AN EXAMINATION OF HYPOTHESES OF FORMATION FOR THE ENIGMATIC MASSIVE DEPOSITS IN AMAZONIS PLANITIA, MARS.
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Massive deposits in the Amazonis Planitia region of Mars (12°S to 18°N, 125° to 220°W) cover both the heavily cratered highland terrain south of the equator and the moderate- to lightly-cratered plains north of the highlands. These unusual materials have stimulated many hypotheses for their formation. Here we review the principal hypotheses of formation for these enigmatic deposits and consider some of the implications associated with each proposal. Excellent Viking Survey mission images (2.5°S to 9°N, 137° to 150°W) provide a useful data set for evaluating the hypotheses of formation. Relative stratigraphic positions and detailed geomorphic information can be obtained from geologic mapping of the deposits at a scale of 1:500,000, which can be supported by the available image quality. The mapping information provides tests for most of the proposed hypotheses, as well as establishing a scientific framework for future collection of high resolution data of the deposits.

The deposits under consideration have been mapped regionally as the Medusa Fossae Formation (1), subdivided locally into from three (1) to seven (2) units. Topographic maps (3) indicate that the deposits are very thick, attaining total exposed thicknesses of up to 3 km in some locations. The surface of the deposits is relatively smooth over broad horizontal reaches, with gentle (low amplitude) undulations the only consistent topographic expression. The deposits are cut by several deep, linear valleys, e.g. Gordii Dorsum (0° to 10°N, 142° to 147°W; 3). All exposures of the material show considerable evidence of erosion by the wind, particularly along their margins (1,4). The average albedo of the deposits is higher than that of both the cratered southern highlands and the lowland plains of the Arcadia Formation to the north (1). The deposits preserve very few impact craters, supporting the relative young age implied by their stratigraphic position (1,2,5).

Several hypotheses have been proposed for the formation of the deposits. The similarity between terrestrial ignimbrites and the deposits in Amazonis Planitia has been noted by several researchers (1,2,6,7). Mapping to date has not identified any internal bedding in the deposits (1,7) although some broad undulations have been attributed to surface expressions of a layered medium (8,9), which leads to the possibility that the deposits could be massive accumulations of variably indurated aeolian materials (1,4,10). A variation on the aeolian debris hypothesis is the proposal that the Amazonis Planitia deposits, plus several other units distributed about Mars, were deposited as polar layered materials at an earlier epoch when Mars’ rotation axis was at a different position (9). The paleopolar origin for these materials implies considerable polar wandering occurred on Mars, with degradation of the deposits occurring through sublimation of trapped volatiles aided by aeolian processes. Another alternative, quite distinct from those mentioned above, is that the major linear valleys cutting through the deposits are exhumed transcurrent faults, implying substantial shear motions within the martian crust, an ancient age for the materials, and extensive chemical alteration of the faulted and uplifted rocks (5,8). This proposal may appear consistent with the recent interpretation that Mars
underwent traditional plate tectonic activity on the northern plains (11), but in detail the
exhumed transcurrent fault hypothesis is at great odds with several of the geomorphic
interpretations associated with the inferred plate motions.

Each of the preceding hypotheses for the formation of the Amazonis deposits
carries certain implications, some of which may be testable with existing data. The
ignimbrite hypothesis appears to have considerable acceptance in the literature,
although many compelling arguments require the eruption to be mafic rather than
silicic (12). Large silicic ignimbrites, particularly in environments where chemical
weathering is minimized and aeolian processes are active, can still give important
information on what features to look for on hypothesized martian ignimbrites. The
8500 km² Los Frailes complex in Bolivia (13) is an excellent candidate for identifying
primary ignimbrite features; identification of such characteristics is being investigated
at present. The lack of any source vent features in Amazonis Planitia remains a
significant obstacle to the ignimbrite hypothesis. The aeolian hypothesis involves
localized deposition of enormous quantities of sediment, at least some of which might
be expected to remain as outliers around the main deposits. The paleopolar
hypothesis implies that internal layering should be present, on a scale that should be
observable in Viking images (i.e., the polar layered terrain). Also, physical evidence of
volatile sublimation might be visible in highest resolution images. The
exhumed/alterated crust hypothesis should be associated with intense fracturing and
jointing of competent material (where hardened by the alteration), at least some of
which should be visible in high resolution images. Images of the deposits from the
Viking Survey mission have a resolution of ~30 m/pixel, showing abundant aeolian
erosion and interesting localized exhumation relationships (Figs. 1 & 2). Detailed
geologic mapping of the Survey mission images can provide new stratigraphic and
g geomorphic constraints to test each of the available hypotheses, as well as provide a
framework for the science rationale behind future collection of high resolution data.


Figure 1 (left). Buried (white arrows) and exhumed (dark arrows) lava flows, covered by the Amazonis Planitia deposit. Viking 463S23; 30 m/pixel; 3.5°N, 140.2°W.

Figure 2 (right). Impact craters buried beneath Amazonis Planitia deposits, being exhumed by aeolian erosion. Viking 462S15; 32 m/pixel; 2.2°N, 140.4°W.