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LATE QUATERNARY EVOLUTION OF THE TERNI BASIN, CENTRAL ITALY: NEW GEOARCHAEOLOGICAL DATA

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ABSTRACT: Bertacchini M., *New geoarchaeological data on the recent evolution of the Terni basin, Central Italy.* (IT ISSN 0394-3356, 2009).
Because of an archaeological find of part of a Hellenistic city wall (ca 5th -3rd century BCE) a well-preserved 10 m thick fluvial sequence was studied close to the centre of the town of Terni, in an area of Central Italy (Umbria) where the geological outcrops are generally scarce. This study was made in a large excavation for a building that permitted direct observation of the sediments that filled the Terni basin and provided a step forward in our knowledge of its geoenvironmental evolution. The sedimentary sequence was deposited by a segment of the ancient Nera river-course (paleo-Nera) in the Late Pleistocene-Early Holocene and its presence is correlated with the development of the first human settlements in the town of Terni. This fluvial sequence shows evidence of a low-sinuosity gravel meander system consisting of transverse gravel bars and gravel sheets in its lower part, that are capped by a 5 m thick levee unit and overbank deposits interbedded with incipient paleosols and a crevasse channel unit. The floristic composition contents in the paleosols of the overbank sequence provide important information on the climatic transition from the Late Glacial to the Holocene. The upper part of the sequence, a paleosol dated with archaeological remains to Roman times, contains important elements that aid in understanding the development of the first phases of urbanisation of the ancient town of Terni.

RIASSUNTO: Bertacchini M., Nuovi dati sull'evoluzione recente della piana di Terni (Italia centrale). *(IT ISSN 0394-3356, 2009).*
Lo scavo ad uso civile realizzato nel sito di Corso del Popolo, nei pressi del centro storico di Terni, ha permesso la diretta osservazione di una potente successione sedimentaria di ambiente fluviale deposta a partire dal Tardo Pleistocene da un antico tratto del fiume Nera (paleo-Nera). Lo studio di dettaglio condotto sulla successione esposta ha rappresentato una importante opportunità per la raccolta di nuove informazioni sull'evoluzione geologico-ambientale recente del bacino di Terni, attraverso indagini di tipo geologico-sedimentologico, mineralogico-petrografico, paleontologico e pollinico, affiancate da dati archeologici. La base della successione è rappresentata da sedimenti ghiaiosi di canale attivo passanti a depositi di esondazione con sequenze di argine, di canale di rotta e di canale di crevasse, intervallati da paleosuoli interessati da una pedogenesi poco evoluta. La variazione del contenuto pollinico registrata all'interno dei depositi di esondazione è da imputare al cambiamento climatico legato alla fine del Tardi-Glaciale ed all'inizio dell'Olocene. L'abbandono del canale fluviale favorisce la formazione di un lago poco profondo o acquitrino e la deposizione di sedimenti carbonatici fini interrotti a tetto da un paleosuolo archeologicamente riferibile al I sec. a.C. I dati stratigrafici e cronologici ottenuti dallo studio della sequenza investigata concorrono a ricostruire con maggior puntualità la situazione geo-ambientale che accompagnò le prime fasi di urbanizzazione della città di Terni.

Keywords: fluvial deposits, paleosols, Holocene, Terni, Central Italy.

Parole chiave: depositi fluviali, paleosuoli, Olocene, Terni, Italia Centrale.

INTRODUCTION

The Terni plain is located in the southern part of the Umbria region, within the central and terminal sectors of the Nera river basin (fig. 1). It is a transition area between the inner Apennine chain and the hills and plains of the western regions of Italy in the Tiber Valley (southern and northern Etruria).

The stratigraphy of the continental deposits filling the Terni basin is not well-known because of the scarcity of useful outcrops. The entire continental succession, which characterises the recent sedimentary deposition of the plain, is largely hidden below the surface. Most of the detailed subsurface geological data collected has come from archaeological or civil excavations and the results of recent studies of the sediments in the Terni basin (BERTACCHINI *et al.*, 2006; FAZZINI & MAFFEI, 2006) have not permitted a recognition of the continuous stratigraphic succession, mainly formed by lacustrine and fluvial-lacustrine sediments, deposited from the VII century BCE until Roman times. In this framework the sequence here studied is fundamental for the knowledge of the sediments filling the Terni basin and for better understanding both the geoenvironmental evolution of the plain and the development of the first human occupation in the centre of Terni. The Terni plain has continuously been a major communication and trade passageway since the Bronze Age, because of its morphological and strategic geographical location (GIONTELLA, 2006).

The town of Terni was formally founded in the 672 BCE (BONOMI PONZI, 2006), even though the oldest significant phase of its urban development was in the 3rd century BCE, in coincidence with the Roman expansion in the Umbria region (PERISSINOTTO, 2006). The ancient name of Terni, *Interamna Nahars*, means "between two rivers", was given because its position at a confluence of the Nera river with the Serra-Tescino stream suggesting a different hydrographic layout at that time. Several authors have hypothesized that both streams have probably changed their courses through time (GRASSINI, 1947; FONTAINE, 1990; FAZZINI & MAFFEI, 2006), on the basis of archaeological data (fig. 1).

This paper presents the data obtained of a vertical sequence of sediments exposed by a civil excavation (over 50 m wide) conducted in summer 2006 along Corso del Popolo road, close to the centre of Terni, which has given us an insight as to the morphologic grounding of this newly founded city in its earliest days.

