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

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Abstract

A series of tourmaline reference materials are developed for in situ oxygen isotope analysis by secondary ion mass spectrometry (SIMS), which allow study of the tourmaline compositions found in most igneous and metamorphic rocks. The new reference material was applied to measure oxygen isotope composition of tourmaline from metagranite, meta-leucogranite, and whiteschist from the Monte Rosa nappe (Western Alps). The protolith and genesis of whiteschist are highly debated in the literature. Whiteschists occur as 10 to 50 m tube-like bodies within the Permian Monte Rosa granite. They consist of chloritoid, talc, phengite, and quartz, with local kyanite, garnet, tourmaline, and carbonates.

Whiteschist tourmaline is characterized by an igneous core and a dravitic overgrowth ($X_{Mg} > 0.9$). The core reveals similar chemical composition and zonation as meta-leucogranitic tourmaline ($X_{Mg} = 0.25$, $\delta^{18}O = 11.3$–11.5‰), proving their common origin. Dravitic overgrowths in whiteschists have lower oxygen isotope compositions (8.9–9.5‰). Tourmaline in metagranite is an intermediate schorl-dravite with X_{Mg} of 0.50. Oxygen isotope data reveal homogeneous composition for metagranite and meta-leucogranite tourmalines of 10.4–11.3‰ and 11.0–11.9‰, respectively. Quartz inclusions in both meta-igneous rocks show the same oxygen isotopic composition as the quartz in the matrix (13.6–13.9‰). In whiteschist the oxygen isotope composition of quartz included in tourmaline cores lost their igneous signature, having the same values as quartz in the matrix (11.4–11.7‰). A network of small fractures filled with dravitic tourmaline can be observed in the igneous core and suggested to serve as a connection between included quartz and matrix, and lead to recrystallization of the inclusion. In contrast, the igneous core of the whiteschist tourmaline fully retained its magmatic oxygen isotope signature, indicating oxygen diffusion is extremely slow in tourmaline. Tourmaline included in high-pressure chloritoid shows the characteristic dravitic overgrowth, demonstrating that chloritoid grew after the metasomatism responsible for the whiteschist formation, but continued to grow during the Alpine metamorphism. Our data on tourmaline and quartz show that tourmaline-bearing whiteschists originated from the related meta-leucogranites, which were locally altered by late magmatic hydrothermal fluids prior to Alpine high-pressure metamorphism.

Keywords: Tourmaline reference materials, SIMS, oxygen isotopes, whiteschist–tourmaline, quartz, Monte Rosa