P-T conditions and chemical changes of veins and associated alteration in Monviso eclogites

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Overview

- Metamorphic rocks such as blueschist and eclogite record the relatively cold conditions within subduction zones due to the cold lithosphere.
- At high temperatures, these rocks progressively dehydrate releasing fluids that can alter rocks and even result in arc volcanism and earthquakes (Schmidt and Poli, 1998; Hacker et al., 2003).
- To understand when these processes occur, these fluids are studied by looking at exhumed, altered rocks, i.e. in the Western Alps.
- Mineral assemblages and chemical changes within the alteration zone will be analyzed in order to estimate P-T conditions and possible chemical change from an interacting fluid.
- In this study, two problems will be investigated:

1. **Problem 1:** Did the fluids travel through the rock at peak metamorphism or after peak metamorphism? To investigate this, we need to figure out when the vein and alteration zone formed relative to the host rock.
2. **Problem 2:** Are there any chemical changes that could have occurred due to exchange between the fluid and host rock? To investigate this, mineral assemblages in the host and alteration zone will be analyzed.

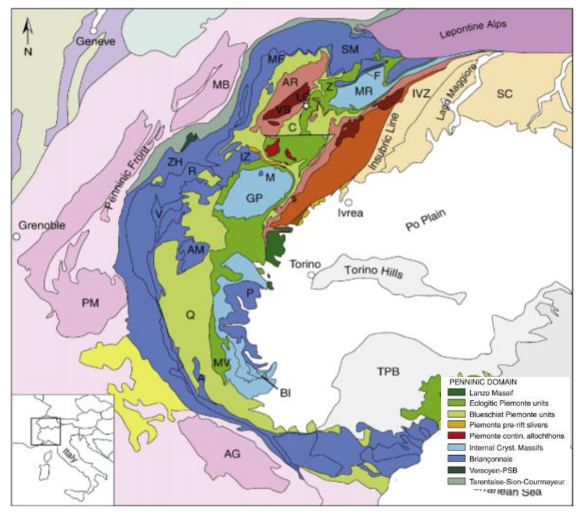

Fig 1: Geological map of the western alps (Beltrando et al., 2010)

Hypotheses

- **Hypothesis 1**: The vein and alteration zone recrystallized at a lower pressure and temperature than the host rock.
- **Hypothesis 2**: The alteration zone adjacent to the vein is chemically different than the host rock as a result of fluid-rock interaction.

Field Area and Sample

Field Area

- Monviso is an exposed ophiolite sequence, located along the French-Italian border.
- Part of the European plate and all of the Tethyan oceanic crust subducted under Apulian plate at 50-40 Ma (Beltrando et al., 2010).
- Peak P-T conditions of 550-580˚C and pressures of 2-2.7 GPa (Angiboust, 2014).

