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THE STRATIGRAPHIC RECORD OF OLIGOCENE-EARLY MIOCENE EVENTS AT THE SOUTH-WESTERN END OF THE PIEDMONT TERTIARY BASIN

ROMANO GELATI & MARIO GNACCOLINI
with contributions by ANDREA MAIOLI

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Riassunto. Nel Monregalese, all'estremità sud-occidentale del Bacino Terziario Ligure-Piemontese (BTLP), la successione dall'Oligocene al Miocene basale presenta caratteri peculiari, notevolmente diversi rispetto a quelli mostrati dalle successioni coeve affioranti nella zona depocentrale del BTLP (Langhe). Nel Monregalese, infatti, si possono osservare, nella parte superiore dell'Oligocene, depositi di piattaforma terrigena o addirittura continentali, ben differenti dai corrispondenti sedimenti emipelagici che caratterizzano l'area delle Langhe. La successione del Monregalese appare inoltre interrotta da importanti superfici di discontinuità, ben osservabili sul terreno, correlabili ad alcuni dei limiti di sequenza evidenziati nella zona depocentrale del BTLP.

Abstract. The Oligocene-Early Miocene succession of the Monregalese area, at the south-western end of the Piedmont Tertiary Basin, is very different in comparison with the coeval succession cropping out in the depocentre of the PTB (Langhe region). The Late Oligocene is locally recorded in the Monregalese by shallow marine siliciclastic deposits: at the same time, hemipelagic mudstones and turbidites deposited in an open sea environment in the Langhe area. The Monregalese succession is interrupted by important discontinuity surfaces, which are correlative with some of the sequence boundaries individuated in the depocentre of the Piedmont Tertiary Basin.

Introduction.

The Piedmont Tertiary Basin (PTB) is an episutural basin which is bounded on the west and on the south by the Western Alps, and on the north by the Basso Monferrato and Collina di Torino regions. The study area, the local name of which is Monregalese, belongs to the westernmost sector of PTB (Fig. 1).

There are only a few recent geologic studies concerning the geologic evolution of the Monregalese (Casnedi, 1971; Lorenz, 1986), because of both the widespread, thick vegetation cover and the peripheral location of this area with respect to the Langhe region, where the Cenozoic succession is very thick and well exposed (Vervloet, 1966; Lorenz, 1969; Gelati et al., 1993; Gnaccolini & Rossi, 1995).

The Monregalese, however, seems to be a key-zone to understand the PTB geologic features. In fact, in this area it is possible to observe shallow marine and continental units that are correlative of the hemipelagic and turbitic succession of the depocentral Langhe region. Furthermore, the thin sedimentary succession of the Monregalese appears to be interrupted by several erosional surfaces, which identify the near-shore continuation of some sequence boundaries recognized in the open marine Langhe deposits.

Stratigraphy

The studied area can be divided into the following three sectors (Fig. 2, 3), characterized by different coeval sedimentary succession:

- the Southern Sector, which develops south of S. Paolo;
- the Western Sector, which develops west of S. Michele di Mondovì;
- the Northern Sector, which extends from S. Michele di Mondovì to the Mongia valley.

The Southern Sector.

In this area, the pre-Cenozoic basement (Dallagiovanna, 1995) is overlain by the following, generally unconformity bounded, stratigraphic units (from the bottom to the top):

Unit S-1. It consists of conglomerates and sandstones arranged in 2-20 m-thick, fining upwards cycles. The conglomerates, which locally exhibit erosional base, are commonly reddish and massive, although in some place a rough horizontal bedding can be observed. Maximum grain size varies from 15 to 80 cm. Sorting and rounding

- Dipartimento di Scienze della Terra dell'Università degli Studi di Milano, via Mangiagalli 34, 20133 Milano, Italy.

