National Aeronautics and Space Administration
Goddard Space Flight Center
Contract No.NAS-5-12487

ST-ACH-LS-10778

ADSORPTION WAY OF THE LOSS OF MOON'S ATMOSPHERE

By

A.M. Gutkin
M.S. Markov
Ts.M. Raitbrud
&
M.V. Slonimskaya

(USSR)

25 NOVEMBER 1968

ST-ACH-LS-10778

ADSORPTION WAY OF THE LOSS OF MOON'S ATMOSPHERE

Doklady Akademii Nauk SSSR
Tom 182, No.6, pp 1294-1295
Izd-vo "NAUKA", Moscow 1968

By
A.M. Gutkin, M.S. Markov
Ts.M. Raitbrud & M.V. Slonimskaya

The Earth's hydrosphere and atmosphere are considered at present as a result of its geological development and their formation is linked with the fusion and degassing of mantle matter [1]. In recent years Ye.K. Markhinin [4] succeeded to evaluate the amount of water vapors and other gases ejected into the atmosphere. These data have shown that during the Earth's geological history, the ejection of volatile constituents by volcanoes (admitting the intensity of volcanic action as being close to contemporary) is quite sufficient for the formation of hydrosphere and atmosphere. One may think that analogous processes of volatile ejections are also inherent to the Moon. This is attested by direct observations of the Moon [2,3].

Recently American investigators [11] systematized all the "non-stationary" points of the visible part of the Moon, which are evidence of endogenic activity on the lunar surface. At the same time, the data on lunar geology, accumulated to date, confirm conclusively the duration of its superficial structures' formation and consequently the period of its geological history [6, 9, 12]. The various age structures being monotypic, we are led to assume also the duration of volcanic activity on the Moon. Furthermore, one may assume the presence on the Moon of other processes, resulting in the generation of gases. In the first place, one should attribute to them the meteorite impacts against the surface of the Moon. The corresponding computations, indicating the role of these processes in local heating of its surface and in evaporation of its matter, were carried out by K.P. Stanyukevich and V.V. Fedynskiy [7]. The decay of radioactive elements entering into the composition of lunar crust could also play a certain role. However, the results of optical and radioastronomical observations indicate that the concentration of gases in the lunar atmosphere is at present vanishingly low (it is at least 10^{12} times lower than the air concentration at sea level of Earth's surface). In order to explain the absence of atmosphere on the Moon, recourse is generally made to the escape mechanism of thermal gas from the lunar surface. Because of small mass of the Moon, the critical velocity is comparatively low (v_k = 2.38 km/sec). The mean velocity of thermal motion of gas molecules with small molecular weight at temperatures that occur on the lunar surface in daytime (300-400°K), has the magnitude of the same order as the critical one, and the dissipation time on the Moon of such gases as H_2, He, is very short. However, for such typical gas of the Earth's atmosphere as N_2, the thermal dissipation time is of the order of 10^7 years, provided it is estimated according to Jean's formula. Using the more precise Shklovskiy's formula, the obtained dissipation time is still greater [10]. For such gases as SO_2, the dissipation time is greater than the age of the Moon.

Thus, the thermal dissipation of gases cannot practically explain the total absence of atmosphere on the Moon. This is why other mechanisms are involved for the explanation of dissipation such as: the ionizing action of solar ultraviolet radiation, the energy transfer to molecules of lunar atmosphere by particles of solar corpuscular radiation (solar wind), formation at certain altitude above the Moon of an ionized layer, analogous to that of the Earth's exosphere, with a 1000-1500°C temperature. No mathematical analysis of the action of these mechanisms is available in literature. Qualitative estimates have an insufficiently well founded character. Thus, for example, the scattering cross-section for the process of energy transfer to molecules by protons with energy of 2 kev, is taken equal to 10^{-15} cm. For these energies, greatly exceeding the energy of ionization and disso iation, the molecule scattering cross-section is by many orders smaller.

It appears, that in order to explain the absence of atmosphere on the Moon, it is necessary to take into account the gas adsorption process by lunar surface. Because of its high porosity, the capability of adsorption by lunar surface should be substantial [5, 8]. The settling of cosmic dust, the fresh lava sheets, the new surfaces forming after settling on the lunar surface of particles arising from meteorite impacts, all this should restore the adsorption capability of the lunar surface. However, the most important aspect of gas absorption process by porous matter of lunar surface, is the thermal diffusion of the adsorbed molecules into the depth of the porous layer under the action of temperature gradient. During the day, the temperature decreases in depth from 300-400°K at the very surface and to 200-250°K at the depth of 0.5-2 m [8]. Inasmuch as the surface diffusion coefficient of the adsorbed atoms is sharply dependent on the temperature, this should induce a diffusion stream inside the porous layer. One may neglect the reverse stream which, generally speaking, will take place during the nighttime, while the temperature gradient is directed outward, as the low temperature at the surface layer will lead to a nearly complete cessation of diffusion processes. If the adsorption heat of gas molecules exceeds the activation energy of diffusion of the gas along the adsorbent's surface, the probability of molecule dsorption is smaller than the pr bability of their migration into the porous layer. The adsorptive escape of such gases will prevail over the dissipation. The investigated phenomenon should result in that the numerous chemical substances should accumulate at a small depth inside the surface layer of lunar crust.

Geological Institute
Akademy of Sciences SSSR

Manuscript received
13 February, 1968

* * * THE END * * *

R E F E R E N C E S

1. A.P. VINOGRADOV, Izv. AN SSSR, ser. geol., No.4, (1967).
2. N.A. KOZYREV, Sborn. Novoe o Lune, Izd-vo AN SSSR, 1963.
3. Yu.N. LIPSKIY, M.M. POSPERGELIS, Byuro astr. soobsch., Astr. tsirkulyar, No.389, 1-2 (1966)
4. E.K. MARKHINI, Rol' vulkanizma v formirovanii zemnoy kory. "NAUKA", 1967. (The vulcanic role in the formation of Earth's crust)

....../

REFERENCES
(continued)

5. PERVYYE PANORAMY LUNNOY POVERKHNOSTI, "NAUKA", 1966. (First Panoramas of the Lunar Surface)
6. A.L. SUKHANOV, B.G. TRIFONOV, Geotektonika, No.4, (1967)
7. K.P. STANYUKOVICH, V.V. FEDYNSKIY, DAN, 57 No.2, (1947).
8. V.S. TROITSKIY, Izv. vyssh. uchebn. zaved., ser. Radiofizika, 9, No.10, (1967).
9. A.V. KHABAKOV, Sborn. LUNA, M., 1960.
10. I.S. SHKLOVSKIY, DAN, 76, NO.2 (1951).
11. B.M. MIDDELCHURST, P.A. MOOR, Sci., 155, No.3761 (1967).
12. J.E. SPURR, Geology Applied to Selenology, 1945.

CONTRACT No.NAS-5-12487
Volt Information Sciences, Inc.,
1145 - 19th Street, N.W.
Washington, D.C. 20036
Tel: 223-6700 (X-36,37)

Translated by
Ludmilla D. Fedine
22 November, 1968
Revised by
Dr. Andre L. Brichant
25 November, 1968