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The "Lanzada-Scermendone Zone": An Ophiolitic Unit of Continental Affinity in the Southern Rhaetic Alps (Prov. Sondrio - Italy)

by *Attilio Montrasio**

Abstract

The Lanzada-Scermendone Zone is a new structural unit in the Central Alps. It extends over 20 km from middle Val Malenco to eastern Val Màsino (Southern Rhaetic Alps, Italy) at the southern margin of the Malenco serpentinites, situated north of the Insubric Line.

It comprises three main lithostratigraphic complexes: 1. *basement rocks of pre-Triassic age* (orthogneisses and paraschists); 2. *platform Triassic metasediments* (quartzites, various types of dolomitic and calcareous marbles); 3. *a complex of "Schistes lustrés" with metaophiolites, probably of Jurassic-Cretaceous age* (micaceous schists and calcschists, Mn-metacherts, prasinites, metagabbros, serpentinites and ophicarbonates).

The Lanzada-Scermendone Zone clearly underlies the Malenco-Forno ophiolite nappe, and therefore does not exhibit any relationship with the Austroalpine Margna nappe overlying the Malenco-Forno unit. On the contrary the Lanzada-Scermendone Zone well corresponds with the Penninic Suretta nappe, including the Avers Bündnerschiefers, because of its similar geometric position below the Malenco-Forno unit and its comparable lithostratigraphy.

The close association of the Lanzada-Scermendone Zone with the truly oceanic Malenco-Forno nappe means, in paleogeographic terms, that the Avers Bündnerschiefers cannot pertain to the Valais basin, rather to the Mesozoic Tethys-facing pre-Piedmontese belt. Consequently, the northerly (sub-Tambò) origin of the Schams nappes is favoured (solution "infra" of the "Schams dilemma").

The above features support a former structural and paleogeographic correlation of the Malenco-Forno and Lanzada-Scermendone coupled ophiolitic units to similar units in the Western Alps. Here ophiolitic sequences of *oceanic affinity* (e.g. Zermatt-Saas Unit), contrast with ophiolitic sequences of *continental affinity* (e.g. Combin Unit) of more external or, alternatively, more internal origin. Some differences in the metamorphic and structural history of these coupled units of the Central and Western Alps result from a different Alpine evolution.

Keywords: ophiolites, stratigraphy, paleogeography. Pennine. Northern Lombardy, Italy.

† *In memory of Gian Pietro Masa, Alpine Guide of the Val Malenco, who died 12.1.1980 while he was climbing "his" beloved mountains.*

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Riassunto

La Zona Lanzada-Scermendone è una nuova unità strutturale delle Alpi Centrali, che si sviluppa per circa 20 km dalla media Val Malenco alla Val Màsino orientale (Alpi Retiche meridionali, Valtellina), nei pressi del margine meridionale delle Serpentiniti della Val Malenco, a nord della Linea Insubrica.

Essa è composta da tre complessi litostratigrafici: 1. *rocce di basamento di età pre-Triassica* (ortogneiss e parascisti); 2. *metasedimenti di piattaforma Triassici* (quarziti, marmi dolomitici e calcarei di vario tipo); 3. *un complesso di Calcescisti con metaofioliti di probabile età Giurassico-Cretacica* (scisti micacei e calcescisti, metacherts a Mn, prasiniti, metagabbri, serpentiniti e oficarbonati).

La Zona Lanzada Scermendone è chiaramente sottoposta alla falda ofiolitica Malenco-Forno, e pertanto non presenta alcun rapporto con la falda Austroalpina della Margna, che a sua volta sovrasta quest'ultima unità. La Zona Lanzada-Scermendone si correla molto bene invece con la falda Pennidica Suretta, comprendente i Calcescisti ofiolitiferi dell'Avers, a motivo della sua posizione strutturale al di sotto della falda Malenco-Forno, e dell'assetto litostratigrafico del tutto simile.

La stretta associazione della Zona Lanzada-Scermendone con la falda Malenco-Forno sicuramente oceanica sta ad indicare che i Calcescisti dell'Avers non possono essere riferiti, paleogeograficamente, al bacino Vallesano, bensì alla zona pre-Piemontese prospiciente il bacino oceanico mesozoico della Tetide. Di conseguenza è favorita una origine settentrionale (sotto la falda Tambò) delle falde dello Schams (soluzione «infra» del «dilemma Schams»).

I caratteri sopra descritti dimostrano una originaria correlazione strutturale e paleogeografica della coppia di unità ofiolitiche Lanzada-Scermendone e Malenco-Forno con analoghe unità nelle Alpi Occidentali. Anche qui, sequenze ofiolitiche di *affinità oceanica* (es. Unità Zermatt-Saas), si contrappongono direttamente a sequenze ofiolitiche di *affinità continentale* (es. Unità Combin) di origine più esterna o, alternativamente, più interna. Alcune differenze nei caratteri metamorfici e strutturali di queste unità, tra le Alpi Centrali ed Occidentali, sono imputabili ad una evoluzione orogenica alquanto differenziata.

Introduction

In the Piemonte ophiolite nappe of the Western Alps, two types of ophiolitic sequences characteristically coexist. They show important differences in their lithostratigraphic, metamorphic and structural character. The Zermatt-Saas and Combin Units are the best known and most representative of such coupled ophiolitic associations. (The following general informations are principally from: BEARTH, 1967, 1973, 1974, 1976; BEARTH and SCHWANDER, 1981; DAL PIAZ, 1965, 1974, 1976; ELTER, 1971, 1972; LEMOINE, 1971; CABY et al., 1978).

The ophiolite sequence of the Zermatt-Saas type includes a basement of greenstones (serpentinized peridotite tectonites, homogeneous or layered metagabbros and oceanic metabasalts). It is overlain by a heterogeneous, pelagic, sedimentary cover of Ligurian affinity (metacherts with marbles, metapelites, calcschists and quartzschists of presumed Jurassic-Cretaceous age). Such sequences are generally interpreted as fragments of oceanic crust that originated in one of the geodynamic environments (mid-ocean ridge, transform fault) of the Mesozoic Piedmontese basin of the Tethys.

