MINERALOGICAL AND PETROGRAPHIC DESCRIPTION OF ORE AND COVERING ROCKS OF TAKHTAKORACHA DEPOSIT (SOUTHERN UZBEKISTAN)

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Abstract. The mineralogical and petrographic composition of Takhtagoracha manganese mine and minerals covering them are shown in the article. Primary and oxidized secondary types of manganese ores have been determined, analyzing the data found in the existing literature, and additional information on the conditions of formation of the previously mentioned ore is provided based on the color-spectral analysis of minerals. Based on them, a conclusion was made about the genesis of the mine.

Key words: Karatepa, Takhtakoracha, Manganese, Dovtash, Brownite, Gausmanite, Psilomelan, Vernadite, Pyrolusite, etc.

Introduction: Takhtakaracha manganese deposit is located in the Karatepa mountain, which is part of the Zarafshan mountain range, and is located on the northern slopes of the Karatepa mountain (Figure 1).

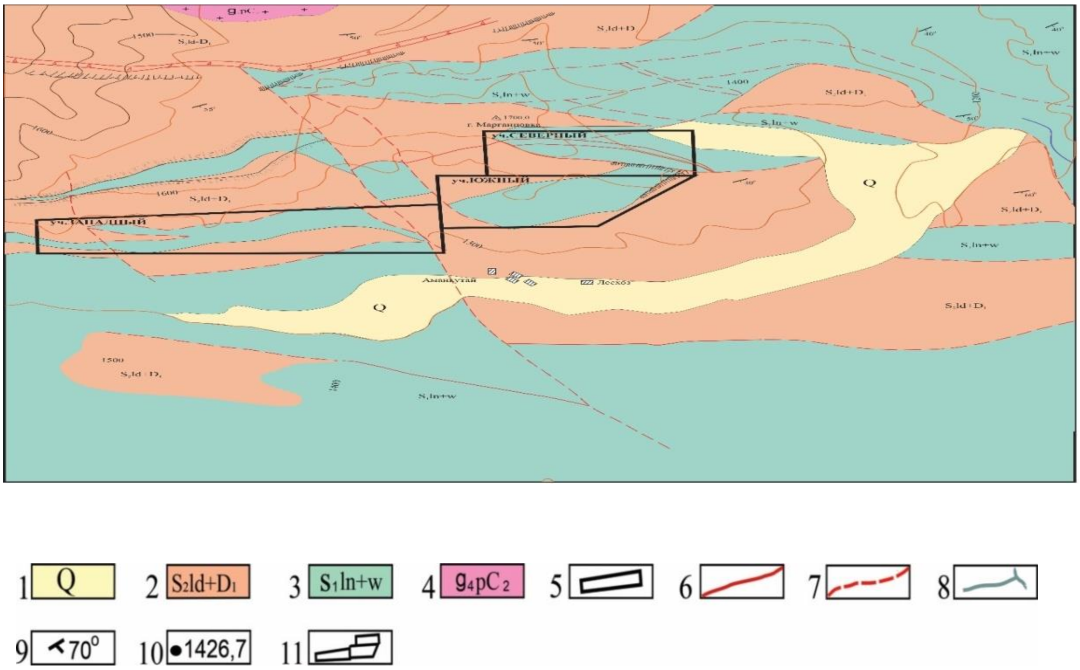

Figure 1. Geological map of Takhtakaracha mine

1-Quaternary deposits 2-marbled limestones 3-calcareous-silica shale (productive horizon in the mine); 4-granites; 5-planned work area; 6-tectonic cracks (identified); 7-tectonic faul; 8-river 9-bed element; 10 - absolute height; 11 - precinct boundary

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The rocks of the Dovtash thick layer have undergone regional and contact metamorphism. Petrological studies revealed that this change was caused by the Karatepa intrusion, which was formed by effusive sedimentary rocks of the Silurian period [1, 2, 4, 6, 11]. Later, under the influence of metamorphism, they altered to sandstone-mica, bimica, chlorite-sericite, graphite-mica shales with greenish and dark gray colors. Magmatic and paragneiss rocks are described as dark and greenish-gray patchy layered formations. According to their geological and structural textural properties, they correspond to metamorphic (pyroclastic) rocks.

Quartz and felsite porphyries, forming interstratal bodies, consist of a mixture of alkali feldspar and quartz and a weakly crystallized felsic mass.

Porphyry quartz tuffs contain fine particles of porphyry, quartz, and feldspar. The astringent mass in it is formed by a mixture of crushed glass, carbonate and quartz.

