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The Ranzano unit boundaries in the type area: Lower Oligocene events in the epi-Ligurian Succession (northern Apennines, Italy)

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Key-words: Lower Oligocene events, unconformity boundaries, calcareous nannofossil biostratigraphy, epi-Ligurian Succession, Ranzano unit, northern Apennines

ABSTRACT

In the Enza Valley area (northern Apennines) the occurrence of two angular unconformities within the lower Oligocene deposits of the epi-Ligurian Succession provides the opportunity to redefine the Ranzano unit in the type area. The calcareous nannofossil biostratigraphy allows us to chronologically constrain the stratigraphic events corresponding to these unconformities. The lower unconformity, which represents the basal boundary of the Ranzano unit, overlaps the middle-upper Eocene deposits of the epi-Ligurian Succession and the Ligurian Units (upper Campanian-Maastrichtian Helminthoid Flysch). This unconformity corresponds to an important erosional event encompassing the Eocene-Oligocene boundary (MNP21a Subzone) which can be related with the progressive uplift, exhumation and erosion of the Ligurian Phase thrust-belt. The upper unconformity directly overlaps a thrust system, affecting the middle Eocene-lower Oligocene deposits of the epi-Ligurian Succession, which can be related to a Rupelian (MNP23 Zone) thrusting phase. According to our data the Ranzano unit of the type area can be considered as the part of epi-Ligurian Succession bracketed between these two major unconformities, thus corresponding to a Rupelian unconformity-bounded lithostratigraphic unit. The regional occurrence of these events, recognized in several sections of the epi-Ligurian Succession and in the eastern Tertiary Piedmont Basin, provides new constraints for the reconstruction of the epi-Ligurian depositional basin.

RIASSUNTO

Nell'area della Val d'Enza (Appennino settentrionale) sono state individuate, su base geologico-strutturale e biostratigrafica (nannofossili calcarei) due importanti superfici di discordanza all'interno dei depositi arenacei dell'Oligocene inferiore della Successione epiligure. La presenza di queste discordanze consente di discutere una possibile ridefinizione dei limiti dell'unità Ranzano nell'area tipo. La discordanza inferiore si sovrappone direttamente ai depositi dell'Eocene medio-superiore della Successione epiligure e al Flysch ad Elmintoidi (Campaniano superiore-Maastrichtiano) appartenente alle sottostanti Unità Liguri. Questa discordanza corrisponde quindi ad un importante evento erosivo al limite Eocene-Oligocene (Sottozona MNP21a). La discordanza superiore, invece, sutura direttamente superfici di sovrascorrimento che, all'interno dei depositi epiliguri dell'Eocene medio-Oligocene inferiore, determinano l'individuazione di più elementi strutturali sovrapposti; i dati biostratigrafici consentono di riferire questa discordanza al Rupeliano (Zona MNP23). L'unità Ranzano dell'area tipo è quindi costituita dai depositi rupeliani compresi tra le due discordanze sopra descritte, rappresentando un'unità stratigrafica limitata da superfici di inconformità, in questo caso coincidenti anche a limiti litostratigrafici. La validità regionale di questa interpretazione sembra confermata dall'individuazione dei due eventi in molte sezioni rappresentative della Successione epiligure dell'Appennino settentrionale.

1. Introduction

In the northern Apennines, the epi-Ligurian Succession (Ricci Lucchi & Ori 1985) represents the sedimentary filling of a large episutural basin developed from middle Eocene to late Miocene onto the Ligurian Units, deformed during the middle Eocene collisional stage (Ligurian Phase, Elter 1973) and previous tectonic phases (Vescovi et al. 1999 and references therein).

South of the Villalvernia-Varzi Line (Elter & Pertusati 1973), the epi-Ligurian Succession is correlated with analogous deposits of the Tertiary Piedmont Basin (e.g. Lorenz 1969; Gelati & Gnaccolini 1982; Di Giulio 1991; Gelati et al. 1993; Mutti et al. 1995) which unconformably overlie both the Ligurian Units (Antola Helminthoid Flysch) and the metamorphic alpine units of the Ligurian Alps (Voltri Group) (Fig. 1).

The syntectonic evolution of the epi-Ligurian Succession is mainly characterized by unconformities which record the thrusting phases connected to the progressive emplacement of the Ligurian Units onto the Adria continental margin units (Tuscan-Umbrian domain). However, the possible occurrence of thrust tectonics affecting the epi-Ligurian Succession has been generally neglected, and the research has been mainly addressed to the sedimentological features of the epi-Ligurian Succession.

The definition of formal lithostratigraphic units within the epi-Ligurian Succession was first proposed by Pieri (1961) and afterwards generally adopted in the literature. According to Pieri (1961) the Oligocene part of the epi-Ligurian Succession is constituted by the Ranzano Sandstone which is intercalated

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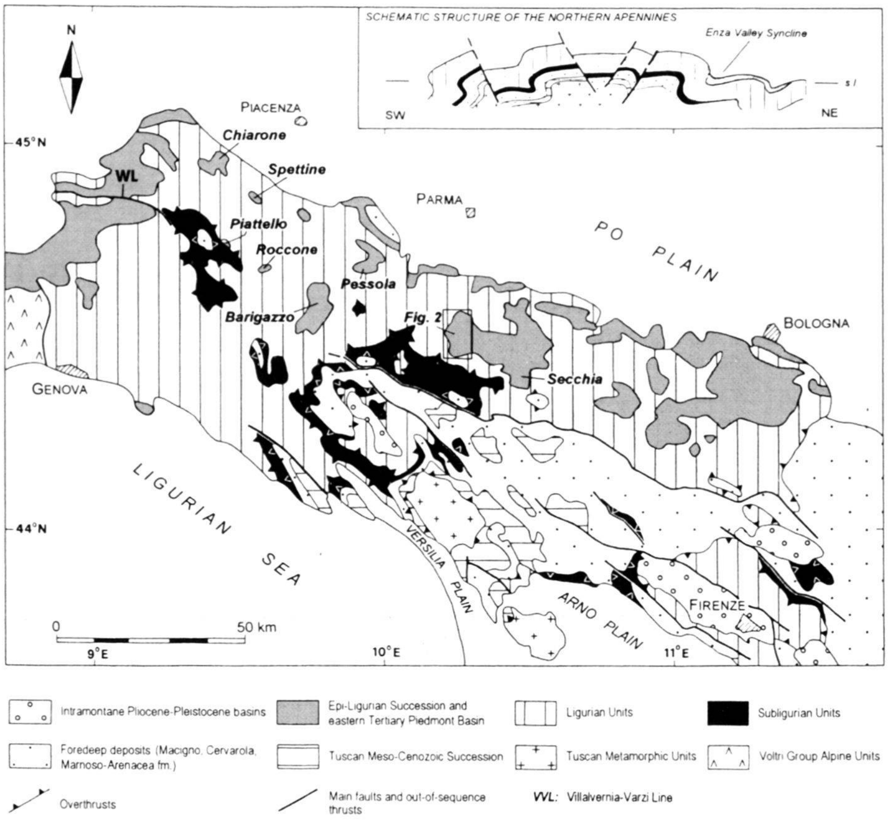

Fig. 1. Tectonic map of the northern Apennines and schematic cross-section.

between the underlying Monte Piano Marl and the overlying Antognola Marl.

