PGE ABUNDANCES IN UPPER MANTLE XENOLITHS FROMTHE CARPATHIAN-PANNONIAN REGION

SZABÓ, Cs.[1*], HATTORI, K.[2], GRIFFIN, W.[3], O'REILLY, S.[3], ARADI, L.[1]
cszabo@elte.hu , lrg.elte.hu

[1]Lithosphere Fluid Research Lab, Department of Petrology and Geochemistry, Eötvös University, Hungary
[2]Department of Earth Sciences, University of Ottawa, Canada
[3]GEMOC, Department of Earth and Planetary Sciences, Macquarie University, Australia

1.Introduction

The distribution of platinum-group elements (PGE - Os, Ir, Ru, Rh, Pt, Pd) has been debated and discussed due to its 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 is the "Late Veneer" model (Chou, 1983), which considers that an influx of chondritic meteorites 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 90% 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.

2. Geological background

The Carpathian-Pannonian region (CPR) was formed by lithospheric extension due to upwelling of the astenospheric mantle in the Neogene. The Plio-Pleistocene alkali basalt volcanism sabrought the lithospheric mantle to the surface at five places in the CPR. We selected 20 sulphide-bearing peridotite xenoliths from Kapfenstein (Styrian Basin - SBVF); Füzes-tó (Bakony-Balaton Highland - BBHVF); Fülek (Fiľakovo), Maskófalva (Mašková) and Bárna-Nagykő (Nógrád-Gömör - NGVF) and Alsórákos (Racoş) - Olthévíz (Hoghiz), Bogáta (Bogata) and Berek (Berec) (Perşani Mountains - PMVF) (*Fig 1*).

