NICKEL-RICH METAL-SULFIDE GLOBULES IN FUSION CRUST OF CHELYABINSK METEORITE

V. V. Sharygin[1,2,3], [1]V.S.Sobolev Institute of Geology and Mineralogy, SB RAS, Novosibirsk, 630090, Russia; [2]Novosibirsk State University, Novosibirsk, 630090, Russia; [3]ExtraTerra Consortium, Institute of Physics and Technology, Ural Federal University, Ekaterinburg 620002, Russia; E-mail: sharygin@igm.nsc.ru.

Introduction: Fusion crust (product of melting in the Earth's atmosphere) is common of all fragments of the Chelyabinsk LL5 chondrite. Its thickness does not exceed 600 μm. Temperature of melting may be estimated in the 1800-2270°C interval. The composition and structure of the fusion crust does not depend on size of meteorite fragments and lithological type, which was involved in melting event (initial chondrite, impact melt, impact veins). In general, it contains numerous gas vesicles and is zoned in structure.The outer zone is cryptocrystalline and contains skeletal new-formed crystals of zoned olivine and magnetite (up to 5 μm) and mafic glass (commonly devitrified). The inner zone consists of larger crystals of olivine, glass and minor magnetite. Both zones also contain relics of initial chromite (rarely olivine) and new-formed Ni-rich metal-sulfide globules (5-50 μm). Chemical and phase composition of such globules drastically differs from metal-sulfide assemblages in other lithologies of the Chelyabinsk meteorite [1-6].

Experimental: Polished samples with fusion crust (Chelyabinsk meteorite) were examined using optical microscope Olympus BX51, scanning microscope TESCAN MIRA 3MLU SEM (EDS) and electron microprobe JEOL JXA-8100 (WDS).

Results and Discussion: The following phases have been observed in metal-sulfide globules: two heazlewoodite solid solutions (Hzss1 - $(Ni,Fe)_{3\pm x}S_2$, Hzss2 – $(Ni,Fe)_{4\pm x}S_3$), godlevskite solid solution (Gdss – $(Ni,Fe)_{7\pm x}S_6$), nickel, awaruite, pentlandite $(Fe,Ni)_9S_8$, tetrataenite, rarely kamacite, taenite and unidentified Os-Ir-Pt-rich phase. Wüstite or bunsenite may appear as thin rim around some globules (Fig. 1). In general, the phase composition of globules strongly varies depending on location in the individual zone of fusion crust. The association of Hzss1 + nickel (or awaruite) ± Os-Ir-Pt phase is dominant for globules from the outer zone, whereas Hzss2, Gdss, pentlandite and other Ni-poorer phases are common for globules located in the inner zone. Unfortunately, it is unclear, whether melting event led to the appearance of one melt (with further separation into metal-sulfide and silicate components) or two individual melt existed independantly.In any case, the interaction of new-formed melts with atmospheric oxygen is a main reason in the appearance of such Ni-rich metal-sulfide paragenesises in the fusion crust of the Chelyabinsk meteorite. As a result, during melting and further crystallization metal-sulfide melt was getting richer in Ni and poorer in Fe than silicate liquid. The platinum-group elements were concentrated in metal-sulfide component with formation of individual phase (mainly as inclusions in Ni-rich metal, Fig. 1) despite of high rate of melting and further crystallization. It is not excluded that part of sulfur evaporated during melting. Such process of melting in the Earth's atmosphere with formation of the fusion crust seems to be common for all chondrites.

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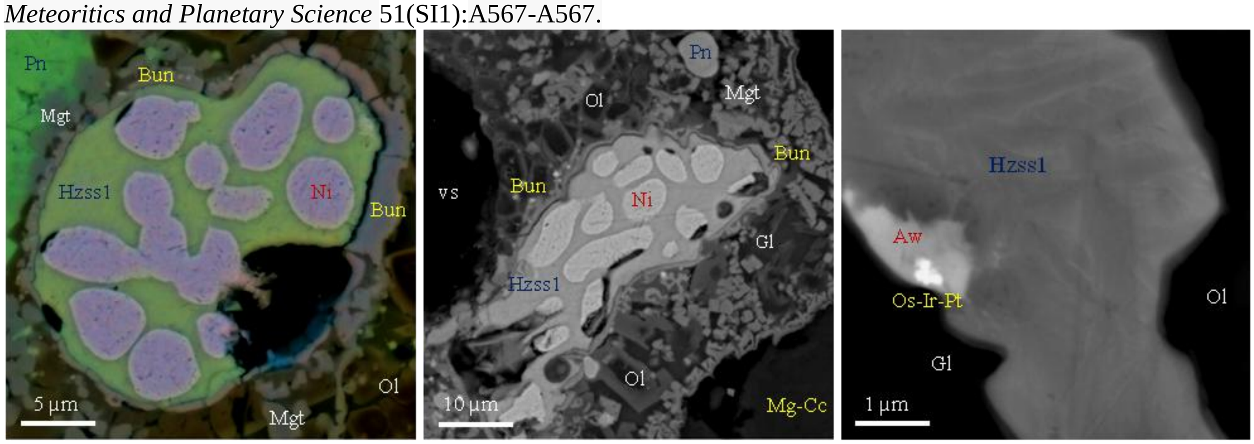

Figure 1. BSE images of some metal-sulfide globules from fusion crust of the Chelyabinsk chondrite. Symbols: Mgt – magnetite; Ol – olivine; Hzss1 – heazlewoodite solid solution $(Ni,Fe)_{3\pm x}S_2$; Ni – nickel; Bun – bunsenite; Pn – pentlandite; Gl – silicate glass; vs – gas vesicle; Aw – awaruite; Mg-Cc – Mg-rich calcite; Os-Ir-Pt - Os-Ir-Pt-rich Fe-Ni-alloy.