THE CASTAGNA UNIT'S MYLONITIC ROCKS: PETROLOGICAL-STRUCTURAL STUDY AND GEODYNAMIC IMPLICATIONS

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INTRODUCTION AND GEOLOGICAL BACKGROUND

In the Alpine stacked-nappe edifice of the Calabrian Peloritani Orogen (CPO), a composite segment located between the southern Apennines and the Sicilian-Maghrebides, the Castagna Unit (Dubois & Glangeaud, 1965) represents one of the continental crust-derived units cropping out in the northern sector of the CPO, both in the Coastal Chain and Sila Massif.

It is a pervasively mylonitized horizon located within the northern Calabride continental crust, sandwiched between the Bagni Unit and the Sila Unit, consisting of medium-high grade metamorphic rocks, mostly paragneiss, augen gneiss, leucocratic orthogneiss and minor micaschist, marble and amphibolite gneiss, intruded by late-Hercynian granitoid rocks (Amodio-Morelli *et al*., 1976; Colonna & Piccarreta, 1976).

At present, it represents one of the still little-known portions of basement within the Calabride continental crust, probably because of the scanty and aged previous knowledge.

All previous knowledge suggest as the pervasive mylonitic deformation, involving these rocks, can be ascribable to the Alpine tectonism as, recently, supported by new geochronological data (Rossetti *et al*., 2001).

Nevertheless, until now, the scanty presence of data in the geological literature about these rocks did not permit a representative petrogenetic model to be proposed.

In this view, this study allowed the tectono-metamorphic history of the poorly-known Castagna Unit to be described focusing on the Sila Piccola area, the southernmost portion of the Sila Massif, where these rocks are widely exposed. Moreover, the yielded results allowed also for a better understanding the geological significance of the Castagna Unit in the geodynamic evolution of the northern sector of the Calabria Peloritani Orogen.

STRUCTURAL INVESTIGATIONS

Detailed structural investigations (1:10.000 scale) have been performed along a NW-SE trending area in the Sila Piccola Massif choosing two geological transects (Fig. 1).

Structural analysis highlighted a pervasive and well developed mylonitic fabric (S_m), produced by a ductile deformative event (D1), which affects both metapelite and orthogneiss, representing the field foliation and a related well defined stretching lineation (L_m). The mylonitic foliation (S_m) obliterated previous metamorphic surfaces, locally preserved as relics in the low strain domains of the metapelite horizons.

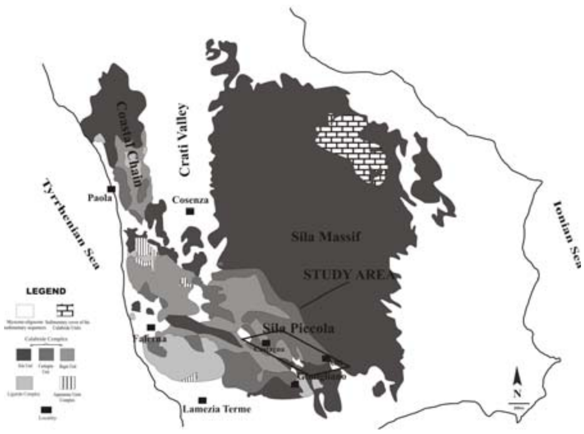

Fig. 1 - Outcrops of Castagna Unit in the northern CPO and location of the study area.

The stretching lineation, marked by elongate quartz and feldspar crystals alignment roughly runs ESE-WNW to ENE-WSW (Fig. 2).

