MAPPING ARSIA MONS LAVA FLOW FIELDS: INSIGHTS INTO FLOW EMPLACEMENT PROCESSES AND FLOW FIELD DEVELOPMENT

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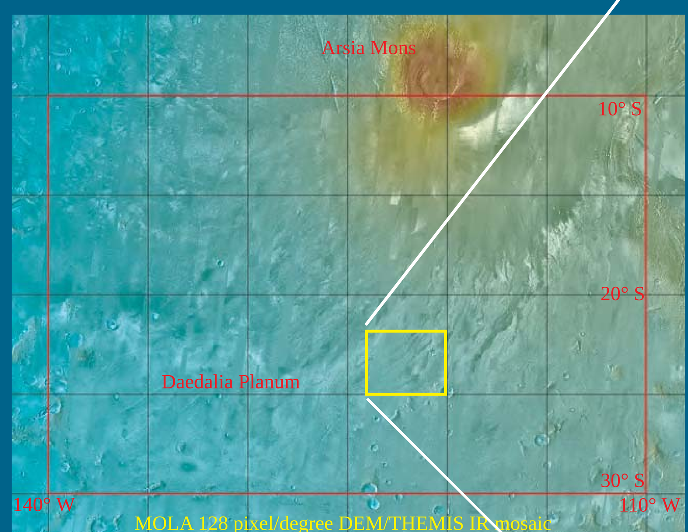
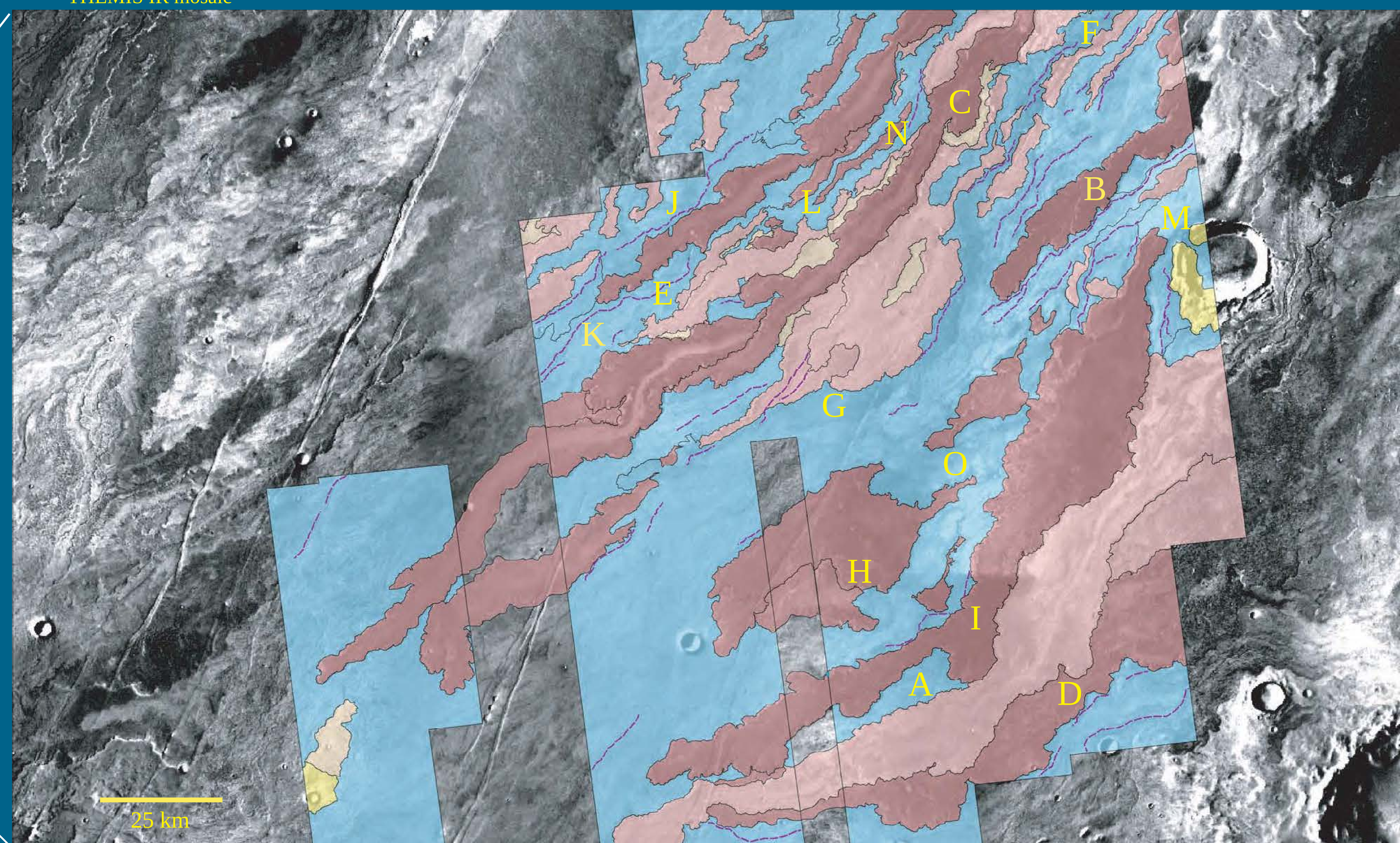
Introduction. Arsia Mons is 461 x 326 km across and 17.7 km high, with exposed relief of 11+ km and flank slopes averaging ~5° [1-2]. Our research [see also 3-4] focuses on the extensive lava flow fields south of Arsia Mons, corresponding to Tharsis Montes and Arsia Mons flow units defined in previous 1:2M scale Viking Orbiter mapping [5-7]. Recent studies of the Tharsis region have utilized Mars Express High Resolution Stereo Camera images to examine evolutionary stages in effusive volcanism [8]. Our current study presents new detailed mapping of part of the flow field in Daedalia Planum using Mars Reconnaissance Orbiter Context Camera (CTX) images to:

a) examine flow morphology and emplacement styles,
b) determine local sequences of flow emplacement, and
c) characterize flow field development.



THEMIS IR mosaic



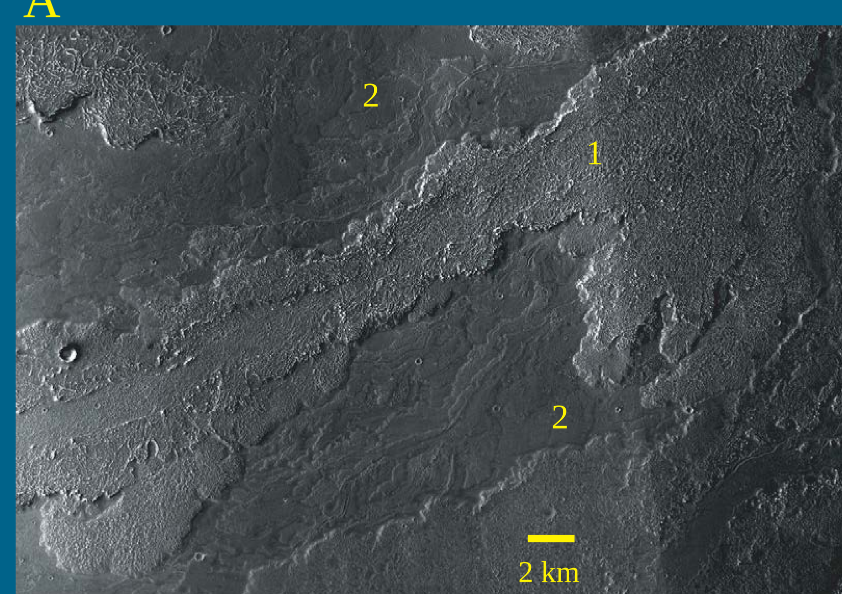
- Bright, rugged flows - Type1
- Bright, rugged flows - Type 2
- Dark, smooth, flows
- Undivided flows
- Crater Materials
- Channel/tube segment

