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NEW BIOSTRATIGRAPHICAL DATA ON UPPERMOST WERFEN FORMATION OF WESTERN DOLOMITES (TRENTO, ITALY)

C. Neri & R. Posenato, Ferrara

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RIASSUNTO

La parte alta della Formazione di Werfen (Trias inferiore) delle Dolomiti occidentali (Trento, Italia) è rappresentata dalle seguenti unità stratigrafiche.

a) Membro di Val Badia: calcari marnoso-siltosi grigi bioturbati, con faune a *Tirolites cassianus*.

b) Membro di Cencenighe: prevalenti calcari e dolomie oolitiche alternati a peliti, di ambiente marino poco profondo e di tidal flat; è caratterizzato nella parte inferiore da faune a *Dinarites dalmatinus* ed *Eumorphotis telleri*, in associazione con *Neoschizodus*, *Bakevella*, *Natiria*, etc.; la parte alta contiene livelli a *Neoschizodus*, *Bakevella*, resti di Crinoidi, in cui si segnala la prima comparsa di *Costatoria costata*.

c) Membro di S. Lucano: dolomie marnoso-siltose, più raramente arenacee, rosse, coinvolte in

cicli tidali. Passa gradualmente, al tetto, ad una unità dolomitica, senza apporto terrigeno (Dolomia del Serla Inferiore), generalmente attribuita all'Anisico inferiore. La fauna, in genere scarsa per il controllo esercitato dall'ambiente, è caratterizzata da *Costatoria costata*, in associazione con *Bakevella*, *Unionites*, *Natiria costata*.

Le macrofaune rinvenute nelle sezioni studiate, relative alle unità b) e c), comprendono 31 taxa, per parte dei quali vengono forniti i dati fin qui acquisiti durante la revisione tassonomica tuttora in corso.

E' analizzato l'inquadramento bio- e cronostratigrafico delle serie delle Dolomiti, correlate tentativamente con la sequenza di Mùc (Dalmazia). In base alle associazioni macrofaunistiche i Membri di Cencenighe e di S. Lucano appartengono allo Spathiano (Scitico superiore; non è finora possibile dire se il limite Scitico-Anisico coincida con il limite litostratigrafico tra la Formazione di Werfen e la Dolomia del Serla Inferiore. Di particolare rilievo è la verifica dell'età scitica superiore di *Costatoria costata* nelle Dolomiti, per l'associazione con *Natiria costata* e per l'assenza di taxa chiaramente anisici nelle macrofaune.

ABSTRACT

The uppermost part of the Werfen Formation (Lower Triassic) in the western Dolomites (Southern Alps, Italy) is represented by the following stratigraphic units:

a) Val Badia Member: gray, silty-marly, bioturbated limestone; it is characterized by the common occurrence of *Tirolites cassianus*.

b) Cencenighe Member: alternating oolitic dolomites and silty-marly mudstones, deposited in tidal flat and shallow marine environments. From a paleontological point of view it is characterized by a rich fossiliferous assemblage with *Dinarites dalmatinus*, *Eumorphotis telleri*, *Neoschizodus*, *Bakevella*, *Natiria costata*, etc., occurring in the lower part of the member. The upper part contains only *Neoschizodus*, *Bakevella*, crinoid remains associated with *Costatoria costata* (first occurrence).

c) S. Lucano Member: red marly-silty-sandy dolomites, forming tidal flat cycles. It is overlain through a transitional boundary by Lower Serla Dolomite, generally referred to Lower Anisian in former literature. The fossil content, generally poor because of the facies control, is characterized by *Costatoria costata*, associated with *Bakevella*, *Unionites*, *Natiria costata*.

The macrofauna of Cencenighe and San Lucano Members in the examined stratigraphic sections, comprise 31 mollusc taxa; some preliminary results on their taxonomical revision, still in progress, are given in this paper.

The bio- and chronostratigraphical setting of the Dolomites sequence is studied; a tentative correlation with the Upper Scythian sequence of Muc (Dalmatia) is carried out.

On the basis of macrofaunistic assemblages, Cencenighe and S. Lucano Members are referred to Spathian (Upper Scythian); there is no evidence so far suggesting that the Scythian-Anisian boundary corresponds with the lithostratigraphic boundary between Werfen Formation and Lower Serla Dolomite.

It is to point out the Upper Scythian age of *Costatoria costata* in the Dolomites, testified by:

- 1) its association with *Natiria costata*,
- 2) the lacking of "true" Anisian taxa in the studied assemblage.

ZUSAMMENFASSUNG

Der oberste Abschnitt der Werfener Formation (Untertrias) ist in den westlichen Dolomiten (Südalpen, Italien) durch folgende stratigraphische Einheiten vertreten:

a) Val-Badia-Member: graue, siltig-mergelige, bioturbate Kalke, üblicherweise gekennzeichnet durch das Vorkommen von *Tirolites cassianus*.

b) Cencenighe-Member: Wechsellagerung oolithischer Dolomite und siltig-mergeliger mudstones und Pelite, gebildet unter Bedingungen eines tidal flat bis zumindest flach-mariner Verhältnisse. Paläontologisch im tieferen Teil durch reiche Faunen mit *Dinarites dalmatinus*, *Eumorphotis telleri*, *Neoschizodus*, *Bakevella*, *Natiria costata* usw. gekennzeichnet. Der obere Teil dieses Members führt nur *Neoschizodus*, *Bakevella*, Crinoidenreste, zusammen mit der erstmals auftretenden *Costatoria costata*.

c) S.-Lucano-Member: rote, mergelig-siltige, seltener bis sandige Dolomite in Zyklen einer tidal-flat-Abfolge. Dieses Member ist durch Übergänge mit dem überlagernden Unteren Sarldolomit verbunden, der nach der bisherigen Literatur bereits ins Anis gestellt wird. Die Fossilführung ist – faziesbedingt – im allgemeinen spärlich und gekennzeichnet durch *Costatoria costata*, vergesellschaftet mit *Bakevella*, *Unionites* und *Natiria costata*.

Die Makrofauna des Cencenighe- und des S.-Lucano-Members umfaßt in den untersuchten Profilen 31 Taxa von Mollusken; einige vorläufige Ergebnisse zu deren noch nicht abgeschlossener taxonomischer Revision werden mitgeteilt.

Die bio- und chronostratigraphische Stellung der erwähnten Schichtfolgen der Dolomiten wurde untersucht; eine Korrelation mit der oberskythischen Abfolge von Muc (Dalmatien) wird versucht.

Aufgrund der Makrofaunen werden das Cencenighe- und das S.-Lucano-Member ins Spathian (Oberskyth) gestellt. Es gibt bislang keine verbindlichen Hinweise, daß die Skyth-Anis-Grenze mit der lithostratigraphischen Grenze zwischen Werfener Schichten und Unterem Sarldolomit zusammenfallen würde.

Hervorzuheben ist, daß das oberskythische Alter von *Costatoria costata* in den Dolomiten belegt ist, zum einen durch das gemeinsame Vorkommen mit *Natiria costata* und zum anderen durch das Fehlen eindeutiger anisischer Taxa in den untersuchten Makrofaunen.

INTRODUCTION

The bio- and chronostratigraphy of the formations at the Scythian/Anisian boundary in the Southern Alps have not been well defined so far; such study is quite difficult because of two factors: on one hand, in correspondence with this interval, peritidal and poorly fossiliferous facies are dominant; on the other hand the strong tectonic activity involving large sectors of this area during the Anisian (BOSELLINI, 1968; ASSERETO et al., 1977) caused the erosion of the lithological units of Upper Scythian, Lower Anisian and frequently of Pelsonian age as well.

The "standard" lithostratigraphic sequence representing the Upper Scythian and the Anisian of the Dolomites is, from the lower to the upper part, characterized by the following units; some sedimentary events of this succession can be generalized to the Southern Alps and can also be recognized out of this area.

1) Upper part of the Werfen Formation: above the Campil Member, dated to the Lower Olenekian and almost completely composed of red siltstones and sandstones (BROGLIO LORIGA et al., 1983), there is a sequence consisting of mixed carbonate and terrigenous lithotypes including the Val Badia Member (predominant bioturbated fossiliferous grey marly limestones) and the Cencenighe Member (red and yellowish oolitic dolomites and limestones); these two members, characterized by classical faunas consisting of *Natiria costata*, "*Turbo*" *rectecostatus*, *Tirolites cassianus* and *Dinarites* ss.pp., are referred to the Spathian on the basis of the Ammonoid faunas (BROGLIO LORIGA et al., 1983). The Cencenighe Member is overlain by the S. Lucano Member, recognized in the Agordo area by PISA et al. (1979) as basal unit of the Lower Serla Formation; later on, several authors (CASATI et al., 1982; BLENDINGER, 1983) correlated it with the Werfen Formation, with which it has significant lithological and depositional affinities; the writers agree upon this statement, further confirmed by the finding of Werfen-like macrofaunas within the S. Lucano Member, which, therefore, is here considered the topmost unit of the Werfen Formation.

2) The so-called Lower Serla Dolomite (Frassené Dolomite Member of the Lower Serla Formation, sensu PISA et al., 1979) follows upwards with a transitional boundary. According to literature, it is generally considered to be of Lower Anisian age; it is composed of whitish well bedded dolomite. The Lower Serla Dolomite differentiates quite strongly from the Werfen lithologies which are characterized by the constant occurrence of terrigenous silty-sandy fraction intercalated into or mixed in different proportions with the carbonate sediments. Between the top of the Werfen succession and the bottom of Lower Serla Dolomite an evaporitic unit may occur in the western Trentino-Lombardia area (Carniola di Bovegno) and in Cadore-Carnia (Lusnizza Formation); the reported chronological attribution of these evaporite sequences range from the Upper Scythian (Carniola di Bovegno, ASSERETO & CASATI, 1965) to Lower Anisian (Lusnizza Formation, ASSERETO et al., 1968; ASSERETO & PISA in DESIO, 1972). A real support of direct biostratigraphical data, however, is lacking.

3) The Lower Serla Dolomite is overlain by Pelsonian and Illyrian units, quite often in stratigraphic discontinuity. The unconformities are generally marked by conglomerates (Peresschichten auct.).

This succession, recently reviewed by DE ZANCHE & FARABEGOLI (1982), is well recorded in the Agordo area (FARABEGOLI et al., 1977; PISA et al., 1979), in Cadore (CASATI et al., 1982), Braies Dolomites (PIA, 1937; BECHSTADT & BRANDNER, 1970), Adige Valley (DE ZANCHE & FARABEGOLI, 1982). In the western Dolomites instead it is generally lacking of some units (Lower Serla Dolomite and more or less considerable parts of Werfen Formation) eroded during the Late Anisian tectonic phase responsible for the uplift of the Badioto-Gardenese Ridge (BOSELLINI, 1968); however, there are still some areas (Val Venegia, north-west slope of Pale di S. Martino, Val Averta) where the succession is mostly preserved.

