THE FALL OF SLOW – SPEED ASTEROIDS ON THE LUNAR SURFACE. Shevchenko[1] V.V., Pugacheva[1] S.G., Feoktistova[1] E.A., E.A., Zharkova[1] A.Yu. [1]Sternberg Astronomical Institute, Moscow State University, 119991 Moscow, University Avenue 13, Russian Federation, sve-pugacheva@yandex.ru

Introduction: A huge amount of asteroids have been discovered in recent years by ground-based telescopes and by WISE - the infrared orbital observatory. For the purposes of improvement of special meteorites and asteroids observations in near-Earth space, as well as in order to study the impact traces of even the smallest objects on the lunar surface, the European Space Agency launched the NELIOTA project. Under the project, a 1.2-meter telescope with superfast high-resolution cameras was installed in the Kryoneri Observatory in Greece.

Meteorites and asteroids strike the lunar surface and surface of other planets and form some circular morphological structures which can be subdivided into impact craters with a diameter of less than 100 m and explosion craters of more than 100 m in diameter. Due to impact of small cosmic bodies the impact craters are getting crushed when they collide with the surface of planets causing partial ejection of targets. Explosion craters are formed out of cosmic bodies that entry into the target rocks so that 70% explosive energy is transferred to heat, and the impactor body evaporates completely. Collisions of asteroids with the Moon cause powerful flares observed by astronomers on its surface already for several hundred years.

Water of ice asteroids and comets:

Simulating Comet Impacts on the Moon by the SOVA algorithm shows that the ice comets lose 95 to 99.9% of the total cometary water during the impact process. Short-period comets have speed 8-10 km per second, with the impact of such low-speed comets, 1% of water remains after evaporation. The low-speed comets account only for 1.5% of lunar craters. Unlike ice comets, the water in the asteroids is in a chemically bound state. The water is blocked in the crystal lattice of minerals and will separate out of the composition only when heated up to 300-1200 degrees (depending on type of minerals).

At impact speed of 14 kilometers per second and impact angle of about 45 degrees, about half the mass of the asteroid does not even reach the melting point and remains in the solid state. A third of all asteroids impacting on the Moon before collision has speed less than 14 kilometers per second. In this case, most of substance of the impacted body remains in the crater - from 30% - 40% at oblique impact, and up to 60-70% - at the vertical one. Scientists founded out that asteroids containing water when impacted could create "reserves" of chemically bound water inside some lunar craters. Based on Scientists' estimates between 2% and 4.5% of lunar craters can contain substantial water reserves in form of hydrated minerals which are sufficiently stable to hold water even in sunlit places [1,7].

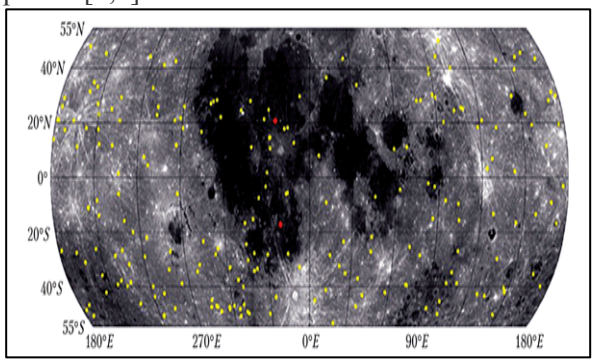

Fig1. Distribution of 222 new craters on the lunar surface, the appearance of which was detected from the images obtained Lunar Reconnaissance Orbiter (photo NASA [6]). The red dots denote observations from the Earth.

New craters with a diameter of 3 - 43 m were detected on large-scale images obtained by a long-focus camera of an artificial moon satellite LRO (Lunar Reconnaissance Orbiter). It is assumed that many craters with a diameter of less than 10 m are formed by "slow" asteroids, the fall rate of which does not exceed 12 km / s. The material of the impactors is largely preserved on the lunar surface in fragmented form inside the crater and in surrounding emissions [5].

The presence of an asteroid substance in the ground of the Moon was proved by the results of studying samples of breccias delivered to the Earth by the Apollo-16 spacecraft and ground samples of the Luna-20 apparatus. Studies of the composition of matter inside craters formed by

"slow" asteroids were obtained from the results of the space missions Chandrayaan-1 (India) and Selena (Kaguya, Japan). As a result of the research, bottom deposits of atypical for the Moon minerals enriched with magnesium spinel and olivine were found.

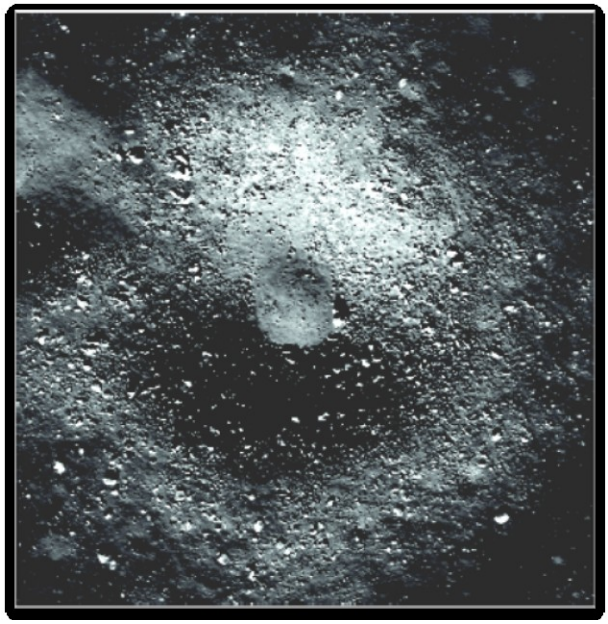

Fig.2. The crater with a diameter of 500 m appeared as a result falling of a small meteorite at a slow speed. The picture was taken from orbit by the camera NAC LRO in the Mare Frigoris [3].

CONCLUSIONS:

Based on the data of 222 craters, it was found out that craters formed by slow moving asteroids with average speed of 10 km per second form craters with a diameter of about 10 m [2, 4, 5]. The composition of the M-type slow moving asteroid as follows: nickel, iron, platinum-group metals. C-type slow moving asteroids compose of carbon and organics, water. S-type slow moving asteroids contain silicates.

Shevchenko in his article investigates slow moving asteroids enriched by S-type and M-type metal fraction close approaching to the Earth and the Moon [5]. As results of simulating the S-type asteroid impact showed that an impact crater with a diameter of 10.1 m and a depth of 2 m on the lunar surface was formed by an impacted stone asteroid 0.8 m in size, whose speed was 10 km / sec. With an asteroid mass of 803.8 kg, the asteroid substance proportion that remained after the impact is 22% of the whole impacted mass. The metal content of asteroids includes: iron - 270.89 kg, nickel - 48.23 kg, cobalt - 2.41 kg, platinum - 0.012 kg. In case of M-type asteroid impact with total mass of 660 kg at the same crater parameters the asteroid substance will have a fully metal content: iron - 556.1 kg, nickel - 99.1, cobalt - 4.9 kg, platinum - 0.025 kg.

The mining profitability of both categories above shall be determined by the technical complexity and cost of their extraction and transportation to the place of use compared to their terrestrial analogues. Delivering hundreds tons of fuel beyond the Earth is a difficult and extremely costly task. Nevertheless, already now there are two relatively large private companies that look forward to explore and produce minerals on asteroids in the future.

References:

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