Flow Field Characteristics and Lava Flow Types. Analysis of CTX images (~5 m/pixel) allows identification of two main flow types in the plains south of Arsia Mons (A):

1) large, relatively thick, bright flows with rugged upper surfaces that display medial channel and levee systems and broad, distal flow lobes, and

2) small, relatively thin, dark flow lobes with mostly featureless surfaces that are typically associated with narrow lava channels or lava tubes.

A



B

Flow Field Mapping. CTX images imported into ArcGIS comprise the primary base for mapping at 1:50K scale. The global THEMIS IR mosaic was used to map some gaps between CTX images. All figures shown here unless otherwise indicated are CTX images exported from the GIS mapping database.

Bright, Rugged Flows

B) Flow with rough, knobby upper surface, longitudinal ridges showing interior flow structure, and multiple small lateral breakout lobes (Type 1)

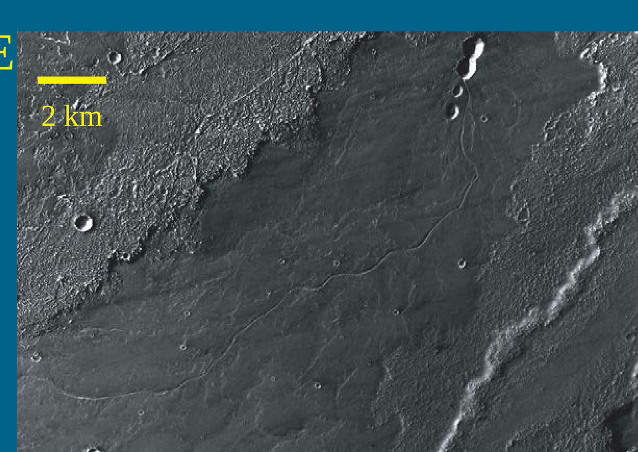
C) Rough flow surface with knobs and concentric ridges showing local flow direction; lateral lobes indicate complex levee structure (Type 1)

D) Sequence of overlapping flows with rough surfaces and well-defined margins. Surface is less rugged than other examples, with more subdued surface features and platy morphology (Type 2)

C

D

E



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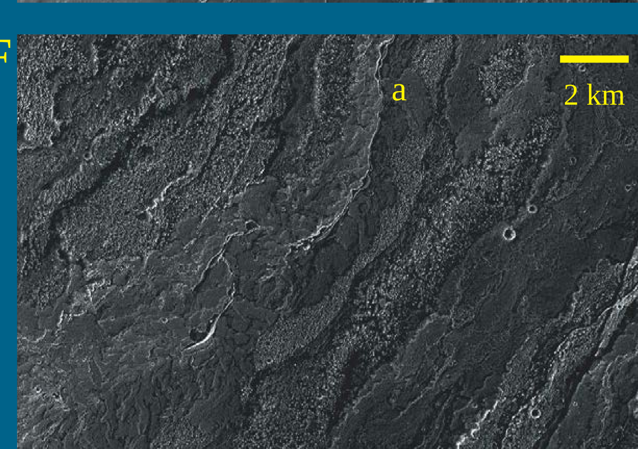