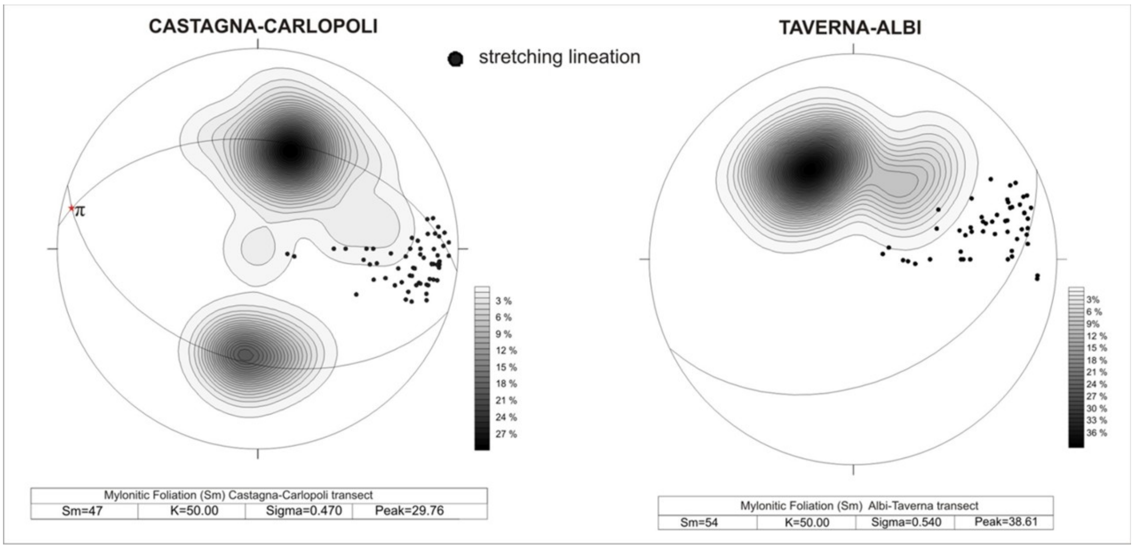

Fig. 2 - Stereoplots showing the orientation of the mylonitic foliation (contours) and the relative stretching lineation (poles) inside the two investigated transects selected in the Sila Piccola area.

At the outcrop and hand-sample scale, several kinematic indicators, mostly represented by σ-type porphyroclasts and S-C structures indicate a consistent dextral top-to ESE-ENE sense of shear at the present-day geographic coordinates.

Locally, a W-SW verging asymmetrical folding involves the mylonitic foliation (S_m) in both metapelite and orthogneiss; these structures suggests a further deformational event (D2), developing in transitional to brittle regime.

The occurrence of undeformed aplite-pegmatitic dikes (Figs. 3a, b), probably linked to the Sila batholith emplacement during the late-Hercynian magmatic activity, crosscutting the mylonitic foliation, both in metapelite and orthogneiss, could be a meaningful structural evidence representing an important time-constraint on the age of the shearing event.