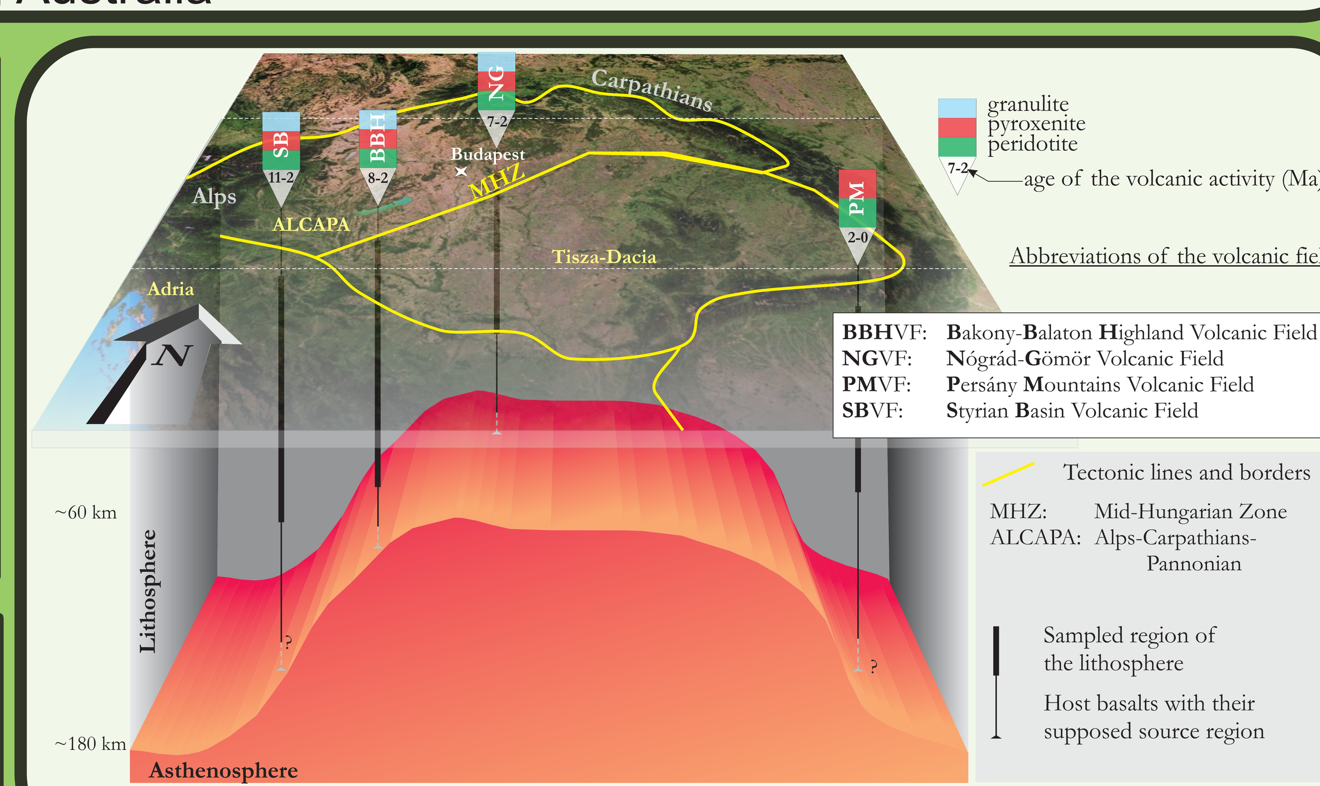

Fig.1 Cross-section through the Carpathian-Pannonian region

3. Xenolith petrography

All of the studied xenoliths are spinel lherzolites, several samples contain minor amphibole. The