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ORIGINAL ARTICLE

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Recovery of carbonate platform production in the Lombardy Basin during the Anisian: paleoecological significance and constrain on paleogeographic evolution

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Abstract In the Central Lombardy Basin (Southern Alps) Anisian carbonate platform marginal facies yielding the first documented occurrence of coral colonies in this area of the Western Tethys has been recognized. These marginal facies identify the east-west transition between two sectors with a different Anisian evolution. West of the recognized marginal facies the Anisian succession is characterised by subtidal bioturbated limestones passing upward to peritidal dolostones, whereas toward the east a thicker succession of subtidal facies persist until the end of the Anisian. The margin belt develops at the passage between a more subsiding eastern portion and a less subsiding one toward the west. The different facies and thickness of the Anisian succession east and west of the marginal facies is indicative of syndepositional tectonics. The transition from subtidal to peritidal facies in the western sector is ascribed to a sea-level fall that favoured the onsetting of peritidal facies on the less subsiding block and of marginal facies on its border. The occurrence of a N-S trending syndepositional Anisian fault system could also explain the scarce progradational evolution of the margin facies, prevented both by the paleobathymetric setting and by the scarce productivity of the Anisian marginal communities. The presence, in the Anisian marginal facies, of crinoids and corals (together with the occurrence of one of the oldest specimen of coralline red algae) outlines the return to normal marine conditions and documents the recovery of the carbonate platform marginal faunal association after the Permo-Triassic crisis in the Western Southern Alps.

Keywords Anisian · Southern Alps · Carbonate platform · Stratigraphy · Paleoecology

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Introduction

The Permian-Triassic extinction led to a profound decline in reef production, but platform growth was less affected, even though the facies changed considerably, with oolites and molluscs becoming important in the Early Triassic: general characteristics of the Early Triassic carbonate factories are the quantitative dominance of micrite (at least partially microbially induced), the absence of calcareous green and red algae, the frequency of molluscs, and the abundance of oolites (e.g., Kiessling et al. 2003). During the Anisian, carbonate platform development reoccurred with the important contribution of reefal debris which are almost absent in Early Triassic carbonate platforms. This is accompanied by the appearance of scleractinian corals and the increasing quantitative importance of dasycladacean green algae, the increasing frequency of crinoids and molluscs, and the scarcity of ooids (Kiessling et al. 2003).

The uncommon Anisian carbonate platform margins record therefore the initial stage of the post-Paleozoic carbonate platform evolution. In the Western Tethys (Lombardy Basin, Western Southern Alps) a small carbonate margin has been recognized (Monte Corru): the analysis of the facies association and distribution of this significant case-history of the Anisian carbonate platform margins documents an important paleoecological and paleogeographical change in the evolution of this part of the Western Tethys.

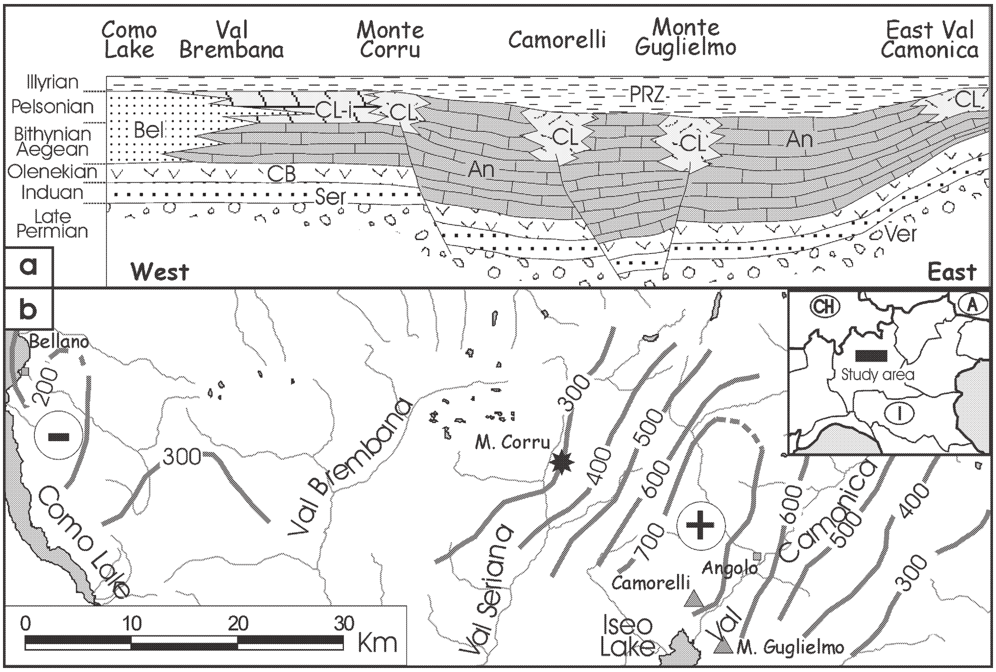


Fig. 1 **a** Lithostratigraphic scheme of the Induan-Anisian succession of the Lombardy Basin: Ver: Verrucano Lombardo; Ser: Servino; CB: Carniola di Bovegno; An: Angolo Limestone; CL: Camorelli Limestone, margin and shoaling bioclastic banks; CL-i: Camorelli Limestone, inner platform peritidal dolostones; Bel: Bellano Formation; PRZ: Prezzo Formation (see text for description of the units). **b** Geographic setting of the Central Southern Alps, with thickness (in metres) of the Anisian succession (excluding the Illyrian basinal Prezzo Limestone). Data from Assereto and Casati 1965, 1968; Gaetani 1983; Gaetani and Gorza 1982; Gaetani et al. 1987; Boni and Cassinis 1973; Sciunnach et al. 1996 and our observations)

Geologic and stratigraphic setting

Within the Lombardy Basin the Anisian succession is mainly preserved in different overthrust tectonic units: due to the Alpine tectonics (Schönborn 1992, Geological map of Provincia di Bergamo 2000), Anisian rocks crop out along an east-west belt, allowing the observation of the east-west facies distribution, but preventing a detailed north-south paleogeographic reconstruction. Nevertheless, the Anisian paleogeography was marked by facies that change from east (proximal terrigenous deposits) to west (neritic fine-grained limestones) and thus the tectonic shortening is almost normal to the facies transition (Fig. 1). A tectonic control on the sedimentation in the Lombardy Basin was inferred by De Zanche and Farabegoli (1983; 1988) and Cassinis and Perotti (1996) during the Anisian.

The Anisian carbonate succession of the Lombardy Basin develops above the coastal (sabkha) deposits of the Early Triassic (Olenekian) Carniola di Bovegno, that lies on the shallow-water siliciclastics and carbonates of the Early Triassic (Induan) “Servino”.

The Anisian succession is characterised by important lateral and vertical changes that led to a complex lithostratigraphic Anisian setting. The Angolo Limestone (Assereto and Casati 1965, 1968) consists of black, bedded and bioturbated neritic limestones (generally packstones and wackestones), that represent, with minor differences, the whole lower-middle Anisian succession east of the Val Seriana and in Val Camonica. West of the Val Seriana the stratigraphic setting changes and the Angolo Limestone is covered by gray to yellowish bedded dolostones with microbialites and fenestral fabric, corresponding to the informal “Membro delle dolomie peritidali” of Jadoul and Rossi (1982). This unit is referred in the new geological map of Italy (1:50.000 Geological Map of Italy, Sheet Clusone, in press) to the Camorelli Limestone.