In Takhtakaracha deposits, the productive sandstone-limestone-clay and mica-clay shales and cherts contain thin interlayers of layers with a low thickness. Limestones are composed of fine-grained calcite aggregates, which contain admixtures of quartz and very fine, coarse, and rounded grains of feldspar, sericite, and muscovite. The mineral rhodochrosite is found among the limestones in the form of speckled and striated lines. Sandstone limestones are almost everywhere rich in manganese and contain trace amounts of manganese.

Materials and methods Mineragraphy of manganese ores

Manganese minerals are mainly embodied in mineral-rich marbled limestones (psilomelan, pyrolusite vernadite, calcite, chalcedony, opal, quartz, and other minerals) and are found in various forms - nest-like, spot-like, porous,

vein-like (Fig. 2).

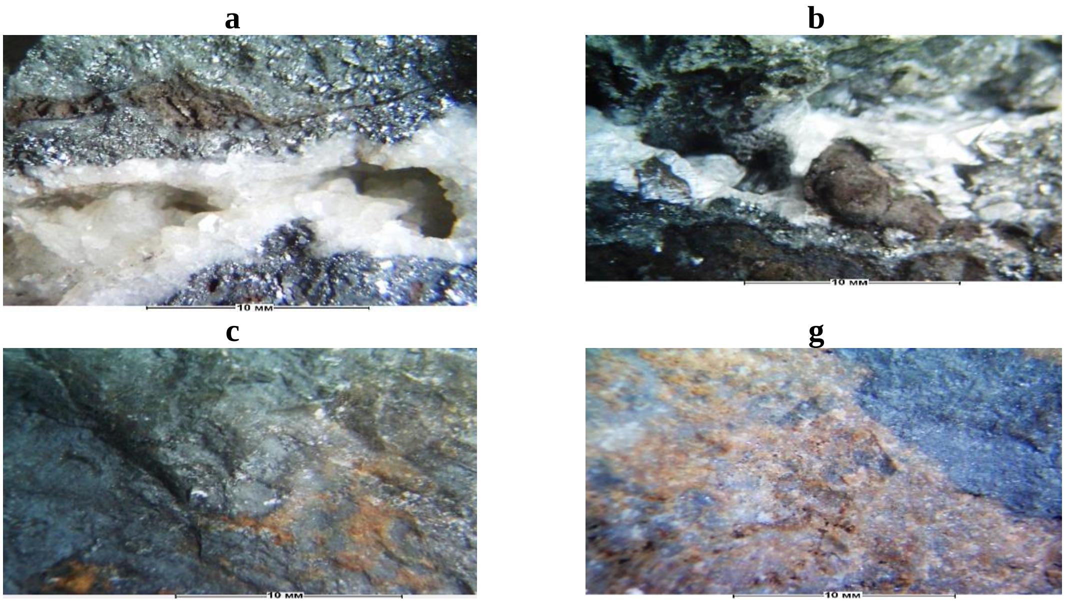

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Figure 2. Recrystallization of pyrolusite: a) calcite druses developed along cracks, b) calcite druses (white) and kidney-shaped vernadites (brown) developed along cracks, c) development of vernadite (light brown) flow forms on pyrolusite (dark gray, gray), g) relict of weakly limonitized limestone (brown) over pyrosite ore (dark gray)

Uneven recrystallized marbled limestone contains calcite (95-99%), quartz (0.3-0.5), muscovite (0.01-0.02), plagioclase (0.01-0.02) and ore minerals (0.2-0.3%) occurs (Fig. 3).

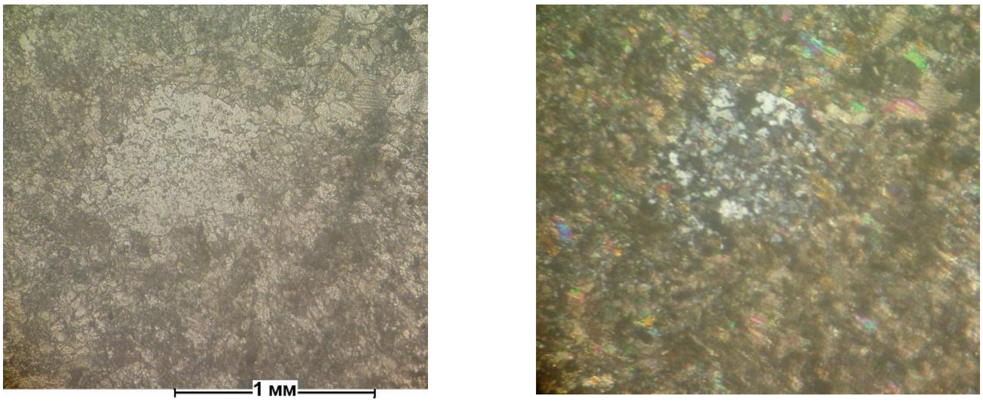


Figure 3. Irregularly recrystallized marbled limestone. The structure is fine-grained, granoblastic. In one and two nicols.