In the rock association of the Combin type, the metaophiolites (prasinites and ovardites, lenses of ±serpentinized ultramafics, metagabbros) and the metacherts (sometimes Mn-rich) are intercalated at various levels in a thick sequence of calcschists of probable Jurassic-Cretaceous age ("Schistes lustrés"). This latter lies (stratigraphically?) on (Permo-?)Triassic platform metasediments like quartzites, dolomites and limestones, that in their turn, discordantly cover a pre-Triassic crystalline basement. The presence of post-Triassic metaophiolites at various levels is interpreted as either due to stratigraphic intercalation (tuffites, basalt flows, olistoliths) or, alternatively, as a result of tectonic complications (rootless isoclinal folds, slices.)

The two ophiolitic associations in question also show differences in their metamorphic character (Zermatt-Saas: with eo-Alpine high pressure-low temperature parageneses and later overprint in greenschists facies; Combin: in greenschists facies). Their reciprocal structural relations are complex, occasionally each unit may lie directly above or below the other.

There is little agreement as to the paleogeographic position of Combin-Zone, whether it is considered to be of more external (distal european margin – external Piedmontese) or more internal origin (african margin – ultra-Piedmontese) of the Mesozoic Tethys, with respect to the Zermatt-Saas Zone, which itself is surely of oceanic affinity (Piedmontese-Ligurian basin).

In the Central Alps the Penninic Suretta nappe, best observed north of the Engadine Line, shows a continental affinity in the lithostratigraphic character of its cover rocks: a thick complex of ophiolitiferous "Schistes lustrés" (Avers Bündnerschiefers), of presumed Jurassic-Cretaceous age, is situated parautochthonously above the (Permo-?)Triassic platform sediments of the nappe (Milnes and Schmutz, 1978, with quoted references).

To the north of the Engadine Line, the existence of an oceanic ophiolite unit closely linked with the Suretta nappe is not certain; it is improbable that such a unit is represented by the Lizum greenschists (P. Nievergelt, pers. commun.). On the other hand, the oceanic ophiolite Platta nappe actually occupies a higher tectonic position, above the Margna nappe. Consequently a more internal origin has been attributed to the Platta nappe compared to the Malenco-Forno ophiolites (Trümpy, 1960, 1969, 1975; Pasquare', 1973).

In the Central Alps and south of the Engadine Line the oceanic character of the Malenco-Forno ophiolite nappe has recently been demonstrated (Montrasio, 1973; Ferrario and Montrasio, 1976; De Capitani et al., 1981). The associated sediments of ligurian type are comparable, apart from the Alpine metamorphic history, to those in the Zermatt-Saas Zone (Bearth, 1967, 1973, 1974; Bearth and Schwander, 1981; Dal Piaz, 1965, 1974, 1976; Baldelli et al., 1983) or in the ophiolitic complexes of the Northern Apennines (Decandia and Elter, 1969, 1972). The Lanzada-Scermendone Zone is identified as an ophiolitic sequence of continental affinity south of the Engadine Line, and will be defined as a new structural unit. It is composed of formations already attributed to diverse tectonic units, and lies well below the Malenco-Forno ophiolite nappe.

The principal objectives of this paper are a tentative stratigraphic reconstruction of the dismembered lithologies of the Lanzada-Scermendone Zone, as well as a discussion of its paleogeographic significance and its present structural setting.

Geological context

North of the Insubric Line on the rhaetic side of the lower Valtellina, between the Màsino and Poschiavo (Puschlav) valleys, the Malenco-Forno ophiolite nappe forms a lenticular body 1-2 km thick, that covers more than 200 km^2 (see Fig. 1). Within this unit the Malenco serpentinites may be distinguished from the Forno Series s.l. (DE CAPITANI et. al., 1981; PERETTI, in prep.) which comprises metabasaltic pillow lavas and pelagic cover metasediments of Ligurian type, presumed to be of Jurassic-Cretaceous age. The ophiolitic complex separates the austroalpine Margna nappe[1], that overlies its northern and southern flanks, from the underlying penninic nappes that border its western flank. The penninic rocks also outcrop in three tectonic windows near the southern margin of the Malenco serpentinites: it is in these windows that the Lanzada-Scermendone Zone appears.

In the west, the Malenco-Forno ophiolite nappe abuts against the Tertiary magmatic rocks of Màsino-Bregaglia. North of Val Sissone the contacts are clearly of intrusive character, but to the south they follow distinct structural elements (TROMMSDORFF and NIEVERGELT, 1984, with quoted references).

The effect of the intrusion in the contact aureole, which is seen in the serpentinites and in metabasalts as a contraction of the isogrades and the appearance of critical minerals (TROMMSDORFF and EVANS, 1972, 1977, 1980; SCHUMACHER, 1975; RIKLIN, 1977; GAUTSCHI, 1980), is superimposed on the Alpine regional greenschists facies metamorphism.

Minor andesitic-basaltic dykes cross-cut the serpentinites as well as the Margna rocks, but are affected by the Màsino-Bregaglia contact metamorphism (GAUTSCHI and MONTRASIO, 1978; TROMMSDORFF and NIEVERGELT, 1984).

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[1] The author believes that the Margna nappe is of austroalpine (paleoafrican) provenance. This interpretation is not original, of course, but has already been proposed by STAUB (1917). Later on however, he rejected this possibility and assigned the Margna to the upper penninic nappes, an interpretation that has been followed by later workers. The structural significance of the Margna nappe and its paleogeographic provenance are one of the unsolved problems in the geology of the Central Alps (TRÜMPY, 1960, 1975, 1976; PASQUARE', 1973, 1975). This problem will not be further discussed, however, since it is only marginally relevant to the theme of this paper.

