Industrial role of nepouite from Elov supergene nickel deposit, Northern Urals

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Abstract. It has been established that nickel varieties of lizardite with a content of 20.64-51.99% NiO refer to nepouite, which was for the first time determined and described as an important industrial mineral component of ore in the Elov supergene deposit. The data of X-Ray diffraction, complex thermal analysis und SEM of nepouite were obtained. Based on the results of research, this mineral was designated as a serpentine of the lizardite-nepouite series. Mg-nepouite was also determined in this assemblage. NiO content in the nepouite varies from 13.00% to 35.18%, MgO — from 18.29% to 44.61%. The thermal analysis of the serpentine shows that the temperature of the Mg-nepouite destruction is 610-615 $^{\circ}$C that is specified to a hydrothermal process. It can be assumed that the serpentines of the lizardite-nepouite series in the weathering crust of the Ural deposits can have both exogenous and low-temperature hydrothermal origin.

1. Introduction

Nepouite is one of the main nickel silicates in supergene nickel deposits, associated with serpentinites in the Urals [5].

Finecrystal scaly nepouite was described in supergene nickel deposits of New Caledonia near town of Nephoui by M. Glasse, and therefore the mineral took its name nepouite. However, for the first time this mineral was found in 1867 in green colloidal mass (from dark-green to pale-green) in Revda district, Middle Urals, and was named revdinskit [1]. Later on this term was eliminated from the mineral classification of International Mineralogical Association.

In the supergene rocks of the Elov deposit nepouite was found for the first time. This mineral is a nickel analog of lizardite in the lizardite-nepouite isomorphic series.

The study of the mineral composition of the supergene ores allows us to indicate the main zones (from top to bottom) [2]: 1) ocherous zone (altered by infiltrate-metasomatic processes of later supergenes); 2) nontronite and smectite zone with superposed infiltrate-metasomatic minerals (chamosite, siderite and magnetite); 3) leached rocks; 4) disintegrated rocks.

Nepouite of the Elov deposit varies enormously in forms of extraction. It occurs in leached rocks and in the upper part of the disintegrated zone.

2. Materials and methods

Nepouite from the Elov nickel deposit (Serov group, North Urals) was studied by X-Ray diffraction analysis ("Mekhanober-Analite", analyst Dr. M.A. Yagovkina), complex thermal analysis (SPMI, analyst Dr. V.L. Ugolkov) und SEM (TU Bergakademie Freiberg, analyst Dr. U. Kempe, SPRIAN, analyst Dr. J.L. Kretser).

3. Geological setting

Disintegrated zone is represented by massive, very fractioned and coarse serpentinites (apoperidotite, apopyroxenite serpentinites of chrysotile-lizardite, lizardite-antigorite and antigorite composition) developed in the lower part of section throughout the whole deposit. In breaking zones, disintegrated serpentinites repeat several times, interchanging with leached friable and strongly decayed material. Nepouite is abundant in lizardite serpentinites in the form of numerous branching veinlets, formed by a fineflake gel structure massive aggregate with blue-grey, pale-blue colour and dull lustre.

The leached zone is developed in ultrabasic rocks everywhere (the thickness is around 50 m). The zone is represented by massive and friable, weakly and strongly leached, altered to some degree, sometimes siliceous, sometimes ocherous serpentinites. The rocks of these horizons differ greatly in outer appearance and represent a consecutive row from weakly weathered massive rocks to strongly leached friable clay material.

Nepouite is observed in the clinochlore-talc metasomatites, presented in the fine-disperse mixtures with clay minerals and goethite, has a soft, earthy structure, of yellow-brown, pale-green, emerald-green colour and of fine-aggregate or spherulitic structure under the microscope. The chemical composition of nepouite is given in Tables 1 and 2. The content of NiO varies from 13.00 to 35.18 %, MgO content — from 18.29 to 44.61 %, i.e. nepouite composition corresponds to composition of Mg-nepouite and proper nepouite.