More westward, the Camorelli Limestone is characterised by terrigenous input (“terrigenous member”, Gaetani et al. 1987) and, close to the Lake Como, the carbonate content decreases and this formation passes to prevailing fan-delta sandstones and conglomerates, referred to different lithostratigraphic units (Bellano Conglomerate; Gaetani 1982; Val Sassina and Val Muggiasca Conglomerates; De Zanche and Farabegoli 1983; Bellano Formation; Sciunnach et al. 1996). Toward the east (Val Camonica, north of the Lake Iseo), this situation is complicated by the occurrence of a lenticular, shallow subtidal carbonate platform body, mainly represented by bio-intraclastic limestones (rich in green algae and oncoids) which represents the typical Camorelli Limestone (Assereto et al. 1965; Assereto and Casati 1965; Gaetani and Gorza 1989). Few kilometres east, another shallow water carbonate succession (Monte Guglielmo Limestone of Cassinis and Zezza 1982; Falletti and Ivanova 2003) is referred to the Camorelli Limestone: it consists of shallow-water bioclastic limestones interfingering with the

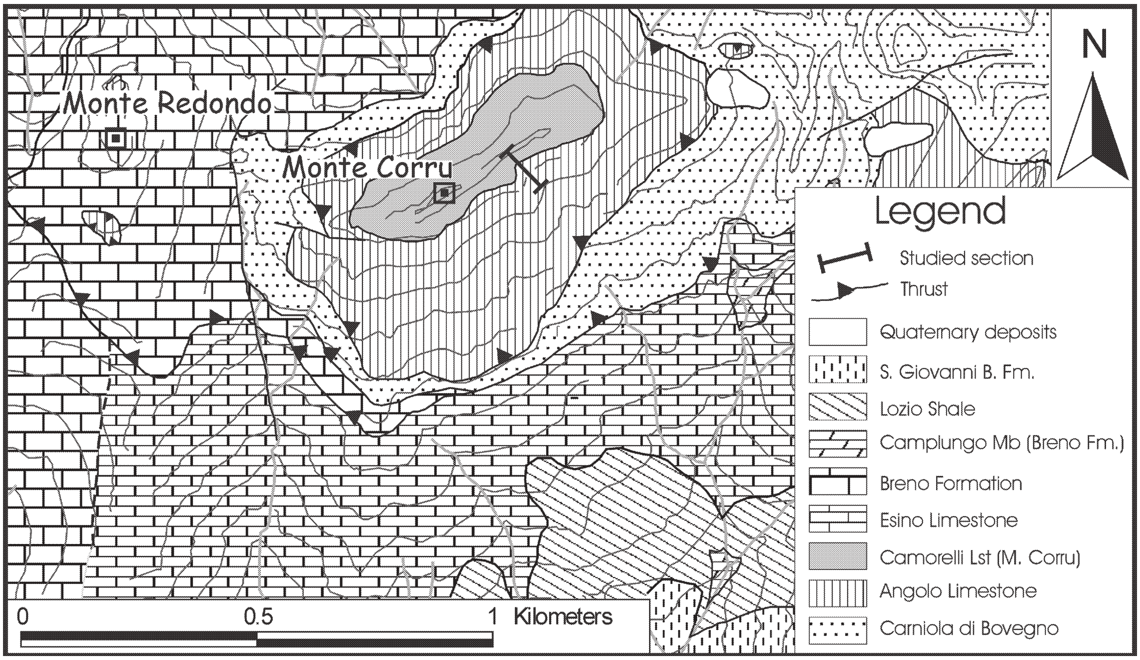


Fig. 2 Geological map of the study area

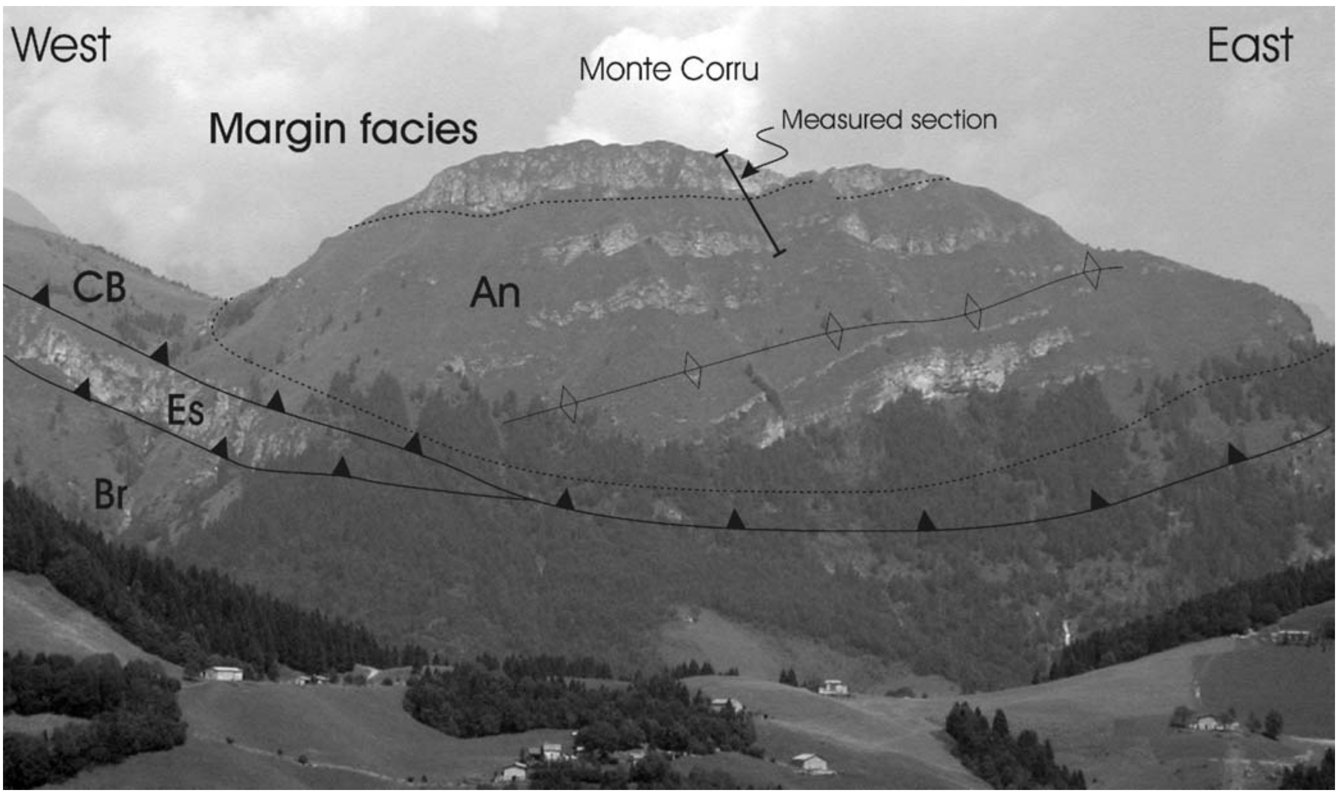


Fig. 3 View of Monte Corru from the south: the massive carbonate platform margin facies directly overlies on the subtidal bioturbated dark limestone of the typical Angolo Limestones. CB: "Carniola di Bovegno"; An: Angolo Limestone; Es: Esino Limestone; Br: Breno Formation

