Quaternary International xxx (2016) 1–13

Contents lists available at ScienceDirect

Quaternary International

journal homepage: www.elsevier.com/locate/quaint

The MIS 5.5 terraced deposit of Fosso del Cupo (Montecelio, Central Italy) and its Mousterian lithic assemblage: Re-evaluation of a nineteenth-century discovery

P. Ceruleo [a], F. Marra [b, *], L. Pandolfi [c], C. Petronio [d], L. Salari [d]

[a] Via Giotto 18, 00019, Tivoli (Roma), Italy
[b] Istituto Nazionale di Geofisica e Vulcanologia, Sezione Sismologia e Tettonofisica, Via di Vigna Murata 605, 00147, Roma, Italy
[c] Dipartimento di Scienze, sezione di Geologia, Università degli Studi "Roma Tre", Largo S. Leonardo Murialdo 1, 00146, Roma, Italy
[d] Dipartimento di Scienze della Terra, Sapienza, Università di Roma, P.le Aldo Moro 5, 00185, Roma, Italy

ARTICLE INFO

Article history:
Available online xxx

Keywords:
Middle Paleolithic lithic industry
Late Pleistocene faunal assemblages
Aggradational successions
Fluvial terraces
Central Italy

ABSTRACT

By means of a geomorphological study and the correlation with the geochronologically constrained terraced deposits of the greater area of Rome, we attribute to the aggradational phase during marine isotopic stage (MIS) 5.5 a terraced deposit firstly described in the earliest local geological reports of the 19th century, in which a small set of lithic artifacts and vertebrate fossil remains was recovered. After this correlation, the sedimentary deposit of Fosso del Cupo represents the only inland occurrence of an aggradational deposit of MIS 5.5 so far recognized in the area of Rome, where a rich record of lithic industries and faunal assemblages has been yielded by the sedimentary successions deposited in response to deglaciation during sea-level rises of MIS 15 through MIS 7. We have implemented the lithic and faunal assemblages through a collection during the geological survey performed in the area where the terraced deposit crops out. With an age tightly constrained around 125 ka, the lithic industry and the faunal assemblage from Fosso del Cupo, although limited in number, represent an important witness of the early development of the local Pontinian culture and should be considered a regional marker, which may concur to improve the knowledge on the Mousterian of Central Italy.

1. Introduction

A rich record of fossil vertebrates and lithic industries has been recovered since the end of the 19th century in the sedimentary deposits cropping out in the area of the central Tyrrhenian Sea margin of Italy nearby Rome ("Campagna Romana", e.g.: Sardella et al., 2006) (Fig. 1). A solid geochronologic framework has been provided in the last 20 years thanks to a large number of $^{40}Ar/^{39}Ar$ ages of volcanic deposits interbedded with these sedimentary successions and by means of paleomagnetic investigations, demonstrating the strict link between glacio-eustatic cycles and sedimentation in this region (Alvarez et al., 1996; Karner and Marra, 1998; Karner and Renne, 1998; Marra et al., 1998a, 1998b; Florindo et al., 2007; Marra and Florindo, 2014). This correlation relies on the concept of aggradational succession deposited in response to sea-level rise during the glacial terminations, which has been defined and applied to identify a suite of ten major aggradational units deposited during the Marine Isotopic Stage (=MIS) 21 thorough MIS 1 in the near coastal to coastal area of Rome (Marra et al., 2008).

The majority of the Middle Pleistocene fossil vertebrates assemblages of Italy has been recovered in the "Campagna Romana" within the alluvial deposits of the Paleo Tiber River and its tributaries, whose outcrops concentrate in the Ponte Galeria area (Fig. 1; Caloi et al., 1998; Di Stefano et al., 1998; Milli and Palombo, 2005; Petronio et al., 2011). A chronostratigraphic revision of the faunal assemblages collected in this area was provided by Marra et al. (2014a) through the method of correlation with the geochronologically constrained aggradational successions. Based on this approach, any fossil that can be referred to an identified geochronologically constrained sedimentary unit can be assigned to a discrete age, corresponding to that of the associated MIS. The aggradational successions in the area of Rome are variably exposed along the banks of the hills shaped from an original pyroclastic

* Corresponding author.
E-mail address: fabrizio.marra@ingv.it (F. Marra).

http://dx.doi.org/10.1016/j.quaint.2016.06.012
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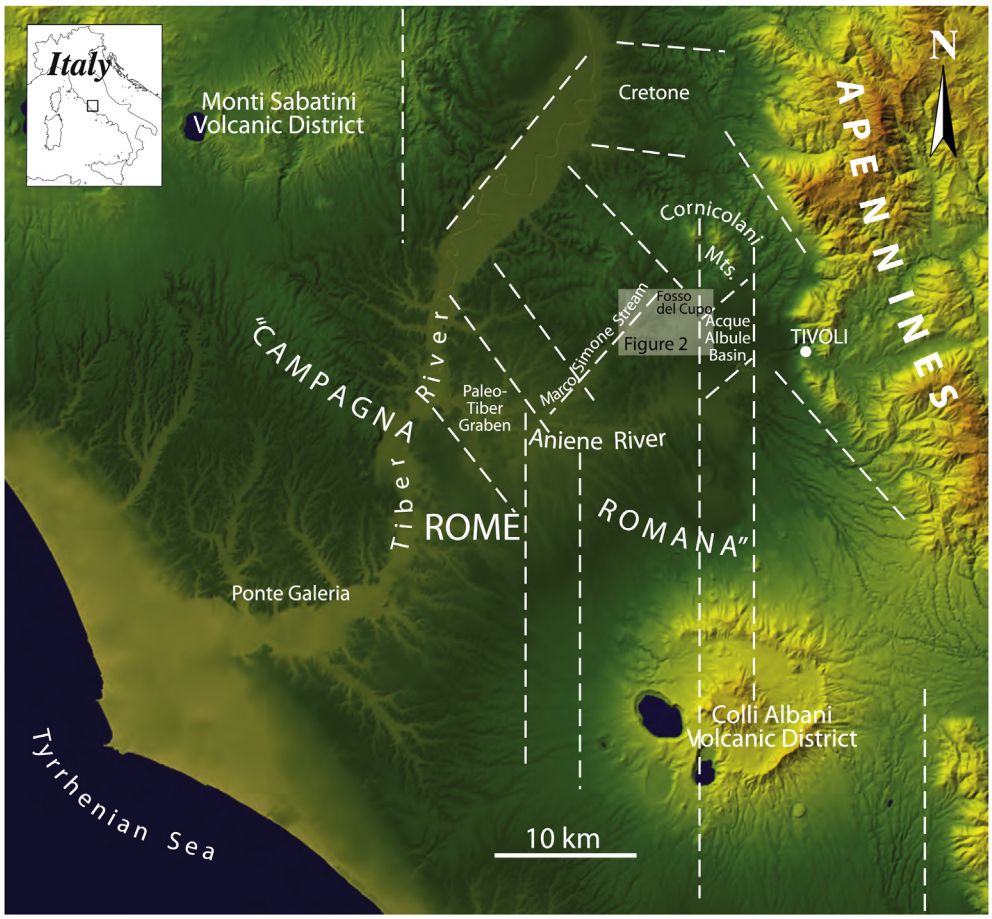

Fig. 1. Digital Elevation Map of the greater area of Rome showing the regional structural setting and location of the investigated sector.

plateau, eroded by fluvial incisions of the Tiber River and its tributaries in consequence of the interplay between glacio-eustatism and a discontinuous regional uplift that affected the Tyrrhenian Sea margin of Central Italy in the last 800 ka (Karner et al., 2001a; Ferranti et al., 2006). Therefore, the stratigraphic record of each glacio-eustatic cycle occurs at different elevation, depending on the absolute sea-level during each glacial/interglacial period and on the amount of uplift experienced since deposition, offering further, geometric criteria for its identification. Based on the methodological approach integrating $^{40}Ar/^{39}Ar$ dating and geomorphological investigation, the geochronological studies have been recently extended to sedimentary deposits hosting Lower-Middle Paleolithic lithic industries (e.g.: Ceruleo et al., 2015) and Neanderthal fossils (e.g.: Marra et al., 2015). Both these works have remarked on the scarcity of sedimentary deposits correlated with MIS 5, with respect to a large record of aggradational deposits correlated with MIS 19 through MIS 7, hosting a wide range of faunal assemblages encompassing the Galerian and Aurelian Mammal Ages (Marra et al., 2014a), as well as, only since MIS 15, a suite of lithic assemblages ascribed to the Acheulean and to the Mousterian cultures (Ceruleo et al., 2015 with references). Indeed, through a review of the literature and considering the recent correlation of the Saccopastore site with MIS 7 (Marra et al., 2015), we have found only one outcrop in this region attributed to MIS 5 (Evangelista and Porcari, 1988). It is a site described by Ponzi (1866–67) in the small valley of Fosso del Cupo, near Montecelio village not far from the town of Tivoli (Fig. 1). Ponzi (1866–67) reported the occurrence of several vertebrate remains and a small set of lithic artifacts from the abovementioned locality. In this light, we have regarded this outcrop as a unique opportunity to describe a paleontologic and palethnologic record with an age tightly constrained around 125 ka in this region, by demonstrating its correlation with MIS 5.

