Diagnostic Morphology for Martian Groundwater Outflows from Flume Experiments

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Introduction

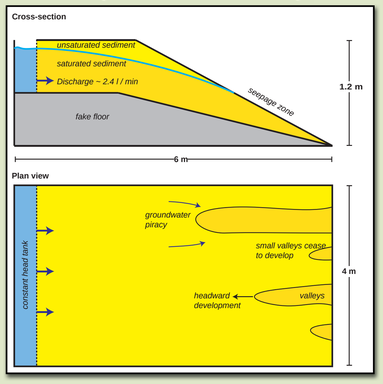
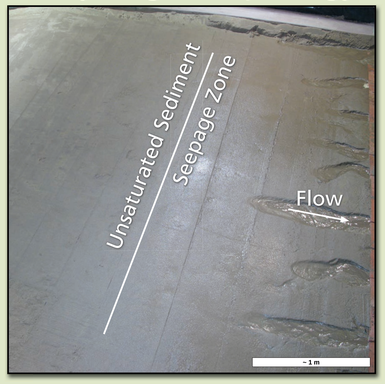
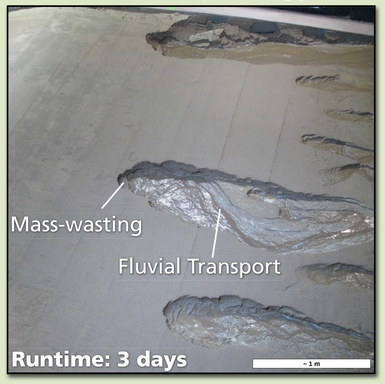
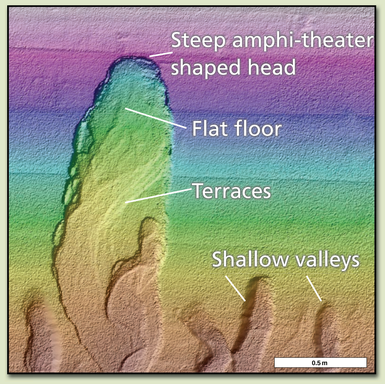
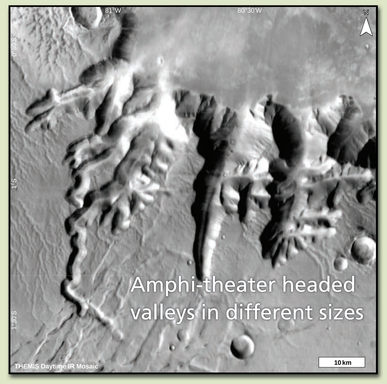
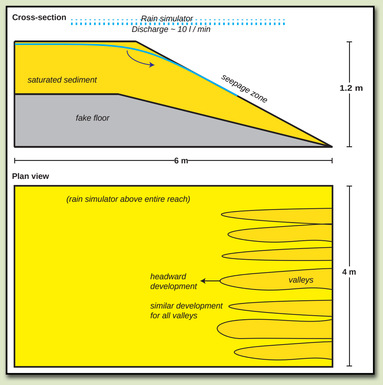
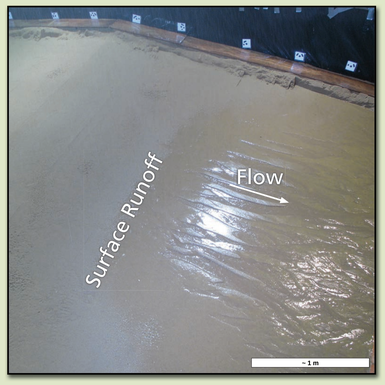
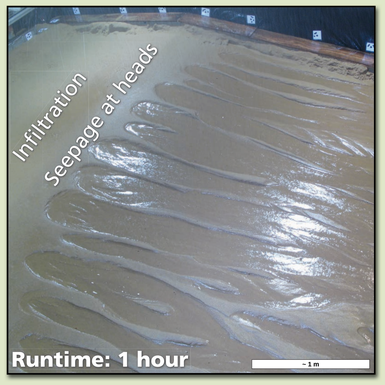
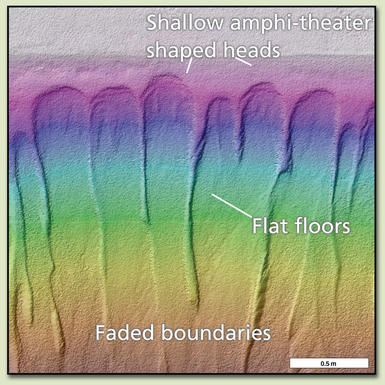
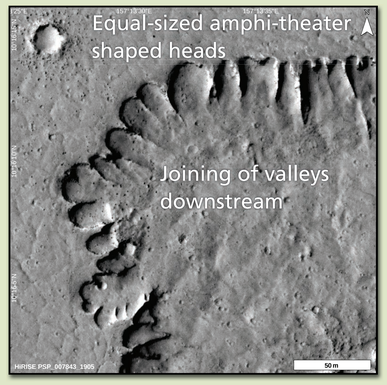
