

Examining the Record of Fluvial Activity on Early Mars:

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

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Cory Hughes^{1,2}, and Caleb Fassett³

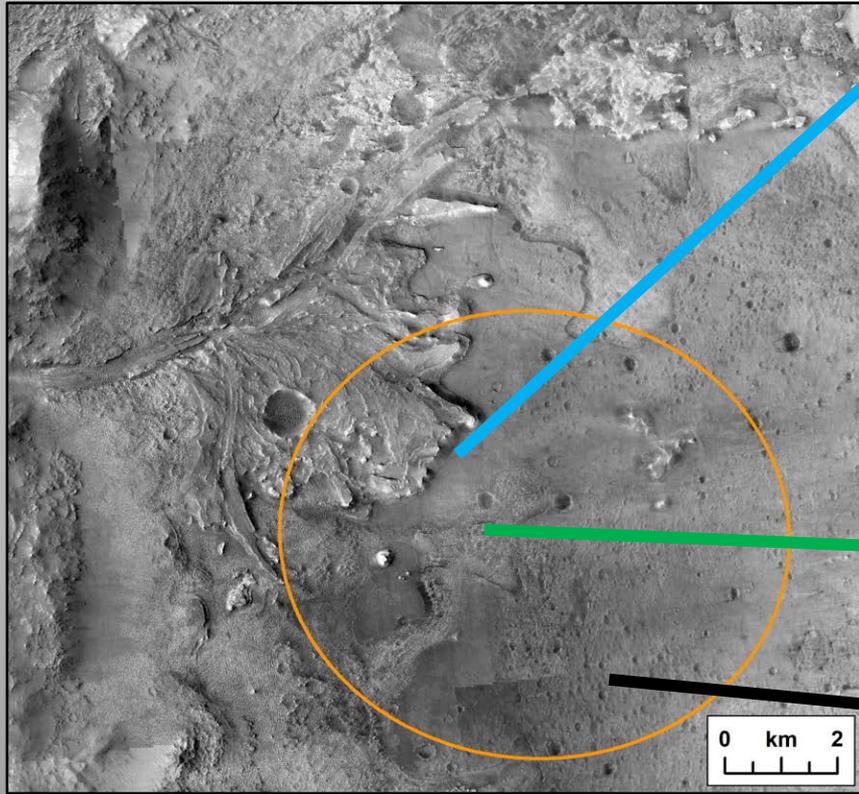
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Preamble

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

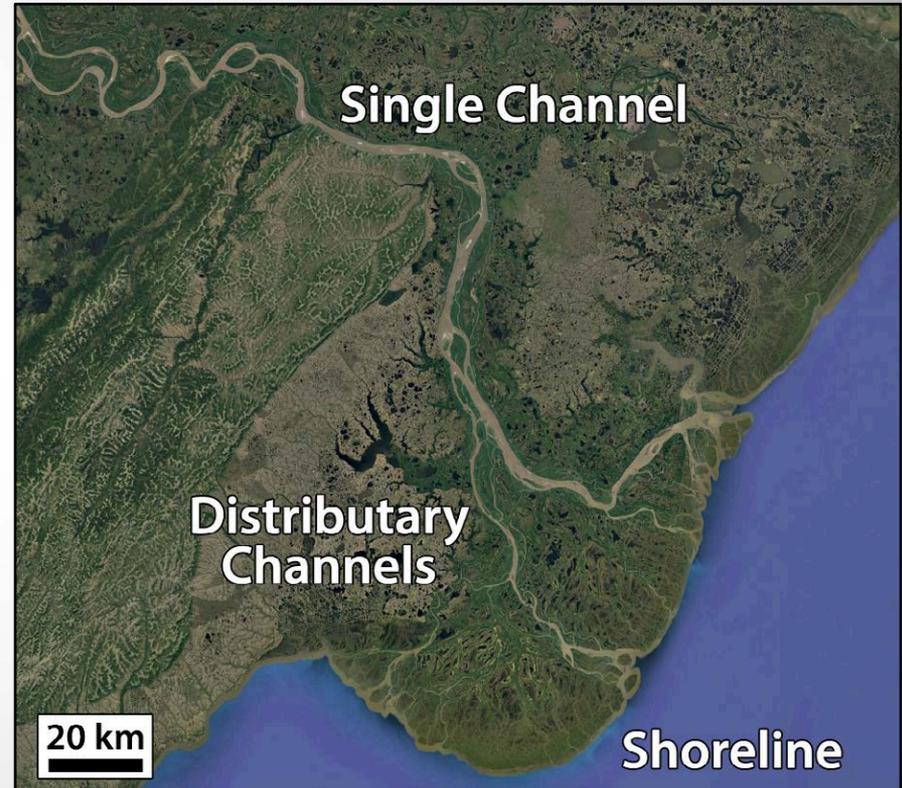


- Fine-grained bottomset deposits with high accumulation and preservation potential for organic matter.
[Lynch et al. talk]
- Carbonate-rich basin fill.
[Horgan et al. and Brown et al. talks]
- Mafic-rich floor unit.
[Kinch and Shahrzad talk]

What can channel deposits tell us?

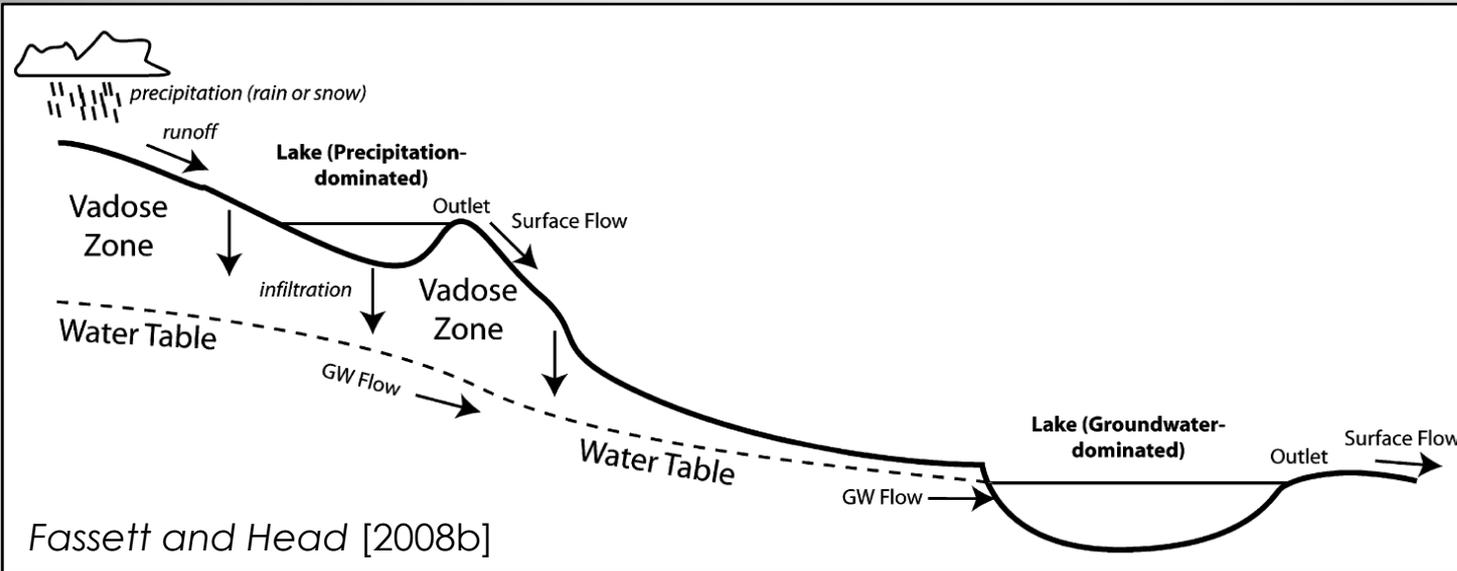
Delta environment provides geologic model for spatial distribution of channel properties. **Provides robust context for depositional environment.**

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



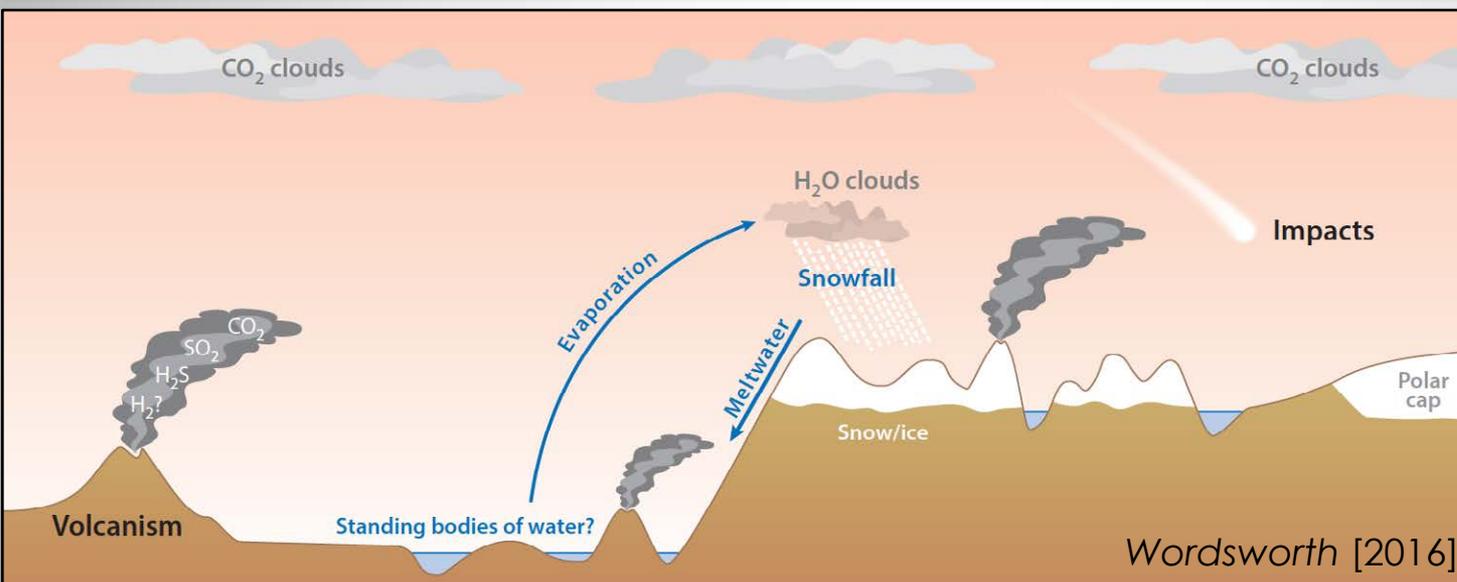
Warm & Wet

Rainfall and surface runoff.

VS.

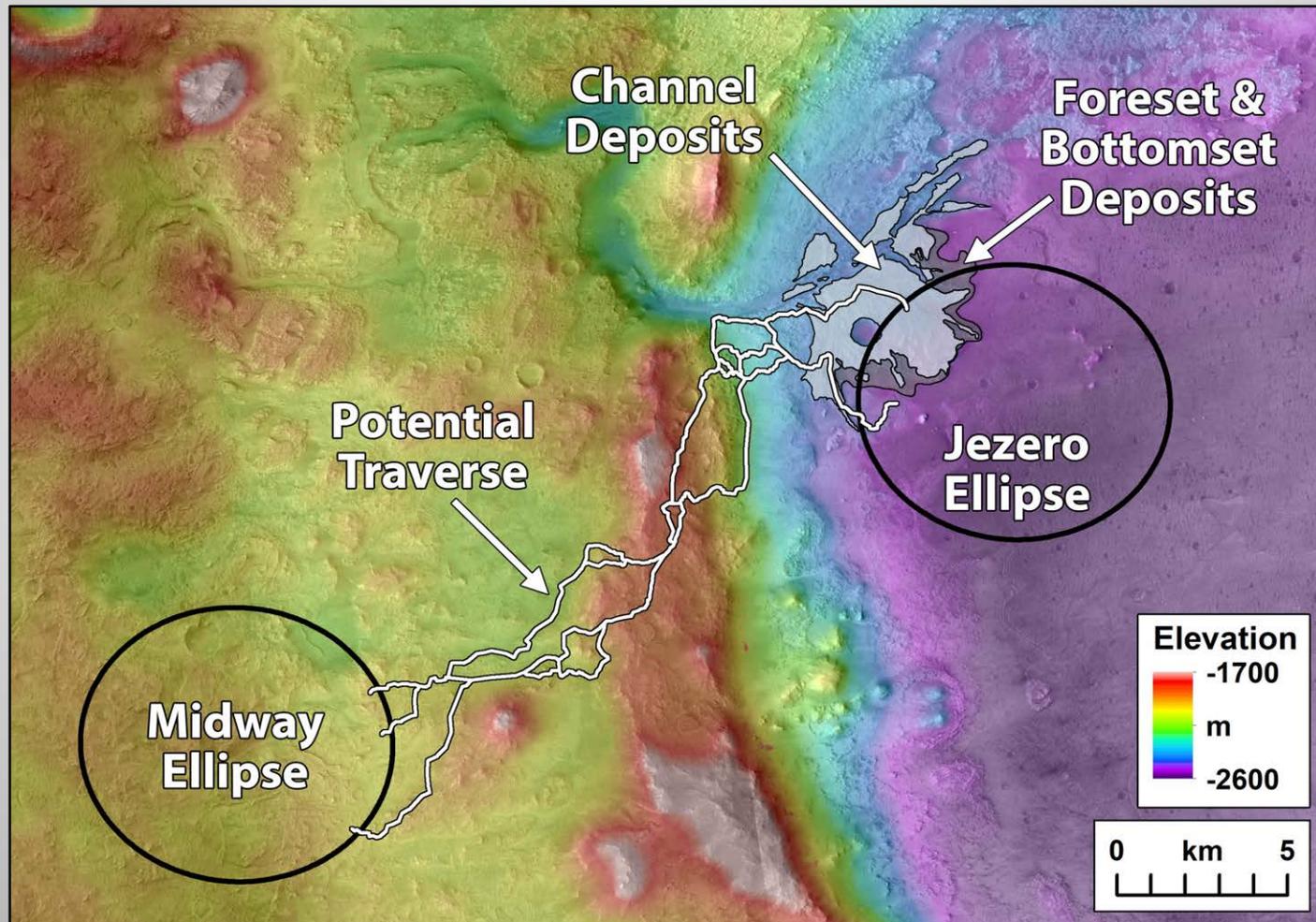
Cold & Icy

Snowfall and transient melting.



