Arc magma genesis from melting of mélange diapirs

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High-alumina and high-alkali basalts occur in subduction-related volcanic settings worldwide, yet their geochemical origin continues to be debated. Recent studies have suggested that buoyant mélange material may rise as low-density plumes or diapirs from the slab-mantle interface into the hot corner of the mantle wedge, where it will melt or induce mantle melting due to dehydration. Because these high-pressure mélange rocks are often dominated by chlorite, they are characterized by high Al_2O_3 content. Thus, chlorite schists are saturated in an Al-phase during partial melting, producing high-Al melts. We present new data from experimental melting and dehydration of chlorite-rich mélange material at mantle wedge conditions that coincide with the range of compositions observed in high-Al arc lavas.

Piston cylinder experiments were performed at conditions that are appropriate for mantle wedge diapirs (990–1150 °C, 1.5–2.5 GPa) using natural mélange rocks from Syros, Greece. Experiments performed at high pressure (2.5 GPa) on essentially pure chlorite schist dehydrate, resulting in a free fluid phase in equilibrium with garnet and 2 spinels. Experimental melts derived from omphacite-epidote-bearing chlorite schists range in composition from basanite (43.4–
43.7 wt% SiO_2, 3.6–3.7 wt% Na_2O+K_2O) to basalt/basaltic andesite (46.9–50.8 wt% SiO_2, 2.2–3.0 wt% Na_2O+K_2O) to very high alkali contents (46.1–59.9 wt% SiO_2, 7.4–11.3 wt% Na_2O+K_2O). Melts derived from talc-chlorite-actinolite schist are dacitic (73.5–73.9 wt% SiO_2, 7.3–7.9 wt% Na_2O+K_2O). All of the experimental melts have very high alumina contents (15.9–20.4 wt% Al_2O_3). Restitic minerals coexisting with melt include clinopyroxene, orthopyroxene, two spinels, ilmenite and/or rutile, magnetite, apatite, amphibole (at lower T) or olivine (at higher T), and garnet (at higher P).

The wide range of silica contents, coupled with the high alumina and high alkali contents of the experimental melts in this study, suggest that a vast array of major element compostitions in volcanic arcs can potentially be explained by melting of chlorite-rich mélange rocks in mantle wedge plumes or diapirs.