Examining the Record of Fluvial Activity on Early Mars:

Extended* Mission Targets at Channel Deposit Outcrops of the Jezero Delta

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4th Mars 2020 Landing Site Workshop
October 17, 2018

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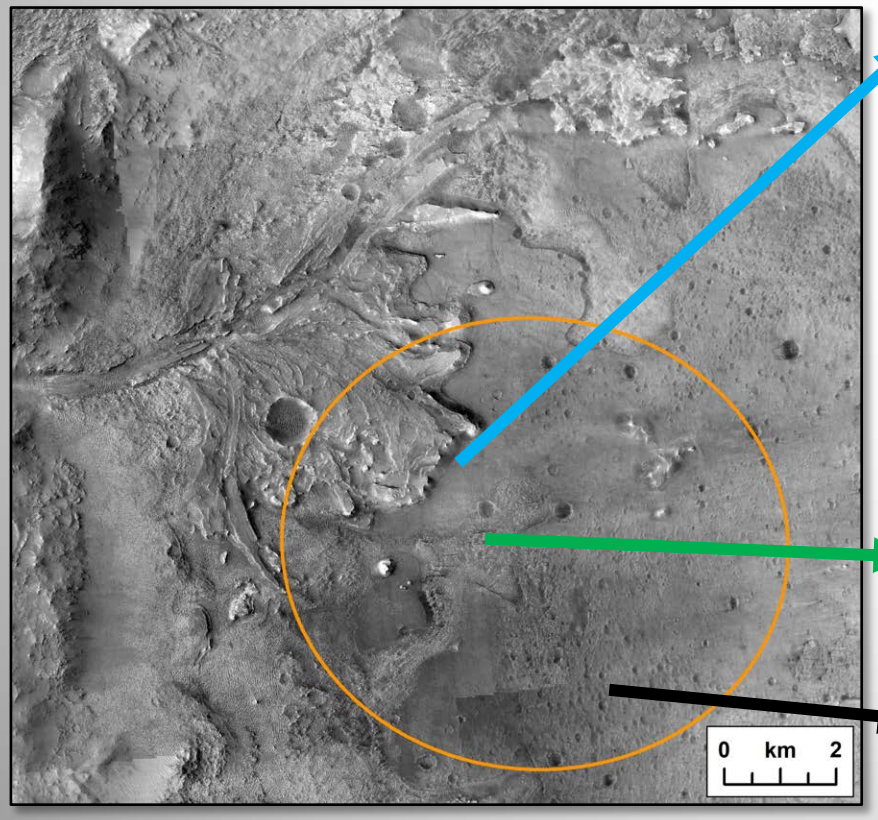
Preamble

Channel deposits provide opportunity to address complementary science questions to three other major targets for exploration in Jezero ellipse:

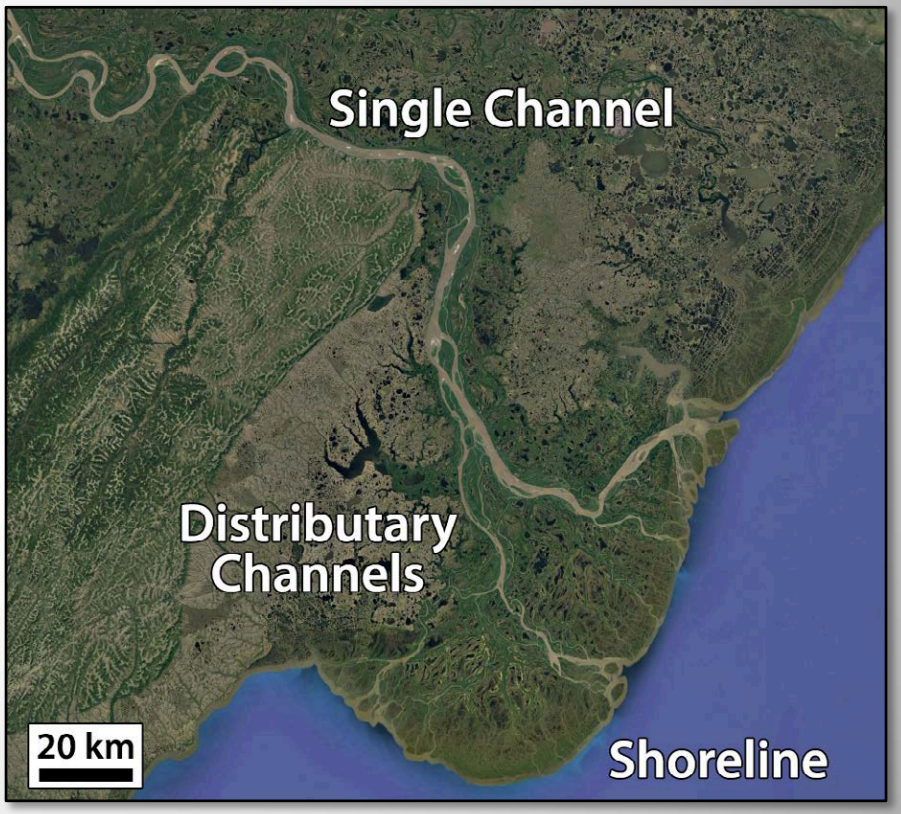


- Fine-grained bottomset deposits with high accumulation and preservation potential for organic matter.
  [*Lynch et al.* talk]
- Carbonate-rich basin fill.
  [*Horgan et al.* and *Brown et al.* talks]
- Mafic-rich floor unit.
  [*Kinch and Shahrzad* talk]

What can channel deposits tell us?

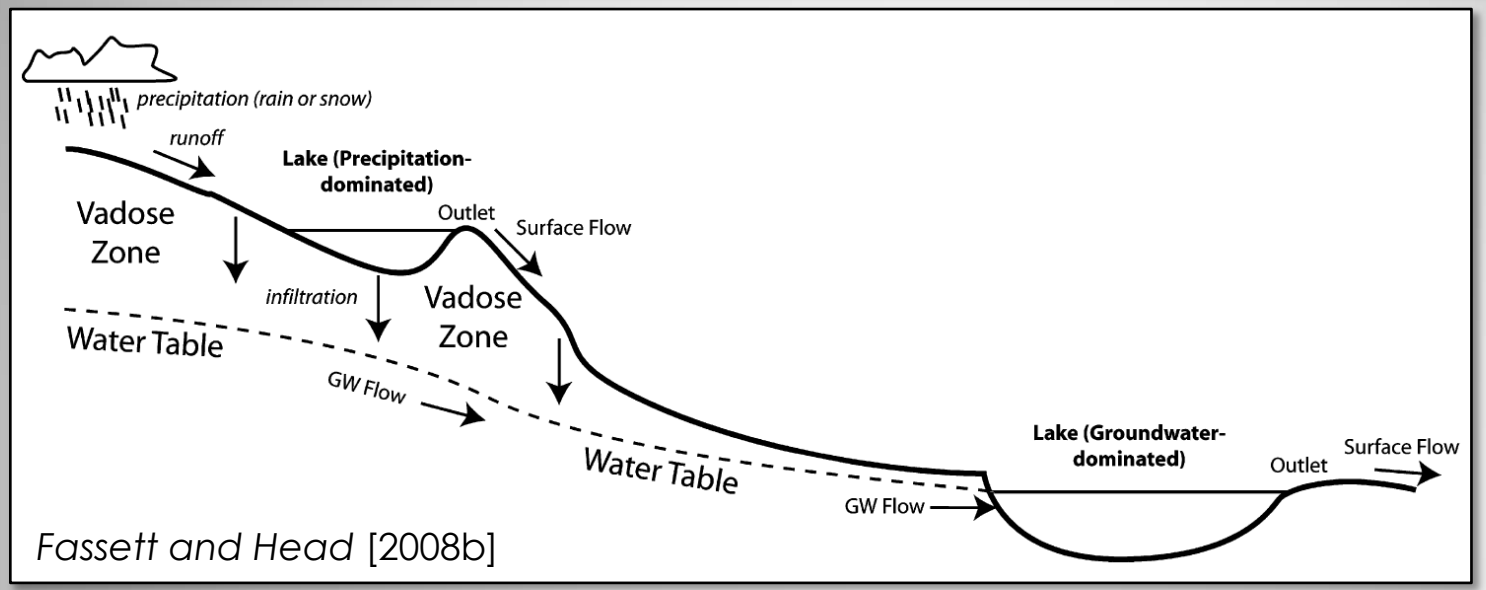
Delta environment provides geologic model for spatial distribution of channel properties. **Provides robust context for depositional environment.**

Fluvial stratigraphy records formative conditions of fluid flow and sediment transport in channels. **Provides a paleoenvironmental record of the martian surface, which can be linked to past climate.**

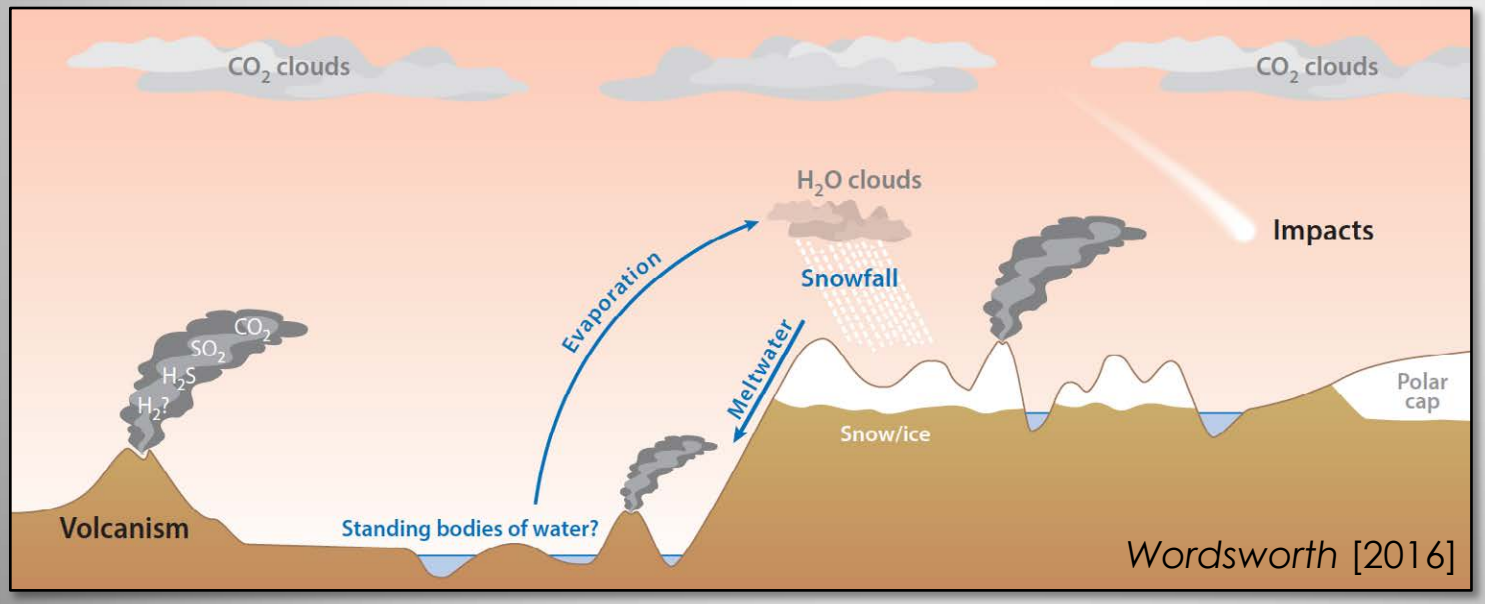


Yukon River Delta

Testing Paradigms for Early Mars Climate



Fassett and Head [2008b]



Wordsworth [2016]

Warm & Wet

Rainfall and surface runoff.

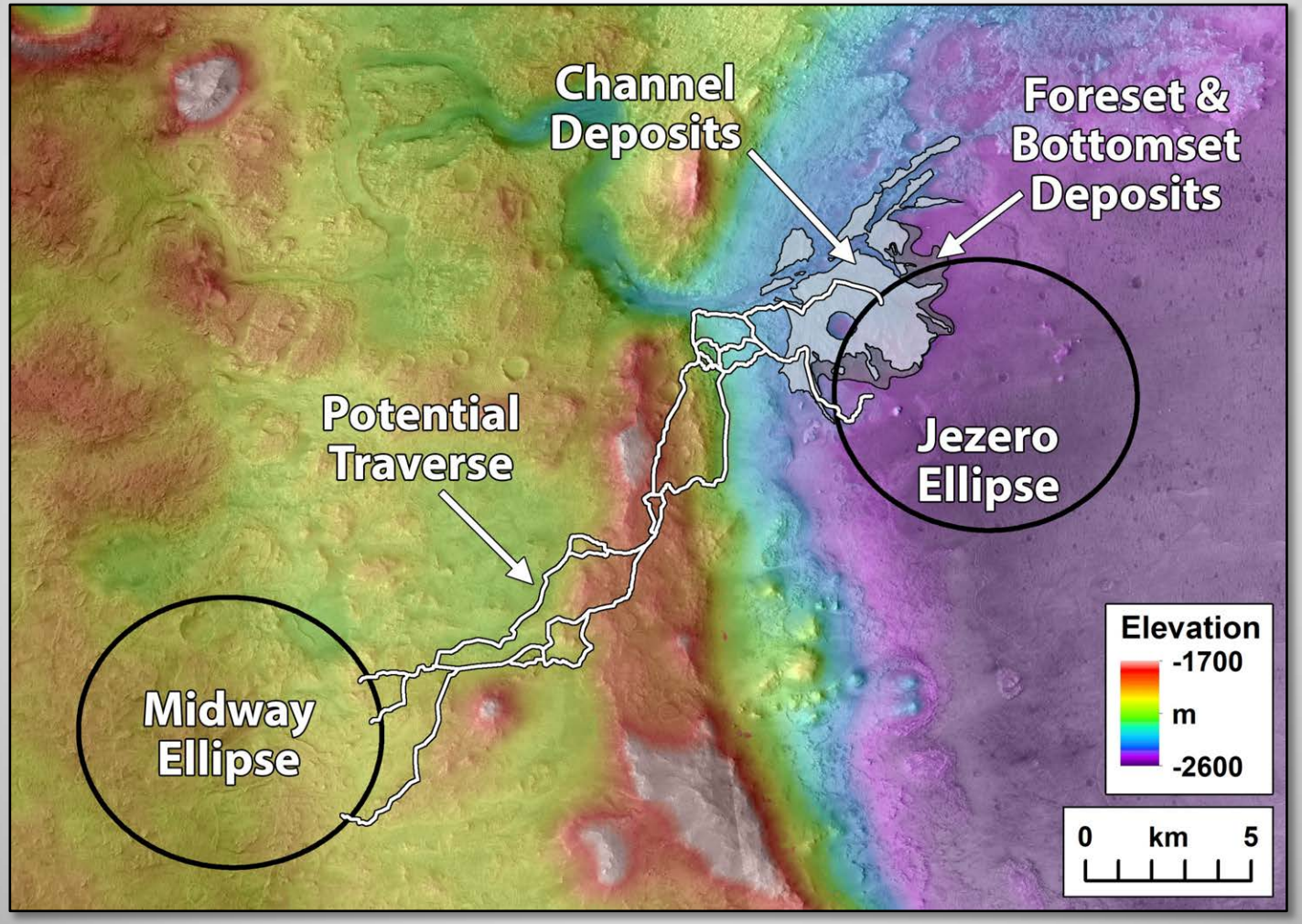
vs.

