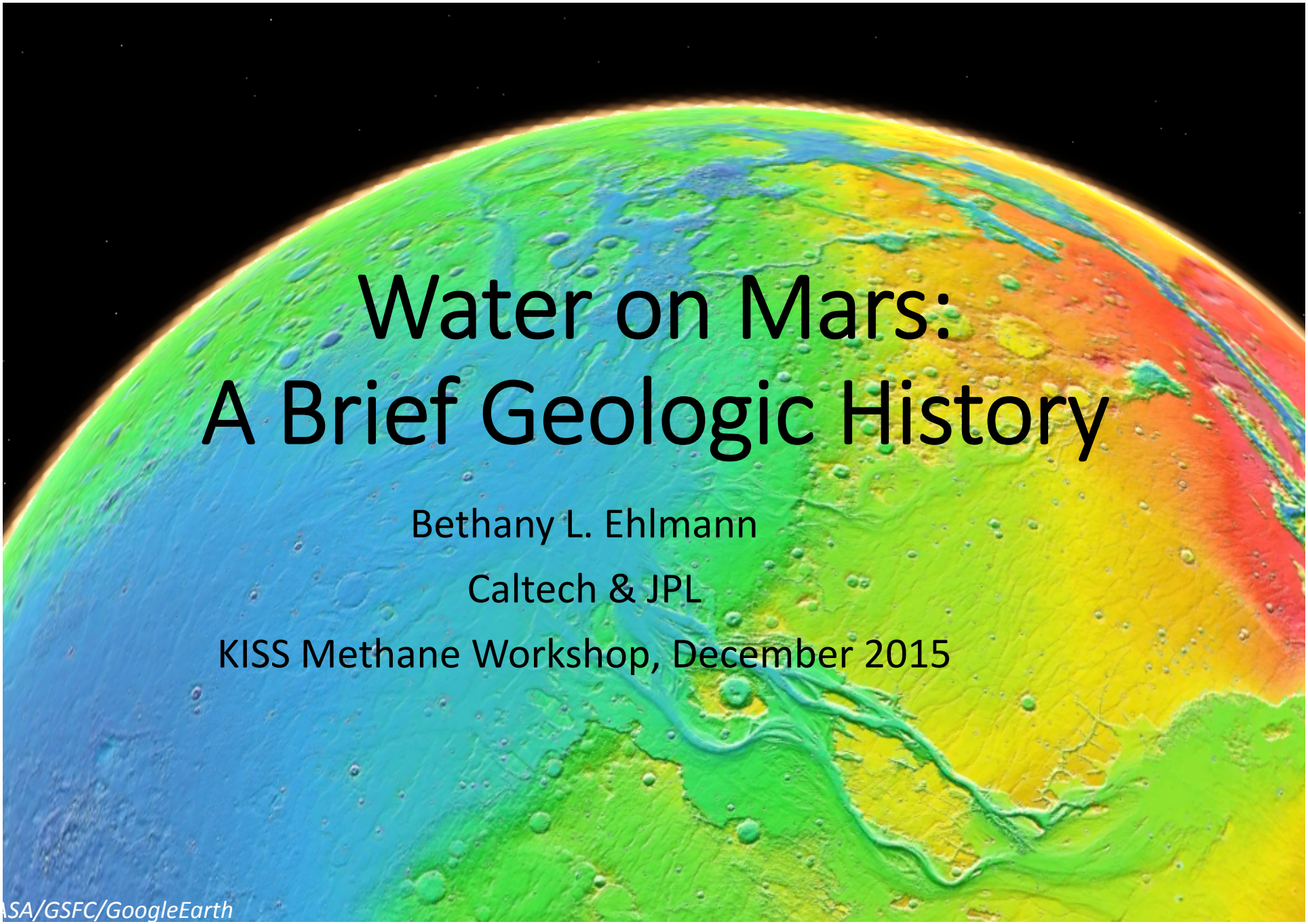


Water on Mars: A Brief Geologic History

Bethany L. Ehlmann

Caltech & JPL

KISS Methane Workshop, December 2015

SA/GSFC/GoogleEarth

Causes of methane detection

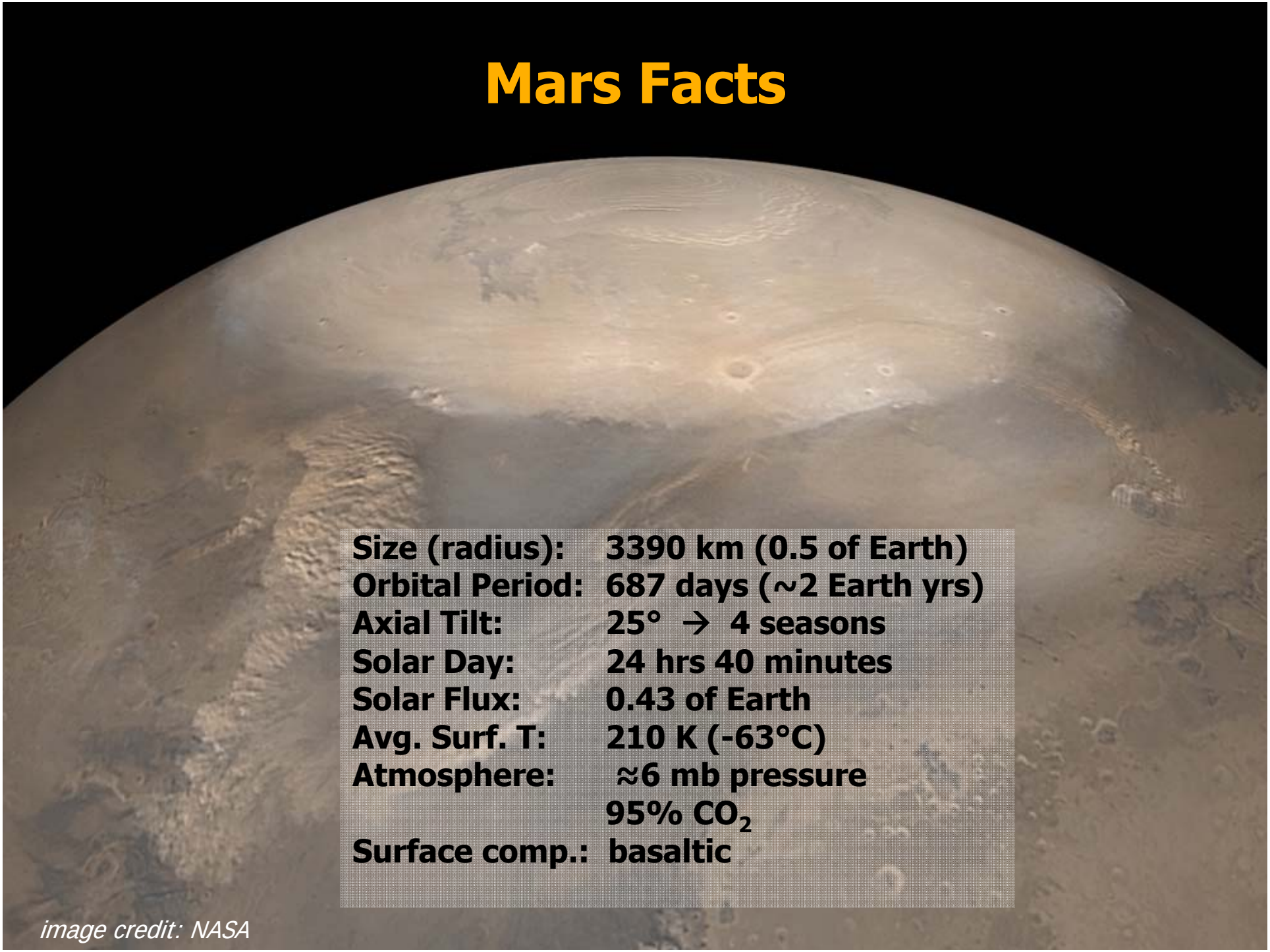
- Metabolic product of microbial life?
- Chemical product of serpentinization/hydrothermal reactions?
- Reduced gas released by Martian volcanism?
- Clathrate from an earlier Martian epoch?

