RE-ASSESSMENT OF HYDROVOLCANISM-BASED RESURFACING WITHIN THE GALAXIAS FOSSAE REGION OF MARS. J. A. Skinner, Jr.[1], L. A. Skinner[2], and J. S. Kargel[3], [1]U. S. Geological Survey, Astrogeology Research Program, 2255 N. Gemini Dr., Flagstaff, AZ 86001 (jskinner@usgs.gov), [2]Dept. of Geology, Northern Arizona University, Flagstaff, AZ 86011 (lisa.skinner@nau.edu), [3]Dept. Hydrology and Water Resources, University of Arizona (kargel@hwr.arizon.edu).

Introduction: Galaxias Fossae is a volcanic fissure system whose low-elevation and mid-latitude position near the northern margin of the Elysium rise places it in a region where volcanic processes and condensed and/or buried volatiles may have interacted in the geologic past [1-2]. Whereas fissure-related channeled deposits are well-displayed in the region and have been historically studied as remnants of volcano-ice interactions [e.g., 3-4], we observe less conspicuous surface textures, material gradations, and subtle tectonic structures within the Galaxias Fossae region that may signify more youthful, localized volcano-ice relationships. Based on analysis of the landforms of Galaxias Fossae and surrounding regions using Mars Orbiter Camera narrow-angle (MOC NA) and Thermal Emission Imaging System (THEMIS) visible (VIS) and infrared range (IR) images, we speculate that Galaxias Fossae evolved through the combined effects of local magmatic heating and episodic accumulation/exhumation of ice-rich lowland mantles throughout the Amazonian.

Geologic setting: Galaxias Fossae form a 600-km-long, 250-km-wide, WNW-trending fissure system that includes a 1-5 km-wide, 80-150 m deep main fossa (long, narrow depression or trough) paralleled by a network of smaller, segmented (100's of meters wide) troughs and other lineaments. Minor NNE-trending troughs and alcoves off the main fossa form a trellis-like pattern that is centered at 142.65°N, 37.25°E near the region's eastern margin. The western end of several of the larger Galaxias Fossae widen, wherein floor materials grade into channeled deposits that bury the eastern margin of Utopia Planitia. These deposits have been interpreted as lahar-like flows mobilized by fissure-related cryospheric heating and resultant collapse and flow of volcanic and lowland materials [5-6]. While the bulk of channeled deposits were emplaced over Vastitas Borealis (VB) materials during the Early Amazonian [7-8], Galaxias Fossae appear to contain more recently emplaced fissure-related deposits, the youngest of the NW Elysium rise [8]. A paucity of small-diameter (<500 m) impact craters alludes to local resurfacing during (perhaps throughout) the Amazonian [e.g., 9]. Materials and landforms of Galaxias Fossae grade NE, N, and NW into homogenously-textured VB materials of as-yet-unresolved provenance [7-8].

Geomorphology: We describe previously unrecognized landforms including lineaments, surface undulations, and depressions with diverse morphologies that we suggest are imprints of unique, relatively youthful geologic processes and environments.

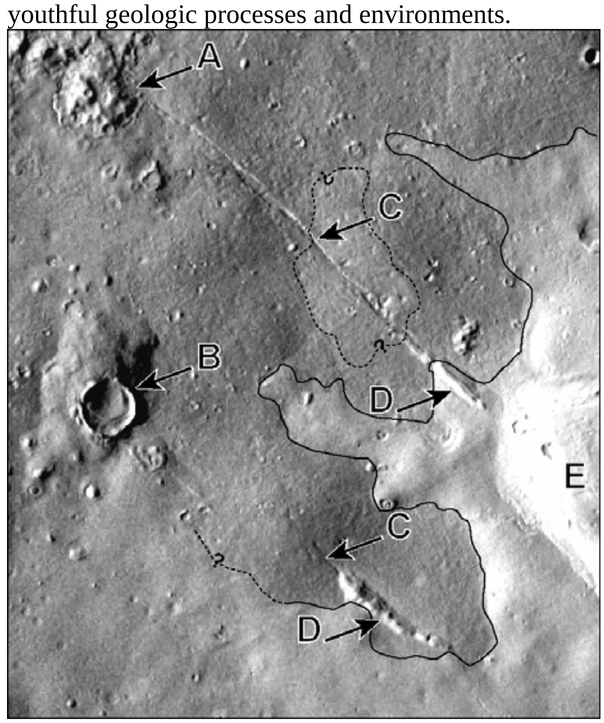

Figure 1. Galaxias Fossae surface showing what we interpret to be extruded mounds of mud-like debris (A), impact crater-like explosive mud vents and debris aprons (B), and adjacent extensional lineaments (C). Ridges (D) may be welded surficial mantle deposits or exhumed, dike-like extrusions. Lineaments often transect rounded mesas (E). Inferred mantle margin (light-toned material) is outlined by solid line (dashed and queried where indistinct) (THEMIS V13201002; 38 m/pixel; centered at ~142.0°E, 38.0°N, ~15 km wide; north at top of image).