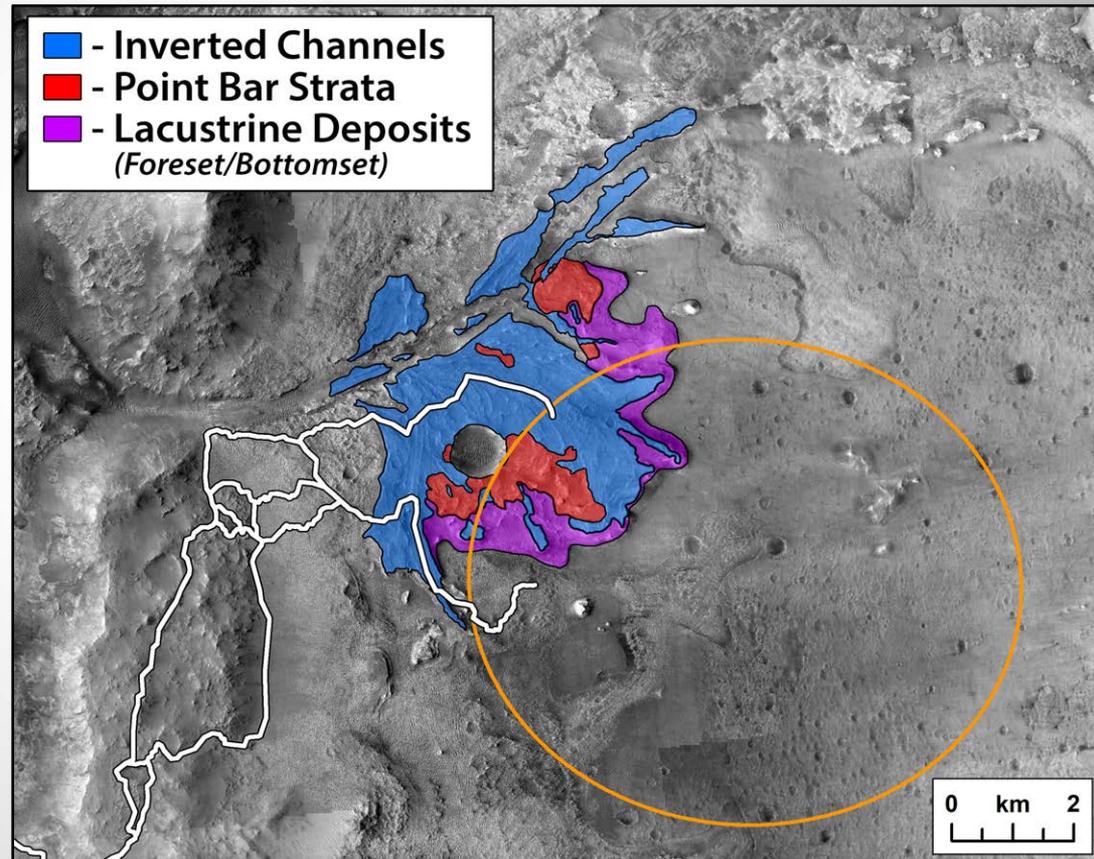
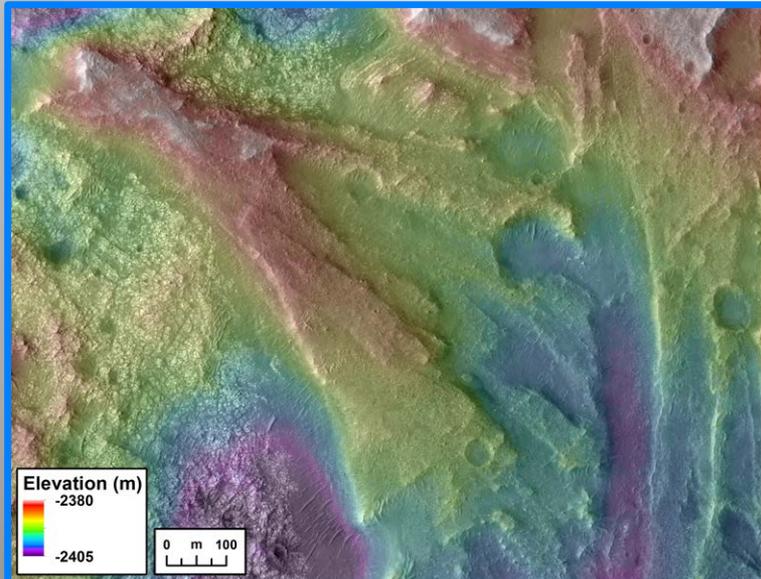
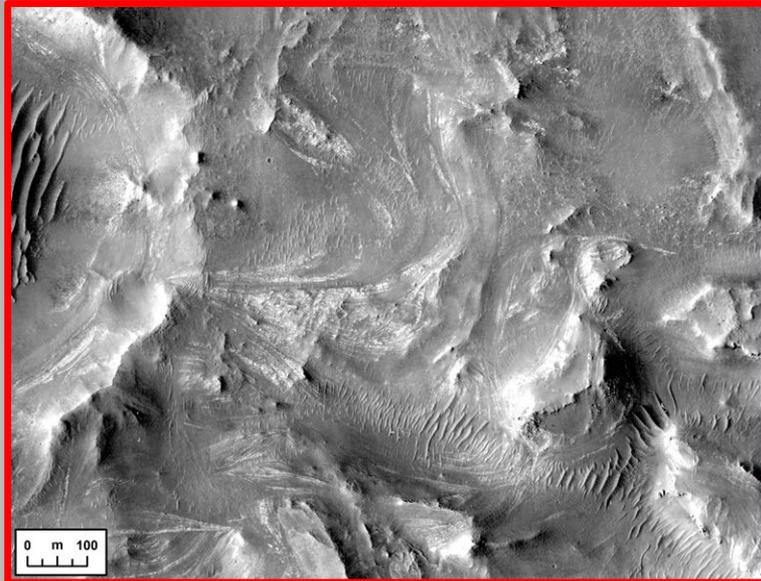
Where are Jezero channel deposits?

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



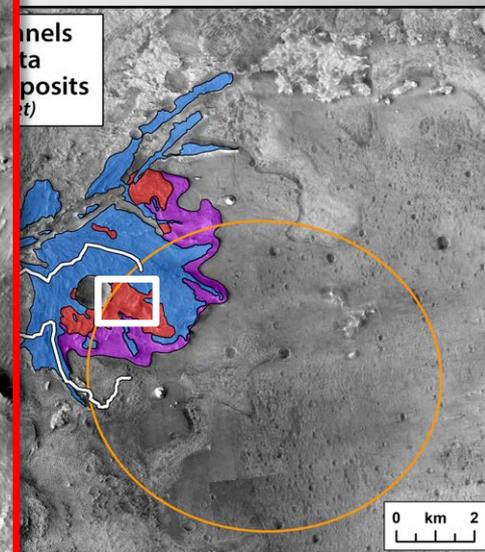
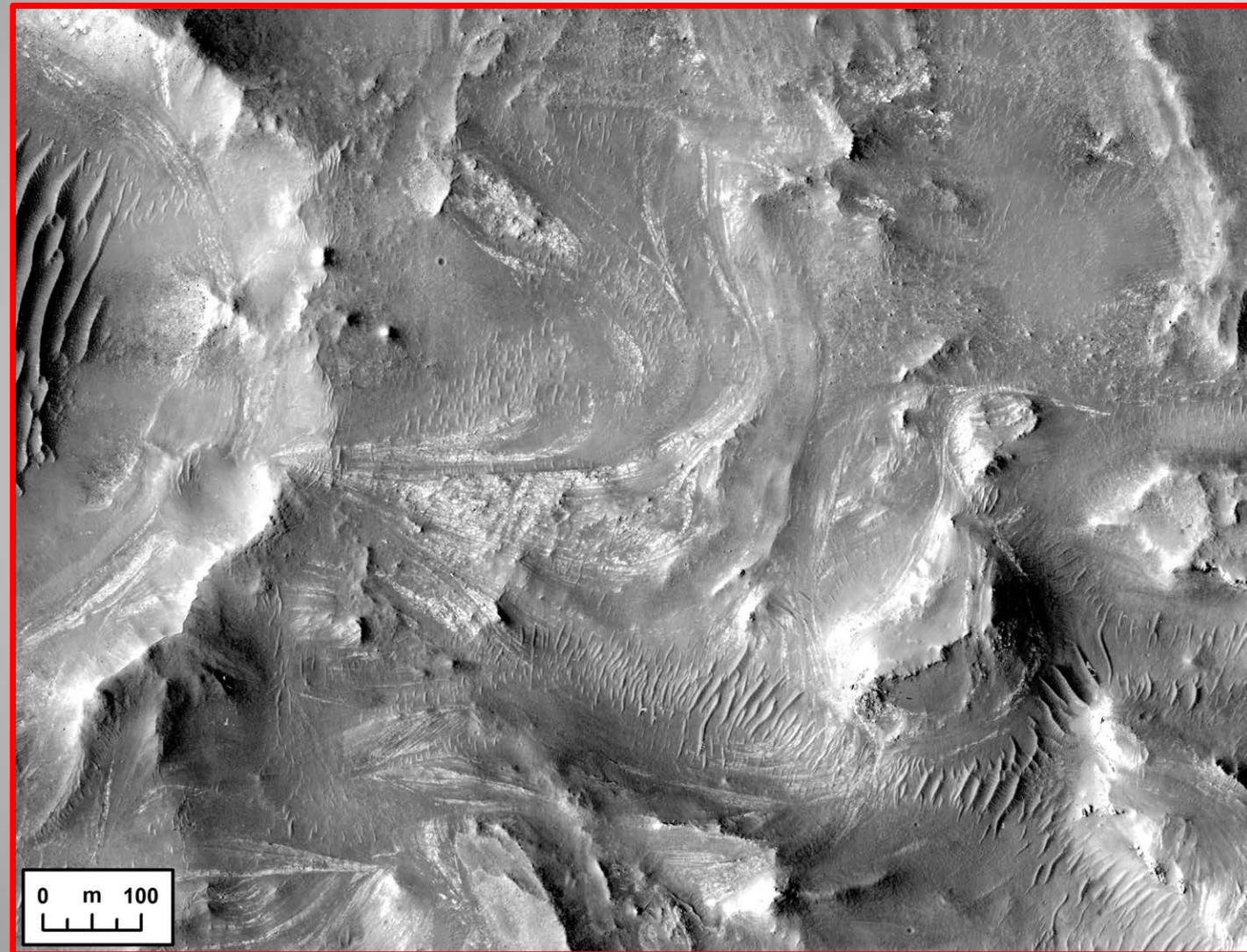
Delta Channel Stratigraphy