The stratigraphy of the Ranzano Sandstone has been described in many articles (Braga 1962, 1963; Fazzini & Tacoli 1963; Mutti et al. 1965; Mutti & De Rosa 1968; Tagliavini 1968; Ghibaudo & Mutti 1973; Fornaciari 1982; Bettelli et al. 1987). Regional stratigraphic subdivisions of the Ranzano Sandstone have been suggested by Mutti et al. (1995) and Martelli et al. (1998).

Over the last few years, thrust tectonics affecting the pre-Bismantova epi-Ligurian Succession has been documented on structural and biostratigraphical basis in Taro, Pessola and Enza valleys (Cerrina Feroni et al. 1994; Costa & Frati 1997; Catanzariti et al. 1999; Ottria 2000). Oligocene-Miocene thrusting events involving the Tertiary Piedmont Basin succession have been described too (D'Atri et al. 1997; Forcella et al. 1999; Capponi et al. 1999).

The aim of this paper is to analyze the stratigraphy of the Ranzano unit in the type area (Enza-Parma valleys) where the discontinuities occurring in the succession have been chronologically determined by the calcareous nannofossil biostratigraphy.

The results of our study, though concerning only the Ranzano type area, provide new constraints to be taken into account for the interpretation of the tectono-sedimentary evolution of the lower part of the epi-Ligurian Succession of the northern Apennines.

2. Geological setting

The studied area is located at the middle Enza Valley and at the Parma Valley right side (Campora-Signano area) (Fig. 2). In these sectors the epi-Ligurian Succession is complete up to the Langhian-Serravalian shallow water deposits of the Bismantova Group (Amorosi et al. 1996 and references therein).

The overall structure of the studied area is represented by a NE-overturned syncline (Bertelli et al. 1986; Emilia-Romagna Region 1990) which affects the pre-Bismantova epi-Ligurian Succession together with the Ligurian (and Subligurian) units of the substratum (Fig. 3).

In the normal limb of this structure, outcropping in the middle Enza Valley, Catanzariti et al. (1999) documented the occurrence of a thrust system, previously not recognized, which affected the uppermost structural levels of the northern Apennines during the early Oligocene. The thrust system is characterized by the overthrusting of two thrust-sheets (TS1 and TS2) over a footwall (Fig. 2, 3, 4A).

The footwall is constituted by the Ligurian Units unconformably topped by the Monte Piano Marl or directly by the Ranzano succession; locally, in the overturned limb, below the Monte Piano Marl, the base of the epi-Ligurian Succession is represented by muddy chaotic deposits (Baiso melange; Bettelli & Panini 1987; Bettelli et al. 1987). The thrust-sheets are mainly composed of the lower part of the epi-Ligurian Succession; the base of TS1 is characterized by middle Eocene strongly deformed claystones referring to the Ligurian Units (Fig. 5).

In the Parma Valley sector lower Oligocene thrusts are mainly developed in the footwall (Fig. 2). In the Zermagnone area a thrust-sheet (TSZ), displaying very limited thickness, overthrust the footwall (Fig. 4B, 5).

Both in Enza and Parma valleys, the lower Oligocene thrust system is sealed by an unconformity surface identified by Catanzariti et al. (1999). Above this unconformity, the stratigraphic succession, which continues up to the Antognola Marl (Rupelian-Burdigalian; Emilia-Romagna Region 1990), is mainly composed of sandstone turbidites. This succession, originally attributed to the Ranzano Sandstone, has been subdivided in two stratigraphic units (Temporia unit and Lagrimone unit; Cerrina Feroni et al. in press) (Fig. 2, 4).

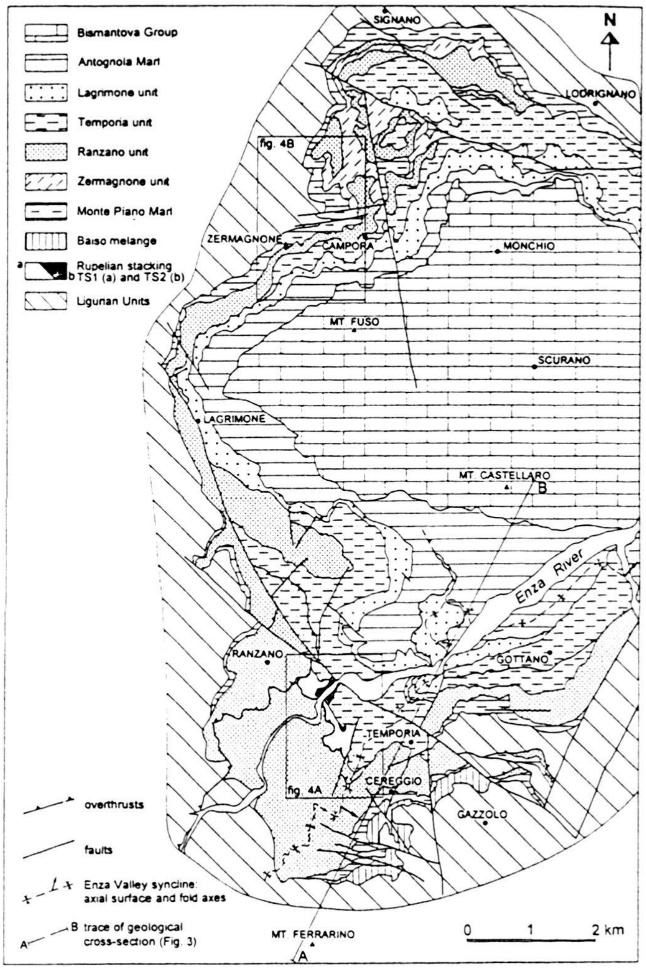

Fig. 2. Geological-structural map of the middle Enza Valley and Parma Valley right side (for location see figure 1).

3. Stratigraphic framework

The studied sections in the epi-Ligurian Succession have been dated by calcareous nannofossil biostratigraphy; the adopted time framework is reported in Fig. 6. The terminal Priabonian-lower Chattian adopted biostratigraphic scheme is that proposed by Catanzariti & Rio in Catanzariti et al. (1997). This regional framework is built on calcareous nannofossil biohorizons recognized in the epi-Ligurian Succession. The upper Lutetian-Priabonian scheme adopts standard biozones of Martini (1971), but different biohorizons. In fact, Catanzariti (1993) demonstrated the lack or uncertain distribution of standard zone markers in the middle-upper Eocene of Appennine region. This study proposes some nannofossil events already recorded in literature, or new ones, alternative to standard events of Martini (1971) or Okada & Bukry (1980). Specially the events *Nannotetrina* spp. FO (first occurrence) and *Dictyococcites bisectus* FO are good biohorizons to mark the bottom of NP15 and NP17 respectively, as proposed by Perch-Nielsen (1985). The *Reticulofenestra umbilicus* FO event, which defines the bottom of Okada & Bukry's (1980) CP14 Zone, has been redefined as *R. umbilicus* larger than 14 μm FO as proposed by Backman & Hermelin (1986). A new event is the first common occurence (FCO) of *Cribrocentrum reticulatum*, defined as acme of *C. reticulatum*. In the studied sediments this biohorizon approximates the first occurence of the rare and discontinuous presence of *Chiasmolithus oamaruensis*, marker of the bottom of NP18 and CP15 standard zones. In the time framework the nannofossil biohorizons chronology derives from calibrations made in the Umbria-Marche region in Central Italy

