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

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ABSTRACT

Plio-quaternary marine deposits are largely documented in western Umbria (central Italy), although they still lack biostratigraphic definition. Contrary to published data, Early Pleistocene deposits outcrop more extensively than previously reported in the Orvieto area. A composite biostratigraphic succession, almost continuous from the top of the *G.* gr. *crassaformis* Zone to the top of the *Gl. cariacoensis* Zone, can be reconstructed in offshore clay sections. Nannofossil assemblages and marker events (b*mG*, t*Cm*, b*lG*, t*Hs*, t*lG*) from the MNN16a to MNN19e subzones have been documented. Lower shoreface – transition to offshore sections as described, are characterized by poor planktonic assemblages; nevertheless, they are still referable to the same stratigraphic interval. Deposits can be partially inserted into the "Chiani – Tevere" depositional cycle, also documented in this area. Moreover, marine conditions persist in the area from the base of the Gelasian to the top of the Calabrian, and it can be modelled as a peripheral, survival sea-branch, cut-off from the main river supply and from continental influence. However, Zanclean to Piacenzian deposits occur in a small area, localized around the town of Orvieto, so the former distinction of superimposed depositional cycles can only be speculative.

Keywords: Early Pleistocene, calcareous nannofossil biostratigraphy, foraminifers, palaeoenvironmental reconstruction, western Umbria.

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)

