Nepheline-normative primitive melt genesis in arcs: mineralogic and lithospheric controls

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Nepheline-normative Ca-rich melts crystallize neither hypersthene nor quartz due to higher Na_2O, K_2O, and CaO contents than tholeiitic basalt and are rare in volcanic arcs compared to water-rich silica-normative magmas. Unlike basalts, nepheline-normative melts cannot derive from partial melting of the upper mantle, but require melting of pyroxenite, an ultramafic pyroxene- and olivine-rich body. The origin and mineralogy of such a pyroxenite body, the depth of melting, and the volcanological and geodynamical significance of such melts remain disputed. We selected olivine-hosted glassy melt inclusions naturally rich in volatiles, from nepheline-normative magmas at La Sommata cone (Aeolian arc) for high-resolution isotopic, major, trace, and volatile element analyses. The inclusions are CaO-rich and nepheline-normative with little variation in Mg# (0.62–0.69; molar MgO/(MgO + FeOtotal), CaO/Al_2O_3 (1.13–1.55), or trace element abundance (*e.g.,* Nb, 3 to 5 ppm, and Y, 12 to 16 ppm). Their δD (–96 to –18 ‰) and $\delta^{11}B$ (–16 to –2 ‰) compositions are globally consistent with values reported in other arc lavas. The mixing trend of these isotopes identify two endmembers, of which one is a dry solid with mantle-like isotopic characters, and the other is a fluid with a strongly negative δD. Accounting for these endmembers, major and trace elements, we show that the La Sommata magma is derived from a high degree of pyroxenite melting without any interaction with peridotite, but with a strong serpentinite-fluid isotopic signature. More broadly, we propose that nepheline-normative melts derive from lower arc crust in association with significant heating due to fluid injection. We note that the association of such melts with tectonic faults that may provide passage to hot mantle fluids/melts suggests that nepheline-normative melts are alos indicators of deep lithospheric fractures. Ingestion of carbonate by hydrous basatic magma can potentially produce high CaO magma. However, calcite ingestion reaction crystallizes cpx not olivine, this scenario is less favorable in producing olivine hosted melt inclusions.