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Mineral Raw Material Base of Magnesite in Ukraine and Its Future Development

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The location, geological and mineralogical structure of talc-magnesite and serpentinite deposits in Ukraine are considered. Rock samples, their mineral and chemical composition are studied. The estimation of reserves is given, possible ways of involvement of ores into the industrial production are discussed . In connection with the development of new technologies of magnesite usage for the magnesium production the feasibility of deposits investigation and exploration in the most promising of them is shown.

Keywords: ROCK, IRON-SILICEOUS FORMATION, TALC-MAGNESITE, CARBONATED SERPENTINITE, BREUNNERITE, RATE OF CHLORINATION, MAGNESIUM-CHLORATE MELT.

Introduction

Currently, within the CIS countries the material for electrolytic production of the marketable magnesium is carnallite, which is produced by mining. During operation the Verkhnekamsk Deposit of natural carnallite since 2006 in the JSC "Silvinit" and JSC "Uralkali" there appeared some technological problems that caused flooding of several mines and a reduction in production [1]. This stimulates interest in developing technologies for magnesium-chlorate melts from magnesite - natural magnesium carbonate. The objective of this study is to review the mineral raw material base of magnesite in Ukraine and analysis of the prospects of their use in metallurgical production.

Results and Discussion

Nowadays in Ukraine there are known two deposites that have not yet developed. Talc-magnesites make deposits of metamorphogenic and hydrothermal-metamorphogenic types that are associated with Precambrian strata containing iron-siliceous formations [2, 3]. They are developed in the submeridional structures (the Krivoy Rog-Kremenchug, Konksk-Belozersk, Bazavlutsk, Orekhov-Pavlograd). The distribution of deposits in these structural-formational zones is uneven. Currently, except these deposits there are a number of other promising ore occurences.

The Pravdinsk deposit (**Figure 1** and **2**) of talc-magnesite and carbonated serpentinite is located near the village Grushovka , Krinichansk district, Dnepropetrovsk region, 25 km south of Dnepropetrovsk. In the geological structure of the deposit there are involved the Precambrian crystalline rocks, their weathering crust and overlying pliocene-quaternary sandy-clayey deposits.

The deposit is located in the southwestern part of the homonymous ultrabasic massif, which is a part of the Zapadnosursk ultrabasite pack. This is a relatively large intrusive body of northwest trending with a steep northeast dip. Length of the massif is 5 km, width from 300 m to 2.5 km, area 11 km^2.

From the north-west and south it contacts with the complex of granitoid rocks, and on the north-east - with the sedimentary-volcanic rocks of the Belozersk group. Ultrabasic rocks of the Pravdinsky massif are presented by chrysotile, antigorite serpentinites, talc-magnesia-serpentine and talc-magnesite rocks, as well as talc-chlorite and chlorite-carbonate-talc schist.

More than two thirds of the massif is composed of serpentinites and talc-magnesite rocks. The latter compose in the massif several bands (deposits), 0.5 to 2.5 km long, adapting to tectonic disturbances or the peripheral parts of the massif.

The deposit includes two ore types: 1 - talc-magnesite rocks, 2 - carbonated serpentinites. This takes into account the chemical (**Table 1**) and the mineral composition as well as technological properties of rocks. The quality evaluation was carried out on the following tables of contents of limiting components of the mass content,%: Mg - not less than 33; Al_2O_3 - not more than 2; CaO - not more than 2.5; Mg/SiO_2 - not less than 1.1.

Talc-magnesia rocks (talc-magnesites) are composed of talc (35-50%) and magnesite (40-60%), and a small amount of serpentine (antigorite), dolomite, magnetite, chlorite. Mass content of main chemical components,%: MgO 32-36; SiO_2 25-30; Al_2O_3 below 2; CaO below 2.

Talc-magnesite rocks have quite constant mineral content (talc, magnesite, breunnerite, with a small amount of serpentine, magnetite, chromite, and sulphides, chlorite, dolomite). Carbonate content in them reaches 15-93%. The quantitative relationship between talc and magnesite vary from 40 to 44%.