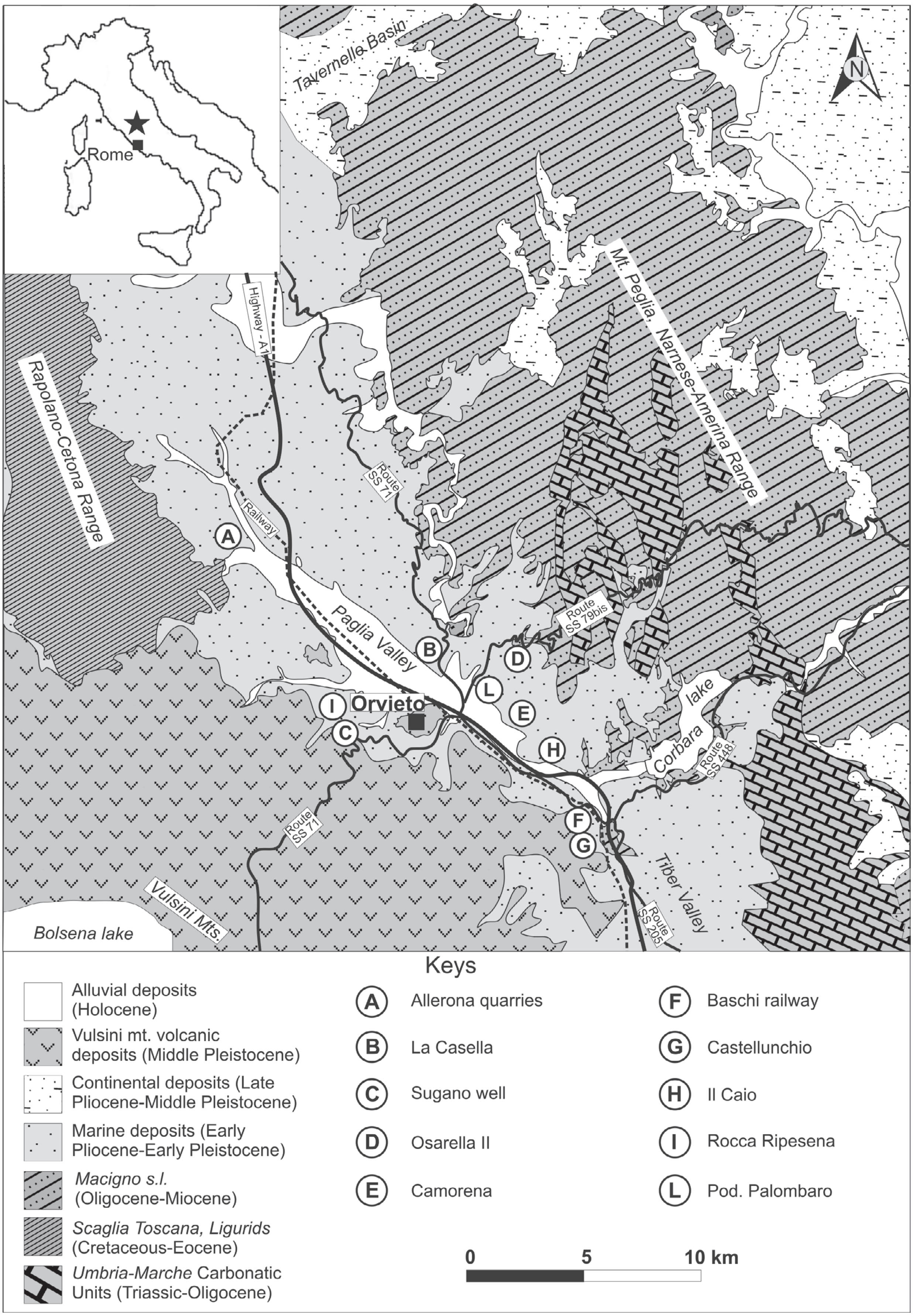

Figure 1: Geological sketch of the study area and location of the study sections. The Rocca Ripesena (CARBONI, 1975), Podere Palombaro (CARBONI & di BELLA, 1996) and Il Caio sections (BIZZARRI et al., 2003) are also indicated.

and MANCINI et al. (2004) proposed the use of the "Tenaglie 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 -Tiber Valley, a *graben* basin limited by East- and West-dipping conjugated normal fault systems, formed as a consequence of Lower Pliocene tectonics (FUNICIELLO 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.l.* 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; FUNICIELLO 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*, *Calcidiscus 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 b*mG* and b*lG* 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 Il Caio section (BIZZARRI et al*.,* 2003).

The Camorena section covers the interval from the MNN19b to MNN19e subzones. A basal fossil assemblage is characterized by small *Gephyrocapsa*, medium *Gephyrocapsa* and *Calcidiscus 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 MNN19e subzone. The LO of *Helicosphaera sellii* and a scattered increase of *Braarudosphaera bigelowii* occur into the MNN19d subzone.

Among foraminifers, *Globigerina cariacoensis* 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