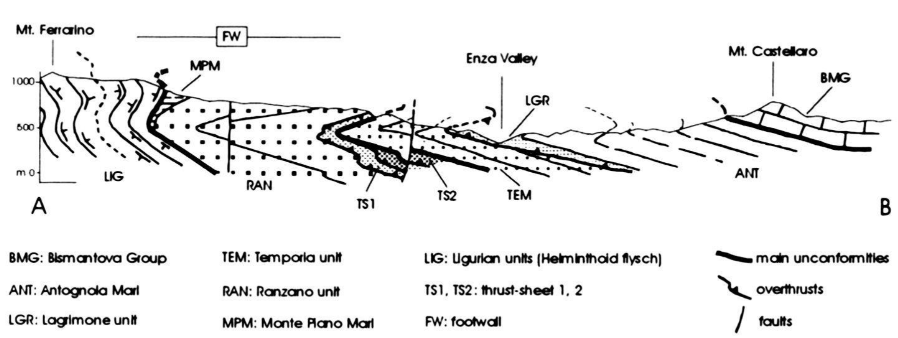

Fig. 3. Geological cross-section across the thrust system of the Enza Valley. For location see figure 2

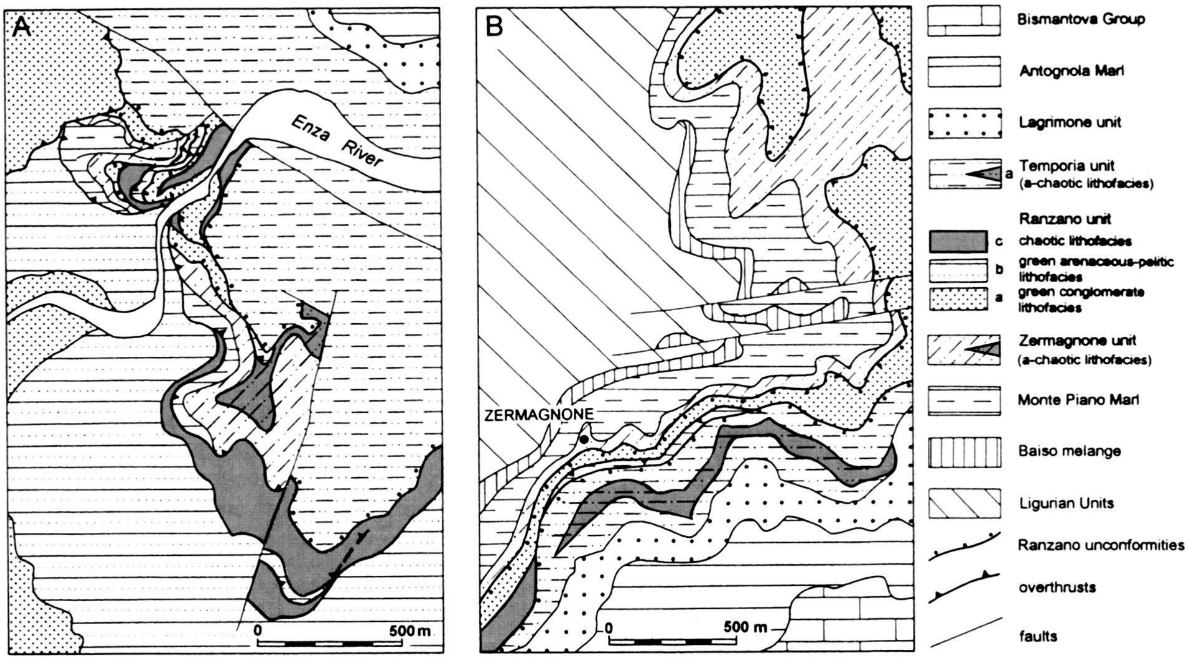

Fig. 4. Geological map of the Ranzano area (A) and Zermagnone area (B). For location see figure 2.

(Monechi & Thierstein 1985; Nocchi et al. 1986; Coccioni et al. 1988; Premoli Silva et al. 1988) and in the South Atlantic (Backman 1987) and referred to the geomagnetic polarity time scale of Cande & Kent (1992; 1995). The biostratigraphic scheme has been correlated to the global chronostratigraphy of Berggren et al. (1995).

The tectono-sedimentary relationships among footwall, thrust-sheets, and unconformable succession of the studied area are represented in Fig. 5 showing also the stratigraphic contents and the biostratigraphic data.

A common feature of all sections is the occurrence of two unconformity surfaces within the succession attributed to the Ranzano Sandstone (e.g. Tagliavini 1968; Emilia-Romagna Region 1990; Martelli et al. 1998); the upper unconformity seals the lower Oligocene stacking (Catanzariti et al. 1999); the lower angular unconformity, locally bounding the top of the Monte Piano Marl and even the Ligurian Units, corresponds to an important erosional event in the basal part of the Ranzano Sandstone Auct.

In this context, the stratigraphic boundaries and internal subdivisions of the Ranzano Sandstone, proposed up to now, seem to lose part of their effectiveness and a new definition of the Ranzano unit can be proposed emphasizing the meaning of the present discontinuities. Therefore, in our interpretation, we reserve the name of Ranzano unit to the part of epi-Ligurian Succession bracketed between the above quoted unconformities. With a different meaning, we maintain the traditional name of Ranzano, because this name immediately reminds a stratigraphic unit with a very well defined role in the post-collisional evolution of the northern Apennines.

In the following, we describe only the Ranzano unit and the underlying and overlying units (respectively Zermagnone unit and Temporia unit); for these latter we introduced new informal definitions referring to the areas where the units show better exposures.

The stratigraphic sections in Fig. 7 show the organization of the stratigraphic units of the considered epi-Ligurian Succession in the studied area.

3.1. Zermagnone unit

The unit occurs in the normal limb of the Enza Valley syncline (TS1 and TS2 of the Enza Valley, footwall of the Parma Valley) (Fig. 2, 3) showing a maximum thickness of about 100 m (TS1). It consists mainly of arenaceous and arenaceous-pelitic turbidites with fine to medium-grained whitish sandstones (white sandstone facies; Fig. 5, 7) showing a quartzose-feldsphatic composition (Cibin 1993). The uppermost part of the Zermagnone unit is, on the contrary, characterized by grey-greenish sandstones (green arenaceous-pelitic facies; Fig. 5, 7) due to the beginning of the ophiolitic sedimentary input.

