SULFIDE MINERALIZATION IN THE KARA IMPACT STRUCTURE, RUSSIA. M.V. Naumov, Karpinsky All-Russia Geological Research Institute, 199106 Sredny pr., 74, St.Petersburg, Russia, m_naumov@mail.ru.

Introduction. The presence of the world class Ni-Cu-PGE sulfide ores in the Sudbury impact structure [1, 2] has driven efforts to study sulfide occurrences in other large terrestrial impact craters. Besides some impact-related base metals deposits had been reported from Serpent Mound, Crooked Creek, Decaturville, and Siljan Ring impact structures [3–7]. Apart form economic aspect, sulfide mineralization could be of significant interest as an example of sulfide formation during the melting of upper crustal rocks without the input of abyssal material; it could be considered as an indicator of crystallization conditions of impact melts as well. In this report, data on sulfide mineralization in the Kara impact structure are given to supplement scanty information about distribution and composition of sulfides in impact structures lacking in economic deposits [8-10].

Kara impact structure. The Kara impact structure (KIS) of 60 km in diameter [11] centered at 69°10′N; 65°00′E is situated on the northwestern slope of the Pai-Khoi Ridge, Arctic Russia. It originated about 65 Ma ago; the strong predominance of fragmental impact melt (suevite) is a feature of the KIS. The total thickness of the suevites exceeds 1 km; their volume is estimated at 1700 km^3 [12]. Thin (up to 10-15 m thick) lenses of massive impact melt occur locally within the suevite cover. The formation of the crater on the shallow (about 100 m) shelf caused abundant impact-induced hydrothermal activity, which mainly affects the suevite deposits [13].

Sulfide mineralization. Sulfides occur within all types of impact and target rocks of the KIS including late-generated clastic dykes intruding the suevite sheet. Three genetic groups of sulfudes (pre-impact, syngenetic, and epigenetic) are distinguished.

Pre-impact sulfides. Target lithologies for the KIS are Early and Middle Paleozoic metasediments (carbonaceous, siliceous slates, metacarbonates) crossed by dolerite dikes, and Permian arenites. Metasedimentary lithologies contain frequent nodules and concretions (up to 1 cm lengthwise) consisting of pyrite with minor chalcopyrite, galena, and sphalerite inclusions. In places, disulfides form continuous interlayers within slates consisting of framboidal pyrite with marcasite and melnikovite relics. Pyrite contains minor Ni, Co, and As impurities, Ni/Co ratio varying considerably. Within dolerites, pre-impact sulfides are represented by Ni-bearing monoclinic pyrrhotite, pentlandite, and sphalerite; all these form fine (5-10 μm) grains within secondary mackinawite and markasite aggregates. Pyrite is characterized by low Ni/Co ratio and Zn admixture.

Syngenetic sulfides were formed by impact melt crystallization. They are hosted by massive impact melt and impact glasses. Pyrite is a predominant sulfide there as well. It forms both rare dissemination and inclusions within thin calcite veinlets. This pyrite is distinguished by low Ni/Co ratio (<1) and low Co and Ni contents. In addition, fine (1-10 μм) pyrrhotite, chalcopyrite, and sphalerite grains occur within the matrix; sphalerite contains (apart from high Fe and Cu) Cd impurity, the latter is an original mark of sphalerite from target slates. In addirion, cuproauride has been reported from impact melt from the southern part of the KIS [14].

Epigenetic sulfides are derived from the impact-generated hydrothermal circulation. Hydrothermal alteration of the suevites is displayed in the recrystallization of vitroclasts and in the development of mineral assemblages forming veins and vugs, as well as impregnated mineralization in the fine-grained matrix of the suevites. Locally, the secondary mineralization contributes up to 30% to rock volume; nevertheless, the number of common vein minerals is strongly limited; it includes pyrite, calcite, and analcime.

Locally (in the Kara River and Sopcha-Yu river valleys in the southern part of the crater), pyrite contributes as much as 20 vol.% to the matrix of the suevites. This is probably due to the abundance of coal-bearing shales and limestones among lithic fragments in suevites from these locations. These coaly and carbonate lithologies probably provide geochemical conditions controlling the precipitation of pyrite and associated minerals. In contrast, in the northern part of the crater, lithoclasts belong exclusively to Permian terrigenous rocks.

Pyrite and minor marcasite form (1) vugs (up to 6 mm in diameter) and disseminated mineralization in the matrix of the suevites together with melnikovite, (2) disseminated euhedral grains at selvages of calcite-analcime veinlets, and (3) thin films enclosing clasts of carbonaceous slates. All pyrites are characterized by high Ni/Co ratio – (3-7):1; predominant impurity in pyrite of the former type mentioned is Ni, while of the second type, Cu, Pb, and Zn. Pyrite frequently contains fine chalcopyrite inclusions and, in places, pyrrhotite relics, the latter gives evidence that Py originated after pre-impact sulfides from lithic fragments.

In all locations, pyrite forms mostly cubic crystals (with bornite films, rarely with minor octahedral faces), more rarely, rhombododecahedrons or cuboctahedrons, or irregularly-shaped aggregates in places. Some pyrites from analcime-calcite veinlets crossing deeper parts of the suevite cover are made by combination of cube and pentagon-dodecahedron, though.

Sulfur isotopes. The sulfur isotope composition of pyrite from suevites varies from −2,4 to −10,3 ‰CDT, while of pyrite from metasedimentary target rocks, from −0,1 to −14,3 ‰CDT; such values are typical for sedimentary sulfides [e.g., 15].

Conclusions. 1. The Kara impact structure is one of the largest terrestrial impact craters containing a thick impact melt rock sequence influenced considerably by post-impact hydrothermal alteration. In this respect, the KIS is one of the best available structures to study distribution of impact-related sulfide mineralization in giant impact craters.

2. Pyrite is a predominant sulfide of all sulfide generations (pre-impact, syngenetic, and epigenetic). Other sulfides (chalcopyrite, sphalerite, galena ets) occur as minor phases alone.

3. Pyrite occurrences throughout the suevite cover are characterized by the strong preference of the cubic habit of crystals, by low total content (less than 0.5%) of trace elements (Cu, Pb, Zn, Ti, Ni, Co), and by very high Ni/Co ratio, that is similar to that of pre-impact pyrite from metasedimentary target rocks. Thus, chemical compositions and structural features of pyrite, which reflect chemical and PT-conditions of mineral formation, are characterized by constancy within all over the suevite sheet.

4. Pyrite generated in suevites by impact-derived hydrothermal processes is depleted in heavy sulfur like pre-impact sedimentary sulfides. In totals, both geochemical and isotope features of sulfides indicate that sulfides in impact melt lithologiess arise at the expense of pre-impact sulfides.

5. Although impact-induced hydrothermal alteration appeared intensely in the KIS, no economic sulfide occurrence was formed there. This effect may be attributed to (1) a relative homogeneity of mineral-forming conditions within the whole suevite sheet, and (2) absence of metallogenic specialization of the target. Sulfide formation in the KIS came to reworking of the pre-impact sulfide mineralization keeping its geochemical and isotope features.

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