CARBON-RICH PHASES IN METEORITES.

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Introduction: The existence and properties of various carbon phases and compounds in meteorites and other extraterrestrial materials have been investigated for many years. The main focus was set on graphitic components and diamonds. Recently, nanodiamonds have been detected in melt veins of highly shocked meteorites such as Chelyabinsk [1, 2], but nanodiamonds belong to only one form of carbon in meteorites. One can find carbon in meteoritic metal in 3 forms. First of all, carbon is component of solid solution as well as Fe-Ni. Graphite and shock-formed carbon polymorphs are the second form. The last form means carbides: cohenite $(Fe,Ni)_3C$, and haxonite $(Fe,Ni)_{23}C_6$. [3, 4].

Samples and Methods: In this work, the structure of two varieties of iron carbides (cohenite, haxonite) in meteorites of various types was studied. Identification of these phases was carried out using optical microscope Axiovert 40 MAT and scanning electron microscope FE-SEM ∑IGMA VP with EDS and EBSD units. Fragments of iron meteorites Odessa (IAB-MG) and Uakit (IIAB), and a fragment of ordinary chondrite Chelyabinsk (LL5) were the objects of this study. Samples were prepared for optical microscopy, scanning electron microscopy (SEM) by standard metallographic procedures: grinding, polishing, and etching with 2% nital.

Discussion: In an Odessa iron meteorite a stripe-like structure is observed in the images of the cohenite during examination (detector of secondary electrons, SEM). These bands in the structure are not related to the chemical composition. Earlier, a similar effect in the cohenite related to magnetic domains manifested in the form of Bitter-Akulov patterns was studied in papers, in which authors used magnetic liquids [5, 6]. Observation of this structure in meteorite Odessa is related to the formation of contrast due to interaction of electrons with magnetic domains, and in an optical microscope, these domains can not be observed in case of absence of ferrofluids.

It is worth noting that the cohenite $(Fe,Ni)_3C$ was also identified in a recently found and registered meteorite Uakit (IIAB) in the Republic of Buryatia. Cracks filled with earth weathering products pass along large inclusions of carbide. Separate inclusions of the cohenite in the meteorite contain accessory minerals, which require additional study.

In the fragment of the ordinary chondrite of Chelyabinsk, it was possible to detect a unique metallic particle containing kamacite, zoned taenite and iron carbide $(Fe, Ni)_{23}C_6$ - haxonite. Iron carbide $(Fe, Ni)_{23}C_6$ has a cubic lattice of a = 10.55 Å, Z = 4. The chemical composition of haxonite: Fe - 89.5%, Co - 0.18%, Ni -4.91%, C - 5.4% [4].

Carbides are formed both at low temperatures as excess phases and during the decay of supersaturated solid solutions. Cohenite is more preferable for the nucleation from carbides, however, sometimes in iron meteorites there are both types of carbides (Fe_3C and $Fe_{23}C_6$). Haxonite can be distinguished from cohenite because it has a cubic lattice and is isotropic in reflected light whereas cohenite is orthorhombic and more anisotropic than schreibersite. Concentrations of Fe+Ni+Co should ideally match 94.7 wt.% for stoichiometric haxonite vs. 93.3 wt.% for cohenite [7].

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