OPENING A WINDOW ON THE PAST: PALEO-HORIZONS ACROSS PLEISTOCENE AND HOLOCENE. MADONNA DELLA GROTTA, PRAIA A MARE, SOUTHERN ITALY

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Abstract

The goal of this study was to identify and characterize three paleo-horizons along a stratigraphic succession embracing sediments from Paleolithic to historic that has been preserved inside a grotto close to the Tyrrhenian Sea in southern Italy. The studied paleo-horizons date back to the transition period between Pleistocene and Holocene, when swift alternations of cold and warm phases profoundly altered the range dynamics of many organisms, including salmonids like *Salmo trutta* and, consequently, the behavior of the humans that occupied the grotto. Morphological observations and preliminary analysis were run to assess if the paleo-horizons preserved information of the human modified behavior. Results confirmed that one of the three paleo-horizons (Bud horizon, dating back to 10,300 cal YBP) had a strongly affected anthropic origin as it contains the rests of terrestrial (mammals, birds, and snails) and aquatic (brown trout and limpet) animals, and showed a hard compaction acquired via hydroconsolidation.

Keywords: *Salmo trutta, paleo-environment, human artifacts, climate change*

Introduction

The study of paleosols containing animal fossils, botanical and pedological remains have a potential for reconstructing paleo-environments (Tabor & Myers, 2015). In particular, the paleosols formed during past climatic conditions represent an important resource for environmental and climatic reconstructions through integrating field scale soil descriptions and investigations at microscopic and sub-microscopic levels, with quantification of morphological, chemical and mineralogical properties (Courchesne et al., 2015). The goal of this study was to

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identify and provide information of three paleo-horizons present along a stratigraphic succession about 12 m thick that started to accumulate more than 14,000 years before present (YBP), and was preserved inside a grotto of southern Italy close to the Tyrrhenian sea (Madonna della Grotta, Praia a mare municipality). This succession was studied by archeologists from 1957 to 1970 (Cardini, 1970), but nowadays it has gained a renewed interest as its layering embraces the last period of the transition between Pleistocene and Holocene, when swift alternations of cold and warm phases profoundly altered the range dynamics of many organisms, including the brown trout (Splendiani et al., 2016). Since humans have occupied the grotto from late Paleolithic, and the grotto is close to the sea, the human diet included fish and other sea food. Pleistocene to Holocene climate change modified the environmental conditions, and it is possible that humans harmonized their behavior and diet to the incoming situations, probably leaving information of these changes in the sediments they contributed to produce.

The aim of this work was to report observations made on three anthropogenic paleo-horizons present along the succession in order to improve the knowledge about past environmental conditions, particularly during the Pleistocene to Holocene transition.

Materials and methods

Nowadays, the top of the stratigraphic succession is at ~50 m above sea level, close to the mouth of the Noce River (Praia a Mare, southern Italy). During archeological excavation campaigns that lasted from 1957 to 1970 (Cardini, 1970), inside the Madonna della Grotta cave a stratigraphic succession about 12 m thick was exposed. We do not know if there is more sediment below this depth. Several layers contained faunal and artifact remains, indicating that humans have occupied the cave from late Upper Paleolithic, at least from around 14,200 calibrated YBP (cal YBP) to historical times (Figure 1). Our work was run on soil samples larger than 0.5 kg that were collected and catalogued during the past archeological campaigns and stored in the headquarters of the Istituto Italiano di Paleontologia Umana (Anagni, Italy). The three selected layers (Figure 1), catalogued as T53 (from 5.9 to 6.0 m of depth), T73 (from 7.9 to 8.0 m), and T79 (from 8.25 to 8.35 m), were considered as anthropogenic paleo-horizons and were consequently named Bu horizons because they show properties of soil B horizons and contained human artifacts (suffix "u") (SSS, 2014). These paleo-horizons had been dated by charcoal ^{14}C analyses by Alessio (1966), and attributed to the medium and upper Paleolithic period by Durante (1978). In particular, T53 dated back to 10,300±100 cal YBP, T73 was slightly older than 12,100±150 cal YBP, and T79 was older than the other two layers, even though no dating was made of it or of layers close to it (Figure 1). For these paleo-horizons, a rough pedological description per Schoeneberger et al. (2002) was possible because of the large amount of the samples come to us.

