Alluvial fan and delta progradation

in Martian crater lakes

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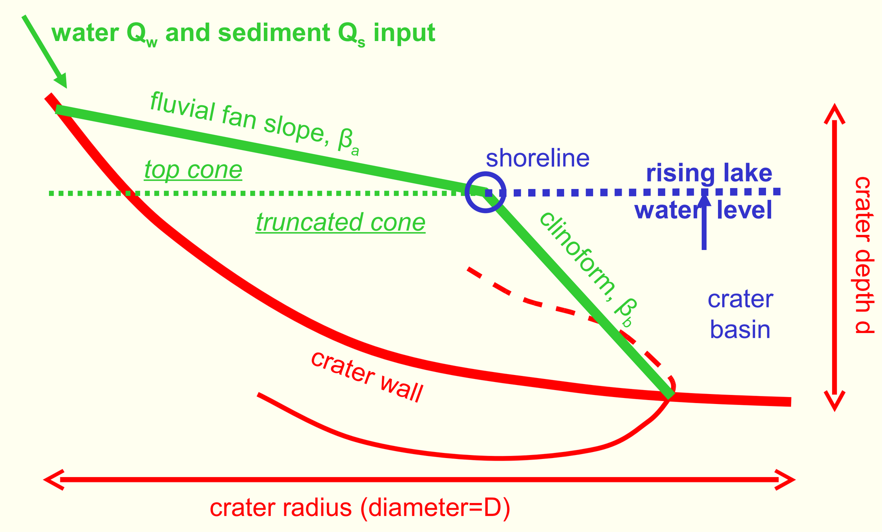
Objective

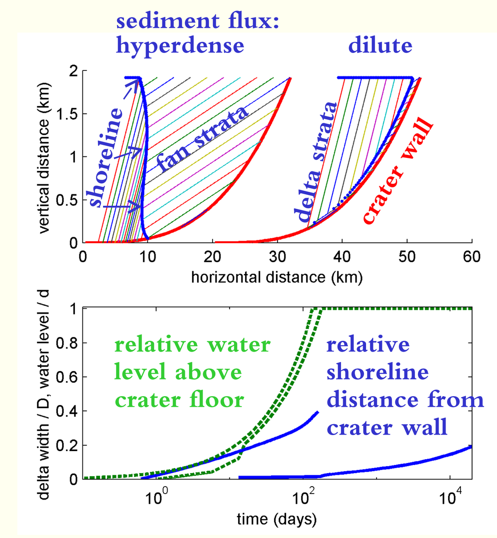
- Reconstruct flow discharge history from alluvial fan and delta morphology and crater size
- Here: develop model for fan/delta morphology for given flow, and generalise results in scenarios

Model setup

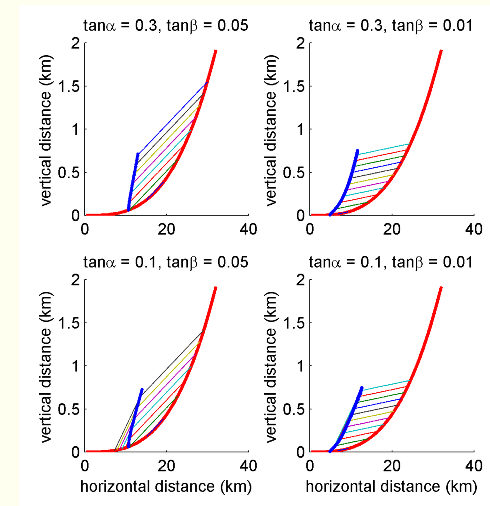
- cone = fan on truncated cone = delta
- input: flow and sediment flux, crater diameter, fluvial and clinoform gradients
- output: shoreline position (→delta volume)
- rectangular basin has analytical solution of cubic equation (first root)
- numerical solution for crater basin using crater size-depth relations[3]



Example output



Effect of gradients



Example delta

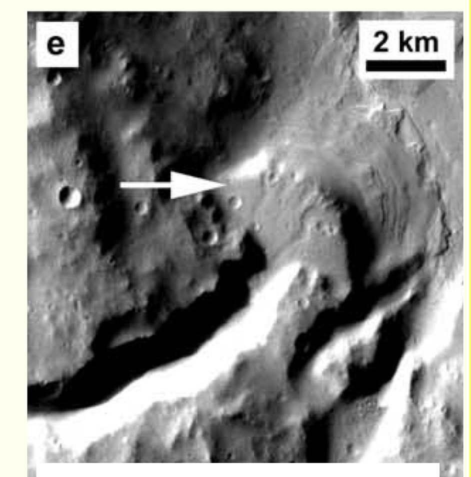


Fig. 13e in Irwin et al. 2005[1]