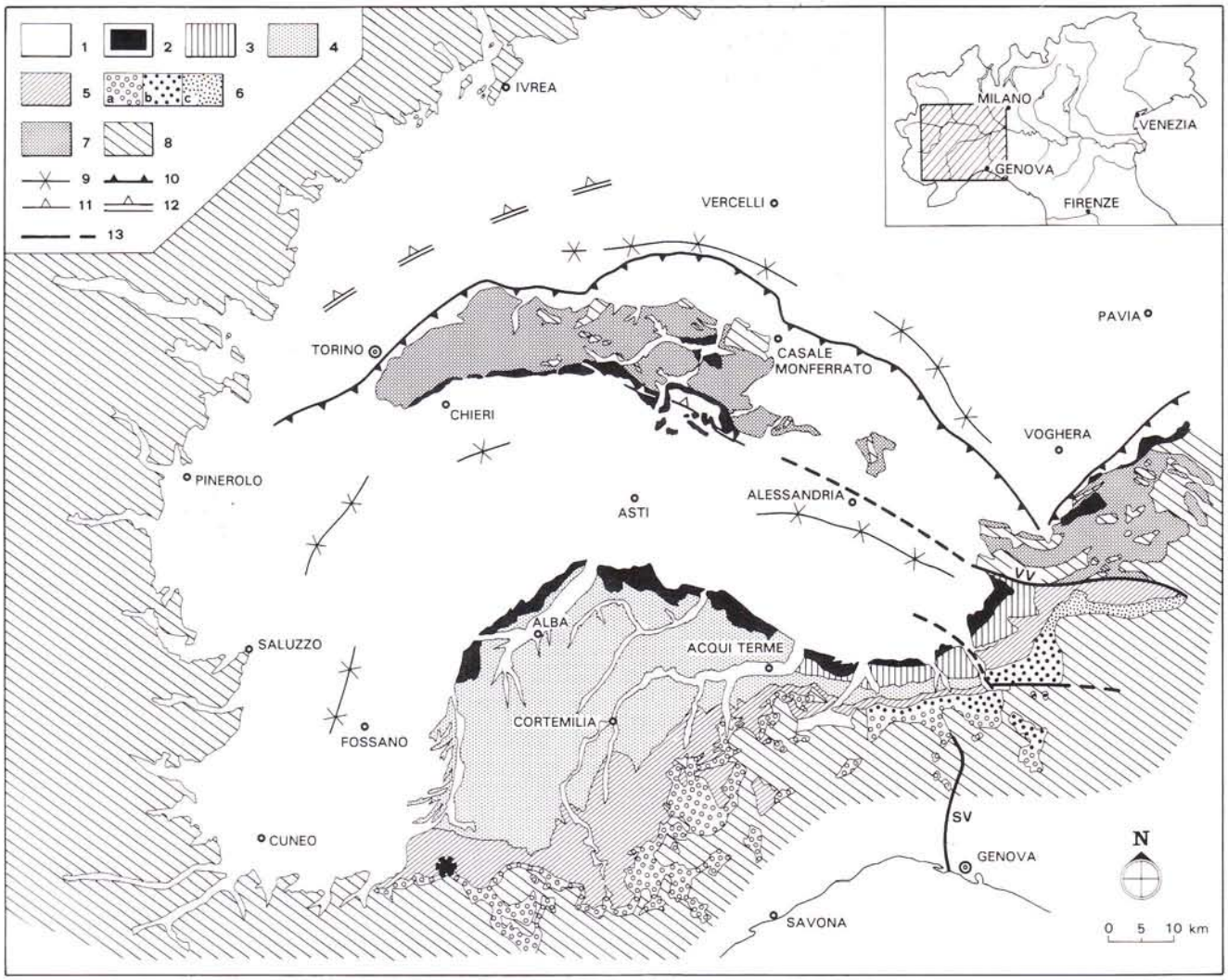

Fig. 1 - The asterisk shows the location of the studied area, at the south-western end of the Piedmont Tertiary Basin. 1) Pliocene to Recent deposits. 2) Messinian deposits. 3) Langhian to Tortonian shelf to slope deposits. 4) Late Burdigalian to Tortonian mainly turbiditic succession; only Burdigalian in the eastern part of the figure. 5) Late Oligocene to Burdigalian turbidite systems and hemipelagic mudstones. 6) Late Eocene to Early Oligocene deposits: a) alluvial to coastal conglomerates, shallow marine sandstones and hemipelagic mudstones; b) slope and base-of-slope, resedimented conglomerates; c) mainly turbidites. 7) Late Eocene to Tortonian siliciclastic deposits of the NW Apennines-Basso Monferrato-Collina di Torino wedge. 8) Alpine and Apenninic allochthonous units. 9) Depocentre axis of the Plio-Quaternary basins. 10) Buried thrust-front of the Collina di Torino-Basso Monferrato-NW Apennines wedge. 11) Buried, south-vergent backthrusts of the Basso Monferrato, active from Messinian onward. 12) Buried, pre-Burdigalian backthrusts of the Western Alps. 13) Tectonic lines: SV Sestri-Voltaggio, VV Villalvernia-Varzi.

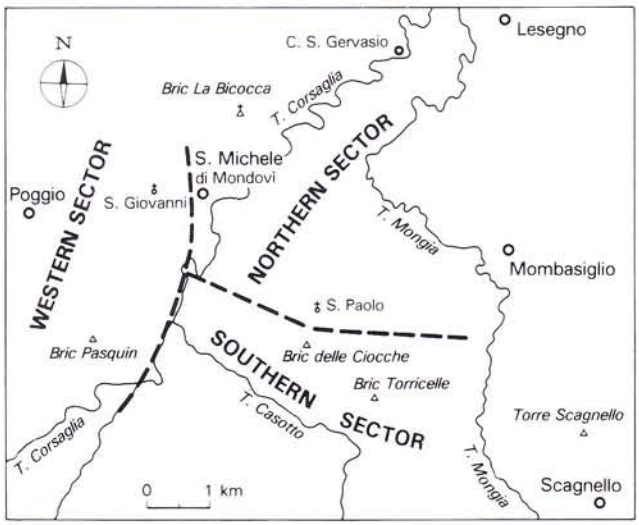

Fig. 2 - The studied area and the envisaged sectors.

are poor to very poor. The main components (5 localities; 100 pebbles/cobbles counted in each locality) are limestones (24-80%), dolostones (12-66%), quartzites (1-16%) and metabasites (0-18%) (Fig. 4).

The reddish sandstone beds (up to 1 m thick), which are often characterized by a fining upwards trend, identify the upper part of the conglomerate-sandstone cycles.

The whole succession reaches a maximum thickness of about 400 m near Scagnello (Fig. 2), and quickly thins westwards, where it shows a thickness of a few tens of metres (Bric Torricelle, T. Corsaglia).

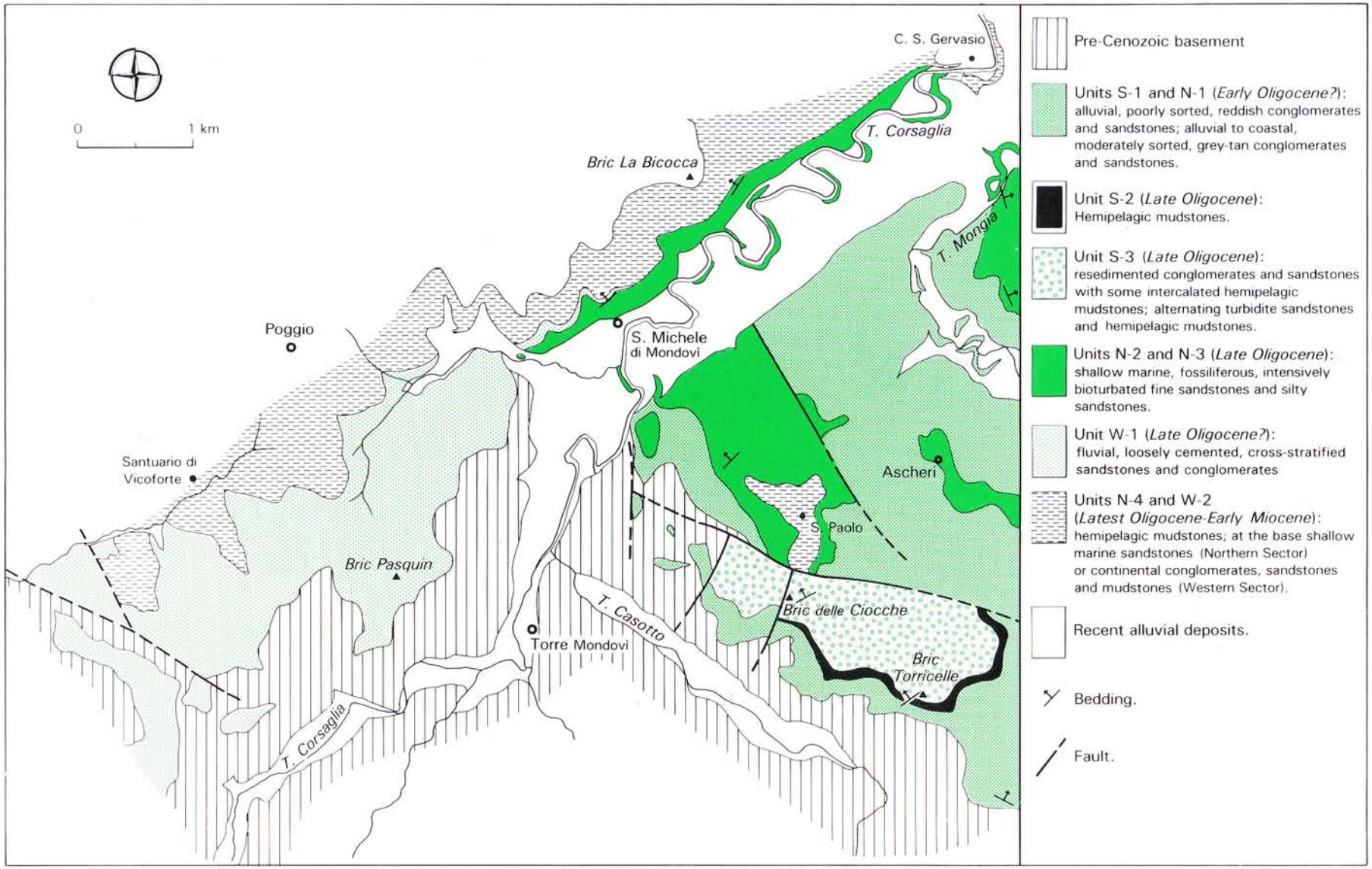

Fig. 3 - Geologic map of the studied area.

