Sinemurian to lowermost Toarcian ammonites of the Brescian Prealps (Southern Alps, Italy): preliminary biostratigraphical framework and correlations

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ABSTRACT: A set of 28 ammonite biohorizons or faunal assemblages is proposed for the Sinemurian, the Pliensbachian and the lowermost Toarcian of the Brescian Prealps, in part based on the published data of the authors of this contribution and partly on new results, derived both from recent field investigations and from the study of the historical collection of Lower Jurassic ammonites preserved in the Museum of Natural Sciences of Brescia (Northern Italy).

The biohorizons are present in the Liassic carbonate succession of the Brescian Prealps, cropping out between the eastern surroundings of Brescia (Botticino), to the east, and Lake Iseo, to the west. Since the Hettangian this region was subjected to Jurassic rifting. The area of study was located on the eastern border of the wide Lombardian Basin, a part of the southern continental passive margin of Tethys. An articulated fault-system, trending from Brescia to the North, separated the western subsiding area of the Val Trompia-Sebino Basin from the eastern Botticino structural high. After the drowning of the Rhetian-Hettangian Corna Platform, the very thick synrift succession of the Medolo Group accumulated in the Val Trompia-Sebino Basin, whereas the coeval reduced sequence of the Rezzato Encrinite and the overlying Botticino Corso Rosso covered the Botticino High, subsequent to the Early Sinemurian.

The ammonite biohorizons and assemblages recognised are quite well integrated and correlable with either the NW European standard zonation or the different zonations proposed for the Tethyan Realm.

INTRODUCTION

This work is part of a research programme aimed at supplying a stratigraphic and palaeontologic framework for the Lower Jurassic succession of the Prealps of Brescia (Lombardy, Northern Italy). The type-locality of the Domerian occurs in this region (Bonarelli 1894): in fact the famous fossiliferous site of Mt. Domaro (Cita *et al.* 1961; Cita 1964; Ferretti 1967; Schirolli 1990, 2002a)