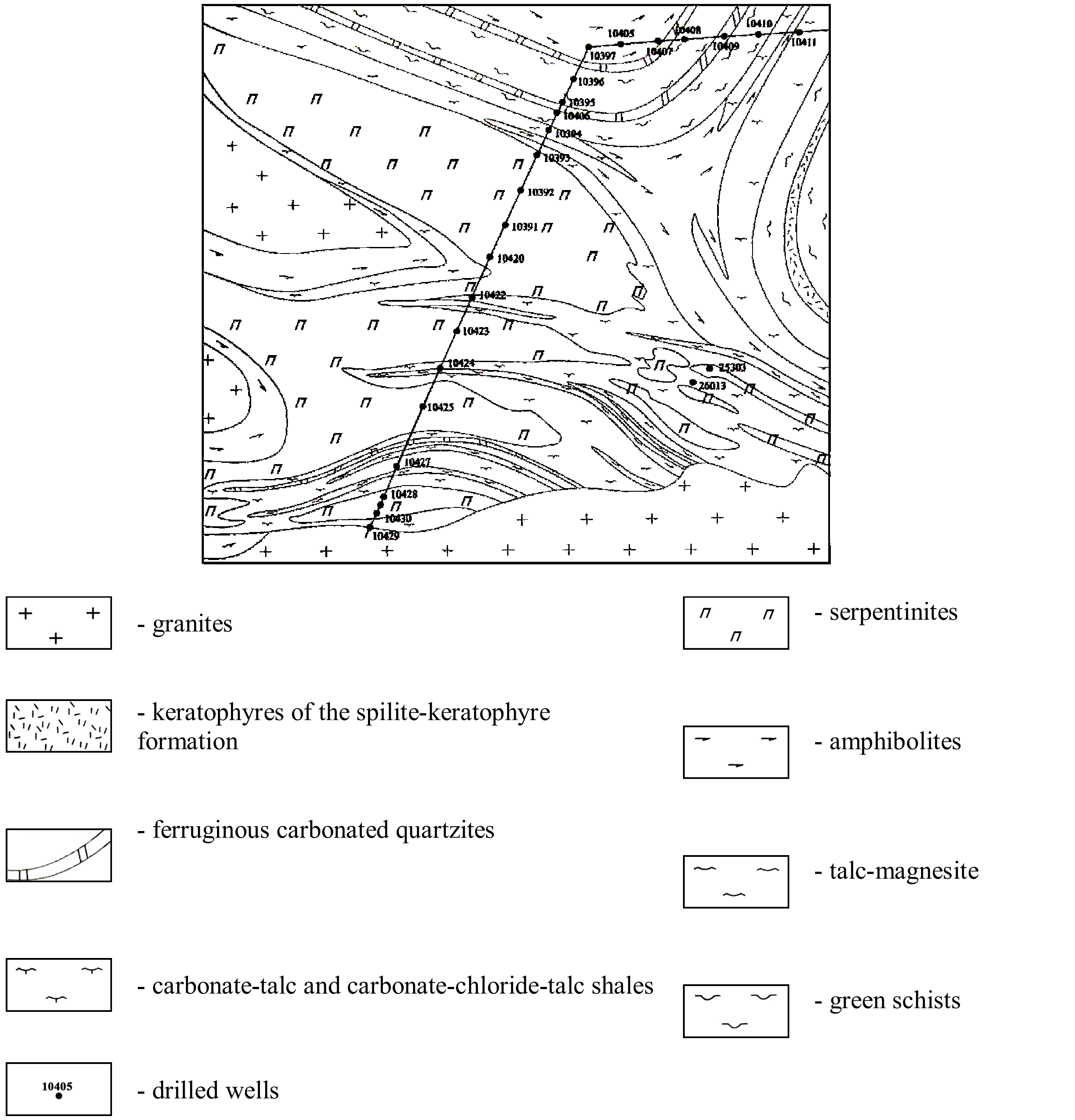

Figure 1. Schematic geological map of the Pravdinsk serpentinite massif of the Sursk centroclinal fold

Table 1. The chemical composition of magnesite of Pravdinsk deposit

Ore type	Mass content, %			
	MgO	SiO_2	Al_2O_3	CaO
Talc-magnesite	34,84-36,41	27,17-29,59	0,28-0,79	0,26-0,76
Carbonated serpentinite	35,42-40,88	29,94-33,26	0,28-0,90	0,16-0,75

The studied samples represent rocks of light gray, gray and greenish-gray colors, medium- and fine-grained, massive texture, sometimes shaly, their structure is porphyroblastic and lepidograinblastic.