Aimed at this scope we have performed a geomorphological study of this area and integrated it with field investigations, including a geological survey and a collection of vertebrate fossils and lithic artifacts (see Appendices). Results of this study allowed us at delimitating the occurrence of the sedimentary deposits correlated with aggradational succession of MIS 5 (Epi-Tyrrhenian Formation, Marra et al., 2015), and at describing the faunal assemblage and the lithic industry recovered within this sediment.

2. Stratigraphic and structural setting

The investigated area is located ca. 25 km northeast of Rome and ca. 10 km west of Tivoli town and close to Montecelio village, in the higher portion of the Aniene River's tributary Marco Simone Stream hydrographic network (Fig. 1). This sector corresponds to a structural high (Fig. 1), bordered to the southwest by the buried NW-SE extensional faults originating the Paleo-Tiber Graben (Marra and Florindo, 2014, and references), hosting a thick succession of Middle-Pleistocene fluvial-lacustrine deposits, and to the east by the Acque Albule north-south trending strike-slip fault system (Frepoli et al., 2010), which originated in Middle-Upper Pleistocene times the homonymous pull-apart basin filled by travertine deposits (Faccenna et al., 1994, 2008). It is in turn lowered with respect to the Apennine's thrust-and-fold belt by the main NW-SE

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extensional fault system bordering the Tyrrhenian Sea margin of Central Italy (Sani et al., 2004, and references). This sector is located at the foot of the Meso-Cenozoic silicic-carbonatic structures of Cornicolani Mounts, on the margin of the Middle-Pleistocene pyroclastic plateau which constitutes the so-called "Campagna Romana" (Fig. 1). The geologic substrate of this area is constituted by Upper Pliocene (Piacenzian) marine clay deposits (Carboni, 1975), and shallow-water, sandy-conglomeratic, channeled deposits. Above it, a discontinuous, eroded succession of volcanic deposits erupted by the Monti Sabatini and the Colli Albani Volcanic Districts mainly between 582 and 365 ka (Marra et al., 2009, 2014b, and references therein) occurs. Unlike the coastal area of Rome, where the remains of a suite of sedimentary successions deposited in response to sea-level rise during the Middle Pleistocene glacial terminations are extensively exposed along the flanks of the hills (Alvarez et al., 1996; Karner and Marra, 1998; Marra et al., 2015), no significant outcrop of fluvio-lacustrine deposits is reported in this sector by available geologic maps (Servizio Geologico d'Italia, 1:100.000). This is likely the combined result of the limited extension of the hydrographic network and the continuous uplift which affected this region (Karner et al., 2001a), causing erosion and removal of the alluvial deposits emplaced within the fluvial incisions (see Marra et al., 2015 for a discussion).

However, a terraced deposit cropping out on the southern bank of Fosso (creek) del Cupo (Fig. 2a) was reported by Ponzi (1866–67), and later interpreted as a fluvial terrace of the Riss-Würm interglacial (Evangelista and Porcari, 1988), corresponding to MIS 5.5 of the $\delta^{18}O$ record (e.g.: Lisiecki and Raymo, 2005). Several vertebrate fossil remains and a small number of lithic artifacts recovered in this deposit (Fig. 2b) were described by Ponzi (1866–67, 1873); successively other authors reported on more faunal findings without associated lithic industries (e.g.: Ashby, 1906; Piccolini, 1924; Rellini et al., 1926; Radmilli, 1953; Evangelista and Porcari, 1988).

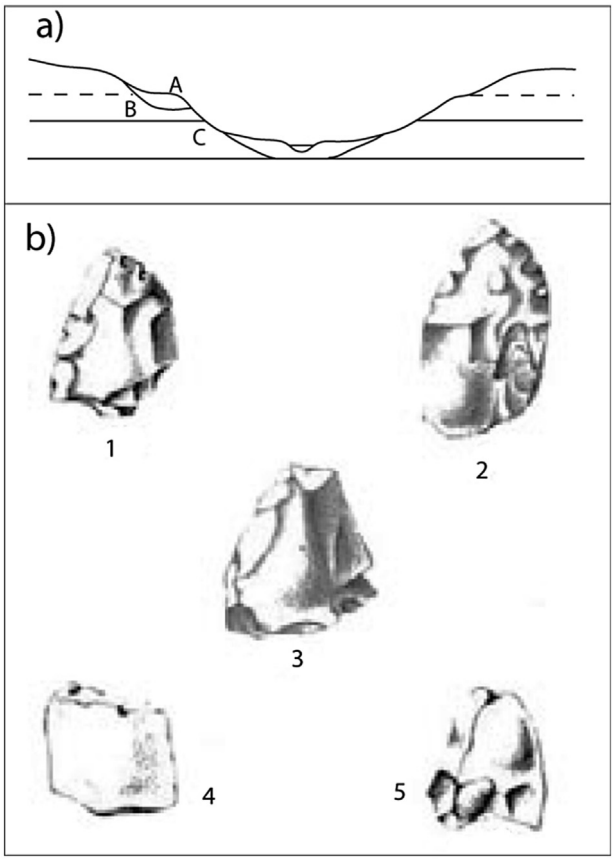

Fig. 2. a) Cross-section realized by Ponzi (1866–67) showing the stratigraphy of Fosso del Cupo Valley and the position of the sedimentary layer (A) from which the small set of lithic artifacts illustrated below (b) and several vertebrate bones were recovered.

In the present work we have performed an integrated field survey and geomorphological study of the area surrounding the small valley of Fosso del Cupo, aimed at recognizing the deposit described by Ponzi and providing a solid chronostratigraphic framework for it. Results are exposed in the following sections.

3. Previous palethnological and paleontological data

Despite the local relevance of the scanty artifacts recovered during a survey in the area around Montecelio promoted by the abbot and amateur geologist Carlo Rusconi in the year 1866, the report of lithic findings at Fosso del Cupo by Ponzi (1866–67) has a great historical significance. This communication follows only 7 years after the report of Prestwich (1859) on the study of the lithic instruments previously described by the French archaeologist Jacques Boucher de Perthes at Abbeville in the Somme Valley, and on those found at the excavation performed under the supervision of Sir Charles Lyell at the Brixham Cave in England, which can be considered to date the official birth of the palethnology, and its acceptance by the scientific community. Not much earlier, previous communication to the "Académie des Sciences" by Boucher de Perthes about his discovery in the year 1838 of several flint artifacts that he interpreted as shaped by prehistoric men, had raised skeptical and sarcastic comments (see Cohen and Hublin, 1989). A few years later, in a scientific meeting in Lucca (Tuscany, Italy) Antonio Salvagnoli Marchetti (1843) described a series of stone artifacts found in a cave at Monte Argentario (Grosseto, Italy), followed by Luigi Ceselli (1866), who reported on the finding of a number of prehistoric instruments associated to fossil bones of large vertebrates at several localities in Rome. Besides the skepticism of the scientific community, these early studies had to face the strong opposition and condemn of the Catholic Church, for their "blasphemous" implications. Notwithstanding this opposition, the promoter of the field survey to investigate the area around Montecelio where he had collected several vertebrate fossil remains, Carlo Rusconi, was the parson of the village, and the scholars to which he sent the invitation, Giuseppe Ponzi, Angelo Secchi, Michele S. De Rossi, were members of the Pontifical Academy of Nuovi Lincei, as well as Luigi Ceselli was an official of the Pontifical States in Rome.