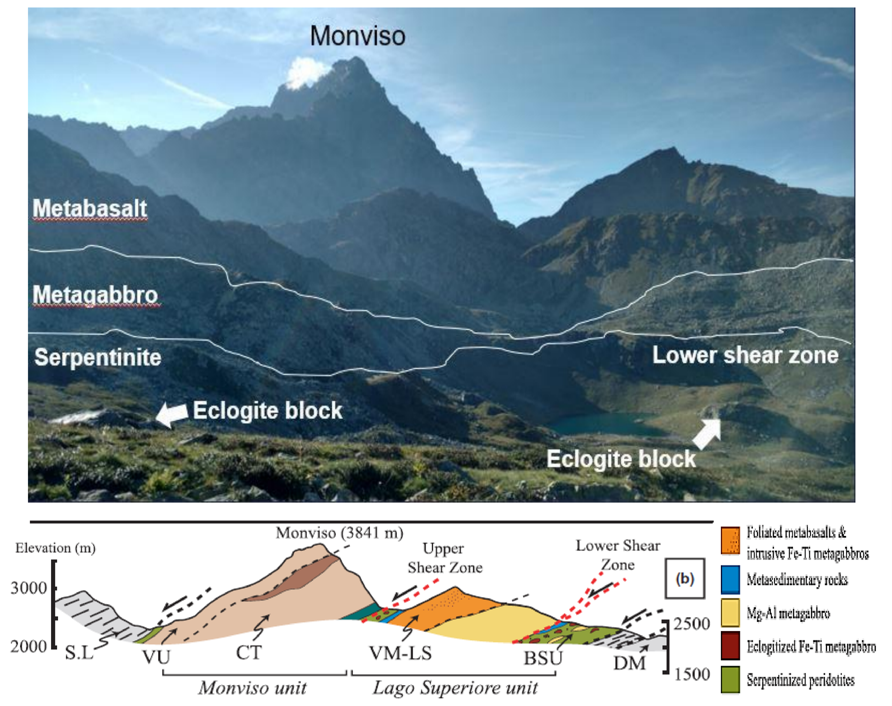

Fig. 2: Field area and cross section of Monviso depicting the ophiolite sequence and Lower Shear Zone (Angiboust et al., 2012)

Sample

Three zones (Fig. 4):
- Host
- alteration
- vein

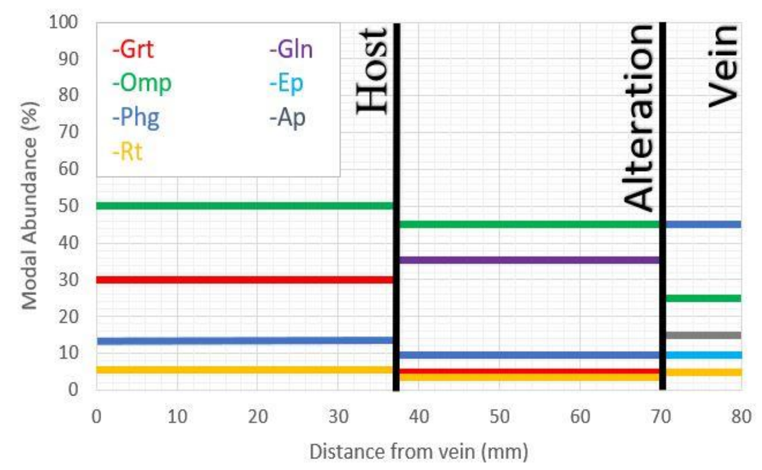

Fig. 3: Estimated modal abundance of each major phase in the three zones

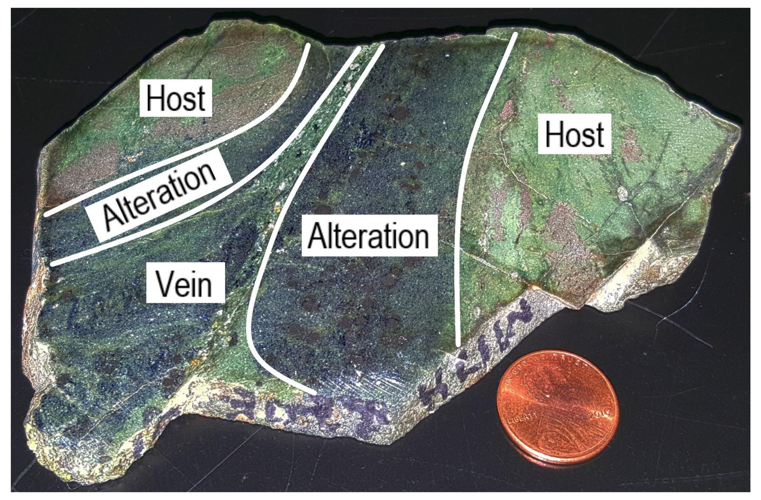

Fig 4: Cross section taken from the eclogite sample with vein, alteration, and host labeled

Methodology

Petrology
- Mineral and textural analysis of 5 thin sections (Fig. 7)
- Identify assemblages of minerals

Electron probe microanalysis
- Identification of major phases within each zone
- Major element composition of select grains for geothermobarometry

X-ray fluorescence
- Bulk rock analysis
- Major, minor, trace element composition
- Total volatile content calculated from LOI (Loss on ignition)
- Fe^{2+}/Fe^{3+} ratios