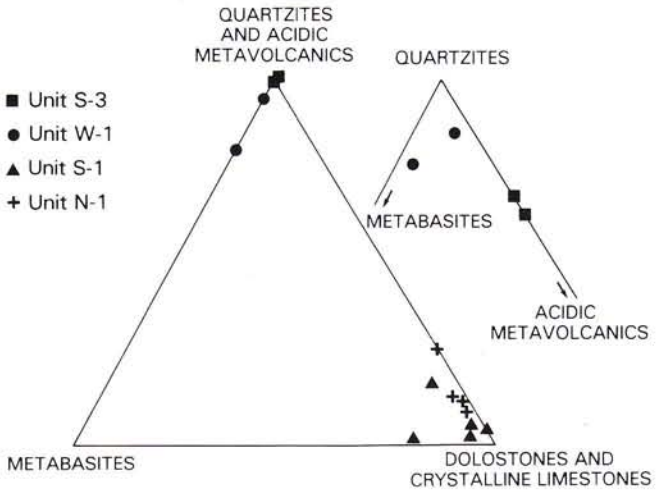

Fig. 4 - Composition of the Monregalese conglomerates (13 localities; 100 pebbles/cobbles counted in each locality). On the left, conglomerates belonging to the Western (Unit W-1), Southern (Units S-1 and S-3) and Northern (Unit N-1) Sectors are considered. On the right, the difference in composition between S-3 and W-1 conglomerates is shown.

On the basis of its stratigraphic position, Unit S-1 can be considered correlative of the well-known Oligocene (probably Early Oligocene) Molare Fm., which crops out east of the studied area, in the Langhe region (cfr. Servizio Geologico d'Italia, 1970, Foglio 81 Ceva, Carta Geologica d'Italia 1:100000).

The lithofacies association of Unit S-1 (Fig. 5), is characteristic of an alluvial fan depositional system, the proximal part of which crops out near Bagnasco, southeast of the studied area ("Bassin continental de Bagnasco", Lorenz, 1969).

Unit S-2. This unit lies unconformably on S-1 and consists of about 20 m of light grey mudstones with some very thin sandstone interbeds. These deposits were attributed by Casnedi (1971) to his "Formazione di S. Paolo, facies della zona orientale" and by Lorenz (1986) to his "conglomérats, grés, sables puis marnes: Aquitanien et Miocène inférieur".

The grey mudstones contain both planktonic and benthic foraminifers. The faunal assemblage is characterized by *Paragloborotalia opima nana, P. pseudokugleri, Globigerina officinalis, G.ouachitaensis, G. praebulloides, G. venezuelana, Globorotaloides suteri, Globoquadrina praedehiscens, G. tripartita, Dentoglobigerina altispira globosa.* This micropaleontological association allows to ascribe Unit S-2 to the Late Oligocene P22 zone (*sensu* Blow, 1969).

Faunal content and lithologic characteristics of Unit S-2 are indicative of an off-shore depositional setting.

Unit S-3. This unit begins with a 30 m thick, coarsening upward succession of mudstones, sandstones and conglomerates. Sandstones and conglomerates predominate. The sandstone beds, up to 60-70 cm-thick, locally show a normal grading and an erosional base. The conglomerates are generally massive, contain blocks up to more than 1 m in size. The clasts commonly consist of quartzites and acidic metavolcanites (Fig. 4), with rare ophiolites and dolostones.

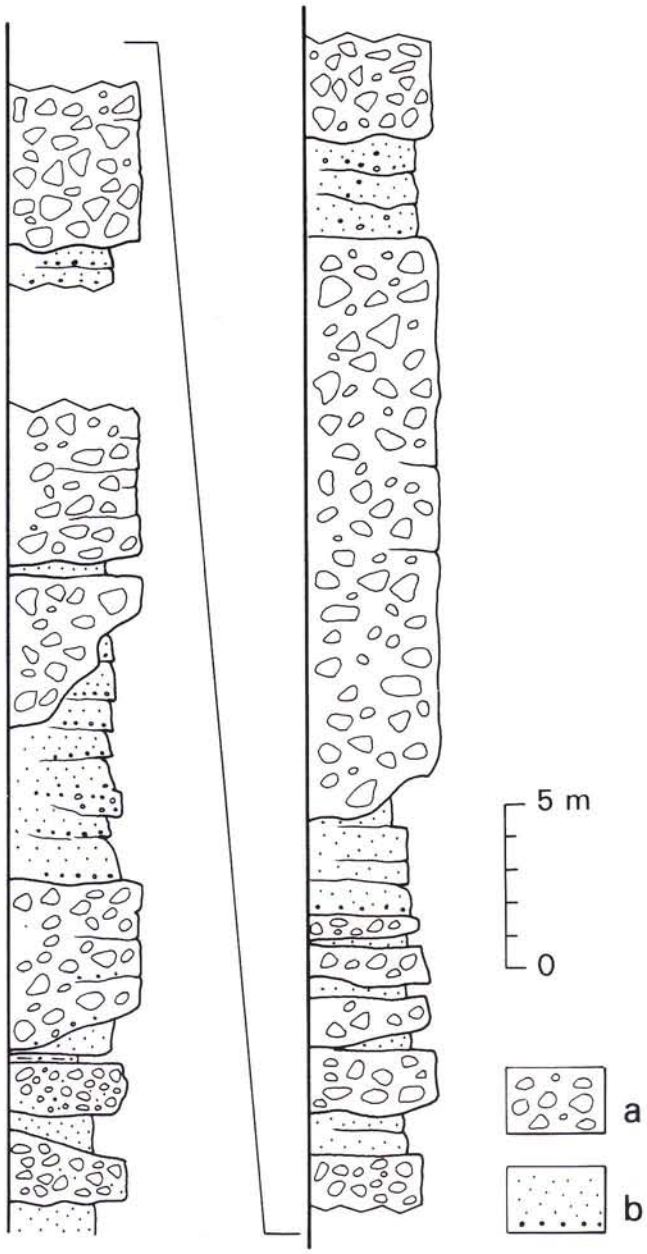

Fig. 5 - Southern Sector, T. Mongia valley, road to Scagnello. Unit S-1: a) poorly sorted, massive conglomerates; b) sandstones and gravelly sandstones.

