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Incorporation of Zn in the destabilization products of muscovite at 1175 °C under disequilibrium conditions, and implications for heavy metal sequestration

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Abstract

This work reports on the thermal decomposition of muscovite within a granite powder doped with 8.5 wt% ZnO and heated during 10 min to 68 h at 1175 °C, and the implications for the sequestration of Zn, and other heavy metalts in such decomposition products. Samples were characterized using analytical scanning and transmission electron microscopy. After 10 min, muscovite is completely pseudomorphosed by Si-rich glass, spinel structure phases, and minor mullite. Spinel phases incorporate Zn, but their compositions depend on their position within the muscovite pseudomorphs. Al-rich oxides crystallize at the core of the pseudomorphs while Zn-Al spinels are located at the rims. The most Al-rich spinels have compositions close to γ-Al_2O_3, a metastable transition alumina, with up to 5 wt% MgO, 2 wt% Fe_2O_3, 4 wt% ZnO, and 9 wt% SiO_2. The most Zn-rich spinels show compositions intermediate between Al_2O_3 and gahnite ($ZnAl_2O_4$), with up to 31 wt% ZnO and significant contents of MgO (3 wt%), Fe_2O_3 (5 wt%), and SiO_2 (10 wt%). After 68 h, stable spinels are gahnite close to the end-member composition with MgO and Fe_2O_3 contents below ca. 5 wt%, and SiO_2 contents ca. 1 wt%. These results support the existence of a metastable solid solution between γ-Al_2O_3 and gahnite. This experimental work shows that Zn can be incorporated in spinel structures after heating at 1175 °C during short durations and Zn is preferentially incorporated in the muscovite pseudomorphs as opposed to the Qtz-Fds glass. Consequently, the thermal breakdown of phyllosilicates can be a viable process to immobilize heavy metals such as Zn.

Keywords: Crystal growth, Al-Zn oxide, gahnite, high-*T* studies, experimental petrology, muscovite, focused ion beam, electron diffraction, electron microscopy