The lower boundary with the Monte Piano Marl, observable along the left Enza side near Ranzano village (TS1), is represented by an alternating passage between sandstone turbidites and grey to light red silty marlstones; this passage occurs within Zone MNP20 (Fig. 5, 7). Therefore the Zer-

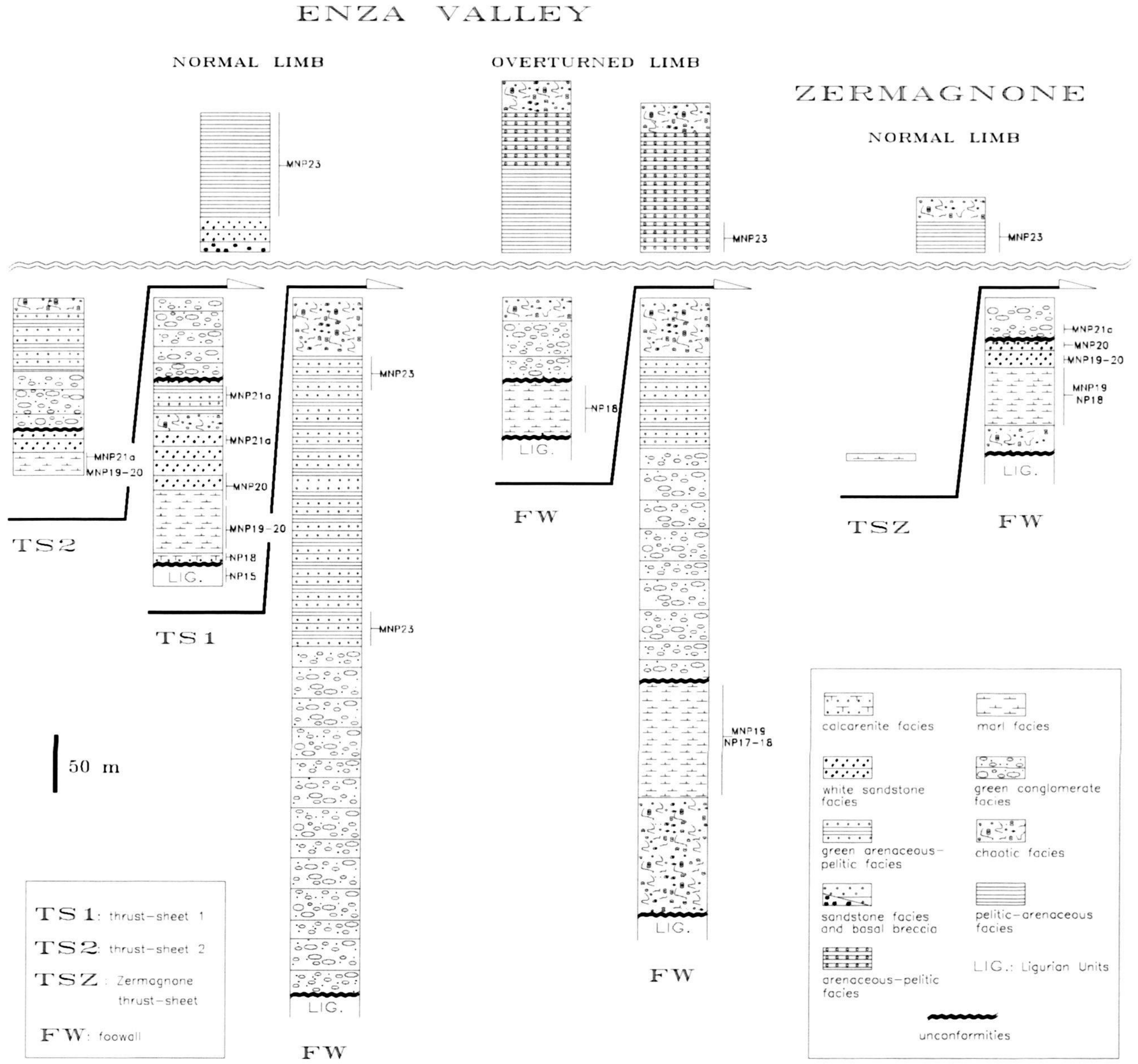

Fig. 5. Tectono-sedimentary relations of the studied epi-Ligurian Succession in the Enza Valley (normal and overturned limb of the Enza Valley syncline) and Zermagnone area (Enza Valley syncline normal limb). Biostratigraphical data from Catanzariti et al. (1999) and Catanzariti in Cerrina Feroni et al. (in press).

magnone unit represents the beginning of the turbiditic sedimentation in the epi-Ligurian Succession.

The calcareous nannofossil assemblage allows to ascribe the Zermagnone unit to the upper Priabonian (MNP20-MNP21a). Zone MNP20 is characterized by the common and continuous occurrence of *Discoaster saipanensis* and *Discoaster barbadiensis*, and by the presence of *Isthmolithus recurvus, Dictyococcites bisectus, Ericsonia formosa, Reticulofenestra umbilicus, Discoaster tanii, Discoaster deflandrei, Sphenolithus moriformis, Sphenolithus radians, Sphenolithus predistentus, Helicosphaera compacta, Helicosphaera reticulata.* The MNP21a Subzone is indicated by the same association where the rosette-shaped Discoasters (*Discoaster barbadiensis* and *Discoaster saipanensis*) are absent.

3.2. Ranzano unit

As redefined in the present study, the Ranzano unit begins with conglomerates and coarse-grained sandstones which are commonly greenish and massive, although banks and thick beds can be observed (green conglomerate facies; Fig. 5, 7). The greenish colour is due to the high proportion (20–30%) of

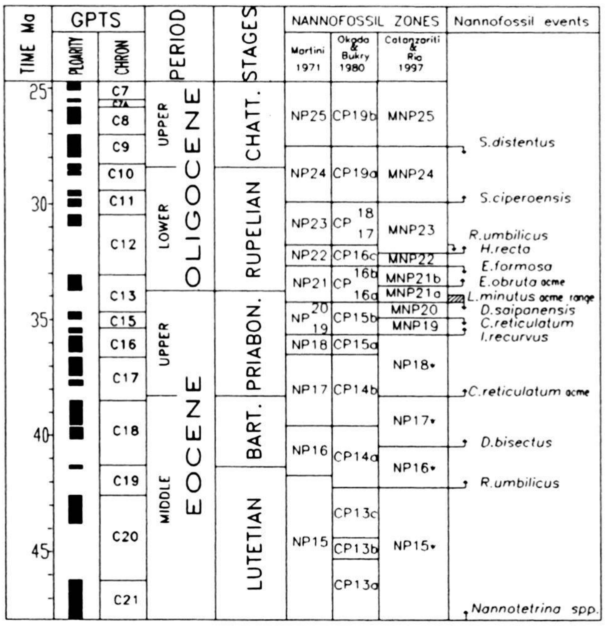

Fig. 6. Adopted time framework. The biostratigraphic scheme is by Catanzariti & Rio in Catanzariti et al. (1997), the Geomagnetic Polarity Time Scale by Cande & Kent (1992, 1995) and the chronostratigraphy by Berggren et al. (1995). The zones with asterisk are emended from Martini (1971). In this work the three major biostratigraphic events are so calibrated:

1) *Ericsonia obruta* FCO, in the lower part of Chron 13N (Coccioni et al. 1988);
2) *Reticulofenestra umbilicus* LO, in the middle part of Chron 12R (Backman 1987);
3) *Helicosphaera recta* FO, tentatively calibrated with the lower part of Chron 12R.

ophiolitic clasts in the conglomerates. The clasts (maximum grain size up to 30 cm) also consist of magmatic rocks (granitoids, rhyolites), metamorphic rocks (gneiss, phyllites) and sedimentary rocks mainly derived from the Ligurian Units (cherts, marly limestones, arenites, etc.).

