Jb. Geol. B.-A.	ISSN 0016-7800	Band **127**	Heft 3	S. 307-319	Wien, Dezember 1984

Late Ladinian Strike-slip Tectonics of the Marmolada-Costabella Area (Dolomites)

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With 9 figures

Südtirol
Dolomiten
Trias
Ladin
Karbonatplattform
Paläogeographie
Lateraltektonik
en echelon-Überschiebungen

Zusammenfassung

Anhand der ladinischen Fazieseinheiten der Marmolada und des Costabellammassivs können spätladinische Lateralverschiebungen nachgewiesen werden. Die ladinischen Sedimente können in eine Karbonatplattformfazies und eine Beckenfazies untergliedert werden. Die Plattformkarbonate bestehen aus einem inneren, meist gebankten Bereich und einem brekziösen Plattformhang, der durch charakteristische, beckenwärts einfallende „Überguß-Schichtung" gekennzeichnet ist. Die Beckensedimente verzahnen sich mit keilförmig progradierenden Ausläufern der Überguß-Schichtung.

Die Faziesverteilung verdeutlicht, daß im Gegensatz zu früheren Auffassungen im Ladin zwei isolierte Plattformen existierten. Die südliche wird „Costabella-Plattform" benannt. Sie umfaßt die Massive zwischen der Vallaccia im W und den Cime dell'Auta im E. Die nördliche, kleinere „Marmolada-Plattform" umfaßt das Marmolada-Massiv und den Collaccio.

Synsedimentäre, NW-SE streichende Störungen begrenzen die innere Plattform und weisen zusammen mit generell NE und SW einfallenden Überguss-Schichten auf eine ursprüngliche NW-SE Erstreckung der Costabella-Plattform hin. Ein ähnlicher Trend ist an der Marmolada zu beobachten.

NNE-SSW streichende Linksseitenverschiebungen sind das dominierende Strukturelement im Untersuchungsgebiet. Sie treten im E der NNE-SSW streichenden Störungszonen des Monzonigebietes und des Cogolmai auf. Nur ein horizontales Zerscheren der Costabella mit einem Linksseitenversatz von 11 km kann ihre heutige Position erklären.

Eine NNW-SSE-Kompression tritt nur im Bereich E der Monzoni-Cogolmai-Störungszone auf. Die Kompression wird durch SSE-vergente Überschiebungen und Falten dokumentiert, die nach E hin deutlich an Bedeutung abnehmen. Diese Phänomene werden als zur Monzoni-Cogolmai-Störungszone gehörende en-echelon Kompressionen gedeutet.

Eine solche tektonische Situation kann durch eine nach NNE auslaufende Linksseitenstörung erklärt werden. Da die NNW-SSE-Kompression unmittelbar N der Marmolada an Intensität deutlich abnimmt, dürfte sich die Cogolmai-Störung unter den Vulkaniten der Padonkette nur noch wenig nach NNE erstrecken.

Das spätladinische Alter der Tektonik wird durch undeformierte vulkanische Gänge belegt, die Faltenstrukturen und Überschiebungen durchschlagen. Spätladinische Vulkanite überlagern an den Cime di Pezza und am Piz Zorlet ein Erosionsrelief, das in einen SSE-vergenten Überschiebungsstapel eingeschnitten ist. Die Monzoni-Intrusion (230 m. a.) schneidet die Monzoni-Störungszone ab.

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Summary

Late Ladinian strike-slip faults can be demonstrated by the matching of Ladinian carbonate facies of the Marmolada-Costabella massif in the central Dolomites. The Ladinian facies of this zone consist of a shallow water carbonate platform facies and a basinal facies. The platform carbonates consist of an internal, generally bedded, facies and an external foreslope talus facies with a characteristical basinward dip of faint bedding ("Überguss-Schichten"). The coeval, well-bedded basinal succession interfingers with detrital carbonate wedges of the foreslope.

In contrast to previous interpretations, the facies pattern of the Marmolada-Costabella area suggests the existence of two different, isolated carbonate platforms in Ladinian times. The southern platform is termed "Costabella platform", which comprises the massifs between the Vallaccia in the W and the Cime dell'Auta in the E. A northern, smaller platform is called

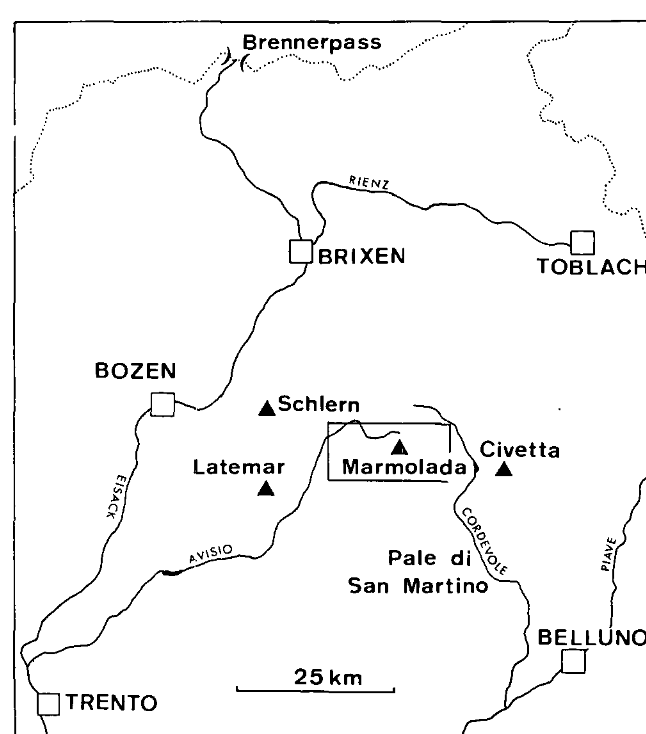


Fig. 1: Location of the study area, marked by the inset rectangle.