These deposits are overlain by a 25 m thick, coarsening upward cycle consisting of alternating mudstones and sandstones. The mudstones yield the following foraminiferal assemblage: *Globoquadrina binaiensis, G. tripartita, G. praedehiscens, Dentoglobigerina galavisi, D. baroemoenensis, Paragloborotalia pseudocontinuosa, P. semivera, P. pseudokugleri, Globigerinoides primordius, Catapsydrax unicavus, C. dissimilis, Globigerina venezuela-*

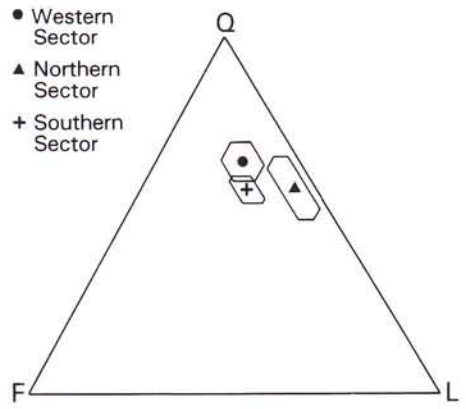

Fig. 6 - The Monregalese sandstones. QFL diagrams: mean values and strandard deviation polygons are indicated. Western Sector: Unit W-1 (9 samples); Northern Sector: Units N-2 and N-3 (9 samples); Southern Sector: Unit S-3 (5 samples).

na. On the basis of this assemblage, the attribution to the P22 zone (Late Oligocene) is suggested.

The sandstone beds, up to 70 cm thick, commonly exhibit a normal grading, locally followed by a horizontally- or cross-laminated division. Current ripple laminations and poorly developed flute casts, which have been observed in two sandstone beds, suggest that the direction of paleocurrents was from NNW.

The deposits belonging to the Unit S-3 were attributed by Casnedi (1971) to his "Formazione di S. Paolo, facies della zona orientale" and by Lorenz (1986) to his "conglomérats, grès, sables puis marnes: Aquitanien et Miocène inférieur".

The sandstones of Unit S-3 are characterized by the following QFL mean composition (5 samples; 250 grains counted): Q = 57.3% (standard deviation 3.7), F = 16.8% (s.d. 2.8), L = 25.7% (s.d. 5.6) (Fig. 6).

The sandstones belonging to the upper part of the unit contain a large quantity of bioclasts. Casnedi & Mosna (1970) report *Operculina* sp., *Cycloclypeus* sp., *Nephrolepidina tourneri*, *Miogypsina* sp., *Miogypsinoides* sp., *Amphistegina* sp. and Discorbidae in a sandstone bed at the top of Unit S-3. Furthermore, rare serpentinite fragments, which are completely lacking in the lower part of the unit, characterize these upper sandstones.

On the basis of the observed facies association, an open-sea depositional environment is inferred for Unit S-3. Turbidity currents and debris flows acted as major sedimentary processes.

The Western Sector.

In this area, the following stratigraphic units, which unconformably overlie the pre-Cenozoic basement, have been identified (from the bottom to the top):

Unit W-1. This unit is well exposed in a quarry located on the northern slope of Bric Pasquin (Fig. 2),

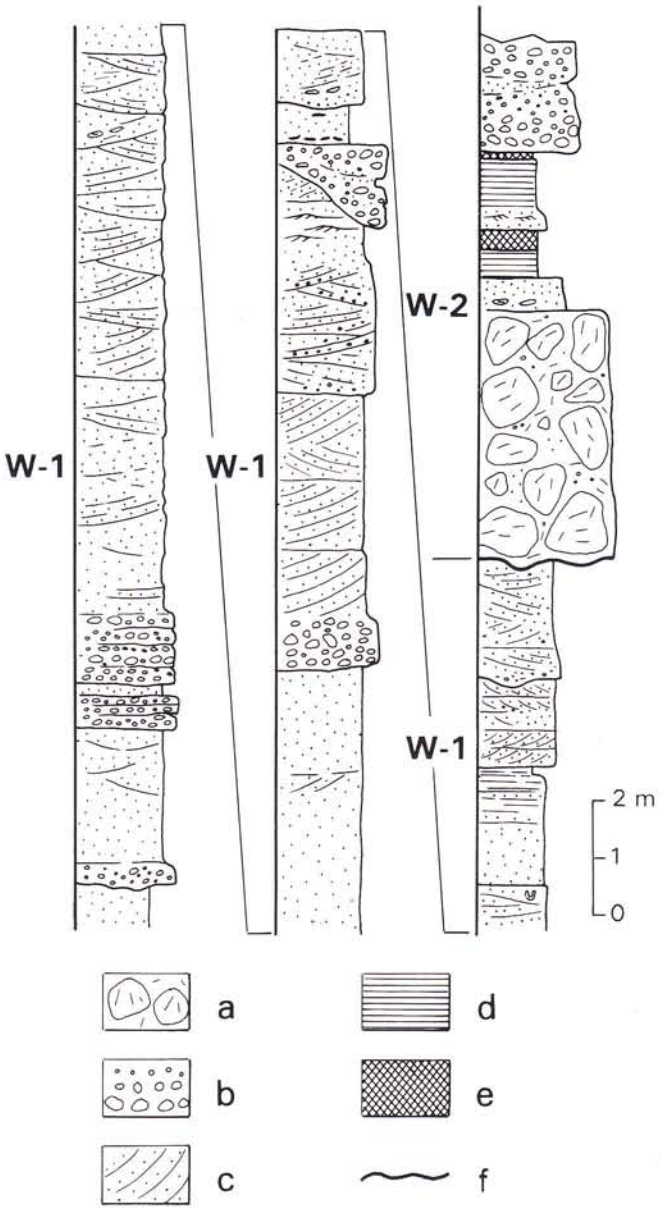

Fig. 7 - Western Sector, northern side of Bric Pasquin. Units W-1 and W-2: a) conglomerate with mudstone boulders; b) massive to horizontally-bedded conglomerates; c) cross-stratified sandstones and gravelly sandstones; d) even-laminated mudstones; e) paleosoils; f) sequence boundary.

where it shows a thickness of about 40 m (Fig. 7). Unit W-1 consists of loosely cemented sandstones and gravelly sandstones, commonly characterized by a well-developed through or tabular cross-bedding. Horizontally bedded or massive conglomerates, which commonly exhibit erosional base, are locally alternating with the sandstones. Some 1 to 4 m thick, fining upward cycles consisting of a basal conglomerate overlain by sandstones and capped by a thin layer of mud rich in plant remains have been observed in the upper part of this unit.

These deposits, according to Casnedi (1971), belong to his "Formazione di S. Paolo, facies della zona occidentale".

Fig. 8 - Mudstone boulders at the base of Unit W-2 (Western Sector), in the quarry located on the northern slope of Bric Pasquin.

The conglomerates mainly consist of well rounded quartzites, with some metabasites and acidic metavolcanites (Fig. 4). The sandstones are characterized by the following QFL mean composition (9 samples; 250 grains counted): Q = 64.8% (standard deviation 7.6), F = 14.2% (s.d. 5.2), L = 20.7% (s.d. 5.6) (Fig. 6).