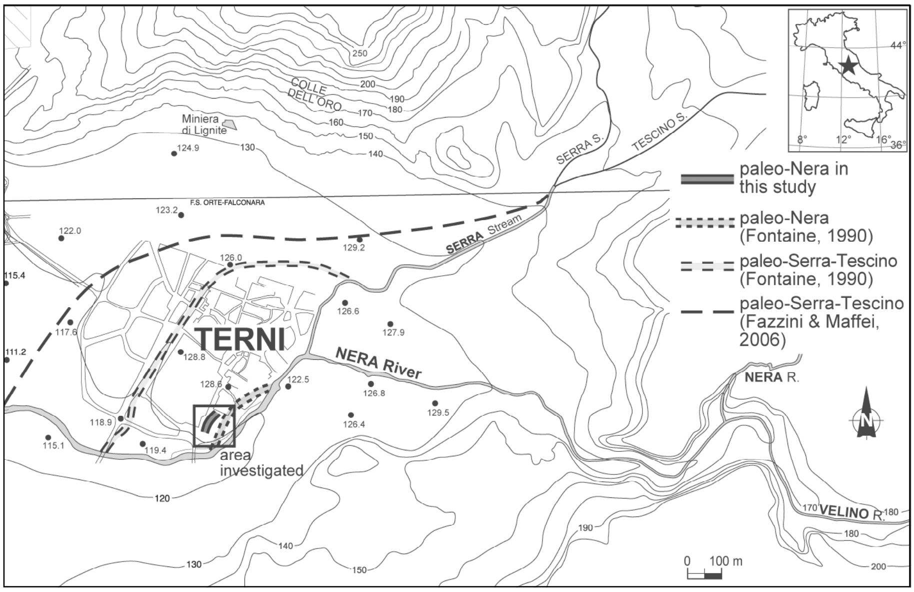

Fig. 1 - Morphological and geographical location of the town of Terni. This map contains the present-day hydrographic system and the stream-course changes both of the Nera River, according to this study and that of Fontaine (1990), together with data concerning the Serra-Tescino stream, according to Grassini (1947), Fontaine (1990) and Fazzini & Maffei (2006). The confluence of the Serra-Tescino stream with the Nera River during medieval times has been suggested by Grassini (1947) and Fontaine (1990).

Ubicazione geografica della città di Terni e rappresentazione cartografica semplificata del suo territorio. Nella mappa è ricostruita la paleoidrografia dei principali corsi d'acqua dell'area: il Fiume Nera, sulla base dei risultati presentati in questa ricerca e dei dati pubblicati da Fontaine (1990); e i torrenti Serra e Tescino, come riportato da Grassini (1947), Fontaine (1990) e Fazzini & Maffei (2006).

GEOLOGICAL SETTING

The Terni plain is one of the fault-bounded intermontane basins formed during the Plio-Quaternary succession of tectonic phases in an extensional regime, which affected the central portion of the northern Apennine chain (Barchi *et al*., 1991; Cattuto *et al*., 1992; Cavinato *et al*., 1993; Brozzetti & Lavecchia, 1995). Accordingly, the elongated NNE-SSW shape of the Terni basin results from the complex interaction of the Martani, Sabini and Val di Serra fault systems boardering the plain (Bonini, 1997; Girotti & Mancini, 2003).

The Terni basin is considered to be the western elongation of the Tiber basin, an intermontane Apenninic depression that was gradually filled with fluvial and lacustrine deposits (Lotti, 1917; Lippi Boncambi, 1960; Ambrosetti *et al*., 1978; Basilici, 1993; Ambrosetti *et al*., 1995; Conti & Girotti, 1977; Girotti & Mancini, 2003). A shallow lake or pond system occupied the Terni basin up to earliest historical times that gradually disappeared due to the alluvial infill from the Nera, Serra and Tescino streams (Bertacchini *et al*., 2006; Fazzini & Maffei, 2006).

The Terni basin is flanked by Martani-Reatini Mountains to the east and Amerini-Narnesi-Sabini Mountains to the west. These higher areas consist of calcareous Meso-Cenozoic units of the Umbria-Marche marine succession, where the headwaters of the Nera river and its main tributaries are located (the Aia and Serra-Tescino streams and the Bianco-Caldaro brook). The predominance of carbonate rocks in this Apennine area greatly control the composition of the sediments transported by the watercourses into the Terni basin as well as the groundwater composition of the region.

METHODS

Preliminary data here presented results from a sedimentological and physical study of the sediments in order to integrate the detailed visual inspection of the deposits and define the lithostratigraphical sequence. These data are a combination of: lithology, grain size, sedimentary structures, colour and any other possible diagnostic element. Colour definitions, such as 2.5 Y 5/4, are referred to Munsell Colour Soil Chart and consists of hue (2.5 Y), lightness (5), and chroma (4). AMS (Accelerator Mass Spectrometry, Nelson et al. 1977; Bennett *et al*. 1977) radiocarbon datings have been carried out from carbon organic remains in the Beta Analytic Inc. Laboratory in Miami, Florida. The datings refer to the IntCal04 calibration data set for terrestrial samples (Reimer *et al*., 2004). The first results on paleontological (macro and micro) and pollen characters cited in this paper have been supplied by personal communications respectively from A. Russo and S. Marvelli. The paleontological samples have been treated with H_2O_2 (2% vol.) and the observations have been carried out on a dry residue, sieved and desiccated in oven at 105 °C. The pollen analysis have been carried out following the standard procedure described by Lowe et al. (1996) in the Archaeoenvironmental Giorgio Nicoli Laboratory in Bologna.

The micromorphological study on paleosol thin sections have been examined under the optical microscope applying the methods of Stoops (2003) and some terminology of Bullock *et al.* (1985) and Brewer (1976).

Mineralogical analyses on pebble coatings observed in the sequence have been conducted by Energy-dispersive X-ray (EDX) technique coupled with an environmental scanning electron microscope ESEM Quanta-200 in the Modena University CIGS Laboratory.

THE SEDIMENTARY SEQUENCE OF THE CORSO DEL POPOLO SITE

This study is based on observations made during the excavation of the Corso del Popolo car park located near the centre of Terni, not far from the present-day course of the Nera River. The examined section has permitted the reconstruction of a 10 m thick sedimentary succession, which was deposited by the watercourse antecedent to the modern Nera.

