Doklady AKAD. NAUK SSSR,
Earth. Sci. Sec. 1965, v. 161, p. 170-172

A NEW TYPE OF ORE SHOW IN KAMCHATKA[1]

O. N. Volynets and N. L. Shilin

Institute of Volcanology, Siberian Division,
Academy of Sciences, USSR
(Presented by Academician V. I. Smirnov, December 2, 1964)

UDC 553.2.042(571.66)=03.82=20

Abstract: A new type of ore show in the Sredinnyy Range, Kamchatka, has the following features: 1) simple mineralogy with three ore minerals--pentlandite, chalcopyrite, and pyrrhotite; 2) the mineral association is similar to copper-nickel sulfide ore of the Noril'sk type, which is of magmatic origin, 3) exsolution textures are missing, but recrystallized areas are present in pyrrhotite; and 4) small amounts of hydrothermal minerals are present.

In the last four or five years several new ore shows of nickel, a metal previously unknown in Kamchatka, were discovered there. The present brief communication deals with one such ore show, detected by the writers in 1962 in the Sredinnyy Range, along the upper course of Kagnisin Creek.

The ore show investigated is a dissemination of copper-nickel ore in unusual biotite-amphibole-feldspar rocks, occurring along the foot wall of a complex amphibolite sill. The section across the strike of the amphibolite body, from the foot to the hanging wall, is as follows:

1. Biotite-amphibole-feldspar rock with disseminations and pockets of sulfides… 30 m thick
2. Biotite-amphibole-feldspar rock with large feldspar porphyroblasts and occasional garnet crystals .... 10 m thick
3. Amphibolite.................................40 m thick
4. Biotite-amphibole-feldspar rock with garnet which becomes more abundant up the section toward the center of the bed, where its tenor reaches 40 to 50%, and then diminishes again….. ……………………………………. 50 m thick

The amphibolite, forming a concordant lenticular parting in gneissoid rocks, obviously originated through regional metamorphism of a basic sill. It is veined by biotite granite, pegmatitic granite and pegmatite.

The country rocks consist of plagioclase (35 to 55%), amphibole (20 to 35%), biotite (10 to 25%) and quartz (5 to 15%). One of their distinctive features is the presence of much rutile and apatite. The rock texture is porphyroblastic to poikiloblastic, with a lepidonematoblastic groundmass texture. The chemical analysis of the country rock is as follows:

SiO_2	TiO_2	Al_2O_3	Fe_2O_3	FeO	MnO	NiO	MgO	CaO	Na_2O	K_2O	H_2O^-	H_2O^+	Σ
52.24	1.26	11.85	1.38	7.32	0.15	0.11	13.28	6.30	1.48	2.22	0.20	2.12	99.91

Recalculation by A. N. Zavaritskiy's method gave the following results (class - silica saturated; group – very poor in alkalis):

a	*c*	*b*	*s*	*f′*	*m′*	*c′*	*Q*	*a/c*	*n*	*t*
6.1	4.5	3 1.8	57.6	24.7	66.8	8.5	–1.5	1.35	52.1	1. 9

Recalculation by P. Niggli's method of numbers showed:

Si	*al*	*fm*	*c*	*alk*	*κ*	*mg*	*t*	*qz*
119	15.9	62.2	15.4	6.5	0.42	0.73	–6	–7

The magma comes from the hornblendite group. The type is hornblenditic. In the section of P. Niggli's tetrahedron, the rock lies in the area occupied by igneous rocks.

The ore minerals occur as individual disseminations or round pockets from 3 to 10 mm across.

The principal ore minerals are pyrrhotite, chalcopyrite and pentlandite. The accessories are two minerals from the linneite group and valleriite. Bravoite, marcasite and melnikovite are common secondary minerals, but limonite, pyrite and covellite are less abundant.

The dominant ore mineral is pyrrhotite which, with its replacement products, accounts for 70 to 75% of the volume of ore pockets. Pyrrhotite forms large irregular grains up to 1 and 4 mm in size; as a rule, 1 to 2 grains of it make up the entire ore pocket, with the other ore minerals grown into them. Many large pyrrhotite crystals are recrystallized into microgranular aggregates with a grain size of 0.1 to 0.2 mm. Such recrystallized areas mostly appear at the edge of ore pockets; they are less common in their central portions. The recyrstallization must have resulted from imposed kinetic-metamorphic processes.

The next most abundant ore mineral, chalcopyrite, accounts for about 15% of the ore. Chalcopyrite concentrations are confined to cracks in

[1] Translated from: O novom dlya Kamchatki tipe rudoproyavleniy. Doklady Akademii Nauk SSSR, 1965, Vol. 161, No. 6, pp. 1412-1415.