The samples were gently disaggregated and sieved at 2 mm. The pH was carried out in H_2O, at 1:2.5 w:v ratio. Total C and N contents were determined by a Carlo

Erba EA1110 (Carlo Erba Instruments, Milan, Italy) dry combustion analyzer. The total organic carbon (TOC) content was determined by dichromate digestion, heating the suspension at 180 °C for 30 min (Allison, 1965). Mineralogy of samples has been determined on the basis of the relative peak-areas obtained by X-ray diffractometric analyses. Crystalline minerals were identified by analyzing manually oriented powdered specimens on a Philips PW 1830 (Philips, Eindhoven, Holland) X-ray diffractometer, using Fe-filtered Co Kα1 radiation (35 kV and 25 mA).

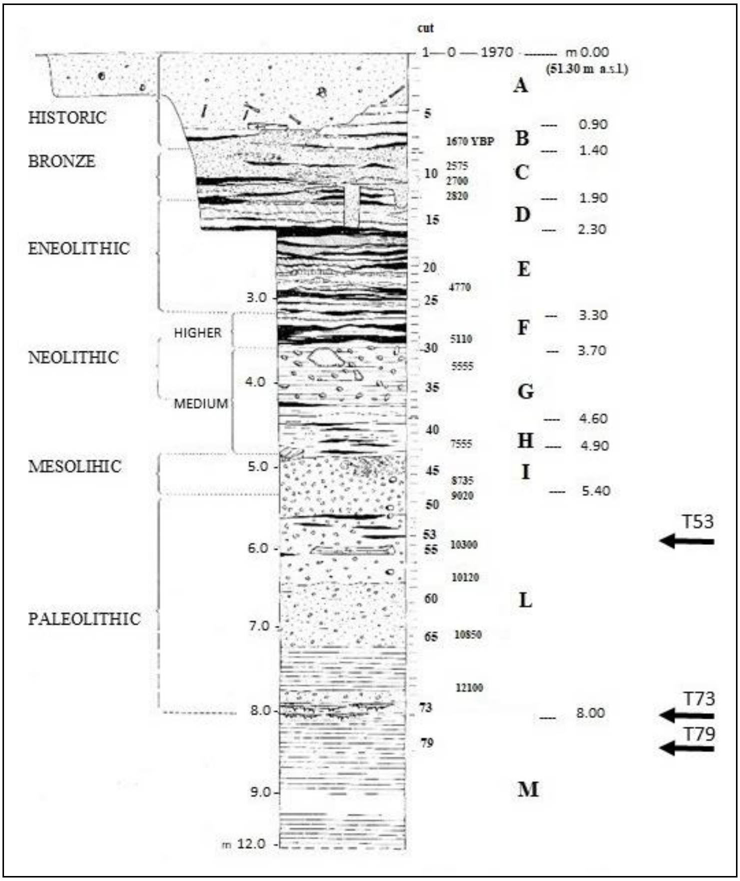

Figure 1
Stratigraphic succession of the Madonna della Grotta cave (Praia a mare, southern Italy), with indication of prehistoric and historic periods, charcoal ^{14}C dating, depth of the cuts referred to the zero-surface of the succession in 1970, and position of the studied paleo-horizons (modified from Cardini, 1970). Notes. a.s.l.= above sea level; YBP=years before present referred to the year 1970 (Cardini, 1970).

Results and discussions

The three horizons differed in color, structure, texture, skeleton content, and contents of artifacts and mollusk remains (Table 1), but differences were clear also for TC, TOC, and TN contents (Table 2). Differences were probably due to both processes of soil sedimentation, alluvial events and anthropic activities.

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The Bud horizon showed the high TOC and TN contents, but also the finest texture and the major abundance of charcoal and bones. This horizon was also the only one containing limpet (*Patella* spp.) and snail (*Helix* spp.) shells, and brown trout (*Salmo trutta* complex) bones (Figure 2).