xenoliths show protogranular to porphyroclastic texture (Fig. 2). Some show poikilitic texture.

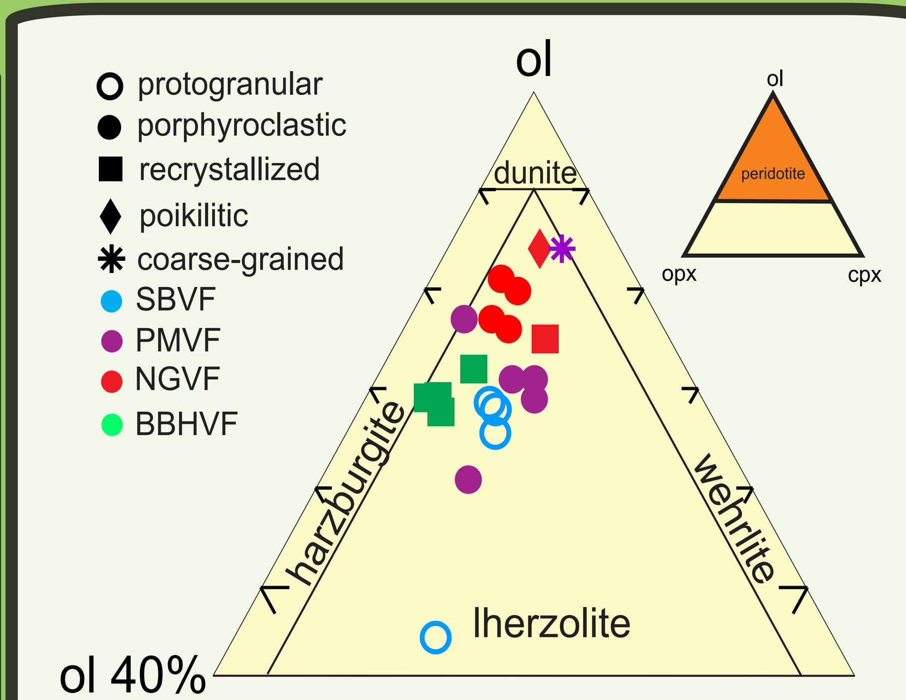

Fig.2 Modal composition of the selected xenoliths in the Streckeisen-diagram (1974).

