

# The Noril'sk-Talnakh Deposits

## THE LARGEST PLATINUM OCCURRENCES IN THE U.S.S.R.

*As a general rule, this Journal does not aim to report on the occurrence or genesis of the platinum-group elements. None the less, the following account is published in the belief that it will interest many readers, and inform them of important platiniferous deposits about which little has been written in Western literature. During August and September, 1990, Professor G. von Gruenewaldt, Director of the Institute for Geological Research on the Bushveld Complex at the University of Pretoria, spent four weeks visiting platinum producing areas in the U.S.S.R. as a guest of that country's Academy of Sciences; his report follows.*

The Noril'sk-Talnakh deposits are situated north of the Arctic Circle in northern Siberia, see Figure 1, in the Province of Krasnojarsk. The area is only accessible by boat from Murmansk, or by a four hour flight from Moscow. The deposit was discovered in about 1860, but serious mining operations did not commence until 1935. Today, the area supports a population of about 300,000, most of whom live in the towns of Noril'sk or Talnakh. Bulk supplies for the region, and ore, are shipped through the harbour town of Dudinka, 120 km due west of Noril'sk on the banks of the Yenisei River.

### Geological Setting

The platinum-group elements are a by-product of massive and disseminated nickel-copper sulphide deposits associated with differentiated mafic (enriched in ferromagnesian silicates) intrusions. The deposits are situated on the northwestern edge of the Siberian platform, see Figure 1, which has been stable since the end of the Palaeozoic period. This platform is separated from the adjoining stable blocks, the Taimir Peninsula to the north and the Ural block to the west, by the Khatanga and Yenisei troughs, respectively. Within western Siberia, the basement rocks are overlain by dolomites and limestones dating from the Silurian period. These, in turn, are overlain by impure calcareous and dolomitic limestones (marls) and sulphate-rich evaporites of Devonian age, lower Carboniferous limestones, and mid-Carboniferous to Permian continental sediments of the Tunguska

Group which include coal measures. Subsequent large scale rifting was heralded by the extrusion of large volumes of flood basalt, known as the Siberian Traps, of late Permian to Triassic age. Continued rifting resulted in the subsidence of the Khatanga and Yenisei troughs and the deposition of thick sedimentary sequences of early Triassic to mid-Tertiary age.

A variety of different intrusions were emplaced simultaneously with the extrusion of the basalt (1). These are mostly basaltic in composition (gabbros), undifferentiated and not mineralised, in contrast to the Noril'sk-type of intrusions which are well mineralised and well differentiated. The unmineralised intrusions are widely distributed, but the distribution of the mineralised intrusions is restricted, and two features seem to be important in their localisation. These are: first the development of a well differentiated sequence of basalts ranging from alkali-basalt, through magnesium-rich (picritic) basalt to silica-rich tholeiitic basalt at the base of the Traps, in the Noril'sk area. Secondly a structural control, in that all mineralised intrusions are emplaced on, or in the proximity of, the very prominent Noril'sk-Karealakh fault, see Figure 2. The most important are the Noril'sk I, Noril'sk II and Mount Chernaya intrusions, near the town of Noril'sk, and the larger Talnakh intrusion some 30 km further to the north. The ones near Noril'sk are intrusive into the continental sediments of the Tunguska Group and the overlying basalts, whereas the Talnakh intrusion was emplaced at a lower stratigraphic level and

