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Tectono-metamorphic map of the Languard-Campo - Serie del Tonale nappes between upper Val Camonica and Valtellina (Central Italian Alps, Austroalpine domain)

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ABSTRACT - A new mapping and correlation technique is tested in order to obtain a more complete representation of the lithostratigraphy and tectono-metamorphic evolution of a section of the Austroalpine domain in the Central Alps (Passo Mortirolo, upper Val Camonica - Valtellina, Italy). The studied sector of the Alpine belt is characterized by a polyphase history during pre-Alpine and Alpine orogenic cycles. In the map new graphic symbols are utilized to represent successive structural stages and to relate them to the sequence of metamorphic re-equilibrations. Symbols are foliation traces superimposed to lithologic information and display, at the map scale, the interpreted structural evolution; each group of structures is distinguished with chronological (dot pattern) and metamorphic (colour) symbols. Relative timing of structures was inferred by structural analysis, while the metamorphic transformations were inferred by a meso-micro-structural and petrographic analysis of metamorphic assemblages marking all fabric elements (e.g. foliations, lineations). In addition, fabric gradients are reported in deformed igneous rocks, where quasi-isotropic fabrics exist in their protoliths, as colour gradients, from light (low strain domains = coronitc fabrics) to full colours (high strain domains = mylonitic fabrics). The inferred tectono-metamorphic evolution is characterized by six (D1a to D5) deformation phases: the first three are pre-Alpine (D1a, D1b and D2), and the last three are Alpine (D3, D4, D5), with a Permian igneous event between them. D1a is characterized by granulite facies metamorphic imprint within metapelites and metabasics; D1b is locally recorded within metapelites as intermediate - temperature/intermediate -pressure amphibolite facies metamorphic assemblages; D2, recorded within metapelites, metabasics, marbles and calc-silicate rocks, is associated with high-temperature/low-pressure metamorphic assemblages; intrusives (diorites, granodiorites) of Permian-age emplaced during D2 deformation. D3 affects both intrusives and country rocks and is associated with high-pressure/intermediate-temperature metamorphic assemblages; D4 and D5 occurred in greenschist facies conditions. Alpine deformations (D3, D4, D5) consist of km-scale shear zones and associated isoclinal folds; strain partitioning at the km-scale produced fabric gradients (from coronitic to mylonitic) well perceived within Permian intrusives.

Key words: Trajectory Map, pre-Alpine and Alpine tectonics, Austroalpine domain, Central Alps.

RIASSUNTO - In questo contributo sono proposti i risultati dell'applicazione di una tecnica moderna di analisi mesoscopica e di correlazione dei dati geologico-strutturali, per ottenere la completa rappresentazione dell'assetto litostratigrafico e dell'evoluzione tettono-metamorfica di una porzione del dominio Austroalpino delle Alpi Centrali (Passo Mortirolo, alta Val Camonica - Valtellina, Italia), caratterizzata da evoluzioni orogeniche, Alpina e pre-Alpina, polifasiche. La carta illustra un nuovo metodo di rappresentazione di strutture sviluppatesi durante stadi successivi di riequilibrazione metamorfica. Le tracce delle foliazioni, sovrapposte alla litostratigrafia, sintetizzano e correlano l'evoluzione tettono-metamorfica alla scala della carta; ogni gruppo di strutture è caratterizzato da un simbolo cronologico (da 1 a 4 punti) e da un simbolo metamorfico (colore). La cronologia relativa è dedotta con l'analisi strutturale, mentre le caratteristiche metamorfiche sono state definite con l'analisi microstrutturale e petrografica delle paragenesi (supporto mineralogico) di ogni elemento dei fabric sovrapposti (foliazioni e/o lineazioni). Inoltre nelle rocce ignee deformate, dove un fabric quasi-isotropo caratterizza i protoliti, sono messi in evidenza i gradienti di fabric; questi sono rappresentati da gradienti di colore, da tenue (domini a bassa deformazione = fabric coronitici) a pieno (domini ad alta deformazione = domini milonitici). L'evoluzione tettono-metamorfica ricostruita mostra sei fasi deformative (D1a-D5), di cui tre pre-Alpine (D1a, D1b e D2), tre Alpine (D3, D4 e D5); esse sono separate da un evento igneo permiano. D1a è caratterizzata da associazioni mineralogiche in facies granulitica, nelle metapeliti e metabasiti; D1b è registrata solo nelle metapeliti, con associazioni mineralogiche in facies anfibolitica di temperatura e pressione intermedia; D2, registrata nelle metapeliti, metabasiti, marmi e rocce calc-silicatiche, è connessa ad associazioni metamorfiche di alta temperatura e bassa pressione; i corpi intrusivi di età permiana (dioriti e granodioriti) si sono messi in posto durante D2. D3 si sviluppa nelle rocce intrusive e negli incassanti ed è connessa ad associazioni metamorfiche di alta pressione e temperatura intermedia; D4 e D5 si sviluppano in condizioni della facies scisti verdi. Le deformazioni alpine (D3, D4 e D5) sono zone di taglio a scala chilometrica, associate a pieghe isoclinali; la ripartizione della deformazione alla scala del chilometro produce gradienti di fabric (da coronitici a milonitici) meglio individuabili nelle rocce intrusive permiane.

Parole chiave: Carta delle Traiettorie delle Foliazioni, tettonica Alpina e pre-Alpina, dominio Austroalpino, Alpi Centrali.

INTRODUCTION

Correlating tectonic and metamorphic events in metamorphic basement leads to contour shapes of tectono-metamorphic units, *i.e.* rock volumes that underwent the same crustal path, during a defined time interval (= P-T-d-t paths). In addition, heterogeneity of deformation in space and time and the generally incomplete development of metamorphic transformations may lead to terrains that are highly inhomogeneous from the structural and metamorphic point of view. This heterogeneity may cause misunderstandings in the definition of tectono-metamorphic units (Spalla *et al.*, 1998; 2000; Spalla and Gosso, 1999; Zucali, 2001; Zucali *et al.*, 2002) and, in turn, be an obstacle to reconstructing the geodynamic evolution. Recent works have shown that detailed field and microstructural correlation of superimposed structures, related fabric gradients, and their mineralogical supports, allow to identify rock volumes which better record the stages of structural (degree of fabric evolution) and metamorphic (degree of metamorphic transformations) re-equilibra-