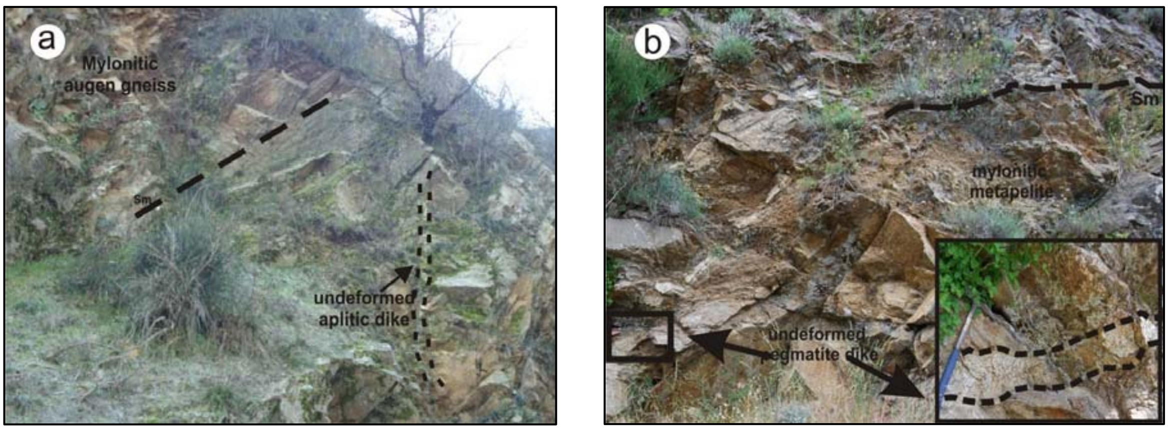

Fig. 3 - Aplite-pegmatitic dikes crosscutting the mylonitic foliation in a) leucogneiss and b) paragneiss.

PETROGRAPHY AND MINERAL CHEMISTRY

Micro-scale analysis revealed the existence of a contrasting sense of shear (Figs. 4a, b), confirmed by quartz LPO analyses, both developed in lower greenschist facies conditions (400°-450°) (Figs. 4c, d). Moreover, during petrographic investigations, a retrograde metamorphic overprint developed during the shearing event, both in metapelite and leucogneiss, has been detected.

