Goldschmidt 2025 Abstract
https://doi.org/10.7185/gold2025.25549

Polybaric differentiation for arc magma genesis: a perspective from alumina saturation index

PENG GAO[1], MARCOS GARCÍA-ARIAS[2], LONG CHEN[3], HUA XIANG[4], HAI-OU GU[5] AND ZI-FU ZHAO[1]

[1]University of Science and Technology of China, Hefei
[2]Universidad de Salamanca
[3]Ocean University of China
[4]State Key Laboratory of Deep Earth and Mineral Exploration, Institute of Geology, Chinese Academy of Geological Sciences
[5]Hefei University of Technology

The crustal level at which arc magma differentiation predominantly occurs remains a subject of debate. Experimental petrology has demonstrated that the SiO_2-ASI (alumina saturation index) relationship of arc magmas could address this issue because it strongly depends on pressure, but these results are far from conclusive due to either insufficient evaluation or inconsistency with geological observations. Using compiled data from arc volcanics and crystallization experiments, this study classifies the arcs as thick (40–63 km), normal (25–35 km) and thin (15–20 km) according to crustal thickness. We find that experimental melts produced at the corresponding arc root pressures can only account for the most aluminous compositions at intermediate SiO_2 content (55–65 wt%), with the typical lesser aluminous compositions requiring lower pressure crystallization. Phase equilibrium modeling is further used to model the crystallization processes from primitive arc rocks on different modes (isobaric and polybaric, equilibrium and fractional). Modeled results verify the experimental findings and highlight that the liquid lines of descent (LLD) from 0.2 GPa overlap the lesser aluminous parts of the SiO_2-ASI plots for arc rocks. LLD from H_2O-poor systems are deviated to lower ASI at constant SiO_2 relative to the H_2O-rich ones. The dominant phase to increase melt ASI is clinopyroxene, whereas garnet at high-pressure and plagioclase at low-pressure (especially H_2O-poor) play an opposite role. This study underscores that polybaric differentiation is more relevant to the genesis of arc volcanics than deep crustal differentiation, irrespective of crustal thickness.