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# THE CONCESIO FORMATION OF THE LOMBARDIAN RIFTED BASIN (SOUTHERN ALPS, ITALY). STRATIGRAPHY OF A JURASSIC CALCAREOUS TURBIDITE UNIT

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*Key-words*: calcareous turbidites, Jurassic, Lombardian Basin, Southern Alps, stratigraphy, syn-rift sediments.

*Riassunto*. La Formazione di Concesio è costituita da due litosomi torbiditici, grosso modo corrispondenti ai membri dei Calcari Nocciola e dei Calcari Medoloidi (Auct.), che si svilupparono da sud-est verso nord-ovest, tra il Toarciano inferiore ed il Batoniano inferiore nel Bacino Sebino, la porzione orientale del Bacino Lombardo.

Il corpo torbiditico inferiore (Toarciano-Aaleniano), alimentato dall'erosione del margine di una piattaforma carbonatica e del suo substrato, si configura come un prisma cuneiforme che termina sopracorrente al bordo occidentale dell'alto strutturale del Botticino. Esso si chiude sottocorrente in relazione di onlap sul margine fagliato orientale dell'alto del M. Cavallo e lateralmente, verso sud, sull'alto liassico di Zandobbio. Nell'area di base-pendio sudorientale, questa unità è formata da corpi calciruditici canalizzati, associati a megabrecce, slumps e pelagiti. Tali corpi vengono sostituiti sottocorrente e verso l'alto stratigrafico, da sequenze cicliche di calcareniti torbiditiche, che richiamano l'organizzazione dei lobi deposizionali, e successivamente da facies di piana bacinale che terminano con un intervallo di emipelagiti marnose.

Il litosoma pelagico-torbiditico superiore, sviluppatosi a partire dal limite Aaleniano-Baiociano, è composto da torbiditi essenzialmente a composizione pelagica, la cui deposizione suggerisce il definitivo annegamento del Plateau di Trento. La sedimentazione torbiditica terminò all'inizio del Batoniano, quando nel Bacino Sebino si registrarono condizioni di sottoalimentazione e di intensificazione dell'attività delle correnti al fondo.

Nel complesso le due unità torbiditiche si organizzano in megasequenze positive. L'inferiore documenta la distensione sinsedimentaria attiva durante il Toarciano-Aaleniano p.p. nell'area sorgente sudorientale, verosimilmente collocata sopra-pendio rispetto alle successioni dell'alto di Botticino. L'attività tettonica originò ripetuti episodi retrogradanti di scivolamento gravitativo, di volume progressivamente decrescente nel tempo, fino alla recessione dell'unità torbiditica. Essa fu sostituita dalla risedimentazione di materiale pelagico a seguito dell'annegamento delle aree di piattaforma circostanti il Bacino Sebino.

*Abstract*. The Concesio Formation consists of two different turbiditic units (roughly corresponding to the Calcari Nocciola and Calcari Medoloidi members Auct.) that were shed from the ESE to the WNW across the Sebino Basin (the easternmost half graben of the Lombardian rift-basin), from the Early Toarcian to the Early Bathonian. In the lower turbidite unit, base-of-slope ruditic channels and related sediments (megabreccias, slumps, overbank turbidites and pelagites) fed by a nearby carbonate platform margin, are replaced downcurrent (westwards) and upsection by sheet-like calcarenite units, very similar to depositional lobes, then by a basin plain facies association. Close to the Aalenian - Bajocian boundary the resulting thinning and fining upwards megasequence was sealed by hemipelagic marlstones, followed upsection by a basin plain facies association of pelagic turbidites and pelagites. This second unit developed as a response of a major flooding event recorded by drowning of the platform succession of the Trento platform.

Turbidite deposition came to end before the Bathonian; during this time interval sediment starvation and bottom current reworking occurred throughout the Sebino Basin, slightly predating the turnover to siliceous pelagic sedimentation (radiolarites of the Selcifero Group). Both the members of the Concesio Formation wedge-out to the south-east, in the Botticino area, and lap out above the western and southern tectonic margins of the Sebino Basin (M. Cavallo and Zandobbio highs).

The architecture of the Concesio turbidite units suggests that Toarcian-Aalenian p.p. synsedimentary extensional activity affected the south-eastern basin margin, leading to retrogressive sliding and erosion of a carbonate platform margin and of the underlying Rhaetian-Liassic succession. The platform probably was to the south-east of the basinal area (in present-day coordinates) and therefore it could have been located upslope with respect to the Botticino High sequences.

## Introduction.

The Lombardian Basin is a structurally complex area of the Mesozoic South-Alpine rifted margin. After the Liassic extension it consisted of several half grabens resting above tilted blocks and bounded by normal faults (from west to east: the M. Nudo, M.Generoso, Albenza, and Sebino basins; Bernoulli, 1964; Gaetani, 1975; Winterer & Bosellini, 1981; Castellarin & Picotti, 1990 and many others). The Ballino-Garda Line separated the Lombardian Basin from the Trento Platform to the east (Castellarin, 1972).

In this area the Liassic rifting determined drowning of the pre-existing Rhaetian-Lower Liassic carbonate platform and the deposition of spiculitic limestones, calcareous breccias and turbidites, that formed syn-rift wedges up to 4 km thick. From the Toarcian an increase of fine-grained siliciclastic input occurred across the

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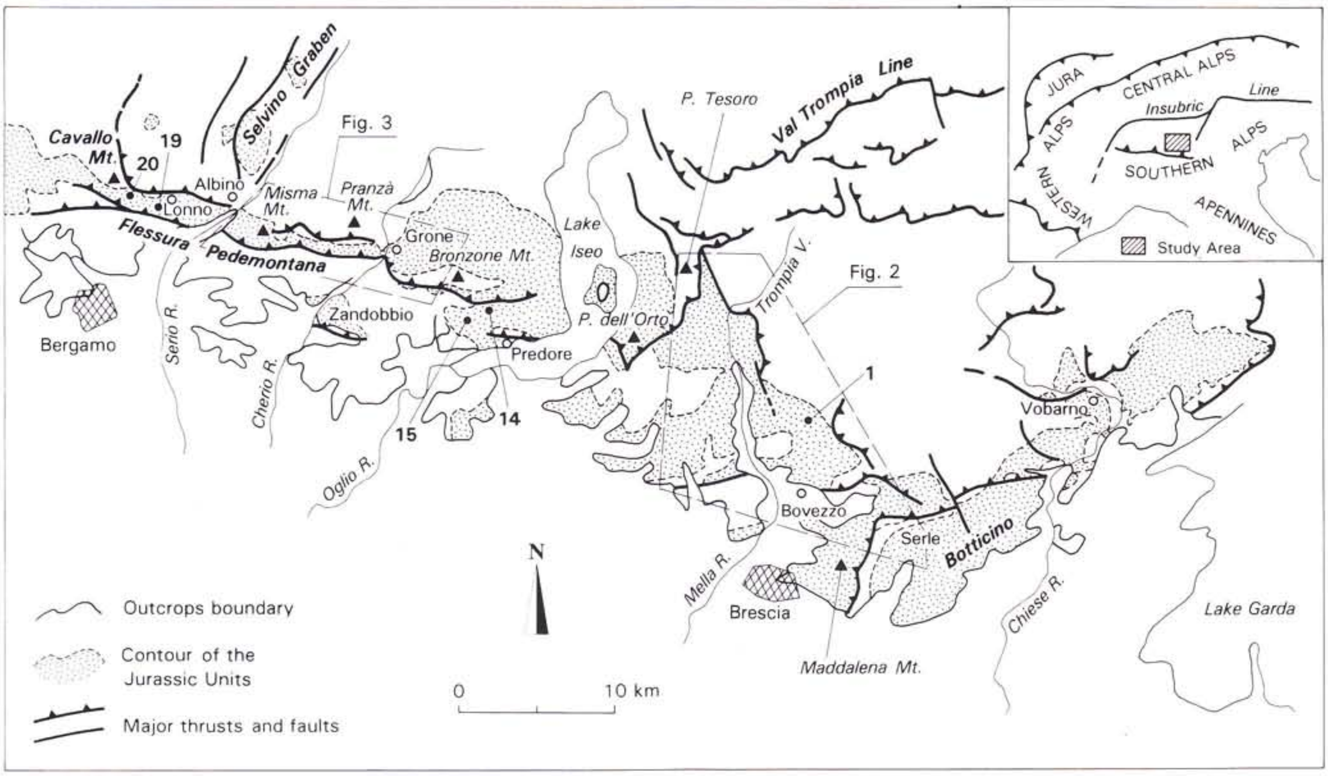


Fig. 1 - Tectonic sketch and location map of the study area. Numbers refer to stratigraphic sections (Fig. 4). The location of the maps of Fig 2 and 3 is also indicated.

Lombardian Basin. Contemporaneously coarse-grained calcareous turbidites, slides and slumps, fed by carbonate platform margins, were deposited in the basins of M. Nudo (to the west) and Sebino (to the east) and along the Ballino-Garda Line. This resulted in the development of different carbonate-marlstone units, that overlapped the drowned margins of the half grabens (the Valmaggiore Fm. in the M. Nudo Basin, the Sogno Fm. in the Albenza central region and the Concesio formation in the Sebino Basin; Kälin & Trümpy, 1977; Gaetani & Poliani, 1978; Cassinis, 1978; Castellarin & Picotti, 1990).