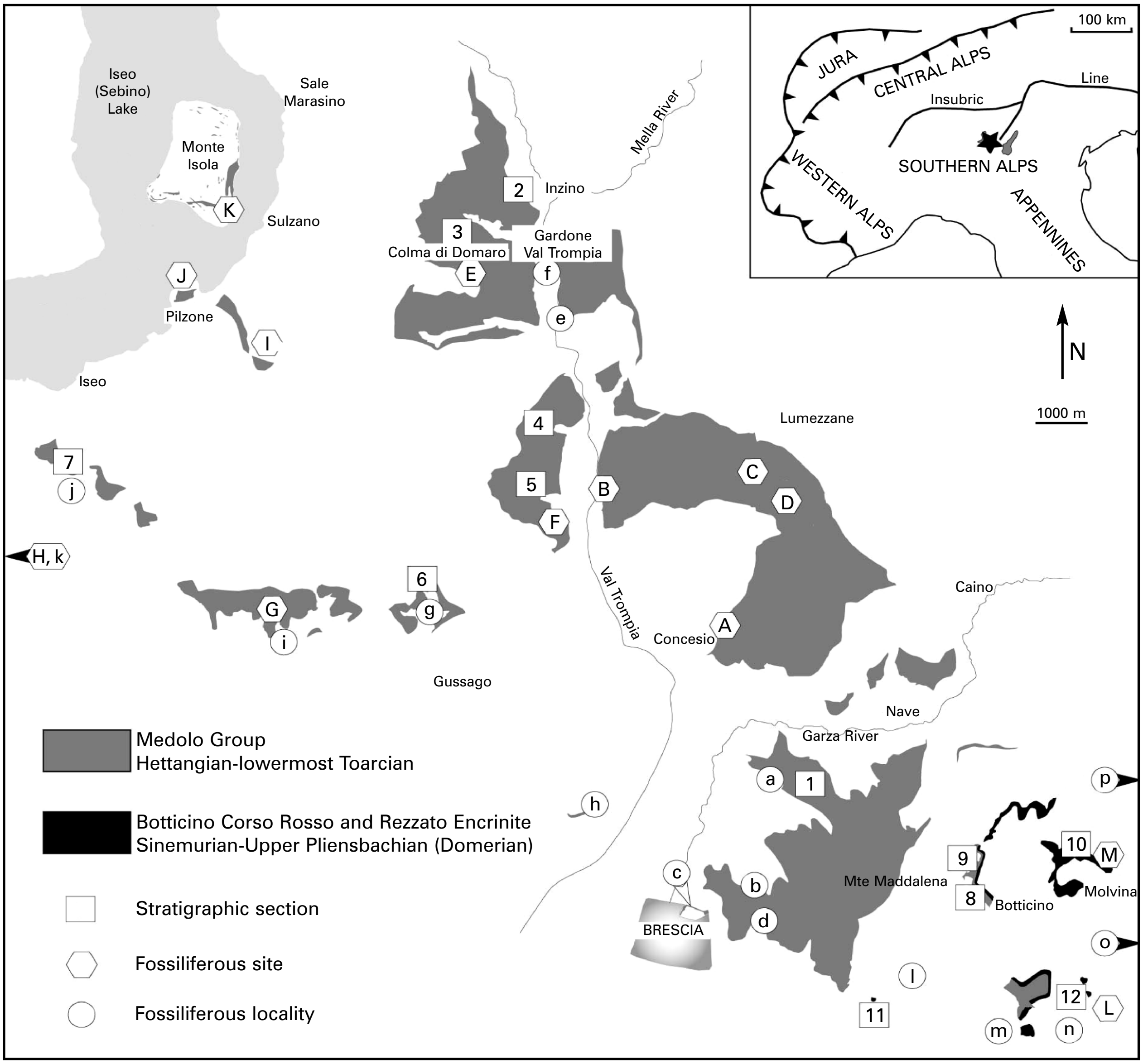


Fig. 1. Geographic and geologic overview of the Sinemurian to lowermost Toarcian lithostratigraphic units cropping out between Botticino and the Lake Iseo. Numbers, capital letters and small letters show respectively the location of the investigated stratigraphical sections, fossiliferous sites and localities listed in the text.

is located close to Gardone Val Trompia (Fig. 1). This study will contribute to putting the well-known Upper Pliensbachian ammonite fauna, which was not collected in place, into a precise regional stratigraphic context.

Data on the stratigraphy of the Brescian Prealps are the result both of a great number of stratigraphic sections described in this area (Schirolli 1994; Dommergues *et al.* 1997; Schirolli 1997) and of new mapping of the region.

The new data come both from recent investigations in the field and from the study of the historical collection of Brescian Lower Jurassic ammonites, preserved in the Museum of Natural Sciences of Brescia. In the latter case, ammonites were at first strongly selected on the basis of the completeness and reliability of the data concerning the site and the level of finding. The subsequent step has been the attribution of the ammonites to a precise biostratigraphic horizon and/or faunal assemblage, also placing the specimens into a more or less accurate lithostratigraphic range within the sedimentary succession.

GEOGRAPHIC AND GEOLOGIC FRAMEWORK

The Sinemurian to lowermost Toarcian ammonite biohorizons described in this contribution occur in the Mesozoic carbonate succession of the Brescian Prealps, cropping out between Botticino, to the eastern surroundings of the city of Brescia, and the Lake Iseo, to the West. These deposits belong to the sedimentary cover of the Southalpine domaine of the Alps, corresponding during the Jurassic to a part of the southern continental passive margin of Tethys. Since the Hettangian this region, likewise the whole of the Southern Alps, was involved in the paroxis-

