

Scythian tectonics in the Southern Alps: Recoaro phase

by V. De Zanche & E. Farabegoli*)

Abstract

In the Recoaro area we have recognized a Triassic tectono-sedimentary cycle, which also includes terminal terrigenous -continental deposits: Mt. Naro Breccia (Upper Scythian) at the base, and Val Leogra Breccia (Lowermost Anisian?) at the top, both containing clasts of the crystalline metamorphic basement. The Mt. Naro Breccia is covered by the Cenogighe Member of the Werfen Formation and is correlatable with the Campil Mb. and Val Badia Mb. of the Dolomites.

The analysis of the sedimentary sequences of the Southern Alps and Northeastern Po Plain indicates that the cycle is tectonically controlled. By Recoaro phase we intend to term the tectonic impulse that produced the cycle.

Riassunto

Nell'area di Recoaro è stato riconosciuto un ciclo sedimentario triassico completo dei termini terrigeni-continentali estremi: la Breccia del Monte Naro (Scitico superiore) alla base e la Breccia della Val Leogra (Anisico basale?) al tetto, entrambe contenenti frammenti del basamento cristallino metamorfico. La Breccia del M. Naro è coperta dal Membro di Cenogighe della Formazione di Werfen ed è correlabile con i Membri di Campil e di Val Badia delle Dolomiti.

L'analisi delle successioni sedimentarie delle aree vicine (Dolomiti, Lombardia, Pianura Padana orientale) dimostra che il ciclo si estende su tutto il Sudalpino e nella Pianura Padana orientale, e che il suo controllo è tettonico. Proponiamo il nome di Fase Recoarèse per l'attività tettonica che l'ha generato.

*) Adresses of the authors: V. De Zanche, Istituto di Geologia dell'Università, Via Giotto 1, I 35100 Padova; E. Farabegoli, Istituto di Geologia dell'Università, Via Zamboni 63-67, I 40127 Bologna.

Zusammenfassung

Im Gebiet von Recoaro wurde ein tektonisch-sedimentärer Zyklus festgestellt, der auch terminal terrigen-kontinentale Ablagerungen einschließt: es handelt sich um die Mt.-Naro-Breccie (oberes Skyth) an der Basis und Val-Leogra-Breccie (unterstes Anis?) im obersten Abschnitt. Beide führen Komponenten des kristallinen Untergrunds. Die Mt.-Naro-Breccie wird durch die Cencenighe-Schichten der Werfener Formation überlagert und ist somit mit den Campiller und Val-Badia-Schichten der Dolomiten vergleichbar.

Die Untersuchung der sedimentären Abfolgen der Südalpen und nord-östlichen Poebene weist darauf hin, daß dieser Zyklus tektonisch kontrolliert wird. Der tektonische Impuls, der diesen Zyklus hervorrief, wird von uns als Recoaro-Phase bezeichnet.

Researchers from the Universities of Bologna and Padua, in agreement with the goals of the Italian Working Group "Triassic of the Tethys realm" of the I.G.C.P. (Project no. 4), have recently paid close attention to the units to be found at the Scythian-Anisian boundary in the Southern Alps.

During research carried out in the Recoaro area (Vicentinian Alps, NE Italy, fig. 1), a polymictic breccia, cropping out in the upper part of the Werfen Formation (Scythian) and containing fragments of the crystalline metamorphic basement, was recognized (cfr. DE ZANCHE et al. 1980).

We believe that this breccia could well be an important key to the tectono-sedimentary Scythian evolution in the Southern Alps. Therefore this work aims at: 1- defining the precise stratigraphic position of the breccia in order to correlate it with some of the lithostratigraphic sub-units into which the Werfen Formation in the Southern Alps has long been subdivided; 2- once more interpreting the Scythian sequence of the Southern Alps in terms of sedimentary cycles in order to obtain information about the paleogeographic and paleotectonic setting of the region.

Introduction

The Scythian sequence in the Southern Alps is composed of terrigenous and carbonate rocks alternating in various proportions from place to place.

Since the last century, for historical reasons this Lower Triassic sequence has been known under different names: 1- *Formazione di Werfen* (or *Werfeniano*) in the Venetian Alps (*Carta Geologica d'Italia* and *Carta Geologica delle Tre Venezie* 1:100.000; sheets Ampezzo, Bassano, Belluno,

