

# Platinum Group Elements Geochemistry of Abyssal Peridotites: An Integrated Study in the Mark Area (Mid-Atlantic Ridge, 20-24 N) Using ICP-MS, LAM-ICPMS, SEM and Nuclear Microprobe (NMP)

Ambre Luguet (luguet@mnhn.fr)<sup>1</sup>, Olivier Alard (oalard@laurel.ocs.mq.edu.au)<sup>2</sup>,  
Jean-Pierre Lorand (lorand@mnhn.fr)<sup>1</sup>, Norman Pearson<sup>2</sup>, Chrys Ryan<sup>3</sup> & Susan O'Reilly<sup>2</sup>

<sup>1</sup> Laboratoire de Minéralogie, ESA 7058, Muséum National d'Histoire Naturelle, 61 rue Buffon, Paris, 75005, France

<sup>2</sup> GEMOC, School of Earth and Planetary Sciences, Macquarie University, Sydney, Australia

<sup>3</sup> CSIRO, North Ride, Sydney, Australia

A comprehensive study of dredged abyssal peridotites from the Kane fracture zone has been undertaken using high-quality whole-rock ICP-MS data, LAM-ICPMS analyses of sulphides and SEM and NMP data. The studied samples are partial melting residues ( $1.5 < \text{Al}_2\text{O}_3 \text{ wt\%} < 3.2$ ;  $6 < \text{F} < 18\%$ ); however, the clinopyroxene displays a wide range of textures that reflect the incomplete extraction of partial melts (Seyler et al., submitted). They all contain magmatic sulphides either intergranular sulphides (pentlandite and minor serpentinisation-derived phases) or minute Ni- and Cu-rich inclusions (pentlandite, chalcopyrite, bornite) in corroded opx and cpx (Luguet and Lorand, 1999). Seafloor weathering produced iron hydroxides from magmatic sulphides. Magmatic sulphide grains are heterogeneously distributed on all scales, irrespective of fertility indices; cpx-poor lherzolites define a sulphide enrichment trend (up to 110 magmatic grains per polished thin section) that testifies sulphide precipitation from melts en route to the surface during adiabatic partial melting.

Whole-rock data indicate broadly chondritic PGE ratios except for  $\text{Ru}_N/\text{Ir}_N$  (1.2; N = CI-chondrite normalised) and  $\text{Pd}_N/\text{Ir}_N$  which varies by a factor 10. Harzburgites are Pd-depleted ( $\text{Pd}_N/\text{Ir}_N = 0.31-0.48$ ), in agreement with the incompatible behaviour of Pd in mantle melting processes. SEM and NMP data reveal primary Os-Ru-Ir alloys which could account for the compatible behaviour of these elements. By contrast,  $\text{Pd}_N/\text{Ir}_N$  (and  $\text{Pt}_N/\text{Ir}_N$  too) increases from the lherzolites (0.27-0.81) to the cpx-poor lherzolites (0.68-2.04). Both ratios positively correlate with sulphide modal contents. These correlations provide unequivocal evidence that immiscible sulphide precipitated in the mantle column during adiabatic partial melting may alter whole-rock PGE ratios (c.f. Rehkämper et al., 1999).

LAM-ICPMS analyses indicate high PGE concentrations in pentlandite, the only sulphide large enough to be analysed

(Fig. 1). As noted in previous works (c.f. Ballhaus and Sylvester, 2000), pentlandite concentrates Os (up to 65 ppm), Ir (up to 53 ppm), Ru (up to 101 ppm), Rh (up to 17 ppm) and Pd (up to 56 ppm). However, the Pt and Pd concentration range spans several orders of magnitude. NMP images reveal discrete areas containing up to several percents Pd and Ag. Pt and Pd vary sympathetically although Pt is systematically depleted relative to Pd and the other PGE (<6 ppm). The huge variation of Pt and Pd contents determine several primitive-mantle normalised PGE patterns. Patterns I and II are Pt- and Pd-depleted ( $\text{Pt}_N/\text{Ir}_N = 0.02$ ;  $\text{Pd}_N/\text{Ir}_N = 0.007-0.34$ ) and may correspond to sulphides that are residual from large melting degrees. Pattern III, characterised by suprachondritic  $\text{Pd}_N/\text{Ir}_N$  (4.3) is indisputably of late-precipitation origin. It has been identified mostly in pentlandite grains adjacent to refertilized cpx. Note that the weathered grains (VI and VII) analysed differ from the unaltered sulphides, only by high Au contents and some scatter in their Ir and Ru relative abundances. Also characteristic of sulphide-rich, cpx-poor lherzolites, patterns IV and V are characterised by lower compatible PGE contents coupled with highly fractionated  $\text{Pd}_N/\text{Ir}_N$  (15 - 505) and Pd contents of pentlandite (up to 50 ppm). These patterns probably correspond to pentlandite and chalcopyrite finely intergrown with pentlandite. Fig. 1 also shows that whole-rock PGE abundances (stippled area) can be satisfactorily balanced by combining pattern III with patterns IV and V in subordinate amounts. In no case, however, can platinum and gold be accounted for by magmatic sulphides. Gold may be located in sulphide weathering products. SEM and NMP scanning has not yet revealed any Pt-rich discrete phase, either associated with magmatic sulphides or disseminated in matrix silicates or spinel. If present, such phases are likely to occur at the sub-micron scale; care must therefore be exercised in using sulphide-silicate partition coefficients for modelling the behaviour of Pt in the oceanic mantle.

