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Structural and petrographic map of the southern Sesia-Lanzo zone (Monte Soglio - Rocca Canavese, western Alps, Italy)

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ABSTRACT - A new foliation trajectory map, synthesised from an original field analysis at 1:10 000 scale, in southern Sesia Lanzo Zone, is represented here with an interpretative structural map, in which relative chronology of overprinting foliations and information on mineral assemblages marking superposed fabrics in each rock type are supplied. These maps, together with the reconstruction of a three-D structural outline of the tectonic contact between Eclogitic Micaschists Complex and Rocca Canavese Thrust Sheets, allow the correlation of structural and metamorphic imprints recorded during Alpine convergence in the two complexes, and their respective connection to metamorphic evolution under eclogitic, blueschist and greenschist facies conditions.

K e y w o r d s : foliation trajectory map, HP-LT Alpine metamorphism, Austroalpine continental crust, Sesia-Lanzo Zone, western Alps.

RIASSUNTO - Una nuova carta delle triettorie delle foliazioni, insieme con la relativa carta strutturale interpretativa, è sintetizzata da un nuovo rilevamento strutturale-petrografico eseguito a scala 1:10 000 nella Zona Sesia-Lanzo meridionale. In entrambe le carte sono contenute le informazioni relative alla cronologia dei fabric sovrapposti, corredate da informazioni sulle paragenesi mineralogiche che li marcano nei differenti litotipi. Queste carte, insieme con la ricostruzione della configurazione tridimensionale del contatto tettonico tra il Complesso dei Micascisti Eclogitici e le scaglie tettoniche di Rocca Canavese, consentono la correlazione delle impronte strutturali e metamorfiche registrate nei due complessi durante la convergenza Alpina e il riconoscimento delle loro mutue relazioni con l'evoluzione metamorfica in ambiente eclogitico, scisti blu e scisti verdi.

P a r o l e c h i a v e : carta delle traiettorie delle foliazioni, metamorfismo alpino di AP-BT, crosta continentale Austroalpina, Zona Sesia-Lanzo, Alpi occidentali.

INTRODUCTION

In the western Alps, the subduction-related high-pressure low-temperature (HP-LT) metamorphic imprint widely affects not only the ophiolites and related sedimentary sequences, but also large volumes of pre-Alpine continental crust, among which the Sesia-Lanzo Zone (SLZ; Fig. 1) is the widest eclogite-facies crustal slice of Late-Cretaceous (eo-Alpine) age. Its Alpine tectonic evolution is compatible with uplift during active oceanic lithosphere subduction (e.g. Spalla *et al.*, 1996). The SLZ consists of three main lithologic complexes (e.g. Dal Piaz *et al.*, 1972; Compagnoni *et al.*, 1977): i) Gneiss Minuti complex (GMC), ii) Eclogitic Micaschists complex (EMC) and iii) II Dioritic-Kinzigitic Zone (IIDK). IIDK consists of kilometric lenses of pelitic and mafic granulites not recording eclogitic re-equilibration. EMC and GMC, both pervasively eclogitised, strongly differ in the volume percentage of greenschist re-equilibration (Stuenitz, 1989; Spalla *et al.*, 1991). In the southern SLZ the metamorphic complex of Rocca Canavese thrust sheets (RCT; Pognante, 1989a; 1989b) has been recognised, on the ground of its strongly contrasted tectono-thermal Alpine evolution (Fig 2). The highly detailed petrologic outline was not supported by a structural analysis of the superposed grid of metamorphic foliations allowing the regional scale correlation of structural and metamorphic stages across the two units. The aim of this contribution is to reconstruct a three-D structural outline of the tectonic contact between EMC and RCT and to elucidate their structural and metamorphic evolution during Alpine convergence. For this purpose, a detailed foliation trajectory map has been synthesised from original field analysis at 1:10 000 scale and proposed in plate I, face to the interpretative map. Relative chronology of overprinting foliations is shown on this map by the foliation trajectory symbols; these symbols represent interpolation of seams of foliation orientation data. In the legend minerals marking successive fabrics in each rock type are added; they suggest the metamorphic conditions peculiar of the successive grou-