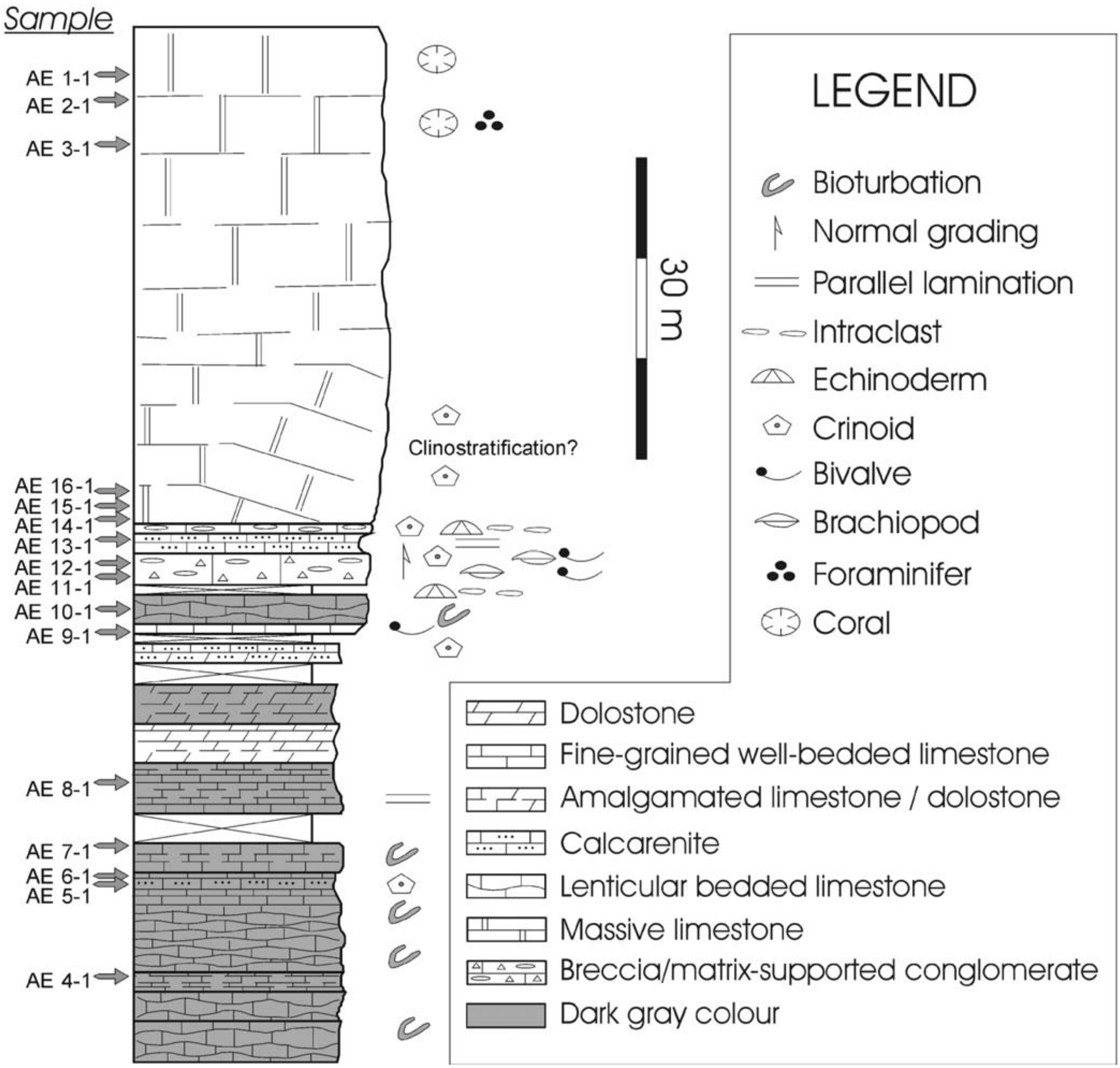


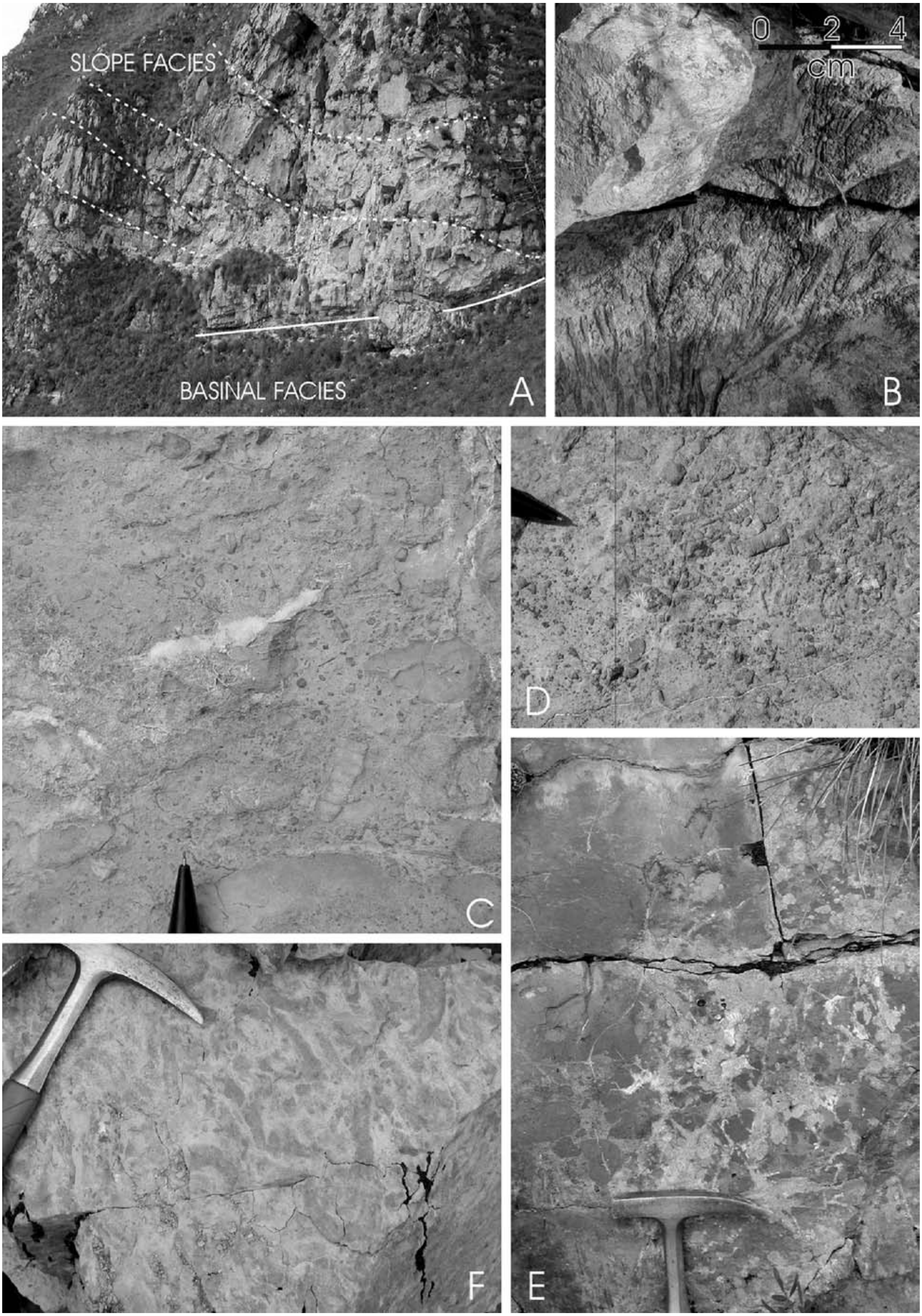
Fig. 4 Monte Corru stratigraphic section

deeper dark bedded limestones of the Angolo Limestone. A northern outcrop of shallow-water inner carbonate platform of the Camorelli Limestone is present in the Giudicarie Valleys (Dosso dei Morti Limestone of Gaetani 1983) and in the Val Trompia area.