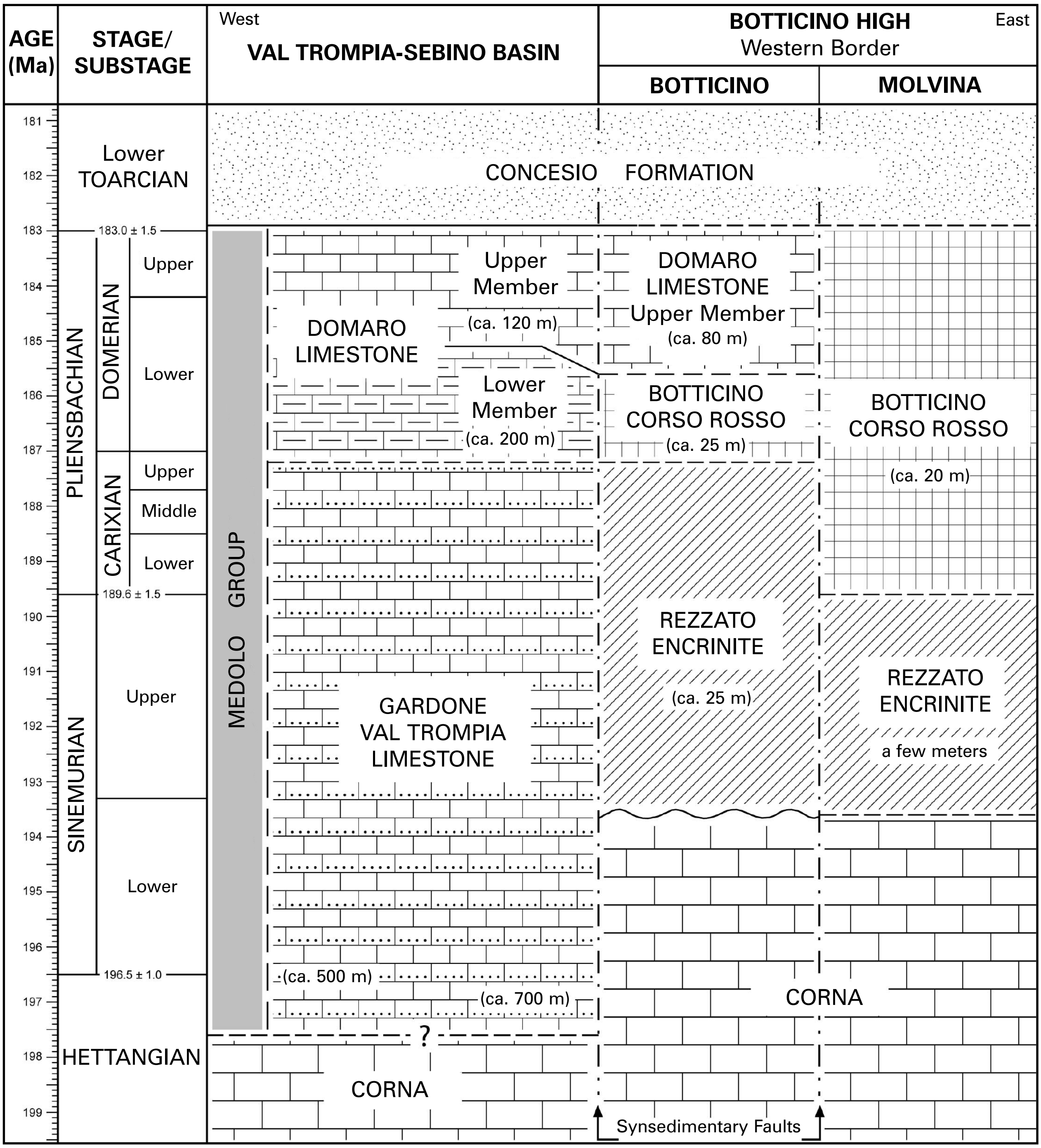


Fig. 2. Stratigraphic setting of the Lower Jurassic in the Brescian Prealps. Time scale after Gradstein *et al.* 2004.

mal phase of Lower Jurassic rifting, following the Norian crustal stretching stage. The East-West direction of the rifting extension produced North-South oriented basins and submarine highs (Gaetani 1975; Bernoulli *et al.* 1979; Winterer, Bosellini 1981; Sarti *et al.* 1992; Bertotti *et al.* 1993). At that time, the Brescian area was located on the eastern border of the wide Lombardian Basin, bounded by the wide Trento Platform to the East (Castellarin 1972; Castellarin, Picotti 1990). Fortunately, the mainly North-South direction of the Alpine shortening during the Tertiary did not obliterate at all the complex pattern created by the block-faulting.

At the beginning of the Jurassic, an articulated fault-system, composed of West-dipping North-South master faults and West-East transfer faults, trending from Brescia to the North, separated a growing western basinal area (Val Trompia-Sebino Basin) from the eastern Botticino structural high (Cassinis 1968; Picotti 1991; Cassinis, Schirolli 1995; Schirolli 1997; Picotti *et al.* 1997). Between the Hettangian and the onset of Toarcian, almost 1000 m of well-stratified cherty marly limestones of the Medolo Group (Gardone Val Trompia Limestone and Domaro Limestone formations) represent the synrift deposition of the Val Trompia-Sebino Basin, following the drowning of the Rhetian?-Hettangian Corna Platform. In contrast, after the Early Sinemurian a nearly coeval reduced sequence, 50 m thick, composed of the calcarenites/siltites of the Rezzato Encrinite (Lower Sinemurian to Upper Carixian) and the overlying thinly-bedded and sometimes nodular ammonitic marly limestones of the Botticino Corso Rosso (Upper Carixian and Domerian), covered the Corna Platform in the Botticino High (Fig. 2).

