ISSN 1028-3358, Doklady Physics, 2017, Vol. 62, No. 10, pp. 486–489. © Pleiades Publishing, Ltd., 2017.
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ASTRONOMY, ASTROPHYSICS, COSMOLOGY

Features in Constructing a Certificate of Strength of Extraterrestrial Material by the Example of the Chelyabinsk Meteorite

S. A. Voropaev[a]*, A. V. Kocherov[b,c], C. A. Lorenz[a], A. V. Korochantsev[a], N. V. Dushenko[a], D. M. Kuzina[d], I. I. Nugmanov[d], and Y. Jianguo[e]

Presented by Academician M.Ya. Marov March 6, 2017

Received March 13, 2017

Abstract—The mechanical properties of various components of the Chelyabinsk meteorite are studied. A measurement technique allowing one to obtain a strength certificate of the material by a minimum necessary number of samples with allowance for defectiveness is developed. Universal expressions for the chondritic component and impact melting have been obtained. The expressions allow one to make general estimates of the strength boundaries for LL type meteorites.

DOI: 10.1134/S1028335817100111

INTRODUCTION

The mechanical properties of meteorites are among key parameters for a justified interpretation of data about the structure of asteroid surfaces and creation of engineering models of their internal structure. Determination of meteorite strength is important for studying processes of meteoroid destruction in the atmosphere, for remote investigations of asteroids by use of spacecraft, and for problems of countermeasures against asteroid danger, as well as for long-term tasks of developing resources on the Moon and on asteroids. Currently, there are only a few works devoted to measurements of the mechanical properties of meteorites. For about 100 meteorites (ordinary chondrites), data are available on the seismic wave velocities, density, and porosity; the elasticity moduli (about 30 meteorites), tensile and compressive strength limits, and thermal expansion coefficients have been studied less [1].

Earlier, it was shown that stresses appearing during the deceleration of a meteoroid body in the atmosphere are significantly less than the fracture strength limits of meteorites of different types [2]. Therefore, the destruction of meteoroids (at least, stone and iron–stone ones) in the atmosphere is determined in many aspects by the preatmospheric fracturing and internal macroscopic structure of meteoroid bodies. Most meteorites are breccias. The S3 impact stage corresponding to the impact pressure in the interval of 10–15 GPa is most wide-spread among meteorites. Its action manifests itself in the formation of fracturing, isolated veinlets of sulfide and silicate melts, and breaks of the optical continuity of mineral grains [3].

Investigations by the authors of [4] have shown a decrease in the compression strength in samples with dimensions of more than 40 mm or, on the contrary, less than 15 mm along one of the sides. Apparently, with a decrease in the sample size, more mechanical interconnected defects (fractures, etc.) go to the external surface of the sample and, correspondingly, destruction occurs along them. As for a large sample, at equal volumetric density of intergrain breaks, the probability of the appearance of macrofractures is higher. For example, a sample of Tsarev chondrite with a size of 1 cm was broken under compression of 46 MPa, while a sample with a size of 10 cm was fractured at 26 MPa. In Slyuta's works, the inhomogeneous distribution of the compression strength values in the SaU 001 and Tsarev meteorites was shown; the variations amounted to about 30%. According to these data, the compression strength limit correlates with the velocity of P-waves. It is assumed that variations in

[a] *Vernadsky Institute of Geochemistry and Analytical Chemistry, Russian Academy of Sciences, Moscow, 119991 Russia*
[b] *Institute of Economics, Ural Branch, Russian Academy of Sciences, Yekaterinburg, 620014 Russia*
[c] *Chelyabinsk State University, Chelyabinsk, 454001 Russia*
[d] *Kazan (Privolzhsky) Federal University, Kazan, 420008 Tatarstan, Russia*
[e] *The State Key Laboratory of Information Engineering in Surveying, Mapping and Remote Sensing, Wuhan University, Wuhan, 430072 China*
**e-mail: Voropaev@geokhi.ru*