Some first-order observations on magma transfer at volcanic arcs

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The viscosity of lavas erupted at volcanic arcs varies over orders of magnitude. A comparison of the relative abundance of viscous lava dome eruptions indicates that the average viscosity of arc lavas also varies considerably between arcs. It will be shown that for continental or transitional arcs with little within-arc crustal deformation and without underlying slab windows or tears, average lava viscosity is anti-correlated with average surface heat flux (R^2=0.77). The latter may be influenced by crustal thickness and crustal magma throughput. To constrain the relative contributions of these parameters, variations of average lava viscosity with average crustal thickness and plate convergence rate are assessed. While crustal thickness appears to have little effect on average lava viscosity, a good anticorrelation exists between average lava viscosity and plate convergence rate (R^2=0.71), with the exception of two arcs that show significant intra-arc crustal deformation. If plate convergence rate is a good proxy of the rate of melt generation within the mantle wedge, these first-order observations indicate that where the rate of mantle melting is high, crustal magma throughput is rapid and efficient, resulting in low viscosity melts migrating through a hot overriding crust; in contrast, where the rate of mantle melting is low, crustal magma transfer is slow and inefficient, resulting in high viscosity melts that may frequently stall within a cool overriding crust prior to eruption. Uranium series geochemical evidence from dome lavas is presented and lends support to this interpretation. This leads to a general model of eruptive style dependence on crustal magma transfer processes. Finally, the observed average viscosity variations of some arcs with underlying slab windows or tears and/or significant intra-arc crustal deformation will be discussed with reference to their geochemical characteristics.

Recent bimodal magmatic processes and their rates in the Torfajökull-Veidivötn area, SE Iceland

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Historical eruptions of bimodal composition eruptions from Torfajökull central volcano and the neighbouring Veidivötn fissure swarm in southeastern Iceland provide insights to the nature and timing of basalt and rhyolite genesis and eruption at an active divergent plate boundary. This study focuses on lavas and tephras of the last two regional eruptions in 871 and 1477AD, using samples that approximate mafic and felsic endmember compositions relative to regional mixing trends. Whole rock and mineral U-Th-Ra isotopic compositions indicate both rapid petrogenetic timescales and limited compositional variation in the basalt and rhyolite magma sources. Torfajökull rhyolites show the greatest ^{230}Th excesses ($\leq$ 17%) at only slightly lower (^{230}Th/^{232}Th) activity ratios than co-eruptive Veidivötn basalts. Both magma types display small but significant ^{226}Ra excesses ($\leq$ 10% and $\leq$ 60% in rhyolites and basalts, respectively). Trace element and U-series isotopic data are consistent with crustal melting dominated by young ($\leq$ 60 kyrs), metasomatized mafic protoliths similar in composition to the Veidivötn tholeiites as source of the 871 and 1477 Torfajökull rhyolites. Young protolith ages are inconsistent with previous models that call on old materials as source rocks for Icelandic rhyolites (e.g., old silicic segregation lenses or isostatically subsided lavas). Zero-age U-Th and few-ka Ra-Th mineral - whole rock isochrons suggest crystallization shortly prior to eruption, consistent with petrographic and compositional indicators that the crystals are phenocrysts, and the data suggest that the rhyolite melts are of Late Holocene age.