Summarizing, the Anisian succession of the Lombardy Basin is characterised by a lower part represented by neritic facies (Angolo Limestone) that west of the Val Seriana evolve into peritidal dolostones and mixed to deltaic terrigenous bodies, whereas toward the west it locally evolves to isolated sandy carbonate highs and to inner platform sectors (Camorelli Limestone). During the Late Anisian (Illyrian) the Angolo Limestone and the Camorelli Limestone are covered by deeper water ammonoid-bearing limestones and marls (Prezzo Limestone), that sharply increase in thickness (from 5–15 to 70–100 metres) east of Val Seriana.

The thickness of the Anisian succession in the Lombardy Basin changes from west to east (Fig. 1b): the

Fig. 5 Details of the Monte Corru Section: **A** Base of the margin facies with possible clinoforms lying on the flat basinal bedded limestones; **B** Detail of a coral patch colony at the top of the Monte Corru section; **C** Paraconglomeratic layers with abundant fine-grained matrix with clasts and crinoid columnalia (basinal facies in **A**); **D** Bioclastic packstone-rudstones with crinoids (basinal facies in **A**); **E** Paraconglomeratic intercalation in the upper part of the basinal succession; **F** Typical bioturbated dark marly limestones of the Angolo Limestone (base of the Monte Corru Section)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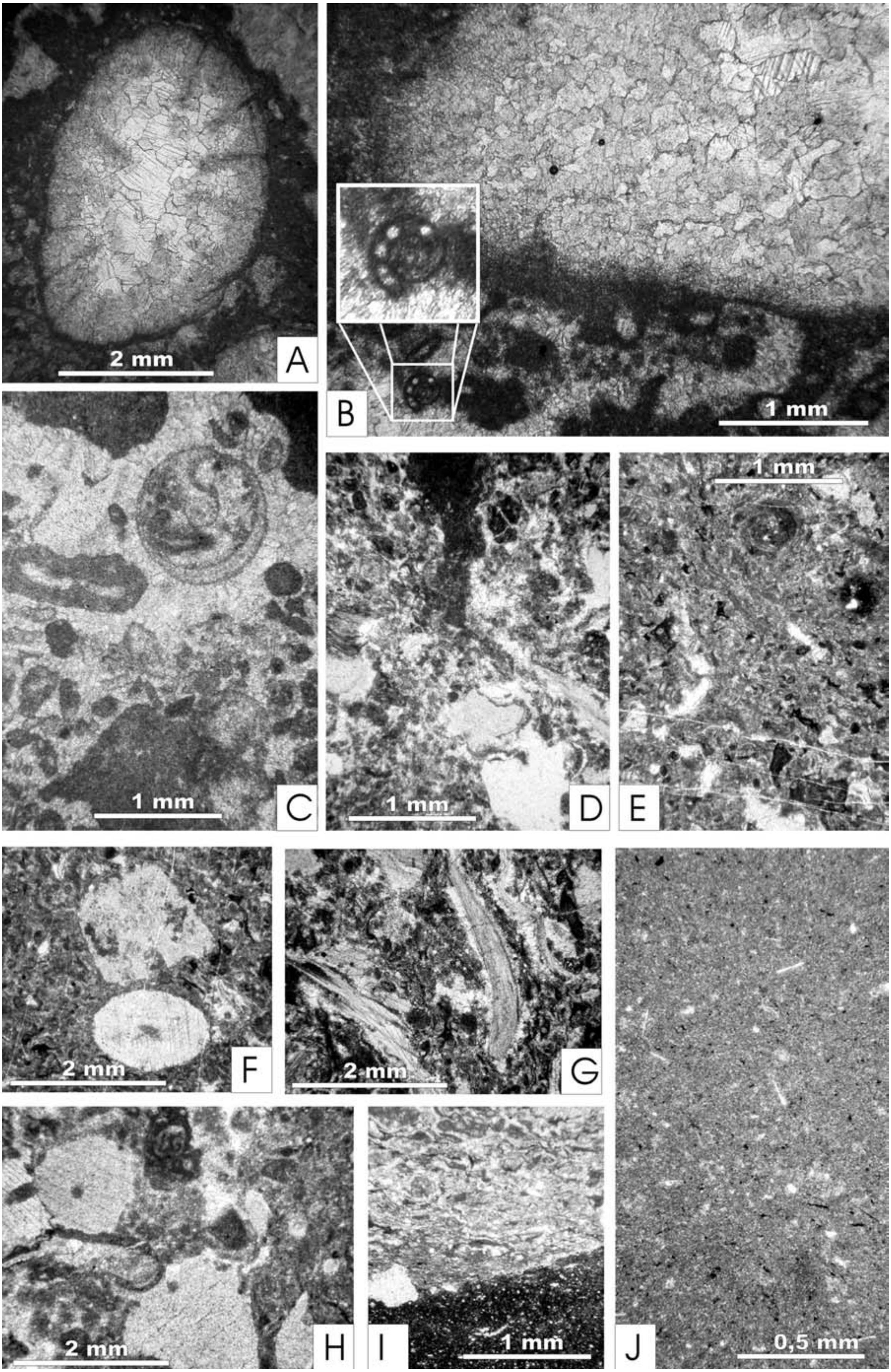
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Bellano Formation reaches 210m (Sciunnach et al. 1996), whereas the Anisian succession is characterised by a thickness ranging between 270–300m (upper Val Brembana). East of the Val Seriana, the thickness of the Anisian sediments (represented by the neritic Angolo Limestone and Prezzo Limestone) increases rapidly. The Angolo Limestone reaches its maximum thickness of 600–700m in Val Camonica (Assereto and Casati 1968; Boni and Cassinis 1973; Geological map of Provincia di Bergamo 2000). The Camorelli Limestone in Val Camonica is coeval with the upper Angolo Formation and reaches a thickness of some 300m (Gaetani and Gorza 1989); a similar thickness of this unit is documented at Monte Guglielmo (Falletti and Ivanova 2003). Both of them lie on more than 300m of the lower Angolo Limestone. In the Giudicarie Valleys (Dosso dei Morti) the Camorelli Limestone ranges from 100 to 200m in thickness (Gaetani 1983).

The nature of the passage between the different Anisian successions has never been investigated in detail: the identification of a carbonate platform margin facies preserved along Val Seriana (Monte Corru section, Fig. 2) coupled with a detailed 1:10000 geological mapping of the Lombardy Basin (in the frame of the CARG Project - Regione Lombardia) led to the reconstruction of the distribution in the Lombardy Basin of the different Anisian facies, allowing to characterise the transitional area between low-subsidence and high-subsidence sectors. The Monte Corru section represents the key for the reconstruction of the environmental factors that controlled the stratigraphic evolution of the Anisian succession in the Lombardy Basin.