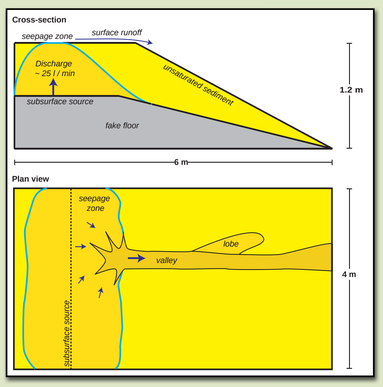
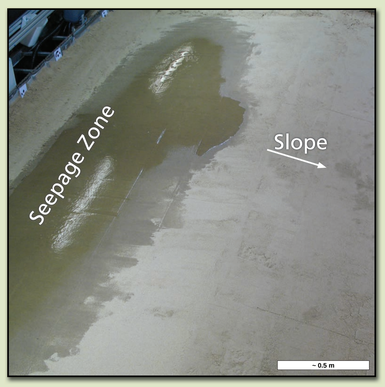
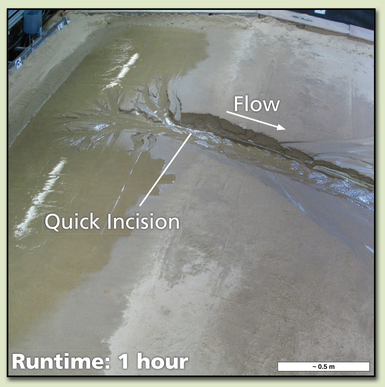
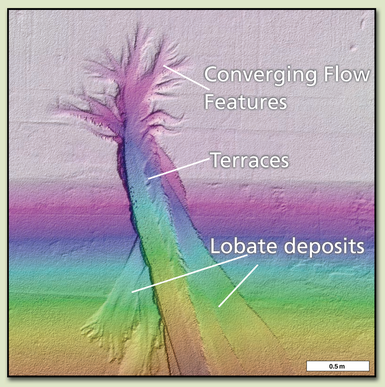
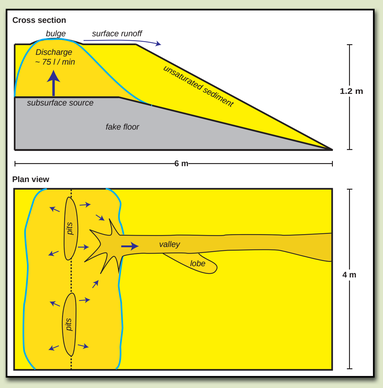
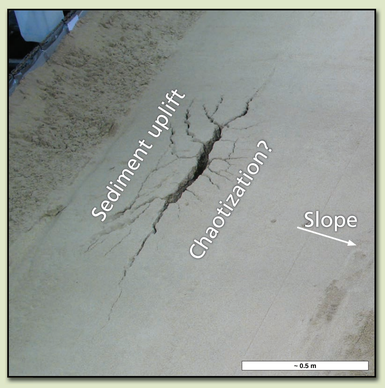
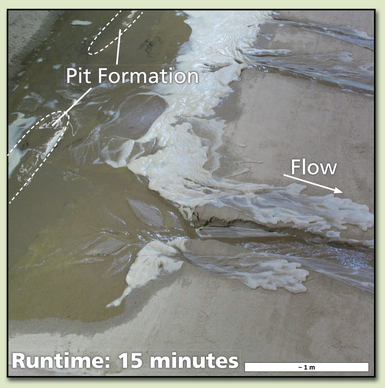
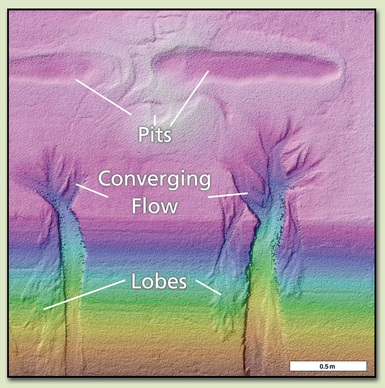
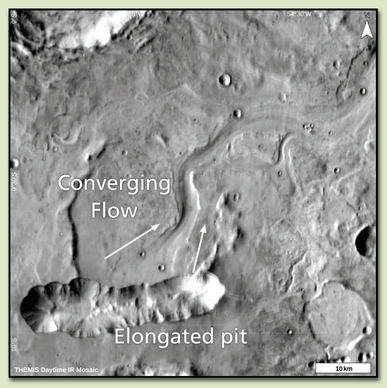
- There are many channels on Mars, but climate conditions were different than on Earth.
- Different sources of water have been proposed for Mars, including groundwater as main source for channel formation [1,2,3].