In the lower part of the unit, sandstones lack serpentinite fragments, whereas in the upper part up to 5% of the total detrital framework of the sandstones locally consists of serpentinite.

The lithofacies association of Unit W-1 is consistent with a braided stream depositional system. Paleocurrent directions are highly variable. The cross-bedding suggests that the directions of the paleocurrents were from SE, W and also from NW. Pebble imbrication in a conglomerate layer is indicative of a provenance from SE.

Unit W-2. This unit lies unconformably on Unit W-1. Because of vegetation, the discontinuity surface can be observed only in the quarry located on the northern slope of Bric Pasquin (Fig. 2).

Unit W-2 (Fig. 7) begins with a massive, clast-supported conglomerate, up to 4 m thick, containing subrounded mudstone boulders up to 1 m in size (Fig. 8). The presence of *Paragloborotalia semivera* and *Paragloborotalia* sp. in these boulders could suggest that their origin is by erosion of open sea Late Oligocene mudstones, similar to those which outcrop in the Southern sector.

The basal conglomerate is overlain by a few metres of alternating conglomerates, sandstones and mudstones, locally arranged in fining upward cycles. The mudstones exhibit a gentle horizontal lamination and are capped by brown or yellow clay paleosoils, from 10 to 30 cm thick.

All these deposits abruptly pass upwards to a thick mudstone succession which contains planktonic foraminifers. The microfossil association consists of *Globoquadrina dehiscens, Paragloborotalia semivera, P. acrostoma, P. pseudocontinuosa* and *Zeaglobigerina woodi*, and allows to ascribe the mudstones to the N4 zone (Early Miocene, Aquitanian) (Iaccarino, 1985). Unit W-2 is comprehensive of the uppermost part of the "Formazione di S. Paolo" and of the lower part of the "Marna di Paroldo" (Casnedi, 1971).

The facies association which characterizes the lowermost part of Unit W-2 is indicative of a continental (alluvial to swamp) environment. The abrupt passage to the mudstones with planktonic foraminifers records the rapid drowning of the area and the establishment of an open sea depositional setting.

The Northern Sector.

In this sector the following, unconformity bounded, stratigraphic units have been identified (from the bottom to the top):

Unit N-1. This unit consists of conglomerates and sandstones, which unconformably overlie the pre-Cenozoic basement. These deposits, from a few tens of metres to about 300 m-thick, can be physically correlated with those of Unit S-1, although in the upper part of Unit N-1 the color grades to tan or light grey and the clasts are a little more sorted and rounded. The main components (4 localities; 100 pebbles/cobbles counted in each locality) are limestones (28-54%), dolostones (20-48%), quartzites (8-26%) and metabasites (0-2%) (Fig. 4).

On the basis of its stratigraphic position, Unit N-1 can be correlated with the Early (?) Oligocene Molare Fm., which outcrops eastwards of the studied area, in the Langhe region.

Unit N-1 is the probable distal, coastal part of the alluvial fan which is identified by Unit S-1 in the Southern sector.

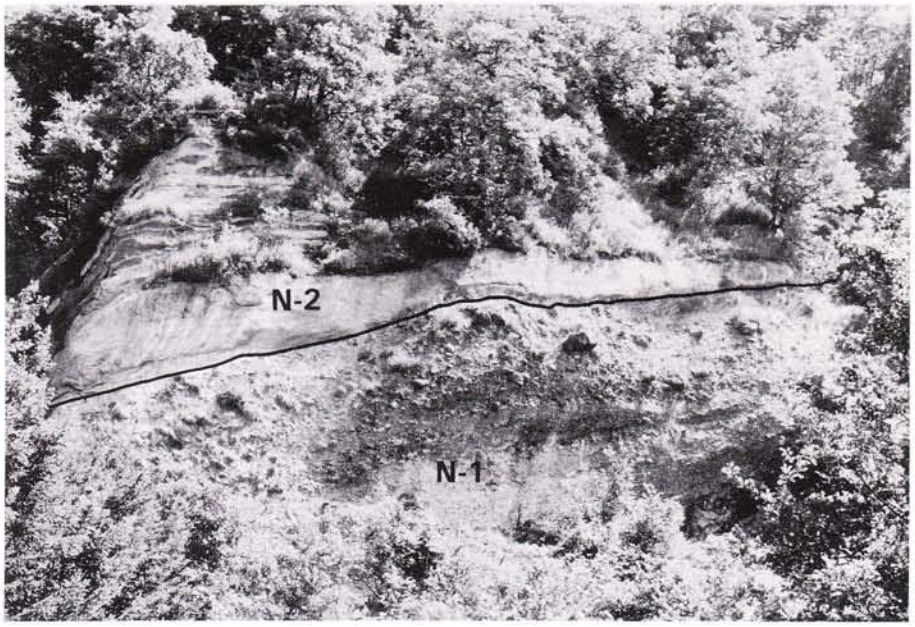

Fig. 9 - The boundary between Units N-1 and N-2 along the T. Mongia, near the Lesegno railway station.

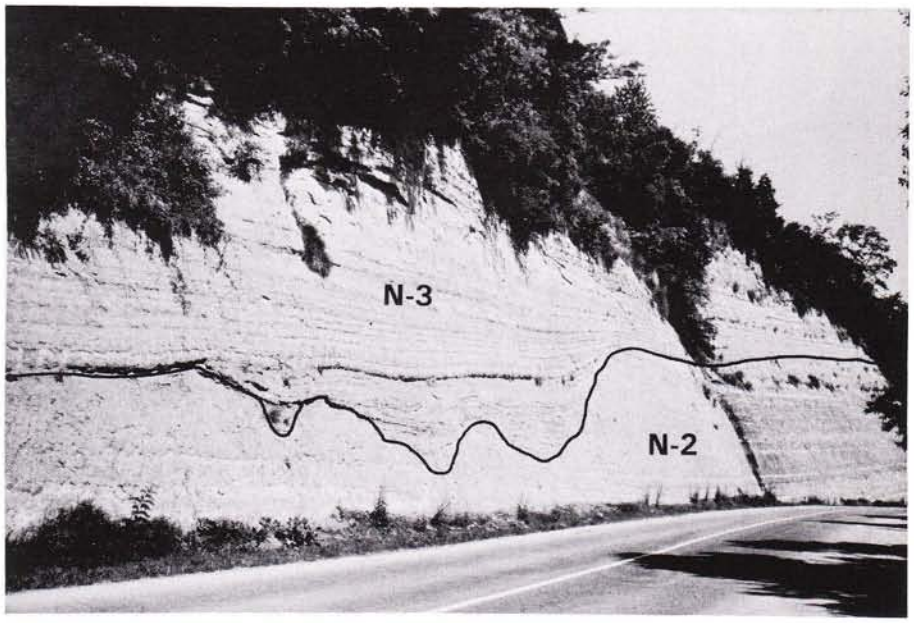

Fig. 10 - A deeply incised erosional surface separates Units N-2 and N-3 at S. Michele di Mondovì.