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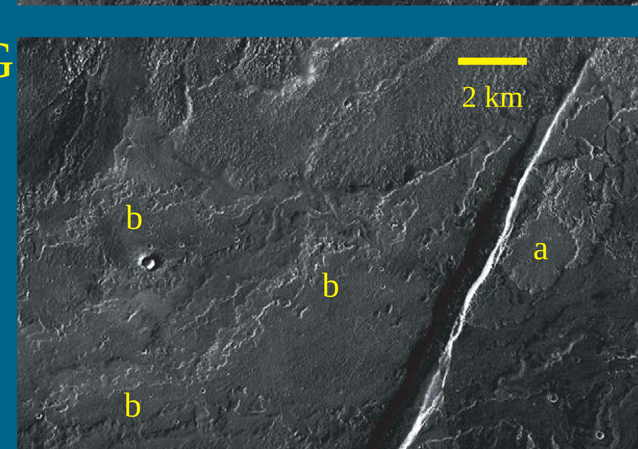


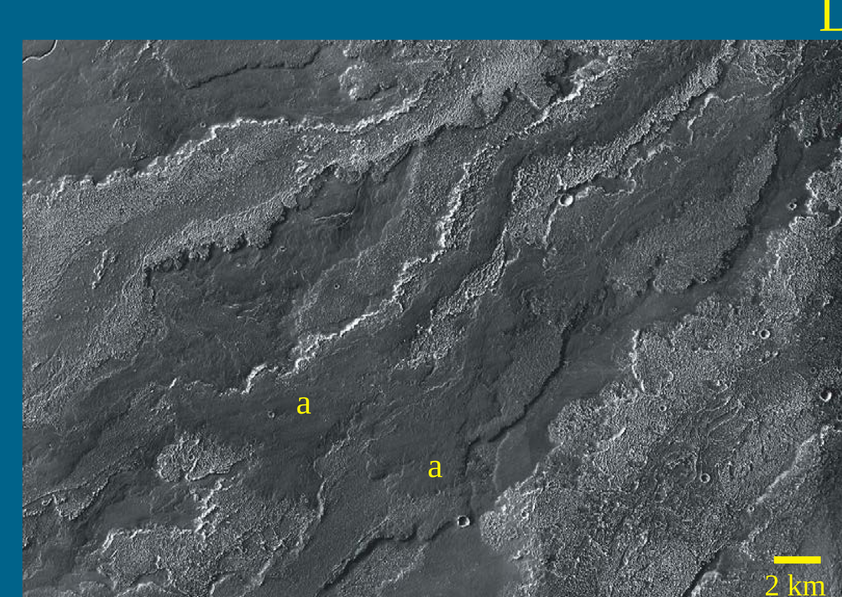
Dark, Smooth Flows

E) Small, sinuous channel extends from chain of elongate craters through dark flow field composed of broad poorly defined lobes

F) Dark flows inundating older rugged flows. Discontinuous channel/tube system at center (a) feeds small, discrete lobes that spread laterally

G) Sequence of dark flows at bottom show margins indicative of both primary (a) and erosional morphologies (b)

L



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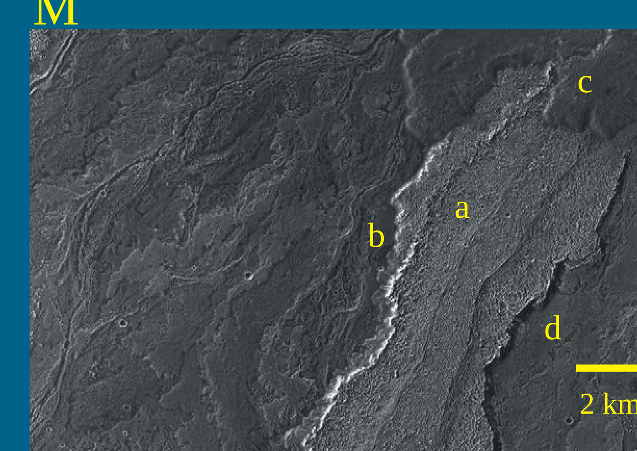
M