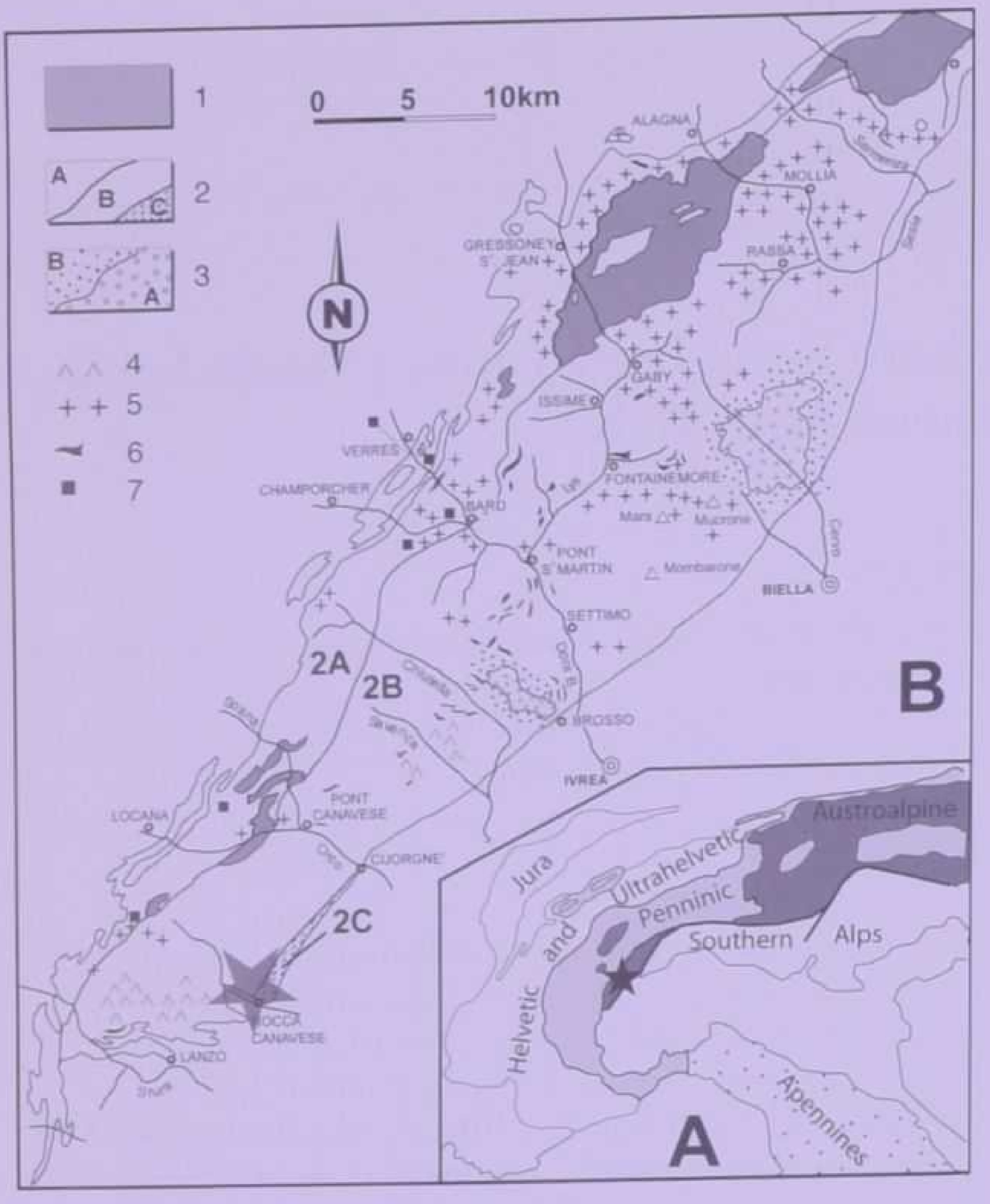
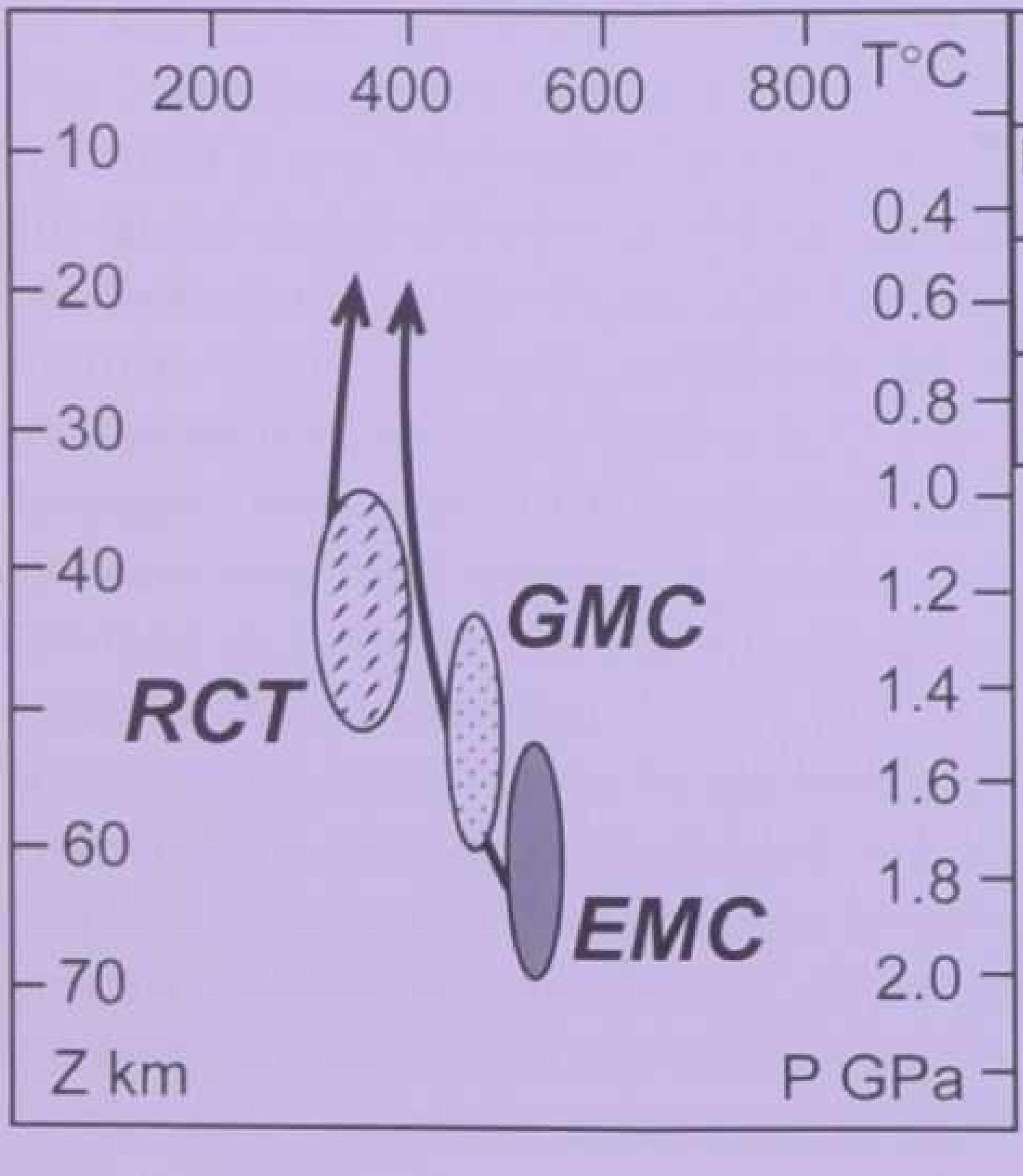


Fig. 1 - A) Tectonic outline of the Alps. B) Simplified geological map of Sesia-Lanzo Zone. Legend: 1 = II Dioritic-Kinzigitic Zone; 2A = Gneiss Minuti Complex (GMC); 2B = Eclogitic Micaschists Complex (EMC); 2C = Rocca Canavese Thrust Sheets; 3A = post-metamorphic Oligocene intrusives; 3B = contact metamorphic aureole; Symbols: 4) metagabbro; 5) metagranitoid; 6) calc-silicate marble; 7) relict eclogite in the GMC. Star locates maps of plate I.

ps of structures, which is indicated by trajectories of different colour. In this way, by means of microstructural analysis of the successive foliations, details on relative chronology of structural imprints and metamorphic environments in which they developed are independently shown and precisely located in space.