Unit N-2. This unit (up to about 130 m thick) lies unconformably on Unit N-1, on which it is onlapping (Fig. 9). At the top, Unit N-2 is bounded by a spectacular erosional surface, which can be observed along the road S. Michele di Mondovì-Niella Tanaro (Fig. 10).

Unit N-2 consists of intensively bioturbated fine sandstones and silty sandstones, containing macroforaminifers, corals, bryozoans, echinoids, bivalves and cuticle remains. Locally, thin sandstone beds exhibiting small scale cross-lamination are intercalated within the bioturbated sandstones. In the lower part of the unit, thin beds of coarse sandstone and some conglomerate lenses are present. These deposits, according to Casnedi (1971), belong to the Formazione di Monesiglio, which in the Langhe region shows alternating hemipelagic mudstones and turbiditic sandstone bodies.

The microfossil association of Unit N-2 is characterized by a very low plankton/benthos ratio. The occurrence, in the lower part of the unit, of *Globigerinoides primordius, Globigerina ciperoensis, G. venezuelana* and *Paragloborotalia opima nana* allows its attribution to the P22 zone (Late Oligocene). The whole unit can be ascribed to Late Oligocene, as inferred from its stratigraphic position.

The dominant facies (bioturbated fine sandstones) are indicative of a sublittoral depositional setting (Fig. 11). Storm events are identified by cross-laminated thin sandstone beds and by coarse sandstone and conglomerate intercalations.

Unit N-3. This unit, about 70 m thick, unconformably overlies Unit N-2, and its upper boundary is identified by an erosional surface (Fig. 12) locally characterized by a well-developed angular unconformity (T.

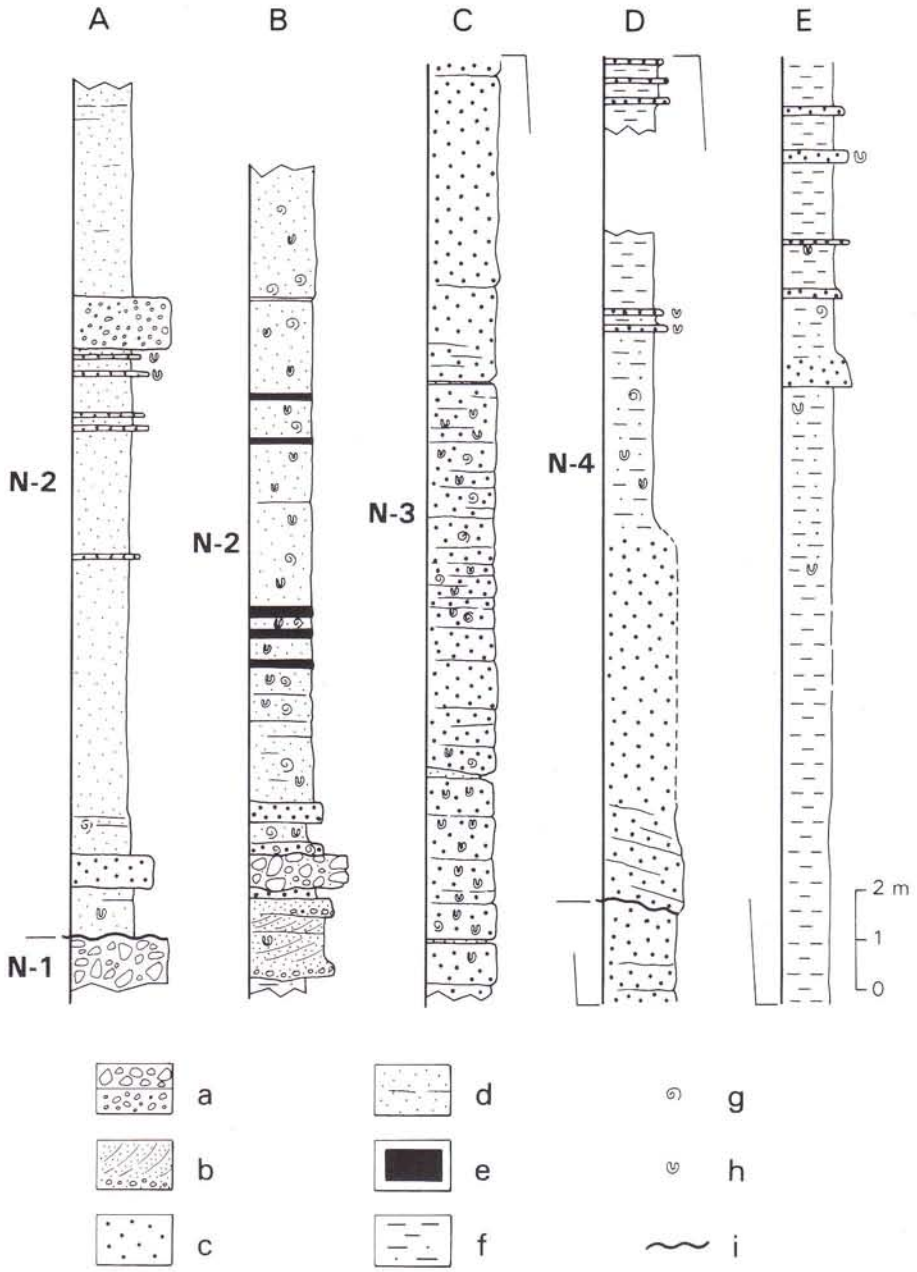

Fig. 11 - Northern Sector: T. Corsaglia south of S. Michele di Mondovì (A), S. Michele di Mondovì (B), road from S. Michele to Niella Tanaro (C,D,E). Units N-1 to N-4: a) conglomerates; b) sandstones and gravelly sandstones, locally with cross-lamination; c) medium- to coarse-grained sandstones, intensively bioturbated and fossiliferous; d) fine-grained, intensively bioturbated sandstones and silty sandstones; e) fine-grained, cross-laminated or horizontally-laminated sandstones; f) mudstones; g) fossils; h) bioturbations; i) sequence boundary.

Corsaglia, in front of C. San Gervasio; Fig. 13). The lower part of the unit consists of very fine to fine sandstones, very similar to those of Unit N-2. The upper part is composed of intensively bioturbated, medium to coarse sandstones containing bivalves, foraminifers, etc. Also these deposits were attributed by Casnedi (1971) to the Formazione di Monesiglio.

The sandstones of both Unit N-2 and N-3 are characterized by the following QFL mean composition (9 samples; 250 grains counted): Q = 57.6% (standard deviation 9.3), F = 5.2% (s.d. 3.5), L = 36.9% (s.d. 9.2) (Fig. 6). Serpentinite fragments are always present (mean on the total detrital framework 6.2%; s.d. 4.6).

The age of Unit N-3, as inferred from its stratigraphic setting, is Late Oligocene. In fact, this unit is intercalated between Unit N-2, belonging to the P22 zone, and Unit N-4, the lower part of which also belongs to the P22 zone.

