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SCIENCE

Geology of the northwestern portion of the Ferriere-Mollieres Shear Zone, Argentera Massif, Italy

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ABSTRACT

The Ferriere-Mollieres Shear Zone (FMSZ) is a regional shear zone cross-cutting the Argentera External Crystalline Massif (Western Alps). It shows a NW-SE striking dextral shear zone separating two Variscan migmatitic complexes: the Tinèe to the SW and the Gesso-Stura-Vesubiè to the NE. Geological-structural mapping at 1:10,000 scale focused on the characterization of mylonitic deformation. A deformation gradient has been observed towards the core of the shear zone marked by the occurrence of ultramylonites and rare phyllonitic layers. Protomylonites passing to unsheared migmatites occur in the outer zones. Low-angle shear zones with a top-to-the S and SW sense of shear cross-cut the previous mylonitic foliation. The FMSZ is a Variscan transpressive shear zone activated during the Late Carboniferous under amphibolite-facies metamorphic condition. The shear zone has been partially reactivated under greenschist-facies metamorphic conditions during Alpine Orogenesis.

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KEYWORDS
Variscan shear zone; Argentera Massif; mylonite; transpression; East Variscan shear zone

1. Introduction

The Argentera Massif is the southernmost External Crystalline Massif of the Alpine chain. The External Crystalline massifs (Mont Blanc, Aiguilles Rouges, Grandes Rousses, Belledonne, Pelvoux, and Argentera) represent the remnants of the Variscan Orogeny, a late Paleozoic orogenic belt formed between 380 and 280 Ma as a result of the collision between Laurussia and Gondwana (Matte, 1986). The External Crystalline Massifs recorded similar evolution common to all Pangean Europe (Von Raumer, Bussy, & Stampfli, 2009). They are composed of a high-to-medium grade metamorphic basement intruded by Permo-Carboniferous granoitoids.

The Argentera Massif is located at the boundary between Italy and France; it is elongated in the NW-SE direction and it is composed of two main metamorphic complexes: the southwestern Tinèe Complex and the northeastern Gesso-Stura-Vesubiè Complex (GSV), which are divided by a regional shear zone, the Ferriere-Mollieres Shear Zone (FMSZ), striking NW-SE and extending from Ferriere to Mollieres villages (Figure 1(a)).

Both metamorphic complexes are made of high-grade migmatitic gneisses mainly derived from a metasedimentary sequence intruded by granitoid bodies during the Early Paleozoic, followed by the emplacement of small mafic bodies during the Early Ordovician (Compagnoni, Ferrando, Lombardo, Radulesco, & Rubatto, 2010; Ferrando, Lombardo, & Compagnoni, 2008). The main difference between the two complexes is the occurrence of a large intrusive body (Argentera Central Granite) cross-cutting the regional foliation, at 292 ± 10 Ma (Ferrara & Malaroda, 1969) in the GSV complex.

The FMSZ was first recognized by Faure-Muret (1955) who refers to it as the 'Valletta Unit' because of its lower metamorphic grade with respect to the high-grade host rocks.

Mylonitic rocks of the FMSZ mainly consist of mylonitic gneiss and micaschist derived from high-grade migmatitic gneisses, interlayered with mylonitic leucogranites and quartzite sheet-like bodies. Musumeci and Colombo (2002) obtained a cooling age for a mylonitic leucogranite (the Rocco Verde leucogranite) of 327 ± 3 Ma by Rb/Sr analyses on the whole rock and magmatic muscovite grains.

This age suggests that the FMSZ was active after the Early Carboniferous.

The presence of unsheared Permo-Triassic sediments above the mylonites of the shear zones allows the activity of the FMSZ to be constrained at the Upper Carboniferous. Sanchez et al. (2011) obtained $^{40}Ar/^{39}Ar$ ages of 20 ± 0.3 Ma on synkinematic phengites from FMSZ micaschists, suggesting an alpine deformation age. In addition, the Fremamorta-Colle del Sabbione shear zone and the Bersezio Fault crop out respectively in the south and east of the Argentera