4. Major element geochemistry

Olivines contains high Mg, their forsterite (Fo) components ranging from 89-91. Spinel shows 0.64 ti 0.82 for Mg# and 0.10 to 0.36 for Cr#. Their compositions plot in the olivine-spinel mantle array (OSMA, Arai, 1994) with the exception of two highly metasomatised sample (*Fig.3 A*). The numbers of Na and Al in the formula of clinopyroxene suggest that rocks from SBVF are the most fertile and those from BBHVF the most depleted in this suite. (*Fig 3 B*)

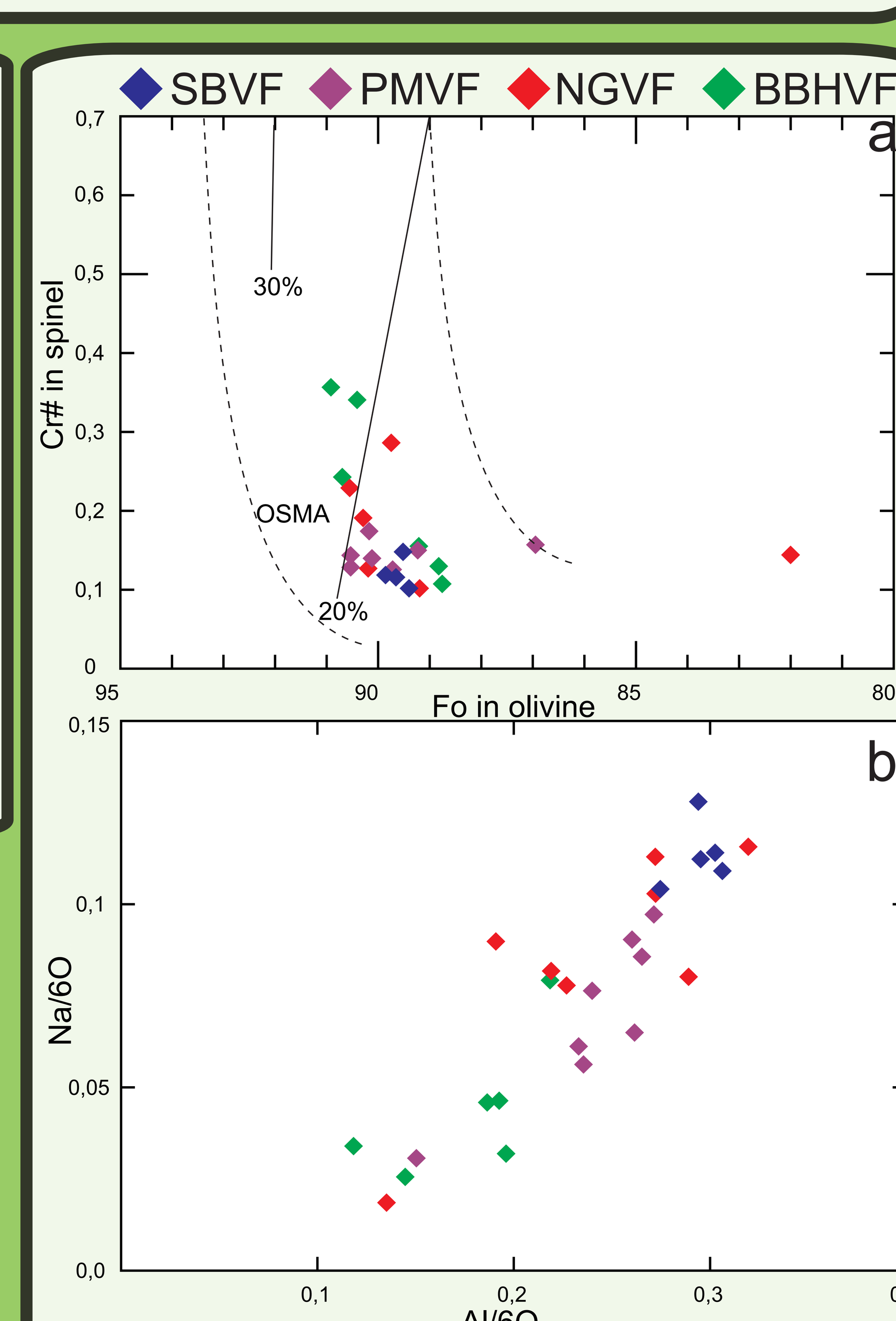

Fig 3. a: Forsterite(Fo) components in olivine and Cr# in spinel in olivine-spinel mantle array (OSMA) of Arai (1994) *b*: Na vs Al in clinopyroxene

