The Vologochan Deposit as a New Important Cu-Ni-PGE Source in the Noril'sk District, Russia: Geological Structure, Mineralogy, and Geochemistry

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Ni-Cu-PGE sulfide deposits in the Noril'sk district represent a unique type of magmatic deposits related to thin ultramafic-mafic bodies within the Siberian traps. Due to their high economic value, their origin has been under examination for a long time. General models include closed or open magmatic systems, and suggest the important role of assimilation of surrounding rocks. These conclusions are mainly based on heavy S isotope results for sulfides and the presence of thick metamorphic and metasomatic areoles around the Talnakh and Kharaelakh intrusions.

A remarkable feature of the Noril'sk area, unlike other regions containing copper-nickel and platinum mineralization, is the presence of such a wide range of intrusion styles, from small occurrences to giant ore fields. This variability allows testing of proposed genetic models by comparing the most important ore-forming factors. The Vologochan deposit is interesting in this regard. Its position, internal structure, and mineralogical as well as geochemical features of the rocks are very close to those of the Kharaelakh intrusion, which contains massive sulfides. However, despite these similarities, the Vologochan deposit only contains disseminated ores with low platinum group metals contents.

The Vologochan deposit is located inside Devonian carbonate terrigenous rocks containing anhydrites. This sill reaches 280 m thick and extends for about 15 km. The stratigraphy, from bottom to top, includes troctolite, olivine, olivine-bearing gabbrodolerite, and gabbrodiorite. The olivine and plagioclase composition varies in the range $Fo_{54–79}$ and $An_{61–90}$, respectively; pyroxene Mg # ranges from 55 to 81. The bottom contact of the Vologochan intrusion (1.5 m) is composed of gabbronorite. Taxitic-textured gabbroic rocks, typical of the ore-bearing intrusions, are distributed locally in the bottom part of the Vologochan intrusion. The composition of this intrusion is similar to that of the Kharaelakh massif, including rare elements distribution, with the exception of the low Cr contents of the Vologochan intrusion. According to Sr-Nd isotope systematics, lithologies show a distinct heterogeneity in the radiogenic strontium component ($^{87}Sr/^{86}Sr_i$ = 0.7056–0.7060 in troctolite; $^{87}Sr/^{86}Sr_i$ = 0.7060–0.7083 in gabbro and gabbrodiorite) and rather constant initial isotope composition of neodymium (epsilon Nd about +1), matching those of economic intrusions.

Zones of disseminated sulfide mineralization can attain 50 m in thickness, and coincide with the presence of troctolite and olivine gabbro. Main ore minerals are represented by pentlandite, chalcopyrite, pyrrhotite, cubanite, talnakhite, troilite; rare minerals include maslovite, atokite, zvyagintsevite, sobolevskite, sperrylite, unnnamed $Pd_2(As,Sb)$, $Pd_2(Sn,As)$, Pd_3Sb, and $(Pd,Ni)_2As$.

The hornfels-rich layers in the lower exocontact are about 5 to 40 m thick. These plagioclase-pyroxene hornfels, along with forsterite, plagioclase-pyroxene-biotite zones, are associated with anhydrite and calciphyre. The hornfels of the upper exocontact (up to 150 m in thickness) consist of biotite-quartz-feldspar, feldspar-pyroxene species, and are associated with anhydrite marble, pyroxene-biotite-calcite-epidote-chlorite-metasomatic rocks, and garnet-pyroxene skarn with anhydrite-calcite and wollastonite.

The example of the Vologochan intrusion demonstrates that both the position among anhydrite-bearing rocks and the presence of thick contact aureoles are not necessary conditions for the formation of rich sulfide mineralization in the Noril'sk area.