Upward the conglomerate facies passes gradually to the green arenaceous-pelitic facies characterized by regular decimetric beds (maximum thickness about 250 m).

The Ranzano unit is locally completed by thick mainly pelitic chaotic deposits containing slides of Ligurian Units, Monte Piano Marl and of the underlying sandstones (chaotic facies; Fig. 5, 7).

The whole succession reaches a maximum thickness of about 600 m in the footwall of the Enza Valley area (Enza Valley syncline normal limb).

The Ranzano unit can be ascribed to the Rupelian, ranging from Zone MNP21a to MNP23. In particular the calcareous nannofossil assemblage, providing the attribution to the MNP21a Zone, derives from samples collected in some pelitic interbeds of the basal conglomerate facies (Zermagnone section; Fig. 5, 7); the assemblage is characterized by *Ericsonia formosa, Reticulofenestra umbilicus, Dictyococcites bisectus, Isthmolithus recurvus, Sphenolithus predistentus, Sphenolithus moriformis, Discoaster deflandrei, Discoaster tanii, Helicosphaera compacta.*

The upper chronological constraint is referable to the lowest part of Zone MNP23 characterized by the concomitant occurrence of *Helicosphaera recta, R. umbilicus* and *I. recurvus* (Fig. 6).

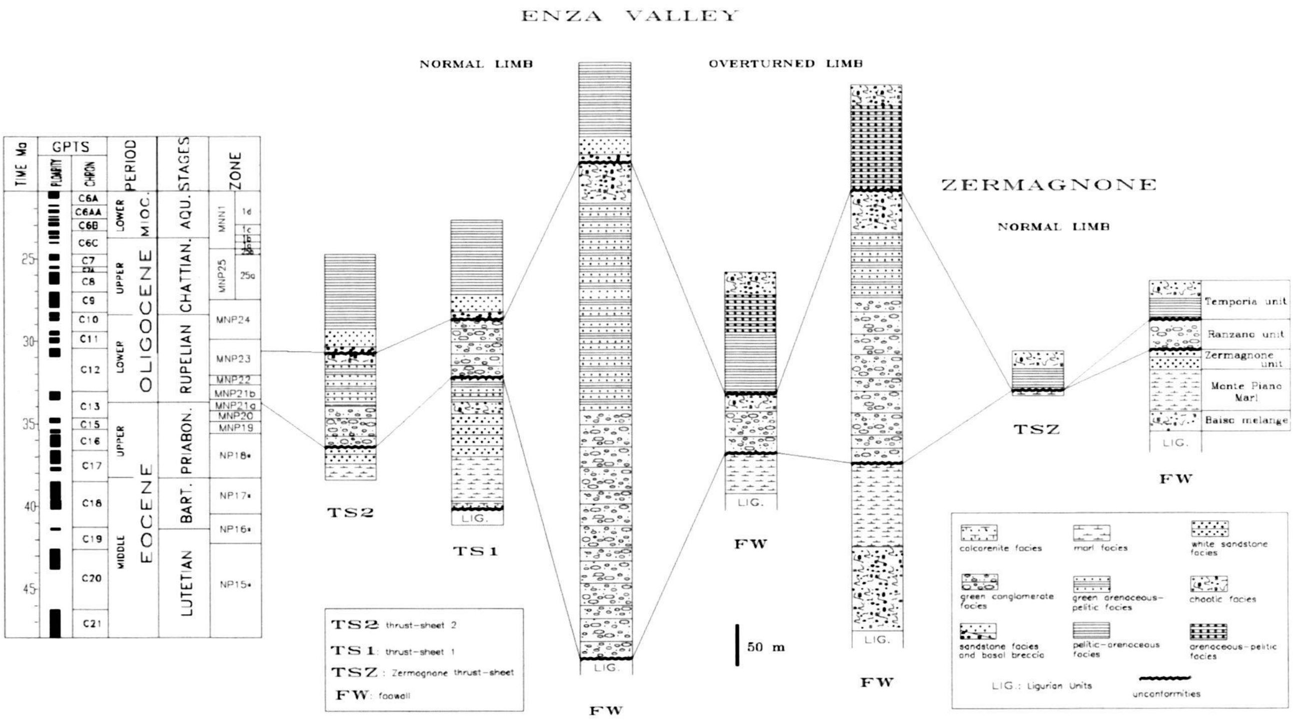

Fig. 7. Stratigraphic framework of the considered epi-Ligurian Succession of the Enza Valley and Zermagnone area (Parma Valley).

Fig. 8. Unconformable contact between the Ranzano conglomerates (pre-Ranzano erosional event) and Mt. Caio Helminthoid Flysch (Enza Valley left side, Ranzano area).

3.3. Temporia unit

The Temporia unit represents the basal part of the succession which unconformably overlaps the lower Oligocene thrust system (Catanzariti et al. 1999; Cerrina Feroni et al. in press). In the stratigraphic sections of Fig. 5 and 7 only the lower part of the Temporia unit is represented, omitting the upward evolution to Lagrimone and Antognola units (Fig. 2, 4).

The sharp and erosional basal boundary of the Temporia unit is exposed along the right side of the Enza River where it is characterized by 10 m-thick breccias overlapping the green arenaceous-pelitic facies belonging to thrust-sheet 2 (Catanzariti et al. 1999). These breccias are followed by about 20 m-thick coarse-grained and poorly cemented sandstones (sandstone facies; Fig. 5, 7). The succession of the Temporia unit consists mainly of arenaceous-pelitic and pelitic-arenaceous facies. The arenites are chiefly made of carbonate clasts; this composition is consistent with the petrofacies D by Cibin (1993) which is characterized by lithic fragments from sedimentary successions such as Helminthoid Flysch, and subordinate amounts of metamorphic lithics and serpentinites. Chaotic deposits also occur in the Temporia succession.

The pelitic-arenaceous facies provided nannofossil assemblages referable to the MNP23 Zone (Rupelian). In particular the samples contain *Helicosphaera recta, Helicosphaera perchnielseniae, Sphenolithus predistentus* and *Sphenolithus distentus* in association with *Dictyococcites bisectus, Cyclicargolithus abisectus* (<10 µm), *Reticulofenestra daviesii, Helicosphaera euphratis, Helicosphaera bramlettei, Discoaster deflandrei.*

4. The Ranzano unit: stratigraphic boundaries in the type area

The Ranzano unit of the type area (Enza Valley) is bracketed between two major events correlative to angular unconformities. The lower discontinuity corresponds to an erosional surface coinciding with the lithostratigraphic boundary: the overlying deposits are conglomerates and coarse-grained sandstones (conglomerate facies; Fig. 7). The erosional feature is very well documented since the conglomerates directly overlie both the lower stratigraphic units of the epi-Ligurian Succession (Zermagnone unit, Monte Piano Marl) and the Ligurian substratum (Fig. 2, 4). In particular, the overlap of the conglomerate facies on the Mt. Caio Helminthoid Flysch, showing overturned setting, can be seen in the Enza River thalweg near the Ranzano village (Fig. 8).