- Breakdown of delivered exogenous organic matter

- Other…

- Intent in this talk is to provide Martian geological context for the mechanisms

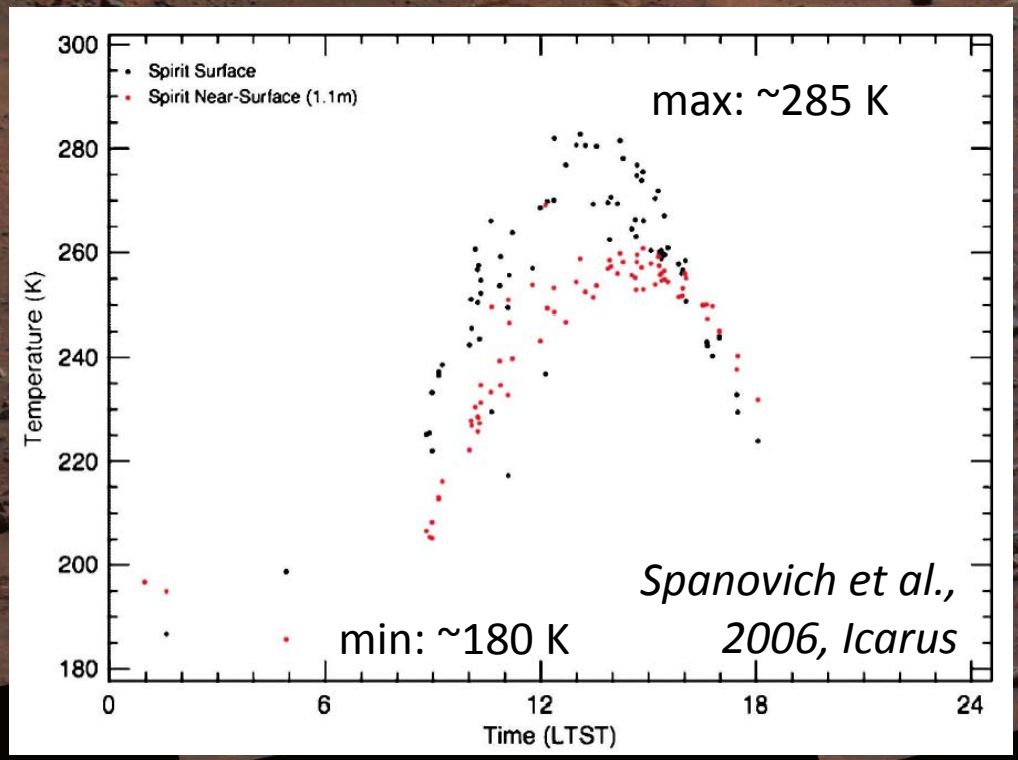
Mars Facts



Size (radius):	**3390 km (0.5 of Earth)**
Orbital Period:	**687 days (~2 Earth yrs)**
Axial Tilt:	**25° → 4 seasons**
Solar Day:	**24 hrs 40 minutes**
Solar Flux:	**0.43 of Earth**
Avg. Surf. T:	**210 K (-63°C)**
Atmosphere:	**≈6 mb pressure**
	95% CO_2
Surface comp.:	**basaltic**

image credit: NASA

equatorial Temperatuers (down to ~140 K at poles)



Spirit, sol 454 (NASA/JPL/Cornell)

Mars Facts

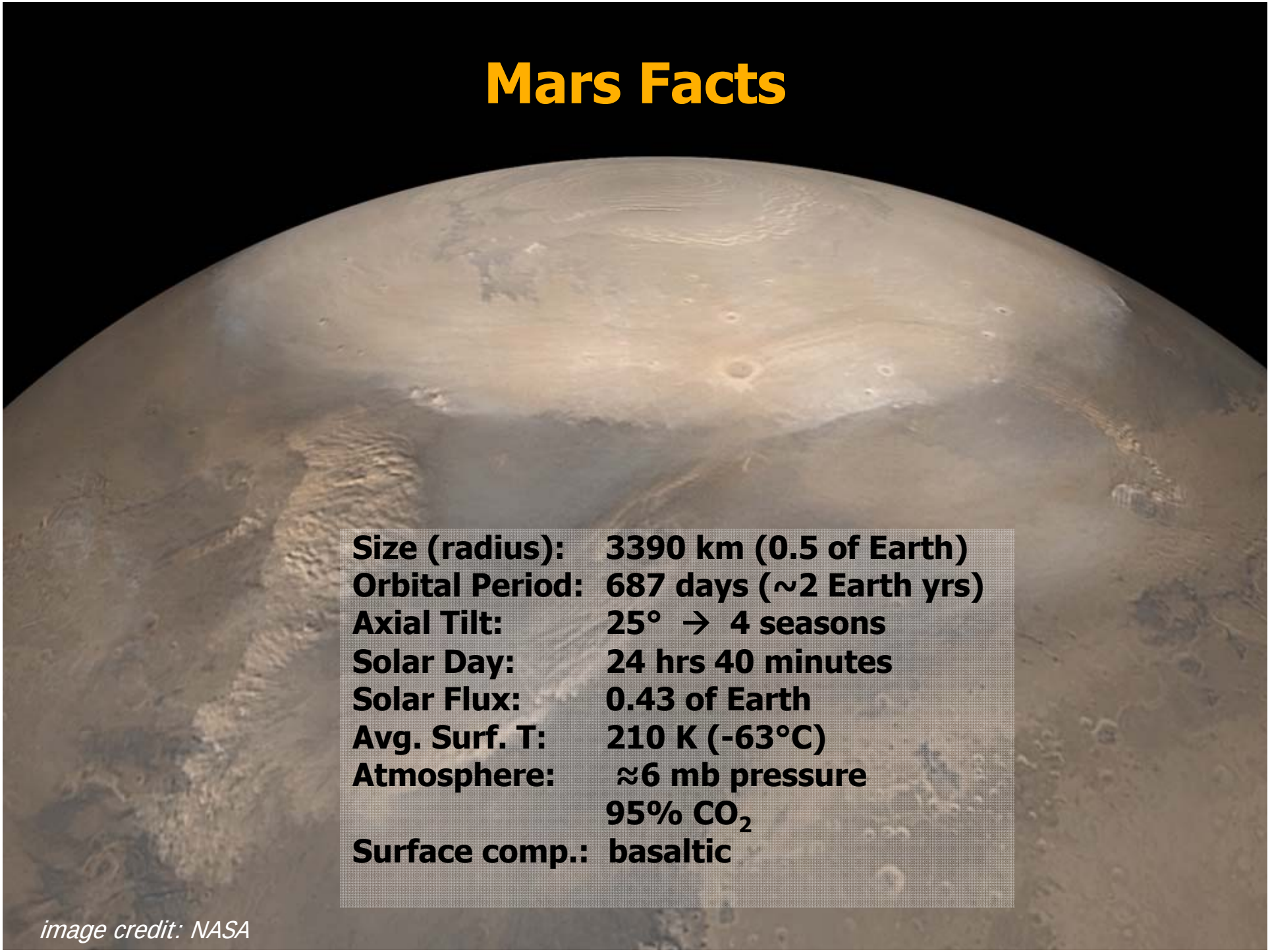


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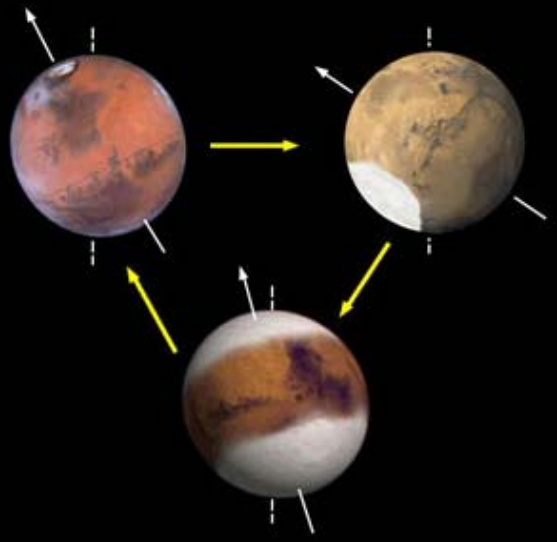
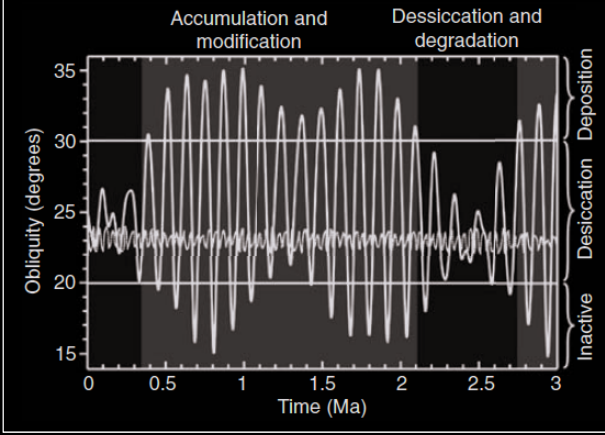
image credit: NASA

Modern Mars: ephermal liquid water? The present is the key to past?

