On the asymmetry of the surface terrestrial planets, caused by the falls of galactic comets

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We present the hypothesis according to which a similar asymmetry the surface of terrestrial planets, which consists in the predominance of the "continents" in the southern hemisphere and "seas" in the northern hemisphere is caused by the bombardment by galactic comets during the period of 5÷1 Ma. Fallings of galactic comets on the planets without an atmosphere create large craters, and on the planets with the gas shall were lead to significant uplifts of the surface that exposed to cometary bombardment.

Key words: galactic comets, craters, planets, newest uplifts of continents

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Introduction. A number of large celestial bodies in the solar system, in particular, Mars and the Moon have a similar asymmetry of the surface. Their sublime "continental" areas of surface are predominate in the southern hemisphere, whereas their "marine" areas are located in the north hemisphere. Our Earth also has the "oceanic" hemisphere and the "continental" hemisphere. This asymmetry explained by different reasons. For the Earth and the Moon this reason is the separation of the Moon from the Earth [*Darvin, 1910*], or a blow on the Earth of the cosmic body of planetary size [*Hartman, Davis, 1975*]. The appearance of asymmetry of Mars also explained by powerful impact event [*Wikipedia*].

Currently, the main relief-forming factor is considered to be fallings on a planet of large cosmic bodies. There are planetesimals that can to form the planets on early stage of their education, as well as asteroids and comets existing in the interplanetary space now. But interplanetary asteroids and ordinary comets – that is not all cosmic bodies that was falling to the planets in the Phanerozoic. The comets which born in the Galaxy were falling to all planets in the much larger number. These comets are generated into zones condensation of gas of the galactic arms and they are enter to the Solar system at the time of finding the Sun in jet streams and the spiral arms of the Galaxy.

The comets from closest to Sun jet stream Orion-Cygnus, falled on planets during period 5÷1 Ma are the best studied. Their speed relative to the Sun is 450 km/s, their mass $\sim 10^{12} \div 10^{17}$ g, and kinetic energy is $\sim 10^{20} \div 10^{25}$ J. The density of the comets nuclei is ~1 g/cm^3. On 80–90% galactic comets are composed of water ice, and 10–15% of the carbon component [*Barenbaum, 2010*].

Objectives of the article. Many facts [*Barenbaum, 2002, 2004, 2008; Barenbaum, Shpekin, 2011, etc.*] give the evidence to suggest that similar asymmetry surface of different planets, consisting in predominance "continents" in the southern hemisphere and "seas" in the northern hemisphere, was generated on the planets due to falls comets of jet stream Orion-Cygnus in the period 5-1 million years ago. It was then on the Earth took place a rapid uplifting continents [*Artyushkov, 2008*], and on Mars, Moon and Mercury, along with this process originated craters [*Barenbaum, 2002*].

The rationale of this hypothesis, proposed below, based on the following basic information about the galactic comets and their interactions with the terrestrial planets [*Barenbaum, 2010*]:

- The number galactic comets were falled on the planet throughout the Phanerozoic in the hundreds or thousands times greater than the interplanetary asteroids and comets of the same dimensions. On planets without an atmosphere, these comets are generate craters ≥10 km in diameter, which are very different in many respects from the craters which produced asteroids and comets.
- In contrast to the interplanetary asteroids and comets falling on the planets randomly, the galactic comets are falling in form "cometary rain". Duration of one cometary rain is ~2÷5 million years, and they cycled repeated through 19-37 million years. Depending on the situation in the Galaxy, the number comets in the showers varies from one to two orders of magnitude. During one

bombardment on the Earth may fall $10^4 \div 10^6$ comets. The latest cometary rain took place 5÷1 Ma and has been a relatively "weak." According to our estimates for this time on the surface of planets with area 100×100 km^2 could fall 3–5 galactic comets.

• Such density fallings of galactic comets, however, is sufficient to completely saturate the surface by craters with diameter 10÷200 km. Limit saturated by these craters the surfaces of the Moon, Mercury and Mars theoretically is about ~100 craters in the area of 1 million km^2. Calculations show that in saturation state funnels of craters occupy 50% all surface.

