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Radiogenic and stable isotope study of the Dyumptaley and Binyuda ultramafic-mafic intrusions and associated Ni-Cu-PGE sulfide ores (Russian Arctic)

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It is commonly assumed that ultramafic-mafic intrusions and associated PGE-Cu-Ni sulphide deposits of Northern Siberia represent a small component of a major episode of mafic activity at ~250 Ma, which included formation of the most extensive flood-basalt province on Earth [1]. Recent studies, however, advocated protracted evolution of the ore-forming magmas parent to the Noril'sk-type intrusions [2, 3, etc.]. Understanding the processes behind the formation of economically important ore deposits is crucial for locating additional deposits in areas that have not been previously considered. This study, therefore, aimed to provide isotope-geochemical fingerprinting to be used in exploration for Ni-Cu-PGE sulfide ores.

We firstly present geochronological and Hf-Nd-Sr-Cu-S isotope data for the same suite of lithologies and associated PGE-Cu-Ni sulphide ores from the Dyumptaley and Binyuda ultramafic-mafic intrusions located in the limits of the Taimyr Peninsula (Russian Arctic). The rocks investigated comprise sulphide-rich varieties of ferrogabbro (i.e. gabbro abnormally high in Fe) and melanocratic troctolite occurring in bottom parts of the Dyumptaley and Binyuda intrusions, respectively.

Zircons are characterized by similar U-Pb ages (256.2±0.9 Ma at Dyumtaley, and 245.7±12 Ma at Binyuda). In contrast, silicate materials show distinct Hf-Nd-Sr isotope signatures (εHf=8.3±3.7, εNd=3.5±0.7 and $^{87}Sr/^{86}Sr_i$=0.70493±0.00021 at Dyumptaley, and εHf=-5.2±0.6, εNd=-3.4±0.3 and $^{87}Sr/^{86}Sr_i$=0.70585±0.00004 at Binyuda). The determined Hf-Nd-Sr variability is interpreted to represent a primary source signature of the lithological units. An important role of the juvenile component is clearly pronounced for the Dyumptaley intrusion, whereas a major contribution from a SCLM or essentially crustal source is inferred for the Binyuda intrusion.

These signatures clearly manifest deviation from those typical of the ore-bearing intrusions from the Noril'sk Province, characterized by a significant time span of zircon and baddeleyite U-Pb ages (from ca. 350 to 230 Ma), relatively constant εNd values (ca. +1±0.5) and heterogeneous radiogenic εHf (from -2.3 to 16.3) and $^{87}Sr/^{86}Sr_i$ (from 0.70552 to 0.70798) [2,3].

In terms of Cu-isotopes, the majority of the analyzed sulfide samples fall within a tight cluster of δ^{65}Cu values (from -1.2 to -0.2‰ with a mean of -0.65‰ and a standard deviation of 0.25‰ at Dyumptaley, and from -0.6 to -0.2‰ ,-0.43±0.09‰ at Binyuda), characteristic of the ores from the economic Ni-Cu-PGE deposits at Talnakh and Stillwater [4]. In contrast, notable difference in δ^{34}S values typifies sulfide ores at Dyumptaley (11.4±0.2‰) and Binyuda (2.1±0.5‰), respectively. We suggest that the Cu-S isotope characteristics of the sulfide ores reflect their primary signature rather than a result of mixed sources or magmatic fractionation of stable isotopes. However, the latter option cannot be ruled out for heavy S isotope composition of sulfide at Dyumtaley. Samples of the disseminated sulfide ore from the Dyumptaley intrusion approach δ^{34}S-δ^{65}Cu parameters of the economic ores at Talnakh and may be considered as most promising in targeting the massive Ni-Cu-PGE sulfide ores.

Integrated radiogenic and stable isotope data provide new constraints on baseline isotope signatures of sulfide ores of the Russian Arctic, demonstrating a potential in combined petrologic and isotope-related mineral deposit studies.

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