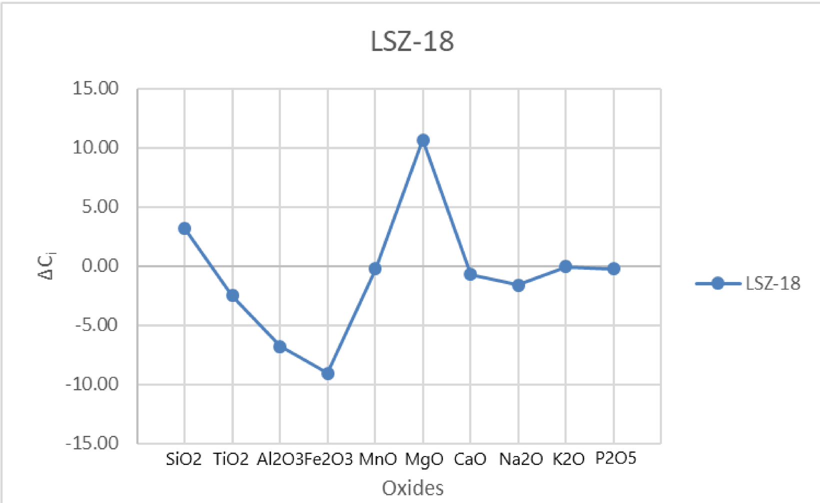

Fig. 5: Example of relative mass transfer of major elements in an LSZ-18 (eclogite; Angiboust et al., 2014; Spandler et al., 2011)

Mass Balance
- We may not be able to assume constant volume.
- Enrichment or depletion of elements relative to an immobile reference in the alteration indicates volume and/or concentration change (Grant, 1986).
- Mass transfer calculations were performed on a sample from Angiboust et al. (2014) to demonstrate feasibility (Fig. 5).

Geothermobarometry

1. Garnet-clinopyroxene Fe^{2+}-Mg geothermometer (Ravna, 2000)

$$T(^\circ C) = [(1939.9 + 3270X_{Ca}^{Grt} - 1396(X_{Ca}^{Grt})^2 + 3319X_{Mn}^{Grt} - 3535(X_{Mn}^{Grt})^2 + 1105X_{Mg\#}^{Grt} - 3561(X_{Mg\#}^{Grt})^2 + 2324(X_{Mg\#}^{Grt})^3 + 169.4P(GPa))/(\ln K_D + 1.223)] - 273$$

K_D = distribution coefficient
X_{Ca}^{Grt} = mole fraction of calcium
P= pressure in (GPa)
X_{Mn}^{Grt} = mole fraction of manganese
$X_{Mg\#}^{Grt}$ = mole fraction of magnesium

2. Garnet-Clinopyroxene-Phengite Barometer (Waters and Martin, 1996)

$$P(GPa) = [28.05 + 0.02044T - 0.002995T\ln(k)]/0.1$$

P= pressure in GPa
T= temperature in Kelvin
k= coefficient

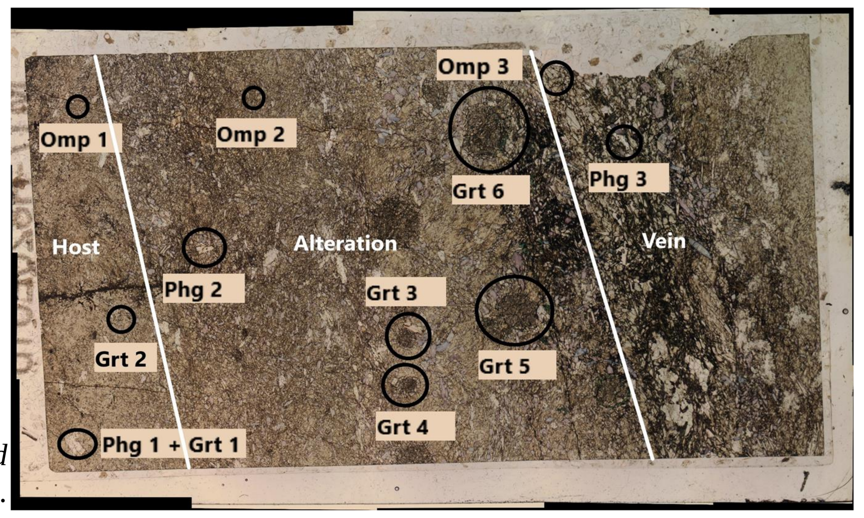

Fig 6 (right): Thin section locations of grains analyzed on the EPMA. Thin section is 27 mm x 46 mm.