THE VAL TROMPIA-SEBINO BASIN SUCCESSION

Subsequent to the Hettangian, a thick (900-1000 m) basinal succession accumulated above the Corna formation in the Val Trompia-Sebino Basin. The Medolo Group represents the first synrift deepening-upward sequence, showing well-bedded cherty limestones and marly limestones, rich in sponge spicules and radiolarians, interbedded with thin layers of marls and argillaceous marls.

Two formations are distinguished in the Medolo Group: the Gardone Val Trompia Limestone (Hettangian? to Upper Carixian), appearing as regularly-bedded hemipelagic to fine- and medium-grained spongolitic-peloidal calciturbidites, and the Domaro Limestone (Uppermost Carixian to Lowermost Toarcian), showing well-stratified pelagic sediments, richer in ammonites and bearing the classical Domerian fauna of Mt. Domaro. Moreover, two members are recognized in the Domaro Limestone: a "lower member", composed both of pelagic calciturbidites and pelagites, and an "upper member", mainly due to a pelagic setting. Platform-derived megabreccias can occur in the basal part of the Gardone Val Trompia Limestone, close to the tectonic lineaments activated by the rifting. Other breccias and slump deposits locally appear in several levels of the Medolo Group (Schirolli 2002b).

The Concesio Formation may belong to the 2nd sedimentary megacycle referred to the Jurassic rifting phase (Schirolli 1997, fig. 67; 2002c) (Lower Toarcian?). The thick- and coarse-grained calciturbidites of this unit, rich in crinoids, overlie the micritic limestones of the Medolo in the basinal area, even if, locally, a lithozone of variegated marlstones, bearing plenty of basal Toarcian ammonites, concordantly covers the top of the Medolo unit.

THE BOTTICINO HIGH SUCCESSION

Immediately to the East of Brescia, the carbonate platform of the Corna was still productive whilst the Medolo Group started to accumulate in the early subsiding Val Trompia-Sebino Basin (Cassinis 1968; Cassinis, Schirolli 1995). Subsequent to the Early Sinemurian, a deepening sequence (50 m thick), very reduced in respect to the succession of the western region, characterizes the stepwise drowning of the platform in the Botticino area. The first step of drowning is marked by the deposition of the Rezzato Encrinite (Schirolli 2002c) above the Corna massive limestone. A 25 m-thick sequence of crinoidal calcarenites, passing upwards into crinoidal-spongolitic calcisiltites occured on the drowned plateau. A rich Sinemurian ammonite assemblage is known just above the top of the Corna limestone (Cassinis, Cantaluppi 1967; Cassinis 1968; Schirolli 1997; Dommergues *et al.* 1997).

During the Late Carixian the Rezzato Encrinite passes transitionally into the more condensed Botticino Corso Rosso (Schirolli 2002c), 20-25 m thick, showing the second step of drowning of the plateau towards a submarine pelagic high.

Thinly-bedded pink calcilutites and red nodular marly limestones, bearing Domerian ammonites, occur in the unit. Only the western edge of the Botticino High shows a three-stage drowning evolution, inferred by the existence of the Upper Member of the Domaro Limestone above the Botticino Corso Rosso. On this marginal block, plenty of mass movement deposits take up the upper part of the Botticino Corso Rosso. Immediately to the East (Molvina block) the Domaro Limestone completely disappears.

At the beginning of Toarcian the variegated marlstones, rich in ammonites, of the Molvina Member (Concesio Formation) drape the entire Botticino High.

STRATIGRAPHICAL SECTIONS AND FOSSILIFEROUS SITES

The following list briefly presents the most important stratigraphical sections, fossiliferous sites and localities considered in this study (numbers and letters are referred to in Fig. 1). Both in the *stratigraphical sections* and in the *fossiliferous sites*, ammonites have been collected from well-known beds, whereas the *fossiliferous locality* indicates limited knowledge of the source area of the collected ammonites, placed into the stratigraphical framework. More details about the stratigraphical and sedimentological features of the Jurassic carbonate succession of the Brescian Prealps occur in Schirolli (1990, 1992, 1997, 2002b). The palaeontologic descriptions of some of the specimens considered also in this work are given by Dommergues *et al.* (1997).

