CRYSTAL STRUCTURE AND CHEMICAL COMPOSITION OF METAL PARTICLES FROM KOLYMSKIY FULGURITE.

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Introduction: Fulgurites are formed as a result of lightning strikes in sand, ground or rock. They look like branched hollow glass tubes several meters long. Conditions at contact point are unique: rapid temperature rise (tens of microseconds) up to 2000 K, current up to 200 kA and high pressure [1]. Fulgurites and impact structures in meteorites have a significant similarity, since their formation energies belong to one range. Minyuk P.S. has found metal spheres 1-3 mm in diameter at the glass part of fulgurite Kolymskiy (Magadan). The first study of these particles showed the presence of α-iron, troilite FeS, shreibersite Fe_3P. These phases are more typical for meteorites [2]. They are extremely rare on the Earth.

Methods: Metal particles were mounted using conductive epoxy resin. Then, samples were prepared using standard metallographic techniques. Microstructure studies were carried out using the Zeiss Axiovert 40 MAT optical microscope and scanning electron microscopy Carl Zeiss Σigma VP with energy dispersive spectroscopy unit. XRD spectra were performed using Shimadzu XRD-7000 loaded with powder from samples of metal particles founded in fulgurite. Spectra were analyzed with XPert High Score Plus software and ICSD database. Rietveld refinement was used for quantitative analysis.

Results and discussion: Optical microscopy showed that the metal particles consist of rounded α-Fe grains surrounded by a phosphide eutectic (α-Fe + Fe_3P + FeS). Faceted crystals of iron phosphides were found inside the α-Fe grains. Shape of these crystals resembles shape of rhabdite crystals from the Sikhote-Alin (IIAB) meteorite [3]. Both the phosphide crystals at the metallic particles of the fulgurite Kolymsky and the microcrystals of the rhabdite from the Sikhote-Alin meteorite contain directions of parallel growth within one grain. This mean existence of similar mechanisms of crystal formation during cooling. The sulfide phase FeS occurs along the perimeter of metallic particles and as individual grains at the α-Fe / phosphide eutectic boundaries. Chemical composition of metal particles phases in at. % acccording to EDS: α-iron contains 98.2% Fe, 1.8% P (1 point); Iron phosphide - 74.6% Fe, 25.4% P (1 point); Iron sulfide - 49.6% Fe, 50.4% S (average of 14 points). In addition, the chemical composition of the aluminosilicate glass of Fulgurite surrounding metal particles was determined, the results (in at%): 75.6% O, 16.3% Si, 5.1% Al , 1.7% Na.

X-ray analysis of the composition of the crystalline components showed the presence of five phases in the sample. The results of the parameters of elementary cells are given in Table 1 (the error is indicated in parentheses).

Table 1. Crystal structure of phases from Kolymskiy fulgurite metal particles

Phase	Crystal lattice	Unit cell parameters			Percentage, %
		a, Å	b, Å	c, Å	
phosphide Fe_3P	tetragonal (I-4)	9,108(5)	9,108(5)	4,462(4)	53
α-Fe	cubic (BCC) (Im-3m)	2,867(3)	2,867(3)	2,867(3)	31
troilite FeS	hexagonal (P-62c)	5,970(5)	5,970(5)	11,696(6)	7
magnetite Fe_3O_4	cubic (Fd-3m)	8,388(7)	8,388(7)	8,388(7)	5
quartz SiO_2	hexagonal (P3221)	4,921(5)	4,921(5)	5,403(6)	4

The crystal structure of the phases of metallic particles and their chemical composition were determined. Phosphides from fulgurite Kolymskiy and phosphides from the meteorite of Sikhote-Alin have significant similarities according to their morphology: in both cases, there are inclusions of faceted phosphides in α-Fe. However, there are differences in chemical composition, nickel is present in significant amounts in meteoritic phases, while in phases of metallic particles it is not detected. So, metallic particles from fulgurite Kolymskiy have terrestrial origin.

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