Cold & Icy

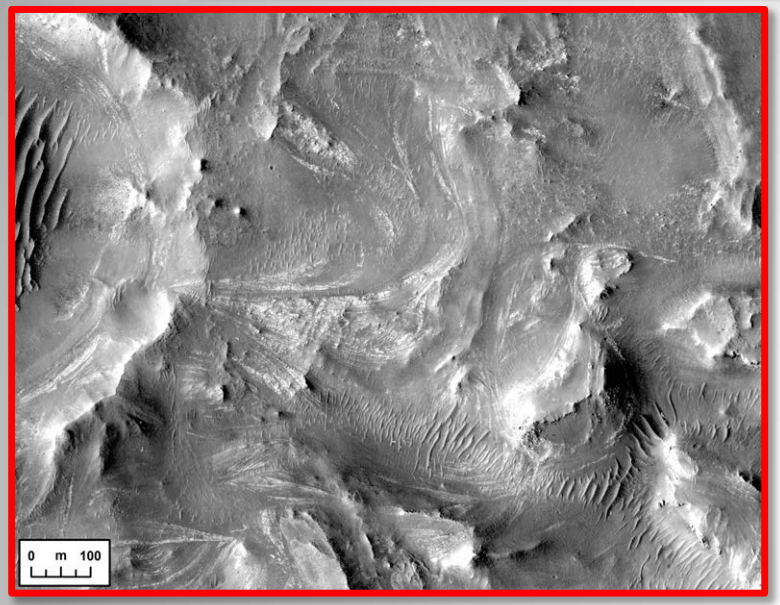
Snowfall and transient melting.

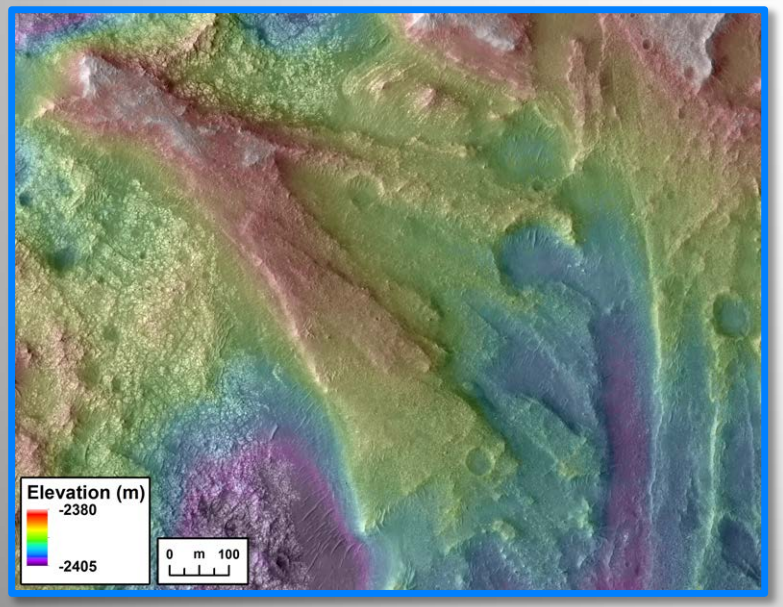
Where are Jezero channel deposits?

Delta channel stratigraphy accessible in newest ellipse and along traverse to Midway during extended mission.

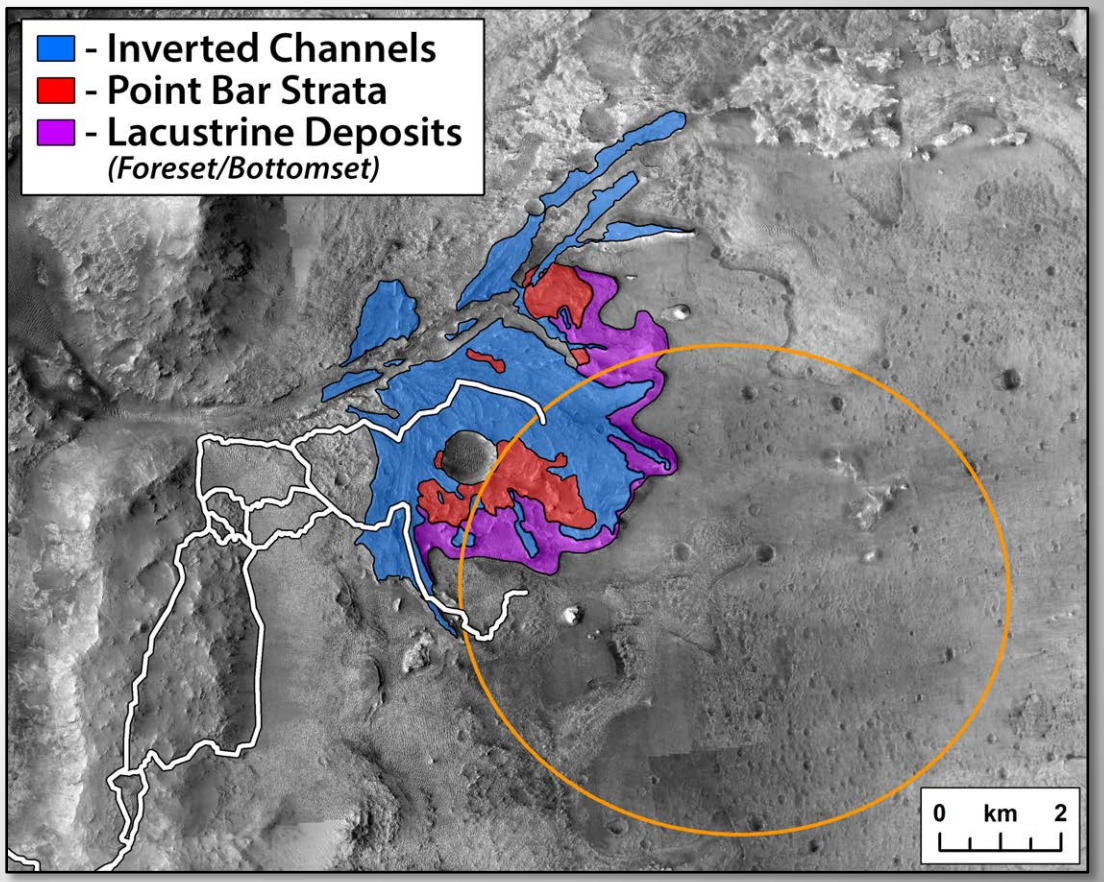


Delta Channel Stratigraphy



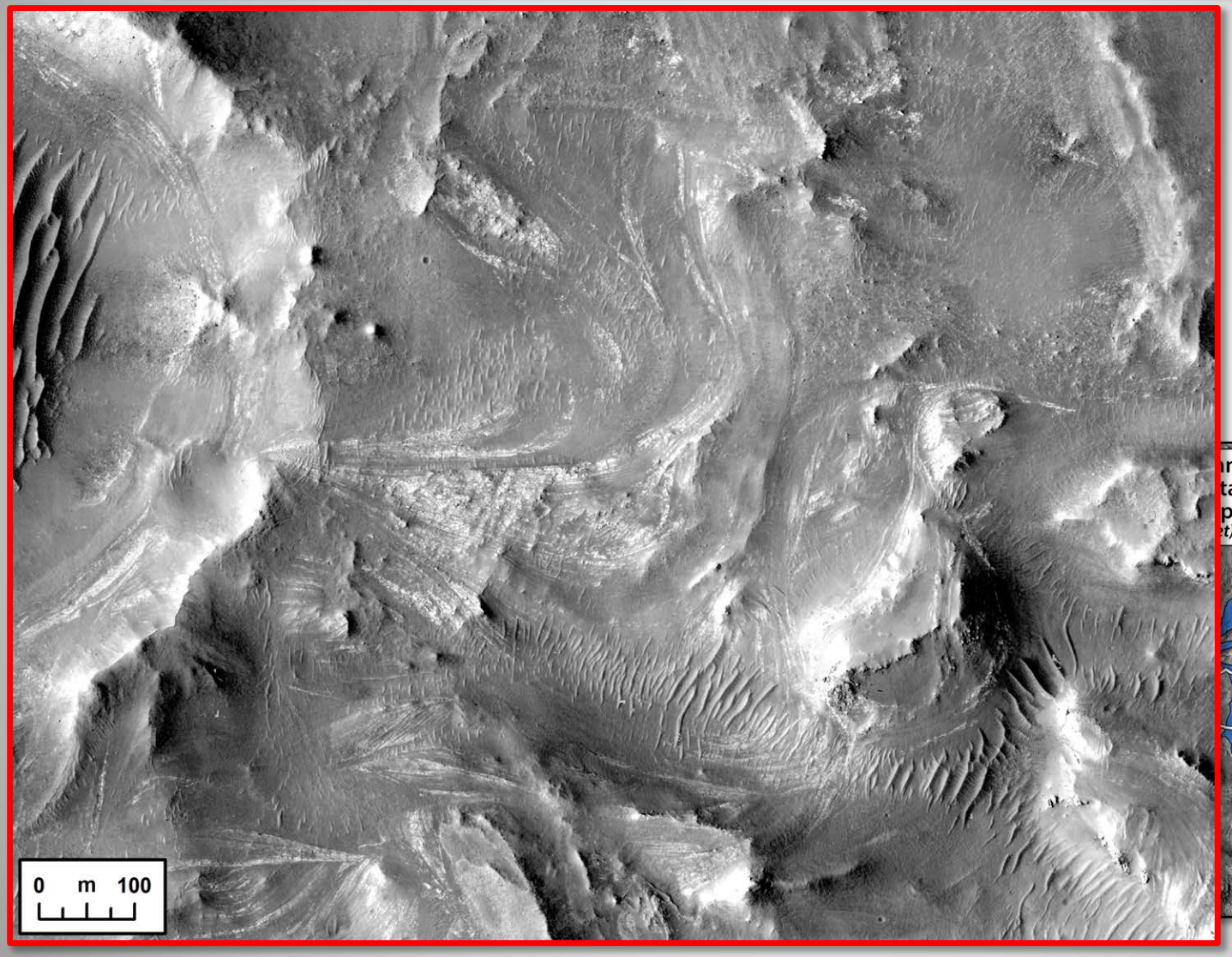


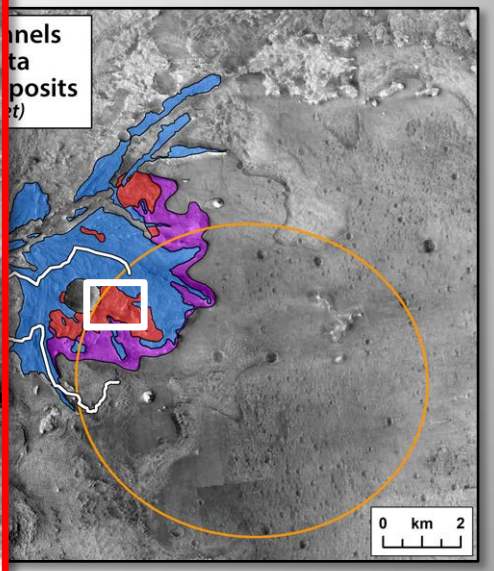
2 Classes of Channel Stratigraphy



Goudge et al. [2018]

Point Bar Strata





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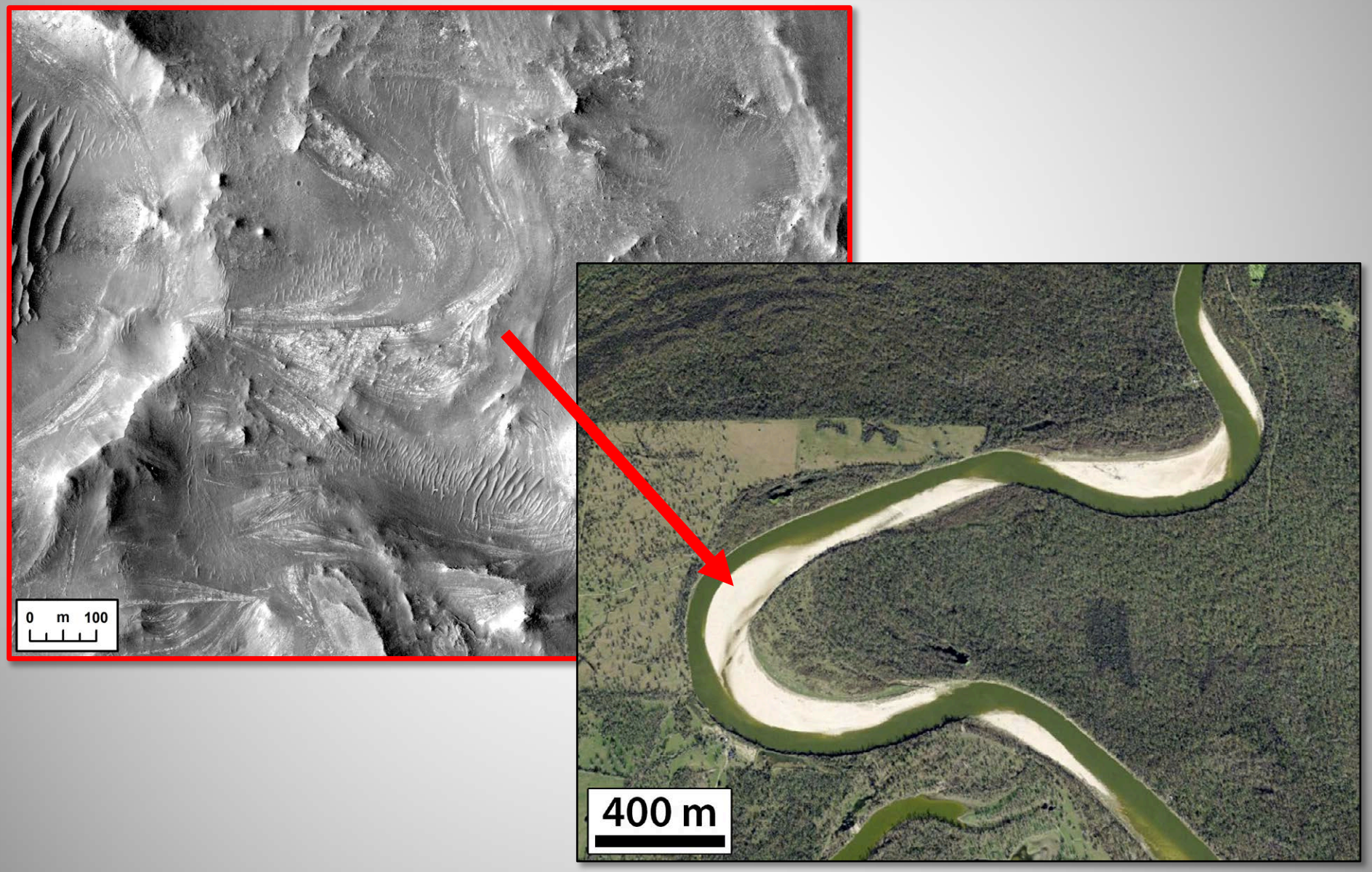

