New biostratigraphic data from the Early Pleistocene tyrrhenian palaeocoast (western Umbria, central Italy)

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1. INTRODUCTION

The Orvieto area (western Umbria, Central Italy) documents the evolution of the Tyrrhenian side of the Northern Apennines during the last 3.5 Ma (Fig. 1). The occurrence of coastal marine environments is documented in the area from the Piacenzian to the Calabrian at least, and the palaeoenvironmental evolution has been classically reconstructed identifying two main sedimentary cycles: Piacenzian p.p. – Gelasian p.p. and Gelasian p.p. – Santernian respectively (AMBROSETTI et al., 1987; GIROTTI & MANCINI, 2003).

The lithostratigraphic succession is represented by the informal units of “Argille di Fabro” (Piacenzian), “Sabbie a Flabellipecten” (Piacenzian), “Conglomerati di Città della Pieve” (Piacenzian p.p. – Gelasian p.p.) and “Argille e Sabbie del Chiani-Tevere” (Santernian p.p.) proposed by AMBROSETTI et al. (1987). GIROTTI & PICCARDI (1994)
Figure 1: Geological sketch of the study area and location of the study sections. The Rocca Ripesena (CARBONI, 1975), Podere Palombaro (CARBONI & di BELLA, 1996) and Il Caio sections (BISSARIRI et al., 2003) are also indicated.
and MANCINI et al. (2004) proposed the use of the “Tena-glie Unit” (Zanclean – Piacenzian) and the “Chiani-Tevere Unit” (Gelasian p.p. – Santernian).

New data from the Orvieto area, (BIZZARRI et al., 2003, 2004; BIZZARRI, 2006), recently contributed to stratigraphic refinement and a palaeoenvironmental review, and are only partially referable to the former stratigraphic scheme.

This paper aims to present integrated sedimentological and micropalaeontological data of some Early Pleistocene sections recently recognized in the Orvieto area, in order to place the reconstruction in the wider stratigraphic and palaeoenvironmental framework of western Umbria.

2. GEOLOGICAL SETTING

The study area (Fig. 1) is located in western Umbria (central Italy), near the town of Orvieto, along the Lower Paglia-Tibber Valley, a graben basin limited by East- and West-dipping conjugated normal fault systems, formed as a consequence of Lower Pliocene tectonics (FUNICIHELLO et al., 1981; AAVV, 1982). The basin accommodated coastal marine environments from the Early Pliocene to the Santernian (AMBROSETTI et al., 1977; 1978a; 1987; GIROTTI & MANCINI, 2003; MANCINI et al., 2004) or Emilian (BIZZARRI et al., 2004; BIZZARRI, 2006; BIZZARRI & BALDANZA, 2006a, 2007). The study area is bounded to the East by the Narnese-Amerina range, to the West by the Rapolano-Cetona range, and by the Vulsini Late Pleistocene volcanic district to the South-West (Fig. 1).

The pre-Pliocene basement is mainly represented on the Rapolano-Cetona range by Cretaceous to Eocene Scaglia Toscana s.l.-Ligurids Units, whereas on the Narnese-Amerina range it is represented by the Tuscan Oligo-Miocene Macigno s.u. Unit in the northern part, and by the Umbria-Marche carbonate succession (Triassic-Oligocene) in the south (JACOBACCI et al., 1967, 1969, 1970; FAZZINI, 1968; DAMIANI et al., 1993). Pliocene-Pleistocene deposits unconformably overlie the rocky basement on both sides of the valleys, up to 500-600 m a.s.l., displaced by Early-Middle Pleistocene and Late Pleistocene-Holocene tectonics (AMBROSETTI et al., 1978b; CATTUTO et al., 1979; FUNICIHELLO et al., 1981; AAVV, 1982). Late Pliocene tectonics (AMBROSETTI et al., 1977; 1978b; 1987, 1989; CATTUTO et al., 1979, 1983, 1997) have often been overestimated as being the cause of the attitude of present-day deposits (BIZZARRI, 2006).

3. STUDY SECTIONS

Data from seven recently described sections (BIZZARRI et al., 2005; BIZZARRI, 2006; BIZZARRI & BALDANZA, 2006b, 2007), covering a wide area around the Orvieto town are presented. New data are also correlated with the three reference sections of the Rocca Ripesena (CARBONI, 1975), Podere Palombaro (CARBONI & DI BELLA, 1996) and Il Caio (BIZZARRI et al., 2003) (Figs. 1, 2).

3.1. Allerona quarries

In the clay quarries north of the Allerona railway station on the western side of the Paglia Valley, a composite section, about 50 m thick has been reconstructed (Figs. 1, 2), divided into lower and upper portions respectively, separated by a 10 m gap. The deposits are represented by grey-blue, massive to thin – laminated silty clay. The fossil content is mainly represented by scattered gastropods and bivalve coquinas. The microfossil assemblage is characterized by ostracods including Aurila sp., Cytheropteron alatum and C. testudo, and rich foraminifer assemblages (Fig. 3).