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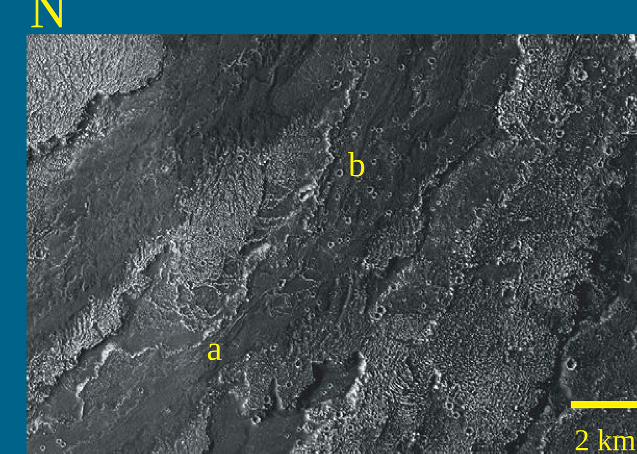

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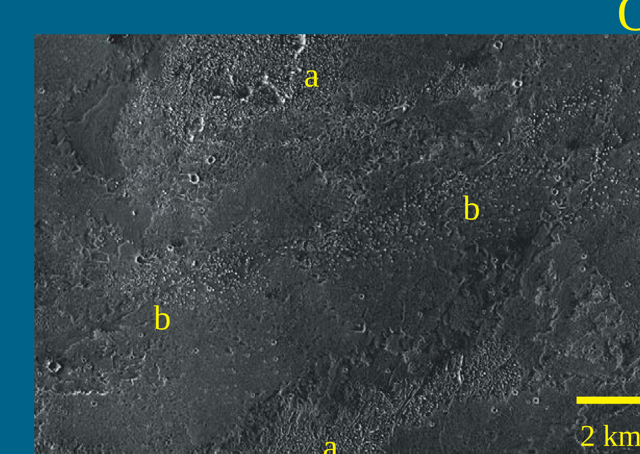


Flow Field Stratigraphy. CTX images reveal complex flow patterns and local interfingering and overlapping relationships.

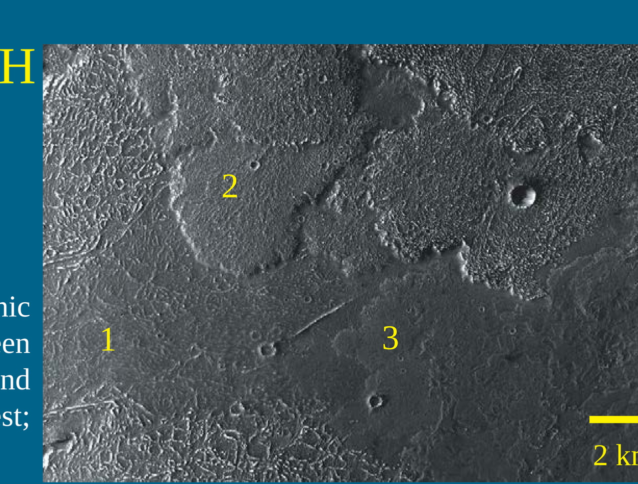
L) Younger dark flows (a) are captured by and cover the central channels of earlier rugged flows

M) Rugged flow with prominent levees (a) truncates narrow channel and extends over associated dark flows (b). Rugged lobe is embayed by other dark flows (c). Note differences in margin morphology of rugged lobe, suggesting partial burial of small lateral lobes along eastern margin (d).

N) Dark flows cover much of older rugged flow surface; prominent lateral levees of older flow (a) remain along with high-standing rims of small craters (b).

