Metasedimentary cover sequences and associated metabasites in the Sabbione Lake zone, Formazza Valley, Italy, northwest Alps

SCHWEIZ. MINERAL. PETROGR. MITT. 78, 133–146, 1998

Metasedimentary cover sequences and associated metabasites in the Sabbione Lake zone, Formazza Valley, Italy, northwest Alps

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Abstract

The Monte Leone nappe is the upper structural unit of the lower Penninic nappes. In the Sabbione Lake region, within the Ossola-Ticino structural domain, metasedimentary rocks outcrop, traditionally considered as the Monte Leone overturned cover sequence. New field observations allow the recognition of two different cover sequences separated by a tectonic contact:

– The Monte Leone cover sequence, defined by a basal part (gypsum-anhydrite, dolomitic marbles and local quartzite levels), locally absent, and by a calcschist sequence representing a high energy depositional environment. Metabasite bodies are associated with this sequence: chemical analyses suggest a basaltic-tholeiitic trend for these rocks, and a WPB affinity of these basalts.

– A cover sequence, called "Bedretto Zone" (HANSEN, 1972), composed of marbles, quartzites, black phyllitic schists and calcschists. In the study area this cover sequence does not appear to be in depositional contact with basement units. Although it is not possible to define a certain depositional environment for this sequence, nevertheless it represents a lower energy depositional environment than the Monte Leone cover sequence.

Field, petrographical and geochemical data are consistent with a continental rift setting, evolving towards a deeper basin for the Monte Leone cover sequence. Two different hypothesis are suggested for the "Bedretto Zone": either a coastal environment or a deep restricted basin, isolated by the Monte Leone basement which forms a structural high. In both cases the paleogeographic position of this sequence can be considered farer from the growing oceanic ridge than the Monte Leone cover sequence.

Keywords: metasediments, geochemistry, Monte Leone nappe, Penninic, Alps, Italy.

Riassunto

La Falda del Monte Leone rappresenta l'elemento strutturale più elevato del complesso delle Falde Pennidiche Inferiori. Nella zona del Lago del Sabbione affiorano rocce metasedimentarie tradizionalmente considerate come la copertura rovesciata dello gneiss del Monte Leone.

I dati di terreno hanno tuttavia permesso di distinguere due differenti sequenze di copertura a contatto tettonico tra loro:

– la copertura del Monte Leone, definita da una porzione basale (gessi-anidriti, marmi dolomitici e locali livelli quarzitici) non sempre presente e da una sequenza calcescistosa composita che sembra indicare la presenza di un ambiente deposizionale ad alta energia. Associati a tale sequenza sono alcuni corpi di metabasiti: analisi chimiche hanno permesso di evidenziare l'affinitá basaltico-tholeiitica di tali rocce, e l'origine WPB di tali basalti;

– una sequenza, denominata "Zona Bedretto" da HANSEN (1972), svincolata nell'area in esame da rocce di basamento e definita da marmi, quarziti, scisti neri filladici e calcescisti. Attualmente non sembra possibile un'interpretazione univoca riguardo l'ambiente di formazione di tale sequenza; questa, tuttavia, sembra indicare la presenza di un bacino deposizionale a bassa energia ambientale.

La sequenza del Monte Leone può essere inserita nel contesto di un processo di rifting continentale successivamente evolutosi verso un'oceanizzazione progressiva del bacino; per la "Zona Bedretto" vengono proposte due dif-

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ferenti ipotesi: rappresenta un'ambiente di tipo costiero, in posizione più esterna rispetto all'asse di distensione, oppure esprime la presenza di un bacino ristretto e profondo, isolato dal basamento del Monte Leone che avrebbe quindi agito da alto strutturale; anche in questo caso è possibile collocare tale sequenza in una posizione più esterna rispetto all'asse di distensione.

1. Introduction

The study area is situated in the Lepontine zone, within the Ossola-Ticino structural domain, where the deepest tectonic units of the Alps outcrop (lower Penninic domain, ARGAND, 1911). The lower Penninic nappes are characterised by a succession of pre-Triassic basement sheets, separated each other by Mesozoic cover sequences; the actual tectono-stratigraphy has been interpreted as the result of an early thrusting and later folding processes (MILNES, 1974 a, b). The early thrusting stage is questioned by HUBER et al. (1980) and by STECK (1987); the latter suggests the presence of a 10 to 20 km thick ductile shear zone underneath the Austroalpine and the Upper Penninic nappes.

Within the Lepontine zone, the Tertiary metamorphic peak shows a gradient between 400–420 °C, 2–3 kb in the north-western part and 580–620 °C, 6–8 kb in the south-eastern part (FRANK, 1983; MERLE et al., 1986).

The highest structural unit of the lower Penninic domain is the Monte Leone nappe. The basement rocks are primarily composed of gneiss (para- and orthogneiss) with few amphibolites. The overturned metasedimentary sequence is called the "Faldbach Zone" or the "Binntal Zone". LEU (1986) describes four levels within the sequence, with associated metabasite bodies, and defines their sedimentary environment.

The present work investigates the cover rocks outcropping in the Sabbione Lake zone: new data about the metabasite bodies will be presented, followed by an interpretation of the depositional paleoenvironment.

2. Lithostratigraphy

The overturned Mesozoic cover sequence of the Monte Leone nappe outcrops in the area of Sabbione Lake (Figs 1, 2). Geological mapping of the whole Formazza Valley (Fig.1) has been carried out to better understand the connections between the Monte Leone nappe and the Lebendun and Antigorio nappes below.

Previously two units, both belonging to the Monte Leone cover sequence, have been recognised in the study area (HANSEN, 1972; LEU, 1986); new field observations allow to distinguish two different cover sequences: the first sequence outcrops in contact with the Monte Leone basement; the second sequence, called "Bedretto Zone" by HANSEN (1972), is separated from the first one by a tectonic contact. It is difficult to define the basement nappe of the latter unit; two hypothesis are suggested below.

2.1. THE MONTE LEONE COVER SEQUENCE

The Monte Leone cover sequence, outcropping below the basement gneiss, is composed of:

– basal part, including local quartzitic horizons, gypsum-anhydrite and dolomitic marbles, in direct contact with the basement gneiss of pre-Triassic age; the basal part has been considered of Permian-Triassic age (CANEPA, 1993);

– heterogeneous calcschists, locally at direct contact with the Monte Leone basement gneiss. Southward the calcschists shows a gradual transition towards a calc-micaschist complex called "Scisti Bruni" or "Bündnerschiefer" (STELLA, 1904; SCHMIDT and PREISWERK, 1905).

A stratigraphic succession has been delineated within the calcschists sequence (BIANCHI, 1996):

– basal metaconglomeratic horizons, containing Triassic dolomite clasts and locally basement pebbles; where the basal part is absent, this level is in direct contact with the basement gneiss (west of the Vannino lake);

– horizons characterised by the presence of Mn-rich garnet and graphite nodules;

– metapelite layers (garnet-staurolite-kyanite micaschists);

– conglomeratic-massive-quartzitic layers containing calcite pebbles;

– minor calcitic quartzites, marble bands, phyllitic-calcschist layers and metacalcarenitic levels.