Ponzi (1866–67, 1873) gave a detailed report of the survey in which he described with particular precision the location and the stratigraphy of the site where the scholars collected several flakes and five tools from the same bed in which a faunal assemblage constituted by fossil remains of *Cervus elaphus*, *Bos primigenius*, *Elephas* sp., and *Rhinoceros thycorhinus* was recovered. The stratigraphic cross-section drawn by Ponzi (1866–67) is reported in Fig. 2a. The uppermost horizon (A) yielding the lithic and faunal remains is described as a 1.75 m thick, fluvial coarse-grained calcareous sand deposit, resembling a loose travertine deposit at the top, and passing downward to sandy clay. It overlies a semi-lithified, yellow-grey tuff, with abundant leucite crystals, 8.30 m thick (B), and a dark red pozzolan deposit, displaying earthy aspect without crystals, 9.45 m thick (C). Secchi (1866–67) specified that the lithic artifacts were extracted from a 50 cm thick horizon of white fine sand within the uppermost layer; Ponzi (1873) described the material as realized in grey and red flint, as that commonly occurring in the 'Corniola' and 'Rosso Ammonitifero' Jurassic members of the silicic-carbonatic Umbro-Marchigiano-Sabina series (Parotto and Praturlon, 1975), cropping out at the nearby

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Cornicolani Mounts (Fig. 1). The author figured 5 of these pieces (Fig. 2b) which are presently housed at the Istituto di Paletnologia dell'Università di Roma "Sapienza", without providing any description. Later on, Rellini (1936–37) described the artifact #2 in Fig. 2b as a very poorly exploited flake, and #3 as a small scraper, obtained from a flake, with a faintly convex surface and displaying retouch in little scales on the opposite face.

In the years following the first survey, several other scholars investigated the area around Montecelio (e.g.: Ashby, 1906; Piccolini, 1924; Rellini et al., 1926; Radmilli, 1953; Evangelista and Porcari, 1988), which was frequently referred as "Inviolatella" from the name of the estate where an ancient tower raises, few km south of Fosso del Cupo (see Fig. 3a). Indeed, these investigations were performed in the larger area surrounding Montecelio, including a variety of different terrains than the specific sedimentary deposit cropping out at Fosso del Cupo, as our geomorphological and stratigraphic reconstruction evidences (see next section). Remarkably, no lithic artifact was recovered during these later investigations which in turn recovered a large number of vertebrate fossil remains, with the exception of a few flint flakes and a scraper, described as a "Mousterian" tool, recovered by Radmilli (1952) in the immediate vicinity of a turning point of the creek course, suggesting that the occurrence of the lithic industry in this area is confined within the sedimentary layer cropping out on the banks of Fosso del Cupo valley described by Ponzi (1866–67). In contrast, both lithic artifacts and fossil remains of the Rusconi Collection housed at the Rodolfo Lanciani Museum, Guidonia-Montecelio, which includes all the findings made by abbot Rusconi during his field surveys in the territory of Montecelio, are clearly collected at different localities with different stratigraphic setting, therefore cannot be attributed to a definite chronologic interval. Indeed, Rusconi (1866–67) describes the stratigraphic provenance of several fossil bones of his collection (including *Sus scrofa* along with *Cervus elaphus*, *Bos primigenius*, *Hippopotamus major*, *Elephas* sp.) from a sedimentary layer rich in volcanoclastic material underlying the outcropping Pozzolan layer, implying an age older than 365 ± 4 ka, at least (Villa Senni eruption cycle, Marra et al., 2009; Fig. 3a). For these reasons, in the present study we have conducted a geologic survey in the sector near Fosso del Cupo, during which we have collected several lithic artifacts and fossils emerging on the surface of the terrain that our stratigraphic and geomorphological investigations allowed at correlating with the MIS 5 terraced deposit, and we describe these materials along with those illustrated by Ponzi (1866–67, 1873) in order to provide geochronologically constrained lithic and faunal assemblages, which can be regarded as a reference record for the Middle Paleolithic and the Melpignano Faunal Unit (FU) of this region, respectively.

4. Methods

4.1. Geomorphological and stratigraphic investigations

Recently acquired geochronologic and stratigraphic data allowed Marra et al. (2015) to correlate two paleo-surfaces occurring around 36 m a.s.l. and 56 m a.s.l. along the coast of Rome with the marine terraces of MIS 5.5 and MIS 7, respectively. Based on the elevation gain of these paleo-surfaces with the Present day alluvial coastal plain, these authors reconstructed the expected elevation of MIS 5 and MIS 7 fluvial terraces in the Aniene River Valley in northern Rome. In the present work we use a similar approach, by reconstructing paleo-surfaces of fluvial terraces in the investigated area around Fosso del Cupo (Fig. 3), and by correlating these surfaces with the Middle-Upper Pleistocene sea-level highstands, combining geometric criteria with chronostratigraphic constraints achieved from the geological field investigation.

We mapped a suite of paleo-surfaces following a simple geomorphological approach, based on the identification of a set of topographic culminations and related flat surfaces ranging few meters around a mean value. The selected topographic points of the reconstructed terraced surfaces include all the hilltops (i.e. each elevation point within a closed, 5 m spaced isoline; triangles in Fig. 3a), and other quasi-equivalent points within almost closed isolines bordering plateau-like sectors (circles in Fig. 3a).

4.2. Palethnological investigations

The collection of the lithic industry was carried out in two small sectors (#1 and #2 in Fig. 4a), located on the terraced surface comprised between 95 and 85 m a.s.l. bordering the fluvial incision of Fosso del Cupo to the north. The collected materials, either lithic artifacts and vertebrate bones, emerge in light-colored, sandy-clayey terrains that the geomorphological and stratigraphic reconstruction performed for this study have correlated with the fluvial-lacustrine sediments of the MIS 5.5 aggradational succession, which occur at lower elevation with respect to darker terrains constitute by pyroclastic deposits, colluvium and paleosoils (Fig. 4a), in which no lithic find occurs.

The study of lithic industry is carried out according to the Bordes' artifacts taxonomy for the classification of tools (Bordes, 1961) in order to provide a description of the collected material and to make comparison with previous studies on Lower Palaeolithic sites of Italy, which were usually conducted according to this methodology. On the other hand, the small number of recovered artifacts (11 tools, 4 cores, 24 flakes) prevents a more quantitative analyses of the lithic industry according to a techno-functional approach (e.g.: Boëda, 2013).

4.3. Paleontological investigations

The fossil remains were collected during the same field surveys on the terraced area to the north of Fosso del Cupo, along with the lithic artifacts (sectors 1 and 2 in Fig. 4a), very close to the section described by Ponzi (1866–67) (3 in Fig. 4a). This material is presently housed in the Rodolfo Lanciani Museum, Guidonia-Montecelio (Appendix 1). Other examined paleontological remains include 190 determinate specimens and 710 indeterminate specimens belonging to the Rusconi Collection and they are also housed at Rodolfo Lanciani Museum. Unfortunately, the specimens belonging to the Rusconi Collection were collected at several localities nearby Montecelio and it is not possible to obtain information on their stratigraphic position. In addition informative labels and/or data on their provenance are missing. Therefore they are not described in the paleontology Section 5.3.

The fossil remains were compared with osteological material, both fossil and recent, stored in the Department of Earth Sciences of the "Sapienza"University of Rome. Biochronology of large mammals follows the scheme proposed by Gliozzi et al. (1997) and later implemented by Marra et al. (2014a).

