STRUCTURAL FEATURES OF SEYMCHAN PALLASITE AFTER SHOCK-WAVE LOADING.

R. F. Muftakhetdinova, V. I. Grokhovsky, M.G. Minin, Institute of Physics and Technology, Ural Federal University, Ekaterinburg, 620002, Russian Federation, e-mail: gizrozka91@bk.ru.

Introduction: Simulation experiments play a large role in understanding the processes arising from the interaction of shock waves with extraterrestrial matter. The use of spherically converging waves allows in a single experiment to obtain a wide range of pressures (from 10 to 300 GPa) and temperatures (from ambient temperature to several thousand degrees) distributed in different zones of one sample. Analogous experiments were previously carried out with the material of the Saratov L4 ordinary chondrite [1] and the Tsarev L5 ordinary chondrite [2], as well as with the iron meteorites, Sikhote-Alin and Chinga [3,4].

This paper presents the results of a study of the structural features of the pallasite part of the Seymchan meteorite after experimental impacts by spherically converging shock waves. The results of measuring the mechanical properties of kamacite are also given.

Samples and Methods: The experiments were carried out at the Russian Federal Nuclear Center (RFNC) – Zababakhin All-Russia Research Institute of Technical Physics in Snezhinsk, Russian Federation according to the method described in [5]. To conduct experiments on compression of balls from a meteorite (pallasite and octahedron parts) of Seymchan, balls with a diameter of 42 ± 0.01 mm were prepared. The average density of the pallasite part of the Seymchan meteorite is 5.10 ± 0.01 g/cm^3. Then, encapsulated in a vacuum inside an 8.8-mm thick steel jacket made of 12KH18N10T steel, and then loaded with a spherically converging shock wave produced by explosives placed on the outside of the steel jacket. After the experiment, the sample was left to slowly cool back to ambient temperature. Microstructure studies were carried out using the Zeiss Axiovert 40 MAT optical microscope, FE-SEM ∑IGMA VP scanning electron microscope and Hysitron TI 750 Nanoindenter.

Results and Discussion: In a sample from the pallasite part of the Seymchan meteorite, after compression by convergent shock waves, olivine crystals lost transparency due to multiple cracks. In the central part, both visual darkening of the silicate phases associated with complete and partial remelting of the starting material, and initially light grains of olivine, which did not have time to melt, are observed. The change in the reflective properties of some silicate grains can be explained by the filling of shrinkage voids with a metal-sulfide melt. Also, at a distance of about 1 cm from the center, in the olivine component of the sample, a nonspherical black ring was formed. The formation of such spherical rings of dark color was previously observed in two ordinary chondrites Chelyabinsk LL5 and Tsarev L5 loaded with shock waves. In this case, the nonspherical shape of the black ring can be explained by the difference in the amplitude of the shock wave in the regions with the initial structural inhomogeneity of the sample. This led to a distortion of the symmetry of the convergence of the waves and a decrease in the cumulation effect in the pallasite ball in comparison with the macro-homogeneous material of the Chelyabinsk and Tsarev meteorites. It is established that formation of fine-dispersed voids as a result of shrinkage processes during the recrystallization of the melt leads to the darkening of the initially light olivine matrix. In contrast to the remelting in the central part, the presence of metal-sulfide associations filling the voids is not observed here. The metal part in this experiment does not show significant traces of plastic deformation or traces of complete melting. From which we can conclude that the temperature did not exceed 1500°C inside the black ring.

Nanoindentation of kamacite was carried out with a load of 10 µN. Measurements were taken from the outer part of the sphere to the center. There is a tendency for the hardness to decrease as it approaches the center. In the outer part, kamacite has a hardness H = 3.97 GPa and an elastic modulus Er = 189 GPa, in the central part H = 3.11 GPa and Er = 161 GPa. Such a decrease in hardness may be associated with the softening effect of high temperatures in the center of the ball.

Acknowledgments: The reported study was funded by Minobrnauki project FEUZ-2020-0059.

References: [1] Bezaeva N. S. et al. 2010. *Meteoritics & Planetary Science* 45:1007. [2] Muftakhetdinova R. F. et al. 2017. *Meteoritics & Planetary Science* 52: A247. [3] Grokhovsky V. I. et al. 1999. *Meteoritics & Planetary Science* 34:A48. [4] Muftakhetdinova R. F. et al. 2018. *Letters on Materials* 54(8): 54-58. [5] Kozlov E. A., Zhukov A. V. 1993. *High Pressure Science and Technology,* 977—980.