ACCESSORY MINERALS FROM IMPACT MELT ROCKS OF THE BOLTYSH STRUCTURE, UKRAINE. OXIDES: THE VARIETIES OF HEMATITE.

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Introduction: The circular sheet of impact melt rocks, 12 km in diameter and to 220 m in thickness, has been observed in the Boltysh crater. The composition of the impact melt rocks and characteristics of the main rock-forming minerals were given in the numerous works [1, 2, 3 to cite a few], where the cores of drillholes 50 and 11475 were used, crossed the whole thickness of the sheet. The accessory minerals of the impact melt rocks are represented by native metals, sulphides, oxides, phosphates and silicates. Oxides of iron and titanium-iron are widely spread in several rock types of impact melt sheet. The SEM EDS-WDS X-ray microanalyses (wt.%) of hematite show some varieties in its composition and the high content of TiO_2, Al_2O_3, Cr_2O_3 and SiO_2 in it.

Preliminary results. *Titanohematite* with high content of TiO_2 was found in the impact melt rocks with cryptocrystalline matrix and pyroxene replaced by chlorite (drillhole 50, interval 650 m). The mineral forms subhedral, irregular, rarely spherulitic grains and segregations from 3-5 μm up to 30 μm in size (Fig. 1). All the grains are homogeneous and do not contain any traces of disintegration. The content of TiO_2 is about 15% and reaches up to 16.23% (TABLE 1). The homogeneous titanohematies with such high content of TiO_2 were not described earlier [4, 5]**.** The content of Al_2O_3 in titanohematite is from 3.25 to 5.35%. The analyses of three grains of mineral discover the content of Cr_2O_3 - 0.05- 0.09%, NiO – 0.05-0.07%, and CoO – 0.06- 0.09%. The platinum group element content is below the detection limit.

The mineral formula was calculated for six oxygen atoms. The determination of the content of Fe^{2+} and ratio of Fe^{2+}/Fe^{3+} were determined using the remainder of oxygen atoms after their saturation of the monovalent cations accordingly to [6]. The formula of the mineral shows its correspondence to a hematite with sum of cations from 3.82 to 3.97 that indicates their slight deficit in the composition.

Titanohematite with content of TiO_2 from 4.6 to 6.2% and Al_2O_3 up to about 5% was determined in the impact melt rock with the glassy matrix from the basal part of the melt sheet in drillhole 50 at the depth 734 m (TABLE 1).

Silicohematite occurs in the impact melt rocks with partly devitrified matrix in drilllhole 11475 in the interval 761 m. It forms subhedral prismatic crystallites to 30 μm in size (Fig. 2). Mineral is always homogenous without any sign of disintegration and does not contain any inclusions. Its crystallites occur in crystalline matrix, and their intergrowth with orthopyroxene and some other minerals was not observed.

The peculiarity of the mineral composition is the high content of SiO_2, that is mainly from 4% to 7% (TABLE 2). Such high SiO_2 content of hematite was not described earlier [4, 5]. The content of Al_2O_3 in its composition varies mainly from 2,5 to 3.5%, and content of TiO_2 is 0.1n%. Composition of mineral is in good correspondence with the hematite formula calculated for six oxygen atoms.

TABLE 1. The composition of titanohematite, drillcore 50.

Sample	9	33	32	31	23
Depth, m			650		734
Wt.%					
Fe_2O_3	75.59	72.03	79.88	75.36	88.87
FeO	2.31	8.04	-	3.85	-
MgO	1.08	-	-	-	-
Al_2O_3	5.35	4.38	3.25	3.48	3.87
V_2O_3	0.62	-	-	-	-
TiO_2	14.89	14.96	15.26	16.23	6.19
Total	99.84	99.41	98.39	98.92	98.93
Number of cations on the basis of 6 oxygen atoms					
Fe^{3+}	2.82	2.75	3.07	2.86	3.35
Fe^{2+}	0.10	0.34	-	0.16	-
Mg	0.08	-	-	-	-
Al	0.31	0.26	0.20	0.21	0.23
V	0.02	-	-	-	-
Ti	0.56	0.57	0.59	0.62	0.23
Total	3.89	3.92	3.86	3.85	3.81

TABLE 2. Composition of silicohematite; drillcore 11475, depth 761 m

Sample	12	28	38	13
Wt.%				
SiO_2	5.09	5.84	5.60	7.21
TiO_2	0.60	0.76	0.67	-
Al_2O_2	2.55	3.19	3.36	3.21
Fe_2O_3	91.76	90.42	90.98	90.12
K_2O	-	0.42	-	-
Total	100.0	100.63	100.61	100.54
Number of cations calculated on the basis of 6 oxygen atoms				
Si	0.25	0.28	0.29	0.35
Ti	0.02	0.02	0.03	-
Al	0.15	0.20	0.18	0.18
Fe^{3+}	3.48	3.47	3.33	3.30
Total	3.90	3.97	3.83	3.83

Accessory hematite with high content of Al_2O_3**,** TiO_2, and Cr_2O_3 was found in the upper part of the impact melt sheet in drillhole 50, depth 598 m. This mineral occurs in chloritized cryptocrystalline impact melt rock. It forms short-prismatic crystallites from 5 to 30 μm in size. The mineral was deter-

mined as hematite, thus the iron in its composition corresponds to Fe^{3+}. Its composition is characterized by high content of Al_2O_3 – from 6.7% to 9.3%, TiO_2 - from 3.6 to 6.3%, and Cr_2O_3 from 3.8 to 4.7% (TABLE 3)**.** The content of V_2O_3 reaches 1%. Composition of the mineral allows us to denominate it as *aluminotitanochromohematite*.

