STRONG PHYSICAL AND MECHANICAL ANISOTROPY OF ORDINARY CHONDRITES. E. N. Slyuta, S. M. Nikitin, A. V. Korochantsev, C. A. Lorents, A. Ya. Skripnik, Vernadsky Institute of Geochemistry and Analytical Chemistry, Russian Academy of Sciences, 119991, Kosygin St. 19, Moscow, Russia. slyuta@mail.ru

Introduction: Sayh al Uhaymir 001 (SAUH 001) is a stony meteorite shower found March 16, 2000 and is one of Oman's largest known meteorite showers [1]. More than 2670 samples weighing more than 450 kg have been collected. On composition the meteorite is ordinary chondrite of L4/5 petrographic type with S2 shock stage. Very important, that this is recent enough falling poorly altered by terrestrial weathering (W1). Tsarev is a stony meteorite shower found at 1968 in Volgograd Province in Russia [2]. 28 samples weighing 1131.7 kg have been collected. The largest mass weighed 284 kg. The fall may have occurred in 1922, December 6 at 07:00 hrs. On composition the meteorite is ordinary chondrite of L5 petrographic type (20.54% total iron) [3]. K-Ar age of the meteorite is estimated within ~1.20-2.33 Ga [4]. The investigated samples are fresh infernally and the crust only slightly weathered.

Technique of experimental researches: Physical and mechanical properties of meteorites were investigated with a complex method of repeated splitting and compression according to the established standard [5]. The method is applied to calculations and designing of mining and the mining equipment, for geological engineering survey and for scientific researches [5]. The chosen technique of researches allows to receive big enough statistics of measurements and, accordingly, reliable enough data on rather small volume of a material, i.e. actually on one sample. This method also appeared convenient for research of three-dimensional distributions of physical and mechanical properties in a separate sample. Sample of meteorite SAUH 001 and two different samples of meteorite Tsarev have been cut in three perpendicular plates, everyone by thickness of 20 mm, and in one or few cubes of 40×40×40 mm in size with the sides parallel to all three plates (Fig. 1, 2 and 3). The method of splitting by wedges with a corner of sharpening 90° with measurement of the enclosed loading and destroying effort was applied to measurement of tensile strength. The length of split was measured with a margin error no more than ±0.5 mm for length not less than 20 mm. Each plate depending on its size broke up to few tens of cubes of semi regular form of (20-30)×(20-30)×(20-30) mm in size. The tensile strength is directed perpendicularly lines of splitting. Each of three plates was split along two ways which are perpendicular to each other. Accordingly, tensile strength also was taken into account for two different directions, for example, x and y, x and z, or y and z according to coordinates of compressive strength. Measurement of a compressive strength was carried out by crush of the cubic samples of the semi regular form received during splitting of plates after measurement of a tensile strength, and of a cube of 40×40×40 mm in size at measurement of deformation characteristics. The axis of compression is normal to a plate.

Results: During the preliminary analysis of compressive strength in a sample of meteorite SAUH 001 [6] at calculation of average value extreme members have been rejected. In result the maximal values have been removed only from one direction which was characterized by higher strength in comparison with others that has resulted in a mistake at calculation of anisotropy. Now this mistake is corrected. Three-dimensional distribution of physical and mechanical properties in samples of meteorite SAUH 001 and Tsarev are shown in Table 1. Compressive strength along one of three directions strongly differs from other two which are almost equal. The directions from smaller to the greater value of compressive strength irrespective of the initial form of a sample had been marked by symbols $\boldsymbol{a_c}$, $\boldsymbol{b_c}$ and $\boldsymbol{c_c}$ correspondingly (Table 1-3, Fig. 1-3). Thus, three-dimensional distribution of compressive strength in all three samples can be approximated by prolate ellipsoid with semi axes of $\boldsymbol{a_c} > \boldsymbol{b_c} \geq \boldsymbol{c_c}$. As against compressive strength the distribution of tensile strength is almost isotropic and can be approximated by sphere (Table 1-3).

The sample of meteorite SAUH 001 had irregular lengthened shape of 9×10×12 cm in size (Fig. 1). Compressive strength of all three plates i.e. all three coordinates is shown in Table 4. The number of measurements corresponds to number of semi regular cubes received from this plate with splitting and subjected to compression and destruction. The smallest plate with the least number of measurements of compressive strength is normal to the longest axis of a meteorite shape (Fig. 1). Obviously, the shape of a meteorite fragment formed at mechanical destruction of a parental body in the Earth's atmosphere depends on the revealed anisotropy of strength, i.e. the long axis of a fragment shape (***a***) coincides with $\boldsymbol{a_c}$ axis of prolate ellipsoid of anisotropy. The sample №15390,9 of meteorites Tsarev is a part of a large fragment and is like thick brick (Fig. 2). Three sides with "sunburn" surface, one of which is partly cut (Fig. 2), are parallel to a long axis of an initial fragment shape that was dictated by the optimum plan of the previous cutting of a large fragment. Hence, the meteorite shape depends on orientation of strength anisotropy ellipsoid too.The long axis ***a*** of a fragment shape also coincides with the $\boldsymbol{a_c}$ of anisotropy ellipsoid. The sample №15384,1 of meteorite Tsarev had the shape like a pyramid (Fig. 3). As authors did not suspect about existence of anisotropy and its possible connection with a shape of a fragment the sample has been cut not in parallel of initial "sunburn" surfaces of a fragment, but under a corner (Fig. 3), i.e. concerning a surface of previous cut being the basis of a pyramid. Difference between the axes of $\boldsymbol{b_c}$ and $\boldsymbol{c_c}$ of strength ellipsoid anisotropy in this sample and their high enough value in relation to $\boldsymbol{b_c}$ and $\boldsymbol{c_c}$ in a sample №15390,9, probably, specifies that true orientation of strength ellipsoid anisotropy in this sample differs from received anisotropy ellipsoid. This, apparently, specifies also smaller value of anisotropy ($\boldsymbol{a_c}/\boldsymbol{c_c}$=1.3) in comparison with size of anisotropy in a sample №15390,9 ($\boldsymbol{a_c}/\boldsymbol{c_c}$=1.6).