Aims

- Knowledge on groundwater-induced channels is minimal due to limited occurence 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 1.20 m deep.
- Simulation of seepage from sub-surface groundwater level from 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 laser-scanned DEMs.

	Experiment Setup	Early Stage Morphology	Final Morphology	Shaded DEM	Mars Look-alike	Key Features
Groundwater Sapping Distant Source						• Different sizes of valleys due to flow piracy. • Theater-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.
Local Infiltration						• Several 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.
Pressurized Groundwater Sub-Lithostatic Pressure						• Converging flow features upstream: feather-shaped head. • Deposition of lobes after first overflow due to infiltration in unsaturated substrate (sieve deposits). • No morphology left by actual seepage process. • Not found on Mars without pits or chaos (see next).
Super-Lithostatic Pressure						• Similar features as sub-lithostatic pressure, but: • Cracks and breaking of surface due to super-lithostatic pressure. • Pits in source area carved by emerging groundwater. • Converging flow features disconnected from source area.

Conclusions

- Different sources of groundwater for channel formation produce distinct types of valleys and channels.
- Groundwater sapping:
  - Produces theater-shaped valley heads.
  - Flow piracy occurs when the water source is distal, this focusses flow and enhances development of a few channels.
- Pressurized groundwater release:
  - Results in channel head with converging flow features.
  - Downstream lobate deposits on unsaturated sediment.
  - Super-lithostatic pressure breaks surface and forms pits in the source area.

Upcoming papers

- Paper on these experiments (and others): formative timescales, diagnostic morphology and hydrological modeling.
- Interpretation of Martian morphology.
- Morphodynamical modeling of these systems.

Movies of the experiments: http://goo.gl/gfUbO

References [1] Howard A.D. & McLane C.F. (1988) WRR 24(1), 1659-1674. [2] Kite E.S. et al. (2011) JGR 116, E07002. [3] Andrews-Hanna J.C. & Phillips R.J. (2007) JGR 112, E08001. **Image credits** HiRISE: NASA/JPL/University of Arizona, THEMIS: NASA/JPL/ASU.

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