2 Classes of Channel Stratigraphy

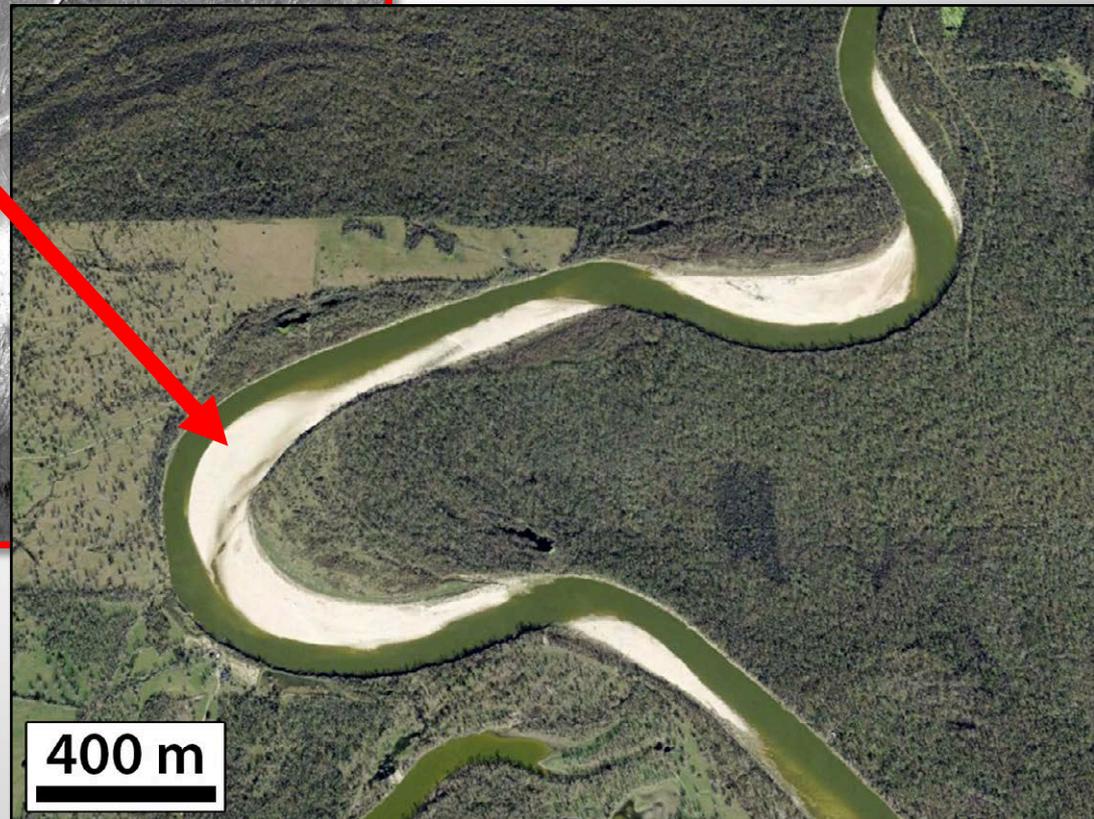
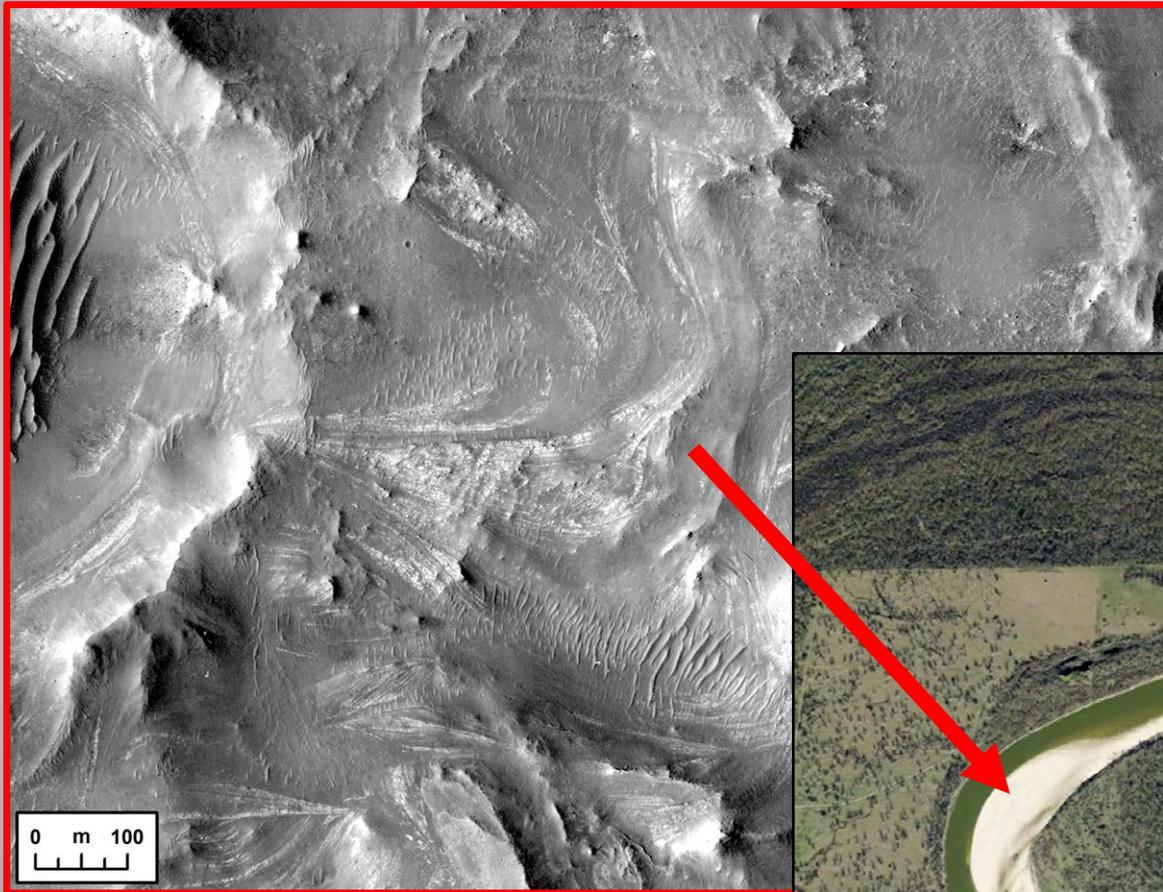


Goudge et al. [2018]

Point Bar Strata

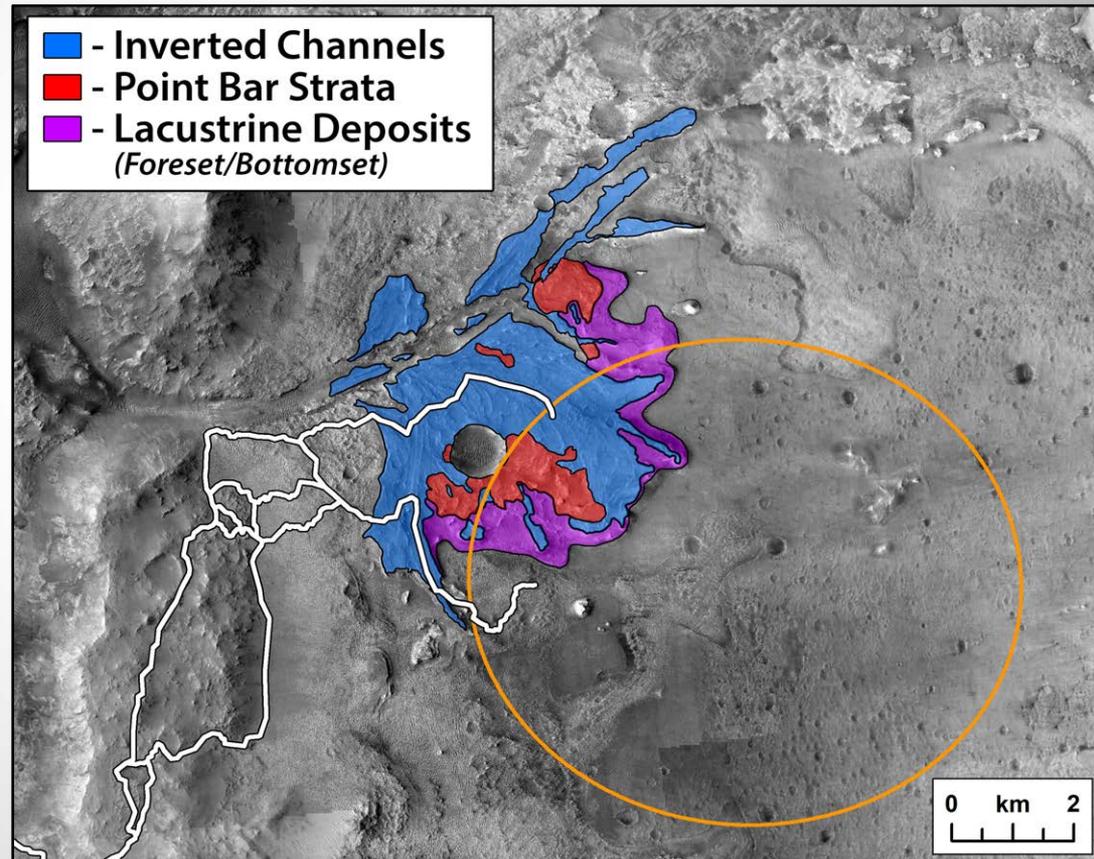
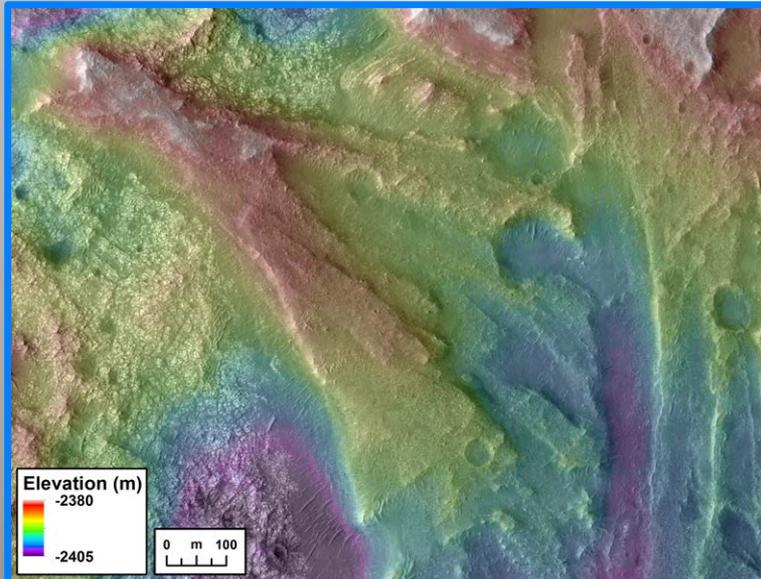
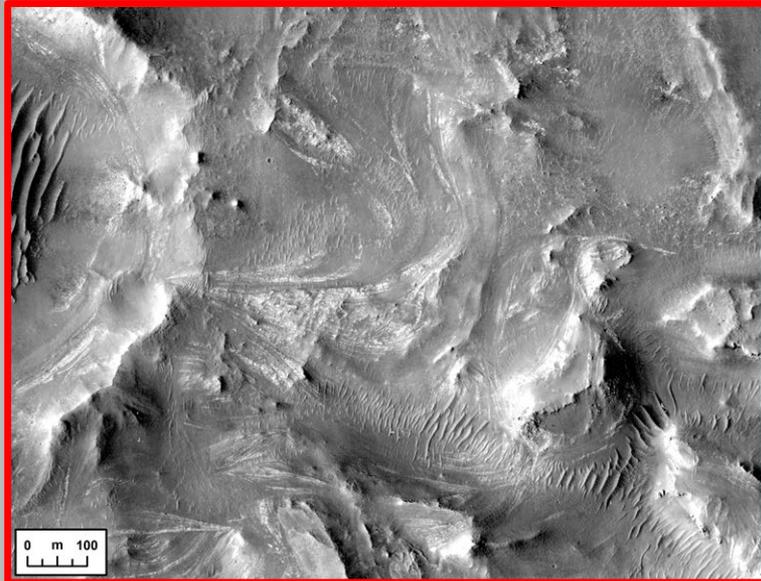


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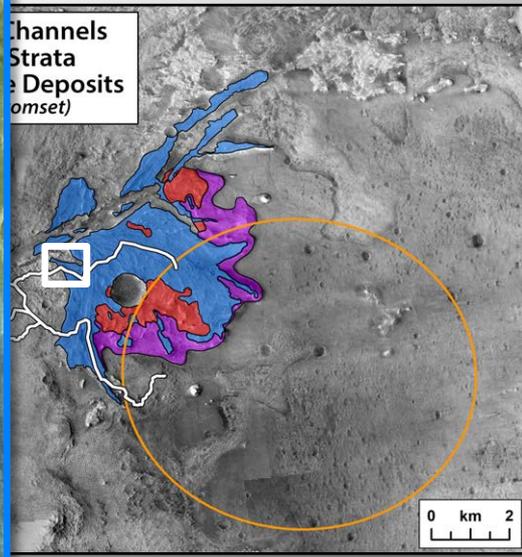
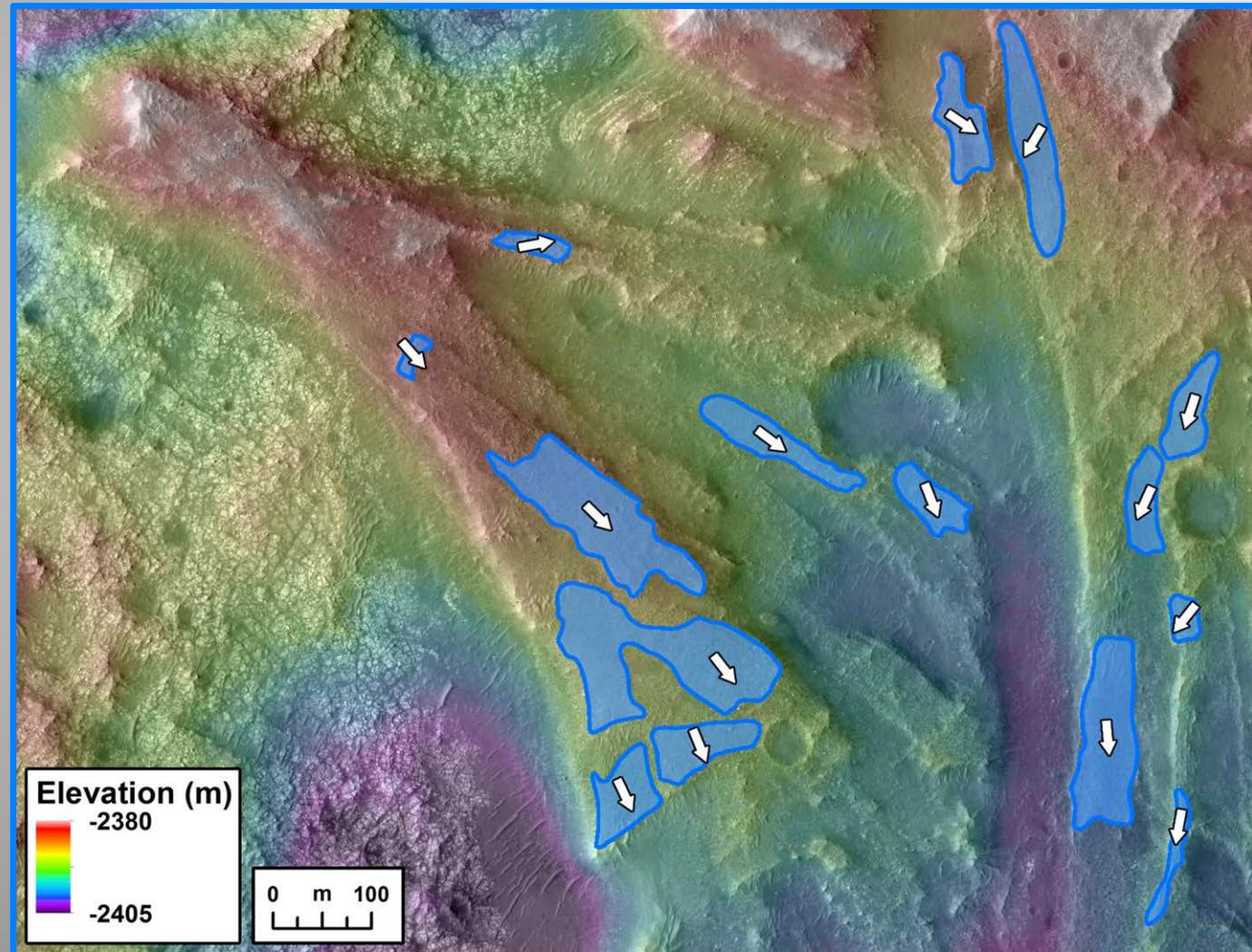


