Eberswalde Talks

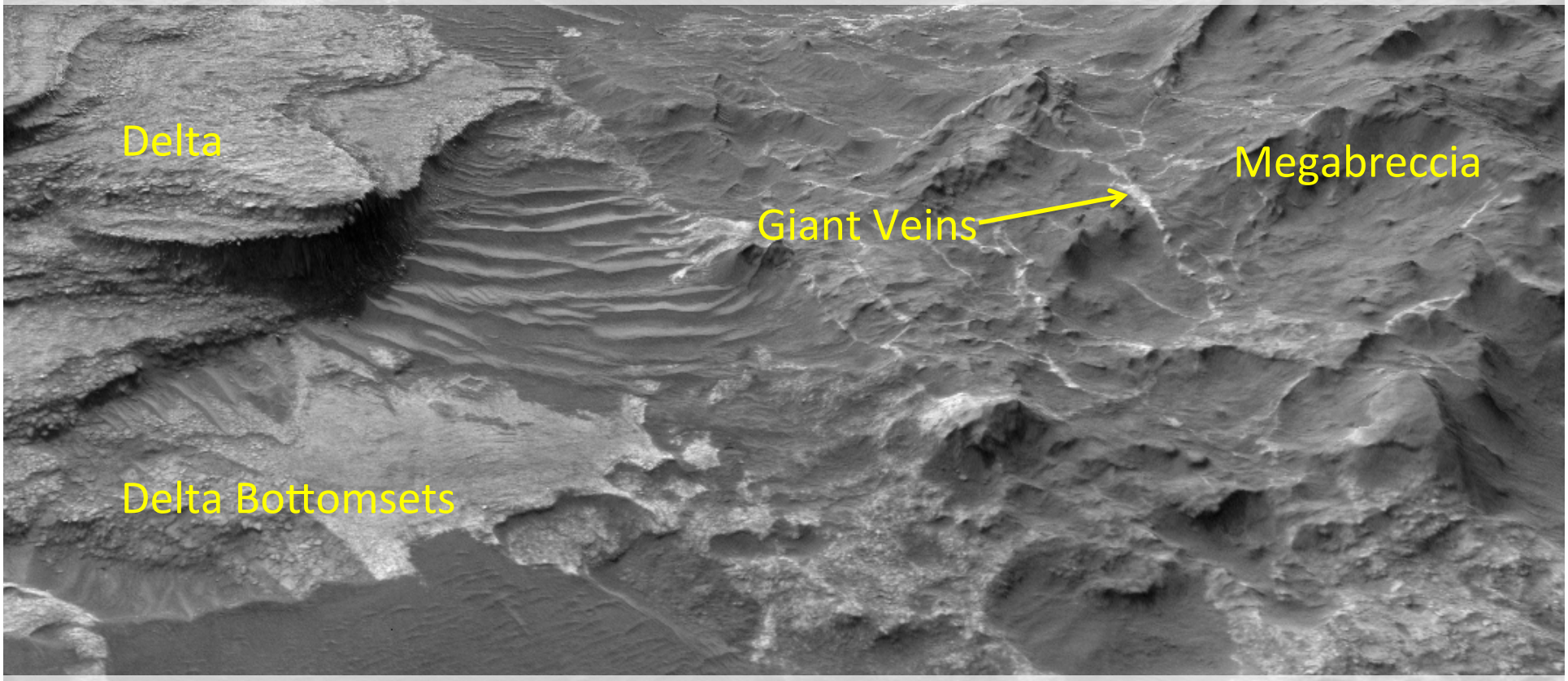
1. **Deltas, Lakes, Megabreccia, and Giant Veins: Interrogating Geologic Diversity for a NASA 2020 Mission to Eberswalde Crater** (20 min) - M. Rice

2. **Chronostratigraphy, Provenance, and Geologic Context of the Eberswalde System** (20 min) - N. Warner

3. **Deltaic Evolution in the Large Closed Basin Eberswalde Crater Lake: Sedimentary Archives of Lake Level History, Habitability, and Biosignature Preservation** (15 min) - S. Gupta

4. **Summary of a Potential Mars2020 Investigation at Eberswalde** (5 min) – M. Rice

Deltas, Lakes, Megabreccia, and Giant Veins: Interrogating Geologic Diversity for a NASA 2020 Mission to Eberswalde Crater



Melissa Rice, *Western Washington University*
Nicholas Warner, *State University of New York at Geneseo*
Sanjeev Gupta, *Imperial College London*

Main Points:

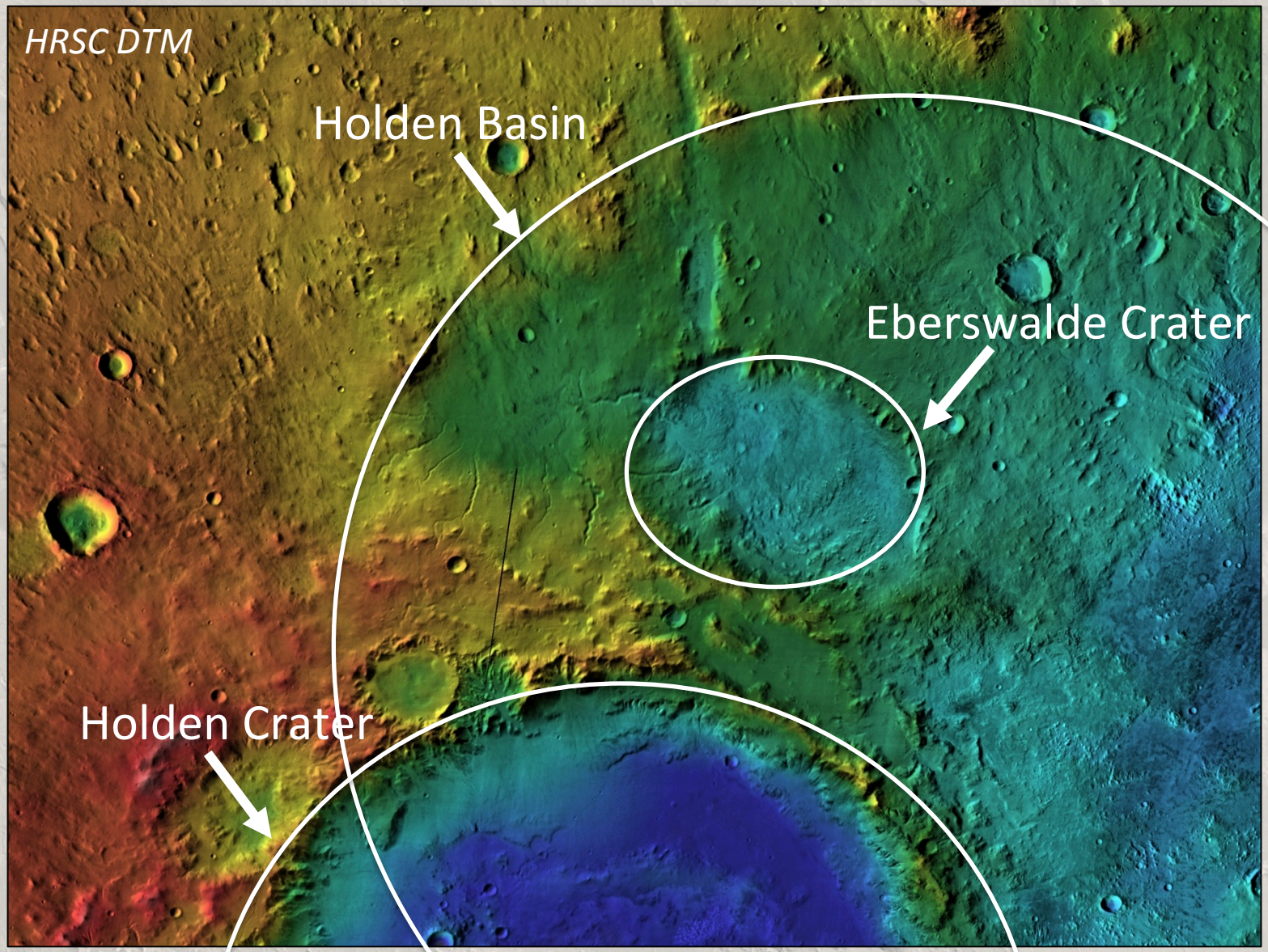
- Eberswalde crater contains a spectacularly-preserved **delta** with **easily-accessible** bottomset deposits (which have a high potential for concentrating and preserving organic biosignatures)