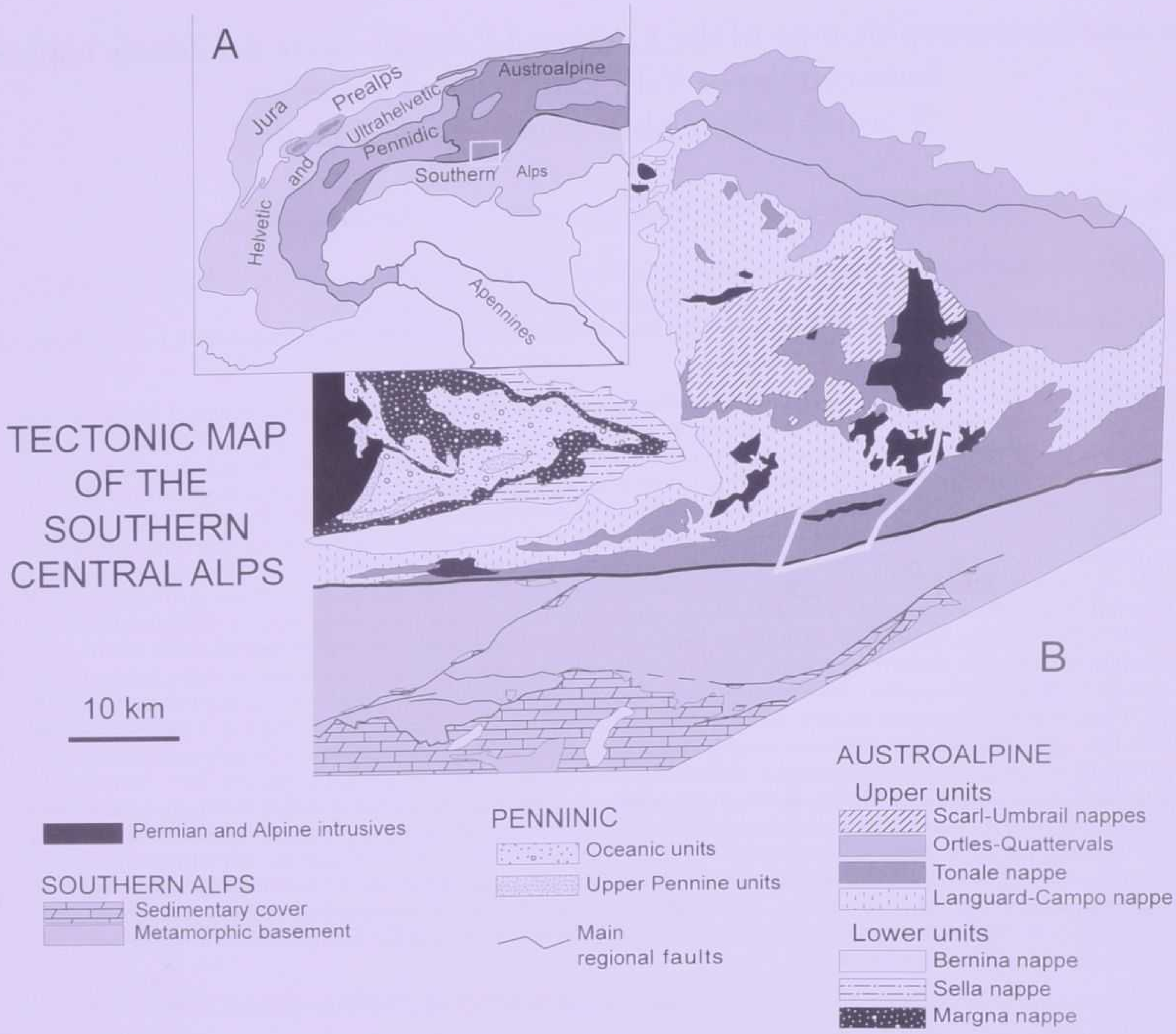
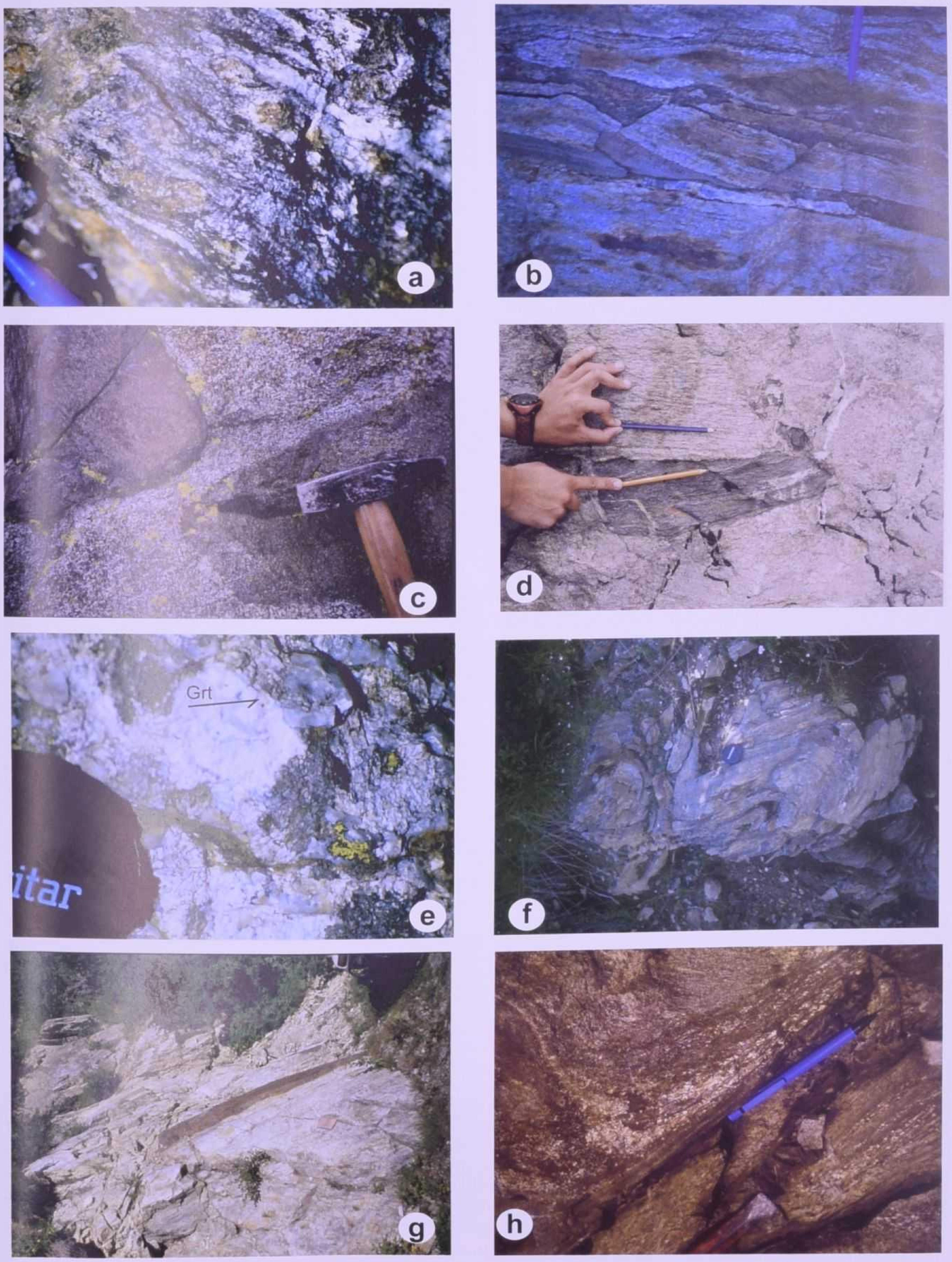


Fig. 1 - A) Tectonic sketch of Northern Italy; B) Structural outline of the Southern Central Alps (modified after Venzo *et al.*, 1971 and Bigi *et al.*, 1990); white polygon locates the map of plate I.

Fig. 2 - Mesoscopic features: **a)** Foliation S2 marked by SPO of biotite, feldspars, sillimanite and quartz within garnet-sillimanite paragneisses at Alpe Troena; cm-size garnet porphyroblasts enclose internal foliation marked by SPO of biotite. **b)** Calc-silicate layers within diopside- garnet amphibolite structured by S2 foliation; an older S1a foliation is relict within fractured calc-silicate layers. **c)** Biotite-gneiss enclaves within coronitic granodiorites at Serottini. **d)** Biotite- sillimanite-bearing gneiss enclaves in lineated metagranitoids preserve S2 foliation marked by SPO of biotite and sillimanite; L-metagranitoids display a mineral lineation at a low angle to S2. **e)** Coronitic garnet-bearing pegmatite; K-feldspar porphyroclast display. Seuhedral habit and quartz is interstitial. A garnet grain occurs at top-right K-feldspar rim. **f)** Calc-silicate rocks at Alpe-Troena folded during D3 deformation. **g)** S3 mylonitic foliation in pegmatites at Alpe Motta; dark layer correspond to biotite- sillimanite-bearing gneiss stretched during D3. The photograph is rotated of about 90 degrees anticlockwise. **h)** Syn-D4 10cm scale shear zone within migmatitic gneisses at Varadega; deformation involves isotropic leucosomes (light layers), which become foliated approaching shear zone.

tion. Moreover, grids representing superimposed tectonic imprints (lineations and foliations; e.g. Gosso *et al.*, 1983; Johnson, 1990; Connors and Lister, 1995), linked to the metamorphic conditions assisting subsequent deforma- tion events (e.g. Austrheim, 1990), are graphic tools that may be properly adopted to display relevant geologic steps in a new type of geological map (Spalla *et al.*, 2000; Zucali *et al.*, 2002). Based on this ground, in this contribu-



tion we apply a mapping and correlation technique to a portion of Austroalpine continental crust from the Central Alps (Val Camonica – Valtellina, Italy). The 1:50 000 scale map of Bonsignore e Ragni (1966) divides this basement in three litho-stratigraphic units: i) the *Scisti del Tonale series*, composed of "catazone" gneisses and micaschists, along with marbles, amphibolites, orthogneisses and pegmatites; ii) the *Cima Rovaia series*, comprising "mesozone" micaschists with interlayered quartzites, biotitie-bearing amphibolites and orthogneisses; iii) the *Pietra Rossa series*, containing "epizone" micaschists and phyllites, with amphibolites, quartzites and orthogneisses. The three units are intruded by Permian granitoids and diorites (Del Moro *et al.*, 1981; Del Moro and Notarpietro, 1987), often weakly deformed and formerly interpreted as Late-Alpine intrusives. In the map presented here (Pl. I), Permian intrusives constitute good markers separating the succession of tectono-metamorphic overprints which affected this basement during the Variscan and Alpine events. The map was completed with the support of the CNR-Prototype Map Project and is here represented in its full extension (a portion of it is being published in the Prototype Map Atlas of Italy of the Florence 2004 International Geological Congress).