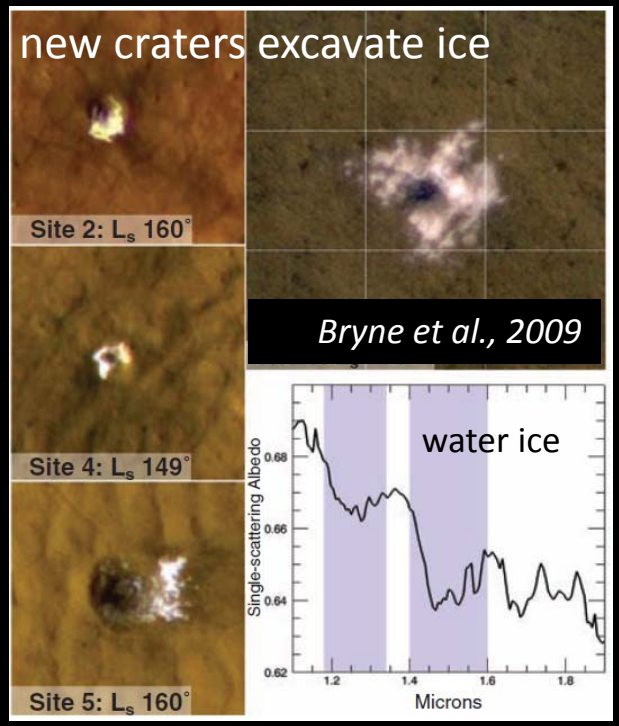
ice ages and glaciation



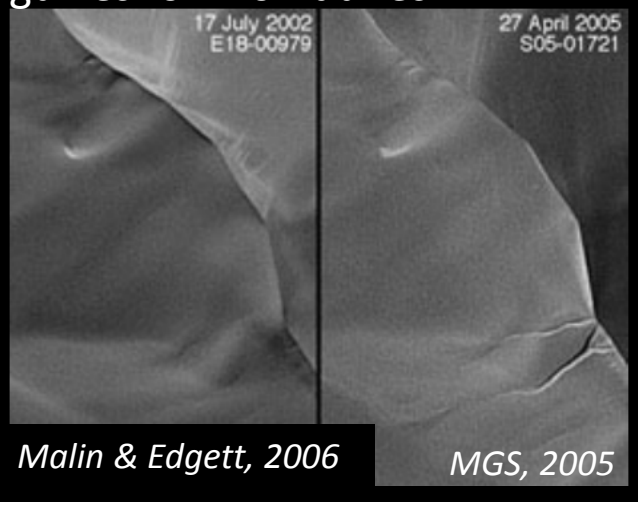
Laskar et al., 2002;
Head et al., 2003



new craters excavate ice



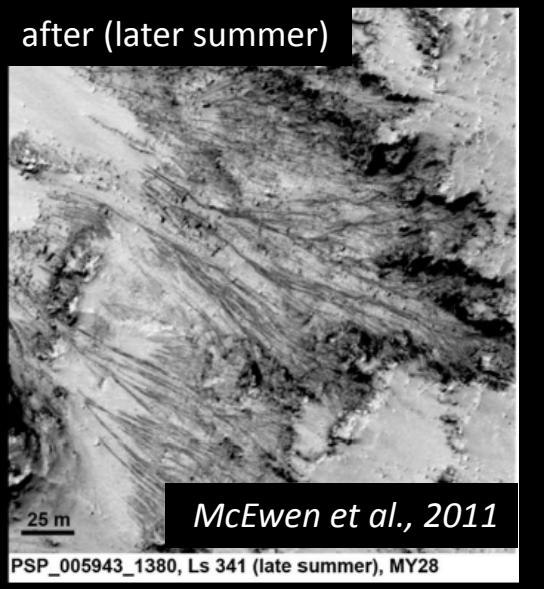
gullies form on dunes



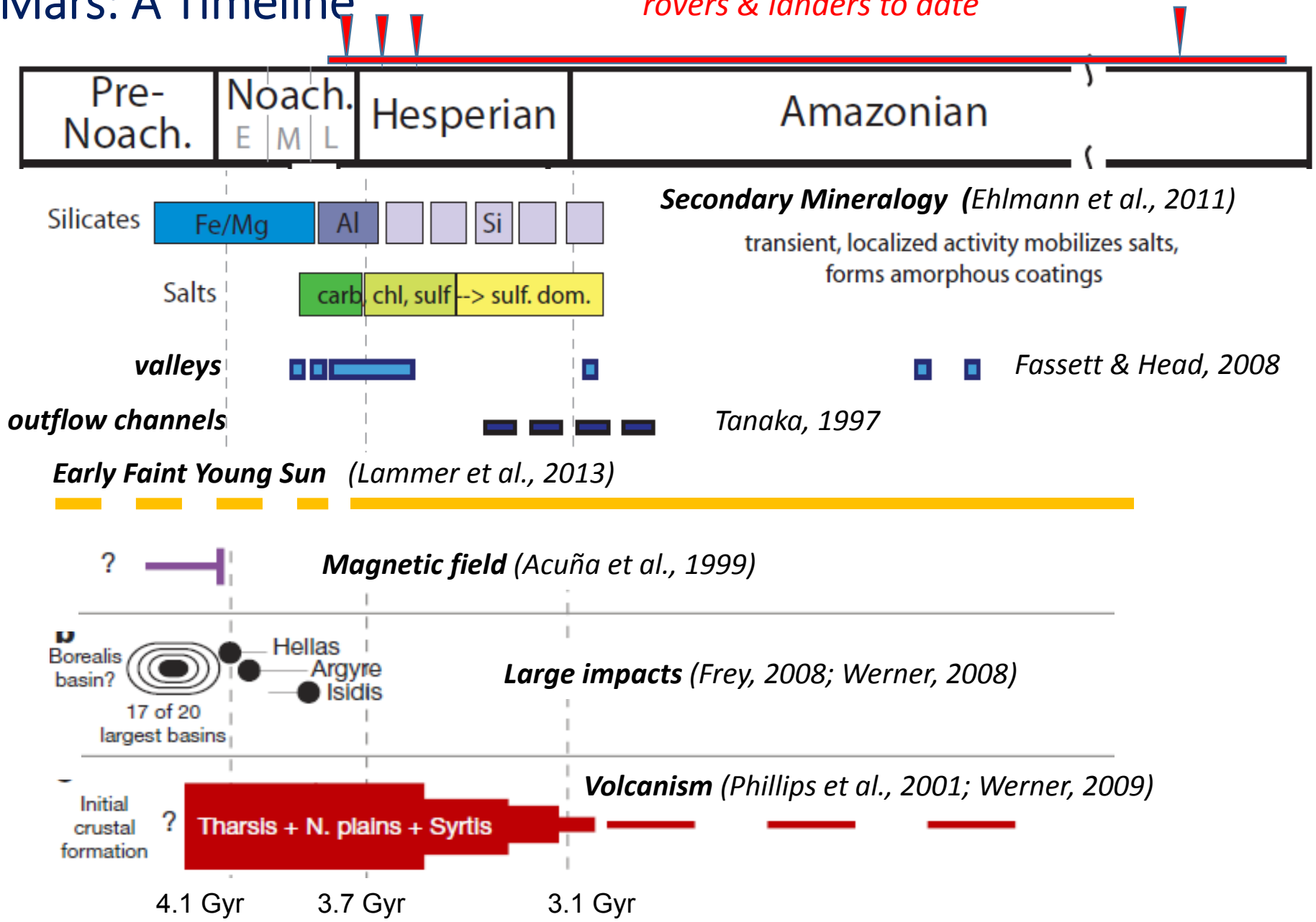
annual slope streak formation by liquid water?

before (early spring)