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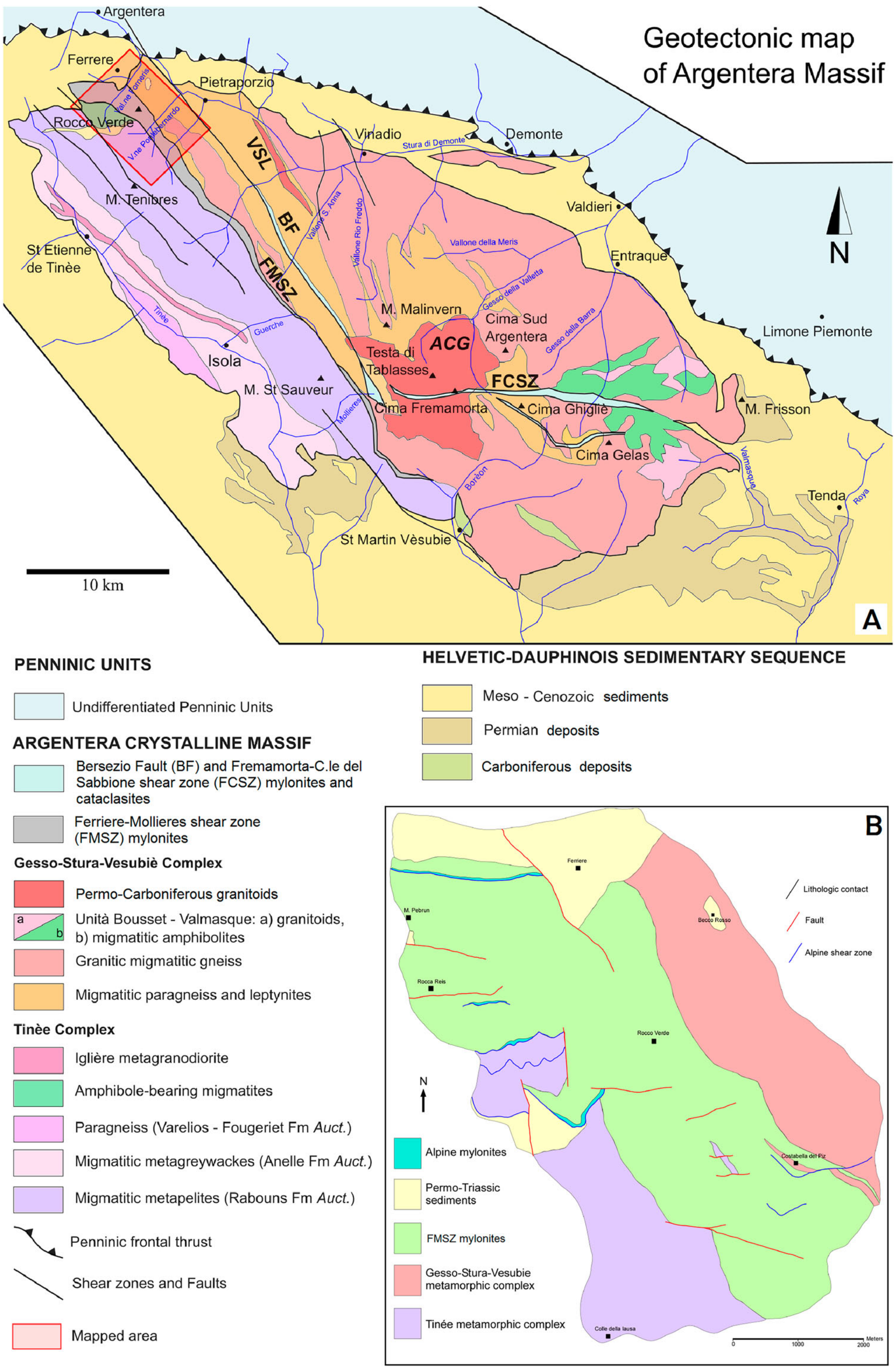

Figure 1. (a) Geotectonic map of the Argentera Massif. The mapped area is located in the northern portion of the FMSZ (red rectangle), where it is overlaid by alpine meso-cenozoic sedimentary sequence; VSL: Valle Stura Leucogranite; ACG: Argentera Central Granite; (b) Tectonic sketch map of the study area. Alpine shear zones are represented in blue and faults in red.

Massif (Figure 1(a)), having developed during the lower Miocene because of an alpine regional brittle transpression recognized by Baietto, Perello, Cadoppi, and Martinotti (2009). The conflicting deformation ages and the lack of a detailed study of the FMSZ, led us to compile a new geological-structural map of a portion of this shear zone to characterize the shear deformation. We present a new 1:10,000 geological map of the northwestern portion of the FMSZ accompanied by geological cross-sections, stereographic projections of the structural data, and a structural setting scheme (Main Map).

2. Methods

The map at 1:10,000 scale covers an area of nearly 45 km^2 that was originally mapped at the 1:5000 scale. The geological map data are presented on a vector topographic basemap (Carta Tecnica Regionale – Regione Piemonte) using the WGS 84 UTM, 32N coordinate system. The study area is a key site in the evolution of the Argentera Massif during the Variscan and Alpine Orogeneses. The first modern geological map of the Argentera Massif was developed during a Ph.D. Thesis (Faure-Muret, 1955), followed by the 'Carta Geologica del Massiccio dell'Argentera' (Malaroda et al., 1970) at 1:50,000 scale, which covers the whole Crystalline Massif. The first geological-structural map of the Massif was compiled by S. Bogdanoff during his Ph.D Thesis (Bogdanoff, 1980), and covers the northwestern portion of the massif. The map we present is based on the above-mentioned work and includes new lithological, structural, and petrographic data (D'Addario and Mammoliti field work during 2015 for the NW part, Simonetti field work during 2015 for the SE part) focused on the characterization of the deformation of the FMSZ. Oriented samples used for the petrographic and microstructural study were cut parallel to the extension lineation and perpendicular to the mylonitic foliation. Mylonites have been classified according to the percentage of matrix and porphyroclasts both at the meso- and at the microscopic scale. Following Sibson (1977) and Passchier and Trouw (2005): protomylonites are characterized by 10–50% of matrix, mylonites have from 50% to 90% of matrix whereas ultramylonites have 50–90% of matrix.

The mapped area falls between Vallone di Ferriere, to the North and Vallone del Piz to the south. Structural data interpretation is based on geometric analysis (equal angle lower-hemisphere stereographic projections) of the main foliation in the tectonic units (Sp) and of mylonitic and cataclastic foliations in the shear zone (Sm). Furthermore, we propose a structural and kinematic setting scheme for the FMSZ.

3. Lithostratigraphy

In the study area migmatites belonging to the Tinée and Gesso-Stura-Vesubie metamorphic complexes are separated by the mylonites of the FMSZ (Figure 1(b)).

Based on the fabric of the mylonites (in particular on the amount of matrix and porphyroclasts), on the recognized paragenesis and related protoliths, protomylonites, mylonites, ultramylonites, and phyllonites have been mapped within the shear zone.

Mylonites developed during the Alpine deformation and Permo-Triassic sediments covering the crystalline basement were also recognized.

