ANISIAN TECTONICS
IN THE PASSO ROLLE AREA

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Abstract - Late Anisian tectonics crop out in the Passo Rolle area. An anticline involving Pelsonian formations is truncated by an unconformity which is onlapped by Illyrian sediments (Morbiac Limestone and Conthin Formation). New stratigraphic and structural interpretations of the area are presented and regional implications are discussed.

Introduction - The Passo Rolle area (Fig.1) is located along a N-S trending Mesozoic normal fault (Passo Rolle Line, BOSELLINI & DOGLIONI, 1986) located at the eastern margin of the Atesina Platform, close to the transition with the Carnico Bellunese Basin, two major structural elements of the Southern Alps (BOSELLINI, 1965). To the east of the fault, the hangingwall is represented by the Pale di S.Martino, characterized by a greater subsidence with respect to the more stable footwall (Lagorai Chain).

The area is situated close to the northern tip line of the Passo Rolle Line. Southwards this fault increases its displacement (Fiera di Primiero) as far as it is cut by the Neogene N60°E trending Valsugana Overthrust. Stratigraphic data indicate that the fault was active as a normal fault both during Triassic and probably Liassic times. But during the Neogene Alpine compression the fault acted as sinistral transfer fault in the Valsugana overthrust hangingwall: this is also supported by the sudden western end of the N60°E trending Pale di S.Martino Syncline along the Passo Rolle Line, against the northward dipping monocline of the Lagorai Chain whose inclination is due to the ramp geometry of the deep Valsugana Overthrust fault plane.

Rocks of Permian to Middle Triassic age crop out in the Passo Rolle area.

Aim of this paper is to briefly describe the complex stratigraphy and tectonics of the Scythian-Anisian units cropping out in the area. As it is well known since the works of PIA (1937), BOSELLINI (1968), BECHSTADT & BRANDNER (1970), FARABEGOLI et al. (1976), ASSERETO et al. (1977), BLENDINGER (1983), etc., the Anisian stratigraphy of the Dolomites is characterized by a great lateral variability in the facies pattern and by wide hiatuses in the sedimentary record. Areas affected by subaerial erosion locally deep enough to cut away the whole Lower Triassic succession (about 500m) occur close to areas where carbonate platforms flanking deep basins were settled. East of the Badia Valley (Pragser Dolomites) and south-east of the Pale di S.Martino (Agordo area) the Late Anisian deposits are organized into two tectono-sedimentary depositional sequences, each one characterized at the base by continental conglomerates. In the western Dolomites (the so called "Dorsale Badioto-Gardenese" (DBG) of BOSELLINI, 1968) only the latest sequence is preserved. The study area is near the border of the "DBG" which is probably westward transferred from the Cordevole area through the Stava Line - Cima Bocche Anticline alignment to the Passo Rolle area. Tectonized remnants of the older Pelsonian sequence are here preserved below the Illyrian one. Moreover, the tectonic lineaments controlling the evolution of the Anisian units were clearly active during the Scythian time, as shown by thicknesses and facies pattern changes of the Werfen Formation.
**Stratigraphy** - The Werfen Formation (Scythian) is represented by the classical sequence of the Dolomites described by BROGLIO LORIGA et al. (1982) consisting in members and horizons (Figs. 2 & 6) arranged in about 6 depositional sequences. A gradual thinning of the Werfen units occurs from south (Crode Rosse) to the north (Malga Fosse - Passo Rolle). It mainly affects the post-Andraz Horizon succession: e.g. the Campil Member is about 150m thick at the Crode Rosse section while is reduced to about 75m at Malga Fosse. This means that at least since the Siusi Member times the southern extremity of the study area is characterized by an higher subsidence rate than the northern sector.

However there are not facies pattern variations associated to thickness changes until the top of the Campil Member. On the contrary, during the deposition of the upper Werfen Formation lateral facies changes controlled by synsedimentary tectonics are observable mainly in the Cencenighe Member (Fig.3). Section 1 (Val Venegia) may be regarded as a standard of the regional situation.

The Val Badia Member (40-50m) is mainly constituted by an alternation of grey silty mudstone and bioclastic or arenaceous storm-layers; strong bioturbation frequently results in amalgamate nodular units.

