TUNNEL VALLEYS AS TERRESTRIAL ANALOGS OF THE INNER CHANNELS OF KASEI VALLES, MARS.

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Introduction: Sediment-floored tunnel valleys are channels eroded under glaciers and ice sheets by pressurized subglacial water flowing in conduits through which sediments are carried. The eroded channels may be considerably larger that the water conduits that carries the sediment load. Channels progressively enlarge as material creeps in towards the conduit, as ice at the base of the glacier deforms to fill in the void. Tunnel valleys are thought to arise from either steady state, low discharge of subglacial meltwater in conjunction with bed deformation, or larger transient discharge events or jökulhlaups [1].

They have a widespread distribution in many areas formerly covered by Pleistocene ice sheets and can occur in isolation or as part of larger anastomosing or dendritic systems. Being the largest form of Nye-channels, tunnel valleys can be up to 4km wide by 100km long. Tunnel valleys have wide, flat bottoms with steep sides and are characterized by overdeepenings, undulatory bed-long profiles, and hanging tributary valleys. They often terminate abruptly at large subaerial ice-contact fans, which may lie up to 100m above the tunnel valley bottom [1].

Inner Channels: Two inner channels of Kasei Valles (Fig. 1a and 2a) share several characteristics with tunnel valleys (Fig. 2b). Like tunnel valleys, they are steep-sided and have a flat floors. The terminus of the upvalley inner channel (Fig. 2a and 3) culminates in a fan shaped deposit that appears to be at an elevation above that of the floor of the inner channel. The downvalley inner channel (Fig. 1a) is distinct and disconnected from the upvalley inner channel (Fig. 2a), being separated by some 20 km, and also appears to have an elevated terminal area (Fig. 1b). MOLA elevation data, indeed, supports these interpretations.

In tunnel valleys, elevated depositional fans are definitive and represent the margin of a glacier or ice sheet where the water and suspended sediment flowing through the conduit emerges at the surface at a glacier margin. The fact that these depositional fans occur at a higher elevation argues the case that the water carrying the sediments was under hydrostatic pressure upon emerging at the margin. In point, water erupted with enough velocity to carry a sediment load to a higher elevation, as apposed to pooling, slowing and dropping the load at the level of the channel floor, as would be the case with overland flow.

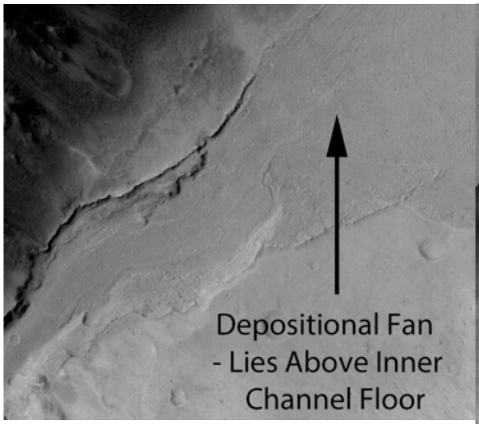
In addition, MOLA elevation data reveals that the downvalley inner channel has an undulatory bed-long profile. Like elevated terminal fans, channel floor elevation undulations are features that are only produced under hydrostatic pressure beneath ice, for overland flow cannot push sediments upslope.

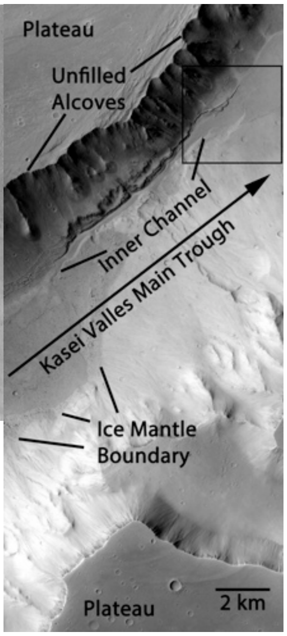
The inner channels are also adorned with hanging valleys and the head of the upstream example shows alcove-like erosion (Fig. 3). In the case of tunnel valleys, tributary channels on a higher level than the floor of the main channel extend outwards and may come in forms ranging from alcove and cirque-like, to more defined and developed channel type (Fig. 2b). In the case of the inner channels, the hanging valleys take on a more cirque-like morphology. Although on a smaller scale, the alcove-like morphology of the head could be related to the alcove eroding processes of the walls of the main Kasei Valles trough (Fig. 1a and 2a), which possibly resulted from icelandic type ice spillover or ice trap processes. Perhaps the alcoves of the head post date the formation of the inner channel.

The similar geomorphology and elevation anomalies of the inner channels strongly support a glacial interpretation. Because the forces and condition that are conducive to tunnel valley genesis are sporadic, being linked to the dynamics of the parent glacier or ice sheet, tunnel valleys may form independently, both spatially and temporally, from one another. Therefore, if the inner channels of Kasei Valles are in fact tunnel valleys, these distinct channels may represent different evolutionary stages of a retreating Kasei Valles glacier.

Another noteworthy feature in the area adjacent to the inner channels is a boundary between widespread ice mantled surfaces and less-ice mantled surfaces straddling the inner channels. It is probable that the ice mantle boundaries visible in Fig. 1a, 2a, and 3 reflect a recent phase of orbital cycle driven surface ice mobilization not related to the period of the formation of the valley and the possible tunnel valleys.

Although thinly mantled, the Kasei Valles alcoves in Fig. 1a and 2a are located at 21 degrees latitude and are not ice filled as many alcoves are at locations at higher latitudes, such as at Dao Vallis at 30 to 35 degrees [2]. This narrow section of Kasei Valles where the inner channels are located may have once been partly filled with ice-rich material in a manner similar to the present ice filled state of Dao Vallis, portions of which share similar geomorphology [2 and 3]. At other times, ice deposition may have been great enough for ice sheets to form and the region of Kasei Valles may previously have resembled the present ice mantled





state of Deuteronilus Mensae at 35 to 45 degrees, which is characterized by icelandic-like ice spillover from plateaus.

References: Benn B.I. and Evans J.A. (1998) Glaciers & Glaciation. Arnold Pub., p.332. [2] Arfstrom, J.D. (2002) LPSC Abstract, 33, 1092. [3] J.D. (2012) Comp. Clim. Ter. Pl. Abstract, 8001 (poster paper at scribd.com).

Figure 1a: (top right): Downvalley inner channel. P18 007970 2014 XI 21N072W, CTX: NASA/JPL/University of Arizona. **1b:** (top left): Inset.

Figure 2a: (middle left): Upvalley inner channel. G17 024703 2009 XN 20N072W, CTX. **2b:** (middle right): Digital elevation model of Vejle Tunnel Valley, Denmark, from: http://dx.doi.org/10.1016/j.quascirev.2005.11.006. **Figure 3:** (bottom) Closeups of Fig. 2a. (left to right) PSP 002287 2010, ESP 024202 2010, PSP 007825 2010, HiRise: NASA/JPL/University of Arizona.