3.1. Permo-Triassic sediments

White-grey quarzites, often showing ripple marks, of Permo-Triassic age (Barale et al., 2015) crop out in the northern part of the study area near Ferriere village. These rocks lay in angular unconformity on the Variscan basement (Bogdanoff, 1986; Faure-Muret, 1955; Sturani, 1962). Above the quarzites a meter-thick layer of tectonic carbonatic breccias, with both gypsum and dolomitic limestone clasts, occurs ('Formazione delle Carniole': Malaroda et al., 1970).

3.2. Gesso-Stura-Vesubiè metamorphic complex

The Gesso-Stura-Vesubiè, metamorphic complex mainly consists of migmatitic paragneiss with biotite, quartz, K-feldspar, plagioclase, and cordierite. This paragenesis is indicative of high-temperature amphibolite-facies metamorphism, probably affecting sedimentary-derived lithotypes. Sometimes a meter-thick leucocratic portion composed of quartz, feldspars, and cordierite is recognizable. Biotite ± white mica define a thin and spaced foliation. The migmatites occupy the whole eastern part of the study area. In the southern part of the study area the migmatites are associated with fine-grained amphibole-bearing migmatitic gneiss with few feldspars.

The Gesso-Stura-Vesubie migmatites are intruded by light-colored lenticular granite bodies consisting mainly of quartz and feldspar, probably associated with the emplacement (299 ± 10 Ma; Ferrara & Malaroda, 1969) of the late Variscan Valle Stura leucogranite.

3.3. Tinée metamorphic complex

The Tinée metamorphic complex is mainly represented by migmatitic gneiss with biotite and sillimanite ('Rabuons Formation' according to Faure-Muret, 1955 and Malaroda et al., 1970) that crops out mainly in the south-eastern part of the mapped area. This paragenesis is indicative of high-temperature amphibolite-facies metamorphism after a para-derived lithotype. Because of the anatectic nature of this lithotype the amount and thickness of leucosomes is variable.

Migmatitic gneisses are sometimes associated with amphibolite bodies composed by quartz, plagioclase, and green amphibole.

Amphibole-bearing migmatitic gneiss crops out in the northwestern part of the mapped area. It consists of light-colored white-green gneiss with amphibole, biotite, quartz, and plagioclase, with massive aspect.

4. The Ferriere-Mollières shear zone

The FMSZ is the main shear zone cross-cutting the Paleozoic basement in the western portion of the Argentera Massif (Compagnoni et al., 2010; Musumeci & Colombo, 2002). It strikes NW–SE and extends from Ferriere (Valle Stura) to the northwest, to Mollières in the southeast. The FMSZ is subject to variations in thickness which progressively decreases from NW to SE. The maximum thickness is reached in the area close to Ferriere village where the shear zone reaches

2 km thickness. Thickness variations of the different types of mylonites at a local scale were also noted.

4.1. Petrography and microstructures of mylonites

The FMSZ is composed of different lithotypes resulting from shearing of the rocks belonging to both metamorphic complexes.

The main lithotypes that constitute the shear zone are: (1) medium-grained dark-green mylonitic schists; (2) biotite and white mica-bearing mylonitic gneisses; (3) mylonitic leucogranite; (4) amphibole-bearing mylonitic gneisses; (5) phyllonites; (6) mylonitic migmatites with biotite and sillimanite; (7) biotite-bearing mylonitic gneiss; (8) protomylonitic migmatites in contact with the Tinée complex.

Medium-grained dark-green mylonitic schists (1) (Figure 2(a)) are constituted of quartz, k-feldspar, and plagioclase porphyroclasts in a fine-grained biotite and white mica matrix (Figure 2(b)). Garnet porphyroclasts are sometimes present and, especially in the northern portion of the FMSZ, biotite is often replaced by chlorite because of retro-metamorphism/alteration or further reactivation of the shear zone. The amount of matrix is about 75%. The transition from mylonites to highly deformed ultramylonitic bands, with a higher amount of matrix (over 90%) and finer grainsize is detectable. Small-size quarzites and marble lenses are associated with the mylonitic schist.

The biotite + white mica mineral assemblage on the mylonitic foliation indicates an initial activation of the shear zone under amphibolite-facies metamorphic condition. The deformation continues during retrograde metamorphism in greenschists facies.

Mylonitic gneisses (2) are constituted of K-feldspar, plagioclase, and quartz porphyroclasts in a fine-grained biotite and white mica matrix. Sillimanite and garnet porphyroclasts are locally preserved (Figure 2(c)) and the amount of matrix is about 60%. Undulose extinction in feldspars and in micas (Simpson & De Paor, 2008), kink bands in micas, core-and-mantle structures (Figure 5(a)) and asymmetrical myrmechites in feldspar have been recognized.

In the northern portion of the study area, between Vallone di Ferriere and Vallone Forneris, a mylonitic leucogranite (3) has been mapped. The leucogranite, also reported by Musumeci and Colombo (2002) close to the summit of Rocco Verde, is composed of k-feldspar, plagioclase, quartz, and white mica (Figure 2(d)). It is often intensively deformed and ultramylonitic bands with a high amount of matrix (over 90%) are recognizable. Leucogranites show flame perthites in K-feldspars, undulose extinction and deformation bands in quartz and K-feldspars.

In the western part of the shear zone amphibole-bearing mylonitic gneisses (4) (Figure 2(e)) form stretched lenses in the central part of the shear zone.

In the central part of the shear zone, it is possible to recognize mica rich fine-grained phyllonites (5) (Figure 2(f,g)) testifying to the most intensely deformed portions of the shear zone.

Moving towards the Tinée metamorphic complex coarse-grained mylonitic migmatitic gneiss (6) with deformed leucosomes of k-feldspar, plagioclase, and quartz in a medium-grained biotite and sillimanite matrix have been mapped (Figure 2(h)). The amount of matrix in this lithotype is about 50–60% and, moving towards the SW, protomylonitic migmatitic gneiss (8) with the same mineral assemblage and about 30–40% of matrix can be recognized.