The limestone contains sparse rounded nests of fine-grained quartz with calcite grains. Plagioclase tablets and muscovite sheets less than 0.15 mm in length are rare. Ore minerals are rare grains are between calcite grains, sometimes they are also observed in quartz nests (Fig. 4).

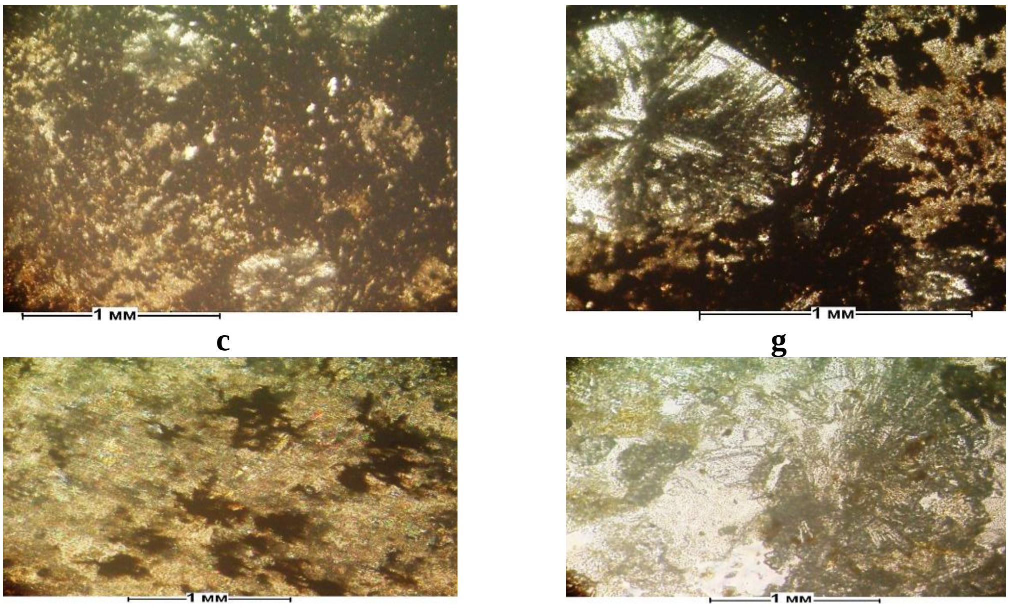


Figure 4. Ore with psilomelane-pyrolusite: a) mineral rich in psilomelane-pyrolusite, b) ore with psilomelane-vernadite - with chalcedony-opal, c) limestone with psilomelane, g) limestone with chalcedony and vernadite. The structure is spherulite, speckled.

Many nests, linear vessels, and round-shaped pyrolusite aggregates are formed in the $\mu MnO \bullet MnO_2 \bullet nH_2O$ (a, brown-black) almost complete cryptocystic main mass of psilomelan.

With chalcedony and opal, MnO_2 (b) is abundant, but most of the small speckled voids are filled with new $MnO_2 \bullet nH_2O$ derivatives of vernadite (b, brown with relief).

Psilomelan-pyrolusite ore contains minerals (65-70%), vernadite (10-15%), calcite (7-10%), chalcedony-opal (3-5%) (Fig. 5).

