

Multiple titanium substitutions in biotites from high-grade metapelitic xenoliths (Euganean Hills, Italy): Complete crystal chemistry and appraisal of petrologic control

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ABSTRACT

Biotites from metapelitic xenoliths included within trachytes from the Euganean Hills (Italy) were analyzed by single-crystal X-ray diffraction (XRD), electron microprobe (EMP), scanning electron microscope (SEM), secondary ion mass spectrometry (SIMS), and Mössbauer spectroscopy. These biotites are Ti-rich and occur in gneissic xenoliths that underwent regional high-*T*/low-*P* metamorphism, at about 750 °C, followed by pyrometamorphism during incorporation in the melt at temperatures close to 950 °C.

Biotites are zoned, with TiO₂ content ranging from 6.79 (cores) to 8.14 wt% (rims). SIMS measurements show that the H₂O content is in the range 2.88–4.08 wt%. The simultaneous occurrence of high-Ti and high-H₂O contents, and the main cation substitutions based on EMP analyses suggest that the role of Ti-oxy in these biotites is less important than Ti-vacancy and Ti-Tschermak substitutions. Single-crystal XRD confirms that the Ti-oxy exchange was indeed effective but not the dominant substitution mechanism.

Based on our data and those taken from literature on petrologically well-constrained systems, we propose that there is a petrologic control on the type of Ti-substitution mechanisms. We consider two types of petrologic groupings for biotites: (1) group A consisting of biotites from H₂O-free or H₂O-poor petrologic environments (e.g., volcanic rocks, ultrabasic xenoliths, and crustal xenoliths in which biotite underwent incongruent melting): Ti substitution in these biotites occurs via Ti-oxy predominantly, or more specifically Fe³⁺-Ti-oxy; and (2) group B consisting of biotites from H₂O-rich petrologic environments (e.g., metamorphic rocks and crustal granitoids): Ti-vacancy, or more specifically Fe³⁺-Ti-vacancy, is the dominant mechanism in them.

It is concluded that during high-grade metamorphism the dominating type of Ti substitution in biotite is controlled by H₂O activity.

Keywords: Biotite, Ti-oxy substitution, SCXRD, SIMS