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Granite formation in arcs: one view from high pressure experiments

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The composition of the continental crust of the Earth is unique in the solar system and is the most accessible witness of differentiation processes. One way to form voluminous granites is by island arc magmatism, where primary mantle derived magmas form and differentiate to produce juvenile continental crust. We review igneous experimental data designed to understand fractionation processes, with an emphasis on the roots of magmatic arcs, focusing on equilibrium and fractional crystallization experiments in dry and hydrous basalts to andesites to simulate the liquid and cumulate lines of descent of primary mantle derived magmas. An evaluation of the major element composition indicates that the cumulate line of descent (CLD) of hydrous systems is fundamentally different from dry systems. Cumulates derived from hydrous experiments display elevated $Al2O_3$ and CaO contents at low SiO_2, producing voluminous andesitic to rhyolitic liquids, which closely overlap with compositions of natural systems, while dry systems follow fundamentally different fractionation paths. The mineralogical and chemical composition of cumulates converges for very different primary hydrous primary mantle magmas, indicating that fundamental phase equilibria under the conditions prevailing in the roots of magmatic arcs exert a strong control on the compositions of derivative andesitic to rhyolitic liquids. Melting experiments on amphibolite or basaltic to andesitic compositions equally produce granitic – rhyolitic liquids of similar composition yet their restites do not present the same variability of the CLD of hydrous fractional crystallization experiments. Despite ubiquitous evidence for assimilation and mixing in volcanic and plutonic rocks, such as mafic enclaves, resorbed phenocrysts, reversed phenocryst compositions and disequilibrium assemblages in arc volcanic rocks, experiments show striking similarities to arc lower crust suggesting that fractionation in the lower crust is fundamental for granite formation.