TABLEMOUNTAINS OF MARS. Carroll Ann Hodges and H.J. Moore, U.S. Geological Survey, Menlo Park, CA 94025

Among the many enigmatic land forms on Mars are narrow ridges, circular to rectangular mesas, buttes, and "two-storied" structures with conical or irregular knobs atop broad, flat, steep-sided pedestals. Such features are particularly concentrated and well developed at lat 40° to 50°N and long 0° to 30°W in a part of the northern plains. Previous explanations for similar features have emphasized erosional stripping that produced remnant outliers of a pre-existing stratigraphic layer (1) or geomorphic surface. Morphologic comparisons with Icelandic landforms, however, suggest the alternative that some of these ridges, plateaus, and buttes may be analogous to the tablemountains and other structures of Iceland that formed during interaction of lava and glacial ice or water (2).

In Iceland, volcanic venting through an icecap formed a basal palagonite (hydrated sideromelane) breccia mass, accompanied by local melting of the ice and eventual subaerial extrusion of a basalt cap (3). Subsequent regression of the ice resulted in the inverted topography now observed: a basaltic plateau or shield volcano overlying a "socle of pillow lavas and palagonite tuffs and breccias" (3). Landforms include steep-sided, serrated ridges and isolated circular to rectangular plateaus, some of which are surmounted by conical volcanic peaks. Many of the plateaus exhibit craters without accompanying tephra cones. The steeply sloping sides of the mesas and ridges apparently are due to the confinement by ice at the time of eruption. Ridges similar to the tablemountains, but lacking the plateau basalt cap, formed by eruption and flow of lava beneath valley glaciers, and other massive palagonite tuffs and breccias resulted from interaction of lava and water (4). Dimensions of the Icelandic ridges and tablemoutains vary widely, but generally they are less than 10 km long and a few km wide at the base; some are circular to square in plan. Heights commonly are a few hundred meters, but one of the most prominent plateaus has a relief of over 1000 m.

The features examined thus far on Mars have horizontal dimensions of a few hundred meters to as much as 10 km and range approximately from less than 100 meters to over 500 m high, so that in scale they appear to be comparable to the Icelandic structures. Some of the plateaus have irregular crater-like depressions; many are surmounted by ridges and knobs. The terrain in which they occur is extensively fractured. In addition to numerous impact craters, associated features include well-developed cones with summit craters that strongly resemble terrestrial cinder cones, suggesting that volcanism was active in this area. Farther to the southwest (at about 20°N, 35°W), narrow curvilinear ridges connecting 3 small buttes can be traced for about 20 km in a region of mounds resembling low volcanic shields (5); the ridges and buttes most closely resemble terrestrial dikes and volcanic necks. The oft-cited evidence for ground ice or permafrost on Mars (6,7,8) and the certainty that volcanism was widespread suggest that a geologic environment similar to that of Iceland may have existed throughout much of the planet's history (particularly at northern latitudes) and therefore the geomorphology of Iceland may provide clues to the interpretation of martian landforms (9).

The existence of abundant water in both solid and liquid form during evolution of the planet's landscape seems incontrovertible (10,11,12,13,14).

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The northern polar cap has been identified principally as water ice, and though its thickness is not precisely known, it may be as much as a kilometer or two (10,11). Isotopic ratios provide evidence that a large amount of water (at least the equivalent of a layer 10 m deep over the entire planet) must ultimately have outgassed from the planet -- a total volume sufficient to have carved the enormous canyons and channel systems (13). Both Viking landers have measured water in the soil samples (15). Furthermore, Viking geochemical analyses suggest that iron-rich clays (smectites) are major constituents of the martian fines -- as they are of the massive palagonite breccias in Iceland; Toulmin, et al. (16) postulated that explosive interaction of iron-rich basaltic magma and subterranean ice could readily account for the large quantities of clay-rich material apparently present at the Martian surface. And Fanale has noted that the 0.3-2.5 μm spectrum of palagonite samples is the closest approximation of natural material to the disc-wide spectrum of Mars that he has yet observed (17).

The case for widespread palagonite on Mars is thus supported by the evidence for large amounts of H_2O and pervasive volcanism, the spectral similarity of terrestrial palagonite to the planet, and the Viking geochemical analyses of martian "soil" (15,16); landforms typical of palagonitic terranes, therefore, may be expected, and we propose that candidates exist in the northern latitudes. There appear to be at least two plausible situations in which interaction of basaltic magma with ice might have occurred. The current maximum seasonal extent of the north polar cap is approximately 40°N (18); its former thickness and extent are unknown, but could have been greater. As in Iceland, subglacial volcanism followed by ice cap retreat could have produced the observed tablemountains and buttes. Alternatively, similar landforms may have resulted from interaction of rising magma with ground ice or permafrost; subsurface palagonitic breccia masses could have developed, perhaps with synchronous plug-like doming and eruption of basalt above the ground surface. Subsequent erosion of much of the hydrothermally altered ground would then have isolated as buttes and mesas the more resistant features directly associated with vents.

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