from a stalagmite record. *Boreas*, *34*(4), 445–455.

Frisia, S., Filippi, M. L., & Borsato, A. (2005). Evoluzione climatico-ambientale in Trentino dal Tardoglaciale all'Olocene: sintesi delle conoscenze alla luce dei risultati emersi dai progetti AQUAPAST e OLOAMBIENT. *Studi Trentini di Scienze Naturali, Acta Geologica*, *82*, 325–330.

von Grafenstein, U., Erlenkeuser, H., Brauer, A., Jouzel, J., & Johnsen, S. (1999). A Mid-European decadal isotope-climate record from 15,500 to 5000 years B.P. *Science*, *284*, 1654–1657.

Guerreschi, A. (1975). L'Epigravettiano di Piancavallo (Pordenone). *Preistoria Alpina*, *11*, 155–193.

Guerreschi, A. (1984). Il sito epigravettiano di Andalo (Trento) ed alcune considerazioni sull'Epigravettiano finale nel nord Italia. *Preistoria Alpina*, *20*, 15–30.

Heiri, O., Brooks, S. J., Renssen, H., Bedford, A., Hazekamp, M., Ilyashuk, B., Jeffers, E. S., Lang, B., Kirilova, E., Kuiper, S., Millet, L., Samartin, S., Toth, M., Verbruggen, F., Watson, J. E., van Asch, N., Lammertsma, E., Amon, L., Birks, H. H., … Lotter, A. F. (2014). Validation of climate model-inferred regional temperature change for late glacial Europe. *Nature Communications*, *5*, 4914.

Ivy-Ochs, S., Kerschner, H., Maisch, M., Christl, M., Kubik, P. W., & Schlüchter, C. (2009). Latest Pleistocene and Holocene glacier variations in the European Alps. *Quaternary Science Reviews*, *28*, 2137–2149.

Lotter, A. F., Birks, H. J. B., Eicher, U., Hofmann, W., Schwander, J., & Wick, L. (2000). Younger Dryas and Allerød summer temperatures at Gerzensee (Switzerland) inferred from fossil pollen and cladoceran assemblages. *Palaeogeography, Palaeoclimatology, Palaeoecology*, *159*(3–4), 349–361.

Mallol, C., & Goldberg, P. (2017). Cave and rock shelter sediments. In C. Nicosia, & G. Stoops (Eds.), *Archaeological soil and sediment micromorphology* (pp. 359–381). Wiley.

Mallol, C., Mentzer, S. M., & Miller, C. E. (2017). Combustion features. In C. Nicosia, & G. Stoops (Eds.), *Archaeological soil and sediment micromorphology* (pp. 299–330). Wiley.

Margaritora, D., Dozio, A., Chelidonio, G., Turrini, M. G., & Peresani, M. (2020). The Lower and Middle Palaeolithic settlements in the Baldo-Lessini mountains. Results from a GIS investigation. *Alpine and Mediterranean Quaternary*, *33*(1), 115–132.

Monegato, M., Scardia, G., Hajdas, I., Rizzini, F., & Piccin, A. (2017). The Alpine LGM in the boreal icesheets game. *Scientific Reports*, *7*, 2078. https://doi.org/10.1038/s41598-017-02148-7

Mottes, E., Bassetti, M., & Gavioli, J. (2014). Sito all'aperto dell'Epigravettiano recente e del Mesolitico antico ad Arco via Serafini. *ada - Archeologia delle Alpi*, *2014*, 203–205.

Mussi, M., & Peresani, M. (2011). Human settlement of Italy during the Younger Dryas. *Quaternary International*, *242*(2), 360–370.

Nannini, N. (2018–2019). *Tra archeozoologia, paleobalistica e antropologia. Lettura degli impatti delle armi da getto epigravettiane su resti faunistici nel Tardoglaciale dell'Italia nord-orientale* [PhD Thesis (supervisor M. Peresani, co-supervisors R. Duches, M. Romandini and A. Fontana), Università di Ferrara, Modena e Reggio Emilia].

Nannini, N., Duches, R., Fontana, A., Romandini, M., Boschin, F., Crezzini, J., & Peresani, M. (2022). Marmot hunting during the Upper Palaeolithic: The specialized exploitation at Grotte di Pradis (Italian pre-Alps). *Quaternary Science Reviews*, *277*, 107364. https://doi.org/10.1016/j.quascirev.2021.107364

Naudinot, N., Tomasso, A., Messager, E., Finsinger, W., Ruffaldi, P., & Langlais, M. (2017). Between Atlantic and Mediterranean: Changes in technology during the Late Glacial in Western Europe and the climate hypothesis. *Quaternary International*, *428*(Part B), 33–49.

