MECHANICAL PROPERTIES OF IRON METEORITES IN THE CONTEXT OF ASTEROID HAZARD

R. F. Muftakhetdinova[1], S. V. Razorenov[2], I. V. Khomskaya[3], V. I. Grokhovsky[1], V. A. Khotinov[1], G. A. Yakovlev[1], E. V. Brusnitsyna[1], A. S. Savinykh[2], G. V. Garkushin[2]

[1]Ural Federal University, Ekaterinburg, Russia

[2]Federal Research Center of Problems of Chemical Physics and Medicinal Chemistry RAS, Chernogolovka, Russia

[3]Mikheev Institute of Metal Physics, Ural Branch, Russian Academy of Sciences, Ekaterinburg, Russia

[4]Zavaritsky Institute of Geology and Geochemistry of the Ural Branch of the Russian Academy of Sciences, Ekaterinburg, Russia

The study of the structure and properties of extraterrestrial materials, such as meteorites, is becoming increasingly relevant in light of the awareness of the cometary-asteroidal threat to Earth and the search for ways to prevent it. Undoubtedly, the nature of destruction during collisions in space and when meteorites enter the Earth's atmosphere largely depends on their mechanical properties [1]. However, currently, information about the mechanical properties of meteorites remains quite limited, and most of the known data has been obtained through compression tests [2]. At this point, meteorites represent a more accessible material for laboratory research compared to substances that have been brought to Earth through various space missions.

The aim of this study was to evaluate the strength characteristics of iron meteorites by conducting both quasi-static and dynamic tests, as well as to analyze the features of their destruction. The tests were carried out on the substance of the iron meteorites Chinga (~17% Ni), Sikhote-Alin' (5–7% Ni), Seymchan (~9.1% Ni), Dronino (~9.3% Ni) and Fe-Ni alloys, which have a composition close to the meteorite.

Static tensile tests were performed at room temperature on a universal INSTRON 3382 machine on flat samples 75 mm long, 2 mm thick and 15 mm wide, cut from the Chinga and Seymchan meteorites, as well as from the Fe-7.7 Ni alloy. The rate sensitivity m of the materials under study was assessed at different deformation rates V_d = 0.2, 2.0 and 20 mm/min, and for the Fe-7.7Ni alloy samples additionally at V_d = 1 mm/min. The dependence with a tendency for plasticity to increase is most clearly observed for the Chinga meteorite.

Shock-wave loading of the samples of the studied materials was carried out on a PP50 pneumatic gun with a caliber of 50 mm with an intensity of ~5.5 and 11 GPa at an average material deformation rate of 10^5 s^{-1} until the moment of spall [3]. Comparative analysis of the obtained data on spallation strength showed that the destruction of the meteorite substance occurs in the range of 2.5–4 GPa, which is associated with both their original macro- and microstructure and the number of induced defects inside the sample. However, the spallation strength of meteorites remains close to the strength of a Fe-Ni alloy of terrestrial origin with a similar chemical composition.

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References

1. **Shustov, B. M.** Asteroid and comet hazards: the role of physical sciences in solving theproblem [Text] // Physics–Uspekhi. – 2011. — Vol. 54, No. 10. – P. 1068–1071. – doi:10.3367/UFNe.0181.201110e.1104.
2. **Petrovic, J. J.** Review Mechanical properties of meteorites and their constituents [Text] // Journal of material science. – 2001. – Vol. 36. – P. 1579–1583. – doi:10.1023/A:1017546429094.
3. **Razorenov, S. V.** The Spall Strength and Hugoniot Elastic Limit of Iron-Nickel Alloys of Meteoritic Origin [Text] / S. V. Razorenov, A. S. Savinykh, G. V. Garkushin et al. // Technical Physics. –2024. –Vol. 69, No. 6. – P. 803–810. – doi: 10.61011/TP.2024.06.58822.87-24 P.803-810.