N89-10783

THE PALEO-OCEAN OF MARS; John E. Brandenburg

Mars Research

The hypothesis that Mars once had an ocean filling the low northern plains to the 0 kilometer elevation contour is based on four observations:

1. The upper limits on Mars' original inventory of water are large enough to permit oceans (a 200 meter layer covering the planet's surface (1)).
2. The presence of myriad water channels of varying age suggests that liquid water exist and flow on the surface during some period or periods in Mars' past (2).
3. The dichotomy separating the low northern plains from older, higher terrain appears to coincide approximately with the 0 kilometer elevation contour around their entire boundary.
4. The present distribution of water vapor on Mars appears strongly asymmetric, with an apparent strong source concentration in the north but little in the south (3).

The resemblance of the northern plains to an old ocean bed was noted by Mutch et. al. (4) and the possibility of a Paleo-ocean was discussed by Chandler (5) and in a paper given at the Case for Mars II conference (6).

I. Extent and Evolution:

If such an ocean had existed it would have represented approximately ¼ of the planets surface filled to a depth of 1.5 km. Following this pattern two smaller seas would have filled Argyre and Hellas Planitia in the south with another small sea in the south polar depression. The amount of water required would have covered the entire surface of Mars to a depth of 400 meters. This figure is only twice the upper limit on water inventory inferred by McElroy (1).

Dating of the Viking landing sites, both on the floor of the Paleo ocean, suggests the ocean existed until 1 to 1.5 Gy ago. Such an ocean would have formed early in the history of Mars when its atmosphere was dense and warm, accompanying a period of intense outgassing. The loss of atmosphere and its accompanying greenhouse effect would have caused a rapid spread of ice across the oceans surface from the northern polar cap. The ocean would have formed an ice sheet covering a mud layer that slowly sublimated from its surface. The water vapor would then be lost to space via ultra violet photolysis. Assuming that the early period of liquid ocean lasted long enough, a weather cycle would have operated in the northern hemisphere of Mars, transporting water by precipitation to the surrounding highlands and forming a water table of depth corresponding to the present 0 kilometer line. This "charged aquifer" could

have provided the source for catastrophic floods later in martian history as the ocean - ice sheet receded and allowed a large hydrostatic pressure head to develop between the aquifers surrounding the ocean basin and the emptying basin itself. The concentration of water in the lowest elevation of Mars during a period when water could run downhill would be preserved as the atmospheric pressure and temperature dropped. The water concentrations would be largely immobilized with transport confined to sublimation and loss to space.

II. Comparison With Other Data

The general absence of cliffs or beaches indicating an old shoreline was noted by Masursky et. al. (2), however, both a sharp cliff line, punctuated by chaotic terrain, and a delta-like deposit occur where Shalbatana Vallis enters the Chryse basin at the 0 kilometer line. A similar delta like feature occurs at the 0 kilometer line in Hrad Vallis in Utopia. The appearance of polygonal ground, ubiquitous on the northern plains and attributed to thick permafrost (7), is roughly coincident with the 0 kilometer contour in the Cydonia Mensaeregion. Such a layer would seem consistent with a muddy, frozen sea bed. The existence of "pedestal craters" on the northern plains has also been attributed to meteor impacts into ice saturated soil.

The Viking landing sites were both on the floor of the hypothesized Paleo-ocean. Does the 'ground truth' available at these sites support this hypothesis? The soil at the landing sites appeared similar to smectite ocean clays (8) found on earth and was covered by a duricrust containing concentrations of water soluble sulphates, carbonates and salt. However, the soil also matched well with plagonites formed by basaltic lava - ice interactions and the duricrust is found in terrestrial deserts.

The chief problem with the hypothesized Paleo-ocean is its long life. If an ocean and later ice sheet covered the northern plains until 1.5 billion years ago the presently observed rate of water loss is insufficient to account for its disappearance by at least two orders of magnitude. Percolation of the water into the regolith, another loss mechanism, would seem inconsistent with a stable ocean bed.

THE PALEO-OCEAN OF MARS;
Brandenburg, J.E.

References:

(1) McElroy, M.B., T.Y. Kong, and Y.L. Yung - J. Geophys. Res., 82, 4378, 1977.

(2) Harold Masursky, J.B. Boyce, A.L. Dial, G.G. Schaber and M.E. Strobell - J. Geophys. Res., 82, 4625, 1977

(3) C.B. Farmer et. al., Science, 194, 1339, 1976.

(4) Mutch, Thomas; Arvidsen, Raymond; Head, James III; Jones, Kenneth; and Saunders, R. Stephen. "The Geology of Mars", Princeton N.J., Princeton University Press, 1976.

(5) David L. Chandler, "Life on Mars", E.P. Dutton, New York, New York, P. 74.

(6) William Beatty et. al., "The Preliminary Findings of the Independent Mars Investigation Team, New Thoughts on Unusual Surface Features", Case For Mars II.Conference, Boulder, Colorado, July 1984.

(7) Micheal H. Carr and Gerald G. Schaber - J. Geophys. Res., 82, 4039, 1977.

(8) Priestley Toulmin III et. al. - J. Geophys. Res., 82, 4625, 1977.