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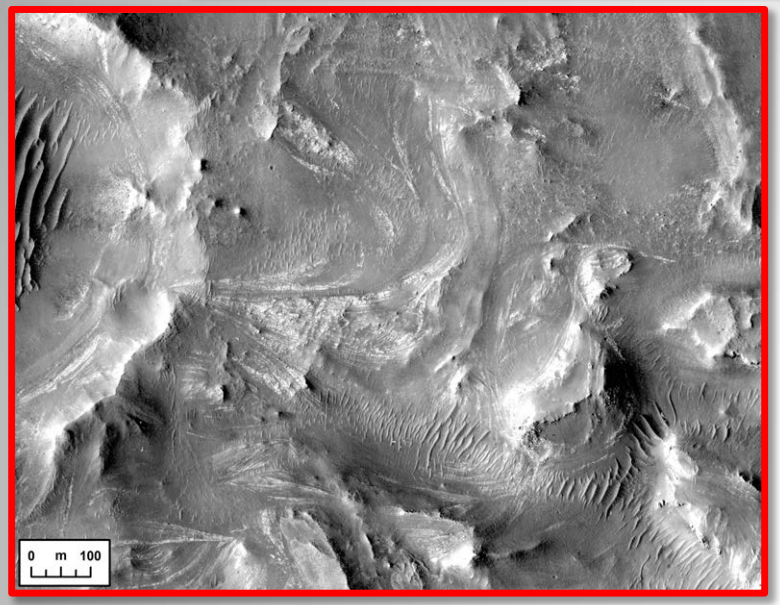

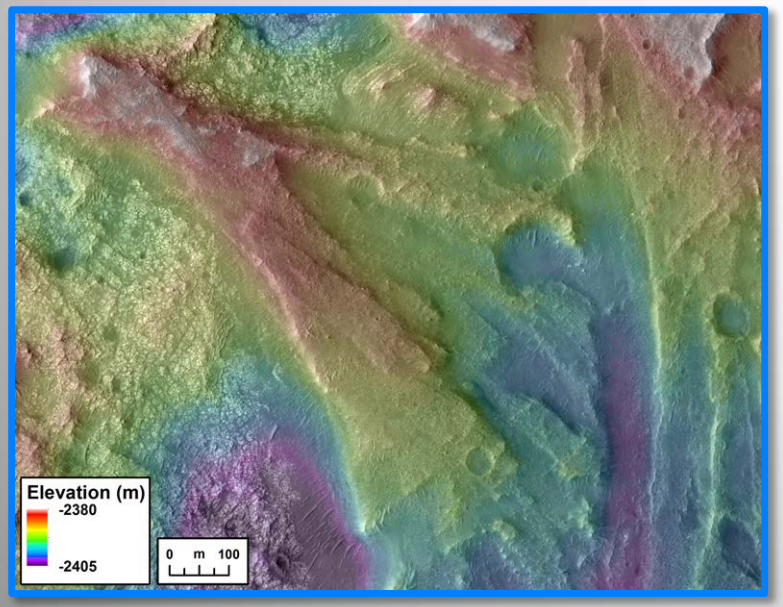

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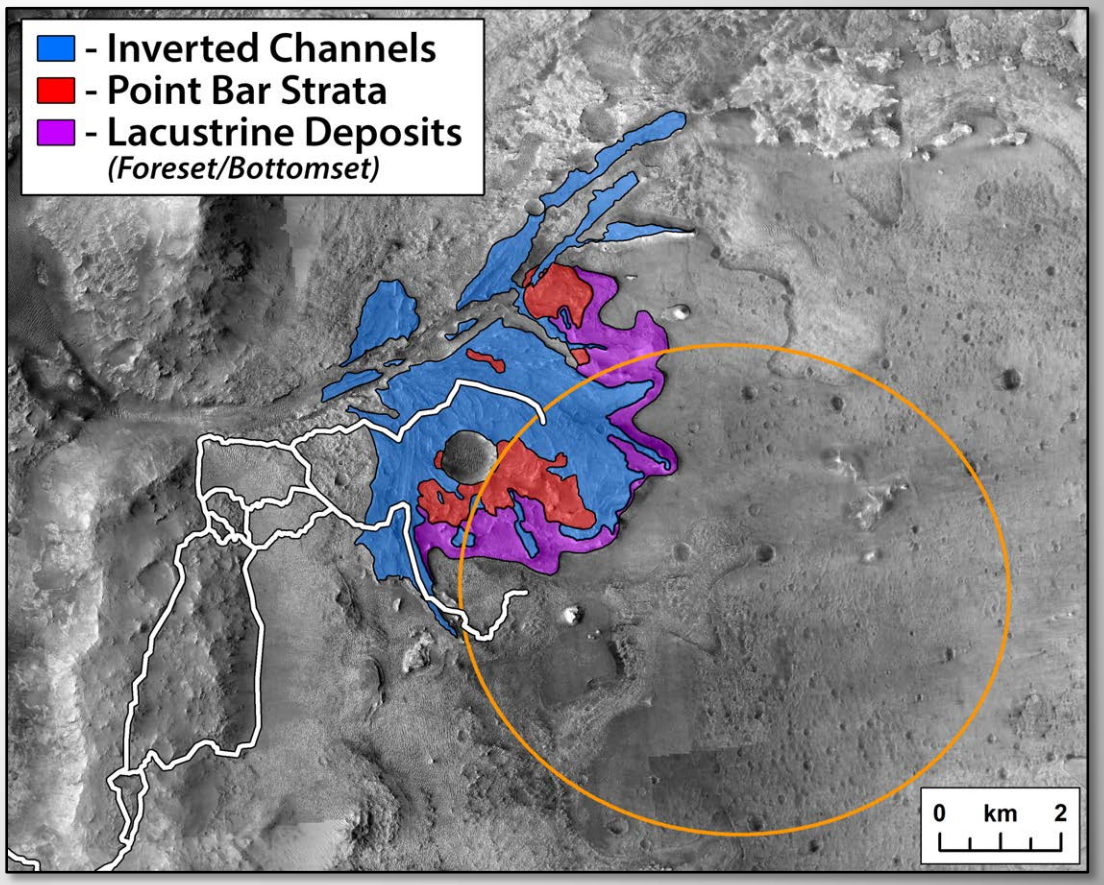
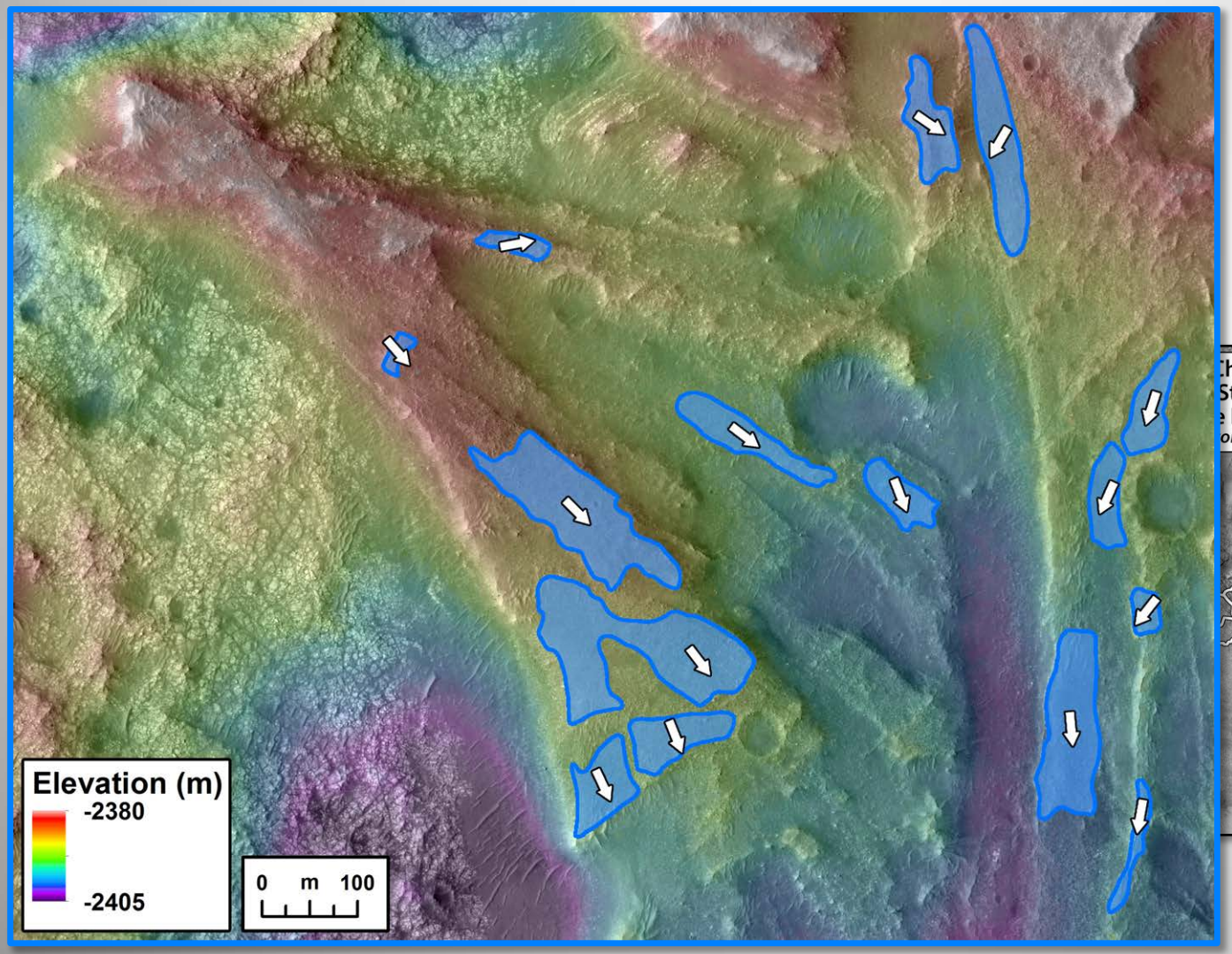
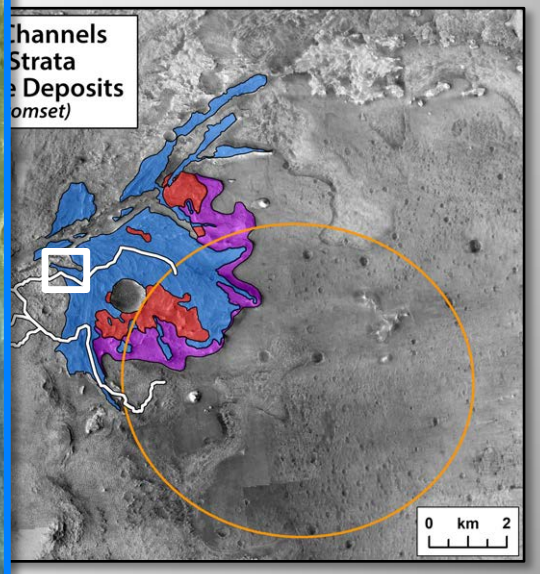
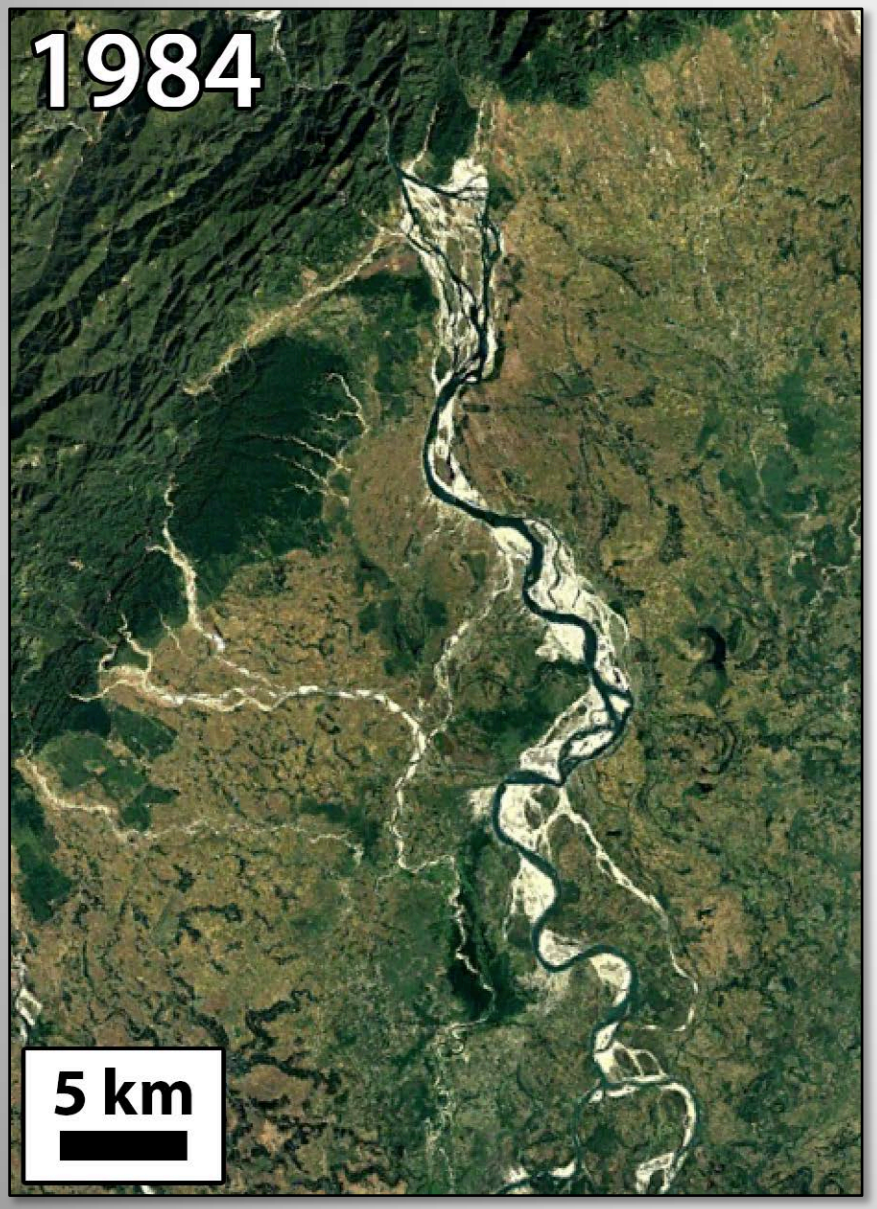


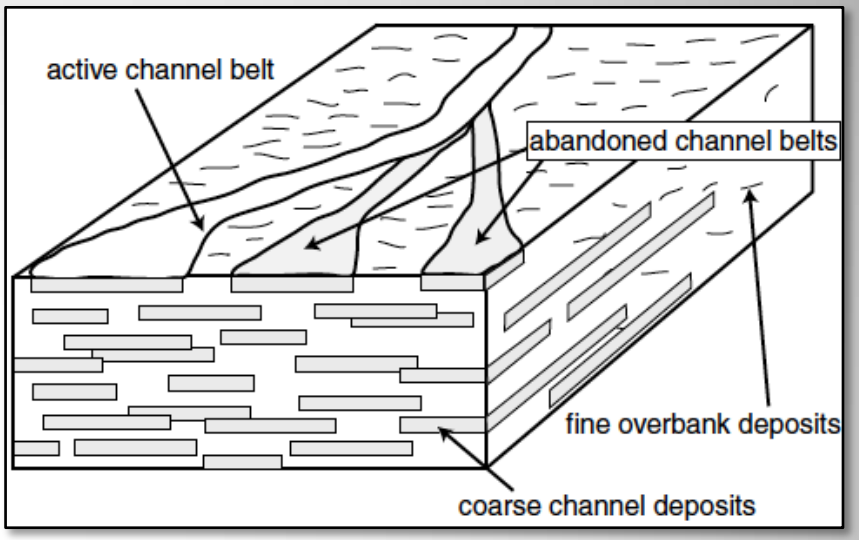
Inverted Channel Bodies





Avulsions + Channel Body Inversion





DiBiase et al. [2013]

