Goldschmidt 2023 Abstract
https://doi.org/10.7185/gold2023.14182

Experimental melting of amphibole-rich metasomes + lherzolite at 1-4 GPa and its constraints for the origin of Na-alkaline magmatism

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An alternative to the traditional view of homogeneous mantle paradigm is the melting of hydrous heterogeneous mantle rocks that contain the so-called hydrous "metasomes" [1-3]. Metasomes comprise mineral assemblages, with the dominant presence of hydrous minerals like mica or amphibole. The melting of hydrous mantle lithologies has been proposed to explain the origin of Na-alkaline lavas [2], traditionally linked to small degree of partial melting of a peridotitic mantle source [4].

We present a new experimental dataset for reaction experiments between natural amphibole-clinopyroxene metasomes and lherzolite that produced Na-rich alkaline melts. Experiments were conducted at 1-4 GPa and 1000 to 1300 °C. The generated melts range from foidite over basanite to phonotephrite. At 1 GPa between 1000 and 1100 °C amphibole is unstable. Instead, amphibole decompression-breakdown products generate phonotephritic melts. At T > 1100 °C, the composition of the melt is controlled by amphibole melting. At 3 and 4 GPa the melt composition is additionally influenced by phlogopite melting and by the presence of garnet in the residue. The melt residues are generally wehrlitic and imply that incongruent melting of metasome produces wehrlitic residue. The melt then reacts with opx from the lherzolite, which again produces wehrlitic residue with different ol/cpx ratios. Therefore, wehrlite formation does not require separate metasomatic processes and can be a direct by-product of alkaline volcanism.

We applied a metasome melting model to the magmas of the Kula volcanic province, Turkey, and show that at 1 GPa basanite melts and phonotephrite melts can cover the whole range of known Kula lava compositions. The Kula lava trend can be therefore generated not by differentiation of basanite but by basanite-phonotephrite melt mixing.

A comparison of high-pressure (3-4 GPa) melts with global nephelinite data shows overlap with most elements but suggest also that the natural nephelinite data are slightly more evolved and do not represent primary metasome melts.

References

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