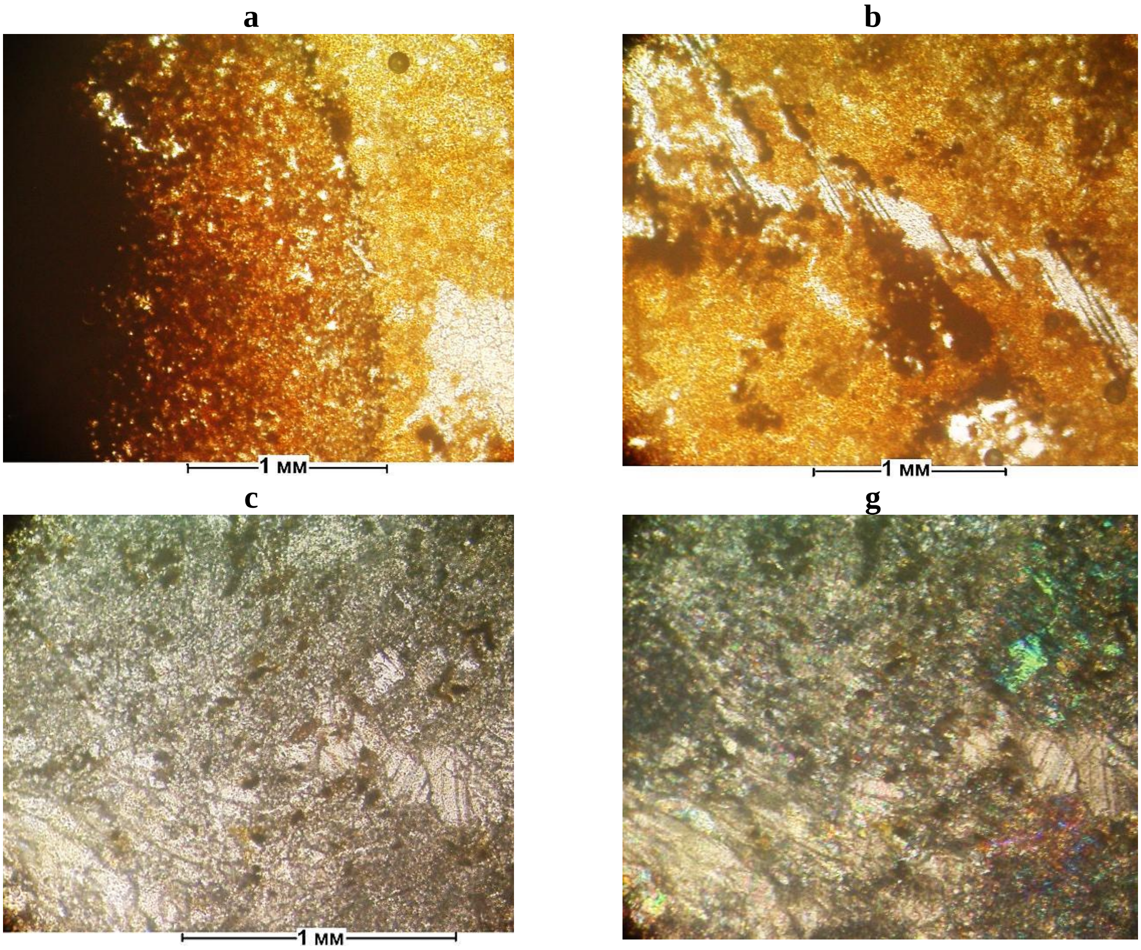


Figure 5. Complete psilomelan-vernadite ore: a) psilomelane-rich ore transformed into vernadite, b) calcite veins in the ore, c) limestone rich in complete mineral, g) it is also breccia.

Whole cryptograined psilomelane (a) changes zonally into micrograined vernadite of varying density and color (reddish-brown and yellow). In some places, it is filled with fine-grained calcite through voids and cracks, sometimes pyrolusite grains have turned into psilomelan, (b) dark brown streaks in the calcite vein). Pyrolusite grains are located in a strictly parallel direction diagonally to the direction of the calcite vein in its various parts.

Limestone has micro- and fine-grained lepidogranoblastic (v), sometimes breccia (g) mottled texture. It contains calcite (80-85%), psilomelan + pyrolusite + vernadite (10-15%). Limestone saturated with microcoatings of psilomelan and pyrolusite at the boundaries of small and fine calcite grains is divided into small, often isometric separations with a diameter of 0.5-0.7 mm. Along the grain boundaries and in the interstitium, new formations occur surrounded by veins of fine-grained calcite with individual grains and coatings of psilomelane, pyrolusite, and vernadite. Fine medium-grained calcite nests often show an indistinct smoky texture.

A distinctive feature of the productive area of the Takhtakaracha ores is its striped appearance. This feature is associated with the alternation in places of silica and carbonate, which has a cryptocrystalline structure that preserves manganese minerals, in the form of thin paths.

Takhtakaracha manganese ores are divided into primary and secondary (oxidized). The primary minerals of this mine are represented by the following syngenetic manganese minerals (manganocalcite, rhodochrosite), and minerals formed as a result of regional and contact metamorphism and hydrothermal processes, which led to the formation of the following complex of minerals (rhodonite, bustamite, garnet-spessartine and manganese-bearing wollastonite and tremolite).

The zone of secondary minerals is reflected in the form of a manganese cap. It consists of oxidized varieties of vernadite, psilomelan, pyrolusite minerals. Among these minerals, there are primary oxide minerals such as manganite, braunite, gausmanite, and relicts (residues) of primary minerals.

Oxidized ores, the richest in manganese, are formed as a result of the most abundant accumulation of primary manganese oxide minerals forming syngenetic ores. It was previously thought that the hypergene process is of great importance in mineral processing. In fact, this process is of secondary importance, since the above complex of primary ores was formed in the process of skarning under the influence of interlayer injections of quartz felcyite porphyries [8], and also later in the Carboniferous time of the Karatyube pluton composed of granitoid rocks [5, 7, 10].

The content of silica, iron and magnesium oxide in them, depending on the result of recrystallization of ores, is given below in Table 1.

