Water fluxing during subduction controls the efficiency of continental crust formation through Earth history

William J. Collins[1] and Hui-Qing Huang[2]

COLLINS, WILLIAM. J. 1, and HUANG, HUI-QING, 2.

1 Earth Dynamics Research Group, and The Institute for Geoscience Research (TIGeR), Department of Applied Geology, Curtin University, GPO Box U1987, WA 6845, Australia.
william.collins@curtin.edu.au

2 Department of Earth & Environmental Sciences, James Cook University, Townsville, Qld, 4811

Although the Earth's continental crust is estimated to have an average andesitic composition, a recent comprehensive analysis of a global dataset of igneous rocks showed that intermediate (andesitic) rocks are much less abundant than mafic and felsic rocks. Furthermore, a global compilation of melt inclusions from arc volcanos also has revealed a dearth of intermediate melts and a fundamental role of felsic melts in the formation of continental crust. However, debate persists as to how felsic melts and such compositional gaps form. We use an updated global compilation of melt inclusion data, and examine experimental studies of basaltic rocks, to suggest that felsic melts dominantly form by water fluxed partial melting of mafic crust, rather than by fractionation of basaltic magmas or dehydration melting. We propose that fractionating hydrous arc basalts exsolve an aqueous phase during strong undercooling in thermally buffered arc roots, creating and stabilising an "enthalpy trap" that dissipates thermal energy by promoting partial melting of pre-existing crust, including newly underplated mafic crust, to produce cool, voluminous felsic melts at temperatures <800 °C. Mafic and felsic components then mix inefficiently to produce the typical spectrum of magmatic arc rocks. It is the variable flux of slab-derived water passing through the mantle and crust during subduction that creates the potential to trigger voluminous crustal melting, leading to efficient production of juvenile and evolved continental crust. Zircon saturation temperatures and Ti-in-zircon geothermometry from granites, Archean to present-day, suggest this has been a dominant process throughout Earth history.