At the end of the rifting stage, turbiditic deposition was replaced by pelagic sedimentation across the entire Lombardian Basin (Middle Jurassic; Gaetani, 1975; Winterer & Bosellini, 1981), and marly pelagites began to drape the drowned Trento Platform to the east (Sturani, 1971).

To investigate the late rifting stage in the eastern part of the Lombardian Basin (the Sebino Basin), the depositional systems of calcareous turbidites of the Concesio Formation have been studied. This contribution is therefore intended to give a comprehensive description of the stratigraphy and facies evolution of this formation in the area between the Botticino and M. Cavallo highs (Fig. 1). The obtained stratigraphic reconstruction allows to discuss some interpretations about 1) the geometry and evolution of the Sebino Basin, and 2) the Toarcian-Middle Jurassic relationships between the Sebino Basin and the adjacent Botticino High, the Ballino-Garda area and the carbonate platform that fed the Concesio turbidites.

### The Sebino basin.

The Sebino Basin represents the easternmost half graben of the Jurassic Lombardian Basin. It was bounded by the Liassic highs of Botticino (east) and M. Cavallo (west) (Cassinis, 1968; Winterer & Bosellini, 1981; Cassinis & Vercesi, 1983; Bertotti et al., 1993). Following a more extended definition, the Sebino Basin reached the Garda-Ballino escarpment which represented the major boundary between the Lombardian Basin and the Trento Plateau (Castellarin, 1972; Castellarin & Picotti, 1990; Sarti et al., 1992). In this second view the Botticino High divided a West Sebino basin (that corresponds to the area of this study) from an East Sebino basin. It is uncertain whether they merged northwards or if they were linked by a system of E-W trending transfer faults (compare Castellarin & Picotti, 1990; Sarti et al., 1992).

Before the onset of Liassic rifting, in the future Sebino Basin area synsedimentary normal faulting involved the Upper Triassic Dolomia Principale carbonate platform, leading to the opening of intraplatform basins (the Magasa, Lumezzane and Iseo basins; Trombetta, 1992; Jadoul et al., 1992; Cassinis et al., 1994).

From the uppermost Norian, tectonic subsidence and subsequent recovery of carbonate platforms repeatedly occurred and determined the alternative deposition of shallow water platform limestones and dolomites (the carbonate platform members of the Calcare di Zu, the Dolomia a Conchodon, the upper member of the Calcare di Sedrina and the Corna Fm.) and of lagoonal marls and shales and open shelf sediments, up to the Early Sinemurian (Masetti et al., 1989; Jadoul et al., 1992; Gaetani, 1970; Gaetani et al., 1992; Cassinis, 1978). To the west of the future Botticino High, in the hanging walls of the Sebino faults or M. Maddalena Line (compare Cassinis, 1968; Sarti et al., 1992; Bertotti et al., 1993; Cassinis & Schirolli, 1995), tectonic subsidence outpaced platform recovery by the Sinemurian, with subsequent drowning to basinal conditions initiating deposition of the Medolo carbonate wedge. In contrast more eastwards, the successions of the Botticino High record shallow water sedimentation of the Corna carbonate platform up to the Early Sinemurian (Cassinis, 1968; Cassinis & Schirolli, 1995), followed by deposition of very thin and condensed pelagic sediments of Liassic to Middle Jurassic age.

The carbonate wedge of the Medolo Group (Calcare di Moltrasio to the west and Calcare di Gardone Val Trompia to the east of Lake Iseo; Calcare di Domaro; Sinemurian-Pliensbachian), consists of cherty pelagic calcilutites, calcareous turbidites and breccias in association with huge slumped masses deposited in base-of-slope environments. It documents synsedimentary tectonic activity of the marginal fault scarps. The Medolo group is more than 900 m thick in the Val Trompia depocenter (Fig. 1 and 2), and rapidly pinches out locally overstepping the basin margins (M. Cavallo, Casati & Gaetani, 1968; Botticino, Cassinis, 1968). Thinning of the whole Medolo succession to a few meters occurred also within the basin itself (Grone-M. Bronzone; M. Misma) (Fig. 3) during the Sinemurian-Pliensbachian time span, documenting the subdivision of the basin into differentially subsiding sectors bounded by minor normal faults.

Normal faulting along the basin margins lasted up to the beginning of the Toarcian (Bertotti et al., 1993) or to slightly later times (Cassinis & Schirolli, 1995). During Middle to Late Jurassic times, no synsedimentary faulting has been documented in the Sebino Basin as well as across the whole Lombardian Basin, with the exception of the Zandobbio area (Fig. 1) (Bersezio & Calcagni, 1994). The thin pelagic sediments and the redeposited units (i.e. the upper part of the Concesio Fm. in the Sebino Basin) as well as the overlaying cherts of the Selcifero Group can therefore represent the post-rift sediments (compare Winterer & Bosellini, 1981; Sarti et al., 1992; Bertotti et al., 1993; Cassinis & Schirolli, 1995).

After the Alpine orogeny, the Mesozoic succession of the Sebino Basin has been decolled from the pre-Scythian clastics and the Variscan Basement at the level of the Lower Triassic evaporites, and has been stacked in a pile of S-verging imbricates. Within this pile the Jurassic succession is preserved only in the southern tectonic units. To the west, between Lake Iseo and M. Cavallo, this succession is involved in the S-verging thrusts of the "Parautoctono delle Prealpi" (Gaetani & Jadoul, 1979; Gaetani et al., 1981; Berra et al., 1991) (Albino, M. Misma-M. Pranzà, Grone-M. Bronzone and Predore thrust sheets) and in the southern thrust-propagation folds of the Flessura Pedemontana (Desio, 1929; Schönborn, 1992) (Fig. 1 and 3). The thrust fronts are displaced by N-S trending strike-slip faults and transfer zones.

To the east of Lake Iseo the Jurassic units belong to the S and SE-vergent fold and thrust belts of the S-Giudicarie area (Castellarin et al., 1988), located south of the Val Trompia overthrust (Fig. 1). To the east of Val Trompia the regional E-W to N110 tectonic trend begins to turn into a NE-SW direction, as a consequence of interference with the South Giudicarie deformation systems (Castellarin et al., 1988).

### The Concesio Formation.

The Concesio Formation was introduced by Cassinis (1968). Previously it was called Medolo Superiore (Cacciamali, 1901), Pietre da Coti (De Alessandri, 1903), Formazione Clastica del Lago d'Iseo - Membro superiore (Vecchia, 1948), Calcari arenacei del Monte Rena (Belloni, 1958).

In the basinal domains the formation overlays the Calcare di Domaro with a sharp boundary. Towards the basin margins the Calcare di Domaro thins out and the Concesio Fm. overlays either a truncation cutting the Liassic units or the thin lateral equivalents of the Medolo Group (the Corso Fm. in the Botticino area) (Cadet, 1965; Cassinis, 1968; Boni & Cassinis, 1973; Gaetani, 1975).

In the study area the upper boundary with the overlaying radiolarites of the Selcifero Lombardo Group is either transitional or sharp (Pasquarè 1965). Locally a red marly horizon rich in pelagic bivalves occurs slightly below the formational boundary. It is partly coeval with the "Lumachella a Posidonia alpina" of the Trento Platform/Plateau (Sturani, 1971; Winterer & Bosellini, 1981).

Towards the north-east, along the Ballino-Garda escarpment, some coarse breccia and megabreccia bodies, which are associated with huge slumps and calcareous turbidites, and have been interpreted as coeval with the Concesio Fm., occur (upper part of Tofino Fm., Castellarin, 1972). They extend to the south to the

