

Interplay between fluid circulation and Alpine metamorphism in the Monte Rosa whiteschist from white mica and quartz in situ oxygen isotope analysis by SIMS

CINDY LUISIER^{1,2,*}, LUKAS P. BAUMGARTNER^{1,†}, ANNE-SOPHIE BOUVIER^{1,‡}, AND BENITA PUTLITZ¹

¹Institute of Earth Sciences, University of Lausanne, 1015 Lausanne, Switzerland

²University of Rennes, CNRS, Géosciences Rennes UMR 6118, Rennes, France

ABSTRACT

In situ oxygen isotope compositions of white mica and quartz have been used to characterize the interplay of metamorphism and fluid events between a metasomatic whiteschist and its granite protolith in the Monte Rosa nappe, Western Alps. New natural muscovite and phengite reference materials were calibrated for in situ Secondary Ion Mass Spectrometry (SIMS) oxygen isotope measurement. White mica and quartz oxygen isotope compositions were measured in situ in one whiteschist and two metagranites. Based on microtextural observation, phengite composition of white mica, and phase petrology modeling, it is possible to identify two events of fluid infiltration and one event of fluid expulsion, all of which were responsible for forming this unique whiteschist occurrence and for tracing its metamorphic evolution from late Permian intrusion to Alpine subduction and finally to the present day, exhumed whiteschist.

Metagranite samples contain three generations of white mica: igneous, high-*P* metamorphic, and late Alpine, retrograde compositions. In the whiteschist samples, we distinguish two distinct Alpine white mica generations: (1) prograde to peak generation and (2) retrograde generation.

The $\delta^{18}\text{O}_{\text{VSMOW}}$ values of white mica and quartz from a whiteschist of 5.3 to 7.3‰ and 9.1 to 10.6‰ are significantly lower than in the metagranites, with 9.1 to 10.8‰ and 13.2 to 14.6‰, respectively. This indicates a complete recrystallization of the whiteschist protolith during intense fluid-rock interaction. Subsequent Alpine metamorphism transformed the protolith into the whiteschist. The isotopic composition of the whiteschist, fine-grained, retrograde white mica (5.3 to 6‰) is lower than that of the high-pressure phengite (6.2 and 7.5‰). The low $\delta^{18}\text{O}$ values could be explained by infiltration of external fluids with $\delta^{18}\text{O}$ values of 2 to 6‰. Such fluids would carry the isotopic signature of the serpentinites of the Piemonte-Liguria Ocean by either equilibration of fluids with or dehydration of serpentinites. Another, more simple explanation would be the infiltration of very small quantities of fluids leading to the breakdown of chloritoid. Local inheritance of the oxygen composition would then hide the origin of the fluids.

Isotope exchange temperatures calculated from high-*P* phengite-quartz pairs in whiteschist give an average temperature of 440 ± 50 °C. These are lower than the best *T*-estimates from phase petrology of 570 °C, at 2.2 GPa. Igneous muscovite-quartz pairs in the metagranite yield 400 ± 40 °C. Only one high-*P* phengite-quartz pair was analyzed, resulting in 350 ± 40 °C. Greenschist facies, low silica phengites give an average temperature of 310 ± 10 °C. Propagation of analytical uncertainty suggests large errors of 60 to 120 °C, due to the relatively small *T*-dependence of the quartz-white mica fractionation factor for oxygen isotopes.

Keywords: White mica reference material, SIMS, oxygen isotopes, Monte Rosa, whiteschist, fluid-rock interaction; Isotopes, Minerals, and Petrology: Honoring John Valley