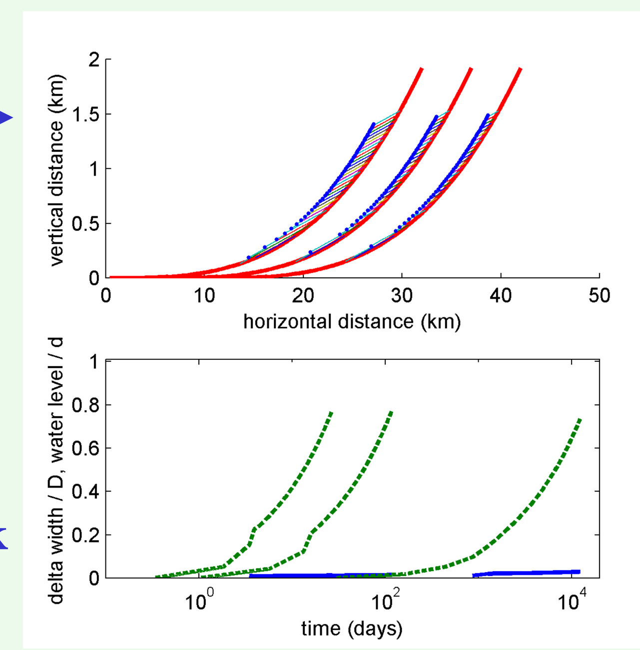
Example study

- Terraced fan deposit, crater D = 64 km
- flow Q_w and sediment Q_s fluxes inferred from channel[2,4]
- Conditions:

Q_w (m^3/s)	Q_s (km^3/day)	ratio	scenario
250000	1.1x10^{-2}	2000	standard
2200	3.9x10^{-4}	500	slow
1010000	3.4x10^{-2}	2800	fast

Modelled scenarios

- slow, standard, fast
- right volume, wrong shape



Conclusion

- shape wrong because in reality time-varying sediment feed: from hyperconcentrated to diluted → first thick fan/delta and then thin sets on top

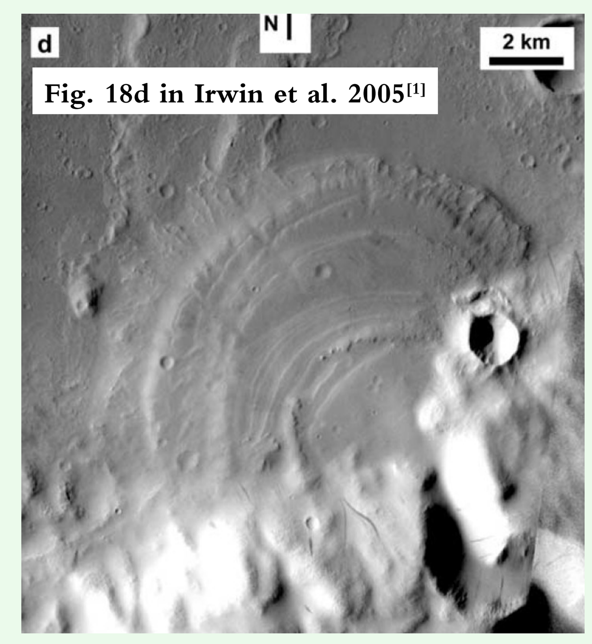


Fig. 18d in Irwin et al. 2005[1]