According to their chemical composition, oxidized minerals belong to the group of carbonate minerals.

Table 1

Results and discussion

Composition of Takhtakaracha ores according to RSM analysis, analyst Mukhamedzhanova D.V., (2022)

Mineral	K_2O	Fe_2O_3	MgO	CaO	MnO_2	Al_2O_3	SrO	SiO_2
Manganodolomite	0,48/0,03		1,66/0,11	4,10/0,19	93,61/2,84			
Manganapatite*				55,75/2,38	2,16/0,06			

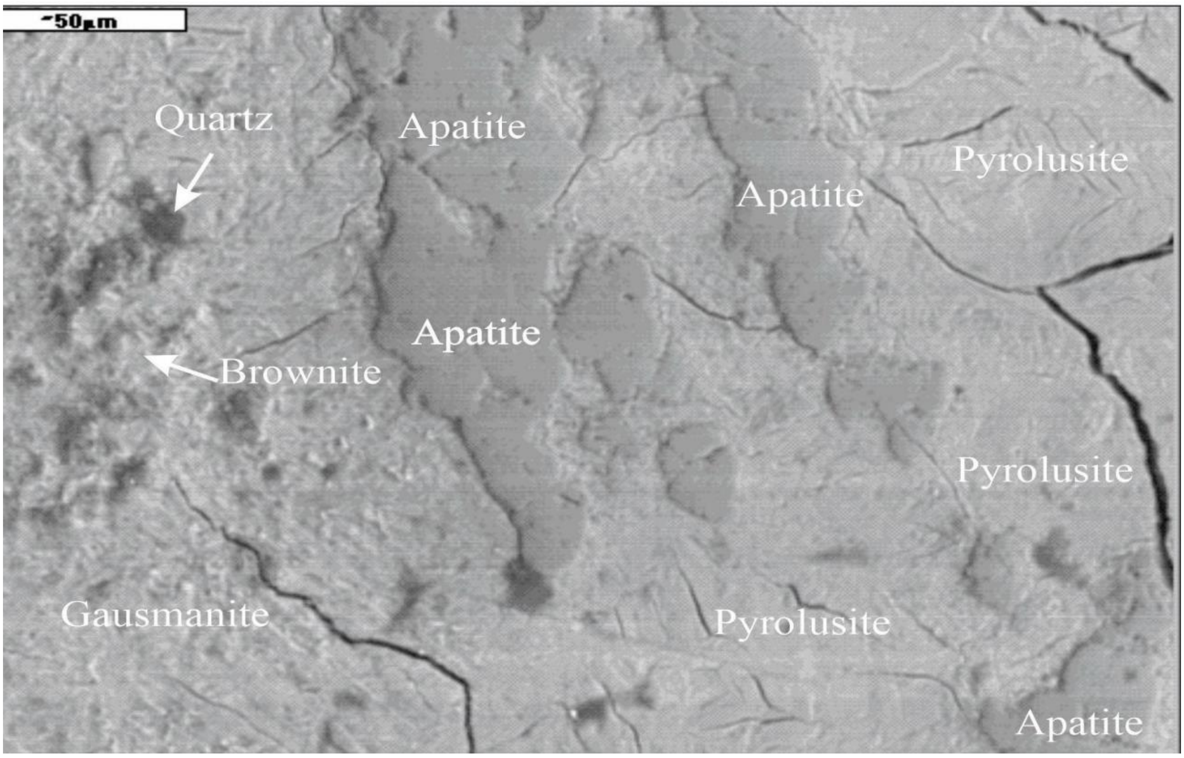
Rhodonite	0,46/0,03		1,81/0,13	5,14/0,27	83,28/2,79			0,56/0,02
Spessartine**	0,36/0,02	10,04/0,34	1,07/0,07	3,83/0,19	57,43/1,80	0,79/0,04		12,17/0,55
Manganocalcite	0,39/0,03		1,21/0,09	5,85/0,32	79,26/2,78		0,56/0,02	
Vernadite					30,69/1,32			
Manganocalcite	0,34/0,02		1,86/0,14	6,19/0,34	78,30/2,75		0,39/0,01	
Tefrolite					1,25/0,03			98,75/2,97
Manganocalcite	0.26/0,02		1,02/0,07	5,64/0,30	82,98/2,81			
Manganocalcite				1,05/0,05	93,16/2,97			
Manganocalcite	0,29/0,02		0,91/0,06	4,06/0,21	86,46/2,85		0,64/0,02	
Manganodolomite	0,28/0,02		1,46/0,11	6,98/0,38	77,76/2,75			
Manganodolomite	0,23/0,01		0,50/0,04	3,29/0,18	84,30/2,89			
Manganodolomite	0,28/0,02		0,64/0,05	3,61/0,19	86,01/2,88			
Manganodolomite	0,47/0,03		1,19/0,09	3,52/0,19	83,07/2,85			
Manganocalcite				1,09/0,05	95,68/2,97			