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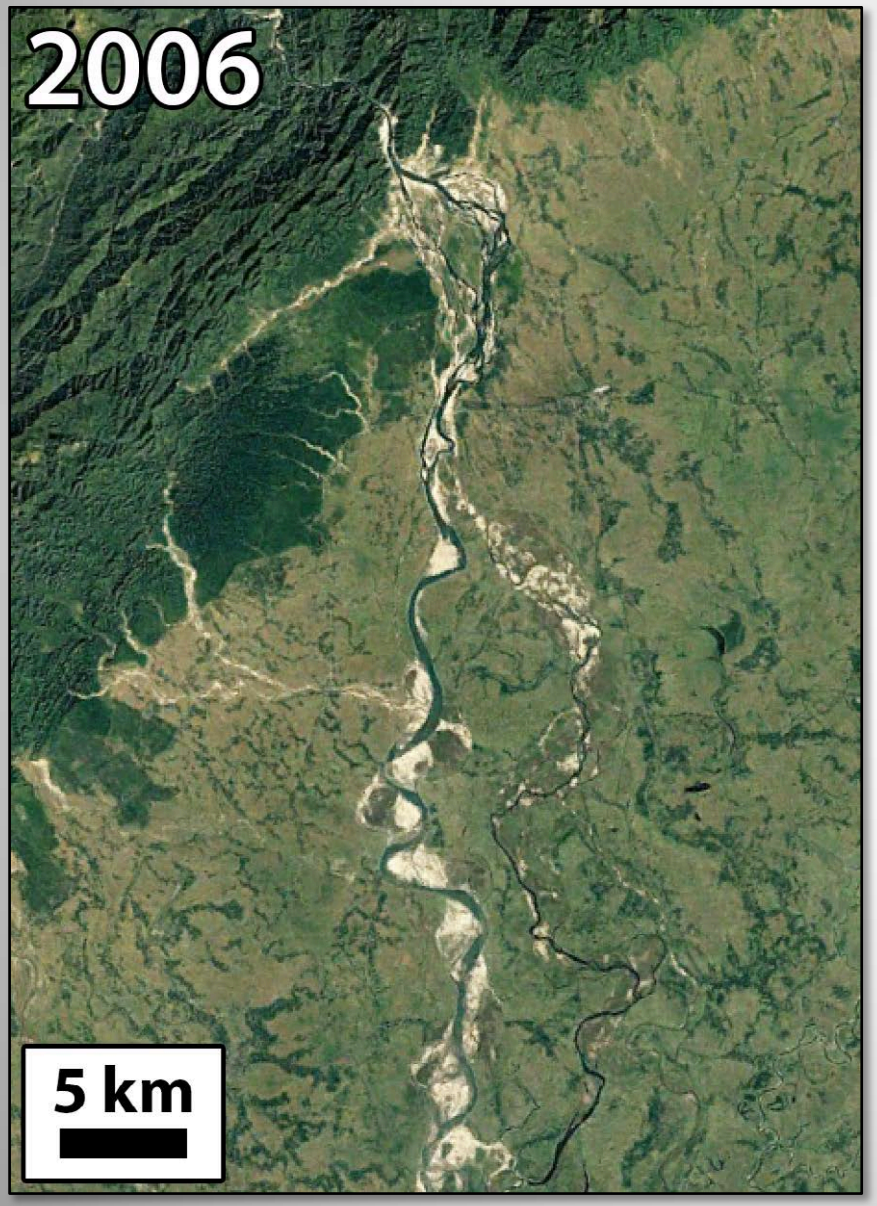

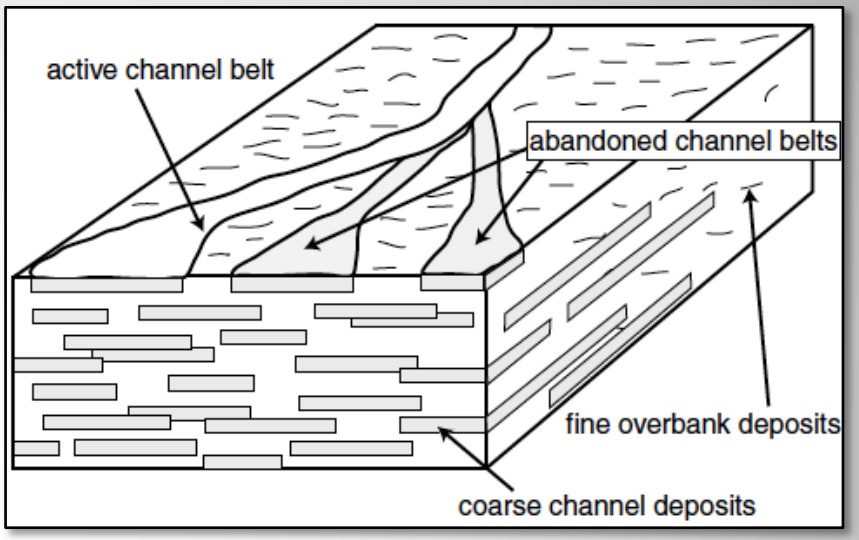

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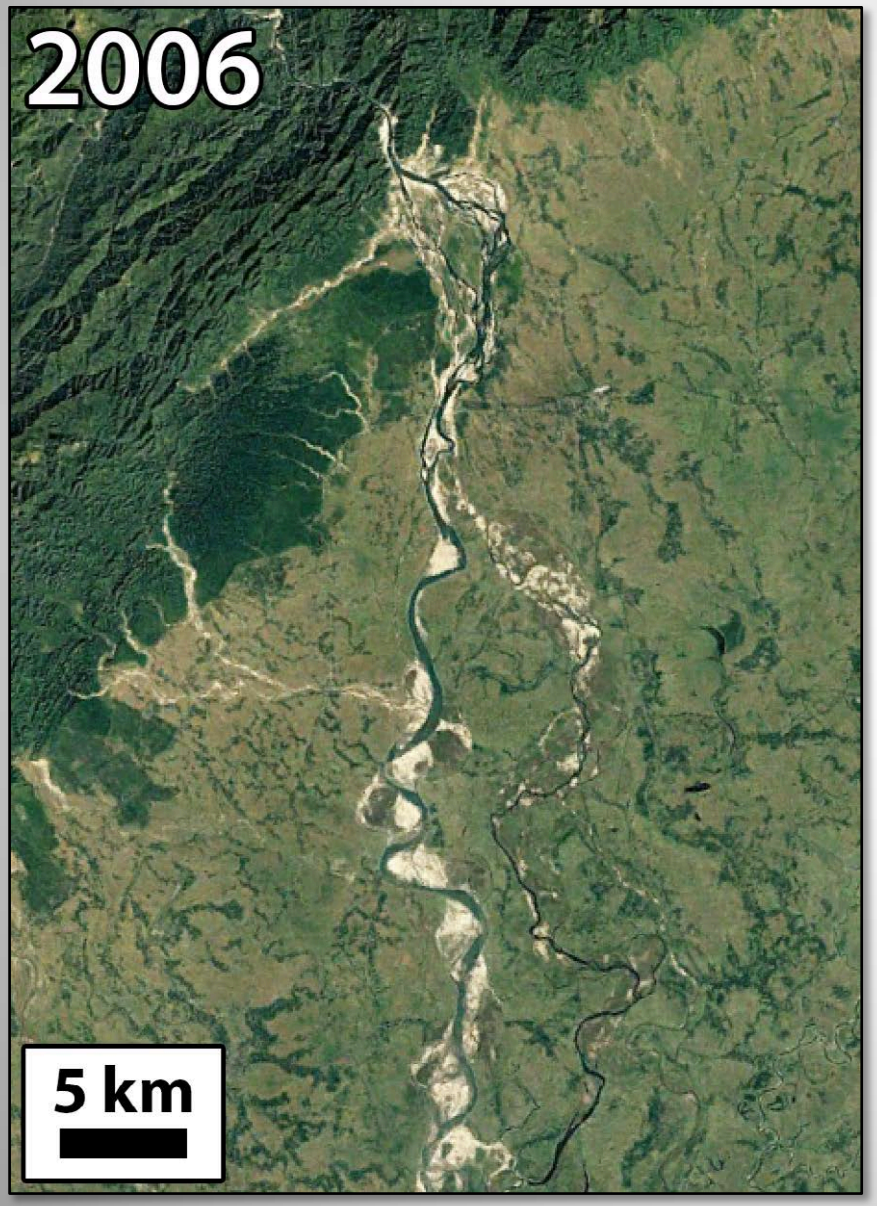

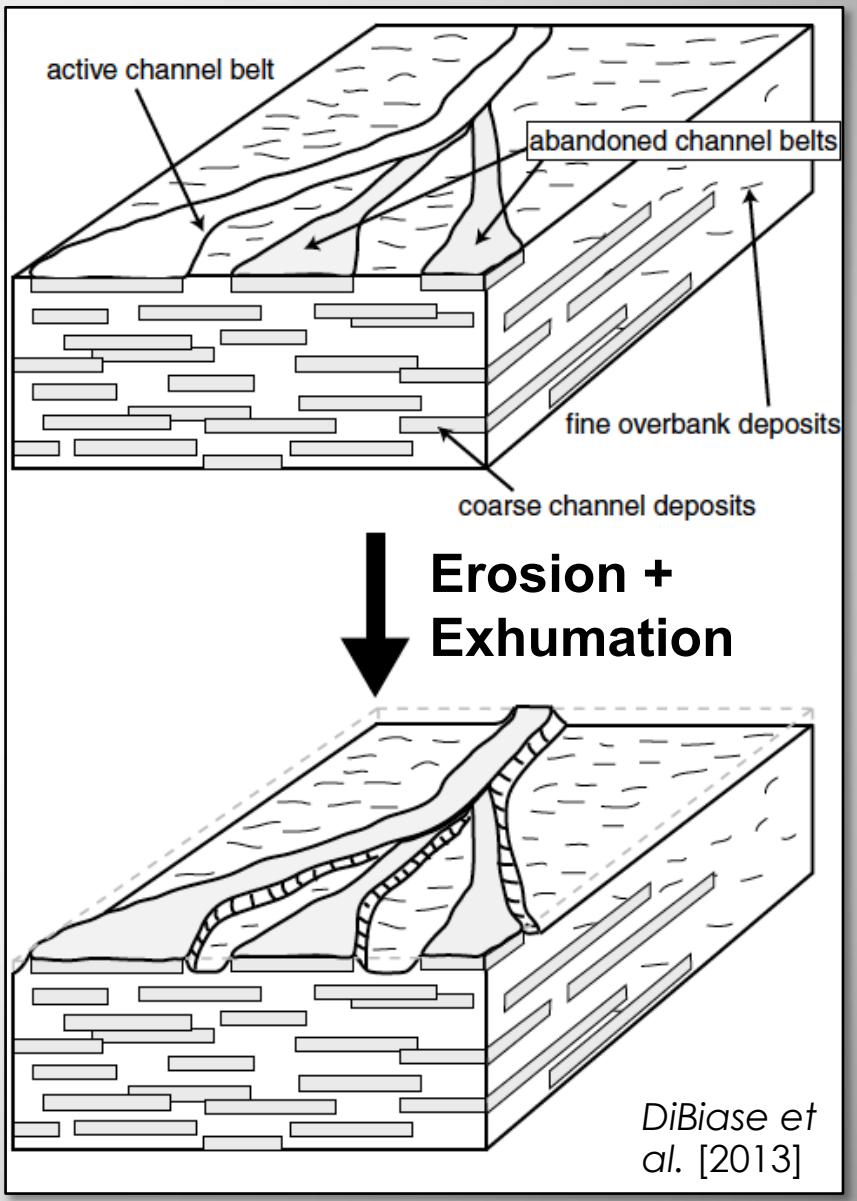

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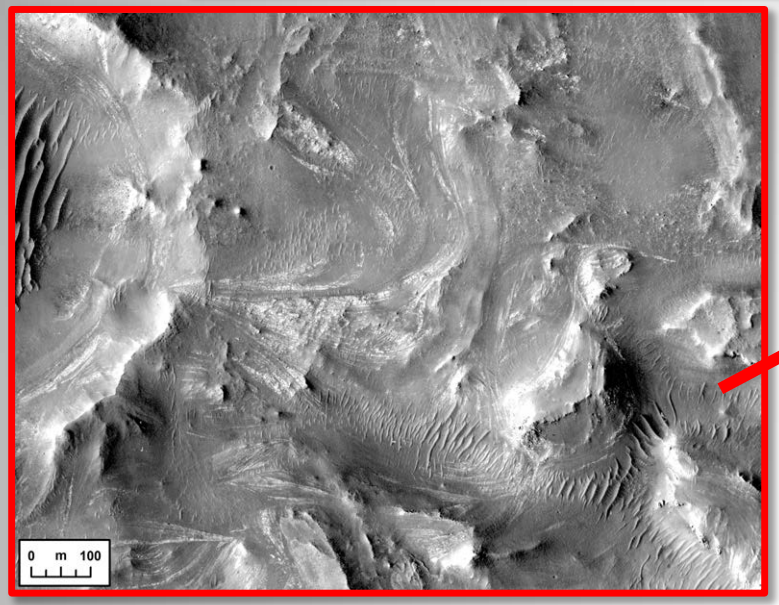