2.1.1. The metabasite bodies

Metabasites crop out around Sabbione Lake, forming three different bodies; detailed geologic mapping (Fig. 3) permits the recognition of structurally different parts within the bodies. In general these rocks show an amphibolitic paragenesis defined mainly by hornblende and plagioclase (oligoclase); it is possible to distinguish:

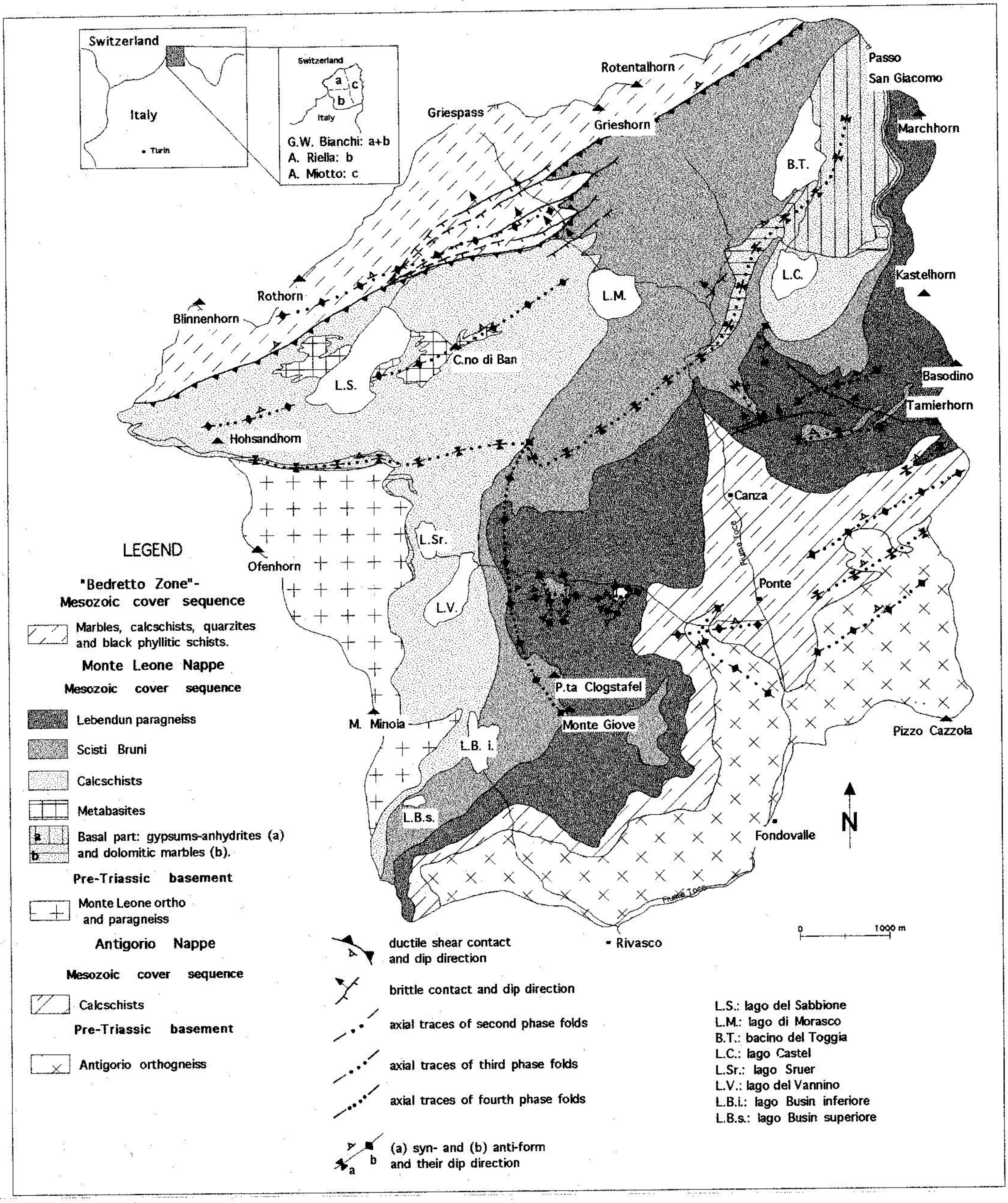

Fig. 1 Schematic geologic map of Formazza Valley. Additional data about the sectors (b) and (c) are available in RIELLA (1996) and MIOTTO (1996).

– metasedimentary breccias, characterised by the presence of a quartzitic-carbonatic proportion and with a clastic texture locally still recognizable. The paragenesis is defined by hornblende, biotite, epidote, plagioclase, carbonate and quartz, with minor apatite, chlorite and sphene;

– meta-pillow lavas and breccias: the original structure is typically obliterated by Alpine tecton-

