

OPAQUE MINERALS IN ENSTATITE CHONDRITES: PERRYITE - SILICOPHOSPHIDE Ni AND Fe IN PCA 91085 AND CONDITIONS OF ITS FORMATION. V. A. Dambaev and A. A. Ulyanov Geological Department, M.V. Lomonosov Moscow State University, Moscow, 119899, Russia. (ulyanov@geol.msu.ru)

Introduction. Perryite was found in enstatite chondrites and achondrites, one anomalous hexahedrite and CO3 chondrite Y-81025. It is 10 finds of perryite (without PCA 91085), mostly in enstatite chondrites. The earlier variant of formula perryite was $(\text{Ni,Fe})_5(\text{Si,P})_2$ and cubic system; new ideal formula $(\text{Ni,Fe})_8(\text{Si,P})_3$, and trigonal system [5]. In this abstract we present results of mineralogical study of perryite.

Materials and methods. Polished thin sections of PCA 91085 was supplied by NASA Johnson Space Centre. SEM CAMSCAN with EDS LINC-10000 and EPM CAMECA SX-50 with 3 WDS were used for determined of chemical composition of mineral phases. The metallic Fe, Ni, Cu, Co, Mg, as well as, Si in andradite, and P in apatite were used as standards. Detection limits were (wt. %): for EDS 0.10-0.15 for Cu, Si and P; 0.2 for Ni; 0.3 for Co; 0.35 for Mg and for WDS 0.01-0.02 for Fe, Ni, Co, Cu, Mg, Si, and 0.03 for P.

Results: In our sample perryite was found as inclusions in silicate matrix in assemblages with kamasite and troilite, or within relatively large (300-400 μm) metal-sulfide inclusions. In the inclusions it forms rims around kamasite-troilite or single crystals in kamasite, troilite, daubreelite, djferfisherite, and silicates. The chemical composition of perryite is (in wt. %): Fe 1.45-14.9, Ni 58.28-73.02, Si 19.85-23.20, P 3.62-6.15, Co 0-0.12, Cu 0-0.70. Atomic ratio $(\text{Fe}+\text{Ni})/(\text{Si}+\text{P})$ range from 2.75 to 2.79 for majority of perryite grains (Fig. 1). The ratio $(\text{Fe}+\text{Ni})/(\text{Si}+\text{P})$ for earlier formula of perryite is 2.5, but for $(\text{Ni,Fe})_8(\text{Si,P})_3$ - 2.67. Thus, formula, advanced by Okada et al. [5] more correspond to existent perryites, than $(\text{Ni,Fe})_5(\text{Si,P})_2$

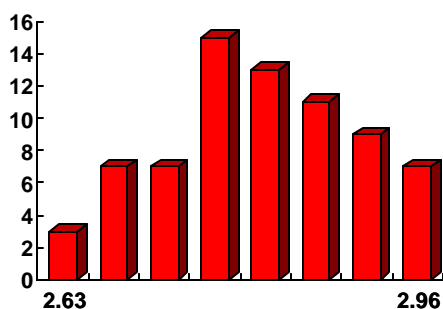


Fig. 1 Histogram of ratio $(\text{Fe}+\text{Ni})/(\text{Si}+\text{P})$ for perryite PCA 91085.

For all perryites increasing of Fe concentration with simultaneous decreasing of Si concentration takes place (Fig 2). Si and P in perryite are substitution 1:1. The composition perryite in PCA 91085 and Mt. Egerton and Norton County [3] are practically identical (Fig 3). Microprobe analyses of perryite in PCA 91085 and its texture and feature of it's locations show two different types of this min-

eral: (i) grain of perryite, which are located in relatively large kamasite-sulphide grains (Fig. 4) and have the permanent composition; (ii) rims around kamasite-troilite and grains in silicate, which often have variable composition. Metal-sulphide grain (Fig. 4) have perryite of the first type. It was formed by liquation, but its texture was controlled by gravitation differentiation. The grain consist of kamasite, perryite, shreibersite, troilite and daubreelite. The top part of a grain consists of daubreelite. Then the zone of exsolution of daubreelite and troilite, and troilite-zone are presented. The bottom half of grain consists of kamasite. Texture of exsolution formed by troilite and daubreelite. Grains of perryite and shreibersite locate into troilite-daubreelite part. Using theoretical density of the minerals we oriented this opaque object for time of cristallization process. Idiomorphic crystals of perryite are crossed with two systems lamellae of exsolutions and terminate in daubreelite (up), and in troilite (bottom). It is suggest, that perryite was formed earlier than troilite-daubreelite matrix. Knowing temperature of exsolutions, it is possible to estimate low limit temperature of perryites formation.

As is known [6], daubreelite under normal conditions is characterized by spinel structure, but at the high temperature and pressure it has polymorphic modifications with hexagonal defective structure type NiAs. At the high temperature and pressure troilite has structure type NiAs also. Thus, the formation of a solid solution in system Fe-Cr-S is possible only for structure of a type NiAs. At the transition FeS and FeCr_2S_4 in low temperature polymorphic modification there should be formation texture of exsolution. The phase transformation in FeCr_2S_4 occurs at 525 $^{\circ}\text{C}$ (20 kbar) and 1060 $^{\circ}\text{C}$ (1 kbar). Maximal pressure for metamorphism of enstatite chondrites established ~ 3 kbar [7]. Using this value, we calculated the temperature of transition daubreelite in phase with spinel structure (980 $^{\circ}\text{C}$). Thus, the exsolution, and consequently, formation of perryite, took place at temperature above 980 $^{\circ}\text{C}$. This temperature higher than this one for Kaidun-III enstatite clast (850-900 $^{\circ}\text{C}$) [3]. Temperature of metamorphism for PCA 91085 estimated by enstatite-oldgamite geothermometer was appreciated 1000 $^{\circ}\text{C}$ [2]. In the result our estimation of low limit of temperature of perryite formation is very similar with data [2].