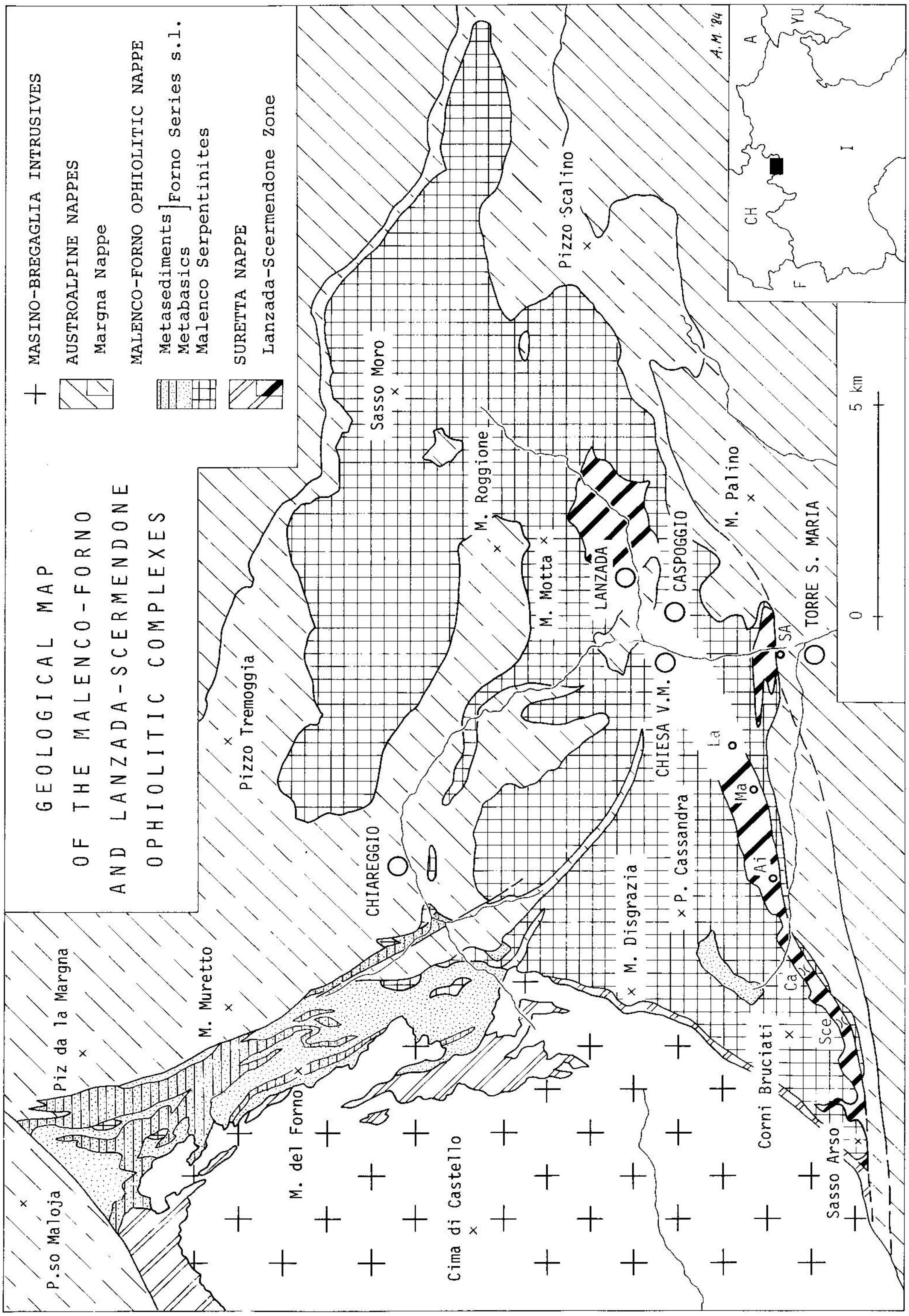

Fig. 1 Geological-structural map of Val Malenco and adjacent areas. The Lanzada-Scermendone Zone outcrops along the southern margin of the Val Malenco serpentinites, in three tectonic windows corresponding to the core of a single anticline dislocated by alpine movements.
(Ai = Alpe Airale; Ca = Passo Caldenno; La = Alpe Lago; Ma = Alpe Mastabbia; SA = Sant'Anna; Sce = Passo di Scermendone).

In the scarce, specific literature only some of the publications of R. Staub treat the problems discussed in the present paper. Near the southern limits of the Malenco serpentinites STAUB (1921) first recognized the tectonic windows of Lanzada, St. Anna and Alpe Airale, although by means of inexact mapping. They are depicted as the emergence of the cores of two distinct anticlines (Table II and III) and are attributed, together with the overlying serpentinites of Val Malenco, to the penninic Suretta nappe. The existence of the Lanzada and St. Anna windows is confirmed in the Geologische Karte der Bernina-Gruppe (STAUB, 1946), while, in contrast to the previous interpretation, the Alpe Airale outcrops are represented as a zone of tectonic slices in which Margna basement rocks, greenstones of the Suretta, and slices of the Mesozoic cover of these two nappes are also involved. In other words, the Alpe Airale window was not longer recognized as such.

THE "LANZADA-SCERMENDONE ZONE"

The Lanzada-Scermendone Zone extends over about twenty kilometers from the Lanterna Valley (middle Malenco Valley) to the Preda Rossa Valley (eastern Màsino Valley) in the form of a narrow band of outcrops near the southern limit of the Malenco serpentinites (see Fig. 1). The identification of this zone is based on its unique and everywhere uniform lithostratigraphy, as well as on its macro- and meso-structural features. In addition to these distinctions, the Lanzada-Scermendone unit occupies a structural position that is well defined with respect to the surrounding units.

In Val Malenco, the nappe pile is involved in an Alpine compressional phase that produced antiforms and synforms (MONTRASIO and TROMMSDORFF, 1984; Fig. 2). Glacial and fluvial erosion in the Malenco, Torreggio-Airale and Terzana Valleys, having reached the base of the Malenco serpentinites in several places, corresponding to the southernmost antiform, has revealed the following three tectonic windows (STAUB, 1921):

- *Lanzada Window,* on both sides of the Lanterna Valley, to the east of Lanzada;
- *St. Anna Window,* on both sides of the middle Malenco Valley, to the north of Torre Santa Maria;
- *Alpe Airale Window,* between Alpe Lago (to the south of Chiesa in Val Malenco) and Sasso Arso (Preda Rossa Valley, eastern Màsino Valley).