Also moving from the core of the shear zone towards the NE, it is possible to observe a transition from the highly deformed previously described mylonites to less deformed biotite-bearing mylonitic gneiss (7) with about 50–60% of matrix. These mylonites are in contact with the Gesso-Stura-Vesubie migmatites.

4.2. Structural and kinematic analysis

In the study area we can clearly recognize a deformation gradient proceeding towards the central higher strained portion of the shear zone (Figure 3).

The prominent structure in the FMSZ is a penetrative mylonitic foliation (Sm) striking N100-140 and steeply dipping towards both the northeast and the southwest. A well-developed mineral lineation (Lm), defined mainly by quartz and feldspar and subordinatly by sillimanite, is also recognizable, trending N110-130 and dipping 20° towards the northwest. Intrafoliar isoclinal syn-shear zone folds (Fm) are sometimes recognizable.

A relict tectonic foliation (Sp-1) has been recognized in the migmatite complexes constituting the wall-rocks of the shear zone. The Sp-1 foliation is affected by isoclinal and tight symmetric folds (Fp) (Figure 4(a)), in which the axial plane foliation (Sp) is parallel to the mylonitic foliation (Sm). The mylonitic foliation (Sm) underwent post-shearing gentle folding (Fm + 1) with sub-horizontal axial planes, probably related to post-

Table 1. Structural elements of the FMSZ and of the adjacent metamorphic complexes in relation to the deformation phase during which they have developed.

	Pre-shear zone deformation	Syn-shear zone deformation	Post-shear zone deformation
FMSZ	–	Mylonitic foliation (Sm); lineation (Lm); syn-shear zone folds (Fm)	Post-shearing gentle folding (Fm + 1)
GSV complex	Relict foliation (Sp-1)	Axial plane foliation (Sp); tight folds (Fp)	Post-shearing gentle folding (Fm + 1) ?
Tinée complex	Relict foliation (Sp-1)	Axial plane foliation (Sp); tight folds (Fp)	Post-shearing gentle folding (Fm + 1) ?

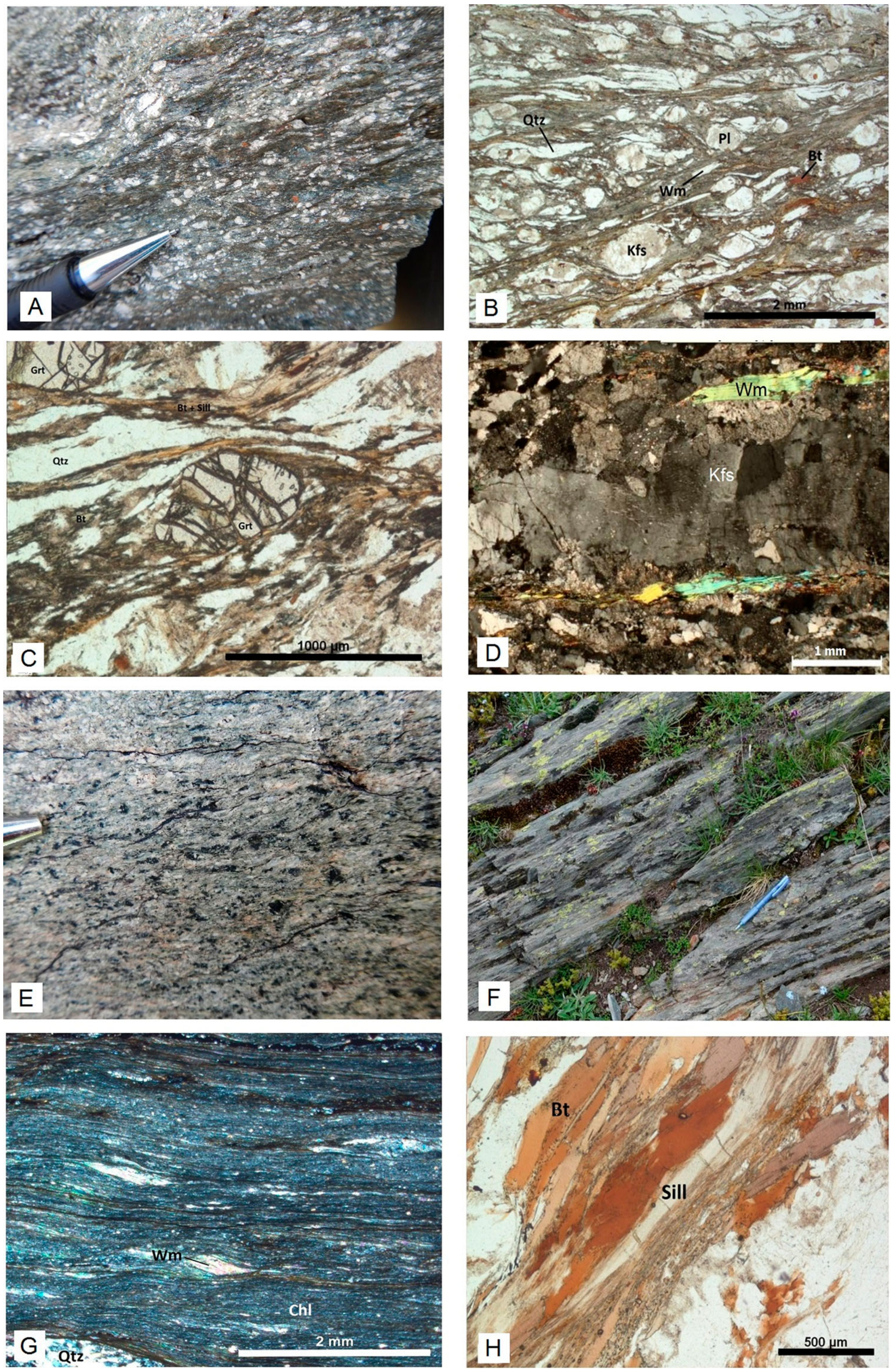

Figure 2. (a) Medium-grained dark-green mylonitic schist; (b) mylonitic schists with biotite and white mica in thin section (parallel nicols); (c) garnet porphyroclasts in mylonitic gneiss with biotite and white mica in thin section (parallel nicols); (d) mylonitic leucogranite in thin section (crossed nicols); (e) amphibole-bearing mylonitic gneiss; (f) phyllonites outcrop; (g) phyllonites in thin section (crossed nicols); (h) biotite and sillimanite in mylonitic migmatitic gneiss in thin section (parallel nicols).

