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Distinguishing the garnet signatures in a global database of adakites

YAJIE GAO[1], HUGH ST.C O'NEILL[2] AND JOHN A MAVROGENES[1]

[1]Australian National University
[2]Monash University
Presenting Author: yajie.gao@anu.edu.au

Some intermediate and more evolved magmas from convergent margin settings, termed adakites, have been proposed as slab melts from their trace-element geochemistry, primarily Sr-Y systematics. Adakites are characterized by high Sr and low Y. The low Y (and Yb) is commonly attributed to garnet control, hence the inference of melting at depth. Sr and Y are relatively well determined by XRF, which may explain why they were chosen at the time of the initial hypotheses for examining geochemical data for this signature[1]. Since then, advances in trace-element analysis have revolutionized geochemical databases, and garnet signatures may now be more certainly identified using complete Rare Earth Element (REE) patterns, which have become routinely measured to high precision. Interpretation of Sr-Y systematics is often ambiguous, and has not been helped by a tradition of plotting Sr/Y against Y, which introduces spurious correlation, obfuscating rather than illuminating relations. Simply plotting Sr against Y on a logarithmic scale shows the same information more clearly.

Decomposing chondrite-normalized REE patterns into orthogonal shape coefficients makes use of all the information in the pattern, thereby increasing sensitivity and reliability[2]. Here we use shape coefficients to identify garnet signatures in a global adakite database. The method can distinguish the role of garnet in the evolution of a magmatic suite by fractional crystallization from its role in partial melting, provided the REE pattern of the source or parental melt is assumed. In either case, the amount of garnet involved may be estimated. The effect of accessory zircon is shown to be negligible by calculating the maximum extent of crystallization, and similar tests can be applied to other minerals. Partial melting modelling of amphibolite without residual garnet starting from upper oceanic crust (UOC) or lower continental crust (LCC) cannot produce the adakite REE patterns. Mixing of UOC melt with marine sediments, which shows similar REE trends to amphibole fractionation, is likewise not able to produce garnet signatures.

[1] Defant, M. J., & Drummond, M. S. (1990). Nature 347, 662-665.

[2] O'Neill, H. St. C. (2016) Journal of Petrology 57, 1463-1508.