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Using Multiphase Solid Inclusions to Constrain the Origin of the Baima Fe-Ti-(V) Oxide Deposit, SW China

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Multiphase solid inclusions within cumulus silicates, particularly olivine, in Fe-Ti oxide ores from the Lower Zone of the Baima intrusion, Emeishan large igneous province, SW China, have been identified for the first time using 2-D scanning electron microscope and 3-D high-resolution X-ray computed tomography. These inclusions are spherical to subspherical and range from 100 to 300 μm in diameter. They are composed dominantly of titanomagnetite and ilmenite with minor apatite, hornblende, phlogopite and pyrrhotite. The titanomagnetite in the inclusions has low Cr contents (<700 ppm) similar to the interstitial titanomagnetite, suggesting that these inclusions cannot be early crystallized mineral aggregates. In contrast, the spherical shape of these inclusions provides evidence of early trapped liquids from which these minerals were crystallized. Based on the composition and modal proportions of the daughter mineral phases within the inclusions, the trapped liquids are estimated to have 82.1 to 59.6 wt% FeO_T, 11.4 to 18.5 wt% TiO_2, 2.69 to 6.12 wt% Al_2O_3, 1.40 to 4.47 wt% MgO, 0.87 to 4.93 wt% SiO_2 and ~1 wt% volatiles including F, S, Cl, P and H_2O. Such a liquid composition deviates far from those of the slightly evolved ferrobasaltic magmas parental to Fe-Ti-(V) oxide-bearing mafic-ultramafic intrusions of the Emeishan large igneous province. It is thus speculated that these trapped liquids are immiscible Fe-Ti oxide melts formed upon cooling of the ferrobasaltic magmas. The net-textured/ disseminated oxide ores have titanomagnetite compositions similar to those in the inclusions, suggesting that the oxide ores of the Baima intrusion have also formed from the Fe-Ti oxide melts immiscibly separated from the ferrobasaltic magmas. We propose that the immiscible Fe-Ti oxide liquids with high density percolated down through crystal-bearing silicate magma and crystallized interconnected Fe-Ti oxide network interstitial to olivine, plagioclase and clinopyroxene. This study highlights that immiscible separation of Fe-Ti oxide liquids from ferrobasaltic magmas is an important mechanism for the formation of magmatic Fe-Ti-(V) oxide deposits hosted in mafic-ultramafic layered intrusions.

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