THERE’S NO CREEP IN SMALL SOLAR SYSTEM BODIES.

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Introduction: Gravitational loading in small bodies in the form of stress deviator caused by mass and a nonequilibrium figure of bodies, is constant and actually exists from the moment of their formation [1,2,3]. The phenomenon of gradual deformation of rock at constant pressure is known as creep. Outwardly the creep phenomenon is similar to yielding but if the last occurs only above yield strength, the creep is appeared at long term loading and at the pressure which are not exceeding yield strength. Theoretically equipotential surface of a gravitational field of a point mass is a sphere. So, according to the creep hypothesis a small body nonequilibrium figure should change to the spherical shape gradually. The more the small body mass of the same structure, the more stress deviator which responsible for deformation, than is closer to the spherical its figure should. So, the nature itself has made unique experiment where gravitation is presented as a volume compression press, and small Solar system bodies of various structure and various masses are presented as investigated samples.

Odinary chondrite: Average value of shape distribution of the 69th fragments of Tsarev meteorite is of b/a=0.76, c/a=0.59 [3,4], and the relation between axes - a:b:c=1.7:1.3:1. On composition the meteorite is ordinary chondrite of L5 type [5]. Shape parameters of the meteorite does not depend on mass and size of fragments and remains to a constant [3,4]. It is necessary to notice that shape parameters of fragments of each type of terrestrial rock under certain conditions of destruction (for example, explosive) are constant indicator [6].

Iron meteorites: Shape parameters of iron meteorites Sikhote-Alin meteoric rain have been measured for 824 individual fragments in mass from 5 to 500 g [3,4], which are of b/a=0.66, c/a=0.43, or a:b:c=3:1.5:1. Shape parameters of Chinge iron meteorite measured for 146 fragments in mass from 80 g to 20 kg are b/a=0.67, c/a=0.33, or a:b:c=2.4:2.0:1 [3,4]. Fragments of the basalt target, obtained from laboratory impact experiments, is characterised by the well defined shape distribution of 2:$\sqrt{2}$:1, or b/a=0.73, c/a=0.50 [7]. Basalt fragments fall between ordinary chondrites and iron meteorites (Fig. 1).

S-asteroids: Average axes relations of 54 S-asteroid is of b/a=0.80, c/a=0.69, a:b:c=1.45:1.16:1 [8, 9]. Shape of ordinary chondrites and S-asteroids enough close (Fig. 1). Shape parameters (c/a) does not depend on mass (Fig. 2). Density of S-asteroids with unknown mass was accepted of 2.92 г sm^{-3} which is average value for S-asteroids with known density [9].

C-asteroids: Size and shape of 60 C-asteroid including Mars’s satellites and Jupeter’s satellite Himalia is known [9]. Average axes relations is of b/a=0.85, c/a=0.80 and a:b:c=1.25:1.06:1. Shape parameters (c/a) does not depend on mass too (Fig. 3). The density of S-asteroids with unknown mass was taken equal to average value (1.79 г sm^{-3}) for asteroids with known density [9].

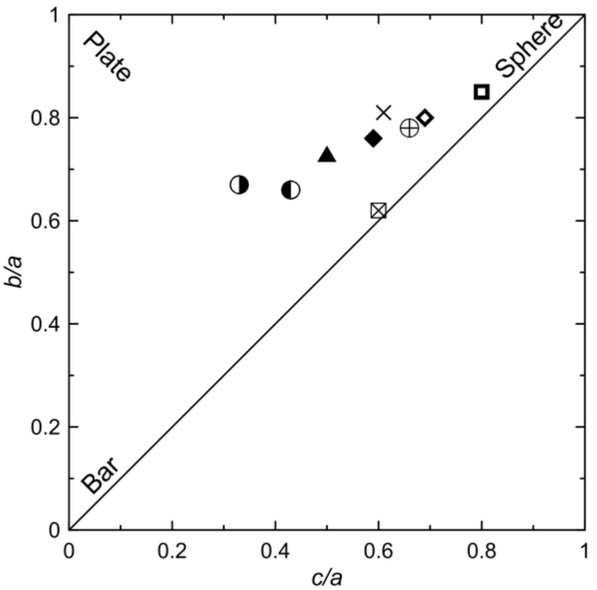

Fig. 1. Shape distribution of meteorites and small Solar system bodies of different composition: ◐ - iron meteorite (Sikhote-Alin); ◑ - iron meteorite (Chinge); ⊕ - metallic asteroids; ▲ - basalt fragments [7]; ◆ - ordinary chondrites (Tsarev); ◇ - S-asteroids; □ - C-asteroids; × - icy small bodies; ⊠ - Kuiper Belt objects (including cometary nuclei).