5. Results

5.1. Geomorphological and stratigraphic reconstruction

The small dataset of topographic culminations (26 data), when statistically analyzed through a maximum 5 m elevation range window, shows a high degree of clustering (Fig. 3c), which allows us at identifying two main classes of elevation values: a largest set of values (9) ranging 102–107 m a.s.l., and a second one (6 values),

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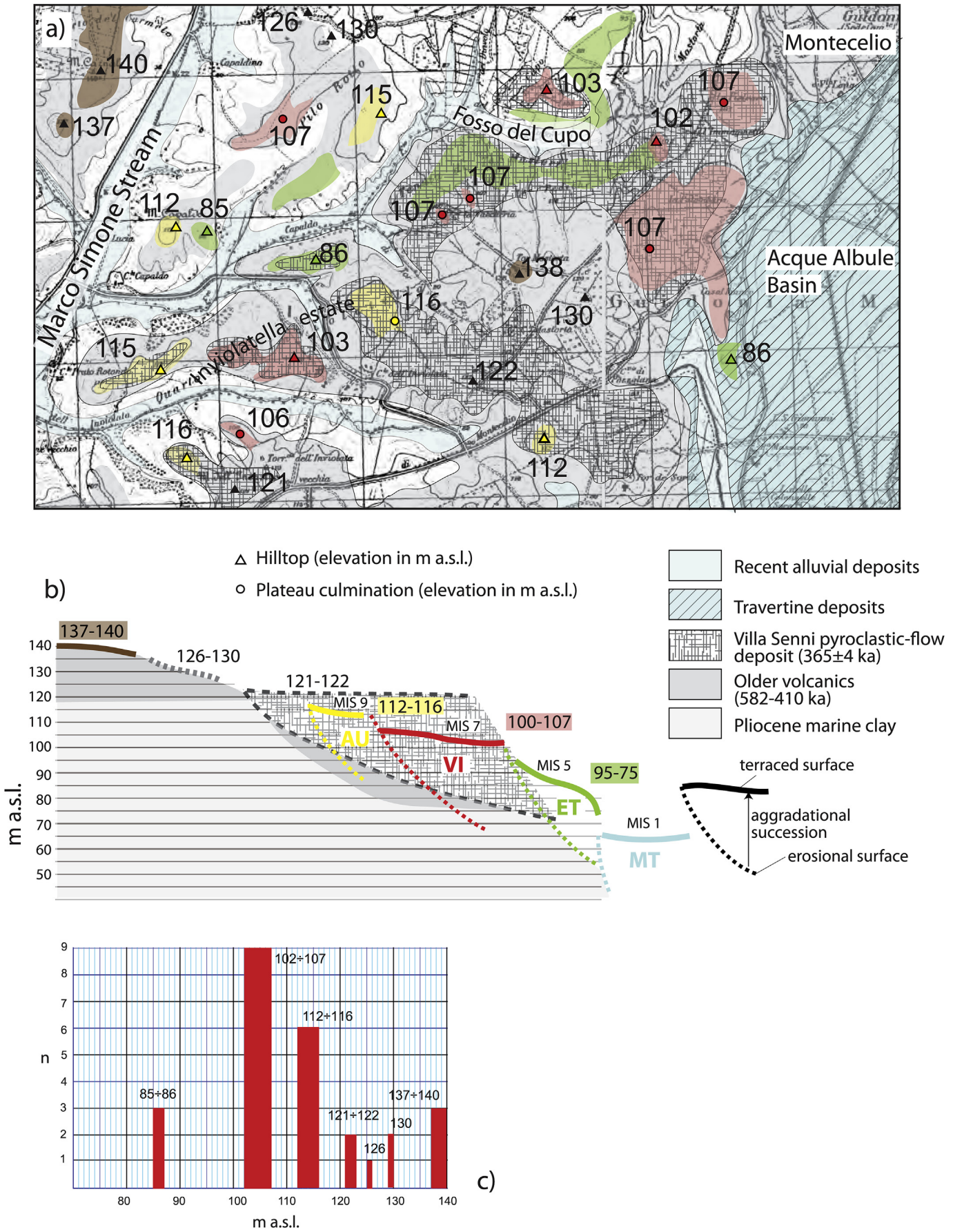

Fig. 3. a) Geologic map of the investigated area showing the reconstructed paleosurfaces (colored areas), according to the geomorphological study described in the text. Relic fluvial terraces, as shown in the schematic cross-section (b), have been recognized based on statistically assessed elevation ranges for all the hilltops and plateau culminations (c). (For interpretation of the references to color in this figure legend, the reader is referred to the web version of this article.)

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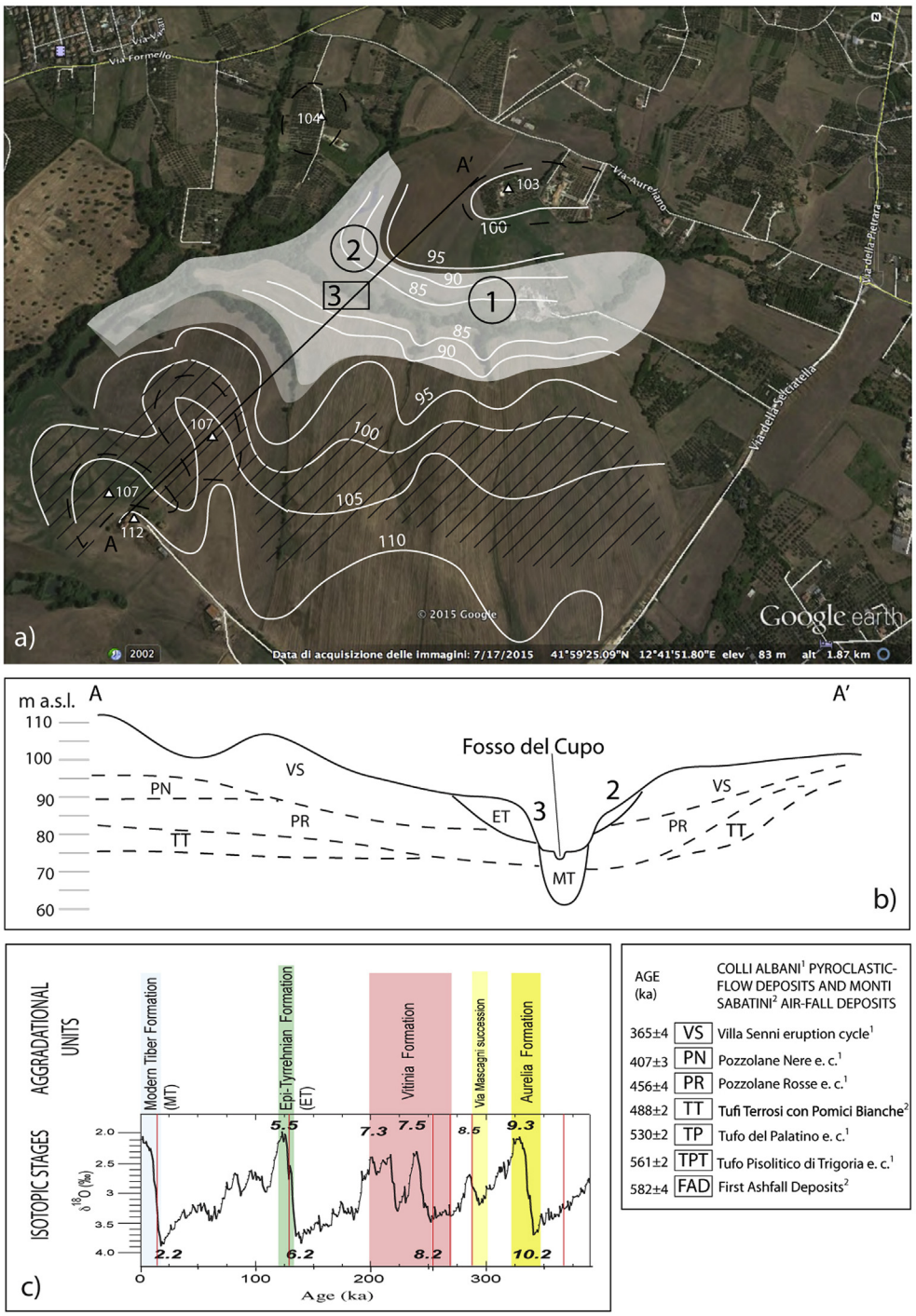

Fig. 4. a) Geomorphological relief of the area surrounding Fosso del Cupo Valley, showing the lowest terraced surface recognized in this study, ranging 95–85 m a.s.l. (shaded area); the two sectors of collection of the lithic industry and fossil remains described in the paper are also shown (#1 and #2). b) Cross-section (A–A′) showing the stratigraphic setting and the geometry of the terraced sedimentary deposit cropping out along the banks of the valley (sector #3), and correlated with MIS 5.5 and the Epi-Tyrrhenian Formation (c).

ranging 112–116 m a.s.l.. Secondary concentrations (3 values) correspond to the highest and to the lowest culminations within the investigated area, ranging 137–140 m a.s.l., and 85–86 m a.s.l., respectively.

The colored areas (brown, yellow, red, green) in Fig. 3a represent portions of surface comprised within the four narrow ranges of elevations described above. We interpret these surfaces as the remnants of as many fluvial terraces formed in this area during the highstand periods, due to the combined effect of regional uplift and sea-level oscillations.