- An opportunity to examine how **potentially long-lived** lacustrine systems were able to survive under changing global climate conditions in the early to mid Hesperian

- **Megabreccias** from the Holden crater impact and **giant veins** are also located in the **center of the ellipse**

- The **"compact diversity"** in the center of the Eberswalde ellipse, and the clear geologic context, would make for an **efficient sampling mission** with the potential for **fundamental scientific discoveries**

Eberswalde Crater predates the formation of Holden Crater to the south, and lies entirely within Holden's continuous ejecta blanket



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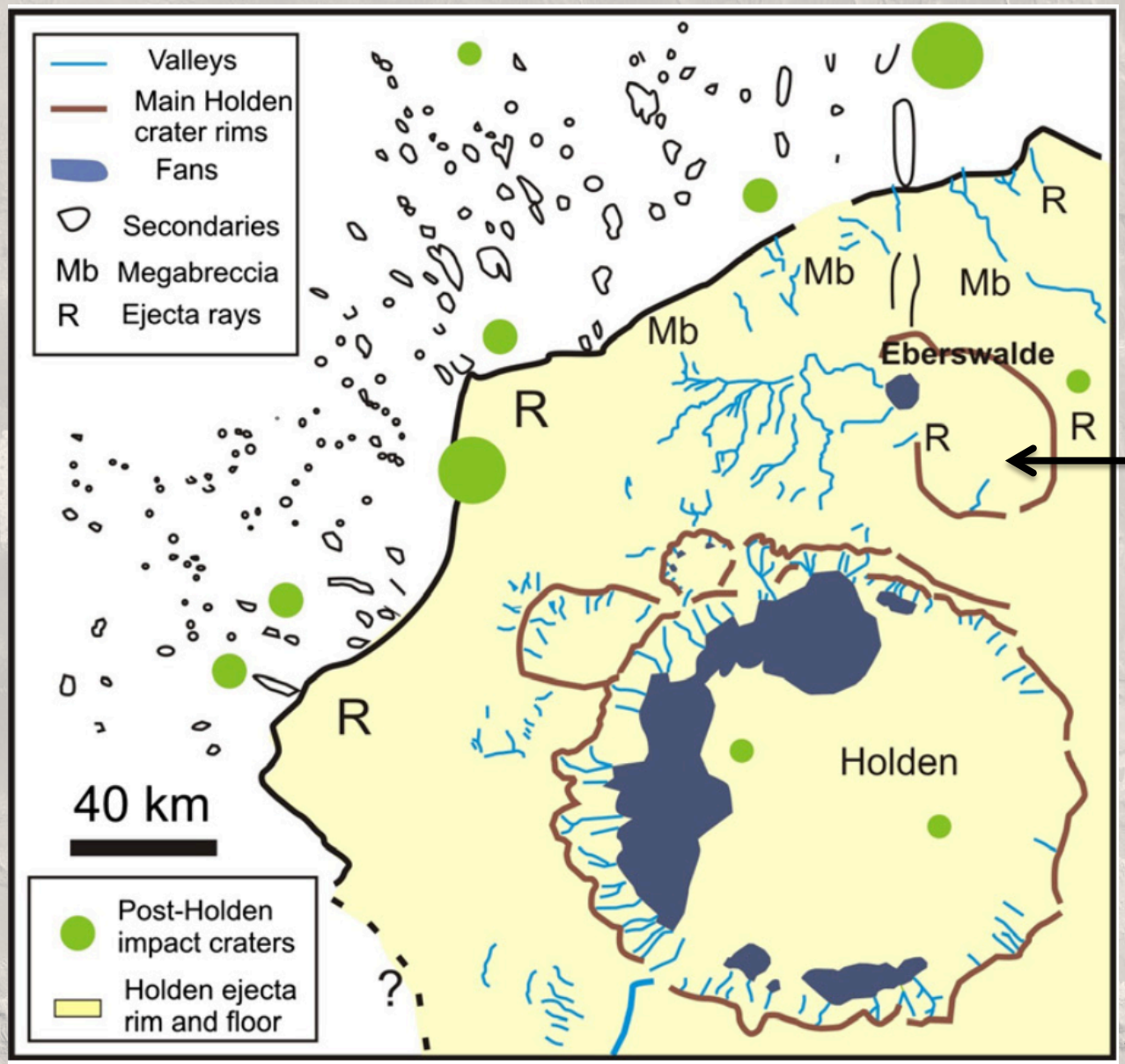
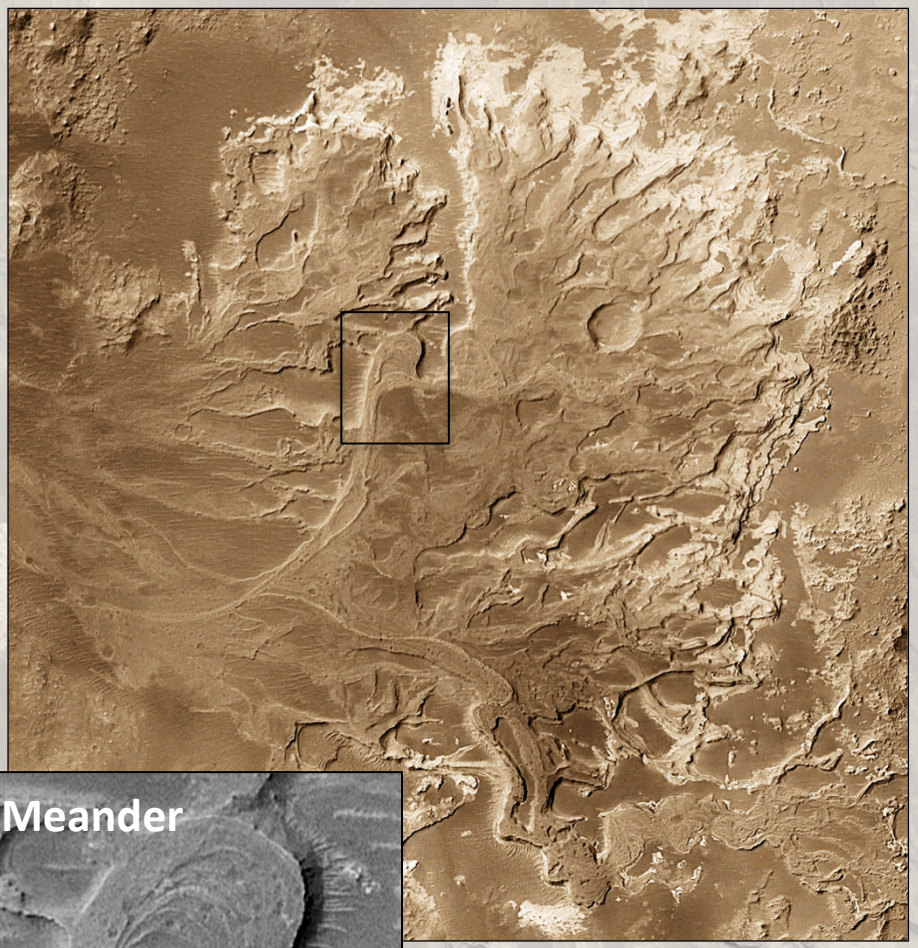