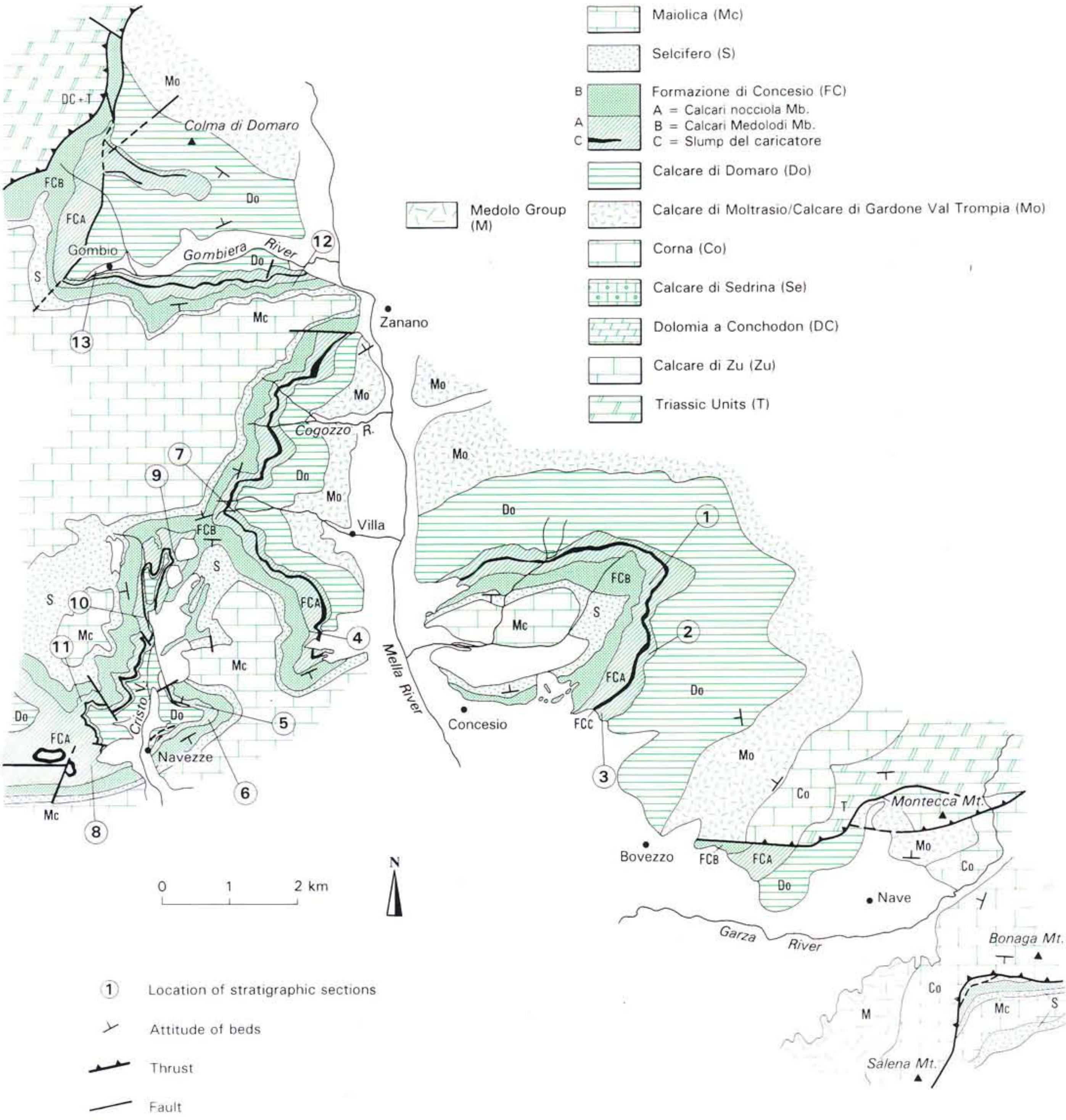


Fig. 2 - Simplified geological map of the lower Val Trompia area, based on 1:10000 mapping. The location of the measured stratigraphic logs is indicated by the circled numbers. Note the widespread occurrence of the Slump del Caricatore and its termination to the west of Lake Iseo.

northern margin of the Botticino High (Vobarno Basin, Castellarin & Picotti, 1990) (Fig. 1), and are overlain by the Navone Fm. or by the Calcari di Corlor (Castellarin, 1972; Cassinis, 1978; Castellarin & Picotti, 1990).

The Concesio Fm. consists of three members (Cassinis, 1968). The lower Calcari Nocciola Mb., 100-150 m thick, is represented by marlstones, marly limestones and calcarenites with some calcirudite layers (Cassinis, 1968; 1978). The Calcari Medoloidi Mb. follows up section. It is represented by rhythmically bedded marly-limestones with cherts (20-100 m, Cassinis, 1968, 1978). The Molvina Mb. laterally replaces the Calcari Nocciola to the east of Brescia, along the margin of the Botticino High. It is some 90 m thick (Cassinis, 1978) and consists of varicoloured marlstones and calcilutites, with some calcirudite lenses.

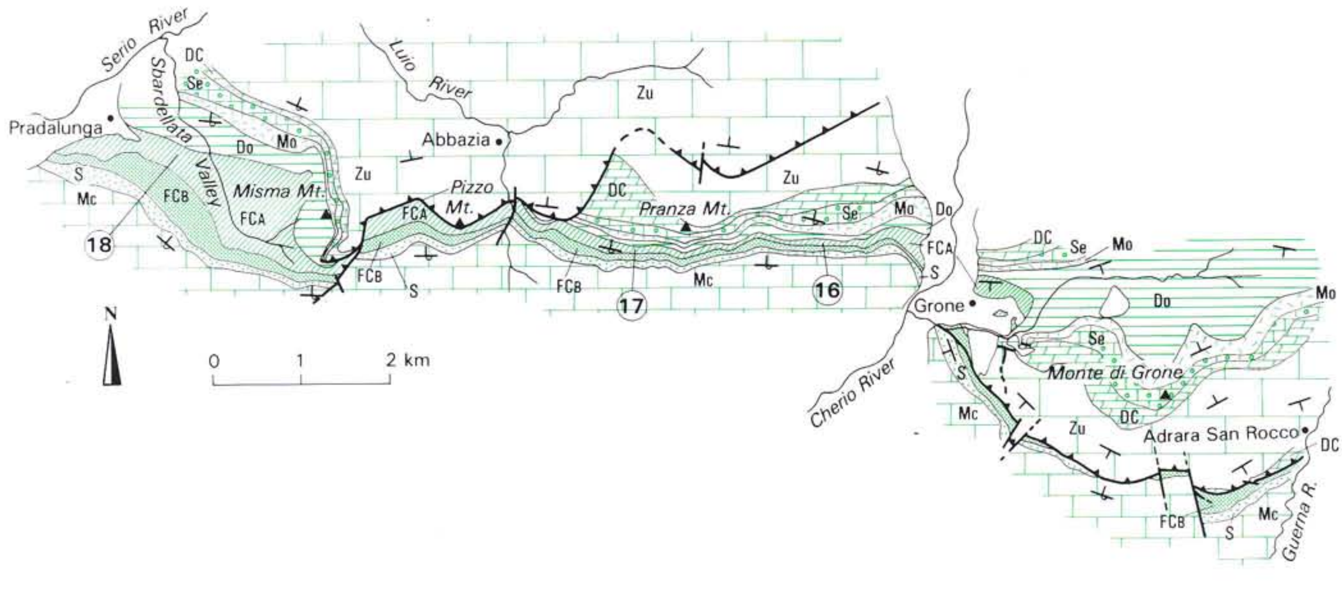


Fig. 3 - Simplified geological map of the Val Adrara-Val Seriana area, based on 1:10000 mapping. The location of the measured stratigraphic logs is indicated by the circled numbers. Same legend as in Fig. 2.

In the Botticino region Cadet (1965) reports a total thickness of 120-150 m for a succession comparable to the Molvina and Calcari Medoloidi Mbs. To the south and west of this area, in the exposures of the Zandobbio Liassic high, the Concesio Fm. pinches out (Bersezio & Calcagni, 1994), like along the margins of the Sebino Basin (M. Cavallo and Botticino) (Casati & Gaetani, 1968; Castellarin & Picotti, 1990). In the Po plain subsurface, the thickness of the Toarcian-Callovian unit is about 50 m (Malossa well; Errico et al., 1978).

Based on ammonite biostratigraphy, the base of the Formation has been attributed to the Lower Toarcian (*Dactylioceras tenuicostatum* zone) in the Val Trompia region (Cassinis, 1968, 1978; Montanari, 1974; Cantaluppi & Cassinis, 1984, Cobianchi, 1992; Schirolli, 1994; Cassinis & Schirolli, 1995). A post-Domerian age is suggested by the presence of Domerian Ammonites in the uppermost Calcare di Domaro in the Val Seriana area (Desio & Airaghi, 1934). A Bajocian, or even slightly younger age (Callovian) is generally attributed to the top of the Concesio Fm. (Vecchia, 1948; Pasquarè, 1965; Cassinis, 1968, 1978; Cassinis & Schirolli, 1995).

The Formation is characterised by the abundance of displaced shallow water bioclasts and grains, suggesting feeding from a nearby and probably contemporaneous carbonate platform (Boni & Cassinis, 1973; Gaetani, 1975; Cassinis, 1978). Provenance from the adjacent Trento Platform (e.g. Winterer & Bosellini, 1981) or from a less distant southern source (Zandobbio area, Gaetani, 1975) have been suggested.

The best exposures of the Concesio Fm. are located in the area west of Botticino, that is in the study area (Fig. 1), where the formation consists of the Calcari Nocciola and Calcari Medoloidi members. The following description therefore mostly refers to these members while a description of the Molvina Member can be found in Cassinis (1968).

Across the study area the Concesio Fm. belongs to different thrusted units.

East of Lake Iseo the outcrops occur in several tectonic slices. Starting from the south-eastern and lower units and moving to the north-western and upper ones they are: the Botticino-Serle folds, the overlying M. Salena-M. Bonaga thrust sheet, the Bovezzo - M. Montecca thrusted unit and the lower Val Trompia folds in the footwall of the M. Tesoro-Punta dell'Orto thrust sheet (Fig. 1 and 2).

To the west of lake Iseo (Fig. 1 and 3) outcrops are present in the Predore thrust sheet and in the fold belt in the footwall of the M. Bronzone-M. Pranzà overthrust, in the Selvino graben that belongs to the Albino thrust sheet and in the Lonno fold zone in the footwall of this thrust, and finally in the southernmost Zandobbio ramp anticline.

Due to the tectonic distortion of the original geometries a true cross section across the depositional basin of the Concesio Fm. cannot be proposed because it is unknown to which extent the different elements have been displaced in a N-S direction. Nevertheless paleocurrent data are consistent across the study area. Therefore the position of the stratigraphic sections belonging to different tectonic units in the correlation scheme of Fig. 4 reflects more or less their original distances from the (south-) eastern and (north-) western basin margins, while their relative positions in the (present-day) N-S direction is uncertain.