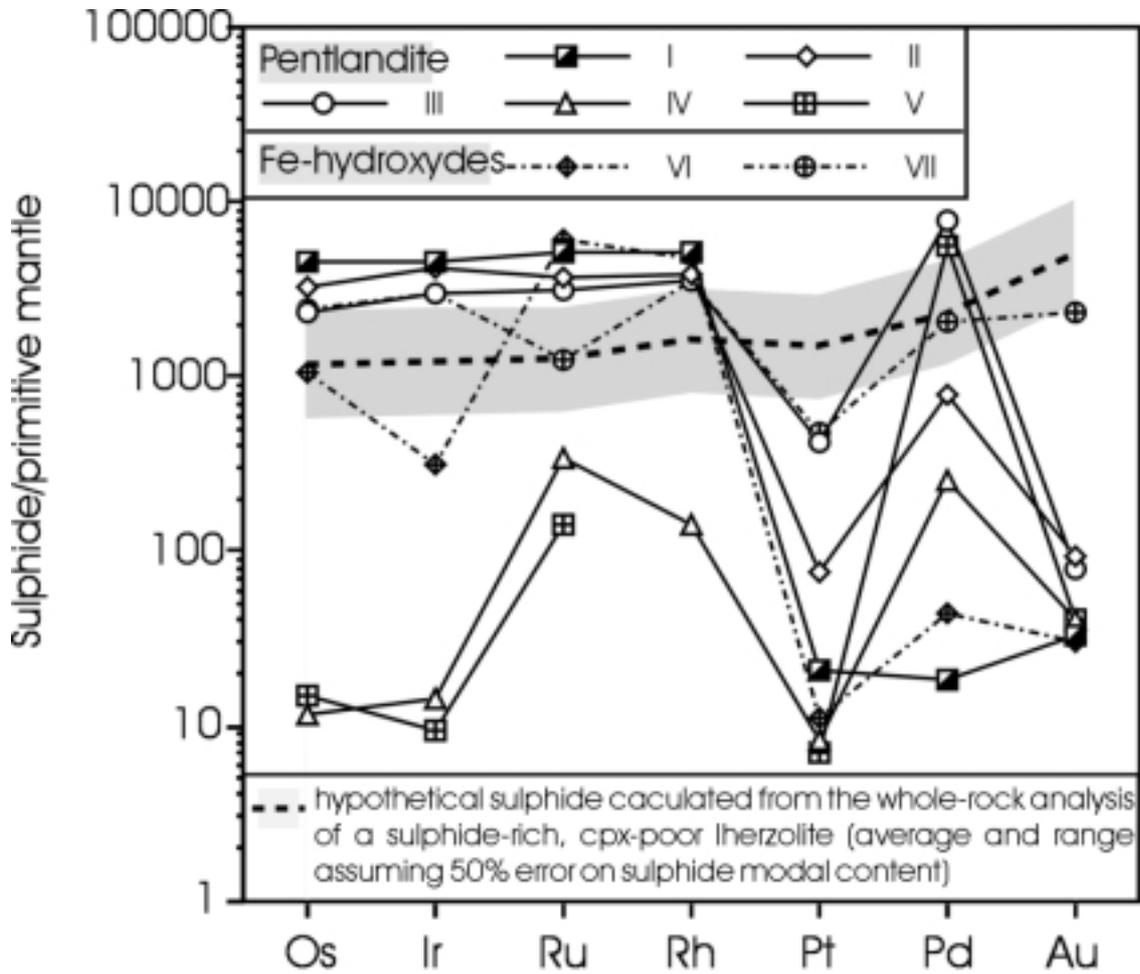


Fig.1: LAM-ICPMS analyses of sulphides.

Ballhaus C & Sylvester P, *Journal of Petrology*, **41**, 545-556, (2000).

Luguet A & Lorand JP, *C.R. Acad. Sci. Paris*, **329**, 637-644, (1999).

Rehkämper M, Halliday AN, Alt J, Fitton JG, Zipfel J & Takazawa E, *Earth Planetary Science Letters*, **172**, 65-81, (1999).