GEOLOGIC OUTLINE

Eo-Alpine HP-LT metamorphism of the SLZ (e.g. Hunziker, 1974; Oberhaensli *et al.*, 1985; Stoeckhert *et al.*, 1986; Rubatto, 1998; Cortiana *et al.*, 1998; Rubatto *et al.*, 1999) is characterised by an eclogite facies imprint followed by blueschist re-equilibration (Dal Piaz *et al.*, 1972; Castelli, 1991; Pognante, 1991 and references therein) and a successive LP-greenschist retro-gradation. The Alpine low T/P regime of this portion of the Austroalpine continental crust facilitated the preservation, in Alpine low-strain domains, of pre-Alpine relic assemblages from granulite to greenschist facies conditions; these relics are preserved to different extent in marbles, meta-pelites, meta-granitoids, meta-gabbros, amphibolites and mafic and acidic granulites (Compagnoni *et al.*, 1977; Spalla *et al.*, 1983; Lardeaux and Spalla, 1991; Rebay and Spalla, 2001 and references therein). The granulite to amphibolite PT evolution has been interpreted as representative of an extension-related uplift during Permian-Triassic times of the Adriatic lower continental crust (Lardeaux and Spalla, 1991; Dal Piaz, 1993), as envisaged in the Ivrea Zone (e.g. Schmid and Wood, 1976; Sills, 1984; Mayer *et al.*, 2000). Relics of the pre-Alpine history are preserved throughout the SLZ (Fig. 1), traditionally subdivided into three main complexes: i) Gneiss Minuti complex (GMC), ii) Eclogitic Micaschists complex (EMC) and iii) II Dioritic-Kinzigitic Zone (IIDK). IIDK consists of kilometric lenses of lower continental crust escaped to the Alpine eclogitic re-equilibration. EMC and GMC, both pervasively eclogitised, strongly differ in the volume percentage of greenschist re-equilibration. GMC is widely greenschist re-equilibrated and follows the continent-ocean tectonic boundary, active during subduction-exhumation processes of SLZ and meta-ophiolites; the greenschist re-equilibration is generally associated with mylonitic textures (Spalla *et al.*, 1983; Stuenitz, 1989; Spalla *et al.*, 1991). The EMC constitutes the innermost part of the SLZ, where the greenschist retrogradation is confined to discrete shear zones, more pervasive towards its inner boundary with



Tectonic Unit	Protolith	P(GPa)-T(°C) peak	Metamorphic age
Rocca Canavese Thrust Sheets	granulites,granitoids, peridotites	>1.0, 300-400	eo-Alpine
Gneiss Minuti Complex	granitoids, mafic, Ca-pelites	1.1-1.2, 400-450	eo-Alpine
Eclogitic Micaschist Complex	kinzigites, granitoids, mafic	1.3-2.0, 500-550	eo-Alpine

Fig. 2 - P-T paths representing the Alpine metamorphic evolution of Gneiss Minuti Complex (GMC), Eclogitic Micaschists Complex (EMC) and Rocca Canavese Thrust Sheets, redrawn after Pognante (1989a; 1989b); table on the right of the P-T diagram shows protoliths, physical conditions of Alpine metamorphism and suggested metamorphic ages for each unit.

Southern Alps. The recognition of the Rocca Canavese thrust sheets (RCT) is more recent (Pognante, 1989a; Pognante, 1989b); they consist of thin crustal slices located along the eastern margin of the Southern SLZ and extending from Rocca Canavese to Courgnè (Fig. 1). The metamorphic evolution of RCT is considerably different from that of the other SLZ complexes; this tectonic unit consists of pre-Alpine granulites, serpentinised tectonitic lherzolites, glaucophane-bearing schists and metagranitoids. The RCT thin tectonic slices are separated by Alpine blueschist mylonitic horizons. According to Pognante (1989a; 1989b), the age of mineral growth is different in RCT and EMC metabasics; in particular lawsonite porphyroblasts overgrew the eclogitic glaucophane, garnet-, minor omphacite- and titanite-bearing foliation in EMC, whereas in RCT lawsonite is syntectonic with the development of a glaucophane/omphacite-bearing foliation and generally shows a pumpellyite thin rim. In this unit the typical eclogite-facies mineral assemblage of EMC is lacking (Pognante, 1989a). After the blueschist facies re-equilibration both EMC and RCT rocks underwent a low-pressure vs. low- to very low-temperature incomplete recrystallisation. P-T trajectories recorded in EMC, GMC and RCT rocks of the southern SLZ are shown in figure 2; coupling of these units was interpreted to have occurred in blueschist facies conditions, synchronous with the early exhumation stages of EMC (Pognante, 1989b).

LITHOLOGY, STRUCTURE AND METAMORPHISM

The syn-metamorphic structural evolution of EMC and RCT is summarized separately in the following. Original fieldwork was carried out at 1:10 000 scale and is synthesised in two separate maps, analytical and interpretative, both at 1:20 000 scale (A and B respectively in plate I). Schmidt diagrams (lower hemisphere) with the orientations of mesoscopic fabric elements are shown with the maps. Fabric orientation data are subdivided into three subareas corresponding to EMC, RCT and to the region close to the boundary between the two units; in the following, their structural and lithologic characters are described separately.

Eclogitic Micaschists Complex (EMC)

This unit contains metapelites with interlayered metabasics and rare metagranitoids (Fig. 3). Four types of metapelites have been distinguished: i) *quartz-rich schists (9)* in map legend of plate I), the most widespread lithotype, composed of quartz, white mica, garnet, titanite ± clinozoisite ± glaucophane ± chloritoid ± lawsonite; ii) *green-phengitic mica schists (10)* with quartz and minor green phengitic mica; a metre-thick layer of metagranitoids with centimetre-sized K-feldspars, white mica, quartz, omphacite, clinozoisite is enclosed in these rocks; iii) *dark grey schists (11)* composed of quartz, albite, epidote, chlorite and green amphibole; *micaschists (13)* with white mica, chlorite, albite, glaucophane and quartz.