Magnesite (breunnerite) is observed in the form of aggregates and grains of isometric, angulous and elongated form, rarely contains porphyroblasts of grayish-white and white colour. Grain size varies in wide limits: from 0.02 to 4.5 mm, mostly grains of size 0,05-0,4 mm. There is uneven distribution of minerals in the rock, the amount ranges from 45 to 55%. The marked area is where the content of magnesite reaches 65-80%. In sections of carbonate-talc rocks the content of magnesite decreases to 40-45%, but the average content of magnesite is 5-10% higher than the content of talc.

Talc in the maximum amounts can be found in the near-contact parts of the deposits. In the south-western part its amount reaches 41,7-80,0%.It forms white, colorless, sometimes transparent grains aggregates of elongated form or submitted by individual thin plates fron 0.01 x 0.03 mm to 0.04 x 0.16 mm in size. Usually, it cements magnesite. Distribution of the mineral in the rock is uneven, often it is isolated in some parts of lenticular and irregular shape, or forms coarse flake veins with pale green coloring, which cut the bulk. As noted talc contains magnesite.

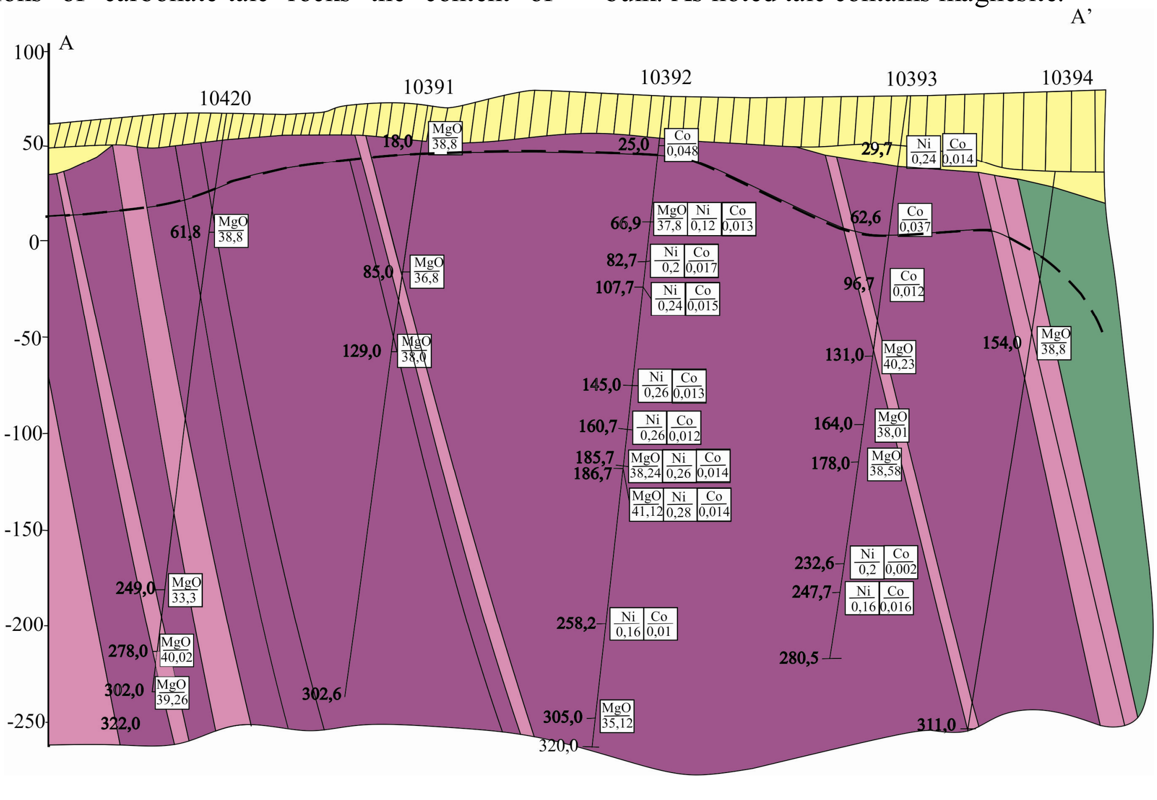

Figure 2. Geological section along the line A-A' of the northern Pravdinsk massif

The content of Fe in it varies from 0.5 to 2.5%, and its iron content is up to 7,7-20%. Chromite is contained in a subordinate amount in association with fuchsite. Pyrite, pyroxene, chalcopyrite, and, rarely, pentlanditeare are widespread. Sporadically it is observed in serpentine form of rare relics (2-5%), but its content is increased in the transitional serpentine-talc-carbonate rocks. Talc-magnesites are complex ores, since except talc (45-50%) and magnesite they contain a high amount of nickel, cobalt and chromium.