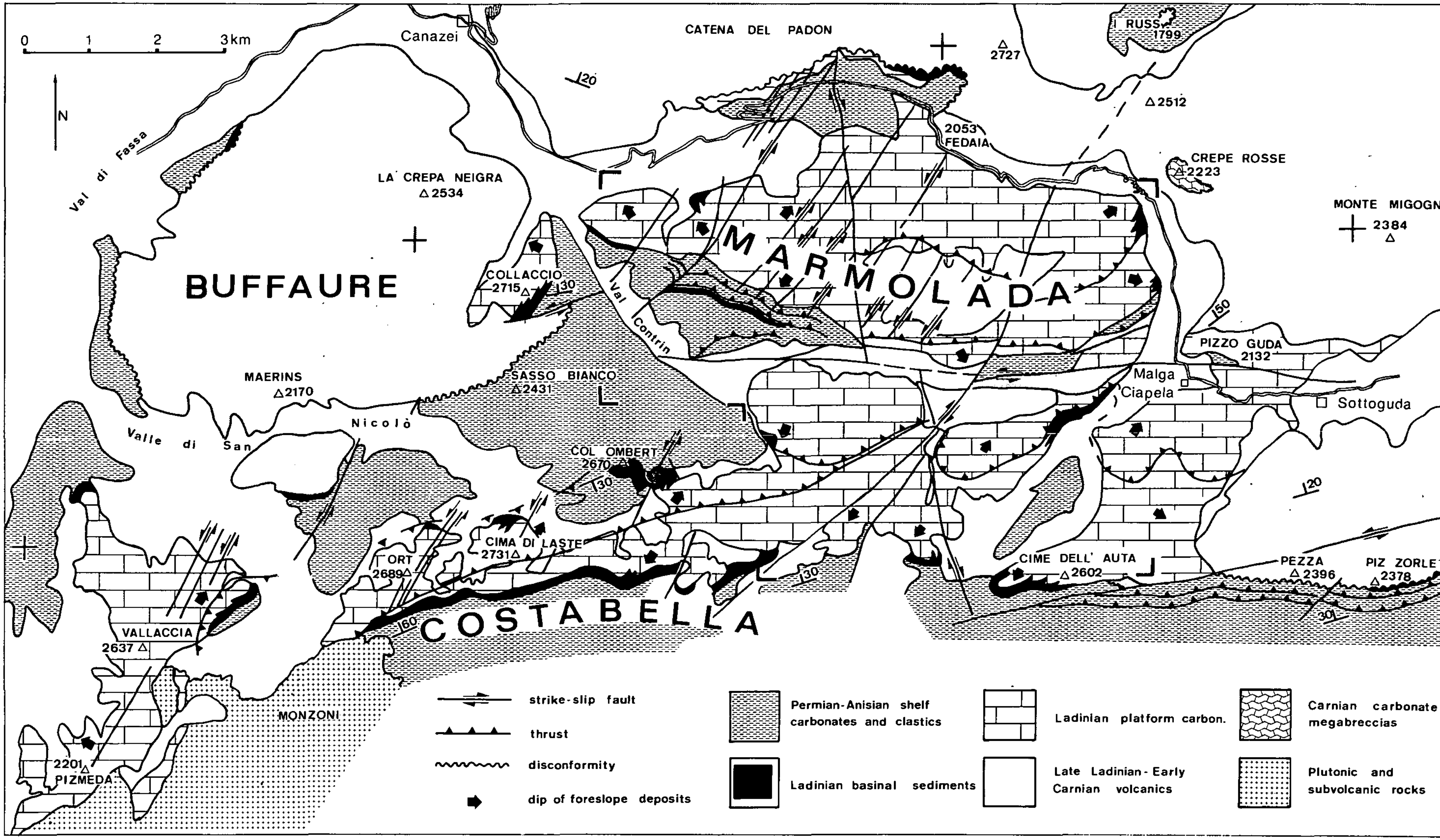
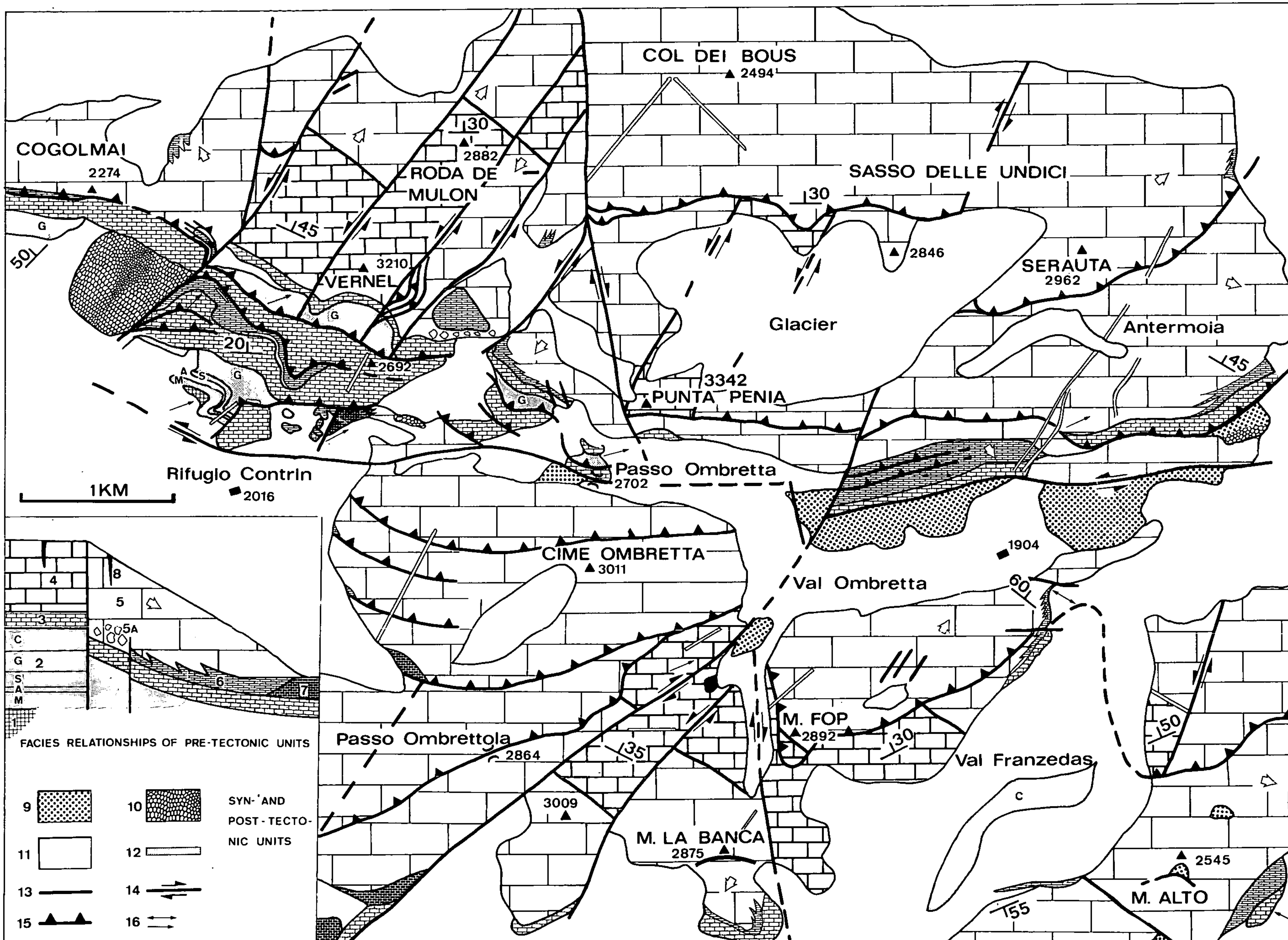


Fig. 2: Geological sketch map of the Marmolada-Costabella area. The black right angles indicate the position of the facies map of fig. 3.

Fig. 3: Facies map of the Marmolada massif and the Cime dell'Auta-Monte Fop area.
1 = Permian Bellerophon Formation; 2 = Early Triassic Werfen Formation; M = Mazzin Member; A = Andraz Horizon; S = Seis Member; G = Gastropodenoolith Member; C = Campil Member; 3 = Late Anisian Sarl Formation; 4 = Ladinian internal platform facies; 5 = Ladinian foreslope talus deposits; A = megabreccias; the arrow indicates the basinward dip of the "Überguß-Schichtung"; 6 = Ladinian basinal Livinallongo Formation; 7 = red limestones of the Livinallongo Formation; 8 = sedimentary dykes; 9 = volcanic re-sediments; 10 = olisthostromatic deposits; 11 = Quaternary cover; 12 = volcanic dykes; 13 = fault; 14 = strike-slip fault; 15 = thrust fault; 16 = fold axes (above: horizontal, below: plunging).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Antermoia
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PUNTA PENIA
Passo Ombretta
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Rifuglo Contrin
2016
1KM
CIME OMBRETTA
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Val Ombretta
M. FOP
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Passo Ombrettola
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FACIES RELATIONSHIPS OF PRE-TECTONIC UNITS
SYN- AND
POST-TECTONIC UNITS

"Marmolada platform" comprising the Marmolada massif and the Collaccio.