The Cencenighe Member (80m) is dominated by red and yellow oolitic bioclastic arenaceous limestones or dolomites alternated to red and grey siltstone and marls. Its vertical evolution is made by: 1) a supratidal horizon (Unit C1a) at the base, consisting of mudcracked siltstone and oolitic dolomites frequently involved in collapse breccias (Fig.3). 2) following a transgressive
trend, C1a is overlain by a subtidal unit constituted by wave- and tide-controlled oolitic bodies alternated to bioturbated siltstone (unit C1). A shallowing of the environment is recorded at the top by a supratidal horizon of regional extent. 3) this is in turn overlain by unit C2, mainly made of hummocky to cross bedded oolitic bodies and bioturbated marls forming a few meters thick CU cycles (prograding littoral shoals).

The S.Lucano Member, (~50m) not represented in Fig.3, is composed by marls, siltstone and dolomites deposited in a lagoonal to supratidal setting.

The lateral deviations of the upper part of the Werfen Formation from the Val Venegia standard are:

1. thickness: the Malga Fosse area still acts as a relative high with reduced thickness of the sedimentary succession while the Crode Rosse area is characterized by an higher subsidence;

2. facies: changes in the facies pattern mainly affect unit C1. In the section 2 this unit is characterized by frequent desiccation structures testifying subaereal exposures. Moreover, the supratidal horizon C1a is here lacking: probably the relative drop of the sea level responsible of the settlement of the peritidal sedimentation in the
seaward located areas results in a nondeposition and subaerial erosion episode on the Malga Fosse high. In the section 3 the unit C1 is represented by a thick sequence of red marly siltstone with minor oolitic intercalations and horizons of laminated gypsum. The sedimentary environment is referred to a lagoonal setting barred to the north by the oolitic shoals of the Malga Fosse high; episodes of major restriction are recorded by the laminated gypsum deposits. The Lower Serla Dolomite (Late Scythian-Early Anisian) is represented by a few thin outcrops which conformably overlies the S.Lucano Member and are unconformably overlain by the deposits of the Late Anisian sequences. It is a carbonate unit made of well bedded dolomites organized in peritidal shallowing upward cycles with stromatolitic horizons. In the study area it has almost been completely eroded during the Late Anisian emersion. In terms of sequence stratigraphy this unit could represent the highstand system tract of the latest Scythian cycle.

The Late Anisian is represented by two depositional sequences bounded by marked unconformities. Every sequence is composed by a transgressive system tract consisting of a continental conglomerate followed by lagoonal sediments (nodular limestones) and by an highstand tract represented by a carbonate platform. The first sequence has been deposited during the Pelsonian - Early Illyrian while the second one is dated to Early - Late Illyrian. While the second sequence is practically ubiquitous throughout the western Dolomites, the first one is only scanty recorded because it was to a large extent eroded during the Illyrian emersion. The best outcrop of the first sequence is located near Rio Marmol (SE of Malga Fosse); its geometrical relationships with the underlying Scythian-Early Anisian units and with the overlying deposits of the second Anisian
sequence as well some details of the stratigraphic sequence are shown in Figs. 4 & 5. Applying the stratigraphic nomenclature introduced by PISA et al. (1978) we have the following units: Voltago Conglomerate (15m); it consists of two units; the lower one is a grey conglomeratic lens-shaped body about 10 m thick with clasts mainly deriving from the Lower Serla Dolomite. It grades upward into a unit made of red muddy sandstones and siltstone with scattered pebbles. Plant remains and roots horizons occur. As it is shown by Fig. 5 the Voltago Conglomerate represents the infilling of the deeper part of a paleovalley cut into the S. Lucano deposits. Calcari Scuri Member (20-30 m); with a transitional contact, an alternation of silty grey marls and whitish dolomites follows upward; it may be interpreted as a lagoonal deposit. It is in turn followed by a succession a few tens of meters thick mainly composed of bioturbated nodular grey to black marly-silty limestones with some marl intercalation in the lower part. This unit is similar both to the "Calcari Scuri del Framont" and to the "Calcari Scuri del Coll'Alto", two coeval members of the Agordo Formation erected by PISA et al. (1978) in the Agordo area and lying between the Voltago Conglomerate and the Upper Serla Formation. The sedimentary environment evolves upwards from lagoonal to shallow marine.

