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Oxygen isotope signature versus radiogenic isotopic compositions (Pb, Sr, Nd, Hf) in the easternmost part of CEVP (SW Poland)

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1 Introduction

The volcanic rocks (basanites, nephelinites, basalts) from southwestern Poland were investigated. They form the easternmost part of the Central European Volcanic Province (CEVP). Pb, Sr, Nd and Hf isotopic ratios were carried out using MC-ICP-MS and TIMS. Oxygen isotopes were determined by LF method.

The volcanic chain occurring in SW Poland is composed of large separated fields (Lubań-Bogatynia, Jawor-Jelenia, Niemcza-Lądek Zdrój, The Opole Silesia) and smaller intrusions. Radiometric ages of basaltoids range from 4 to 40 Ma (Alibert et al. 1987, Birkenmajer et al. 2002). Volcanic rocks are situated along zones of deep fractures active since Paleozoic. They are emplaced in various geological units and rocks of different ages and lithologies.

2 Samples and analytical techniques

Oxygen isotopes were measured in olivine phenocrysts and rock chips (below 1mm diameter). Samples were analysed by laser fluorination at the Laboratory of Stable Isotopes at the Royal Holloway University of London based on methods described by Sharp (1990).

Pb, Sr, Nd and Hf were chemically purified in the clean laboratory at the Danish Lithosphere Centre in Copenhagen (Ulfbeck et al. 2003, Peate & Baker 2003). Pb, Nd and Hf isotopic composition was analysed by double focussing, magnetic sector VG AXIOM multiple collector inductively coupled plasma mass spectrometry (MC-ICP-MS). Sr isotopes were measured by conventional thermal ionisation mass spectrometry (TIMS) in the Geological Institute at the University of Copenhagen.

3 Results

Studied volcanic rocks represent alkali magmas, moderately deficient in silica (SiO_2=40-47,85 wt%). According TAS diagram they locate mostly in the basanite and nephelinite fields. They show quite high MgO content (8,07-15,16 wt%). Na_2O content (2,1-7,77 wt%) exceeds K_2O content (0,41-4,97 wt%).

Our samples show HIMU-like characteristics with radiogenic lead isotopic ratios ($^{206}Pb/^{204}Pb$=19.4-20.8). These ratios are much higher than $^{206}Pb/^{204}Pb$ in lavas from the Eifel and Vogelsberg regions (Germany), from Western Bohemia (Czech Rebublic) and Moravia (Czech Republic). There is strong positive correlation between Nd and Hf isotopic ratios, and they plot below the main mantle array. Most of the samples have a restricted range in εHf (+6.0-+7.9) and εNd (+3.5-+5.0), but basalts from the central region (the Fore-Sudetic Block and Kaczawa Mts.) have higher εHf (+10.8-+13.1) and εNd (+5.9-+7.4). Basalts from the westernmost (Bogatynia – Zgorzelec area) show lower εHf (+4.7-+5.9) and εNd (+2.5-+3.2) and higher $^{208}Pb/^{204}Pb$ (for a given $^{206}Pb/^{204}Pb$). The $^{87}Sr/^{86}Sr$ are quite low (0,70326-0,7044), and they confirm general trend of decreasing of Sr isotopic ratios across CEVP (from W to E) postulated by Blusztajn and Hart (1989).

Oxygen isotopes represent quite narrow range of isotopic ratios ($\delta^{18}O$ = 4,86 – 5,35 for olivines and $\delta^{18}O$ = 4,93 – 5,89 for whole rock). One third of results for whole rock show slight elevating trend which can be related to low-temperature alteration of these rocks.

4 Discussion and Conclusions

The isotopic variations observed in mafic lavas were used to clarify the role of petrogenetic processes and heterogeneities in the mantle source:

1. Basanites and nephelinites represent primitive alkaline magmas, which could be the effect of partial melting in the depleted mantle source.

2. There is visible positive correlation between Nd and Hf isotopic ratios, which could be explained by mixing between depleted mantle and old subducted sediments in OIB mantle reservoir.

3. There is strong influence of HIMU component in the mantle which can indicate old (1 Ga) subducted oceanic crust.

4. Three component mixing (DM-HIMU-EMI) in the mantle source is considered.

5. The most depleted isotopic signature is observed in the Fore Sudetic Block, while the most enriched signature in the SW 'corner' (Bogatynia-Zgorzelec area), which belongs to the NE prolongation of Eger rift area with more plume-like flavour. The depleted signature could then represent ambient depleted upper mantle MORB source.

6. Oxygen isotopic ratios confirm existence of HIMU endmember in the mantle source and no influence (or very little) of crustal contamination.

7. The geographic variation observed in Hf and Nd isotope compositions doesn't exist in Pb, Sr and O isotopic characteristics.

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