Table 1

Line No.	Octahedral crystal		Mikheyev's polydymite		Acicular crystal		Mikheyev's siegenite	
	I	d_α/n	*I*	d_α/n	*I*	d_α/n	*I*	d_α/n
1	1	5.57			2	3.75		
2	2	5.09			4	3.35	2	3.36
3	2	4.20			10	2.85	10	2.85
4	1	3.66			4	2.65		
5	5	3.35	3	3.35	3	2.36	7	2.36
6	2	(3.16)			7	2.04		
7	1	3.08			3	1.817	3	1.83
8	10	2.85	8	2.85	2	1.716		
9	1	2.60			6	1.669	10	1.67
10	5	2.35	8	2.365				
11	1	1.937	3	1.931				
12	4	1.815	5	1.821				
13	10	1.667	9	1.673				
14	1	1.437	2	1.443				
15	2	1.285						
16	1	1.266	2	1.264				
17	2	1.230	4	1.232				
18	2	1.181	3	1.183				
19	3	1.092	3	1.092				
20	3	1.056	3	1.085				

crystals of pyrrhotite, to the boundaries between grains and, occasionally, to the periphery of ore pockets. They are either irregular grains (0.2 to 0.5 mm across) or stringers up to 2.0 and 4.0 mm long and 0.2 to 0.5 mm wide. There is another generation of chalcopyrite: small grains up to 0.1 mm in size, developed among rock-forming minerals, chiefly near pockets of pyrrhotite. It is interesting that, although chalcopyrite is 7 to 10 times as infrequent as pyrrhotite in ore pockets, their proportions in small disseminations do not exceed 1:2 and 1:3.

The last of the principal ore minerals, pentlandite, does not account for more than 10% of the volume of the ore. It forms normal crystals, localized at the edge of ore pockets, or irregular grains closely associated with chalcopyrite, which are often confined to the gouge of its stringers in pyrrhotite. Considerably less common are small irregular vermiform ingrowths of pentlandite in pyrrhotite. The dimensions of crystals and grains of pentlandite do not exceed 0.2 to 0.4 mm.

Considerably more infrequent than those listed above are linneite group minerals and valleriite. Minerals of the linneite group form octahedral, prismatic, well-defined crystals or acicular aggregates, no more than 0.4 mm in size at the most, while valleriite constitutes minute laths confined to grains of chalcopyrite. The X-ray powder patterns of minerals of the linneite group, obligingly photographed by A. D. Genkin, are presented in Table 1.

The ores, especially the pentlandite and pyrrhotite, have experienced supergene alteration. Pentlandite is replaced by bravoite, and all stages of its replacement are visible, beginning with the emergence of bravoite along irregular cracks in pentlandite crystals and ending with their total replacement. More than half of the slides examined showed pentlandite entirely replaced by bravoite. The secondary minerals developed from pyrrhotite include melnikovite, marcasite, pyrite and limonite, with the latter being plainly later than the first three and separated from them in time. The secondary minerals are spread along the cleavage cracks in pyrrhotite or occur where its grains abut other minerals (particularly gangue minerals). Reticulate replacement textures are most distinctive. Unlike pentlandite and pyrrhotite, chalcopyrite is usually much less altered, and only to a very minor extent is it limonitized and covellitized.

Chemical analysis of ore concentrate, extracted from a crushed sample by magnetic separation, gives Ni and Cu contents of 6.39% and 0.73%, respectively (analyzed by Arapova and Nesterova, Institute of Ore Geology, Petrology, Mineralogy and Geochemistry USSR Academy of Sciences).

Summing up what has been said briefly of the mineralogy of the ores, it is necessary to emphasize the following features specific to them:

1. The ore mineralogy is extremely simple; actually (disregarding the secondary minerals), the ore consists of three minerals - -pentlandite, chalcopyrite and pyrrhotite.
2. This mineral association is similar to copper-nickel sulfide ore of the Noril'sk type, which is of magmatic origin; of the principal minerals, it lacks only magnetite (it is interesting to note that the sequence of genesis of the principal ore minerals here is generally the same: first pyrrhotite, then chalcopyrite and pentlandite).
3. The ores lack most conspicuously the solid solution dissociation textures so typical of the systems chalcopyrite - pyrrhotite, pentlandite - pyrrhotite.
4. Recrystallized areas are present in the pyrrhotite.

5. The ores contain, in very small amounts, such hydrothermal minerals as those of the linneite group.

6. The supergene replacement of pentlandite by bravoite is widespread.

In view of all the aforesaid and the fact that analogous ore shows have also been detected in unmetamorphosed basic rocks of younger age elsewhere in Kamchatka (M. M. Lebedev, 1959--Dukuk Pass, Sredinnyy Range; A. M. Sadreyev and B. K. Dolmatov, 1960--Kronotsk district, eastern Kamchatka), it is logical to suppose that the ore show studied in metamorphosed ore disseminated through originally basic rocks, altered to amphibolite in the process of regional metamorphism. Arguing for this is the ore mineral association--pentlandite, chalcopyrite, pyrrhotite--atypical of any other process of mineralization. The lack of clear evidence of metamorphism in the ores (disregarding the recrystallization of pyrrhotite due, obviously, to superimposed late processes of dynamic metamorphism) can be attributed to the complete recrystallization of ore minerals during regional metamorphism. Indirect signs of such recrystallization are extremely simple ore mineralogy and the absence of solid solution dissociation textures.

The fairly wide development in Kamchatka of basic to ultrabasic intrusive formations in both the Upper Cretaceous to Paleogene and older metamorphic complexes highlights the finds of nickel minerals in them and makes it necessary to study the rocks of these complexes in more detail in geologic mapping in view of the possibility of discovering economic deposits of copper-nickel ore.

Received December 1, 1964