The basal portion of the section contains poor calcareous nannofossil assemblages with small Gephyrocapsa, Calciscus macintyrei and Discoaster spp., referable to the MNN16a-MNN18 Zone (Piacenzian – Gelasian pp.). Higher in the section, the calcareous nannofossil assemblages are well preserved allowing identification of the Gelasian-Calabrian interval, continuous from the MNN19a to the MNN19d subzones. The bmG and bG nannofossil events are observed, marking the base of the MNN19b and MNN19b subzones, respectively.

3.2. Camorena

The Camorena section outcrops in badlands 3 km south-east of Orvieto (Fig. 1), where an Early Pleistocene marine succession is exposed. The section is about 50 m thick (Fig. 2) and is exclusively composed of laminated, grey-blue clay/silty clay. Analysis concentrated on continuous measurement and sampling of a 36 m thick clay succession in the upper part of the section. Samples from the basal part show micropalaeontological assemblages characteristic of the base of the Calabrian, with the occurrence of Globorotalia inflata and Hyalinea balthica. Two pyroclastic, pyroxene-bearing interbeds occur (BIZZARRI et al., 2004) between 2.20 m and 3.50 m and at 15.50 m respectively. These are in the MNN19c and MNN19d subzones, are biostratigraphically constrained at 1.619 Ma and ~1.50 Ma respectively and correlate to volcanoclastic deposits documented in the II Caio section (BIZZARRI et al., 2003).

The Camorena section covers the interval from the MNN19b to MNN19c subzones. A basal fossil assemblage is characterized by small Gephyrocapsa, medium Gephyrocapsa and Calciscus macintyrei, marking an Early Pleistocene age referable to the MNN19b Subzone. The Last Occurrence (LO) of C. macintyrei, followed by the First Occurrence (FO) of large Gephyrocapsa, allows identification of the MNN19c subzone. Finally the LO of large Gephyrocapsa marks the base of the MNN19c subzone. The LO of Helicosphaera sellii and a scattered increase of Braarudosphera bigelowii occur into the MNN19d subzone.

Among foraminifers, Globoigerina cariacensis occurs at the base of the section, in an assemblage with Globorotalia inflata. Hyalinea balthica is also present.

3.3. Sugano well

On the western side of the Paglia Valley, 4 km south of Orvieto, near Sugano, a water well was recently drilled through
Figure 2: Sedimentological and stratigraphic logs of the study sections, grouped according to palaeoenvironmental attribution. The fan-delta section of Il Caio (BIZZARRI et al., 2003) is also shown.
Figure 3: Semi-quantitative distribution chart of selected benthonic and planktonic foraminifers from the study sections. Length of lines is proportional to section thickness. SW = Sugano well.
landslide deposits (4 m) and Vulsini Mts. volcanic deposits (9 m), reaching the underlying grey-blue marine clay. Samples recovered, contain both a rich and well preserved microfauna and pyroclastic minerals (pyroxenes) and pumice. The foraminiferal assemblages (Fig. 3) are associated with the ostracods *Cytheropteron alatum* and *Aurila* sp.

The section also produced a very rich calcareous nanofossil assemblage which is characterized, in the lowermost sample, by small *Gephyrocapsa* and medium *Gephyrocapsa* referable to the MNN19c subzone. The first occurrence of large *Gephyrocapsa* specimens, in the uppermost part of the section, marks the base of the MNN19d subzone.

3.4. Osarella II

The section (BIZZARRI, 2001, 2006) is located along the SS 79 bis road at about 275 m a.s.l. It is represented by 18 m of sandy deposits, and comprises three intervals:

*Interval 1* – The lowermost 7 m are represented by well sorted fine sand to silty sand. Massive, bioturbated levels and thin laminated horizons almost regularly alternate.

Planar to undulate lamination is organized in 10–40 cm thick horizons which regularly alternate with massive beds. Lamina sets (<5 cm thick) repeat at a 1–1.5 cm interval, and each lamina is 3–4 mm in thickness. Lamination is marked by rhythmic colour and minimal grain size variations. Water escape structures (convolute lamination) also occur locally.

Bioturbation is not organized and is identified as Thalassinoides isp.; it locally alternates with shell horizons and scattered large gastropods and bivalves (*Natica tigrina, Trachelochetus romanus, Neverita josephinia, Ostrea lamellosa, Hynia prismatica*).

*Interval 2* is 5 m thick and composed of moderately sorted medium to coarse grained sand beds. In spite of diffuse bioturbation, still referable to Thalassinoides isp., each bed is characterized by an erosional base, a litho- and bioclastic lag, normal gradation and, in the uppermost part, faint cross-lamination. The fossil content is poor, but still represented predominantly by molluscs.

