

Volcanic Deltas and Possible Martian Analogs

Tuyas are defined by the presence of lava-fed deltas (Skilling, 2002). The deltas represent a late subaerial progradational phase of edifice-building (Smellie, 2000). Although the deltas are constructed on top of a subaqueous tuff cone and/or pillow mound, these earlier-formed constructs do not significantly affect the final shape of the edifice. The lavas are the volcanic equivalent of topset beds in a sedimentary delta. They overlie cogenetic coarse hyaloclastite breccias (equivalent to sedimentary delta foreset beds), which dip radially outward at steep repose angles (25-40°). The breccias formed by a combination of quench-induced shattering and avalanching at the delta brinkpoint (Skilling, 2002). The junction between the lavas and dipping breccias is a planar surface (passage zone) that records the water level coeval with delta formation (Jones, 1969, 1970).

Most of the images on this page were provided by Ian Skilling.

Figure 1: Primary morphologies and post-depositional modification of subaqueous coherent lava lobes and their derived breccias. Note that post-depositional modification may deform the primary morphology of lava bodies and breccia units (see Fig. 2; from Skilling, 2002).

Figure 2: Conceptual depiction of the variety of clast generation and emplacement processes that may occur in a basaltic pahoehoe lava-fed delta (a). James Ross Island Volcanic Group facies described in Skilling (2002) also illustrated. Not all lava-fed delta processes are illustrated (see text and (b) and (c) for further details). Lt and Ll lava facies are also not illustrated. Note that large-scale gravitational slides and marine, fluvial and glacial processes that operate in alluvial deltaic environments are not illustrated; (b, c): interpretation of source for dominant coarse clasts in Cf facies; (d): interpretation of source for dominant coarse clasts in Ca facies (from Skilling, 2002).

Figure 3: Characteristics which may be used to distinguish marine and englacial basaltic lava-fed deltas. Note that non-glacial lacustrine deltas may also share many of the features of englacial examples, including catastrophic drainage and basin collapse (from Skilling, 2002).

Figure 4: Foreset-bedded pillow breccias of a lava-fed delta, emplaced on more massive deposits (James Ross Island, Antarctica; image taken by Ian Skilling, courtesy British Antarctic Survey).

Figure 5: Contact of two basaltic lava-fed delta lobes. Note wedge-like block of subaerial lava(?) between the two foreset-bedded lobes, and horizontally-bedded massive diamictites on lower RHS (James Ross Island, Antarctica; image taken by Ian Skilling, courtesy British Antarctic Survey).

Figure 6: More distal view of deltas in figure 5.

Figure 7: Foreset-bedded pillow breccias of delta lobe emplaced on more massive pillow breccias (slumped delta deposits?) forming a topographic high (James Ross Island, Antarctica; image taken by Ian Skilling, courtesy British Antarctic Survey).

Figure 8: stacked subaerial lava forming the cap of a basaltic pahoehoe lava-fed delta (Brown Bluff, Antarctica; image taken by Ian Skilling, courtesy British Antarctic Survey).

Figure 9: Spectacular cross-section of basaltic pahoehoe lava-fed delta illustrating the passage zone (contact of subaerial and subaqueous facies); note coherent lava lobes dipping down the foresets (Antarctica; image taken by Ian Skilling, courtesy British Antarctic Survey).

Figure 10: Cross-sections of basaltic pahoehoe lava-fed deltas illustrating passage zones, and foreset-bedded pillow breccias. Note prominent gravitational sliding.

Figure 11: Cross-section of brink-point area of basaltic pahoehoe lava-fed delta. Note lava ploughed into underlying Surtseyan deposits (see Skilling, 2002 for further details).

Figure 12: Passage Zone area of basaltic lava-fed delta. Water-cooled lava bodies like this are common at the water level (Brown Bluff, Antarctica; image taken by Ian Skilling, courtesy British Antarctic Survey).

Figure 13: Foreset-bedded pillow breccias of basaltic lava-fed delta. Note intercalated paler-colored Surtseyan tephra (Brown Bluff, Antarctica; image taken by Ian Skilling, courtesy British Antarctic Survey).

Figure 14: Pillow breccia within a debris chute (visible as darker band in central upper part of image). Debris chutes like this are common on many types of coarse steepface deltas (Skilling, 1994, 2002; Brown Bluff, Antarctica; image taken by Ian Skilling, courtesy British Antarctic Survey).

Figure 15: Spectacular foreset-bedded pillow breccias of a basaltic pahoehoe lava-fed delta (James Ross Island, Antarctica; image taken by Ian Skilling, courtesy British Antarctic Survey).

Figure 16: Pillow breccia at base of a debris chute. Debris chutes like this are common on many types of coarse steepface deltas (Skilling, 1994, 2002) (Brown Bluff, Antarctica; image taken by Ian Skilling, courtesy British Antarctic Survey).

Figure 17: Passage Zone area of basaltic lava-fed delta. Water-cooled lava bodies like this are very common at the water level (Hloundufell, Iceland; image taken by Ian Skilling).

Figure 18: Passage Zone area of basaltic lava-fed delta. Water-cooled lava bodies like this are very common at the water level (Hloundufell, Iceland; image taken by Ian Skilling).

