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Parameterized lattice strain models for REE partitioning between amphibole and silicate melt

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ABSTRACT

The distribution of rare earth elements (REEs) between amphibole and silicate melt is important for understanding a wide variety of igneous and metamorphic processes in the lithosphere. In this study, we used published experimental REE and Y partitioning data between amphibole and silicate melt, the lattice strain model, and nonlinear least-squares regression method to parameterize key partitioning parameters in the lattice strain model (D_0, r_0, and E) as a function of pressure, temperature, and both amphibole and melt compositions. Two models, which give nearly identical results, are obtained in this study. In the first model, D_0 depends on temperature and amphibole composition: it positively correlates with Ti content and negative correlates with temperature and Mg, Na, and K contents in the amphibole. In the second model, D_0 depends solely on the melt composition: it positively correlates with Si content and negatively correlates with Ti and Ca contents in the melt. In both the mineral and melt composition models, r_0 negatively correlates with the ferromagnesian content in the M4 site of the amphibole, and E is a constant. The very similar coefficients in the equations for r_0 and best-fit values for E in the two models allow us to connect the two models through amphibole-melt phase equilibria. An application of our model to amphiboles in mantle xenoliths shows that observed major element compositional variations in amphibole alone can give rise to order of magnitude variations in amphibole-melt REE partition coefficients. Together with experimental data simulating fractional crystallization of arc magmas, out models suggest that: (1) REE partition coefficients between amphibole and melt can vary by an order of magnitude during arc magma crystallization due to variation in the temperature and composition of the amphibole and melt, and that (2) amphibole fractional crystallization plays a key role in depleting the middle REEs relative to heavy REEs and light REEs in arc magmas.

Keywords: REE and Y partition coefficients, amphibole, amphibole melting in the mantle, amphibole fractional crystallization