Mantle metasomatism by slab-derived carbonate melts

ANASTASIA GOLUBKOVA[1]* AND MAX W. SCHMIDT[1]

[1]ETH Zurich, Clausiusstrasse 25, 8092 Zurich (anastasia.golubkova@erdw.ethz.ch)

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 ($K_2Mg(CO_3)_2 \pm H_2O$) [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 ºC. 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 ºC below an average mantle geotherm, allowing for the presence and further migration of K-rich carbonate ($+H_2O$) fluids or melts at favorable fO_2 conditions. Fluid path will be marked by metasomatic enrichment of mantle peridotites in K, C, and incompatible elements. At 6 GPa and ~ 1200 ºC, 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 $K_2Mg(CO_3)_2 + H_2O$ 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_2O-CO_2-H_2O liquids are expected to freeze only at depths of ≤ 110 – 115 km, supported by multiphase K,Na,C-carbonate inclusions as reported in mantle-derived material equilibrated at ~ 35 kbar. Isotopic constraints on the source enrichment of alkali-rich utramafic magmas (kimberlites, lamprophyres, ol lamproites-group II kimberlites) emplaced within AR cratons also indicate the widespread involvement of ancient slab-derived metasomatic agents [5].

[1] Enggist *et al* (2012) *CMP* **163**, 467-481. [2] Shatskiy *et al* (2013) *AmMin* **98**, 1593-1603. [3] Giuliani *et al* (2012), *Geol* **40**, 967-970. [4] Grassi & Schmidt (2011) *CMP* **162**, 169-191. [5] Artemieva & Mooney (2001). *JGR* **106 (B8)**, 16387-16414. [6] Kargin *et al* (2014). *Petr* **22(2)**, 1-37.