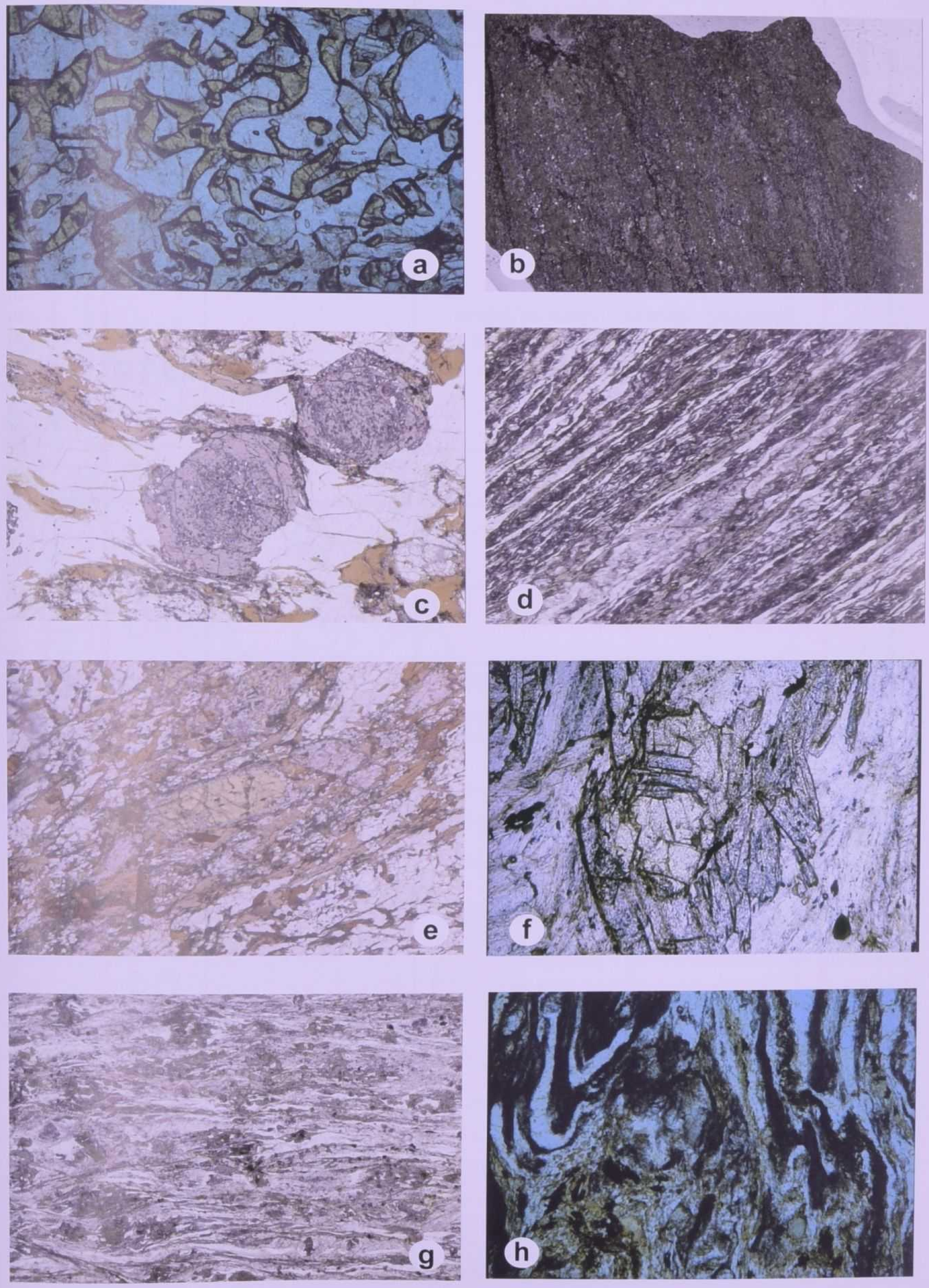
GEOLOGICAL OUTLINE

The polymetamorphic rock association located in the Italian Central Alps, between upper Valtellina and Val Camonica (Fig. 1), belongs to the Upper Austroalpine units, including the Languard - Campo nappe (LCN) and the Tonale Series (TS). LCN and TS immediately north of the Tonale (Insubric) fault system display in general a steeply dipping attitude (SSB=Southern Steep Belt) and have been attributed to the Upper Austroalpine domain (Bigi *et al.*, 1990; Schmid *et al.*, 1996). More in detail, the LCN is the uppermost tectonic element, overlapping the Lower Austroalpine (Margna, Sella and Bernina) nappes; the Sella and underlying Margna nappes are partly separated by oceanic units (Platta). Previous works have underlined the differences between the LCN and TS rocks, based on lithological features and depth of their crustal derivation. In the LCN, low to medium grade muscovite, biotite- and minor staurolite-bearing gneisses and micaschists with interlayered amphibolites, marbles, quartzites and pegmatites have been recognised, whereas in the TS higher grade sillimanite-bearing gneisses and micaschists, garnet- and biotite-bearing amphibolites, marbles and pegmatites have been described. In both these units, post-Variscan intrusives (granitoids, diorites and minor gabbros) commonly occur (Bockemühl and Pfister, 1985; König, 1964; Bonsignore and Ragni, 1966; 1968; Venzo *et al.*, 1971; Del Moro *et al.*, 1981; Tribuzio *et al.*, 1999). Werling (1992) identified the Pejo-Mortirolo Line as the northern limit of the TS with regard to the underlying LCN. Mineral ages of igneous rocks span over two time intervals (see Gazzola *et al.*, 2000): the first one, ranging from 298 to 224 Ma, has been interpreted as igneous cooling ages; the second, from 125 to 78 Ma, represents the Cretaceous re-activation during Alpine tectonics. Within LCN and TS Permian intrusives, high-pressure- low temperature imprint may be referred to the Alpine metamorphic re-equilibration (Gazzola *et al.*, 2000; Zucali, 2001). It may be more precisely defined within surrounding LCN and TS metapelites characterised by compatible metamorphic assemblages of Eo-Alpine age: chloritoid + garnet + white mica, in metapelites at Cima Verda; chloritoid + garnet + white mica + kyanite + Mg-chlorite in metapelites at Monte Pagano and Monte Serottini; staurolite + garnet + white mica + chloritoid + tschermakite, in Passo Gavia metapelites (Spalla *et al.*, 1995; Tomaschek and Blümel, 1998; Gazzola *et al.*, 2000; Zucali, 2001). These parageneses contrast with the classic idea that the LCN recorded metamorphic conditions never exceeding greenschist facies during the Alpine evolution (Froitzheim *et al.*, 1994 and references therein) and suggests that LCN and TS underwent a common Alpine tectono-metamorphic evolution. This is also supported by the quite homogeneous lithostratigraphic setting of the two nappes, in which main differences consist in areal distribution of intrusives or pre-Alpine high-grade rocks (Spalla *et al.*, 1995; Gazzola *et al.*, 2000; Zucali, 2001). For this reason description of structural and petrographic characters of lithotypes will be held without separation for LCN and TS. Recent studies on the Periadriatic and adjacent fault systems (*i.e.* pseudotachilites belonging to the Mortirolo Line, Mancktelow *et al.*, 1999), individuated a tectonic re-activation during Eocene – Oligocene times.

