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7. Calculations are based on the electromagnetic scattering theory of K. Schwartz and G. Schubert [*J. Geophys. Res.* **78**, 6496 (1973)]; see also G. Schubert, K. Schwartz, C. P. Sonett, D. S. Colburn, B. F. Smith, in *Proceedings of the Fourth Lunar Science Conference* (Pergamon, Elmsford, N.Y., 1973), vol. 3, pp. 2909–2923; G. Schubert, C. P. Sonett, K. Schwartz, H. J. Lee, *J. Geophys. Res.* **78**, 2094 (1973); B. F. Smith, D. S. Colburn, G. Schubert, K. Schwartz, C. P. Sonett, *ibid.*, p. 5437.
8. This assessment is based on the observed coherence properties of Apollo 15 data in the instrument sensor coordinate system. Only between about midnight and dawn of the first lunation has the strongly polarized character of the LSM signals in the local tangential plane not been apparent.
9. The existence of mascons, or positive gravity anomalies associated with the circular mare basins such as Imbrium and Serenitatis, was discovered by P. M. Muller and W. L. Sjogren [*Science* **161**, 680 (1968)]. Recent work has shown that the best models for these mass concentrations are near-surface disks [see, for example, W. L. Sjogren, P. Gottlieb, P. M. Muller, W. Wollenhaupt, *ibid.* **175**, 165 (1972)].
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Mercury: Does Its Atmosphere Contain Water?

Abstract. *The atmosphere of Mercury, like that of the moon, is maintained in an extremely tenuous minimum state by weak solar wind accretion and radioactive decay processes, and depleted by strong removal mechanisms. Unlike the moon, it has a high daytime surface temperature that promotes the production of water vapor, which may be the dominant atmospheric constituent derived from solar wind protons.*

Mercury's atmosphere is probably in a minimum state (10^{-10} mbar) which is maintained by solar wind accumulation and radioactive decay within the planet (*1*). It is destroyed by the loss mechanisms of gravitational escape, ion-sweeping by the solar wind electric field, and escape of suprathermal photodissociation fragments. These processes provide a quantitative understanding of the lunar atmosphere, as measured by instruments carried to the moon in the Apollo missions (*2*). Thus, a reasonable model for Mercury may be constructed, provided the scaling laws for the sources and losses are known. The details of such a model are being presented elsewhere (*3*). I suggest here an important difference that may exist between the moon and Mercury, namely that the primary proton-derived component of Mercury's atmosphere is H_2O, whereas for the moon it is probably H_2 (*4, 5*).

Since Mercury's dayside temperatures range between 100° and 325°C (*6*), chemical reactions of hydrogen with the oxygen in the soil can cause an outgassing of water vapor from the surface. This is a common occurrence in pyrolysis experiments on lunar samples (*7*). Although significant terrestrial water contamination is present, a major portion of the water is of solar wind origin (*8*). Apparently, energetic particle bombardment provides large numbers of dislocated oxygen atoms in the silicate lattice, which combine with hydrogen atoms to form OH and H_2O. This has been demonstrated experimentally by Cadenhead and Buergel (*9*), who show that molecular hydrogen is chemisorbed in outgassed lunar samples at 150°C and released as water vapor in the region 200° to 400°C.

Solar wind hydrogen is probably stored as H_2O in the outermost layers of lunar soil grains [to about 0.4 μm, according to Leich *et al.* (*10*)]. At lunar temperatures, the water is locked within the soil, and prolonged exposure to solar wind protons leads to H_2 production. It is probable that near the subsolar point, where the temperature reaches 100°C, some H_2O is given off (*5*). At Mercury's daytime temperatures, H_2O would be released as long as oxygen is available within the soil. The H_2O physisorbs on the cold night side (− 175°C). If the loss of suprathermal atomic hydrogen by photodissociation of H_2O exactly balanced the solar wind input, a balance of interchange of H_2O would occur between the atmosphere and the surface. (The OH and O photodissociation fragments are not energetic enough to escape, and ultimately recombine with hydrogen at the surface to reform H_2O.) However, loss of H_2O^+ ions from the atmosphere through solar wind sweeping would exhaust the oxygen within a few hundred years, were it not for various processes of erosion which tend to expose fresh surface. To maintain the oxygen supply to the atmosphere, an erosion rate R of at least 2 Å per year is needed. For $R > 650$ Å per year, the solar wind flux would not be sufficient to saturate the surface. In that case, the surface would act as a sink for solar wind and atmospheric hydrogen.

On the moon, erosive processes are of three types: solar wind sputtering, micrometeoroid impact, and gradual mixing of surface material by a number of poorly understood mechanisms. For a solar wind sputtering rate of 0.05 atom per incident atom (*11*), the solar wind removal rate is about 1 Å per year. This value is consistent with an estimate of 300 years for the time scale for removing the amorphous coating of the grains (*12*). Micrometeoroid removal rates of 10 Å per year are estimated by Neukem (*13*). Dust impact measurements from spacecraft indicate micrometeoroid fluxes of 2×10^{-9} g cm^{-2} year^{-1} (with a large uncertainty), which are capable of eroding 10 to 20 Å per year (*14*). Stirring of the soil inferred from cosmic-ray track ages imply effective values of $R > 40$ Å per year (*15*). Thus, sufficient stirring and scouring have occurred at the moon's distance, and it is reasonable to expect similar if not higher rates at the orbit of Mercury.