## Lithostratigraphy

West of the Botticino area, field correlation allowed to recognise a succession of five lithozones in the Concesio Fm. (Fig. 4). The lower lithozones 1-3 roughly belong to the Calcari Nocciola Mb., while the upper lithozones 4-5 belong to the Calcari Medoloidi Mb. The two members consist of pelagic-hemipelagic and redeposited facies (mainly turbiditic, associated with other gravity flow deposits, like slumps, slides, pebbly mudstones and breccias). The facies association of the Molvina Mb. is quite different, consisting mostly of pelagic calcilutites and marlstones. In its lower part the Molvina Mb. contains some coarse-grained beds, coeval with analogous strata belonging to lithozones 2 and 3 of the Calcari Nocciola Mb.

### The Calcari Nocciola Member (lithozones 1-3).

On a regional scale, this unit shows a lenticular geometry, with its maximum total thickness of about 300 m in the Lake Iseo area (Viadanica section, Fig. 4). In the eastern Botticino area (Serle syncline, Cassinis, 1968) the Calcari Nocciola gradually pinches out. To the west the member abruptly onlaps the steep eastern margin of the M. Cavallo high (Olera section, Fig. 4).

In the complete sections the lower boundary is a sharp surface at the top of the Calcare di Domaro, which is overlain by the marlstones of lithozone 1. Close to the basin margins (Pradalunga, Bedolè sections, Fig. 4) the uppermost Calcare di Domaro contains huge slumped bodies, mostly consisting of intraformational slope materials and some clasts from the older Liassic units.

The upper boundary of the Calcari Nocciola Mb. is represented by transition from marlstones of the uppermost lithozone 3 to the overlaying cherty limestones of lithozone 4.

Everywhere in lower Val Trompia the member shows traces of hydrocarbons, probably migrated from the Triassic source rocks.

Lithozone 1. The lower lithozone of the Concesio Fm. generally consists of grey to light brown marlstones

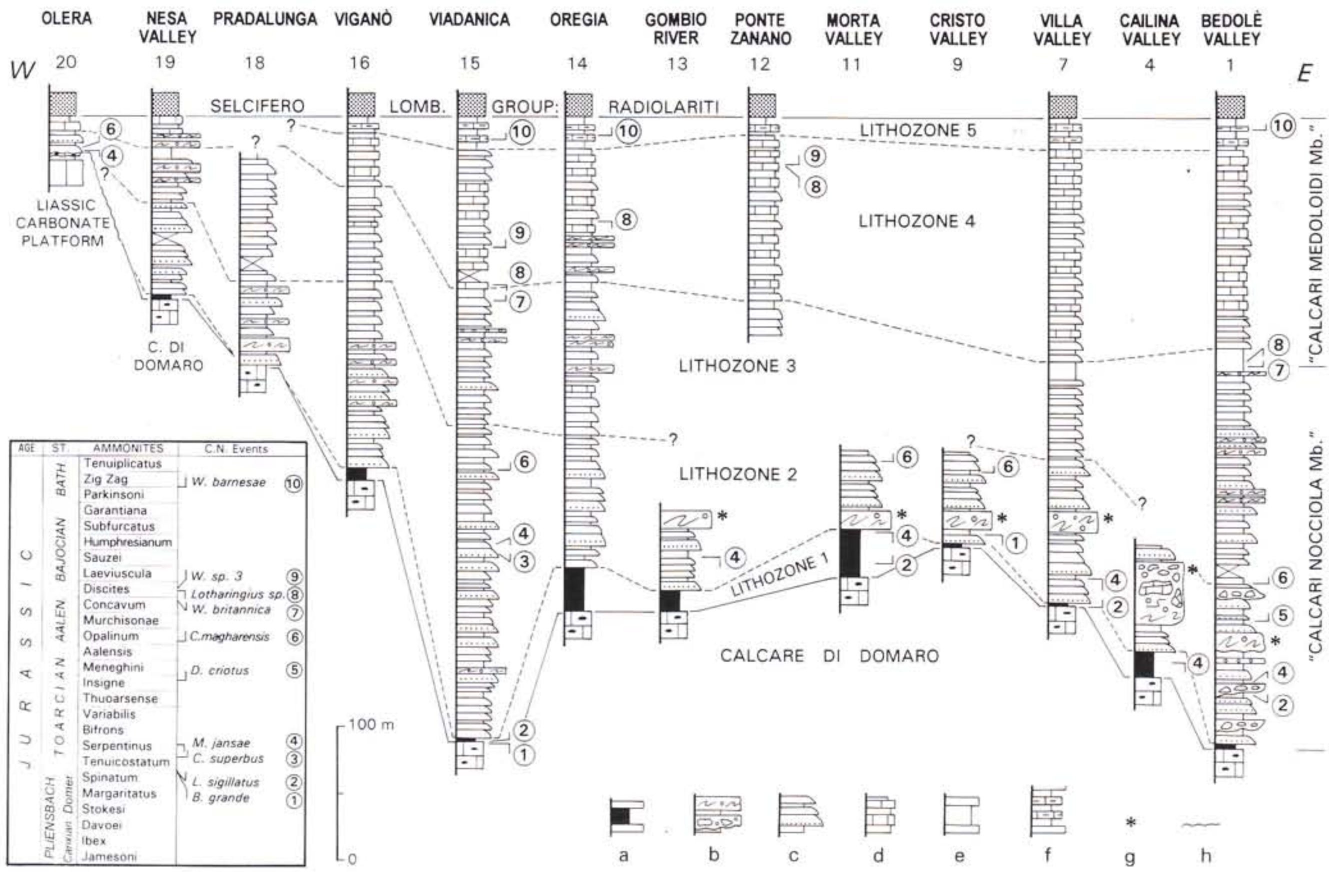


Fig. 4 - Stratigraphic correlation scheme, based on 13 selected measured sections. Lithostratigraphic correlation as well as biostratigraphic data are shown. Location of logs is in Fig. 1, 2 and 3. Legend: a) facies association of lithozone 1 (hemipelagic marlstones and marly turbidites); b) disorganised or graded calcirudites (below) and slumps (above); c) coarse-grained (below) to fine-grained (above) calcareous redeposited strata, in association with hemipelagic marlstones; d) pelagic-hemipelagic marlstones and limestones; e) pelagic and turbiditic marls and silty marlstones of the uppermost part of lithozone 3; f) facies association of lithozone 5 (thin bedded pelagic marlstones); g) Slump del Caricatore marker bed; h) unconformity. The calcareous nannofossils events are indicated by circled numbers (1-10).

and marly limestones. The contact with the underlying calcilutites of the Calcare di Domaro is abrupt, suggesting the existence of a paraconformity whose hiatus is below biostratigraphic resolution. Thickness of the lithozone varies between 0 and 35 m (Valle Morta and Pradalunga sections, Fig. 4). The lithozone is absent in the westernmost sections (Olera, Fig. 4) due to onlap termination and in the M. Misma area, where the Domaro-Concesio boundary is marked by the presence of slumps and thick beds of resedimented, oolitic-crinoidal calcarenites.

In the thinner successions the lithozone consists of crudely stratified and burrowed hemipelagic marlstones and marly limestones, devoid of clastic intercalations. Sometimes the marlstones are red and show a pseudo-nodular texture, like in the Grone-M.Pranzà area (Fig. 3) where ammonoids have been found (Vecchia, 1948).

In contrast in the thicker successions fine-grained turbidites grade up from a lower marly hemipelagic unit. The turbidites consist of thin to medium-bedded, frequently lenticular strata of very fine grained calcarenites, graded to parallel laminated. The presence of a distinct marker-bed and biostratigraphic calibration (see below) document a heteropy between this upper part of lithozone 1 and the lower part of lithozone 2, in the central Val Trompia outcrops (Fig. 2; Bedolè, Villa and Cristo sections, Fig. 4 and 5) and in the Lake Iseo area (Viadanica, Viganò sections, Fig. 4 and 6).

Lithozone 2. This is the coarsest lithozone of the Concesio Fm. Its maximum thickness is about 235 m in the Viadanica area (Fig. 4) from where the unit wedges out towards the basin margins. The lithozone shows distinct facies variations from east to west, along the belt of outcrops.

Towards the Botticino eastern margin (M. Bonaga-M. Salena, Fig. 2), lithozone 2 is represented by some lenticular calcirudite beds, up to 1 m thick, eroding grey-brown to green and red marlstones that possibly belong to the lower part of the Molvina Member.