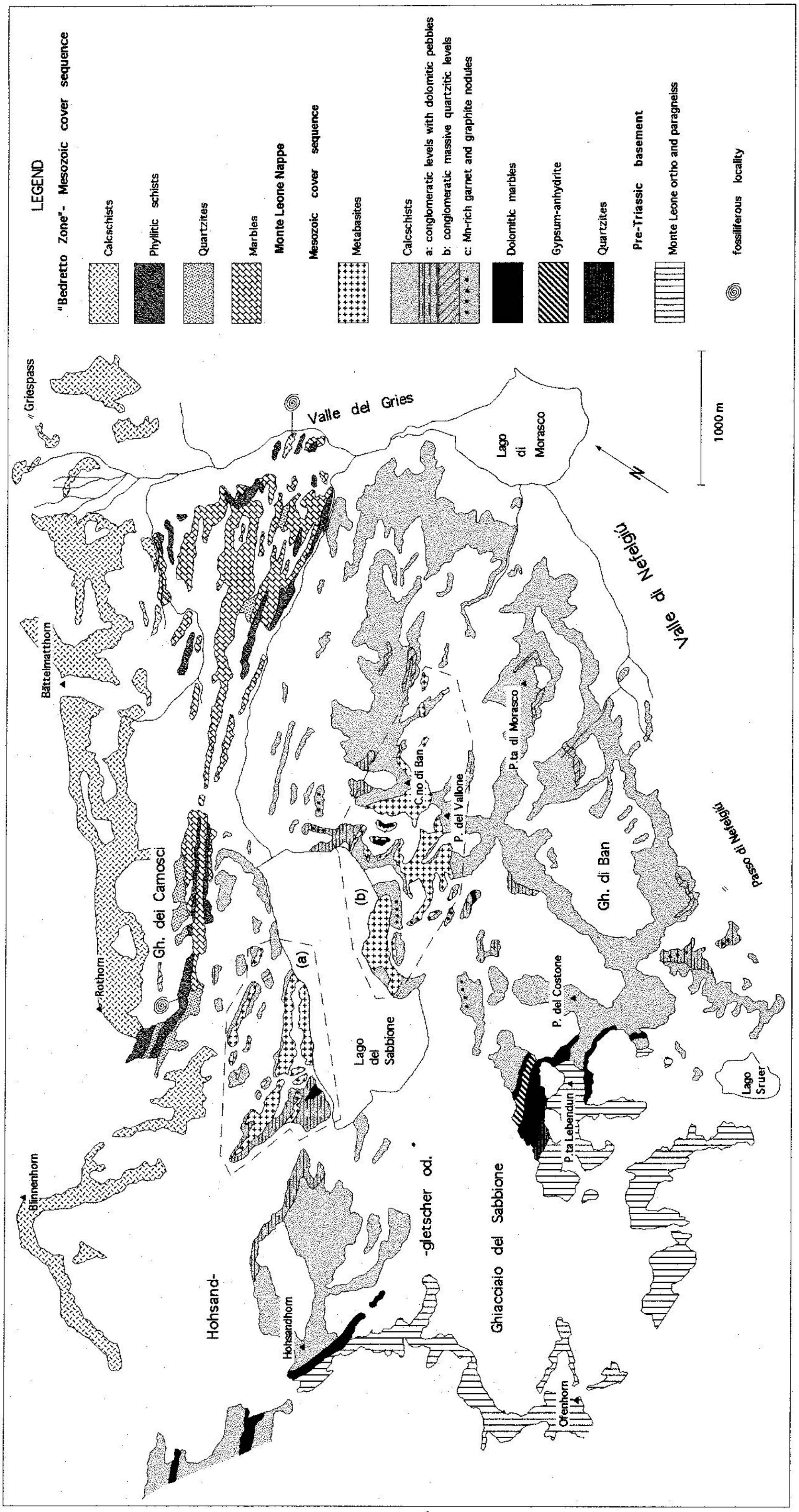

Fig. 2 Schematic geologic map of the study area. Dashed areas (a) and (b) are shown in figure 3.

ic deformations, but in places it is still recognizable (west bank of the Sabbione lake). The rock is formed of fine grained hornblende and plagioclase matrix and subordinate epidote, sphene and rutile;

– parts with gabbroic or microgabbroic texture, showing local and gradual transition to finer grained rocks; the mineral composition is usually homogeneous, defined by hornblende, plagioclase, biotite and epidote; garnet may be present;

– horizons with a typical light-green colour, characterised by alternations of amphibole, carbonatic and quartzite-feldspathic layers; metric bands are locally present, including millimetric lenticular structures with a feldspathic composition. The thickness of these levels is usually limited (decimeters to meters) and the distribution of this facies is restricted to external margins of the metabasites, always in contact with other lithologies.

Based on field and microscope observations (BIANCHI, 1996), the metabasites are interpreted in terms of primary magmatic facies:

– the last levels can be interpreted as cooling rims, due to the small thickness, the presence of these levels along the contact with the adjacent lithologies and the evidences of reaction rim between these two parts;

– an external position can be also attributed to the meta-pillows lavas and breccias, evidence of submarine volcanic activity;

– similar positions can be referred to the metasedimentary breccias, due to their clastic structure, probably due to syn-sedimentary volcanism;

– recognition of magmatic textures, often coarse grained, permits the interpretation of the metagabbros as the inner parts of basic magmatic sills. Probably they were not very widespread originally, because of their occurrence in limited area and the common transition to finer grained varieties.

The contacts with other lithologies are usually well exposed throughout the study area: the metabasites are in contact with calcschists, marbles, dolomitic marbles and calcitic quartzites. On the other hand only the metabreccias, the cooling rims and, less commonly, the meta-pillows are observed along the contacts. The transition is typically gradual, with the development of rocks with intermediate mineralogical composition (BIANCHI, 1996).

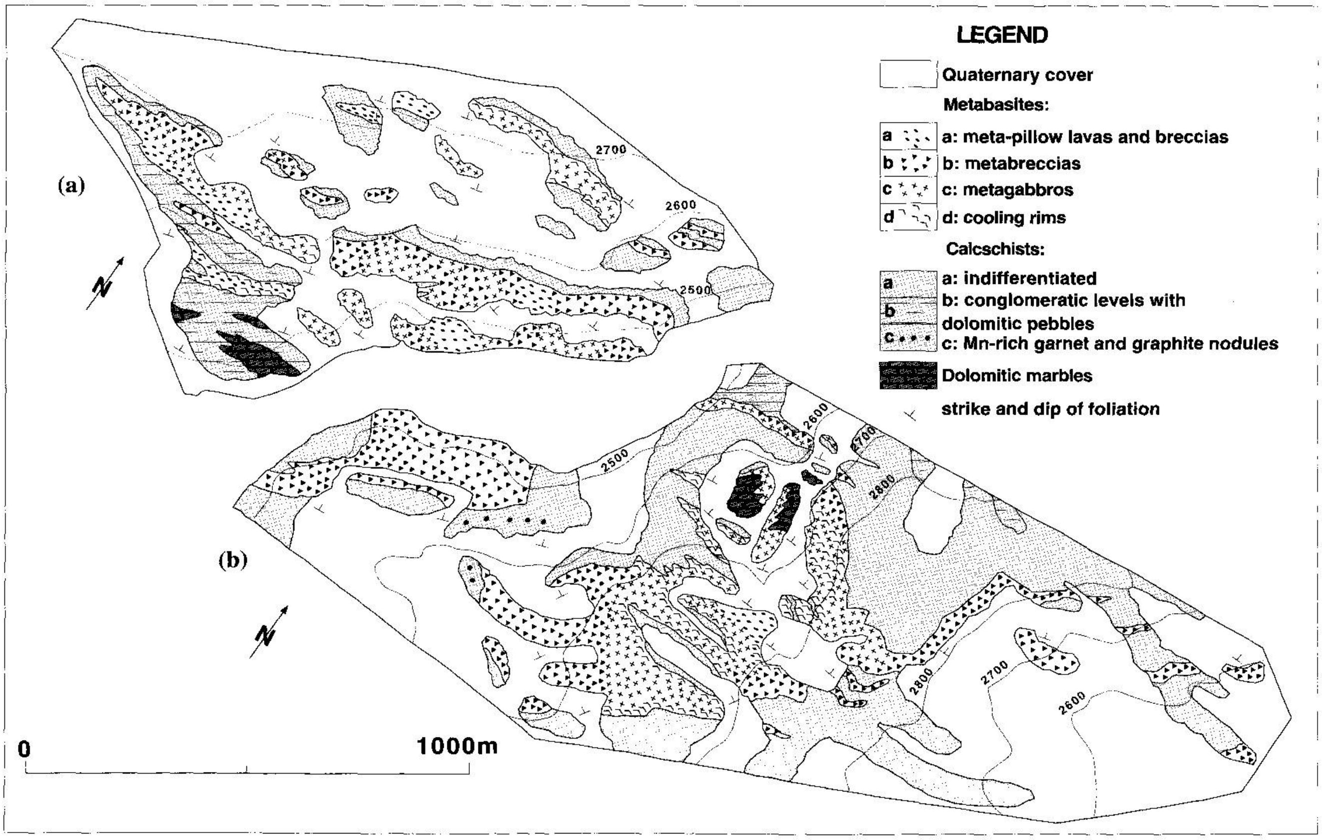

Fig. 3 Detailed maps of the metabasite bodies.