Eberswalde Crater

Mangold et al. (2012)

Spectacularly-preserved delta in western Eberswalde crater



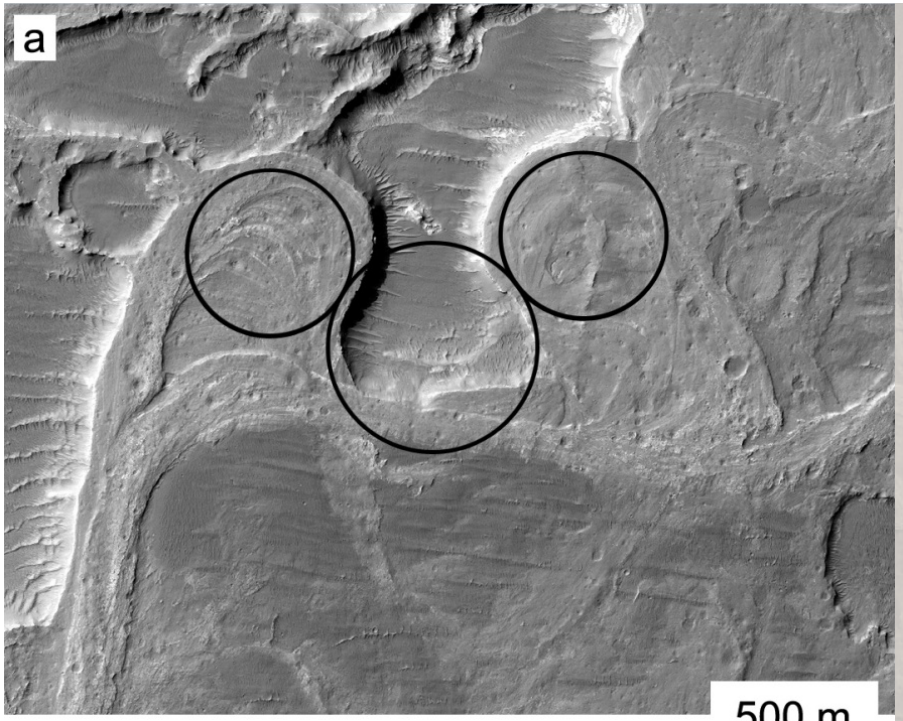
MOC image, credit NASA/JPL-Caltech/MSSS

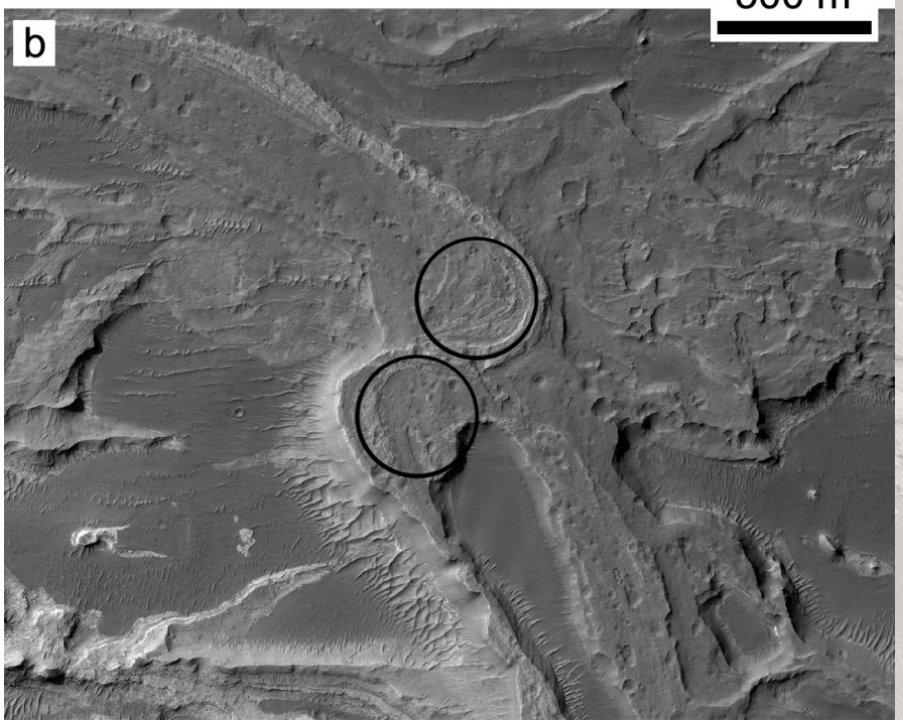
Consensus in literature for a delta:

Malin and Edgett (2003), Moore et al. (2003), Bhattacharya et al. (2005), Lewis and Aharonson (2006), Wood (2006), Pondrelli et al. (2008, 2011), Rice et al. (2011, 2013), Mangold et al. (2012), Irwin et al. (2013, 2015)

Defining deltaic features summarized by Irwin et al. (2015):

- Meander migration and cutoff
- Transition from sinuous to straight distal ridges
- Interfingering of sedimentary strata
- Gradient of deposit surface
- Steep margins of deposit