Metabasics mainly consist of glaucophanites, minor volumes of eclogites and amphibolites. *Glaucophanites (7)* occur as centimetre- to 1.5 kilometres-scale lenses within the surrounding gneisses, are composed of 1-5 mm-scale glaucophane, clinozoisite, white mica, quartz, and titanite ± garnet ± omphacite ± lawsonite. Omphacite is abundant in the NW part of the area (Alpe Mecio, Pl. I), where glaucophanites contains eclogitic pods; lawsonite has a heterogeneous distribution at the scale of the outcrop and it occurs as isolated crystals or as mineral aggregates that constitute up to 80% of the rock volume. Glaucophanites occurring in the southern part area, close to the boundary with RCT, have a sub-millimetre grain size; lawsonite is rare with a grain size never exceeding 1 centimetre and occurring as isolated rhombic grains. *Garnet-absent mica-rich glaucophanites (8)* are composed of glaucophane, white mica, clinozoisite, quartz, albite, calcite and titanite. *Amphibolites (5)* occur in a single outcrop along the ridge between Rocca Lunga and Testa Brusa (Pl. I) and consist of 10-20 cm-thick undeformed and poorly re-equilibrated lenses within the glaucophanites. They are composed of 1-2 cm dark green hornblende within a white matrix of original plagioclase, now completely replaced by a very fine aggregate of clinozoisite, white mica, albite and garnet (Fig. 3). A 1-3 cm thick layering is defined by alternating amphibole-rich and plagioclase-rich horizons. *Eclogites (6)* occur in the northern part of the area as 20 centimetres to 1-metre layers or as lozenge shaped pods within the glaucophanites (Fig. 3). They are composed of omphacite, clinozoisite, titanite and minor garnet and glaucophane.

In the EMC rocks, four groups of structures (D1, D2, D3 and D4) developed during Alpine metamorphic minerals growth:

-D1 is preserved as a relic foliation (S1) in eclogites (Alpe Mecio, Pl. I) and is defined by alternating omphacite-rich and clinozoisite-rich horizons and by the dimensional preferred orientation of mineral grains. Centimetre-thick massive veins with sharp boundaries crosscut at a high angle mineral layering S1; they are filled exclusively by clinozoisite or are composite with omphacite at the rims and glaucophane at the cores. Microstructural analysis indicates that, in the eclogites, S1 foliation is contemporaneous with the development of the assemblage

Omp + Ep + Rt + Qtz + Ap ± Grt

(Fig. 4), indicating that D1 developed at pressures exceeding the amphibole stability field in eclogite facies conditions, as already described in other localities of EMC (Gosso *et al.*, 1993; Spalla *et al.*, 1997).

Foliation S2 is the most pervasive fabric in EMC, consisting of a mineral layering in metabasics and of a differentiated foliation in metapelites. This foliation shows a mylonitic character, locally in the northern part of the area, but more frequently in the southern EMC unit (Plate I). D2 isoclinal folds are metric in size and very rare (Rocca Lunga e Rocca Perabianca, Pl. I). S2 is sub-horizontal to gently dipping towards the east in the northern sector of EMC unit and is steep and northeast striking in the southern sector of EMC, close to the contact with RCT (see Schmidt nets in plate I). In quartz-rich schists, S2 films are defined by the orientation of white mica, glaucophane or chloritoid, whereas quartz, garnet and titanite occur in S2 microlithons. Lawsonite occurs as lozenge-shaped crystals, up to 20 centimetres in size, at the contact with the metabasites. In green-phengitic micaschists foliation S1, consisting of millimetre-thick alternating layers, is defined by the shape preferred orientation of mica. In metagranitoids S1 wraps around K-feldspar porphyroclasts and is marked by the alignment of white mica, omphacite and clinozoisite; microlithons are composed by garnet and quartz.

Microstructural analysis indicates that the stable mineral assemblages during D2 are

white mica + Gl ± Cld + Qtz + Grt + Ttn ± Lws in metapelites

and

white mica + Omp + Qtz + Grt + Czo in metagranitoids.

In glaucophanites S2 foliation is defined both by the dimensional preferred orientation of amphibole, clinozoisite, white mica, titanite and re-oriented porphyroclasts of omphacite and by the millimetre- to centimetre-scale alternating clinozoisite-rich and amphibole-rich horizons (Fig. 4). Omphacite is abundant in the NW part of the area, where glaucophanites contain eclogite pods. Lawsonite porphyroblasts retain an internal foliation (Si) continuous with the external S2 foliation (Se), suggesting a late growth with respect to S2 development. Garnet-absent mica-rich glaucophanites, instead, contain a S2 foliation defined by the shape preferred orientation of glaucophane, white mica, clinozoisite, quartz and titanite and by the variation of glaucophane and yellowish mica modal amount at the millimetre-scale.

Microstructural investigations in EMC metabasics allow inferring that at the end of D2 the stable mineral assemblage was:

Gl + Czo + Qtz ± Grt + Ttn ± white mica ± Lws

indicating that S2 developed in blueschist facies conditions.

D3 tight to isoclinal folding is associated with the formation of a pervasive S3 foliation, locally with mylonitic character, and to widespread reactivation of S2 planes in glaucophanites. In metapelites S3 consists of a spaced, discontinuous foliation evolved up to stages 5 and 6 of Bell and Rubenach (1983), whereas the composite fabric S2/S3, due to the granular scale reactivation of S2, is the most pervasive in glaucophanites. S3 in northern EMC unit gently dips towards the east and B3 plunges about 30° towards the north-east. Near the boundary with RCT, S3 turns to an east-west trend, with a steep dipping toward north. In metapelites S3 is defined by the dimensional preferred orientation of chlorite, white mica and green amphibole or by a mineral layering defined by alternating albite- and chlorite-rich levels.