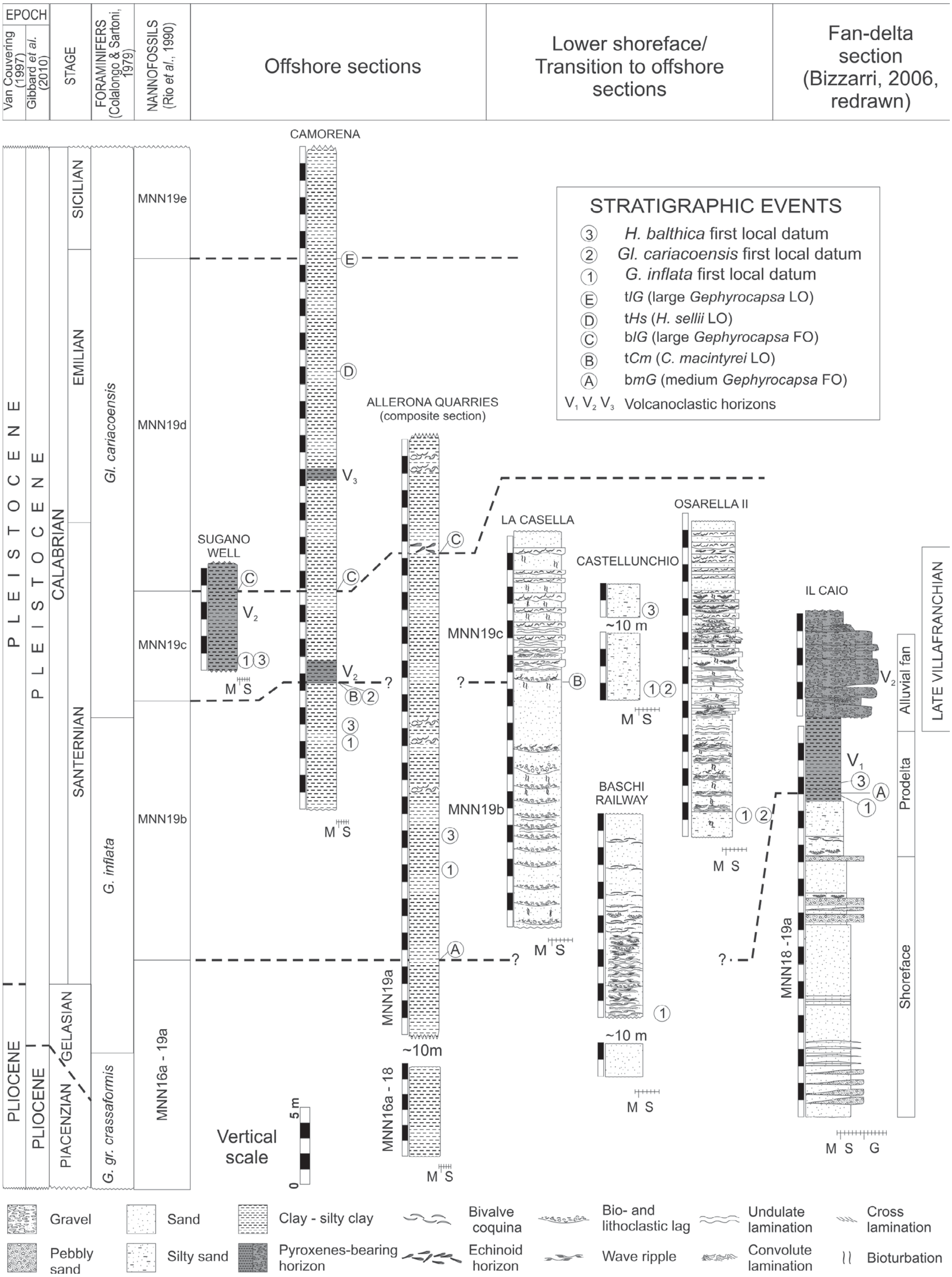

Figure 2: Sedimentological and stratigraphic logs of the study sections, grouped according to palaeoenvironmental attribution. The fan-delta section of Il Caio (BIZZARRI et al., 2003) is also shown.