The Anisian carbonate platform margin of Monte Corru: facies characteristics and stratigraphic framework

The Monte Corru section: facies and stratigraphic evolution

Immediately east of the Val Seriana, a particular lithofacies of the Camorelli Limestone, (previously mapped as the Esino Limestone, Ladinian in age; Geological Map of Italy, Sheet 1:100000 Breno; 1:50000, Geological Map of Provincia di Bergamo 2000) outcrops at the top of Monte Corru (Fig. 3).

The succession of Monte Corru (Fig. 4) documents the vertical transition from low-energy outer neritic facies to shallow subtidal carbonate platform marginal facies. The base of the Anisian succession is represented by dark, intensely bioturbated (pseudonodular) fine-grained limestones typical of the Angolo Limestone (Fig. 5e, f). Upsection, the succession evolves to 20 to 40m of well-bedded centimetre to decimeter-thick dark limestones (mainly bioclastic-intraclastic packstones, with bivalves and brachiopods, locally rich in crinoids and echinoids; Fig. 5c, d). The common occurrence of normal grading (locally associated with scoured bases) and of shallow-water grains and bioclasts documents that these carbonates resedimented from a nearby carbonate factory that exported sand-sized limestones toward deeper settings. Within this facies, a few intercalations of calcirudites up to 10cm thick yielding cm-size intraclasts and large columnalia (up to 3cm in size) of crinoids are found. The top of this coarsening-upward succession is represented by a few metres of coarse bioclastic-intraclastic limestones (rich in crinoids and shell fragments and intraformational soft and partly lithified clasts up to 5cm in size) in beds from 30cm to more than one metre thick. Above, massive gray limestones cover the basinal succession. Within the massive limestones problematic discontinuities could testify a 20 to 30° steep irregular clinostratification, but the outcropping conditions and the tectonics do not allow to be sure about the origin of these surfaces (Fig. 5a). At the base, these limestones are mainly represented by breccias with abundant fine-grained matrix, which reach a thickness of 70m: the uppermost part is characterised by small patch reefs with corals in life position (Fig. 4a), covering bioclastic and intraclastic packstones. Coral colonies are generally small and organized in patches. Coral framestones are characterised by colonies up to 20cm in height: encrusting foraminiferans generally grow on the corals; the matrix is generally represented by peloidal wackestones. The top of the succession is not preserved due to erosion.

The microfacies of the succession of Monte Corru (Fig. 6) documents the passage from outer neritic, low-energy muddy environments to shallower settings, characterised by coarser, higher energy bioclastic deposits. The lower portion corresponds to the typical setting of the Angolo Limestone, deposited below the fair-weather wave base, with a rich benthic fauna documented by the intense burrowings. The shallowing-upward trend from low-energy subtidal limestone to coral patch reefs is marked by the deposition of intra-bioclastic limestones, rich in crinoids, that increase in thickness upsection. Within these facies, thalli of a probable red algae have been recognized (see "Micropaleontological assemblage").

Fig. 6 Microfacies of the Monte Corru Section: **A** Transversal section of a corallite from the patches of Monte Corru, sample AE 3.1; **B** Recrystallised coral framestone; septa are hardly recognizable in the coral in the upper part of the picture; note the encrusting foraminiferan on the corallite and the small *Meandrospira dinarica*; sample AE3.1; **C** Bio-intraclastic grainstone with a small gastropod and coated grains (probably a fragment of bivalve), AE1.1; **D** Intraclastic packstone (automicritic?) with rare bioclasts (mainly crinoids), AE14b.1; **E** Bioturbated intraclastic packstone, AE7.1; **F** Intra-bioclastic packstone with large columnalia; AE14.1; **G** Bio-intraclastic packstone with abundant brachiopod shells, AE14.1; **H** Bioclastic packstone with predominant crinoid columnalia, AE12.1; **I** Contact (with erosional base) between an intra-bioclastic packstone (above) with a fine-grained bioclastic wackestone, AE9.1; **J** Intraclastic-pelletiferous wackestone; the thin whitish lines are laminae of muscovite, AE6.1