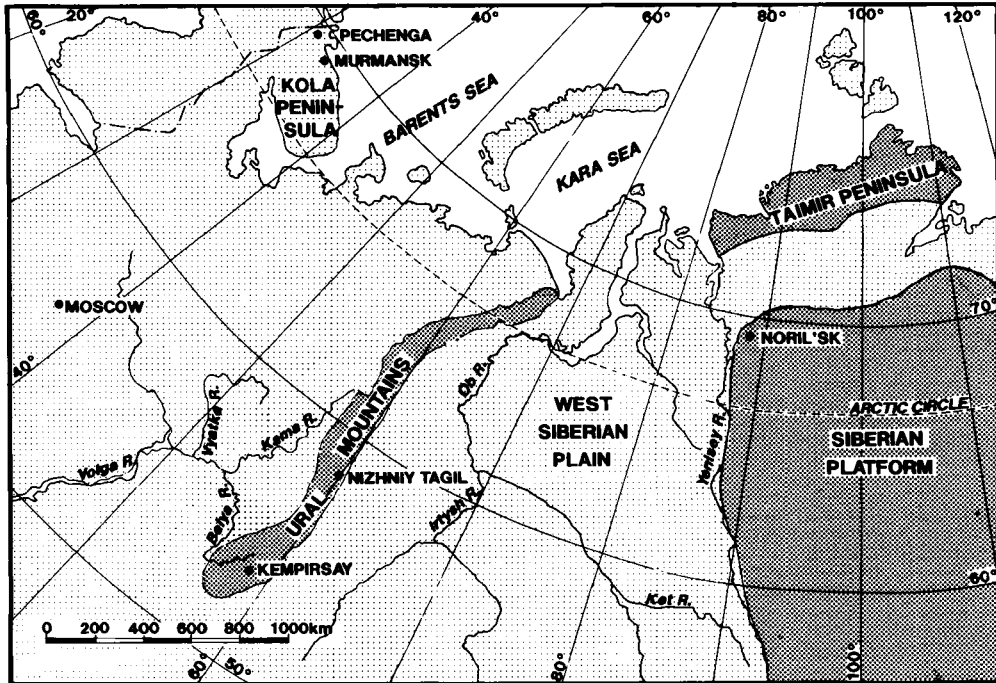


Fig.1 The Noril'sk-Talnakh nickel-copper-platinum- group metal deposits are situated well north of the Arctic Circle on the northwestern edge of the Siberian platform. The only other producer of platinum-group metals in the Soviet Union is Pechenga. Alluvial platinum was mined extensively in the past in the Nizhniy Tagil area of the Ural Mountains. Comparatively high concentrations of ruthenium, iridium and osmium in the chromite ores of Kempirsay could constitute a future resource of these metals

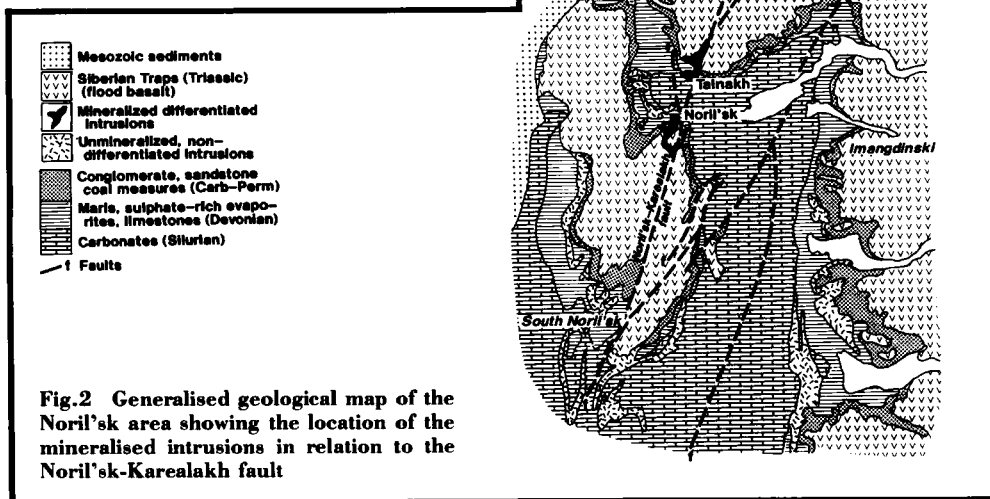


Fig.2 Generalised geological map of the Noril'sk area showing the location of the mineralised intrusions in relation to the Noril'sk-Karealakh fault

