Parameterized lattice strain models for HFSE partitioning between amphibole and silicate melt with application to arc magma evolution

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The role of amphibole fractional crystallization in generating differentiation trends in arc magmas [1, 2] can be better understood by constraining the parameters responsible for the large range in experimentally determined trace element partition coefficients between amphibole and melt. In this study, we used published experimental high field strength element (HFSE) partitioning data between amphibole and silicate melt, the lattice strain model [3], and non-linear least squares regression method to parameterize key parameters in the lattice strain model (D_0, r_0, and E) for amphibole as a function of pressure, temperature, and both mineral and melt compositions. In our tetravalent HFSE (Zr, Hf, Ti) partitioning model, D_0 negatively correlates with Ti content in the melt, r_0 negatively correlates with Ti content in the amphibole, and E positively correlates with r_0. The pentavalent HFSE (Nb, Ta) partition coefficients were empirically modelled as a function of amphibole composition and D_{Hf}. Application of our tetravalent and pentavalent HFSE partitioning models and our previous REE partitioning model [4] to experimental data simulating fractional crystallization of arc magmas [5] suggests that (1) HFSE and REE partition coefficients between amphibole and melt can vary by a factor of three and ten respectively during arc magma crystallization due to variation in the amphibole and melt compositions, (2) amphibole fractional crystallization causes significant fractionation within and between HFSEs and REEs (e.g. it increases Zr/Hf and Zr/Nd ratios, and decreases Dy/Yb and Dy/Dy* ratios) in arc magmas, and finally (3) it plays a key role in buffering the HFSE and REE concentration in arc magmas.

References

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