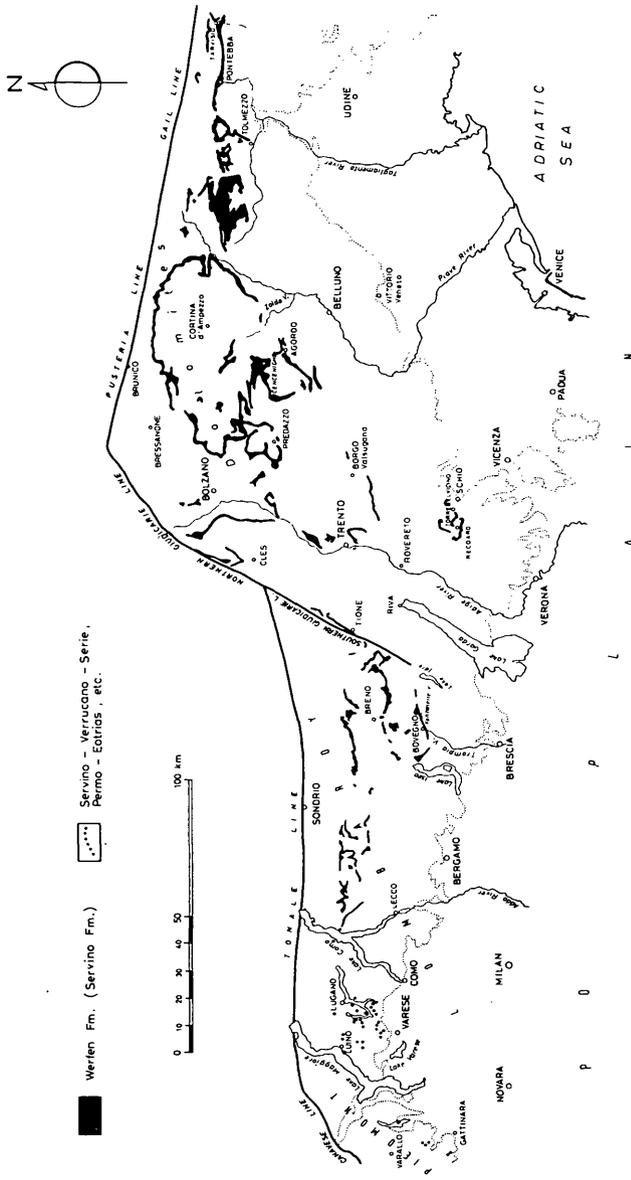


Fig. 1 - Werfen (Servino) Formation, Servino-Verrucano-Serie, Permo-Eotrias, etc. in the Southern Alps (from: Geologische Karte der Schweiz 1:500 000; Geologische Karte der Republik Österreich und der Nachbargebiete 1:500 000; Carta Geologica dell'area di Recoaro 1:20 000; BERNOULLI 1964; CASSINIS 1968).

Bolzano, Bressanone, Feltre, Monguelfo, Monte Adamello, Monte Marmolada, Pieve di Cadore, Riva, Schio, Trento); 2- Formazione del Servino in Lombardy (Carta Geologica d'Italia 1:100.000: sheets Bergamo, Breno, Chiavenna, Como, Sondrio, Tirano, Varese); 3- Other names have been used in the Western part of the Southern Alps where the strong terrigenous and continental character of the sequence and the lack of recent studies have made it difficult to separate the Triassic succession from the Permian one. Comprehensive and informal names - e.g.: Servino Verrucano-Serie in the Lugano area (LEHNER, 1952; BERNOULLI, 1964: Geologische Karte der Schweiz 1: 500.000 - 1972); Arenarie ed elementi di porfido (FRANCHI 1904), Permo-Eotrias (BAGGIO, 1965; FRIZ, 1966), Formazione delle arenarie (CARRARO & FIORA, 1974) in Piemont - have been used.

Since the last century the Werfen (or Servino) Formation has been subdivided into three parts. They are, from bottom to top: 1- "Siusi Beds" (Seisser Schichten WISSMANN in MÜNSTER & WISSMANN, 1841): prevailing carbonates alternated with light coloured siltstones; 2- "Gastropod Oolite" (Gastropodenoolith LEPSIUS, 1878); red and brown oolitic and bioclastic calcarenites, rich in small gastropods, alternating with sandstones and siltstones; 3- "Campil Beds" (Campiller Schichten von RICHTHOFEN, 1860): mainly red-violet sandstones, siltstones and oolitic limestones. This division was used until fifteen years ago.

During the last twenty years a profound revision of the Werfen Formation (Servino Formation) has been made. Its lower and upper limits have been carefully defined, while the "Siusi Beds" and the "Campil Beds" have been subdivided into formal members, key-beds, and lithozones; the Gastropod Oolite being undivided. On the whole, the Werfen Formation has been considered as a tabular shaped body with a transgressive attitude: it gradually overlapped (from East to West) a widespread and flat area of Upper Permian age; weak movements are documented by small transgressive-regressive cycles without widespread erosional processes (cfr: POLLINI & CASSINIS, 1963; ASSERETO & CASATI, 1965; CASSINIS, 1968, fig. 4; LEONARDI, 1968, p. 414; ASSERETO et al., 1973, fig. 4).

As the process of stratigraphic revision is still in course, the knowledge of the Lower Triassic deposits is not homogeneous all over the region. This is the reason why a complete and detailed stratigraphic and paleogeographic picture of Lower Triassic in the Southern Alps is still lacking. Therefore we shall describe in detail the best known areas (Dolomites, Eastern Lombardy, Recoaro) whereas we shall only give a schematic description of the others (Western Lombardy, Lugano area, Piedmont, Po Plain).

The Scythian sequences

a - Dolomites

The Werfen Formation in this area is certainly the best-known sequence in the Southern Alps. The unit covers the lagoonal limestones of the Bellerophon Formation (Upper Permian) through a locally erosional paraconformity (ASSERETO et al., 1973); its upper boundary is transitional to the tidal-flat carbonates of the Lower Serla Formation (Uppermost Scythian ? - Lower Anisian) (PIA, 1937; BECHSTÄDT & BRANDNER, 1970;

