Geochemical features of the basic-ultrabasic rocks of the Udokan-Chiney region (Siberia, Russia)

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The problem and the main goal of the study

Mantle magma's intrusions inside the Southern framework of the Siberian platform reflect the main destruction episodes on the Earth. They are the Paleopangea falling to pieces in the Early proterozoic époque and the tectonic activity in Kz. To understand the magmatic evolution and the associated ore-forming processes in the Udokan-Chiney region it is necessary to study geochemical features of the basic-ultrabasic rocks from numerous massifs located inside this area.

Results

The composition of the rocks (main and trace elements) from different Paleoproterozoic massifs – Chiney, Luktur, Mylove, and Neoproterozoic massifs – Doros, Udokan Great Dyke, so as the Mz and Kz basalts have been studied by XRF and ICP-MS. In this range (from ancient to modern rocks) there is an evolution of its compositions: close to N-MORB – E-MORB – OIB. La/Yb and Th/Ta ratios of the studied massifs change significantly (fig.1) and demonstrate the role of the different sources in their magma generation.

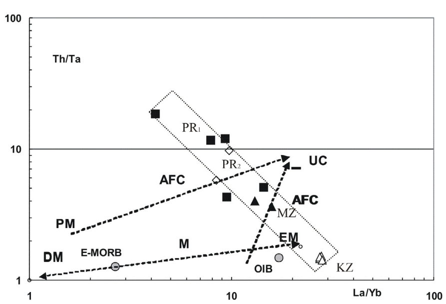

Figure 1: La/Yb *vs.* Th/Ta diagram for the studied complexes from Udokan-Chiney region.

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Nothing paradoxical about Helium concentrations in OIBs

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We show that the He concentration paradox, as well as the full range of noble gas concentrations observed in mid-ocean ridge basalt (MORB) and ocean island basalt (OIB) glasses, can self-consistently be explained by disequilibrium, open-system degassing of the erupting magma. We demonstrate that a higher CO_2 and H_2O content of OIBs, compared to MORBs, leads to more extensive degassing of He in OIB magmas.

Outgassing during melt production at mid-ocean ridges has led to a volatile depleted upper-mantle MORB source with low $^3He/^4He$ ratios. Consequently, $^3He/^4He$ ratios in OIBs, often a factor of 4-6 higher than in MORBs, are conventionally viewed as evidence for an undegassed, primitive mantle source. However, this conventional model provides no viable explanation for why noble gas abundances in OIBs are an order of magnitude lower than in MORBs. This has been called the "He concentration paradox", which has contributed to a long-standing controversy about the structure and dynamics of Earth's mantle.

If, during magma eruption there is insufficient time for all volatiles to diffuse from the melt into gaseous bubbles, the abundance of dissolved volatile species is controlled by both solubility and diffusivity. Because of its relatively high diffusivity, He degassing of OIB and MORB magmas is not significantly limited by diffusion and is predominantly controlled by solubility. On-average higher CO_2 content of OIBs relative to MORBs dilutes He in the exsolved gas phase, thereby lowering partial pressures and decreasing absolute He solubility. This explains why OIB lavas have lower He abundances than MORBs, even though the OIB parental magma is more He rich. On the other hand, degassing of Ne and Ar is limited by diffusion during eruption of both MORB and OIB magmas. When combined with higher He loss in OIBs, this explains the low He/Ne and He/Ar ratios of OIBs relative to MORBs.

The observed noble gas content in OIBs is entirely consistent with degassing of a parental magma derived from a mantle source with a primordial component and total ^3He, ^{22}Ne, and ^{36}Ar abundances of approximately $4{\times}10^{-9}$, $1{\times}10^{-9}$, and $3{\times}10^{-9}$ cm^3 STP g^{-1}, respectively. The percentage of primitive mantle component in the OIB source is on average less than 20%, but our present calculations do not constrain the size nor the location of the primitive reservoir. Regardless of whole mantle convection, it appears that part of the Earth's mantle has remained relatively undegassed and primordial in volatile content over Earth's history.