• An important factor causing the anisotropy of planets surface, is the obliquity of the plane ecliptic at an angle of 62° to the plane of the Galaxy in which the comets moved. The available evidence suggests that the last time the galactic comets mainly fell on the southern hemisphere planets, the axis rotation of which is perpendicular to the ecliptic or deviates from this direction weakly. Among them the Earth, Mars, and Mercury, as well as the Moon.

• The presence gaseous envelope at planet radically changes the physics of the interaction galactic comets with the planets. In the atmosphere of the Earth galactic comets are completely destroyed, forming hypersonic jet consisting of evaporated cometary material and shock heated air. Reaching the surface, this jet does not create a crater and uses the most part its energy to heat ~100-200 km layer of rocks under the place of comet impact. In the future this thermal energy is released in different tectonomagmatic processes. In the oceans and seas this are, above all, the outpouring of lava to the bottom and the formation seamounts, and on the continents are the uplifting surface and the formation intrusions [*Barenbaum, 2008, 2011*].

• In the atmosphere of Mars, to 100 times less dense than at the Earth, the nuclei of galactic comets partially evaporate, which leads simultaneously to two effects: to lifting continental surface and to appearance of craters on it. At this, however, craters on Mars turn out systematically smaller in diameter than for example on the Moon and Mercury, which have not the gas shells.

We illustrate this conclusions using relevant evidence.

Factual data and its discussion. In Fig. 1a shows a relief map of Mars, and in Fig. 1b shows the area occupied by funnels craters on both sides of the border in Fig. 1a.

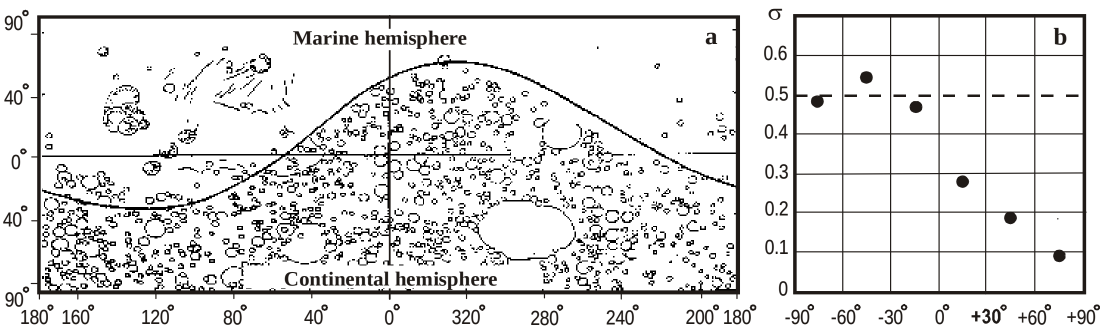

Fig. 1. a) The asymmetric structure of the surface of Mars [*Shaded relief map of Mars, 1972*]. Line shows the boundary between the "maritime" and the "continental" hemispheres of Mars, separating the regions with different density of large craters [*Kazimirov, 1977*]; b) Calculation of the share surface of Mars under craters with a diameter ≥ 10 km in the bands of latitude 30° on both sides of the border [*Barenbaum, 2002*], dashed line – the theoretical limit saturation of the surface by craters with diameter ≥ 10 km

In Fig. 1a schematically shown surface of the Mars, which is segregated the tectonic boundary into two hemispheres: the southeastern of tectonically passive – "continental" and the northwestern tectonically active – "maritime". Continental hemisphere is known to be elevated above the maritime by 2–6 km, and completely covered with large craters, whereas surface of the maritime hemisphere is presented of smooth plain with few amount of craters. The boundary between the hemispheres also is unusual. She is obtained as the trace of the cross section of a spherical surface of Mars by the plane inclined to his rotation axis at an angle of 35° [*Kazimirov, 1977*].

In Fig. 1b shown calculated according to data [*Kazimirov et al, 1980*] portion of the surface Mars covered by craters on both sides of his tectonic boundary. From the calculations follows that the continental hemisphere of Mars is maximal saturated by craters. Moreover if in this hemisphere cometary craters are dominated, on the equator of the Mars amount craters created by comets and asteroids becomes equal, and at the North pole Mars the cometary craters practically disappear.

