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An evaluation of garnet fractionation proxies in arc magmas

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The view that the chemical compositions and trends observed in igneous suites formed at arcs may encapsulate information about the mineral species fractionating from magmas during their differentiation in the crust is widely agreed. One mineral of particular interest in this respect is garnet, because its stability is pressure sensitive and, therefore, the presence or absence of chemical fingerprints giving away its fractionation may inform about the depth of magma differentiation and, possibly, about magma source conditions and crustal thickness. A series of major and trace elements and their ratios showing affinity for garnet are commonly used as indicators of its fractionation, but whether the trends displayed by such elements and ratios in differentiating arc magmas indeed carry evidence of garnet fractionation remains ambiguous. In order to assess how the fractionation of garnet and other minerals contribute to arc differentiation, here the instantaneous chemical effects imposed by the removal of these minerals on the evolving magmas are evaluated with the help of a global compilation of arc data, data retrieved from a large number of melting experiments, and thermodynamic modeling. Results of the analysis suggest that, when plotted against differentiation indicators MgO or SiO_2, parameters proposed to serve as garnet fractionation proxies such as FeO, MnO, FeO/MgO, MnO/MgO, Sr/Y, Gd/Yb, Dy/Yb display limited or no capability to discriminate garnet present vs. garnet absent magma evolution in arcs. This is either because the chemical effects of garnet removal are in practice indistinguishable from—or overwhelmed/masked by—the effects of other crystallizing minerals, or because unrealistic scenarios of garnet fractionation would be required to explain the observed natural trends. While these findings indicate that arc differentiation trends in general carry no conclusive evidence of garnet fractionation, they do not necessarily imply the absence of this mineral from the crystallizing assemblages.