Style of effusive arc volcanism, links to subduction velocity, and implications for magma transfer

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Lava domes: young eruptions of old magmas

The controls of petrogenetic processes on the style of effusive volcanic eruptions at subduction zones are constrained on a global scale: ^{238}U-^{230}Th and other compositional data from young arc volcanics, combined with geospeedometry and information on eruptive style, show that crystal-rich viscous lava domes are commonly generated by remelting of previously intruded old plutonic protoliths.

Links with crustal temperature

The distribution of worldwide lava dome compositions at arcs, with andesites being dominant and increasingly evolved magmas increasingly less abundant, indicates that lava dome formation is favourable in environments where there is insufficient time for magmatic differentiation. This suggests that those magma bodies that solidify to form the plutonic protoliths of dome lavas are often small and ephemeral due to low ambient crustal temperatures. In contrast, higher crustal temperatures will increase the time available for magmatic differentiation, but will also impede magmatic solidification and therefore suppress lava dome formation. This model is consistent with a good correlation of the proportion of Holocene effusive arc lavas that erupt as lava domes [1] with inferred surface heat flux [2] in continental arcs (R^2=0.59).

Correlation with subduction parameters and implications

Dome proportion may thus be used as an indicator for crustal temperature, which *a priori* may depend on type and thickness of the arc crust, and on magma flux rate. Lava dome proportion correslates weakly with crustal thickness (t_c), moderately well with the inverse of subduction velocity ($1/V_{cba}$), and best with t_c/V_{cba} (R^2=0.59). Subduction velocity appears to be a good proxy for magma flux rate.

Hence, on timescales of less than of 10^4 yrs and lengthscales of 10^5-10^6 m, magma flux through the arc crust is in steady state. This observation casts doubt on the recently suggested existence of coexisting melts of vastly different ages and compositions in lower crustal 'hot zones' [3].

References

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