Structural setting

On a regional scale, some important anomalous relations exist among the three tectonic windows. While the Lanzada and Alpe Airale windows are the continuation of each other along an ENE-WSW direction, the smaller St. Anna window appears displaced 2–3 km towards the south, with its structural lineations orientated E–W. In addition, the crest line of this antiformal rock body seems to be depressed some hundred metres lower than the other two. Such a structural situation allows three possible interpretations:

a) Both the Lanzada and Alpe Airale windows are continous in outcrop, below the Quaternary cover, and the St. Anna window belongs to a more southern antiform structure.
b) Both the Lanzada and Alpe Airale windows, due to an abrupt and deep axial plunge of the antiform or to a local tectonic trough, meet at depth below the serpentinites at a point corresponding to the villages of Chiesa in Val Malenco and Caspoggio; the St. Anna window has the same status as in a).
c) All three windows of Lanzada, St. Anna and Alpe Airale are part of a single antiform, of which the St. Anna window represents a dislocated segment that has been downthrown several hundred metres, displaced some kilometers towards the SE, and rotated 25° clockwise.

This last interpretation, which the author holds to be more probable, is based on the recognition of an important structure, transversal with respect to the main Alpine lineaments, showing tectonic deepening and horizontal displacements (A. MONTRASIO, in prep.)[2]. Such a structure involves the smaller St. Anna window but leaves the remaining two windows almost unaffected on the either side.

The "three windows" would therefore be considered as limbs of a single tectonic window corresponding to a single antiform structure.

The antiform appears to be a multiple fold (e.g. St. Anna window, see Fig. 1) that is highly compressed and intensely disrupted. The crest line of the antiformal surface enveloping the Lanzada-Scermendone Zone plunges slightly to the ENE, connecting the Alpe Airale and Lanzada windows, on the opposite side of the trough involving the St. Anna window. Note that at Passo Scermendone this crest line runs out of the topography at heights greater than 2600 m, while to the east of Tornadri, at a distance of 14 km, it intersects the topography at about 1150 m. The axes of the meso-folds are consistent with the general trend although their attitude varies more widely, from horizontal to moderately inclined to the ENE.

Similarly, in the St. Anna window the principal axes emerge on the western flank of the Malenco Valley at an altitude of 1730 m and then plunge into the eastern slope at about 1400 m, some 3 km away. The axes of the mesofolds show a more irregular trend, with eastward-bearing, moderate to strong plunges (up to 70–80°). These local anomalies are probably connected with the tectonic trough (see footnote 2).

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[2] This small tectonic trough, 3–5 km wide and some 30 km long, runs NW-SE between the Engadine Line and the Insubric Line roughly between Passo del Maloja and Sondrio. It shows important

The above-mentioned antiform is highly compressed at its western extreme as far as Lanzada, whereas it appears more open along its eastern continuation until it disappears under the Malenco serpentinites. It may be followed a further few kilometres up to the Pizzo Scalino, converging on, and becoming confused with, the Passo d'Ur antiform (BELTRAMI et al., 1975). Towards the west the antiform is present up to the confluence of Terzana Valley and Preda Rossa Valley, where its relation to the Bergell tonalite and to the metamorphic rocks inserted between the Malenco serpentinites and Bergell tonalite itself remains obscure.

In places, where it had most effect, the above-mentioned Alpine compression caused a reduction in the thickness and even omission of some of the structural units along the southern flank of the antiform. On the southern margin of the Alpe Airale window, the Malenco serpentinites, which originally must have completely enveloped the Lanzada-Scermendone Zone, have been reduced to a thin, discontinuous horizon. On the southern side of the St. Anna window, the Lanzada-Scermendone rocks locally come directly into contact with the Monte Canale orthogneisses of the austroalpine Bernina nappe (MOIOLI, 1981), thereby indicating that the Malenco-Forno, Margna and Sella units have been tectonically eliminated, even though they are still recognisable immediately to the east and west of the window. Forthermore, between the Lanzada window and the Margna nappe, the Malenco Serpentinites have a thickness of 200 m along the southern slope of Lanterna Valley while on the opposite slope, within the northern flank of the same antiform, the serpentinites reach a thickness of at least 1200 metres.

The underlying position of the Lanzada-Scermendone Zone with respect to the Malenco-Forno ophiolite nappe is clearly evident in the Lanzada and St. Anna windows: in the latter case, despite the tectonic omission of several units already mentioned, the occasional closure of the window below the serpentinites is nevertheless recognisable on both slopes of the Malenco Valley. The same does not hold for the Alpe Airale window, where, however, a number of other significant relations have been observed:

- At many points along its northern margin, the Malenco serpentinites evidently override the Lanzada-Scermendone rocks (Figs. 2 and 3).
- In the axial zone of the window, antiformal structures have been recognized. The rest of the unit appears to be modelled after these structures (Fig. 2).
- Along its southern margin, the window is bordered by a discontinuous horizon of serpentinites which may be interpreted as a relict of the original envelope.

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transcurrent movements and includes the Muretto Line (RIKLIN, 1978). It also seems to be responsible for the anomalous topographic and structural position of the crystalline basement limb of Margna nappe that outcrops between Costi Battaini (Chiesa in Val Malenco) and Lanzada.

