DETERMINATION OF THE MAIN SOURCE OF WATER IN LUNAR COLD TRAPS.

Berezhnoi A.A., Sternberg State Astronomical Institute, Moscow University, 119899, Moscow, Russia
e-mail: ber@sai.msu.su

The American spasecraft Lunar Prospector discovered a great amount of water ice in the lunar polar regions [1]. What is the origin of this ice?

There are some sources of water on the Moon: comet impacts [2], mini-comet impacts, micrometeorite bombardment, solar wind. Now we will show that the determination of the D/H ratio in lunar water can state the origin of this water. Let us examine in greater detail the collision of a comet with the Moon. Under such an impact the following occur in succession: essentially complete vaporization of the commentary matter; vaporization, melting, and fragmentation of the regalith by the shock wave from the explosion; ejection of the mixed multiphase commentary matter and lunar soil; and, the formation of an impact crater.

We assume that a small part of the cometary matter remains in the lunar gravitational field. As the hot cloud expands, quenching occurs: The chemical composition of the impact vapor stops changing, and corresponds to the equilibrium composition at the moment of quenching. The chemical composition of impact vapor forming the temporary lunar atmosphere depends from the elemental composition of hot cloud, the quenching temperature and pressure. We shall assume that the elemental composition of a comet is identical to that of Halley's comet [3]. In this case the water produced during the collision between a comet and Moon if quenching temperature is less than 2000 K (it is possible if condensed dust particles plays a role of a catalyst of a chemical reactions) and dust/ice mass ratio in commentary nuclei is less than 10. Such conditions persist for majority collisions between comets and Moon.

An important feature of water of cometary origin is the anomalous high content of deuterium. The ratio D/H in comets is of the order of $3*10^{-4}$ (in the coma of cornet Hale-Bopp [4]). Thermodynamic calculations show that as the impact cloud expands, enrichment of the water by deuterium by approximately a factor of 1.5-3 occurs as a result of isotopic exchange (enrichment coefficient depends from H_2O/ H_2 mass ratio in temporary lunar atmosphere and quenching temperature of isotopic exchange reactions).

During collisions between mini-comets and the Moon the quenching temperature of chemical reactions is higher than for case of comet impact. Due to this fact the ratio between produced water mass and mini-comet mass is less than for case of comet impact. The D/H ratio in mini-comets is unknown. But thermodynamic calculations show that enrichment coefficient of the water by deuterium for case of mini-comet impacts is similar to this coefficient for case of comet impacts.

We assume that the capture coefficients of HDO and H_2O are same. Than the isotopic composition of hydrogen formed by the interaction of the solar wind with lunar soil is identical to that of the solar wind (D/H~ $2*10^{-5}$[5]. And D/H in water of meteoritic origin corresponds to the isotopic composition of hydrogen in meteorites (D/H~ (2-5)$*10^{-4}$ [6].

The D/H ratio in water in lunar cold traps may increase 2-3 times in comparison to this value in the temporary lunar atmosphere because the sublimation rate for HDO is less then for H_2O.

So the falling of comets onto the Moon leads to the formation of ice with definite isotopic composition in cold traps: The ratio D/H is much higher than for other sources of water. The comet hypothesis of the origin of lunar ice can be checked during the next lunar missions, and if confirmed, then definite progress will have been made in understanding the composition and, accordingly, the nature of comets.

References:

1. Feldman W.C. et al., Science, V. 281, No. 5382, p. 1496-1500, 1998
2. Shevchenko V.V., Solar System Research, V. 32, No. 4, p. 310-314, 1998
3. Delsemme A.H., Royal Soc. Philos. Transact., Ser. A, V. 325, No. 1587, p. 509-523, 1988
4. Meier R. *el al.*. Science 279, 1707 (1998)
5. Geiss J., Reeves H., Astron. Astroph., V. 93, No. 1, p. 189-199, 1981
6. Kerridge J.F., Proc. NIPR Symp. Antarctic. Meteorites, V. 6, p. 293-303, 1993.