*Interval 3* in the uppermost part of the section, alternates well sorted fine sand beds with horizons composed of large oysters, pectinids and other bivalves. Thalassinoides traces still occur, often emphasizing the original morphology at the base of shell beds. Furthermore, a 25 cm thick, oligotopic large *Glycymeris* sp. horizon characterizes the base of the interval, whereas a 50 cm thick bed composed of echinoid fragments occurs in the uppermost part.

This section contains nanofossil assemblages referable to the MNN19b and c subzones. The foraminiferal assemblages are poor and dominated by shallow water benthic species (Fig. 3). It is interesting to note the presence, although rare, of *Globigerina cariacoensis* in the assemblage with *Globorotalia inflata*.

3.5. La Casella

The section has been described along the SS 71 road at the 41 km mark (BIZZARRI, 2001, 2006), and extends for about 25 m, between 150 and 175 m a.s.l. (Fig. 1). Sedimentological features allow differentiation of two intervals:

*Interval 1* is represented in the lowermost 13 m by well sorted, grey to blue very fine sand and silty sand. Beds appear massive, due to bioturbation (mainly Thalassinoides isp., but also “v” shaped indeterminate forms). They are occasionally interbedded with up to 10 cm thick, medium to coarse grained sandy lithoclastic lags. The bioturbation increases in the last few metres, where wavy to gently cross laminations also occur. Gastropods and bivalves (Thericium sp., Hynia sp., Natica sp., Glans sp. and Ostrea spp.) also increase upwards, although shell fragments are documented throughout the section.

*Interval 2* is characterised by 10 m of well sorted fine to very fine grained, yellowish sand. The sediments are massive, with dispersed large scattered bivalves and gastropods and common Thalassinoides isp. traces. They are interrupted by irregular intervals of bioclastic lags, often bioturbated, and by horizons of large oysters and pectinids, mainly made of *Ostrea lamellosa, Chlamys* spp. and Flabellipsecten flabeliformis. Barnacles also locally occur.

The microfossil content (Fig. 3) is dominated by shallow water benthonic taxa. The section comprises calcareous nanofossil assemblages characterized by small *Gephyrocapsa*, medium *Gephyrocapsa* and *C. macintyrei* in the basal samples. The disappearance of *C. macintyrei*, in the middle part of the section, allows identifying both the MNN19b and 19c subzones.

3.6. Baschi railway

The section outcrops along the SS 205 road (Fig. 1), near the Baschi train station (BIZZARRI, 2001, 2006). It is 12 m thick, and represented by well sorted, grey to yellowish, fine grained sand and silty-sand. The lowermost part is characterized by wavy to faint cross lamination, organized in 5 cm thick lamina sets, and by pervasive Thalassinoides isp. bioturbation. Both bioclastic lags and large oyster and pectinid coquinas occur throughout the section. Large, scattered bivalve and scaphopod specimens (*Glans* sp., *Thericium* sp., *Chlamys* spp., *Haustrator vermicularis, Aporrhais* sp., *Ostrea lamellosa, Ostrea* sp., *Dentalium* spp.) have been recognized.

The section allows reconstruction of a succession of calcareous nanofossil events which document the MNN19 a and b subzones.

3.7. Castellunchio

The 10 m reconstructed section, located in the vicinity of the Baschi railway section (Fig. 1), is represented by massive, gray-blue very fine sand and silty sand. *G. cariacoensis* and *G. inflata* are recognized from the base of the section, whereas Hyalinea balthica occurs in the uppermost part. The outcrop is attributable to the MNN19b and c Nannoplankton subzones.

3.8. Previous reference sections for the study area

Rocca Ripesena – A section in clay deposits, approximately 60 m thick, was reconstructed by CARBONI (1975), a few
kilometres west from Orvieto, not far from the Sugano well site, (Fig. 1). Samples were collected from between 200 – 250 m a.s.l. The author, attributed the section to the Piacenzian, mainly on the basis of G. gr. crassaformis distribution. The landscape has been strongly modified during the last 30 years, and the exposure today appears very different with respect to the original. Yet, the Rocca Ripesena area has been newly sampled, between 250 – 260 m a.s.l., which is about at the top of the old section of CARBONI (1975). Samples document a very rich and preserved nannofossil assemblage, referable to the MNN 19 c subzone. H. balthica and G. cariacoensis also occur. As a Pliocene age cannot be totally rejected for the base of the section, the new data allow reference of the top to the Calabrian.