tectonic collapse (Figure 4(b)). This tectonic event is not related to a ductile pervasive axial plane foliation at the outcrop scale whereas at the microscale sometimes it is expressed as a crenulation cleavage.

Table 1 shows the structural elements of the FMSZ and of the adjacent metamorphic complexes in relation to the deformation phase during which they have developed.

The FMSZ shows kinematic indicators pointing to a dextral sense of shear (top-to-the southwest). Protomylonites preserve the gneissic and migmatitic textures and show kinematic indicators such as S-C fabric, mantled objects, quarter structures, and mica fish. In the mylonites, mylonitic foliation is pervasive and marked by abundant crystallization of micaceous minerals. Besides the above-mentioned kinematic indicators, mylonites show quartz oblique foliation and C′-type shear bands. In the ultramylonites, grain size reduction due to high deformation was observed and kinematic indicators are limited to S-C′ fabric and rare rotated porphyroclasts.

In the mapped area, we also recognized low-angle shear zones cutting the mylonitic foliation and showing inverse top-to-the south kinematics. Brittle normal faults affect the mylonitic foliation pointing to later extension at higher structural levels.

4.3. Metamorphism and deformation in the FMSZ

According to previous authors (Bogdanoff, 1980, 1986; Bogdanoff, Menot, & Vivier, 1991; Corsini, Ruffet, & Caby, 2004; Faure-Muret, 1955; Malaroda et al., 1970; Musumeci & Colombo, 2002; Sanchez et al., 2011), mylonitic rocks of the FMSZ developed under low-grade metamorphic conditions ($T < 400°C$).

In contrast our fieldwork, coupled with microstructural and petrographic analyses, highlights a range of metamorphic conditions at which shearing occurred:

- in biotite–sillimanite–white mica-bearing mylonitic gneisses quartz displays mainly subgrain rotation recrystallization (Piazolo & Passchier, 2002; Stipp, Stunitz, Heilbronner, & Schmid, 2002) (Figure 5(b)) and locally grain boundary migration. These deformation mechanisms coupled with the growth of biotite, sillimanite, and white mica along C/C′-type planes suggest medium-grade conditions ($T > \sim 550°C$), consistent with an amphibolite facies;
- an inner portion of the shear zone, composed of biotite and white mica-bearing mylonitic micaschists, is characterized by lower deformation temperatures ($450°C < T < 500°C$) and shows both bulging (Shigematsu, 1999; Stipp et al., 2002) and subgrain rotation recrystallization in quartz (Piazolo & Passchier, 2002; Stipp et al., 2002);
- the core of the FMSZ is characterized by the occurrence of sheared leucogranitic bodies associated with phyllonitic bands. Quartz is noted for bulging (Drury, Humphreys, & White, 1985; Shigematsu, 1999; Stipp et al., 2002) and subgrain rotation recrystallization mechanisms (Piazolo & Passchier,