Table 1. Chemical composition of nepouite from the Elov deposit, mass. %[a]

Oxides	1	2	3	4	5	6	7	8	9	10	Average
SiO_2	46.63	46.67	46.72	45.30	46.02	46.12	46.65	43.78	50.98	51.10	47.04
Al_2O_3	0.64	0.75	0.70	0.34	1.05	0.45	0.56	0.71	0.74	1.18	0.78
FeO	1.71	1.87	1.43	0.99	1.30	1.19	1.48	1.42	3.03	1.80	1.62
MnO	0.74	0.31	0.44	0.10	0.28	0.20	0.35	0.00	0.14	0.56	0.31
MgO	25.48	23.87	23.03	21.44	23.57	23.78	23.89	18.29	22.34	26.74	23.24
NiO	24.50	26.53	27.15	31.82	27.59	28.26	26.86	35.18	22.77	17.55	26.82
CaO	-	-	-	-	-	-	-	0.16	0.00	0.26	0.21
CoO	0.31	0.00	0.54	0.00	0.18	0.00	0.21	0.46	0.00	0.19	0.19
Summ	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00

[a] SEM, TU Bergakademie Freiberg, analyst Dr. U. Kempe

Table 2. Chemical composition of nepouite from the Elov deposit, mass. %[a]

Oxides	1	2	3	4	5	Average
SiO_2	38.69	38.59	39.99	39.69	39.84	39.36
Al_2O_3	0.00	0.00	0.00	1.51	1.65	0.64
FeO	1.46	1.18	1.30	1.18	1.37	1.29
MnO	0.00	0.00	0.00	0.00	0.00	0.00
MgO	42.33	40.65	41.75	44.61	25.64	38.99
NiO	17.52	19.58	16.97	13.00	31.51	19.72
CoO	0.00	0.00	0.00	0.00	0.00	0.00
Summ	100.00	100.00	100.00	100.00	100.00	100.00

[a] SEM, St-Petersburg, RIAN, analyst Dr. J.L. Kretser.

Since the nepouite is nonstoichiometric and included in isomorphic lizardite-nepouite series, Ni in it is in isomorphic relations with Mg.

According to the obtained XRD data, the nepouite occurs in the form of polymorphous modification 2OR in the ores of the Elov deposit. The value of its first most intensive basal reflex d001 differs from 7.21 Å to 7.32 Å (table 3). In general, the intensity of the nepouite reflexes is considerably lower than that of lizardite.

Table 3. X-ray diffraction data of nepouite[a]

Elov deposit, North Urals 1		Lipov deposit, Middle Urals 2		Yugoslavia 3		New Caledonia 4	
d	I	d	I	d	I	d	I
7.303	100	7.32	100	7.28	100	7.25	100
4.469	10	4.56	40	4.57	20	4.55	35
-	-	-	-	3.90	5	-	-
3.620	48	3.69	100	3.63	43	3.62	100
-	-	3.10	10	-	-	-	-
2.877	13	2.87	10	-	-	-	-
2.701	23	-	-	-	-	-	-
2.599	8	2.64	20	2.635	20	2.642	40
2.523	54	2.45	60	2.475	40	2.479	60
2.409	8	2.42	40	-	-	-	-
2.208	13	-	-	2.281	7	-	-
2.126	15	2.12	20	2.133	14	2.149	15
2.008	4	-	-	-	-	-	-
-	-	-	-	1.787	5	-	-
-	-	1.52	60	1.527	23	1.529	60
-	-	1.49	40	1.500	14	1.500	30
-	-	1.45	20	-	-	-	-
-	-	1.40	10	1.302	11	1.303	25
-	-	1.10	10	-	-	-	-

[a] 1 - X-ray phase analyses were carried out by a Giegerflex-D/max X-ray powder diffractometer in the laboratory of the Mekhanobr-Analit Joint-Stock Co. (M.A. Yagovkina, analyst); 2 – Tekhnologicheskaya mineralogiya…, [6, tab. 2.14]; 3 – Maksimovich [4]; 4 - Montoya, Baur [7].