Val Trompia-Sebino Basin

Stratigraphical sections: Mompiano (1), Inzino (2), Mt. Domaro (3), Cogozzo (4), Villa (5), Val Navezze (Gussago) (6), Provaglio d'Iseo (7).

Fossiliferous sites: Concesio (A), Pregno (B), Val Porcino (Lumezzane) (C), Poffe di Lumezzane (D), Mt Domaro (E), Mt. Zoadello (F), Mt. Delma (G), Borgonato (H), Punta dell'Orto (I), Montecolo di Pilzone (J), Montisola (K).

Fossiliferous localities: Mompiano (a), Costalunga (b), Colle Cidneo (c), Ronchi di Brescia (d), Ponte Zanano (e), Gardone Val Trompia (f), Val Navezze (Gussago) (g), Urago Mella (h), Saiano (i), Provaglio d'Iseo (j), Adro (k).

Botticino High

Stratigraphical sections: Botticino Mattina (8), Lassa (9), Molvina (10), St. Eufemia (11), Mt. Marguzzo (12).

Fossiliferous sites: Mazzano (L), Molvina (Mt. Sapone) (M).

Fossiliferous localities: Caionvico (l), Rezzato (m), Virle (n), Gazzolo (Nuvolera) (o), Serle (p).

BIOCHRONOLOGICAL HORIZONS AND/OR FAUNAL ASSEMBLAGES

Twenty-eight ammonite biohorizons and/or faunal assemblages can be recognised in the Sinemurian to lowermost Toarcian succession of the Brescian Prealps (Fig. 3), from the abovementioned localities shown in Fig. 1. Some typical ammonites from this region are figured in the plate (Pl. 1). The new data deriving both from the recent field investigations and from the study of the historical collection of Lower Jurassic ammonites preserved in the Museum of Natural Sciences of Brescia confirm the presence of the previously identified by ammonite horizons referred to Dommergues *et al.* (1997) all over the region. There follows the list of the biohorizons:

- *Arnioceras* sp. horizon, Semicostatum to Obtusum Zone (Lower to Upper Sinemurian);
- *Asteroceras* sp. horizon, Obtusum Zone (Upper Sinemurian) (from Cantaluppi 1966);
- Assemblage a, Raricostatum Zone (Upper Sinemurian);
- *Echioceras quenstedti* horizon, Raricostatum Zone (Upper Sinemurian);
- Assemblage b, Jamesoni Zone (Lower Pliensbachian);
- *Miltoceras* aff. *sellae* horizon, Jamesoni Zone (Lower Pliensbachian);
- *Tropidoceras flandrini/Uptonia* cf. *jamesoni* horizon, Jamesoni Zone (Lower Pliensbachian);
- *Tropidoceras* aff. *demonense* horizon, Ibex Zone (Lower Pliensbachian);
- *Metaderoceras* cf. *gemmellaroi* horizon, Ibex Zone (Lower Pliensbachian);
- *Dubariceras dubari* horizon, Ibex Zone (Lower Pliensbachian);
- *Fuciniceras* gr. *mellahense* horizon, Ibex Zone (Lower Pliensbachian);
- *Reynesocoeloceras* aff. *simulans planicosta* horizon, Davoei Zone (Lower Pliensbachian);

