Geophysical Research Abstracts
Vol. 13, EGU2011-4578-1, 2011
EGU General Assembly 2011

New insights on the origin of ultramafic-mafic intrusions and associated PGE-Cu-Ni sulphide deposits of the Talnakh ore junction (Noril'sk province, Russia): geophysical and geochronological evidence

Kreshimir N. Malitch (1,2) and Rais M. Latypov (2)

(1) Russian Geological Research Institute, St. Petersburg, Russian Federation (knm_2004a@yahoo.com), (2) University of Oulu, P.O. Box 3000, Oulu, Finland

There is a general consensus that mantle-derived ultramafic-mafic magmas and PGE-Ni-Cu deposits of the Noril'sk province (Russia) are closely linked, implying that juvenile mantle-derived materials are intrinsic to their petrogenesis (e.g., Tuganova 2000; Arndt et al. 2005). It is further assumed that the world-class platinum-group-element (PGE)-Cu-Ni sulphide deposits of the Noril'sk Province (e.g., Noril'sk-1, Talnakh and Kharaelakh) are linked to the voluminous amount of plume-related magmatism which may have supplied metals, as well as to interaction with country rocks that provided additional sulphur.

Clues for the location of one of the richest ore camps come from geophysical data. According to the seismic data (Egorkin et al. 1984; Malitch et al. 1987), a transition zone has been identified at the base of the crust of the Noril'sk region, with higher velocities of longitudinal waves (7.3 km/s) than those typical for the crust. This zone has been considered as a manifestation of ultramafic material injected in the subcrustal levels of the lithosphere. The thickness of this zone is 5-10 km, with a spatial extent of about 500 km at depths of 32-43 km. Most likely, a giant portion of ultramafic-mafic material rich in sulphides preceded tholeite-basaltic volcanism, which contributed to the removal of these bodies to form relatively small hybrid 'layered' intrusions. It is noteworthy that the location of economic intrusions is restricted to the above-mentioned transition zone, which is considered a typical feature of the basal part of the crust from oceanic and other continental paleorifts (Belousov 1982; Ramberg & Morgan 1984, among others).

The analysis of the deep structure of the Noril'sk area allows for the connection of the formation of PGE-Cu-Ni deposits in paleorift structures (Malitch et al. 1988) with peculiar geological and geophysical parameters. These include high-gradient downfolds in the basement, intense abundance of horst-graben structures of the crust, high-density detachments of the crust and mantle, large volumes of intruded mass of mantle material in the presence of waveguides with inversion of seismic velocities and seismic intermediate layer between the crust and mantle. Identification of deep structures with a differentiated crust of transitional type as exemplified at Noril'sk serves as an important criterion for regional tectonic forecasting.

New U-Pb geochronological data (Malitch et al. 2010a; 2010b; Malitch & Petrov, 2010) suggest an extended period of ultramafic-mafic activity consistent with multiple magmatic events during protracted evolution of economic ultramafic-mafic intrusions of the Noril'sk area. This implies that a prolonged period for concentration of the ore components in staging chambers might be a key factor for formation of economic deposits and allows for a re-evaluation of the genetic characteristics of PGE-Cu-Ni sulphide mineralization. Sulphide ores, thus, had a prehistory related to the concentration of sulphides from the large volume of ultramafic-mafic magmas parental to Noril'sk-type intrusions, followed by partial assimilation of crustal material and isolation of significant amounts of sulphide liquid, resulting in the possibility of its capture by later magmatic melts that serve as the vehicle which facilitated their passage to the surface.

If the formation of the basalts was indeed restricted to the Permian-Triassic boundary as advocated, mostly recently by Reichow et al. (2009 and references cited therein), the mentioned above U-Pb studies provide little supporting evidence for a genetic link between the chalcophile element-depleted basalts and the sulphide-rich Noril'sk-type intrusions, and imply that their relationship could have been coincidental. Similar conclusions, arising from different lines of reasoning, have been reached previously by, among others, Godlevsky (1959), Tuganova (1991), Czamanske et al. (1995) and Latypov (2002; 2007), and are in conflict with the conduit model proposed by Naldrett et al. (1995).