The internal platform is separated from the foreslope by NW–SE trending syn-sedimentary faults at the two massifs. NE and SW dipping foreslope talus deposits suggest an original NW–SE orientation of the Costabella platform.

NNE–SSW trending left-lateral faults are dominant structural elements in the investigated area. They occur in the E of a fault zone across the Monzoni valley and the Cogolmai. A left-lateral displacement of 11 km can explain the present position of the Costabella platform.

A NNW–SSE compression is documented in the E of the Monzoni- and Cogolmai fault zones. SSW vergent thrusts and folds occur here. Thrust displacement and thickness of the thrust sets decreases rapidly to the E and suggest an en-echelon pattern of compressional structures.

A tectonic setting similar to that of the Marmolada-Costabella area can be expected at the termination of a NNE–SSW trending strike-slip fault. The decrease of compressional phenomena N of the Marmolada suggests a termination of the Monzoni-Cogolmai fault zone below the volcanics of the Padon range.

The Late Ladinian age of deformation is documented by volcanic dykes which crosscut folds and thrusts. Late Ladinian volcanics rest disconformably on eroded thrust sets along the Pezza–Piz Zorlet range. The Monzoni intrusion (230 m. a.) cuts the Monzoni fault zone.

1. Introduction

The Dolomites, a part of the Southern Alps, have been deformed only moderately by Alpine tectonics (CASTELLARIN & VAI, 1981). Therefore, they are an excellent terrain for the study of Triassic tectonics. The presence of Middle Triassic compressional structures in a localized zone in the central Dolomites (PISA et al., 1980) is a unique phenomenon in the Alps and has been poorly understood. The contemporary calk-alkaline and shoshonitic igneous activity (CASTELLARIN et al., 1977) led CASTELLARIN et al. (1980) to postulate a sinking of the lower crust below the upper crust. This mechanism, similar to a subduction, should account for compressional structures and chemism of magmatic rocks. Recently, however, the Dolomites have been considered as a Triassic oblique-slip mobile zone in the NW Tethys realm (BRANDNER, 1984). This interpreation is chiefly based upon data from the Late Anisian, where there is contemporary extensional and compressional tectonics and mismatch of depositional sites and source areas of conglomerates.

The purpose of the present work is to present some new data from the central Dolomites, which suggest considerable Late Ladinian strike-slip movements. In this work, horizontal displacements are demonstrated by the mismatch of particular Ladinian carbonate facies boundaries. The Ladinian carbonates of the Marmolada-Costabella area (for location see Fig. 1) lack a modern description of facies. Only ROSSI (1962) distinguished between bedded and massive platform carbonates and different basinal sediments of the Costabella range.

2. Setting of the Dolomites in Ladinian times

Most part of the Ladinian was a period of considerable tectonic subsidence in the Dolomites. It started with a tectonic pulse at the Anisian-Ladinian boundary which lead to the drowning of a widespread Late Anisian shallow water carbonate platform (Upper Sarl- or Serla Formation). Consequently, deposits of a starved basin cover the Upper Sarl Formation at many places in the Dolomites. Some elevated areas of the fragmented carbonate bank acted as nuclei for the Ladinian carbonate platforms, whose lithotypes lack a formal stratigraphic term. They are conveniently known as Schlern or Sciliar Dolomite, Marmolada Limestone, Rosetta Dolomite or Latemar Limestone. The enormous growth potential of shallow water carbonates could compensate the strong subsidence in these areas. Characteristical facies units formed.

The Ladinian carbonate platforms consist of an internal, mostly bedded part (Latemar Limestone or Rosetta Dolomite) and an external "clinoform" (Marmolada Limestone or Schlern Dolomite) with a basinward dip of faint bedding. This is the so-called "Überguß-Schichtung" (MOJSISOVICS, 1879), which frequently provides direct evidence of the original platform geometries. The coeval basinal sequence (Livinallongo Formation or Buchensteiner Formation) is a chiefly calcareous succession of radiolarian micrites with a various amount of interbedded terrigeneous and volcanoclastic ("Pietra Verde") turbidites. Carbonate debris flows and grain flows occur abundantly in the vicinity of the shallow water carbonate platforms.

This period of subsidence continued into the Late Ladinian, as could be determined by the dating of basinal sediments (GASSER, 1978) and shallow water carbonates (GAETANI et al., 1981). Its termination in Late Ladinian times was accompanied by emersion and karstification of most carbonate platforms (CROS, 1974; CROS & LAGNY, 1969), intensive tectonic movements, eruption of shoshonitic lavas and the emplacement of the famous intrusive bodies of Predazzo and Monzoni (BOSELLINI et al., 1982).

3. Ladinian facies of the Marmolada-Costabella area

3.1. Platform carbonates

3.1.1. Internal platform facies (Fig. 3)

The typically well-bedded limestones of the internal platform have a thickness of about 500 metres (Monte La Banca, Roda de Mulon, Fig. 4). The characteristical facies of these rocks is a sparitic grapestone or rudstone with abundant megalumps, dasycladaceean algae and thick-shelled gastopods. Channelized rudstones are common and probably represent fillings of tidal channels. Teepee structures and small patch reefs composed of calcareous sponges and colonial corals occur occasionally.

3.1.2. Foreslope talus deposits (Fig. 3)

Foreslope talus deposits may reach a thickness of 600 metres (Serauta). They consist of calcareous breccias and microbreccias. Megabreccias have been observed only at the Vernel (Figs. 3 & 7). Here, boulders may reach a size of some tens of metres. The components are re-deposited detrital limestones, reef debris of calcareous sponges and corals together with *Tubiphytes*, and debris of the internal platform. Reefs have been observed in the vicinity of the internal platform. The characterstical fibrous cement of these deposits has been known as "Großoolith-Struktur" (SALOMON, 1895).