2.2. THE "BEDRETTO ZONE"

The cover sequence outcropping in the north part of the study area is known as "Bedretto Zone" (HANSEN, 1972) and it has been considered as part of the Monte Leone cover sequence. We think that the present level of data do not permit a definitive correlation of this cover sequence with a basement nappe. This sequence is defined by:

– marbles, forming a continuous band with local alternation with the other rocks of the sequence and also present as meter-scale lenses within the calcschists. In the field it is possible to distinguish different varieties of marbles: particularly notable are H_2S bearing marbles and marbles containing quartzitic bands. The latter can show a gradual transition toward pure quartzites (north-west of Sabbione Lake and around Camosci glacier);

– quartzites and quartzitic-micaschists crop out at different levels of the sequence, passing to micaschists or calc-micaschists. An unusual facies is observed in the quartzites around the Camosci glacier, which have a decameter-scale band of texturally homogeneous quartzite locally containing a fraction of carbonate and discontinuous millimeter-scale mica horizons; these outcrops typically have a well defined sedimentary bedding;

– phyllitic black schists, usually associated with the marbles. A similar lithology is found as local horizons within the calcschists in both cover sequences; however the phyllitic black schists do not contain any carbonate, so they can be easily separated from the other phyllitic calcschist. The mineral association consists of biotite, white mica, plagioclase (oligoclase), quartz, staurolite, zoisite/clinozoisite and ilmenite; garnet porphyroblasts are common, graphite is diffused throughout the lithology, giving the rock its typical black colour. The phyllitic black schists show a primary contact with the above mentioned quartzite, as can be seen in the Camosci glacier area. In the same area a centimeter-scale, fine-grained darker horizon, containing fragments of fossils recognizable as bivalves, sponge spicules and radiolaria is found (Fig. 4);

– a calcschist complex: it appears quite homogeneous, but it is possible to define textural and compositional variations. Phyllitic-calcschist layers, metapelite (micaschist) levels, marble bands or lenses and metacalcarenite horizons (containing fragments of fossils identified as echinoderms; Fig. 5) are identified; all are similar to the lithologies described in the Monte Leone cover Sequence. Nevertheless the calcschists of the "Bedretto Zone" can be distinguished from the

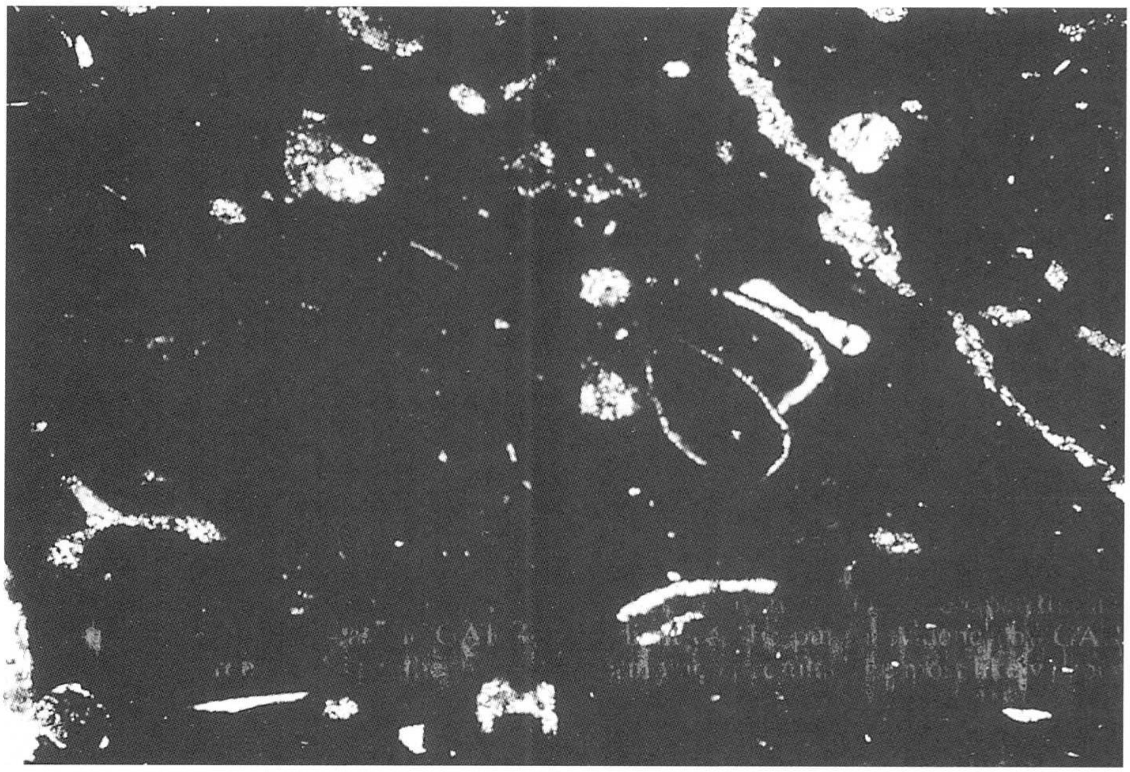

Fig. 4 Fragments of bivalves (Bi), sponge spicules (Sp) and radiolaria (Ra). Polarizer only; magnification 100×.

previously described calcschists because of the absence of the metaconglomeratic levels, containing dolomite and basement pebbles, as well as the horizons characterized by the presence of the Mn-rich garnet and graphite nodules.

2.4. THE CONTACT BETWEEN THE MONTE LEONE AND THE "BEDRETTO ZONE"

In the field only a few outcrops showing the contact between the two sequences have been observed, a quaternary cover being commonly present along the contact band. In places tectonic breccias with a carbonatic matrix outcrop along the contact; in other places it appears very difficult to find evidence of a tectonic contact because it concerns very similar lithologies (above all the calcschists of both the sequences, with associated marbles and phyllitic schists). Furthermore the contact has acted on rock bodies subsequently involved in the Alpine metamorphism and tectonic deformations.

Moreover the central part of the area is characterized by the presence of a east-west strike fault system (Fig. 1), interpreted as the consequence of the brittle resumption of a pre-existing ductile band. The tectonic release connected with the recent and present uplift can easily explain the formation of this fault zone; the rate of the uplift, typical of the entire Lepontine domain (JEANRICHARD, 1975; BRADBURY and NOLEN-HOEKSEMA, 1985), prevents the development of a more important system.