A detailed multidisciplinary stratigraphical investigation has been carried out based on geological, mineralogical, petrographical-micromorphological and paleontological evidences along with pollen and archaeological data. Four main different units have been recognized in the investigated sequence.

Unit A, at the base of the excavation, consists of a 3 m thick sedimentary sequence mainly composed of gravel with subordinate pebbly-sand and sand. This unit, whose lower limit is not exposed, abruptly passes to a finer deposit of the overlying Unit B. The sedimentary structures observed in these deposits are mainly represented by trough-shaped and planar cross-beds, which develop in a meter-long continuous sets. The gravels are generally moderately sorted. They are composed of rounded to subrounded calcareous and cherty, medium to large pebbles, ranging 1÷3 cm (mean diameter). Units of single depositional events are in sets about 40 cm thick and an angle of about 20°, suggesting a main watercourse flow from NE to SW.

The gravels are clast-supported with less than 10% smaller sized clasts of sand and mud as matrix. Pebbles are coated by a reddish-black thin iron-manganese film and there is very little matrix between the clasts. Horizontally bedded gravel sheets are present in the upper portion of Unit A. They are formed of rounded medium to very large pebbles and subordinate cobbles, slightly imbricated. They appear as moderately sorted, graded, clast-supported deposits with subordinate sand and mud.

Unit B overlies Unit A and is formed by a 5 m thick sequence consisting of a well-developed cyclicity, which is cadenced by dark brown levels presenting pedogenic modification. Each cycle is characterized by a basal sandy unit overlain by a pedogenised horizon of coarser-grained sediment (B1) or of finer-grained sediment (B2). Each simple pedofacies sequence (KRAUS,

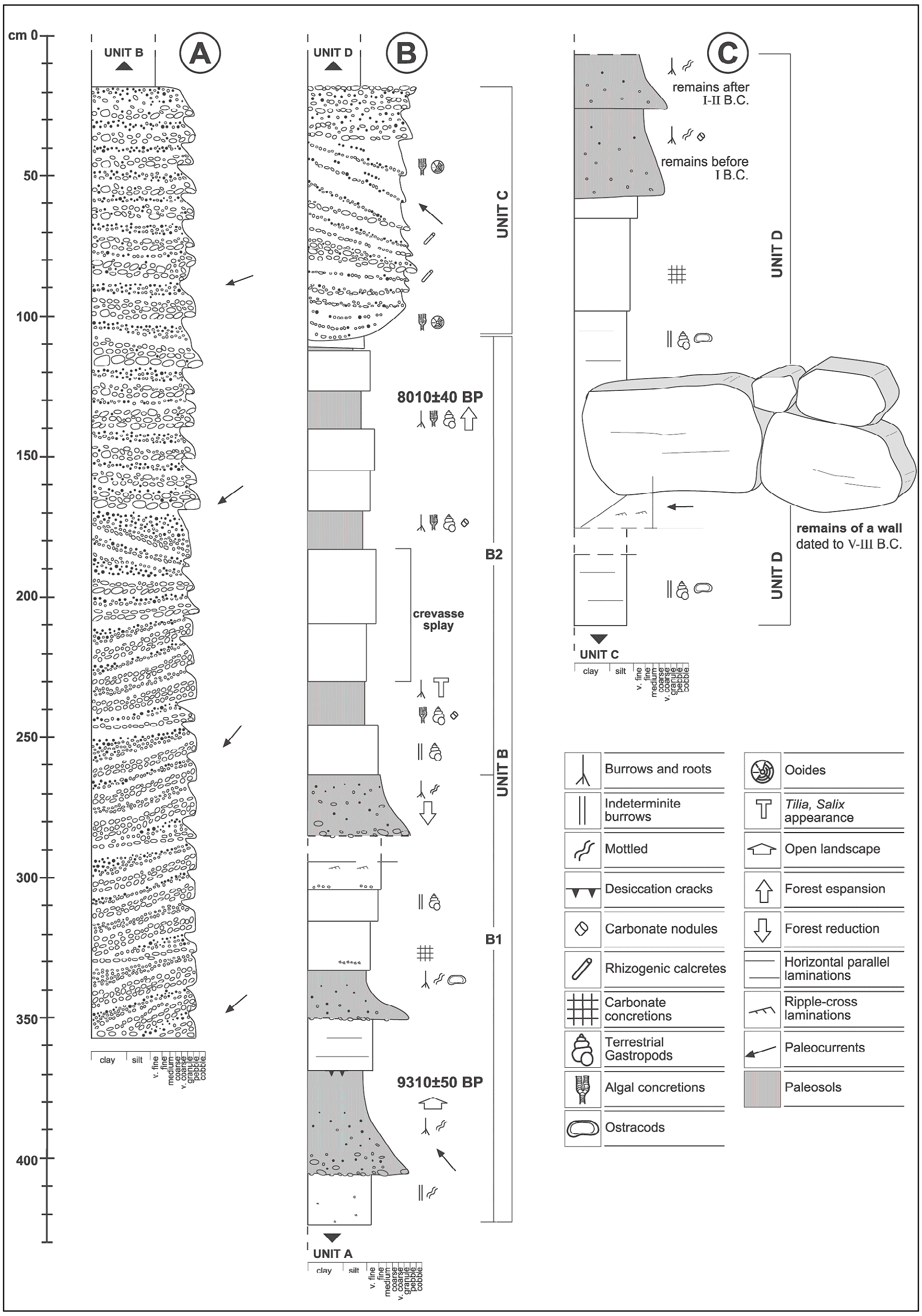

Fig. 2 - Stratigraphic section studied in the Corso del Popolo site of the Terni basin. The different units are described in text. A: Unit A, related to coarse-grained point bar deposits; B: Unit B, an overbank sequence formed of levee (B1) and crevasse-splay (B2) sediments interbedded with floodplain deposits; Unit C, a crevasse channel deposit; C: Unit D, sequence due to a cut-off event.