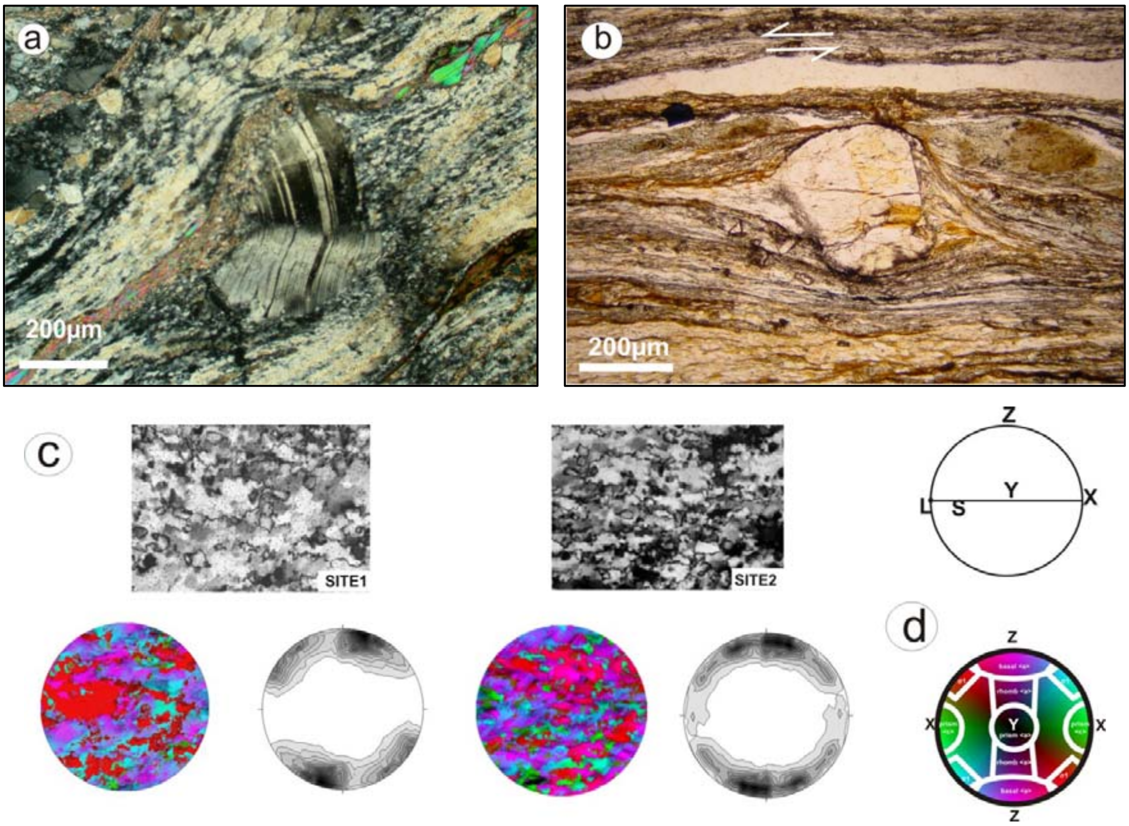

Fig. 4 - a-b) Mylonitic microstructures showing the contrasting sense of shear; c) Selected quartz rich-domains in leucogneiss samples and relative quartz c axis patterns obtained by AAVA software (equal area projection, lower hemisphere; S is the reference foliation plane; L is the reference direction, parallel to stretching lineation); d) Reference stereoplot with slip systems activated at shear temperature. Modified after Schmidt & Casey (1986).

The syn-kinematic growth of Bt + Pl + Sil + Qtz in the pressure shadows of garnet porphyroclasts, within the low strained domains of metapelite seems to indicate hydration reactions, probably responsible of re-equilibration mechanisms from higher to lower metamorphic grade, under amphibolite facies conditions.

Additionally, the syn-shearing crystal growth of Chl + Wm + Qtz ± Pl in strongly milonitized gneissic horizons (paragneiss and orthogneiss) documents shearing activity in greenschist facies conditions.

Petrographic and minerochemical analyses allowed to identify the relics of a pre-mylonitic cycle, represented by oligoclase-andesine plagioclase (Pl_I; An_{27} to An_{32}), biotite (Bt_I; X_{Fe} = 0.44-0.53; Ti/11ox = 0.11-0.14) and quartz inclusions inside the garnet porphyroclasts (Grt_I), within the low strain domains of mylonitic paragneiss. Those large idioblastic to sub-idioblastic garnet porphyroclasts (sub-centimeter to centimeter), mainly Alm-Prp solid solution with low contents of Grs and Sps, show homogeneous interiors (Figs. 5a, b). This petrological feature could indicate a long residence time at HT conditions in the crust, able to attenuate or obliterate the original growth zoning in garnet crystals trough diffusion mechanisms (Blackburn, 1969; Woodsworth, 1977).

Nevertheless, evidences of a narrow high-Spessartine rim ($Alm_{72}Pyr_{16}Sps_7Grs_6$) (Figs. 5b, c) in the homogeneous garnets porphyroclasts (Grt_I), interpreted as a retrograde metamorphic overgrowth (de Béthune *et al.*, 1975) could be related to the early stage of the subsequent syn-mylonitic retrograde metamorphic evolution recorded in these rocks.