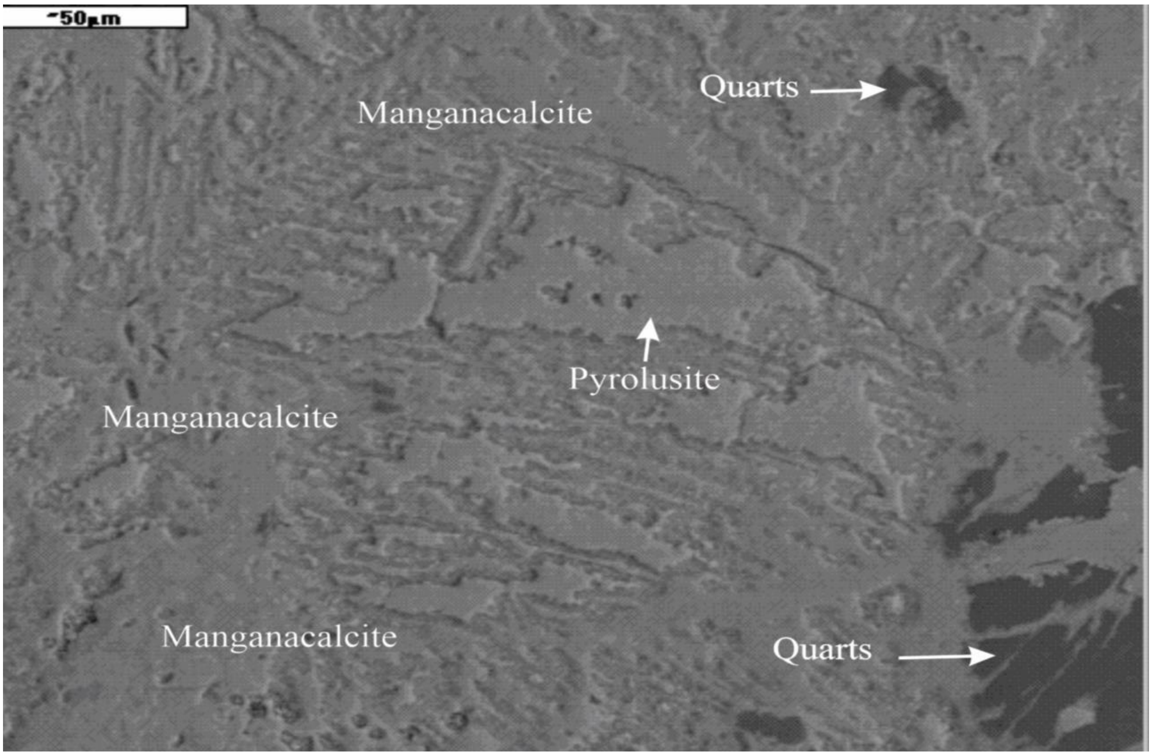
Note: single sample rtsults
* P_2O_5 - 41,41/1,40 и Yb_2O – 67/0,01
** Cr_2O_3 – 8,40/0,30

Note. In the denominator, the mass content is % denominator, the appendix to the table is the structural formulas of identified minerals from the table.

1)К0,03 Mg0.11 Ca0.19 Mn2.84
2) Ca 2.38 Mn 0.06 P2O5 1.40 Yb2O 0.01
3)К 0,03 Mg0.13 Ca 0.27 Mn 2.79 SiO 2 0.02
4)К0,02 Fe2O3 0,34 Mg 0,07 Ca 0,19 Mn 1,80 Al2O3 0,04 SiO2 0.55 Cr2O3 0,30
5)К0,03 Mg 0,09 Ca 0,32 Mn 2,78 SrO 0,02
6)Mn1,32
7) К 0,02 Mg0,14 Ca 0,34 Mn 2,75 SrO 0,01
8)Mn 0,03 SiO2 2,97
9) К 0,02 Mg 0,07 Ca 0,30 Mn 2,81
10)Ca 0,05 Mn 2,97
11) К 0,02 Mg 0,06 Ca 0,21 Mn 2,85 SrO 0,02
12)К 0,02 Mg 0,11 Ca 0,38 Mn 2,75
13) К0,01 Mg 0,04 Ca 0,18 Mn 2,89

14) K 0,02 Mg0,05 Ca 0,19 Mn 2,88
15)K0,03 Mg 0,09 Ca 0,19 Mn 2,85
16)Ca 0,05 Mn 2,97