Topographic features of the Mars we associate with falling galactic comets to its southeastern hemisphere perpendicular to the plane of the tectonic boundary. The difference in height between the hemispheres, according to our estimates [*Barenbaum, 2004*], can be explained by heating to the status of partial melting the layer rocks of lithosphere under continents by the thickness 100–250 km. The presence in the equatorial region of maritime hemisphere of four volcanoes in height from 15 to 25 km also indicates the existence martian asthenosphere.

Distributions of craters on the Mars, the Moon, the Mercury, as well as on the Earth are shown in Fig. 2. We see (Fig. 2a) that the craters on the continents are not only considerably exceeding amount craters on the seas, but they also differ in the distribution of diameters. If the craters on the seas obey to the back quadratic dependence, the craters on the continents are distributed exponentially (Fig. 2b), by analogy with the galactic comets. In comparison with the Moon and the Mercury, the martian continents depleted by large cometary craters. On Earth cometary craters are absent altogether. All Earth's craters formed by asteroids, and their deviation from the distribution by the back quadratic dependence is caused by observational selection.

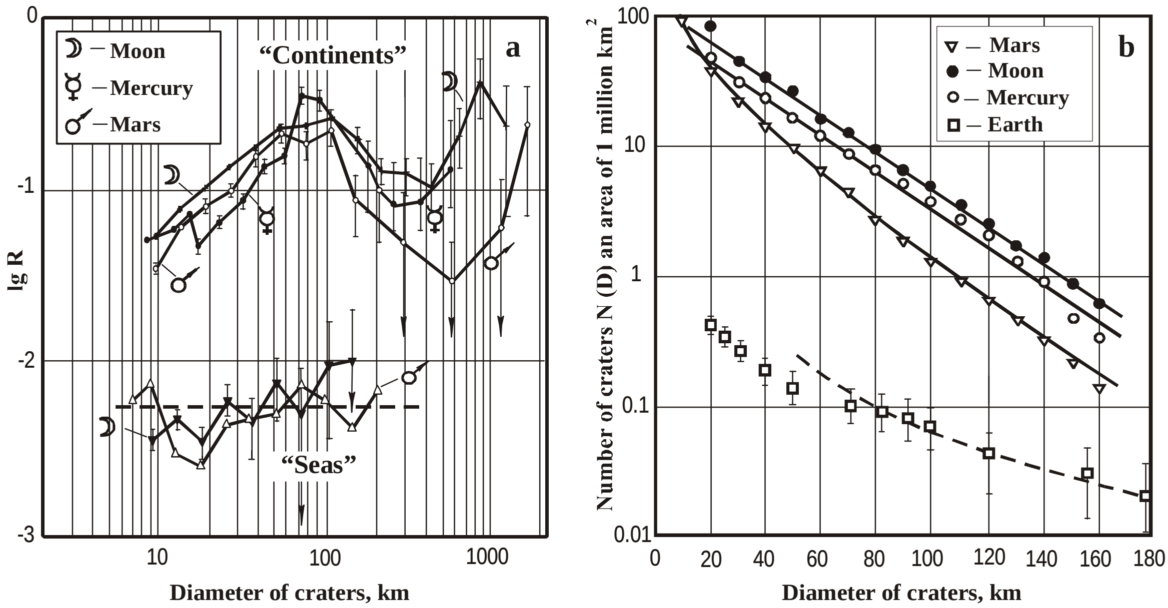

Fig. 2. The distributions of the density craters by diameter: a) the differential dependence N(ΔD) with step ΔD = D÷√2D in a special log-scale [*Voronow et al, 1986*] and b) the integral dependence N(> D) in a semi-logarithmic scale [*Barenbaum, 2002*], constructed according to data [*Kazimirov et al, 1980*]. The dashed line on both pictures corresponds to the back quadratic dependence by D

In the process of orbital Sun motion in the Galaxy, the galactic comets bombard the different areas of the planet, in result zone of maximal fall comets moves along the spherical surface of planets. In Fig. 3 the density of falling galactic comets to the Earth, calculated for the last 700 Ma [Barenbaum, 2002], we compare with the borders cycles Bertrand by data [*Khain, 2000*], with the periods existence of the supercontinents Pangea and Pannotia by data [*Bozhko, 2003*] and with the latitude distribution of glacial covers by data [*Chumakov, 2001*].