MAPPING STRATEGY

In the map of plate I, we have applied structural correlation criteria, widely used in various terrains (Williams, 1985) and integrated them with microstructural analysis (in view of more detailed petro-structural analyses of metamorphic assemblages, see Gazzola *et al.*, 2000; Zucali,

Fig. 3 - Microscopic features (photomicrographs): **a)** Garnet-pyroxene-plagioclase symplectites within calc-silicate rocks; plane polarised light, long side of photograph = 0.5mm. **b)** Garnet-bearing amphibolite; S2 foliation is marked by SPO of amphibole and by the alignment of plagioclase aggregates; long side of photograph = 3 cm. **c)** Zoned garnet porphyroblasts within biotite- sillimanite-bearing micaschists at Varadega; plane polarised light, long side of photograph = 2mm. **d)** Mineral lineation, within L-metagranitoids of Varadega, marked by SPO of amphibole, biotite and plagioclase; plane polarised light, long side of photograph = 2mm. **e)** Staurolite porphyroblast rimmed by andalusite, within biotite- sillimanite-garnet-bearing metapelite; plane polarised light, long side of photograph = 2mm. **f)** Staurolite porphyroblast, within white mica- garnet- chloritoid-bearing micaschists, overgrown by chloritoid; plane polarised light, long side of photograph = 0.5mm. **g)** Syn-D4 mylonitic texture within metadiorites; amphibole SPO, white mica -rich layers and alignment of plagioclase + epidote aggregates mark mylonitic foliation; plane polarised light, long side of photograph =1cm; **h)** D4 microfolding of S3 mylonitic foliation in metagranodiorites; plane polarised light, long side of photograph =5mm.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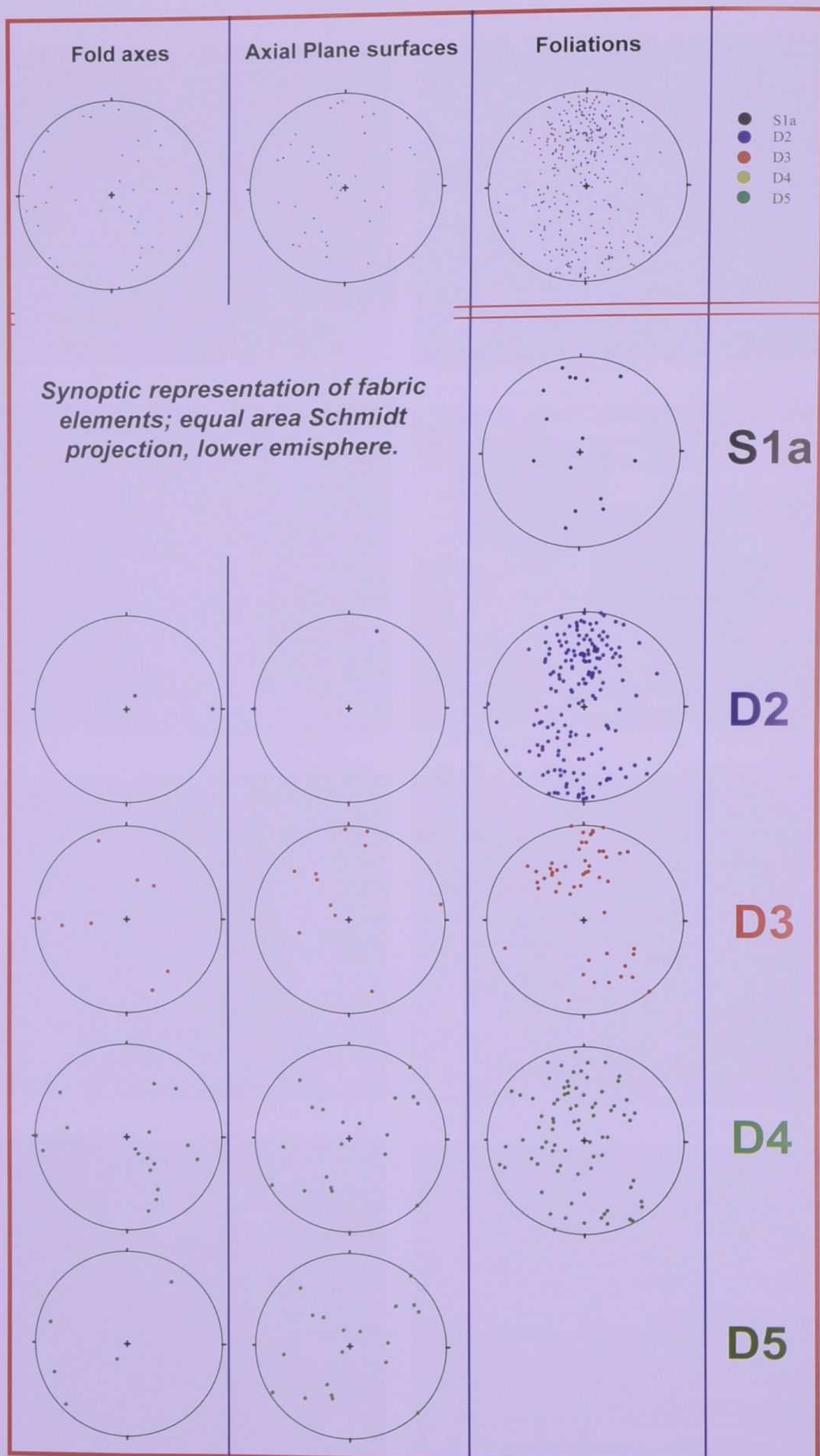

Fig. 4 - Synoptic view of fabric elements orientations; equal area Schmidt stereographic projections, lower hemisphere.

	DEFORMATION		METAMORPHISM	MAGMATISM	AGE
pre-Alpine	D1	D1a	Gr		
pre-Alpine	D1	D1b	IT-IP		
pre-Alpine	pre/syn-D2		HT-LP	Grt-Pe	313±3 Ma*
pre-Alpine	D2		HT-LP	D, GD ± Pe	260-280 Ma**
pre-Alpine	post-D2		IT-LP		<260
Alpine	D3		IT-HP		>78 Ma**
Alpine	D4-D5		Gs		<78 Ma**

Time →

* Thoeni, 1980; **Del Moro *et al.* 1981 - Del Moro e Notarpietro, 1987

Gr= granulite facies; Gs= greenschist facies; HT= High Temperature; IT= Intermediate Temperature; HP= High Pressure; IP= Intermediate Pressure; LP= Low Pressure; Pe= pegmatite; D= diorite; GD= granodiorite.

Fig. 5 - Sequence of geological events recorded in LCN and TS rocks during pre-Alpine and Alpine times.

2001). All rocks are described and mapped considering their mineral composition (e.g. micaschist, paragneiss, amphibolite), the type of planar and linear structural elements (e.g. foliation, lineation, etc.) and their corresponding mineral support. These data are represented in the petro-structural map as coloured foliation traces, superimposed on standard lithological information. Each chronologic family of foliations is attributed to a relative time class (S1, S2, S3, etc.), respectively indicated by the increasing number of dots in the foliation symbol, and characterised by the metamorphic conditions in which it developed (marked by colours of the trace symbol); the latter interpretation is attested by the assemblage constituting the mineralogical support of the foliation. In the case of protoliths with nearly isotropic fabric (igneous rocks), three separate classes of foliation intensity are mapped: i) weak syn-metamorphic foliation, preserving more than 90% of textural igneous relics (= coronite texture); ii) syn-metamorphic foliation, preserving more than 10% of textural igneous relics (= tectonite texture); iii) syn-metamorphic foliation, preserving less than 10% of textural igneous relics (= mylonite texture). Tectonitic and mylonitic textures commonly correspond to chemically most reactivated sites; consequently, after chronological and kinematic analysis, thermo-barometric estimates have been mainly performed within microsites of syn-kinematic metamorphic transformations (margins of films and lithons).

The application of this integrated field and laboratory method at the regional scale allows petro-structural data to be presented by means of a foliation traces map (Pl. I). The resulting map presents a lithostratigraphy which is structurally and petrologically constrained; it is a mosaic of superimposed foliation traces, which includes representation of: i) rotation, displacement and overprinting of structures of successive age, ii) incompatibilities of metamorphic assemblages related to planar and linear fabrics, shown by relative time class and colour of foliation traces; iii) map-scale foliation intensity gradients (finite strain gradients) achieved during a given metamorphic stage, iv) areas preserving contrasted stages of structural and metamorphic re-equilibrations. This correlation method not only allows to define "critical" volumes that behave homogeneously during time, but also to relate progressive structural and metamorphic variations of crustal slices, in response to tectonic and thermal changes at lithosphere-scale. This type of data presentation offers the advantage of a facilitated and synthetic appraisal of most part of the geological history in basement units which display a complex tectonometamorphic evolution.

