**THE INHOMOGENEITY OF THE CHELYABINSK METEORITE'S STRENGTH PROPERTIES.** S. Voropaev[1], C. Lorenz[1], A. Korochantsev[1], A. Kocherov[2], D. Kuzina[3], I. Nugmanov[3] [1]Vernadsky Institute of geochemistry and analytical chemistry RAS, Moscow, Kosygina Str. 19, 119991, Russia, voropaev@geokhi.ru; [2]Chelyabinsk State University, Chelyabinsk, 454001, Russia; [3]Kazan Federal University, Kazan, 420008, Russia.

**Introduction:** Since the fall of large meteorites is big and real danger, study of composition, physical, mechanical (FM) and particularly the strength properties of near-Earth asteroids is of considerable interest. FM properties of stony, stony-iron and iron meteorites are significantly different due to their structural and compositional differences [1]. Previous works, e.g. [2] were showed a strong dependence of elastic wave velocities from porosity and suggested an anisotropic distribution of FM properties in a sample of the meteorite. Small asteroid, entered the Earth's atmosphere in February 15, 2013, was brightly destroying over Chelyabinsk [3]. Based on the analyses of mineralogical [4], chemical and isotopic compositions of the Chelyabinsk meteorite, it is classified as shocked (S4) LL5 chondrite: LL5 [5]. Analysis of the trajectory of the fall and an orbit showed that the meteorite Chelyabinsk is a fragment of the asteroid belonged to the near-Earth population. Analysis of the isotope systems Sm-Nd and Rb-Sr of the meteorite Chelyabinsk demonstrates two isochrons with age of 4.56 billion and 290 million years [5]. The last event, probably related to the impact event, which caused intense melting of Chelyabinsk parent body.

**Samples and analytical procedure:** To adequately assess variations in the FM properties of the Chelyabinsk meteorite, a study of different samples of the meteorite was undertaken. Some of the samples are composed of a light petrology of a typical chondritic texture (A-type). Also, there are dark samples, mainly composing of shock-melted material (B-type). In the first measurement, the A-type sample, 20x20x30 mm in size (Fig.1a) was analysed for determination of the elasticity modulus, Poisson's ratio, and ultimate strength in uniaxial compression (perfomed by A. Latypov, KFU). In the second measurement, the B-type sample of 25x25x50 mm in size was analyzed. same measurements were done with (Fig. 1b) in the uniaxial compression (perfomed by by I. Nugmanov, KFU). The tests were performed in the Laboratory of soil mechanics (Institute of Geology and Petroleum Technologies, KFU), using a GTYN 441179.050 instrumental complex for uni- and triaxial compression. The complex is a set of functionallycombined units: the device for axial kinematic loads, test apparatus, measuring force sensor, displacement unit, and an electronic instrumentation. Vertical load applied to the sample continuously at a given rate of loading. The maximum value are: for vertical load - 30 kN, for vertical deformation of the sample - 20 mm, for radial deformation of the sample - 6 mm. Accuracy of displacement sensors is 0,00001 mm, accuracy of the force sensor is 0.0001 MPa.

**Results and discussion:** Characteristics determined were the elasticity modulus (Young's), Poisson's ratio and maximum strength in uniaxial compression. To determine the deformation characteristics, the results of each test were constructed as the dependence $\varepsilon 1 = f(\sigma)$ and $\varepsilon 2 = f(\varepsilon 1)$. Modulus of elasticity (Young's) and Poisson's ratio were determined in the initial linear sections of the corresponding dependencies.

Table 1. Elastic and strength properties of the meteorite Chelyabinsk.

| Sample | Young's modulus, E, MPa | Poisson' ratio, ν | Comressive strength (uniaxial), MPa |
|---|---|---|---|
| A-type | 8621 | 0.2 | 45.2 |
| B-type | 8775 | - | 73.6 |

Table 1 shows the values of elastic deformation and strength characteristics for two different samples of the meteorite Chelyabinsk. Because of the fracture of the dark sample and the small radial deformation at the level of the sensor sensitivity to lateral strain, the calculation of its Poisson's ratio was not carried out. Our preliminary measurements demonstrate an increase of strength and elastic properties from the original chondritic material to impact melt lithology of the Chelyabinsk. It's easy to explain by the decrease of the number and size of crystalline mineral grains, and more homogeneous structure of the shock melt, which is the main component of the B-type sample. For the perspective studies of the asteroids, the tensile and shear strength are of great interest, too. But, for acquiring of these parameters it is necessary to perform a mumber of experiments with triaxial compression. This is the goal of the our subsequent investigations.

Occurring of the local areas of high mechanical strength due to the impact melting of the surface layer of the asteroids due must be considered when planning future missions, which assumes the sample return.

Also, understanding the inhomogeneity of the strength properties can help in the choice of methods of destruction of potentially hazardous asteroids and exploration of the asteroids.

**References:** [1] Flynn G. J. (2005) *Highlights of Astronomy 13* (Engvold O., Ed.) Astron. Soc. Of Pacific, 766-767; [2] Yomogida K. and Matsui T. (1983) *Journal of Geophysical Research, 88,* 9513-9533; [3] Popova O. et al. (2013), *Science, 342*, 1069-1073; [4] Voropaev S. et al. (2013) *Geochemistry International, 51*, 593-598; [5] Galimov E.M. et al. (2013) *Geochemistry International, 51*, 522-539.

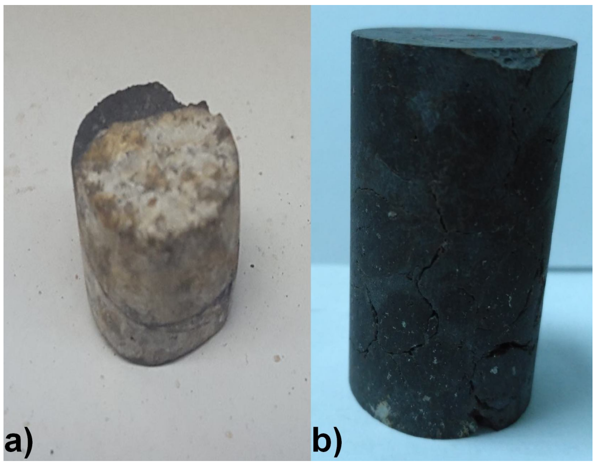


Fig. 1 a) A-type sample; b) B- type sample of the meteorite Chelyabinsk.