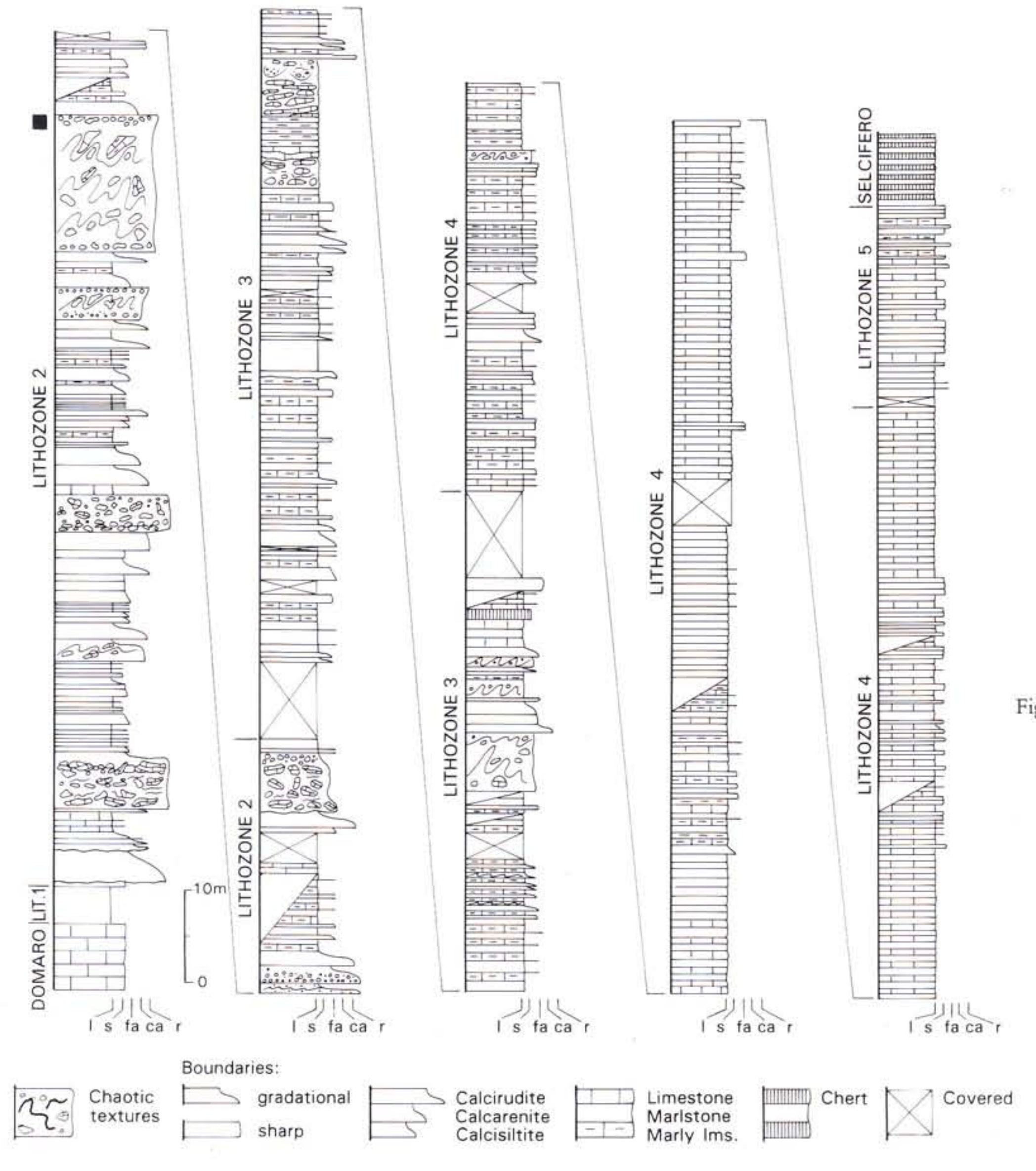


Fig. 5 - Facies sequences of the Val Bedolè section (location in Fig. 1 and 3). Grain size scale: l = lutite, s = siltite, fa = fine arenite, ca = coarse arenite, r = rudite. The black square on the left indicates the Slump del Caricatore marker bed. The partly unexposed intervals are unornamented on the left side of the log. See the text for discussion.

Moving westwards the succession thickens progressively. In the Val Trompia region (Fig. 4, sections 1-12) the typical coarse-grained facies association can be observed (Fig. 5). It consists of lenticular bodies, that are formed, from bottom to top, by disorganised, coarse calcirudites, that grade up into first massive, then laminated calcarenites, covered by marlstones. Clasts, up to dm-size, are mostly lithoclasts of the older Mesozoic succession, intraclasts, bioclasts, with a high percentage of shallow water taxa, ooids and oncoids (individual or in aggregates and clasts). Through all this succession the sand-sized divisions and the bioclasts are frequently silicified.

These sediments usually form thinning and fining upwards sequences, up to 16 m thick (Fig. 5), that are vertically stacked and laterally cut across older ones at the scale of some hundred meters. The fining upwards sequences are separated by packages of thin-bedded and medium to coarse-grained calcarenites, alternating with hemipelagic marlstones and calcilutites. The coarse and lenticular units get less and less abundant up section. Consequently the upper part of lithozone 2 mostly consists of turbiditic calcarenites rarely characterised by lenticular geometries at the outcrops' scale.

Paleocurrent directions (Fig. 7) have been obtained in turbidites and current deposited beds from sole marks, imbrication of bioclasts, alignment of echinoid spines and attitude of frontal laminae in sets of tabular cross-beds. They document a provenance from the ESE to SSE in present-day co-ordinates, and indicate that the belt of outcrops is arranged along the general current direction, with only a partial cross-section in Val Trompia. Minor indications of provenance from the NW have been also found in the central part of the study area.

A huge slide-slump body is interbedded within lithozone 2 (Slump del Caricatore, Cantaluppi & Cassinis, 1984). It consists of meter-sized blocks, forming a megabreccia interval, followed up section by a pebbly mudstone with a fluidal matrix of marlstone or calcilutite, then by a graded calcirudite-calcarenite (Fig. 5). This unit was emplaced during several individual sliding and slumping episodes and represents a marker bed, that has been mapped across the whole lower Val Trompia. It pinches out less than 4 km east of lake Iseo and in the southernmost and northernmost outcrops of Val Trompia (Figs 2, 3 and 4). Below this marker, the lowermost channelized bodies of lithozone 2 interfinger with and fringe out within the marlstones of lithozone 1.

Moving down current to the western area (Oregia, Viadanica sections, Fig. 4) lithozone 2 reaches its maximum thickness. In this area the channelized calcirudite beds become rare and more fine grained than in the eastern area. The facies sequences of the Viadanica area (Fig. 6) are typical for this region. Fining and thinning upwards sequences can be recognised in the lower part of the lithozone only. These sequences are sometimes based by up to 4 m thick beds of fine calcirudites that rapidly grade into calcarenites, and sometimes show almost complete Bouma sequences. At the outcrop scale the fining upwards bodies show a sheet-like shape. They are be separated from each other by marlstone-shale intervals or by thin bedded, turbiditic calcarenites. Thickening upwards sequences formed by parallel-bedded sets of strata at a metric scale and characterised by base-incomplete turbidites have been also observed (Fig. 6).

Slumps and rare lenticular breccia bodies rarely occur in the lower and upper parts of the unit in the Viadanica-Oregia area.

In the westernmost M. Misma-Pradalunga area, lithozone 2 generally represents the base of the Concesio Fm. It is separated from the underlying Domaro Fm. by the presence of slumps, that are followed upwards by graded, very coarse calcarenites, mostly composed of ooids, echinoid and crinoid fragments and other bioclasts, with a minor proportion of lithoclasts. Paleocurrent indicators at the base of these beds suggest a possible northern sediment source.

Towards the western termination of the Concesio Fm., lithozone 2 laps out rapidly, and doesn't reach the westernmost outcrops near M. Cavallo (Olera section, Fig. 4). Before wedging out the lithozone is represented by fine-grained and very thick-bedded turbiditic calcarenite strata, generally grading upwards into thick marlstone divisions.

Lithozone 3. The total thickness of lithozone 3 ranges between 15 and 120 m, with the maximum value in the Iseo region (Oregia, Viadanica sections, Fig. 4). Towards the west the lithozone corresponds to a very thin (15 m) and almost completely silicified succession of fine to medium grained turbiditic calcarenites, that laps onto the shallow water Liassic units of the M.Cavallo high.

Lithozone 3 mostly consists of medium to fine-grained calcarenites that form parallel-bedded, graded to laminated strata, sometimes showing base-incomplete Bouma sequences, capped by marlstone divisions up to 50 cm thick. Completely silicified strata and/or strata sets are frequent, and concentrate in the upper part of the lithozone; chert nodules and lenses are abundant in the calcarenites. Calcirudite beds are very rare to absent, while intraformational slumps and pebbly mudstones occur in the upper part of the unit (Fig. 5 and 6).

Near the top of the lithozone the turbiditic calcarenites progressively disappear and are replaced by grey to olive-green and brown marlstones, burrowed to parallel laminated, that form medium strata separated by thin to medium, parallel-bedded silty marlstones, sometimes