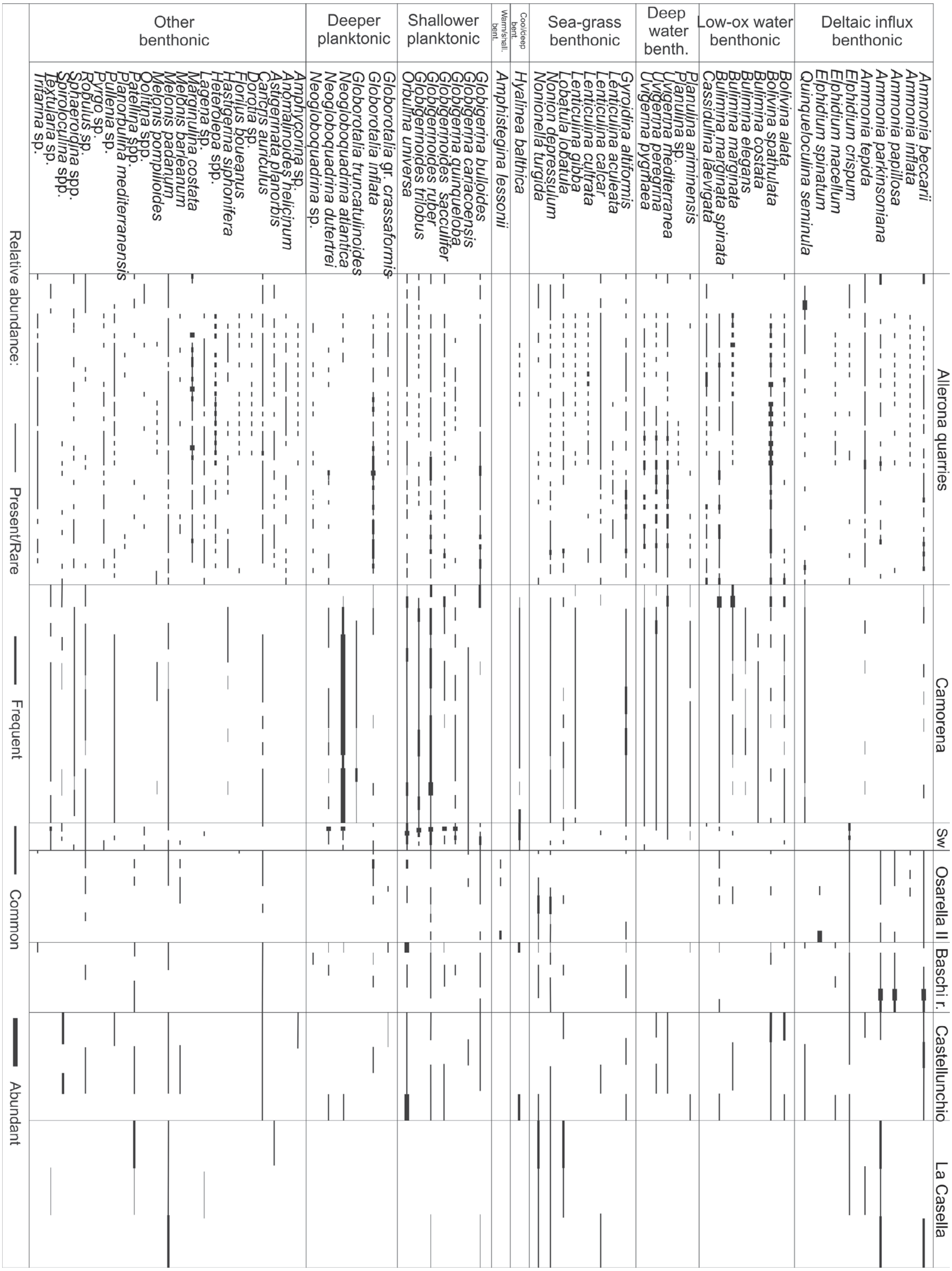

Figure 3: Semi-quantitative distribution chart of selected benthonic and planktonic foraminifers from the study sections. Length of lines is proportional to section thickness. SW=Sugano well.

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 foraminifer assemblages (Fig. 3) are associated with the ostracods *Cytheropteron alatum* and *Aurila* sp.

The section also produced a very rich calcareous nannofossil 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 (<5cm 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 *Thalissinoides* 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, oligotypic large *Glicymeris* 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 nannofossil 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 *Flabellipecten flabelliformis*. Barnacles also locally occur.

The microfossil content (Fig. 3) is dominated by shallow water benthonic *taxa*. The section comprises calcareous nannofossil 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., *Haustator vermicularis*, *Aporrhais* sp., *Ostrea lamellosa*, *Ostrea* sp., *Dentalium* spp.) have been recognized.

The section allows reconstruction of a succession of calcareous nannofossil 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 Nannoplancton 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 Chiani-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 MNN19c 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 volcanoclastic 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 (MNN19b Subzone) and the presence of *G. cariacoensis* documents a Santernian 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 Santernian 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 Allerona 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 benthonic 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 Castelluncchio 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, Calcidiscidae* 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 sections (Figs. 2, 3), documenting the *G. inflata* and *Gl. 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; GIROTTI & 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; GIROTTI & 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 nannoplankton 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.

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