The facies association is indicative of a sublittoral depositional setting, with a shallowing-upwards trend.

Unit N-4. This unit begins with bioturbated, fossiliferous coarse sandstones (maximum thickness about 10 m), which locally contain large mudstone boulders very similar to those observed at the base of Unit W-2. These deposits make gradual transition to a 70 m thick interval of fossiliferous, bioturbated mudstones, with locally intercalated sandstone beds which commonly exhibit erosional base and normal grading.

Units N-4 includes the uppermost part of the Formazione di Monesiglio and the lower part of the Marna di Paroldo (Casnedi, 1971).

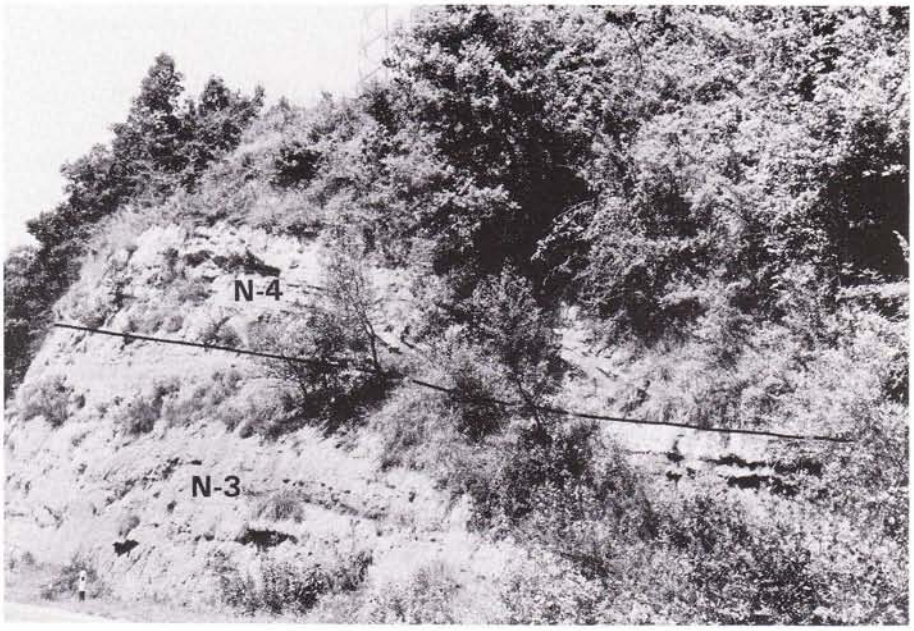

Fig. 12 - The boundary between Units N-3 and N-4 along the road S. Michele di Mondovì-Niella Tanaro.

In the lower part of the mudstone interval, the following faunal assemblage has been recovered: *Globigerinoides primordius, Paragloborotalia pseudokugleri, Globorotaloides testarugosa, Globoquadrina tripartita, G. binaiensis, Globigerina venezuelana, G. officinalis* (zone P22, Late Oligocene). Upwards, the occurrence of *Globoquadrina dehiscens* and the diversification of the genus *Globigerinoides* is indicative of the passage to the foraminiferal zone N4 (Early Miocene).

On the basis of facies association, Unit N-4 may be ascribed to a sublittoral environment, which rapidly evolved to a hemipelagic depositional setting.

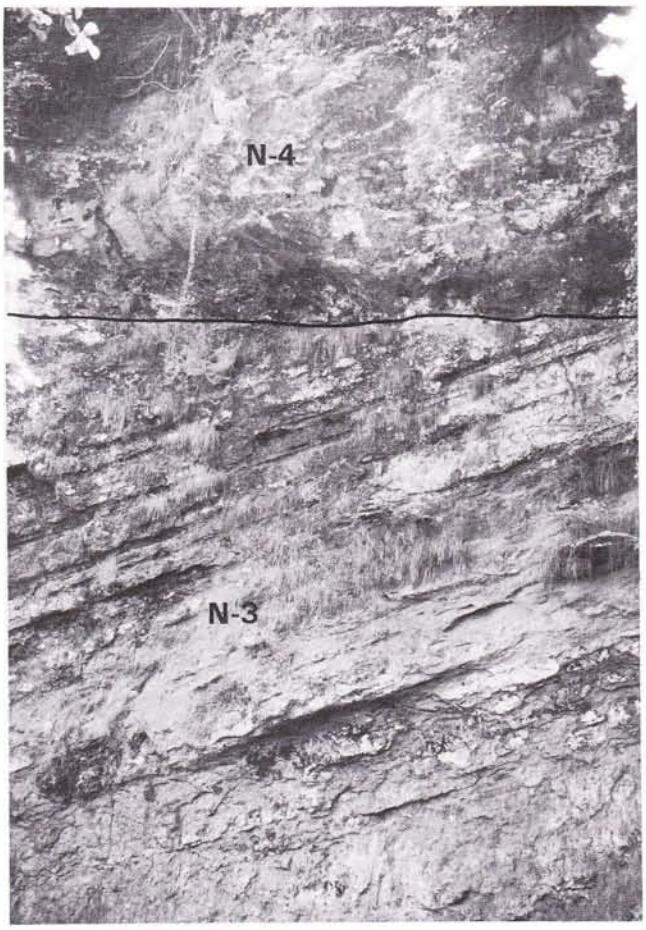

Fig. 13 - Angular unconformity at the boundary between Units N-3 and N-4 along the T. Corsaglia, in front of C. San Gervasio.

Stratigraphic correlations and depositional sequences

The correlation between the alluvial fan conglomerates which crop out at the base of the Cenozoic succession in both Southern and Northern Sectors (Units S-1 and N-1) is supported by the physical continuity of the outcrops in the field (Fig. 3, 14).

Units N-2 (shallow marine deposits) and S-2 (offshore deposits) unconformably lie on the forementioned continental deposits, respectively in the Northern (Fig. 9) and Southern Sectors. Both these units, even if with different facies, mark the beginning of the marine sedimentation in the studied area. On this ground, Units N-2 and S-2 can reasonably be considered as correlative.

The interfingering between Units W-1 and N-3 is well exposed immediately northwards of S. Michele di Mondovì. The upper boundary of both these units with, respectively, Unit W-2 and N-4 (Fig. 12, 13), is identified by a discontinuity. W-2 and N-4 begin with continental or near-shore deposits, locally containing large mudstone boulders (Fig. 8). These sediments are overlain by open sea mudstones. The lateral continuity of the mudstones supports the correlation between Units W-2 and N-4.