Microstructural analyses show that the greenschist facies mineral assemblage

Chl + Qtz + Act/Tr + Ab ± Ep ± white mica + Ttn

defines S3 in metapelites whereas the syn-D3 greenschist retrogradation generates in metabasics the mineral assemblage

Act + Ab + Chl + Qtz + Ttn ± Ep ± white mica ± Cal.

The greenschist syn-D3 re-equilibration is particularly developed in the metabasites with abundant lawsonite crystals, which are replaced by a fine-grained aggregate of zoisite/clinozoisite ± albite ± chlorite ± white mica.

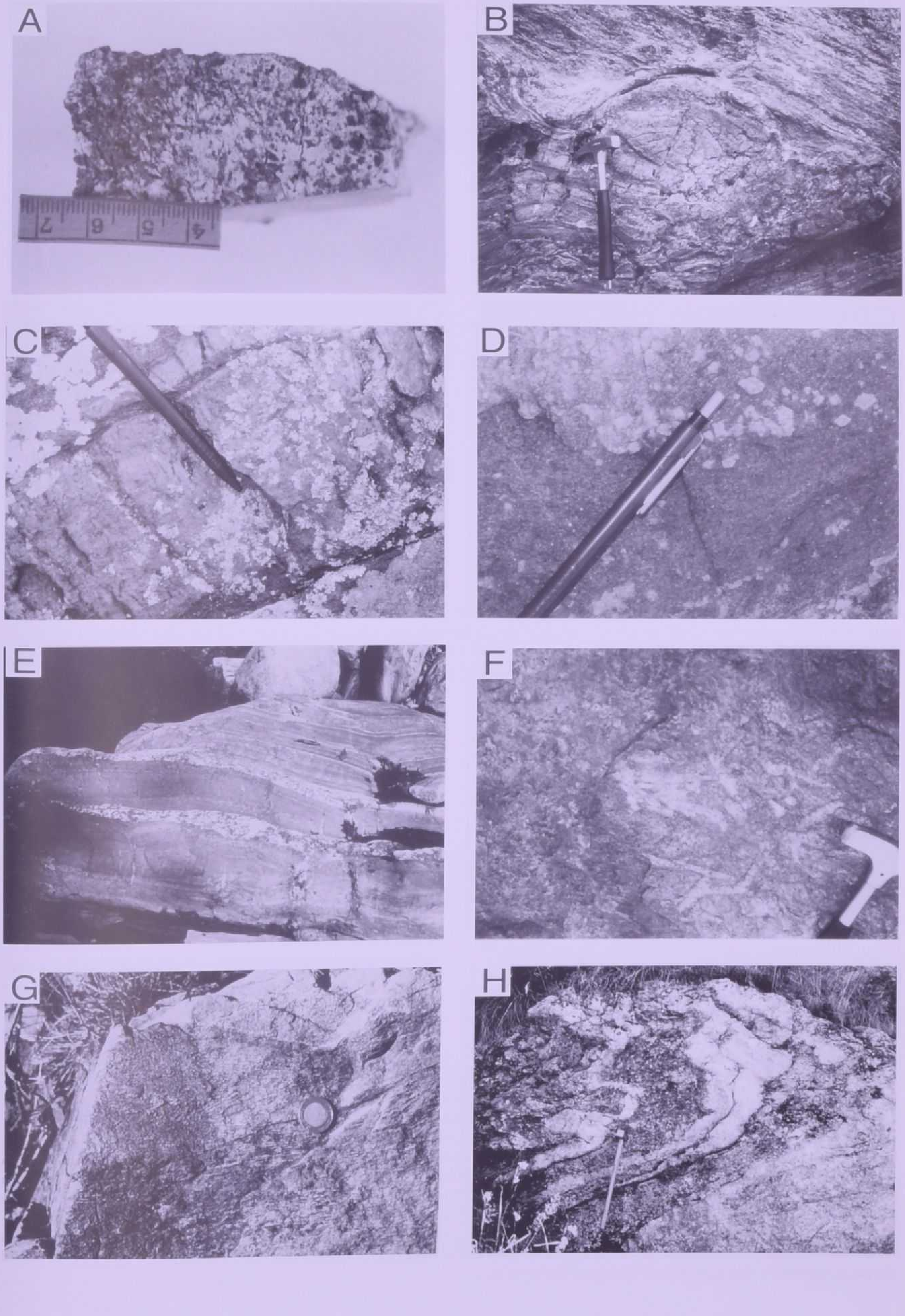
D4 structures consist of 10 centimetres to 10 metres scale tight to isoclinal folds, locally associated with an axial plane foliation of crenulation cleavage type (Rio dell'Osio, Pl. I). During D4 greenschist facies mineral assemblages are stable both in metapelites and metabasics.

Rocca Canavese Thrust Sheets (RCT)

This unit contains metapelites, chlorite-schists, impure marbles, metabasics and ultramafics containing small pods of metagabbro (Fig. 5). Metapelites consist of quartz-rich schists (*Rocca Canavese schists – 17* in Pl. I), commonly composed of quartz, white mica, chlorite and albite; locally (east of Rio dell'Osio, Pl. I) glaucophane, garnet and chloritoid are preserved. *Chlorite-schists (18)* are composed of chlorite and albite ± quartz and occur as centimetre- to metre-thick layers within, or at the contact with glaucophanites. *Silicate marbles (19)* with calcite, quartz, white mica, chloritoid, chlorite and opaque minerals contain lawsonite porphyroblasts, widely replaced by calcite, chlorite, opaque minerals and white mica or, more rarely, albite.