Ricostruzione della successione stratigrafica del sito di Corso del Popolo a Terni. Sono indicate le diverse unità come descritte nel testo. A: Unità A, caratterizzata da sedimenti ghiaiosi di canale attivo; B: Unità B, depositi di esondazione con sequenze di argine (B1) e di canale di rotta (B2) intervallati da paleosuoli interessati da una pedogenesi poco evoluta; C: Unità C: deposito di canale di crevasse; D: Unità D, depositi dovuti alla formazione di un lago poco profondo o acquitri -no conseguente all'abbandono del canale fluviale.

1987) is capped by the base of the ensuing cycle with little or no erosion; except the top of Unit B, which was truncated by the erosive deposition of Unit C (Fig. 2).

The simple pedofacies sequence (B1) is made of coarsening-upward cycles of fine sandstones and siltstones showing weakly identifiable ripple-cross lamination and matrix-supported graded gravel deposits formed of brown-reddish pebbles and cobbles. The gravel levels have been affected by pedogenic modification including root structures, scattered desiccation cracks and mottling. These pedofeatures have also been examined in a thin section where, when mottling is present, there is a clearly visible considerable scattered enrichment in interstitial oxides of iron and manganese. This weakly developed pedogenic modification has been observed in the gravel layers of B1 in association with unaltered parent material characterized by sandstones, siltstones and lithic fragments.

The lowest gravel layer in B1 has been studied in greater detail to obtain a better understanding of the relations between Unit B and the underlying Unit A. The finer sediment in the lower part of this horizon is dark brown (7.5 YR 3/2-4) and yellow brown mottled (10 YR 5/6), passing to yellow-reddish brown mottled (7.5 YR 5/6) in the upper part. The second and relative younger dark brown (10 YR 4/2) gravel layer in B1 (fig. 2) is indicated by prevalent amounts of pedogenic modification that is, however, more immaturely developed; mottling is observed but desiccation cracks are not present.

A determination of the absolute age through ASM radiocarbon dating has yielded a value of 9310±50 BP (10660-10310 cal BP; Beta-238366). The pollen data of the base of B1 have revealed a moderate presence of deciduous oaks with *Fraxinus* in an open landscape and a high content of non-arboreal pollen (Cichorioideae). At the top of B1, arboreal vegetation underwent a clear reduction, without disappearing completely.

The simple pedofacies sequence B2 overlies B1; it is formed by fining upward cycles of laterally discontinuous exposure sheet-like siltstones and very-fine sandstones, interspersed with dark-coloured pedogenised mudstones (10 YR 5/2; 4/2). Each cycle of sandy layers capped by a single paleosol is repeated at least six times moving upward B2, with a range in thickness of each one from 0.4 to 1 m.

No erosional surfaces are observed between two subsequent cycles, passing upward B2. The last cycle at the top of B2, and corresponding to the top of Unit B, is truncated and eroded by a channelized-shape gravel deposit (Unit C). In general, the sediment forming the base of each series consists of a beige-coloured (10 YR 6/4; 7/2-4; 8/4-6) calcareous sandy siltstone or fine sandstone that passes upwards to a fine siltstone. The primary structures are generally not preserved but, where identifiable, they present cross and horizontal lamination.

The top of each cycle is dominated by crumbly calcareous mudstones on which a single paleosol profile (Freytet, 1973), with an immature pedogenic evolution, develops. These paleosols present dark brown coloured zones with burrowing, root traces, rare calcite nodules, and bacterial concretions. The micromorphological data confirm the pedofeatures observed in outcropping and show the correlation between root traces and calcite nodules, when the nodules are present. The paleosol of the uppermost cycle B2 was not truncated, and lies at the base of the gravel channelized-shape deposit. It is the only horizon to show rare *papulae* pedofeatures (Brewer, 1976) in a thin section. This deposit has a radiometric age of 8010±40 BP (9010-8730 cal BP; Beta-238365).

An appreciable vegetation change occurred at the beginning of the deposition of the simple pedofacies sequence B2, mainly due to the early appearance of *Tilia* and *Salix*, while the landscape was still fairly open. Moving upward along the sequence, the pollen content increases, both in quantity and diversity of species; the deciduous oaks accompanied by several other arboreal taxa (*Fraxinus, Tilia, Carpinus, Pinus, Salix, Alnus* ecc.) define a forested landscape.

The upper part of Unit B is engraved and eroded by a coarse-grained channelized-shape deposit, here indicated as Unit C (fig. 2).

Unit C appears as a lens, a few meters wide and one meter thick, with gentle flanks and an erosive concave base. The channel-filling is formed by moderately sorted to well sorted graded coarse to pebbly sands up to pebble gravels. The finer sediments at the base of the channel present ooids and tubular bacterial structures and show trough cross bedding (Miall, 1996). Penetrative rhizolite laminar calcretes are present, due to the calcification around roots (Wright *et al.*, 1995). These are 3-5 cm thick and 40 cm long and develop along the main cross-bedding surfaces. They correspond to beige calcareous cementation normally developed around root mats and show alveolar septal structures in a thin section (Wright *et al.*, 1995).

A pebble to cobble gravel sheet closes the coarsening upward channel-filling and exhibits a slightly convex shape.

Unit D constitutes a 4 m thick sequence characterized by calcareous, gold-coloured (10 YR 8/2-3), fine siltstones with faintly planar lamination at the base. This deposit continues at the base of the upper section examined at the Corso del Popolo site. In about two meters of thickness it is possible to observe siltstones or mudstones with Ostracods and pulmonate Gastropods (in course of determination), bioturbation, root tubules and carbonate concretions.