The results of the complex thermal analysis of Mg-nepouite are given in Figures 1 and 2 and correspond to lizardite results. Two well-observed endothermal maximums at 57-62 °C and 610-615 °C are shown on the DSC-curves (Figure 1). The first is connected with the loss of adsorbed water, the second – at 490-685 °C (curve 1) and 479-677 °C (curve 2) – with the loss of constituent water in amount of 13.08 % and 6.34 %, correspondingly. The temperature of the second endothermal effect of nepouite is somehow lower than that of lizardite (606-798 °C). Except endothermal effects, there is a narrow intensive exothermal effect of nepouite at 823 (824) °C (Figure 1) that is common to lizardite (827 °C). High intensity of this exoeffect proves the allocation of the Elov nepouite to Mg variety.

The listed intervals of endo- and exoeffects of nepouite during heating are well observed on the DTG curves (Figure 2). There are three steps of the weight lost in the intervals of 30-200 °C, 600-800 °C and 800-900 °C. The composition of thermal destruction products was determined by masspectral analysis. The later indicated steam in all three intervals, including the last interval. Obviously, the most considerable water loss happens in the interval of 600-800 °C that corresponds to the removal of some hydroxyls in nepouite structure during its reorganization in Ni talc. Further mass loss in the interval of 800-900 °C is connected with the removal of hydroxyls from Ni talc in its reorganization in Ni olivine.

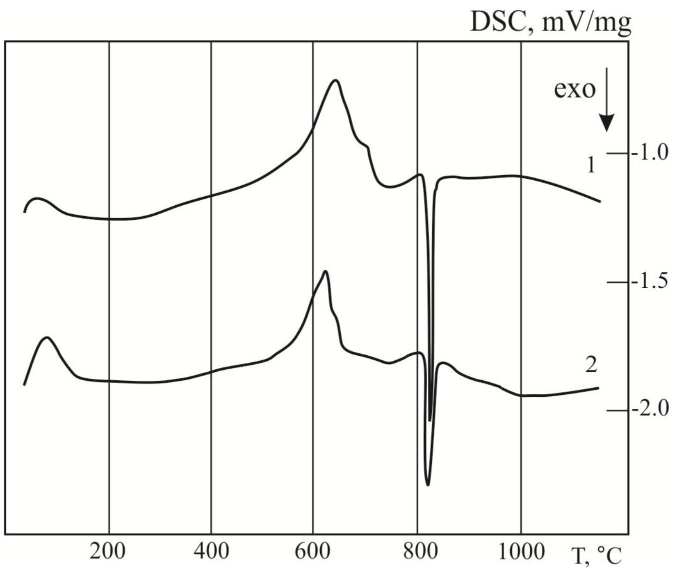

Figure 1. DSC curves of Mg-nepouite from the Elov deposit.

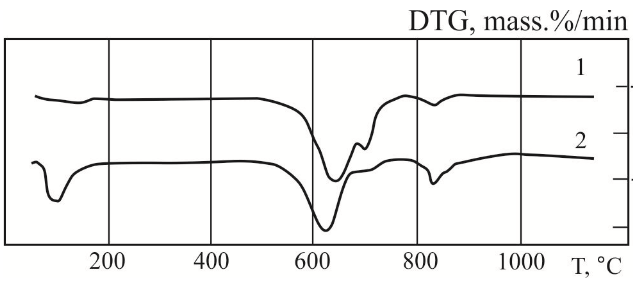

Figure 2. DTG curves of Mg-nepouit from the Elov deposit.

4. Conclusion

1. The nickel varieties of lizardite in the Elov deposit with a content of 20.64-51.99 % NiO are classified as nepouit. In the lizardite-nepouite series, it is proposed to distinguish between the intermediate varieties - nickel lizardite and magnesium nepouite.

2. Nepouite is abundant in the zone of leached rocks and in the upper part of the zone of disintegration of the Elov deposit.

3. According to the thermal analysis, the temperature of decomposition of the nepouite structure is 610-615 °C.

4. Experimental studies of the $Mg_3Si_2O_5(OH)_4$-$Ni_3Si_2O_5(OH)_4$ system [3], as well as the isotope data of A.V. Uhanov [8], show that the upper temperature of lizardite-nepouite resistance is peculiar to the hydrothermal process. It can be assumed that the serpentines of the lizardite-nepouite series in the weathering crust of the Ural deposits can have both exogenous and low-temperature hydrothermal origin.

5. Acknowledgments

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