5. Clinopyroxene trace element geochemistry

Based on LA-ICPMS data for clinopyroxene, 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 extraction after metasomatism causing a slight decrease in LREE (*Fig 4*).

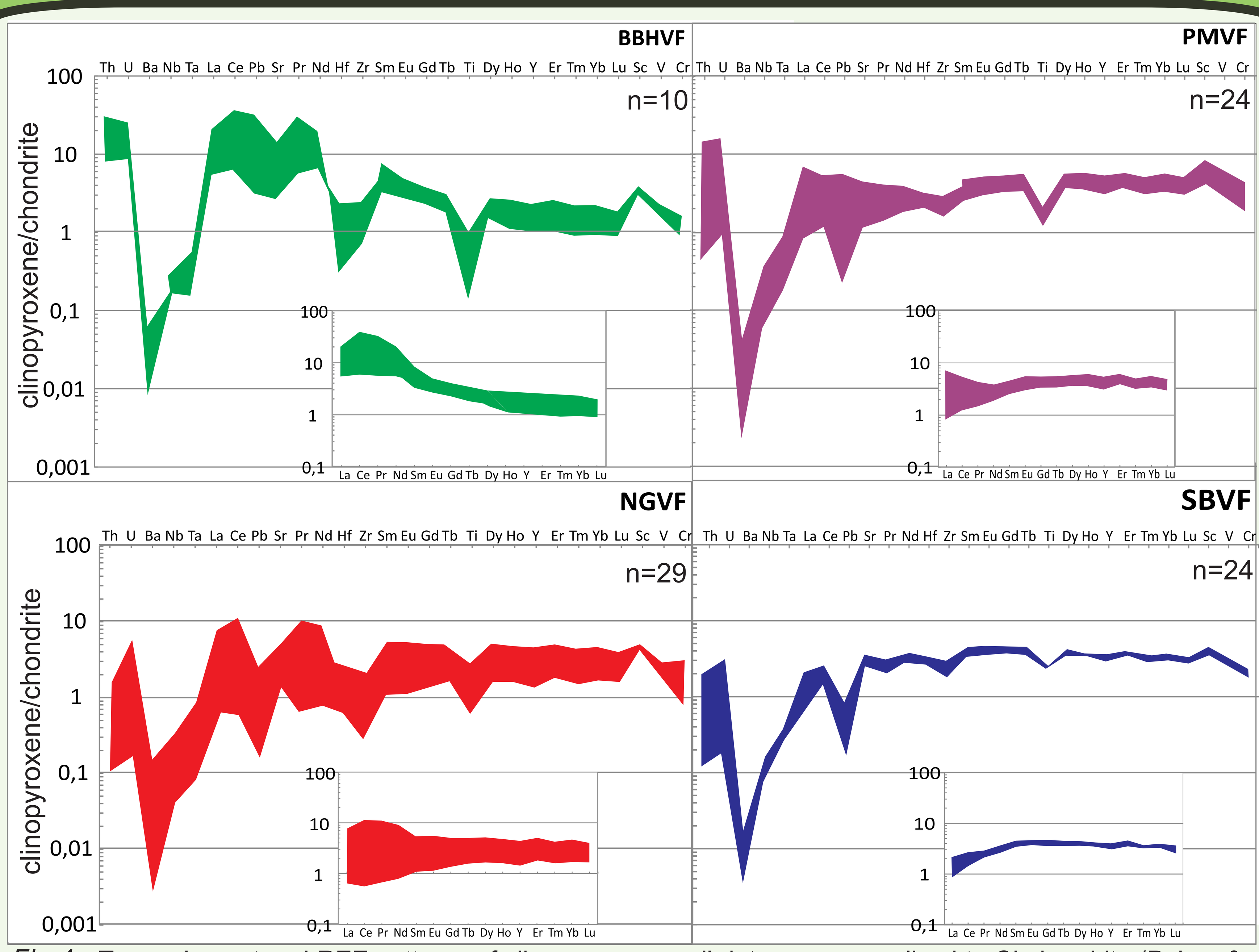

Fig 4. Trace element and REE patterns of clinopyroxenes, all datas are normalized to CI chondrite (Palme & Jones 2004).