Discussion. Summarizing, Ti-, Al-, Si-, and Cr-bearing varieties of hematite occur in several rock types of the impact melt sheet of the Boltysh structure. All the varieties have some important differences in their composition in several parts of the profile of the melt sheet. The high content of isomorphic admixtures and the diversity in their composition are characteristic for the whole studied cores of the impact melt sheet. It is supposed that the main cause of the high content of isomorphic admixtures in hematite is the high temperature of the melt at the beginning of its crystallization.

According to [4], the complete solid solution of hematite and ilmenite can be obtained at the temperatures from 1050°C or higher. As it was shown by the experiments in the system Fe_2O_3 – FeO – TiO_2 [7], the content of TiO_2 from 10 to 20% determines the stability of hematite relative to magnetite in the temperature interval from 1350°C to 1590°C. This data allows us to explain the formation of titanohematite with very high content of TiO_2 during the decrease of the temperatures of impact melt down to about 1590ºC.

The high content of Al_2O_3 in hematites, especially in aluminotitanochromohematite, is possible due to high temperatures of impact melt: the solid solution of about 10% of Al_2O_3 in hematite reaches at the temperatures of about 1300°C [8].

Thus, the high temperatures of crystallization of hematite, the dry composition of impact melt that produced the glassy matrix, and the high speed of the cooling of the melt sheet are the three most important factors that assist the formation and preservation of the described varieties of homogenous hematite with the high content of the isomorphic admixtures.

References: [1] Grieve R.A.F. et al. (1987) *Contrib. Mineral. Petrol*., 96, 56-62. [2] Gurov E.P. et al. (2011) *Geophys. Journ.*, 33, No 5, 66-89. (in Russian). [3] Masaitis V.L. et al. (1980) *The geology of astroblemes:* Nedra Press, Leningrad, 232 p. [4] Deer W.A., Howie R.A., and Zussman J. (1963) *Rock-Forming Minerals*, v.2, Longmans, London, 368 p. [5] *Minerals*, Reference book, v.2, 2, Acad. Sci. USSR publ., Moscow, 342 p. (in Russian). [6] Reed S.J.B. (2005) *Electron microscopic analysis and scanning electron microscopy in geology*, Cambridge Univer. Press, 232 p. [7] MacChesney J.B., and Muan A. (1959) *Amer. Mineral.,* 44, 926-945. [8] Muan A., Gee C.L. (1956) *Journ. Amer. Ceram. Soc.* 39, 207-214.

TABLE 3. Composition of aluminotitanochromohematite, drillcore 50, depth 598 m

Sample	11	8	7
Wt.%			
TiO_2	5.45	6.22	3.58
Al_2O_3	6.70	7.21	7.56
Cr_2O_3	4.15	4.67	3.83
V_2O_3	1.01	0.69	0.96
Fe_2O_3	81.84	80.98	84.06
Total	99.15	99.78	99.99
Number of cations on the basis of 6 oxygen atoms			
TiO	0.21	0.23	0.14
Al	0.40	0.42	0.45
Cr	0.17	0.18	0.15
V	0.03	0.02	0.03
Fe^{3+}	3.11	3.04	3.17
Total	3.92	3.89	3.94

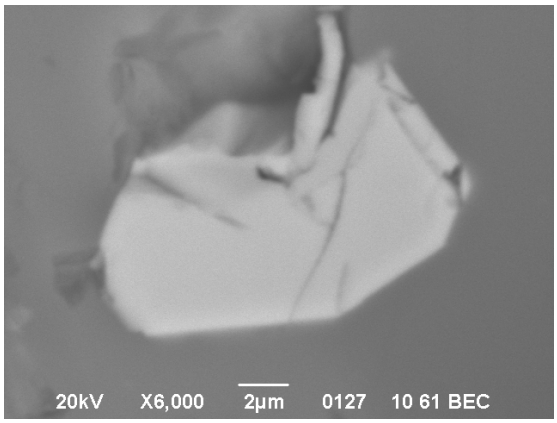

Fig.1. Subhedral grain of titanohematite in matrix. SEM image, BEC mode.

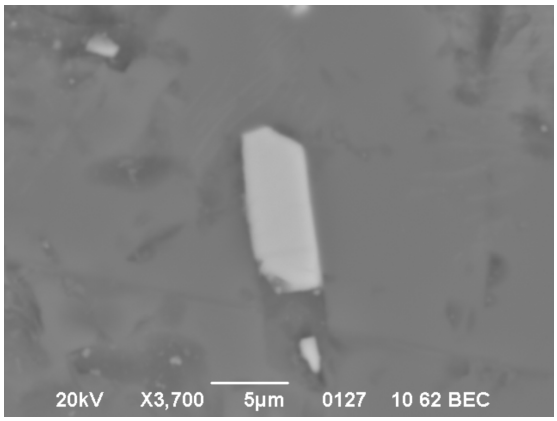

Fig. 2. Prismatic crystallite of silicohematite in glassy matrix. SEM image, BEC mode.