Upper Serla Formation; it is represented by stratified light grey carbonate sediments overlying the nodular limestone unit (Fig. 5). The second sequence of the Late Anisian overlies the folded and eroded first sequence through an angular unconformity (Figs. 4 & 5), or different units of the Late Scythian-Early Anisian succession. It consists in the study area of two formations: the Morbiac Limestone (nodular marly limestone) and the Contrin Formation (algal carbonate platform). The Richthofen Conglomerate which represents the base of the sequence in all the Dolomites is lacking in the Passo Rolle area: only thin discontinuous lenses and pockets of conglomerates occur at the base of the Morbiac Limestone onlapping the footrock of the Illyrian unconformity. As to the south-east (Gares Valley, Cencenighe, etc.) the Richthofen Conglomerate is several tens of meters thick, its absence in the Passo Rolle area is a further evidence of the paleohigh character of this zone.

Tectonics - The Passo Rolle area (the head of the Cismon Valley) is cut by several N-S trending normal faults lowering the eastern part of the valley. They show an anastomosed pattern
and southwards tend to increase their displacement. The fault planes show both normal and horizontal (sinistral and dextral) displacements supporting a polyphasic history of the Passo Rolle Line. To the east in the shear zone hangingwall there is a thickness increase of the Early Triassic formations indicating an active and greater subsidence in that part. The Alpine deformation inherited these features, and thrust geometries have been conditioned by the stratigraphic and structural background (Figs. 2 & 6). For instance the Cimon della Pala Overthrust has its flat only where the Cencenighe Member presents evaporitic deposits; the overthrust is conjugates with the Rosetta Overthrust (CASTIGLIONI, 1939) to form a classic pop-up structure within the wider Pale di S.Martino Syncline. An interesting paleostructure crops out at the NW slope toe of the Cimon della Pala (Fig. 4): a N30-40°E trending anticline involving Late Anisian (Pelsonian) sediments is eroded and sealed by Late Anisian (Illyrian) rocks. The fold is detached in the lower evaporitic layers of the Werfen Formation. The isolated character of this anticline and its buckle geometry would indicate a transpressive tectonic setting. Middle Triassic strike-slip tectonics have been proposed in the Dolomites (BRANDNER, 1984; BLENDINGER, 1983; 1985; DOGLIONI, 1984; 1987; 1988; BOSELLINI & DOGLIONI, 1988). According to DOGLIONI (1984) the Passo Rolle Line could have been active as a dextral transtensional antithetic fault during Middle Triassic times with respect to the sinistral N70-90°E trending Stava Line - Cima Bocche Anticline transpressive alignment; in this case the Late Pelsonian fold discovered at the slope toe of the Cimon della Pala could represent an en-échelon anticline.

In a more regional view this local tectonic information is useful in unraveling the Anisian puzzle. Since the BOSELLINI's (1968) paper was clear that the Dolomites underwent during Anisian times a significative tectonic deformation. The Anisian unconformities have been mapped almost all over the Dolomites indicating each time a different structural situation and a different degree of Anisian erosion. The
maximum erosion is once again localized on the top of the Atesina Platform, but there also are active features of Anisian age E-W oriented, like the Cima Bocche Anticline which shows a decrease of the Anisian erosion at its limbs and an increase of the Richthofen Conglomerate all around it, supporting a growth fold activity for the Cima Bocche structure. This anticline was strongly active also during Ladinian times (CASTELLARIN et al., 1982; DOGLIONI, 1984). The Passo Rolle area is located to the south of the Cima Bocche Anticline and the tip line of the Passo Rolle Line is close to the southern limb of the anticline supporting a coeval life of the structures. In conclusion, the Anisian deformations now observable in the Dolomites are probably related to the same geodynamic setting responsible for the Ladinian and Carnian tectonics. Moreover, facies and thickness changes of the Werfen Formation would also predict a Scythian onset of tectonics.

Acknowledgements - Thanks to Prof. A. Bosellini and A. Castellarin for the critical reading of the text and to Prof. G. Gatto, D. Masetti, D. Rossi and Dr. G. Ferioli for the useful discussions. Thanks also to Dr. P. Pizzolotto for her help in drawings. This paper was supported by MPI 60% (grants Prof. A. Bosellini and Dr. C. Neri) and was presented to the "CNR Alpi" meeting in Bologna the 19-12-1988.

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Testo pervenuto il 29 dicembre 1988.