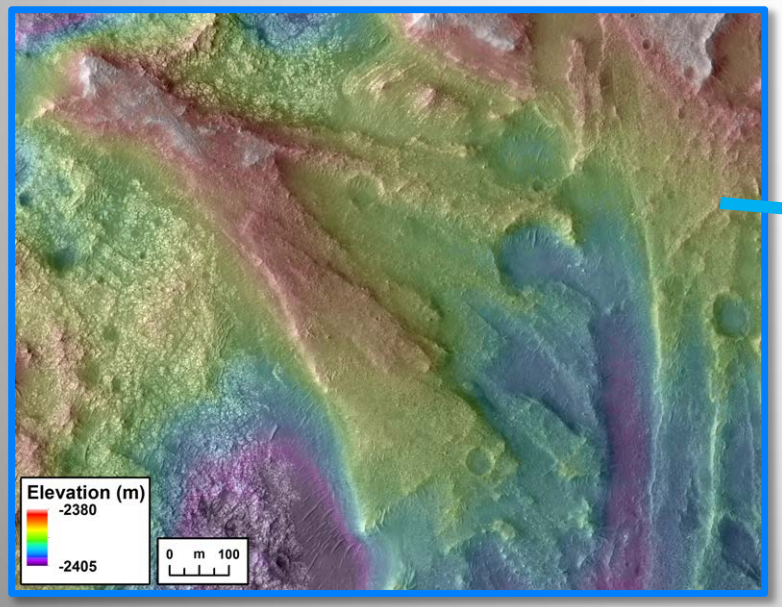

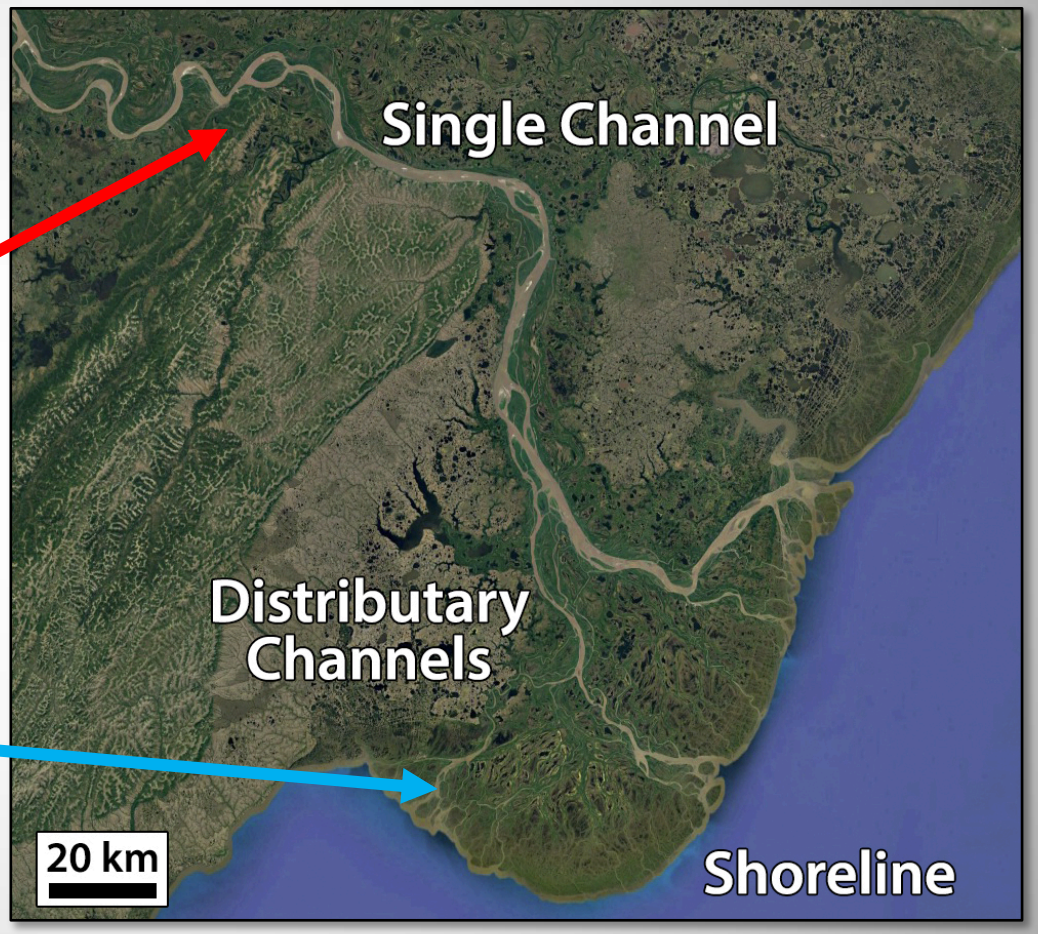

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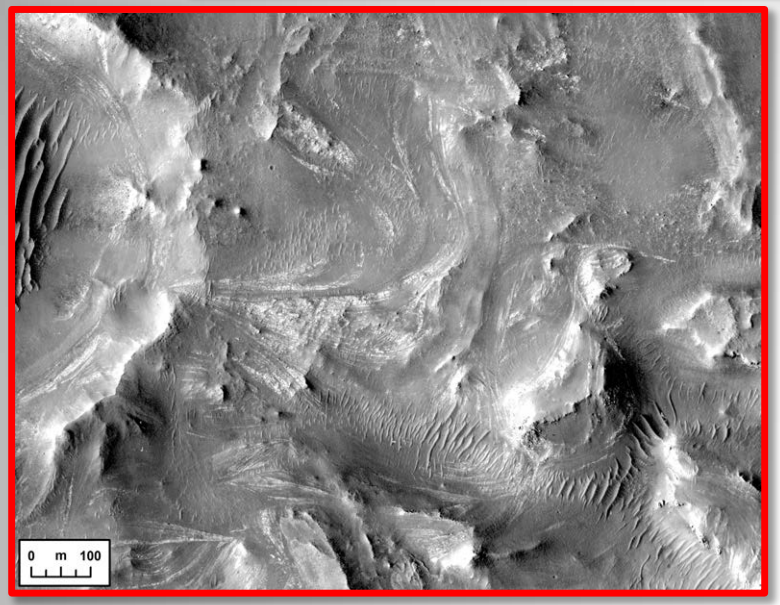
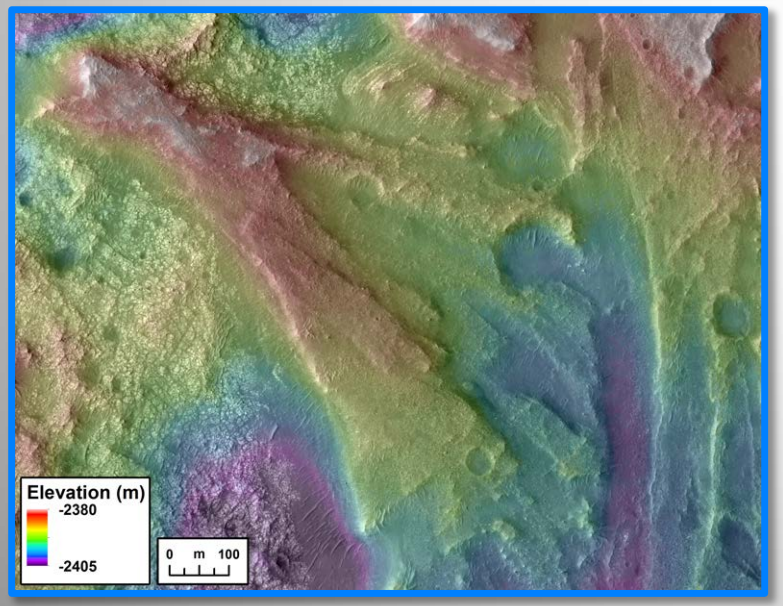
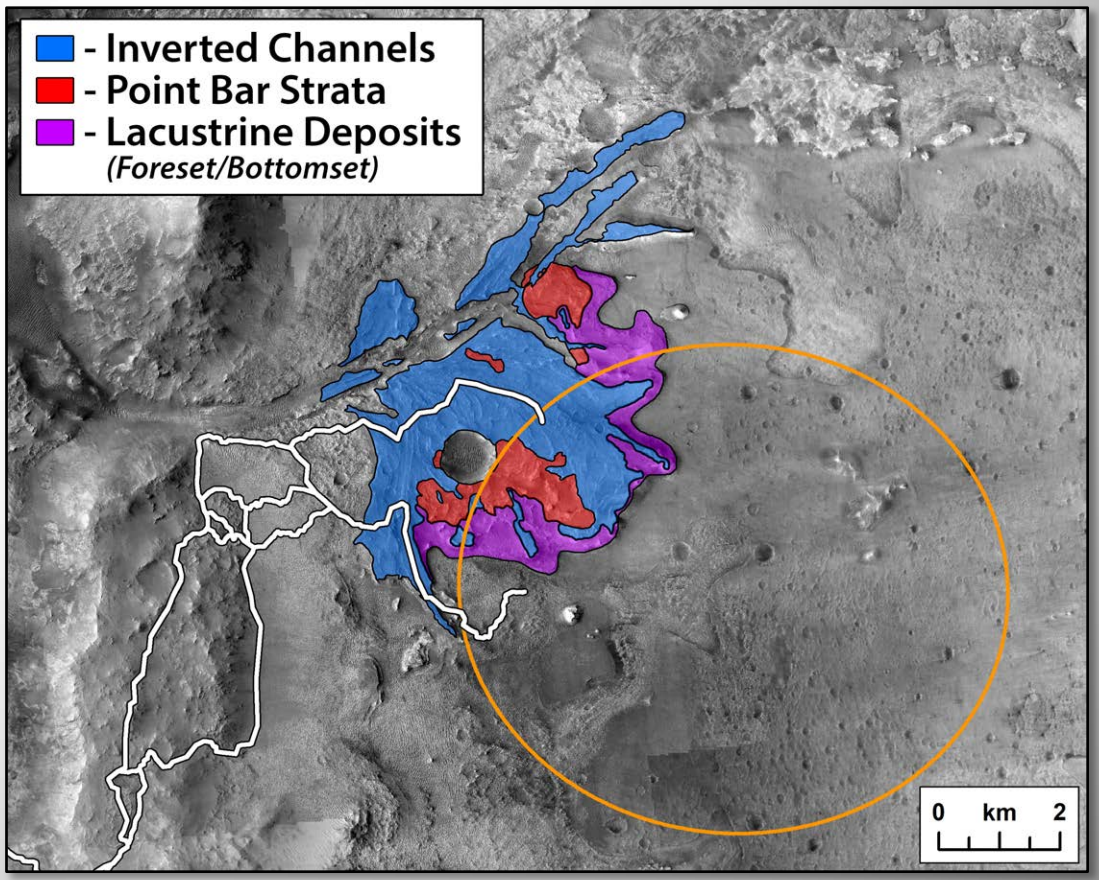




Context for stratigraphy is clear from orbit, what could be learned on ground?



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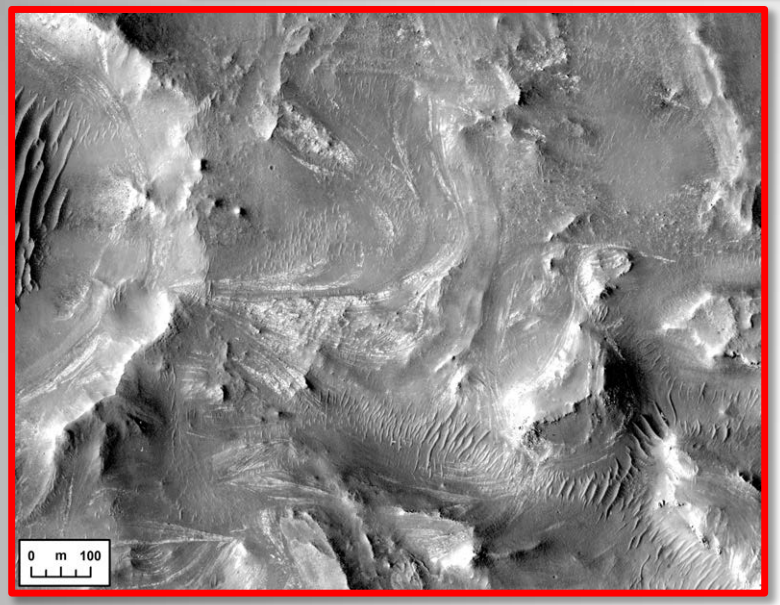

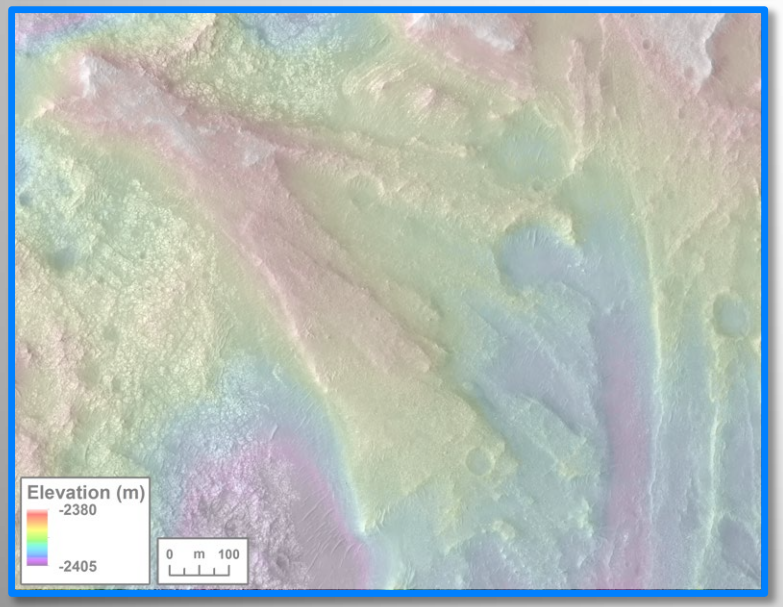

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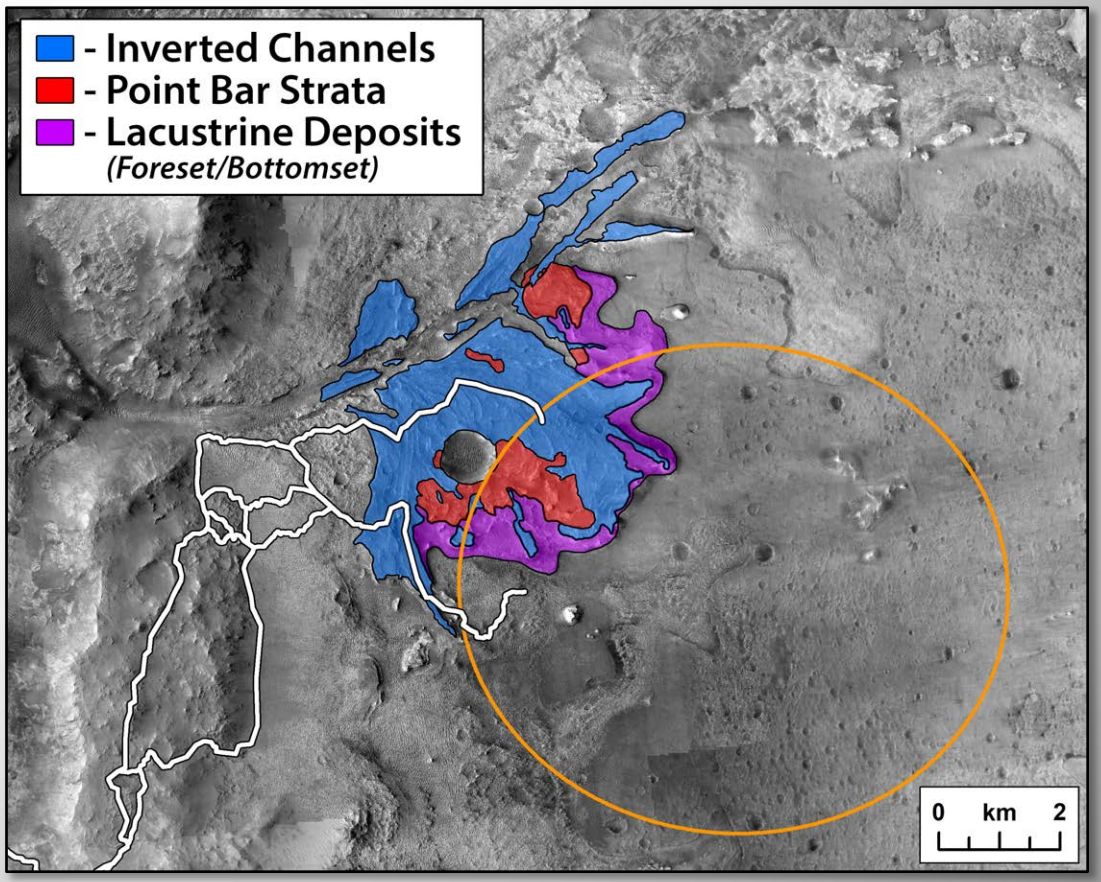
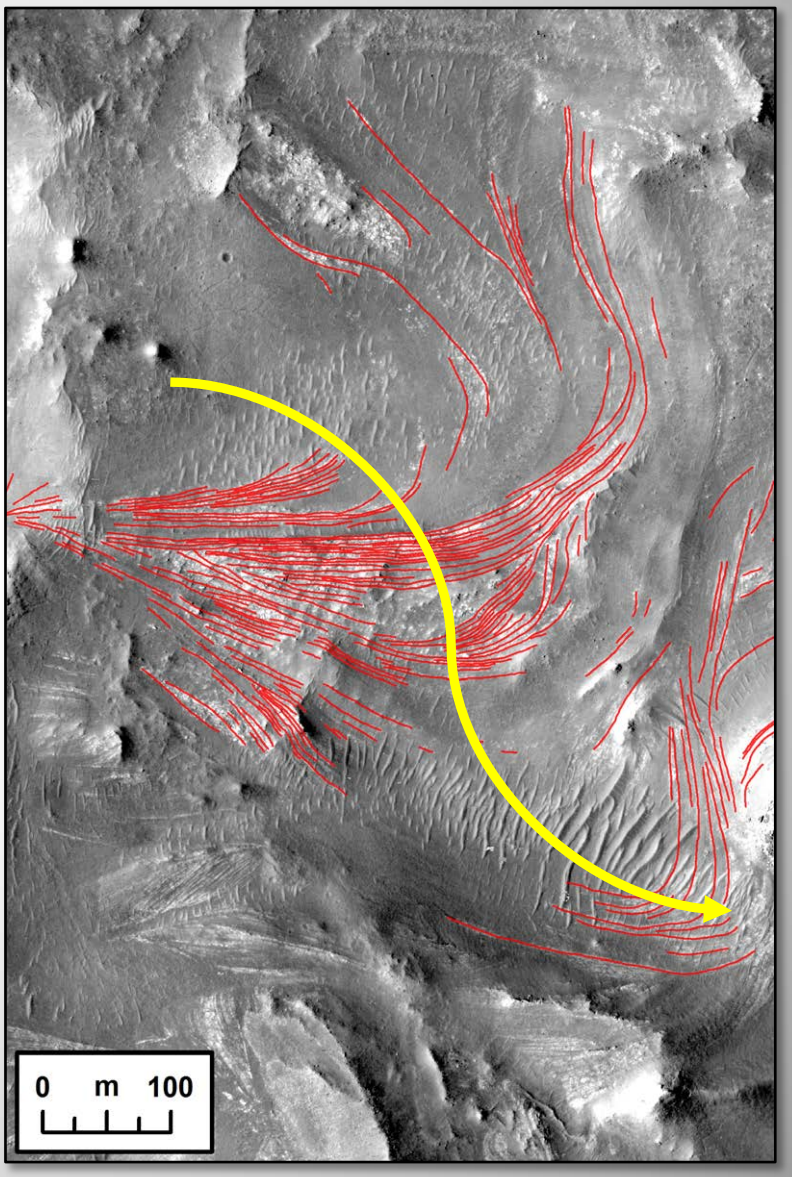