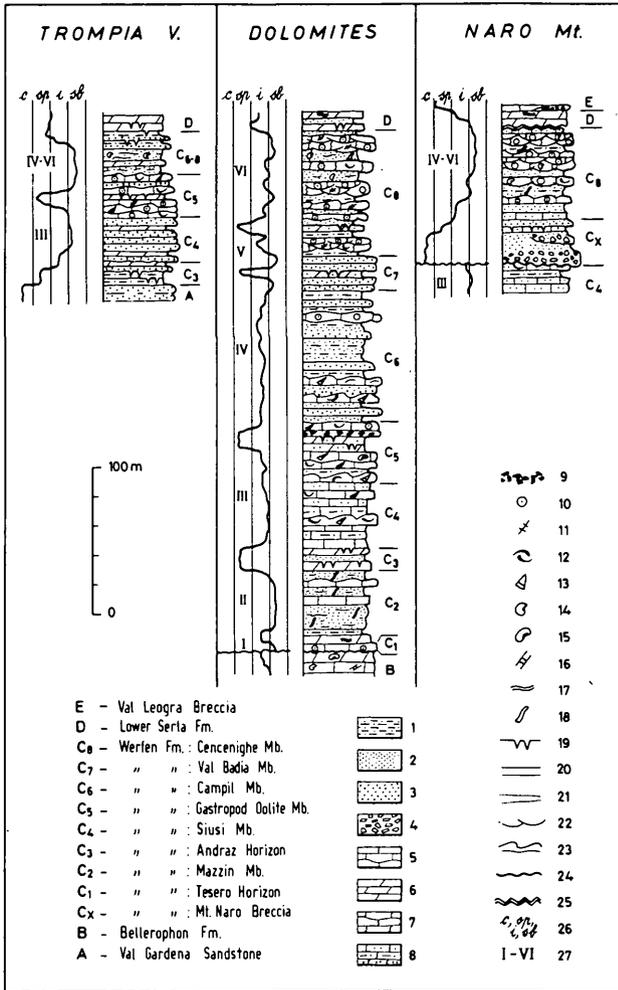


Fig. 2 - Schematic sections of the Werfen (Servino) Formation in the Southern Alps. Lithostratigraphic units: A, ..., E; Lithologies: 1- silty marl and marly siltstone; 2- siltstone and fine-grained sandstone; 3- medium- to very-coarse-grained sandstone; 4- breccia; 5- limestone and dolomitic limestone; 6- aphanitic dolomite; 7- crystalline dolomite; 8- terrigenous-carbonate rocks; 9- intraformational breccia; Components and fossils: 10- oolite; 11- crinoids; 12- pelecypods; 13- gastropods; 14- foraminifers; 15- ostracods; 16- calcareous algae; 17- stromatolites; 18- bioturbation; Other symbols: 19- mud-cracks; 20- even-bedding; 21- low-angle cross-bedding; 22- trough cross-bedding; 23- lenticular bedding; 24- erosional surface; 25- faults; 26- environments: c- continental, sp- supratidal, i- intertidal, sb- subtidal; 27- sedimentary cycles: I - VI.

FARABEGOLI et al., 1977) The Werfen Formation is about 400 m thick and is subdivided into eight formal subunits (members and key-beds) (BOSELLINI, 1968; ROSSI, 1969; FARABEGOLI et al., 1977). The "Dolomites" column in fig. 2, which schematically represents this unit, is a composite section which includes various sections measured in the Agordo area, the Zoldo area and in the central Dolomites (1). For a more detailed stratigraphic and paleoenvironmental description we refer to the authors mentioned above and to BROGLIO LORIGA et al. in GAETANI Ed. (1979).

The Scythian sequence of the Dolomites can be summarized from bottom to top as follows: C₁ - Tesero Horizon: grey oolitic limestones; C₂ - Mazzin Member: grey, often mottled, pelite and micrite; C₃ - Andraz Horizon: yellow and reddish, often vuggy, dolomite and silty dolomite; C₄ - Siusi Member: grey micrite and marly micrite alternating with biocalcarenes bearing gastropods and pelecypods; C₅ - Gastropod Oolite: alternating grey and brown biocalcarenes and biocalcirudites with gastropods and pelecypods and grey arenaceous micrite; a 25 m thick lithozone consisting of yellow and red silty dolomicrospatites is present; C₆ - Campil Member: prevailing red-violet siltstone and sandstone alternated with oolitic and bioclastic calcarenites bearing gastropods; C₇ - Val Badia Member: sandstone, siltstone and grey-green limestone. In the Agordo area, this member contains a meter-thick horizon of yellow and pink vuggy silty dolomicrites; C₈ - Cencenighe Member: alternating grey, red and green siltstones, sandstones, calcarenites and biocalcarenes, in which one or more meter-thick horizons of yellow and red vuggy silty dolomicrites are often included.

On the whole, the depositional environment of the Werfen Formation can be ascribed to a "vast epeiric sea" (ASSERETO et al., 1973), and particularly to a shallow "coastal zone (bay, open lagoon)" (BROGLIO LORIGA et al. in GAETANI Ed., 1979).

In the sequence at least six minor sedimentary cycles (2), comprised between prevailing supratidal carbonates, are recognizable; some of these supratidal deposits have a regional continuity (C₃ and C₅ p.p.). The terrigenous contents, on the contrary, as reflected by the terrigenous/carbonates ratio, follow a simpler general trend. In fact only two main terrigenous events, separated by a carbonate one (C₅), may be recognized. Even if conclusive data which make it possible to establish clearly the hierarchic relationships between the cycles are missing, the occurrence of two distinct terrigenous lithozones seems to point out the existence of two major sedimentary cycles, including cycles of lower orders. (I-III, IV-VI in fig. 2). The Gastropod Oolite (C₅), which divides the two major cycles, can be related partly to the first and partly to the second cycle. It is interesting to note the good correspondence between this division and the tripartition favoured by 19th century authors.

-
- 1) Some stratigraphic sections were measured by E. FARABEGOLI and G. PISA working together, during 1971-1975.
 - 2) We mean "sedimentary cycle" a transgressive-regressive phase, without any reference to the hierarchic order or scale (cfr. MUTTI, 1978). We have made a distinction between the major cycles, which are widespread within the Southern Alps, and the minor ones, which characterize smaller areas (e.g. Dolomites, Lombardy, etc.).

b - Eastern Lombardy (Giudicarie Valley and Camonica Valley)

On the average, the Servino Formation in eastern Lombardy is thinner (100-150 m) than the Werfen Formation in the Dolomites; even if it shows a greater lateral variability of lithofacies, it is divisible into three parts according to the 19th century authors.