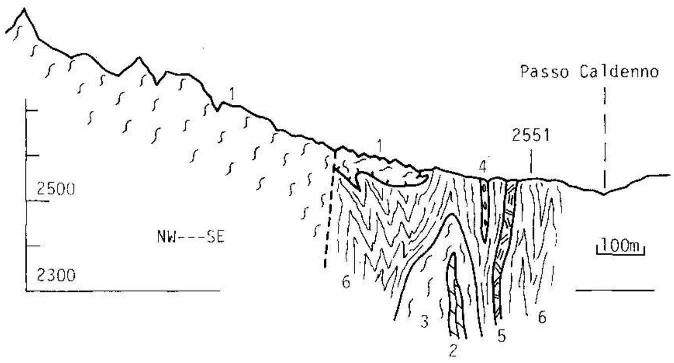

Fig. 2 Geological cross-section at Passo Caldenno, along the ridge, SE of Corni Bruciati. The schematic section shows that the Malenco serpentinites overly the Lanzada-Scermendone Zone, and that this zone has an antiformal structure with a core comprising serpentinites and dolomites.
1.: *Malenco-Forno ophiolite nappe:* serpentinites
2.-6.: *Lanzada-Scermendone Zone:* 2. white dolomitic marbles (Mid-Triassic); 3. serpentinites; 4. prasinites; 5. metagabbros; 6. "Schistes lustrés".

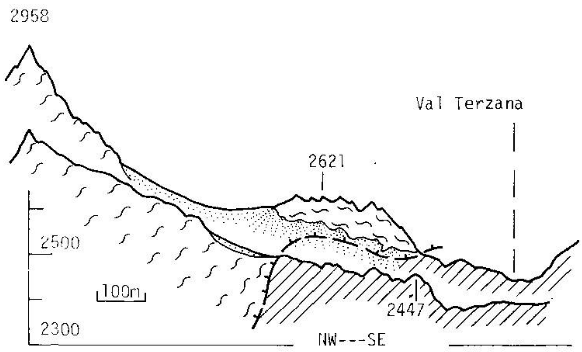

Fig. 3 Two schematic geological cross-sections, separated by about 400 m, showing the situation slightly to the west of Passo di Scermendone. The sections illustrate that the Malenco serpentinites (~) overly the Lanzada-Scermendone Zone (oblique hatching) on the northern margin of the Alpe Airale Window. (The centre of the lower section corresponds to Fig. 4.)

From the above points it is clear that the rocks attributed to the Lanzada-Scermendone Zone cannot correspond even in part to the Margna nappe (Staub, 1946; Venzo et al., 1971), since a third structural unit, the Malenco-Forno ophiolite nappe, lies inserted between the other two.

The underlying structural position with respect to the ophiolite nappe would thus assign the Lanzada-Scermendone Zone to the penninic Suretta nappe s.l. In fact numerous indications favour the stratigraphic correlation of their respective cover rocks (see Introduction and Stratigraphy), whereas evidence do not exist against their structural correlation.

Another structural correlation problem of the Lanzada-Scermendone unit concerns the metamorphites (paragneisses, migmatites, marbles, amphibolites) that outcrop along the western margin of the Malenco-Forno ophiolite nappe between Preda Rossa Valley, Sella di Pioda and Cima di Vazzeda (Staub, 1921, 1946; VENZO et al., 1971; WENK and CORNELIUS, 1977). As far as the writer is aware, no completely convincing correlation of these rocks as been suggested, notwithstanding the vicinity of their outcrops, some apparent petrographic similarities and the analogy of the structural position. The problem remains open.

Stratigraphy

The Lanzada-Scermendone Zone is made up of a wide range of lithotypes, the petrographic characteristics of which will be described in another article.

The lithologies of the Lanzada-Scermendone Zone are here tentatively ordered in a stratigraphic sequence. Such a task is a very complex and delicate one, due to the pervasive restructuring and breakup caused by the polyphase alpine metamorphism and the Alpine to late-Alpine phases of deformation. Investigations of Conodonts in carbonate facies have given only negative results (MOIOLI, 1981; A. Nicora, pers. comm.).

The stratigraphic reconstruction is essentially based on the following parameters: petrographic character of the rocks, the presence of stratigraphically significant lithologies and lithologic associations (e.g. Mn-metacherts + ophiolites; basement rocks + Triassic sediments + rocks of ophiolitic affinity), and well defined geometric position of the unit in question. All these characteristics which distinguish the Lanzada-Scermendone Zone from the contiguous units, have been compared to analogous structural units in the Western and Central Alps (see Introduction) which serve as a paradigm for stratigraphic ordering. In this way it has been possible *to interpret in stratigraphic terms the petrographic and structural characteristics* of the dismembered Lanzada-Scermendone lithologies.

However, an attempt at such a correlation is considerably limited by the present geographic distance between the units being compared, the difference in their stratigraphic and metamorphic evolution, and by the current inadequate understanding. Thus the stratigraphic reconstruction of Lanzada-Scermendone lithologies that is proposed herein must be considered as a first approximation requiring refinements.

The Lanzada-Scermendone lithologies may be easily grouped in the following lithostratigraphic complexes:

A – ***Crystalline basement (pre-Triassic).*** The *augen- and banded orthogneisses, biotite-paragneisses* and *garnet-bearing biotite-micaschists,* characterized by pre-Alpine and Alpine overprints (BELTRAMI et al., 1975; VILLA, 1982) are the oldest rocks of the Lanzada-Scermendone Zone; they represents fragments of a sialic crust upon which the (Permo-?)Triassic sequence was deposited.

B – ***(Permo-?)Triassic platform sequence.*** The basal member of this sequence comprises *very pure, white to greenish quartzites* that are interpreted as meta-are-