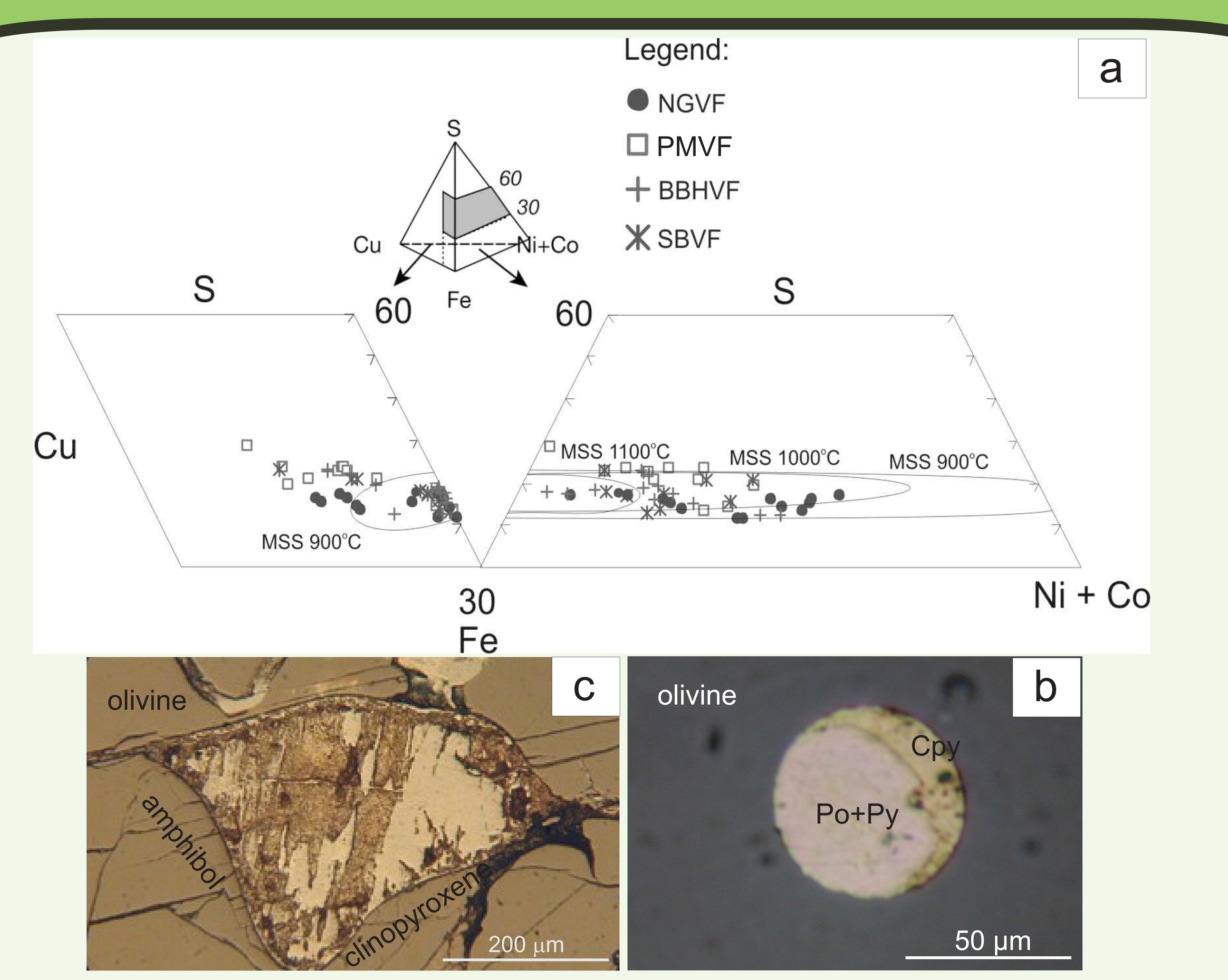

Fig.5 A. Major elements of sulphides., B. spherical primary sulphide inclusion in olivine, under reflected light, C. partially altered interstitial sulphide, under reflected light.

6. Sulfide petrography and minerals

Two types of sulphide grains are distinguished: 1) primary sulphide blebs enclosed in mantle silicates and spinel (*Fig 5B*) and 2) sulphides along grain boundaries of silicates (*Fig 5C*). In general, sulphide inclusions likely represent ancient mantle material, whereas interstitial sulfide grains correspond to young mantle events. Their materials could have interacted with metasomatic fluids and/or percolating melts. The sulphide assemblages usually consist of monosulfide solid solution (mss), pyrrhotite (Po), pentlandite (Pn), chalcopyrite (Cpy) (*Fig 5A*).

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 sulphide 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*).