Pod. Palombaro – CARBONI & DI BELLA (1996) analyzed the Podere Palombaro section (near Orvieto) and documented a Pleistocene age for this clayey sequence outcropping on the left bank of the Paglia River, which was attributed to the Piacenzian (CARBONI, 1975; BARBERI et al., 1994) or Pliocene/Pleistocene age (AMBROSETTI et al., 1987). The studied sediments were correlated to the Chi ani-Tevere sandy clay formation (Argille e Sabbie del Chiani-Tevere, AMBROSETTI et al., 1987), on the base of benthic foraminiferal assemblages. The P. Palombaro represented the “key section” that allowed the authors to identify the Early Pleistocene (G. cariacoensis Zone), where the age of exposed Pleistocene sediments “has always been debated” because of the lack of planktonic markers (CARBONI & DI BELLA, 1996). Several samples (not in situ) were recently collected nearby, which confirm the previous data, and furthermore, Hyalinea balthica is also present. The nannofossil assemblages are attributable to the MNN19e subzone, thus confirming the presence of Early Pleistocene deposits in the Pod. Palombaro area.

Il Caio – Detailed analysis of the Il Caio section (Figs. 1, 2) is reported in BIZZARRI et al. (2003) and BIZZARRI (2006). Deposits are represented by shoreface sand, with distal alluvial gravel, in the lowermost part, by prodelta silt and clay in the intermediate part and by alluvial fan gravel and sand in the upper part (Fig. 2). A fan delta environment was reconstructed (BIZZARRI et al., 2003; BIZZARRI, 2006). New sampling of this section, complemented by mineralogical analysis of volcaniclastic episodes, allows better understanding of its stratigraphy. The base of the section is devoid of calcareous nannofossils because of the predominantly medium sand grain size. The middle-upper portion is instead characterized by a thin interval of silt to clay sediments; the samples here contain good calcareous nannofossil assemblages which are characterized by abundant small Gephyrocapsa, common medium Gephyrocapsa and very few specimens of C. macintyrei. The microfossil assemblages are represented by Globorotalia inflata and Globigerina cariacoensis. This interval has been attributed to the Early Pleistocene (MN19b Subzone) and the presence of G. cariacoensis documents a Santorian age. The occurrence of pyroxene crystals, micas and pumice dispersed in marine fine grained sediments, documents the presence of a volcanoclastic event that can be attributed to the Santorian and precedes those found in the Camorena section.

4. DISCUSSION

4.1. Sedimentological evidences and palaeoenvironmental reconstruction

The study sections belong to a distal low energy marine environment, in front of a beach, alternately dominated by deposition and wave action. The correlatable proximal deposition, (not considered here except for the Il Caio section), is represented by beachface gravel and cross-stratified upper shoreface sand. All proximal and distal deposits belong to a river-fed coastal system, supplied by a number of local alluvial fans draining both sides of the valley (BIZZARRI, 2006, 2007).

The monotonous clay-silty clay sequences of the Alle rona quarries, Camorena and Sugano well outcrops were deposited below wave base, and provide evidence of an offshore environment, with a maximum depth ranging from 80 to 120 m. Sieve analyses reveal a high percentage (98.5 to 99.3%) of grains finer than 0.63 μm (4 φ of the Hudden Wentworth scale). According to DUNBAR & BARRETT (2005), grain size 4 φ represents the real borderline for settling processes, at least in marine environments, where more than 80% of grains finer than 4 φ is indicative of a settling-dominated offshore environment, with a minimum 60 m water depth. The foraminiferal assemblages, indeed, are dominated by planktonic specimens and by low-oxygen taxa rather than by deep water bentonic specimens (Fig. 3).

Alternatively, the other four sections document a faint wave action, and are referable to an environment across the transition to offshore and the lower shoreface. Normally graded beds, as well as bioclastic lags and shell beds, are interpreted as tempestites. The Baschi railway and Castellunchio sections document no environmental modification. Conversely, the La Casella and Osarella II sections show a slight shallowing upward trend, from transition to offshore to lower shoreface. Concerning the foraminifers (Fig. 3), these four sections are dominated by shallow water proximal specimens, whereas planktonic taxa rarely occur.

4.2. Stratigraphic data

The seven sections presented above allow recognition of an almost continuous stratigraphic succession of marker events, from the Piacenzian to the uppermost Calabrian.

The nannofossil assemblages are of medium – good preservation, and are characterized by the common presence of Gephyrocapsidae, Reticulofenestridae, Calcisphaeridae and Coccolithus pelagicus. Furthermore, the low abundance of specimens only allows a semi-quantitative approach, to evaluate the distribution of the most significant taxa. Moreover, a variable number of reworked specimens (from Cretaceous to Miocene) are present. Calcareous nannofossil events documented in the seven successions are totally comparable to those found in the western Mediterranean (DI STEFANO, 1998; DE KAENEL et al., 1999; RAFFI, 2002).

