
Methane of indigenous origin has been detected in Lunar Soil, e.g. (1), and pyrolysis experiments on size fractions of lunar soil have indicated the association of this methane with solar wind implanted rare gases (2). Two problems associated with the synthesis of methane in the surface layers of soil grains are: (i) stability of methane to ionization in layers accessible to solar wind protons (2); and (ii) absence of comparable quantities of ammonia (3). Synthesis of methane and its stability in the harsh radiation environment of lunar soil has a relevance for the methane molecules observed in interstellar space. In the present model we suggest a specific site and a mechanism which explains the two features mentioned above.

When solids are bombarded with high fluence of low energy hydrogen and helium ions, the diffusing ions coalesce in the form of bubbles of gas. Such bubbles have been observed in the grains of lunar breccias (4), as well as in the grains of lunar soil (5). In this model we propose the bubbles as reaction cells in which the methane is synthesized.

Atoms captured in a bubble cannot leave it easily (6) and the bubbles serve as a trap for the diffusing atoms. Most of gas in the bubbles in soil grains would consist of hydrogen and helium. However, the bubbles would also trap atoms of other elements which diffuse through the lattice. A significant fraction of implanted carbon atoms diffuse and are redistributed in the crystals (7). This is illustrated by the pyrolysis runs of mineral targets implanted with low (0.3 kev/n) and high (1 kev/n) energy ions (8).

It has been suggested that due to the reactivity of atomic nitrogen and the stability of its bonds with lunar cations, the efficiency of retention of nitrogen in soil grains may approach hundred percent (9). The ratio of carbon to nitrogen is observed to be smaller in the lunar soil than in the solar wind (9). This indicates that the diffusion of nitrogen atoms and the probability of their capture in the bubbles is small compared to carbon atoms. Hence ammonia cannot be synthesized in bubbles by a similar mechanism in quantities comparable to methane.

The gas pressures in the bubbles are of the order of a few thousand atmospheres. Since they are situated within ~500 Å of the surface (10), they would also receive some UV irradiation. Methane would be synthesized in these bubbles by a process similar to the Bergius process of synthesis of hydrocarbons from coal. In this process coal is hydrogenated at 400-450°C in the presence of iron oxide at 200 atm. of hydrogen. In case of bubbles, the temperature is lower, but the gas pressures are higher. Though there is no catalyst present, the activation energy could be provided by the UV irradiation and the time scales involved are much larger. The synthesis of methane in bubbles would also account for its
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The stability against ionization. The methane molecules in bubbles cannot be effectively destroyed by ionization, since it would immediately recombine with the abundant hydrogen atoms present in the bubbles.

The concentration of methane produced by this mechanism, estimated using the bubble density observed in the breccia grains, is of about the same order as that observed in soils. The ion implantation experiments carried out so far, e.g. (7), are not conclusive enough to support the mechanism outlined above. Experiments with low fluxes of $^{13}$C and D ions on samples pre-irradiated with $^4$He ions to produce helium bubbles would serve as a test for the model suggested here.