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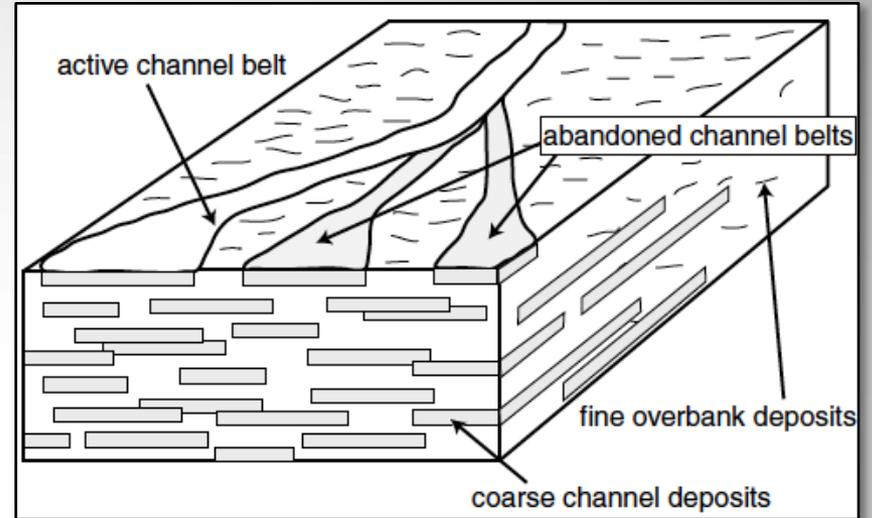
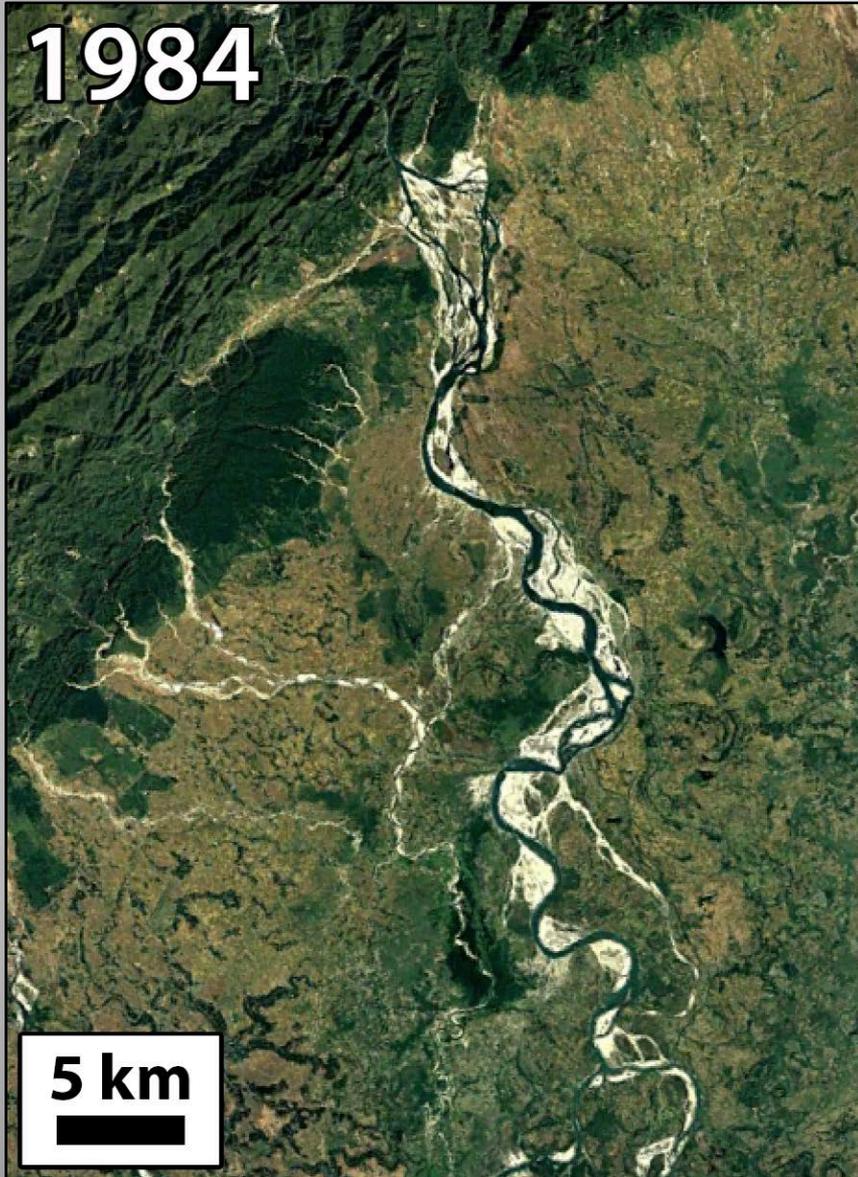
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Inverted Channel Bodies

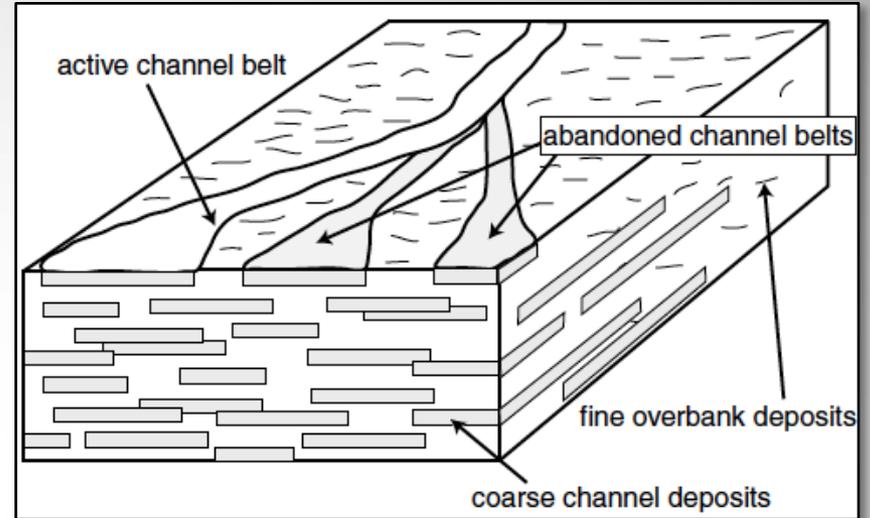


Avulsions + Channel Body Inversion



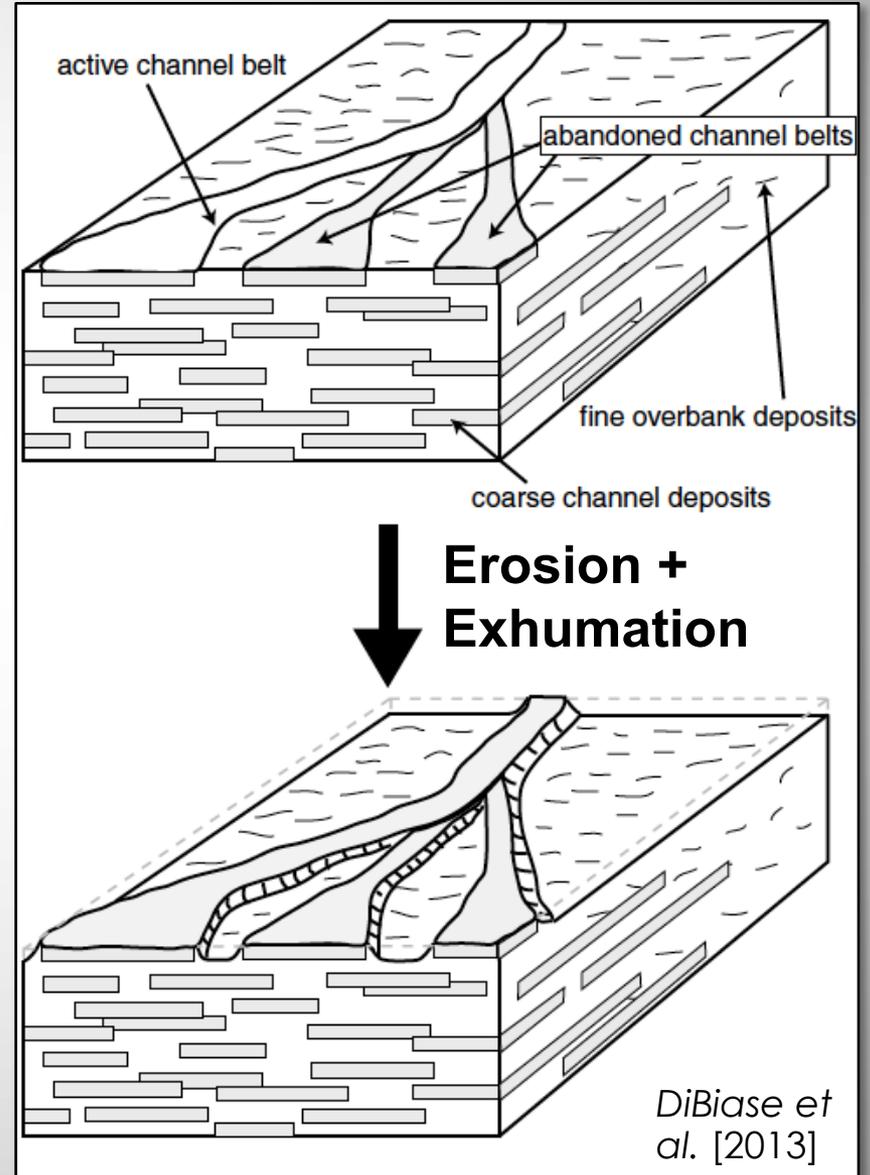
DiBiase et al. [2013]

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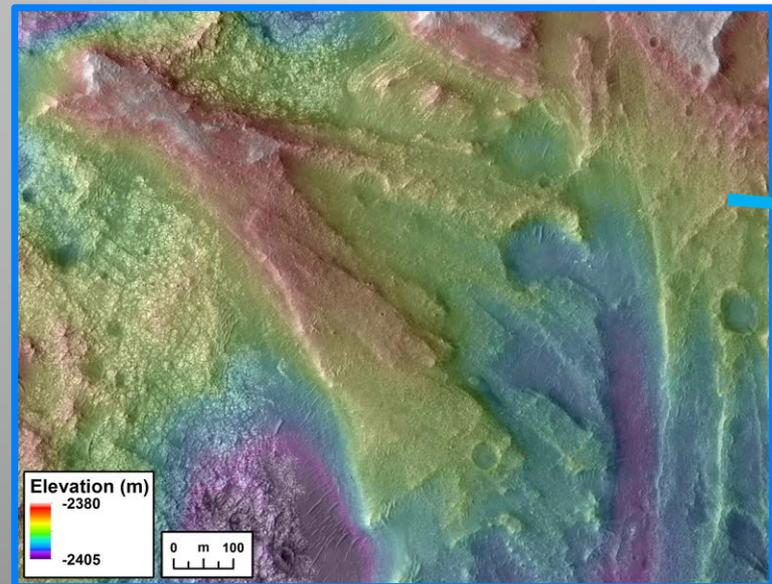
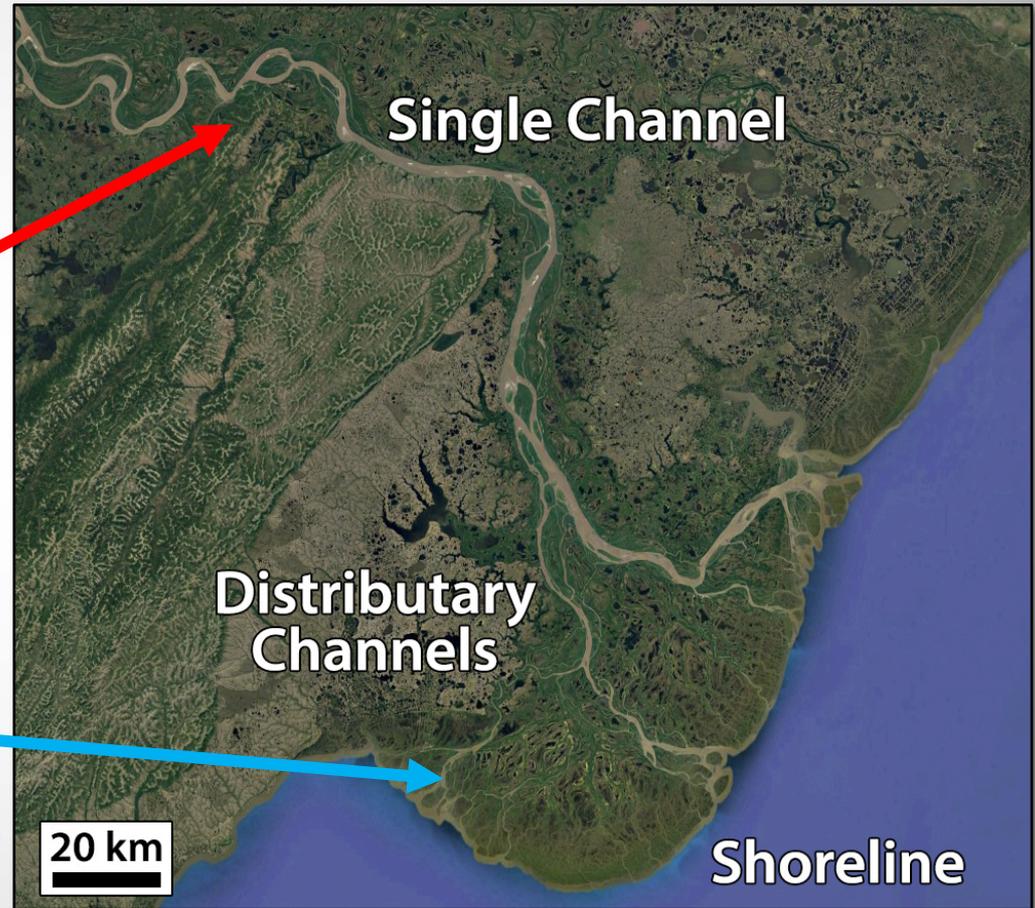
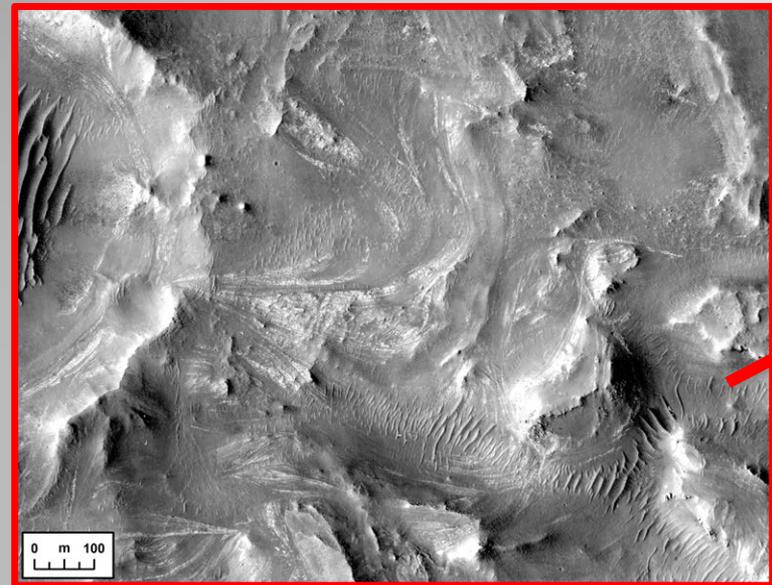