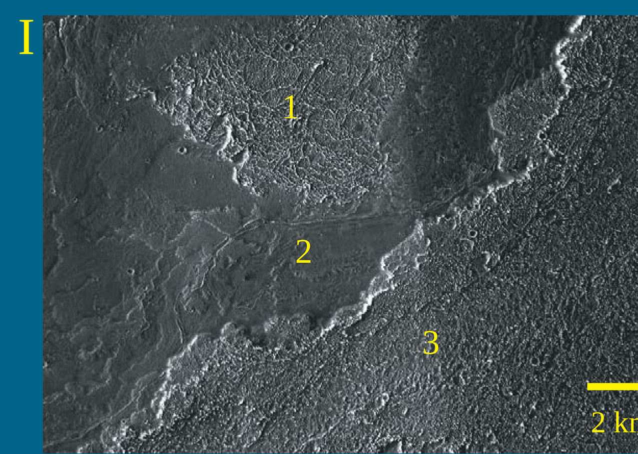
O) Dark flows bury rugged flow surfaces (a) but field of knobs from rugged flows preserved in some regions (b)

H



Note local stratigraphic relationships between and among bright and dark flows (1-oldest; 3-youngest)

I



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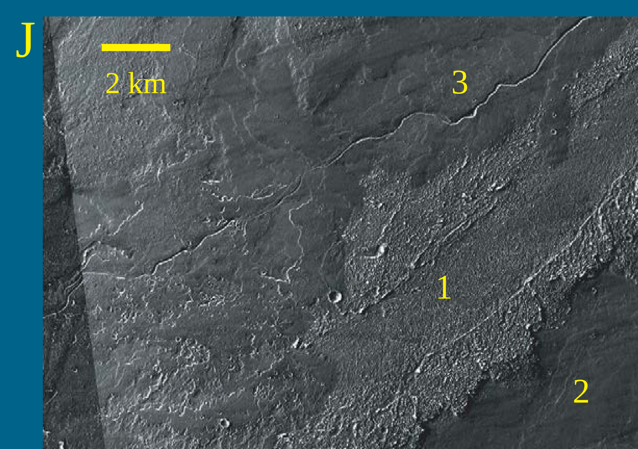

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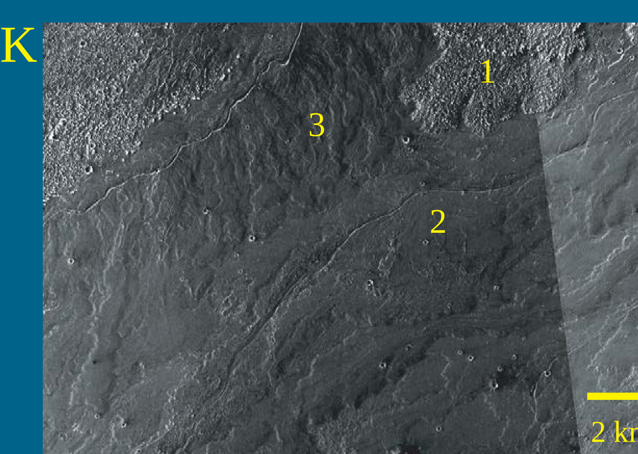


Contact Relationships Between Flows. CTX images reveal important details regarding local sequences of flow emplacement that allow reconstruction of complex flow field surfaces. Distinct embayment relationships are observed between and among both types of flows recognized.