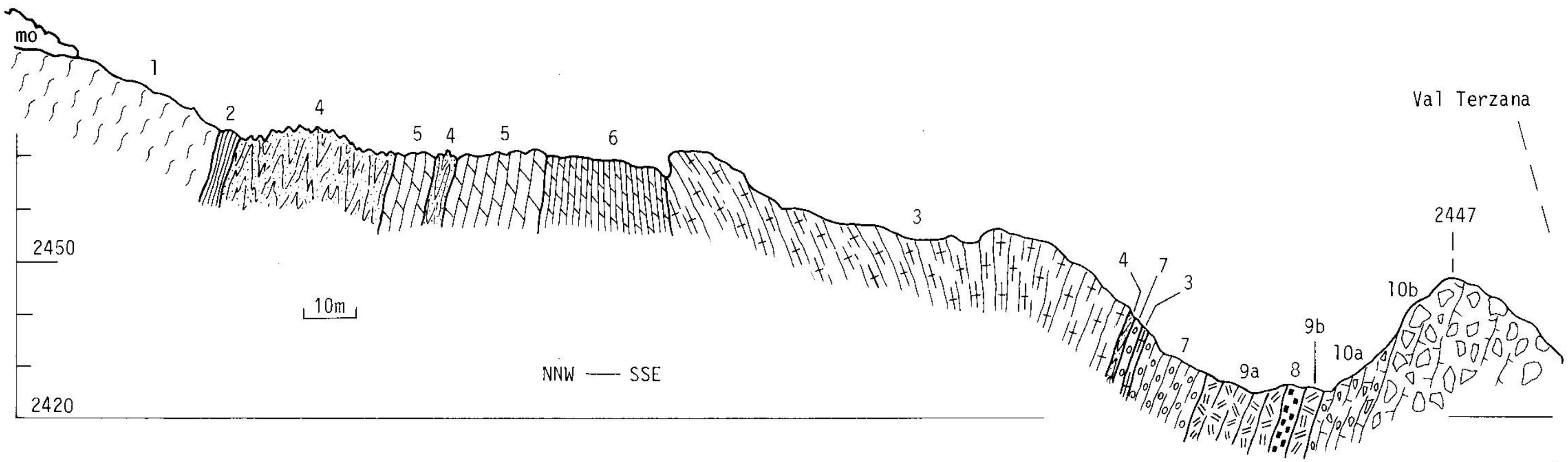

Fig. 4 Geological sections across the Lanzada-Scermendone Zone, 900 m west of Passo di Scermendone. The repeated alternation of some lithologies indicates thrust slices and/or folding phenomena. However, the existence of local stratigraphic contacts may be nevertheless assumed: the three (Permo-?)Triassic quartzite horizons (4) are always in contact with the pre-Triassic metamorphic basement rocks (2 and 3) and/or with the dolomites of the Mid-Triassic (5), that respectively represent the stratigraphic bottom and top of the quartzites

1.: *Malenco-Forno ophiolite nappe:* serpentinites.

2.–10.: *Lanzada-Scermendone Zone:* 2. paragneiss with amphibolite and pegmatite boudins (pre-Triassic); 3. augen orthogneiss (pre-Triassic); 4. very pure, white quartzites (Permo?-Triassic); 5. white dolomitic marbles (Mid-Triassic); 6. gray dolomitic marbles bearing Ca-silicates (Mid-Triassic); 7. prasinites; 8. quartz-schists bearing Mn-garnet and magnetite (U. Jurassic-Cretaceous); 9. metagabbros (9a. fine-grained; 9b. coarse-grained); 10. ophicarbonates (10a. well bedded, with aboundant carbonate matrix; 10b. massive, poorly-bedded, containing many serpentinite blocks).

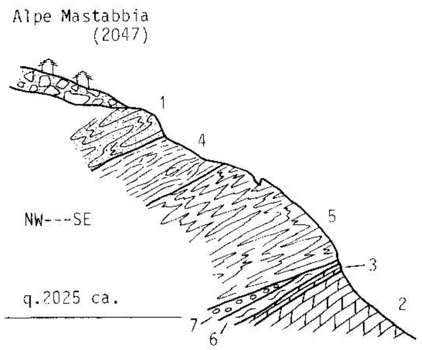

Fig. 5 Schematic geological section across the Lanzada-Scermendone Zone, at Alpe Mastabbia. In the tectonized sequence (folding, slices), two quartzitic formations are evident: pure quartzites (Permo?-Triassic meta-arenites) and quartz-schists bearing magnetite and/or Mn-garnet (U. Jurassic or L. Cretaceous metaradiolarites). The assignment to the Liassic of the calcschists bearing Fe-carbonate mineralizations is entirely hypothetial (see text). *Lanzada-Scermendone Zone:* 1. very pure, white quartzites (Permo?-Triassic); 2. white dolomitic marbles (Mid-Triassic); 3. gray dolomitic marbles bearing Ca-silicates (Mid-Triassic); 4. calcschists bearing Fe-carbonate nodules (Liassic?); 5. micaceous schists with horizons of magnetite-bearing quartzschists (lower part) or Mn-garnet (upper part) (U. Jurassic or L. Cretaceous); 6. serpentine schists; 7. laminated prasinites.

nites and meta-conglomerates of probable Lower Triassic (or U. Permian - L. Triassic) age. They are almost always in direct contact with white dolomites (Mid-Triassic, see below) and with orthogneisses and paraschists (pre-Triassic) that respectively represent the stratigraphic top and bottom. This suggests that probably lenses including series of stratigraphic contacts, or at least single contacts, of the original sequence have been preserved despite highly accentuated tectonism (see Fig. 4).

Continental platform sediments of Mid-Triassic facies follow stratigraphically the Lower Triassic quartzites; they consist of *massive, white, calcitic to dolomitic marbles* and of *thin bedded, gray dolomitic marbles* bearing tremolite and other Ca-silicates. Important additional indications in favour of a Mid-Triassic age for these rocks are some thin horizons of *albitic, sphene-rich, brittle micaschists* (probably intercalations of acid tuffites[3]) and *stratiform Pb(-Zn) mineralizations* in the marbles (JERVIS, 1873; MOIOLI, 1981).

The Alpine metamorphism has produced important metasomatic deposits of talc within the dolomites.

Near Alpe Mastabbia (see Fig. 5), *brownish calcschists containing Fe-carbonate nodules* are present, quite dinstinct from other calcschists of the Lanzada-Scermendone Zone (see below); they are very similar to Liassic formations de-

[3] Intercalations of sercite-albite and chlorite-albite schists, interpreted as tuffites, have been assigned to the Mid-Triassic, pre-Piemont units of the Voltri Group (CORTESOGNO et al., 1982). Pyroclastic horizons of acid to basic compositions are present in Anisian-Ladinian formations of all the Southern Calcareous Alps (PASQUARE' and ROSSI, 1969). CRISCI et al. (1984) have determined K/Ar and Rb/Sr dates of 225 ± 7 to 218 ± 6 m.y. for some rhyolitic to basaltic pyroclastic horizons of the Southern Calcareous Alps in Lombardy.

scribed by ELTER (1971), LEMOINE (1971) and BEARTH (1967) and their possible correlation with the pre-ophiolitic calcschists of the Western Alps should not be overlooked.