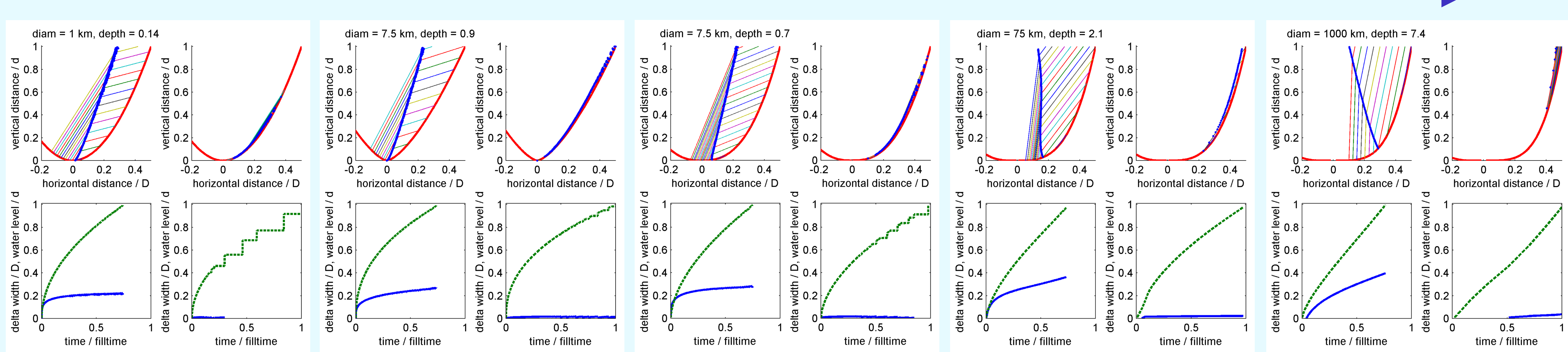
Conclusion

- delta shape for hyperdensity flows depends on ratio of crater diameter/depth
- as does exposure of lee slope (formed in progradation) or alluvial slope (formed in regression)
- delta location for dilute flows depends on crater wall steepness
- (drowned) deltas for dilute flows look like fans or veneers!

Crater size scenarios

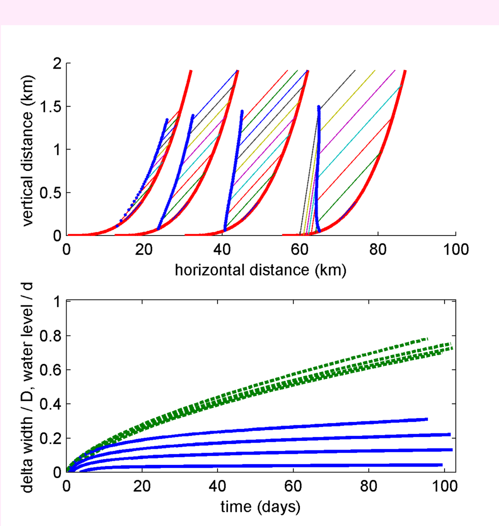
- crater fill time (water) = 100 days, so water flux increases with crater volume
- left of plot pairs: Q_w/Q_s = 3; right of plot pairs: Q_w/Q_s = 1000

increasing crater diameter (simple → complex at 7.5 km)