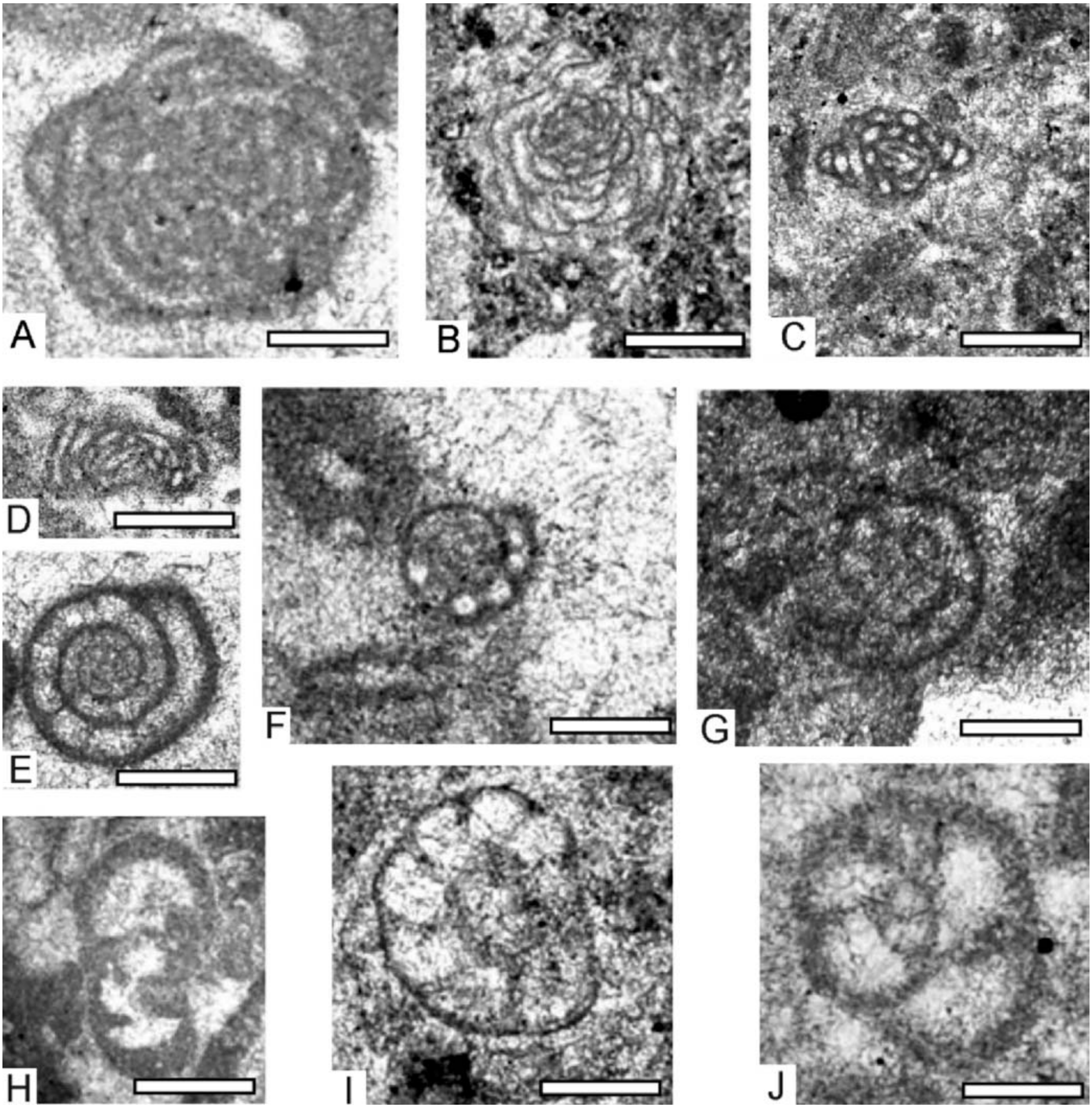


Fig. 7 Foraminifera of the Monte Corru Section: **A-B** *Pilammina densa* Pantic, 1965: **A** Sample AE1-1, scale bar = 150 µm; **B** Sample AE11-1, scale bar = 150 µm; **C-D** *Pilamminella semiplana* Kochansky-Devid and Pantic, 1966: **C** Sample AE1-b, scale bar = 250 µm; **D** Sample AE7-1, scale bar = 250 µm. **E-G** *Meandrospira dinarica* Kochansky-Devid and Pantic, 1965: **E** Sample AE7-1, scale bar = 150 µm; **F** Sample AE3-1, scale bar = 150 µm; **G** Sample AE11-1, scale bar = 150 µm. **H, J** Endotriadidae sp.: **H** Sample AE3-1, scale bar = 250 µm; **J** Sample AE3-1, scale bar = 250 µm; **I** Duostominidae, sample AE16-1, scale bar = 125 µm

Stratigraphy of the surrounding areas

Observations at Monte Corru have been integrated with data collected from selected successions east and west of this area, documenting a complex lithostratigraphic and environmental evolution of the Anisian units in the Lombardy Basin.

West of the Val Seriana, above vuggy dolostones (carnioules) and shales of the Carniola di Bovegno, dark, bioturbated limestones with rare, yellowish marly intercalations represent the base of the Angolo Limestone. The abundant occurrence of crinoids documents the transition from restricted (Carniola di Bovegno) to neritic open marine (Angolo Limestone) environmental conditions, as testified by intraclastic wackestones and packstones, often

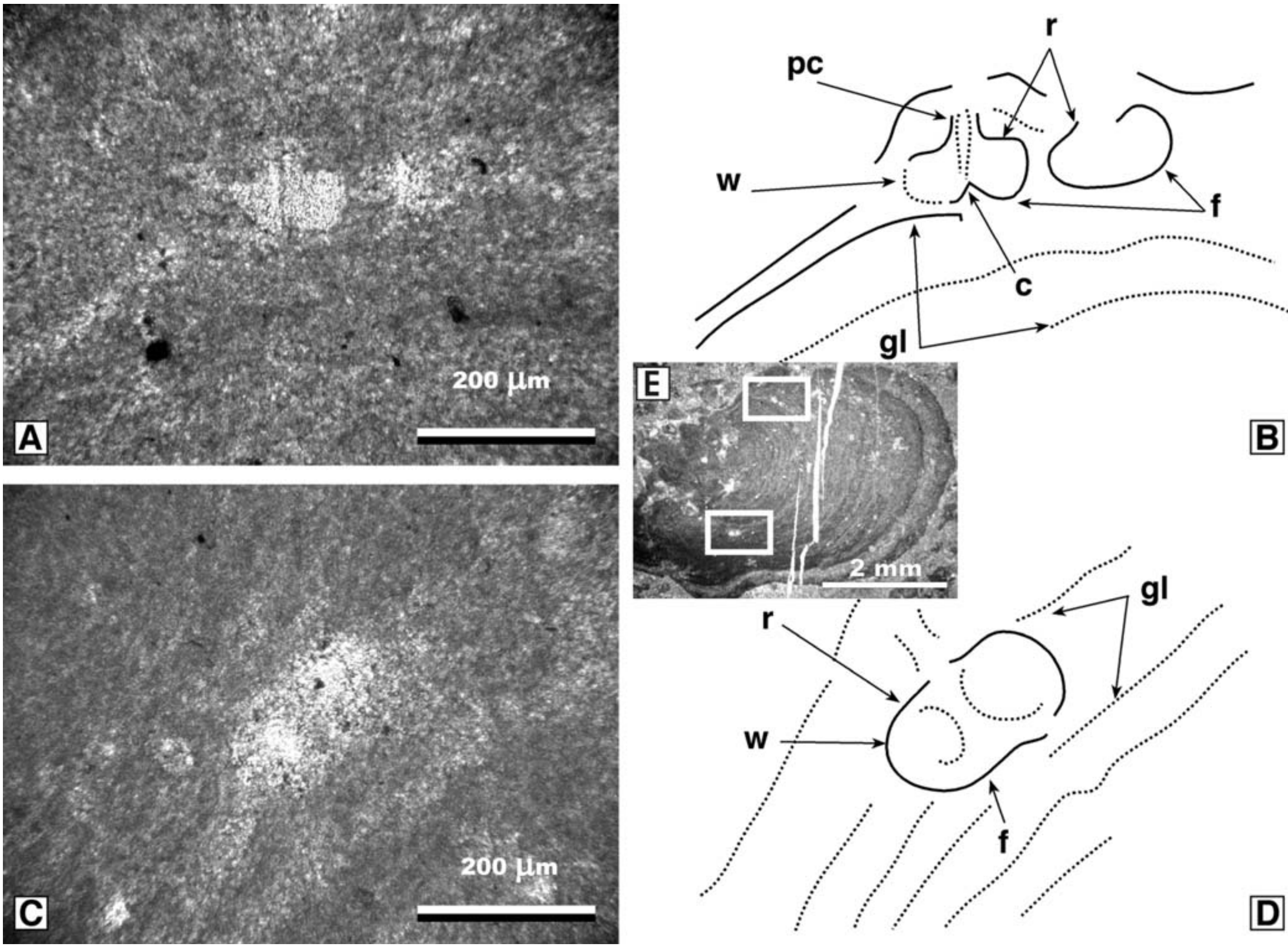


Fig. 8 A-D Microphotographs and diagrammatic drawings of the coralline-type thalli showing some anatomical characters of the possible conceptacles: pc, pore canal; r, roof; w, conceptacle wall; c, central columella; gl, growth-lines. **E** Coralline-type algae with the position of the details of **A-B** (above) and **C-D** (below, sample AE 12)

bioturbated, documenting the existence of an abundant infauna. The Angolo Limestone reaches a thickness of some 150–250m. Above, with a rapid transition, the dark limestones are replaced by bedded gray dolostones (often yellowish when weathered), with abundant planar stromatolites. Microfacies are mainly represented by bindstones and intraclastic-pelletiferous wackestones-packstones; skeletal grains are generally scarce, only locally dasycladaceans and small bivalves are present. The sedimentological features indicate a deposition in a shallow-water peritidal environment as proved by the common occurrence of fenestral fabric.

The top of the Camorelli Limestone is marked by a sharp boundary, locally (Valcanale) characterised by thin breccia beds, followed by two to five metres of dark, marly limestones. Limestones are generally rich in crinoids and, less frequently, in brachiopods and bivalves; poorly preserved ammonites are locally present. This horizon corresponds to the "Banco a Brachiopodi" of the Grigna Massif (Gaetani et al. 1987). The top of the Anisian succession is represented by up to 15m of black, bedded limestones and marls (Calcare di Prezzo).

East of the Monte Corru the Anisian succession is markedly different. The Angolo Limestone is still represented dark, bedded to pseudonodular (due to intense burrowing) intraclastic wackestones and packstones and persists until the deposition of the Prezzo Limestone, representing all the Angolo Limestone.