In summary, three regimes for Mercury's atmosphere can occur: (i) $R < 2$ Å per year. The surface is fully reduced and the atmospheric hydrogen is in the form of H_2 with a mean surface density of 3.7×10^5 cm^{-3}. (ii) 2 Å per year $< R <$ 650 Å per year. The soil is unreduced, and saturated with H_2O in the outermost layers of the grains. The hydrogen desorbs in the form of H_2O with a mean surface density of 1.6×10^6 cm^{-3}. (iii) $R > 650$ Å per year. The soil is unreduced and unsaturated with H_2O. The atmosphere will not be derived from the solar wind, but will consist of products of meteoroid volatilization.

If model ii prevailed on Mercury for a significant period in its history, ice could have accumulated in the polar regions in permanently shaded areas, as suggested for the moon by Watson *et al.* (*16*). Furthermore, if stirring of the soil layers were dominant, the equivalent of about a meter in depth of unreduced metals would be distributed within the regolith. This "smelting" process due to the combined action of solar heating and solar wind reduction would occur for any large bodies in the inner solar system. It has been suggested that the moon may have originally formed in this region (*17*) and later been captured by the earth. If so, the presence of pure metals at large depths in the lunar regolith would strengthen arguments for the moon's origin as a twin of Mercury.

Ultraviolet measurements from the Mariner 10 flyby of Mercury in March 1974 should provide definitive evidence of the present existence of H_2O in its atmosphere. The Lyman-alpha (1216 Å) channel will measure the scattered light from atomic hydrogen produced by photodissociation from both H_2 and H_2O. Knowledge of the scale height and intensity of the dayglow emission will lead to the identification of a photodissociation component and its parent molecule. If planetary outgassing is unimportant and the atmosphere is indeed a minimum atmosphere, these results will determine which of the three regimes is the best description and thus provide useful bounds on the present surface erosion rate.

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Stimulation of 24,25-Dihydroxyvitamin D_3 Production by 1,25-Dihydroxyvitamin D_3

Abstract. *Vitamin D–deficient rats produce [^{3}H]1,25-dihydroxyvitamin D_3 from [^{3}H]25-hydroxyvitamin D_3 regardless of dietary content of calcium or phosphate. A daily dose of 130 picomoles of 1,25-dihydroxyvitamin D_3 for a period of 5 days reduces production of [^{3}H]1,25-dihydroxyvitamin D_3 to essentially zero and stimulates production of [^{3}H]24,25-dihydroxyvitamin D_3. A daily dose of 325 picomoles of 25-hydroxyvitamin D_3 has a similar but less dramatic effect. On the other hand, 650 picomoles daily of 24,25-dihydroxyvitamin D_3 given to vitamin D–deficient rats had no effect. Thus it appears that 1,25-dihydroxyvitamin D_3 is an important factor in the regulation of kidney metabolism of 25-hydroxyvitamin D_3.*

There is strong evidence that 1,25-dihydroxyvitamin D_3 [1,25-$(OH)_2$-D_3] represents a metabolically active form of vitamin D in the stimulation of intestinal calcium transport and bone calcium mobilization (*1*). Its production in the kidney is strongly regulated in a complex manner by serum calcium (*2*), parathyroid hormone (*3*), and serum inorganic phosphorus concentrations (*4*). It has been suggested that hypocalcemia results in parathyroid secretion which in turn stimulates production of 1,25-$(OH)_2$-D_3. Hypophosphatemia, which results from low dietary phosphorus, also stimulates 1,25-$(OH)_2$-D_3 production (*4*). Generally, when 1,25-$(OH)_2$-D_3 production is diminished, 24,25-dihydroxyvitamin D_3 [24,25-$(OH)_2$-D_3] production is increased (*2*). However, in vitamin D–deficient rats or chicks only 1,25-$(OH)_2$-D_3 is produced regardless of dietary content and serum concentrations of calcium and phosphorus (*2*, *3*). The present report emphasizes that vitamin D–deficient rats produce [^{3}H]-1,25-$(OH)_2$-D_3 from [^{3}H]25-OH-D_3 regardless of dietary contents of calcium and phosphorus and further demonstrates that 1,25-$(OH)_2$-D_3 inhibits [^{3}H]1,25-$(OH)_2$-D_3 production in vitamin D–deficient rats and stimulates the production of [^{3}H]24,25-$(OH)_2$-D_3.

Weanling male rats (Holtzman) were fed a vitamin D–deficient diet that contained either 0.02 percent calcium and 0.3 percent phosphorus (low calcium–adequate phosphorus), 1.2 percent calcium and 0.1 percent phosphorus (high calcium–low phosphorus), or 1.2 percent calcium and 0.3 percent phosphorus (high calcium–adequate phosphorus) (*5*). The diet and water were given without restriction for 2 weeks. At the end of 2 weeks the rats were given, intraperitoneally, either 325 pmole of 25-hydroxyvitamin D_3 (25-OH-D_3) (*6*), 650 pmole of 24,25-$(OH)_2$-D_3, or 130 pmole of 1,25-$(OH)_2$-D_3 dissolved in 0.1 ml of ethanol every day for 5 days. The control group received the ethanol vehicle in the same manner.

After the 5 days of treatment, 325 pmole of 25-[26,27-^{3}H]OH-D_3 dissolved in 0.05 ml of ethanol was given intrajugularly to all rats. Twelve hours later the rats were killed and their blood was collected to yield serum. A portion of the serum was used for the determination of inorganic phosphorus by the colorimetric assay (*7*) and an-