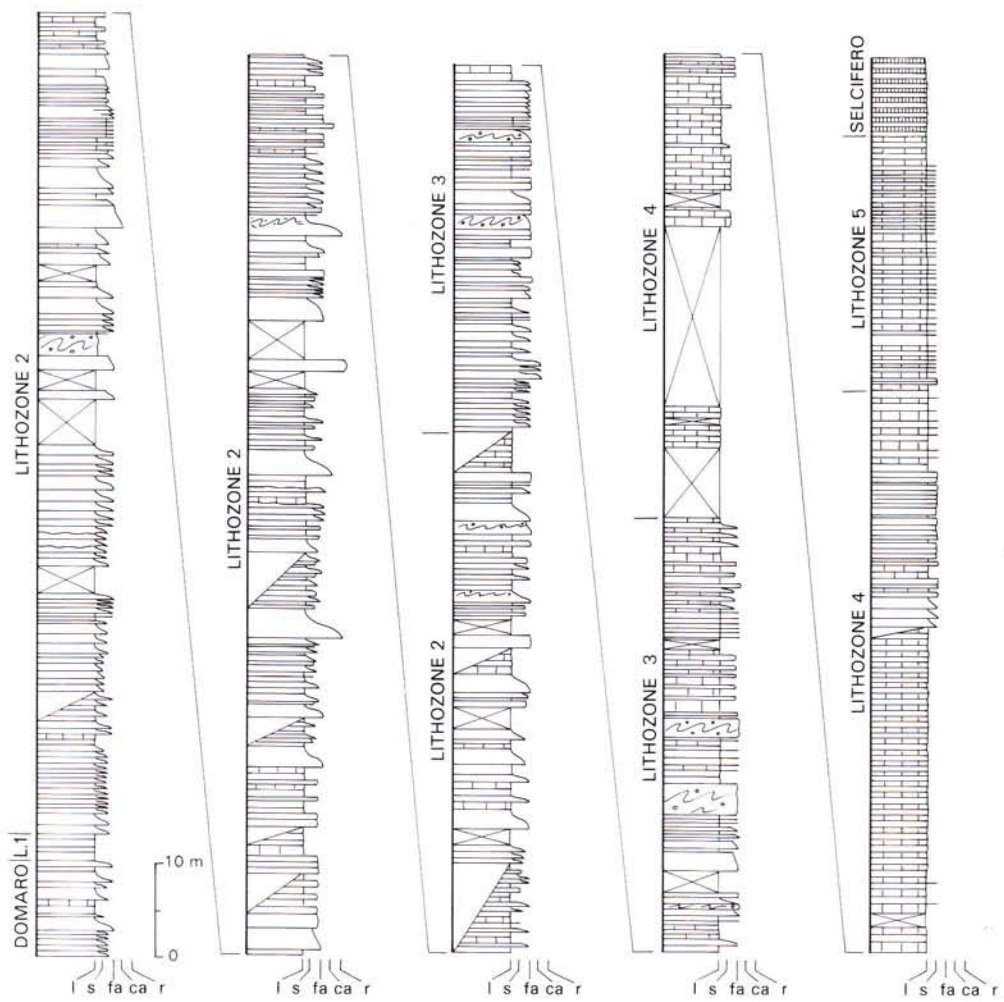


Fig. 6 - Facies sequences of the Viadanica section. Location in Fig. 1. Grain size scale and legend are the same of Fig. 5. See the text for discussion.

graded and parallel-laminated. This interval, up to 25 m thick, is best recognisable in the Val Trompia area, and corresponds to a marlstone-rich transitional boundary between lithozones 3 and 4, in the area west of Lake Iseo (Fig. 4).

The turbiditic beds of lithozone 3 form 2-10 m thick strata sets, which are separated by m-thick hemipelagic marlstone units. In the Val Trompia area the vertical stacking patterns consist of thick intervals, characterised by an acyclical arrangement of alternating turbiditic calcarenites and hemipelagic marls (Fig. 5), associated with some parallel-bedded groups of strata that form thinning and fining upwards sequences. Moving down current, towards Lake Iseo and the westernmost areas, the acyclical stacking of strata prevails, but some parallel-bedded groups of strata form thickening and fining upwards sequences (Fig. 6). Paleocurrent trends in this lithozone are comparable to those obtained from lithozone 2, suggesting a SSE and ESE provenance.

### The Calcari Medoloidi Member (lithozones 4-5).

This member is characterised by its wedge shape; its maximum thickness is about 170 m in the eastern area. The Calcari Medoloidi Mb. gradually thins and pinches-out west- and southwards. In the Botticino region the member is partly replaced by the upper part of the Molvina member, while in the northern outcrops of the Garda area it is partly coeval with the crinoidal limestones rich of pelagic bivalves of the Calcari di Corlor (Boni & Cassinis, 1973) and with the cherty calcilutites of the Navone Fm. (Cassinis, 1978). In the study area the lower boundary of this member is transitional. The upper boundary with the Selcifero Lombardo Group is either transitional or sharp, in the latter case suggesting the possible existence of a paraconformity, whose hiatus is unknown because the base of the radiolarites of the Selcifero is not dated across most of the Lombardian Basin.

Lithozone 4. This lithozone represents the major part of the Calcari Medoloidi across the study area. It consists of an irregular alternance of cherty calcilutites, marlstones and fine calcarenites-calcisiltites. Intraformational slumps and pebbly mudstones occur in this unit, west of Lake Iseo (Oregia and Nesa Valley sections, Fig. 4). The calcarenites are thin to medium, parallel-bedded strata, occurring frequently near the lower transitional boundary and in the lower part of the lithozone. They also form some strata sets in the upper part. These beds rarely showing a graded base, are generally parallel-laminated in the upper part. Compositionally they consist of radiolarian molds, pelagic bivalve fragments, sponge spicules and crinoid bioclasts, therefore differing from the arenites of the lower member. The light grey, cherty calcilutites form parallel-bedded, medium strata, in which bioturbation is frequent and chert nodules are abundant. These pelagic strata alternate with grey to olive green hemipelagic marlstones, parallel-laminated to burrowed, forming cm-thick interbeds or dm-m-thick units.

In the western part of the study area the lower part of the lithozone consists of turbiditic, fine calcarenites-calcisiltites, in association with marlstones and rare calcilutites. The marlstone layers and interbeds progressively disappear upwards. The upper part of the unit therefore consists of calcilutite layers, sometimes bundled in sets of 3 to 5 beds, associated with scattered turbiditic beds or bed-sets. West of Lake Iseo, the uppermost interval of the lithozone is completely silicified, resulting in a group of brown to pink chert layers. In the same area the overall thinning of the lithozone is due to a more pronounced reduction in thickness of the lower turbiditic and marly interval than of the upper pelagic one.

Lithozone 5. This lithozone represents the uppermost 15-25 m of the Concesio Fm., east of the M.Misma-Viganò area (Fig. 3 and 4). Where the lithozone is present, red marlstones form a 6-11 m thick key-horizon, generally located 2-4 m below the Concesio-Selcifero Lombardo boundary. This horizon at places consists of two red units separated by a grey calcilutite-marlstone interval. The marlstones and marly limestones contain pelagic bivalves, crinoid fragments, belemnites and radiolarians, sometimes concentrated in pockets and laminae. The marlstone beds are generally separated by sharp, oxidized surfaces, where belemnites and bioclasts are concentrated and oriented, suggesting current reworking and reduction of sedimentation rate. Some nodular, dm-thick beds are also typical of this interval.

## Biostratigraphy

The biostratigraphic analysis, based on calcareous nannofossils, has been performed on more than two hundred samples. The obtained biostratigraphic subdivision is preliminary because few sections only yielded good biostratigraphic data; others contained scattered and badly preserved nannofossil assemblages.

Nevertheless, it has been possible to record some of the already established bioevents (Fig. 4) (Bown, 1987; Cobianchi, 1992; Reale et al., 1991). Of these bioevents, FO of *Lotharingius sigillatus*, FO of *Carinolithus superbus*, LO of *Mitrolithus jansae*, FO of *Carinolithus magharensis*, FO of *Watznaueria britannica*, LO of *Lotharingius* sp., FO of *Watznaueria* sp. 3 and FO of *Watznaueria barnesae*, are consistent throughout the study area, despite the heavy diagenetic overprint which deleted the solution-prone coccoliths.

Several of the biostratigraphic markers well established for the middle Jurassic were not recorded in some of the studied sections, because of the poor preservation of the nannofossil assemblages. Other bioevents, such as LO of *Biscutum grande* and FO of *Discorhabdus criotus*, are not consistent throughout the study area, mainly because of low abundance and bad preservation of the assemblages. Therefore the preservation of the nannofossil assemblages conditions the biostratigraphic resolution in the Concesio Formation, which is lower than in better preserved coeval material.

The biostratigraphic criteria adopted take into account the material preservation and the depositional patterns (frequent turbiditic events) of the sediments. They are:

1) use of the FO, that minimise the importance of redeposition (this pattern could extend considerably the distribution interval of the markers, particularly towards younger terms);

2) use of solution and overgrowth resistant species, easy to detect even in samples with a heavy diagenetic overprint, to establish reliable bioevents.

The direct calibration of the nannofossil bioevents to ammonite biostratigraphy was not attempted in the studied sections, because none of them yielded ammonites. Calibration was therefore based on the available literature. Taking into account that in the Boreal realm calcareous nannofossils bioevents are slightly younger than in Mediterranean areas (the former Tethys Ocean), because of the now well established provinciality (Bown, 1987), we based our correlation mainly on data from the Southern Alps (Erba, 1990; Cobianchi, 1992) and from the Apennines (Young et al., 1986; Reale et al., 1991).

The ages assigned to the biostratigraphic events used in this work are as follows:

1) LO *B. grande*: Spinatum Z., Late Pliensbachian (Bown,1987);

2) FO *L. sigillatus*: Tenuicostatum Z., Early Toarcian (Cobianchi, 1992);

3) FO *C. superbus*: Tenuicostatum Z., Early Toarcian (Mattioli, 1995);

4) LO *M. jansae*: Serpentinus Z., Early Toarcian (Reale et al., 1991; Cobianchi, 1992);

5) FO *D. criotus*, Insigne Z., Late Toarcian (Mattioli, 1995);

6) FO *C. magharensis*, Opalinum Z., Early Aalenian (Reale et al:, 1991; Cobianchi, 1992);

7) FO *W. britannica*, Concavum Z., Late Aalenian (Reale et al., 1991; Cobianchi, 1992);

8) LO "early" *Lotharingius* sp. (*L.sigillatus, L.velatus, L.barozi*), Discites Z., Early Bajocian (Cobianchi, 1992);

9) FO *Watznaueria* sp. 3, Discites Z., Early Bajocian (Erba, 1990; Cobianchi et al., 1992; Cobianchi, 1992);

10) FO *W. barnesae*, Zig Zag Z., Early Bathonian (Erba, 1990; Cobianchi et al., 1992).