The timing of the erosional event which produced the Ranzano unit basal unconformity can be well constrained in the study area. The biostratigraphic data indicate that the erosional event occurred within the MNP21a. In fact, both the youngest deposits below the erosion (TS1 section) and the first dated Ranzano sediments above the erosion (Zermagnone section) belong to the MNP21a Zone (Eocene-Oligocene transition) (Fig. 5, 7). Therefore the unconformity does not match with a relevant stratigraphic hiatus.

The basal unconformity is not directly referable to a tectonic phase connected to the progressive thrusting of the underlying Ligurian Units onto the external Tuscan-Umbrian foredeep domain. Rather the Ranzano succession records the progressive erosion experienced by the thrust-belt built during the Ligurian Phase.

The timing of the pre-Ranzano event (Eocene-Oligocene transition of the adopted time framework) seems to correspond to the third order cycle boundary TA4.4 (Haq et al. 1988) coinciding with the base of the Chron C13n and approximately with the Eocene-Oligocene boundary (Fig. 9, 10). This evidence suggests that an eustatic component cannot be excluded in the control of the development of the pre-Ranzano event. At this time, geological events (biostratigraphic, sedimentological and tectonic events) are recorded in the world caused by the reorganization of lands (Pomerol & Premoli Silva 1986). However, the possible correlation between events and global sea-level changes in the context of a tectonically active region such as the northern Apennines needs further constraints (see discussion in Mutti 1990; Catanzariti et al. 1997).

On the contrary, as already said, the unconformity overlying the Ranzano unit seals a thrust system composed, in the Enza Valley, of two thrust-sheets thrusted above the footwall. This thrust system derives from a lower Oligocene (Rupelian) contractional phase showing a northeastward tectonic transport direction (Catanzariti et al. 1999). Comparing the stratigraphy of thrust-sheets to the one of the footwall (Fig. 5, 7), a rather high degree of relative allochthony of the thrust-sheets can be hypothesized. However, the occurrence of chaotic levels at the top of the Ranzano unit in the footwall and in the thrust-sheets indicates tectonic instability in the whole basin, forerunning the lower Oligocene thrust tectonics. The documented ages at the top of the footwall (basal MNP23) and in the post-stacking unconformable Temporia unit (not basal MNP23) allow the Ranzano upper unconformity to be placed within the MNP23 Zone (Rupelian).

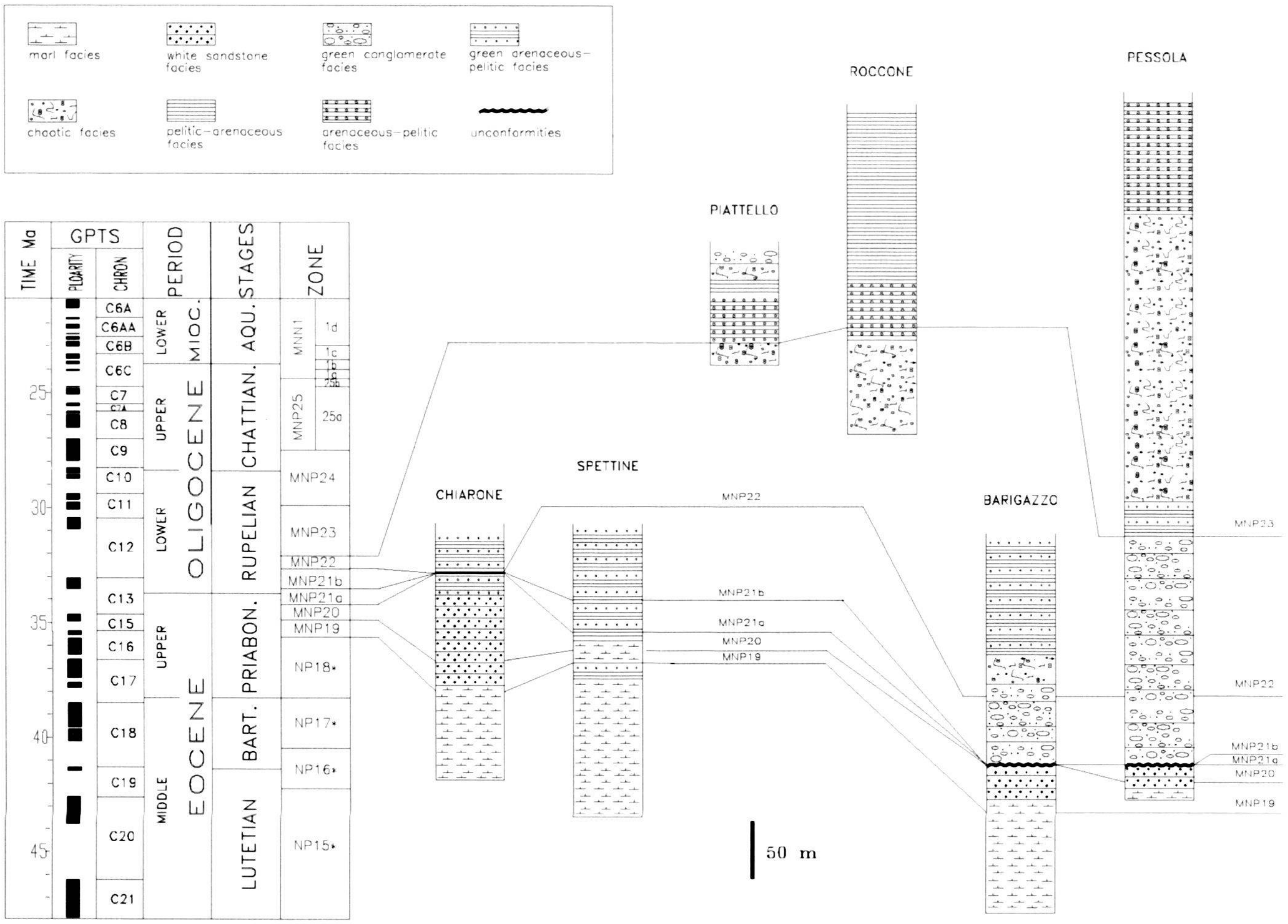

Fig. 9. Biostratigraphic correlation among selected sections in the lower epi-Ligurian Succession of the northern Apennines. For location see Fig. 1. Data after Catanzariti et al. (1997).

5. The Ranzano unit in the northern Apennines: discussion and regional correlations

In the Enza Valley, the occurrence of an unconformity sealing the Rupelian stacking allows us to separate the Ranzano unit (below) from the overlying unconformable succession characterized by mainly arenaceous-pelitic deposits (Temporia unit).

Although Rupelian thrusts in the epi-Ligurian Succession have not been documented at the regional scale, a correlation between the well known sections of the epi-Ligurian Succession (Fig. 9) and the Ranzano type area (Enza-Parma section) can be suggested (Fig. 10). In Fig. 10 it is also reported the Secchia section where the biostratigraphic data are still incomplete.

In particular the chaotic deposits occurring in the Enza Valley in the uppermost part of the Ranzano unit can be correlated with analogous deposits (Specchio Unit), which can reach hundreds of meters in thickness (Pessola section). According to Mutti et al. (1995) the chaotic deposits of the Specchio Unit represent the record of a Rupelian compressive phase (their Ligurian Phase III) in the Ranzano succession. Therefore it is possible to place regionally the unconformity bounding the top of the Ranzano unit above the Specchio chaotic level. This is unconformably topped by conglomerate and sandstone turbidites (Roccone Unit; Mutti et al. 1995) and consequently the Temporia unit of the Enza-Parma sector may correspond to the Roccone Unit (Tab. 1).

