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Origin of Monte Rosa whiteschist from in-situ tourmaline and quartz oxygen isotope analysis by SIMS

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The origin of whiteschist is highly debated in the literature. Their chemistry has been interpreted as a result of the metasomatic alteration of a granitic protolith, due to either a fluid flux derived from serpentine dehydration in the subduction zone close to peak conditions [1] or due to the late magmatic hydrothermal alteration [2]. Here we present arguments based on oxygen isotope analysis of tourmaline to confirm the late hydrothermal origin of the whiteschists.

The Monte Rosa nappe belongs to the internal crystalline massifs of the Western Alps, together with Dora Maira and the Grand Paradiso. Whiteschists occur as 10 to 50 meters bodies within a Permian-age granite. They consist of chloritoid, talc, phengite, and quartz, with local kyanite, garnet, tourmaline and carbonates. The granite host is a porphyritic biotite granite crosscut by numerous tourmaline rich pegmatites and aplites dykes. The latter can be traced into the whiteschist bodies. Tourmaline-bearing granite, pegmatite and whiteschist from the Monte Rosa nappe were investigated by detailed in-situ oxygen isotope study of quartz and tourmaline. Analyses were performed by a CAMECA1280HR using newly developed tourmaline reference materials [3]. Chemical data and textural observations complete the isotopic results.

Tourmalines from granitic and pegmatitic samples are characterized by oscillatory growth zoning produced by small changes in Mg, Fe, Al and Na. The pegmatitic tourmaline is a schorl (X_{Mg} = 0.25 – 0.17), while the granitic tourmaline is an intermediate schorl-dravite with X_{Mg} of $\sim$ 0.5. Oxygen isotope data reveal homogeneous composition for granitic and pegmatitic tourmalines of 11.0 $\pm$ 0.2‰ (1s) and 11.5 $\pm$ 0.2‰ respectively. In both rock types, quartz inclusions show the same oxygen isotopic composition as the quartz in the matrix (13.6 – 13.9‰). The tourmalines within the whiteschists are characterized by a core composition similar to pegmatitic tourmalines (X_{Mg} $\sim$ 0.25, 11.3 – 11.5‰) and a dravitic overgrowth (X_{Mg} $>$ 0.9). The overgrowths have lower oxygen isotope compositions (8.9 – 9.5‰). The oxygen isotope composition of quartz included in tourmaline cores lost their magmatic values, obtaining the values of the whiteschist matrix quartz (11.4 – 11.7‰). A network of small cracks filled with dravitic tourmaline can be observed in the magmatic core and could serve as connection of included quartz leading to its recrystallization. Hence, the quartz-tourmaline oxygen isotope fractionation is equilibrated for newly formed tourmaline. Magmatic tourmaline fully retained its igneous oxygen isotope signature. In one of the whiteschist samples, a tourmaline included in high-pressure chloritoid shows the characteristic dravitic overgrowth, demonstrating that chloritoid began to grow after the metasomatism responsible for the whiteschist formation, but continued to grow during the Alpine metamorphism.

Our new in situ oxygen isotope data on tourmaline and quartz, combined with major elements and microstructural observations show that tourmaline-bearing whiteschists originated from the pegmatites prior to Alpine high-pressure metamorphism, confirming their hydrothermal origin.

References:

[1] Ferrando (2012) Terra Nova 24, 423-426

[2] Pawlig and Baumgartner (2001) SMPM 81, 329-346

[3] Marger et al. (2017) Tourmaline 2017 Conference Abstract