LITHOLOGICAL SETTING

Lithological description refers to rocks represented in map of plate I; rocks have been divided and described on the basis of their mineral composition (volume %) and mesoscopic structure. Distinction operated in the map legend of plate I are here reported in small caps, while in italics are reported lithologies grouped under the same colour on the map. Mesoscopic features of some lithologies are illustrated in figure 2. The distictive categories LCN and TS are not anymore applicable in the following description, which is purely based on combination of structural and petrographic histories.

METADIORITES

Coronitic metadiorites

Mineral composition (% vol): black amphibole (50-60), green amphibole (≤5), plagioclase (30-40), biotite (0-10), quartz (0-5), garnet (0-10) and white mica (0-10).

Coronitic metadiorites preserve igneous textures: dark-coloured amphibole is euhedral and may be rimmed by greenish amphibole; plagioclase is interstitial. Amphibole grain-size ranges from mm to 1.5 cm; amphibole and biotite (= 0.5cm) may occur as round aggregates never exceeding 1cm in diameter. Garnet overgrows plagioclase microstructural sites together with zoisite/clinozoisite and white mica.

Tectonitic metadiorites

Mineral composition (% vol): amphibole (=20), green amphibole (≤30), plagioclase (20-35), biotite (0-10), quartz (0-5), garnet (=10) and white mica (10-20).

Tectonitic metadiorites show grain-size reduction with respect to coronitic types, and a discontinuous foliation marked by shape preferred orientation (SPO) of amphibole and white mica. Dark-coloured igneous amphibole is generally porphyroclastic and is wrapped by the foliation, locally displaying SPO. Tectonitic metadiorites may be L, S or L-S tectonites. Within S-tectonites, SPO of greenish amphibole, biotite and white mica marks films alternating with discontinuous plagioclase-rich lithons; within L-tectonites, SPO of amphibole defines mineral lineation. Mineral composition varies with respect to that of coronitic types, showing a modal increase of green amphibole, white mica and garnet.

Mylonitic metadiorites

Mineral composition (% vol): amphibole (≤5), green amphibole (50-60), plagioclase (10-20), biotite (0-5), quartz (0-5), garnet (10-15) and white mica (15-20) and chlorite (0-5).

The mylonitic foliation is marked by strong grain-size reduction (Fig. 3g). Mylonitic foliation is defined by SPO of green amphibole, aggregates of fine-grained green amphibole and narrow bands of plagioclase or white mica SPO. Garnet may occur as porphyroblasts or in aggregates elongated in the mylonitic foliation. Within mylonitic metadiorites mm-size shear bands are marked by SPO green amphibole and white mica (*s-c* structures).

Metagabbros

Mineral composition (% vol): amphibole (40-60), plagioclase (20-30), biotite (5-10), olivine (0-5) and quartz (0-5).

Metagabbros are commonly undeformed and preserve their igneous textures; amphibole is euhedral and coarse-grained (up to 1.5cm). Plagioclase is interstitial or subhedral. Olivine occurs as fine-grained grains or aggregates, while biotite occurs as fine-grained aggregates (<5mm) around amphiboles.

METAGRANODIORITES

Coronitic metagranodiorites

Mineral composition (% vol): plagioclase (15-25), K-feldspar (5-10), quartz (20-35), biotite (10-15), garnet (0-10), white mica (10-25), chlorite (10-20) and amphibole (0-5).

Coronitic metagranodiorites are characterized by relics of undeformed, fine to medium grain-size igneous texture (Fig. 2c); K-feldspar grains generally have euhedral to subhedral habit, 1 to 3 cm in size and white to pink colour. Biotite and plagioclase are subhedral while quartz is interstitial; white mica occurs as thin aggregates replacing biotite or K-feldspar and garnet occurs as isolated sub-mm grains. Metagranodiorites with coronitic structures contain dark enclaves, up to 10cm in size, with a slightly more basic composition (e.g. biotite>30%, plagioclase>25%).

Tectonitic metagranodiorites

Mineral composition (% vol): plagioclase (20-35), K-feldspar (5-15), quartz (20-40), biotite (15-25), garnet (0-10), white mica (10-20) and chlorite (5-20)

Medium-grained tectonitic metagranodiorites show a discontinuous foliation marked by SPO of biotite, white mica and chlorite, while K-feldspar, plagioclase, quartz and garnet occur in lithons. K-feldspar porphyroblasts are wrapped by a foliation, only locally showing parallel SPO.

Mylonitic metagranodiorites

Mineral composition (% vol): plagioclase (15-25), K-feldspar (5-10), quartz (20-40), biotite (0-10), garnet (0-10), white mica (15-25) and chlorite (15-30).

Mylonitic metagranodiorites show a grain size reduction with respect to coronitic and teconitic types; SPO of white mica, chlorite and minor biotite define films alternating with mm-sized quartz- plagioclase-rich lithons. The mylonitic foliation is associated with mm-sized shear planes (i.e. *s-c* structures).

Acid layered granulites

Mineral composition (% vol.): biotite (30-50), quartz (10-30), plagioclase (5-10), sillimanite (5-10), garnet (5-10), ortho-amphibole (5-10), cordierite (0-30) and K-feldspar (0-5).

Mineral layering is defined by alternate films and lithons: biotite SPO and sillimanite aggregate elongation mark S2 films while garnet, plagioclase, quartz, K-feldspar, cordierite occur in lithons. Biotite-rich films may range from 1 to 4 mm in thickness; quartz-garnet-rich lithons may reach up to 1.5 cm in thickness. Locally large orthoamphibole porphyroblasts (2-3cm) occur within lithons and dispaly SPO parallel to mineral layering and biotite foliation.

Migmatitic gneisses

Mineral composition (% vol.): biotite (= 35), quartz (= 30), K-feldspar (10 - 20), plagioclase (5 - 10), garnet (5 – 10), sillimanite (≤ 5)

In migmatitic gneisses (Fig. 2h), lens-shaped quartz-rich layers (leucosome) generally display isotropic textures with euhedral to subhedral K-feldspar, interstitial plagioclase and quartz, euhedral biotite and minor fine-grained white mica. Garnet grains and porphyroblasts may occur both in leucosomes and melanosomes. Quartz-rich isotropic leucosomes alternating with biotite- sillimanite-rich melanosomes are peculiar of planar migmatitic gneisses. Quartz-rich leucosomes may also be oblique to the biotite- sillimanite-bearing foliation. These rocks are located in the southern sector of the area (Alpe Troena - Lagazzuolo, plate I).

Garnet- biotite- sillimanite-bearing paragneisses

Mineral composition (% vol.): biotite (≤ 40), quartz (20 – 30), K-feldspar (10 - 20), plagioclase (5 - 10), garnet (5 – 10) and sillimanite (≤ 5).

Fine grained, brownish coloured gneisses characterized by anastomosed and discontinuous foliation marked by biotite- sillimanite-rich films alternating with quartz- K-feldspar-rich lithons. Biotite-rich films vary in thickness from mm to 1 cm; sillimanite may occur as white-greyish aggregates a few mm-thick and 2-3 cm long. Lithons generally consist of quartz, K-feldspar, plagioclase, garnet and sometimes biotite. Garnet porphyroblasts generally display euhedral shape and brownish colour; in places X/Y shape ratio of garnets ranges up to 3/1, with longer side generally parallel to main foliation; biotite inclusions may define an internal foliation oblique to the external one.

Garnet- biotite - sillimanite-bearing micaschists

Mineral composition (% vol.): biotite (≤50), quartz (10-30), K-feldspar (5-15), plagioclase (5-10), sillimanite (0-10), garnet (0-10), white mica (0-5) and minor kyanite and chloritoid replacing andalusite.