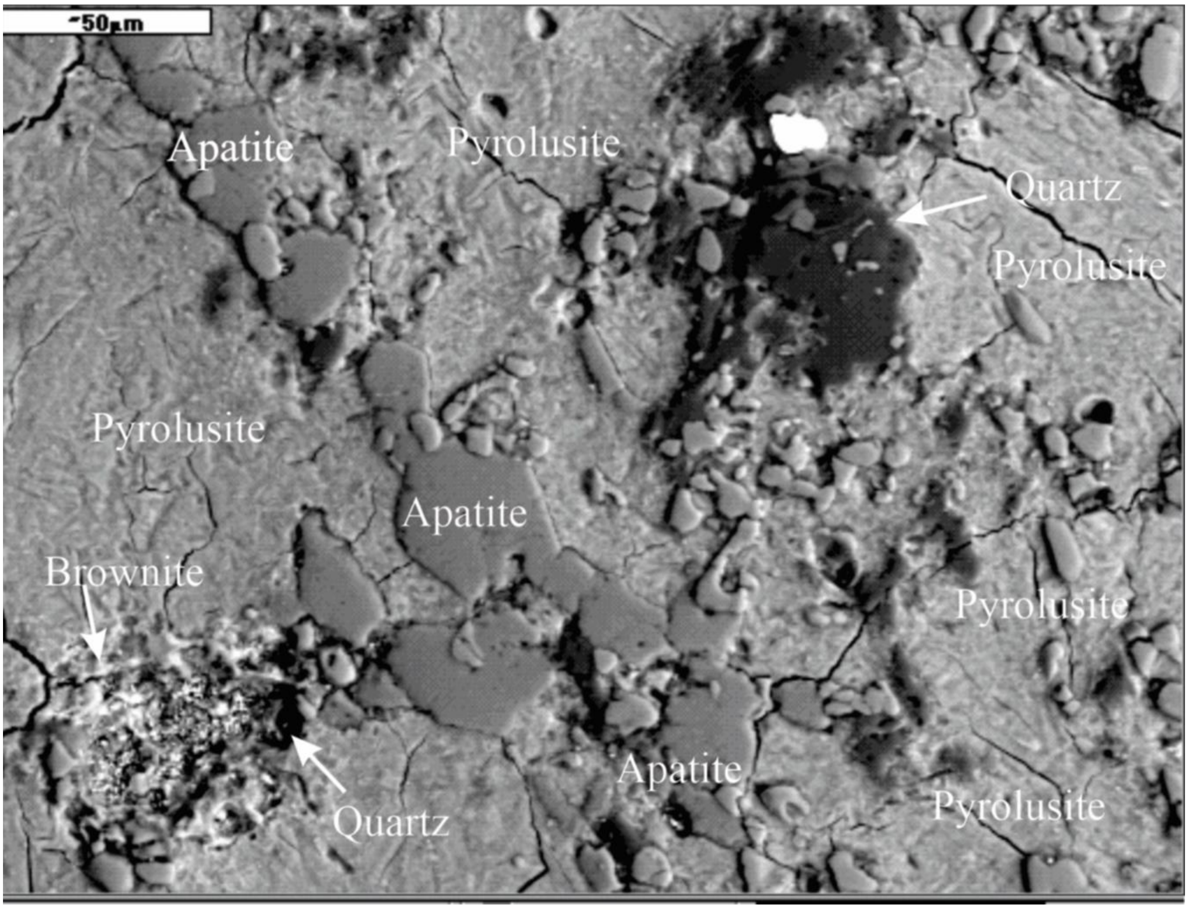


Fig. 6. Structural-age relationships of minerals of manganese ores on an electron microprobe

When establishing the relationship between the mineralization of the Takhtakaracha manganese deposit and studying the structural position of various types of manganese ores according to the RSMA, it is shown in Fig. 6.

In the cross-sectional images in Figure 6, large pyrolusite crystals dominate, with apatite crystals developed to the right of the inclined crack in the middle of the image. Since they form under hydrothermal conditions, they are not faceted crystals, but have a slight resemblance to an ellipsoid, on the one hand. Thin grains of black quartz are more common on the right side of the veins of dark gray color, similar to pyrolusite. Formless oblong and round grains of hausmannite crystals are found on the right side of the quartz vein. Brownite and rounded quartz symplectites occur clearly on the right side of the vein (see fig. 6, b)

The ore minerals are mainly manganocalcite and appear dark black in color. The edges of the crystals are indistinct, indicating that they were formed at the same time as the adjacent crystals. In the lower right corner of the picture, a rounded quartz grain can be seen, and it can be called a restite of terregenous quartz sandstone.