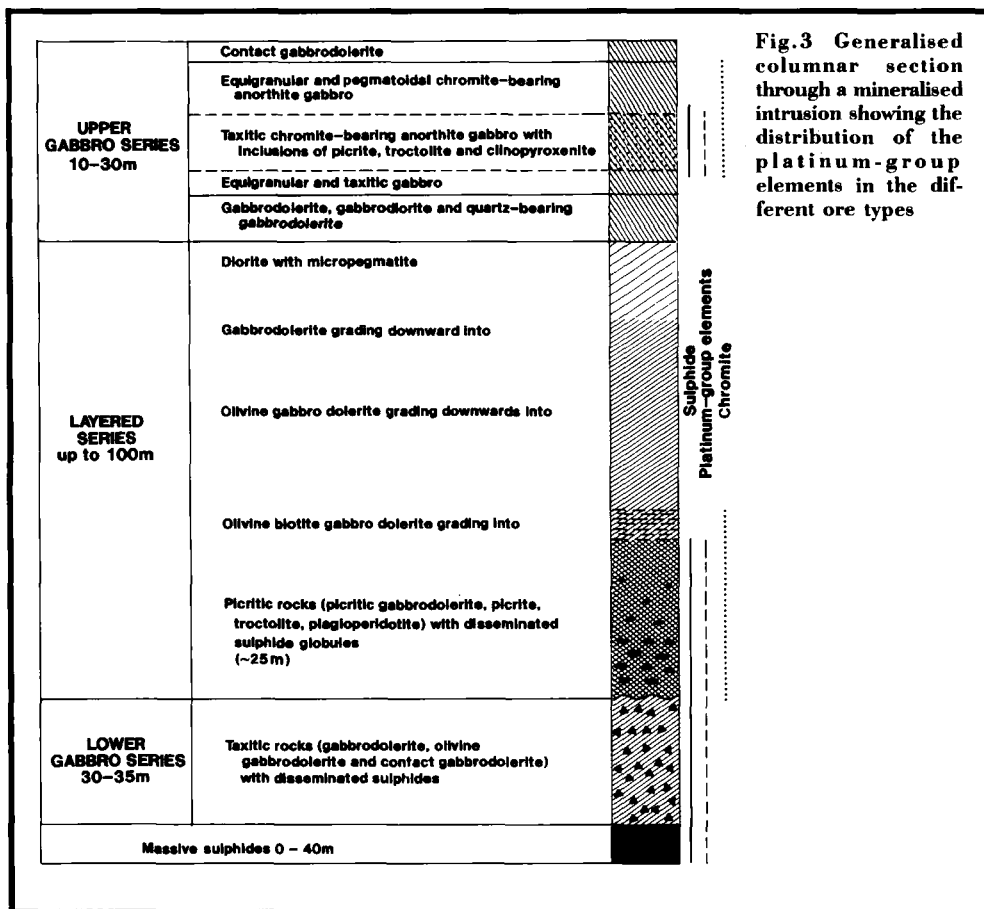


Fig.3 Generalised columnar section through a mineralised intrusion showing the distribution of the platinum-group elements in the different ore types

is intrusive into limestones and evaporites.

Exploration along the Noril'sk-Karealakh fault has also indicated some mineralisation in the South Noril'sk and Talminskaya areas, as well as in igneous rocks associated with a parallel fault in the Imangdinsky area. The differentiated, mineralised intrusions are generally between 50 and 150 m thick, and are subdivided on the basis of lithology into three zones, see Figure 3.

### Mineralisation

Massive nickel-copper-platinum-group element sulphide ores are restricted to the basal portions, usually where the intrusions thicken. However, massive ore is frequently separated from the mafic intrusion by intervening sediments, and displays intrusive relations to the sediments and to the mafic intrusion. Breccia ore,

usually copper-rich, suggests extensive mobilisation of the ore, and consists of fragments of intrusive or sedimentary rocks, depending on the setting, in a matrix of massive ore. The fragments and surrounding rocks of the breccia ore are frequently heavily impregnated with sulphide. Skarn-type mineralisation is developed where mineralised portions of the intrusion are in contact with limestones.