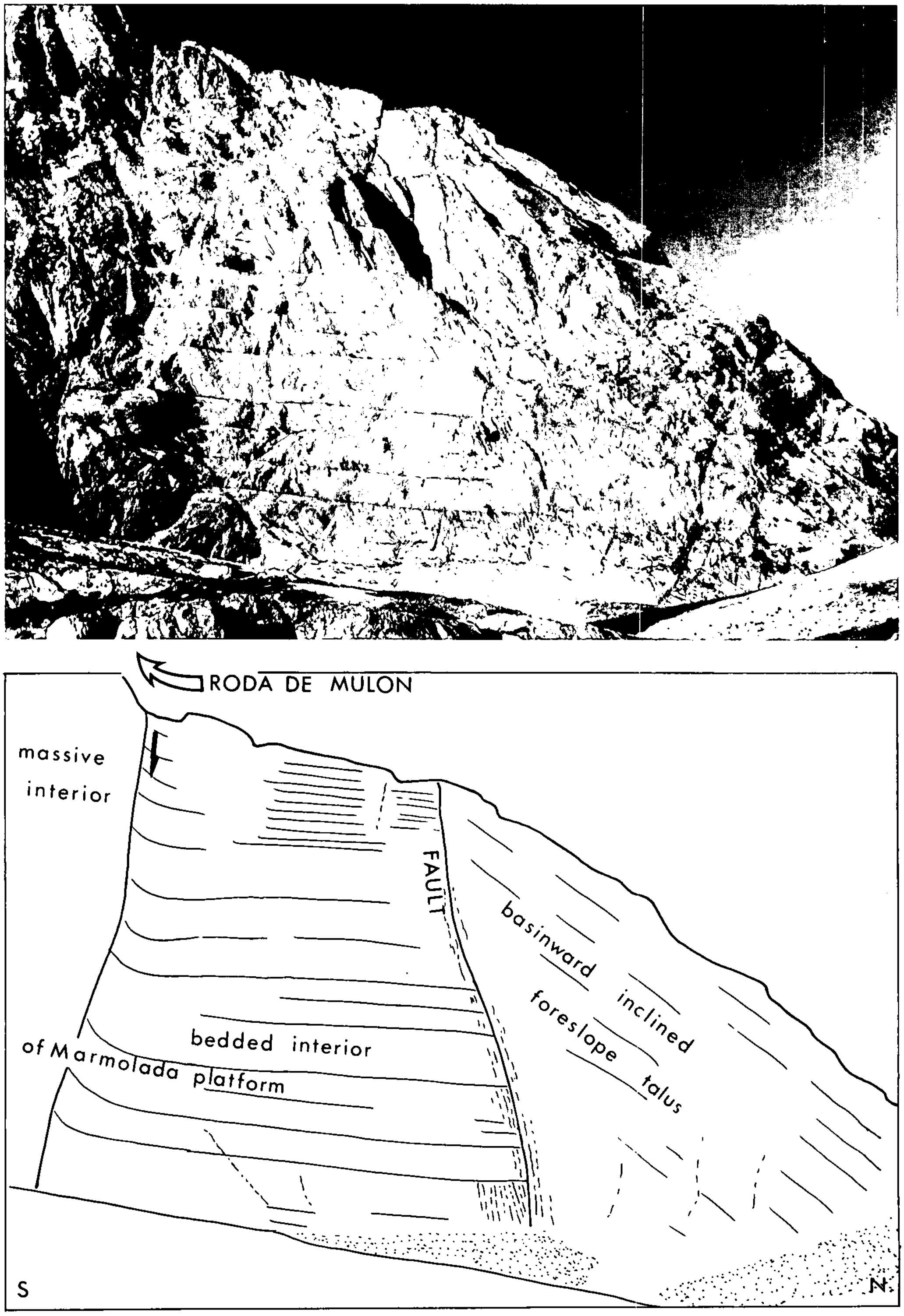


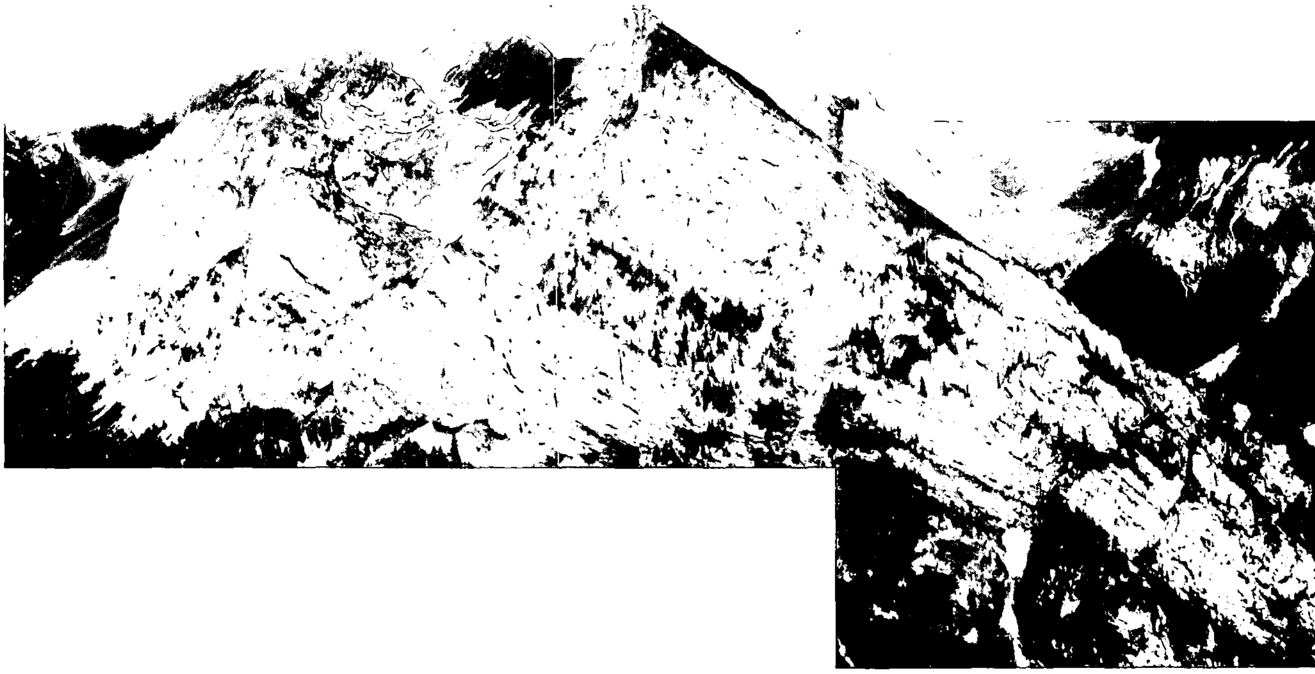
Fig. 4: Separation of the internal platform facies from the foreslope talus by a synsedimentary fault. The narrow zone of well bedded limestones is separated from the massive facies by a synsedimentary fault at the Roda de Mulon, indicated by dragfolds of the bedded facies at the left. Height of outcrop is about 200 m.

The basinward dip of foreslope talus deposits amounts to approximately 30° (Fig. 4). Distal portions prograde onto the coeval basinal sequence as detrital carbonate wedges (Fig. 5).

3.2. Basinal sediments (Fig. 3)

The basinal sediments are up to 100 metres thick (Costabella) and are generally overlain by foreslope talus deposits (Fig. 3, inset facies section, Fig. 5). They are micritic, nodular limestones with thin-shelled pelecypods and radiolaria (see also Rossi, 1962). Thick bedded, light micrites with ammonites and dolomites occur occasionally at the base of the succession. Silica nodules and chert layers are common. Typical "Pietra Verde" turbidites are interbedded at the southern margin of Costabella.

At some places, the Livinallongo Formation is developed as a 50–100 metres thick sequence of well bedded, red limestones (Rossi, 1962, for occurrence see