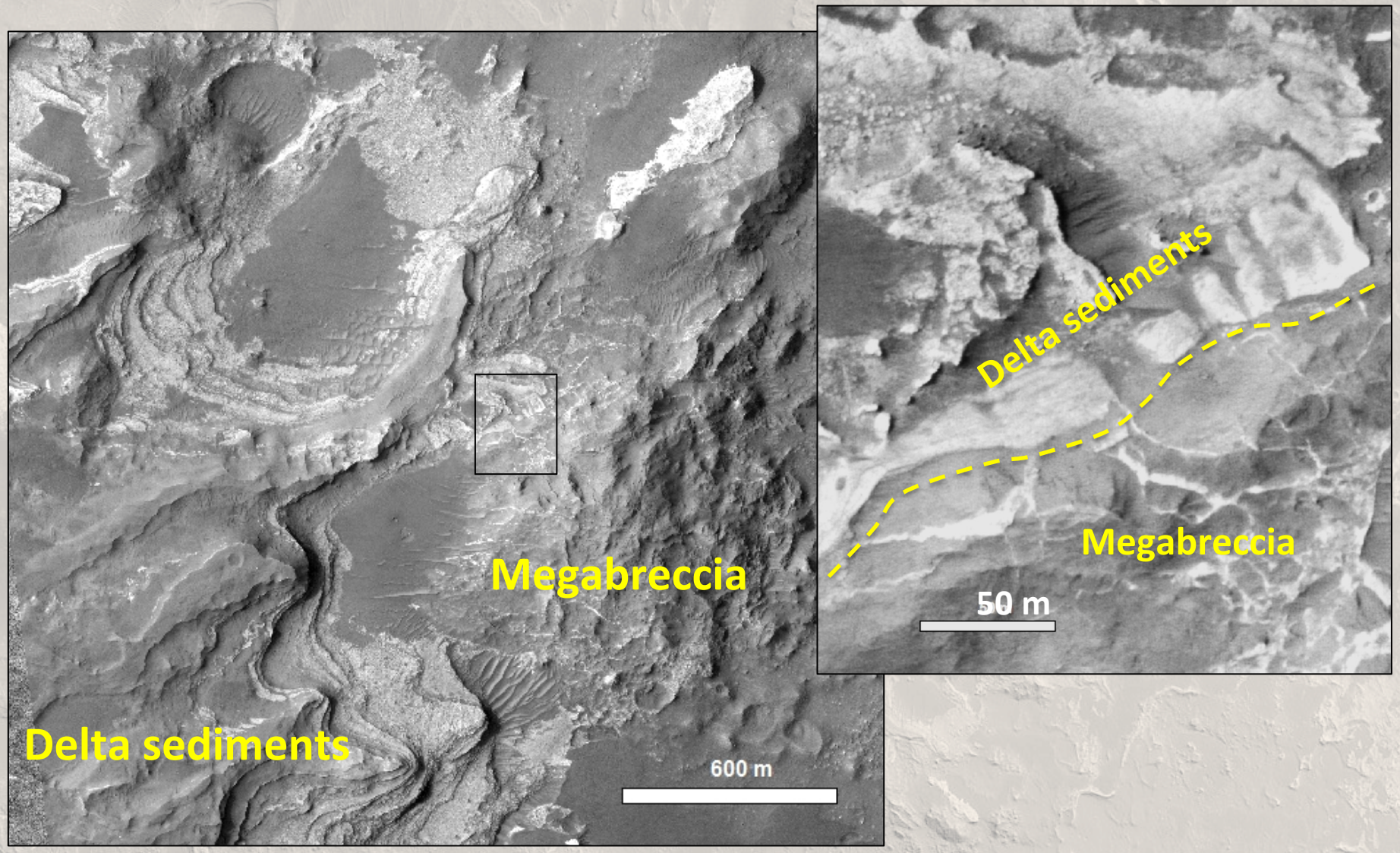


The presence of meanders requires cohesion from ice, clays, or cements (or, on Earth, vegetation)

Songhua River, China (Google)

Irwin et al., 2020 1st Workshop presentation

Development of the Eberswalde delta occurred AFTER the Holden-forming impact, because delta sediments onlap impact megabreccia deposits on crater floor



Paleohydrology of Eberswalde system suggests 10^4 - 10^6 years of deposition to form the delta (Irwin et al., 2015)

Width-wavelength relationships in two inverted paleochannels

- Consistent with meandering rivers on Earth
- Inverted channels are well-preserved here

Bank-full flow for inverted paleochannels

- From width: 450 m^3/s (north), 140 m^3/s (south)
- From wavelength: 400 m^3/s (north), 180 m^3/s (south)

- **Annual snowmelt or infrequent moderate rainfall are possible** (Irwin et al., 2015)

Annual runoff (lake levels of –1350 and –1400 m, 5,000 km^2 watershed)

For evaporation of 1 m/y: 8–16 cm/y

For evaporation of 0.1 m/y: 0.8–1.6 cm/y

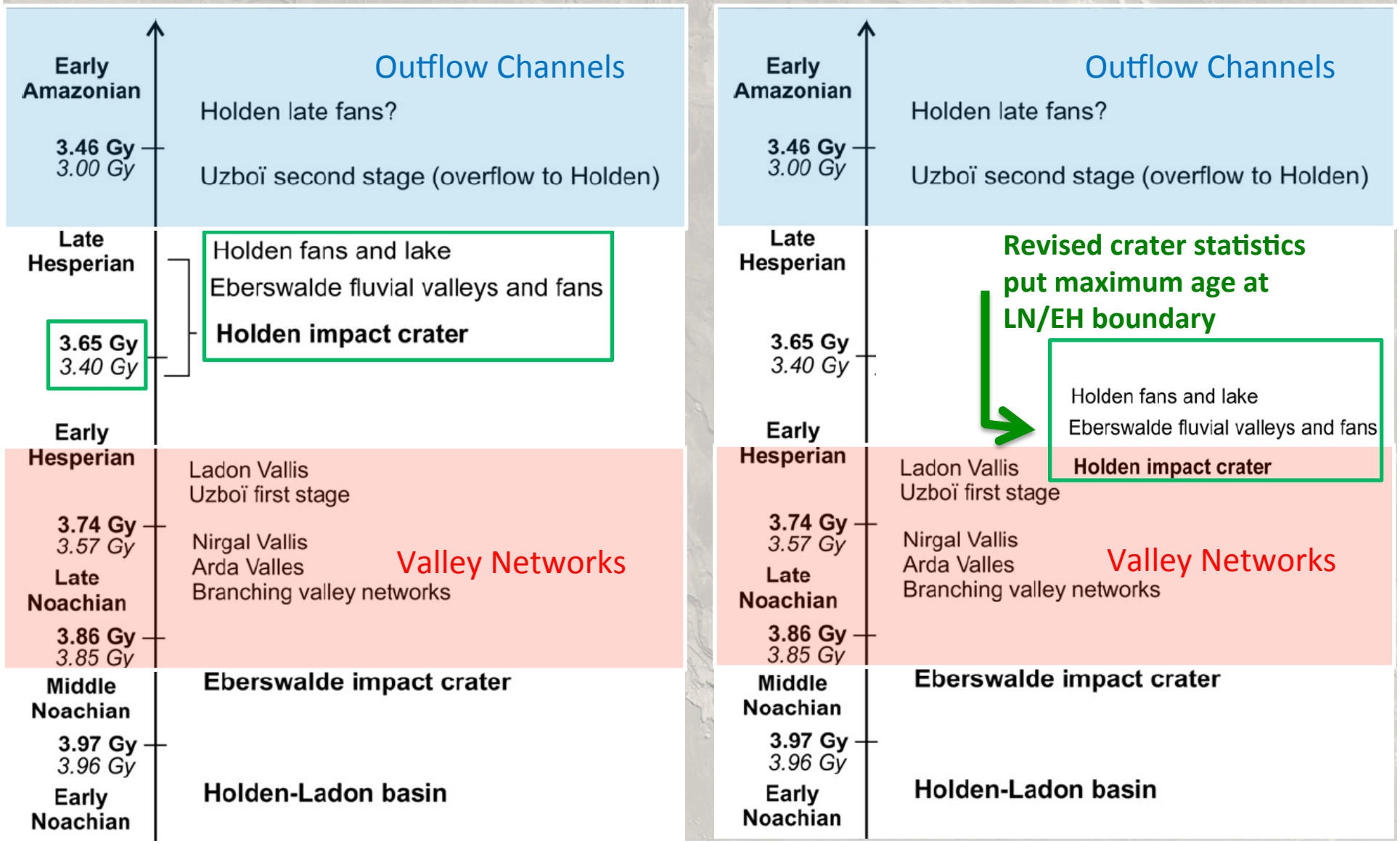
Deposition timescale (deposit volume of 6 km^3)