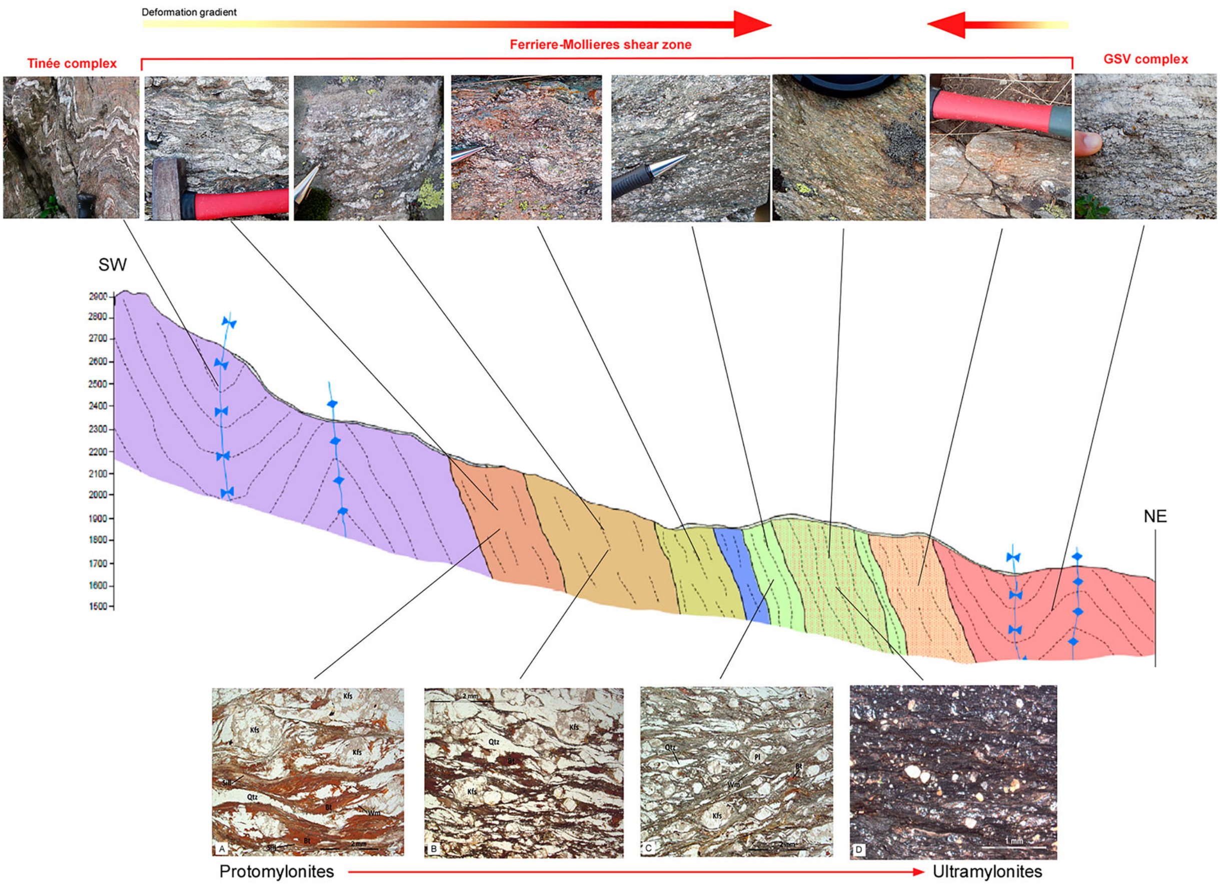

Figure 3. Deformation gradient along the Ponte Bernardo Valley. Tinée migmatites are represented in violet and amphibole-bearing migmatitic gneiss are represented in blue. GSV migmatites are represented in red. With the various shades of brown, green, and orange are represented the different types of mylonites belonging to FMSZ. In both the metamorphic complexes axial planes of the syn-shear zone folds are represented in blue. The deformation gradient is evident both at the meso-scale in the images above, where the transition from unsheared lithotypes of the two metamorphic complexes to the FMSZ mylonites and ultramylonites is clearly visible, and in thin section in which the transition from protomylonitic lithotypes to the highly deformed ultramylonites is clearly detectable: (a) protomylonites (parallel nicols); (b,c): mylonites (parallel nicols); (d) ultramylonites (crossed nicols).

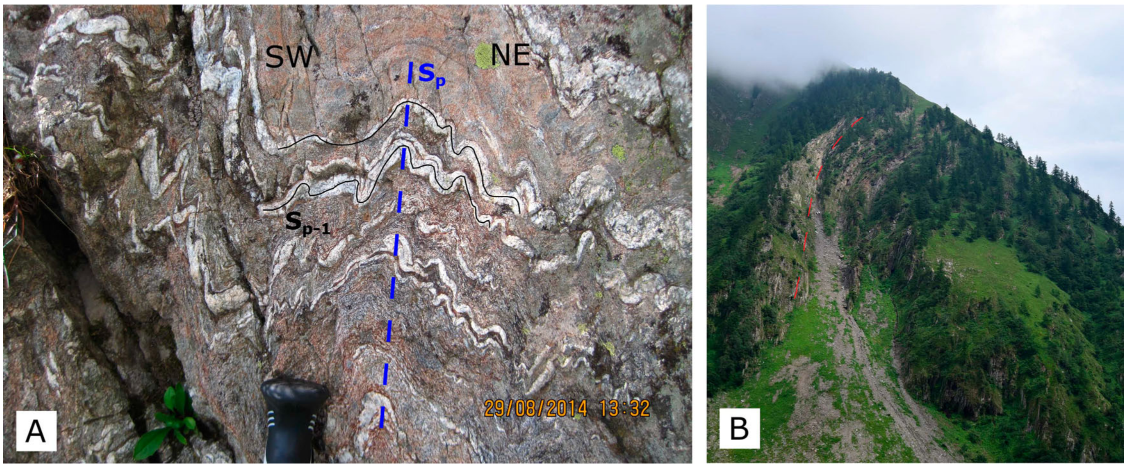

Figure 4. (a) Mesoscopic Fp folding in migmatitic gneisses of the Tineè complex. The relict foliation is represented by leucosomes of migmatites (Sp-1). Axial plane cleavage is reported in blue (Sp); (b) post-shearing gentle folding (Fm + 1) with sub-horizontal axial plane in mylonitic rocks of the FMSZ.

2002; Stipp et al., 2002). These features testify to a deformation temperature >350–400°C.

5. Alpine shear zones

We also identified later shear zones cross-cutting the mylonites of the FMZS and the migmatites of the two wall-rocks metamorphic complexes. These shear zones range from m- to dm-thick and are characterized by the presence of fine-grained green mylonitic schist made up of quartz and feldspar porphyroclasts in a fine-grained chlorite and white mica matrix. This mineral assemblage is indicative of low-grade metamorphic conditions. Biotite relicts, indicating a previous higher metamorphic grade, are still recognizable. The amount of matrix is about 65–75%. These shear zones are characterized by an E-W striking foliation (Sa),