Nicosia, C. & Stoops, G. (Eds.) (2017). *Archaeological soil and sediment micromorphology*. Wiley.

Palma di Cesnola, A. (2001). *Le Paléolithique supérieur en Italie*. Jérome Millon.

Patauner, E. (2019–2020). *Ricostruzione dei processi formativi di Riparo Cornafessa (Ala, TN). Indagini micromorfologiche* [Master Thesis (supervisor D.E. Angelucci, co-supervisors R. Duches and M. Zambaldi), Università di Ferrara, Modena-Reggio, Verona and Trento].

Peresani, M. (2012). Fifty thousand years of flint knapping and tool shaping across the Mousterian and Uluzzian sequence of Fumane cave. *Quaternary International*, *247*, 125–150.

Peresani, M., Bertola, S., De Stefani, M., & Di Anastasio, G. (1999–2000). Bus de La Lum and the Epigravettian occupation of the Venetian Pre-Alps during the Younger Dryas. *Rivista di Scienze Preistoriche*, *50*, 103–132.

Peresani, M., Cremaschi, M., Ferraro, F., Falguères, C., Bahain, J.-J., Gruppioni, G., Sibilia, E., Quarta, G., Calcagnile, L., & Dolo, J.-M. (2008). Age of the final Middle Palaeolithic and Uluzzian levels at Fumane Cave, Northern Italy, using 14C, ESR, 234U/230Th and thermoluminescence methods. *Journal of Archaeological Science*, *35*(11), 2986–2996.

Peresani, M., Duches, R., Miolo, R., Romandini, M., & Ziggiotti, S. (2011). Small specialized hunting sites and their role in Epigravettian subsistence strategies. A case study in Northern Italy. In F. Bon, S. Costamagno, & N. Valdeyron (Eds.), *Hunting camps in prehistory. Current archaeological approaches*, *Proceedings of the International Symposium* (pp. 251–266). University Toulouse II—Le Mirail, P@lethnology, 3.

Peresani, M., Monegato, G., Ravazzi, C., Bertola, S., Margaritora, D., Breda, M., Fontana, A., Fontana, F., Janković, I., Karavanić, I., Komšo, D., Mozzi, P., Pini, R., Furlanetto, G., De Amicis, M. G. M., Perhoč, Z., Posth, C., Ronchi, L., Rossato, S., … Zerboni, A. (2021). Hunter-gatherers across the great Adriatic-Po region during the Last Glacial Maximum: Environmental and cultural dynamics. *Quaternary International*, *581–582*, 128–163.

Pola, M., Ricciato, A., Fantoni, R., Fabbri, P., & Zampieri, D. (2014). Architecture of the western margin of the North Adriatic foreland: The Schio-Vicenza fault system. *Italian Journal of Geosciences*, *133*(2), 223–234.

Rasmussen, S. O., Bigler, M., Blockley, S. P., Blunier, T., Buchardt, S. L., Clausen, H. B., Cvijanovic, I., Dahl-Jensen, D., Johnsen, S. J., Fischer, H., Gkinis, V., Guillevic, M., Hoek, W. Z., Lowe, J. J., Pedro, J. B., Popp, T., Seierstad, I. K., Steffensen, J. P., Svensson, A. M., … Winstrup, M. (2014). A stratigraphic framework for abrupt climatic changes during the Last Glacial period based on three synchronized Greenland ice-core records: Refining and extending the INTIMATE event stratigraphy. *Quaternary Science Reviews*, *106*, 14–28.

Ravazzi, C. (2005). Il Tardoglaciale: Suddivisione stratigrafica, evoluzione sedimentaria e vegetazionale nelle Alpi e in Pianura Padana. *Studi Trentini di Scienze Naturali, Acta Geologica*, *82*, 17–29.

Ravazzi, C., Peresani, M., Pini, R., & Vescovi, E. (2007). Il Tardoglaciale nelle Alpi italiane e in Pianura Padana. Evoluzione stratigrafica, storia della vegetazione e del popolamento antropico. *Il Quaternario*, *20*(2), 163–184.