In order to correlate these paleo-surfaces with the corresponding MIS, we combine a simple principle of geometric relationship with respect to the present alluvial plains, which constitute the MIS 1 terrace, with the chronostratigraphic constraint provided by their position with respect to the pyroclastic-flow deposit of the Villa Senni eruption sequence, dated

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at 365 ± 4 ka (Marra et al., 2009). We have mapped the Villa Senni deposit in this area through field data and revising previous geologic mapping (e.g.: sheet 150 of the 1:100.000 geologic map by Servizio Geologico d'Italia) in which stratigraphic relationships were biased by the lack of knowledge upon the mechanisms of emplacement of the Colli Albani volcanic products. Indeed, we have observed a systematic topographic inversion, with the youngest pyroclastic-flow deposit of Villa Senni eruption cycle (365 ± ka, Marra et al., 2009) occurring at a lower elevation with respect to the older pyroclastic-flow deposit of Tufo Pisolitico di Trigoria (561 ± 1 ka, Marra et al., 2009), and to the air-fall deposit erupted by the Monti Sabatini district in the time span 582 ± 1–410 ± 2 ka (Karner et al., 2001b), capping the highest hilltops. This is a consequence of the progressive uplift of this sector since 600 ka (Karner et al., 2001a), combined to the fact that the pyroclastic-flow deposit of Villa Senni emplaced during the regressive phase of MIS 10, filling the paleo-incisions excavated during the low-stand of the sea-level (Karner and Marra, 1998), and forming a pyroclastic plateau 365 ka, successively re-eroded due to the continued sea-level fall until 350 ka (see morphostratigraphic scheme in Fig. 3b). The remnants of this pyroclastic plateau are found at 121–122 m a.s.l. (Fig. 3a, b), allowing us at identifying the underlying paleo-surface at 112–116 m a.s.l. as the terrace formed during the successive highstand of MIS 9, ca. 325 ka, by the deposits of the Aurelia Formation which filled the paleo-valleys (Fig. 3b). Consistent with this correlation, the underlying, wider paleo-surface occurring 102–107 m a.s.l., correlates well the geometric features of MIS 7 terrace, which in this region is the most preserved one and displays elevation gain in the order of 40 m with respect to MIS 1 terrace (Marra et al., 2015). Also consistent with observation in Marra et al. (2015) about the scarce preservation of the MIS 5 terrace in the larger area of Rome, we have correlated with this isotopic stage a poorly defined, lowest paleo-surface comprised between 95 and 75 m a.s.l. (Fig. 3b), which we have interpreted as pertaining to the topographic culminations at 85–86 m a.s.l. (Fig. 3a). Remarkably, this paleo-surface is well represented on both sides of the Fosso del Cupo valley (Fig. 4a), where Ponzi (1866–67) described the terraced deposit later attributed to MIS 5 (Evangelista and Porcari, 1988).

Our field survey allowed us to recognize the different nature of the terrains exposed by ploughing in the sector represented by the shadowed area in Fig. 4a, which are constituted by whitish sandy silt with sparse carbonatic concretions, as opposed to the brownish earth conglobating remnants of pyroclastic deposit, orange in color, with characteristic large leucite crystals and holocrystalline lithic inclusion ("Italite"), typical of the "Pozzolanelle" upper pyroclastic-flow deposit of the Vila Senni eruption cycle (Freda et al., 1997). The soil derived by alteration of the "Pozzolanelle" extends to the

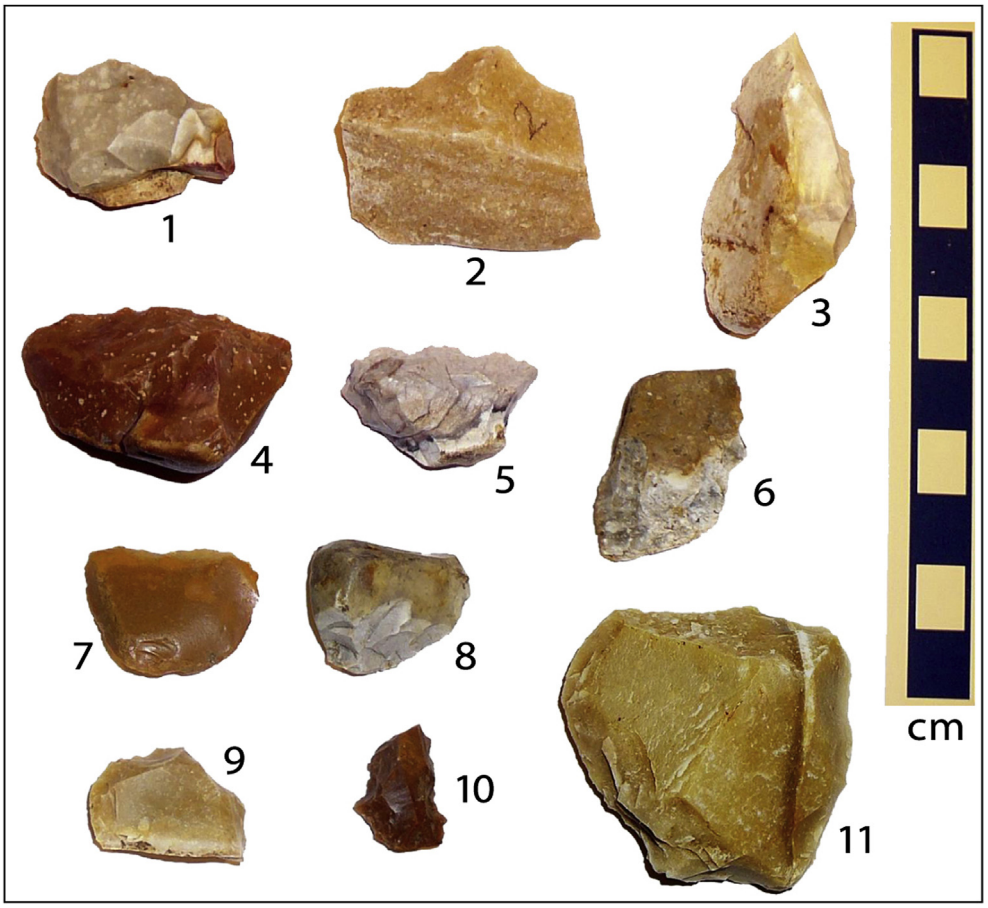

Fig. 5. Tools from the lithic assemblage recovered during the collection performed in the sectors #1 and #2 reported in Fig. 4a. 1 – Single convex side-scraper on pebble, thick, retouch in little scales, butt lacking; 2 – Pièce écaillé on flake, irregular retouch in little scales, butt lacking; 3 – Single convex side-scraper on pebble, thick, retouch in little scales, butt lacking, retains part of the cortex; 4 – Convex transverse scraper on flake, retouch in little scales, punctiform butt; 5 – Denticulate scraper on flake, thick, retouch in little scales, butt lacking; 6 – Single convex side-scraper on pebble, retouch in little scales, straight butt; 7 – Straight transverse scraper on flake retaining a large portion of the cortex, retouch in little scales, cortical butt; 8 – Single convex side-scraper on flake retaining a large portion of the cortex, retouch in little scales, cortical butt; 9 – Convex transverse scraper on thick flake retaining portion of the cortex, retouch in little scales, cortical butt; 10 – Denticulate scraper on a little flake, thick, retouch in little scales, cortical butt; 11 – Double scraper on a large flake, retouch in little scales, without cortex, punctiform butt.

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plateau culminations at 103–107 m a.s.l., and at 112 m a.s.l. (Fig. 4a). A partial exposure of the sedimentary deposits occurs on the steep scarp constituting the bank of the fluvial incision hosting the Fosso del Cupo (sector #3 in Fig. 4a), where white, sandy clay with freshwater gastropods crops out, as illustrated in cross-section A–A′ of Fig. 4b. Comparison of the cross-section realized for this study with the one reported by Ponzi (1866–67) (Fig. 2a) shows the strict correspondence of these outcrops, allowing us at correlating the sedimentary deposit occurring in both sections with the aggradational succession of MIS 5 (Epi-Tyrrhenian Formation), and constraining its age in the interval 130–120 ka (Fig. 4c). Moreover, the description of the two volcanic layers as rich in leucite crystals (the uppermost one) and dark red in color (the lowest one), is suggestive of an erosional, direct contact of the Pozzolanelle (characterized by abundant euhedral leucite in the matrix) above the Pozzolone Rosse (typically red in color) pyroclastic-flow deposit, as reported in the cross-section A–A′ in Fig. 4b, and as commonly verified in the field, consistent with emplacement of the Villa Senni deposits during the erosional phase of MIS 10. In contrast, the description made by Rusconi (1866–67) of the bed from which other fossil remains were recovered as a sedimentary layer interbedded between two volcanic deposits fits well the stratigraphic setting at the Inviolatella estate (Fig. 3a), where the base of the Villa Senni pyroclastic-flow deposit is exposed.

