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A novel approach to determine high-pressure high-temperature fluid and melt compositions using diamond-trap experiments

RONIT KESSEL,[1,*] PETER ULMER,[1] THOMAS PETTKE,[2] MAX W. SCHMIDT,[1] AND ALAN B. THOMPSON[1]

[1]Institut für Mineralogie und Petrographie, ETH-Zentrum, Zürich, Switzerland
[2]Institut für Isotopengeologie und Mineralische Rohstoffe, ETH-Zentrum, Zürich, Switzerland

ABSTRACT

We have developed a novel analytical technique for diamond-trap experiments to directly analyze high-pressure, high-temperature fluid and melt compositions in equilibrium with mantle material. Experiments were conducted at a pressure of 6 GPa and temperatures between 900–1200 °C in a multi-anvil apparatus with a synthetic K-free eclogite doped with 860 ppm Cs, ~20 wt% H_2O, and a layer of diamond aggregates serving as a fluid/melt trap. Experiments at identical conditions were analyzed with two different methods. In the new, "freezing," approach, the capsule was frozen prior to opening and kept frozen during laser-ablation ICP-MS analysis, thus ablating the quenched fluid (precipitates together with water that unmixed upon quenching) in a solid state. Cesium, fractionating completely into the fluid or melt phase, was used as an internal standard for calculating the fluid compositions. Calculated uncertainties on H_2O content in the fluid composition are 0.7–2.5%. In the conventional "evaporation" approach, water from the unmixed fluid was first evaporated from the capsule, then the remaining fluid precipitates were analyzed by LA-ICP-MS. The compositions of the residual eclogitic minerals were measured by electron microprobe, and the fluid composition was then determined by mass-balance. Uncertainties in mineral compositions lead to poor precision in fluid composition in this latter approach. Results of the two methods of fluid analysis were found to be in good agreement. Because the "freezing" approach analyzes the entire fluid directly and does not rely on mass balance for calculating fluid compositions, our new method provides a superior means for determining the composition of fluids. Secondly, it avoids loss of cations that remain soluble in water (e.g., Cs, K) after quenching the experiment.