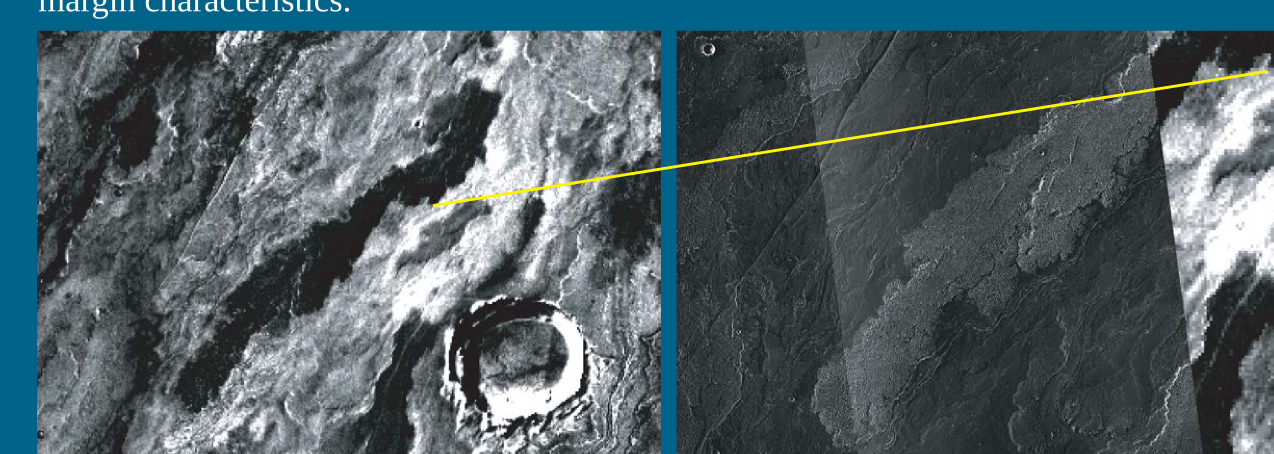
H) Bright, rugged flow covers platy rugged flow; both embayed by dark flows

I) Rugged flow with channel and levee system covers dark flows and narrow channel

J) Dark flows associated with narrow channel embay rugged flow.

K) Numerous small, dark flow lobes extend from channel/tube system and cover dark flows.

Comparison of THEMIS IR and CTX Images. Thermophysical differences observed in THEMIS IR images (as at left) allow flow margins and central channels to be clearly delineated in some cases. However, comparisons to corresponding CTX images are necessary to properly interpret flow boundaries. While the 3- to 10-km-wide flow at center left is well-defined, closer examination using CTX (right) reveals that the margins of the rugged flow are embayed, adding uncertainty to interpretations based on flow dimensions or margin characteristics.



Summary and Implications

1) Flow field mapping using CTX images provides important insights into physical volcanic processes and allows reconstruction of complex volcanic surfaces.

2) The characteristics of the different flow types, their surface morphologies, and interactions with local topography (embayment of other flows, deflection by obstacles, and capture by topographic lows) provide critical clues to understanding flow rheology and emplacement styles. General analogies to terrestrial basaltic volcanoes appear to be valid, with comparable suites and diversity of volcanic features and similarities in flow morphology [e.g., 9-10].

3) A quantitative, process-oriented understanding of Martian volcanism needs to be informed by accurate constraints on flow dimensions and incorporation of multiple scales and styles of flow emplacement.

4) Although in the Daedalia Planum study region the darker, tube/channel fed flows are generally younger than the thicker, rugged leveed flows, the observed diversity of flow stratigraphy and complexity of interactions suggests that lava sources with different eruptive styles and magnitudes were distributed throughout the region and active contemporaneously.

References. [1] Plescia, J.B. (2004), J. Geophys. Res., 109, E03003, doi:10.1029/2002JE002031. [2] Scott, D.H. and J.R. Zimbelman (1995), U.S. Geol. Surv. Misc. Invest. Ser. Map I-2480. [3] Crown, D.A. et al. (2009), LPSC XL, abstract 2252. [4] Ramsey, M.S. and D.A. Crown (2010), LPSC XLI, abstract 1111. [5] Scott, D.H. (1981), U.S. Geol. Surv. Misc. Invest. Ser. Map I-1274. [6] Scott, D.H. et al. (1981), U.S. Geol. Surv. Misc. Invest. Ser. Map I-1275. [7] Scott, D.H. et al. (1981), U.S. Geol. Surv. Misc. Invest. Ser. Map I-1272. [8] Bleacher, J.E. et al. (2007), J. Geophys. Res., 112, E09005, doi:10.1029/2006JE002873. [9] Wolfe, E.W. (1988), U.S. Geol. Surv. Prof. Paper 1463. [10] Peitersen, M.N. and D.A. Crown (1999), J. Geophys. Res., 104, 8473-8488.