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 relations⁴

Example study

• Terraced fan deposit, crater D = 64 km
• flow Q_w and sediment Q_s fluxes inferred from channel⁵
• Conditions:
  - Q_w (m³/s) / Q_s (km³/day) ratio inferred from channel⁵
  - Q_w = 250000, 2200, 1010000 (ratio: 1.1x10⁻², 3.9x10⁻⁴, 3.4x10⁻³)

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!

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; experiments⁶

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

⁴ Hauber et al. First Mars Express Conference, Noordwijk, 2004
⁵ Hauber et al. 2005
⁶ Hauber et al. 2007 and this conference

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