The Lombardian Servino has been described in detail by CASSINIS (1968) and split into eight lithological sequences (op. cit., fig. 3), referable to some of the subunits of the Werfen Formation (cfr. ASSERETO et al., 1973). The "Trompia V." section in fig. 2 was measured in Fontanelle Valley (see fig. 1) and is to be considered representative of the unit in the region (cfr. CASSINIS op. cit.; ASSERETO et al. op. cit.). Its lower boundary with the Val Gardena Sandstone (Middle-Upper Permian) is sharply defined; the upper one is transitional to the tidal-flat carbonates of the Bovegno "Carniola" (Uppermost Scythian? - Lower Anisian). The lack of the two lowermost members (C_1 and C_2) can be explained with the transgressive general trend of the unit from East to West, as pointed out by ASSERETO et al. (op. cit.). On the whole, the sedimentary environment is similar to that of the Werfen Formation in the Dolomites.

The vertical evolution of the environments reflects two sedimentary cycles (III, IV-VI in fig. 2) delimited by supratidal carbonates. Furthermore, there are only two main terrigenous pulses, corresponding with the sub-intertidal parts. This evolution is partly similar to that of the Dolomites; besides the lack of the two lowermost members, it differs from the latter because of: 1 - the scarcity, towards the top, of terrigenous facies in general and red ones in particular. It is therefore impossible to distinguish the Campil Members from the Cencenighe Members; 2 - the much stronger terrigenous character of its lower portion.

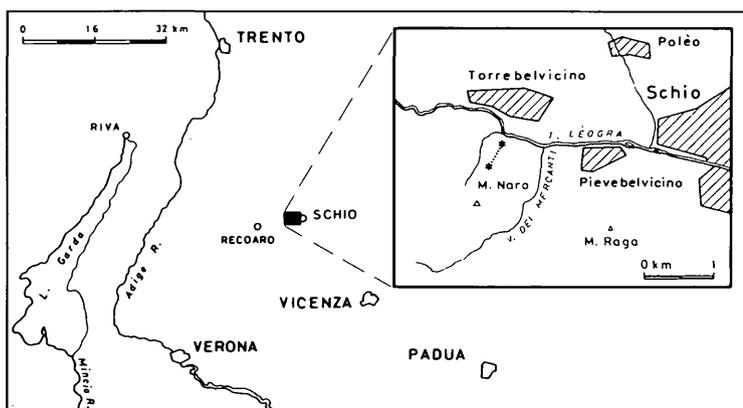


Fig. 3 Location map of the Mt. Naro section

c - Western Lombardy - Lugano area - Piedmont

So far, a detailed regional study of the Lower Triassic sequence is missing. According to the authors who have worked recently on this unit (TRUMPY, 1930, 1958, 1960; DE SITTER 1939; DE SITTER & DE SITTER KOOMANS, 1949; BERNOULLI, 1964; ASSERETO & CASATI, 1965; CASSINIS, 1968; GIANOTTI, 1968) there is a variation of the characters of the unit: it gets gradually thinner (100-150 m) and more terrigenous towards the West.

The analysis of some stratigraphical sections located between the Seriana Valley and the Sassina Valley testifies, on one hand, to the increase of the terrigenous character of the unit, particularly in the lower part; on the other hand, it shows a conspicuous increase of thickness (more than 200 m) in Muggiasca Valley. Just West of Muggiasca Valley, the Servino Formation (and likewise the Bovegno "Carniola") is only sporadically mentioned (e.g. FRAUENFELDER, 1916); it is generally replaced by a conglomeratic-arenaceous sequence denominated "Servino-Verrucano-Serie" (LEHNER, 1952; BERNOULLI, 1964; Geol. Karte der Schweiz 1:500.000, 1972), "Permo-Eotrias" (BAGGIO, 1965; FRIZ, 1966), etc. The examination of the classical sequences of Bellano and of "Gaeta", respectively on the left and right hand of Lake Como, points out clearly that they are incomplete due to faults which have suppressed parts of the Permian sequence and all of the Scythian.

Although we have sufficient data to question previous interpretations we are not yet ready to present an integrated picture of the area West of Lake Como.

d - Recoaro area

The Scythian sequence of the Recoaro area is certainly one of the less known in the Southern Alps. It has been correlated with the "Werfener Schichten" of the Dolomites by BEYRICH (1875); BITTNER (1879) recognized the "Seisser Schichten" ("Siusi Beds") in its grey, yellow, reddish lower part, followed upwards by an oolitic calcareous horizon (Gastropod Oolite). MOJSISOVICS (1876) held the opinion that in the Vicentinian Alps the "Naticella costata-Schichten" (= Campil Beds) were missing; BITTNER (1883) on the contrary interpreted the upper part of the Werfen Formation, consisting of red sandstones and siltstones, as the side-correspondent of the "Campil Beds" in the Dolomites and in the Giudicarie area.

Recently MOSTLER (1976) affirms that in the Recoaro area the Gastropod Oolite is sometimes associated with intraformational breccias and, furthermore, that the biosparites, oosparites and dolomicrites, typical for the uppermost "Campil Beds" in the Atesin Platform, are lacking; according to the author this absence is due to a Lower Anisian erosional event.