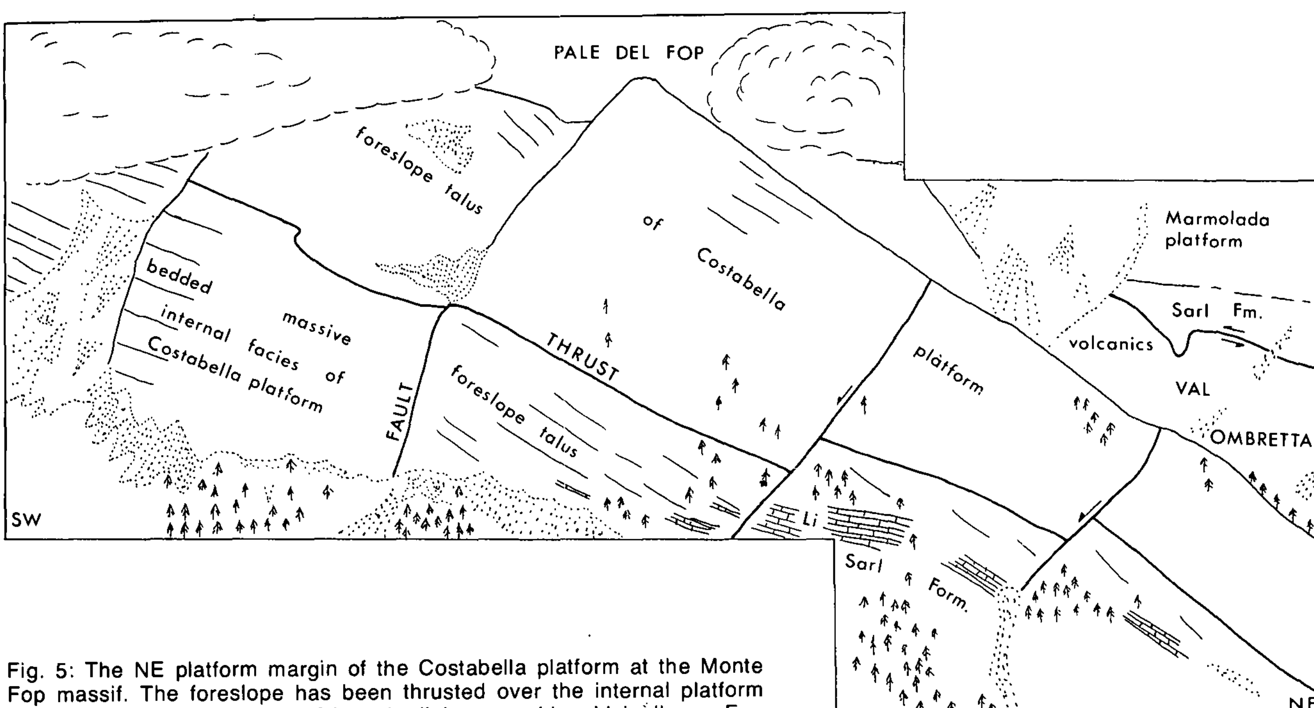


Fig. 5: The NE platform margin of the Costabella platform at the Monte Fop massif. The foreslope has been thrusted over the internal platform along a SSE vergent thrust of Late Ladinian age. Li = Livinàllongo Fm.

Figs. 3 & 9). It is distinguished from the facies described above by the scarcity of "Pietra Verde", of silifications and the richness in cephalopods. Similar deposits also occur at the Sass da Putia (Peitlerkofel) in the northern Dolomites and are interpreted as deposits of a pelagic plateau (FOIS, 1981).

4. Evidence of the Ladinian paleogeography

The available paleogeographic maps for the Ladinian of the central Dolomites consider the Marmolada-Costabella area as remnants of a broad shallow water carbonate platform (BOSELLINI 1984; BOSELLINI & ROSSI, 1974; GAETANI et al., 1981). Some new evidences of the Ladinian paleogeography and the progradation of the carbonate platforms are provided by the following observations:

A) The internal platform is separated from the foreslope by syn-sedimentary faults (Figs. 4 & 5). In contrast to BOSELLINI's (1984) model, there is no progradation of the internal platform towards the basin. Only the foreslope talus progrades (Fig. 5).

B) The general direction of these faults is NW–SE (Fig. 3). The foreslope talus deposits of the Costabella platform suggest an identical platform strike at those places where the internal facies is not exposed. The almost undisturbed Latemar and Schlern – Rosengarten massifs show a similar trend of original platform geometry (GAETANI et al., 1981, fig. 2).

C) At the Ombretta Valley, the southern carbonate massif terminates to the NE (Monte Fop, Figs. 3 & 5), the Marmolada massif shows a pattern of southward inclined foreslope talus deposits. Therefore, two different carbonate platforms existed in Ladinian times. I call the southern one "Costabella platform", the northern one "Marmolada platform" (Fig. 9 D).

D) The Costabella platform ends to the ESE at the Monte Alto – Cime dell'Auta massif toward a basinal area which extends up to the NNE trending Civetta massif. I call this area "Cordevole basin". The WNW termination of the Costabella platform is exposed at the Vallaccia – Pizmeda massif. Here, the carbonate platform faces an area which was characterized by basinal sedimentation from the Late Anisian on (MASETTI & NERI, 1980). This is the "Fassa basin" which separated the Costabella from the Schlern platform (Fig. 9 D). The SW termination of the Costabella platform (Fig. 2) suggests a basinal area ("Pellegrino basin"), where presently only Permian volcanics crop out. The NE termination of the Costabella platform (Fig. 2) suggests a basin in the area of the Contrin- and Ombretta valleys. This ba-