The different evolution east and west of the Val Seriana and the presence of the Prezzo Limestone above both the Camorelli Limestone and the Angolo Limestone document that while the peritidal facies of the Camorelli Limestone was deposited westward, the deeper facies of the Angolo Limestone persisted eastward. East of Monte Corru the top of the Angolo Limestone is sharp, but no evidence of emersion or of a significant interruption of the sedimentation is present. The bioclastic limestones recognized westward ("Banco a Brachiopodi") are less evident (probably due to the dilution of the bioclastic content in a thicker succession) and the Prezzo Limestone is characterised by a thickness of 50–80m and by a prevalence of marls and shales with respect to limestones. East of Val Camonica, the thickness of the Angolo Formation decreases to about 300m and shows a shallowing-upward trend, resembling the succession recognized west of the Val Seriana.

The Anisian succession along the Val Seriana represents the key for the reconstruction of the paleogeographic relationships between two different coeval successions.

Micropaleontological assemblage

The foraminiferal assemblage is marked by the presence of an assemblage which is typical of Anisian carbonate platforms of the Tethyan realm (Rettori 1995) (Fig. 7). The assemblage consists of *Pilammina densa* Pantic, *Meandrospira dinarica* Kochansky-Devid and Pantic and *Pilamminella semiplana* (Kochansky-Devid and Pantic). Triassic involutinids such as *Aulotortus? eotriasicus* Zaninetti, Rettori and Martini, which is generally associated with the above mentioned three taxa in Pelsonian Tethyan deposits. (Zaninetti et al.1994; Rettori 1995) have never been recorded in the assemblage studied.

The absence of this involutinid species could be due to stratigraphic reasons and allows to refer our successions below the first occurrence of *A.? eotriasicus* which can be referred to the late Pelsonian on the basis of conodont zonation (Rettori et al. 1994). We exclude that the absence of involutinids is related to environmental conditions. In fact, according to Marquez and Trifonova (2000), the primary absence of aragonitic forms is linked to important changes in water chemistry usually occurring in regressive phases. In our samples, however, the constant presence of aragonitic taxa such as Duostominidae (Robertinida) (di Bari and Rettori 1996) exclude this interpretation. Bilocular foraminiferans (earlandiids) are also present and multilocular forms such as "Trochamminidae" and Endotriadidae have also been recorded, but much more sporadically.

Undetermined probable corallinacean red algae in association with the foraminiferans have been recognized (Fig. 8). The specimens show a warty thallus characterised by distinctive growth steps. Thallus construction consists of horizontally aligned cylindrical rounded cells which are highly micritised and recrystallised. Monomerous or dimerous construction was not discerned (Fig. 8). Cell fusions are not clearly visible but their occurrence is suggested by the thallus cell pattern. Two possible reproductive structures were recognised (Fig. 8). They may be ascribed to uniporate conceptacles: one section passes parallel to the pore canal (Fig. 8A) and one cuts the conceptacle tangentially (Fig. 8C). The conceptacle chamber appears elliptical with an evident cylindrical pore canal. The conceptacle is characterised by a central columella the filaments of which protrude into the base of the pore canal (Fig. 8B).

The studied calcareous thalli resemble coralline red algae (Corallinales, Rhodophyta) which are characterised by a tissue composed of cell filaments. Although the examined specimens do not show clear ventral filaments, they have well microcrystalline preservation of the thalli suggesting the preservation of primary calcitic mineralogy of the cell walls. The presence of possible uniporate conceptacles and cell fusions would suggest a possible ascription to the subfamily Mastophoroideae, however, further material has to be found in order to illustrate and describe in detail these anatomical features.

Discussion

Lithostratigraphy

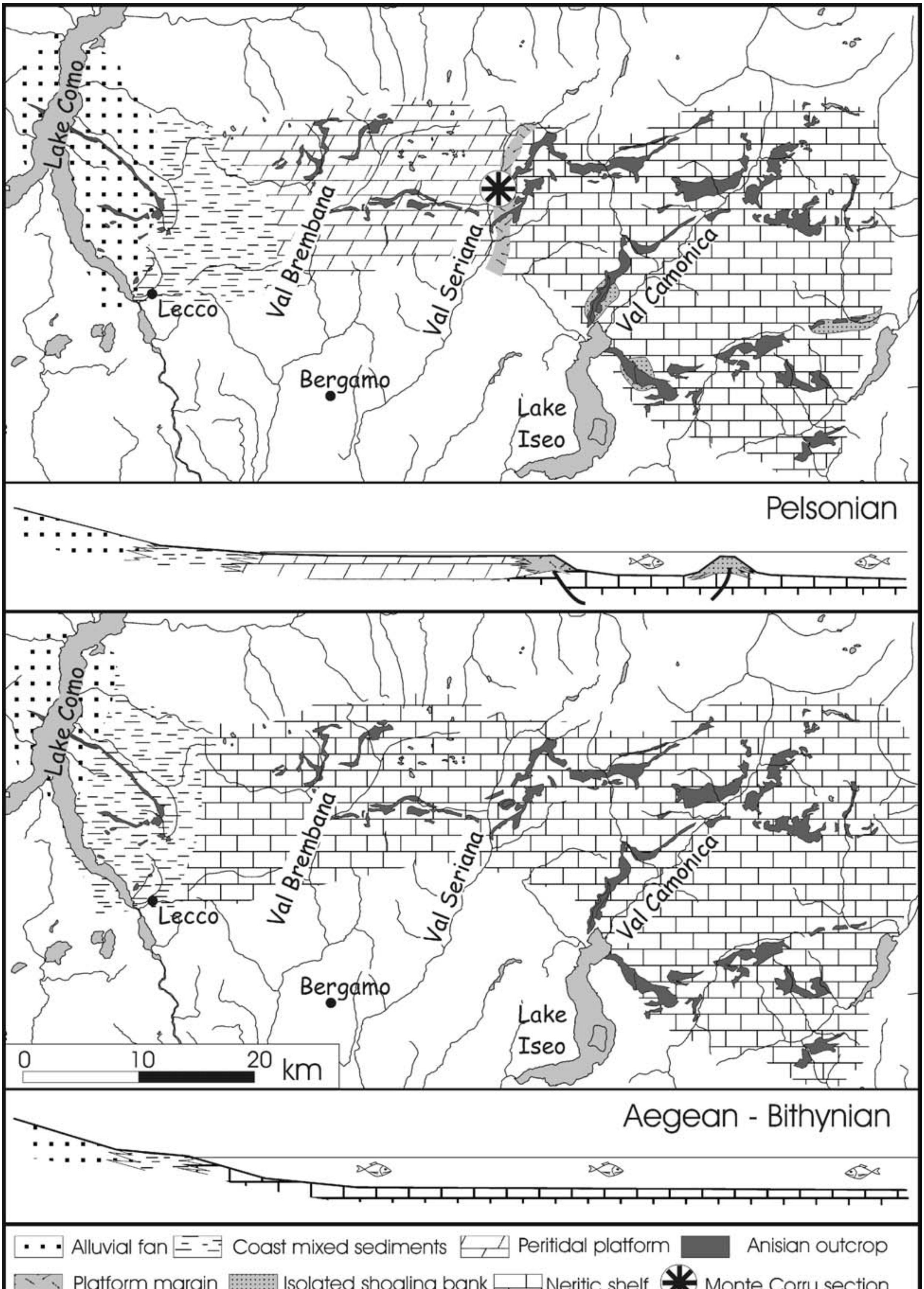
The Anisian carbonate platform margin of Monte Corru marks the transition between the western peritidal dolostones of the Camorelli Limestone and the eastern dark bioturbated subtidal limestones of the Angolo Limestone. West of Monte Corru, the absence of similar lithofacies at the vertical passage between the Angolo Limestone and the overlying Camoreli Limestone, the constant thickness of the two units and the sharp vertical passage between them excludes the gradual progradation of margin facies from west to east and indicates that an important stratigraphic change affected all the portion of the Lombardy Basin west of the Val Seriana (Fig. 9). The thickness and the different bathymetry of the Anisian succession east and west of the Monte Corru margin indicate a rapid change in the subsidence rate, denoting the presence of a fault system with a moderate tectonic activity not able to develop a high-relief morphology with the production of scarp breccias, rather than a ramp setting.