Lineaments. Segmented, positive- and negative-relief lineaments are common throughout the region (Fig. 1) and generally trend WNW and parallel to the main Galaxias fossa. Lineaments form shallow troughs within a rugged, dark-toned unit and both troughs and stubby ridges within overlying smooth, light-toned, mantle materials (Fig. 1). Lineament morphologies vary along trend and are sometimes comprised of an arrangement of circular or elongate pits or by central concavities with raised, lobate margins that onlap adjacent terrain. Lineaments are less frequent south of the main fissure where, if they exist, they are buried by rugged, lobate materials sourced from Elysium Fossae.

Surface undulations. Surfaces adjacent to larger fossae and within the trellis-patterned region have been deformed into undulations that parallel trough segments. Distal to the fossae, the light-toned surfaces consist of smooth swales generally spaced ~100 m apart. These undulations grade laterally into sharp crests composed of small pits in closer proximity to the fossae, which then coalesce and widen to form iregular depressions adjacent to the fossae. These depressions appear to extend onlt down through surficial units.

Craters. Rimmed depressions and raised, irregularly-shaped, variously-sized craters and crater clusters are common throughout the area. Some depressions are characterized by rounded, light-toned pitted domes aligned with the regional fossae pattern and superposing plains and mesas. Other depressions are irregular in shape and size and are defined by lobate margins and surface undulations, especially near intersecting fissures. Many circular to subcircular craters, both individual and coalesced, are distinguishable from impact craters only on their alignment with regional fissures, clustering, breached rims, and/or partial envelopment by lobate aprons.

Interpretation: Regional, Tharsis- and Elysium-related stresses and superposed topography localized the formation of fissures and volcanically- and/or geothermally-driven resurfacing in the study area. We propose that Galaxias Fossae are a set of lowland fractures whose cross-cutting relationships with regional terrains indicate resurfacing activity as recently as the Middle to Late Amazonian. We interpret the narrow lineaments in a similar fashion to larger fossae: fissures and/or narrow graben formed as the result of accommodation of tensile stresses created by the Hesperian growth of the Elysium rise. We speculate that tectonic re-activation of Galaxias Fossae during the Middle to Late Amazonian resulted in the growth of the narrow graben. This activity appears to have been accompanied by relatively shallow magmatic intrusion and/or heating in the vicinity of the trellis-patterned fissures. We speculate that ruggedly-textured clusters of rimmed depressions are geothermally-mobilized materials that were extruded into or exploded through overlying mantles. Raised lineaments may be dike-like intrusions that were later exhumed from within the mantle. These features may be similar to composite maars observed in the Yukon Delta Wildlife Refuge, Alaska [10].

The episodic deposition of low-density, poorly-indurated, ice-rich mantles during the Amazonian likely resulted in rheological and density interfaces within the uppermost Martian regolith. Surface undulations, which occur only adjacent to larger fossae and within mantle materials, suggest Amazonian tectonic re-activations were accommodated through ductile, soft sediment-like deformation above buried rheological interfaces. We propose these undulations formed through either deformation of mantle deposits over faults buried below the regolith interface and/or compression of mantle deposits from subtle uplift and extension of underlying strata.

Our formational scenarios run askew of previous volcano-ice interpretations for Galaxias Fossae [e.g., 4-5] in two fundamental ways. The first fundamental difference is that we suggest the extruded material was largely non-magmatic. In our scenario, subsurface heating and release of volatiles result in buried density contrasts and upward intrusion or diapiric ascent of buoyant material [11]. We expect volatile-rich masses preferentially ascended along existing fractures. Upon reaching the Martian surface, sufficiently heated and volatile-enriched masses either extruded to form mud-like mounds or violently exploded to form impact-like vents with enveloping debris aprons. Ascent rate, mobilization depth, geothermal gradient, and physical/chemical properties of mobilized materials could each affect diapir explosivity, resulting in the observed diverse morphologies. The second fundamental difference between our scenario and past interpretations is that we propose that magmatism caused the mobilization, ascent, and intrusion of slurries *into* transient surficial mantles, partly fluidizing these potentially ice-rich deposits and resulting in the lateral migration of muddy debris away from the linear vent and through the overlying mantle. Mantle materials were likely incorporated in the slurries, causing the deposits to be virtually indistinguishable in surface albedo and texture from surrounding, undisturbed mantled terrains. Textural gradations of surfaces around Galaxias Fossae may have resulted from heterogeneous movement of flows along buried density interfaces.

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