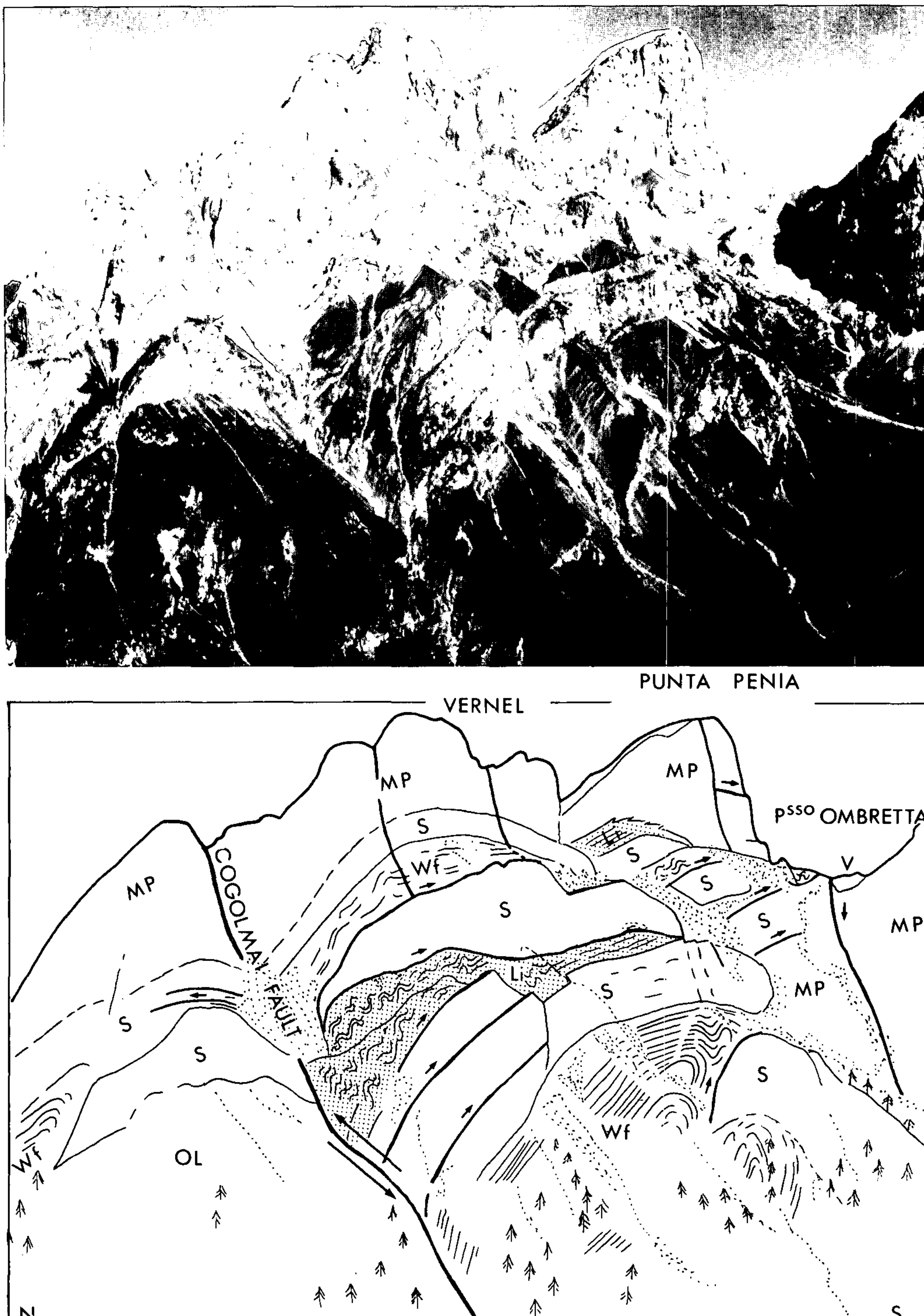


Fig. 6: The Late Ladinian thrust set of the Vernel Massif. The bedding-parallel thrusts are limited to the W by the Cogolmai fault and form, together with minor thrusts in the NW of the Cogolmai fault, a characteristical "flower structure". Wf = Werfen Formation; S = Sarl Formation; Li = Livinallongo Formation; MP = Ladinian limestones of the Marmolada platform; OL = olisthostromatic deposits; V = volcanics.

sin is documented by the distal Livinallongo Formation within the thrust set of the Contrin valley and accordingly denominated "Contrin basin" (Fig. 9 D). Along the Ombretta valley, it has been squeezed together completely.

E) The Marmolada platform terminates to the S and SW along the Ombretta- and Contrin valleys (Fig. 3), to the E and NE at the Serauta, to the N at the Fedaia lake, to the W and NW at the Collaccio and the Cogolmai. The present outcrops suggest that it was a comparatively small platform.

5. Recognition of strike-slip faults of the Marmolada – Costabella

Strike-slip displacements can best be demonstrated by the matching of particular facies along a fault (READING, 1980). Ladinian facies of the study area provide the following clues for the recognition of strike-slip faults:

A) Mismatch of facies boundaries. The vertical boundary from the internal platform to the foreslope (Fig. 4) is frequently displaced horizontally along faults.

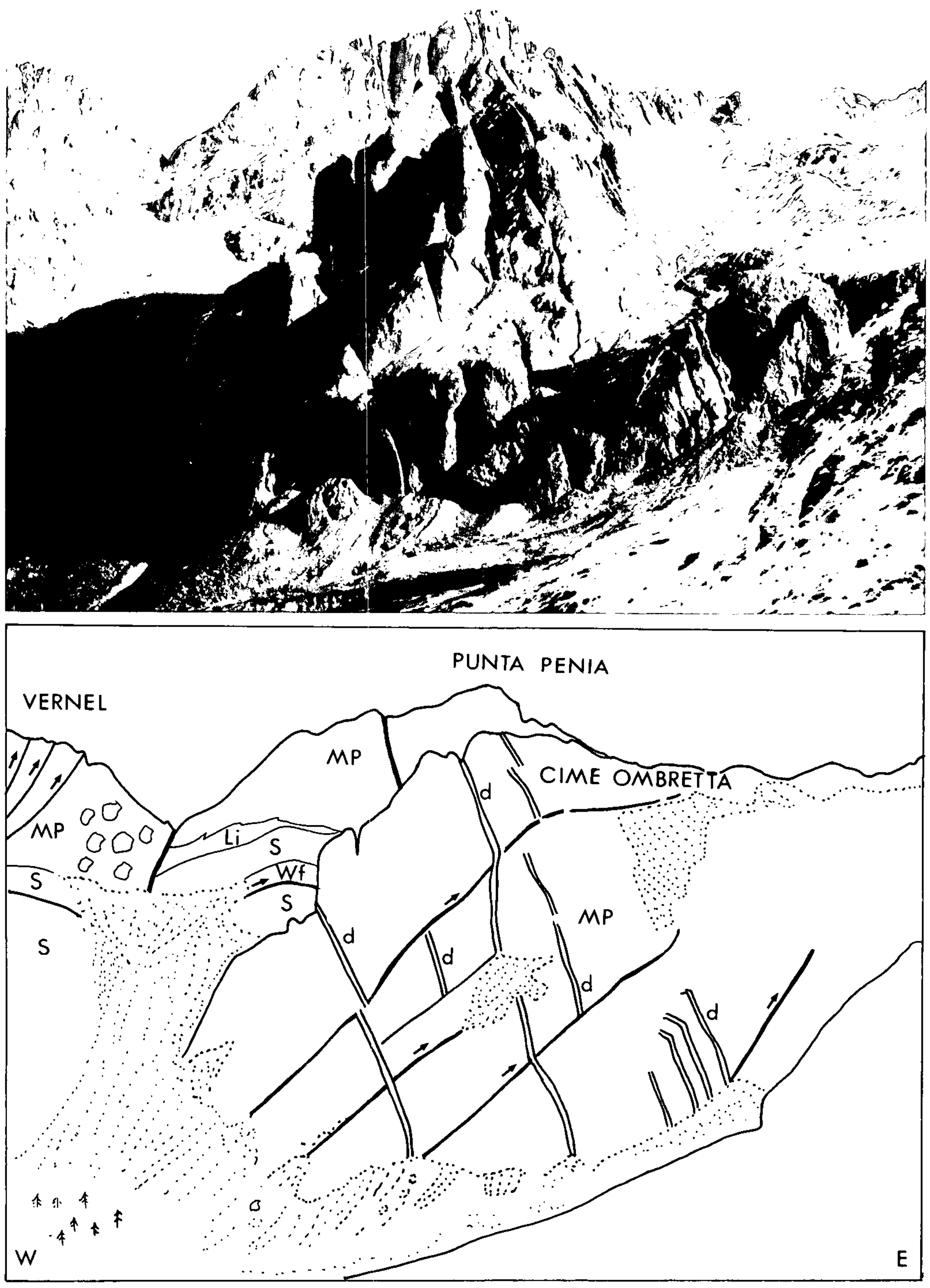


Fig. 7: Late Ladinian thrusts of the Cime Ombretta, crosscut by NE–SW oriented volcanic dykes (d). For explanation of the letters see fig. 6. Note the upward spreading fault zone at the Vernel which is associated with a left-lateral fault immediately W of the margin of the photo.

B) Proximal-distal relationships of the Livinallongo Formation. The proximal portions of the basinal succession start at a distance of a few hundred metres from the boundary fault A and reach a thickness of about 100 m at a distance of 2 km (for example SW of Passo Ombrettola). A proximal Livinallongo section in the close vicinity of a very distal one requires, therefore, a horizontal displacement to understand this situation (for example S of Col Ombert at Passo Pasche).

C) Mismatch of post-sedimentary faults. Some faults have been displaced horizontally along more recent ones (Fig. 3).

6. Strike-slip faults and associated structures

6.1. Strike-slip faults

Four different systems of strike-slip faults can be demonstrated in the study area. The following description starts with the most recent ones.

A) A NE–SW trending right-lateral fault. The right-lateral displacement of about 600 m can be demonstrated near the Passo Ombrettola. The age of this fault is unknown.