Carbonated serpentinites are composed of serpentine (lizardite, antigorite, serpophyte (60-80%), carbonate (Ca-Mg-Fe) (20-40%), including magnesite (10-30%), talc, magnetite, and chromite. Occasionally there are observed olivine, bastite, sulfides, etc., their chemical composition (mass content,%): MgO 36-41; SiO_2 31-37; Al_2O_3 <1,0; CaO <2,0; P and S in small quantities. Productive strata of the deposit with talc-magnesite and carbonated serpentinites occur among the metamorphic rocks in the form of steeply dipping (60-85 °) plate-like deposits of north-western (submeridian) strike. The length of this strata along is 800 m, width at the surface 150-350 m, power 80-350 m. It is explored to a depth of 160-180 m, and the individual wells of up to 350 m. By the zone of violations and off-analysis rock section in the central part of the field the strata is divided into the south-west and north-eastern areas (blocks). In the first section it is of 600 m long and 80-180 m is the power, in the second - length is 800 m, 100-380 m is the power. The power of the zone of the separating off-analysis rock section is 10-45 m, with increasing depth, it also increases. In the surface of the it is represented by chlorite-carbonate-talc rocks and with depth, the role of carbonate-talc-chlorite and chlorite-actinolite rocks grows.

Distribution of serpentinite and talc-magnesites in the south-western part of the deposit is close to uniform, in the north-eastern part there is observed growth of serpentinites from the north-west to south-east.

Pravdinsk deposit of talc-magnesites and carbonated serpentinite was discovered in 1964 in the Novomoskovsk exploration company. It was explored in 1964-1968, proceeded exploration in 1971-1972. PGA "Южукргеология" with the approval of the State Commission for Reserves of the Soviet Union in 1973, total reserves in categories A + B + C1 made 105.134 million tons, including Category B - 29.502 million tons, C1 - 75 632 tons, with an average grade of talc-magnesite and serpentinite carbonated 55 and 45%, respectively. Forecast resources to a depth of 150 m are about 300 million tons of reserves established for the following condition on the content of components in the sample and on the block, mass content,%: MgO not less than 38.4; Al_2O_3 less than 2; CaO, not more than 2.5; Mg/SiO_2 not less than 1.1. Maximum capacity of conditioned layers included in the calculation of reserves is -6 m, an approximate ratio of overburden to thickness of seam 2 m^3.

In calculating the reserves there was used the method of parallel vertical cuts.

Technological research of talc-magnesite and carbonated serpentinite made during the exploration, confirmed the profitability and possibility of producing the following basic conditioned including high-grade products.

1. Magnesite-breunnerite (yield 40%) and talc concentrate of grades A and B (yield 48%) of multi-purpose, which are produced by flotation.

2. Forsterite refractories obtained directly from talc-magnesite and from carbonate serpentinite - provided 25% of magnesia concentrate adding.

3. Finely ground talc-magnesite and carbonate-serpentine flour, which can be used as a filler in various industries: the manufacture of insecticides for crop protection as a highly effective fertilizer and magnesium ameliorator for acidic soils, as a component for heat-resistant concrete for more durable roofing material, and for the production of special glass and slag glass-ceramic.

4. Blocks of ore, from which refractory brick for rotary kiln can be produced.

The deposit is characterized by favorable mining-technical and economic conditions (low roof, a large capacity of the ore bodies and small water inflow into the pit) and can be worked out by opencast methods. Overburden rocks are weathering crust and sand-shale formations of the Neogene-Quaternary age (sand, clay, loam) with a total capacity of 5 to 35 m. The loose rocks have an average capacity of 16 m with average thickness of soft overburden of 16 m and 3.9 m rock overburden. Joint Stock Company "Днепр-Металл АГ" obtained a license to develop this deposit and is preparing for its development [3].

Veselyanka talc-magnesite deposit was discovered in 1952-1955 15 km south-east of the railway station Fisaki on the left side of the river Conca near the village Veselyanka, Zaporizhzhya region, 25 km from Zaporizhzhya on the Moscow-Simferopol highway. The district is composed of Precambrian crystalline schist (serpentinites, talc-carbonate, talc-chlorite, chlorite-amphibole rocks). The talc-magnesite rocks deposit is represented by three disconnected with each other steeply dipping (70-80 °) deposits that can accommodate lenses and layers of serpentinite.