At the top of the sequence there is a yellow brown (2.5 Y 5/4) mottled paleosol containing archaeological remains that accumulated before the 1st century BCE (Superintendence to Archaeological properties of Umbria, personal communication).

An important structure, part of a huge wall of Hellenistic age (5th-3rd century BCE) has been found above the muddy sandstones with ripple lamination on the northern side of the site excavation. The presence of significant human exploitation of the Corso del Popolo area since that time has probably contributed to erase all other parts of that wall.

INTERPRETATION

Integrating lithological, sedimentological, mineralogical aspects with physical evidence and paleontological and pollen data, allows us to reconstruct a reasonable picture of the alluvial environment where the continental studied succession accumulated. Each unit is related to characteristic depositional processes.

Unit A shows sediments and sedimentary structures deposited by fluvial processes in an alluvial plain, probably due to the accumulation of lag deposits within transverse gravel bars and horizontal beds (lithofacies Gp, Gt and Gh of MIALL, 1996). According to Jackson (1976), GUSTAVSON (1978) and MIALL (1996), this sequence is probably related to a coarse-grained point bar deposit characterized by lateral accretion and gravel bedform elements. Extensive continuous sets of trough cross-strata are interpretable as due to a moderately stable bar related to a gravel-bed wandering fluvial system (ASHMORE, 1991; WOOLDRIDGE & HICKIN, 2005).

Such an important supply of coarse-grained gravelly sediments requires the effects of intense physical weathering processes and extreme ranges in fluvial discharge to favour their deposition. Post-depositional movement of fluids through the sediments also caused intense fluid washing with a concomitant removal of most fine-grained sediment, therefore little matrix remains.

Unit B shows a coarsening-upward simple pedofacies sequence at the bottom (B1), which is overlaid by a fining-upward simple pedofacies sequence (B2), both are interbedded with incipient paleosols. Unit B developed in a floodplain area proximal to the active channel. It corresponds to a vertical sequence of overbank environments constituted by progressive sandy levee (B1) and crevasse-splay (B2) sediments associated with finer-grained floodplain deposits.

The passage between unaltered fluvial sediments and paleosols is apparently related to an alternating succession between periods of flood events and periods of quiescence without fluvial sedimentation. The sequence B1 suggests relatively rapid accretion rates on the basis of poorly developed pedogenic modification. The paleosol at the base of this unit can be interpreted as an entisol that, even though immature, testifies to a slight decrease in the sedimentation rate (KRAUS, 1987). The strong presence of burrowing, rooting and calcite nodules as pedogenic features in the paleosols observed in the sequence B2, hints that the deposition of new sediments were relatively frequent over a period of time but sufficiently infrequent as to permit the triggering of such aspects of pedogenic modification.

The pollen assemblage of the lowest part of B1 is interpreted as representing a semi-arid and cool phase where moderate deciduous oaks dominated the open landscapes. The marked vegetational reduction recorded at the top of B1 suggests a worsening of the severe climatic conditions.

Moving upward B2, a significant vegetational change is marked. The appearance of *Tilia* and *Salix* at the base and a significant expansion of *Tilia* and various other tree taxa at the top of the sequence, evidence a more temperate and humid climate than in the previous phase.

Unit C marks a limited erosive event, which cut the top of Unit B sequence. It is characterized by a coarse-grained lens deposited by a crevasse channel, which probably is correlated to the sediments of the cut-off event of Unit D.

The penetrative rhizolite laminar calcretes, which occurred as calcareous cementation around root mats, suggest a carbonate-rich groundwater environment associated to an increase of temperature, which favoured the calcium-carbonate precipitation.

Unit D is associated with a shallow lake, pond or marshy environment overlies a structure that represents a probable cut-off process from the active stream-channel (SMITH *et al*., 1989; WILLIS & BEHRENSMEYER, 1994; MIALL, 1996). Unit D represents the beginning of a new geoenvironmental situation favouring the development of a shallow carbonate lacustrine-palustrine environment related to a shallow, fresh-water lake (PLATT & WRIGHT, 1992) and a more humid climate. This interpretation is also based on the first results obtained from fossil species present in the sediments at the bottom of Unit D. The degree of pedogenic modification increases upwards in the sequence.

DISCUSSION OF THE RESULTS

The sediments and sedimentary structures observed in the Corso del Popolo fluvial succession on the Terni plain are representative of an ancient stream course, flowing on the eastern side of the present-day town of Terni. The collected data suggest that this stream acted as an ancient segment of a paleo-Nera river located close to the west of the present-day course of the Nera river. This geological result proves the change in the Nera river-course originally hypothesised by FONTAINE (1990) on the basis of archaeological speculations (fig. 1).

The studied sequence represents a rare example of a continuous succession deposited from the Late Pleistocene-Early Holocene up to Roman times observed in the Terni basin.

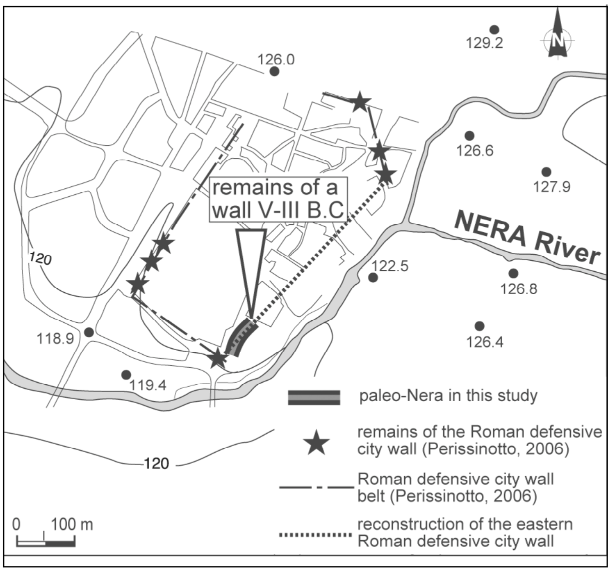

Fig. 3 - Hypothesis of reconstruction of the oldest defensive wall built around the centre of Terni during the 5th-3rd century BCE (mod. ZAMPOLINI FAUSTINI, 2006)

Schema ricostruttivo della cinta muraria a difesa dell'antica città di Terni tracciato sulla base del rinvenimento del tratto di muro ascrivibile al V-III sec. a.C. citato nel testo (mod. ZAMPOLINI FAUSTINI, 2006).