These rocks are characterized by a compositional layering marked by alternate biotite-rich films and quartz-feldspar-rich lithons; in the field, the main foliation is laterally persistent and defined by compositional layering and SPO of biotite and sillimanite (≤ 10 % vol.) within films. Biotite-rich domains vary between 2 mm and 1 cm in thickness. Garnet and K-feldspar porphyroblasts (2-30mm) generally occur within lithons and films as isolated grains or aggregates. Garnet-rich layers may also occur, generally parallel to films. Sillimanite, grey to white in colour, is generally fibrous and parallel to the main foliation. White mica commonly occurs as isolated grains within biotite-rich films, not more than 5 mm in thickness. Quartz-rich lithons, are 1 mm up to 3 cm in size; K-feldspar and plagioclase SPO may define a mineral lineation within lithons; quartz ribbons may also occur displaying high X/Y ratio, up to 10:1 (X>Y>Z are fabric directions). These micaschists are mainly located between Motto della Scala, Dosso San Giacomo and Alpe Troena (Pl. I).

Biotite- amphibole- chlorite-bearing gneisses

Mineral composition (% vol.): white mica (5 - 10), biotite (10 - 40), quartz (20 – 30), plagioclase (5 - 10), garnet (5 – 10), K-feldspar (0-5), chlorite and amphibole (5-10).

Biotite- white mica- chlorite-rich layers, alternating with quartz- plagioclase- amphibole-rich lithons define cm-thick compositional layering. Biotite-rich films vary in thickness from mm to 1 cm. Plagioclase and amphibole SPO marks main foliation and mineral lineation in lithons. Garnet porphyroblasts may also occur within lithons or films. These rocks are fine-grained and chlorite occurs as very fine-grained aggregates, partially replacing with white mica, the biotite grains. K-feldspar grains, ≤ 5mm in size, generally occur in lithons associated with aggregates of randomly oriented white mica; garnet occurs as rounded grains, ≤ 2mm in size, generally in quartz- and K-feldspar-rich microlithons.

White mica- garnet- chlorite-bearing micaschists

Mineral composition (% vol.): white mica (20 - 40), biotite (10 –20), quartz (10 – 15), staurolite (0 - 10), garnet (5 – 10), plagioclase (0 – 5), chloritoid (≤ 5), kyanite (≤ 5) and sillimanite (≤ 5).

Mineral layering is defined by alternate films and lithons: films are composed of white mica and biotite, generally displaying well defined SPO parallel to the mineral layering; lithons are composed of a quartz and plagioclase aggregate. Staurolite, garnet and kyanite porphyroblasts are common within lithons and are wrapped by mica films. Even though staurolite and kyanite grains generally lie within the main foliation, they do not mark mineral lineations. Mica-rich films mark a spaced foliation, from discontinuous to quasi-continuous in shape with respect to the amount of quartz; mica-layers generally range from mm to cm in size. White mica may also occur as cm-sized single flakes, while biotite never exceeds 0.5 cm. Dark thin aggregates of chloritoid rim staurolite porphyroblasts, or overgrow them (Fig. 3f); fine-grained chlorite may rim garnet, chloritoid, staurolite, and white mica or it occurs within the main foliation. These rocks generally occur south of Cima Cadì and at Dossoni.

Marbles and calc-silicate rocks

Mineral composition (% vol.): carbonates (≤80), brown biotite (Phl?) (≤5) and diopside (≤10)

These rocks consist of carbonate-rich bands (≤ 40cm-thick) alternating with thin (≤1cm) biotite-rich white to grey layers, locally containing diopside. They occur as up to 3m-thick levels, interbedded within biotite- garnet- sillimanite-bearing paragneisses, migmatitic gneisses, amphibolites and garnet-bearing pegmatites (Fig. 2b); the lithologic boundaries are generally parallel to the main foliation of gneisses.

Diopside, garnet, scapolite calc-silicate rocks

Mineral composition (% vol): carbonates (40), garnet (10), diopside (10), scapolite (10), plagioclase (10), biotite (5), epidote (5).

Calc-silicate rocks are generally banded, consisting of 10cm-thick garnet, epidote, carbonate-rich layers alternating with diopside, plagioclase, scapolite, carbonate-rich layers (Fig. 3a); several centimetres-thick garnet-rich layers also occur parallel to the compositional banding. Diopside-rich layers vary in thickness from 1 to 10cm; the limit between diopside-rich and garnet-rich layers is sometimes fuzzy. Diopside, garnet, scapolite calc-silicates may occur as metre-scale beds within biotite- garnet- sillimanite-bearing paragneisses, migmatitic gneisses, marbles, amphibolites and garnet-bearing pegmatites; the lithologic boundaries are generally parallel to the main foliation of gneisses.

Quartzites

Mineral composition (% vol): quartz (80-100), white mica (5-10), biotite (5-10) and chlorite (≤5).

Quartzites display granoblastic texture; SPO of white mica and biotite marks a weak planar discontinuous fabric. They occur as m-thick layers within metapelites, and are parallel to the main foliation.

Garnet, clinopyroxene amphibolites

Mineral composition (% vol): amphibole (50-70), plagioclase (10-30), scapolite (0-10), garnet (0-10), biotite (5-10), quartz (0-5), K-feldspar (0-5), clinopyroxene (0-5).

Amphibolites are fine-grained, dark rocks characterised by a pervasive compositional layering, defined by mm- to cm-thick amphibole-rich layers, alternating with mm- to cm-thick plagioclase- scapolite-rich layers (Fig. 3b). Amphibole shows a SPO parallel to the compositional layering and defines a mineral lineation. Biotite and plagioclase SPO is parallel to the compositional layering, and define a mm-thick foliation. Garnet occurs as porphyroblasts, from mm- to 1cm in size. Diopside mostly occurs within plagioclase- scapolite-rich layers and is randomly oriented; mm-thick biotite-rich layers define a compositional layering, which is also parallel to the main foliation of gneisses and micaschists.

Garnet hornblendites

Mineral composition (% vol): amphibole (70-90), garnet (≤10), biotite (≤10)

Hornblendites are characterized by a mineral lineation defined by SPO of mm- to cm-sized amphibole crystals; garnet generally occurs as ≤5mm isolated grains. The mineral lineation is broadly parallel to the main foliation of biotite- sillimanite-bearing gneisses and micaschists.

Orthogneisses

Mineral composition (% vol): plagioclase (20-35), K-feldspar (5-15), quartz (20-40), biotite (15-25), garnet (0-5), epidote (0-5), white mica (10-20) and chlorite (0-10).

Orthogneisses are characterized by augen textures, contain cm-sized K-feldspar porphyroclasts enveloped by a mm-scale mylonitic foliation marked by biotite-rich films separating quartz- and K-feldspar-rich microlithons. K-feldspar porphyroblasts may preserve subhedral shape and display SPO parallel to the mylonitic foliation. Quartz ribbons also occur and range from 2 to 10mm; biotite and plagioclase SPO also mark the main foliation. Epidote may occur within quartz- plagioclase-rich layers while chlorite partially replaces biotite.

L-metagranitoids *(Gneiss listati del M.te Varadega, auct.)*

Mineral composition (% vol): plagioclase (20-35), K-feldspar (0-15), quartz (10-40), biotite (15-25), amphibole (0-10), garnet (0-5), epidote (0-5), white mica (0-20) and chlorite (0-10).

L-tectonitic metagranitoids are characterized by a mineral lineation defined by SPO of plagioclase, biotite lenticular aggregates and K-feldspar (Figs. 2d and 3d). Amphibole occurs within lithons and may display SPO parallel to the mineral lineation; ribbons of quartz are parallel to the mineral lineations as well.

Garnet, tourmaline-bearing pegmatites

Mineral composition (% vol): quartz (40%), white mica (20%), K-feldspar (15%), plagiocalse (15%), garnet (≤5%), tourmaline (≤5%) and biotite (≤1%).

Pegmatites are m-sized dykes (Figs. 2e, 2g), discordant with respect to the foliation of sillimanite- biotite-bearing and migmatitic paragneisses, amphibolites and calc-silicate rocks. They preserve the igneous texture within m-sized low-strain domains, in which K-feldspar and plagioclase are euhedral cm-sized grains, while quartz is interstitial. Garnet and tourmaline occur as isolated grains up to 1cm in size. Within high-strain domains igneous primary textures are no more preserved and pegmatites are characterized by a mylonitic foliation marked by SPO of white mica, plagioclase, K-feldspar and quartz; in the mylonitic foliation K-feldspar porphyroclasts are wrapped by a white mica-bearing foliation. Thin aggregates of garnet and tourmaline are parallel to the foliation.