C - ***"Schistes lustrés" with metaophiolites (Jurassic-Cretaceous).*** Beside the *typical calcschists* (carbonate rocks bearing white micas), *pyrite-bearing chlorite micaschists* are also widely found, easily comparable to the dark argillaceous schists occasionally bearing pyrite (BEARTH, 1973) and to the black argillaceous schists (LEMOINE, 1971; ELTER, 1971), frequently found in the Cretaceous "Schistes lustrés" of the Western Alps. These rocks probably represent primary sapropelitic sediments.

As a rule, thin (cm-m), continous horizons of *quartzschists and micaceous quartzites bearing Mn and magnetite* are associated with the "Schistes lustrés" (between "i Corti" and Alpe Castellaccio in the St. Anna window, and between Alpe Mastabbia and Alpe Airale in the Alpe Airale window). However, they are also found directly in contact with metaophiolites (e.g. with metagabbro in Val Terzana; see Fig. 4). These siliceous rocks are generally interpreted as metacherts ± metaradiolarites of probable Upper Jurassic or Lower Cretaceous age.

A large quantity and variety of metaophiolites are present in the Lanzada-Scermendone Zone. *Prasinites* in horizons from m to dam thick as well as in much larger masses, alternate with large and small bodies of *serpentinites, ophicarbonates* and lenses of *metagabbros*. These metagabbros have been located up until now only to the west of Alpe Airale.

Fine- to coarse-grained, at places banded, prasinites show the typical quadriphase mineralogical composition: albite + blue-green amphibole + epidote + chlorite; little post-kinematic garnet is often found (BELTRAMI et al., 1975). Preliminary chemical data (BRAMBATI and LONGARETTI, 1983) outline two groups of prasinites; the first one with a typical tholeiitic trend, the second one without any magmatic trend, this latter corresponding to quartz- and micas-rich prasinites. These two groupes of prasinites probably are metamorphic products of basaltic flows and tuffitic horizons, respectively[4].

Metagabbros, serpentinites and ophicarbonates are collectively interpreted as olistoliths in "Schistes lustrés" or alternatively, as tectonic slices or rootless isoclinal folds. Ophicarbonates in the Lanzada-Scermendone Zone show some indications in favour of a sedimentary origin (see 10a in Fig. 4). Also the metagabbros locally have the appearance of breccias (sedimentary?, tectonic?).

Tectonism of the contiguous Malenco-Forno nappe and Lanzada-Scermendone unit has rendered the assignment of structural position to the lenses of serpentinites and ophicalcites very difficult (both rock types are present in both

[4] In the Suretta nappe, north of the Engadine Line, prasinite horizons, distinctly of basaltic and truffitic origin, have been recently discovered in the Avers Bündnerschiefers (P. Nievergelt, pers. comm.).

ophiolitic units). In some cases though, this has been possible; just east of Passo di Caldenno, for example, the core of a serpentinite antiform completely surrounded by calcschists, metagabbros, prasinites and orthogneisses, shows no possible relation whatsoever to the Malenco serpentinites (see Fig. 2).

Discussion and conclusion

The paracontinental character of the Lanzada-Scermendone Zone is supported by the coexistence of an ophiolitic complex (Jurassic-Cretaceous) with platform sediments (Permo-?Triassic) and with fragments of sialic crust (pre-Triassic).

A very strong, polyphasic Alpine deformation prevents to state whether the original relations among the three lithologic complexes in question were really stratigraphic. But such a status is principally presumed on the analogy of the Suretta nappe (MILNES and SCHMUTZ, 1978, with quoted references), to which the Lanzada-Scermendone Zone must be compared. The structural equivalence of this unit and the Suretta nappe has been already emphasized (STAUB, 1921, 1946), and is here supported by its geometric relations with respect to the Malenco-Forno and Margna units (see Structural Setting). On the other hand, the lithostratigraphic correlation of the Lanzada-Scermendone Zone with the Suretta nappe is suggested by the uniqueness and uniformality of their sedimentary cover (see Stratigraphy). Therefore the Lanzada-Scermendone Zone could be regarded as a more internal, or southernmost, portion ("root zone") of the Suretta nappe. The above characteristic rock sequences, overlying the crystalline basement of the Suretta nappe, from its frontal to its internal parts over a distance of almost 50 km, give additional evidence for a substantial autochthony of the Jurassic-Cretaceous cover as a whole.

The paleogeographic provenance of the Suretta nappe s.l. (i.e. including the Avers Bündnerschiefers) from the distal european southern margin of the Mesozoic Tethys, has been already proposed (see KELTS, 1981, with quoted references), but not generally accepted (see discussion in TRÜMPY, 1969, 1980). The lithostratigraphic characteristics of the Lanzada-Scermendone Zone, similar to the Suretta nappe s.l., as well as its structural position directly underlying the Malenco-Forno oceanic unit, confirms such an interpretation. Therefore the Lanzada-Scermendone Zone (and consequently the Suretta nappe as a whole) must be viewed as a pre-Piedmontese (or external Piedmontese) paracontinental belt, corresponding, from the structural point of view, to the upper Penninic units of the Western Alps; the Malenco-Forno nappe, in turn, is equivalent to the oceanic internal Piedmontese (or Piedmontese-Ligurian) elements.

The pertainance of the Avers Bündnerschiefers to the pre-Piedmontese belt, apparently favours the northerly (sub-Tambò) origin of the Schams nappes (solution "infra" of the "Schams dilemma") (see discussion in: TRÜMPY, 1969, 1980).

