The genesis of silicic magmas in shallow crustal cold zones

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A number of currently popular models for the genesis of silicic arc magmas invoke repeated intrusion and partial melting and differentiation at the base of the crust. However a number of observations suggest that this may be the exception rather than the norm: (1) geobarometry often indicates shallow pressure (typically 0.1-0.3 GPa) evolution; (2) incongruent melting of amhibolite at elevated pressures should yield magmas in equilibrium with high pressure phases like garnet, but rare earth element patterns almost ubiquiously preclude this; (3) compositionally zoned caldera forming erptions suggest differentiation at near surface depths; (4) U-series data most commonly indicate differentiation over millennia which requires rapid cooling that in turn is most easilly explained by crystallisation and differentiation by cooling of relatively small magma volumes in the shallow (i.e. cool) crust.

In order to further test these ideas, we combined new and published experimental phase equilibria for appropriate silicic arc magma compositions. When projected on ternary sections of the basalt tetrahedron (including diopside-quartz-olivine and plagioclase-quartz-olivine) recent data for Tongan andesitites and dacites plot either on or close to 1 atmosphere cotectics for the rock's phenocryst phases, suggesting low pressure differentiation. This is consistent with new experimental results for a Tongan andesite. Using our own and published data from arc volcanoes around the world we find that the majority are consistent with differentiation at low pressures. We conclude that evidence for the genesis of silicic arc magmas at higher pressures is generally lacking.