Omphacitites (14) occur as a metre-thick layer at the contact with ultramafics along Torrente Fandaglia (Pl. I). They are composed of omphacite (= 95%), quartz, epidote, opaque minerals and minor pumpellyite. *Glaucophanites (14)* layers are interbedded within the surrounding schists and contain glaucophane, epidote, white mica, quartz, and titanite ± rutile ± garnet ± omphacite, albite, chlorite, actinolitic amphibole, minor stilpnomelane and green biotite. The RCT glaucophanites, in

Fig. 3 - Eclogitic Micaschists Complex: A) Poorly re-equilibrated amphibolite occurring in small lenses within glaucophanites, Rocca Lunga and Testa Brusa (Plate I): pre-Alpine green hornblende is well preserved, whereas original plagioclase is completely replaced by very fine-grained aggregate of Alpine minerals. Polished section is perpendicular to mineral lineation. B) Amphibole-free eclogite boudin at the contact between glaucophanites and micaschists. S1 syn-eclogitic foliation, preserved in the boudin, is at a high angle with S2 in glaucophanites. C) Fractured eclogite layer: S1 foliation is marked by alternating omphacite-rich and epidote-rich layers; fractures are filled by clinozoisite or omphacite and glaucophane. D) Randomly oriented crystal of lozenge-shaped lawsonite in glaucophanite. E) Glaucophanite interlayered with mafic schists; lithologic layering is parallel to S2 mylonitic foliation. F) Micaschist with randomly oriented lawsonite prisms on S2 foliation. G) Quartz-rich glaucophanite with S2 bent by a D3 fold. H) D4 folds bending the compositional layering in the quartz-rich schist; a crenulation cleavage type foliation crosscuts the layering in the fold hinge at a high angle.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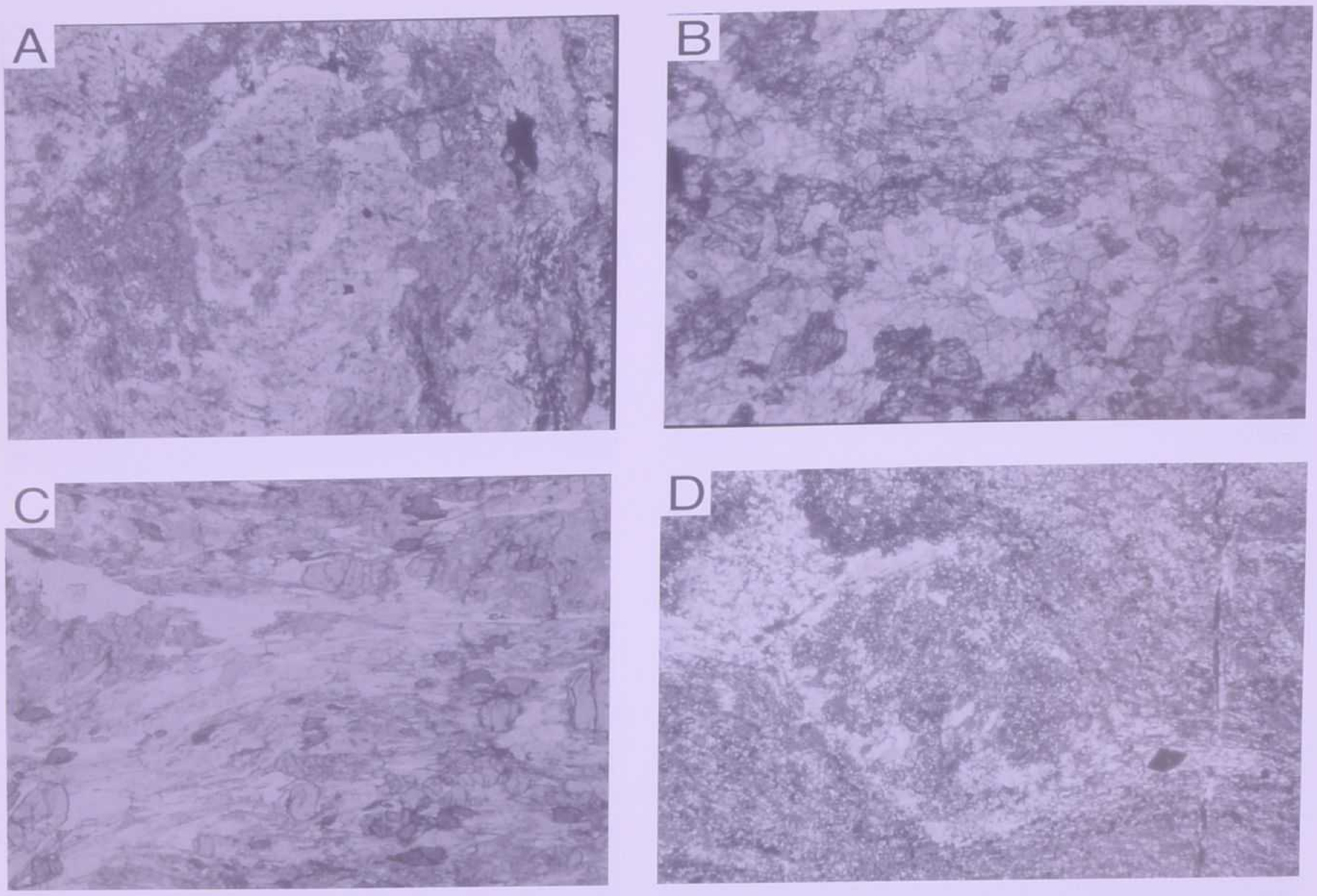
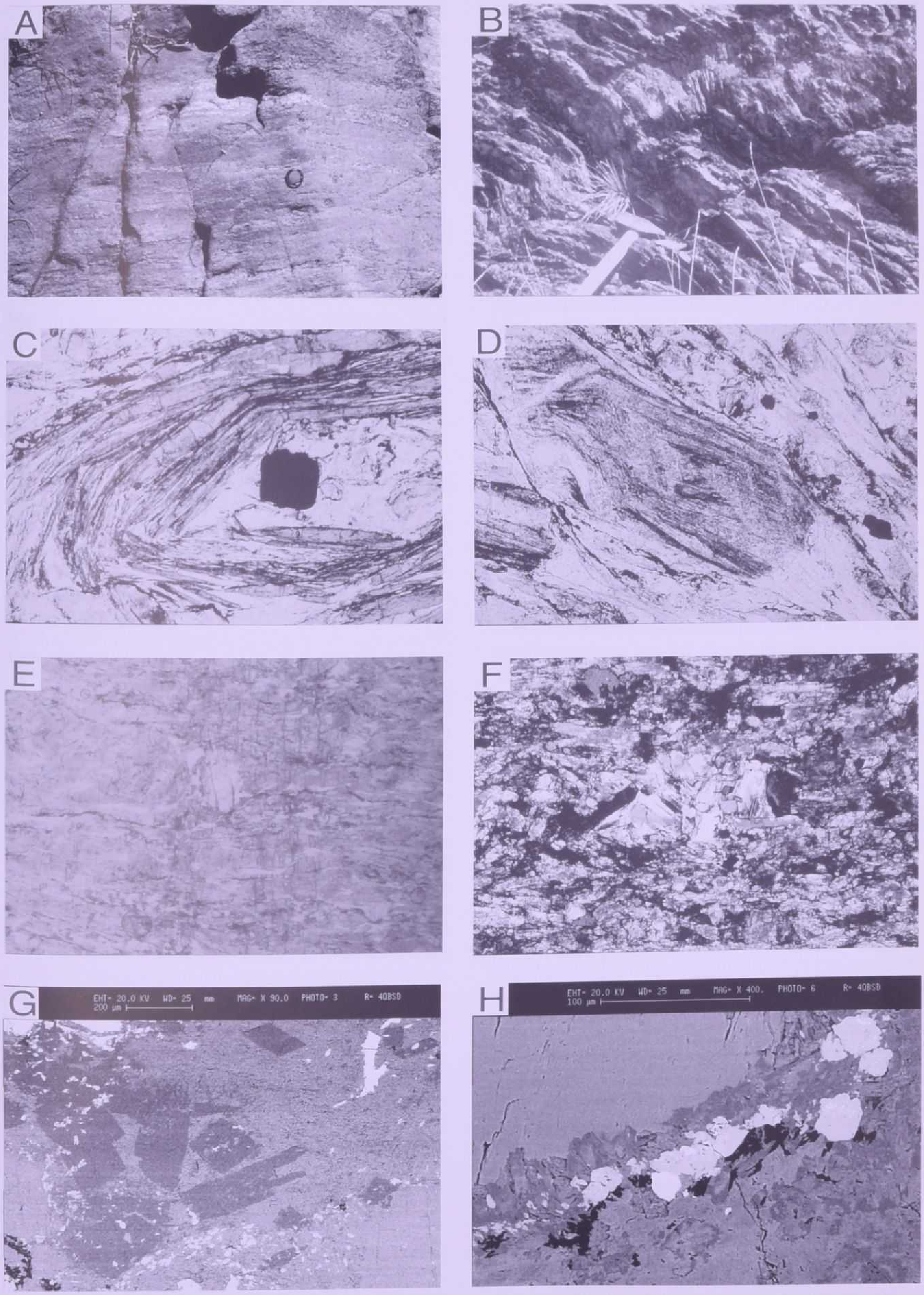


