American Mineralogist, Volume 102, pages 1006–1020, 2017

Controls on trace-element partitioning among co-crystallizing minerals: Evidence from the Panzhihua layered intrusion, SW China

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Abstract

The factors and processes that control trace-element partitioning among co-crystallizing cumulus minerals in layered intrusions have long been controversial. Here we address this issue using new laser ablation ICP-MS trace element data for magnetite, ilmenite, and clinopyroxene from the Panzhihua layered intrusion in the Emeishan large igneous province, SW China. The cumulus minerals display strong Ni, Co, and Cr depletions, indicative of parental magmas low in concentration of these elements probably due to prior sulfide removal and the fractionation of chromite or Cr-magnetite in a staging magma chamber at depth. Both magnetite and clinopyroxene show cyclical variations in some transition elements (e.g., Cr, V, and Ni) along the stratigraphic section. The average concentrations of these transition elements in magnetite are positively correlated with those in clinopyroxene, likely resulting from co-crystallization of magnetite and clinopyroxene. The incompatible element (e.g., Zr, Hf, and Nb) concentrations of the cumulus minerals from the Lower Zone are highly variable compared to those of the Middle and Upper Zones. These large variations in trace element compositions are attributed to a "trapped liquid shift" in the Lower Zone. Ilmenite crystals from the Panzhihua intrusion may have undergone extensive modification of transition elements during subsolidus re-equilibration with magnetite, leading to the decoupled variations of transition elements in ilmenite across the Lower Zone stratigraphy. Our study indicates that systematic trace element variations of the main cumulus mineral assemblage, rather than a single mineral, need to be considered to better constrain the magmatic differentiation and elemental fractionation of layered intrusions.

Keywords: Mineral trace element geochemistry, Fe-Ti oxides, co-crystallization, Panzhihua layered intrusion, Emeishan large igneous province