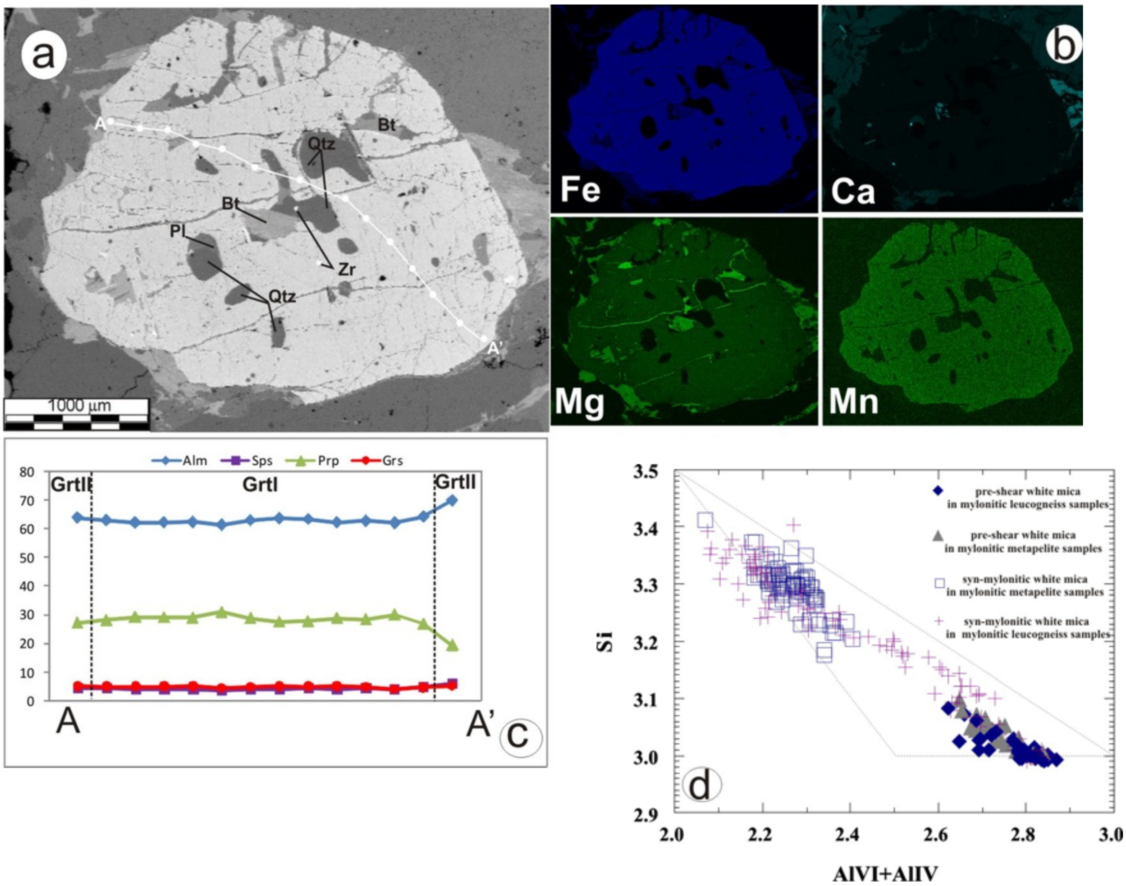

Fig. 5 - a) Representative SEM image, (b) relative X-ray maps, and c) representative compositional profile of garnet porphyroclasts in mylonitic metapelite of the Castagna Unit; d) Si *vs.* Al_{tot} compositional diagram for white mica in leucogneiss and paragneiss of the Castagna Unit.

Petrological investigations of strongly mylonitic horizons, mostly leucogneiss, allowed to uravel the late stage of this retrograde trajectory. In detail, mineral chemical analyses revealed the occurrence of two different textural generation of white mica: a) a pre-mylonitic white mica showing a fish texture (Wm_I; Si 3.00-3.23 a.p.f.u.); b) a sin-shear white mica (Wm_{II}).

The syn-mylonitic white mica showed a bi-modal compositional distribution in the phengite content (Fig. 5d): a high phengite white mica (Si 3.23-3.40 a.p.f.u.), probably related to a higher pressure mylonitic stage; a low to intermediate phengite one (*e.g.*, Si 3.00-3.23 a.p.f.u.), here interpreted as relic of a previous mylonitic stage developed at lower pressure conditions.

THERMOBAROMETRIC HISTORY

Derived P-T estimates in this study entirely describe the retrograde metamorphic evolution related to the syn-mylonitic shearing stage since the pervasive deformation and strong re-equilibration during the evolution of the ductile shear zone produced a loss of information about the old pre-shear metamorphic history.

Thermodynamic modelling by means of P-T pseudosection computations, applied in the low strained domains of mylonitic paragneiss, allowed to constrain a reliable P-T field (P ranging from 570 to 680 MPa at T of 595 °C), taking into account the textural equilibrium and compositional isophlet intersections among the narrow retrograde rims of the re-homogenised garnets and minerals in the matrix, specifically biotite (Bt_{II}; $(Fe/Fe+Mg)_{44\text{-}47}$) and plagioclase ($Pl_{II}$; $An_{27\text{-}32}$). It is probably consistent with the early stages of the retrograde metamorphic trajectory related to the shearing event at upper amphibolite facies conditions.