5.2. Palethnology

The lithic artifacts recovered in Fosso del Cupo Valley, sectors #1 and #2 (Fig. 4a; Table 1), are represented by 10 tools, essentially constituted by small to medium sized scrapers, described in Fig. 5. Moreover, there are 4 irregular cores (three retaining cortex; Fig. 6a), and 24 small flakes, only three retaining cortex and six with butt (3 punctiform, 2 cortical, 1 thick faceted convex) (Fig. 6b). One larger tool (#11 in Fig. 5) has been recovered on the terraced surface to the south of Fosso del Cupo, close to sector #3 in Fig. 4a.

Table 1
Lithic industry of Fosso del Cupo: classification after Bordes' (1961) typology.

Lithic industry	n.	%
Tools	11	28.2%
Cores	4	10.3%
Flakes	24	61.5%
Total	39	100.00%

Butt	Tools		Flakes		Total	
	n.	%	n.	%	n.	%
Lacking	4	36.36	18	75.0	22	62.85
Smooth	1	9.09	–	–	1	2.85
Cortical	4	36.36	2	8.3	6	17.14
Punctiform	2	18.18	3	12.5	5	14.28
Faceted straight	–	–	–	–	–	–
Faceted convex	–	–	1	4.2	1	2.85
Faceted concave	–	–	–	–	–	–
Bihedral	–	–	–	–	–	–
Total	11	100.00	24	100.00	35	100.00

Typological Bordes' list		n.	%
9	Single straight side-scraper	4	36.36
15	Double convex side-scraper	1	9.09
22	Straight transverse scraper	1	9.09
23	Convex transverse scraper	2	18.18
43	Denticulate	2	18.18
45–50	Retouched flake	1	9.09
	Total	11	100.00

All the artifacts are well preserved, without evidence of rolling and smoothing, and do not display patina (Figs. 5 and 6), suggesting that they were actually embedded in the terraced fluvial-lacustrine deposits and emerged on the surface as a consequence of ploughing.

In the overall, the lithic industry of Fosso del Cupo, including also the few pieces illustrated by Ponzi (1866–67) and described by Rellini (1941), is poor from a technological point of view and lacks of a definite typology, probably also as a consequence of the quality of the exploited materials. The reduced dimensions of the artifacts are indeed suggestive of the fact that the available lithic material was essentially represented by the small silicic pebbles occurring in the fluvial gravel layers and in the channeled clastic deposits cropping out locally, which were eroded and transported from the nearby Cornicolani Mounts. However, several instruments display features similar to those pertaining to the local Pontinian culture (Blanc, 1939), which is characterized by the use of the bipolar technique, a low Levallois index, a high percentage of scrapers and by the presence of naturally backed knives (Rolfo et al., 2013, and references therein). In particular three sidecrapers (#6, #7 and #8 in Fig. 5) and one flake (#9 in Fig. 6), with cortex made on completely cortical flakes or calotte from small sized pebbles, have typical Pontinian appearance. Although other typical tools recurring in the Pontinian assemblages, like transverse and pointed scrapers made on completely cortical flakes or calotte, and centripetal cores are absent, the recovered lithic industry can be attributed to a generic Pontinian facies of the local Mousterian, also considering the lack of any Upper Paleolithic or Neolithic element.

5.3. Paleontology

The fossil remains collected on the terraced area to the north of Fosso del Cupo (Fig. 7) include the following taxa:

5.3.1. Elephantidae

Two fragments of tusk are recognized within the material collected at Fosso del Cupo. Unfortunately it is not possible to distinguish between *Palaeoloxodon* and *Mammuthus*.

5.3.2. Panthera spelaea

The cave lion is only represented by a scapholunatum (Fig. 7A) which displays the typical morphologies of the taxon (see for example Diedrich, 2011: Fig. 5, n° 6).

5.3.3. Vulpes vulpes

A small sized hemimandible without teeth, display the horizontal ramus relatively low and smaller than in *C. lupus*. It resembles in dimensions the mandibles of several red fox specimens collected in the Late Pleistocene of Ingarano (Petronio et al., 2006).

5.3.4. Stephanorhinus sp.

A fragment of an upper deciduous can be referred to the genus *Stephanorhinus*. Indeed, the ectoloph profile does not display the typical characters of the genus *Coelodonta* (e.g., wavy profile, marked hypsodonty) (Fig. 7B).

5.3.5. Equus hydruntinus

The species is represented by a first or second upper molar of relatively small size (Fig. 7C). The enamel thick is relatively weak, the interstylar faces have a flattened trend, the pilasters are simples and do not have a tendency to double, the plis caballin is lacking and the protocone is short. These features are typical of this species (Conti et al., 2010).

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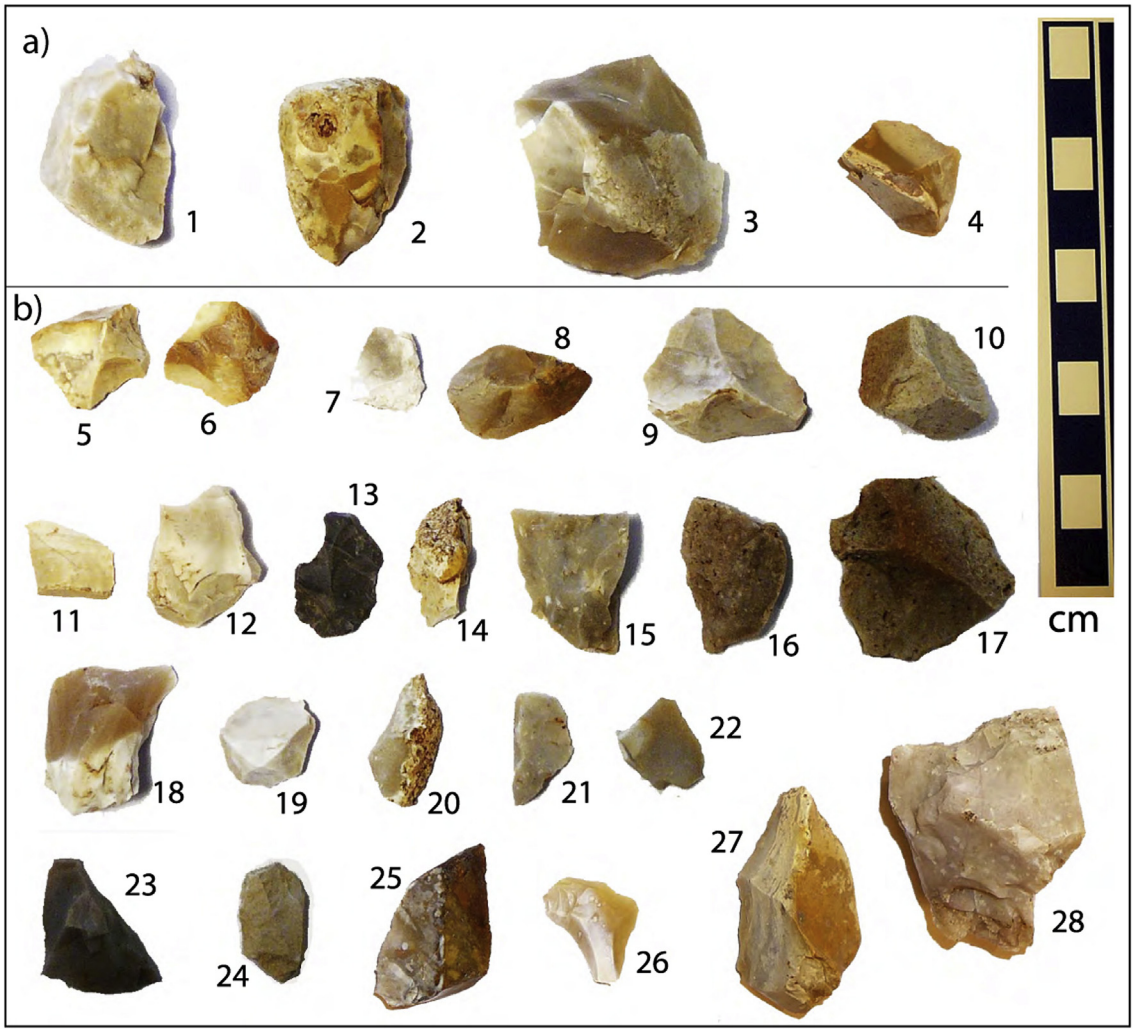

Fig. 6. a) Cores and b) flakes from the lithic assemblage recovered during the collection performed in the sectors #1 and #2 reported in Fig. 4a.