Table 1. *Morphological description of the three considered paleo-horizons along the stratigraphic succession of Madonna della Grotta, Praia a Mare (Southern Italy)*

Layer No.	Horizons	Depth (m)	Colour[a]	Structure[b]	Texture[c]	Consistence	Skeleton (%)	Other observations
T53	Bud	5.9-6.0	10YR 5/4	3m,c abk; fi	scl	sticky	30	Artifacts, abundant mammalian and bird bones, fish bones, *Patella* sp. and *Helix* sp. shells; abundant charcoal and vegetal remnants; slacking and popping
T73	Bu	7.9-8.0	7.5YR 5/4	2f,m abk; fr	l	sticky	80	Skeletal particles are calcareous, and have sharp and sub-rounded edges and dimensions of few cm
T79	Bu	8.25-8.35	7.5YR 4/4	3m,c sbk; fr	l	sticky	15	Skeletal particles are calcareous, have rounded edges and dimensions of mm and cm

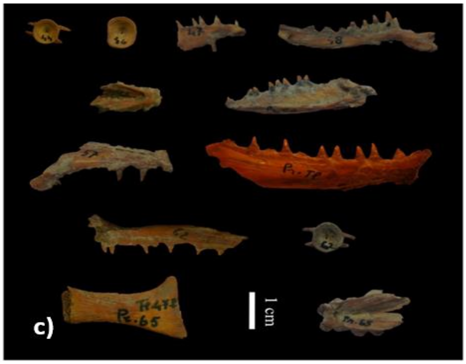
[a] moist and crushed, according to the Munsell Soil Color Charts.
[b] 2 = moderate, 3 = strong; m = medium, c = coarse; abk = angular blocky, sbk = subangular blocky; fi = firm, fr = friable.
[c] scl = silty clay loam; l = loam.

Table 2. *Values of pH and contents of total carbon (TC), total organic carbon (TOC), and total nitrogen (TN) of the three considered paleo-horizons along the stratigraphic succession of Madonna della Grotta, Praia a mare (southern Italy). Number in parentheses are the standard deviations.*

Layer No.	Horizons	pH	TC $g\ kg^{-1}$	TOC $g\ kg^{-1}$	TN $g\ kg^{-1}$
T53	Bud	8.43 (0.02)	65.10 (0.01)	18.57 (0.42)	2.25 (0.01)
T73	Bu	8.71 (0.02)	59.58 (0.02)	0.01 (0.00)	<d.l.
T79	Bu	8.62 (0.03)	44.43 (0.03)	1.43 (0.08)	<d.l.

<d.l. = below the detection limit.

Figure 2
Photographs of Helix *spp.* (a), Patella *spp.* (b) *and* Salmo trutta (c) *sub-fossil remains from the T53 layer (Bud paleo-horizon) of Madonna della Grotta cave (Praia a mare, southern Italy).*



The combination of high TOC, TN, charcoal, shells and bones attested the high contribution of human activity to the formation of Bud. This horizon is also the only one among the three that behaved as densic material (this is the reason of the suffix "d" of the Bud designation), namely with a noncemented rupture-resistance reply to compression forces. Mineralogical observations showed the presence in all the horizons of common minerals like calcite, plagioclases, and dolomites, but also of small amounts of volcanic materials. Since texture and mineralogy were similar to the other two horizons, the Bud horizon probably acquired compaction because of mechanical compaction (Soil Survey Staff, 2014) at a water-saturated conditions (or *quasi*-saturated) when it was at surface (about 10,300 cal YBP). The hydroconsolidation process was proved to be responsible for the formation of indurated and non-cemented horizons like fragipan (Assallay et al., 1998; Scalenghe et al., 2004), which has characteristics very similar to those of the Bud horizon (slacking and popping, see Table 1). In the case of the considered stratigraphy, since it is inside a grotto, the causes of water saturation can be many, either natural (dripping from the cave vault or fluvial ingress, for example) or human-made (washing surface, dumping of animal offal and other water-rich wastes, or other).
The presence of fish bones and marine mollusk shells in the Bud horizon indicated that, together with terrestrial animals (mammals, birds, and snails), marine orga-

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nisms were an important diet component for the cave inhabitants around 10,300 cal YBP. It is probable that, after a warm period, the resurgence of cold temperatures has favored trout anadromous behavior (i.e., migration to the sea for feeding purpose) with the consequent achievement of large body size, so inducing humans to include this fish in their diet (see Durante, 1978; Splendiani et al. 2016).

Conclusions

Among three paleo-horizons studied, the Bud, which corresponds to the T53 layer (10,300 cal YBP), showed the highest content of human artifacts and remains of sea/river and terrestrial food. The introduction of sea food in the diet was coeval with the changing of human activity as this horizon was also relatively rich of charcoal and showed a hard consistence (noncemented) possibly acquired through hydroconsolidation. Since the stratigraphic succession is inside the Madonna della Grotta cave, the saturation of the material that then became the Bud horizon could have occurred because of natural events or anthropic activities that will be object of future studies.

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