Fig. 4 - Photomicrographs of EMC rocks. A) Glaucophane rims pre-Alpine green hornblende in amphibolite; fine-grained matrix: white mica, epidote, garnet and chlorite developed on plagioclase micro-site. Plane polarised light, 10 X. B) S1 foliation in eclogite defined by shape preferred orientation of clinozoisite, omphacite and rutile. Plane polarised light, 2.5 X. C) S2 foliation in glaucophanite marked by orientation of glaucophane, white mica and quartz ribbons. Plane polarised light, 10 X. D) Lawsonite pseudomorphs in a glaucophanite layer. Crossed polars, 10 X.

the mapped area are free of lawsonite porphyroblasts described by Pognante (1989a; 1989b). Glaucophanites generally are fine-grained, particularly close to the contact with EMC rocks. *Garnet-absent mica-rich glaucophanites (15)* are composed of glaucophane, white mica with a yellowish colour, epidote, quartz, albite, calcite, titanite, albite, chlorite and actinolitic amphibole. Ultramafics, mainly *serpentinites (20)* with orthopyroxene and minor opaque minerals, occur as metre to hundred metre-thick layers within gneisses or glaucophanites. Metric lenses of partially re-equilibrated peridotites, with orthopyroxene rimmed by diopside, are preserved within low strain zones in the serpentinites along the Fandaglia stream. Locally (Madonna della Neve in plate I) centimetre-thick pods of metagabbro, with euhedral orthopyroxene and interstitial plagioclase, occur within serpentinites. The plagioclase microstructural site is occupied by fine aggregates of epidote, white mica, garnet, and glaucophane. Pumpellyite occurs in porphyroblasts associated with chlorite and actinolitic amphibole (Fig. 5).

D1 is preserved as a relict foliation (S1) in metabasics (Fig. 5) and in small, rare undeformed domains of metapelites (east of Rio dell'Osio, Pl. I). S1 consists of a mineral layering or a differentiated foliation, locally with a mylonitic character. In glaucophanites S1 foliation is de-

Fig. 5 - Rocca Canavese Thrust Sheets: A) Micaschist with S2 mylonitic foliation defined by alternating quartz ribbons and micaceous layers. B) Thinly-spaced S2 mylonitic foliation, bent by D3 open folds in serpentinite. C) Shape preferred orientation of chloritoid defines S1 foliation in silicate-rich marbles; S1 foliation is isoclinally folded by D2 structures. Photomicrograph with plane polarised light, 10 X. D) Lawsonite phantom wrapped by white mica, chlorite and opaque-bearing S2 foliation in silicate-rich marble. Photomicrograph with plane polarised light, 10 X. E) Mylonitic glaucophanite with S1 mylonitic foliation marked by glaucophane$_{II}$ shape preferred orientation, opaque minerals trails and quartz ribbons; glaucophane$_{I}$ porphyroclast, at the centre, is transversal to mylonitic S1. Photomicrograph with plane polarised light, 10 X. F) Omphacitite: shape preferred orientation of omphacite$_{II}$ define S1 mylonitic foliation. Pumpellyite porphyroblasts overgrow the foliation (twinned crystal at the centre). Photomicrograph with crossed polars, 10 X. G) BSE-SEM image of metagabbro: randomly oriented crystals of pumpellyite overgrow plagioclase micro-sites. H) BSE-SEM image of metagabbro: garnet and glaucophane rim the boundary between clinopyroxene and former plagioclase, completely replaced by a thin aggregate of epidote and white mica.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fined both by the dimensional preferred orientation of glaucophane, clinozoisite, white mica, titanite and by the millimetre- to centimetre-scale alternating clinozoisite-rich and amphibole-rich horizons. Where S1 is mylonitic, D1 fabric is marked by glaucophane, white mica, epidote, titanite, garnet and quartz, generally in ribbons. $Epidote_I$ and $glaucophane_I$ porphyroclasts are wrapped by foliation S1; locally *s-c* fabrics are observed with *s* and *c* planes marked by epidote, glaucophane and white mica. In omphacitites S1 is mylonitic and rounded $omphacite_I$ porphyroclasts are wrapped by small size $omphacite_{II}$ prisms, with shape preferred orientation parallel to S1. Porphyroclasts represent relics of probably prograde premylonitic assemblages. Opaque minerals form trails parallel to S1. Quartz + omphacite veins crosscut at a high angle the S1 foliation. Pumpellyite porphyroblasts overgrow S1.

