Solubility of Ru, Rh and Ir in spinel and olivine: can the nugget effect be avoided?

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In-situ concentrations of compatible platinum group elements (IPGEs) in olivine and chromite are important for understanding of mantle evolution and processes controlling of PGE fractionation. Ru in Cr-spinel has become an effective exploration indicator and geochemical tracer for copper-nickel sulfide-type platinum group element deposits [1, 2]. Obtaining reliable solubilities of IPGEs and Rh in minerals remains challenging because of the presence of abundant micronuggets of platinum group minerals (PGMs).

We report a new approach for the determination of PGE solubilities in olivine and spinel, which avoids the micro-nugget problem by diffusing the PGE into single crystals [3]. Extrapolation of the diffusion profile to the diffusion interface gives the equilibrium solubility of the PGE in the crystal at the imposed temperature and oxygen fugacity. We performed diffusion experiments for Rh, Ru and Ir into olivine and spinel at 1300 to 1400ºC, over a range of oxygen fugacities from the FMQ buffer to six log units above (FMQ+ 6.6, in air). For all the experiments, the activities of the main oxide components were controlled using two-phase buffering assemblages.

Experiments demonstrated a strong effect of activity of major components (mineral paragenesis) on the solubilities of the IPGEs and Rh in spinel and olivine at given temperatures and oxigen fugacities. Solubility of IPGEs and Rh increases as a function of fO_2 for both spinel and olivine.

The results of our study provide equilibrium concentrations of IPGEs and Rh and their diffusivities in spinel and olivine, which reveal the mechanisms of PGEs incorporation in these minerals and helps elucidate their fractionation in magmatic systems.

[1] Locmelis et al. (2018) Ore Geology Reviews 97, 152–170. [2] Park et al. (2017) Geochimica Cosmochimica Acta 216, 393-416. [3] Zhukova et al. (2018) Chem Geol 494, 19-29.