The datum agrees with the occurrence of G. inflata in all of the sections (except for the La Casella section), and with the occurrence of Gl. cariacoensis in four of the sec-
tions (Figs. 2, 3), documenting the *G. inflata* and *G. cariacoensis* Zones, according to the schemes of COLALONGO & SARTONI (1979) and IACCARINO & PREMOLI SILVA (2007). The lowermost Allerona quarries section, on the basis of the nannofossil and foraminiferal assemblages, belongs to the *G. gr. crassaformis* Zone and ranges from the MNN16a to MNN18 Nannofossil Zones.

Biostratigraphic data and sedimentological analyses, document uninterrupted Late Gelasian-Calabrian marine sedimentation in the Orvieto area for the first time. Moreover, the offshore succession seems to be continuous and concordant, at least since the Late Pliocene.

Finally, a brief remark on the benthonic specimen *Hyalinea balthica* is opportune. *H. balthica* is commonly documented at 6 of the sections, in sediments varying from clay to silt, to fine sand, proving that its presence is independent of grain size. The lowermost first local datum for the *taxon* occurs inside the MNN19b subzone, at the base of the Calabrian, still supporting the Early Pleistocene age for the Orvieto area deposits. The first appearance datum of *H. balthica*, well-known as a “cold guest” marked the Santernian-Emilian boundary (AZZAROLI et al., 1997), particularly in the Adriatic successions. In the Orvieto area, the first occurrence of *H. balthica* occurs in the Santernian, and is thus significantly earlier.

In our sections, *H. balthica* is widely and continuously documented in offshore deposits (Fig. 2), and often in an assemblage with both deep water benthic and deeper planktonic microorganisms (Fig. 3). Furthermore, the occurrence of *H. balthica* suggests isolation and cooling at the sea-floor (ROSS, 1984; BERGAMIN & DI BELLA, 1997), which is a possible consequence of sea-water column stratification. These palaeoecological inferences are preliminary, and a broader approach is needed. At the moment, our data lower the *taxon* appearance, which thus can be considered a sea-floor palaeotemperature proxy, whereas its stratigraphic importance needs to be reconsidered.

### 4.2.1. Volcanoclastic horizons

In the Il Caio section (Fig. 2), the occurrence of distal pyroclastic fallout material has been recently suggested (BIZZARRI et al., 2003). As described above (Sections 3.2, 3.3), similar volcanoclastic deposits, mainly represented by leucite-bearing pumice and idiomorphic pyroxenes, occur in the Camorena and Sugano well sections (Fig. 2), attributed to Early Pleistocene (BIZZARRI et al., 2003; BIZZARRI, 2006).

New analyses involving the Il Caio section, (still in progress (PANDOLFI, 2006; PECCERILLO et al., 2010a, 2010b)), attest to an affinity with the Roman Comagmatic Province. The new calcareous nannofossil stratigraphic data indicate that the lowermost volcanoclastic event occurred during the MNN 19b subzone, whereas a Late Villafranchian freshwater mollusc assemblage in the upper part of the section (BIZZARRI et al., 2003), indicates an age older than 1.4 Ma for its uppermost part (Fig. 2). As a consequence, the age of the uppermost volcanic products can be approximated in a range between 1.4 Ma and 1.62 Ma. Similar age constraints characterize marine deposits in the other four outcrops, where distal fallout deposits cover a time span of about 300 ky (MNN 19 b–d subzones). Biostratigraphic constraints clearly mark the occurrence of three successive steps in volcanic activity, from the MNN 19b to the MNN 19d subzones (Fig. 2).

The source of volcanics was probably a small, still unknown eruptive centre, and its discontinuous activity covered a time span of at least 300 ky (PECCERILLO et al., 2010b). The correlation of these events looks reliable, and its age constraint is different from that of the Middle Pleistocene “Paleobolsena” volcanic event (SANTI, 1990; GILLOT et al., 1991; NAPPI et al., 1994).

### 5. CONCLUSION

The stratigraphic reconstruction contributes to our understanding of evolution of the Tuscan-Umbria-Latium area. Starting from the mid 1970’s, Pliocene and Pleistocene deposits in the area have been referred to two 3rd order sedimentary cycles, separated by the “Acquatraversa” erosion/tectonic phase (BLANCH, 1955; AMBROSETTI et al., 1977; 1987; GIORotti & Mancini, 2003; Mancini et al., 2004). None of the authors recorded marine deposits after the Santernian, so the ultimate marine regression must have already occurred in the Early Pleistocene.

All of the studied sections belong to the same environmental domain, and to the same depositional cycle (“Chiani – Tevere” cycle: AMBROSETTI et al., 1987; GIOROTTI & MANCINI, 2003; Mancini et al., 2004), even though the temporal extension of that cycle (Gelasian pp.–Santernian) seems to be limited.