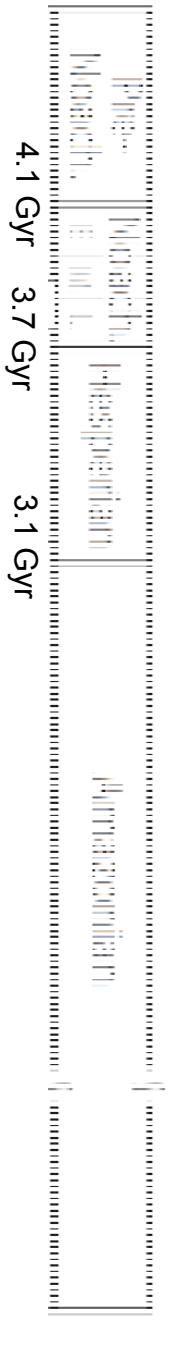
after (later summer)



Mars: A Timeline



Ehlmann et al., 2011, Nature



Martian Environments

"Deep phyllosilicates"

Layered phyllosilicates

Carbonate Deposits

Deep Lakes

Chloride playas

Layered Sulfates

Volcanic fumaroles

Outflow channels

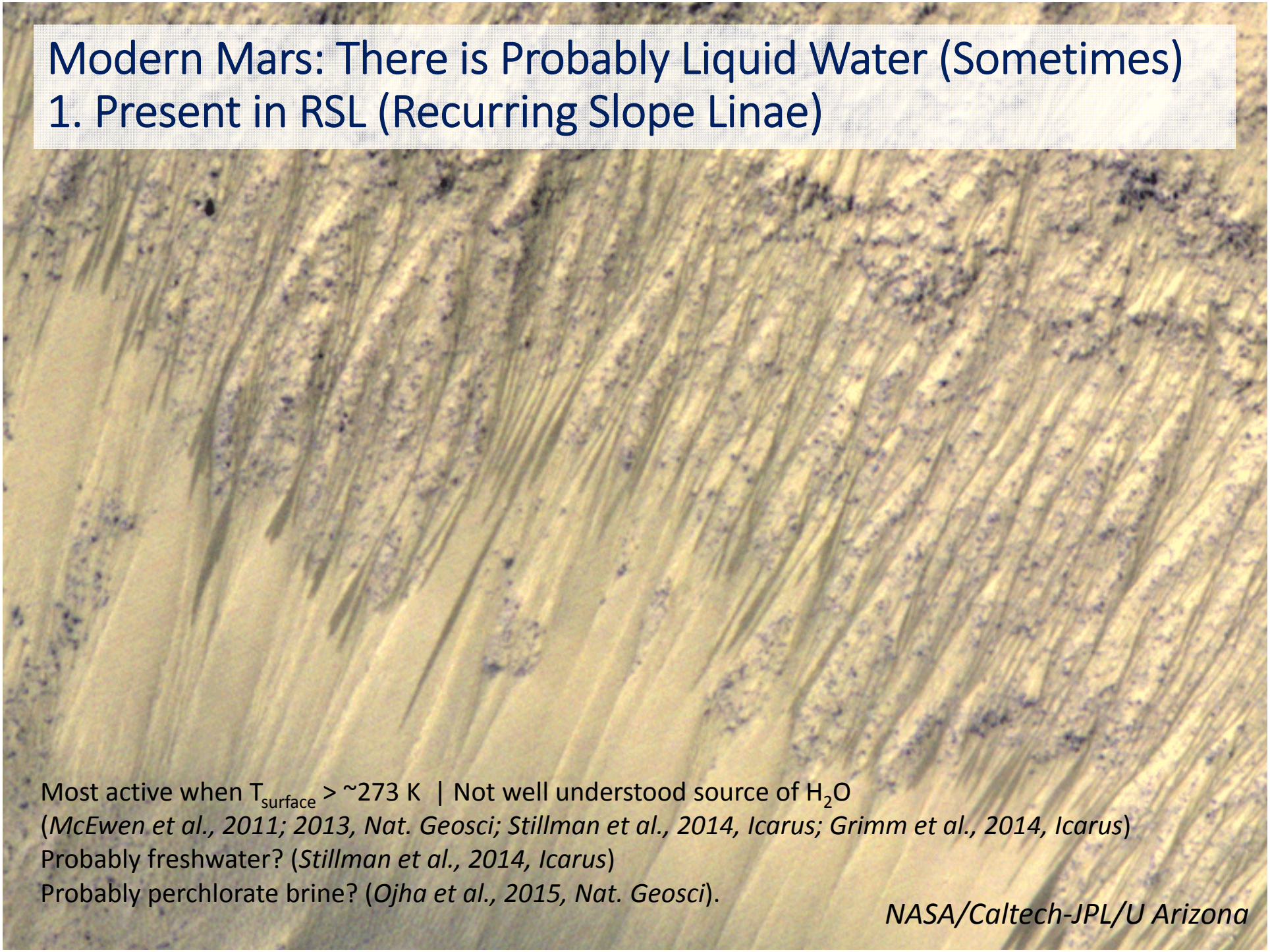
Amazonian gullies

Salty soils

RSL (recurring slope linae)

Moden Liquid Water?

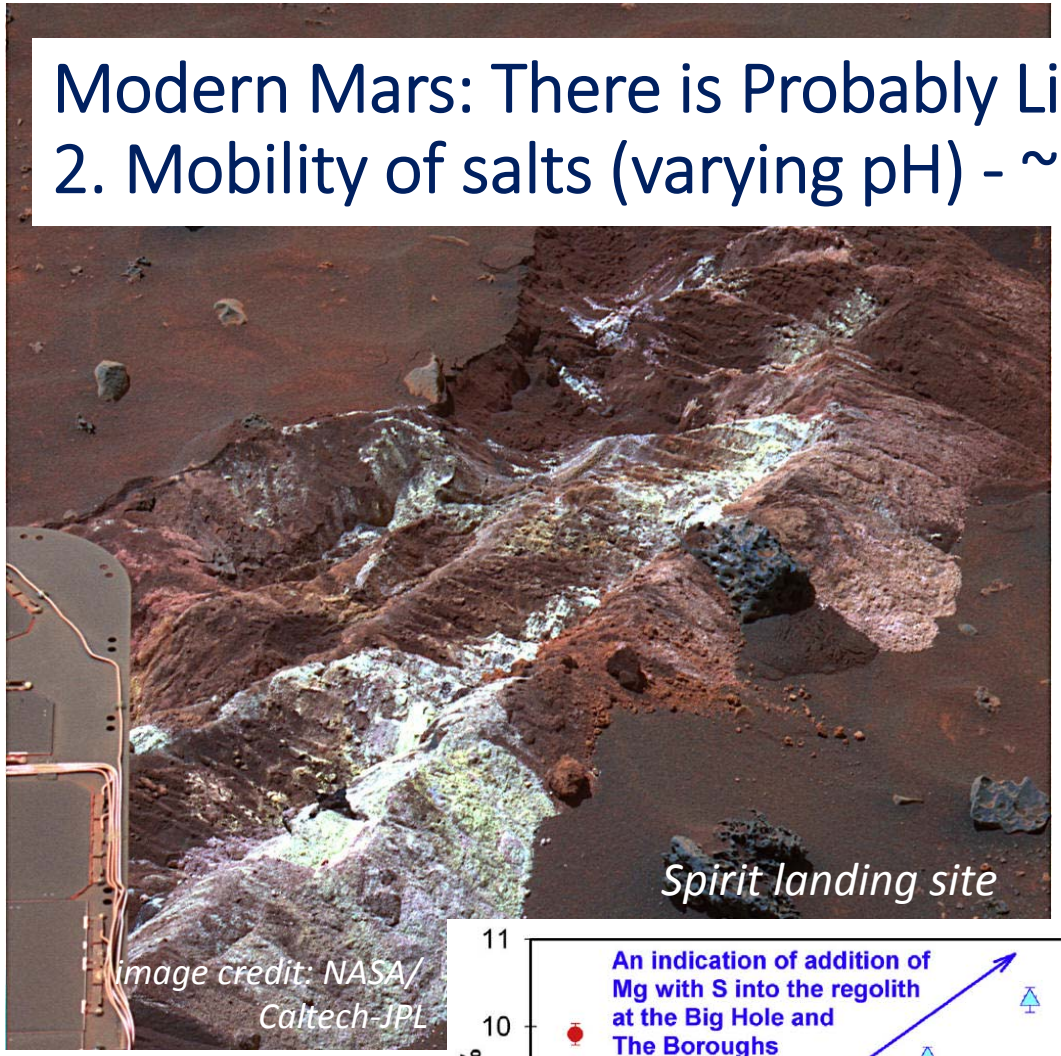
Modern Mars: There is Probably Liquid Water (Sometimes)
1. Present in RSL (Recurring Slope Linae)



Most active when $T_{surface}$ > ~273 K | Not well understood source of H_2O
(*McEwen et al., 2011; 2013, Nat. Geosci; Stillman et al., 2014, Icarus; Grimm et al., 2014, Icarus*)
Probably freshwater? (*Stillman et al., 2014, Icarus*)
Probably perchlorate brine? (*Ojha et al., 2015, Nat. Geosci*).