As mentioned above, a detailed analysis of the whole unit is lacking; only recently has its uppermost part been related to the Cencenighe Member in the Dolomites (DE ZANCHE et al. 1980). On the average the sequence is 250 m thick (DE BOER, 1963; BARBIERI et al., 1977, 1980), hence much thinner than the maximum thickness in the Dolomites. Furthermore, the Werfen Formation is even thinner, at places of the Recoaro area.

On the northern slope of Mt. Naro (West of Schio), for instance, it is only 150 m thick; in fact, here the sequence is sharply cut into two parts by an erosional and unconformable surface (see "Naro Mt." column in fig. 2). The lower part is generically referable to the "Siusi Beds" Aucutt.; the base of the upper part consists of a ruditic-arenaceous-pelitic lithozone, 33 m thick. We propose to call it by the local name: Breccia del Monte Naro (Mt. Naro Breccia). By gradual transition, it is overlain by grey, red and green oolitic calcarenites, sandstones and siltstones containing *Meandrospira pusilla* (HO). This sequence, 53 m thick, is referable to the Cencenighe Member. Light-coloured, parallel bedded dolomicrites and dolomicrospatites, devoid of significant fossils, gradually follow upwards: this sequence is referable to the Lower Serla Formation (sensu PISA et al., 1979, cfr. DE ZANCHE et al. 1980).

At the top of the Mt. Naro section (fig. 2) some lenticular beds of breccia, containing clasts of the metamorphic basement, occur (Val Leogra Breccia, DE ZANCHE et al., 1980; DE ZANCHE et al., in press).

The Mt. Naro Breccia is devoid of fossils and is arranged according to a "positive" (fining upwards) megasequence. The rudites are grey-coloured, either very-thick (130-150 cm) or medium-thick bedded. The very thick beds are continuous beyond single outcrops and massive, and show at places reverse graded bedding. The medium-thick beds are either solitary, lenticular, discontinuous, planar-convex with an erosional base, or arranged in cosets of trough cross-beds. In the lower part, the sandstones and the siltstones are grey and have a prevailing planar-parallel bedding and lamination; towards the top, they become yellowish and then reddish, the marly contents increase, the small-scale trough cross-laminations prevail and frequent millimetre-centimetre sized dessication-cracks occur. Compositionally the clastic succession consists of carbonates (50%), metamorphic rocks (30%) and quartz (20%); therefore such rocks are to be considered immature litharenites (rudites). The nature of the clasts has been recognized as: 1- grey micrites; 2- grey silty-arenaceous micrites; 3- grey microcrystalline dolomites; 4- grey biomicrites with big pelecypods; 5- marly siltstones and sandstones; 6- dark grey biomicrites with gastropods; 7- grey and reddish, fairly sorted, medium- and coarse-grained sandstones, with prevalent quartz; 8- chloritic phyllites; 9- polycrystalline quartz; 10- muscovite. Lithologies 1-5 are to be referred to the "Siusi Beds" Aucutt. of the Werfen Formation (3.); lithology 6 dubitatively to the Bellerophon Formation; lithologies 7 and 9-10 p.p. to the Val Gardena Sandstone; lithologies 8 and 9-10 p.p. to the metamorphic crystalline basement.

The clast roundness is low: phyllitic fragments are very angular to angular, quartzitic fragments are angular, carbonate ones are very angular to subangular. The cement is carbonatic; the matrix is pelitic and amounts more than 5%; therefore according to FOLK (1974) such rocks are to be considered texturally immature.

There is a gradual passage towards the overlying Cencenighe Member which may be identified through the decrease of terrigenous contents and the increase of either micrites or marine oolitic biomicrites. The lower boundary of the unit has been placed at the lowermost bed of marine fossiliferous micrites.

The transitions between the Cencenighe Member and the Lower Serla Formation and between the latter and the V. Leogra Breccia are gradual.

The environmental evolution of the Scythian-Anisian sequence described above can be summarized in the following five stages:

- 1 - tidal-flats, lagoons, oolitic bars ("Siusi Beds" + Gastropod Oolite);
- 2 - emergence with strong erosion, followed by a prevailing depositional phase in a torrential environment of braided type, with channels first strongly incised then ephemeral. Lastly an alluvial plain in arid evaporitic conditions (ruditic-arenaceous-pelitic lithozone = Mt. Naro Breccia);
- 3 - gradual transition to open marine conditions occurred through the setting up of a shallow water subenvironment (oolitic bar and inter-bar with a strong terrigenous supply: Cencenighe Member);
- 4 - the decrease of terrigenous supply occurred contemporaneously with the gradual transition to carbonate deposition (Lower Serla Formation) characterized successively by lagoonal (subtidal), intertidal and supratidal conditions.
- 5 - the terrigenous supply recommenced in the Lower Anisian and the crystalline basement was once again eroded in a neighbouring area (V. Leogra Breccia).

On the whole, it is possible to distinguish two sedimentary cycles in the sequence (III, IV-VI in fig. 2); the second one includes its terminal terrigenous-continental deposits, both containing clasts of the crystalline metamorphic basement.

e - Northeastern Po Plain

The data from two AGIP oil wells have made it possible to recognize two totally different sequences: a southern one, located SE of Padua, where Scythian deposits are very thick, and a northern one between Vicenza and Schio in which the Scythian terrains are missing due to a Triassic erosional event.

Lithostratigraphic correlations

As mentioned above, the lower portion of the Mt. Naro Scythian sequence is referable to the "Siusi Beds" Auctt. p.p.; in this section the typical facies of the Gastropod Oolite have not been recognized, but it occurs in many other localities of the Recoaro area.