Generally the sequence of the Dolomites presents a good correspondence with the development of other important sequences in European, Alpine and Extra-Alpine areas such as Dalmatia (SCAVNICAR & SUSNJARA, 1983; HERAK et al., 1983), Hungary (Transdanubian Range, BALOGH, 1980), the Northern Calcareous Alps (TOLLMANN, 1960; MOSTLER & ROSSNER, 1977).

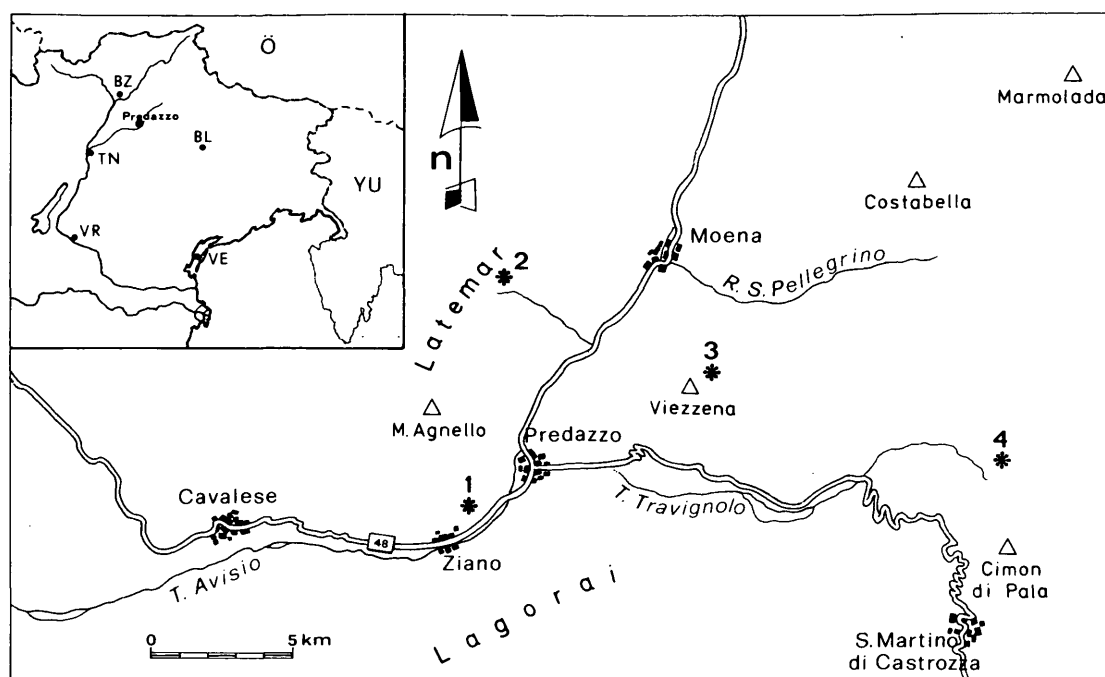


Fig. 1: Map of the investigated area and location of the stratigraphic sections; 1 - Val Averta; 2 - Val Sorda; 3 - Piavac-Lusia; 4 - Val Venegia

Generally, near the Scythian-Anisian boundary, the successions of these areas are characterized by a carbonate, often dolomitic unit, poor in terrigenous input, which directly overlays a mixed carbonate-terrigenous complex referred to the topmost part of the Werfen Formation (*Tirolites* beds, Campiller Schichten auct. p.p.). Traditionally, the boundary between the Scythian and the Anisian stage was thought to correspond approximately to this lithological transition, although more recently there is a tendency to move this boundary upwards, into some unspecified part of the upper carbonate complex, usually barren; in this respect, for instance, KRISTYN's considerations (1974) as regards the Muć sequence (Dalmatia) should be mentioned.

The fact that the *Tirolites* beds of the quoted areas overlay a strongly terrigenous unit (red siltstones and sandstones), which can be easily correlated with the Campil Member of the Dolomites, greatly increases the affinity between the Southern Alps successions and the Dalmatia and Hungary sequences.

As regards the paleontological and biostratigraphical aspects of the Dolomites sequences, notable macrofaunas were known exclusively from Val Badia and Cencenighe Members; in the Val Badia Member the rich fossiliferous assemblages are distributed with frequency and regularity from the bottom to the top (BROGLIO LORIGA et al., 1983); on the contrary, from the Cencenighe Member rare fossiliferous beds, characterized by *Dinarites dalmatinus* and *Eumorphotis telleri*, were reported. In spite of the abundant content and taxonomic variety, these geographically scattered beds represent a small vertical interval within the member; an idea of the faunal vertical distribution which could be obtained from several overlaying horizons in a synthetic stratigraphic section, was so far missing. As regards the S. Lucano Member and the Lower Serla Dolomite, only the micropaleontological content, restricted to the forams *Glomospira* and *Meandrospira*, was known.

The authors of this article started their research with the aim of reconstructing the faunal composition and its vertical distribution in the interval between

the Val Badia Member and the Lower Serla Dolomite. The first results of this research, reported here, are related to some stratigraphic sections of the western Dolomites with reference to Cencenighe and S. Lucano Members. This work is now in progress (including Braies Dolomites, Cadore and Adige Valley) and will try to create a detailed biostratigraphical scale available for the whole Southern Alps area, evaluate its chronostratigraphical meaning and establish its correlations with other European sequences.

LITHOSTRATIGRAPHY AND SETTING OF THE FOSSILIFEROUS HORIZONS

The stratigraphic sections studied in this work occur in the western Dolomites (fig. 1); two of them (Val Sorda and Piavac-Lusia) are truncated by the Late Anisian erosion at the middle part of the Cencenighe Member, whereas another one (Val Averta) also includes the S. Lucano Member and the lower part of Lower Serla Dolomite (fig. 2).

Cencenighe Member

In the investigated area it is about 80 m thick; it consists of a great variety of lithotypes, the most typical of which are represented by red and yellowish oolitic-bioclastic calcarenites usually dolomitized, frequently organized in bodies some metres thick, which can be interpreted, on the basis of the associated depositional structures, as intertidal sand-flats and bars mainly controlled by tidal currents and storm waves. These oolitic bodies normally alternate with the following lithofacies:

- a) bioturbated, grey or reddish silty-marly dolomites and marls, sometimes fossiliferous, associated with decimetre-thick oolitic-bioclastic storm layers (subtidal);
- b) red siltstones, marly and silty dolomites, marls characterized by wavy bedding and lenticular bedding, sometimes with desiccation structures (from high intertidal to supratidal).

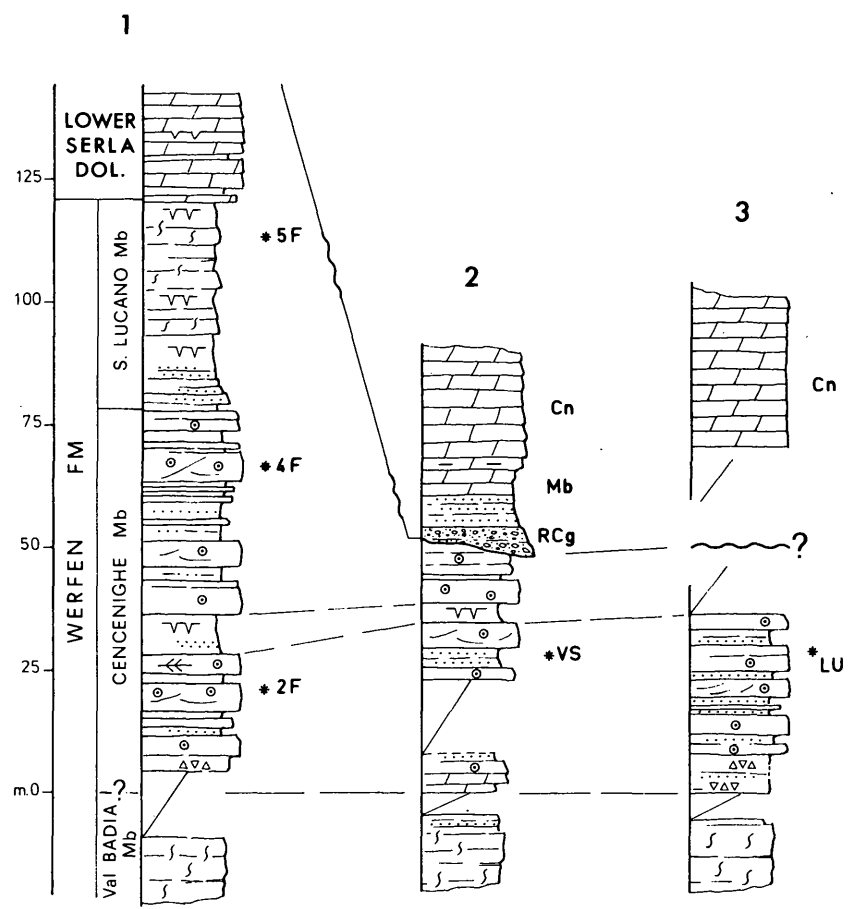


Fig. 2: Stratigraphical sections showing the vertical setting of the studied fossiliferous layers; 1 - Val Averta; 2 - Val Sorda; 3 - Piavac-Lusia; RCg - Richthofen Conglomerate (Upper Anisian); Mb - Morbiac Limestone (Upper Anisian); Cn - Contrin Formation (Upper Anisian); other symbols as in fig. 4

For a more detailed description of the lithofacies and depositional theme, reference should be made to FARABEGOLI et al. (1977), who first described the Cencenighe Member, PISA et al. (1979) and BROGLIO LORIGA et al. (1983).

The Cencenighe Member overlies the Badia Member, mainly composed of gray, marly and silty limestones, highly bioturbated and rich in fossils; in the studied sections the boundary between the two members is covered by vegetation or poorly exposed. In the Piavac-Lusia and Val Averta sections some evidences of supratidal conditions are observed within the lowermost part of Cencenighe Member; they are recorded by collapse breccias and vuggy dolomites which intercalated with the first exposed oolitic layers. In the Val Venegia section (fig. 3) (where the sequence is exposed better) the top of Val Badia Member is represented by a tidal cycle culminating with siltstones and vuggy marly-silty dolomites which show desiccation crack and are directly overlain by highly vuggy oolitic dolomites involved in collapse breccias. So it is possible that in the sampled sections most of the cover at the boundary between the two members should affect the Val Badia Member, the top of which consists of lithotypes far more erodible than its most typical bioturbated subtidal facies.

The following description of the Cencenighe Member is mainly based on the stratigraphic section of Val Averta, the only one complete and relatively well exposed (figs 2, 4); this section has been divided into some informal units, to make the explanation easier.