Summary: Obviously, the shape of the investigated fragments is under the control of the revealed strength anisotropy. In spite of the fact that strength of meteorite SAUH 001 and meteorite Tsarev differs twice, they are characterized by identical size of anisotropy (Table 1). At least, it is valid in relation to a sample №15390,9 of meteorite Tsarev, where orientation of anisotropy ellipsoid also coincides with orientation of the main axes of the initial shape of a fragment. Apparently, anisotropy ellipsoid allows orientating different fragments of a meteorite concerning their position

in a meteoroid before its destruction in the Earth's atmosphere. If anisotropy is observed in small (meteorite SAUH 001) and enough large (meteorite Tsarev) fragments of meteorites and there was in the meteoroids, then it should be also in parental bodies of meteorites, i.e. in small coherent rocky bodies (asteroids). Anisotropy comprises the genetic information on conditions of formation of ordinary chondrites, may be and other types of primitive meteorites also. Physical and mechanical properties of a material as a whole are determined by mineralogical and petrographic structure of a material. Features of this structure and its connection with anisotropy are investigated with directed thin sections.

Fig. 1. Cutting plan of SAUH 001, where a_c, b_c and c_c are coordinates of compressive strength anisotropy.

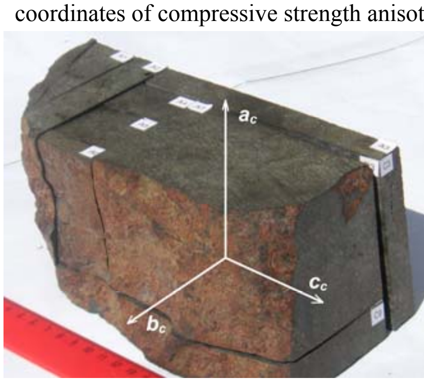

Fig. 2. Cutting plan of #15390,9 sample of Tsarev, where a_c, b_c and c_c are coordinates of anisotropy.

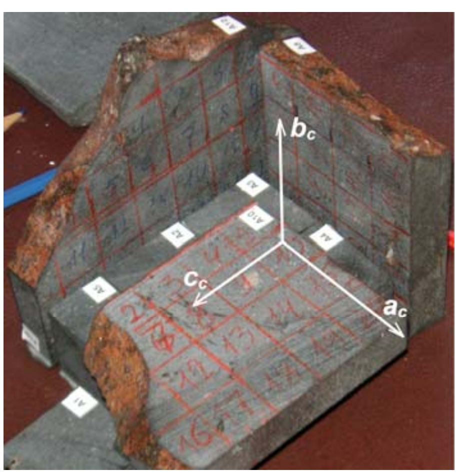

Fig. 3. Cutting plan of #15390,9 sample of Tsarev, where a_c, b_c and c_c are coordinates of anisotropy.

Table 1. Anisotropy of mechanical properties of SAUH 001

Name	a_c	b_c	c_c	Anisotropy, a_c/c_c
Compressive strength, Mpa	**143**	**94**	**91**	**1.6**
Number of measurements	6	7	10	
Variation coef., %	20	29	23	
Tensile strength, Mpa	**18**	**17**	**18**	
Number of measurements	13	13	14	
Variation coef., %	28	26	27	

Table 2. Anisotropy of mechanical properties of #15390,9

Name	a_c	b_c	c_c	Anisotropy, a_c/c_c
Compressive strength, Mpa	**262**	**168**	**160**	**1.6**
Number of measurements	25	27	13	
Variation coef., %	19	37	29	
Tensile strength, Mpa	**28**	**34**	**27**	
Number of measurements	23	20	33	
Variation coef., %	32	35	31	

Table 3. Anisotropy of mechanical properties of #15384,1

Name	a_c	b_c	c_c	Anisotropy, a_c/c_c
Compressive strength, Mpa	**223**	**182**	**174**	**1.3**
Number of measurements	22	17	20	
Variation coef., %	29	25	29	
Tensile strength, Mpa	**31**	**34**	**29**	
Number of measurements	12	24	25	
Variation coef., %	33	30	42	

Table 4. Compressive strength of plates of SAUH 001, Mpa

#	a_c	b_c	c_c
1	144	75	76
2	109	88	96
3	172	76	76
4	111	57	69
5	174	108	104
6	146	124	119
7		130	57
8			107
9			86
10			117

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