The overlying Mt. Naro Breccia, covered by the Cencenighe Member, contains clasts of the underlying Permian and Scythian sequence and, probably, fragments of the Gastropod Oolite. Therefore the Mt. Naro Breccia is correlatable with the Campil Member and the Val Badia Member in the Dolomites. This correlation is also confirmed by the presence of clasts belonging to the Gastropod Oolite or to the Siusi Member in the sandstones of the base of the V. Badia Member (fig. 6) cropping out in the Cencenighe section (Western Dolomites). As a strongly terrigenous interval, generically referable to the "Campil Beds" Auctt. p.p., is recognizable also in Lombardy we think that the proposed correlation can be extended at least to the whole Southern Alps.

Moreover, according to the AGIP data, such a correlation seems to be valid for a part of the Northeastern Po Plain.

Paleogeographic and paleotectonic interpretation

As appears from the above mentioned data, the upper portion of the Werfen Formation in the Southern Alps corresponds with the lower part of a sedimentary cycle. Generally it lies between the Gastropod Oolite and the lowermost part of the "Gracilis Formation". In the Recoaro area this cycle includes its extreme terrigenous-continental terms: Mt. Naro Breccia (Upper Scythian) at the base and Val Leogra Breccia (Lower Anisian) at the top (cfr. DE ZANCHE et al., 1980). The composition of the Mt. Naro Breccia suggests that the whole underlying sedimentary sequence and parts of the crystalline basement were eroded. As sections, in which the crystalline basement is directly overlain by the upper part of the Werfen Formation, are so far unknown in the Southern Alps, it is necessary to admit a source of the clasts from the South, that is from the Po Plain area. As a matter of fact two different stratigraphical sections occur in the Northeastern Po Plain, South of Recoaro (AGIP unpublished data): a southern one in which the Scythian sequence is thick and continuous and a northern one where the Werfen Formation is missing by erosion. The latter must belong to the source area of the clasts of both the above mentioned breccias.

As a partial confirmation of this interpretation, we should like to mention that DE ZANCHE et al. (in press), on the basis of the high metamorphic/carbonate clast ratio recognized in the Val Leogra Breccia, suggested that in such an area large parts of the sedimentary cover were missing already during Lower Anisian time. This lack seems to have been caused by the above mentioned Upper Scythian erosional event; the prevalent terrigenous character and the great thickness of the Upper Scythian terrains recognized in the southern AGIP well strengthens such an interpretation.

The thickness of the eroded sedimentary cover is 300 m at least; therefore, the Upper Scythian uplift of the area is of about the same size. Furthermore, the peritidal facies of the "basinal" area suggest that the rate of sedimentation was equal to and compensated for the rate of subsidence.

The presence of a small emerged area with strong erosion (Recoaro area p.p., Northeastern Po Plain p.p.) which appeared during the Upper Scythian (Spathian), surrounded by a wide peritidal area (Southern Alps p.p., Northeastern Po Plain p.p.) permits us to exclude a eustatic character for the uppermost cycle and suggests on the contrary a local tectonic origin.

Even if true seaways never formed (as happened, on the contrary, during Anisian and above all during Ladinian (cfr. BECHSTÄDT et al., 1978), free connections with areas of open sea were possible at least at intervals; this is documented by the presence of ammonites in the "Campil Beds" Auctt. of the Dolomites (cfr. LEONARDI, 1968).

Even if it is impossible to define exactly the geometry of the substratum of the emerged area (or areas), the character of the sedimentary cycle as well as the depth of the erosion and the extension of the emerged area point out to a strong similarity between the Upper Scythian cycle and the Anisian cycles of the Dolomites (PIA, 1937; BOSELLINI, 1968; BECHSTÄDT & BRANDNER, 1970; FARABEGOLI et al., 1977; ASSERETO et al., 1977; PISA et al., 1979; DE ZANCHE et al., in press).

As the increase of the terrigenous supply during Upper Scythian does not occur only in the Southern Alps, but seems to be a supraregional event (cfr. for instance TOLLMANN, 1976 for the Austroalpine), we propose to emphasize this tectonic phase giving it the name of Recoaro phase.

Also the Lower Scythian cycle (see p.294), showing an evolutive trend similar to that of the upper one, could be related to an older tectonic event; the lack of data has not yet permitted to locate the emerged area (or areas).

Acknowledgements

The authors are very grateful to Prof. A. BOSELLINI (Ferrara) and to Prof. F. RICCI LUCCHI (Bologna) who revised the manuscript.

Thanks are due to AGIP who kindly set at our disposal some data and thin sections of two oil wells.

This work was sponsored by the Centro di Studio per i Problemi dell'Orogeno delle Alpi Orientali - C.N.R. - Padova, and by the Ministero P. I., Contributo Ricerca Scientifica M: 02292813.