Reimer, P. J., Bard, E., Bayliss, A., Beck, J. W., Blackwell, P. G., Bronk Ramsey, C., Buck, C. E., Cheng, H., Edwards, R. L., Friedrich, M., Grootes, P. M., Guilderson, T. P., Haflidason, H., Hajdas, I., Hatté, C., Heaton, T. J., Hoffmann, D. L., Hogg, A. G., & van der Plicht, J. (2013). IntCal13 and Marine13 radiocarbon age calibration curves 0-50,000 years cal BP. *Radiocarbon*, *55*(4), 1869–1887. https://doi.org/10.2458/azu_js_rc.55.16947

Renssen, H., Goosse, H., Roche, D. M., & Seppä, H. (2018). The global hydroclimate response during the Younger Dryas event. *Quaternary Science Reviews*, *193*, 84–97.

Salzani, L. (1981). *Preistoria in Valpolicella*. Centro di documentazione per la storia della Valpolicella.

Sauro, U. (1973). *Il paesaggio degli alti Lessini, studio geomorfologico*. Museo Civico di Storia Naturale di Verona.

Stoops, G. (2003). *Guidelines for analysis and description of soil and regolith thin sections*. Soil Science Society of America.

Stoops, G., Marcelino, V., & Mees, F. (Eds.) (2018). *Interpretation of micromorphological features of soils and regoliths* (2nd ed.). Elsevier.

Straus, J., & Goebel, T. (Eds.) (2011). Humans and Younger Dryas: Dead end, short detour, or open road to the Holocene. *Quaternary International*, *242*(2), 259–584.

Stuiver, M., Reimer, P. J., & Reimer, R. W. (2020). *CALIB 8.2* [WWW program]. http://calib.org

Tarquini, S., Isola, I., Favalli, M., Mazzarini, F., Bisson, M., Pareschi, M. T., & Boschi, E. (2007). TINITALY/01: A new Triangular Irregular Network of Italy. *Annals of Geophysics*, *50*, 407–425.

Tarquini, S., Vinci, S., Favalli, M., Doumaz, F., Fornaciai, A., & Nannipieri, L. (2012). Release of a 10-m-resolution DEM for the Italian territory: Comparison with global-coverage DEMs and anaglyph-mode exploration via the web. *Computers & Geosciences*, *38*, 168–170. https://doi.org/10.1016/j.cageo.2011.04.018

Tinner, W., & Vescovi, E. (2005). Ecologia e oscillazioni del limite degli alberi nelle Alpi dal Pleniglaciale al presente. *Studi Trentini di Scienze Naturali, Acta Geologica*, *82*, 7–15.

Tomasso, A., Fat Cheung, C., Fornage-Bontemps, S., Langlais, M., & Naudinot, N. (2018). Winter is coming: What happened in western European mountains between 12.9 and 12.6 ka cal. BP (beginning of the GS1). *Quaternary International*, *465*, 210–221.

Tomasso, A., Serradimigni, M., Ricci, G., & Mihailovic, D. (2020). Lost in transition: Between late pleistocene and Early Holocene around the Adriatic. *Quaternary International*, *564*, 3–15.

Vandevelde, S., Brochier, J. É., Desachy, B., Petit, C., & Slimak, L. (2018). Sooted concretions: A new micro-chronological tool for high temporal resolution archaeology. *Quaternary International*, *474*, 103–118.

Vescovi, E., Ravazzi, C., Tinner, W., Arpenti, A., Finsinger, W., Pini, R., Valsecchi, V., Wick, L., & Ammann, B. (2007). Interactions between climate and vegetation on the Southern side of the Alps and adjacent areas during the Late-Glacial period as recorded by lake and mire sediment archives. *Quaternary Science Reviews*, *26*, 1650–1669.

Woodward, J. C., & Goldberg, P. (2001). The sedimentary records in Mediterranean rockshelters and caves: Archives of environmental change. *Geoarchaeology*, *16*, 327–354.

Zammarchi, D. (2019–2020). *Riparo Cornafessa (Sega di Ala, TN) nella transizione Pleistocene—Olocene. Studio delle industrie litiche e analisi delle distribuzioni spaziali* [Master Thesis (supervisor M. Peresani, co-supervisors F. Cavulli and R. Duches). Università di Ferrara, Modena-Reggio, Verona and Trento].

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