On the basis of stratigraphy, nature of the unit boundaries and correlations, four depositional sequen-

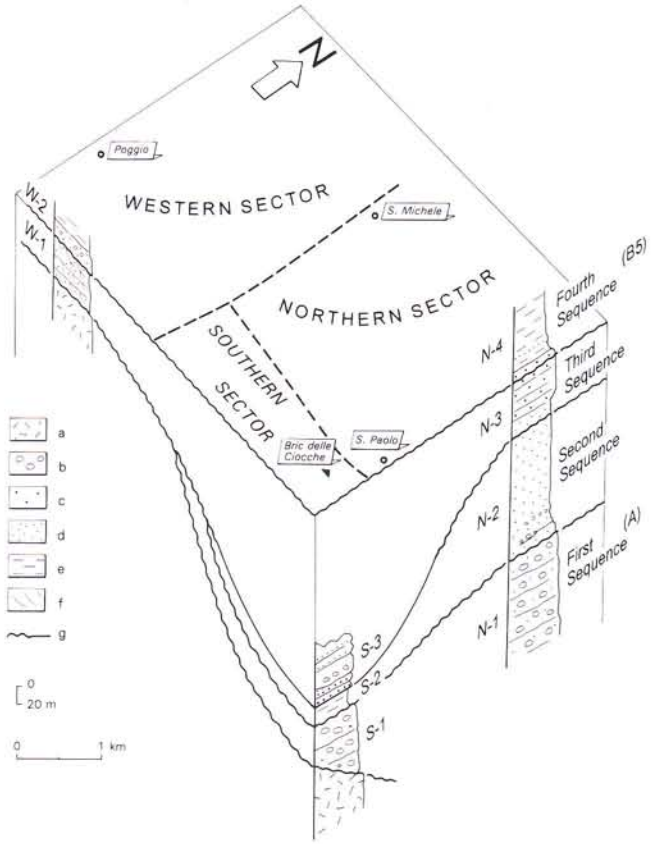

Fig. 14 - Fence-diagram of the Oligocene-Early Miocene successions in the Western, Southern and Northern Sectors of the Monregalese region. W-1, W-2, S-1 to S-3, N1 to N-4 refer to the stratigraphic units cropping out in the above quoted sectors: a) pre-Cenozoic basement; b) conglomerates and gravelly sandstones; c) medium- to coarse-grained sandstones; d) fine-grained sandstones; e) mudstones; f) cross-stratification; g) sequence boundary. The envisaged four depositional sequences are also indicated: (A) and (B5) refer to the depositional sequences individuated in the basin depocentre (Langhe region), north-east of the studied area (Gelati et al., 1993).

ces, which cover the time interval spanning from Oligocene to Early Miocene (Fig. 14), have been recognized in the study area.

The *first sequence* is identified by the continental deposits of Units N-1 and S-1, which unconformably lie on the pre-Cenozoic basement. Its upper boundary corresponds to the unconformity above which the first marine deposits onlap.

Units N-2 and S-2 belong to the *second sequence*. In the Northern Sector this sequence is bounded at the top by a deeply incised erosional surface, whereas in the Southern Sector it is bounded by a correlative surface, which marks the onset of turbiditic sedimentation.

The *third sequence* consists of the turbidite succession of Unit S-3 and by Units W-1 and N-3, respectively composed of continental and sublittoral deposits. The third sequence is separated from the overlying *fourth sequence*, formed by Units W-2 and N-4, by a discontinuity which locally exhibits a well-developed angular unconformity.

The four sequences recognized can be correlated with some of the sequences which have been distinguished in the depocentre of the PTB (Gelati et al., 1993), where the coeval deposits are represented by a thick succession of turbidites and hemipelagic mudstones. In particular, the fourth sequence seems to be correlative of the Langhe sequence B5 (both of them begin at the top of the foraminiferal zone P22), while the first sequence, owing to its stratigraphic setting, could be considered as correlative of the Group A sequences outcropping in the Langhe area. The second and third sequences, both belonging to the P22 zone, could be tentatively correlated with the Langhe sequences B2, B3 or B4.

Oligocene-Early Miocene geologic evolution of the "Monregalese"

The Oligocene to Early Miocene geologic evolution of the Monregalese, i.e. at the southwestern termination of the PTB, has been reconstructed as follows (Fig. 14):

- During the Early (?) Oligocene an alluvial fan depositional system developed in the Southern and Northern Sectors, whereas in the Western Sector pre-Cenozoic basement rocks were exposed (first depositional sequence, Early Oligocene ?).

- After a period characterized by non-deposition, marine sedimentation started in both the Northern and Southern Sectors (second depositional sequence, Late Oligocene).

- Subsequently, a deep erosional surface was incised into the shallow marine deposits of the second sequence of the Northern Sector. At the same time, turbiditic sedimentation began in the Southern Sector. The recovery of sediment deposition in the Northern Sector is again recorded by shallow marine sediments. At the same time, the basement rocks of the Western Sector were coated by alluvial deposits (third depositional sequence, Late Oligocene).

- The uplift and the erosion of both the Northern and Western Sectors are testified by the angular unconformity which characterizes the boundary between the third and the fourth sequences. No data are available for the Southern Sector.

- In the Western and Northern Sectors, the subsequent recovery of sediment deposition (fourth depositional sequence) is identified by continental to coastal deposits, which locally contain large mudstone boulders yielding planktonic foraminifers. These boulders must come from an area where Late Oligocene open sea de-

posits had been exposed and subjected to subaerial erosion. The location of this area is still uncertain.

- Finally, the Western and Northern Sectors rapidly drowned to open sea conditions (very Late Oligocene-Early Miocene).

Concluding remarks

The Oligocene to Early Miocene stratigraphic succession of the Monregalese, at the southwestern tip of the Piedmont Tertiary Basin, reveals the existence of three sectors, which are characterized by different depositional environments related to their geologic evolution.

These three sectors were probably limited by NNE-SSW and WNW-ESE synsedimentary fault systems, roughly parallel to the T. Corsaglia and T. Casotto-T. Mongia valleys, the presence of which can be inferred from the abrupt lateral facies variations between sectors. Tectonics appears to have had a dominant role in controlling the geologic evolution of the whole region. Its major role is recorded by the geometric characteristics of the sequence boundaries between the first and second sequences and between the third and fourth sequences.

The main features of the investigated sedimentary successions indicate that the geologic evolution of the Northern, Western and Southern Sectors was very diversified. During Oligocene, the Western Sector was characterized by a continental setting; alluvial sediments covered the basement rock only in Late Oligocene. In the Northern Sector alluvial sediments deposited since Early Oligocene, whereas a shallow marine setting developed during Late Oligocene. Both Western and Northern Sectors drowned at the Oligocene-Miocene boundary.

The Southern Sector suffered alluvial sedimentation during Early Oligocene, as it happened in the Northern one. In the former sector, however, an open sea sedimentation took place since Late Oligocene.

Taking into account the sediment composition, an identical feeding area can be inferred for the conglomerates of the first sequence (Units S-1 and N-1). The characteristics of the conglomerates of the third sequence (Units S-3 and W-1) point to source areas completely different from the previous one. Within the third sequence, the sandstone composition shows that the Western and Southern Sectors (Units W-1 and S-3) have been probably fed by similar source rocks, while a somewhat different provenance could be supposed for the Northern Sector sediments (Unit N-3), which are generally characterized by lesser percentages of feldspar and by higher serpentinite contents.

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