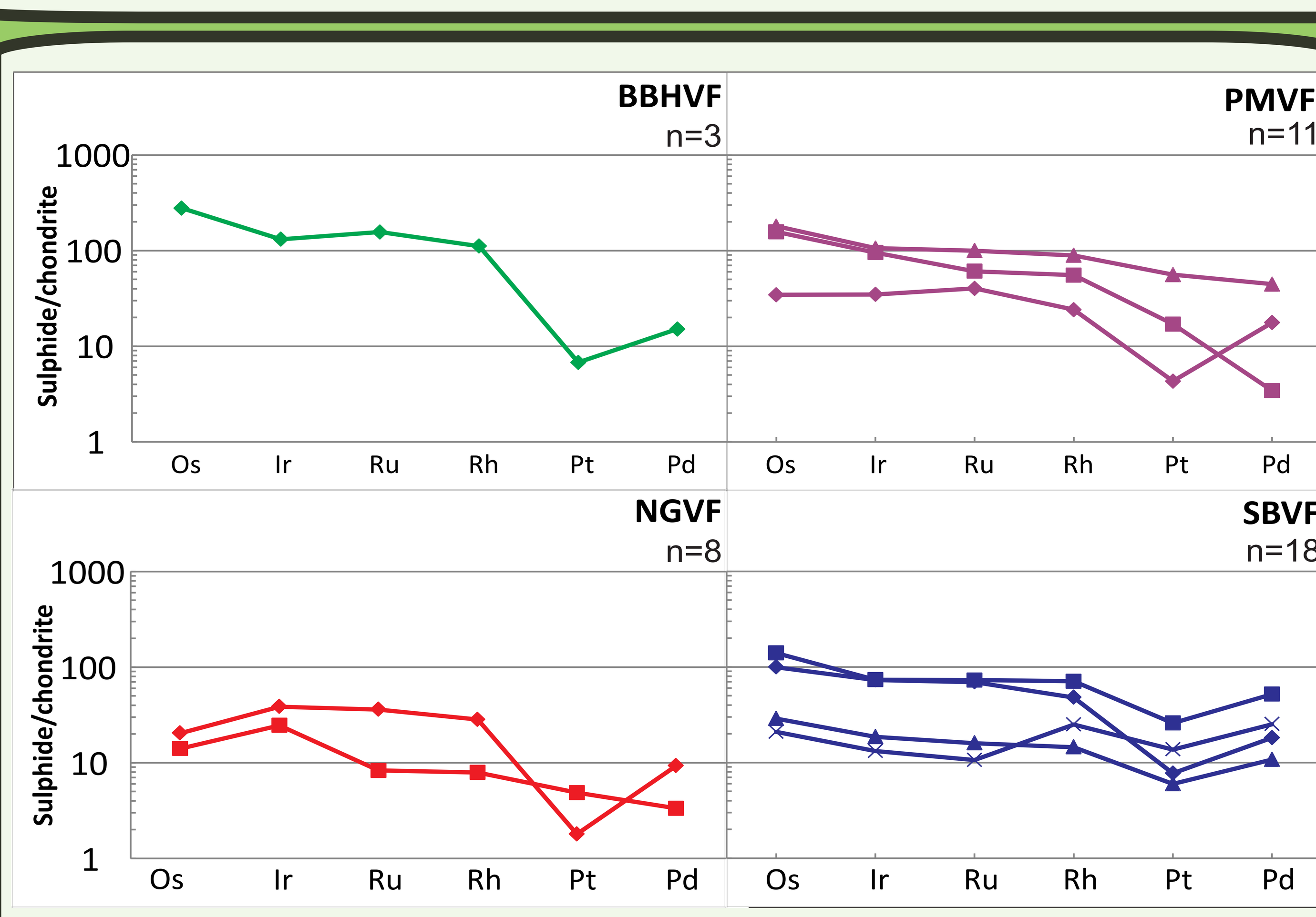

Fig. 6 Platinum-group element abundance in sulphide blebs from *in-situ* analyses, normalized to CI chondrite (Palme & Jones, 2004).

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/Ir in xenoliths from SBVF and PMVF are slightly below the chondritic ratio, whereas those from BBHVF 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 BBHVF 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 BBHVF xenoliths, which have the widest range in Al contents. Comparing to other post-Archean lherzolite mantle xenoliths, the PGE patterns are similar with slightly lower concentrations in some cases (*Fig 7).*