Figure 19: Passage Zone area of basaltic lava-fed delta. Steeply-dipping pillow lava tubes below subhorizontal subaerial pahoehoe lava flows (Hloundufell, Iceland; image taken by Ian Skilling).

Figure 20: Probable littoral cone associated with basaltic lava-fed delta formation (Hloundufell, Iceland; image taken by Ian Skilling).

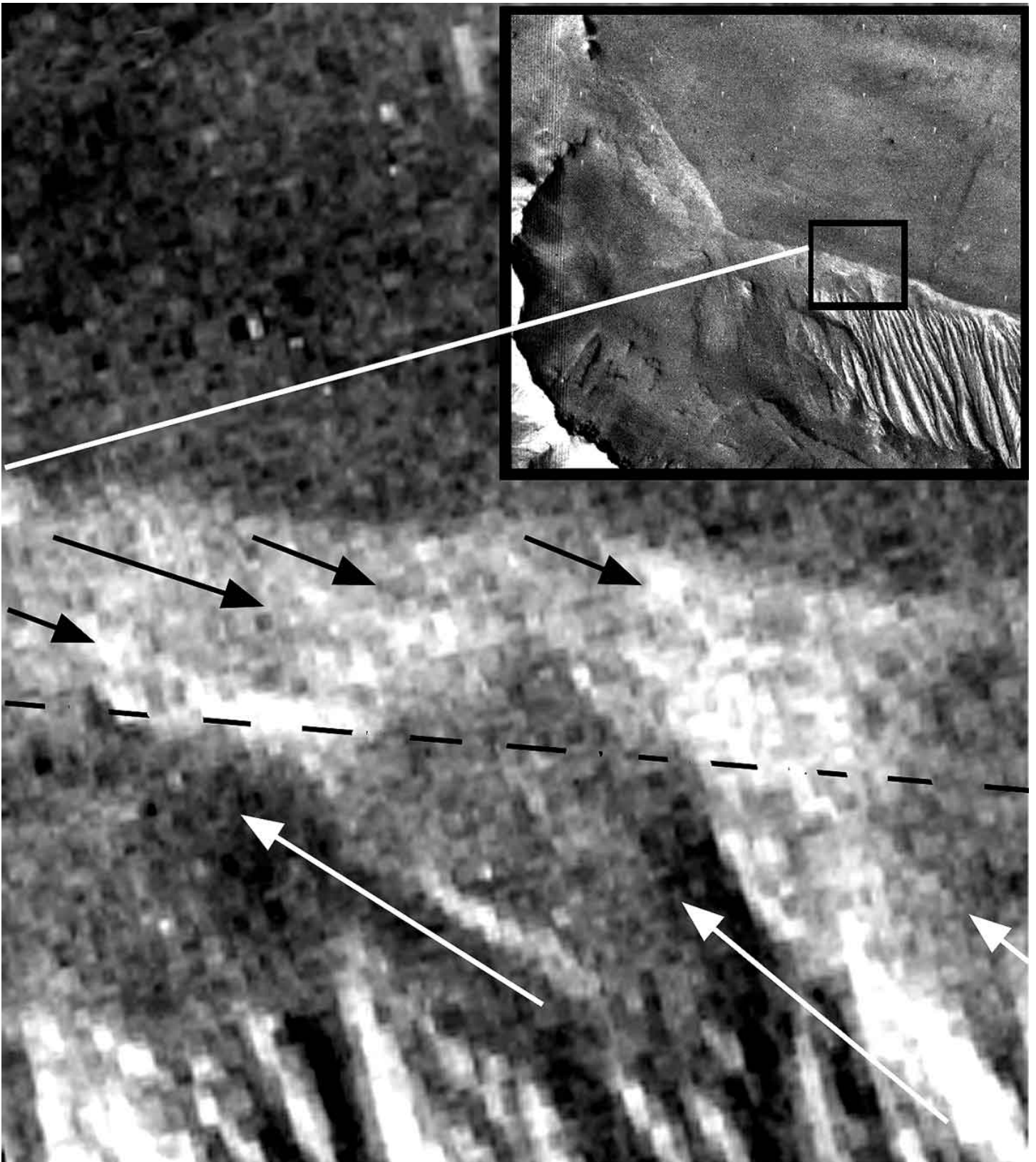


Figure 21: Possible Martian lava delta in part of Viking Orbiter image 815A45 (inset 26 m/p) showing northwest edge of Baetis Mensa in central Ophir Chasma; the enlargement shows caprock of possible topset lava beds (black arrows) and steeply dipping foreset beds (white arrows) above the fluting; compare with figures 9 and 15 (adapted from Chapman and Tanaka, 2001).

Figure 22: Top of Figure shows possible Martian lava delta in part of MOC image E501398 (1.5 km wide; image rotated 180°; courtesy of Malin Space Science Systems); bottom of figure shows black lines that map layering on the MOC image, the caprock is horizontally bedded (topset beds?) the lower layers bend around downslope pointing wedges of wind-eroded flutes indicating dipping strata (foreset beds?); inset shows yellow location of figure on Ganges Chasma ILLD.

References to Help Understand Lava-fed Deltas (up to 2002)

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