NASA/Caltech-JPL/U Arizona

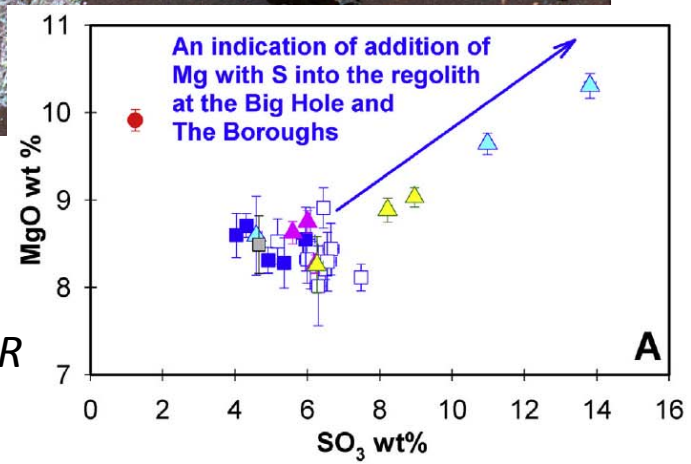
Modern Mars: There is Probably Liquid Water (Sometimes)
2. Mobility of salts (varying pH) - ~10^3-10^5 yr scale

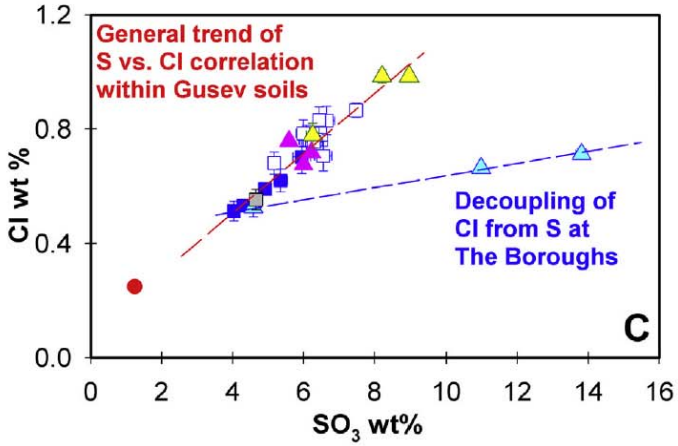


The chemistry of regolith upper cm's shows salt mobility

- $(Ca,Mg,Fe)SO_4$
- $(Na,Mg)Cl$
- $(Ca,Mg)ClO_4$

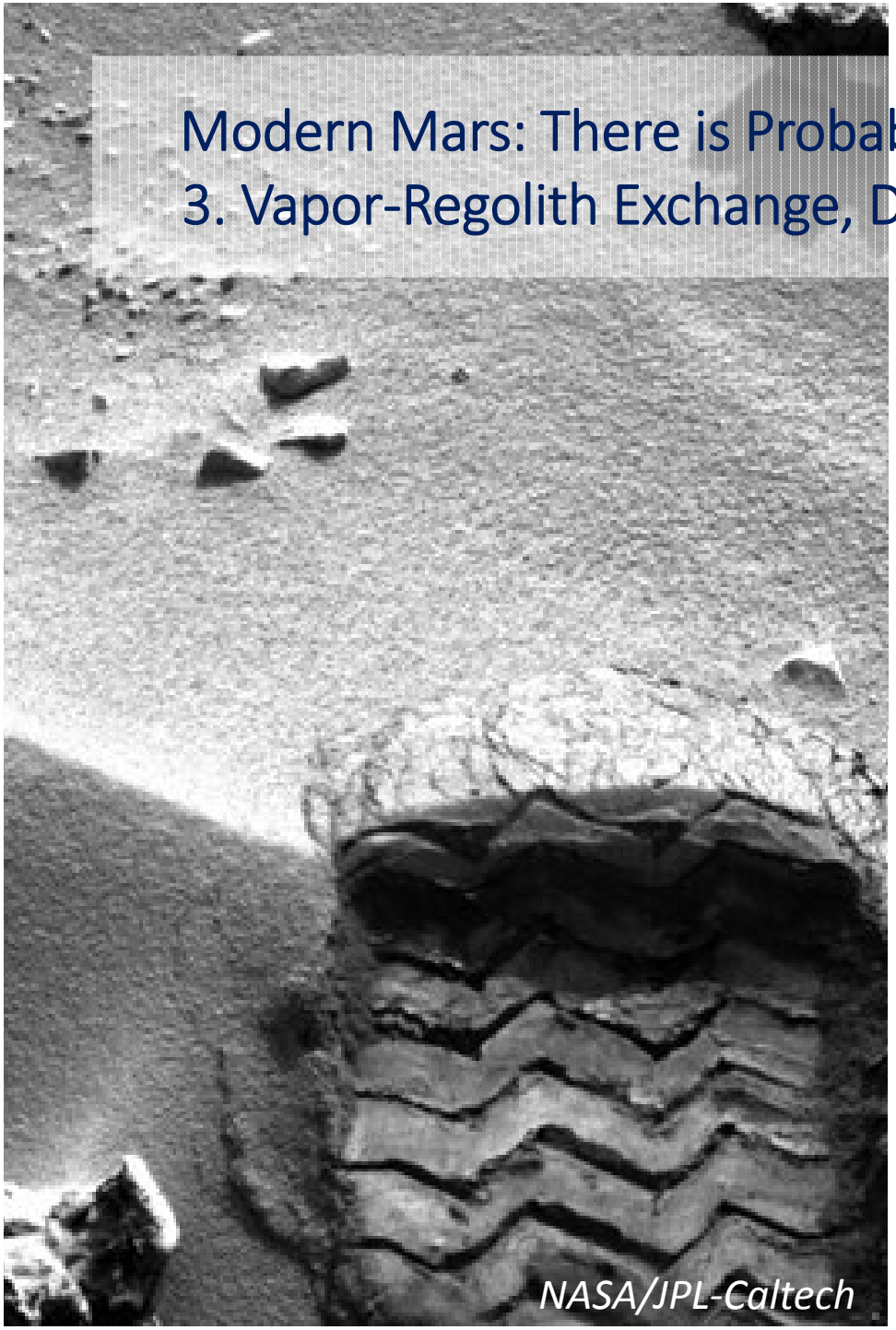
Salts may change hydration state in modern Mars T-RH conditions (*Vaniman et al., 2004, Nature*)