#### Age of the Concesio depositional events.

From the recorded bioevents and their calibration, it has been possible to date the major depositional events, the facies variations and the lithozones of the Concesio Formation through the Toarcian-Bathonian time interval (Fig. 4).

The lower part of the formation, overlying the Calcare di Domaro, is Early Toarcian in age across the entire study area. In the eastern sections (Bedolè, Cailina and Villa valley sections, Fig. 4) the Pliensbachian-Toarcian boundary is not well constrained. Nevertheless the occurrence of *L. sigillatus* just above the base of the Concesio Formation indicates an Early Toarcian age, in agreement with previous ammonite and nannofossil biostratigraphic data from adjacent areas (Cantaluppi & Cassinis, 1984; Cobianchi, 1992). In the westernmost section of Olera (Fig. 4) the lower formational boundary is represented by lithozone 3 directly overlying the Domaro Limestone, and is dated as Early Aalenian because of the presence of *C. magharensis* in the first calcarenitic bed. It is noteworthy that few centimetres below the contact, the underlying Domaro Limestone contains a nannofossil assemblage rich in *M. jansae*, that makes it Pliensbachian in age; this datum confirms the onlap relationship of the here incomplete Concesio Fm. onto the dramatically reduced (less than 1m) Calcare di Domaro.

The marker bed represented by the Slump del Caricatore in the Val Trompia area can be attributed to the Early Toarcian. Lithozone 1 and the lower part of lithozone 2 (below the marker bed where present) are of the same age, according to the recorded bioevents; in particular, the LO of *M. jansae* always occurs below the marker bed (Gombio river, Morta valley, Villa valley, Cailina valley and Bedolè valley sections). This datum allows to correlate this part of the succession with the lower part of lithozone 2 in the more western Viadanica section, where the marker bed is absent. Sedimentation patterns typical of lithozone 2 continue above the slump, until the Toarcian-Aalenian boundary (Bedolè valley and Viadanica sections, Fig. 4, where the lithozone 2-lithozone 3 transition is slightly above the FO of *C. magharensis*).

Lithozone 4 can be dated as Bajocian through the entire area, according to the first occurrence of *W. britannica*. Finally, on the base of the FO of *W. barneasae*, the upper part of lithozone 5 has been attributed to the Lower Bathonian. The upper boundary of the Concesio Formation could not be dated due to absence of nannofossils in the exclusively cherty and clayey lithologies of the overlaying radiolarites of the Selcifero Lombardo Group.

### Geometry and evolution of the Concesio turbiditic units

#### Basin geometry within the Alpine thrusts.

As it was previously shown, the different outcrops of the Concesio Formation are at present scattered across several Alpine thrust sheets. Their palinspastic restoration would imply kinematic inversion of the thrust movements along the Flessura Pedemontana, "Parautoctono delle Prealpi" and Orobic thrust systems (Gaetani & Jadoul, 1979; Bersezio et al., 1992; Schönborn, 1992, with references therein). Several attempts, involving contrasting kinematic solutions and different assumptions about the amount of shortening within the different thrust systems, have been presented up to date (Schönborn, 1992; Castellarin et al., 1988, 1992; Castellarin & Picotti, 1990; Doglioni & Bosellini, 1988). Unfortunately these attempts don't allow a reliable and well constrained reconstruction of the shape of the Jurassic Sebino Basin. The same degree of uncertainty affects the determination of the position of the depositional area of the Concesio Formation with respect to the Trento plateau during Jurassic time. For example in Schönborn's (1992) palinspastic reconstructions the sector west of the Giudicarie Line is restored about 80 km to the north of its present position, taking fixed the position of the Trento plateau area, while different amounts of shortening were proposed by Doglioni & Bosellini (1988) and Castellarin et al. (1992).

Bearing in mind these limitations an attempt to constrain the geometry of the Concesio depositional basin can be proposed.

The basin was ESE-WNW elongated, in the present-day co-ordinates, as suggested by paleocurrent data in the turbidite units (Fig. 7).

The southern and western basin margins are preserved in the Zandobbio and M. Cavallo areas only, where onlap terminations above the tectonic margins of the mentioned Early Liassic structural highs are exposed.

The northern basin margin has not been preserved. The available information from the northernmost outcrops of the western area (Selvino, Fig. 7), document

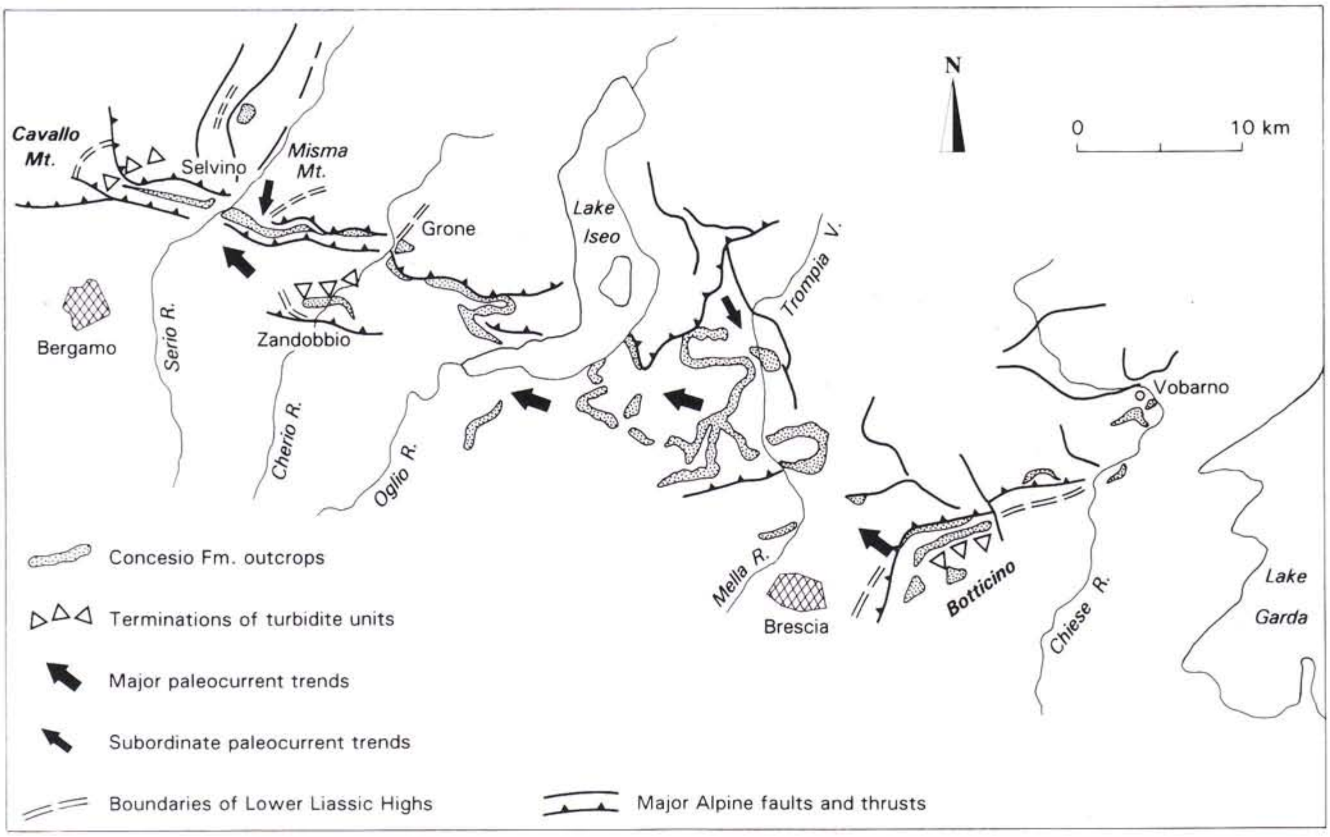


Fig. 7 - Occurrence of the Concesio Formation unit across the Sebino Basin. The lateral terminations of the turbidite lithosomes and their paleocurrent trends, are shown in the present-day configuration of outcrops. Note that palinspastic reconstruction would restore the Concesio Fm. several kms north of the present-day position of Lake Garda. Both the Vobarno and the Botticino regions could have been located up current with respect to the channelized part of the Calcari Nocciola turbidite unit.

thinning of the whole succession and a facies assemblage very similar to that of the M. Cavallo onlap. In contrast, to the east of Lake Iseo (M. Domaro), the northernmost exposures show only a limited thickness reduction, in association with a wedging out of the Middle Toarcian Slump del Caricatore and of the major ruditic bodies. From these observations a regional termination of the turbiditic unit to the north can be only inferred.

Along the eastern boundary of the Concesio basin, a physical correlation between the Val Trompia successions and the Botticino High area is not possible. In the western Botticino, scattered rudite and arenite lenses of Toarcian age are intercalated between hemipelagic marlstones. These beds terminate south-eastwards, i.e. up current, where the pelagic-hemipelagic facies of the Molvina and Calcari Medoloidi members (Cassinis, 1968, 1978) are dominant. Farther east the entire Concesio Fm. thins to a few meters, documenting the position of the eastern basin margin.