STRUCTURAL ANALYSIS

The LCN and TS have been considered until now as being affected by Alpine metamorphic imprint, never exceeding greenschist facies conditions (e.g. Bockemühl and Pfister, 1985). However, new petrologic and structural data suggest higher-pressure conditions for this metamorphism (Spalla *et al.*, 1995; Gazzola *et al.*, 2000; Zucali, 2001). The occurrence of Permian intrusives (Fig. 1) discriminates structures and metamorphic imprints of Alpine age from those of pre-Alpine age in older protoliths. Metaintrusives of various type and size are interlayered mutually or in the country rocks, and are deformed together with the LCN and TS gneisses during the Alpine orogenesis. Alpine deformations may therefore be recognised by comparing the deformation sequence in the Permian metaintrusives with that of the older country rocks. In the latter, two planar fabrics, related fold systems and shear zones formed in medium to high grade metamorphic conditions before emplacement of Permian intrusives. After intrusion, three groups of syn-metamorphic structures developed during the Alpine orogenic cycle.

Within the overall rock association (pre-Permian crust and Permian igneous bodies) five groups of superimposed mesostructures may be separated on the basis of geometrical and kinematic compatibility analysis (Turner and Weiss, 1963; Hobbs *et al.*, 1976; Ramsay *et al.*, 1983; Williams *et al.*, 1985; Passchier *et al.*, 1990).

D1 deformation (D1a + D1b)

Within D1 deformation two different fabrics were separated: S1a and L1a are marked by sillimanite-bearing assemblages (staurolite-free); S1b is marked by staurolite-bearing assemblage. S1a and S1b both occur as relics within S2 foliation, but no overprinting relationships have been detected between D1a and D1b structures.

D1a deformation: foliation S1a and lineation L1a occur within biotite- garnet- sillimanite-bearing paragneisses, micaschists, amphibolites, calc-silicate rocks, and granulitic gneisses. Within micaschists and gneisses, S1a is a continuous foliation marked by SPO of biotite, quartz, plagioclase and K-feldspar, and by mm- to cm-thick lithons alternating with quartz- K-feldspar-rich and biotite-rich layers. Fibrous sillimanite commonly occurs within mica-rich layers displaying SPO parallel to foliation. Sillimanite and K-feldspar SPO marks the mineral lineation L1a in micaschists and gneisses. Within amphibolites, S1a is marked by SPO of diopside, amphibole and plagioclase and by cm-thick compositional layering (diopside-amphibole-rich and plagioclase-rich layers). Within calc-silicate rocks garnet- plagioclase- scapolite-rich and diopside-rich layers define S1a. Strike of S1a foliation (S1a in figure 4) is oriented E-W, with dips ranging between 10 and 90°. Microstructural observation indicates that deformation D1a took place in granulite facies conditions.

D1b deformation: S1b is mm-thick foliation within staurolite-bearing micaschists; white mica, biotite and staurolite SPO mark S1b foliation, alternating with mm-thick quartz-rich lithons also defining S1b foliation, which contain garnet porphyroblasts. S1b is an up to mm-thick relict foliation within S2 films or is preserved in metre-sized lenses, which escaped deformation phase D2. In places, andalusite rims staurolite porphyroblasts and postdates D2 fabrics (Fig. 3e). S1b occurs either within micaschists at Cima Cadì – Motto della Scala, or as cm-sized relict prisms within metapelites at Monte Serottini. Microstructural relationships suggest that D1b developed under intermediate pressure amphibolite facies conditions.

D2 deformation

D2 phase is generally represented by foliation S2, well preserved within biotite- garnet- sillimanite-bearing gneisses, micaschists and amphibolites. SPO of biotite, sillimanite and quartz mark S2 foliation within gneisses and micaschists. Within amphibolites, hornblende SPO and plagioclase SPO, or amphibole-rich and plagioclase-rich compositional layering, mark foliation S2. D2 deformation may even be represented by cm to dm-thick tight to isoclinal folds. D2 folds mostly occur within metapelites as crenulation folds involving S1. D2 folds may describe m- to 100 m-scale systems where amphibolites and calc-silicate rocks are involved. AP2 generally shows east-west strike direction and different dipping values. A2 shows variable attitudes; S2 generally reproduces the AP2 attitudes, showing a cluster of poles to planes along north-south direction (Fig. 4). D2 structures are well represented around Lago Lagazzuolo and at Tabladash, where marbles, calc-silicate rocks and amphibolites trace metric folds within biotite-sillimanite gneisses. S2 is the most pervasive foliation in gneisses and locally it encloses S1a; in biotite-sillimanite gneisses of Alpe Troena, cm-sized garnet retains an internal foliation, which is marked by biotite and shows a high angle with respect to S2 (Fig. 3c); at Lagazzuolo, calc-silicate rocks infolded with biotite-gneisses during D2 do not develop axial plane foliation; the latter is well marked in the surrounding gneisses. Microstructural analysis attributes deformation D2 to high temperature – low pressure metamorphic conditions.

Igneous structures of garnet-pegmatites

Pegmatite layers, retaining igneous features (Fig. 2e), are associated with gneisses, biotite-sillimanite-garnet micaschists, amphibolites and calc-silicate rocks. Pegmatite levels are mostly oriented parallel to foliation S1a; locally thin levels of pegmatite are embodied in amphibolites at a high angle to S1, and later are affected by D2 deformation (Zucali, 2001). K-feldspar and plagioclase are euhedral and may reach 5cm in size. White mica forms aggregates of up to 2cm in size; garnet occurs as mm-sized, pink euhedral grains; quartz is interstitial with respect to K-feldspar, plagioclase and white mica. Tourmaline is black coloured and may reach 3 cm in size. Contacts between pegmatites and other rocks never show reaction rims or chilled margins. Pegmatites are irregular in shape, and only seldom are layer-shaped.

Igneous structures of diorites and granodiorites

The diorites which escaped Alpine deformations are ten-to hundred metres long lozenges. They display fine- to medium-grain size and a granular texture, may include plagioclase1, green-brown to deep brown hornblende, biotite1 and quartz as main igneous components; plagioclase1 and hornblende define an intergranular to ophitic texture. Apatite, titanite1, monazite, ± zircon, ilmenite and magnetite occur as accessory phases. Scarce colourless clinopyroxene may be enclosed in plagioclase or in poikilitic amphibole. In the less-deformed domains, successive Alpine transformations developed as coronas or pseudomorphic replacement. Igneous plagioclase is generally replaced by garnet, epidote, albite-rich plagioclase ± white mica1. Brown hornblende generally displays dusty cores containing ilmenite needles and is rimmed by a blue-green amphibole2. Poorly deformed granodiorites are heterogranular rocks in which the igneous components plagioclase1, K-feldspar1, quartz and biotite1 are well preserved. In places, feldspar individuals are subidiomorphic phenocrysts and quartz is generally interstitial. Plagioclase, K-feldspar and quartz may represent up to 90% of the modal composition of these rocks, with quartz being ≤ 30%. Apatite, titanite, allanite and opaque minerals occur as accessory phases. Igneous plagioclase is replaced by a fine-grained aggregate of epidote, white mica, garnet and albite; red-brown igneous biotite is rimmed by garnet and white mica and contains ilmenite exsolutions. Mafic enclaves of dioritic composition are round-shaped and display wriggly soft-contacts; they are generally fine-grained or show porphyric texture.

D1 and D2 fabrics are never recorded in diorites and granodiorites; igneous contacts between diorites and the country rocks are never preserved, being always reworked during Alpine polyphase tectonics. Granodiorites may occur within 10 cm-sized tension-gashes at a high angle with respect to S2, or show fuzzy contacts with gneisses and schists foliated by S2. These characters suggest a syn-D2 emplacement of granodiorites; their relationships with dioritic enclaves indicate mingling between dioritic and granodioritic magmas.