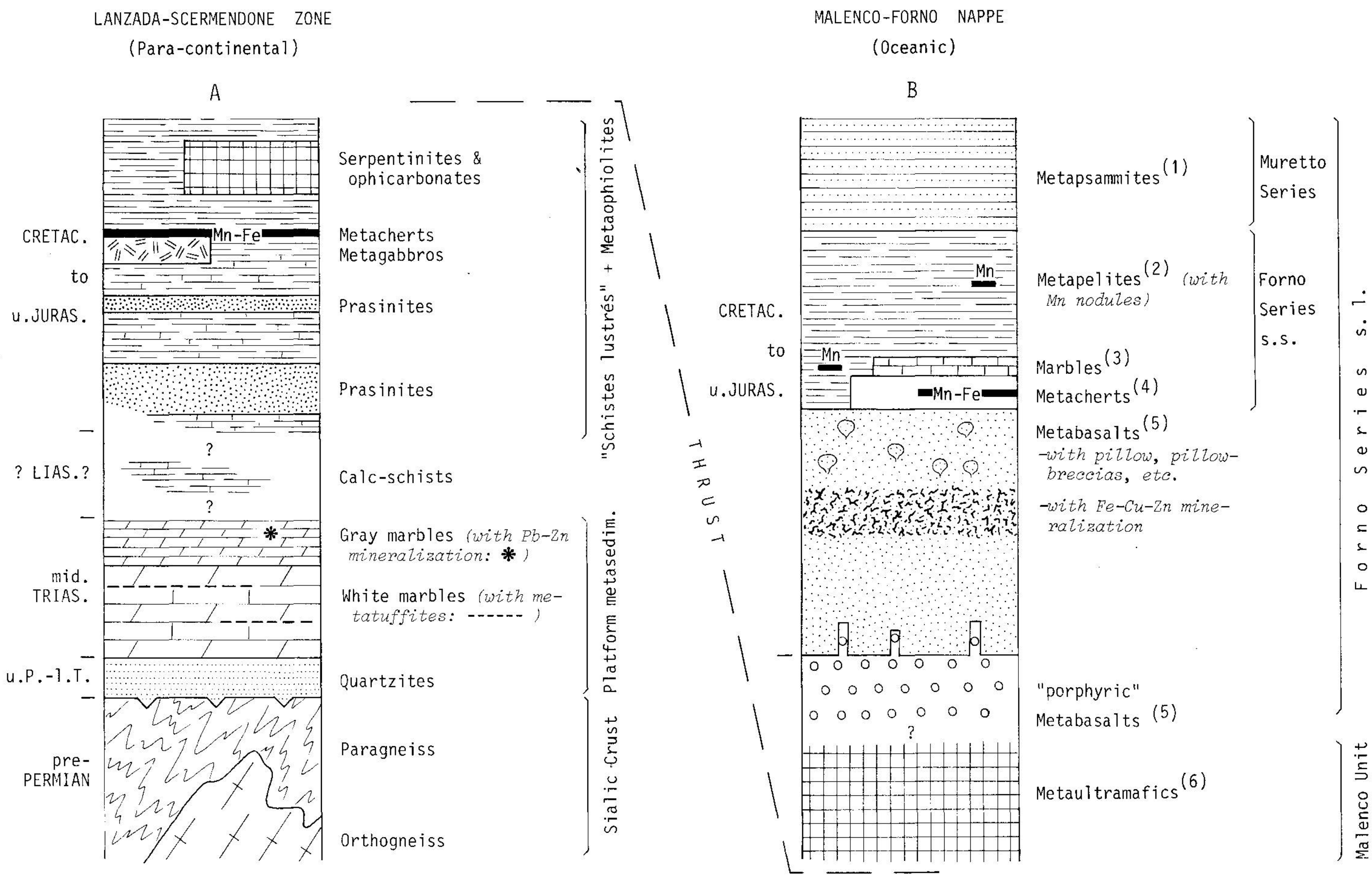

Fig. 6 Schematic lithostratigraphic sequences of two coupled ophiolitic units in the Malenco-Maloja area, and their structural relationships: A – the paracontinental Lanzada-Scermendone Zone (this paper); B – the oceanic Malenco-Forno nappe (De Capitani, Ferrario and Montrasio, 1981, with new original data from Peretti, in preparation).
(1–6 in sequence B: the corresponding lithologic units are: 1-Plagioclase-diopside quartzschists; 2-Andalusite-garnet biotitic schists; 3-Marble bearing Ca-silicates; 4-Thin banded quartzites ("Basal quartzites"); 5-Monte del Forno amphiolites; 6-Malenco serpentinites.

The lithostratigraphic setting of the Lanzada-Scermendone Zone emphasizes the presence, also in the Central Alps, of an ophiolitic unit of continental affinity closely associated with a truly oceanic ophiolitic unit, which is represented here by the overlying Malenco-Forno nappe (Fig. 6).

This later on supports the correlation, based on both structural and paleogeographic reasoning, with similar coupled ophiolitic units in the Western Alps (e.g.:Combin / Zermatt-Saas, BEARTH, 1967, 1973; DAL PIAZ, 1965, 1974; Ensemble A / Ensemble B, ELTER, 1971).

A correspondence of lithostratigraphic, structural and paleogeographic aspects between the Central and Western Alps appears to be more evident, as far as the upper Penninic is concerned. It will be even more so, when the already assumed (STAUB, 1917) but later on discarded (STAUB, 1921, 1946) equivalence of the Margna and the Dent Blanche nappes could be, once and for all, demonstrated. From the structural point of view, these two units, both probably Austroalpine, lie directly upon coupled ophiolite complexes, on the opposite sides of the Lepontine culmination of the Alpine edifice.

Some observations in the Lanzada-Scermendone Zone are more problematic to explain. Metacherts, for example, closely (stratigraphically?) associated with metagabbros and ophicalcites (see Fig. 4), could possibly indicate a more oceanic character than is assumed for this zone. Such problems also worry geologists in the Western Alps (BALDELLI et al., 1983).

Future studies might help to solve some of the problems as well as to improve the reconstruction of the stratigraphy of the Lanzada-Scermendone Zone. The petrochemical and metamorphic characteristics of its lithologies will be described elsewhere.

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