For water/sediment volume ratio of 1,000: tens to hundreds of thousands of years

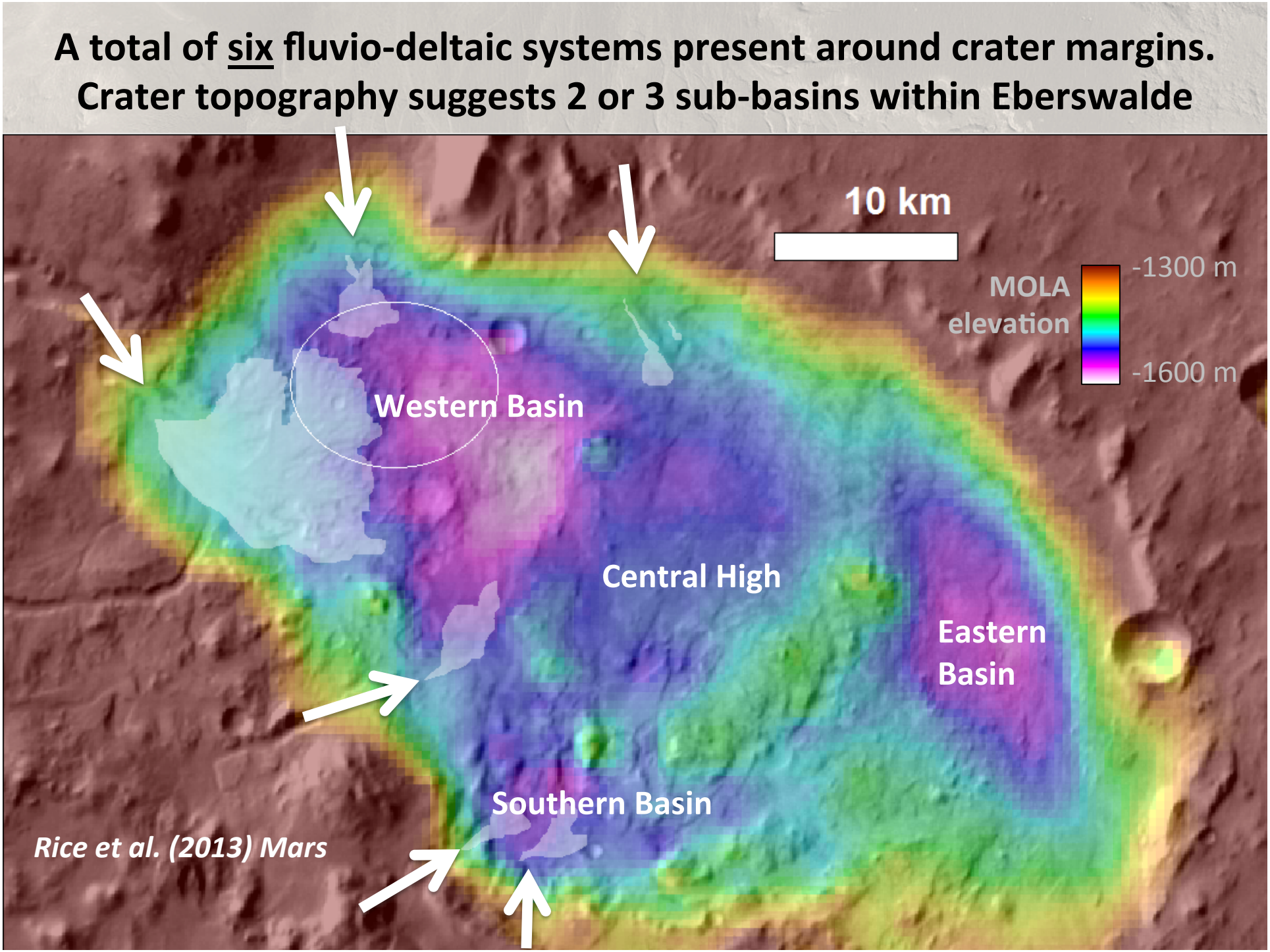
For water/sediment volume ratio of 10,000: hundreds of thousands to millions of yrs

Irwin et al., 2020 1st Workshop presentation

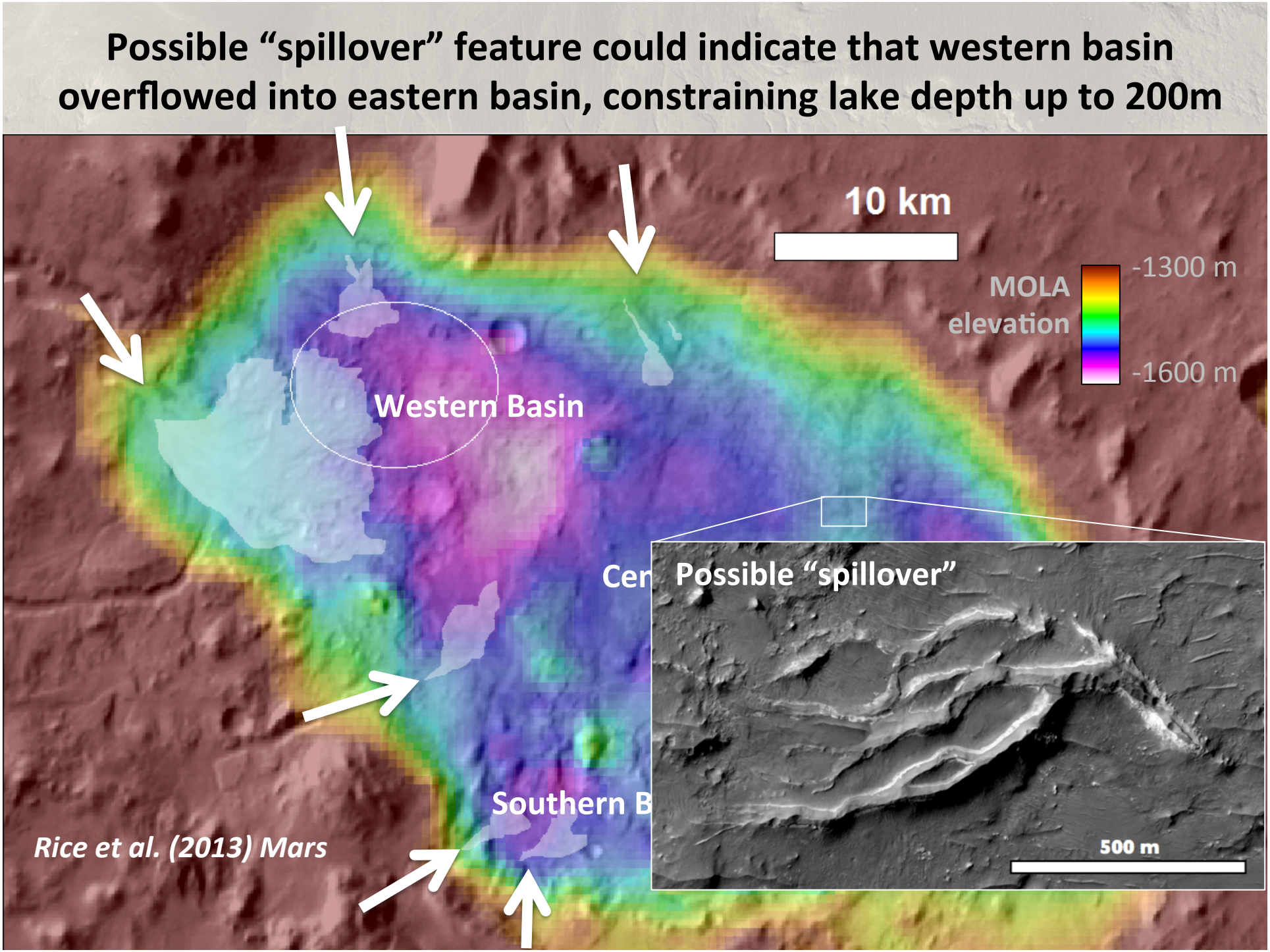
Delta development may have occurred towards the end of the Late Noachian – Early Hesperian "optimum" of valley network formation



