Zircons from ultramafic-mafic intrusions at Noril'sk area (Russia): A compositional and U-Pb study

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World-class platinum-group-element (PGE)-Cu-Ni deposits closely linked to intracontinental paleorift-related ultramafic-mafic intrusions are located in the northwestern corner of the Siberian craton, Russia. In spite of its significant metallogenic potential, age constraints for majority of the ore-bearing intrusions are poorly defined. Similarly, timing and duration of the ore concentration responsible to form an economic deposit has been rarely evaluated quantitatively.

This study presents the results of trace element data and uranium-lead ages for about 550 grains of zircons, which were extracted using ppm-mineralogy technique (NATI Research JSC, St, Petersburg, http://www.natires.com) from drill core samples from the various types of igneous bodies. The latter include economic PGE-Cu-Ni deposits associated with the Noril'sk-1 (drill core MN-2), Talnakh (OUG-2) and Kharaelakh (KZ-844) intrusions, subeconomic deposits related to the Chernogorsk (MP-2), Zub-Marksheider (MP-27) and Vologochan (OV-29) intrusions and none economic the Nizhny Talnakh (TG-31) intrusion. Isotope geochemical data (102 REE analyses and 616 U-Pb measurements) were determined with secondary ion mass spectrometer SHRIMP-II at All-Russia Geological Research Institute.

Zircons are characterized by a fuzzy (smoky) cathode luminescence, with a virtual total absence of zoning. Petrographic inspection, however, revealed at least two generations of zircon that show distinct solid inclusion assemblage. In the binary Th-U diagram, the investigated zircons (Th/U = 0.8-7.5) are clearly different from zircons derived from various geological settings and only partly match zircons from MARID suite (Kinny and Dawson 1992). In REE discrimination diagrams $(Sm/La)_N$ – La and Ce/Ce* - $(Sm/La)_N$ zircons mainly plot in the field of "magmatic" zircon (after Hoskin, 2005), with a tale approaching the "hydrothermal" field.

Four age groups of zircon were determined, with concordant U-Pb ages that vary in the range 220-260 Ma. Polyphase grains also preserve domains with U-Pb ages that cluster around 300 and 340 Ma. Rare detrital grains (around 1900 Ma) have been also observed. Our new findings are in a good agreement with assumption about the interaction of distinct magmas and a prolonged duration of component fractionation in the magmatic system. Consequently, these processes could lead to high degrees of separation and concentration of ore elements and formation of specific ore magma of unique scales and concentrations.

Linking between Mid Ocean Ridge basalts and Abyssal peridotites from Nd isotopes

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We have analyzed the trace element concentrations and Sr, Nd isotopic compositions of clinopyroxene (cpx) separates from abyssal peridotites (AP) from three different locations – South West Indian Ridge (SWIR), Mid Cayman Rise (MCR) and Mid Atlantic Ridge (MAR).

AP from all locations have trace element characteristics indicative of variable degrees of melt depletion. The SWIR peridotites from three different dredges show similar moderate to strong LREE (Light Rare Earth Elements) depletion, however the three dredges have distinct Nd isotopic composition. Nd-isotopic compositions of the cpx from the SWIR are on average higher than the ridge basalts. Cpxs from dredge VAN85 have some of the most depleted in REE abundances with $Ce_N < 0.1$ and $Yb_N < 10$. Cpxs from this dredge have high Nd-isotopes ratios (0.513086-0.513320) all higher than the Nd-isotopes ratios of the associated basalts. Dredge VAN78 is more homogeneous in Nd-isotope ratios (0.513003-0.513046) that fall within the range of Nd-isotope ratios of the associated basalts and display a less depleted REE pattern (Ce_N = 2-5) than dredge VAN85. In contrast cpxs from dredge VAN96 have elevated LREE abundances (Ce_N =8) and have most enriched Nd-isotope ratios (0.512885-0.512933) and are similar to the associated basalts. The cpxs from dredge VAN85 and VAN78 are not in equilibrium with the ridge basalts whereas the REE patterns from dredge VAN96 indicate that these cpxs could be in equilibrium with the associated MORB.

Cpxs from MCR peridotites all show extreme depletion in LREE abundances (Ce_N <0.4) and have variable HREE (Yb_N =4-17). The cpxs are too depleted in LREE to be in direct equilibrium with MORB. Nd-isotope ratios (0.513115-0.513425) of the cpxs overlap with the Nd-isotopes ratios of the associated basalts (0.512961-0.513190) and extend to higher ratios.

Cpxs from MAR show two orders of magnitude variation in Ce concentration (Ce_N =0.7-0.007) with Yb_N ~3. Nd-isotope ratios (0.513011-0.513190) of the cpxs are indistinguishable from the associated basalts.

The large variation in REE patterns at all locations indicates that there is significant heterogeneity in the sub-ridge mantle. The discrepancy in Nd-isotope ratios between basalts and AP at SWIR and MCR requires a low Nd-isotopic composition component not shown in the peridotites to contribute to the basalts. However, the fact that at some places basalts and peridotites overlap indicates that this low-Nd-isotopic composition component is not a ubiquitous component in the sub-ridge mantle.