D3 deformation

D3 structures consist of tight to isoclinal-shape, cm to km-scale folds, occurring within all lithotypes (e.g. in calc-silicate rocks in Fig. 2f). S3 foliation occurs as axial plane to folds or within shear zones; L3 mineral lineation may also occur along S3 planes or within shear zones. Within micaschists and gneisses, SPO of white mica, quartz and locally of chloritoid marks foliation S3; white mica aggregates define lineation L3. The geometry of S3 is characterized by mm-thick white mica-rich films, alternating with quartz-rich cm-thick lithons. Garnet and chloritoid generally occur within lithons as porphyroblasts up to 1 cm in size. Pre-Alpine staurolite porphyroclasts may be present within S3 lithons; they are generally wrapped by white mica-bearing S3 foliation and are replaced by chloritoid and kyanite aggregates. Within amphibolites, calc-silicate rocks and pegmatites, D3 structures are m-scale folds or shear zones; S3 is developed only within m-scale shear zones. Within amphibolites, S3 mm-thick foliation is marked by SPO of amphibole and plagioclase, while within calc-silicates S3 is marked by SPO of white mica, amphibole, calcite and diopside. Within pegmatites, mm-thick white mica films, wrapping around K-feldspar porphyroclasts, define mylonitic foliation S3; small grain-size garnet trails occur along S3 films and lithons. In metapelites and metabasics, mineral assemblages defining D3 fabric elements indicate high pressure-intermediate temperature metamorphic conditions. In Permian intrusive rocks (diorites and granodiorites), deformation gradients generate fabric gradients from coronitic to mylonitic types, which can be detected at different scales (10cm -10m).

Coronitic

The corona microstructure perfectly coincides with a parent rock igneous texture with a very weak development of planar or linear fabrics (weak syn-metamorphic foliation, preserving more than 90% of textural igneous relicts); metamorphic minerals stable during D3 define coronas around igneous minerals (see above).

Tectonitic

In tectonitic textural domains (syn-metamorphic foliation, preserving more than 10% of textural and mineralogical igneous relicts), S3 occurs as a variably persistent and spaced foliation; relict igneous minerals generally occur within white mica- amphibole rich films, which mark foliation S3. Cm-sized igneous hornblende porphyroclasts are wrapped by S3, which is defined by blue-green amphibole and white mica in metadiorites. In these rocks, L3 mineral lineation is marked by amphibole SPO, and lies on foliation S3. In metagranodiorites, igneous biotite and K-feldspar show SPO, generally parallel to S3; quartz, epidote, albite-rich plagioclase and minor garnet constitute mm- to cm-thick S3 lithons and S3 films; microstructures are supported by white mica.

Mylonitic

In mylonitic domains (syn-metamorphic foliation, preserving less than 10% of textural igneous relics), S3 occurs as a mm-thick continuous foliation or as a spaced mineral layering defined by alternating amphibole-rich and plagioclase-epidote-rich layers in metadiorites. In metagranodiorites, white mica-rich domains alternate to quartz-plagioclase-layers. SPO of amphibole and white mica mark mylonitic foliation S3 in metadiorites, while SPO of white mica and plagioclase marks S3 in metagranodiorites. Amphibole marking L3 is light green-coloured, easily distinguished by dark pre-Alpine hornblende. Orientation of fold axial planes (AP3) and of associated axes (A3) are rather scattered (Fig. 4), and this is probably due to D4 and D5 deformations; S3 strike is preferentially oriented E-W, with dips ranging from 45 to 90°.

Mineral parageneses developed during D3 deformation of Permian intrusive protoliths are compatible with contemporaneous assemblages detected in the country rocks (Gazzola *et al.*, 2000).

D4 DEFORMATION

D4 structures consist of folds and m-scale shear zones (Figs. 2h and 3h). D4 folds bend pre-existing foliations and develop from cm-scale crenulations to m-scale isoclinal folds. Tight to isoclinal D4 folds may also be associated with a S4 axial plane foliation; SPO of white mica, chlorite and quartz ± new biotite mark foliation S4 within micaschists, gneisses, metagranodiorites and metadiorites; within metadiorites and amphibolites green-amphibole also develops during D4.

Orientations of foliation S4 are generally scattered and PA4 attitudes mainly coincide with those of D4 shear zones (Fig. 4); D4 folds refold D3 structures generating large-scale type 3 (Ramsay, 1967) interference patterns.

D5 DEFORMATION

Structures of deformation D5 occur as m- to 10m-scale folds and m-scale shear zones. Foliation S5 developed as a crenulation cleavage and axial plane foliation, or as a mylonitic foliation within shear zones. S5 differentiated foliation is marked by SPO of white mica, chlorite ± new greenish biotite.

D4 and D5 deformations took place in greenschist facies conditions, as suggested by related syn-kinematic mineral assemblages, detected in all rock types.

DISCUSSION AND CONCLUSIONS

In the new type of geological map proposed here, the technique of representation of fabric elements and metamorphic imprints facilitates immediate correlation of petrologic data with the structural history. This is feasible by using a mapping method that benefits from rapid integrations between field and laboratory analysis. Moreover, this strategy facilitates validation of the geological interpretation, because the two types of interpretative conclusions, based on structural and metamorphic evolutions, are located in space by means of easily handled symbols; space correlation of fabric elements and distribution of metamorphic imprints allow to verify directly on the map the interaction between degree of fabric evolution and rate of metamorphic transformations. Particularly in the case of the poly-orogenic Austroalpine lamellar units of the Central Alps, embricated in a steep belt, such kind of map shows the spatial distribution of rock volumes retaining different steps of a complex geologic history. Correlation in space of successive chronologic steps of the whole history displays a logically interconnected mosaic of superposed strain heterogeneities, accumulated at each incremental tectonic imprint.

With this new evolutionary type of map, the geological history of the Languard-Campo - Serie del Tonale nappes is fully illustrated in its pre-Alpine and Alpine stages; they are also synthesised in figure 5. Pre-Alpine evolution is characterized by D1 stage, displayed by two fabric relics (S1a and S1b) developed under contrasting metamorphic conditions; they were followed by the emplacement of garnet-bearing pegmatites. Successively Early Permian D2 deformation, characterised by a foliation widely developed within metapelites, was imprinted both in the Languard-Campo and Serie del Tonale rocks, under high temperature-low pressure conditions. During this high thermal regime, diorites, granodiorites and minor gabbros emplaced. Post-D2 stage is characterized by the growth of andalusite and new white mica within metapelites.

Alpine tectono-metamorphic evolution started with D3 deformation, which affected Permian intrusives and their country rocks. It took place in high pressure-intermediate temperature metamorphic conditions, compatible with a stage of tectonic burial of Permian upper and intermediate crust (Gazzola *et al.*, 2000; Zucali, 2001). D4 and D5 deformations developed in greenschist facies conditions during exhumation towards shallower crustal levels. Strain partitioning during polyphase Alpine evolution is responsible for the preservation of pre-Alpine igneous or metamorphic fabrics over large areas in the northern and southern sectors of the map. In its central portion, the Alpine fabric evolution is highly evolved (locally to a decrenulation stage) and very little of the pre-Alpine fabric and mineral relics are preserved in metaintrusives and in their country rocks. Notwithstanding, the whole area underwent equivalent tectonic and thermal histories during Alpine times. D2 deformation is the earliest common tectonic imprint recorded by the LCN and TS rocks and it coincides with the emplacement of Permian intrusive stocks; from this time on, the LCN and TS rocks constituted a single tectono-metamorphic unit, which maintained its coherence during the entire subsequent Alpine orogenic history. This type of map sustains at the same time a more objective reconstruction of the pre-Alpine litostratigraphy: walking correlation on a single rock layer along negative deformation gradients (i.e. from mylonitic towards coronitic textures) made clear the recognition of the intrusive origin of highly deformed thin intercalations of amphibole-, white mica-, plagioclase-, garnet-bearing gneisses (recognised as mylonitic metadiorites) and of white mica-, plagioclase-, garnet-bearing gneisses (recognised as mylonitic metagranodiorites). Detection of such protolithes helps to understand the diachronicity of the present day lithostratigraphy due to the severe transposition of pre-Permian lithostratigraphy and of Permian intrusive stocks, during Alpine polyphase deformation. In addition a specific type of metamorphic transformation introduces a petrographic (and nomenclatural in the map legend) change in biotite-, garnet-, sillimanite-bearing paragneisses, which were equally occurring in the whole area prior to Alpine (D3 + D4 + D5) metamorphic and structural evolution; these rocks are at present transformed into white mica-, garnet-, chlorite-bearing micaschists and gneisses in the central part of the map, where Alpine structural reworking was more penetrative (and metamorphic transformation modally more developed).

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