Microstructural investigations in RCT glaucophanites allow inferring that at the end of D1 the stable mineral assemblage was:

Gl + Czo + Qtz ± Grt + Rt/Ttn + white mica

and

Omp + Ep + Qtz + opaque minerals

in omphacitites, indicating that S1 developed under blueschist facies conditions.

D2 is responsible for the development of the most pervasive foliation (S2), in places showing mylonitic character, and very rare small-scale (10 cm) isoclinal folds. In metapelites S2 consists of a spaced, discontinuous foliation, generally evolved up to stages 5 and 6 of Bell and Rubenach, (1983). In glaucophanites a composite fabric S1/S2 results from the granular scale reactivation of S1 during D2. S2 in RCT unit is generally trending north south and steeply dipping towards the east; locally (Torrente Fandaglia – Pl. I) S2 is sub-vertical and north-northwest trending (see the 3-D view in plate I). Foliation S2 is defined by white mica, quartz, chlorite and green amphibole; rarely porphyroclasts of glaucophane, chloritoid and garnet are rotated in S2, generally with strong internal deformation; albite porphyroblasts overgrow S2. In chlorite-schists S2 is marked by chlorite and albite ± quartz occupy microlithons; S2 is defined by fine-grained mineral aggregates and locally displays mylonitic texture. In marbles S2 films are defined by the orientation of white mica, calcite, quartz, chlorite, opaque minerals and reoriented chloritoid porphyroclasts; lawsonite porphyroclasts are pseudomorphosed by white mica, opaque minerals and calcite. In glaucophanites S2 is defined by chlorite, actinolitic amphibole, minor stilpnomelane and green biotite; the latter two developed in microboudin necks of amphibole and garnet, respectively. Titanite partly replaces rutile and forms micro-aggregates elongated in the S2 foliation. In serpentinites S2 is the dominant fabric and is defined by serpentine and opaque-rich layers alternating with porphyroclastic orthopyroxene-rich layers.

Reconstruction of deformation-metamorphism relationships at the micro-scale suggests that the greenschist facies mineral assemblage

Chl + white mica + Qtz + Act/Tr + Ab ± Ep + Ttn

defines the S2 foliation in metapelites, whereas the syn-D3 greenschist retrogradation generates, in metabasics, the mineral assemblage

Act + Ab + Chl + Qtz + Ttn ± Ep ± white mica ± Pmp ± Stp.

The syn-D2 greenschist re-equilibration is particularly evolved in the metabasics, where lozenge-shaped pumpellyite crystals probably replace lawsonite.

D3 structures consist of centimetre scale open to isoclinal folds, locally associated with a crenulation cleavage type (Torrente Fandaglia, Pl. I). Greenschist facies mineral assemblages marking S2 are stable during D3 both in metapelites and metabasics.

SUMMARY AND CONCLUSIONS

To sum up, the meso- and micro-structural analysis in this part of the southern SLZ evidences that the sequence of Alpine deformation stages is different in the northern sector of the map, corresponding to the EMC outcropping area, with respect to the southern mapped sector, corresponding to the RCT outcropping area; actually four superposed groups of structures have been detected in EMC and only three in RCT. In addition, the association of relative fabric age and metamorphic environment is not univocal across the mapped area: D1 deformation developed in eclogite facies conditions in EMC and in blueschist facies conditions in RCT. Blueschist mineral assemblages marking D2 fabrics in EMC are equivalent to assemblages marking D1 fabrics in RCT; the same equivalence exists between syn-D3 and syn-D2 mineral assemblages in EMC and RCT (both developed in greenschist facies conditions). These metamorphic compatibilities between fabrics, with different relative chronology in each complex, and the spatial continuity of foliation trajectories across the boundary between the EMC and RCT complexes allow considering them as contemporaneous (D2 in EMC = D1 in RCT and D3 in EMC = D2 in RCT). These results indicate that if correlation had been based exclusively on relative chronology of superimposed fabric, in each complex, it would have generated a connection between syn-metamorphic structures that actually developed in different times and at markedly different depths (e.g. eclogitic D1 structures in EMC with blueschist D1 structures in RCT). Correlation is facilitated by the foliation trajectory maps of Pl. I representing the finite strain field by means of the planar fabrics configuration, and containing systematic information on successive mineral re-equilibration steps associated with the structural evolution; the representation technique proposed in this geological map facilitates the immediate recognition of the rock volumes characterised by a coherent sequence of structural and metamorphic imprints.

Since the eclogite facies metamorphic imprint and the related fabric is recorded exclusively in EMC rocks, these rocks experienced a deeper tectonic trajectory than that of the RCT rocks. The coupling between RCT and

EMC occurred during the blueschist facies tectonic imprints as suggested by the occurrence of numerous blueschist mylonitic seams at the boundary between the two units. The widespread occurrence of greenschist mylonites, often reworking the earlier blueschist mylonitic bands, indicates that the tectonic contact was reactivated at shallower crustal levels during the exhumation.

Finally the orientation data in the two maps allowed a three-D representation of this composite tectonic contact, which is synthesized in the block diagram of plate I.

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