5.3.6. Sus scrofa

A third lower molar can be attributed to the wild boar (Fig. 7D). The tooth is relatively small and much worn.

5.3.7. Bos primigenius

The auroch is documented at Fosso del Cupo by a distal trochlea of humerus, a pyramidal, a fragmented central tarsal bone and a subintact second phalanx (Fig. 7E). Dimensions and morphologies of the bones are similar to those of several Late Pleistocene remains of auroch collected from different Italian localities (e.g., Avetrana, Taranto: Pandolfi et al., 2011, 2013).

5.3.8. Cervus elaphus ssp.

The species is represented by a lower part of antler with the rose, two distal epiphysis of radius and a first phalanx (Fig. 7F). The dimensions of the collected remains are larger than those of *D. dama* but are not useful to discriminate between the different subspecies of red deer occurred in Italy during the Middle and Late Pleistocene.

5.3.9. Dama dama dama

Two lower parts of fall antler (Fig. 7G), one with complete brow tine, are attributed to the evolved subspecies of European fallow deer, *Dama dama dama*. Indeed, they do not show any part of the beam between the rose and the brow tine, as in *D. clactoniana* and in the living fallow deer, while in *D. dama tiberina* a short part of beam is usually present (Di Stefano and Petronio, 1997); the dimensions and the proportions of the specimens exclude an attribution to *D. clactoniana* (see Di Stefano, 1995), whereas the obtuse angle between the beam and the brow tine range within the variability of extant fallow deer (Di Stefano, 1995; Di Stefano and Petronio, 1997). Another antler fragment (a portion of palm without spellers) and several postcranial remains of medium sized cervid (a distal epiphysis of humerus, a distal epiphysis of radius, a proximal epiphysis of metacarpal bone, a distal epiphysis of tibia, three astragali (Fig. 7H–I), a fragmented central tarsal bone) display morphological features of fallow deer (Di Stefano, 1996; Lister, 1996) and dimensions close to *D. dama dama* (see Di Stefano, 1995).

5.4. Biochronology

The analysis of the mammal remains collected at Fosso del Cupo confirms the taxa yet recorded by Ponzi (1866–67), in particular the presence of *C. elaphus*, *B. primigenius* and an indeterminate Proboscidean. The occurrence of a rhinoceros has been also reported by Ponzi (1866–67); two teeth of the steppe rhinoceros *S. hemitoechus* belonging to the Rusconi Collection could correspond to the specimens referred as *Rhinoceros thycorhinus* by Ponzi

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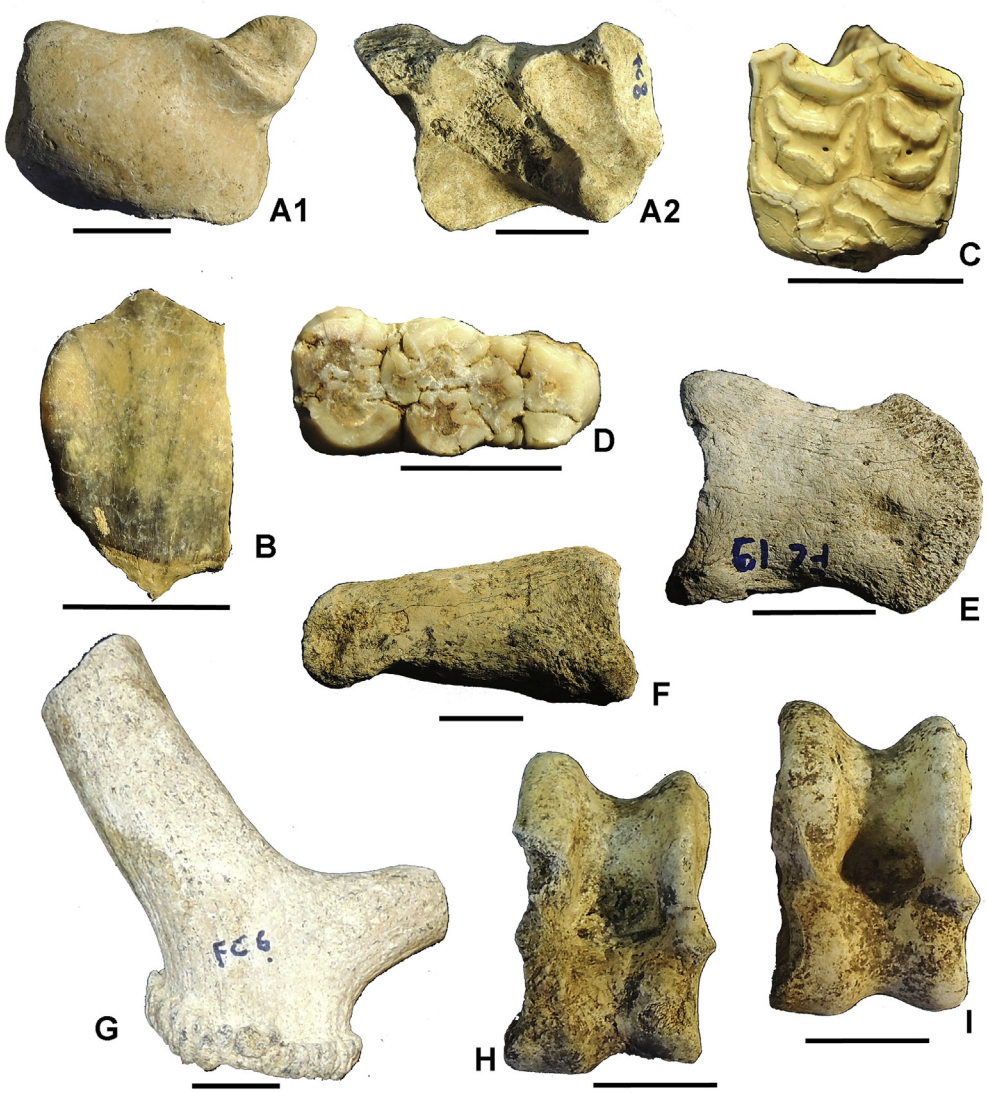

Fig. 7. Selected mammal remains from the vertebrate assemblage recovered in the sectors #1 and #2 reported in Fig. 4a. **A**: scapholunatum of *Panthera spelaea*, 1) dorsal view, 2) ventral view; **B**: fragment of upper deciduous of *Stephanorhinus* sp., labial view; **C**: upper molar of *Equus hydruntinus*, occlusal view; **D**: third lower molar of *Sus scrofa*, occlusal view; **E**: second phalanx of *Bos primigenius*, lateral view; **F**: first phalanx of *Cervus elaphus*, lateral view; **G**: fragmented antler of *Dama dama dama*, lateral view; **H** and **I**: astragali of *Dama dama dama*, anterior view. Scale bars equal 2 cm.

(1866–67). In addition to these taxa we also recorded the presence of *P. spelaea*, *V. vulpes*, *S. scrofa*, *E. hydruntinus* and *D. dama*.

