Table 2
Observations and model results.

Channel segment	w_{chan} (m)	l_{chan} (m)	d_{chan} (m)	V_{lava} (km^3)†	w_{lava} (m)	Slope (°)
Upper	90	725	32	.0021	93	6.2
Middle	100	1036	28	.0029	93	4.2
Lower	275*	3400	150	.0701	93	13.5
	Velocity (m s^{-1})	d_{lava} (m)	*Re*	Volume flux (m^3 s^{-1})	Mechanical erosion rate (m s^{-1})	Modeled depth (m)
Upper	20	2.6	14,269	2375	2.8×10^{-5}	69
Middle	17	2.9	13,804	2375	1.9×10^{-5}	47
Lower	25	2.0	14,000	2375	6.1×10^{-5}	150
	Velocity (m s^{-1})	d_{lava} (m)	*Re*	Volume flux (m^3 s^{-1})	Thermal erosion rate (m s^{-1})	Modeled depth (m)
Upper	14	1.6	6429	1158	2.31×10^{-5}	116
Middle	12	1.9	6481	1158	2.03×10^{-5}	102
Lower	18	1.3	6447	1158	2.99×10^{-5}	150

C_f and velocity calculations made using Keszthelyi and Self (1998); C_t = 0.002681.
Mechanical erosion rate and modeled depth determined using Siewert and Ferlito (2008), assuming a formation duration of 30 Earth days.
Thermal erosion rate and modeled depth determined using Hulme (1973), assuming a formation duration of 60 Earth days.
* Corrected for subsequent slumping.
† Upper and middle channel segments have a rectangular cross-section, the lower channel segment has a v-shaped cross-section.

the flowing lava is 0.075 km^3, a value that represents 1.3% of the volume of lava that flowed through the channel.

The terminus of the channel (Fig. 2e) is characterized by a shallower and narrower channel with a rectangular cross-section. As the slope changes from the larger-scale v-shaped channel to the smaller-scale rectangular channel, remnants of lava flows can be observed once more outside the channel (Fig. 2e; black arrows). These flows radiate away from the channel, indicating flow down-slope towards the crater floor. The locations of the flows outside the upper and terminal channel segments suggest that the channel overflowed where the slope on which it formed changed abruptly from steep to more gradual. The low volume of these deposits suggests that these breaches occurred early in channel formation, declining in frequency as the channel eroded to greater depths.

4. Calculating erosion rates

The observations made of channel dimensions and slope can be used to determine the input parameters needed to solve for lava flow velocity (Eqs. (3) and (4)) and channel erosion rates (Eqs. (1)–(3)). Eqs. (3)–(5) are solved iteratively to calculate the volumetric lava flux and channel formation duration. The calculated formation duration is then used to match the depth of erosion that is observed in the lower channel segment because channel depth is best constrained for that channel segment. The resulting calculated lava flux is held constant in the analysis of the remaining channel segments in order to satisfy continuity of flow through the channel.

As expected, lava depth within the channel changed as the slope and flow velocity were varied. The estimated depths of lava that flowed through the channel are summarized in Table 2. The lava depth is greatest for the most gradually sloped middle segment and least for the steepest lower channel segment, consistent with lava thinning as slope (and thus lava velocity) increases. These depths were estimated assuming a constant lava flow width of 93 m, chosen to match the width of the breach in the crater rim crest where lava initially flowed into the channel. Changing this width does not alter the results qualitatively. Velocities calculated for these flow conditions are summarized in Table 2 and indicate that the lava velocity increased as the channel gradient increased. In each case, the calculated *Re* (also shown in Table 2) is within the range of values for which this model applies (10^3–10^5).

These velocities and lava depths have been used together with the measured slopes to calculate the erosion rates required to form the channel in both the mechanical (Eq. (1)) and thermal (Eq. (2)) erosion regimes. Results of these calculations are summarized in Table 2. At more gradual slopes, thermal erosion becomes increasingly more efficient than mechanical erosion, but as slope increases, mechanical erosion is consistently more efficient than thermal erosion.

The modeled eroded depths of these channel segments can be determined using the duration of channel formation (Eq. (5)), where the volume of lava that flowed through the channel is 5.8 km^3 as calculated in Section 3, and using the flow parameters defined above that assumed a lower channel segment depth of 150 m. This calculation was performed separately for each erosion regime, as each regime depends on lava depth and velocity in unique ways. For mechanical erosion, the model yields a duration of channel formation of 30 Earth days and a lava flux of ~2300 m^3 s^{-1}, and the channel depths are predicted to be 54 m for the upper segment, 32 m for the middle segment, and 150 m for the lower segment. For thermal erosion, the model yields a duration of channel formation of 60 Earth days and a lava flux of ~1200 m^3 s^{-1}, and the channel depths for thermal erosion are predicted to be 116 m for the upper segment, 102 m for the middle segment, and 150 m for the lower segment. The duration of channel formation is longer for the thermal erosion model because the erosion rate of the standard lower channel is slower (see Table 2), meaning it takes a longer time period to erode the lower channel segment to 150 m. The calculated channel depths in the thermal erosion scenario are too great in the upper and middle channel segments (observed to be 32 m and 28 m, respectively), suggesting that mechanical erosion was likely the dominant erosion regime present during channel formation.

The mechanical erosion rates responsible for the formation of an eroded channel are heavily dependent on the erodibility factor *K* of the bedrock, where *K* is the ratio of an erodibility factor *b* and the strength of the substrate Y_s, and a larger value of *K* indicates a more easily eroded substrate. Expected values of *b* for erosive wear by hard particles lie in the range of 10^{-4}–10^{-1} (Zum Gahr, 1998), and values of Y_s range from 1 to 25 MPa for dry impact ejecta and basaltic basement rock (Tanaka and Golombek, 1989) and from 1 kPa to 1 MPa for poorly consolidated martian soil (Arvidson et al., 2004). The combination of these factors yields a range of *K* values from 10^{-10} to 10^{-4}. For a given *K*, the model determines the lava flux and time required to erode through that material to match the channel depth observed in the lower channel segment, akin to the method used for thermal erosion. As indicated earlier, steeper slopes correspond to higher flow velocities and unit stream power estimates, so as slope increases, conditions become increasingly optimal for mechanical