Point Bars Record Flooding History

- Coherent point bar packages record lateral migration of >500 m.
- Each point bar stratum represents one (or a few) flood events.
  [e.g., *Allen*, 1965; *Edwards et al.*, 1983]
- Strata in coherent packages are not separated by obvious signs of erosion.



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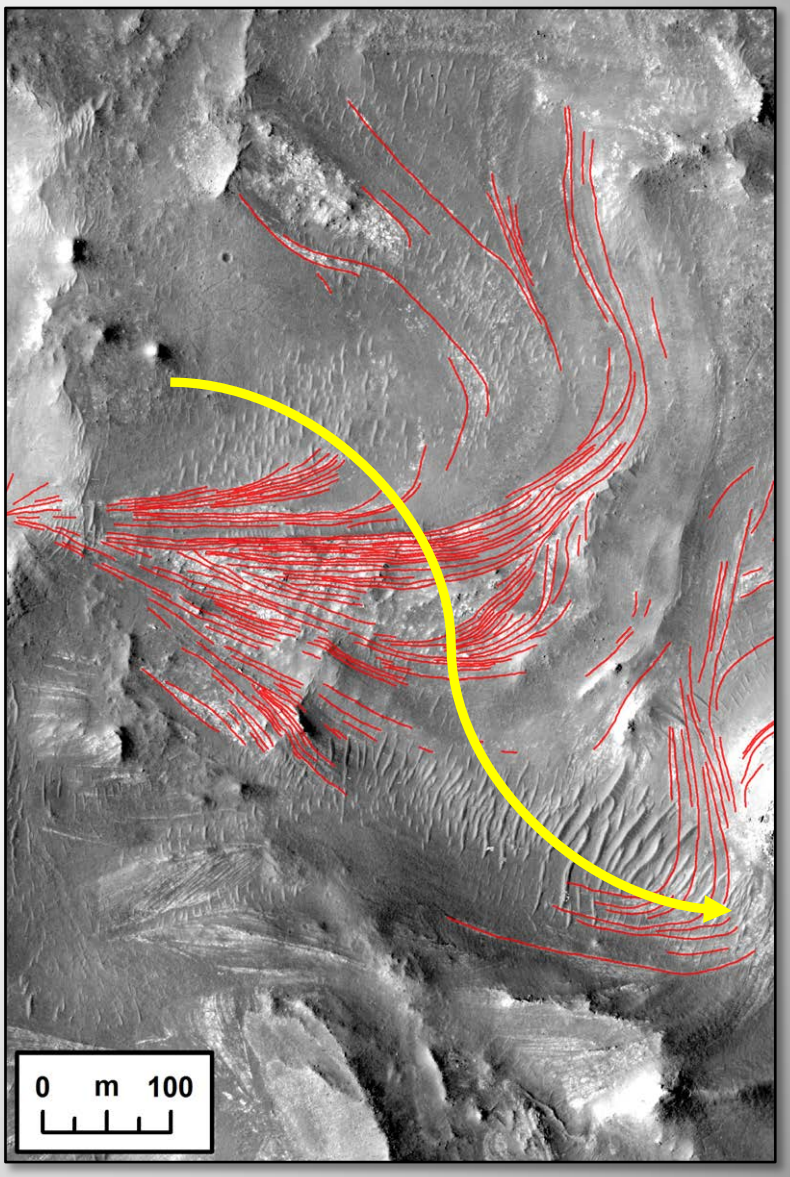
Further Testable Hypothesis and Questions:

- **Delta-forming climate experienced regional flooding at short timescales.** **[*Goudge et al.*, 2018]**
- What were magnitudes and recurrence intervals of channel-forming floods?
- What allowed for channel meandering on Mars in the absence of land plants? [e.g., *Matsubara et al.*, 2015]
- Is there evidence of ice reworking between floods?



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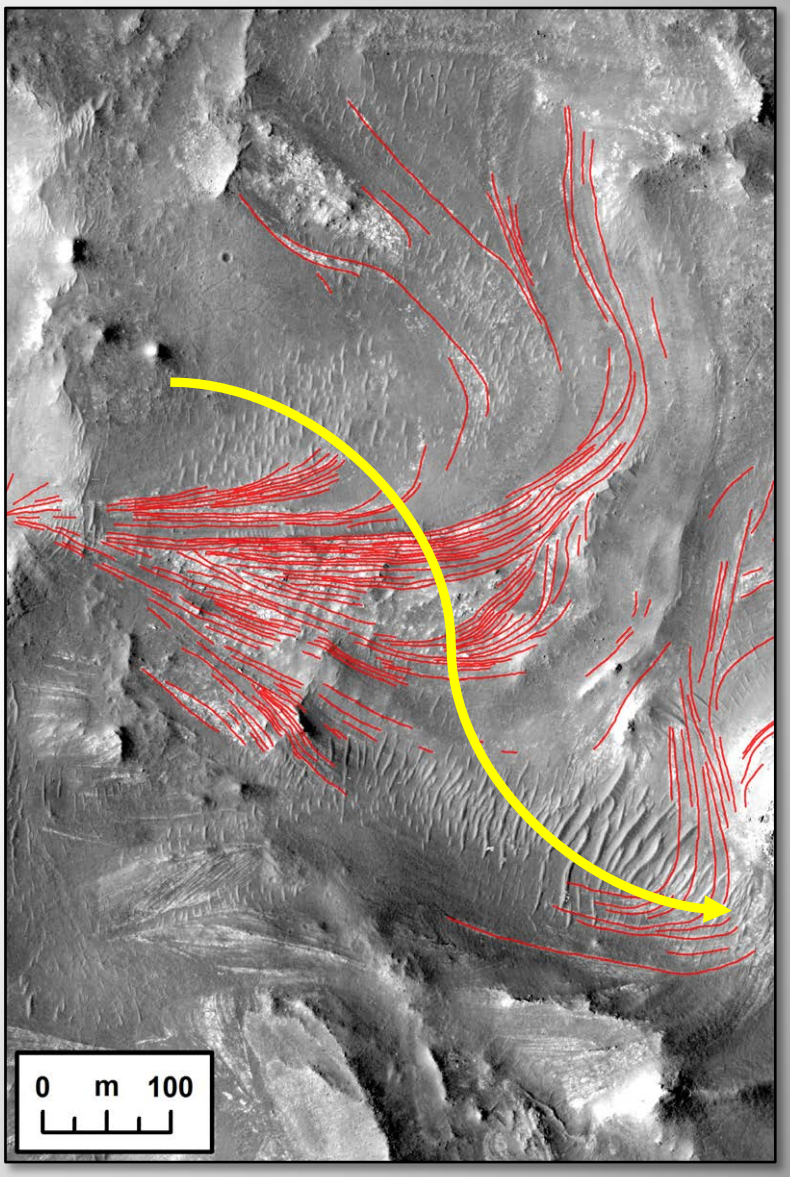

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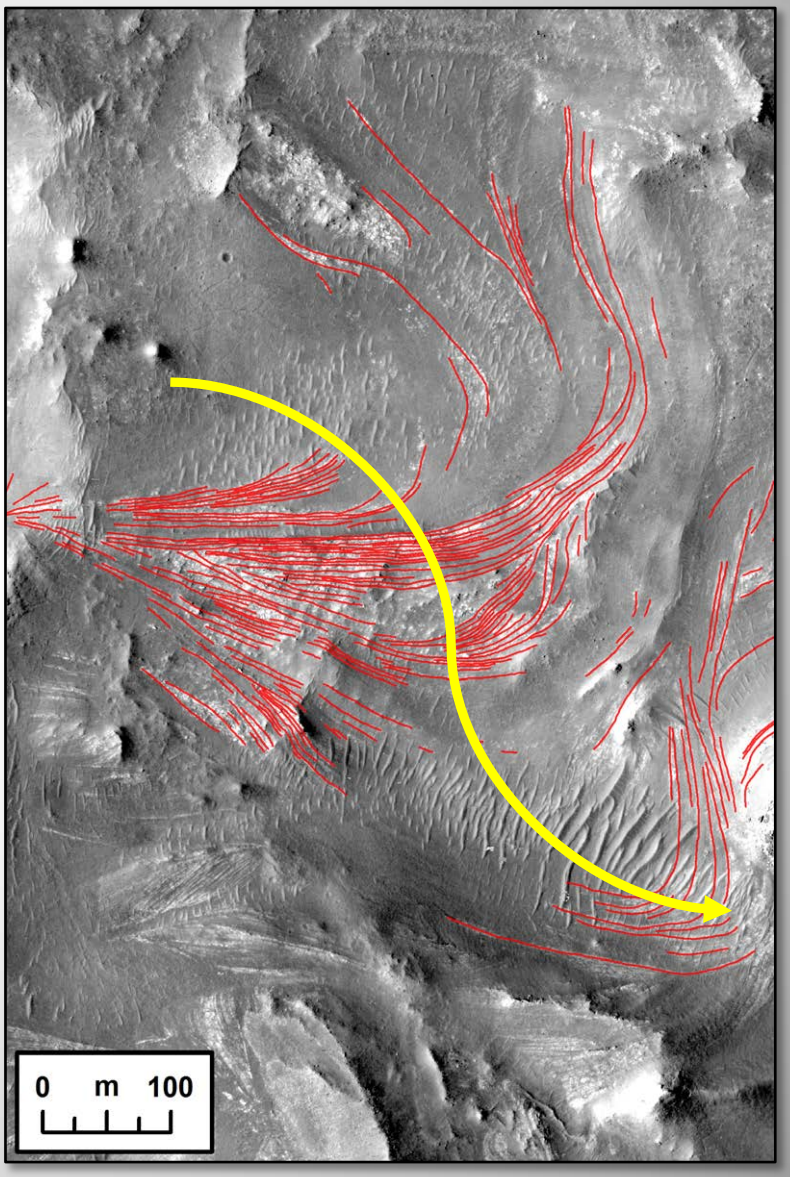

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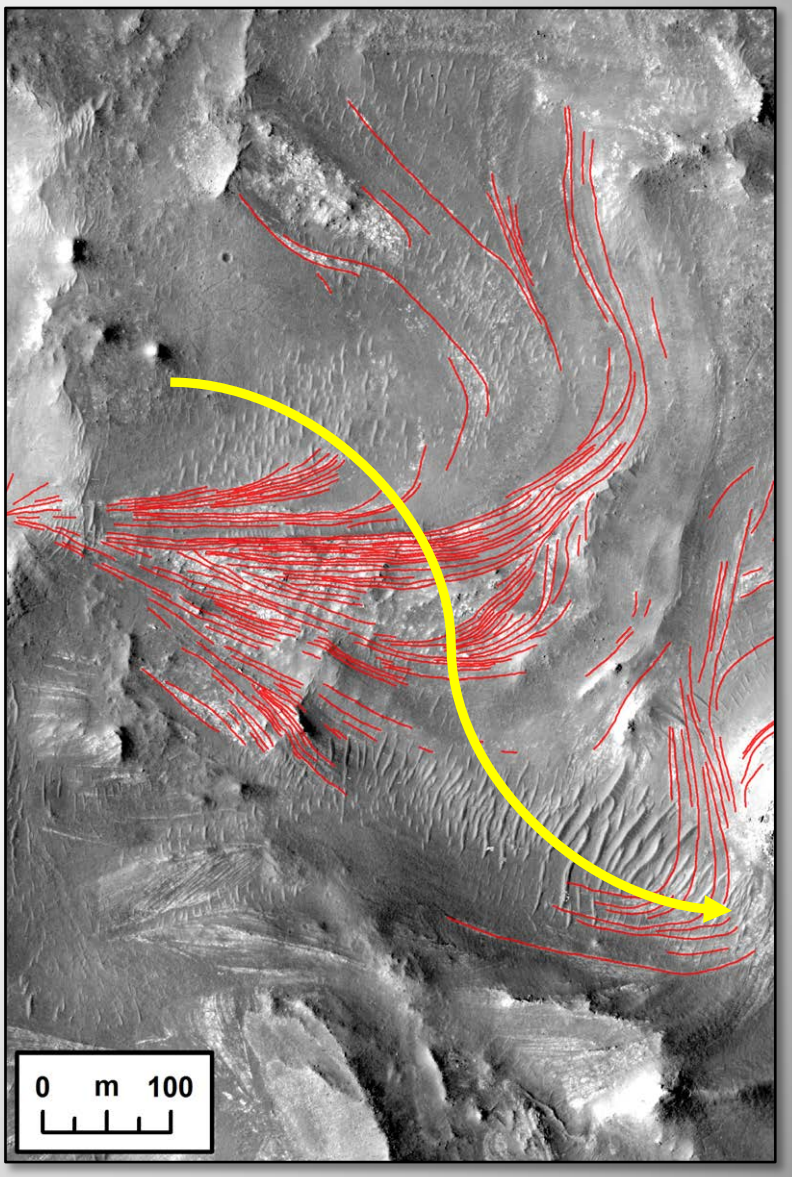
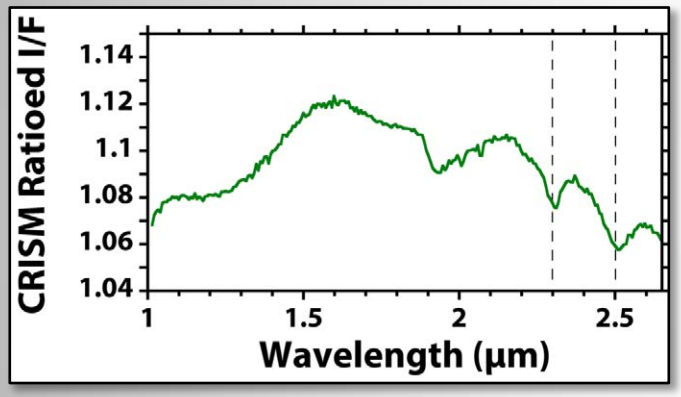