In the Pessola section (Fig. 9) the biostratigraphy confirms that the upper boundary of the Ranzano unit falls within the MNP23, being possible that the first occurrence of *H. recta* is in the arenaceous-pelitic deposits below the chaotic deposits of Specchio (compare Catanzariti et al. 1997).

In the Piattello and Roccone sections, the upper boundary of Ranzano unit can be placed between the chaotic deposits and the overlying sandstone facies respectively representing the chaotic facies of the Ranzano unit and the basal part of the Temporia unit of the Enza-Parma sector (Fig. 10).

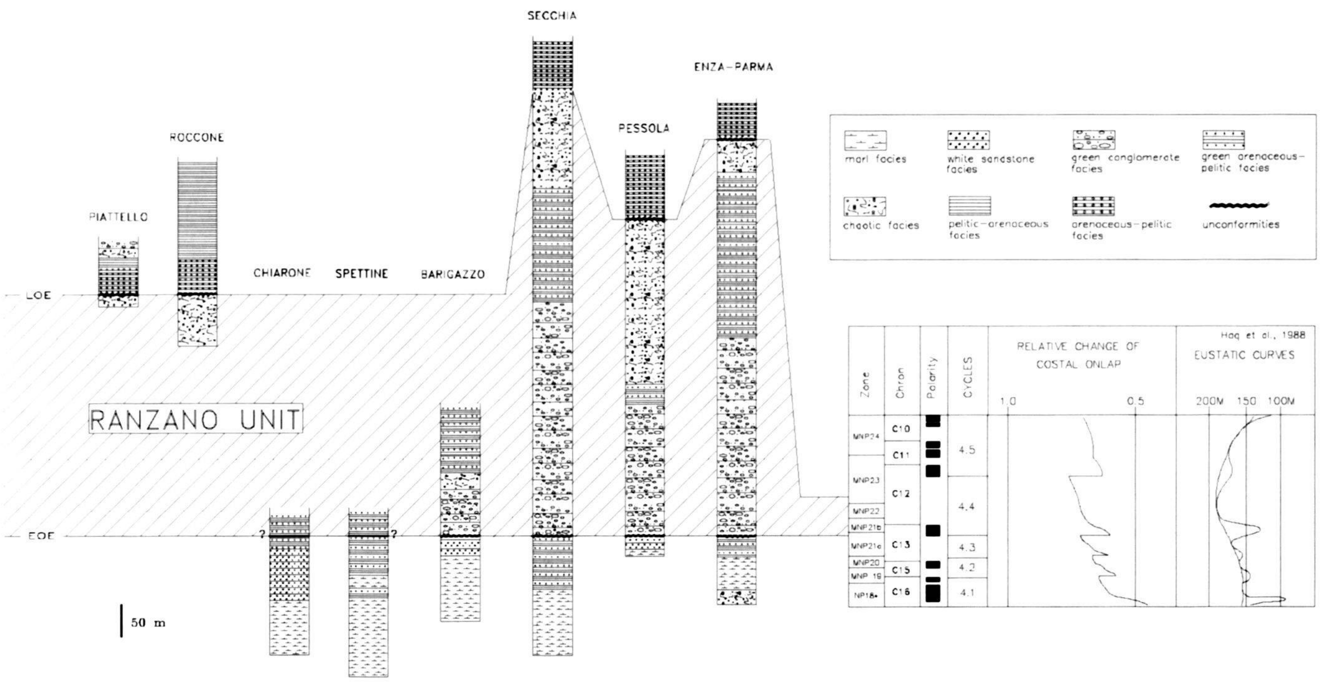

Fig. 10. Biostratigraphic correlation between the Ranzano unit in the selected sections of Fig. 9 and the Ranzano type area (Enza-Parma section) and comparison with the third order sequences of Haq et al. (1988). LOE: Lower Oligocene event; EOE: Eocene-Oligocene boundary event.

The base of the Ranzano unit as we propose, corresponds to a major unconformity associated with a facies change at the Eocene-Oligocene boundary, and can be easily recognized in the sections where the green conglomerates are well developed (Fig. 10). In the Barigazzo and Pessola sections the pre-Ranzano erosional event corresponds to an important biostratigraphic hiatus and it is possible that it might have occurred within the MNP21a as in the Enza-Parma sector. The biostratigraphic data of the Secchia section indicate that the pre-Ranzano erosional event might have occurred within the MNP21a Zone (Cerrina Feroni et al. in press).

The location of the lower boundary of the Ranzano unit is more problematic where the succession is made up of arenaceous-pelitic deposits and no discontinuity has been detected (Chiarone and Spettine sections; Fig. 9). However, in these sections, on the basis of the available biostratigraphic data (Catanzariti et al. 1997), the Eocene-Oligocene boundary corresponds to a biostratigraphic hiatus which may record the pre-Ranzano erosional event. In the Chiarone section the hiatus ranges from Zone MNP21a to the MNP21b occurring in the green arenaceous-pelitic turbidites. In the Spettine section, a very narrow biostratigraphic hiatus could be tentatively located within Zone MNP21a. In fact, although the detailed sampling, the biostratigraphic data (Catanzariti et al. 1997) do not document the *Lanternithus minutus* acme event. This event has been documented in the lower part of Zone MNP21 (Fig. 6) in the Umbria-Marche Apennines (Monechi 1986; Coccioni et al. 1988).

The pre-Ranzano erosional event has been utilized by Mutti et al. (1995) for defining the base of the Pessola Unit. On the contrary, for Martelli et al. (1998) this regional discontinuity does not correspond to a boundary (Tav. 1); these authors define the base of their Val Pessola member coinciding with the onset of the ophiolitic sedimentary input in the epi-Ligurian Succession which occurs below the Ranzano basal unconformity within the Zermagnone unit. The variation of the arenite composition by itself seems a lower rank criterion with respect of the occurrence of regional unconformity surfaces for subdividing the stratigraphic units (see also discussion in Mutti et al. 1995).

In the Enza-Parma sector (Zermagnone and TS1 sections) and in the reference section of Monte Piano (Taro Valley; Vescovi & Rio 1981), the Zermagnone unit shows a conformable stratigraphic contact with the underlying Monte Piano Marl.

According to our interpretation, in the Enza Valley type area, the first turbiditic sandstones overlying the Monte Piano Marl occur below a major regional unconformity, and therefore must be removed from the bounds of the Ranzano unit.

At a more regional scale, the sandstones which represent the onset of the turbiditic sedimentation in the epi-Ligurian Succession unconformably overlie the pelitic deposits of the

Tab. 1. Comparison of the Ranzano unit suggested in the present paper with the subdivisions of the Ranzano Sandstone proposed by Mutti et al. (1995) and Martelli et al. (1998).