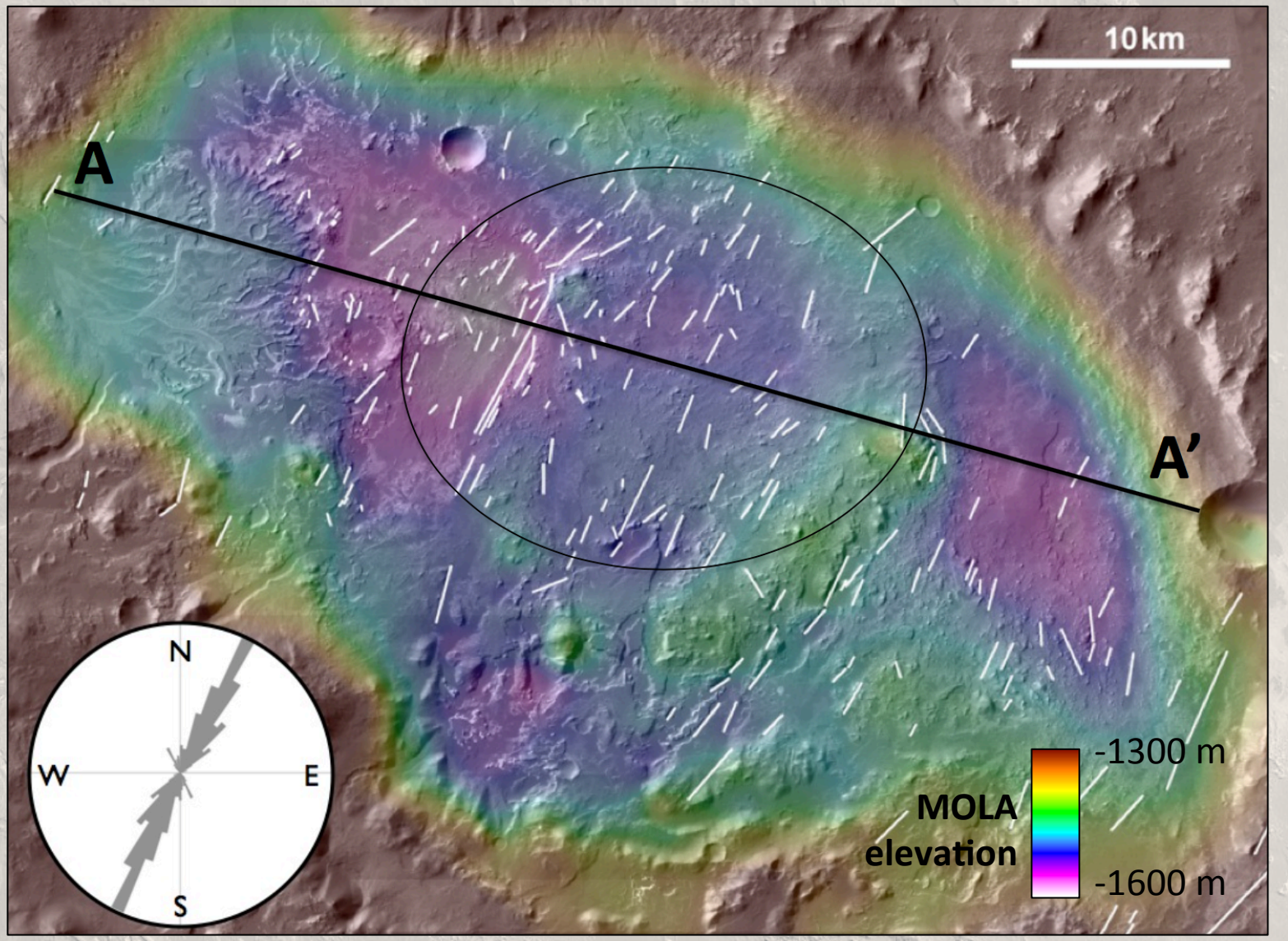
A total of six fluvio-deltaic systems present around crater margins. Crater topography suggests 2 or 3 sub-basins within Eberswalde



Possible “spillover” feature could indicate that western basin overflowed into eastern basin, constraining lake depth up to 200m