2.5. LITHOSTRATIGRAPHIC CONSIDERATIONS

Although it is possible to describe the stratigraphic setting of the investigated rocks, basing primarily on field observations, nevertheless the metamorphic and tectonic overprint has limited the interpretation of the original sedimentary environment. Since ARGAND (1911) the Monte Leone basement, as the other basement nappes, has been considered of pre-Triassic age. The sedimentary records preserved within the Monte Leone cover sequence suggest the presence of a continental riftogenic basin which develops into an oceanic basin.

The basal part, of probable Permo-Triassic age, in primary contact with the basement gneiss, could represent evaporitic deposits connected with a shallow water basin. Locally this part is absent and the calcschists are in direct contact with the Monte Leone basement.

The calcschist sequence shows stratigraphic relationships with the basal part of the basement gneiss: it represents the transgressive evolution of

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Fig. 5 Fragments of echinoderms. Polarizer only; magnification 40×.

the basin, initially with high energy deposits (metaconglomeratic levels, with basement and dolomitic-marbles pebbles), then with deposits of a lower energy environment (detritic sediments, non calcschists). Next to the basal conglomeratic horizons, levels characterized by the presence of Mn-rich garnet and graphite nodules are found. The distribution of these horizons and the chemical composition of the garnets (MnO over 20 wt%; BIANCHI, 1996) suggest the influence of circulating fluids enriched in Fe, Mn and other elements, due to the contamination of basic rocks connected with the evolution of the basin. The presence of the metabasite bodies seem to confirm this hypothesis. These bodies can be interpreted as sills and syn-sedimentary extrusions representing the early stages of the ocean rifting: the geochemical results discussed below support this interpretation.

Supposed a Permo-Triassic age for the basal part of the sequence, according to literature data and field observations and, lacking further informations, based on the stratigraphic continuity, it could be possible to attribute a Lower Jurassic age to the calcschist sequence and the associated metabasites. LEU (1986) considers a Cretaceous age of the calcschist sequence and the metabasites. Nevertheless, they show a sedimentary contact with the basal part or the basement gneiss, therefore an improbable gap in the sedimentation during the entire Jurassic is required; otherwise a tectonic contact should be present, which has not been observed.

More difficult is the interpretation of the "Bedretto Zone": in the study area it is not in contact with any basement nappe, so that it is not possible to establish any stratigraphic polarity.

H_2S bearing marbles and marbles containing quartzitic levels have been described above: the former could have a protolith of grey "fetid" limestones, expressing the presence of a shallow water environment with restricted carbonatic platform (WALKER, 1984); the latter could represent arenaceous intercalations, connected with detritic contributions due to the presence of river deltas interrupting the carbonatic platform; otherwise they can be interpreted as cherty limestones of deep water environment.

The quartzites can be interpreted in the same way: they could represent arenaceous deposits of a proximal environment or deep water chert deposits (WALKER, 1984).

Three hypothesis can be made about the phyllitic black schists:

– they represent deep water deposits, connected with a restricted basin; this could explain the presence of the radiolaria and the total absence of carbonate (deposition below the CCD, see also LEU, 1986). Nevertheless, the presence of bivalves, whose shell should initially have been composed of carbonate, contrasts the idea of the deposition below the CCD;

Tab. 1 Chemical analyses of the metabasite bodies.

	N1	N2	N3	N4	N5	N6	N7
SiO_2	51.23	48.94	49.37	47.40	49.56	48.74	53.87
TiO_2	0.36	1.57	1.02	1.37	1.40	1.96	0.76
Al_2O_3	12.17	15.35	13.38	14.19	14.97	14.54	13.19
Fe_2O_3	3.80	3.07	2.70	5.94	4.51	3.25	3.34
FeO	7.56	7.05	5.98	4.92	5.66	8.06	4.38
MnO	0.19	0.19	0.19	0.15	0.13	0.19	0.14
MgO	10.08	7.95	10.68	10.91	7.99	6.78	7.67
CaO	9.84	10.50	10.76	8.89	10.13	10.81	10.51
Na_2O	0.94	2.90	2.66	2.60	3.54	3.18	3.86
K_2O	0.91	0.27	0.57	0.74	0.20	0.43	0.18
P_2O_5	0.01	0.13	0.09	0.13	0.11	0.10	0.10
H_2O	1.68	1.25	1.46	1.76	0.93	1.41	0.87
CO_2	0.55	0.30	0.30	0.27	0.46	0.27	0.38
Cr_2O_3	0.07	0.04	0.08	0.08	0.05	0.01	0.01
NiO	0.01	0.02	0.04	0.05	0.02	0.01	0.01
Total	99.40	99.53	99.28	99.40	99.66	99.74	99.27
Ba	84	10	53	50	< 3	24	16
Rb	18	4	19	30	4	10	4
Sr	23	149	96	161	202	132	201
Pb	< 2	< 2	< 2	< 2	< 2	< 2	< 2
Th	< 1	< 1	< 1	< 1	< 1	< 1	13
U	< 2	< 2	< 2	< 2	< 2	< 2	< 2
Nb	< 5	< 5	< 5	< 5	< 5	< 5	10
La	< 4	10	12	< 4	< 4	< 4	27
Ce	< 6	< 6	< 6	< 6	< 6	22	73
Nd	< 3	6	6	8	7	13	43
Y	< 1	20	11	16	20	23	29
Zr	< 2	120	77	99	107	107	185
V	258	274	191	233	253	482	103
Cr	496	284	600	549	370	43	85
Ni	47	144	349	381	170	52	61
Co	58	54	56	65	56	57	34
Cu	< 4	< 4	< 4	< 4	< 4	< 4	< 4
Zn	170	65	38	75	82	60	52
Ga	9	10	8	9	8	11	15
Hf	< 2	< 2	< 2	< 2	< 2	< 2	2
S	42	38	36	278	33	40	87

– they represent coastal clays deposited in an anoxyc environment; the presence of the radiolaria seems to exclude this hypothesis;

– they represent marly deposits inside a mainly carbonatic sequence or clayey intercalations inside pelagic limestones (like the "black shale" of Aptian-Albian age); however, these deposits keep a fraction of carbonate, here totally absent, or they have lower thickness than observed.

Further investigations and whole rock analyses would aid in better characterising this lithology.