Figure 6, c shows the continuation of the quartz vein. In this place, pyrolusite crystals form the main area. Here, on the right side of the vein, apatite crystals formed in the form of rounded crystals, and they are widespread. In the upper right corner of the image is a piece of black quartz, next to which is visible a round white mineral, whose composition, according to microprobe analysis, is estimated to be wolframite. If it was formed at high temperature in

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hydrothermal conditions, then it corresponds to the mineral wolframite. If later an admixture of sulfur is determined in it, then the mineral can be sulfides of wolframungistite, which will be established in the course of further research. On fig. 6d, apatite crystals formed in the selvedges of a quartz vein. They are also available on the left side of the vein. Apatite crystals that began to form in a quartz vein recrystallized in hydrothermal solutions penetrating into the apatite crystal, which led to an increase in the size of their crystals.

A characteristic feature of rich secondary oxidized types of minerals is the low content of phosphorus and sulfur in them, which indicates the participation in the formation of minerals of primary oxide compounds of manganese with a small amount of phosphorus in the ore-forming solution.

The sandstones and limestones surrounding the ore contain varying amounts of manganese. The amount of calcium oxide and silica in them is >50%. Substances of iron, magnesium and aluminum are present in them in almost the same amount as in minerals.

The complex of manganese ores is represented by brownite, hausmannite, psilomelane, and pyrolusite. At the Takhtakaracha deposit, before our studies, all ores belonged to the types of secondary oxidized, formed due to primary carbonate or silicate manganese-containing minerals. V.S. Chekunov 1963., Yu.I. Ilkhamov (1962-1965), A.M. Musaev (1999). Statistical calculation of volume fractions in transparent sections of silica showed the presence of minerals in mines (on average%): brownite - 18.22, hausmanite - 20.24, psilomelane - 40.37, pyrolusite - 18.97, vernadite - 2.20. The primary ore-forming minerals of this deposit are oxide minerals (brunite, hausmanite, psilomelane, and manganite). Manganite was not found in the samples; it was isolated only on the basis of the analysis of thermograms. Psilomelan has two types of origin: 1) alternating with primary brownite and hausmannite; 2) developing on the interstitium of secondary minerals. It is assumed that pyrolusite was formed as a result of direct crystallization of manganese gels. V.S. Chekunov, A.M. Musaev showed that secondary minerals at depth consist of psilomelane and pyrolusite [3, 8].

Thermal analyzes are confirmed by the mineralogical method. The ores have a siliceous composition, and the amount of silica in them varies due to the degree of skarning under the influence of exhalation solutions from syngenetic volcanogenic quartz-porphyry subvolcanic dikes. Other components are also involved in the structure of ores: calcium oxide, iron, phosphorus and sulfur. The ores also contain the minerals goethite, pyrite, limonite, potassium feldspar, and sericite in minor amounts. Manganese, in ore bodies - 7-10% and more. A large amount of manganese is mainly in the form of a tetravalent end-member, and the content of silica can be 20-70% and even higher depending on the types of minerals. Calcium oxide is about 5-35%. Aluminium, iron, magnesium, phosphorus and sulphurous substances are found in almost as small quantities as in minerals. This feature indicates that manganese ore is suitable for the needs of the metallurgical industry. Determining the primary oxide nature of the ores makes it possible to overestimate the prospects of the mine in terms of depth and give a recommendation for the resumption of exploration work in deep horizons. These conclusions are confirmed by the discovery of primary oxidized ores by drilling at a depth of more than 100 m.

CONCLUSION: The Takhtakaracha manganese deposit is located on the northern slope of the Karatyube Mountains, the western outskirts of the Zarafshan Range, in the upper reaches of the Amankotan stream. Administratively, it belongs to the Urgut district of the Samarkand region.

Silurian (shales, limestones, manganese ores) and Quaternary deposits are involved in the geological structure of the Takhtakaracha manganese deposit.

The ore layer consists of limestones, siliceous, sandy limestones, among which there are manganese ore bodies. They are located sequentially with each other, forming a single stratum rich in minerals.

The width of the ore layer is 10-60 m, the thickness of the ore bodies is from 0.7 to 17 m. The content of manganese varies from 6.9 to 46.3%. In all areas of the study area, ore bodies are eroded and well preserved in relatively high (expected) places.

The mineral resource base of manganese in Uzbekistan mainly consists of refractory carbonate, silicate-carbonate, oxidized ores of the Karatyube Range. Due to their polymineral content, high dispersion and not very rich in useful components (the average amount of metal is up to 20%), it is technologically more difficult to enrich them compared to foreign types. The location of mineralization in Takhtakaracha, morphostructural types of ore bodies and geological and structural conditions are similar to those observed at the Dautash deposit. The main ore-forming minerals are pyrolusite (18.97%), psilomelane (40.37%), brownite (18.22%), hausmanite (20.24%) and vernadite (2.2%).

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