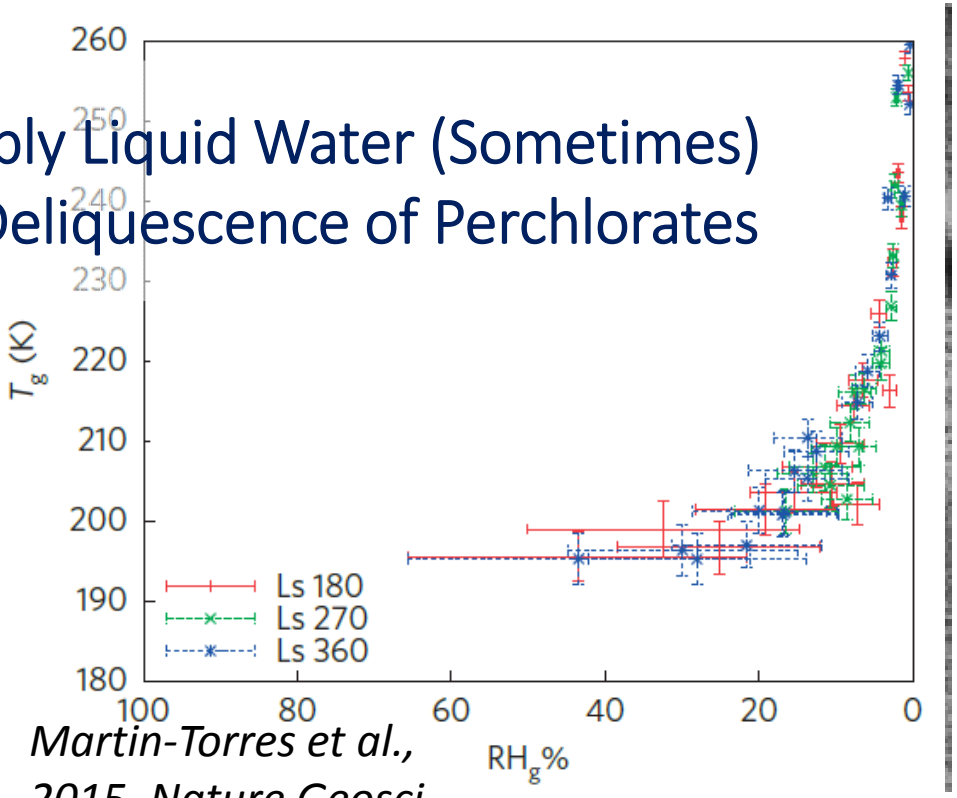




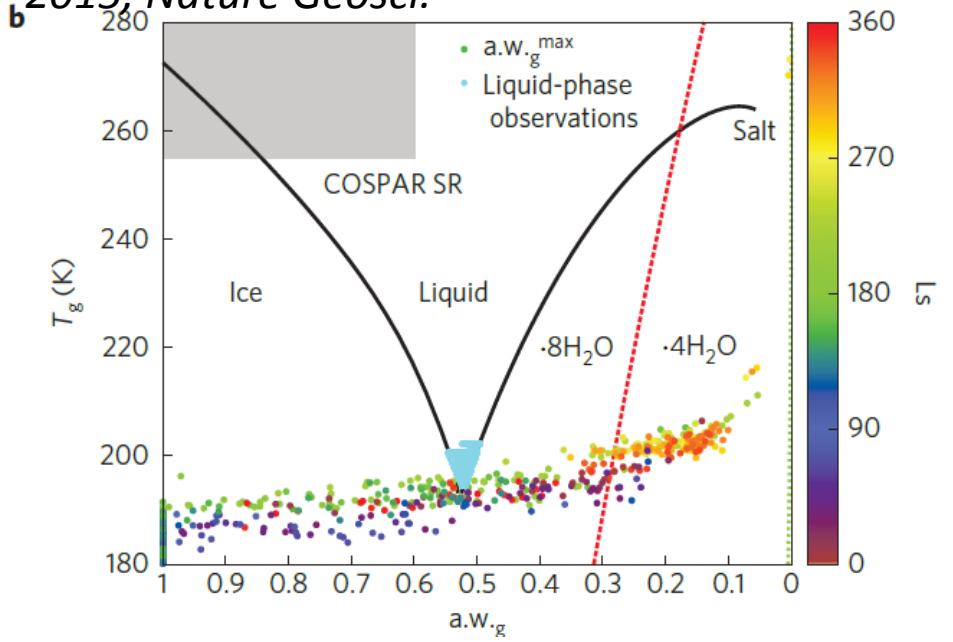
Wang et al., 2006, JGR

Modern Mars: There is Probably Liquid Water (Sometimes)
3. Vapor-Regolith Exchange, Deliquescence of Perchlorates





Martin-Torres et al., 2015, Nature Geosci.



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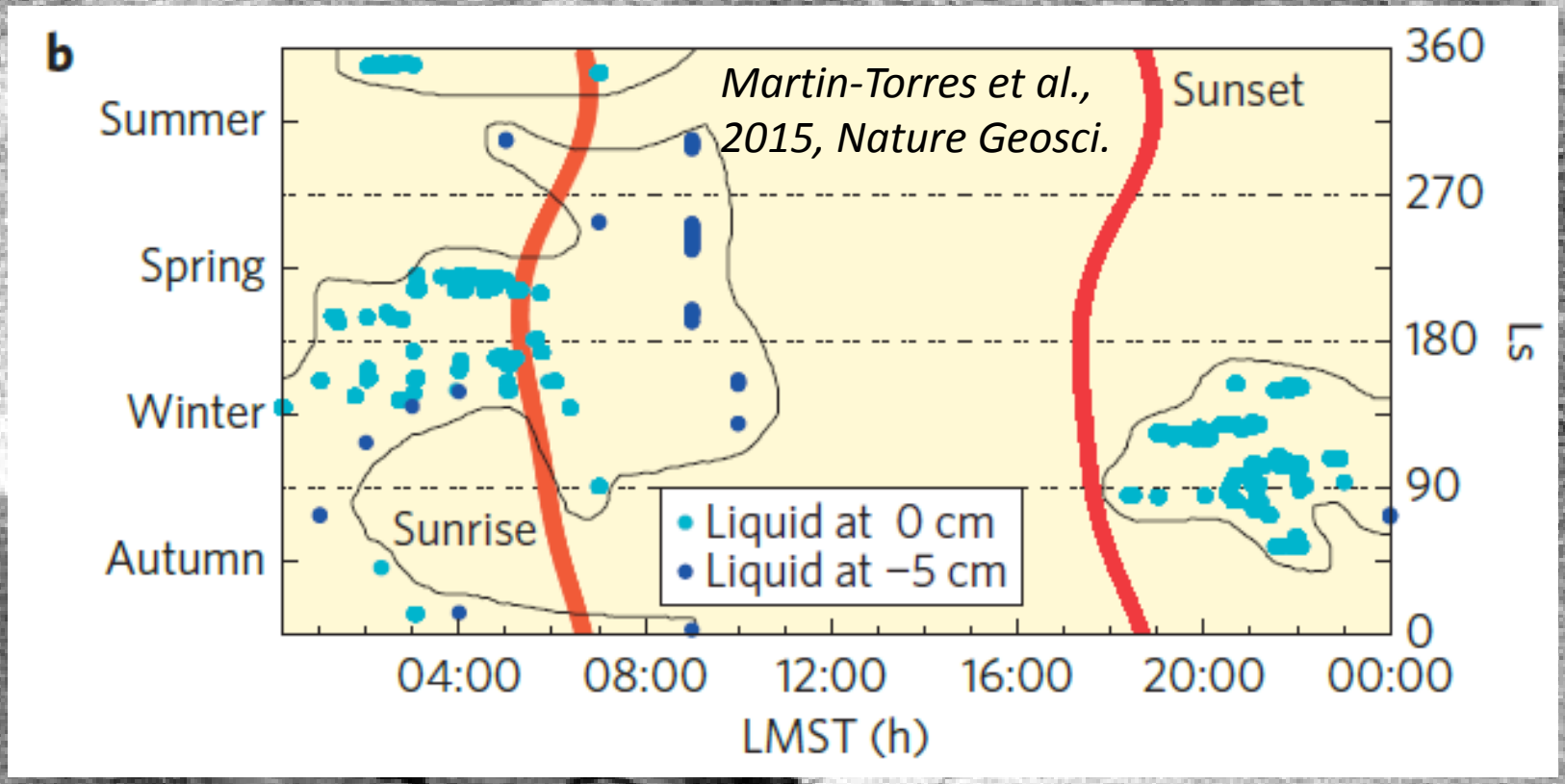
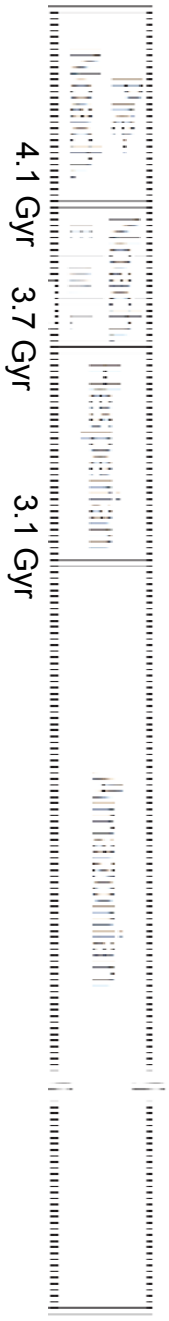


NASA/JPL-Caltech



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Volcanic fumaroles

Outflow channels

Amazonian gullies

Salty soils

RSL (recurring slope linae)