Bibliography

- ASSERETO, R.; BOSELLINI, A.; FANTINI SESTINI, N. & W.C. SWEET (1973): The Permian-Triassic boundary in the Southern Alps (Italy) - In: LOGAN, A. & L.V.HILLS, (Ed.): The Permian and Triassic Systems and their Mutual Boundary. - Can. Soc. Petr. Geol., 2, 176-199, Calgary.
- ASSERETO, R.; BRUSCA, C.; GAETANI, M. & F. JADOUL (1977): Le mineralizzazioni Pb-Zn nel Triassico delle Dolomiti. Quadro geologico e interpretazione genetica. - L'Industria Mineraria, 28, 367-402, Roma.
- ASSERETO, R. & P. CASATI, (1965): Revisione della Stratigrafica permotriassica della Val Camonica meridionale (Lombardia). - Riv.Ital.Pal. Strat., 71, 999-1097, Milano.
- BAGGIO, P. (1965): Geologia della zona del Canavese nel settore occidentale Levone-Cuorneg (Prealpi Piemontesi). - Mem.Acc.Patavina SS.LL. AA., 77, 41-72, Padova.
- BARBIERI, G.; DE ZANCHE, V.; DI LALLO, E.; MIETTO, P. & R. SEDEA, (1977): Middle Triassic emersion phases in the Recoaro area (Vicentinian Alps, NE Italy). - N.Jb.Geol.Paläont.Mh., 523-531, Stuttgart.
- BARBIERI, G.; DE VECCHI, Gp.; DE ZANCHE, V.; DI LALLO, E.; FRIZZO, P.; MIETTO, P. & R. SEDEA, (1980): Note illustrative della Carta geologica dell'area di Recoaro. - Mem.Sc.Geol., 34, 23-52, Padova.
- BECHSTADT, T. & R. BRANDNER, (1970): Das Anis zwischen S. Vigil und Höhlensteintal (Prager und Olinger Dolomiten, Südtirol). - Festb.Geol. Inst. 300-J.-Feier Univ. Innsbruck, 9-113, Innsbruck.
- BECHSTADT, T.; BRANDNER, R.; MOSTLER, H. & K. SCHMIDT, (1978): Middle Triassic Block Faulting in the Eastern und Southern Alps.- Alps Appennines Hellenides, 98-103, Stuttgart.
- BERNOULLI, D. (1964). Zur Geologie des Monte Generoso (Lombardische Alpen). - Beitr.Geol.Karte Schweiz, N.F., 118, 134 pp., Bern.
- BEYRICH, E. (1875): Über die Parallelisierung der Muschelkalk-Ablagerungen von Ampezzo und Recoaro. - Zeit.deutsch.geol.Gesell., 27, 470, Berlin.
- BITTNER, A. (1879): Trias von Recoaro. - Verh.k.k.geol.R.-A., 3, 71-78, Wien.
- BITTNER, A. (1883): Bericht über die geologischen Aufnahmen im Triasgebiete von Recoaro. - Jb.k.k.geol.R.-A., 33, 563-635, Wien.
- BOSELLINI, A. (1968): Paleogeologia pre-anisica delle Dolomiti centro-settentrionali. - Atti Acc.Naz.Lincei, 9, 1-32, Roma.
- CARRARO, F. & L. FIORA, (1974): Studio petrografico e stratigrafico delle tuffiti mediotriassiche dei lembi di Crevacuore e di Sostegno (Biellese orientale). - Riv.Ital.Paleont.Strat., 80, 167-192, Milano.
- CASSINIS, G. (1968): Studio stratigrafico del "Servino" di Passo Valdi (Trias inferiore dell'alta Val Caffaro). - Atti Ist.Geol.Univ. Pavia, 19, 15-39, Pavia.
- DE BOER, J. (1963): The geology of the Vicentinian Alps (NE-Italy). - Geol. Ultraiect., 11, 1-178, Utrecht.
- DE SITTER, L.U. (1939): Les porphyres Luganois et leurs enveloppes. - Leid.Geol.Med., 2, 1-61, Leiden.
- DE SITTER, L.U. & C.M. DE SITTER KOOMANS, (1948): The geology of the Bergamasc Alps, Lombqrdia, Italy. - Leid.Geol.Med., 14, 1-257, Leiden.
- DE ZANCHE, V.; FARABEGOLI, E.; MIETTO, P. & R. SEDEA, (1980): Le unità litostratigrafiche al limite Scitico-Anisico nel Recoarese (Prealpi Vicentine). - Mem.Sc.Geol., 34, 195-204, Padova.