The calcschist sequence shows similar characteristics as the Monte Leone calcschists; nevertheless it lacks meta-conglomeratic horizons as well as Mn-rich garnets and graphite nodules, so they

Tab. 2 Synoptic table of compositional, geochemical, geotectonic characteristics and summary conclusions of the analysed samples. Question marks denotes uncertain determinations.

rock type	meta-basalt	meta-gabbro	meta-basalt	meta-gabbro	meta-basalt	meta-gabbro	cooling rim
locality	Sabbione lake	P. del Vallone	C.no di Ban	C.no di Ban	P. del Vallone	Sabbione lake	Sabbione lake
sample	N1	N2	N3	N4	N5	N6	N7
diagram/results							
Al_2O_3 TiO_2 COLOMBI 1989	?	basaltic liquid	basaltic liquid	basaltic liquid	basaltic liquid	basaltic liquid	basaltic liquid
TiO_2 Fe^{tot}/MgO COLOMBI 1989	cpx-plg gabbros	meta-basalts	meta-basalts	meta-basalts	meta-basalts	meta-basalts	meta-basalts
FeO_{tot}-MgO $Na_2O + K_2O$ MORSE 1988	ophiolitic basalts	ophiolitic basalts	ophiolitic basalts	ophiolitic basalts	ophiolitic basalts	ophiolitic basalts	ophiolitic basalts
$Na_2O + K_2O$ SiO2 MOINE 1969	basalt	basalt	basalt	basalt	basalt	basalt	andesitic basalt
TiO_2 Zr/P_2O_5 FLOYD and WINCHESTER 1975	tholeiitic basalt	tholeiitic basalt	tholeiitic basalt	tholeiitic basalt	tholeiitic basalt	tholeiitic basalt	tholeiitic basalt
Nb/Y Zr/P_2O_5 FLOYD and WINCHESTER 1975	tholeiitic	tholeiitic	tholeiitic	tholeiitic	tholeiitic	tholeiitic	tholeiitic
Ti/Y Nb/Y PEARCE 1982	tholeiitic	tholeiitic	tholeiitic	tholeiitic	tholeiitic	tholeiitic	tholeiitic
Spider Rock/MORB PEARCE 1982	WPB	WPB	WPB	WPB	WPB	WPB	WPB
Conclusions	tholeiitic basalt WPB	tholeiitic basalt WPB	tholeiitic basalt WPB	tholeiitic basalt WPB	tholeiitic basalt WPB	tholeiitic basalt WPB	tholeiitic basalt WPB

can be interpreted as a detritic sequence with local increases in the pelitic proportion (micaschists) or transitions towards pelagic limestones (marbles). Therefore this calcschist sequence seems to express the presence of a tectonically less active basin.

Basing on the considerations exposed above it is possible to define two different sedimentary environments for the "Bedretto Zone" Auct. (Fig. 10):

– a proximal environment (Fig. 10a), characterized by the presence of carbonate platforms, arenaceous-detritic contributions due to the presence of river bars and with coastal anoxic lagoons; this environment has subsequently evolved towards a carbonate-detrital sedimentation, typical of a deeper basin. Furthermore the "Bedretto Zone" Auct. should have been deposited in a position with a lower environment energy;

– a deep water environment (Fig. 10b), characterized by the sedimentation of pelagic limestones, organic matter rich-clay intercalations, and quartzites with a possible organogenic origin. In this case the sequence should express an isolated and deep basin; the Monte Leone basement represents a structural high isolating the basin mentioned above.

3. Whole rock geochemistry

Field and microscope data have been complemented by major and trace elements analyses (Tab. 1) on seven samples from the metabasites. They were made by one of the authors (BIANCHI) in the "Centre d'Analyse Minérale" (C.A.M.) of the University of Lausanne. The limited number of analyses demands prudence in the interpretation of the data; nevertheless, it is possible to draw some further inferences by these data. The aims of these analyses were to define the chemical composition of the metabasite bodies, to understand the nature and the geochemical affinity of the protoliths and their geotectonic settings. Further investigations are required for a better definition of these rocks.

The relative mobility of the chemical elements has been determined by comparing major and trace elements with Zr, which is usually considered to be immobile during metamorphism (PFEIFER et al., 1989). Most of the major elements do not show a true linear correlation with Zr, trace elements show instead a good linear correlation (BIANCHI, 1996). Metamorphism and subsequent fluid contamination can explain the scattered distribution of the major elements.

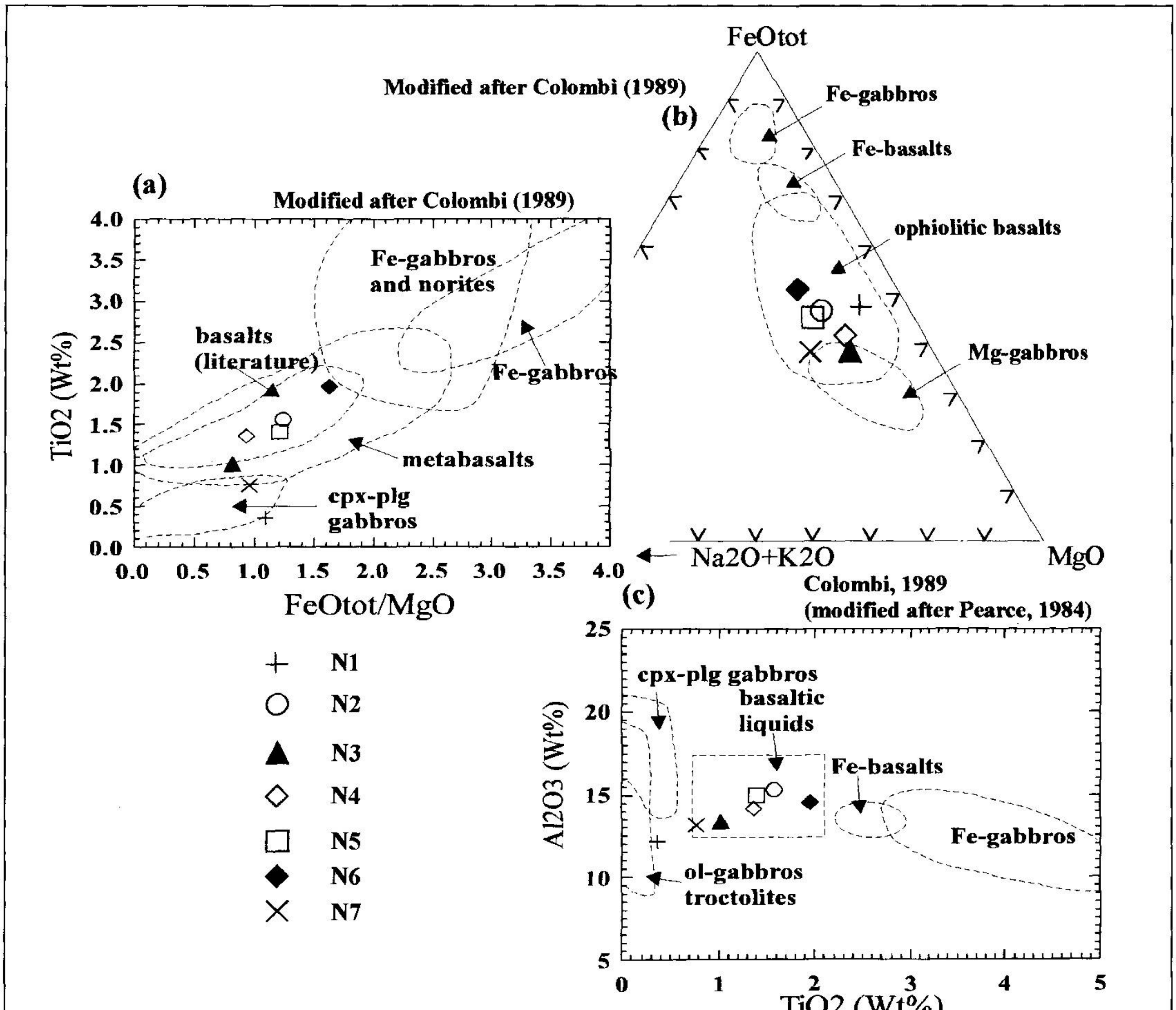

Fig. 6 Discrimination diagrams for mafic rocks. (a and c) The analysed samples fall in the field of the basaltic liquid or of the metabasalts, except for the sample N1; (b) confirms an ophiolitic basalt composition.