The first deposit is of lenticular shape, elongated in the latitudinal direction. It can be traced along strike for 600 m at power of 50 to 100 m at a depth of deposit can be traced up to 100 m. The reservoir rocks in the north overlap chlorite and quartz-chlorite schist. In the southern part there are observed contact and interbedded talc-magnesite rocks with amphibolite and actinolite schist. There are granite, which in the form of veins reveal rocks of glandular formation. Talc-magnesite deposit includes layer of chlorite, biotite and biotite-chlorite-talc schist with capacity 0.2-2.0 m.

The deposit is traced to 1280 m and a depth of 100 m, its power is from 75 to 180 m. The steep falls of the deposit in the north-east at an angle of 75-80 °. In the area there are deposits of pink veined granite. Talc-magnesites consist of magnesite (24-63%), talc (16-48%), serpentine (3,0-30%), magnetite (3,0-8,0%). There is a presence of noble greenish-blue talc in the form of veins with capacity 5-20 cm.

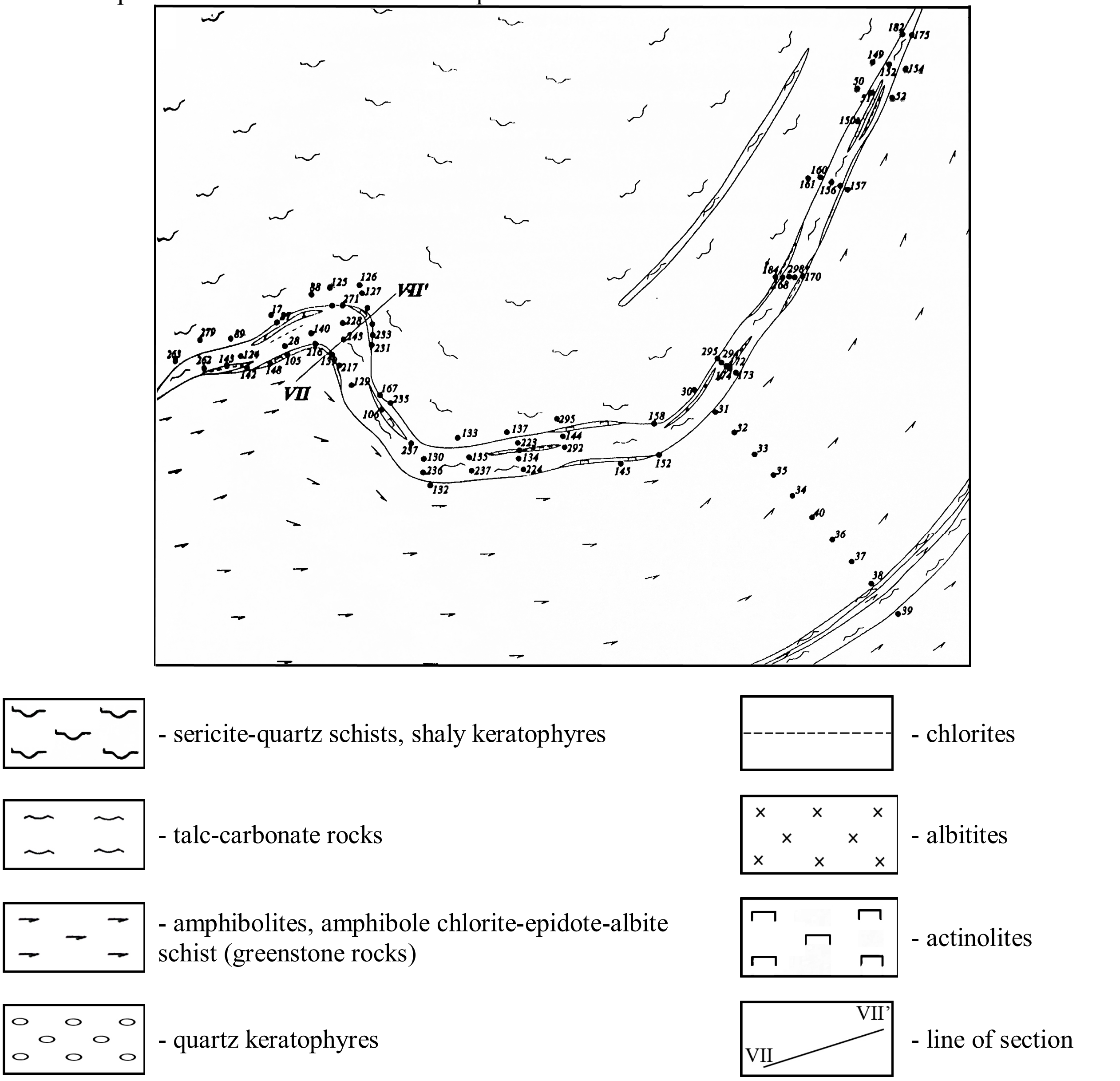

Figure 3. Schematic geological map of the Veselianka deposit of talc-carbonate rocks

The third deposit, traced on 500 m at power of up to 100 m, has a sub-latitudinal strike and dip angle of 80-85 °. There is established the presence of pure talc-magnesite, which consists of equal quantities of talc and magnesite, and serpentine-talc-magnesite and talc which plays a minor role, and the main minerals is breunnerite and serpentine (antigorite). Magnesite is in a variable quantity and dominates the antigorite.

The most common type of talc-magnesite - a greenish-gray rock, heavy, oily to the touch, porous. There is a good blocking - a characteristic property of rocks suitable for sawing refractory bricks. Mineral content of the deposit is,%: 46-92 magnesite, talc, 42-77; magnetite 1.5-10, quartz and pyrite 1.0-2.0 to 1.0. The chemical composition of talc-magnesite is relatively constant (mass content,%):MgO 18,5-36,6; SiO_2 30,8; TiO_2 0,04; Al_2O_3 0,2-0,9; Fe_2O_3 0,1-4,5; FeO 4,5-6,6; MnO 0,08-0,2; CaO 1,28; (Na_2O + K_2O) 0,08-0,16; P_2O_5 0,02; SO_3 0,4-0,5; H_2O 0,06-0,78; CO_2 25,0; 24,80. The rocks also contain trace elements: Ni, Co, Cr, Zr, Cu, Pb, Ag, P, Zn [3].