The supratidal horizon representing the base of the member (unit A) is followed by a mainly subtidal interval (unit B) composed of alternating oolitic beds 1-2 m thick, and silty units, without a precise trend (symmetric and random sequences). In the upper part of unit B, in the three investigated sections, an important fossiliferous layer has been found which contains the most significant taxa of the Cencenighe Member including *Dinarites dalmatinus* and *Eumorphotis telleri*, although there is predominance, in number of specimens, of *Neoschizodus* and *Bakevellia*. In Piavac-Lusia and Val Averta (VA, 2F) fossils are concentrated in a decimetre-thick layer forming a

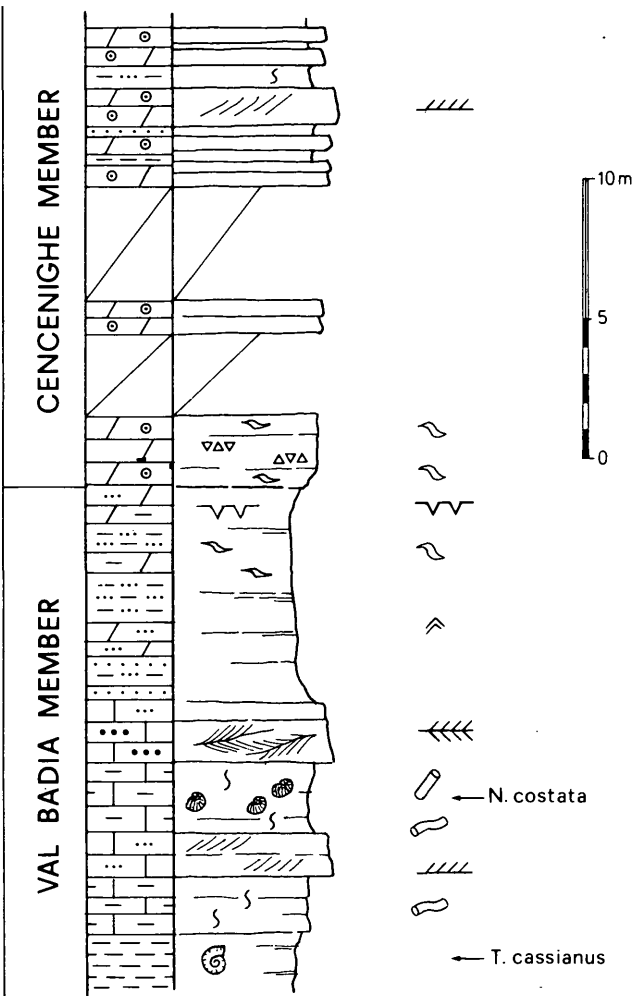


Fig. 3: Boundary between Val Badia Member and Cencenighe Member, Val Venegia section. Symbols as in fig. 4.

coquina at the top of oolitic beds; they probably represent storm accumulations. In Val Sorda the fossils are distributed in a bed of siltstones and fine-grained sandstones approximately 50 cm thick, affected by load structures. The most important information which can be obtained from these faunas is remarkable diversity compared to the standard of the Werfen Formation.

In Val Averta fossils occur also in bioturbated siltstones overlying the main fossiliferous layer (VA, 2F) and in a decimetre-thick storm layer in between (VA, 3F); the fauna composition is similar but less rich of that reported in the main level. Furthermore, within the whole unit B the bioclastic component is quite predominant and is mainly repre-

sented by pelecypod-valves, usually iso-orientated along the laminae of the cross-bedded oolitic sets. In most cases classification is not even possible at genus level.

The following unit C, approximately 5-6 m thick, consists of prevailing red siltstones and marly-silty dolomites with lenticular bedding, rich in desiccation structures (mud-cracks, tepee) recording a pre-dominant supratidal mud-flat environment; these rocks rest (through a transitional contact) on top of a herringbone oolitic and arenaceous body (sand-flat), therefore completing a classical tidal flat cycle. This supratidal horizon occurs in all sections of the middle and western Dolomites, including the type section of Cencenighe Agordino (Val Cordevole), and divides the member into two large regressive sequences. In the following unit D there is a more or less gradual restoration of the subtidal conditions recorded by the predominance in the middle-high part of the unit of CU-sequences which testify the progradation phases of the tidal oolitic bars on the subtidal shelf pelites.

In the upper part of such sequences, within an intertidal calcarenite body having herringbone structures, the fauna 4F of Val Averta has been found; it is represented by a bivalve coquina where *Neoschizodus ovatus* prevails. "Myophoriae" are the most frequent fossils in the upper part of the Cencenighe Member as documented by several stratigraphic sections from Val d'Adige to Cordevole, and frequently form current and storm accumulations with features similar to the "Myophoria banks" of the Lombardian Servino Formation (CASSINIS, 1968).

In the upper half of the Cencenighe Member crinoid remains are also very frequent; they can form true encrinite layers. For this reason in the past this part of the series was often said to belong to the so-called "*Dadocrinus gracilis* beds" (BROGLIO LORIGA in LEONARDI, 1967, p. 130; ROSSI, 1973); generally they were dated to the Lower Anisian. This term, now no more used in the Dolomites stratigraphy, actually meant rather heterogeneous litho-stratigraphic units, unified only by the common occurrence of crinoid remains, and partly belonging to the Werfen Formation and partly to the Morbiac Limestone (Upper Anisian); accordingly they can be by no means correlated with the Gracilis Formation of Recoaro area which lies between the Lower Serla Dolomite and the Pelsonian Recoaro Limestone (DE ZANCHE et al., 1980).

S. Lucano Member

It overlies the Cencenighe Member with a transitional passage; the lower boundary is marked by the disappearance of oolitic and bioclastic calcarenites characterizing the Cencenighe Member. The prevailing lithotypes are represented by fine-grained sandstones, siltstones, marls, arenaceous-silty-marly dolomites, which are reddish, violet and yellowish in colour. Its thickness may vary from approximately 40 m in Val Averta section to 60 m reported in Val Venegia, at the western slopes of Cima Valles; it is therefore much thicker compared to the Agordo area where the member was formally established by PISA et al. (1979) (in the standard section of Torrente Framont it is 19 m thick to which, according to the writers' criteria, about 7 m of "gray marls and quartz silty-dolomites" transitional to Lower Serla Dolomite can be added). In Val Averta section the lower part of S. Lucano Member is made up by predominant red siltstones and sandstones, arenaceous and silty dolomites, marl; the above lithotypes show flaser-, wavy- and lenticular bedding and are organized in FU-sequences (tidal cycles) some metres thick, with desiccation structures at the top; bioturbation is scarce.

The upper part of the member, similarly deposited in a peritidal context, is characterized by a less intense terrigenous content and less environmental energy; the prevailing lithofacies are the following:

- a) Pure dolomites to marly-silty dolomites, seldom with arenaceous content; the colour varies from red to violet; they are nodular, highly bioturbated with rhynchocorallids, horizontal and vertical burrows; they form sets with a thickness ranging from a few decimetres to little more than 1 m.
- b) Laminated marly and silty dolomites, with thin siltstones and calcarenite intercalations having a ripple and megaripple geometry with wave structures; they form sets normally less than 1 m thick.
- c) Laminated red silty marls with lenticular bedding and mud-cracks, forming sets some decimetres thick.

Although the bad exposure frequently makes it difficult to infer the depositional theme, locally the above mentioned lithofacies are organized in cycles a-b-c, with a thickness varying from something more than 1 m to 4-5 m, where the term a) represents the subtidal and c) the supratidal part.

The macrofauna 5F of Val Averta, the first so far found in the S. Lucano Member of the Dolomites, containing 7 taxa with Werfen affinity (*Natiria costata* etc. in association with *Costatoria costata*) comes from a 30-40 cm thick layer of slightly nodular dolomites (lithofacies a) approximately 7 m below the top of the member; fossils are scattered in the sediment and consist of badly preserved composite moulds and casts.

The uppermost 3 m of the member consist of prevailing grey-whitish marly-silty dolomites and laminated marls, scarcely bioturbated with centimetre intercalations of siltstones and parallel-laminated silty dolomites; desiccation structures also occur. This unit, corresponding with the "grey marls and quartz silty-dolomites" of FARABEGOLI et al. (1977), represents the transition to the overlying unit referred to Lower Serla Dolomite.

Lower Serla Dolomite

White stratified dolomites (layers 5 to 50 cm thick), with centimetre and decimetre marly intercalations and tepee horizons. The marly interlayers gradually decrease upwards to disappear at 12-13 m above the base. The thickness of the formation has not been defined; also because of the poor exposure, it has not been possible to recognize a stratigraphic discontinuity with respect to the overlying Contrin Formation (Upper Anisian). The fossiliferous content is restricted to rare badly-preserved foraminifers (*Glomospira* sp.).

PALEONTOLOGY

The fossils occurring in the stratigraphical sections described in this paper were already known to the early authors who dealt with the stratigraphy of the Southern Alps (WISSMANN & MÜNSTER, 1841; HAUER, 1850; LEPSIUS, 1878; TOMMASI, 1895; WITTENBURG, 1908; OGILVIE GORDON, 1927; LEONARDI, 1935). The most comprehensive works on mollusc faunas of the Dolomites are confined almost entirely to TOMMASI (1895) and LEONARDI (1935). Since LEONARDI's work some occasional revision has been made, for instance, on the gen. *Eumorphotis* BITTNER (ICHIKAWA, 1958), on ammonites (KUMMEL, 1969), on Pectinidae (ALLASINAZ, 1972).

Some years ago, preliminary revision of *Eumorphotis* and *Claraia* from the Dolomites has been carried out during a stratigraphical revision of Werfen Formation by BROGLIO LORIGA et al. (1983).

Although the Scythian faunas of the Southern Alps have been studied and known for more than a century, their taxonomic position is rather confused for these different reasons.

- 1 - The "Werfenian" fossils are mostly represented by natural casts, internal and composite moulds (sensu McALESTER, 1962; BAMBACH, 1973), which only rarely make it possible to observe important taxonomic features (i.e. the hinges and the internal features of the pelecypods).
- 2 - To a varying extent the fossils are affected by deformation, mostly due to the diagenetic compaction and plasticity of the marly sediments where they were included. The deformation produces extremely variable outlines and shapes in specimens belonging to the same species, making their specific recognition very difficult.
- 3 - The old practice to establish new species and sub-species at any morphological variation, frequently on the basis of a restricted number of specimens, resulted in a great nomenclature proliferation, which does not correspond with the low diversity of the Scythian faunas (BROGLIO LORIGA et al., 1983, p. 551).
- 4 - Some further problems arise from the classification of Southern Alps Lower Triassic fossils into the taxa erected on the German Muschelkalk material, pertaining to a different geographical area and to a different and generally younger stratigraphic unit. The use of these taxonomic names for the "Werfenian" faunas was allowed mainly by the poor preservation of the fossils and by a rough resemblance to German material. It is possible that some misinterpretation was done by early authors.