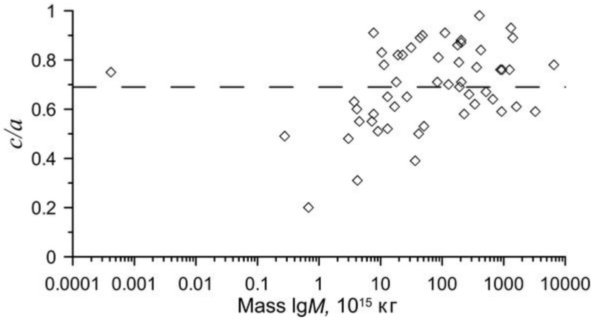

Fig. 2. Shape distribution of S-asteroids depending on mass. Dashed line is c/a=0.69.

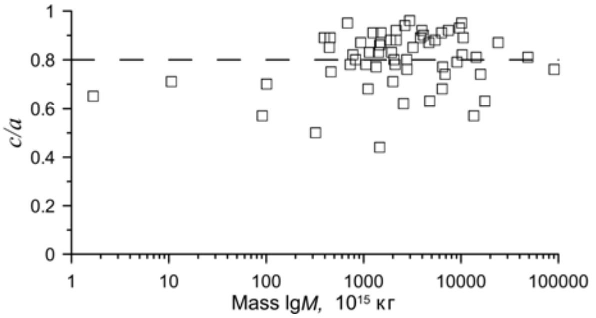

Fig. 3. Shape distribution of C-asteroids depending on mass. Dashed line is c/a=0.80.

Metallic asteroids: 10 asteroids of M-type have metal structure [3]. Only for 7 asteroids from 10 shape parameters are known [3,4]. Shape parameters of metal asteroids except for 216 Kleopatra are of $b/a=0.78$, $c/a=0.66$, and $a{:}b{:}c=1.51{:}1.18{:}1$, and uncluding Kleopatra - $b/a=0.73$, $c/a=0.62$, and $a{:}b{:}c=1.61{:}1.18{:}1$. Shape of metal asteroids too strongly differs from shape of fragments of iron meteorites (Fig. 1) Shape parameters (c/a) also does not depend on mass (Fig. 4). Density of metal asteroids with unknown mass was taken of 7 g sm^{-3} [3].

Small icy bodies: Shape parameters of the 14th small icy bodies are known (Table 1). Average relation of the main axes of icy bodies is of $b/a=0.81$, $c/a=0.61$, or $a{:}b{:}c=1.64{:}1.33{:}1$ [9]. Shape parameters (c/a) does not depend on mass (Fig. 5).

Kuiper Belt objects: Shape parameters of cometary nuclei [2] and two Kuiper ojects [10] are known (Table 2). Average shape parameters are of $b/a=0.62$, $c/a=0.60$, or $a{:}b{:}c=1.67{:}1.03{:}1$ (Fig. 1). Shape parameters (c/a) also does not depend on mass (Fig. 6).