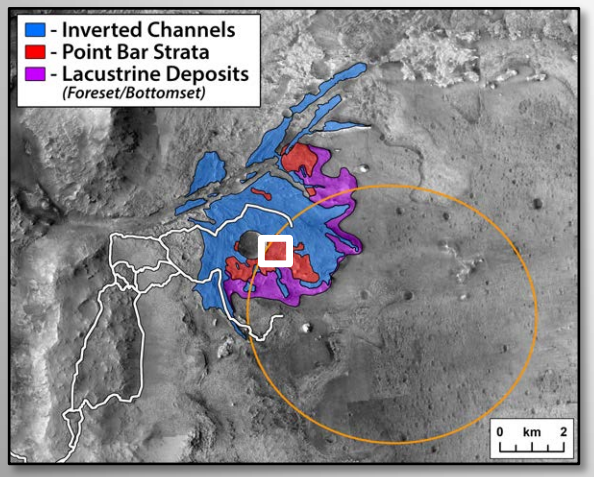
Carbonate-Rich Point Bar Strata

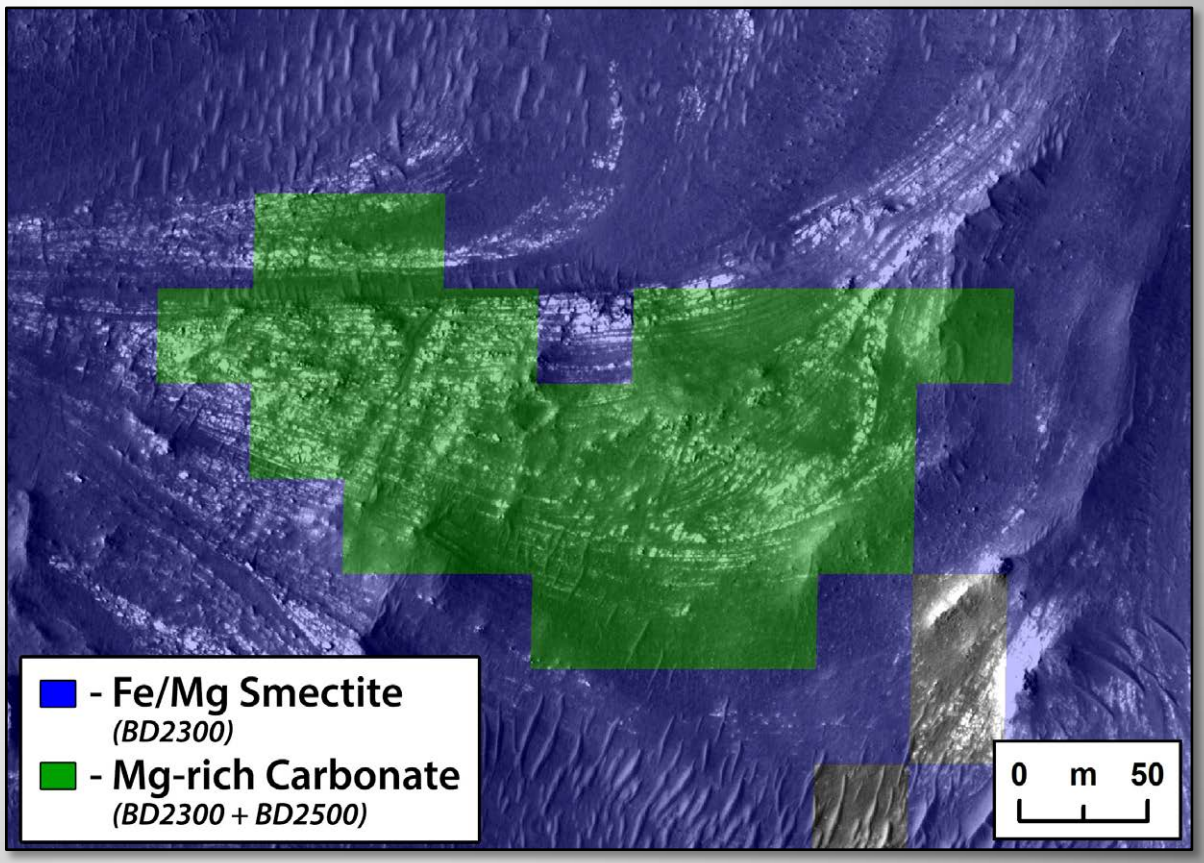
Point bar strata display strong carbonate signatures.

Testable Hypothesis: Point bar strata are cemented by carbonate.

Goudge et al. [2017]



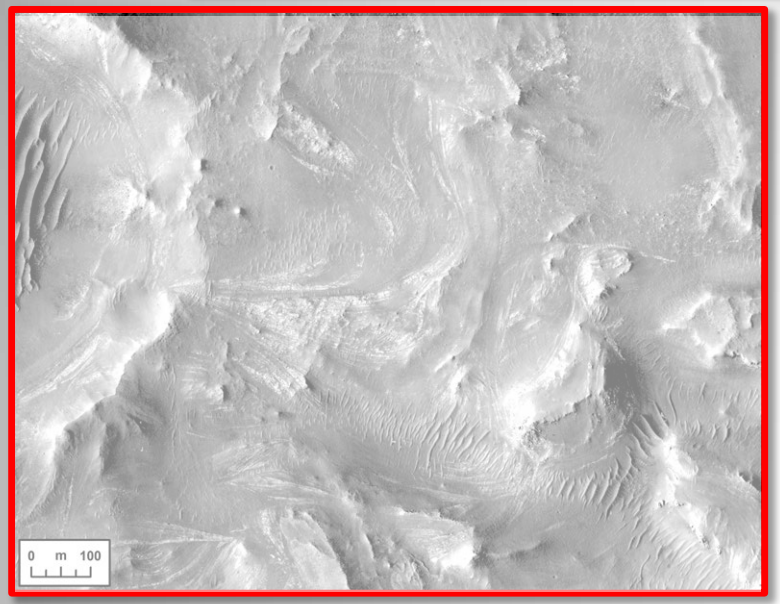


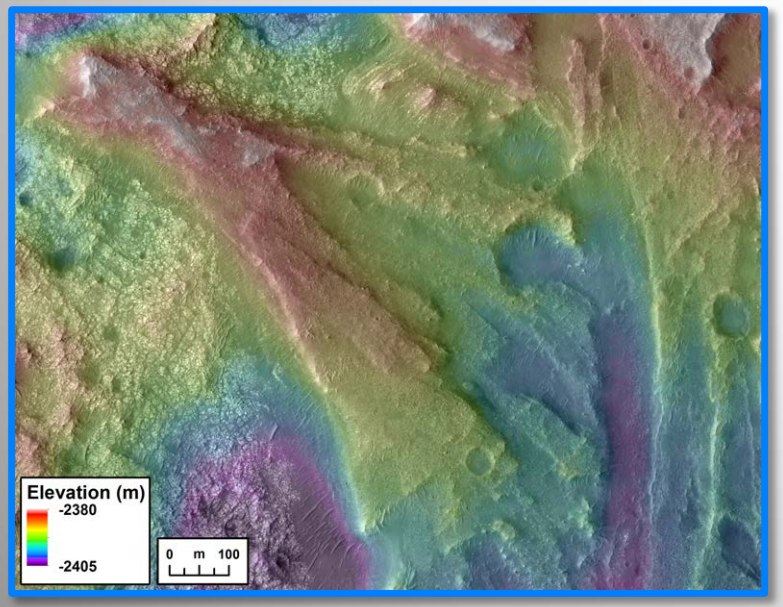


Carbonate in Multiple Contexts

- Jezero provides access to carbonate in at least two contexts: associated with point bar strata, and in basin fill [e.g., *Horgan et al.* & *Brown et al.* talks].
- **Analysis of carbonate (*in situ* and as returned samples) provides unique opportunity to study crucial aspects of early Mars environment** [e.g., *Niles et al.*, 2012; *Hallis et al.* talk], **including:**
  - Martian carbon reservoirs.
  - Past fluid geochemistry.
  - Atmospheric chemistry and evolution.
  - Surface-atmospheric coupling, including temperature of carbonate precipitation [e.g., *Halevy et al.*, 2011].

Inverted Channel Deposits





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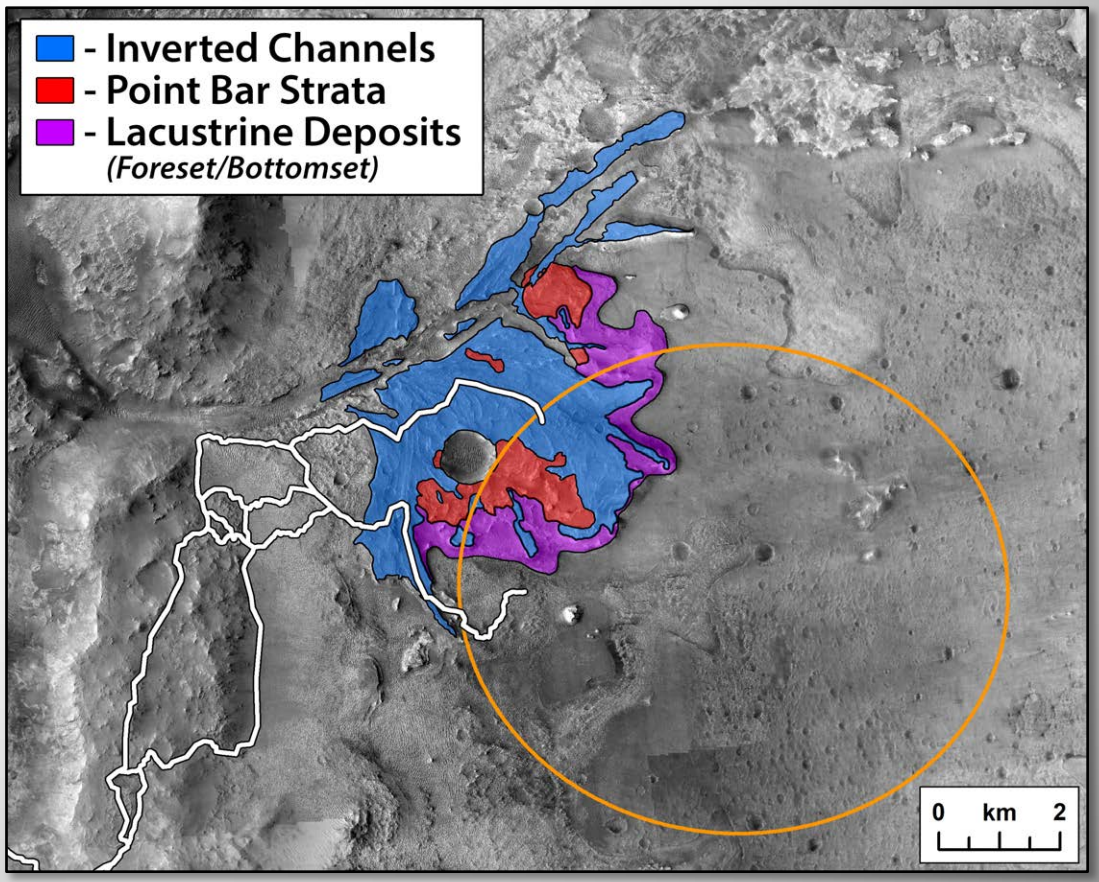
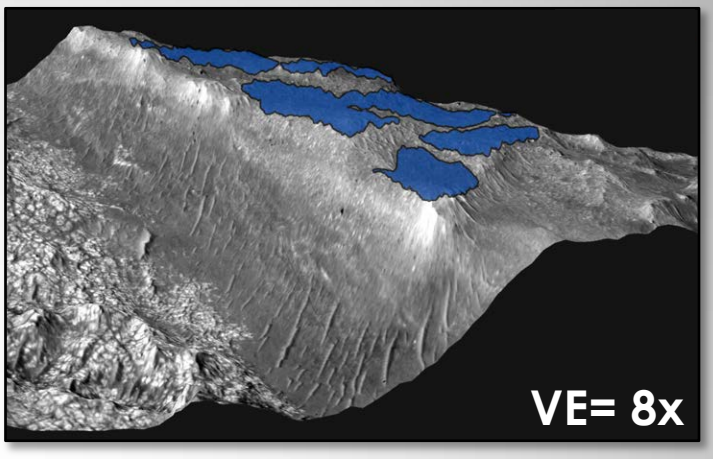
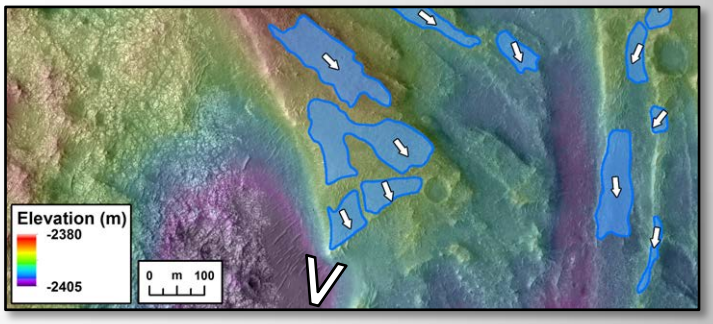
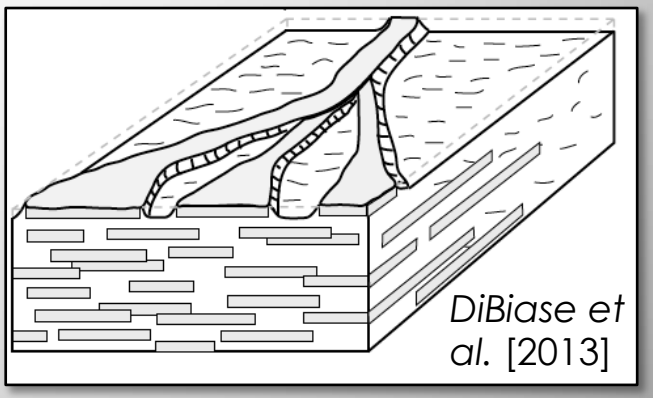


Channel Bodies are Stacked

- Ridges are composed of multiple stacked channel bodies.
- Channels preferentially occupied same locations on delta.
  [*Mohrig et al.*, 2000; *Edmonds et al.*, 2006]
- Channel bodies are separated by fine-grained floodplain strata.
  [e.g., *Mohrig et al.*, 2000]



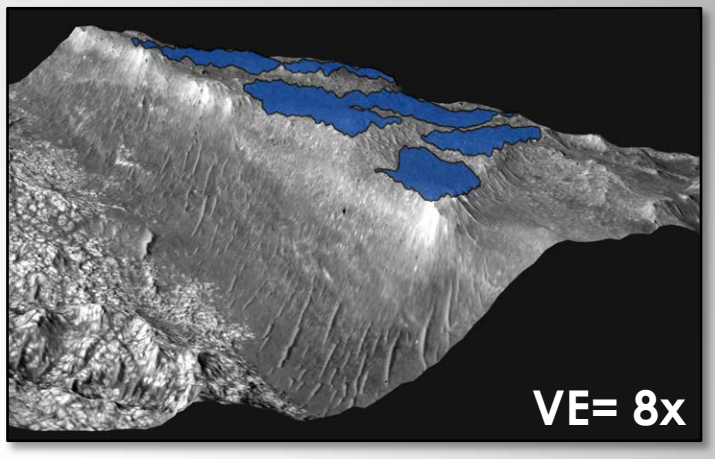


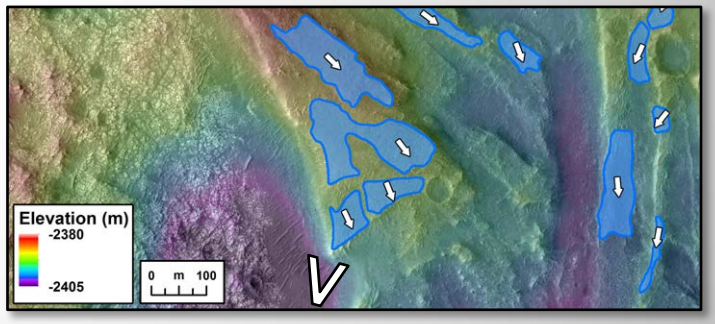


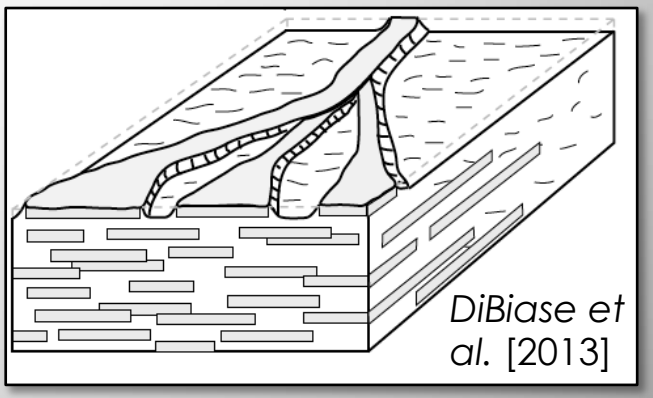
Channel Bodies are Stacked

Further Testable Hypothesis and Questions:

- **How do flow estimates compare with point bar strata? *Gives idea of flow partitioning.* [*Goudge et al.*, 2018]**
- What was relative frequency of channel reoccupation?
- What is cementing agent? *Must provide sufficient strength for topographic inversion.*
- Is there evidence of interaction with ice cover near shoreline? Waves?