PURPOSES

Purposes of the paleontological part of this paper are:

- a critical approach to the taxonomic revision of the so-called "*Myacites*", "*Myophoria*", "*Gervilleia*", "*Myalina*"; a revision about these fossils is still in progress and some preliminary results are given.

- A complete illustration of the macrofaunal assemblage founded in the Upper Scythian (Cencenighe and S. Lucano Members).

LEGENDA

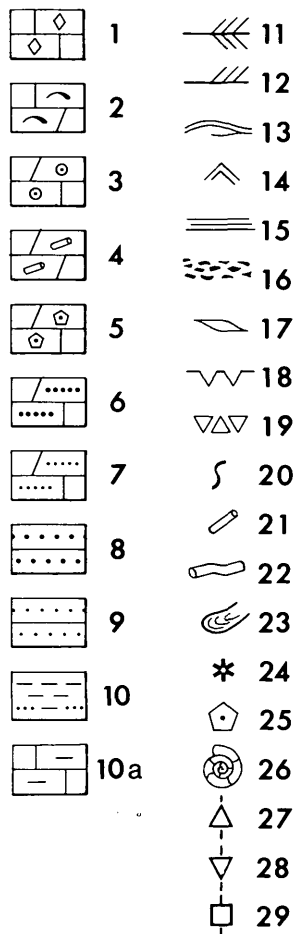


Fig. 4: Cencenighe Member and S. Lucano Member, Val Averta section.
 Legend: 1 - calcarenites (in general); 2 - bioclastic (bivalves) limestone and dolomite; 3 - oolitic dolomite and limestone; 4 - intra-clastic dolomite; 5 - bioclastic (encrinitic) limestone and dolomite; 6 - arenaceous dolomite and limestone; 7 - silty dolomite and limestone; 8 - sandstone; 9 - siltstone; 10 - marl and silty marl; 10 a - marly mudstone; 11 - herringbone; 12 - cross-bedding; 13 - hummocky cross lamination; 14 - wave ripples; 15 - even lamination; 16 - intra-formational breccias; 17 - fenestrae; 18 - mud-cracks and teepes; 19 - evaporitic breccia; 20 - bioturbation; 21 - vertical burrows; 22 - horizontal (deposit-feeders) burrows; 23 - rhizocorallid burrows; 24 - main fossiliferous layers (in *1F numbers within brackets refer to table 1); 25 - crinoid remains; 26 - *Meandrospira pusilla* (HO); 27 - FU-sequence; 28 - CU-sequence; 29 - random and symmetrical sequences.

CONVENTIONS

Because of the previously quoted problems it needs to state some conventions about fossil classification here used.

Reviewed taxa

The fossils belonging to these groups have been classified according to the indications of the quoted authors:

Eumorphotis - ICHIKAWA (1958); BROGLIO LORIGA et al. (1983); BROGLIO LORIGA & MIRABELLA (1984, in press).

Pectinids - ALLASINAZ (1972).

Ammonoids - KUMMEL (1969). According to KUMMEL's indications, we have placed all the *Dinarites* specimens, characterized by extremely changeable ornamentation, in the species *D. dalmatinus* (HAUER), which is regarded as a "single, variable species" (KUMMEL, 1969; p. 507), which, through a complete gradation, range from strong radial ribbed to smooth form (see pl. 4, figs. 1-6).

Not reviewed, but well defined taxa

Some fossils, as not being reviewed recently, are rather well-defined and easily recognizable; they are *Costatoria costata* (ZENKER) and the gastropods *Natiria costata* (MUNSTER) and "*Turbo*" *rectecostatus* HAUER, widely used as biostratigraphic markers. The gastropods show problems only respect to the genus. The genus *Turbo*, according to the "Treatise", appears only in the Upper Cretaceous; therefore HAUER's species would not pertain to such taxon. In *Natiria costata* some taxonomic characters (i.e. callus, umbellicus, etc.) are lacking, due to the preservation degree; as YIN & YOCHELSON (1983) have already observed on Chinese material, this does not allow to state if the species belongs to the gen. *Natiria* or another genus. However, the specific names of the gastropods have been used since the last century to indicate two well-defined morphological groups without any ambiguity.

Problematic taxa

The pelecypods "*Myacites*" (also known as *Homomya*, *Pleuromya*, *Anoplophora*, *Anodontophora* etc.), *Gervilleia* and *Myophoria* are the most problematic taxa in the examined fauna, as the systematics of these groups bases on characters which cannot be easily recognized in the specimens found in the Werfen Formation.

This classification work needs to be supported by a taxonomic review, which is difficult as the types of many species created in the first half of the 19th century have now been lost and we know neither the locus typicus nor the stratum typicum of the different species.

We have tried to clarify the meaning in which the taxonomical names are used, through illustrations and references to literature. It is possible that the present nomenclature pattern may change during our revision; however, the illustrated morphogroups should maintain their validity.

About the pelecypods, the complete lists of bibliographic references until 1931 are reported in Fossilium Catalogus (DIENER, 1923; KUTASSY, 1931); the workers report only:

- selected references posterior to Fossilium Catalogus;
- findings in the Southern Alps;
- changes in the generic attribution of the taxa;
- exhaustive descriptions and illustrations.

Group "*Gervilleia*" Auctt.

Most of the studied specimens from the Dolomites pertain to the gen. *Bakevella* KING, 1848 (according to COX in MOORE (ed.), 1969), except some with a high torsion probably ascribable to the gen.

Hoernesia LAUBE, 1866 (pl. 1, figs 8, 9).

The following six morphogroups have been recognized on the basis of the outline and of the maximum obliquity angle (sensu ALLASINAZ, 1964; "angolo di massima obliquità", p. 686, f. 2).

Bakevella castelli (WITTENBURG)

(pl. 1, figs 1, 2)

- 1908 a *Edentula castelli* WITTENBURG, p. 78, text-fig. 11.
1908 b *Edentula castelli* - WITTENBURG, p. 32, pl. 4, f. 11-13.
1927 *Edentula castelli* - OGILVIE GORDON, p. 29, pl. 2, f. 31.

Originally attributed to gen. *Edentula* WAAGEN, 1907 (= *Waagenoperna*, TOKUYAMA, 1959); this morpho-species belongs to the gen. *Bakevella* for the postero-lateral teeth in the mature stage occurring both in specimens of our collection and in WITTENBURG's illustrations.

Bakevella albertii (MÜNSTER)

(pl. 1, figs. 3-4)

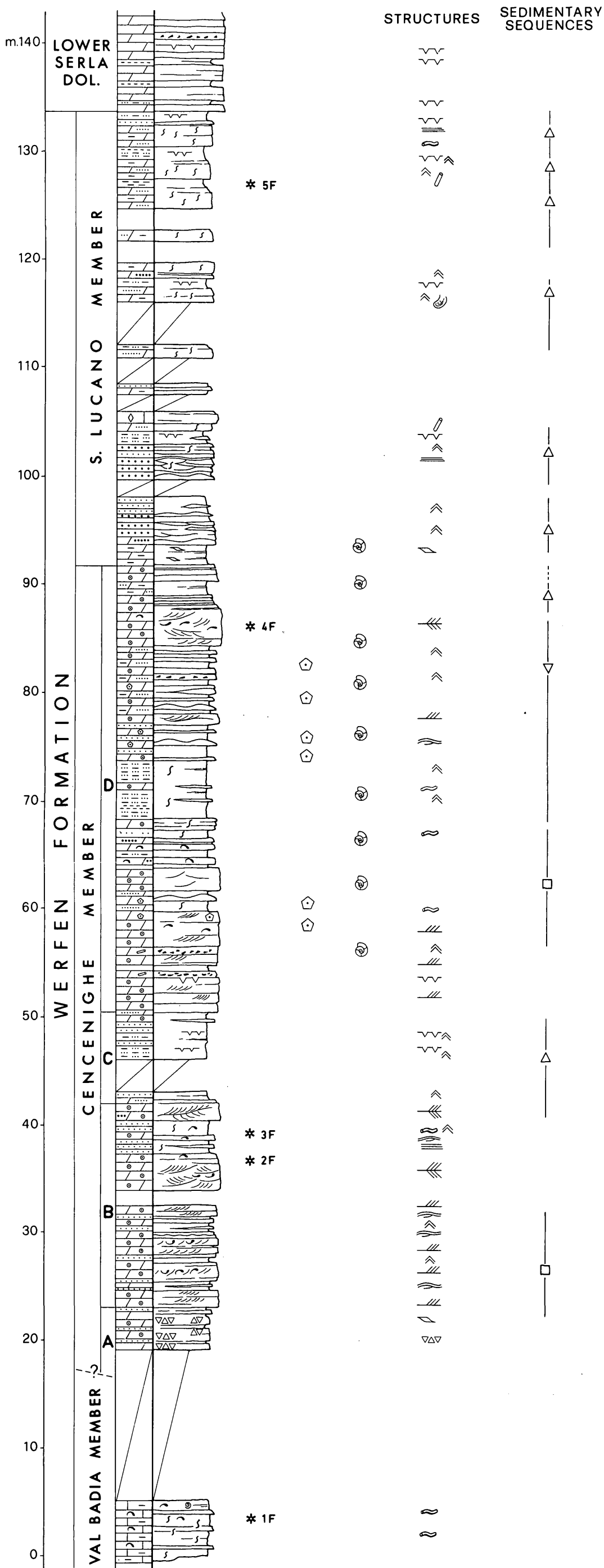
- 1838 *Avicula alberti* MÜNSTER (in GOLDFUSS), p. 127, pl. 116, f. 9.
1851 *Gervillia albertii* - CREDNER, p. 654, pl. 6, f. 7 a-d.
1904 *Gervilleia albertii* - FRECH, p. 15, textfigs 14 a, b.
1935 *Gervilleia mytiloides* (SCHLOTH.) - LEONARDI, p. 50, pl. 2, f. 13.

In the past *Bakevella albertii* was considered to be synonymous of *B. mytiloides* (= *Solenites mytiloides* SCHLOTHEIM, 1820, p. 81, lacking of original illustration). If the original types of *B. mytiloides* will not be found, it will probably be declared invalid SCHLOTHEIM's species, because the original description was insufficient and lacking of illustration.

Bakevella gr. *exporrecta* (LEPSIUS)

(pl. 1, figs. 10, 11)

- 1878 *Gervillia exporrecta* LEPSIUS, p. 352, pl. 1, f. 6 a-c.
1878 *Gervillia incurvata* LEPSIUS, p. 353, pl. 1, f. 3 a, b.
1895 *Gervillia meneghinii* TOMMASI, p. 55, pl. 3, f. 14 a, b.
1907 *Gervilleia exporrecta* - FRECH, p. 13, pl. 1, f. 5 a, b, 6.
1935 *Gervilleia exporrecta* - LEONARDI, p. 52, pl. 2, f. 10-11.