Table 1. Shape of small icy bodies

№	Name	R_m, km	b/a	c/a	Dens., kg m^{-3}	Ref.
1	Amalthea	83.5	0.58	0.51	857	[11,12]
2	Pan	14.1	0.91	0.60	420	[13,14]
3	Daphnis	3.8	0.95	0.74	340	[13,14]
4	Atlas	15.1	0.87	0.46	460	[13,15]
5	Prometheus	43.1	0.59	0.44	480	[13,15]
6	Pandora	40.7	0.78	0.62	490	[13,15]
7	Epimetheus	58.1	0.88	0.82	640	[13,15]
8	Janus	89.5	0.91	0.75	630	[13,15]
9	Pallene	2.5	0.97	0.67	-	[13]
10	Telesto	12.4	0.72	0.61	-	[13]
11	Calypso	10.7	0.76	0.46	-	[13]
12	Polydeuces	1.3	0.80	0.67	-	[13]
13	Helene	17.6	0.88	0.60	-	[13]
14	Hyperion	135	0.74	0.57	544	[13,16]

Table 2. Shape of Kuiper Belt objects

Comet, KBO	R_m, km	b/a	c/a	Density, kg m^{-3}	Ref.
Borrelli	2.17	0.40	0.40	300	[17]
Churyumov–Gerasimenko	2.03	0.76	0.76	500	[18]
Wild 2	1.96	0.73	0.60	600	[19]
Tempel 1	2.84	0.64	0.64	600	[20]
Halley	5.04	0.50	0.50	280	[21]
1994 VK8	108	0.68	0.68	-	[10]
1998 SM165	213	0.60	0.60	-	[10]

Summary: All small Solar system bodies depending on composition have own shape parameters. The shape dependence on strength of rocky small bodies is observed (Fig. 1). The compressive strength of basalt is within 150-350 MPa [1], ordinary chondrites and accordingly S-asteroids - 105-203 MPa [22], carbonaceous chondrites and accordingly C-asteroids - 35-70 MPa [9]. There's no a/c dependence on mass of small bodies. So, the creep hypothesis in small Solar system bodies is invalid. Hence, all small Solar system bodies irrespective of their structure are elastic bodies which possess ultimate strength (tensile strength, compression strength) and yield strength. This statement is valid for small Solar system bodies of defferent composition - from icy to metal which extremely differ by physical-mechanical and rheological properties.

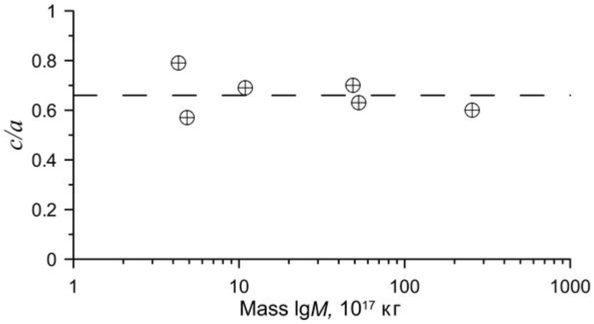

Fig. 4. Shape distribution of metallic asteroids depending on mass. Dashed line is $c/a=0.66$.

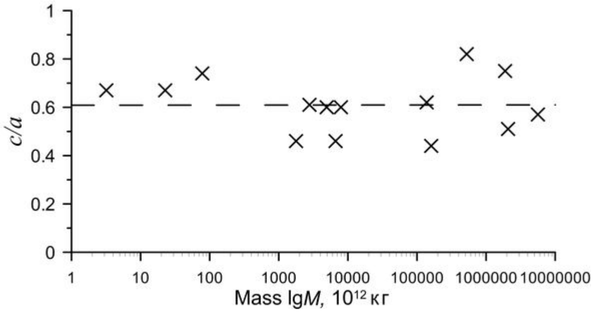

Fig. 5. Shape distribution of small icy bodies depending on mass. Dashed line is $c/a=0.61$.

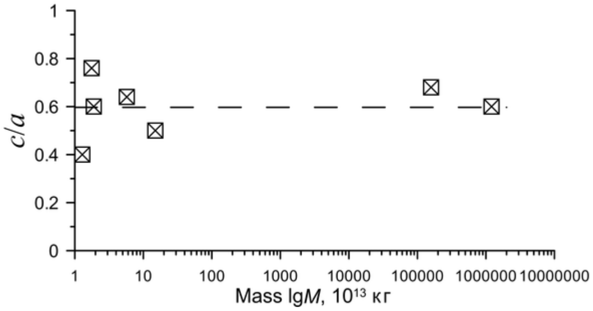

Fig. 6. Shape distribution of Kuiper Belt objects depending on mass. Dashed line is $c/a=0.60$

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