Conclusions:

In PCA 91085 and some other enstatite meteorites there are two types of perryite: (i) single crystals of perryite in large kamasite-sulfides grains with very low variation in chemical composition and (ii) rims on kamasite-troilite and inclusions in silicates with large variation in composition. Low limit of the temperature of perryite formation in PCA 91085 is 980 $^{\circ}\text{C}$.

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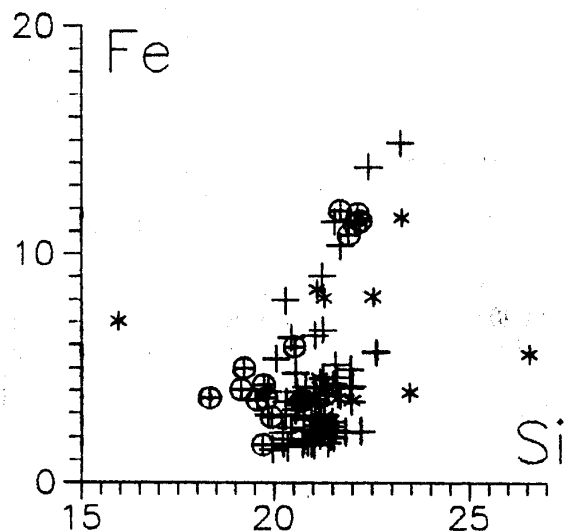


Fig. 2. Composition of perryite from PCA 91085 (+) (our data), Mount Egerton, North County (⊕) and other meteorites (*) [1, 3, 4].

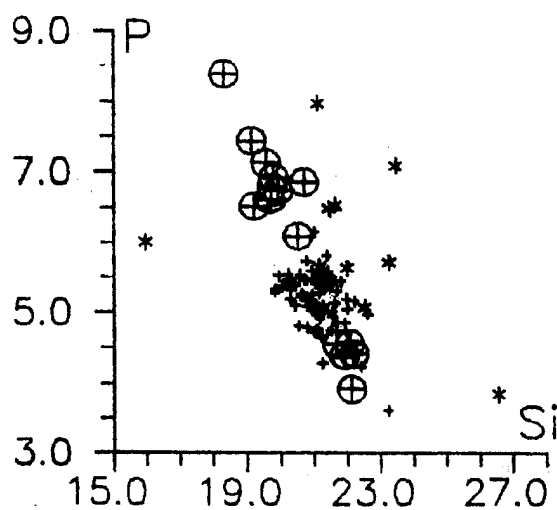


Fig. 3. Composition of perryite from PCA 91085 (+) (our data), Mount Egerton, Norton County (⊕) and other meteorites (*) [1, 3, 4].

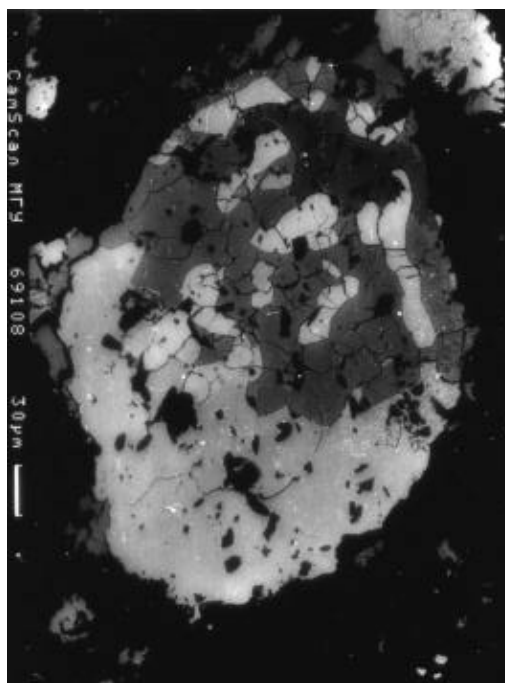


Fig. 4. Metal-sulphide grain: perryite (white), shreibersite (white), troilite (grey), daubreelite (dark) and kamasite (white).

References: 1. Pokrovskiy P.V. et al. *Meteoritica*, 1979, **37**, 138-139. 2. Petrichenko A.S. et al. 22 *Microsymp. Comparative. Planet.* 1995, 76-77 3. Grocovsky V.I. and Ivanov A.V. *Lunar Planet. Sci. Conf. XVII*, 1986, 291-292. 4. Kallemeyn G.W., Wasson J.T. *Geochim. Cosmochim. Acta* 1986, **50**, 2153-2164. 5. Okada A. et al. *Acta Cryst.* 1991, sect. C, 1358-1361. 6. Vaughan D.J, Craig J.R. *Mineral chemistry of metal sulfides*. 1978. 7. Dodd R.T. *Meteorites. A petrologic-chemical synthesis*. 1981.