1982 *Gervilleia exporrecta* - CHEN, p. 213, pl. 13, f. 16-18.

This heterogeneous group is represented by a great number of specimens characterized by a wide range of morphological variability, which is in some extent ascribable to deformation. Many specimens are classifiable as *B. exporrecta*, others could pertain to *B. incurvata* (LEPSIUS) and other to *B. meneghinii* (TOMMASI); however the occurrence of a lot of transitional stages (without a well defined trend) between *B. exporrecta* and the latter two species, makes it difficult to draw the species boundary inside the group. It is possible that further examination of the types of the three quoted species may confirm the present view of the writers that *B. meneghinii*, *B. incurvata* and *B. exporrecta* are conspecific. In this case, the species-name has to be *B. exporrecta*, which has the priority on *B. meneghinii*, and it is better known and better defined than *B. incurvata*.

Bakevellia cf. *exporrecta* var. *linearis*
(OGILVIE GORDON)
(pl. 1, figs. 6, 7)

1878 *Gervillia polyodonta* STROMBECK - LEPSIUS, p. 352, pl. 1, f. 4 a-c.

1899 *Gervilleia* cfr. *exporrecta* - BITTNER, p. 16, pl. 3, f. 13, 15.

1927 *Gervillia exporrecta* var. *linearis* OGILVIE GORDON, p. 37, pl. 3, f. 14.

1935 *Gervilleia polyodonta* - LEONARDI, p. 51, pl. 2, f. 18.

The specimens show a close affinity to *G. polyodonta* STROM. as described by LEPSIUS (op. cit.). However, BITTNER (1899) expressed the view that the specimens of LEPSIUS are different from the STROMBECK type, because the former are inequivalve, while this type is equivalve. BITTNER, therefore, stated that the specimens figured by LEPSIUS show features more similar to *B. exporrecta* and referred them to this species. Later, OGILVIE GORDON (1927), finding in the Dolomites some *Gervilleia* similar to the specimens of LEPSIUS and following BITTNER's observations, recognized some other distinctive features: the umbo is placed forward and the inflated area near the line of maximum obliquity is more elongated and narrower than in *B. exporrecta*. Consequently,

she suggested to establish "temporarily" the *linearis* variety of *B. exporrecta*. The specimens here presented show the features described by OGILVIE GORDON; the writers follow her attribution with some reservation, because she figured only one specimen, partially covered by sediment and by other *Gervilleia*.

Bakevellia cf. *ladina* (LEONARDI)
(pl. 1, fig 5 A)

1932 *Gervilleia ladina* LEONARDI, p. 34, f. 4

1935 *Gervilleia ladina* - LEONARDI, p. 52, pl. 2, f. 17.

1943 ? *Gervilleia ladina* BONI, p. 14, pl. 2, f. 8.

The specimens, represented only by internal moulds of left valves, show an outline similar to *B. ladina* according to its original description and illustration. However, the specimens occurring in the bed 4F of Val Averta show smaller size (about 1/3) than LEONARDI's species; furthermore, they do not show the complete morphology of the posterior wing and anterior auricle, due to the kind of preservation.

Bakevellia cf. *costata* (SCHLOTHEIM)
(sensu CREDNER, 1851, p. 647, pl. 6, f. 3 a, b)
(pl. 1, fig. 5 B)

1820 *Mytulites costatus* SCHLOTHEIM, p. 298, pl. 37, f. 2.

1851 *Gervillia costata* - CREDNER, p. 647, pl. 6, f. 3 a, b.

1972 *Bakevellia* (*Neobakevellia*) *costata* - FARSAN, p. 146, pl. 38, f. 1-5.

In the outline the specimens of this morphogroup are comparable with *B. costata* from the German Muschelkalk, but they slightly differ in the concentric ornamentation, less pronounced in our specimens, and in less developed anterior auricle.

Group "*Myacites*" Auctt.

The group, including only endobionts, shows the greatest taxonomic problems and the greatest nomenclature confusion, both at generic and specific levels, as the main taxonomic elements are not preserved. From time to time the Lower Triassic species of "*Myacites*" have been referred to genera *Homomya*

AGASSIZ, 1843; *Pleuromya* AGASSIZ, 1843; *Anoplophora* ALBERTI, 1864; *Anodontophora* COSSMANN, 1897. According to COX (in MOORE (ed.), 1969, p. N842) the genus-name "*Myacites*" is not available for purposes of nomenclature. Furthermore, COX (op. cit.) stated that the genera *Anoplophora* and *Anodontophora* (type-species *Myacites fassaensis* WISSMANN, 1841; from Lower Triassic) are synonymous of *Unionites* WISSMANN, 1841 (type-species *U. muensteri* WISSMANN, 1841; from Carnian). Following this statement, in the paper the so-called "*Myacites*" *fassaensis* and "*M.*" *canalensis* are placed in the genus *Unionites*.

About genera "*Homomya*" and "*Pleuromya*", these taxonomic names are used here in the meaning of early authors, because the objective lacking of some important taxonomic features does not allow to follow the revision of the genera by COX (op. cit.).

Unionites fassaensis (WISSMANN)
(sensu HAUER, 1850, p. 3, pl. 1, f. 4)

- 1841 *Myacites fassaensis* WISSMANN, p. 9, pl. 16, f. 2 a-c.
- 1850 *Myacites fassaensis* - HAUER, p. 3, pl. 1, f. 4.
- 1846 *Anoplophora fassaensis* - ALBERTI, p. 137, pl. 3, f. 8 a, b.
- 1882 *Pleuromya (Myacites) fassaensis* - TOMMASI, p. 63, pl. 1, f. 9 a, b.
- 1895 *Pleuromya (Myacites) fassaensis* - TOMMASI, p. 62, pl. 4, f. 2, 3.
- 1889 *Anodontophora (Myacites) fassaensis* - BITTNER, p. 22, pl. 3, f. 28-33.
- 1922 *Homomya fassaensis* - BENDER, p. 55, pl. 1, f. 6 a-c, pl. 2, f. 6-9.
- 1927 *Anodontophora (Myacites) fassaensis* - OGILVIE GORDON, p. 27, pl. 2, f. 25 a, b.
- 1935 *Homomya fassaensis* - LEONARDI, p. 32, pl. 1, f. 5.
- 1937 *Homomya fassaensis* - VIALLI, p. 97, pl. 6, f. 17.
- 1963 *Unionites fassaensis* - CIRIACKS, p. 82, pl. 16, f. 13.
- 1982 *Unionites fassaensis* - CHEN, p. 218, pl. 2, f. 16.

The classification of this species is not based on WISSMANN's original illustrations, because the illustrated type-specimens are very different from one to the other and their description is very insufficient.

The determination of this taxa follows the picture by HAUER (1850, pl. 1, fig. 4), which is the first representative illustration subsequent to the one by WISSMANN.

Unionites fassaensis var. *brevis* (BITTNER)
(pl. 2, fig. 9)

- 1901 *Myacites fassaensis* var. *brevis* BITTNER, p. 84, pl. 9, f. 13-17.
- 1907 *Anoplophora fassaensis* mut. *bittneri* FRECH, p. 41, pl. 7, f. 1 a, b.
- 1927 *Anodontophora (Myacites) fassaensis* var. *brevis* - OGILVIE GORDON, p. 27, pl. 2, f. 26, 27.
- 1935 *Homomya fassaensis* var. *brevis* - LEONARDI, p. 33, pl. 1, f. 6.
- 1937 *Homomya fassaensis* var. *brevis* - VIALLI, p. 98, pl. 6, f. 18.

The specimens strongly resemble *U. fassaensis* var. *brevis* from the Lower Triassic of Bakony.

Unionites canalensis (CATULLO)
(sensu SCHAUROTH, 1859, p. 327, pl. 2, f. 17)
(pl. 2, fig. 8)

- 1847 *Tellina canalensis* CATULLO, p. 56, pl. 4, f. 4.
- 1859 *Tellina (Myacites) canalensis* - SCHAUROTH, p. 327, pl. 2, f. 17.
- 1882 *Pleuromya (Tellina) canalensis* - TOMMASI, p. 64, pl. 1, f. 10.
- 1895 *Pleuromya (Tellina) canalensis* - TOMMASI, p. 63, pl. 4, f. 5 a-e.
- 1889 *Anodontophora (Myacites) canalensis* - BITTNER, p. 23, pl. 3, f. 34-38.
- 1901 *Myacites canalensis* - BITTNER, p. 85, pl. 9, f. 11-12.
- 1908 b *Anoplophora canalensis* - WITTENBURG, p. 33, pl. 5, f. 6.
- 1927 *Anodontophora (Myacites) canalensis* - OGILVIE GORDON, p. 28, pl. 2, f. 28.
- 1935 *Homomya canalensis* - LEONARDI, p. 35, pl. 1, f. 13-15.
- 1937 *Homomya canalensis* - VIALLI, p. 95, pl. 6, f. 7-9.
- 1963 *Unionites canalensis* - CIRIACKS, p. 81, pl. 16, f. 11-12.
- 1982 *Unionites canalensis* - CHEN, p. 218, pl. 3, f. 12, 15, 19.

According to OMBONI (1882), who has seen the types, CATULLO's illustration would not comply with the original types; therefore, *Tellina canalensis* should be rather considered as synonym of *U. fassaensis*. Nevertheless most authors accepted the species as interpreted by SCHAUROTH (1859). In this latest meaning *U. canalensis* represents a morphological group definitely different from *U. fassaensis*.

"Homomya" sp.
(pl. 2, fig. 7)

This group includes specimens in the outline closely similar to *Homomya albertii* (VOLTZ) from German Muschelkalk, but different in the lack of anterior concentric folds characterizing VOLTZ's species. The classification at genus level is doubtful, as the "Treatise" placed most of *"Homomya"* from Muschelkalk into *Pachymya* (*Arcomya*) ROEMER, 1839. As our knowledge is still insufficient to illuminate the problem, we have provisionally classified these specimens according to early authors' opinions.

"Pleuromya" elongata (SCHLOTHEIM)
(pl. 2, fig. 10)

- 1820 *Myacites elongatus* SCHLOTHEIM, p. 109, pl. 33, f. 3 a, b.
1922 *Pleuromya elongata* - BENDER, p. 90, pl. 3, f. 2 a-c, 3.
1927 *Anodontophora (Myacites) elongata* - OGILVIE GORDON, p. 28, pl. 2, f. 29.
1935 *Pleuromya elongata* - LEONARDI, p. 37, pl. 1, f. 19, 22.

