PGE ABUNDANCES IN UPPER MANTLE XENOLITHS FROM THE CARPATHIAN-PANNONIAN REGION

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1. Introduction
The distribution of platinum-group elements (PGE - Os, Ir, Ru, Rh, Pt, Pd) has been debated and discussed due to their geochemical significance and economic importance. Laboratory experiments revealed that the abundance of PGE in the silicate Earth is several magnitudes higher than it is expected and their Pd/Ir and Ru/Pt ratios are nearly chondritic. A widely accepted theory for this additional amount of PGE in the silicate Earth is the "Late Veneer" model (Chou, 1983), which considers that an influx of chondritic meteors after core formation during the "Late Heavy Bombardment" (4-3.8 Ga) caused high PGE abundance and chondritic ratios. Among the known geochemical processes PGE are used to trace melting and metasomatic events in Earth's mantle (Lorand et al., 2008; Alard et al., 2011). Sulphides contain around 30% of PGE in the mantle. We studied the PGE contents of these sulfides in xenoliths hosted by basalt, kimberlite and lamprophyre, and evaluated the PGE budget of the mantle.

5. Clinopyroxene trace element geochemistry
Based on LA-ICPMS data for clinopyroxenes, all of the samples are enriched in incompatible elements, except Ba, Nb and Ta, compared to chondrites, which suggests metasomatism by mafic melt. However, some samples went through a small degree of melt alteration after metasomatism causing a slight decrease in LREE (Fig 4).

7. In-situ PGE analyses on sulfide grains
Six PGE's were analyzed in-situ in sulfide grains with LA-MC-ICPMS (Alard et al., 2000). The whole sulfide inclusions were ablated, hence the concentrations represent the bulk sulfide grains. Total PGE concentrations range between 4 and 796 ppm. The majority of sulfides show high and variable abundances of Os, Ir, Ru and negatively sloped PPGE (Rh, Pt, Pd) pattern in some cases with extremely low Pt concentrations (Fig 6).

8. Bulk xenolith PGE analyses
Total PGE contents of the xenoliths range between 7 and 21 ppb regardless of location. Ir-type PGE show overall high concentration (5-12 ppb), which confirms the residual mantle origin of the studied xenoliths. Os/Cr in xenoliths from SBVF and PMVF are slightly below the chondritic ratio, whereas those from BBHV are above the chondritic value. Ru/Ir is ca. 30% higher than the chondritic value in the majority of xenoliths from SBVF and PMVF. In contrast, xenoliths from the BBHV show chondritic Ru/Ir, except samples strongly depleted in Al. These PGE ratios do not show correlations with Al contents. Pt and Pd contents and their ratios with Ir-type PGE correlate with Al, as expected, due to incompatible nature of Pt and Pd during partial melting (Fig. 8). This is prominent in the BBHV xenoliths, which have the widest range in Al contents. Comparing to other post-Archean Hawaiian xenoliths, the PGE patterns are similar with slightly lower concentrations in some cases (Fig. 7).

References:
Wittig et al. (2010) Lithos, 115, 10-28

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Fig. 1 Cross-section through the Carpathian-Pannonian region.

Fig. 2 Modal composition of the selected xenoliths in the Streckeisen-diagram (1974).

Fig. 3 a. Fo contents in olivine and Cr²⁺ in spinel in olivine-spinel mantle array (OSMA) of Ara (1994). b. Na vs Os.

Fig. 4 Trace element and REE patterns of clinopyroxenes, all data are normalized to CI chondrite (Palme & Jones, 2004).

Fig. 5 A. Major elements of sulphides. B, spherical primary sulphide inclusion in olivine, under reflected light. C, partially altered interstitial sulphide, under reflected light.

Fig. 6 Platinum-group element abundance in sulphide blebs from in-situ analyses, normalized to CI chondrite (Palme & Jones, 2004).

Fig. 7 PGE abundance in bulk xenoliths compared to post-Archean ilherzolite xenoliths (grey field - Lorand & Alard, 2001; Schmidt et al., 2003; Becker et al., 2006; Wittig et al., 2011), normalized to chondrite.

Fig. 8 The ratios of Ir-like type (PGE) to Pd type (PGE) in bulk rocks. Note that Rh concentrations were not determined.