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Conference or Workshop Item

EGU2020-3463
https://doi.org/10.5194/egusphere-egu2020-3463
EGU General Assembly 2020

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Introduction: Eskers are sinuous sedimentary ridges that are widespread across formerly glaciated landscapes on Earth. They form when sediment in subglacial tunnels is deposited by meltwater. Some sinuous ridges on Mars have been identified as eskers; whilst some are thought to have formed early in Mars' history beneath extensive ice sheets, smaller, younger systems associated with extant glaciers in Mars' mid latitudes have also been identified. Elevated geothermal heating and formation during periods with more extensive glaciation have been suggested as possible prerequisites for recent Martian esker deposition.

Here, we adapt a model of esker formation with g and other constants altered to Martian values, using it initially to investigate the impact of Martian conditions on subglacial tunnel systems, before investigating the effect of varying water discharge on esker deposition.

Methods: To investigate the effect of these values on the operation of subglacial tunnel systems we first conduct a series of model experiments with steady water discharge, varying the assumed liquid density (r_w) from 1000 kgm^{-3} to 1980 kgm^{-3} (the density of saturated perchlorate brine) and ice hardness (A) from 2.4x10^{-24} Pa^{-3}s^{-1} to 5x10^{-27} Pa^{-3}s^{-1} (a temperature range of 0°C to -50°C). We then investigate the impact of variable water discharge on esker formation to simulate very simply a possible release of meltwater from an assumed geothermal event beneath a Martian glacier or ice cap.

Results and Discussion: A key aspect of model behaviour is the decrease in sediment carrying capacity towards the ice margin due to increased tunnel size as ice thins. Our results suggest that Martian parameters emphasise this effect, making deposition more likely over a greater length of the conduit. Lower gravity has the largest impact; it reduces the modeled closure rate of subglacial tunnels markedly as this varies with overburden stress (and hence g) cubed. Frictional heating from flowing water also drops, but much less sensitively. Thus, for a given discharge, the tunnels tend to be larger, leading to lower water pressure and a reduction in flow power. This effect is amplified for harder ice. Higher inferred fluid density raises the flow power, but by a smaller amount.

These effects are clearly seen in the variable discharge experiments. Sediment is deposited on the falling limb of the hydrograph, when the tunnels are larger than the equivalent steady-state water discharge would produce. Sediment deposition occurs much further upglacier from the glacier snout, and occurs earlier on the falling limb leading to longer periods in which deposition occurs.

Conclusions: Our results suggest that esker formation within a subglacial meltwater tunnel would be more likely on Mars than Earth, primarily because subglacial tunnels tend to be larger for equivalent water discharges, with consequent lower water flow velocities. This allows sediment deposition over longer lengths of tunnel, and to greater depths, than for terrestrial systems. Future work will use measured bed topography of a mid-latitude esker to assess the impact of topography on deposition patterns and esker morphology, and we will expand the range of discharges and sediment supply regimes investigated.