Modern (and ancient) climate cycles and water avaialability

obliquity changes

Sun

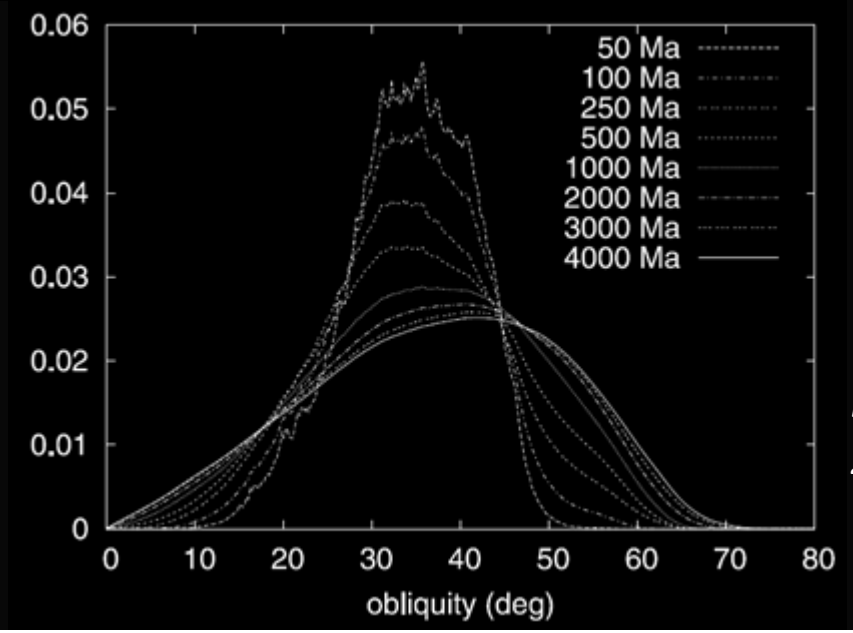
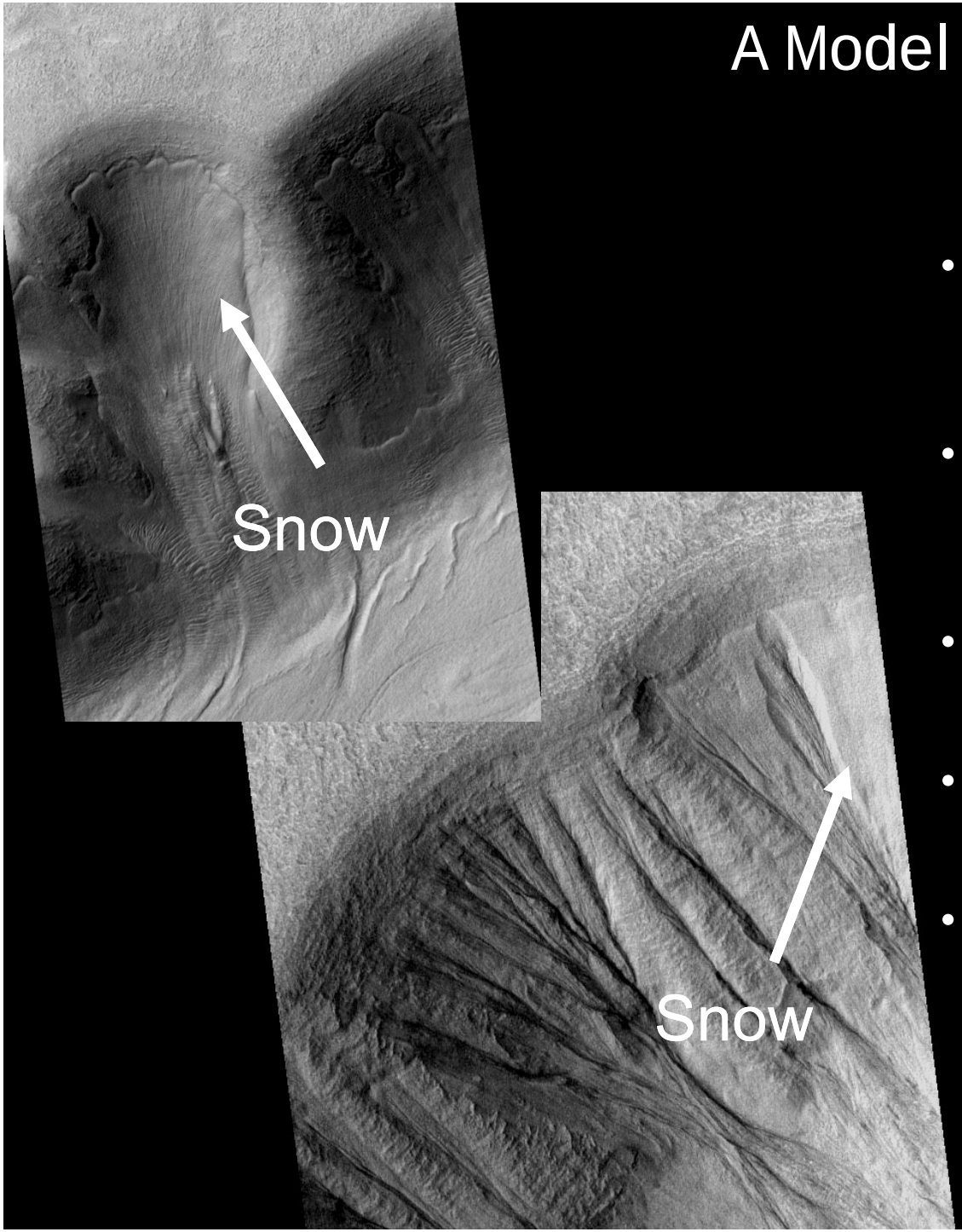


figure adapted from P. Christensen figure

Laskar et al., 2004, Icarus

A Model For Gully Formation



- Snow layer accumulates in mid-latitudes during high obliquity
- Melting of snow produces runoff that erodes gullies beneath protective snow layer
- Dirty snow will melt: icy dirt will not
- Snow dissipates, revealing gullies
- Patches of dust-covered snow remain today as mantles on pole-facing slopes

Christensen, Nature 2003

Gullies (blue) and Pasted-on Terrain (red)