The micropalaeontological content allows detailed stratigraphic reconstruction, with identification of the calcareous nanoplankton Zone MNN19 (RIO et al., 1990) and relative MNN19a to MNN19e subzones. Moreover, lithological and sedimentological data confirm both lateral and vertical environmental continuity, and the lack of major unconformities do not allow definition of a Lithostratigraphic Unit limit. Considering the new data presented herein, stratigraphic revision seems to be necessary, as well as re-interpretation of the palaeogeographic patterns. The data confirm the persistence of marine conditions in the Orvieto area from the Gelasian to the top of the Calabrian at least, either un- or only partially influenced by continental progradation, unlike the southern areas, where a continental environment is already documented, from the Santernian (GIROTTI & MANCINI, 2003; Mancini et al., 2004). The Orvieto area can be illustrated as a restricted satellite basin in which marine conditions remain, protected from the influence of the main rivers during the Early Pleistocene and accommodating only negligible supply from tributary rivers (BIZZARRI, 2006).

Contrary to former palaeogeographic interpretations, the occurrence of Early Pleistocene marine deposits is largely documented in the Orvieto area. The offshore clay deposits allow reconstruction of a composite biostratigraphic succession (Fig. 2), almost continuous from the top of the *G. gr. crassaformis* Zone to the top of the *Gl. cariacoensis* Zone.
As expected, the datum becomes less clear in more proximal marine deposits. Nevertheless, nannofossil assemblages and bioevents still allow reference of these deposits to the MNN19a, MNN19b and MNN19c subzones. Deposits can be partially attributed to the “Chiani – Tevere” depositional cycle, which thus also appears largely documented in the study area.

REFERENCES

AAVV (1982): Bacino del Fiume Paglia (Umbria – Toscana): studi strutturali, idrogeologici e geochimici.– Relazione finale sul tema di ricerca: “Studi geologici, idrogeologici e geofisiici finalizzati alla ricerca di flussi caldi nel sottosuolo”, CNR – Progetto Finalizzato Energetica, 16, 112 p.

AMBROSETTI, P., CARBONI, M.G., CONTI, M.A., COSTANTINI, A., ESU, D., GANDIN, A., GIROTTI, O., LAZZAROTTO, A., MAZZANTI, R., NICOSIA, U., PARISI, G. & SANDRELLI, F. (1978a): Evoluția paleogeografică și tectonică în bacinii Tosco – Umbro – Laziali nel Pliocene e nel Pleistocene inferiore.– Mem. Soc. Geol. It., 19, 573–580.

AMBROSETTI, P., CATTUTO, C., CONTI, M.A., NICOSIA, U. & PARISI, G. (1978b): Dati preliminari sulla neotettonica del foglio 130 (Orvieto). – Contributi preliminari alla realizzazione della Carta Neotettonica d’Italia: C.N.R.– Progetto Finalizzato Geodinamica, 155, 391–397.

AMBROSETTI, P., CONTI, M.A., PARISI, G., KOTSAKIS, T. & N/ZOTTI, R. (2001): Faacies costiere plioceniche nell’area di Corbara (Orvieto, Italia Centrale): gli affioramenti di Camorena e del Caio. La geologia del Quaternario in Italia: temi emergenti e zone d’ombre, Aiqua National Meeting, Rome, Feb. 16–18, 2004.– Abstract Book, p. 100.

AMBROSETTI, P., AMBROSETTI, P., ARGENTI, P. & BALDANZA, A. (2005): Il Pleistocene inferiore in facies marine nei dintorni di Corbara (Orvieto, Italia Centrale): gli affioramenti di Camorena e del Caio

BIZZARRI, R. (2005): Rocky coasts, sand and gravel beaches from Late Pliocene and Early Pleistocene of the Orvieto area (western Umbria, central Italy).– Geologia Epitome, 1, 166.

BIZZARRI, R. & BALDANZA, A. (2005): Rocky coasts, sand and gravel beaches from Late Pliocene and Early Pleistocene of the Orvieto area (western Umbria, central Italy).– Geologia Epitome, 1, 166.

BIZZARRI, R. & BALDANZA, A. (2006a): Stratigrafia e cicli sedimentari nel Pleistocene inferiore dell’area orvietana (Umbria, Italia Centrale): considerazioni sull’Unità del Chiani-Tevere.– Il sollevamento quaternario nella penisola italiana e nelle aree limitrofe, Aiqua National Meeting, Rome, Feb. 6–8, 2006.– Abstract Book, 23–24.

BIZZARRI, R. & BALDANZA, A. (2006b): On the meaning of the Amphistegina levels in the Plio – Pleistocene of the Orvieto area (Central Italy).– In: COCCIONI, R. & MARSHALL, A. (eds.): Proceedings of the Second and Third Italian Meetings on Environmental Micropaleontology. Grzybowsk Foundation Special Publication, 11, 13–20.

BIZZARRI, R. & BALDANZA, A. (2007): Late Pliocene and Early Pleistocene of the Orvieto area (central Italy): a stratigraphic review.– Geologia Epitome, 2, 399.