References:

Arndt, N.T., Lesher, C.M., Czamanske, G.K. (2005): Magmas and magmatic Ni-Cu-(PGE) deposits. Economic Geology 100th Anniversary Volume, 5-23.

Belousov, V.V. (1982): Transition zones between continents and oceans. Nedra Press, Moscow, 150 pp. (in Russian).

Czamanske, G.K., Zen'ko, T.E., Fedorenko, V.A. et al. (1995): Petrography and geochemical characterization of ore-bearing intrusions of the Noril'sk type, Siberia; with discussion of their origin. Resource Geology Special Issue 18, 1-48.

Egorkin, A.V., Zyuganov, S.K.,,Chernyshev, N.M. (1984): Upper mantle of Siberia. 27-th Intern. Geol. Congress, Moscow. Geophysics 8, 27-42.

Godlevsky, M.N. (1959) Traps and ore-bearing intrusions of the Noril'sk region. Gostekhmetizdat, Moscow, 68 pp. (in Russian).

Latypov, R.M. (2002): Phase equilibria constraints on relations of ore-bearing intrusions with flood basalts in the Noril'sk region, Russia. Contrib. Mineral. Petrol. 143, 438-449.

Latypov, R.M. (2007): Noril'sk- and Lower Talnakh-type intrusions are not conduits for overlying flood basalts: insights from residual gabbroic sequence of intrusions. Applied Earth Science (Trans. IMM B) 116, 215-225.

Malitch, K.N., Badanina, I.Yu., Tuganova, E.V. (2010a): Magmatic evolution of the ultramafic-mafic intrusions of the Noril'sk Province (Russia): insights from compositional and geochronological data. Lithosphera 10 (5), 37-63 (in Russian).

Malitch, K.N., Belousova, E.A., Griffin, W.L. et al. (2010b) Magmatic evolution of the ultramafic-mafic Kharaelakh intrusion (Siberian Craton, Russia): insights from trace-element, U-Pb and Hf-isotope data on zircon. Contrib. Mineral. Petrol. 159 (6), 753-768.

Malitch, K.N., Petrov, O.V. (2010) Geochronology and Hf-Nd-Sr-Os-S isotope systematics of the Noril'sk-type intrusions: New insights for prolonged evolution and source heterogeneity. Giant Ore Deposits Down-Under. 13th Quadrennial IAGOD Symposium Proceedings. Government of South Australia, 234-236.

Malitch, N.S., Grinson, A.S., Tuganova, E.V. et al. (1988): Rifting of the Siberian platform. 28th session of Intern. Geol. Congress. Tectonic processes. Nauka Press, Moscow, 184-193 (in Russian).

Malitch, N.S., Mironyuk, E.P., Tuganova, E.V. et al. (1987): Geological structure of the USSR and regularities of distribution of mineral deposits: The Siberian Platform 4 (Eds. Malitch, N.S., Masaitis, V.L. & Surkov, V.S.). Nedra Press, Leningrad, 448 pp (in Russian).

Naldrett, A.J., Fedorenko, V.A., Lightfoot, P.C. et al. (1995): Ni-Cu-PGE deposits of Noril'sk region, Siberia: their formation in conduits for flood basalt volcanism. Transactions of the Institute of Mining and Metallurgy 104, B18-B36.

Ramberg, I., Morgan, P. (1984): Physical characteristics and evolutionary trends of continental rifts. 27-th Intern. Geol. Congress. Tectonics, Nauka Press, Moscow, 78-109.

Reichow, M.K., Pringle, M.S., Al'mukhamedov, A.I. et al. (2009): The timing and extent of the eruption of the Siberian Traps large igneous province: Implications for the end-Permian environmental crisis. Earth Planet. Sci. Lett. 277, 9-20.

Tuganova, E.V. (1991) Petrological geodynamical model of formation of sulfide copper-nickel deposits. Soviet Geology and Geophysics 32 (6), 1-7.

Tuganova, E.V. (2000): Petrographic types, genesis and occurrence of PGE-Cu-Ni sulfide deposits. VSEGEI Press, St. Petersburg, 102 pp (in Russian).