Present work	Mutti et al. 1995		Martelli et al. 1998	
Temporia unit	Ranzano Sandstone	Roccone Unit	Varano de' Melegari Member	Albergana Member
Ranzano unit		Specchio Unit		
		Val Pessola Unit	Val Pessola Member	
Zermagnone unit		Val Chiarone Unit		
		Pizzo d'Oca Unit	Pizzo d'Oca Member	
Monte Piano Marl				

Monte Piano Marl and therefore belong to an unconformity-bounded unit (Pizzo d'Oca Unit; Mutti et al. 1995). The boundary between the Monte Piano Marl and the overlying turbiditic sandstones seems to pass from a lithostratigraphic boundary (Zermagnone unit of the Enza Valley) to an unconformity surface (Pizzo d'Oca Unit), moving toward the marginal sector of the upper Eocene epi-Ligurian basin. However, also the Pizzo d'Oca Unit should be separated from the Ranzano unit; starting from the stratigraphy exposed in the Enza Valley type area, the regional unconformity bounding at the base the green conglomerate facies appears the better lower boundary for the Ranzano unit. The type area of the Zermagnone unit does not coincide to the Ranzano unit type area; it can be placed in the basin sector where the corresponding deposits of the Pizzo d'Oca Unit unconformably overlie the Monte Piano Marl.

The discussed depositional setting indicates that, between the upper Eocene and the lower Oligocene, the epi-Ligurian basin was characterized by a remarkable time-space mobility.

Outside the outcrop areas of the epi-Ligurian Succession, the record of an event referable to the pre-Ranzano erosional event is well expressed in the succession of the eastern sector of the Tertiary Piedmont Basin. In particular this event can be connected to the Rupelian transgression (Mutti et al. 1995) which is documented by the sedimentation of the Val Borbera Conglomerate (e.g. Gnaccolini 1974, 1988; Gelati & Gnaccolini 1978; cf. Molare-Borbera; Mutti et al. 1995). These Rupelian deposits, consisting of an up to 2500 m thick succession of continental to marine conglomerates, unconformably lie on the Antola Helminthoid Flysch, and on the upper Eocene succession of the Tertiary Piedmont Basin (Monte Piano Marl, Pizzo d'Oca Unit). The compositional trend of the Val Borbera Conglomerate documents the progressive process of exhumation of a structural building, which ends with the erosion of rocks showing HP/LT metamorphism (Di Biase & Pandolfi 1999).

The possible correlation of the erosional event and transgressive deposits (Ranzano unit conglomerates and Val Borbera Conglomerate) suggests that the epi-Ligurian basin and the Tertiary Piedmont Basin were part of a single large basin

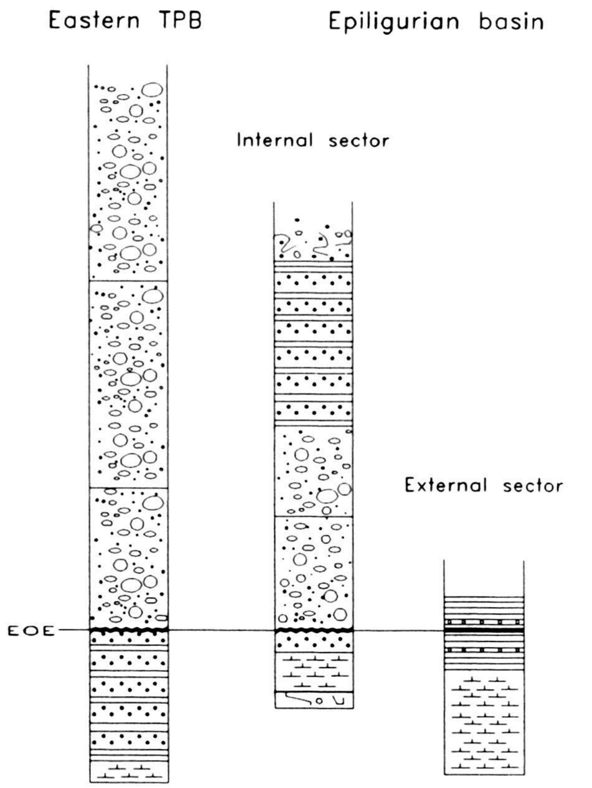

Fig. 11. Stratigraphic correlation between the eastern sector of the Tertiary Piedmont Basin and the two sector of the epi-Ligurian Succession basin respectively characterized by proximal and distal facies. EOE: Eocene-Oligocene boundary event (pre-Ranzano erosional event).

(Tertiary epi-Mesoalpine Basin; Mutti et al. 1995), where the external sector was characterized by the epi-Ligurian Succession (Fig. 11). In this context, although the original relations among the outcrop areas are completely obliterated by subsequent subaereal erosion, the epi-Ligurian basin may be tentatively subdivided in two further longitudinal sectors (internal and external). The Ranzano unit is mainly characterized by paleocurrent directions outlining a transverse turbiditic supply (Mutti et al. 1965, 1995). Therefore the internal sector, closer to the eastern Tertiary Piedmont Basin, is represented by the sections where the relatively proximal conglomerates of the Ranzano unit occur (Barigazzo, Pessola, Enza, Secchia sections). The external sector is instead characterized by sections (Chiarone and Spettine sections) where the Ranzano unit is completely represented by more distal arenaceous-pelitic turbidites and the pre-Ranzano event seems to correspond to a paraconformity surface.

Also the Albergana section outcropping in the Bologna Apennine can be referred to the external sector of the epi-Ligurian basin. In fact, the Ranzano unit of the Albergana section is entirely characterized by Rupelian pelitic deposits with rare, thin, intercalations of sandstones (Bettelli et al. 1991; Martelli et al. 1998). Within these deposits no unconformity has been documented; however the stratigraphic record of the pre-Ranzano event may be represented by the wide-ranging hiatus, corresponding to the Bartonian-Priabonian (up to the MNP21a) (Martelli et al. 1998; Catanzariti unpublished data).

6. Concluding remarks

The results of our study indicate that the Ranzano unit of the epi-Ligurian Succession corresponds to a Rupelian unconformity-bounded stratigraphic, whose limits are also defined by lithostratigraphic units. Even if we do not propose any formal definition, the coincidence of lithostratigraphic boundaries with regional unconformities, such as discussed for the Ranzano unit, is in complete agreement with the indications of the International Stratigraphic Guide (Salvador 1994), which suggests that the union of adjacent strata separated by regional unconformities into a single lithostratigraphic unit should preferably be avoided.

While the unconformity which represents the upper boundary of the Ranzano unit in the type area overlies the Rupelian stacking, the regional angular unconformity which characterizes the basal boundary does not overlie a thrust system. The tectono-sedimentary evolution causing the erosional event at the Eocene-Oligocene transition and the overlying Ranzano succession seems instead to represent the progressive uplift, exhumation and erosion of the thrust belt developed during the Ligurian Phase.

The stratigraphic events documented in the Ranzano unit type area can be recognized in the epi-Ligurian Succession cropping out in other sectors of the northern Apennines. In particular, the pre-Ranzano erosional event (Eocene-Oligocene boundary event) can be also correlated with the angular unconformity which characterizes the base of the Val Borbera Conglomerate of the eastern Tertiary Piedmont Basin. Therefore the epi-Ligurian Succession and the Tertiary Piedmont Basin succession can be referred to the same depositional basin where the more external sectors are possibly represented by the conglomerate-free Ranzano succession.

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