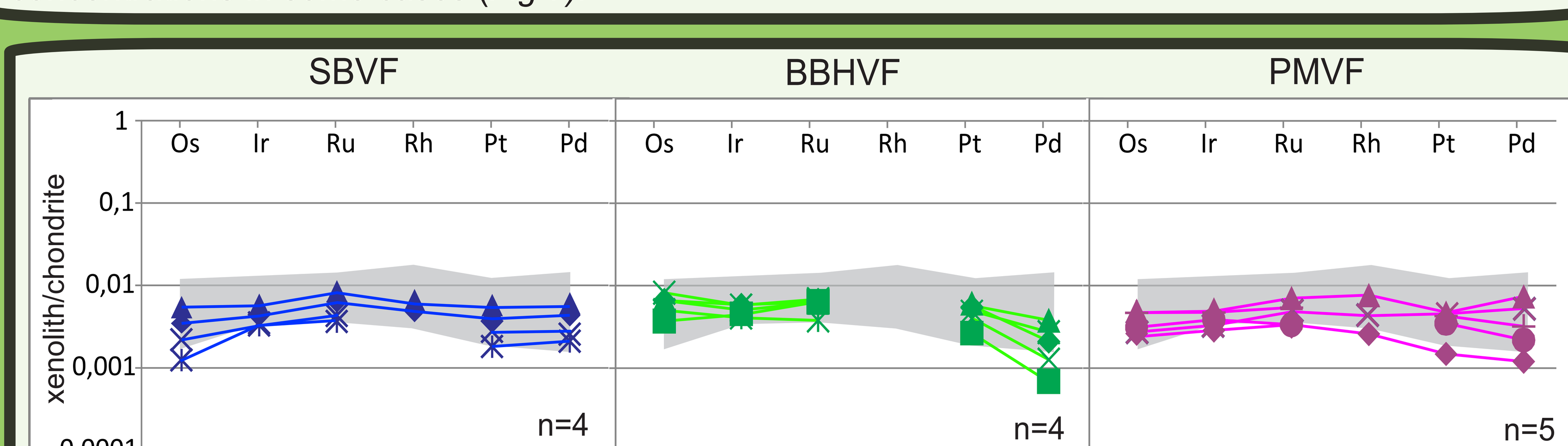

Fig 7. PGE abundance in bulk xenoliths compared to post-Archean lherzolite xenoliths (gray field - Lorand & Alard, 2001; Schmidt et al., 2003; Becker et al., 2006; Wittig et al., 2010), normalized to chondrite.

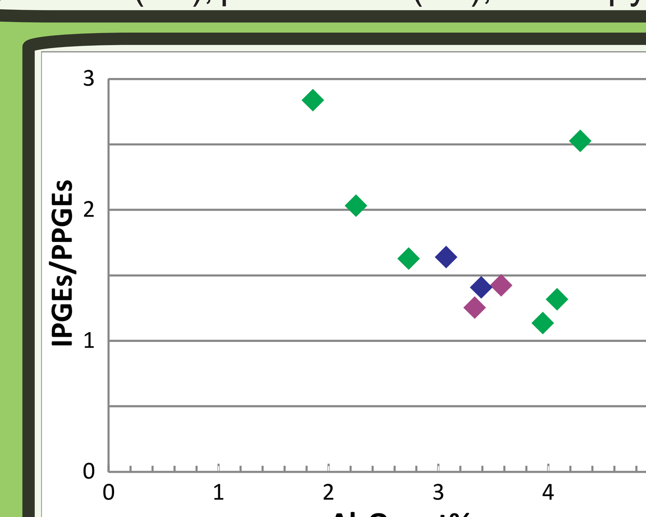

Fig.8 The ratios of Iridium-type (IPGE) to Palladium-type (PPGE) platinum group elements vs. Al_2O_3 in bulk rocks. Note that Rh concentrations were not determined.

8. Conclusions

PGE abundance and distribution in the upper mantle under the CPR were studied first in this work. Our data reveal that the PGE distribution in the mantle beneath the CPR is heterogeneous and each of the xenolith localities studied has its own PGE pattern.

Most of the PGE patterns show high and variable abundances of Os, Ir, Ru and Rh, with decreasing abundances of Pd and a strong negative Pt anomaly. The PGE abundance is explained by different degrees of melting and metasomatism in the CPR mantle however the texture is not necessarily correlated with PGE patterns.

The PGE patterns and abundance for the CPR xenoliths are similar to those of post-Archean lherzolite xenoliths elsewhere.

References:
Alard et al. (2000) Nature 407: 891-894
Alard et al. (2011) J. Petrol., 52:. 2009-2045
Arai (1994) Chem Geol 111: 191-204.
Becker et al. (2006) GCA, 70: 4528-4550
Chou et al. (1983) J. Geophys. Res., 88: A507-A518
Lorand et al.(2008) Elements, 4: 247-252
Palme & Jones. (2004) Treatise on Geochemistry, 1:41-61
Schmidt et al. (2003) Chem. Geol.,196:. 77 – 110
Wittig et al. (2010) Lithos, 115:. 15-26

Acknowledgements:
Thank all the members of the Lithosphere Fluid Research Lab. This research was granted by the Hungarian Science Foundation (OTKA, 78425 to Cs. Szabó) and TÁMOP project nr. 4.2.1./B-09/KMR-2010-0003 by the European Union and the European Social Fund to Cs. Szabó and L. Aradi.

This poster was presented at the 22nd V. M. Goldschmidt Conference, June 24-29 2012 in Montreal, Canada