B) E–W and ENE–WSW trending left-lateral faults. The E–W trending fault across the Ombretta valley is a steeply northward inclined fault with a horizontal displacement of about 1 km and a vertical displacement of about 100 metres (visible at Pizzo Guda and Collaccio). The Triassic age of this fault can be demonstrated at the Collaccio and E of Sottoguda, where it is covered by Latest Ladinian and Early Carnian volcanics.

The ENE–WSW trending fault N of the Pezza – Piz Zorlet range traces to the W up to the Predazzo area, where it is cut by the Predazzo Caldera (DOGLIONI, 1984). The left-lateral character is documented by en-enchelon folds with WNW–ESE axes in its vicinity (for example at Monte Alto).

C) A N–S trending right-lateral fault which cuts across the Marmolada massif and the Monte la Banca. It is a steeply E inclined fault, which caused an intensive mylonitization of the Ladinian carbonates. The horizontal displacement of 2 km can be determined by the matching of the internal platform facies of the Punta Penia and the stripe E of the Roda de Mulon. The palinspastic maps of Fig. 9 start from the present situation (Fig. 9A). In Fig. 9 B the above described fault and the E–W fault of (B) have been restorted. The original NE–SW extent of the internal facies of the Costabella paltform amounted, therefore, to about 3 km. The minimum NE–SW extent of this facies at the Marmolada amounted to 2,3 km.

D) NNE–SSW trending left-lateral faults. These faults constitute the dominant structural elements of the investigated area. Two major fault zones, associated with intensive mylonitization of carbonates, can be distinguished:

●The fault zone which parallels the Monzoni valley between the Vallaccia and the Ort. It is buried below the volcanics of the Buffaure massif in the N. The post-tectonic Monzoni intrusion (CASTELLARIN et al., 1982 b) with radiometric ages of 230 m. a. (BORSI et al., 1968; i. e. Late Ladinian according to ODIN & LETOLLE, 1982; Early Carnian according to HARLAND et al., 1983) cuts this fault zone in the S.

●The fault zone immediately E of the Cogolmai which is covered by the volcanics of the Padon range in the N.

These two fault zones confine the SSE vergent thrusts (see 6.2.) to the W. The left-lateral faults in the E of these zones are older than the thrusts and document a pre-compressional phase of sinistral shear. Figure 9 C illustrates these pre-compressional left-lateral displacements.

Fig. 8: Folded Ladinian basinal sediments with ENE–WSW oriented axes, crosscut by a volcanic dyke (approximately 30 cm wide). South of Col Ombert (Passo Pasche).

The total amount of left-lateral displacement approximates 11 km (Fig. 9 B) and has been calculated from the present position of the W and E termination of the Costabella platform (Vallaccia and Cime dell'Auta).

6.2. Thrusts

The thrusts of the Marmolada-Costabella area have a SSE vergence. An exception is the NNW vergent thrust immediately N of Col Ombert. Most thrusts are bedding-parallel faults or cut the beds at a moderate angle (10–30°, for example at the Serauta and the Sasso delle Undici). The present steep N inclination of many fault planes (Fig. 6) is the result of tilting movements, which are older than the Early Carnian "Marmolada Conglomerates" and younger than the generally tilted volcanic dykes (see also the geological sections of Rossi, 1962).

The thrust sets include Permian to Ladinian strata. Re-deposited volcanics, chiefly in a distal turbiditic facies (SE of the Serauta) are occasionally involved in thrusts. The compressional zone extends to the E up to the Cordevole valley, where it terminates abruptly along the western margin of the Civetta massif.

Characteristical features of the thrusts are:

A) The decrease of displacement to the E. This can be demonstrated at the Costabella platform. In the W, the NE slope (Cima di Laste) has been pushed up to the distal SW slope (Costabella range). Thrust displacement amounts here to the width of the internal facies (about 4 km in a NNW–SSE section) plus some of the slope width (1–2 km). In the E, the NE slope has been pushed up to the internal facies (Pale del Fop, Fig. 5), so that thrust displacement is only 1–2 km in this area. A similar situation can be demonstrated at the Marmolada massif. In the W, near the Cogolmai fault zone, the internal platform has been pushed up to the Contrin basin, in the E only the platform margin has been repeated tectonically (Serauta).

B) The decrease of thickness of thrust sets to the E. Near the Cogolmai fault zone, the thrust set has a thickness of about 1000 m (Fig. 6). Along the Pezza – Piz Zorlet range there is an only 200 m thick thrust set of Anisian carbonates (Sarl Formation, which has been referred as to "Marmolada Limestone" by Nöth, 1929; Rossi et al., 1977 and Viel, 1979) with slices of Early Triassic Werfen rocks.

The Triassic age of compression is directly documented by volcanic dykes, which crosscut through thrusts (Figs. 3 & 7) and associated folds (Fig. 8). Locally, these phenomena have been recognized by Ampferer (1929), Rossi (1977) and Castellarin et al. (1982 a).

Along the Pezza – Piz Zorlet range, Late Ladinian volcanic re-sediments (Rossi et al., 1977; Viel, 1979) rest disconformably on a SSE vergent thrust set, which has been deeply incised by Late Ladinian erosion at some places. Similar erosional phenomena are developed throughout the compressional zone (see also Cros, 1974) and at the Buffaure massif (Castellarin et al., 1977), which locally caused a juxtaposition of volcanics on Werfen rocks. An erosion of such an extensive area can hardly be understood in terms of a "tectonic denudation" (Castellarin et al., 1977; Bosellini et al., 1982), but may readily be explained as a consequence of compressional uplift of the Marmolada – Costabella area and the adjacent zones.

An attempt of a palinspastic restoration of the thrusts is illustrated in Fig. 9 C.

6.3. Flower structures and half-flowers

Flower structures (Harding & Lowell, 1979) are upward-spreading fault zones diverging from a major strike-slip fault in a transpressional regime. Modern flower structures are known from seismic profiles across the San Andreas fault system (Wilcox et al., 1973). A Triassic flower structure is well exposed in the vicinity of the Cogolmai fault zone (Fig. 6). Toward this zone, the bedding-parallel thrusts of the Contrin valley become vertical faults. Half-flowers are developed at the Vernel and at the Vallaccia (Figs. 3 & 7) immediately west of the Monzoni fault zone.

7. Evidence of a strike-slip related compression

Identical structural patterns make it often difficult to distinguish between a compression caused by pure shear an one caused by simple shear (Mitchell & Reading, 1981). In the Marmolada – Costabella area, compression could have been caused by a sinistral shear couple with a NNE–SSW orientation as well as by pure shear with NNW–SSE orientation. The following characteristics, however, suggest a strike-slip related compression in the investigated area.

A) Sharp limitation of the compressional zone. In the W of the Monzoni- and Cogolmai-fault zones there is almost no trace of a NNW–SSE compression. The western part of the Vallaccia, the Latemar, the Rosengarten – Schlern massif are subhorizontal carbonate platforms which have maintained most of their original shape. The Civetta and the Pale di San Martino present a similar scenery. A NNW–SSE compression occurs exclusively in the area between these carbonate massifs. Similar, sharply limited compressional zones confined by lateral fault zones are expected to occur at the termination of a major strike-slip fault (Reading, 1982). The rapid decrease of compressional phenomena only a few kilometres to the N of the Marmolada (Arabba area, Doglioni, 1982), suggest a termiantion of the Monzoni – Cogolmai fault zone immediately north of the Marmolada.

