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

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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).
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