A variety of different massive ore types are developed. The most common is termed pyrrhotite-chalcopyrite ore which grades about 3 per cent nickel, 4 per cent copper and 12 to 15 ppm platinum-group elements, with a platinum:palladium ratio of 0.3. Locally the massive ores are considerably enriched in copper (Figure 4) and consist almost entirely of the minerals cubanite and pentlandite. In these

copper-enriched ores, the platinum-group element content can increase to more than 60 ppm and numerous centimetre-sized platinum group minerals occur near the upper contact of this type of massive ore.

The Talnakh intrusion covers an area of about 80 sq km, and about 32 sq km is underlain by massive ore which attains a thickness of 40 m in the Oktyabrski Mine. Disseminated ore, on the other hand, has a much wider distribution and is developed over 60 sq km, that is 75 per cent of the intrusion (Figure 4). The thickness of the disseminated ore varies between 20 and 60 m, usually in accordance with the thickness of the intrusions.

Four different types of disseminated ore can be distinguished:

(i) Heavy disseminations in the taxitic Lower Gabbro Series, usually as large irregularly shaped

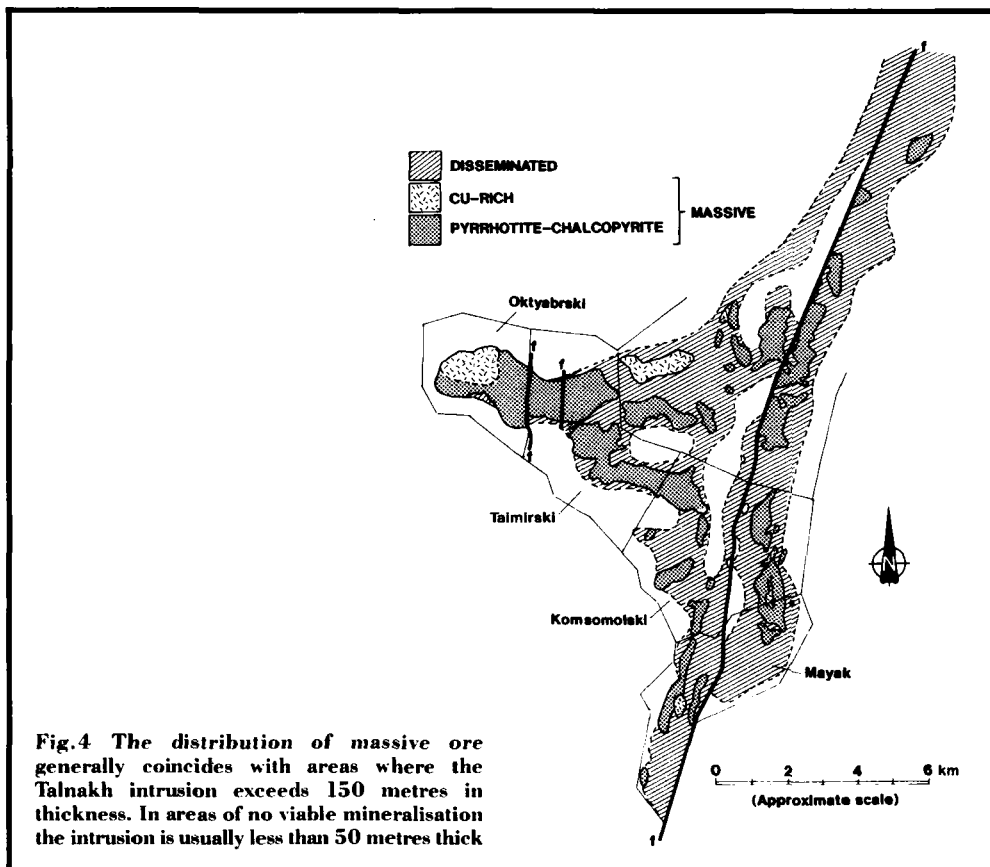
sulphide patches. The texture of the taxitic rock is very variable in that it contains coarse grained patches; plagioclase-rich segregations and fragments of gabbroic rocks, amongst others.

(ii) The overlying picrite is characterised by the presence of numerous sulphide globules which are flattened parallel to the igneous layering. A notable texture is the distinct separation of pyrrhotite in the lower part of the spheres and chalcopyrite in the upper portion. Interstitial disseminated sulphides occur throughout this type of mineralisation.

