Mantle metasomatism by slab-derived carbonate melts

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The lithosphere beneath cratons may largely be affected by metasomitic infiltration of slab-derived alkali-rich carbonate melts. In this study we estimate the scale of this process on the basis of our experimental results, literature data on the stabilities of phlogopite [1] and carbonates (K\(_2\)Mg(CO\(_3\))\(_2\)±H\(_2\)O) [2], and occurrence of alkali-bearing carbonate inclusions in mantle-derived material [3]. Our experiments simulate metasomatic reactions between slab-derived carbonate melts [4] and mantle peridotites at 8-13 GPa and 900-1400 °C. According to the results obtained, the extent of metasomatic perturbation in lithosphere can reach > 200 km: from the base of deep lithospheric roots, with the thickness up to 300 km [5], to shallower depths of ~ 110 km. At ~ 390 km depth percolation of slab-derived K-rich dolomitic melts transforms mantle peridotites into alkali-rich carbonated garnet wehrlites. Solidi of such metasomatized peridotites are defined by the stability of KMg-double carbonate and lie ~ 220 °C below an average mantle geotherm, allowing for the presence and further migration of K-rich carbonate (+H\(_2\)O) fluids or melts at favorable \(f_{O_2}\) conditions. Fluid path will be marked by metasomatic enrichment of mantle peridotites in K, C, and incompatible elements. At 6 GPa and ~ 1200 °C, i.e. conditions of a cold cratonic geotherm, phlogopite becomes part of the stable mineral assemblage. Nevertheless, these conditions still exceed the temperature stability of K\(_2\)Mg(CO\(_3\))\(_2\)±H\(_2\)O and hence do not inhibit further fluid migration. Complete solidification can be achieved only at shallower depths within the cold Archean lithosphere. Based on cratonic geotherms, K\(_2\)O-CO\(_2\)-H\(_2\)O liquids are expected to freeze only at depths of ≤ 110 – 115 km, supported by multiphase K\(_2\)Na\(_2\)-carbonate inclusions as reported in mantle-derived material equilibrated at ~ 35 kbar. Isotopic constraints on the source enrichment of alkali-rich ultramafic magmas (kimberlites, lamprophyres, ol lamproites-group II kimberlites) emplaced within AR cratons also indicate the widespread involvement of ancient slab-derived metasomatic agents [5].