The detailed analysis of the sedimentary succession show an interesting geoenvironmental evolution of the basin, passing from a coarse-grained point bar sequence deposited by a low-sinuosity fluvial system (Unit A), grading to an overbank succession composed of levee deposits (B1) and crevasse-splays (B2), cyclically interrupted by immature paleosols. A crevasse channel (Unit C) truncates the overbank deposits and marks the transition to a shallow lacustrine-palustrine environment related to a cut-off event.

The AMS radiometric dating determined at the base of Unit B links the visible part of Unit A to the effects of the final phases of the last glacial portion of Late Pleistocene (Busschers *et al*., 2007), which favoured the large supply of the coarse-grained sediments forming Unit A. A Late Glacial climatic situation which is comparable with the last glacier advance of the Gran Sasso Massif in the Central Apennines dated by Giraudi & Frezzotti (1997) at ca. 11000 yr B.P.

The sequence of the overbank deposits (Unit B), in spite of their laterally discontinuous exposure, suggests that deposition occurred in a relatively proximal position with respect to the paleo-Nera river-channel, starting from 9310±50 BP (10660-10310 cal BP). The overbank sequence was generated by sporadic flood events followed by pedogenesis, which was periodically interrupted by crevasse-splay deposition until 8010±40 BP (9010-8730 cal BP), when a crevasse channel (Unit C) cut the sequence and ended the overbank deposition.

The pollen assemblage and the forest reduction recorded in the lower part of Unit B is related to a semiarid and cool phase. This was successive the marked vegetational fluctuation proved at Rieti Basin (Ricci Lucchi *et al*., 2000) and at Lagaccione, near Lago di Bolsena, until a few centuries after 10850±105 yr B.P. (Magri, 1996), and which the Authors consider related to the Younger Dryas event.

The vegetation associated to the upper part of Unit B suggests a progressive considerable forest expansion, which is interpretable as due to a more temperate and humid climate. The increase of arboreal plants marks the transition to Holocene as observed in other sites of Central Italy (Follieri *et al*., 1989; Calderoni *et al*., 1994; Watts *et al*., 1996; Magri, 1999; Magri and Sadori, 1999; Ricci Lucchi *et al*., 2000).

Palustrine-shallow lacustrine and calcareous sediments close the Corso del Popolo sequence (Unit D) were deposited in a cut-off shallow lake or pond environment related to a temperate wet climate, where the rising temperature was favourable to the deposition of the calcium-carbonate. Similar environmental conditions are documented at Rieti Basin (Ricci Lucchi *et al*., 2000), Lagaccione (Magri, 1999) and Lago di Vico (Magri & Sandori, 1999) during the interval 8000-7000 yr BP.

The environmental changes recorded in the sediments of the Terni sequence from the middle Holocene were a consequence of climatic changes affected by regional and local factors.

It is more difficult to put forward a reconstruction hypothesis based on the scarce remains of the wall of Hellenistic age (ca 5th -3rd century BCE) found at the Corso del Popolo site. This wall apparently represented a portion of the eastern side of the oldest defensive wall built around the town of Terni, at the beginning of its Roman political organization (fig. 3).

CONCLUSIONS

Fluvial systems may contain important archives for improving the understanding of present and past landscape stability.

The wide fluvial sequence of the Corso del Popolo site on the Terni plain is an unusual occasion to observe a well-preserved sediment record of an ancient course of Nera River starting from the Late Pleistocene.

Detailed analyses of the geometry and internal lithological variation of the fluvial succession, as well as the pedogenic features and pollen assemblages of alluvial paleosols in the overbank deposits, have permitted a more detailed reconstruction of the recent geoenvironmental evolution of the Terni plain to be improved and, meanwhile, some historical and archaeological speculations concerning the ancient hydrographic system of the town of Terni to be addressed, even in a humble site such as a future car-park.

Considering the vertical evolution of the sedimentary sequence recorded in Terni, it is possible to relate the sedimentological and ecological evidences observed to significant changes in climatc conditions due to the transition between the last phases of Late Glacial times and the more temperate and humid beginning of the Holocene. These results are in agreement with the records from other sites in Central Italy: Valle di Castiglione (Follieri *et al*., 1989), Lago Lungo (Calderoni *et al*., 1994), Lago Albano (Lowe *et al*., 1996), Lagaccione (Magri, 1999), Lago di Vico (Magri & Sadorì, 1999), Rieti (Ricci Lucchi *et al*., 2000).

The Terni site can be considered an important archive of paleoenvironmental and paleoclimate record for the global climatic transition from the end of the Last Glacial times to the beginning of Holocene, while the ensuing climatic changes recorded in the sediments were progressively affected by regional and local environmental factors.

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REFERENCES

Ashmore P.E. (1991) - *How do gravel-bed rivers braid?* Canad. Jour. Ear. Sc., **28**, pp. 237-293.

Ambrosetti P., Basilici G., Capasso Barbato L., Carboni

G., DI STEFANO G., ESU D., GLIOZZI E., PETRONIO C., SARDELLA R. & SQUAZZINI E. (1995) - *Il Pleistocene inferiore nel ramo Sud-Occidentale del Bacino Tiberino (Umbria): aspetti litostratigrafici e biostratigrafici.* Il Quaternario, **8**(1), pp. 19-36.