This morpho-species, easy to recognize, is not common in the studied stratigraphic units. At the genus level the taxonomic problems are the same as of *"Homomya" sp.*: poor preservation of the main taxonomic features and insufficient knowledge about the original material.

Group *"Myophoria"* Auctt.

Since the 19th century several workers reported the common occurrence in the "Werfener Schichten" of the species *Myophoria ovata* (GOLDFUSS) and *M. laevigata*

(ZIETHEN), originally described from the German Muschelkalk. According to COX (in MOORE (ed.), 1969) the latter is the type-species of *Neoschizodus* GIEBEL, 1856. The material collected from the Dolomites does not display new evidences to discuss this classification.

Neoschizodus cf. laevigatus (ZIETHEN)
(pl. 2, fig. 1)

- 1830 *Trigonia laevigata* ZIETHEN, p. 94, pl. 71, f. 2, 6 (not seen).
1838 *Lyrodon laevigatum* - GOLDFUSS, p. 197, pl. 135, f. 12.
1856 *Neoschizodus laevigatus* - GIEBEL, p. 40, pl. 3, f. 1, 9, 10.
1864 *Myophoria laevigata* - ALBERTI, p. 115.
1878 *Myophoria laevigata* - LEPSIUS, p. 356.
1935 *Myophoria laevigata* - LEONARDI, p. 41, pl. 1, f. 30, 31, 33.
1960 *Neoschizodus cf. laevigatus* - NAKAZAWA, p. 56, pl. 6, f. 21-32.
1963 *Myophoria laevigata* - CIRIACKS, p. 82, pl. 16, f. 18, 19.

Our specimens differ from the typical forms of German Muschelkalk and of the Anisian of the Southern Alps in the less pronounced keel and the slightly more elongated outline.

? *Neoschizodus laevigatus* var. *elongatus* (PHILIPPI)
(sensu OGILVIE GORDON, 1927)
(pl. 2, fig. 2)

- 1927 *Myophoria laevigata* var. *elongata* PHILIPPI - OGILVIE GORDON, p. 33, pl. 3, f. 4, 14.
1935 *Myophoria laevigata* var. *elongata* - LEONARDI, p. 42, pl. 1, f. 32.

This is a homogeneous group with characters closely similar to that of *M. laevigata* var. *elongata* figured out by OGILVIE GORDON (op. cit.). However, the authors observe that specimens from the Dolomites possess a slight depression in front of the marginal carina, which causes a shallow sinus in the ventral margin. In addition, concentric ornamentation traces differentiate also our specimens from those figured out as *M. laevigata* var. *elongata* by SCHMIDT (1928, p. 185, textfig. 425). Due to such evidences, the

specimens of this group display some resemblances to *Lyriomyophoria elegans* (DUNKER), which, however, shows a more pronounced concentric ornamentation.

Neoschizodus ovatus (GOLDFUSS)

(pl. 2, fig. 3-5)

- 1838 *Lyrodon ovatum* GOLDFUSS, p. 197, p. 135, f. 11.
1856 *Neoschizodus ovatus* - GIEBEL, p. 42, pl. 4, f. 6 (not seen).
1864 *Myophoria ovata* - ALBERTI, p. 118.
1878 *Myophoria ovata* - LEPSIUS, p. 355, pl. 1, f. 7 a, b.
1895 *Myophoria ovata* - TOMMASI, p. 16, pl. 1, f. 19.
1935 *Myophoria ovata* - LEONARDI, p. 41, pl. 1, f. 29.
1943 *Myophoria ovata* - BONI, p. 5, pl. 1, f. 10.
GOLDFUSS's typical form prevails in the lower layers of Cencenighe Memer. The specimens of the uppermost fossiliferous bed (VA, 4F) show more elongated outline and have L/H ratio higher than 1.40; according to RUBENSTRUNCK, 1909 (fide OGILVIE GORDON, 1927), they can be referred to *N. ovatus* var. *elongatus* GIEBEL.

Group "*Myalina*" Auctt.

Rare myalinids (7 specimens) have been found in all the three fossiliferous layers with *Dinarites dalmatinus* (HAUER); they have been attributed, on the basis of CIRIACKS's and CHEN's determination, to the gen. *Promyalina* KITTL, 1904.

The specimens show a great morphological variability. Due to the exiguity of the sample, at present it is impossible to state if it is intra- or inter-specific variability. They are therefore temporarily referred to a single group.

Promyalina eduliformis. (SCHLOTH.)

var. *praecursor* (RENZ)

(pl. 2, figs 11, 12)

- 1904 *Myalina eduliformis* mut. *praecursor* RENZ, in FRECH, p. 21, textfig. 23 (not fig. 24, 25)
?1938 *Myalina putiatinensis* KIPARISOVA, p. 292, pl. 6, f. 10-12.

- 1943 ? *Mytilus eduliformis* var. *praecursor* - BONI, p. 10, pl. 2, f. 18.

- ?1963 *Promyalina putiatinensis* - CIRIACKS, p. 75, pl. 16, f. 1-5.

- ?1982 *Promyalina intermedia* CHEN, p. 212, pl. 3, f. 10, 11.

Some specimens display also some similarities with *P. putiatinensis* (KIPARISOVA) which, in turn, is not very different from RENZ's type (only fig. 23). The relationships and the difference between these two taxa are so far confused that it is questionable to classify such specimens as *P. putiatinensis* or *P. praecursor*. Furthermore, neither of the two species pertains to the same age of our specimens; *P. putiatinensis* occurs in the *Claraia* beds of S. Ussuri and western USA, while the species by RENZ comes from Anisian of the Transdanubian range (Hungary).

BIOSTRATIGRAPHICAL AND CHRONOSTRATIGRAPHICAL CONSIDERATIONS

Cencenighe and S. Lucano Members were established by FARABEGOLI et al. (1977) and PISA et al. (1979), who did not report significant macrofaunal associations in these units. Based on the stratigraphic position of these units, their lateral relationship (assumed heteropic change among Cencenighe Member; S. Lucano Member and Lower Serla Dolomite), and the micropaleontologic content (Foraminifera pertaining to the gen. *Meandrospira*), the quoted authors suggested an Upper Scythian-Lower Anisian age for both Cencenighe and S. Lucano Members, and considered the Lower Serla Dolomite as Lower Anisian. Previously, ROSSI (1973) placed the oolitic sequences of Cencenighe Member within the Lower Anisian; at that time this member was ascribed to "*Dadocrinus gracilis* beds" due to the high frequency of crinoid remains. Actually there is no evidence that the crinoid remains of Cencenighe Member belong to *Dadocrinus gracilis*, thus suggesting Anisian age; GAETANI (1969) had already criticized the biostratigraphic value attributed to these remains.

When *Dinarites dalmatinus* and other fossils of Cencenighe Member (BROGLIO LORIGA et al., 1983) were found, this unit was recognized as belonging to the Upper Scythian (Spathian); nevertheless the occasional characters of these findings, concentrated on the lower part of the member, and the lack of

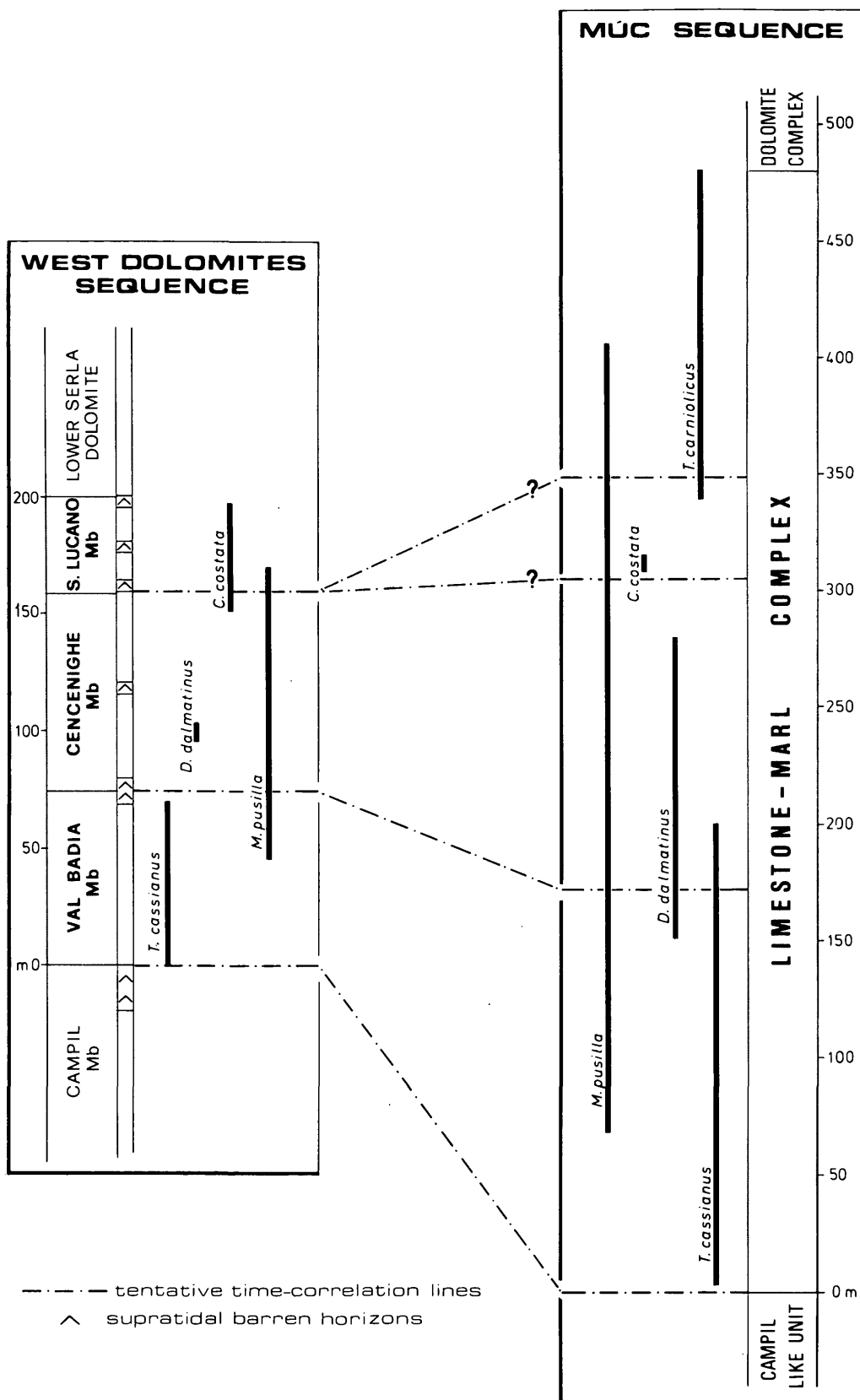


Fig. 5: Tentative correlation of upper Werfen Formation in Muć (Dalmatia) and western Dolomites. Data on Muć sequence from HERAK et al. (1983) and SCAVNICAR & SUSNJARA (1983).

data on S. Lucano Member did not make it possible to classify precisely the upper part of the Werfen Formation.