By comparing the calculation results with actual data it should be borne in mind that the flux of galactic comets bombarding the Earth greatly variety. The number falling comets significantly depend on the position of the Sun in an orbit, and sharply increase in the zones gas-condensation in the galactic arms. The comets most intense were falling in the late Cambrian and Ordovician and the Triassic. In order to simplify the analysis results of the calculation, this circumstance in Fig. 3a is not reflected. In the calculations we also ignored the precession and nutation of the Earth's axis and assumed that the ecliptic plane has a precession with period 2.7 billion years in the direction coinciding with motion of the Sun in the Galaxy.

According to Fig. 3a the galactic comets are alternately bombard the northern and the southern hemispheres of the Earth. Moreover, due to changes the orbital velocity of the Sun, the comets fall on the southern hemisphere longer time than on the northern. Thereby the surface in southern hemisphere ascends more active. By this circumstance we explain [*Barenbaum et al, 2004*] the processes of agglomeration supercontinents in the southern hemisphere as well as the latitudes of the spread ice sheets (Fig. 3c) which arisen on the places of cometary fallings.

It should be noted the surface of Earth's southern hemisphere rises today. According to the GPS data the average radius of southern hemisphere is growing annually by about 1.37 mm, whereas radius of the northern hemisphere shows no growth [*Barkin, 2007*].

The calculations of the density fallings comets in the period of the last bombardment in full can be applied to the Mars, the rotation axis of which is tilted like the Earth.

Phenomenon of newest uplifts. This name has been given to the phenomenon simultaneous surface uplift of almost all the continents of the Earth, which took place during the period from 5 to 1 million years ago. Height of the raises was greatly varied. On the Pacific coast, height of the raises had reached the first few hundred meters, on the Siberian platform – 200–1000 m, in South Africa – from 300-400 m in the west and up 900–1200 m of the east. The fastest growth occurred in the mountainous terrain. For example, the Arabian platform increased its height by 2 km, the Alps – by 3 km, and the Himalayas – by 6 km. Under most of the mountains there was a significant rise of the asthenosphere that in some places led to an outpouring of magma to the surface.