AMBROSETTI P., CARBONI M.G., CONTI M.A., COSTANTINI A,, ESU D., GANDIN A., GIROTTI O., LAZZARETTO A., MOZZANTI R., NICOSIA U, PARISI G. & SANDRELLI F. (1978) - *Evoluzione paleogeografia e tettonica nei bacini tosco-umbro-laziali nel Pliocene e nel Pleistocene inferiore.* Mem. Soc. Geol. It., **19**, pp. 573-580.

BARCHI M., BROZZETTI F. & LAVECCHIA G. (1991) - *Analisi strutturale e geometria dei bacini della media valle del Tevere e della Valle Umbra*. Boll. Soc. Geol. It., **110**, pp. 65-76.

BASILICI G. (1993) - *Sedimentary facies in an extensional and deep-lacustrine depositional system: the Pliocene Tiberino Basin, Central Italy.* Sed. Geol., **109**, pp. 73-94.

BENNETT C.L., BEUKENS R.P., CLOVER M.R., GOVE H.E., LIEBERT R.B., LITHERLAND A.E., PURSER K.H. & SONDHEIM W.E. (1977) - *Radiocarbon dating using electrostatic accelerators: Negative ions provide the key*. Science, **198**, pp. 508-510.

BERTACCHINI M, MARCHESINI M., MARVELLI S. (2006) - *Risultati preliminari sull'evoluzione paleoambientale e paleoclimatica del sito archeologico di Maratta Bassa (Terni).* In: Angelelli C., Bonomi Ponzi L. (a cura di) "Terni - Interamna Nahars. Nascita e sviluppo di una città alla luce delle più recenti ricerche archeologiche" Collection de l'École Française de Rome, **362**, Roma, pp. 95-107.

BONINI M. (1997) - *Evoluzione tettonica plio-pleistocenica ed analisi strutturale del settore centro-meridionale del bacino Tiberino e del bacino di Rieti (Appennino Umbro-Sabino).* Boll. Soc. Geol. It., **116**, pp. 279-318.

BONOMI PONZI L. (2006) - *Introduzione*. In: Angelelli C., Bonomi Ponzi L. (a cura di) "Terni - Interamna Nahars. Nascita e sviluppo di una città alla luce delle più recenti ricerche archeologiche" Collection de l'École Française de Rome, **362**, Roma, pp. 1-17.

BREWER R. (1976) - *Fabric and Mineral Analiysis of Soils.* Robert E. Krieger Publishing Company, New York, 482 pp.

BROZZETTI F. & LAVECCHIA G. (1995) - *Evoluzione del campo degli sforzi e storia deformativa nell'area dei Monti Martani (Umbria)*. Boll. Soc. Geol. It., **114**, pp. 155-176.

BULLOCK P., FEDOROFF N., JONGERIUS A., STOOPS G., TURBINA T. & BABEL C. (1985) - *Handbook for Soil Thin Section Description.* Waine Research Publication, Albrighton, 152 pp.

BUSSCHER F.S., KASSE C., VAN BALEN R.T., VANDENBERGH J., COHEN K.M., WEERT H.J.T., WALLING J., JOHNS C., P. CLEVERINGA & BUNNIK F.P.M. (2007) - *Late Pleistocene evolution of the Rhine-Meuse system in the southern North Sea basin: imprints of climate change, sea-level oscillation and glacio-isostacy*. Quat. Science Rev., Vol. **26** (25-28), pp. 3216-3248.

CALDERONI G., CARRARA C., FERRELI L., FOLLIERI M., GLIOZZI E., MAGRI D., NARCISI B., PAROTTO M., SADORI L. & SERVA L. (1994) - *Paleoenvironmental, paleoclimatic and chronological interpretations of a late-Quaternary sediment core from Piana di Rieti (central Apennines, Italy)*. Giornale di Geologia, **56** (2), pp. 43-72.

CATTUTO C., GREGORI L., MELELLI L., TARAMELLI A. & TROIANI C. (2002) - *Paleogeographic evolution of the Terni basin (Umbria, Italy).* Boll. Soc. Geol. It., Vol. spec. **1**, pp. 865-872.

CAVINATO G.P. (1993) - *Recent tectonic evolution of the Quaternary deposits of the Rieti Basin (Central Apennines, Italy) southern part.* Geologica Romana, **29**, 411-434, Roma.

CONTI M.A. & GIROTTI O. (1977) - *Il Villafranchiano nel "Lago Tiberino", ramo sud-occidentale: schema stratigrafico e tettonico.* Geol. Rom., pp. 16, 67-80.

Fontaine P. (1990) - *Cités et enceintes de l'Ombrie antique*. Bruxelles-Roma, pp. 11-130.

FAZZINI P.† & MAFFEI M. (2006) - *Appunti di geologia e geomorfologia della Conca Ternana*. In: Angelelli C., Bonomi Ponzi L. (a cura di) "*Terni - Interamna Nahars. Nascita e sviluppo di una città alla luce delle più recenti ricerche archeologiche*" Collection de l'École Française de Rome, **362**, Roma, 57-62.

FOLLIERI M., MAGRI D. & SADORI L. (1989) - *Pollen stratigraphical synthesis from Valle di Castiglione (Roma). Quat. Int.,* **3–4**, pp. 81–84.

FREYTET P. (1973) - *Petrography and Paleo-Environment of continental carbonate deposits with particular reference to the Upper Cretaceous and Lower Eocene of Languedoc (Southern France).* Sed. Geol., **10**, pp. 25-60.

GIONTELLA C. (2006) - *L'abitato di Maratta (campagne di scavo 2001-2002).* In: Angelelli C., Bonomi Ponzi L. (a cura di) *"Terni – Interamna Nahars. Nascita e sviluppo di una città alla luce delle più recenti ricerche archeologiche"* Collection de l'École Française de Rome, **362**, Roma, 78-93.

