Experimental melting of phlogopite-peridotite at 1 GPa – Implications for potassic magmatism

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Phlogopite has been recognized as a common phase in the subcontinental lithosphere, where it forms by percolation of ascending deeper fluids/melts. This hydrous phase is also assumed to be present in subduction zones as a result of mantle wedge metasomatism following slab dehydration. As a water repository, phlogopite could thus play a key role during partial melting in such settings and imprints peculiar trace element signatures in magmas. However, the stability of phlogopite in a natural mantle composition, as well as its fluid-absent melting reactions have never been determined.

We conducted piston-cylinder experiments at 1 GPa to determine the stability of phlogopite in both lherzolite and harzburgite under water-undersaturated conditions. Accounting for the effect of F in natural peridotites, we show that phlogopite and melt coexist over 150°C above the solidus (1015°C) at moderate degrees of melting (up to 11.5 %). The melting reactions have been quantified and appear continuous and incongruent – e.g. for lherzolite:

1.00 phl + 0.95 cpx + 0.89 opx + 0.1 sp = 0.93 ol + 1.98 melt

Low-degree melts are silica-saturated (from trachyte to basaltic andesite with increasing degrees of melting). Their K_2O content is buffered by the presence of phlogopite, depending on the source fertility, from ~4 wt% in lherzolite to ~7 wt% in harzburgite. We also determined the trace element partition coefficients between phlogopite and such hydrous, silica-rich melts.

Our data show that magmas with less than 4 wt% K_2O cannot be in equilibrium with residual mantle phlogopite. Conversely, magmas containing more than 7 wt% K_2O cannot come from a phlogopite-peridotite source. Potassic post-collisional lavas (e.g., from Tibet) exhibit a wide range of silica contents (60 – 45 wt% for Mg# > 0.65), with constant K_2O values (~4 wt% for southern Tibet). Such major element trends are in agreement with a phlogopite-bearing mantle source in post-collisional settings, an argument also supported by trace element partitioning models.

EARLYTIME: An initiative to evaluate and improve U-Pb and Pb-Pb dating of meteorites

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Understanding the formation of the Solar System in detail requires an accurate chronological framework for meteorites with precision and accuracy of at least several 100,000 years. Only the absolute Pb-Pb chronometer, with supporting U-Pb data and uranium isotopic composition, provides assumption-free dates with this resolution. However, constructing a timeline for the first ca. 10 Myr of the Solar System using this method requires comparing dates derived from diverse materials from different laboratories and analytical methods, instrumentation and data reduction schemes.

We propose a cooperative, community-based initiative that would start with a systematic evaluation of the compatibility of U-Pb and Pb-Pb data generated by different laboratories and then seek means to improve and standardize methods to the extent possible. An important first step will be the production, distribution and analyses of synthetic standard Pb solutions mixed to replicate a typical 4.56 Ga Pb-Pb data array to test the compatibility of different mass spectrometry approaches and data reduction schemes. This will be coupled with isotopic analyses of a synthetic U solution to be used in the "age" calculation. The results of this phase will be presented as a blind test of the consistency of results from participating laboratories.

The initiative will further prioritize: 1) developing software that would standardize data reduction and presentation, 2) exploring and establishing means to reduce Pb blanks in the sample handling, dissolution and chemical separation of meteoritic materials, 3) obtaining and distributing suitable natural material(s) that will test the full analytical procedures of participating laboratories, 4) working with the well-established EARTHTIME community to evaluate the feasibility of making more ^{202}Pb and ^{205}Pb such that a Pb double spike would be widely available to the community for meteoritic work, and 4) building a consensus on the variation or consistency of the U isotopic ratio(s) of inner Solar System materials. Information about the initiative, that we propose be called "EARLYTIME", will be made accessible via a dedicated website.

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