

Correlation of REE with Moho Depth for Modern Volcanic Arc Basalts

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REE ratios established in volcanic arc basalts can be related to the depth of the Mohorovicic Discontinuity. This relation has been established using a database of modern arc basalts where seismic data is available to directly interpret the Moho depth. A dataset of >1100 basalt analyses from over 50 active volcanoes, representing most major arc systems around the globe, indicates an exponential increase in the maximum Ce/Y, La/Y and Ce/Yb ratios between Moho depths of 15-50km.

The relation between REE ratios of arc basalts to Moho depth is established in open system basaltic magma chambers where multiple cycles of recharge by primitive magma compositions are coupled with ongoing fractionation. This allows incompatible element ratios to be enriched to a maximum upper limit, dependant on the partition coefficients of crystallising phases that are related directly to the pressure and therefore depth of generation. Specifically, in hydrous arc magmas, the crystallising assemblage changes from olivine + plagioclase + clinopyroxene to two pyroxene dominated at greater depth, that progressively increases the bulk partition co-efficient for HREE and thus systematically increases the HREE/LREE with depth during fractionation. However, garnet is not part of this crystallising assemblage, only becoming a precipitating phase with advanced degrees of fractionation, when the magma is not basaltic. REE ratios are independent from the major element concentrations as new parental melts can significantly increase the major element concentrations while only moderately influencing the elevated REE ratios.

This calibration of REE ratios to Moho depth in volcanic arc basalts has the potential to provide estimations of crustal thickness through space and time within ancient orogenic systems. This calibration has been applied to the accretionary orogen of New Zealand's south island. The results show considerable changes in lithospheric thickness between 380 Ma and 100 Ma. The estimated lithospheric thickness generated by the REE/Moho calibration is in strong agreement with the current developed orogenic history for this system, lending support to the viability of this exciting new calibration of REE ratios to Moho depth in volcanic arc basalt.