BIZZARRI, R. & BALDANZA, A. (2009): Plio-Pleistocene deltaic deposits in the Città della Pieve area (western Umbria, central Italy): facies analysis and inferred relations with the South Chiana Valley fluvial deposits.– Il Quaternario, 22/2, 127–138.

BIZZARRI, R., AMBROSETTI, P., ARGENTI, P. & BALDANZA, A. (2004): Il Pleistocene inferiore in facies marine nei dintorni di Corbara (Orvieto, Italia Centrale): gli affioramenti di Camorena e del Caio. La geologia del Quaternario in Italia: temi emergenti e zone d’ombre, Aiqua National Meeting, Rome, Feb. 16–18, 2004.– Abstract Book, p. 100.

BIZZARRI, R., AMBROSETTI, P., ARGENTI, P., GATTA, G.D. & BALDANZA, A. (2003): L’affioramento del Caio (Lago di Corbara, Orvieto, Italia Centrale) nell’ambito dell’evoluzione paleogeografica pleistocenica della Valle del Tevere: evidenze sedimentologiche e stratigrafiche.– Il Quaternario, 16/2, 240–255.

BIZZARRI, R., PASSERI, L. & BALDANZA, A. (2005): Rocky coasts, sand and gravel beaches from Late Pliocene and Early Pleistocene of the Orvieto area (western Umbria, central Italy).– Geologia Epitome, 1, 166.

BLANCH, A.C. (1955): Giacimento Paleolitico Inferiore di Torre in Pitea e giacimenti levullosio – musterianni di Palo e di Palidoro.– Quaternaria, 2, 305–308.

CARBONI, M.G. (1975): Biosтратigrafia di alcuni affioramenti plio-pleistocenici del versante tirrenico dell’Italia centrale.– Geol. Rom., 14, 63–86.

CARBONI, M.G. & DI BELLA, L. (1996): The Pleistocene section of Podere Palombo (Umbria).– Geol. Rom., 32, 97–108.

CATTUTO, C., CONTI, M.A., NICOSIA, U. & PARISI, G. (1979): Relazione sulla neotettonica dei fogli 130, 131, 137 e 138.– Contributi preliminari alla realizzazione della Carta Neotettonica d’Italia: C.N.R.– Progetto Finalizzato Geodinamica, 251, 13–28.

CATTUTO, C., CENCETTI, C. & GREGORI, L. (1997): A un vistoso esempio di controllo strutturale e di morfogenesi fluviale tra Todi e Baschi (Fg.130 Carta d’Italia).– Il Quaternario, 10, 181–190.

CATTUTO, C., GREGORI, L. & PARISI, G. (1998): Indizi di tettonica pleistocenica nel bacino del T. Tresa (Lago Trasimeno).– Geogr. Fis. Dinam. Quat., 1, 16–20.

CATTUTO, C., CONTI, M.A., PARISI, G. & SPROVIERI, R. (1997): Biostratigrafi a di alcuni affi oramenti plio-cenici nei dintorni di Città della Pieve (Umbria).– Boll. Soc. Geol. It., 96, 605–635.

COTTONE, A., COLALONGO, M.L., NAKAGAWA, H., PASINI, G., RIO, D., RUGGIERI, G., SARTONI, S. & PROVERI, R. (1997): Il Pliocene-Pleistocene boundary in Italy.– In: VAN COUVERING, J.A. (ed.): The Pleistocene boundary and the beginning of the Quaternary. Cambridge University Press, Cambridge, 141–155.

BARBERI, F., BUONASORTE, G., CIONI, R., FIORELISI, A., FORESI, L., IACCARINO, S., LAURENZI, M.A., SBRANA, A., VERNIA, L. & VILLA, I.M. (1994): Plio-Pleistocene geological evolution of the geothermal area of Tuscania and Latium.– Mem. Descr. Carta Geol. It., 49, 77–134.

BOLZAN, G. & DE STEFANO, E. (1998): Calcareous nannofossil quantitative biostratigraphy of Holes 969E and 963B (eastern Mediterranean).– In: ROBERTSON, M.C. & KLAUS, A. (eds.): Proceeding ODP Scientific Results, 161, 159–183. doi:10.2973/odp.proc.x.161.250.1999

DI STEFANO, E., MIRELLA, G. & MURAT, A. (1999): Calcareous nannofossil quantitative biostratigraphy of Holes 969E and 963B (eastern Mediterranean).– In: ROB-
ERTSON, A.H.F., EIMES, K.C., RICHTER, C. & CAMERLENGHI, A. (eds.): Proceeding ODP Scientific Results, 160, 99–112. doi:10.2973/odp.proc.sr.160.009.1998

DUNBAR, G.B. & BARRETT, P.J. (2005): Estimating palaeobathymetry of wave-graded continental shelves from sediment texture.– Sedimentology, 52, 235–254. doi: 10.1111/j.1365-3091.2004.00695.x

FAZZINI, P. (1968): La geologia dei Monti d’Amelia (Tr).– Mem. Soc. Geol. It., 7, 441–469.