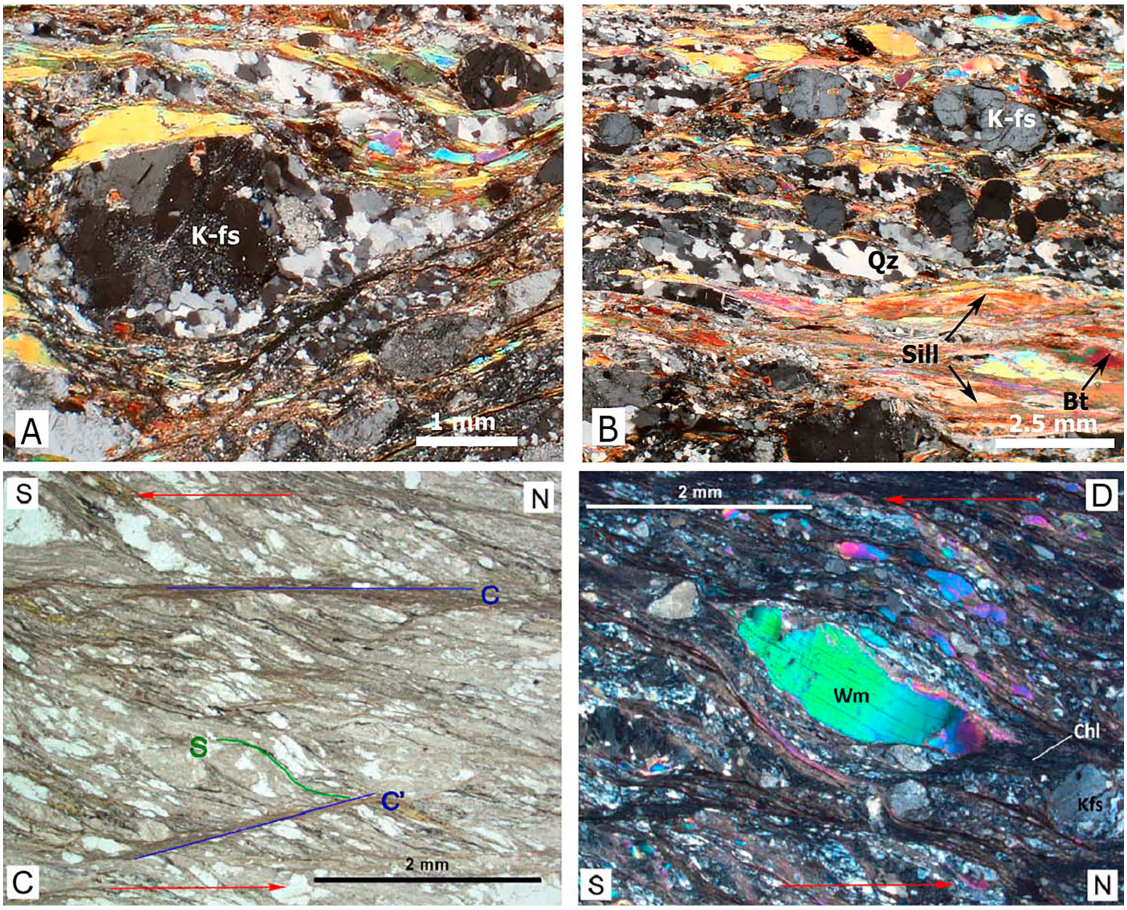

Figure 5. (a) Undulose extinction in k-feldspar (crossed nicols); (b) Bt-Sill-Wm-bearing mylonitic gneiss (crossed nicols); (c) S-C and S-C′ fabrics in the alpine mylonites (parallel nicols). S planes are marked in green, C and C′ planes are marked in blue; (d) micafish, in the alpine mylonites (crossed nicols). Sense of shear indicators show a top-to-the S sense of movement (red arrows).

shallowly to moderately dipping to the N and with a N plunging mineral lineation. We identified kinematic indicators, mainly micafish, S-C and S-C′ fabrics, which indicate an inverse top-to-the S (Figure 5(c,d)) or top-to-the SW sense of shear.

The best examples of these shear zones are located near the Colle Panieris and M. Peiron in the western part of the study area and along the Costabella del Piz crest in the southern part of the area. The former shear zone (Figure 6(a)) is responsible for the overthrusting of the lithotypes of the FMSZ above the post-Variscan sediments of the Helvetic-Dauphinois sequence; the latter (Figure 6(b)) cross-cuts the sub-vertical mylonitic foliation of the Ferriere-Mollieres mylonites.

Because of the superposition relationships between these shear zones and the mylonites of the FMSZ and due to the presence of low-grade metamorphic mylonites, it is possible to interpret these shear zones as developed during the alpine deformation.

This interpretation is in agreement with the occurrence of a regional brittle transpression recognized by Baietto et al. (2009) during the lower Miocene responsible of the development of the top-to-the-S Fremamorta-Colle del Sabbione shear zone (located in the southern part of the massif) that represents the biggest alpine fault in the Argentera Massif.

6. Discussion and conclusion

Recent detailed structural-geological mapping and structural and petrographical analysis allowed the identification and mapping of the different types of mylonites within the FMSZ and led to a new interpretation of the zone. Considering that:

- The axial plane cleavage of the folds observed in migmatitic complexes strike parallel to mylonitic foliation, and because of this the folding event occurred in a strain regime compatible with the shearing deformation in the FMSZ;
- the gentle plunging of the mineral lineation (about 20° towards NW) and the sub-vertical orientation