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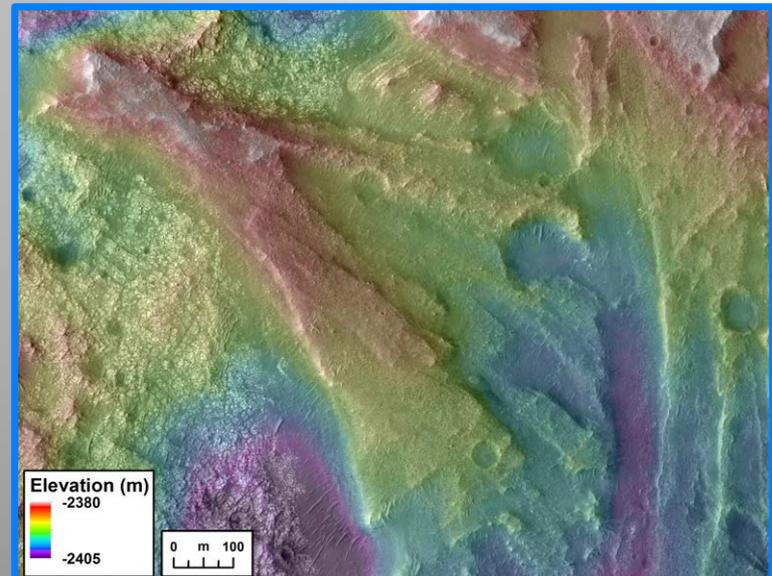
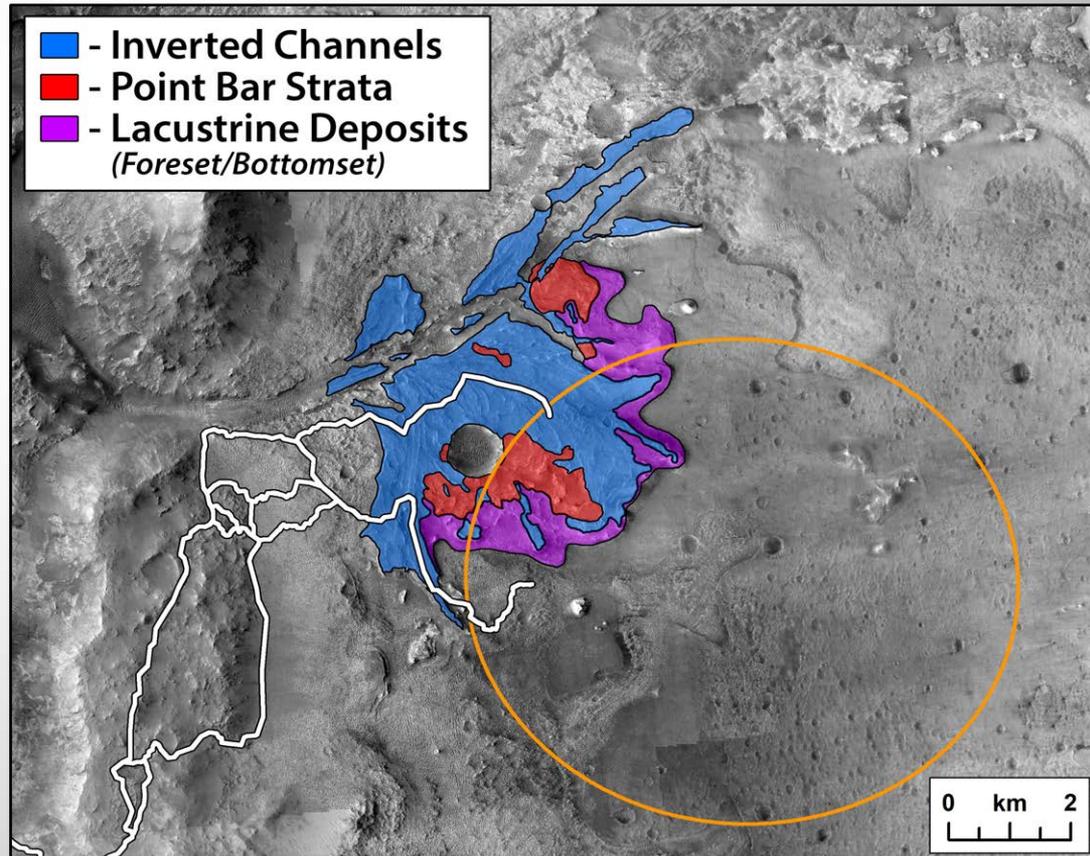


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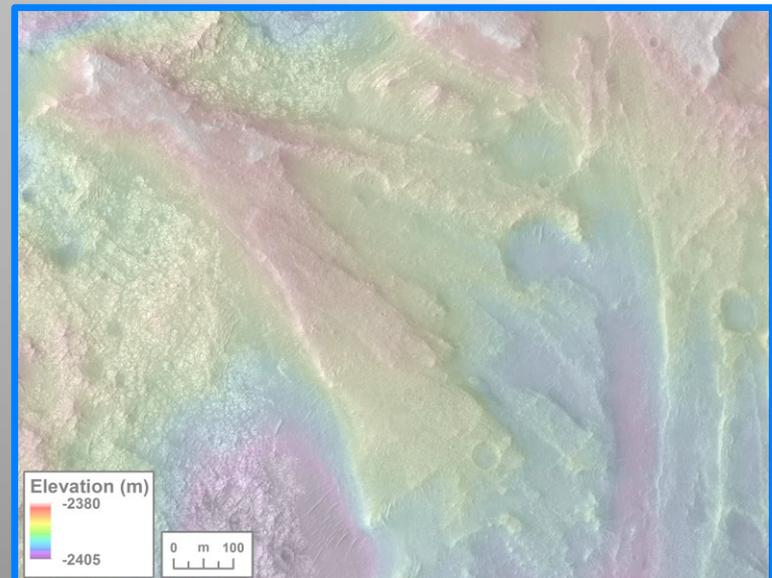
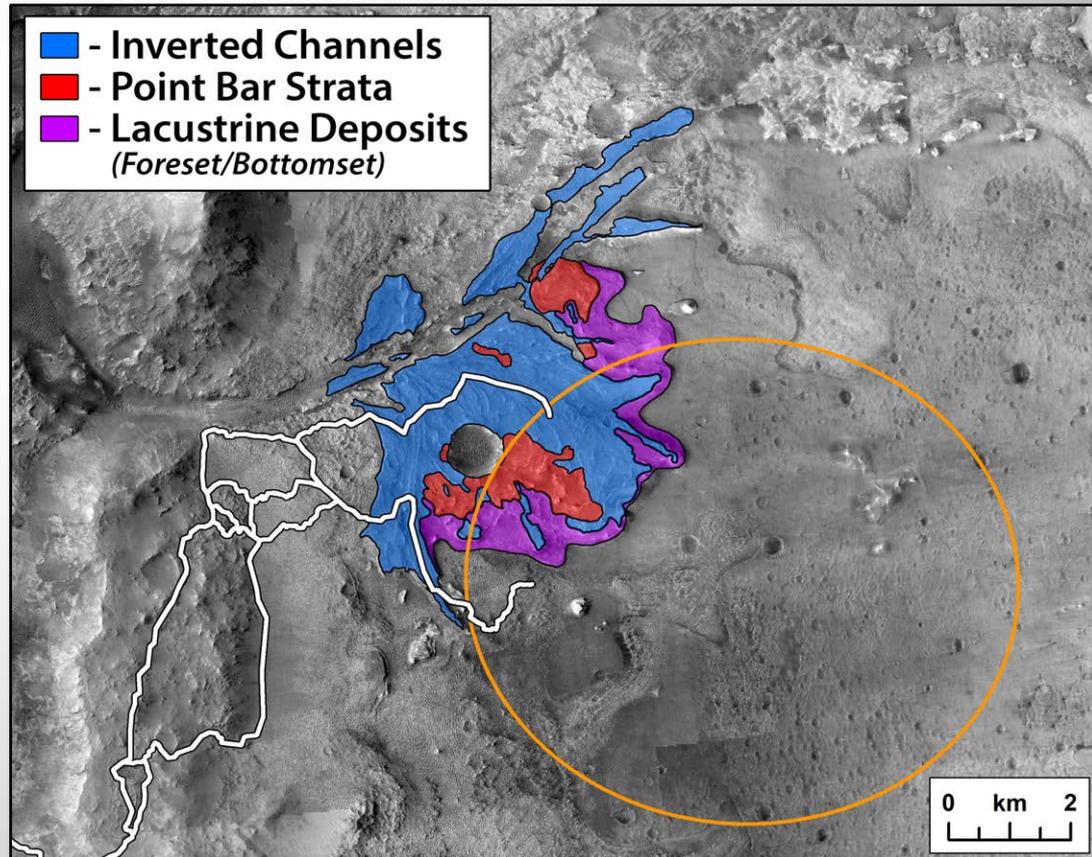
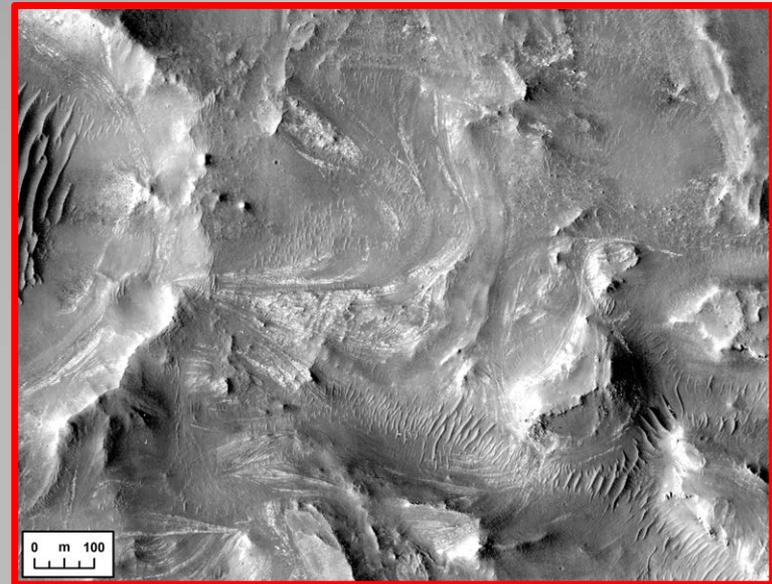
Delta Channel Stratigraphy