(iii) Upwards, these sulphides spheres decrease and make way for comparatively weak interstitial sulphide disseminations.

(iv) Weak sulphide disseminations in the upper taxitic gabbro, within the Upper Gabbro Series.

The disseminated ore has grades in the order



of 0.3 per cent nickel, 0.4 per cent copper and 5 ppm platinum-group elements with a platinum:palladium ratio of about 0.25. It is of interest to note that the content of the platinum-group elements of the sulphides in the disseminated ore is higher than in the massive ore! Nickel and copper values in the upper taxite are, however, considerably lower, but what makes this layer of great interest is the recently recognised high platinum-group elements content with recorded values of up to 40 ppm with a platinum:palladium ratio as high as 0.7.

### **Mining Operations**

Although no production figures were made available U.S.S.R. sales of platinum and palladium to the western world have amounted consistently to about 2,000,000 ounces annually over the past few years. If a local consumption of 1,000,000 ounces is assumed then the production of platinum-group elements from the Noril'sk area must amount to about 3,000,000 ounces, as the contribution made by other platinum-group element producing regions in the U.S.S.R., notably the Pechenga area, where grades are only 0.4 ppm and 0.04 ppm total platinum-group elements in massive and disseminated ores, respectively, is negligible in comparison.

At present nickel, copper and platinum-group elements are produced from six mines. Disseminated ore is being mined at an open cast operation on the Noril'sk I orebody, while the down dip extension is being mined underground in the Zapoljarni Mine. Four underground mines exploit the considerably larger Talnakh orebodies. These are the Oktyabrski, Taimirski, Komsomolski and Mayak Mines (Figure 4). In addition, the Gluboky and Skalesty Mines are presently being developed on the deeper parts of the orebody. Reserves of massive ores are estimated to last for another 50 years, and those of disseminated ores to last well beyond the twenty-first century at present production rates. Visits were arranged to the open cast mine at Noril'sk and the Oktyabrski Mine, while considerable time was also spent studying different ore types at mine dumps and in boreholes.

The refineries at Noril'sk produce nickel, copper and cobalt metal. Platinum-group metals concentrate is shipped to a platinum refinery in Krasnojarsk. All raw materials for the refining of the base metals, such as coal and pure silica sands, are obtained in the immediate surrounding of Noril'sk. The slags are used for concrete back-fill of the underground workings, the cement being produced locally from limestone and gypsum deposits. Electricity is generated in two power stations, one at Talnakh and the other at Noril'sk from gas which is piped to these plants. The gasfields are about 150 km due west, in the sedimentary succession of the Yenisei trough.

### **Petrogenesis**

The origin of the mineralisation is still being hotly debated. One school of thought considers the mineralised intrusion to be shallow magma chambers in which basaltic magma of the Siberian Traps resided and became contaminated with sulphur from surrounding evaporite sequences prior to their extrusion as basalt (2). The immiscible sulphide liquid which formed in response to the contamination then extracted the nickel, copper and platinum-group elements from the fairly large volumes of magma as it passed through the chamber on its way to the surface. The other school of thought (1) postulates that a large volume of immiscible sulphide liquid formed at depth in a large magma chamber. This sulphide magma was emplaced, together with a comparatively small volume of silicate magma as a mixture of two immiscible liquids, into the sedimentary and lower basalt sequences.

### **Acknowledgements**

I am greatly indebted to my two hosts, Professor Vadim Distler and Dr. Alexis Sokolov, as well as to their colleagues at the Academy of Sciences of the U.S.S.R., for their wonderful hospitality and for making the visit to Noril'sk possible. Thanks are also due to the many geologists at Noril'sk who shared their knowledge so readily with me.

### **References**

- 1 D. A. Dyuzhikov, V. V. Distler and B. M. Strunin, "Geology and Ore Deposits of the Noril'sk District", Nauka, Moscow, 1988, p.279 (in Russian)
- 2 A. J. Naldrett, "Magmatic Sulphide Deposits", Oxford University Press, 1989, p.186