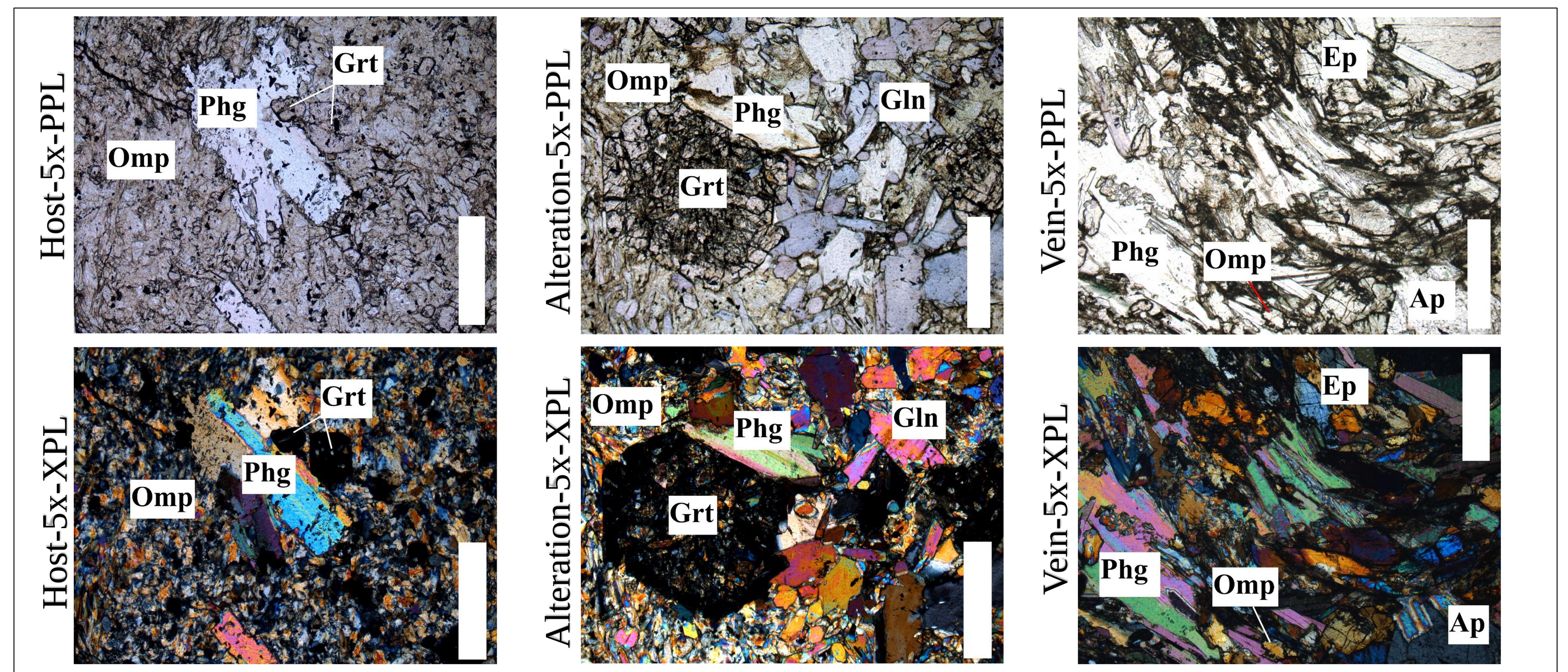

Fig. 7: Photomicrographs of host, alteration, and vein. Scale bars equal 1mm

Preliminary Results

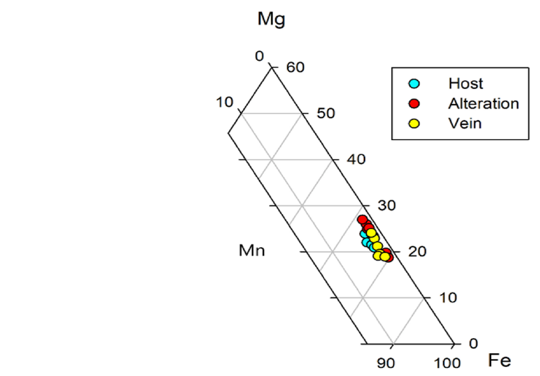

Fig. 8: Ternary diagram of garnet compositions from each major zone

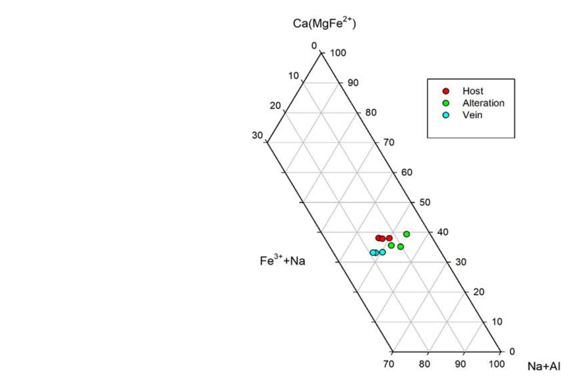

Fig. 9: Ternary diagram of omphacite compositions from each major zone

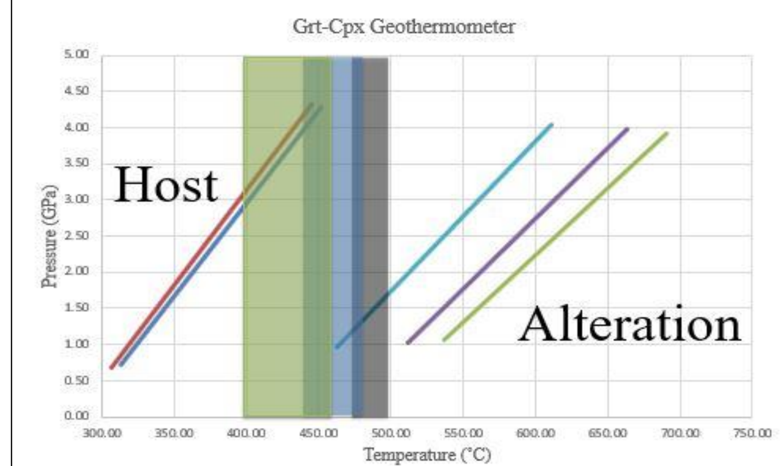

Fig. 10: P-T diagram of predicted temperature ranges of host rock and alteration zone plotted with a range of predictions from Angiboust et al. (2012; black) and Groppo and Castelli (2010; green and blue).

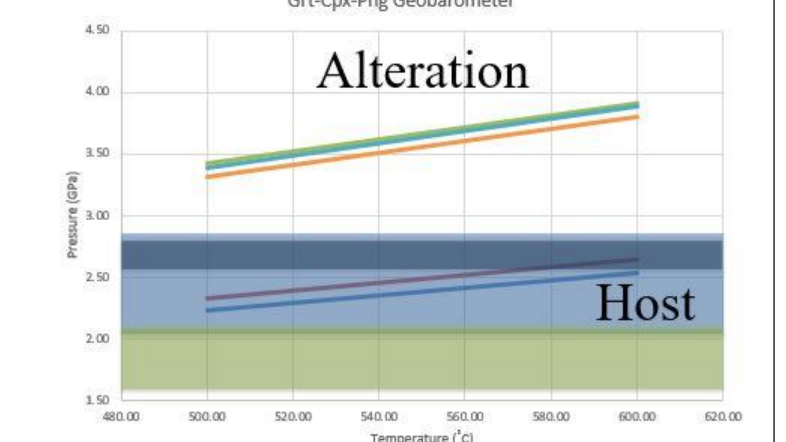

Fig. 11: P-T diagram of predicted pressure ranges of host rock and alteration zone plotted with a range of predictions from Angiboust et al. (2012; black) and Groppo and Castelli (2010; green and blue).

Discussion

- There is a homogeneous composition of garnets throughout the sample.
- Host omphacite points have a slightly greater Fe^{2+}/Fe^{3+} ratio compared to alteration/vein.
- Some P-T estimates overlap those for Angiboust et al. (2012) and Groppo and Castelli (2010).
- Analyses were made on grains that were not touching, which may affect the P-T estimates.

Future Work

- EPMA will be conducted on major phase mineral assemblages using grains in direct contact to produce more reasonable P-T conditions before start of Fall 2018.
- XRF powder samples will be sent to Franklin & Marshall College, and data will be processed Fall 2018.
- Zirconium in rutile will be analyzed to produce temperature estimates using the Zr-in-rutile geothermometer (Tomkins et al., 2007).

References

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