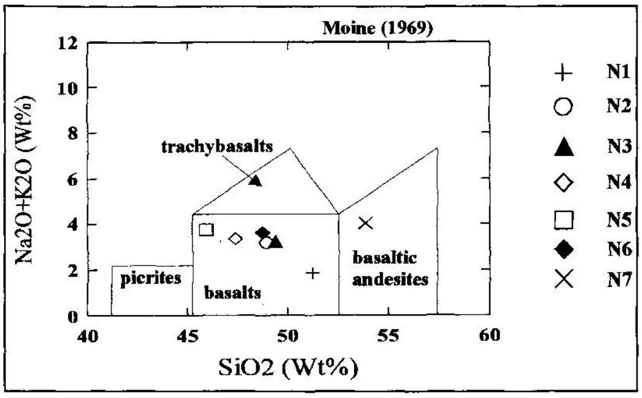

Fig. 7 The samples except N7 show a basaltic composition; N7 is basaltic andesitic.

The chemical composition of the analysed samples (Tab. 1) is comparable with basalts known from literature data (RAYMOND, 1995); in particular the contents in TiO_2, K_2O and Na_2O seem to be comparable to tholéiitic basalts. This interpretation is confirmed by the diagrams of figure 6. The samples N1 and N7 may display a different behaviour, due to a different chemical composition (higher contents in SiO_2 and lower contents in TiO_2, see figure 7 and table 1) and due to contamination during the magmatic or the metamorphic evolution.

Figure 8 displays discrimination plots for the metabasites which confirm that the protoliths are typical of tholeiitic composition.

Diagrams generally used to define the geotectonic setting of basalts reveal ambiguous results for the analysed samples (BIANCHI, 1996). However from spider diagrams (Fig. 9) it can be concluded that the metabasites evolved in a WPB setting.

Based on the results discussed above (summarized in Tab. 1) it is possible to suggest a tholeiitic basaltic composition for the metabasites; although further investigations and analyses on a higher number of samples are needed to better

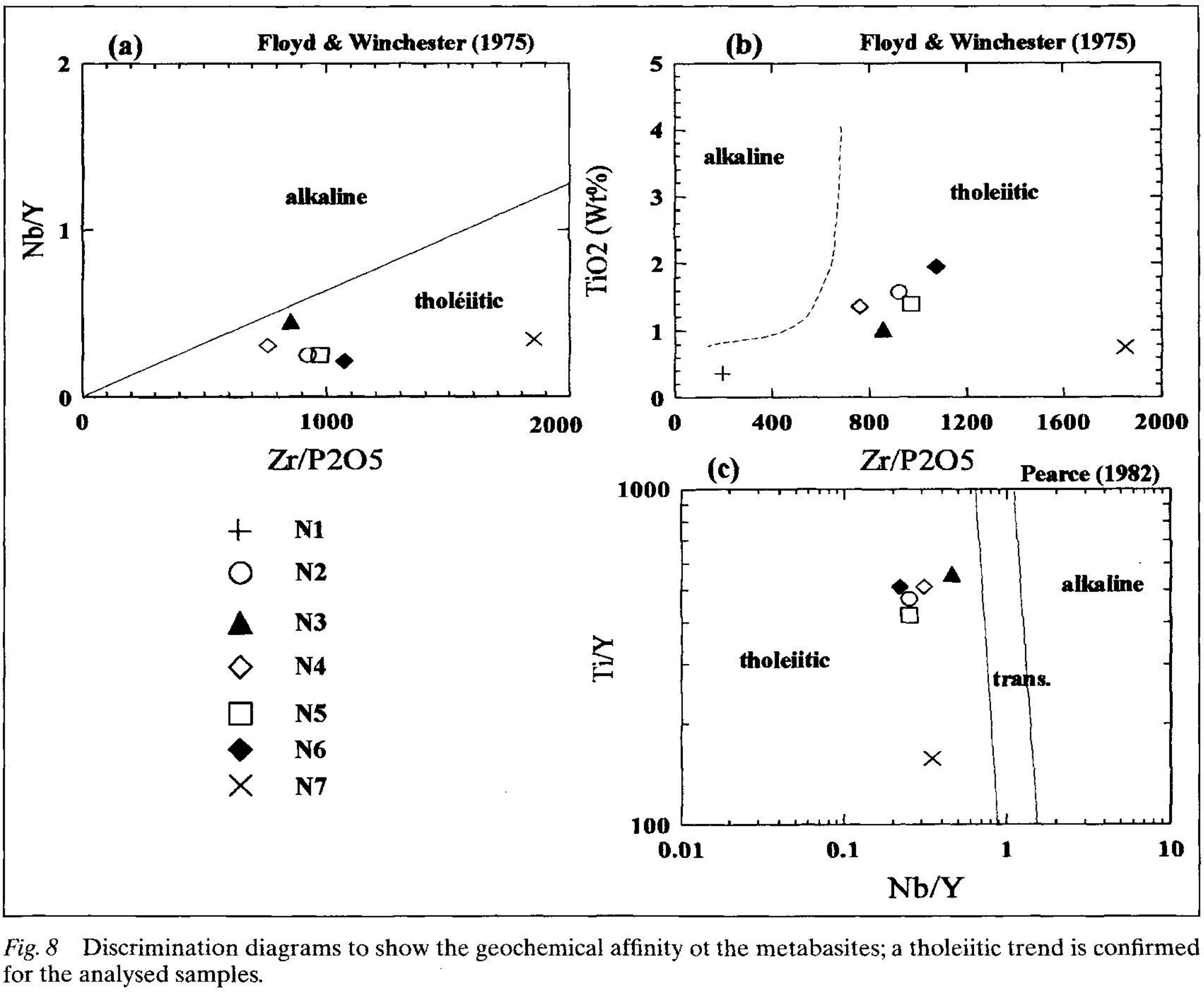

Fig. 8 Discrimination diagrams to show the geochemical affinity ot the metabasites; a tholeiitic trend is confirmed for the analysed samples.