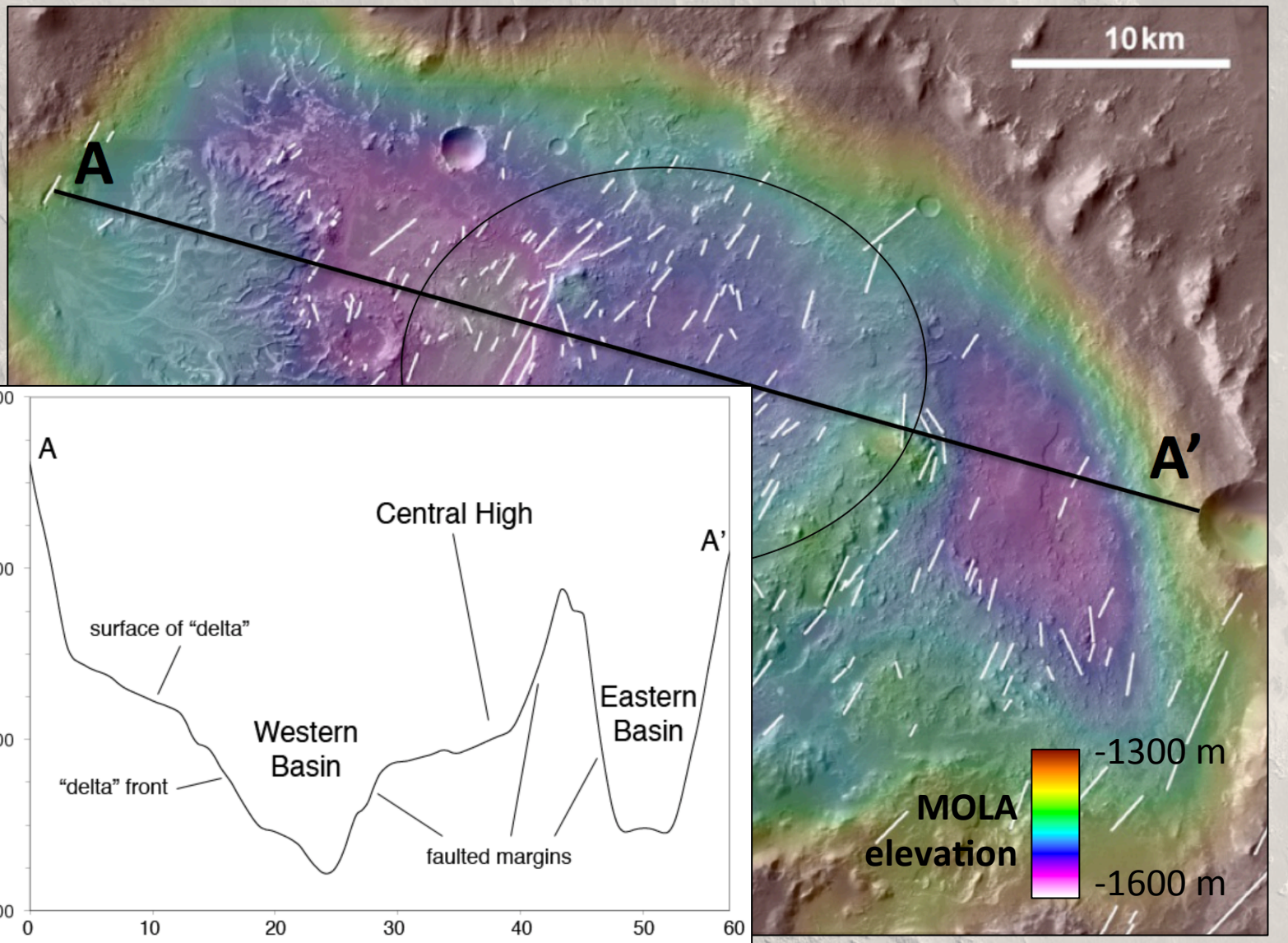


Eberswalde crater floor has been modified by a system of faults with a strong NNE-SSW trend



Rice et al. (2011) GRL

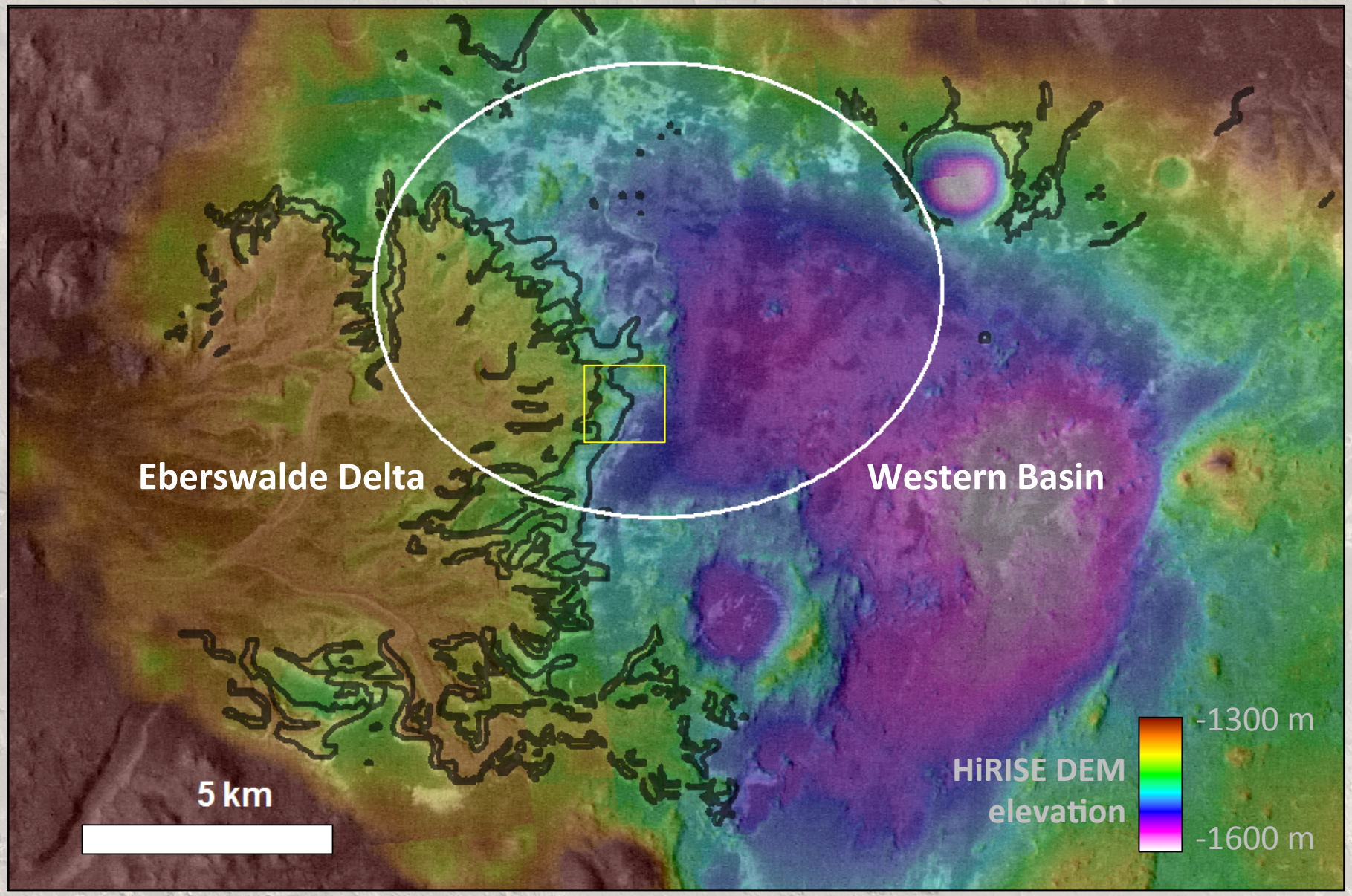
Crater topography appears to be controlled by the NNE-SSW trending faults