The existence of faulted blocks is inferred also to explain the occurrence of isolated carbonate platform within the Angolo Limestone of Eastern Lombardy (Camorelli Limestone, Monte Guglielmo Limestone, Dosso dei Morti Limestone) by Falletti and Ivanova (2003).

The carbonate platform margin of Monte Corru lies on some 200m of Angolo Limestone: margin facies are not preserved both eastward and westward, where they pass to peritidal facies (Camorelli Limestone) westward, or neritic facies (Angolo Limestone) eastward. According to this information, we suggest that the margin facies probably developed as a mainly stationary margin, as no significant progradational episodes are documented eastward and no margin facies are preserved between the Camorelli Limestone and Angolo Limestone westward. The possible clinostratification observed in the Monte Corru section could represent the result of the aggradation of a low-productivity carbonate margin facing a more subsiding area and not the result of a progradation.

The absence of breccia aprons indicates a low relief of the margin facies. Only some 20–25km eastward, peritidal dolostones referred to the Camorelli Limestone, indicate the occurrence of another less subsiding area (Dosso Alto, Dosso dei Morti), whereas between these

Fig. 9 Paleogeographic reconstruction of the Lombardy Basin and schematic cross sections: the Monte Corru succession represent the seaward margin of the large intertidal flat developed between Val Seriana and the terrigenous prism of the Bellano Formation


Lake Como
Lecco
Val Brembana
Val Seriana
Val Camonica
Bergamo
Lake Iseo
Pelsonian
Lake Como
Lecco
Val Brembana
Val Seriana
Val Camonica
Bergamo
Lake Iseo
0 10 20 km
Aegean - Bithynian
Alluvial fan
Coast mixed sediments
Peritidal platform
Anisian outcrop
Platform margin
Isolated shoaling bank
Neritic shelf
Monte Corru section

two portions (Val Camonica sub-basin) only more or less isolated highs are present (Monte Guglielmo, Camorelli).

Biostratigraphically the foraminiferal assemblage *Meandrospira dinarica-Pilammina densa-Pilamminella semiplana* allows to refer the carbonate platform margin of Monte Corru to the Bithynian-Pelsonian time interval below the first appearance of *Aulotortus? eotriasicus* which occurs in the late Pelsonian as documented in the Eros limestone of Hydra Island on the basis of conodonts (Rettori et al. 1994). In our material this absence seems to have a stratigraphic value rather than being linked to ecological conditions of the depositional paleoenvironment.

Paleoecological implications

The Anisian represents the period of recovery of biogenic carbonate production after the crisis of the carbonate producing communities at the Permian-Triassic boundary. Up to now, in the Lombardy Basin only isolated carbonate platforms, consisting of bioclastic-intraclastic banks, were documented (Gaetani and Gorza 1989; Falletti and Ivanova 2003). The Monte Corru succession documents the first evidence of a carbonate platform margin in the Lombardy Basin, smaller but similar to those which later characterise the Ladinian depositional system of the whole Southern Alps. The development of a typical carbonate margin implies the existence of a community able to produce enough carbonate to keep up with the subsidence rate, but still not able to prograde toward the deeper areas with the impressive production rate of the Ladinian margins (i.e. Maurer 2000). The herein described first occurrence of coral patch reefs in the Lombardy Basin indicates the beginning of the colonization by these organisms of the ecological niches that remained empty after the Permo-Triassic crisis. This return of coelenterata as carbonate producing organisms seems to be almost synchronous worldwide during the Anisian and can be ascribed, as suggested by Stanley (2003), to the appraisal of coelenterates that managed to secrete a calcified structure, rather than a return of forms that managed to survive, after the Permian-Triassic crisis, in some hidden areas in forgotten corners of the Earth.

Paleogeographic implications

According to the new data regarding the Anisian facies distribution in the Central Lombardy Basin together with the stratigraphic data available in the geological literature, it is possible to suggest a paleogeographic reconstruction of the Lombardy Basin during the Anisian.

The reconstruction of the westernmost Lombardy Basin proposed by Gaetani et al. (1987), De Zanche and Farabegoli (1988) and Sciunnach et al. (1996) indicates the occurrence of emerged lands WNW of the Lake Como, as documented by the distribution of the terrigenous facies of the Bellano Formation. Moving eastward, the terrigenous bodies leave place to neritic calcareous facies (Angolo Limestone) covered by peritidal dolostones (Camorelli Limestone).

The Anisian evolution of the Lombardy Basin can be summarized as follows: a) the different subsidence rate identified two sectors with different (i.e. few tens of metres) paleodepth since the deposition of the Angolo Limestone; b) a relative sea level fall (probably corresponding to the base of sequence AI-II of (Gaetani et al. 1998) allowed the development of peritidal conditions (Camorelli Limestone) on most of the less subsident areas, whereas deeper conditions persisted eastward; c) at the passage between the two new paleogeographic settings, a narrow margin belt developed, on the footwall of a normal fault system bordering the more subsiding eastern sectors. Isolated carbonate banks (probably characterised by a low relief with respect to the surrounding areas) developed in the Val Camonica area: they can therefore be interpreted as shoals, swiped by currents, where mainly bioclastic and intraclastic sands deposited. These shoals, developed on horst structures (Falletti and Ivanova 2003), were not able to spread over the surroundings basinal areas, probably due to the scarce productivity of the carbonate factory.

Conclusions

The study of the facies distribution and of the evolution of the Anisian succession in the Lombardy Basin documents the existence of a moderate syndepositional tectonic activity that led to the identification of relative highs (where shallow-water sandy limestones and peritidal dolostones of the Camorelli Limestone deposited) and areas where neritic conditions persisted until the Late Anisian, with the deposition of bioturbated limestones (Angolo Limestone). The N-S oriented border between the two sectors yielded favourable ecological niches for the development of margin facies characterised by crinoids and corals that represent the oldest documented occurrence of Coelenteratesa in the Lombardy Basin.

The facies distribution documents the return to shallower conditions toward the east, indicating that the more subsiding area (Val Camonica Basin) was about 30km wide in east-west direction.

It is interesting to stress that the Illyrian neritic ammonoid-bearing marls and limestones of the Prezzo Limestone cover both the highs (Camorelli Limestone) and the more subsiding portions (Angolo Limestone), denoting the well-known regional transgressional stage occurring in the Lombardy Basin at the base of the Illyrian. This event was able to overprint all the previous different paleogeographic settings, documenting the end of the Anisian syndepositional tectonics that has no evidence to continue in the overlying Ladinian succession.

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