Martian Groundwater Outflows in Flume Experiments
Processes and Morphological Properties


Faculty of Geosciences, Utrecht University, the Netherlands

INTRODUCTION
- There are many channels on Mars, but climate conditions were different than on Earth.
- Different sources of water have been proposed for Mars, including groundwater as the main source for channel formation [1,2,3].

AIMS
- Knowledge on groundwater-induced channels is minimal due to limited occurrence on Earth.
- We aim to extend the knowledge on related processes and resulting morphology for these systems from scaled flume experiments.

METHODS
- Experimental setup consists of a flume of 6 m long X 4 m wide and 1.2 m deep.
- Simulation of seepage from subsurface groundwater level to a distant source using a constant head tank.
- Seepage from a local source (e.g. melt or precipitation) was simulated by rain simulators.
- Pressurized aquifer release using a subsurface drainage pipe with forced discharge, at:
  - Sub-lithostatic pressure (only seepage)
  - Super-lithostatic pressure (sediment lifted by water pressure)
- Data: time-lapse imagery and lasercan DEMs.

EXPERIMENT MOVIES
http://geoo.png/540

EXPERIMENT SETUP

EARLY STAGE MORPHOLOGY

FINAL MORPHOLOGY

SHADED DEM

MARS LOOK-ALIKE

KEY FEATURES
- Different sizes of valleys due to flow piracy.
- Theatre-shaped valley heads due to mass wasting processes.
- Valley depth relates to groundwater level:
  - Further developed valleys are deeper as groundwater level is deeper upstream.
  - Different valleys similar in size, due to absence of flow piracy.
- Headward development by mass wasting.
- Shallow valleys, due to high groundwater level.
- Simulated in experiment as precipitation, but could be melt of snow or subsurface ice.

CONCLUSIONS
- Similar features as sub-lithostatic pressure, but:
  - Cracks and breaking of surface due to super-lithostatic pressure.
  - Pits in source area caused by emerging groundwater.
  - Converging flow features disconnected from source area.

REFERENCES

MORPHOLOGICAL ANALYSIS (SAPPING ONLY)
- Valleys become wider, deeper and longer during the experiments.
  - In the local case, widening slows as valleys develop (Fig. 4a). In the local case, the rate remains fairly constant.
  - Valley lengthening slows in both types of experiments (Fig. 4b).
- Erosion takes place in pulses, which are more sudden in the distal cases (Fig. 4d) due to the collapsing nature of the headward development and widening.

MORPHOLOGICAL DEVELOPMENT (SAPPING ONLY)
- In both cases, valleys are steeper in the upstream part (Fig. 2). This related to the difference in processes: mudflows in the upstream end, fluvial transport downstream.
- Valleys become more U-shaped when they develop (Fig. 2). Valleys fed by distal groundwater have a higher shape index, as the valleys have steeper cliffs.

GROUNDCOLUMN SAPPING LOCAL INFILTRATION

GROUNDWATER SAPPING DISTANT SOURCE

PRESSURIZED GROUNDWATER SUB-LITHOSTATIC PRESSURE

Initial surface

Distance along valley (m)

valley length (m)

Valley width (m)

Valley depth (m)

Erosion rate, E (g s

Valley width, W (m)

Valley length, L (m)

Distance along valley (m)

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