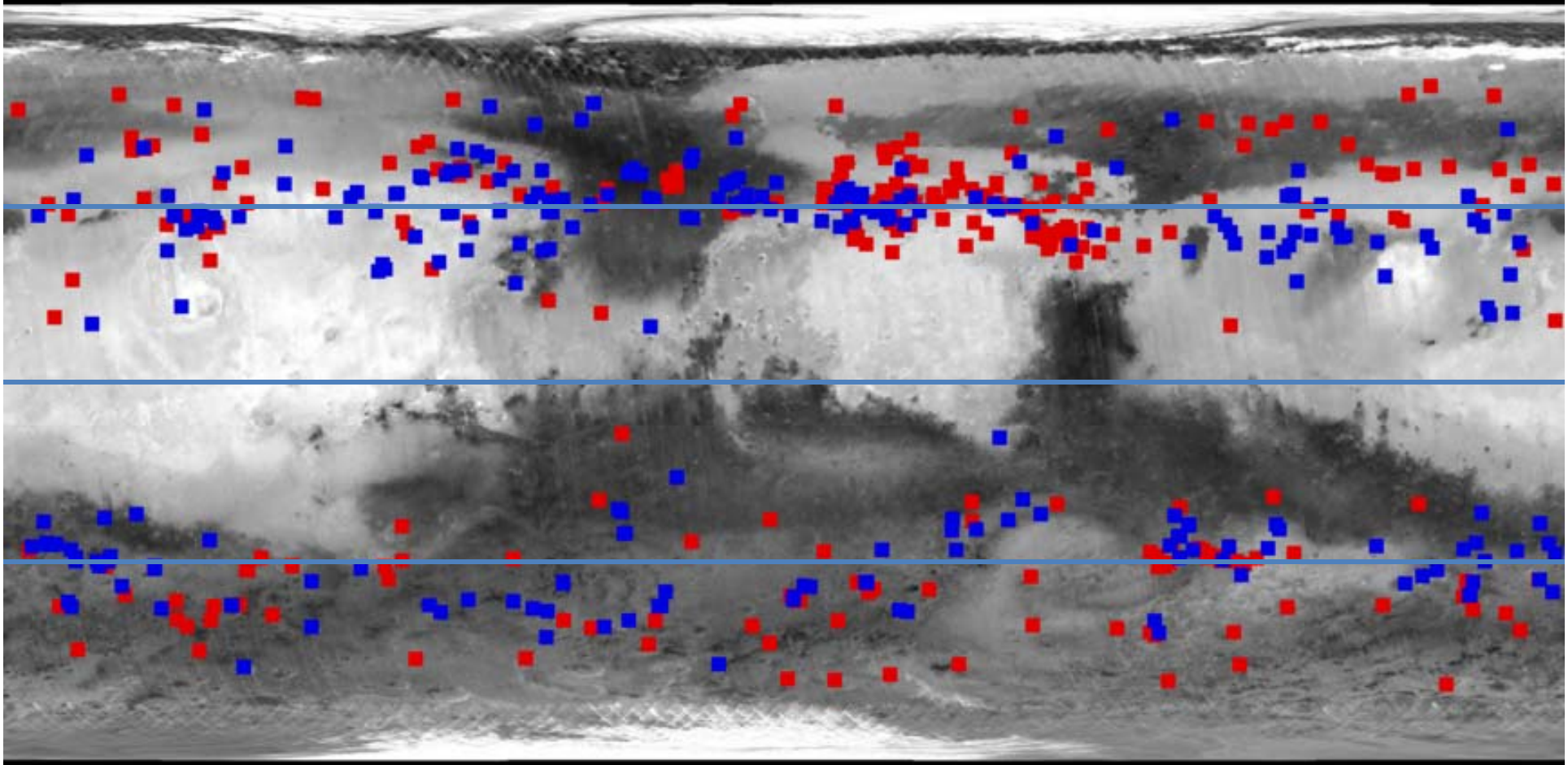
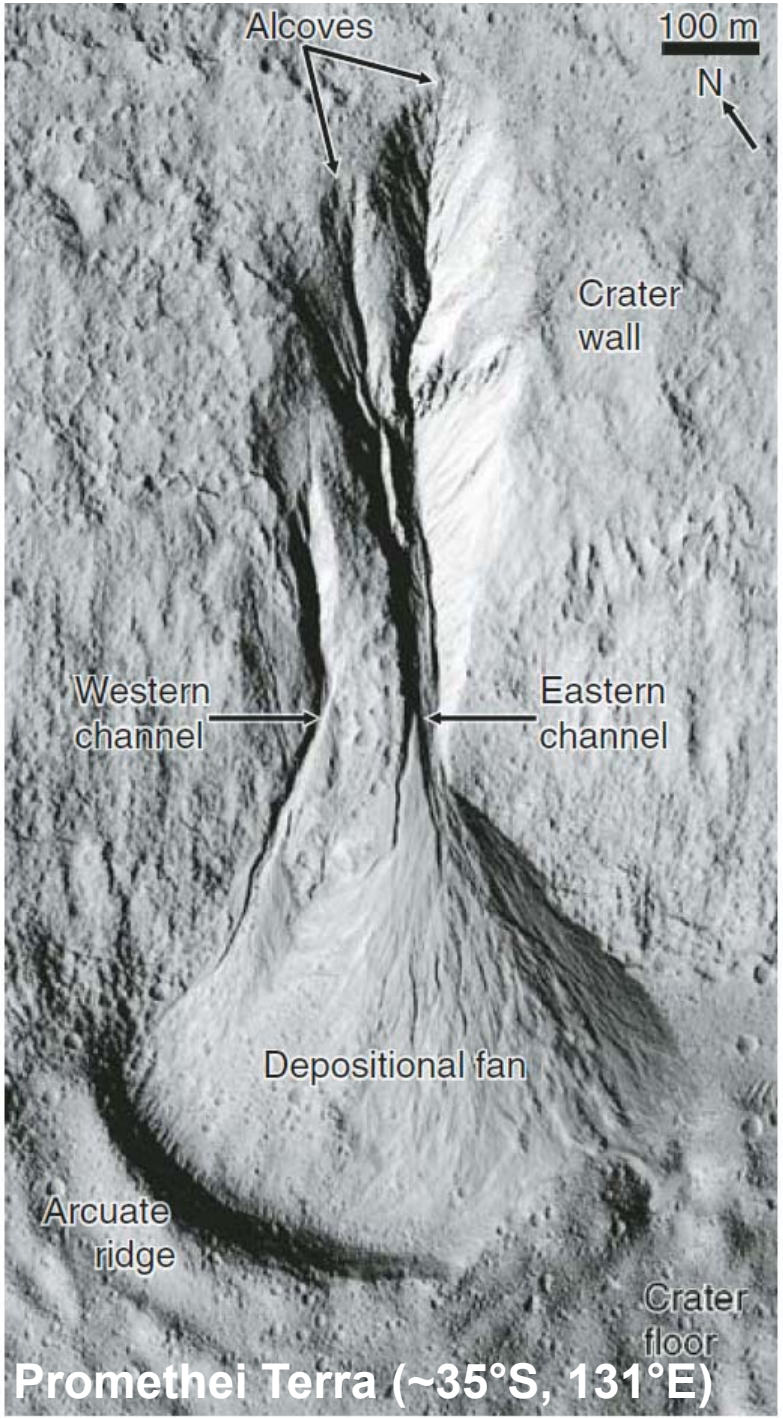
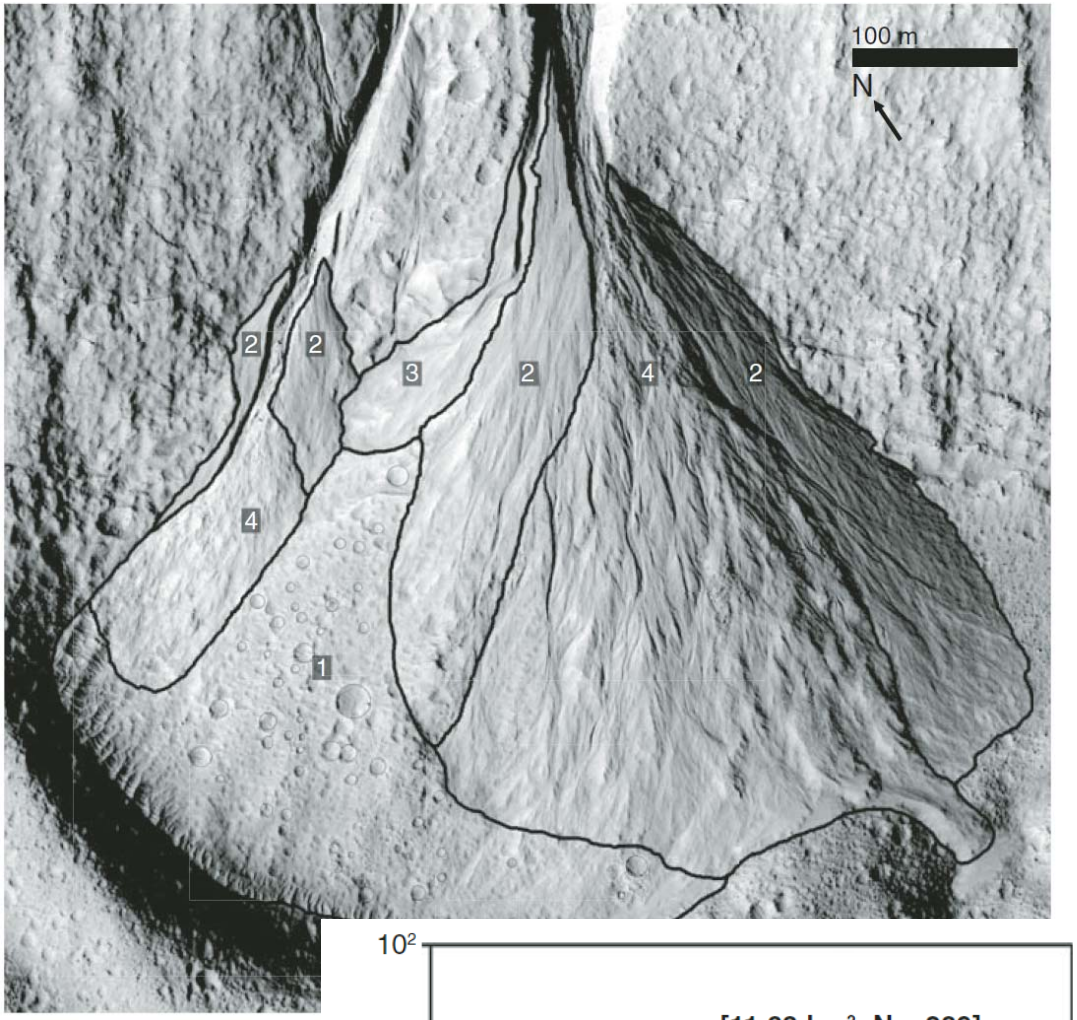


figure from P. Christensen





Modern Alluvial Activity

Schon et al., 2009, Geology