B) En-echelon pattern of thrusts. The compressional phenomena decrease with increasing distance from the Monzoni- and Cogolmai fault zones and suggest an en-echelon pattern of thrusts. En-echelon compressional structures are typically arranged along strike-slip fault (Wilcox et al., 1973).

C) Contemporary extensional structures. The compressional zone contains almost no trace of extensional faults which should occur along NNW–SSE directions (Fig. 9 C). Contemporary zones of extension, however, are marked by the contemporary volcanism (see also Reading, 1980). Volcanic dykes with a NNW–SSE orientation are common immediately W of the compressional zone (Latemar, Schlern, Rosengarten) and at the Pale di San Martino. They

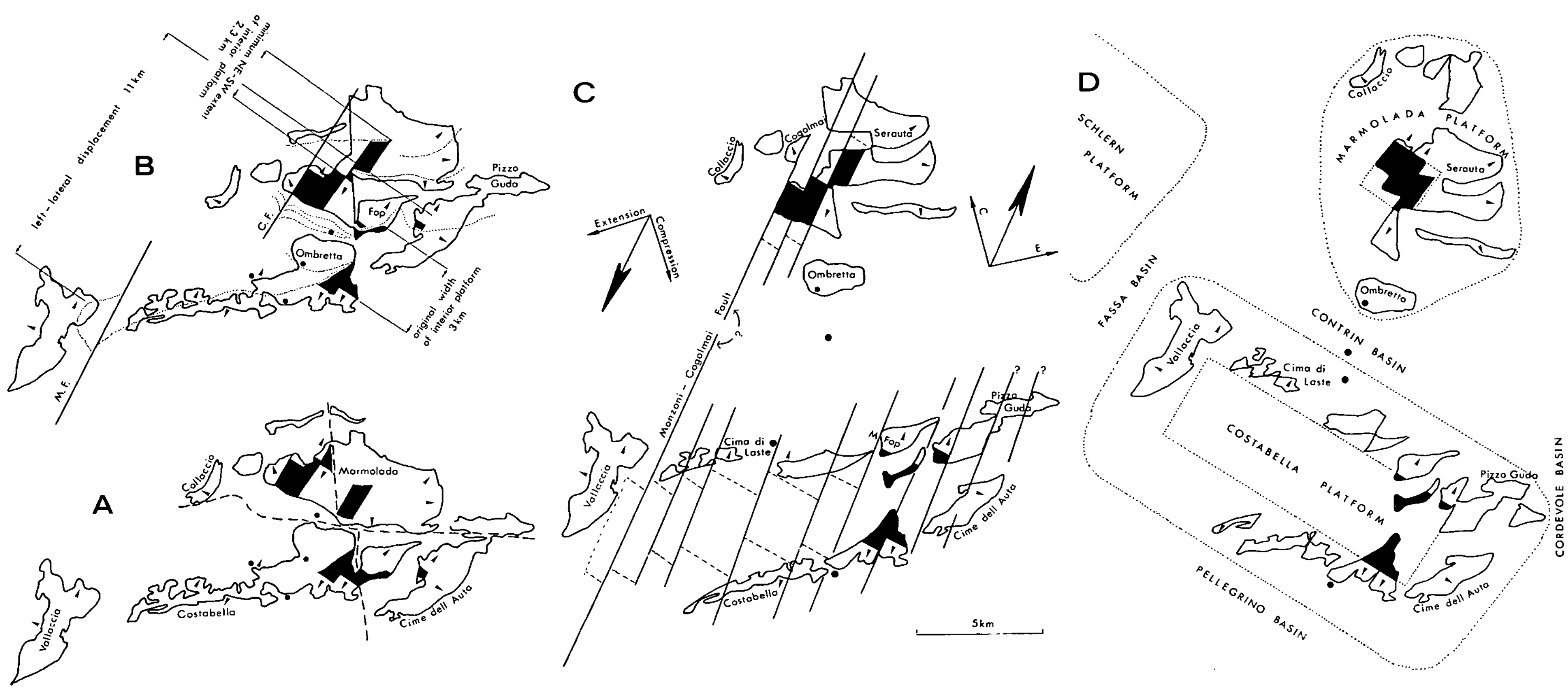


Fig. 9: Palinspastic maps of the Marmolada-Costabella area. Black = outcrops of the internal platform facies; white = outcrops of the foreslope talus deposits; arrows = basinward dip of foreslope talus deposits; black circles = outcrops of the red limestones of the basinal succession.

A: Present day outcrops of Ladinian platform carbonates. The dashed lines illustrate the strike-slip faults whiche become restorted in B.
B: Restoration of the W–W left-lateral fault and the N–S right-lateral fault. The stippled lines illustrate the thrusts which become restorted in C.
C: Restoration of the thrusts. The NNE–SSW trending lines illustrate the strike-slip faults which become restorted in D.
D: Presumed Ladinian paleogeography of the Marmolada-Costabella area, characterized by two different carbonate platforms whith an orientation similar to the undisturbed Schlern platform.

may document an area of contemporary extension in the close vicinity of a limited compressional zone. This is a typical feature of a strike-slip related setting (BALLANCE & READING, 1980).

The volcanic dykes which crosscut the compressional zone have a completely different orientation (chiefly NE–SW). They suggest a different stress pattern at the time of their formation, which would readily fit with the E–W orientated left-lateral faults.

8. Conclusions

A) The Ladinian carbonate facies of the Marmolada – Costabella area provide a clue for the recognition of strike-slip faults. They can be subdivided into an internal, generally bedded, platform facies, an external foreslope talus facies characterized by a basinward inclination of faint bedding and detrital carbonate wedges, which interfinger with the coeval basinal succession.

B) The facies pattern of the Marmolada – Costabella area suggests the existence of two different, isolated carbonate platforms in Ladinian times.

C) The pattern of foreslope talus deposits and the limitation of the internal platform towards the slope by syn-sedimentary faults suggests an original NW–SE orientation of the Costabella platform. Similar faults are also developed at the smaller Marmolada platform.

D) Left-lateral faults with a NNE–SSW orientation are dominant structural elements of the investigated area. They occur in the E of the Monzoni area and the Cogolmai. A left-lateral displacement of 11 km can explain the present position of the Costabella platform.

E) A NNW–SSE compression occurs in the E of the Monzoni- and Cogolmai fault zones. Compression is documented by SSE vergent thrusts and folds. Decrease of thrust displacements and thickness of thrust sets to the E suggest an en-echelon pattern of compressional structures related to the Monzoni- and Cogolmai fault zones.

F) The termination of a NNE–SSW trending left-lateral fault to the NNE can account for the localized compression of the Marmolada – Costabella area. A termination of the Monzoni – Costabella fault zone to the NNE is suggested by the decrease of compressional phenomena only a few kilometres N of the Marmolada.

G) Volcanic dykes crosscut folds and thrusts. Late Ladinian volcanics rest disconformably on SSE vergent thrust sets. The Monzoni intrusion cuts the Monzoni fault zone.

Acknowledgements

This work has been supported by the Deutsche Forschungsgemeinschaft. I thank the mayors of Rocca Pietore (BL), Canazei (TN) and Pozza di Fassa (TN) for their permission to tent in the mountains while the field work was carried out. Helpful suggestions on an earlier draft of the manuscript have been made by Prof. J. WENDT (Tübingen), Prof. D. BERNOULLI (Basel) and Dott. C. DOGLIONI (Ferrara). W. WETZEL (Tübingen) provided the photos.

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Manuskript bei der Schriftleitung eingelangt am 14. Mai 1984.