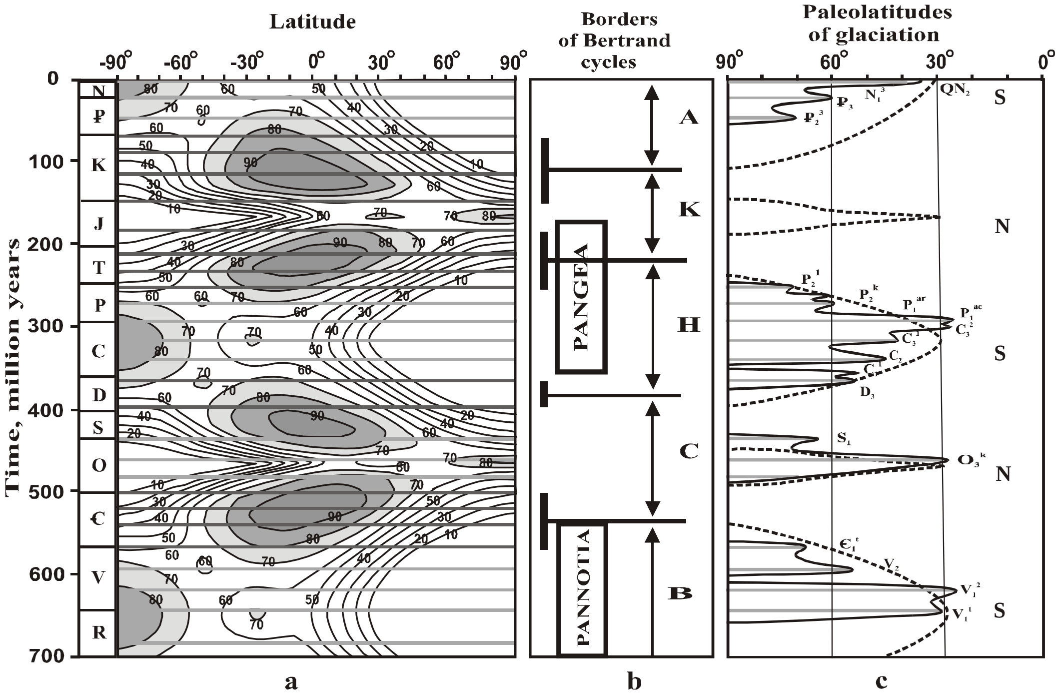

Fig. 3. Comparison of the density fallings galactic comets to Earth (a) with the borders of cycles Bertrand [*Khain, 2000*] and with periods of existence supercontinents Pangea and Pannotia [*Bozhko, 2003*] (b), and as well as with the paleolatitudes propagation ice covers [*Chumakov, 2001*] (c). Narrow horizontal bars show the times of cometary bombardment, taken 5 million years. Shown darker color the cometary bombardment, corresponding to the borders cycles Bertrand: C – Baikal, C – Caledonian, H – Hercynian, K – Cimmerian and A – Alpine. The calculations outside the horizontal bars have no meaning. The figures have lines of isodences indicate percentage of maximum intensity, accepted equal 100%. At Fig. c the dotted line indicates the angle between the direction of the Galactic center and the Earth's axis, which defines the region paleolatitudes fallings comets. N and S – the "northern" and "southern" glaciations.

The Phenomenon of newest uplifts is explained [*Artyushkov, 2008*] by replacement a layer of the continental lithosphere thickness of ~100 km on layer of hot asthenosphere. As a result the viscosity in the replaceable layer is reduces by 4 orders of magnitude, and the temperature is an increase by hundreds of degrees Celsius. Our estimates show [*Barenbaum, 2008*] that for the explanation of the newest uplifts is needed energy $\geq 10^{27}$ J.

We [*Barenbaum, 2012*] evaluated the thermal effect that is created by falling on the Earth galactic comets of various energies. The calculations were performed for a cube of rocks with sides 100 km under the assumption that the comet's energy expended on heating of rocks, is distributed in the volume of a cube evenly. We calculated heating temperature and the corresponding to this temperature the elongation edges of a cube. It is shown that by heating of the column rocks by length 100 km for every 100°, it elevates Earth's surface by 300 m. But if for small comets these effects are small the comet with the energy of $\sim 10^{25}$ J heats the substance more than 1000° that leads to a complete melting of the rocks in the volume 10^6 km^3.

Comets such energies, however, is very small. At the time of last bombardment their probability falling to area 100×100 km^2 is order of $\sim 10^{-3}$. For comets medium-energy $\sim 10^{22}$–10^{24} J likelihood of falls on the same area are much higher. Such comets heat the rocks at hundreds of degrees, and they are able to provide lift of Earth's surface for miles.

These estimates are well consistent with the observed height of newest uplifts as well as with the degree of heating of underlying rocks. Clearly, that fallings of galactic comets can to produce highly non-uniform heating the rocks of the lithosphere beneath the continents in the lateral plane, and as in depth. Undoubtedly and the fact that additional heating of rocks at the lower boundary of the lithosphere in a state close to the liquids, inevitably leads to the melting and to chemical transformation of minerals in the processes of eclogitization.

Thus we can assert the fallings of galactic comets leads to origin at the base of the lithosphere the thick layer of rocks, which may be nonuniformly heated and partially molten. This layer we can justifiably be named as the asthenosphere. The existence of the asthenosphere it is characteristic phenomenon not only for the Earth but as well as for all terrestrial planets. The appearance of this layer under the Earth's continents leads to a significant raise of their surface, and under the oceans bottom leads to the intense outpouring of lava, especially in the zones of mid-ocean ridges.

Summary and conclusions

1. The modern predominance of sublime "continental" regions of the surface planets in the southern hemisphere and of low "marine" regions in the northern hemisphere, it is mainly consequence the bombardment of the planets by the galactic comets in period 5÷1 Ma.

2. Fall galactic comets are a general cause of the raise considerable parts of the planet surface and appearance of large impact craters on the same surface. The surface rises on planets with dense atmosphere, whereas the craters arise on the planets without the atmosphere. On the Mars, which possesses a rarefied gas environment this two processes occur simultaneously.

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