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



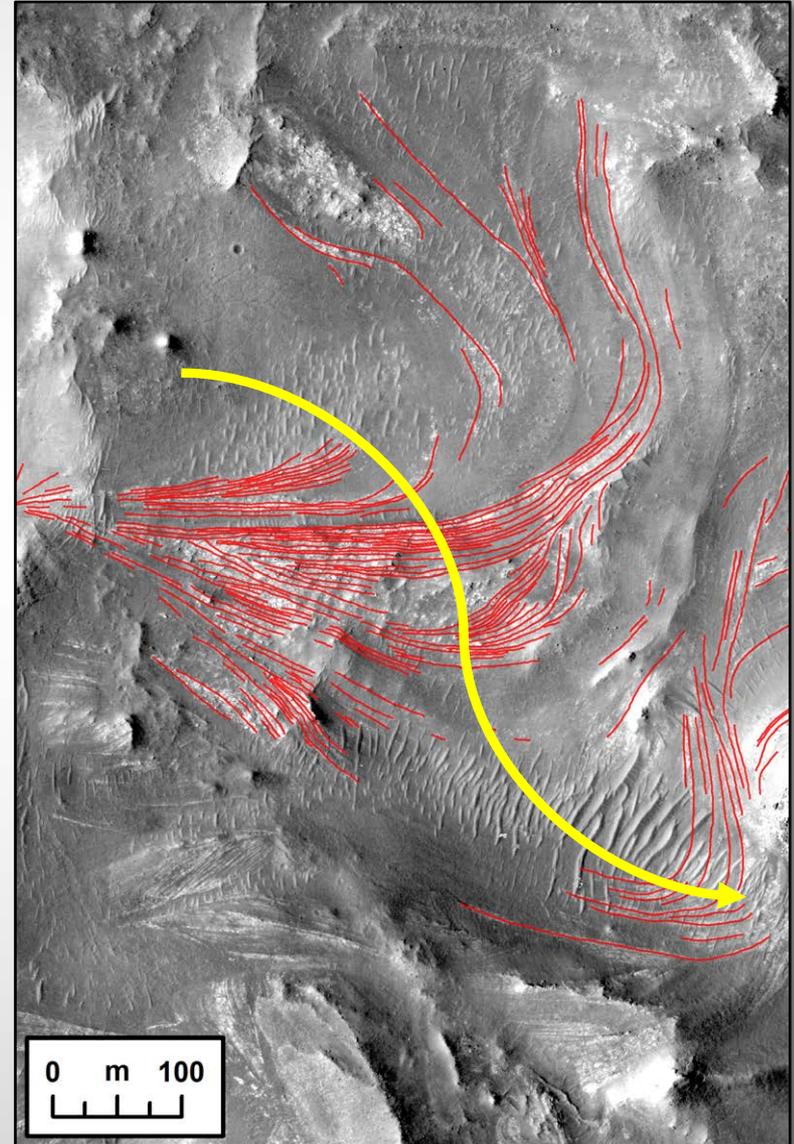
Point Bar Stratigraphy

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



Point Bars Record Flooding History

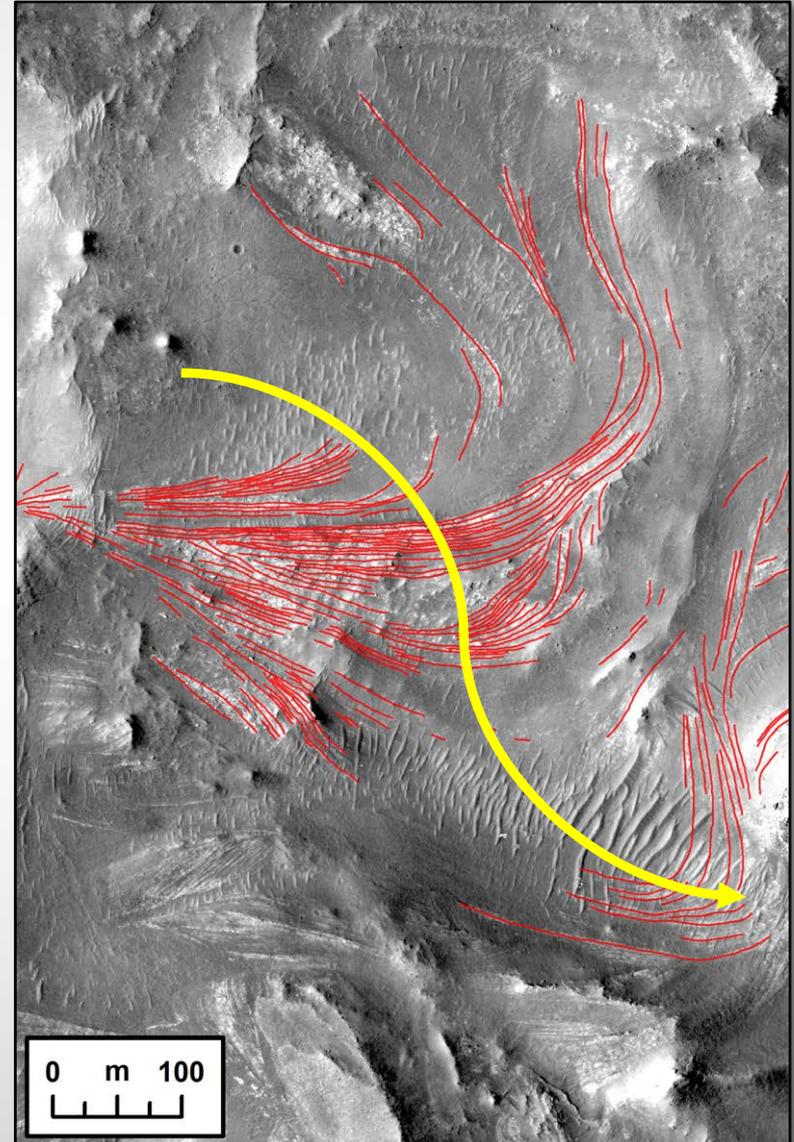
- Coherent point bar packages record lateral migration of >500 m.
- Each point bar stratum represents one (or a few) flood events.
[e.g., Allen, 1965; Edwards et al., 1983]
- Strata in coherent packages are not separated by obvious signs of erosion.



Point Bars Record Flooding History

Further Testable Hypothesis and Questions:

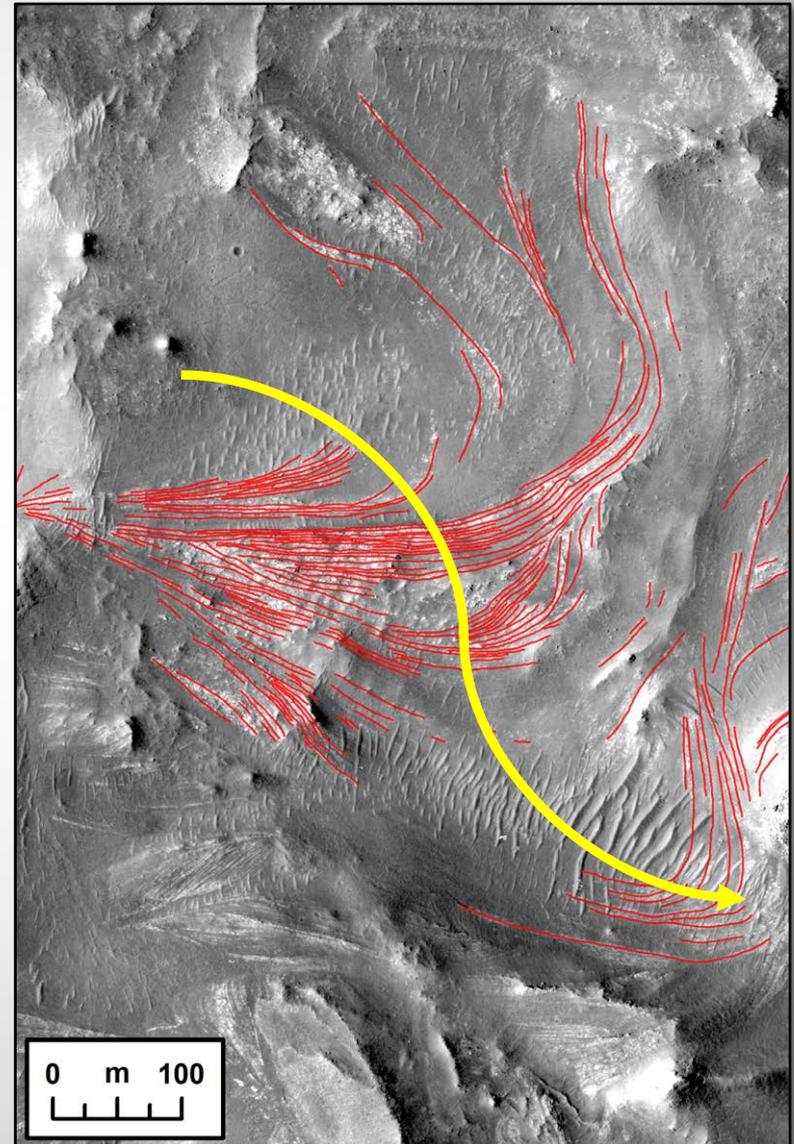
- **Delta-forming climate experienced regional flooding at short timescales.**
[Goudge et al., 2018]
- What were magnitudes and recurrence intervals of channel-forming floods?
- What allowed for channel meandering on Mars in the absence of land plants?
[e.g., Matsubara et al., 2015]
- Is there evidence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



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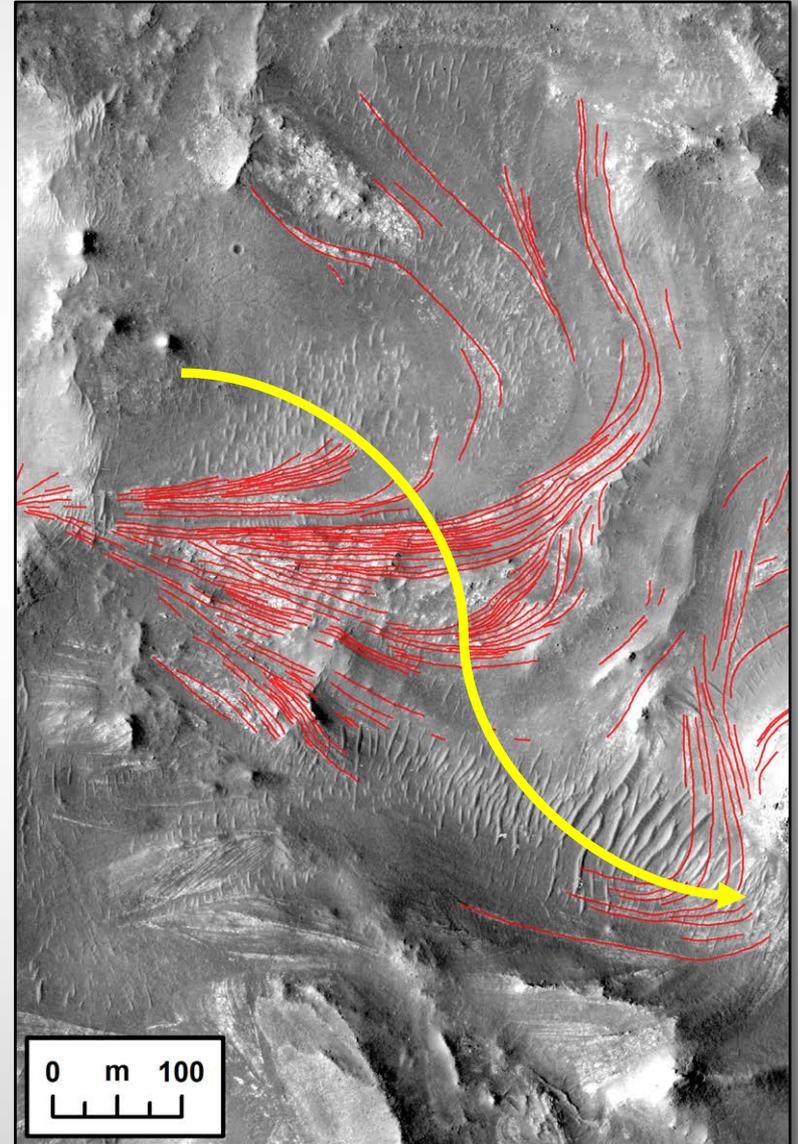
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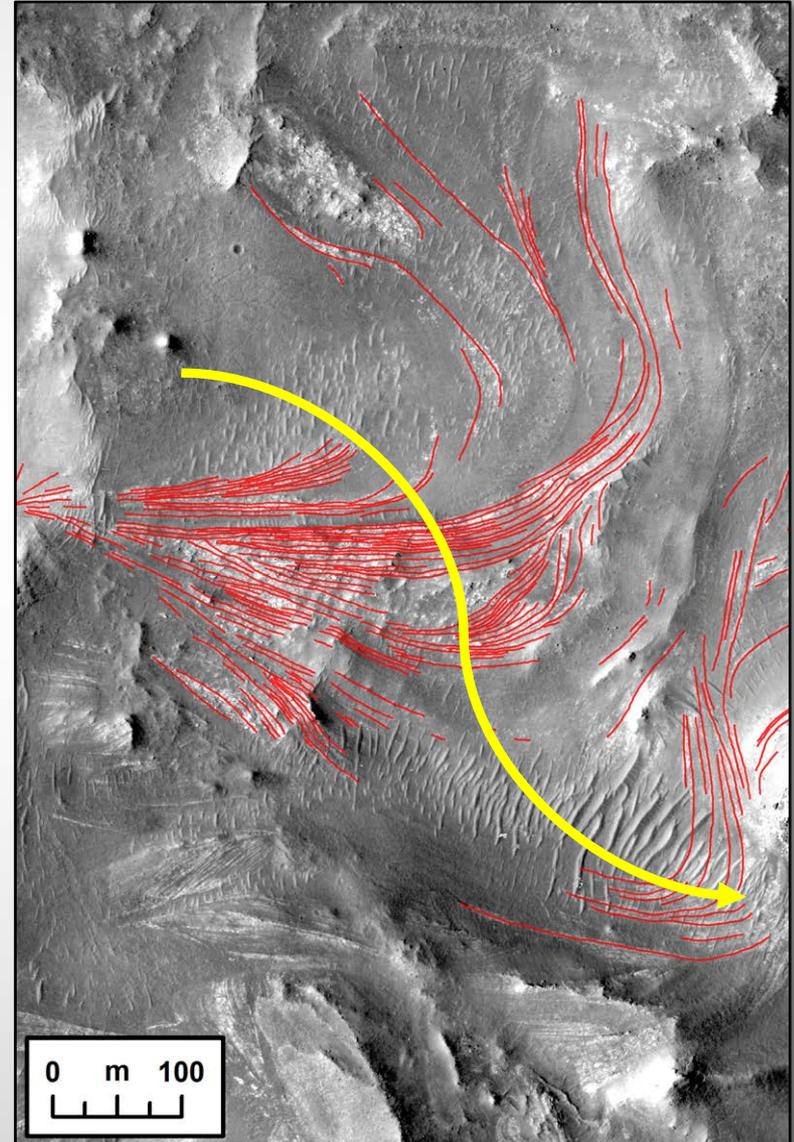
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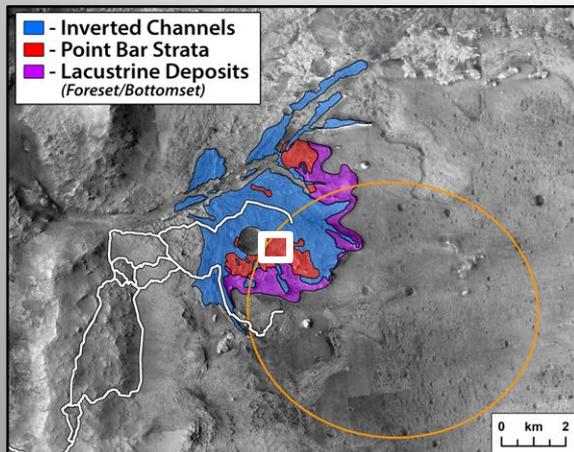
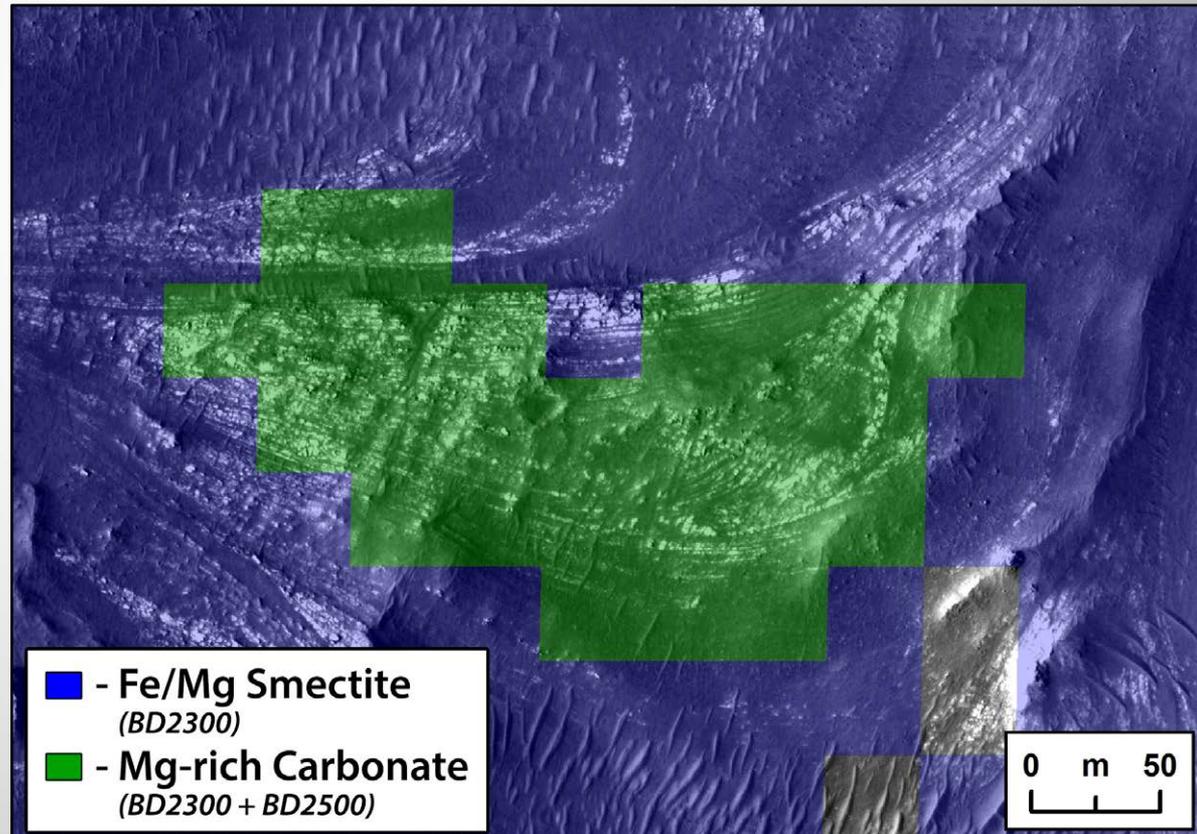
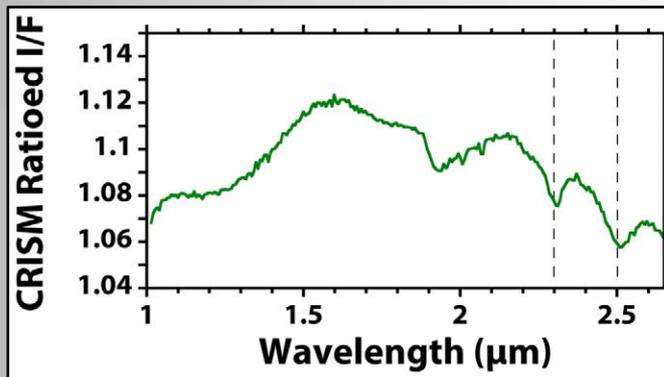