In general, the chemical composition of talc-magnesite in this deposit and rocks of the Krivoy Rog, which are promising to new magnesite objects is close enough (**Table 2**).

Table 2. Chemical composition of talc-magnesite of the Veselianka deposit rocks of the Krivoy Rog group

Components	Mass content, %				
	1	2	3	4	5
SiO_2	30,68	28,78	32,24	46,77	47,79
MgO	33,66	32,88	36,27	26,23	25,54
CaO	1,12	1,31	0,60	1,53	0,48
MnO	—	0,17	0.16	—	0,79
Al_2O_3	0,71	2,60	2,58	9,36	5,68
Cr_2O_3	0,67	—	—	—	—
Fe_2O_3	5,98	4,68	5,27	3,46	3,89
FeO	4,47	5,13	4,60	5,41	7,03
Alkalies	0,06	—	—	—	—
CO_2	22,34	20,00	19,30	—	—
H_2O	2,38	2,74	—	0,85	0,85

The numbers mark: Veselyanka deposit 1 - talc-magnesite, average sample; 2 - the same as the eastern section; 3 - the same average sample enrichment; Krivoy Rog, mine "МОПР"; 4 - talc schist, 5 - the same beam Dubovaia [1].

Testing of talc-magnesites of VeselyanKa deposit showed that they are suitable for the production of the same products as from ore deposits of Pravdinsk.

Veselyanka deposit was discovered in 1957, its stock is not approved. It is by category (thousand tons):A - 16338, B - 13717, C_1 - 102204, A+B+C_1 - 132260. The forecast resources of category P2 to a depth of 200 m make 250 million tons. Overburden with capacity 40-80 m is presented by the weathering crust and loose sandy-clay sediments. The deposit is very promising and its real value can be adjusted after setting the detailed exploration [3].

The technological schemes of extracting magnesium from serpentinite based on hydrochloric acid leaching of the ore or waste asbestos to the receipt and subsequent processing solutions and magnesium chloride containing balance were developed [4]. Their industrial implementation will require some expenditure on establishment and operation of the hydrometallurgical processing.