The subsequent retrograde mylonitic evolution has been inferred mainly, from the mylonitic leucogneiss horizons using the conventional thermobarometric approach, by means of the phengite barometer (Massonne & Schreyer, 1987) coupled with the shearing-temperature estimation, yielded by Lattice Preferred Orientation (LPO) analyses on selected quartz-rich domains.

The bi-modal distribution in the phengite content of the syn-kinematic white mica, enhanced by minerochemical analyses, suggests the hypothesis of two different baric regimes related to the mylonitic event. Indeed, the high-phengite compositions for the syn-shear white mica, plotted on the Massonne & Schreyer (1987) diagram, allowed to constrain intermediate to high pressure conditions (400 to 800 MPa).

The low to intermediate phengite ones, instead, suggest pressure values < 400 MPa supporting the hypothesis of a further mylonitic event likely developed under lower pressure conditions.

Quartz *c* axis orientation patterns analyses allowed to constrain shearing temperature consistent with lower greenschist facies conditions (*i.e*. 400-450 °C) as revealed by the dominant basal <a> active slip systems (Fig. 4c); evidences of prism <c> slip system activation consistent with higher shearing temperature (Schmid & Casey, 1986) were identified.

CONCLUSIVE REMARKS

New structural, microstructural and petrologic analyses carried out on the mylonitic rocks belonging to the Castagna Unit suggested a poly-orogenic tectono-metamorphic history for this poorly-known sector of calabrian crystalline basement and the existence of two different ductile deformational events (Fig. 6).

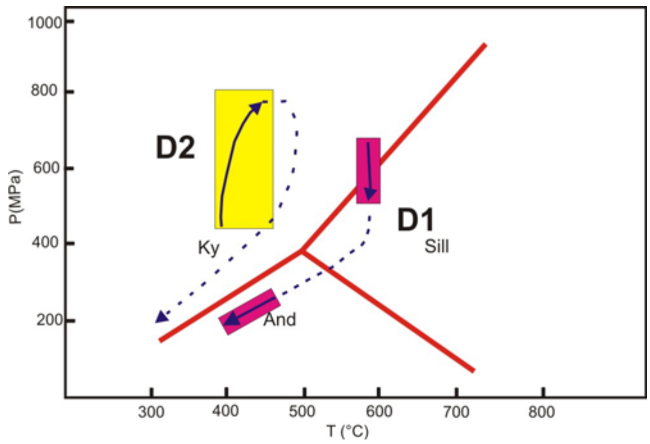

Fig. 6 - PTD path diagram for the Castagna Unit.

The former HT-LP mylonitic event (D1) shows an early metamorphic stage ($D1_A$), identified in the low strain domains of metapelite, by means thermodynamic modelling, and a late stage ($D1_B$) constrained, mainly by the analysis of the leucogneiss horizons, taking into account the low-phengite content in the syn-shear white mica and the quartz LPO analyses.

The subsequent well-developed HP-LT mylonitic overprint (D2), constrained through the P values derived from the high phengite compositions in the syn-mylonitic white mica and the T estimates yielded by means "c" axis orientation patterns.

In this scenario, the "Castagna Unit" can be interpreted as a late to post-Hercynian shear zone, as also enhanced by structural evidence of late-Hercynian undeformed leucocratic dikes crosscutting the mylonitic foliation, probably linked to the Sila batholith (Graeßner *et al.*, 2000) subsequently, locally, re-activated during the building of the Alpine Orogen, as supported by geochronological data reported in the literature of a 56 My (Borsi & Dubois, 1968), interpreted as a re-equilibration during the Alpine Orogeny.

The asymmetrical folding involving the mylonitic foliation (S_m) suggests a shallower deformative event (D3), probably ascribable to the staking and thrusting stages of the Alpine-Apennine tectonic activity in the central Mediterranean area.

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