- DE ZANCHE, V.; FARABEGOLI, E.; MIETTO, P. & R. SEDEA, (in press): A report of a "Lower Anisian" breccia in the Recoaro area (Vicentian Alps, NE Italy). - Mem.Acc.Patavina SS.LL.AA., Padova.
- FARABEGOLI, E.; PISA, G. & E. OTT, (1977): Risultati preliminari sull'Anisico della conca di Agordo e dell'alta Val di Zoldo (Dolomiti sudorientali). - Boll.Soc.Geol.It., 95, 659-703, Roma.
- FOLK, R.L. (1974): Petrology of sedimentary rocks. - Hemphill Publishing Co., 182 pp., Austin.
- FRANCHI, S. (1904): Nuovi affioramenti di Trias e di Lias in Valsesia e nel Biellese. - Boll.R.Comit.Geol.It., 35, 4-21, Roma.
- FRAUENFELDER, A. (1916): Beiträge zur Geologie der Tessiner Kalkalpen. - Ecl.Geol.Helv., 14, 247-371, Basel.
- FRIZ, C. (1966): Il significato della serie geologica a nord-ovest di Gattinara per il problema cronologico granito-porfidi. - Mem.Acc.Patavina SS.LL.AA., 78, 171-193, Padova.
- GAETANI, M. (Ed.) (1979) with contributions of BOSELLINI, A.; BROGLIO LORIGA, C.; CASATI, P.; CASTELLARIN, A.; DE ZANCHE, V.; FARABEGOLI, E.; FERRI, R.; FOIS, E.; GAETANI, M.; JADOU, F.; MASETTI, D.; MIETTO, P.; NERI, C.; NICORA, A.; PREMOLI SILVA, I.; SCHLAGER, W.; SEDEA, R.; TINTORI, A.; VIEL, G. & J. WENDT: Riccardo Assereto and Giulio Pisa Field Symposium on Triassic Stratigraphy in Southern Alps. - Field-Guide book, Milano.
- GIANOTTI, R. (1968): Considerazioni sul margine settentrionale del Gruppo delle Grigne (Lombardia centrale). - Atti Ist.Geol.Univ.Pavia, 18, 82-101, Pavia.
- LEHNER, P. (1952): Zur Geologie des Gebietes des Denti della Vecchia, des M. Bogfia, des M. Bré und des M. Salvatore bei Lugano. - Ecl. Geol.Helv., 45, 85-159, Basel.
- LEONARDI, P. (1968): Le Dolomiti, Geologia dei monti tra Isarco e Piave. - 1019 pp., Rovereto.
- LEPSIUS, R. (1878): Das Westliche Südtirol, geologisch dargestellt. - 375 pp., Berlin.
- MARINELLI, M.; VIEL, G. & E. FARABEGOLI (in press): Il Permo-Trias delle Alpi Meridionali: evoluzione tardo-ercinica di un bacino marginale di retroarco. - L'Industria Mineraria, Roma.
- MOJSISOVICS, E.M. (1876): Die Triasbildungen bei Recoaro im Vincentinischen. - Verhandl.k.k.geol.Reichsanst., 10, 238-241, Wien.
- MOSTLER, H. (1976): Die stratigraphische Stellung der Gipsvorkommen in der Trias von Recoaro (Vincentin, Italien). - Geol.Paläont.Mitt.Innsbruck, 5/6, 1-20, Innsbruck.
- MÜNSTER, G.G. & H.L. WISSMANN, (1841): Beiträge zur Geognosie und Petrefactenkunde des südöstlichen Tyrols. - In: MÜNSTER, G.G.: Beiträge zur Petrefactenkunde 4, 4-9, Bayreuth.
- MUTTI, E. (1978): Analisi di facies, In: RICCI LUCCHI, F.: Sedimentologia. - III, 22-39, Bologna.
- PIA, J. (1937): Stratigraphie und Tektonik der Pragser Dolomiten in Südtirol. - 248 pp., Wien.
- PISA, G.; FARABEGOLI, E. & E. OTT, (1979): Stratigrafia e paleogeografia dei terreni anisici della conca di Agordo e dell'alta Val di Zoldo (Dolomiti sudorientali). - Mem.Soc.Geol.It., 18, 63-92, Roma.
- POLLINI, A. & G. CASSINIS, (1963): Evolution structurale et sédimentaire du bassin triasique de la Lombardie. - B.R.G.M., 15, 428-437, Paris.
- RICHTHOFEN, J. von (1860): Geognostische Beschreibung der Umgegend von Predazzo, St. Cassian und der Seiser Alpen in Südtirol. - 327 pp., Gotha.

- ROSSI, D. (1969): Formazione di Werfen. In: Note illustrative della Carta Geologica d'Italia. Foglio 11 "M. Marmolada". - Serv.Geol.d'Italia, 27-29, Roma.
- TOLLMANN, A. (1976): Analyse des klassischen nordalpinen Mesozoikums. - 580 pp., Franz Deuticke, Wien.
- TRÜMPY, E. (1930): Beitrag zur Geologie der Grignagruppe am Comersee (Lombardei). - Ecl.Geol.Helv., 23, 379-487, Basel.
- TRÜMPY, E. (1958): Remarks of the preorogenic history of the Alps. - Geol.en.Mijnb., N.S., 20, 340-352, s'Gravenhage.
- TRÜMPY, E. (1960): Paleotectonic evolution of the central and western Alps. - Bull.Geol.Soc.America, 71, 843, New York.

Tafelerläuterung

- Fig. 4 - Mt. Naro Breccia: prevailing metamorphic clasts. (x 5)
- Fig. 5 - Mt. Naro Breccia: prevailing sedimentary clasts and subordinate metamorphic fragments. (x 5)
- Fig. 6 - Polymictic medium-grained sandstone consisting of prevailing quartz grains and subordinately of lithic carbonate clasts. Fragments of oolites similar to those of the underlying Gastropod Oolite and Siusi Member may be recognized. (x 20) Werfen Formation, lowermost part of the Val Badia Member (Cencenighe section, Dolomites).

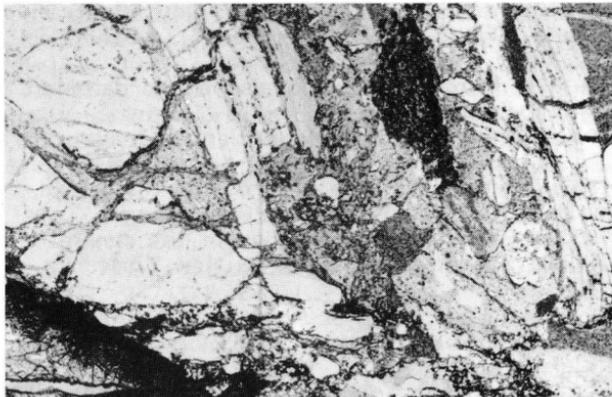


Fig. 4



Fig. 5

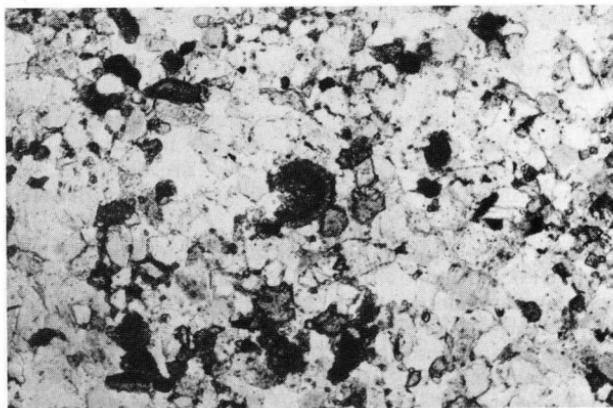


Fig. 6