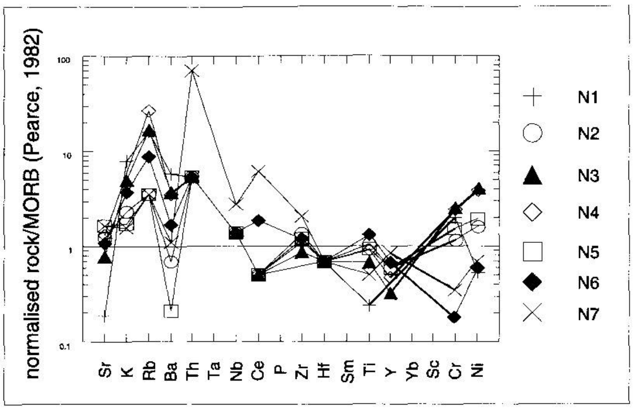

Fig. 9 Spider diagram showing a WPB pattern for the analysed samples.

clarify the origin of these rocks, we can assume of a *within plate basalt* affinity.

The geotectonic setting described supports the results of previous studies about the Geisspfad Ultramafic Complex, a peridotite body outcropping above the Monte Leone gneiss (PASTORELLI et al., 1995): the Geisspfad peridotite represents a slice of sub-continental lithospheric mantle which evolved, during a pre-oceanic rifting stage, the surface; the extensional tectonics was accompanied by intrusion of mafic magmas, and the mafic layers in the Mesozoic cover sequence record a syn-sedimentary basic volcanic activity.

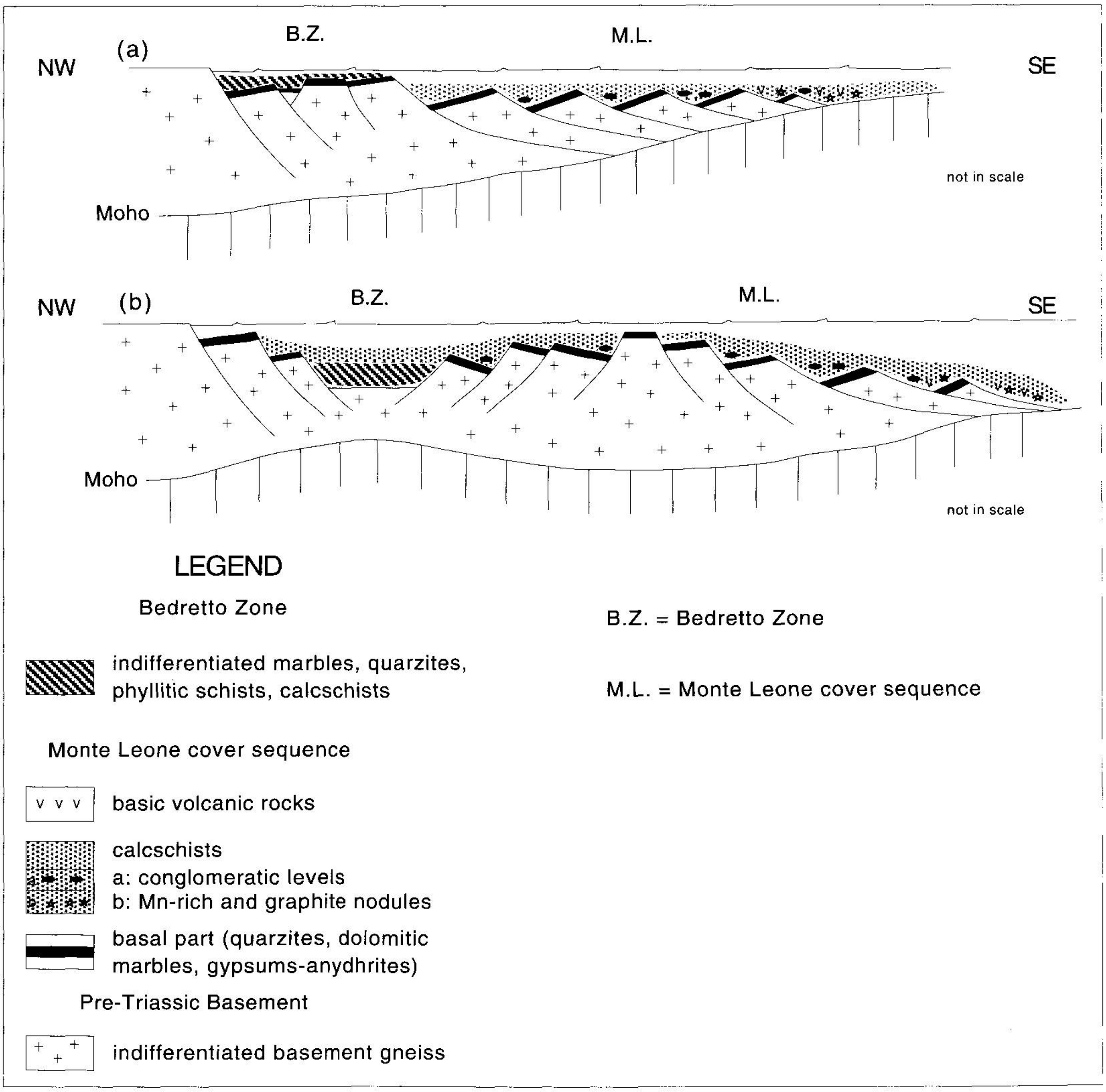

Fig. 10 Paleogeographic reconstruction of the study area at Early Jurassic.

4. Conclusions

The data suggests that the investigated rocks belong to two different cover sequences, with a tectonic contact between them.

One sequence is in direct contact with the Monte Leone basement. Metabasite bodies are associated with the Monte Leone cover sequence: they are interpreted as representing syn-sedimentary basic volcanic activities. The first chemical investigation of these bodies suggests a tholeiitic trend, with a WPB affinity. The tectonic activity suggested by the metabasites is supported by the presence of high energy deposits inside the Monte Leone cover sequence (metaconglomeratic levels).

The second sequence is the "Bedretto Zone" Auct.: in the study area it is not in contact with any basement rock, so that it is not possible to correlate this cover sequence with a basement nappe. The stratigraphic meaning of this sequence is uncertain (Fig. 10):

– it could represent a pelagic environment, in a isolated and restrict basin: the Monte Leone basement should have acted as a structural high to isolate this basin from the oceanic ridge (Fig. 10a);

– it could represent a proximal sequence of a coastal environment (Fig. 10b).

Acknowledgements

We would like to thank A. Riella and A. Miotto for the contribution of data; R.H. Pfeifer who allowed to use the laboratories of the CAM (Université de Lausanne); Ed Sobel for the English language revision of the manuscript; the reviewers, P. Thélin and H. Hunziker, for their useful suggestions.

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Received April 15, 1997; revision accepted September 10, 1997.