In recent years the Institute of titanium carried out investigations of processing magnesite by chlorination and getting chlorine magnesium melts for the electrolytic production of magnesium [5-7]. Based on a sound study of the mechanism and kinetics of the chlorination there is shown a possibility and advisability of replacing the solid reducing agent used in the process into the gas - carbon monoxide. Gasification of the desoxidant made it possible to simplify the hardware and technological scheme of the preparation of reagents for the chlorination process and increase on the pilot aggregate 3 times the specific rate of the chlorination process. During the industrial design of the technology, it provides a significant reduction in capital expenditure and the cost of the resulting molten magnesium chloride and the produced from it metal. The obtained results of the research and development allow considering magnesite as an alternative raw material for the magnesium industry.

The raw materials used in these studies are magnesites from Satka and Kirgiteysk deposit (Russia), characterized by low content of impurities (up to 2.0-6.0%). To use magnesite by the developed technology in Ukrainian deposits in which the magnesium oxide content is lower, it is required a pre-process testing, and possibly the development of methods of purification from accompanying impurities.

Nevertheless, the presence of certain infrastructure, minor maintenance costs considered for the deposit design, allow us to consider them as quite promising. Particularly interesting in this regard is Veselyanka deposit, located 25-30 km from Zaporizhzhya enterprises - Titanium-Magnesium Works (SE "ZTMK"), PJSC Semiconductor Plant and PJSC "Запорожогнеупор". This creates the prospect of complex using of its ores, especially if the methods of selective chlorination from the silica ore components make it possible to establish obtaining the required quality of trichlorosilane to produce polysilicon.

Conclusions

In recent years, re-evaluation of mineral raw material base of magnesite in Ukraine was not performed. However, given the fact that the economic and industrial demand for this raw material has changed, it is advisable to revise the facilities and supply the exploration of the most promising of them. This will allow expanding mineral raw material base for the refractory and magnesium industry, and perhaps for other industries. The effectiveness of the use of magnesite deposits of Ukraine for the production of magnesium and other related items can be resolved on the basis of prior research and technological testing of raw materials in the considered deposits.

References

1. Mordyushenko O. “Uralkalii” likvidiruet fabriki, Gazeta “Kommersant”, 2011, № 74 (4615). *

2. Bondarchuk V.G. Geologiya rodovyshch korysnykh kopalyn, K.: Naukova dumka, 1966, 302 p. *

3. Metalichni i nemetalichni korysni kopalyny Ukrainy. Tom II. Nemetalichni korysni kopalyny/Gurskiy D.S., Yesipchuk K.Yu., Kalinin V.I. ta in., K.-Lviv: Tsentr Evropy, 2006, 552 p. **

4. Kompleksnaya pererabotka promyshlennykh otkhodov s polucheniem syrya dlya proizvodstva magniya i kremnezemnoi produktsii/ Fryeidlina R.G., Gribov V.I. // Tsvetnaya metallurgiya, 2010, № 6, P. 29-37. *

5. Zakonomernosti mekhanizma vzaimodyeistviya magnezita so smesyu khlora i oksida ugleroda i massoperenos v rassmatrivaemoi sisteme / Pruttskov D.V., Lupinos S.M., Ryabukhin Yu.M. // Teoriya i praktika metallurgii, 2010, № 3-4 (76-77), P. 110-116. *

6. Issledovanie protsessa khlorirovaniya magnezita smesyu khlora i oksida ugleroda na pilotnoi ustanovke / Pruttskov D.V., Lupinos S.M., Krivoruchko N.P. // Metalurgiya: naukovi pratsi ZDIA, Zaporizhzhya: RVV ZDIA, 2010, Vyp. 21, P. 33-43. *

7. Lupinos S.M. Issledovanie protsessov khlorirovaniya oksidnogo magnievogo syrya s ispolzovaniem tverdogo vosstanovitelya // Metallurg. i gornorud. prom-st, 2011, № 2, P. 75-79. *

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Минерально-сырьевая база магнезита Украины и перспективы ее освоения

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Рассмотрены расположение, геологическая и минералогическая структура месторождений тальковагнезитов и серпентинитов Украины. Изучены образцы пород, их минералогический и химический состав. Дана оценка запасов месторождений, рассмотрены возможные направления вовлечения руд в промышленное производство. В связи с разработкой новых технологий использования магнезита для производства магния показана целесообразность ревизии месторождений и постановки разведки на наиболее перспективных из них.