Mechanisms of Platinum-group Element Fractionation in Ultramafic Melts and Implications for the Exploration for Magmatic Nickel Sulphide Deposits

Marek Locmelis

GEMOC ARC National Key Centre, Department of Earth and Planetary Sciences,
Macquarie University

Sydney, Australia

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ABSTRACT

Platinum-group elements (PGE) are important as petrogenetic tracers, but owing to their low abundances and complex behaviour they are among the least understood elements in geochemistry. This study investigates the mechanisms of PGE fractionation in ultramafic systems (komatiites, komatiitic basalts, ferro-picrites) and focuses on the role of chromite. Samples from a range of occurrences have been analysed to assess potential controls on PGE behaviour, such as geochemical affinities (Munro-type and Karasjok-type), age (2.0 and 2.7 Ga), emplacement styles, metamorphic grade and nickel-sulphide mineralisation endowment and style.

Data obtained by in-situ laser ablation ICP-MS analysis provide the first direct evidence that Ru can exist in solid solution in chromite with concentrations up to several hundred ppb. The data show that the behaviour of Ru is dominantly controlled by the sulphide-saturation state. In systems that did not equilibrate with a sulphide liquid, chromites have distinctly higher Ru concentrations than chromites from systems that interacted with a sulphur-source during crystallisation. Carius tube digestion isotope dilution ICP-MS analyses of chromite separates confirm the accuracy of the in-situ study and also show that Ir is weakly compatible in chromite. Anomalously high Pt and Pd concentrations in chromite separates reflect the presence of platinum-group minerals (PGM) and suggest that PGM are common accessory phases in komatiites. A study of the PGE-mineralogy shows that PGM in komatiites can be of magmatic and post-magmatic origin and that they often remain undetected due to grain sizes less than 5 μm. As a consequence, the presence of PGE minerals has to be taken into account when whole-rock PGE signatures are interpreted.

The association of Ru-poor chromites with Ni mineralisation and Ru-rich chromites with barren systems provides a new tool for the exploration for nickel-sulphide deposits. This model applies to all magma types and is independent of the age, the geochemical affinity, and other sample characteristics.

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