erosion to dominate the formation of the channel. Fig. 3 demonstrates that less consolidated substrates (high b, thus high K) transition to a mechanical erosion regime at shallower slopes than more consolidated substrates (low b, thus low K).

The value of K is unique for each geologic setting and must be determined experimentally. Our best estimate of K is 0.5×10^{-9} (i.e., a b value of 0.5×10^{-3} and an average Y_s of 1 MPa), a value that yields a reasonable lava volume flux ($\sim$2300 $m^3 s^{-1}$) consistent with estimates for the source eruption in Cerberus Fossae (Jaeger et al., 2010), a formation duration of $\sim$30 Earth days, and a velocity range of 17–25 $m s^{-1}$. Other values of K can also produce reasonable results; for example, a K of 1.5×10^{-9} (a b of 1.5×10^{-3}) yields an expected volume flux of 7100 $m^3 s^{-1}$ and a formation duration of $\sim$10 Earth days. A smaller value of K (0.1×10^{-9}, a b of 0.1×10^{-3}) yields a lower expected flux (500 $m^3 s^{-1}$) and a longer formation duration ($\sim$140 Earth days), and a larger value of K (2.5×10^{-9}, a b of 2.5×10^{-3}) yields a higher expected flux (11,900 $m^3 s^{-1}$) and a shorter formation duration ($\sim$6 Earth days). These scenarios are summarized in Fig. 3. While the value of K changes the estimated lava flux and formation duration for each scenario, it does not change the modeled channel depths obtained for each channel segment.

5. Discussion

5.1. Model results

Observations of channel morphology suggest that as slope increased, the lava became more efficient at eroding into the substrate, carving a deeper and wider channel in the lower channel segment. Model results support these qualitative interpretations of relationships between channel morphology and mechanical erosion rate. The lowest lava flow velocities of 17 $m s^{-1}$ and 20 $m s^{-1}$ correspond with the shallower upper and middle channel segments, respectively, while the highest lava flow velocity of 25 $m s^{-1}$ corresponds to the steeper lower channel segment. Similarly, the highest erosion rates, both mechanical and thermal, occurred in the steep lower segment, where the lava velocity was highest. The increase in mechanical erosion rate is more significant than that in thermal erosion rates (Fig. 4), indicating that mechanical erosion is more strongly influenced by changes in slope. This more significant change in mechanical erosion rate occurs because the physical energy of the flow increases with an increase in slope, enhancing the efficiency of erosion more significantly in the case of mechanical erosion than thermal erosion, which depends more heavily on the thermal energy of the flowing lava. Thermal erosion becomes more efficient than mechanical erosion at gradual slopes less than about 5°, indicating that thermal erosion is more likely to be observed in channels forming on Mars at these slopes. Channels forming on gradients of about 5° are likely to have very comparable erosion rates at these inferred fluxes in both the mechanical and thermal regimes, suggesting that both erosion regimes are comparably efficient during channel formation under these conditions on the martian surface. Channels forming at these fluxes on gradients greater than about 5° would have significantly higher mechanical erosion rates than thermal erosion rates, indicating that mechanical erosion would be the dominant process present during channel formation on steep martian slopes. The slopes observed in the

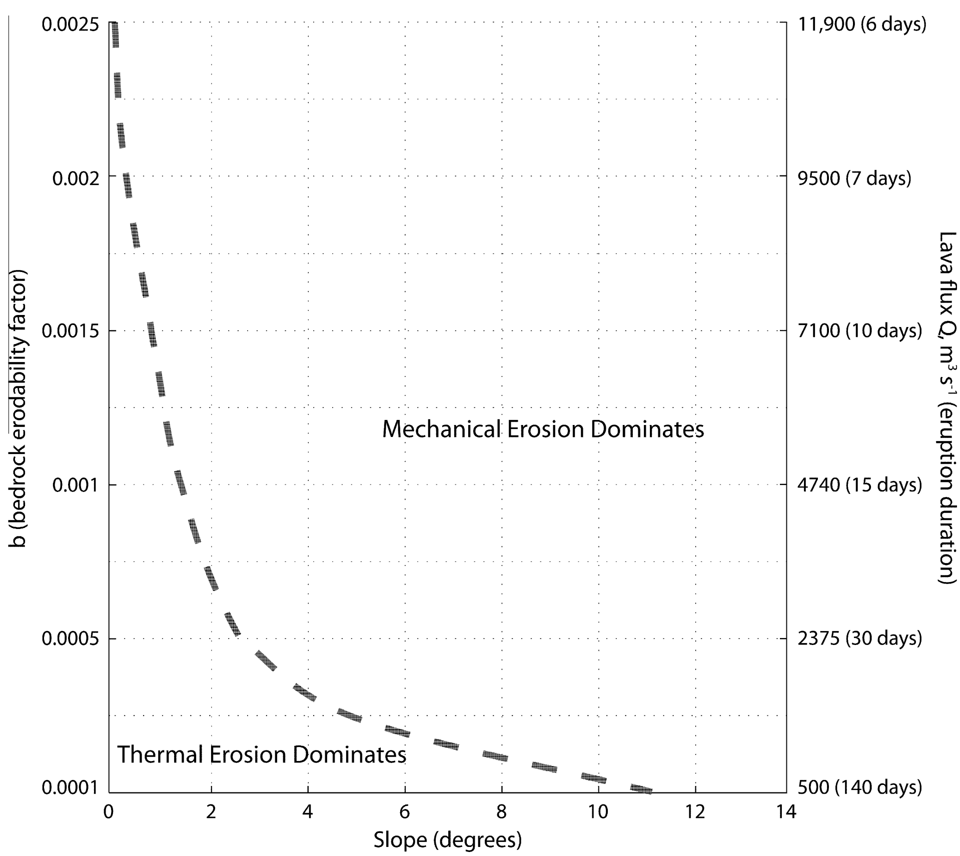

Fig. 3. Bedrock erodibility b vs. channel slope, where b is related to the proportionality erodibility constant $K = b/Y_s$. Bedrock erodibility is related to both lava flux and formation time (shown on the second y-axis), where a more erodible substrate (higher b) leads to a higher lava flux and a shorter formation duration being required to form a channel of depth 150 m such as the lower channel segment observed in the Elysium Planitia impact crater. Mechanical erosion is more efficient on steep slopes whereas thermal erosion is more efficient on shallow slopes, and less consolidated material (high b) is more susceptible to mechanical erosion at shallower slopes than more consolidated material (low b).