The recorded taxa, at species level, suggest that the local fauna from the sandy level of Fosso del Cupo can be referred to the late Middle or early Late Pleistocene (Table 2). Many species identified at Fosso del Cupo occurred during the Middle and Late Pleistocene, i.e. *P. spelaea*, *S. scrofa*, *E. hydruntinus*, *D. dama*. The red deer, *C. elaphus*, which still lives in Italy, is not a useful discriminator between MIS 7 and MIS 5, because such distinction might be provided by identification at the subspecies level only, and can be made by comparison of well-preserved and complete antlers, which are not reported among the fossil remains of Fosso del Cupo. In particular the endemic forms *C. elaphus aretinus* and *C. elaphus rianensis* occurring during MIS 9 and 7 (Torre in Pietra and Vitinia Faunal Units) were replaced by a subspecies of *C. elaphus* ssp. with antler morphology similar to that of the extant populations at the beginning of Late Pleistocene (Di Stefano and Petronio, 1993, 2002; Petronio et al., 2007, 2011; Di Stefano et al., 2015). The occurrence of the genus *Dama* in Italy has been recently referred to ca. 650 ka by Marra et al. (2014a) (Vitinia lower gravels). According to Gliozzi et al. (1997) and Petronio et al. (2011), the first occurrence of the species *D. clactoniana* was during the Isernia FU, but Breda and Lister (2013) recently suggested a close affinity of these fossil remains with *D. roberti*. *D. clactoniana* occurred in several Middle Pleistocene localities chronologically related with Fontana Ranuccio and Torre in Pietra FUs (correlated with MIS 13–11 and MIS 9; Petronio et al., 2011; Marra et al., 2014a). Remains of an archaic fallow deer, *D. dama tiberina*, were reported from fluvial-lacustrine deposits in the area of Rome chronologically related with MIS 8.5–7 (Marra et al., 2014a, 2015), whereas, the extant subspecies, *D. dama dama*, occurred for the first time at the beginning of the Late Pleistocene, it was particularly abundant during the last interglacial, it has gradually rarefied during the Last Glacial, and became extinct in Italy before the Last Glacial Maximum (Di Stefano and Petronio, 1997; Petronio et al., 2007, 2011; Marra et al., 2014a). A similar chronological information is provided by the presence of *E. hydruntinus* which was firstly recorded in Italy during MIS 8.5, it was more common during the Late Pleistocene and became extinct

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in Italy in the middle Holocene (Conti et al., 2010; Marra et al., 2014a, 2015). *B. primigenius* occurred early in Italy at Venosa-Notarchirico, ca. 600 ka (Cassoli et al., 1999; Lefèvre et al., 2010), and it was recorded together with *Bison schoetensacki* (see Cassoli et al., 1999). The auroch has been recorded in the fossiliferous localities of the Roman area geochronologically dated at ca 500 ka (Valle Giulia Formation, MIS 13, Marra et al., 2014a). The early aurochs appear smaller and slender than those from the late Middle Pleistocene (Pandolfi et al., 2011, 2013) and they probably origin from African species of the genus *Bos* (see Martínez-Navarro and Rabinovich, 2011; Martínez-Navarro et al., 2014). The parallelism in the diffusion of the *Bos* and the Acheulean culture (Mode II tools) has been established by Martínez-Navarro et al. (2007, 2010) and also recently confirmed by Ceruleo et al. (2015).

Pleistocene, consistent with correlation of the deposit with MIS 5 (Table 2).

Consistently, the typological affinity with the Pontinian facies of the local Mousterian displayed by the recovered lithic industry suggests an age ranging 120–36 ka for the terraced deposit of Fosso del Cupo. The Pontinian lithic industries have been firstly described by Blanc (1939) who used this name for the Mousterian assemblages recovered in cave at Mount Circeo and in several surface sites of the Pontina Plain along the southern coast of Latium. Following the interpretative model proposed in Palma di Cesnola (2001) the Mousterian culture of Italy developed in several parallel clusters represented by different territorial enclaves, each one preserving its techno-cultural characteristics, the Pontinian culture being one of these clusters. However, also due to the fact that most

Table 2
Mammal remains recovered from Fosso del Cupo (Montecelio, Central Italy) and distribution range in the late Middle and early Late Pleistocene of Italy of the taxa identified. NISP: number of identified specimens; FU: Faunal Unit; MIS: Marine Isotope Stage.

species	NISP	Torre in Pietra FU (MIS 10-9)	Vitinia FU (MIS 8.5-7)	Melpignano FU (MIS 5)
Elephantidae	2			
Panthera spelaea	1			
Vulpes vulpes	1			
Stephanorhinus sp.	1			
Equus hydruntinus	1			
Sus scrofa	1			
Bos primigenius	4			
Cervus elaphus ssp.	4			
Dama dama dama	11			

Stephanorhinus is well testified in the Peninsula during the whole Pleistocene. The genus became extinct during the first half of MIS 3, probably around 40 ka (Pandolfi and Tagliacozzo, 2015).

6. Discussion of the chronologic indicators

Due to the lack of outcropping sections, we have applied a geomorphologic criterion to date the terraced deposits of Fosso del Cupo described by Ponzi (1866–67). The employed approach relies on the fact that this region experienced ~50 m of uplift since 200 ka (Karner et al., 2001a), in consequence of which the paleo-surfaces of the depositional successions emplaced during MIS 7 and MIS 5 form a suite of terraces that in the coastal area are raised 55 and 35 m, respectively, with respect to the alluvial plains created by the last aggradation phase of MIS 1, providing a simple and straightforward method of correlation. Comparison of the cross-section realized for this study with the one reported by Ponzi (Fig. 2a) allowed us to correlate the sedimentary deposit occurring in both sections with the aggradational succession of MIS 5.5 (Epi-Tyrrhenian Formation), and constraining its age in the interval 130–120 ka (Fig. 4c).

The identified fossil remains, at species level, suggests an age spanning from MIS 8.5 to MIS 3 (approximately from 280 to 40 ka); however, the occurrence of the evolved fallow deer subspecies, *D. dama dama*, the most abundant taxon recovered at Fosso del Cupo, restricts the chronological range to the first half of the Late

of the Pontinian assemblages occurs at open-air sites, the definition of a precise chronological context and of definite technological and typological features has been problematic (Rolfo et al., 2013). Based on the studies of Guattari and Breuil caves at Monte Circeo, and Moscerini and Sant'Agostino caves on the southern coast (Schwarcz et al., 1990–91), and to the studies in the Colli Albani area (D'Ambrosio et al., 2010), which have documented the northwestern areal extension, a broad interval spanning 120–36 ka has been so far outlined for the Pontinian assemblages.

7. Conclusions

The scarcity of outcropping sedimentary deposits correlated with the aggradational cycle of the penultimate glacial termination (MIS 5) discussed in the recent literature (Marra et al., 2015) represents a limiting factor to the study of the Late Pleistocene faunal assemblages and to the Middle Paleolithic lithic industries of the coastal area of Latium, as opposed to the rich record yielded by the sedimentary deposits of the previous glacio-eustatic cycles, spanning MIS 15 through MIS 7.

The geomorphological and stratigraphic study conducted in the area of Fosso del Cupo allowed us at identify the sedimentary deposits in which the occurrence of a small set of lithic artifacts associated with vertebrate fossils was reported in the literature of the 19th century (Ponzi, 1866–67), and to demonstrate its correlation with the aggradational succession of MIS 5.5 (Epi-Tyrrhenian Formation, Marra et al., 2015). Therefore, the lithic industry and the

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faunal assemblage recovered by a dedicate surface collection that we performed in the terraced deposits around the site described by Ponzi (1866–67) can be ascribed to the Pontinian culture and to the Melpignano Faunal Unit, respectively (Tables 1 and 2).

With its tight age constraint close to 125 ka, the lithic industry of Fosso del Cupo, although limited in number, represents an important witness of the early development of the Pontinian culture and should be considered a regional marker, which may concur to improve the knowledge on the Mousterian of Central Italy.

Appendix 1. List of Fossil remains collected at Fosso del Cupo

FC1	Articular fragment of humerus *Bos primigenius*
FC2	Fragments of antler *Dama dama dama*
FC3	Fragment of scafocuboid *Bos primigenius*
FC4	Pyramidal *Bos primigenius*
FC5	Distal epiphysis of humerus *Dama dama dama*
FC6	Fragment of antler with the rosette *Dama dama dama*
FC7	Astragalus *Dama dama dama*
FC8	Scafolunatum *Panthera spelaea*
FC9	Astragalus *Dama dama dama*
FC10	Astragalus *Dama dama dama*
FC11	Upper first or second molar *Equus hydruntinus*
FC12	Fragment of antler with rosette *Cervus elaphus*
FC13	Distal epiphysis of tibia *Dama dama dama*
FC14	Fragment of antler *Dama dama dama*
FC15	Proximal epiphysis of metacarpal *Dama dama dama*
FC16	Scaphoocuboid *Dama dama dama*
FC17	Fragment of radius *Dama dama dama*
FC18	Fragment of the distal epiphysis of radius *Cervus elaphus*
FC19	Fragment of second phalanx *Bos primigenius*
FC20	Fragmentary mandible *Vulpes vulpes*
FC21	First phalanx *Cervus elaphus*
FC22	Third lower molar *Sus scrofa*
FC23	Fragment of deciduous tooth *Stephanorhinus* sp.
FC24	Fragment of the distal epiphysis of radius *Cervus elaphus*
FC25	Two fragments of tusk Elephantidae

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