- *Fuciniceras lavinianum* horizon, Margaritatus Zone (Upper Pliensbachian);
- *Fuciniceras* gr. *isseli* horizon, Margaritatus Zone (Upper Pliensbachian);
- *Fuciniceras* aff. *marianii* horizon, Margaritatus Zone (Upper Pliensbachian);
- *Fuciniceras celebratum* horizon, Margaritatus Zone (Upper Pliensbachian);
- *Arieticeras* aff. *apertum* horizon, Margaritatus Zone (Upper Pliensbachian);
- *Reynesoceras ragazzoni* horizon, Margaritatus Zone (Upper Pliensbachian);
- *Arieticeras* aff. *macrum* horizon, Margaritatus Zone (Upper Pliensbachian);
- *Arieticeras ugdulenai* horizon, Margaritatus Zone (Upper Pliensbachian);
- *Arieticeras* gr. *bertrandi* horizon, Margaritatus Zone (Upper Pliensbachian);
- *Arieticeras* gr. *algovianum* horizon, Margaritatus Zone (Upper Pliensbachian);
- *Pleuroceras solare* horizon, Spinatum Zone (Upper Pliensbachian);
- *Canavaria* gr. *naxensis* horizon, Spinatum Zone (Upper Pliensbachian);
- *Lioceratoides* cf. *grecoi* horizon, Spinatum Zone (Upper Pliensbachian);
- *Paltarpites* cf. *jucundus* horizon, Spinatum Zone (Upper Pliensbachian);
- *Dactylioceras* sp. horizon, Tenuicostatum Zone (Toarcian);
- *Paltarpites* sp. horizon, Tenuicostatum Zone (Toarcian).

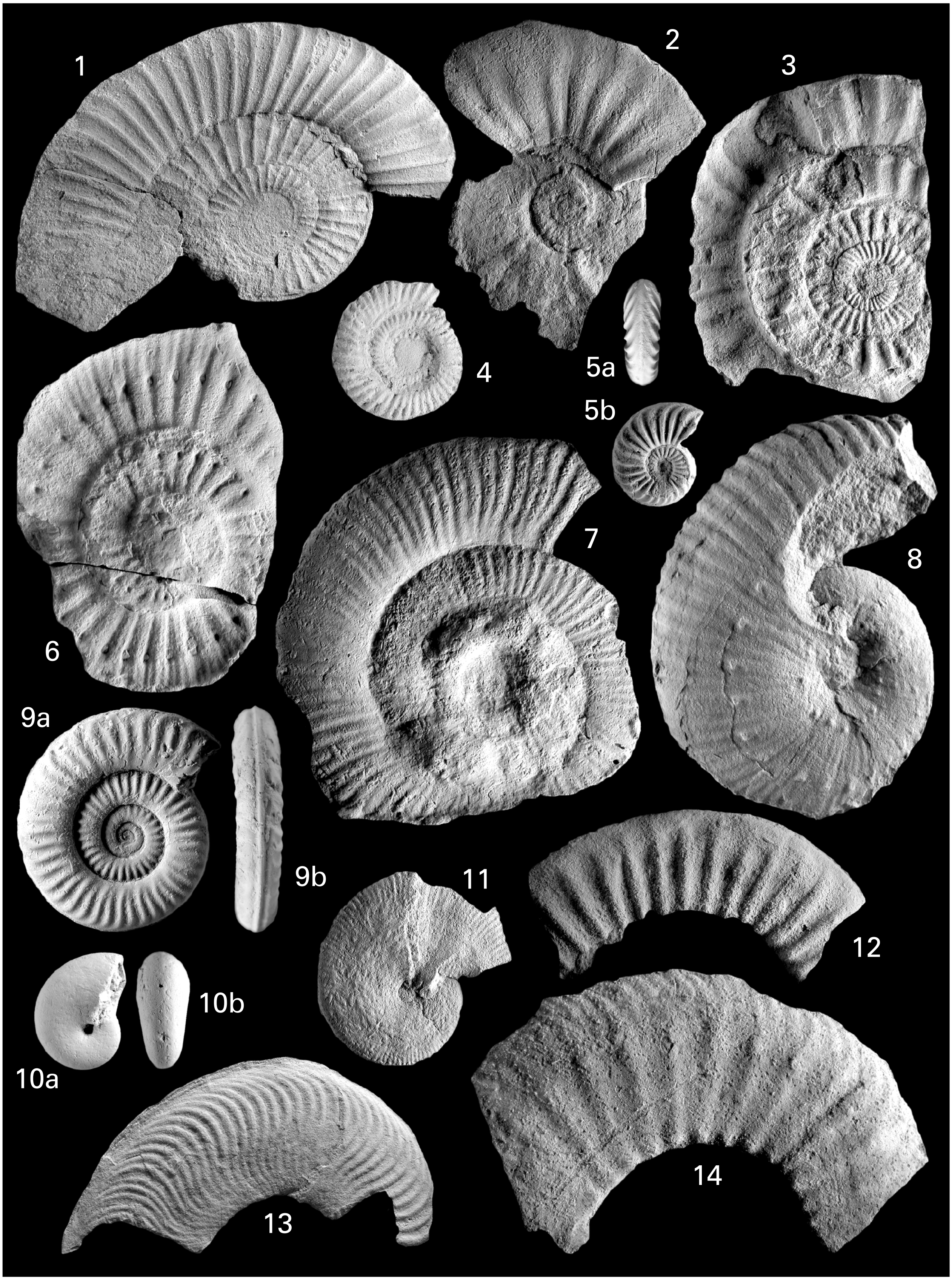
Four new horizons can be proposed in this work:

- *Asteroceras* sp. horizon (MSNBS-PA507, Pl. 1: 2), Obtusum Zone (Upper Sinemurian). This biostratigraphical unit is recorded from Montisola and confirms the presence of the Obtusum Zone in the Brescian Prealps (see also Cantaluppi 1966, pl. 1: 3).
- *Echioceras quenstedti* horizon (MSNBS-PA1529, Pl. 1: 3), Raricostatum Zone (Upper Sinemurian). The presence of this horizon is known from Gardone Val Trompia. It characterizes very precisely the base of the Raricostatum Subzone in the Alps (Subbriançonnais and Upper Austroalpine).
- *Miltoceras* aff. *sellae* horizon (MSNBS-PA413, Pl. 1: 6), Jamesoni Zone (Lower Pliensbachian). Known from the Brescia surroundings, this unit characterizes the middle part of the Jamesoni Zone. These index species allows good correlation in the western Tethys and in the circum-Pacific realms.
- *Pleuroceras solare* horizon (MSNBS-PA338, Pl. 1: 5), Spinatum Zone (Upper Pliensbachian). Recorded from Caionvico-Botticino, this horizon indicates the Apyrenum Subzone. Well known in the Euroboral realm, the index species is also a precious tool for correlation at the western Tethys scale.

In Fig. 3 the biohorizons proposed in this work are set into the context of the more complete biostratigraphic framework of other regions, such as the Apennines (Dommergues *et al.* 1994; Faraoni *et al.* 1996; Macchioni 2001; Venturi, Nannarone 2002; Venturi *et al.* 2005), the Austroalpine Domain (Dommergues, Meister 1990; Meister *et al.* 1994; Dommergues *et al.* 1995; Blau 1998; Geczy, Meister 1998; Blau, Meister 2000; Meister, Friebe 2003) and the Betic Range (Braga 1983). Moreover, Fig. 3 sets out the terminology used for zones, sub-zones, horizons and for the correlation between the North-

Plate 1

1 – *Arnioceras* sp. MSNBS-PA189, Brescia surroundings, Gardone Val Trompia Limestone, Sinemurian (Bucklandi Zone to Obtusum Zone); 2 – *Asteroceras* sp. MSNBS-PA507, Montisola, Gardone Val Trompia Limestone, Upper Sinemurian (Obtusum Zone, *Asteroceras* sp. horizon); 3 – *Echioceras* gr. *quenstedti* (Schafhäutl), MSNBS-PA1529, Gardone Val Trompia, Gardone Val Trompia Limestone, Upper Sinemurian (Raricostatum Zone, Raricostatum Subzone, *E. quenstedti* horizon); 4 – *Reynesoceras ragazzoni* (Hauer), MSNBS-PA5004, Costalunga, Domaro Limestone, Upper Pliensbachian (Margaritatus Zone, Gibbosus Subzone, *R. ragazzoni* horizon); 5 a-b – *Pleuroceras* gr. *solare* (Phillips), MSNBS-PA338, Caionvico-Botticino, Domaro Limestone, Upper Pliensbachian (Spinatum Zone, *P. solare* horizon); a lateral view, b ventral view; 6 – *Miltoceras* aff. *sellae* (Gemmellaro), MSNBS-PA413, Brescia surroundings, Gardone Val Trompia Limestone, Lower Pliensbachian (Jamesoni Zone, *M*. aff. *sellae* horizon); 7 – *Dubariceras dubari* Dommergues, Mouterde, Rivas, MSNBS-PA317, Botticino (?), Lower Pliensbachian (Ibex Zone, *D. dubari* horizon); 8 – *Becheiceras* sp., MSNBS-PA1523, Ponte Zanano, Gardone Val Trompia Limestone (?), Pliensbachian (Ibex Zone to Margaritatus Zone, Gibbosus Subzone); 9 a-b – *Arieticeras* gr. *algovianum* (Oppel), MSNBS-PA5008, Costalunga, Domaro Limestone, Upper Pliensbachian (Margaritatus Zone, Gibbosus Subzone, *A*. gr. *algovianum* horizon); a lateral view, b ventral view; 10 a-b – *Phylloceras* gr. *frondosum-hebertinum* (Reynes), MSNBS-PA1540, Concesio, Domaro Limestone, Upper Sinemurian to Lower Toarcian; a lateral view, b ventral view; 11 – *Partschiceras* gr. *striatocostatum* (Meneghini), MSNBS-PACa3, Colle Cidneo Domaro Limestone, Upper Sinemurian to Lower (?) Toarcian; 12 – *Emaciaticeras* sp., MSNBS-PAu44, Costalunga, Domaro Limestone, Upper Pliensbachian (Spinatum Zone); 13 – *Fuciniceras* aff. *celebratum* (Fucini), MSNBS-PACa4, Colle Cidneo Domaro Limestone, Upper Pliensbachian (Margaritatus Zone, Stokesi Subzone, *F. celebratum* horizon); 14 – *Tropidoceras flandrini* (Dumortier), MSNBS-PA1663, Brescia surroundings, Gardone Val Trompia Limestone, Lower Pliensbachian (Upper Jamesoni Zone to Middle Ibex Zone).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West European Domain and the Tethyan Domain as given by Dean *et al.* 1961; Dommergues *et al.* 1997; Corna *et al.* 1997; Blau, Meister 2000; Meister *et al.* 2003.