FUNCIIELLO, R., PAROTTO, M. & PRATURLON, A. (1981): Carta Neotettonica d’Italia – CNR – Progetto Finalizzato Geodinamica, 269 p.

GILLOT, P.Y., NAPPI, G., SANTI, P. & RENZULLI, A. (1991): Space-time evolution of the Vulsini Volcanic Complexes, central Italy.– Terra Abstract, 3/1, 446. doi: 10.1111/j.1365-3121.1991.tb00859.x

GIROTTI, O. & MANCINI, M. (2003): Plio – Pleistocene stratigraphy and relations between marine and non – marine successions in the middle valley of Tiber river (Latium, Umbria).– Il Quaternario, 16, 89–106.

GIROTTI, O. & PICCARDI, E. (1994): Linee di riva del Pleistocene inferiore sul versante sinistro della media valle del F. Tevere.– Il Quaternario, 7, 525–536.

IACCARINO, S. & PREMOLI SILVA, I. (2007): Practical manual of Neogene planktonic Foraminifera.– International School on Planktonic Foraminifera, VI Course: Neogene, Perugia, Feb. 19–23, 2007.

JACOBACCI, A., MALATESTA, A. & MARTELLI, G. (1969): Note illustrative della Carta Geologica d’Italia alla scala 1:10000; foglio 121 “Montepulciano”.– Italian Geological Survey, 73 p.

JACOBACCI, A., MARTELLI, G. & NAPPI, G. (1967). Note illustrative della Carta Geologica d’Italia alla scala 1:100000; foglio 129 “Santa Fiora”.– Italian Geological Survey, 61 p.

JACOBACCI, A., BERGOMI, C., CENTAMORE, E., MALATESTA, A., MALFERRARI, N., MARTELLI, G., PANNUZZI, L. & ZATINNI, N. (1970): Note illustrative della Carta Geologica d’Italia alla scala 1:100000; fogli 115 “Cittá di Castello”, 122 “Perugia”, 130 “Orvieto”.– Italian Geological Survey, 147 p.

MANCINI, M., GIROTTI, O. & CAVINATO, G.P. (2004): Il Pliocene ed il Quaternario della Media Valle del Tevere (Appennino Centrale).– Geol. Rom., 37, 175–236.

NAPPI, G., CAPACCIONI, B., RENZULLI, A., SANTI, P. & VALENTINI, L. (1994): Stratigraphy of the Orvieto-Bagnoregio Ignimbrite eruption (Eastern Vulsini District, Central Italy).– Memorie Descrittive della Carta Geologica d’Italia, 49, 241–254.

PANDOLFI, D. (2006): Analisi petrologica e geochemica delle vulcani- tì della sezione del Caio (Corbara, Umbria occidentale).– Unpubl. Bs. Thesis, Perugia University, 140 p.

PECCERILLO, A., BIZZARRI, R., BALDANZA, A., PETRELLI, M. & FAMIANI, F. (2010a): Early Pleistocene remote pyroclastic fall-out material in western Umbria continental and marine deposits: composition, provenance and correlation potentiality. “Le correlazioni marino – continentali nel Quaternario”, Aiqua National Meeting, Bari, Feb. 25–26, 2010.– Abstract Book, 30–31.

PECCERILLO, A., BIZZARRI, R., BALDANZA, A., PETRELLI, M. & FAMIANI, F. (2010b): Early Pleistocene distal pyroclastic-fall-out material in continental and marine deposits of western Umbria (Italy): chemical composition, provenance and correlation potential.– Il Quaternario, 23/2, 231–236.

RAFFI, I. (2002): Revision of the early – middle Pleistocene calcareous nannofossil biochronology (1.75-0.85 Ma).– Mar. Micropaleontol., 45, 25–55. doi: 10.1016/S0377-8398(01)00044-5

RIO, D., RAFFI, I. & VILLA, G. (1990): Pliocene-Pleistocene calcareous nannofossil distribution patterns in the Western Mediterranean.– In: KASTENS, K. & MASCLE, J. (eds.): Proceeding ODP Scientific Results, 107, 513–533. doi:10.2973/odp.proc.sr.107.164. 1990.

ROSS, C.R. (1984): Hylalinea balthica and its late Quaternary paleoecological implications: Strait of Sicily.– J. Foramin. Res., 14/2, 134–139. doi: 10.2113/gsjfr.14.2.134

SANTI, P. (1990): New geochronological data of the Vulsini Volcanic District (central Italy). “Genesi e differenziazione del magmatismo potassico del bordo tirrenico”.– SIMP Meeting, Ischia, 15–18 Ottobre 1990.

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