Carbonate-Rich Point Bar Strata

Point bar strata display strong carbonate signatures.

Testable Hypothesis: Point bar strata are cemented by carbonate.

Goudge et al. [2017]

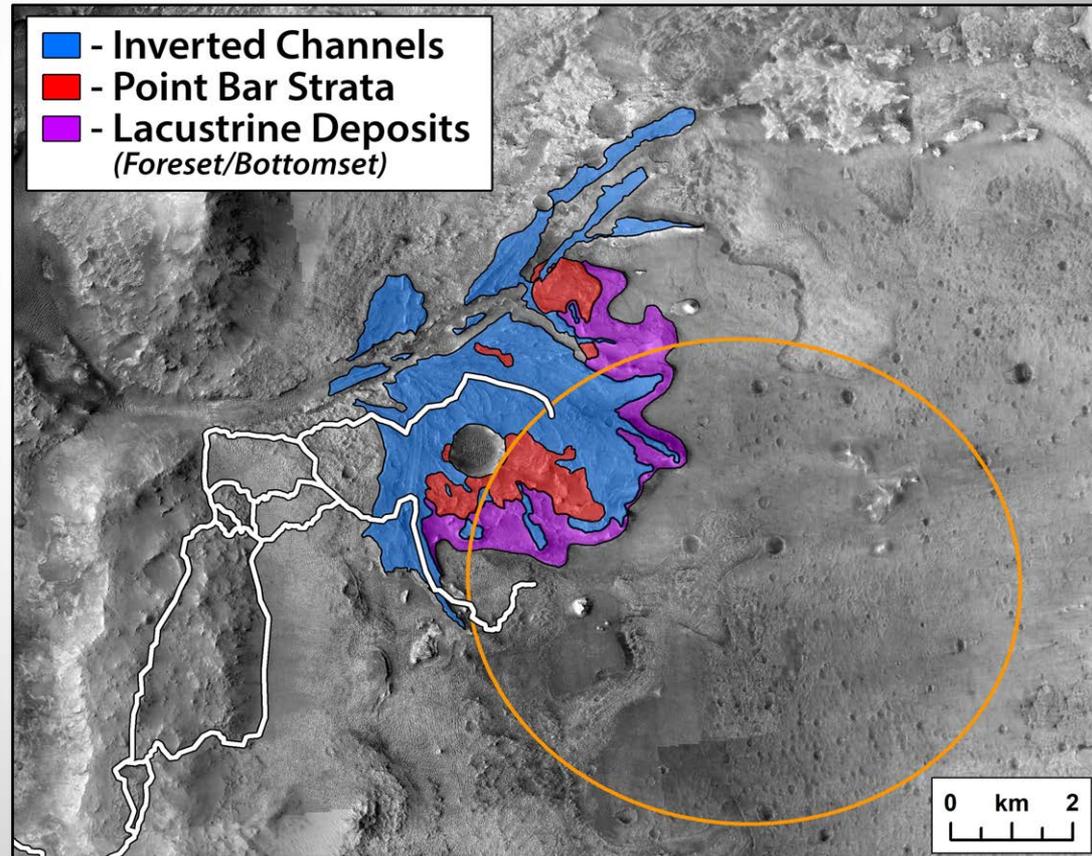
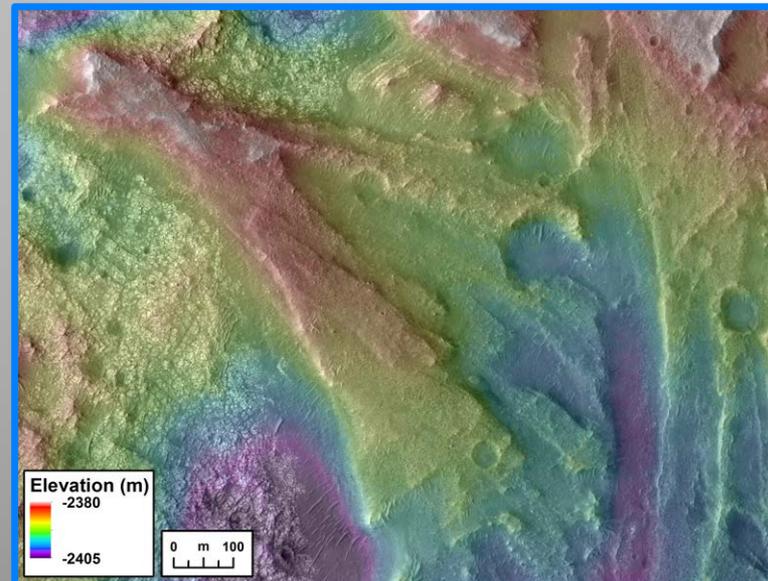
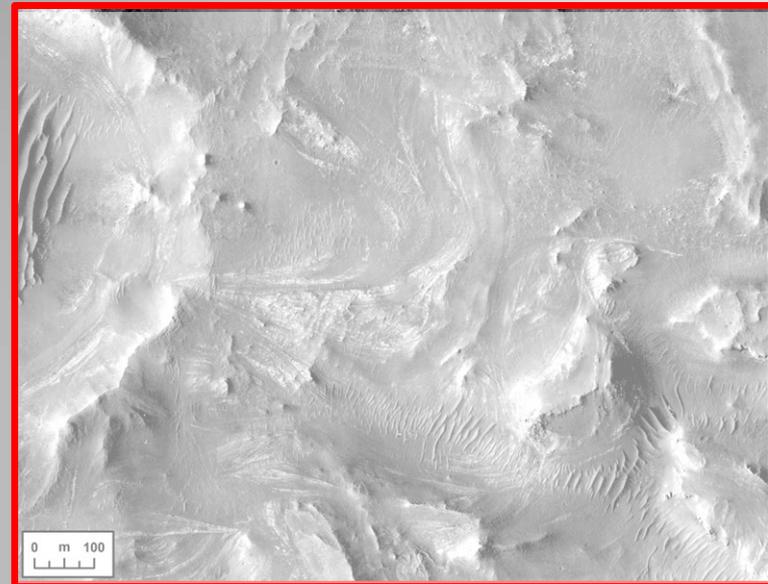


Carbonate in Multiple Contexts

- 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

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

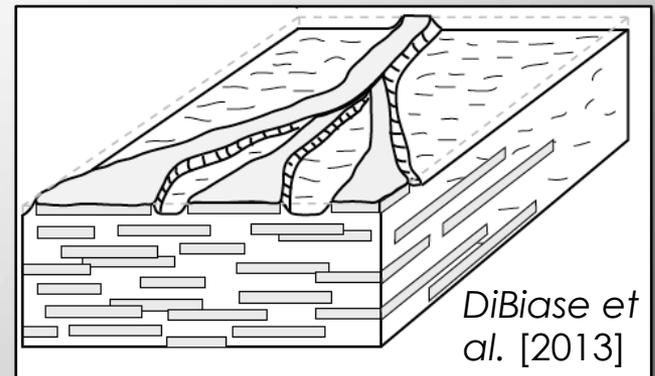
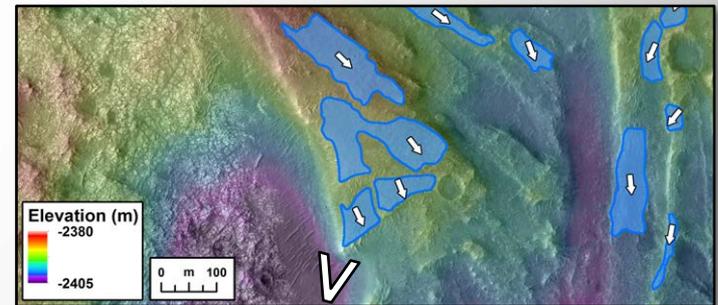
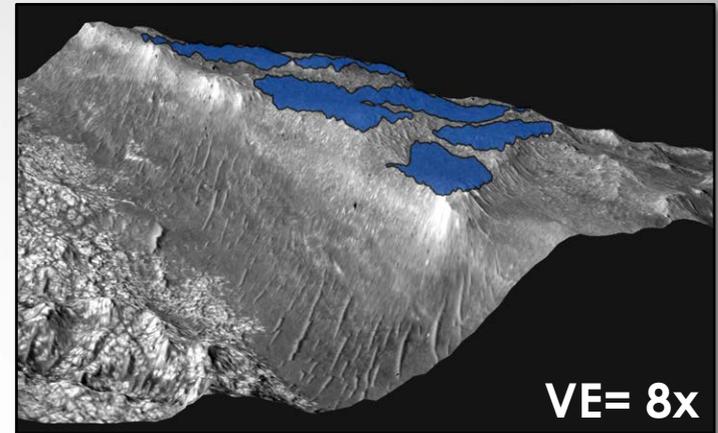


Channel Bodies are Stacked

- Ridges are composed of multiple stacked channel bodies.
- Channels preferentially occupied same locations on delta.
- Channel bodies are separated by fine-grained floodplain strata.