CONCLUSIONS

A more accurate stratigraphical framework for the Lower Jurassic succession of the Brescian Prealps, including the well-known type-locality of the Domerian, has been attained thanks to the new data resulting both from the recent field investigations and from the study of the historical collection of Lower Jurassic ammonites, preserved in the Museum of Natural Sciences of Brescia (Lombardy, Northern Italy). A set of twenty-eight ammonite biohorizons and/or faunal assemblages are proposed for the Sinemurian, the Pliensbachian and the lowermost Toarcian in this region. The *Asteroceras* sp. horizon (Obtusum Zone), the *Echioceras quenstedti* horizon (Raricostatum Zone), the *Miltoceras* aff. *sellae* horizon (Jamesoni Zone) and the *Pleuroceras solare* horizon (Spinatum Zone) are new biohorizons recorded in the succession studied, allowing more thorough correlations both between the Val Trompia-Sebino Basin and the Botticino High and with the other domains of Tethys.

The Obtusum Zone is recognized in the basal part of the Gardone Val Trompia Limestone, determining the Zone of a "generic Lotharingian" in Montisola, as reported in literature (Vecchia 1946). For the first time the Raricostatum Subzone is cited in the Medolo succession of Mt. Domaro at Gardone Val Trompia. The *Miltoceras* aff. *sellae* horizon recognized in the Gardone Val Trompia Limestone allows the correlation of this level of the basinal succession with the coeval faunal Assemblage A (Dommergues *et al.* 1997), previously found at the base of the Rezzato Encrinite in the Botticino High. Also the Apyrenum Zone in the upper part of the Domaro Limestone was unknown in the Botticino High, whilst in the basinal area, Del Campana (1900) figured Apyrenum Zone ammonites from Mt. Domaro, and there was only a citation of the existence of this Subzone, not supported by figured specimens, coming from the Caricatore section in Gussago (Cantaluppi, Cassinis 1984). The Ibex Zone and the Margaritatus Zone appear to be the two mainly fossiliferous levels of the Medolo Group in the hills around Brescia (Mompiano, Costalunga, Colle Cidneo, Ronchi localities).

The ammonite biohorizons and assemblages recognized are quite well integrated and correlable with either the North-West European standard zonation or the different zonations given for the Tethyan realm (Appennines, Subbeticas and Austrian and Hungarian Upper Austroalpine). Most of these stratigraphical units are based on Tethyan taxa. Only two horizons (*Tropidoceras flandrini*/*Uptonia* cf. *jamesoni* horizon and *Pleuroceras solare* horizon) show North-West European affinites. Moreover the *Echioceras quenstedti* horizon is only known from the northern margin of Tethys, mainly from the Upper Austroalpine units.

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