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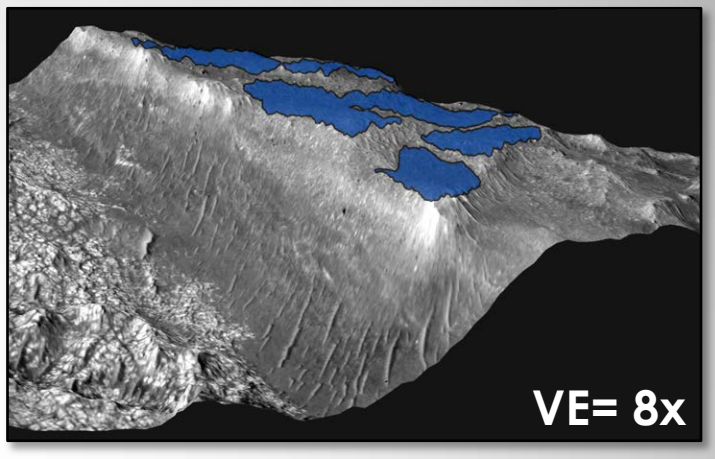
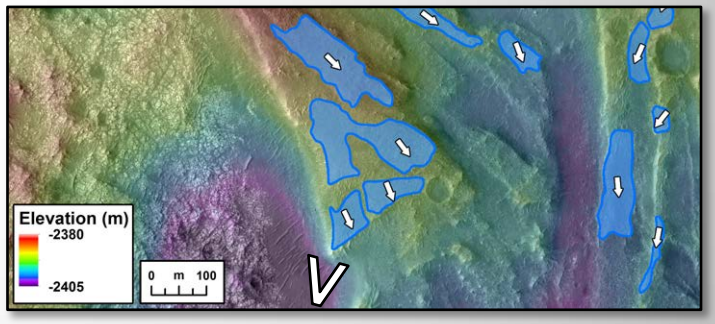
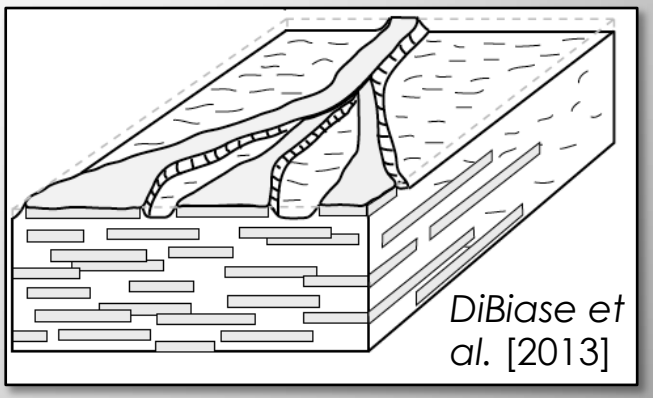


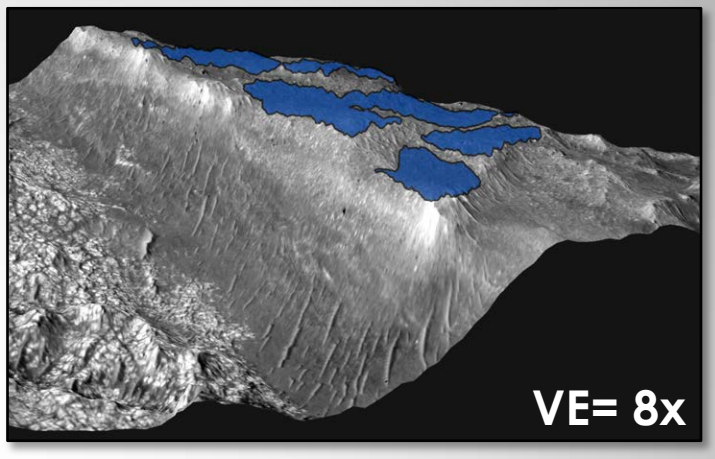


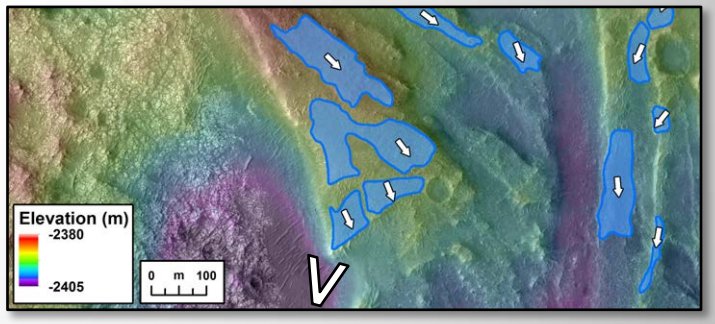


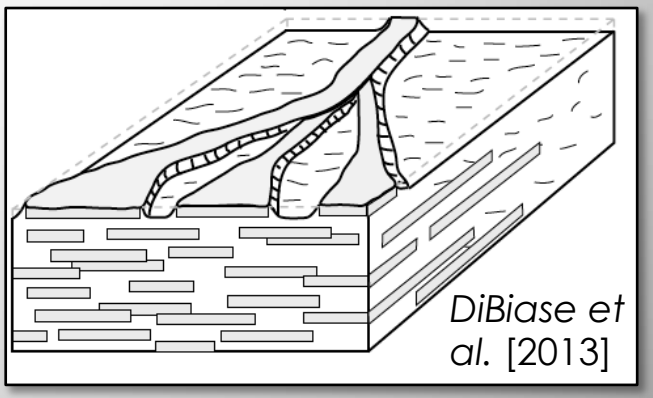
Channel Bodies are Stacked

Further Testable Hypothesis and Questions:

- How do flow estimates compare with point bar strata? *Gives idea of flow partitioning.* [*Goudge et al.*, 2018]
- What was relative frequency of channel reoccupation?
- **What is cementing agent? *Must provide sufficient strength for topographic inversion*.**
- Is there evidence of interaction with ice cover near shoreline? Waves?







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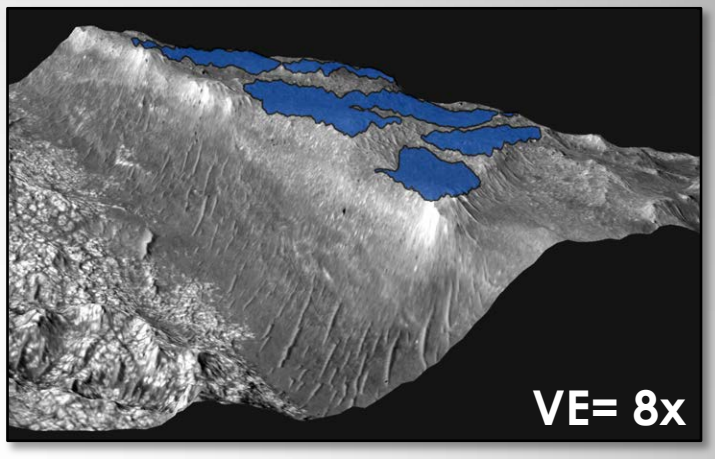
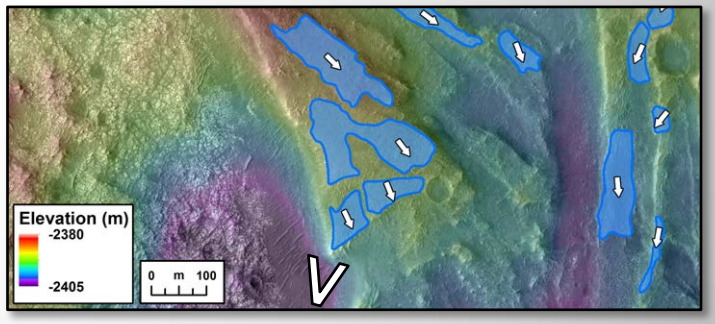
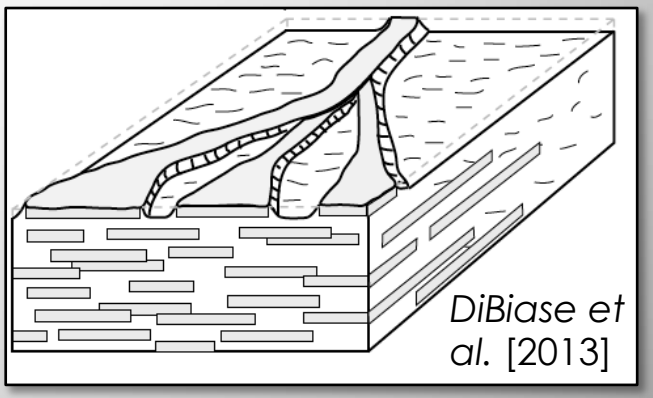
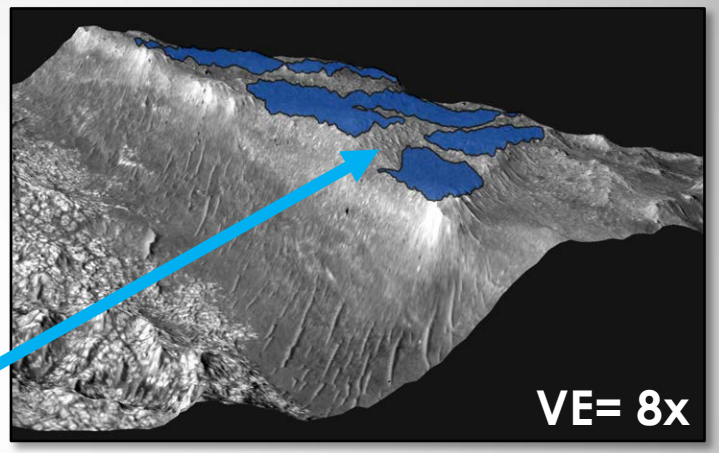


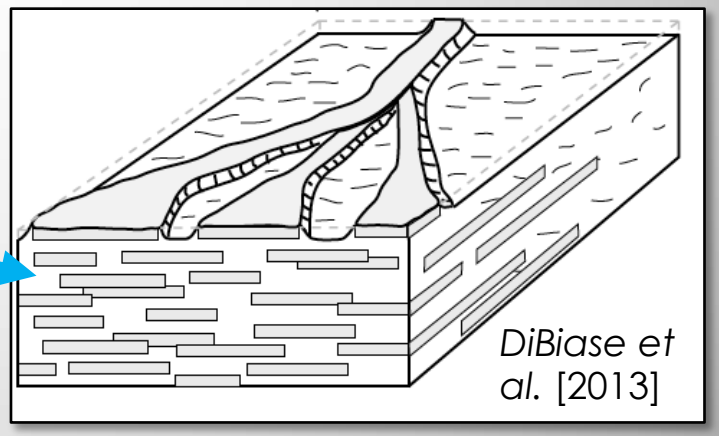




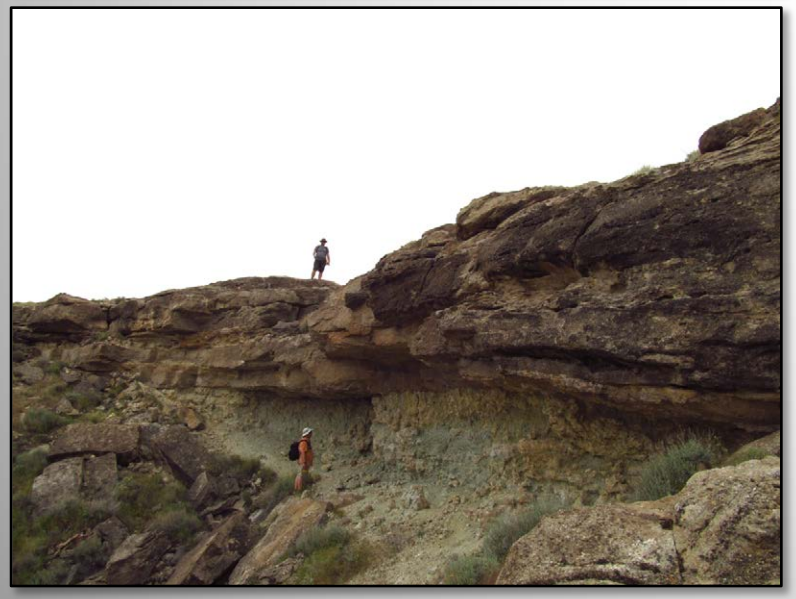
Fine-Grained Floodplain Strata

Channel bodies are separated by fine-grained floodplain strata.
[e.g., *Mohrig et al.*, 2000]





Fine-Grained Floodplain Strata



- Floodplain packages can be several meters thick. *Proxy for channel reoccupation timescale*.
- If fine grained material is clay rich, would bind and stabilize organic matter.
  [e.g., *Wattel-Koekkoek et al.*, 2001; *Kennedy et al.*, 2002; *Ehlmann et al.*, 2008a]
- **Additional quiescent depositional environment with potential for organic matter preservation**.
  [e.g., *Tockner et al.*, 1999; *Summons et al.*, 2011]

Summary

- Jezero delta channel deposits can be placed in a well-understood depositional context.
- **Deposits provide a paleoenvironmental record of the early martian surface. Can be used to test models of the early martian climate.**
- Can explore delta channel deposits in primary and extended mission.
- *Opportunity to address complementary science questions to what would be learned by studying delta bottomsets, carbonate-rich basin fill, and mafic-rich floor unit.*