Still recently BLENDINGER (1983) ascribed the Cencenighe Member, at least partly, to the Lower Anisian.

The new fossil material found in the Southern Alps together with new significant data on the biostratigraphy of the upper part of the Werfen Formation outside this area (see particularly HERAK et al., 1983) made it possible to reconsider the question of dating of these lithostratigraphic units.

The data on the Dolomites show the following faunal sequence in the upper part of Werfen Formation:

- 1) *Tirolites cassianus* faunae; they characterize the Val Badia Member and include *Eumorphotis kittli*, *Unionites*, *Neoschizodus*, "*Turbo*" *rectecostatus*, *Natiria costata*, etc.; the main biostratigraphic markers (*T. cassianus*, *E. kittli*) frequently occur from base to top of the member (BROGLIO LORIGA et al., 1983); in the upper part of the *cassianus* interval the occurrence of rare and poorly preserved specimens of *Dinarites* sp. is possible.
- 2) *Dinarites dalmatinus* faunae, represented by rich fossiliferous horizons in the lower part of Cencenighe Member; such horizons are characterized by the presence of *Eumorphotis telleri*, *Natiria costata*, "*Turbo*" *rectecostatus* as well as high frequency of the pelecypods *Unionites*, *Neoschizodus*, *Bakevella*, which are quantitatively prevailing in the fauna.
- 3) After a large poorly fossiliferous interval, close to top of Cencenighe Member an association mainly consisting of *Neoschizodus* occurs, also including *Bakevella* and the first specimens of *Costatoria costata* with small sizes and few ribs; *E. telleri* and *D. dalmatinus* have disappeared; they have never been found in this stratigraphic position in any of the Dolomites-sections (with the exception of a badly preserved specimen of *Dinarites* sp. from the top of the Cencenighe Member near Passo Rolle). In this interval crinoid remains are found frequently.

- 4) The overlying S. Lucano Member shows a diminished fossiliferous content due to the predominance of inter- and supratidal conditions. In Val Averta section a fossiliferous layer with *Costatoria costata*, *Bakevella*, *Unionites*, *Neoschizodus* and *Natiria costata* was found close to the top of the Member.

The biostratigraphical investigation of other areas in the Southern Alps, still in progress, is emphasizing that *C. costata* is a rather frequent component of the faunal associations of upper Cencenighe and S. Lucano Members; it occurs in many layers, regularly above the *Dinarites* beds.

Many authors used *C. costata* as marker of the Upper Scythian and Scythian-Anisian boundary; its range could reach as far as the Lower Anisian, as is proved by the association with *Myophoria vulgaris* reported by KOZUR (1975) and *Coenothyris vulgaris* reported by GANEV (1974). Within the Dolomites the lack of true Anisian elements and the presence of elements with a Werfenian affinity in the fossil assemblage with *Costatoria costata* exclude a younger age than Upper Scythian for such faunae.

As for the microfauna, in the sequences here described the foraminifer *Meandrospira pusilla* (HO), frequently associated with forms pertaining to the gen. *Glomospira* and *Glomospirella*, is well recorded in the upper part of the Val Badia Member, in the whole Cencenighe Member (where it has its acme-zone) and in the lower part of S. Lucano Member. In the Lower Serla Dolomite only a few specimens, poorly preserved, of *Glomospira* and *Glomospirella* were found.

Data on conodonts concerning the examined stratigraphic sections are not available so far; according to BRANDNER et al. (1984) both Val Badia and Cencenighe Members of the Dolomites would pertain to the *Neospathodus triangularis* zone; furthermore, the occurrence of *N. homeri* at the top of the series is recorded (Cencenighe Member p.p.? - S. Lucano Member?).

The faunal sequence here described can lead to bio- and chronostratigraphic consideration. However, we must take into account, that from Cencenighe Member upwards, presence or absence of the different taxa can be strongly controlled by the environment,

i.e. recurring influence of peritidal conditions. From a biostratigraphic point of view the sequence of faunae of Cencenighe and S. Lucano Members may represent a useful means of correlation within the Southern Alps; besides it may emphasize the importance of comparisons with similar faunal sequences outside this area.

Faunae comparable with those occurring in the Dolomites are present in Hungary, Dalmatia and the Upper Austroalpine units of the Eastern Alps. The data available from literature are not always homogeneous because the exact position in the succession of the different fossils is not always provided and, due to the confusion of nomenclature of Werfenian fossils, we cannot always be sure that a species-name actually refers to a well-defined morphological group.

A sufficiently detailed comparison is possible with the Muć section (Dalmatia), recently examined by KRYSTYN (1974) and HERAK et al. (1983) from a biostratigraphic point of view, and by SCAVNICAR & SUSNJARA (1983) from a sedimentological standpoint.

The sequences, showing sedimentary facies generally similar to those occurring in the Val Badia Member of the Dolomites, contain ammonoid faunae already described by KITTL (1903), which make it possible to recognize two zones, a lower one with *Tirolites cassianus* and an upper one with *T. carniolicus*.

Although the base of the *carniolicus* zone conventionally corresponds with the top of the *cassianus* zone, between the uppermost finding of *T. cassianus* and the first occurrence of *T. carniolicus* an interval of about 150 m occurs, where ammonoids of the genus *Dinarites* (including *D. dalmatinus*), gastropods and bivalves are found; just below the first occurrence of *T. carniolicus* the abundant presence of *Costatoria costata* has to be pointed out.

Therefore the following elements occur both in the Southern Alps and Dalmatia:

- a) a well recorded *T. cassianus* zone;
- b) an interval (above this zone) characterized by *Dinarites*, associated with other fossils;
- c) the presence of *Costatoria costata* in stratigraphic levels higher than *cassianus* zone.

In the sequence of the Southern Alps a definitely smaller number of ammonoids than in the Muć series is found. The absence of *Tirolites carniolicus* in the upper part of the Werfen Formation could be explained in two contrasting ways:

- 1) the unit corresponding with *T. carniolicus* beds in the Dolomites is to be placed above *C. costata* layers and, therefore, into the barren dolomitic complex corresponding with Lower Serla Dolomite.
- 2) The absence of *T. carniolicus* can be ascribed to facies control; the equivalent of *carniolicus* beds could be represented by S. Lucano Member, and probably the upper part of Cencenighe Member. This assumption is illustrated in the tentative correlation between the Dolomites and Muć sequences in fig. 5.

In both cases Cencenighe Member as well as S. Lucano Member would entirely belong to the Scythian.

There is no evidence so far suggesting that the Scythian-Anisian boundary corresponds with the lithostratigraphic boundary between Werfen Formation and Lower Serla Dolomite or lies within the sterile dolomitic complex represented by the latter formation, as it has been suggested by KRYSTYN (1974) for Dalmatia.

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-TABLE 1-		Lusia-Piavac	Val Sorda	Val Averta 2F	Val Averta 4F	Val Averta 5F
FOSSILS-LIST OF CENCENIGHE AND St.LUCANO MEMBERS						
(For the setting of the fossiliferous layers see fig.2)						
1	<u>Promyalina eduliformis</u> (Schlotheim) var. <u>praecursor</u> (Renz)	*	*	*		
2	<u>Bakevella castelli</u> (Wittenburg)	*				
3	<u>B.albertii</u> (Münster)	*	*	*		
4	<u>B. gr. exporrecta</u> (Lepsius)	*	*	*	*	*
5	<u>B. cf. exporrecta</u> var. <u>linearis</u> (Ogilvie Gordon)	*	*	*	*	
6	<u>B. cf. ladina</u> (Leonardi)				*	
7	<u>B. cf. costata</u> (Schlotheim)				*	
8	<u>Hoernesia</u> sp.		*			
9	<u>Eumorphotis telleri</u> (Bittner)	*	*	*		
10	<u>E. tenuistriata</u> (Bittner)		*			
11	<u>E. reticulata</u> (Richthofen) <u>sensu</u> (Wittenburg)		*			
12	<u>E. cf. beneckeii</u> (Bittner)		*			
13	<u>Leptochondria albertii</u> (Goldfuss)	*	*	*		
14	<u>Entolium discites</u> (Schlotheim) var. <u>microtis</u> (Bittner)		*	*		
15	<u>Schythentolium tyrolicum</u> (Wittenburg)	*	*	*		
16	<u>Avichlamys tellinii</u> (Tommasi)	*	*	*		
17	<u>Neoschizodus</u> cf. <u>laevigatus</u> (Ziethen)		*	*		
18	? <u>N.laevigatus</u> var. <u>elongatus</u> (Phil.) <u>sensu</u> (Ogilvie Gord.)		*	*		
19	<u>N. ovatus</u> (Goldfuss)	*	*	*	*	*
20	<u>Costatoria costata</u> (Zenker)				*	*
21	<u>Unionites canalensis</u> (Catullo) <u>sensu</u> (Schaueroth)	*	*	*		
22	<u>U. fassaensis</u> (Wissmann) <u>sensu</u> (Hauer)					*
23	<u>U. fassaensis</u> var. <u>brevis</u> (Bittner)		*			
24	" <u>Pleuromya</u> " <u>elongata</u> (Schlotheim)		*			
25	" <u>Homomya</u> " sp.		*		*	
26	<u>Naticopsis gaillardoti</u> (Lefroy)	*	*	*		*
27	<u>Natiria costata</u> (Münster)	*	*	*		*
28	" <u>Turbo</u> " <u>rectecostatus</u> Hauer	*	*			
29	<u>Coelostylina werfensis</u> Wittenburg				*	*
30	<u>Poligyryna gracilior</u> (Schaueroth)	*				
31	<u>Dinarites dalmatinus</u> (Hauer)	*	*	*		
Cencenighe=Cencenighe Member; \$=San Lucano Member		Cencenighe \$				

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EXPLANATION OF PLATES

Plate 1

- Fig. 1: *Bakevellia castelli* (WITTENBURG). Internal cast of R.V., with posterior lateral teeth; Cresta del Piavac, Passo Lusia (x 1.5).
- Fig. 2: *Bakevellia castelli* (WITTENBURG). Internal cast of L.V., with shell remains. Lusia-Piavac (x 1.5).
- Fig. 3: *Bakevellia albertii* (MÜNSTER). Composite mould of R.V.; Val Sorda (x 2).
- Fig. 4: *Bakevellia albertii* (MÜNSTER). Composite mould of L.V. Val Sorda (x 2).
- Fig. 5, A: *Bakevellia* cf. *ladina* (LEONARDI). Internal cast of L.V.; Val Averta 4 F (x 2).
- B: *Bakevellia* cf. *costata* (SCHLOTHEIM). Internal cast of L.V.; Val Averta 4 F (x 2).
- Fig. 6, 7: *Bakevellia* cf. *exporrecta* (LEPSIUS) var. *linearis* (OGILVIE GORDON). Composite mould of L.V.; Val Sorda (x 2).
- Fig. 8: *Hoernesia* sp. Composite mould of R.V.; Val Sorda (x 2).
- Fig. 9: *Hoernesia* sp. Composite mould of L.V.; Val Sorda (x 2).
- Fig. 10: *Bakevellia* gr. *exporrecta* (LEPSIUS). Composite mould of R.V.; Val Sorda (x 2).
- Fig. 11: *Bakevellia* gr. *exporrecta* (LEPSIUS). Composite mould of L.V.; Val Sorda (x 2).