The overall thickness of the Concesio Fm. is relatively constant. This fact suggests that the Toarcian-Aalenian turbidites were able to smooth the older intrabasinal relief (e.g. M. Misma, Grone, M. Bronzone) associated with minor intrabasinal faults, possibly antithetic to the marginal master faults.

**Evolution of the Toarcian-Aalenian and Bajocian turbidite units.**

The stratigraphic description documents that the Calcari Nocciola and the Calcari Medoloidi members of the Concesio Fm. represent two different turbiditic units, separated by a marly hemipelagic interval at the Aalenian-Bajocian boundary, and characterised by different compositions of their clastic content.

The Calcari Nocciola platform-derived turbidites. Paleocurrent directions, facies trends, composition of sediment and biostratigraphy, indicate that the lower turbiditic unit of the Concesio Fm. spread from ESE to WNW in present-day co-ordinates (Fig. 7), during the Early Toarcian-Late Aalenian time span. It was fed mostly by a carbonate platform margin located to the SE, and by the basin-margin slopes.

A regional facies transition occurs down current, from the south-eastern slope, characterised by the hemipelagic facies association of the Molvina Mb. (Cassinis, 1968) in the Botticino-Serle area, to the more western base-of-slope deposits. The latter are represented by ruditic-arenitic turbidites, filling channels which had been cut into hemipelagic marls (interfingering lithozones 1 and 2, Val Trompia). Farther west (Iseo-Serio), where the channelized units are progressively replaced by tabular sedimentary bodies that sometimes show thickening upwards sequences (lithozone 2), the sedimentary patterns suggest redeposition over a wider area. In this western depocentre most of the sand-sized sediment was deposited, forming sheet-like units similar to the depositional lobes of the siliciclastic turbidite systems (Walker, 1978; Mutti, 1992, with references). The calcarenites of this member consist of limestone lithoclasts together with intraclasts, mixed shallow water and pelagic biota, ooids and aggregate grains, suggesting erosion of the Mesozoic (upper Triassic and Liassic) substratum and of a nearby carbonate platform.

In the south-eastern base-of-slope area, the Lower Toarcian slide-slump body (Slump del Caricatore), that spread over an area of at least 100 km$^2$, is intercalated into the channelized succession of lithozone 2. Its terminations towards north, south and west and the occurrence of vertical and lateral facies transitions from megabreccia to pebbly mudstone, suggest a provenance from the south or south-east. Taking into account their compositional similarities, a common source area can be suggested for the Slump del Caricatore and the channelized rudites of lithozone 2. Mixing of boulders and clasts from the underlying Liassic pelagites and turbidites (Medolo Group), older platform carbonates (Corna and Zu Fms.) and possibly coeval shallow water fossils and grains, points to sliding from a tectonically active slope exposing the Rhaetian-Liassic succession up to the Medolo basinal sediments. Intraformational slumps, devoid of platform clasts, are present also in the underlying uppermost Domaro Fm. (Upper Pliensbachian) of the Val Trompia area, suggesting that destabilization and erosion retrogressed along the upper slope from the Pliensbachian to the Toarcian. Considering that the emplacement of the Slump del Caricatore does not correlate with a regional variation of the sedimentation patterns, a tectonic triggering is suggested for this event.

The Aalenian part of the Calcari Nocciola turbidite unit (lithozone 3) is characterised by fine-grained arenitic turbidites, that either form positive sequences, or are acyclically stacked in a basin plain facies association; they are followed up section by a marlstone unit consisting of hemipelagites with muddy turbidites, that marks the end of platform-derived calcareous resedimentation throughout the Sebino Basin close to the Aalenian-Bajocian boundary. This evolution is underlined also by the composition of the turbidites of lithozone 3, which typically contain more intraclasts and pelagic biota than the underlying ones. The presence of some slumps in the upper part of the Calcari Nocciola can be at present explained only by slumping from local sources close to the western marginal area (M. Cavallo structural high and adjacents).

By the vertical stacking of lithozones 1-3, the Calcari Nocciola form a thinning and fining upward sequence. Ruditic channel fills in the lower part and in a proximal position are replaced upwards and basinwards by sheet-like bodies of arenitic turbidites in fining and/or thickening upwards sequences, comparable to depositional lobe units, then by a basin-plain facies association. This kind of architecture is typical of successions deposited in the carbonate base-of-slope settings (Mullins & Cook, 1986; Eberli, 1987), controlled by synsedimentary sliding and slumping from the upper slope and platform margin. The presence of huge mass gravity deposits and the redeposition of older Mesozoic clasts mixed with platform-derived grains suggests that syndepositional tectonic activity could have triggered the sediment gravity flows. Volume and graine-size of the gravity-driven sediments decrease upwards; it could be a consequence of retrogressive sliding in the source area, related to ongoing and vanishing extensional faulting along the eastern boundary of the Sebino Basin.

If the present-day relative positions of the Val Trompia and Botticino areas mirror, at least to some extent, their Jurassic physical relationships, then the reduced sequence of the Botticino High would represent the bypass middle slope across which the gravity flows and the catastrophic mass movements, fed by the faulted platform margin, reached the Sebino Basin to the west. Whether the adjacent platform was the northern or southern part of the Trento High, or another, is unclear yet, mostly depending on the palinspastic restoration of the Alpine thrusts.

**The Calcari Medoloidi pelagic turbidites.** Throughout the whole outcrop area the Calcari Medoloidi unit is characterised by the association of pelagic turbidites with pelagic-hemipelagic marlstones and calcilutites. The sheet-like pelagic turbidite units mostly occur in the lower part of the member (lithozone 4). This typical basin-plain facies association developed starting from the Aalenian-Bajocian boundary, after recession of the underlying turbidite unit, marking the onset of redeposition from a pelagic plateau, from which the turbidites bearing pelagic bivalves have been supplied. During the same time, in the western Venetian platform area, packstones and grainstones rich of pelagic bivalves became widespread (Lumachella a *Posidonia alpina*, Sturani, 1971) draping a regional hard-ground surface. A correlation between these two events has been already proposed (Winterer & Bosellini, 1981) but was not documented yet.

Slumps have been found in the lower part of the member. Their occurrence is again attributed to redeposition from the western M. Cavallo and possibly other (northern?) structural highs.

Turbidite beds become progressively more fine-grained and rare up section, and are replaced by pelagic cherty limestones, that are pervasively silicified. These features document a pronounced drop of the sedimentation rate, concurrent with the development of reddish, condensed and current-reworked horizons (lithozone 5) that could extend up to the Lower Bathonian. This event, that predates the transition to the siliceous pelagites of the Selcifero Group, is interpreted as a response to the drowning of the Trento plateau and to regional deepening of the basin floor, after the end of normal faulting.

## Conclusions

1) The Concesio Fm. consists of two different turbidite units that spread during the Early Toarcian-Bajocian time, from ESE to WNW across the Sebino Basin. The end of turbidite sedimentation is marked by a starved and current-reworked interval possibly of Early Bathonian age, predating the deposition of the radiolarites of the Selcifero Group. The two turbiditic units, roughly corresponding to the Calcari Nocciola and Calcari Medoloidi members of Cassinis (1968), are separated by an interval of basinwide occurring hemipelagic marlstones that developed close to the Aalenian-Bajocian boundary.

2) Both turbidite units are composed by thinning and fining upwards cycles. The lower turbiditic unit, fed by the faulted Triassic-Liassic succession and by a contemporaneous platform margin, consists of lower slope channels and related sediments, down current and up section replaced by calcarenitic lobes and basin plain deposits. This unit possibly developed after retrogressive sliding from the faulted margin of a carbonate platform margin to the south-east. The emplacement of megabreccias and slumps supports the hypothesis that synsedimentary tectonics triggered mass gravity flows and turbidity currents.

After the recession of this base-of-slope apron system (Aalenian-Bajocian boundary), the upper turbiditic unit, consisting of basin plain pelagic turbidites coeval with the shelf sediments of the western Trento Plateau, spread across the whole Sebino Basin. No indications of synsedimentary faulting are recorded by this latter unit, that developed contemporaneously to drowning of the Trento Plateau. Nevertheless a local western provenance cannot be excluded for part of these sediments.

3) The boundaries to the Concesio turbidite units are represented by the tectonic slopes along the margins of the Sebino Basin. Up to the Aalenian, extension affected the south-eastern basin margin, that is correlated with the eastern margin of the Botticino High area. The latter could represent a bypass slope, characterised by deposition of pelagites and nodular limestones of the Molvina member, between the feeding carbonate platform and the turbiditic basin. As an alternative the Concesio turbidites could be linked with their source by the Vobarno-M.Coro basinal corridor, between the Teglie and Botticino highs (Castellarin & Picotti, 1990). In both cases, whether the Trento High or some prolongation of the same, represented the adjacent feeding platform is uncertain, depending on the particularities of restoration along the Giudicarie Alpine deformation systems.

The Concesio turbidites onlapped southwards and (north-)westwards the erosional slopes that bound the Zandobbio and M. Cavallo Liassic Highs. In contrast the older (Liassic) intrabasinal high along the central and western sides of the Sebino basin (M. Misma, Grone, M. Bronzone), documented by Sinemurian-Pliensbachian reduced successions, apparently were drowned by the Toarcian and therefore could be covered by the Concesio turbidites after smoothing of their relief.

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