[Mohrig et al., 2000; Edmonds et al., 2006]

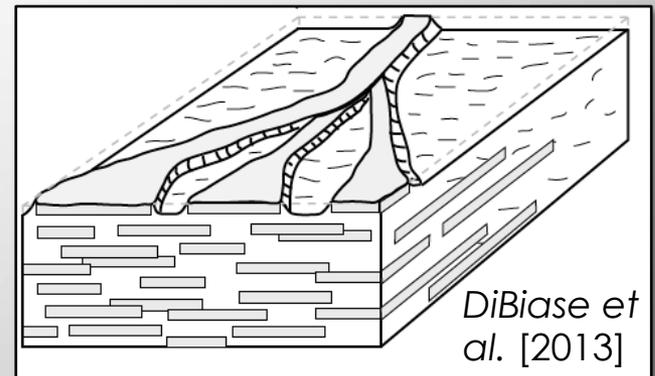
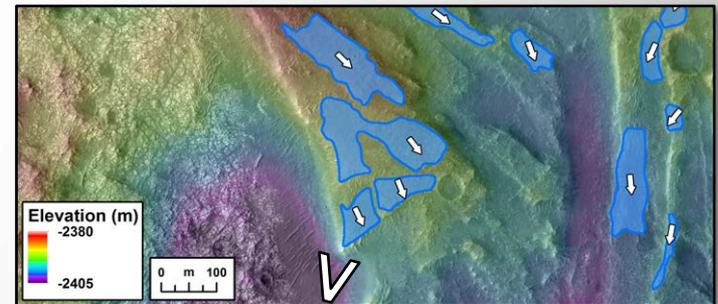
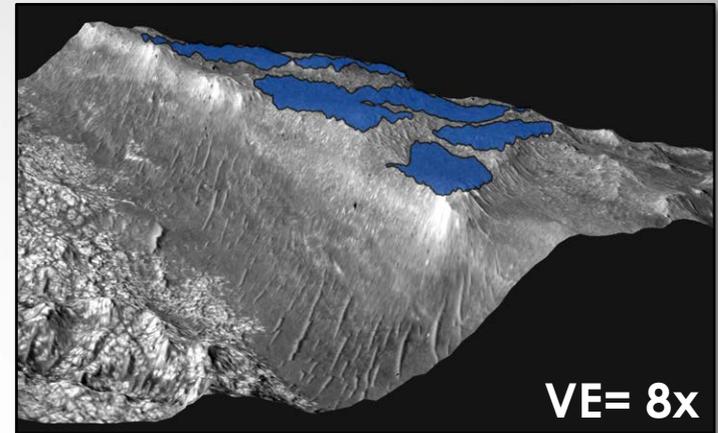
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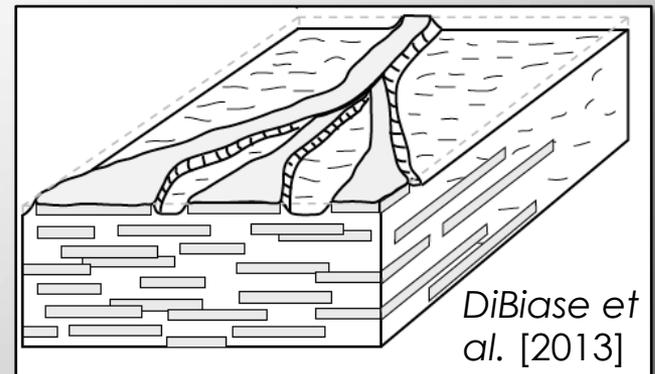
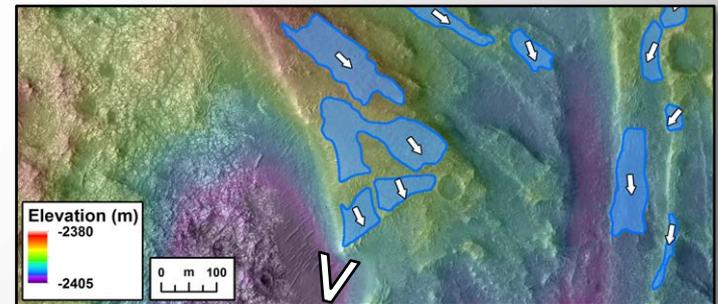
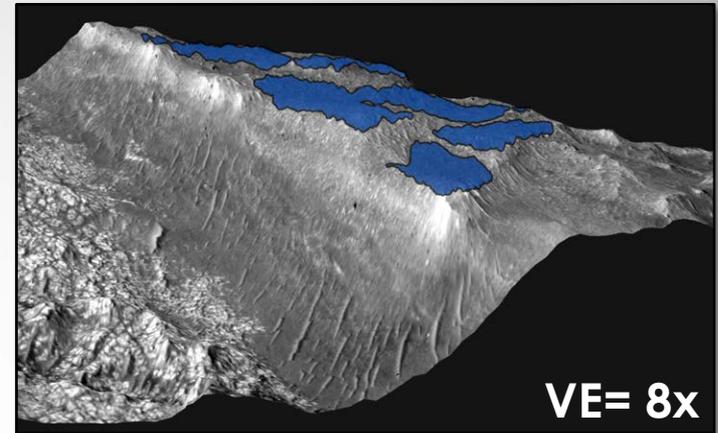
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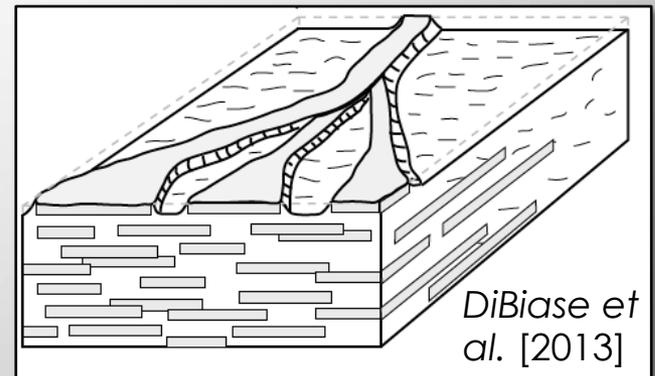
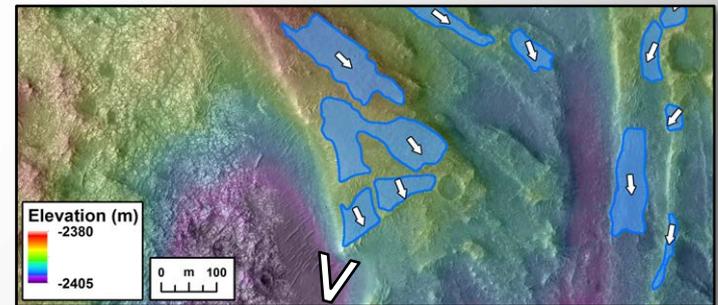
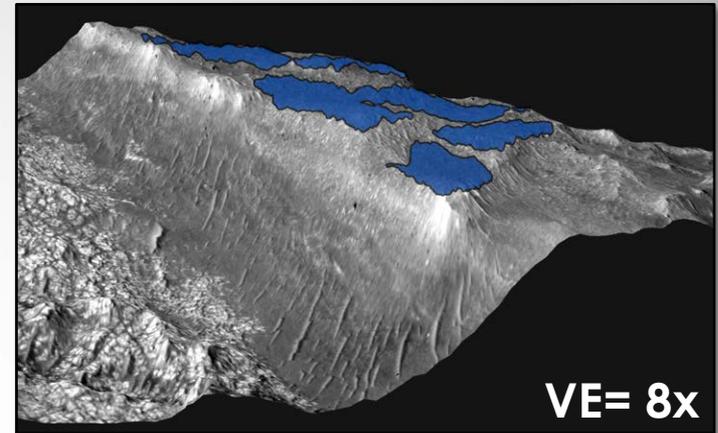
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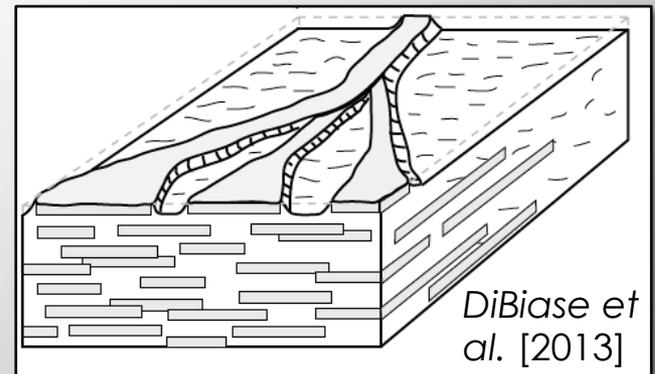
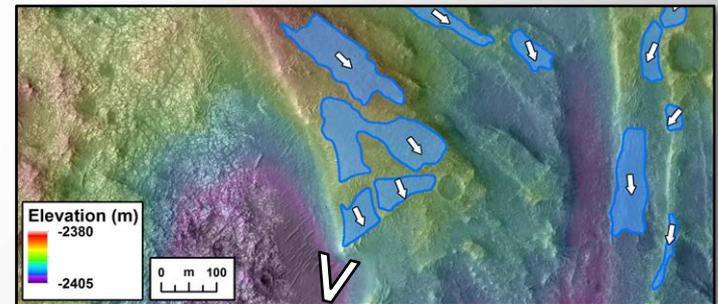
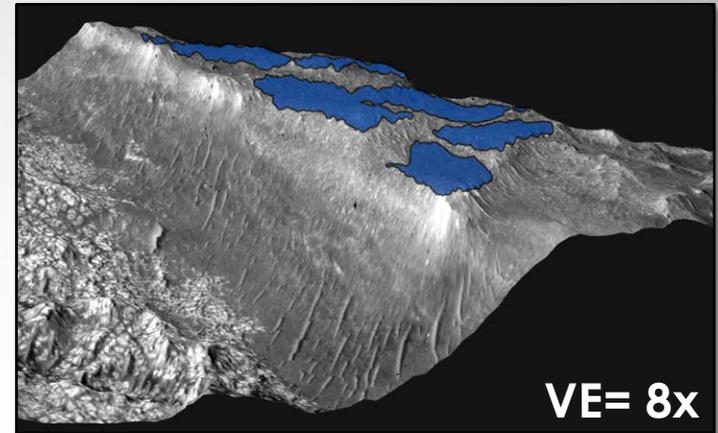
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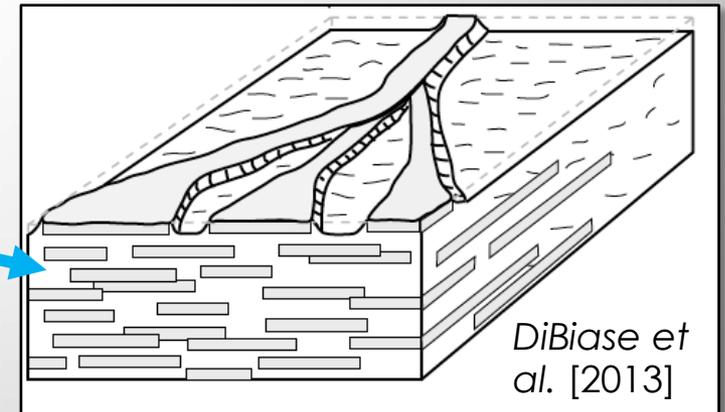
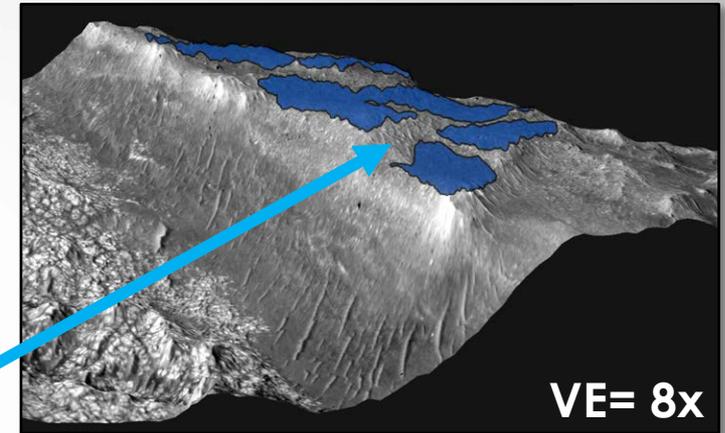
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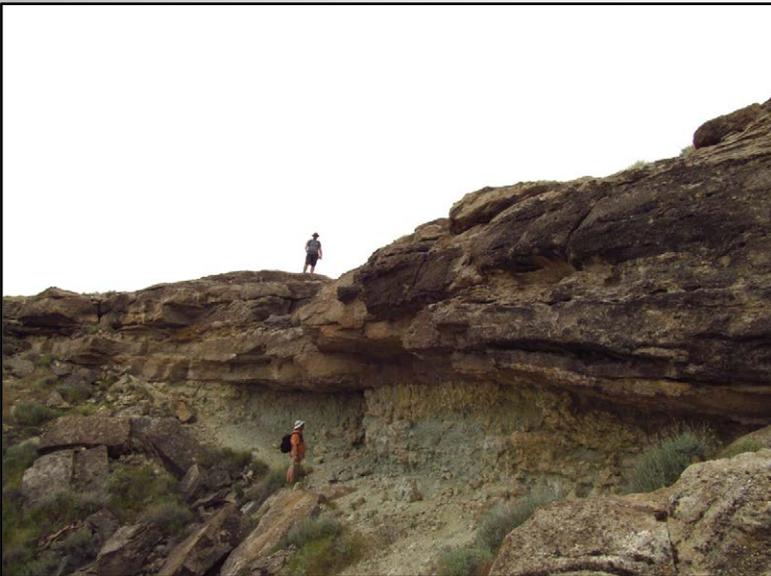
Fine-Grained Floodplain Strata

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.*