Plate 2

- Fig. 1: *Neoschizodus* cf. *laevigatus* (ZIETHEN). Composite mould of R.V.; Val Sorda (x 2).
- Fig. 2: ? *Neoschizodus* cf. *laevigatus* var. *elongatus* (PHILIPPI). Composite mould of L.V.; Val Sorda (x 2).
- Fig. 3, 4, 5: *Neoschizodus ovatus* (GOLDFUSS). Composite mould from Val Sorda (x 2) (fig. 3); internal cast from Val Averta 4 F (x 1.5) (fig. 4) and Val Averta 2 F (x 1) (fig. 5). All L.V.

- Fig. 6: *Costatoria costata* (ZENKER). Internal cast of L.V.; Val Averta 5 F (x 2).
- Fig. 7: "*Homomya*" sp. Composite mould of L.V.; Val Sorda (x 1.5).
- Fig. 8: *Unionites canalensis* (CATULLO) sensu (SCHAUROTH). Composite mould of R.V.; Val Sorda (x 1.5).
- Fig. 9: *Unionites fassaensis* (WISSMANN) var. *brevis* (BITTNER). Composite mould of R.V.; Val Sorda (x 1.5).
- Fig. 10: "*Pleuromya*" *elongata* (SCHLOTHEIM). Composite mould of R.V.; Val Sorda (x 1.5).
- Fig. 11: *Promyalina eduliformis* (SCHLOTHEIM) var. *praecursor* (RENZ). Internal cast of R.V.; Lusia-Piavac (x 2).
- Fig. 12: *Promyalina eduliformis* (SCHLOTHEIM) var. *praecursor* (RENZ). Composite mould of L.V.; Val Sorda (x 2).

Plate 3

- Fig. 1: *Leptochondria albertii* (GOLDFUSS). Composite mould of L.V.; Val Sorda (x 2).
- Fig. 2: *Aviclamys tellinii* (TOMMASI). Composite mould of L.V.; Val Sorda (x 2).
- Fig. 3: *Scythentolium tirolicum* (WITTENBURG). Pseudomorphic shell, Val Averta (x 2).
- Fig. 4: *Entolium discites* (SCHLOTHEIM) var. *microtis* (WITTENBURG). Val Averta (x 2).
- Fig. 5: *Eumorphotis telleri* (BITTNER). Composite mould of R.V.; Val Sorda (x 1).
- Fig. 6: *Eumorphotis telleri* (BITTNER). Composite mould of L.V.; Val Sorda (x 1).
- Fig. 7, 8: "*Turbo*" *rectecostatus* HAUER. Composite mould from Val Sorda (x 1.5).
- Fig. 9: *Coelostylina werfensis* WITTENBURG. Internal cast from Val Averta 4 F (x 3).
- Fig. 10, 11: *Natiria costata* (MÜNSTER). Composite mould; Val Sorda (x 1.5).
- Fig. 12: *Naticopsis gaillardati* (LEFROY). Internal cast from Lusia-Piavac (x 1.5).

Plate 4

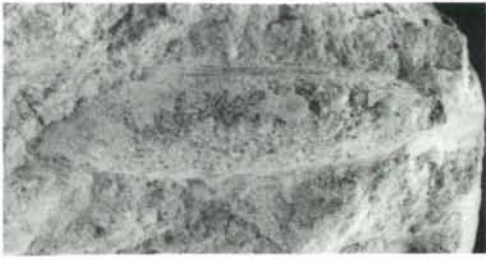
- Figs. 1-6: *Dinarites dalmatinus* (HAUER) sensu KUMMEL (1969) (all specimens are x 1.5) According to KITTL (1903), the following species occur:
Figs 1 a, b: *Dinarites muchianus* (HAUER)
Figs 2, 4 a, b, 5 a, b: *Dinarites dalmatinus* (HAUER)
Figs 3, 6: *Dinarites nudus* TOMMASI
- Localities: 1 a, b: Val Averta 2 F
2, 3, 6: Val Sorda
4 a, b, 5: Lusia-Piavac

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C. Neri dealt mainly with the lithostratigraphy, R. Posenato studied the paleontological problems; conclusions are common.

Dr. Claudio Neri, Dr. Renato Posenato, Istituto di Geologia dell'Università, C.so Ercole 1° d'Este 32, I-44100 Ferrara, Italy.

Plate 1



1



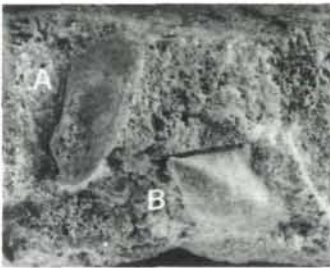
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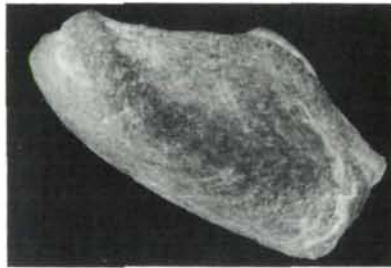
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4



5



6



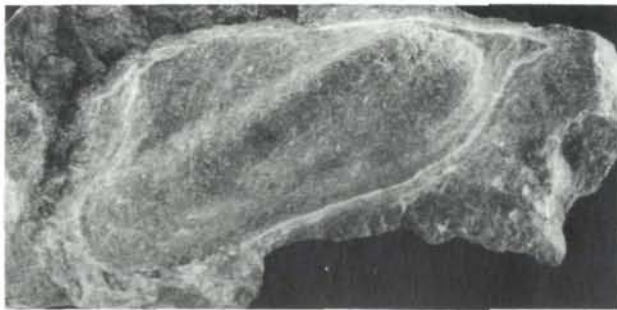
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8



9

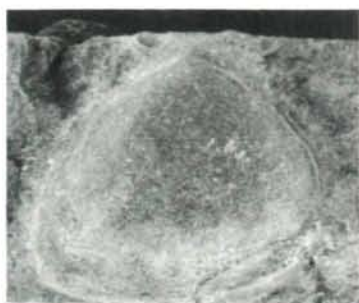


10



11

Plate 2



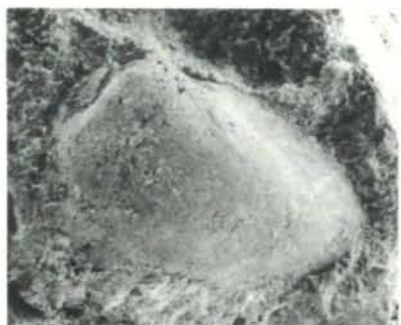
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2



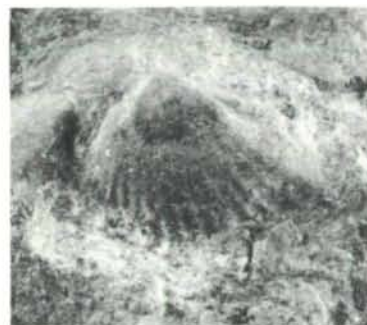
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4



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6



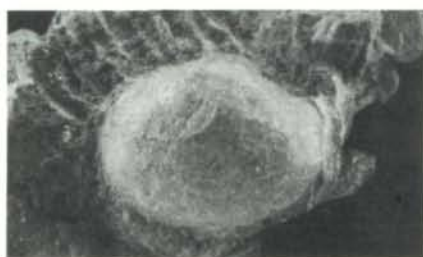
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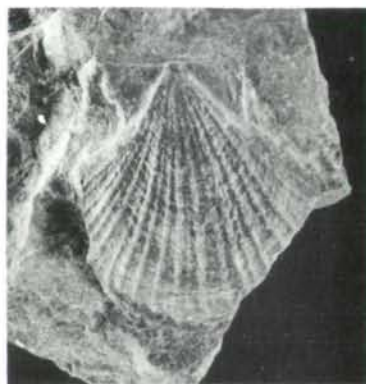


12

Plate 3



1



2



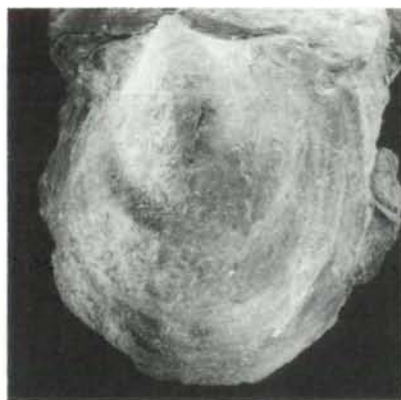
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6



7



8



9



10



11

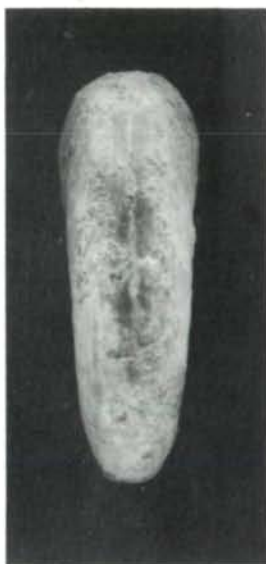


12

Plate 4



1a



1b



2



3



4a



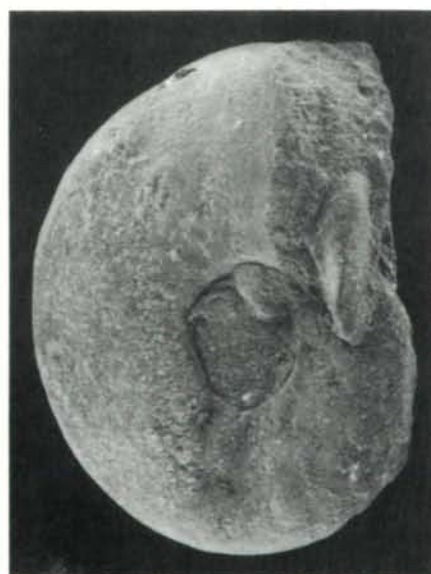
4b



5a



5b



6