GIRAUDI C. & FREZZOTTI M. (1997) - *Late Pleistocene Glacial Events in the Central Apennines, Italy*. Quaternary Research, **48**, pp. 280–290.

GIROTTI O. & MANCINI M. (2003) - *Plio-Pleistocene stratigraphy and relations between marine and non marine succession in the middle valley of the Tiber River (Latium, Umbria).* Il Quaternario, **168**(1Bis), pp. 89-106.

GRASSINI P. (1947) - *Delimitazione dell'antica Terni secondo scoperte archeologiche.* Boll. Deputazione Storia Patria per l'Umbria, vol. XLIV, pp. 34-38.

GUSTAVSON T.C. (1978) - *Bed forms and stratification types of modern gravel meander lobes, Nueces River, Texas*. Sediment., **25**, pp. 401-426.

JACKSON R.G. II (1976) - *Depositional model of point bars in the lower Wabash River.* J. Sediment. Petrol., **46**, pp. 579-594

KRAUS M.J. (1987) - *Integration of channel and floodplain suites, II. Vertical relations of alluvial paleosols*. J. Sediment.Petrol., **57** (4), pp. 602-612.

LIPPI BONCAMBI C. (1960) - *Umbria*. Bibliografia geologica d'Italia, vol. **7**, XV. C.N.R., Roma, 102 pp.

LOTTI B. (1917) - *L'antico Lago Tiberino e le ligniti dell'Umbria*. La Miniera italiana, **7**(1), pp. 274-275.

LOWE J.J., ACCORSI C.A., BANDINI MAZZANTI M., BISHOP A., Van der Kaars S., Forlani L., Mercuri A.M., Rivalenti C., Torri P. & Watson C. (1996) - *Pollen stratigraphy of sediment sequences from crater lakes Albano and Nemi (near Rome) and from the central Adriatic, spanning the interval from oxygen isotope Stage 2 to the present day*. Mem. Ist. It. Idrobiol., **55**, 71-98.

Magri D. (1999) - *Late Quaternary vegetation history at Lagaccione near Lago di Bolsena (central Italy).* Rev. Paleob. Palynol., **106** (3-4), pp. 171-208.

Magri D. & Sadori L. (1999) - *Late Pleistocene and Holocene pollen stratigraphy at Lago di Vico (central Italy)*. Veg. Hist. Archaeobot., **8**, 247-260.

Miall A.D. (1996) - *The Geology of fluvial deposits*. Springer-Verlag Berlin Heidelberg, 582 pp.

Nelson, D.E., Korteling R.G. & Stott W.R. (1977) - *Carbon-14: Direct detection at natural concentrations.* Science, **198**, pp. 507-508.

Perissinotto C. (2006) - *La delimitazione e la difesa di Interamna Nahars in età medievale.* In: Angelelli A. e Bonomi Ponzi L. (a cura) *Terni - Interamna Nahars. Nascita e sviluppo di una città alla luce delle più recenti ricerche archeologiche*. École Française Rome, pp. 271-307.

Platt N.H. & Wright V.P. (1992) - *Palustrine carbonates and the Florida Everglades: towards an exposure index for the fresh-water environments*. Journal Sedimentary Petrology **62**, pp. 1058-1071.

Reimer P.J, Baillie M. G.L., Bard E., Bayliss A., Beck J.W., Bertrand C. J.H., Blackwell P.G., Buck C.E., Burr G.S., Cutler K.B., Damon P.E., Edwards R.L., Fairbanks R.G., F.M., Guilderson T.P., Hogg A.G., Hughen K.A., Kromer B., McCormac G., Manning S., Ramsey C.B., Reimer R.W., Remmele S., Southon J.R., Stuiver M., Talamo S., Taylor F.W., Van der Plicht J., Weyhenmeyer C.E. (2004) - *IntCal04 terrestrial radiocarbon age calibration, 0-26 cal kyr BP*. Radiocarbon, **46** (3), pp. 1029–1058.

Smith N.D., Cross T.A., Dufficy J.P. and Clough S.R. (1989) - *Anatomy of an avulsion*. Sedimentology, **36**, pp. 1-23.

Stoops G. (2003) - *Guidelines for Analysis and Description of soil and Regolith Thin section.* Soil Science Society of America, Madison, 184 pp.

Watts W.A., Allen J.R.M., Huntley B. & Fritz S.C. (1996) - *Vegetation history and climate of the last 15,000 years at Laghi di Monticchio, southern Italy. Quat. Sci. Rev.* **15**, pp. 113–132

Willis B.J. & Behrensmeyer A.K. (1994) - *Architecture of Miocene overbank deposits in northern Pakistan*. J. Sediment. Res., B**64**, pp. 60-67.

Wooldridge C.L. & Hickin E.J. (2005) - *Radar architecture and evolution of channel bars in wandering gravel-bed rivers: Fraser and Squamish Rivers, British Columbia, Canada.* Jour. Sediment. Res., **75**, pp. 844-860.

Wright V.P., Platt N.H., Marriot S.B. & Beck V.H. (1995) - *A classification of rhizogenic (root-formed) calcretes, with examples from the Upper Jurassic-Lower Cretaceous of Spain and Upper Cretaceous of southern France*. Sedimentary Geology, **100** (1-4), pp. 143-158.

Zampolini Faustini S. (2006) - *Topografia ed urbanistica di Interamna Nahars tra vecchi dati e nuove scoperte.* In: Angelelli A. e Bonomi Ponzi L. (a cura) *Terni - Interamna Nahars. Nascita e sviluppo di una città alla luce delle più recenti ricerche archeologiche.* École Française Rome, pp. 141-161.

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