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Apatite stability and partitioning in silicate melts

PATRICK MANSELLE, MA, STEPHEN F. FOLEY AND SVYATOSLAV S SHCHEKA

Macquarie University

Presenting Author: patrick.manselle@hdr.mq.edu.au

Trace element ratios in volcanic arc rocks are commonly used to infer the origin and magmatic history of melts as they ascend through the crust. These can used to infer processes like fractionation or partial melting if the partitioning behaviour of each element and mineral is known, making partitioning information of common minerals essential to understanding the nature of crustal processes. Many amphibole mineral cumulates from crustal xenoliths contain apatite as an accessory phase. Apatites are known to incorporate higher concentrations of trace elements than other common minerals such as amphibole group minerals or pyroxenes (e.g. D_{La} 11.4 for apatite [1], 0.129 for amphibole [2]). Prior experimental studies of apatite partitioning in artificial compositions approximating silicic melts have similar patterns but have wide variations between studies (e.g. D_{La} in basaltic andesitic melts vary from 4.85 [1] to 28.2 [3]). They also tend to have extremely high levels of P_2O_5 in the starting material. Fractionation of apatite depletes the melt in light REE and enriches it in heavy REE, similar to the fractionation of amphibole group minerals, but may affect the Dy/Yb ratio more strongly. The fractionation of relatively small amounts of apatite could significantly affect “amphibole sponge” models of fractionation in the lower and middle crust. However, despite the possible significance of apatite fractionation, there are no reliable experimental partitioning data for apatite in silicic melts for several crucial elements.

This study addresses the role of apatite in convergence zone magmas, presenting new partition coefficients for numerous trace elements, including the full suite of rare earth elements, between apatite and melts with intermediate silica contents. Our results confirm that apatite preferentially incorporates the middle and light rare earth elements. We show that D_{REE} for apatite in basaltic andesite melts range from 1.9-3.7, with peaks at the light REE. Results for many elements are consistent with previous apatite partition coefficients for in basaltic andesite melts.

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