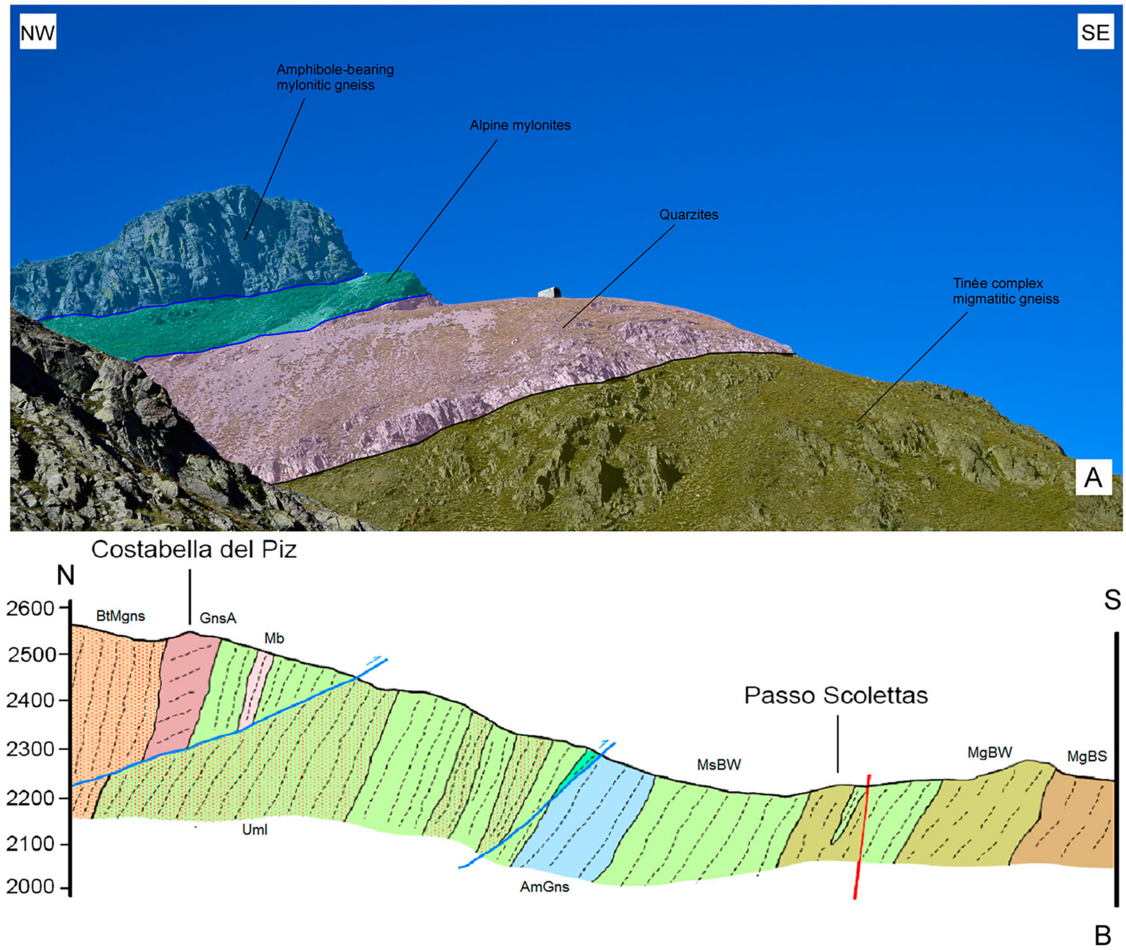

Figure 6. (a) Alpine shear zone located near the Colle Panieris and M. Peiron in the western part of the study area where the Ferriere-Mollieres mylonitic gneissess are thrusted over the sediments of the Permo-Triassic sediments; (b) alpine shear zones (in blue) along the Costabella del Piz crest cutting the sub-vertical mylonitic foliation of the Ferriere-Mollieres mylonites represented in black. MgBS: mylonitic gneiss with biotite and sillimanite; MgBW: mylonitic gneiss with biotite and white mica; MsBW: mylonitic schists with biotite and white mica; Uml: ultramylonites; AmGns: amphibole-bearing mylonitic gneiss; Mb: marble; GnsA: migmatitic gneiss with biotite and amphibole; BtMGns: biotite-bearing mylonitic gneiss.

of the mylonitic foliation are indicative, according to the model proposed by Sanderson and Marchini (1984) and Fossen, Tikoff, and Teyssier (1994), of a transpressive deformation regime with a prevailing transcurrent kinematic, coupled with a minor inverse component;

- crystallization of sillimanite and biotite along the mylonitic foliation in the low strain external portions of the FMSZ suggests that the shear zone developed under medium-grade metamorphic condition;
- crystallization of abundant white mica and less biotite (locally replaced by chlorite) in the core of the FMSZ suggests a retrograde metamorphic condition to greenschist-facies;
- the set of temperatures identified by the study of metamorphism and deformation mechanisms in the shear zone allows us to infer that the FMSZ started to be active under amphibolite-facies metamorphic conditions and then evolved towards lower temperatures, reaching the higher greenschist-facies metamorphic conditions.

We suggest that the FMSZ is a Variscan transpressive shear zone activated during the Late Carboniferous (Musumeci & Colombo, 2002). Shear started under amphibolite-facies metamorphic conditions and continued during retro-metamorphism. The FMSZ was subsequently reactivated under greenschist-facies. Age data obtained by Sanchez et al. (2011) could testify to Alpine reactivation of some portions of the FMSZ. The discovery of top-to-the S and the SW shear zones involving post-Variscan sediments is in agreement with the ages proposed by Sanchez et al. (2011).

The occurrence of a dextral, high- to low-temperature shear zone affecting the Variscan basement of the Argentera Massif is in good agreement with the activity of the Eastern Variscan shear zone (Corsini & Rolland, 2009) recognized in the Corsica-Sardinia massif, Maures-Esterel, External Crystalline Massifs and constrained at c. 320 Ma (Carosi & Palmeri, 2002; Carosi, Frassi, Iacopini, & Montomoli, 2005; Carosi, Montomoli, Tiepolo, & Frassi, 2012; Di Vincenzo, Carosi, & Palmeri, 2004).

The new and updated geological information about the northern portion of the Ferriere-Mollières Shear Zone can form the basis for further studies on the tectono-metamorphic evolution of shear zones in the Variscan basements.

Software

The map database and final map layout was built using Esri ArcGIS. Topographic maps were acquired from Carta Tecnica Regionale Numerica of the Regione Piemonte (www.regione.piemonte.it).

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Disclosure statement

No potential conflict of interest was reported by the authors.

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