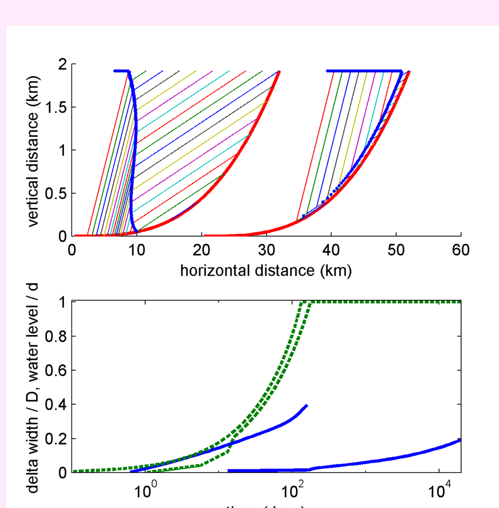
Concentration scenarios

- Q_w/Q_s = 200, 20, 7, 3
- transgression→regression

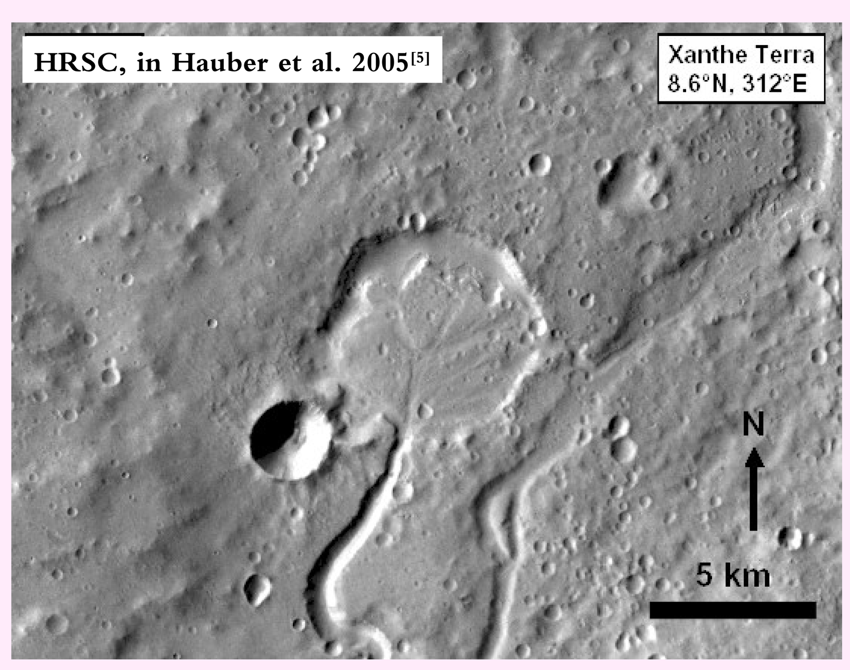


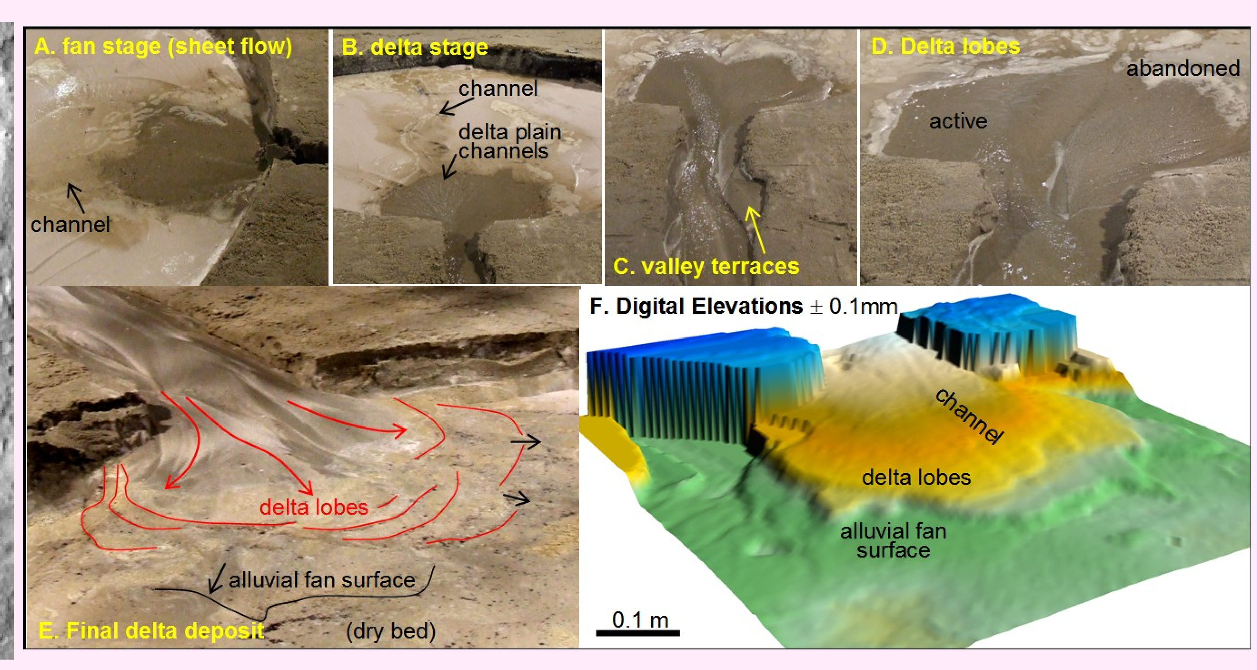
Overflowing scenario

- surplus water flows out
- typical Gilbert delta form



Examples overflowing/delta progradation; experiments[4]





General conclusions

- Crater size and (time-varying) flow discharge constrain water level history;
  - Sediment discharge additionally constrains shoreline position and delta volume; *not* like typical Gilbert delta
- 'typical' delta and fan shapes more likely in hyperconcentrated sediment load (debris-flows),
  - or (fans only) in very leaky craters or multiple small events
- Crater wall clingers or drapes more likely in diluted sediment load (river-flows)
- Future work: couple this model to channel model for effects of time-varying sediment concentration

References

[1] Irwin, R.P., A.D. Howard, R.A. Craddock, and J.M. Moore (2005), JGR 110, E12S15, doi:10.1029/2005JE002460.
[2] Kleinhans, M.G. (2005), JGR 110, E12003, doi:10.1029/2005JE002521.
[3] Garvin, J.B. and J.J. Frawley (1998), GRL 25, 24, 4405-4408.
[4] Kraal, E., M. van Dijk, G. Postma and M. Kleinhans, AGU fall meeting 2007 and this conference
[5] Hauber et al. First Mars Express Conference, Noordwijk, 2004

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