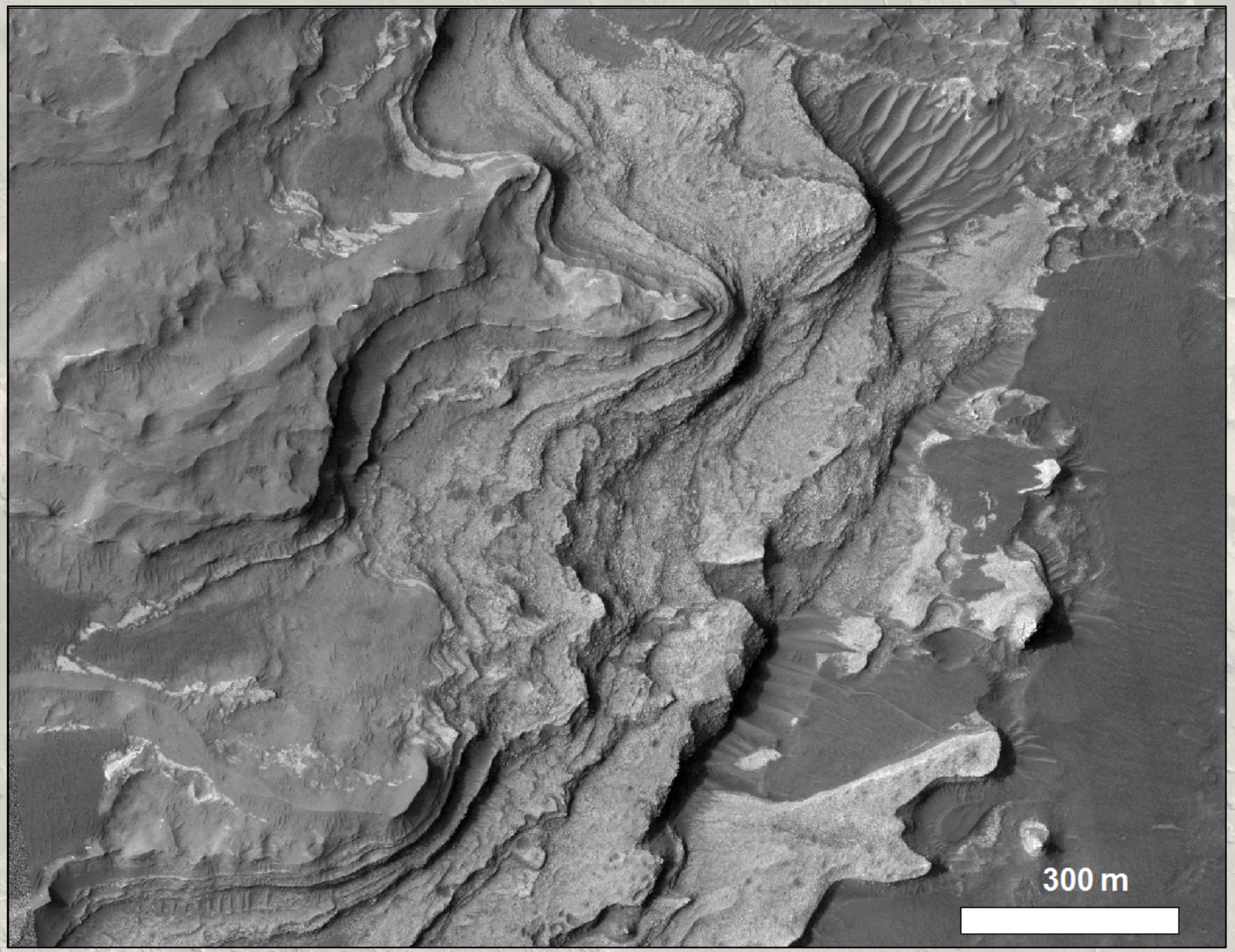
Rice et al., GRL, *submitted*

Rice et al. (2011) GRL

Delta front and other crater floor units have undergone extensive erosion and exhumation *(see next talk by N. Warner)*



Erosion of delta front into bays and headlands may indicate a dominant direction of ongoing erosion *(see talk by J. Williams)*



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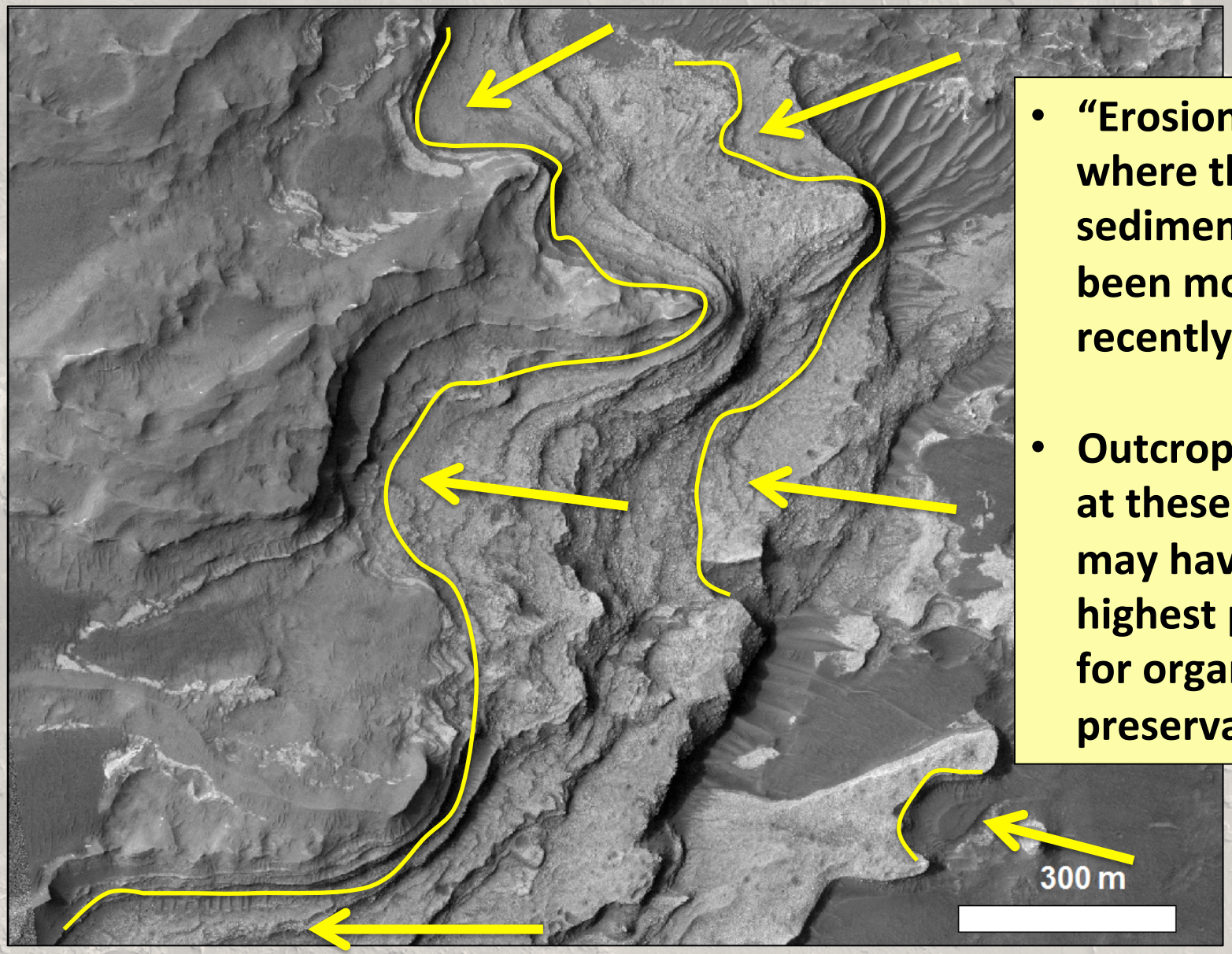
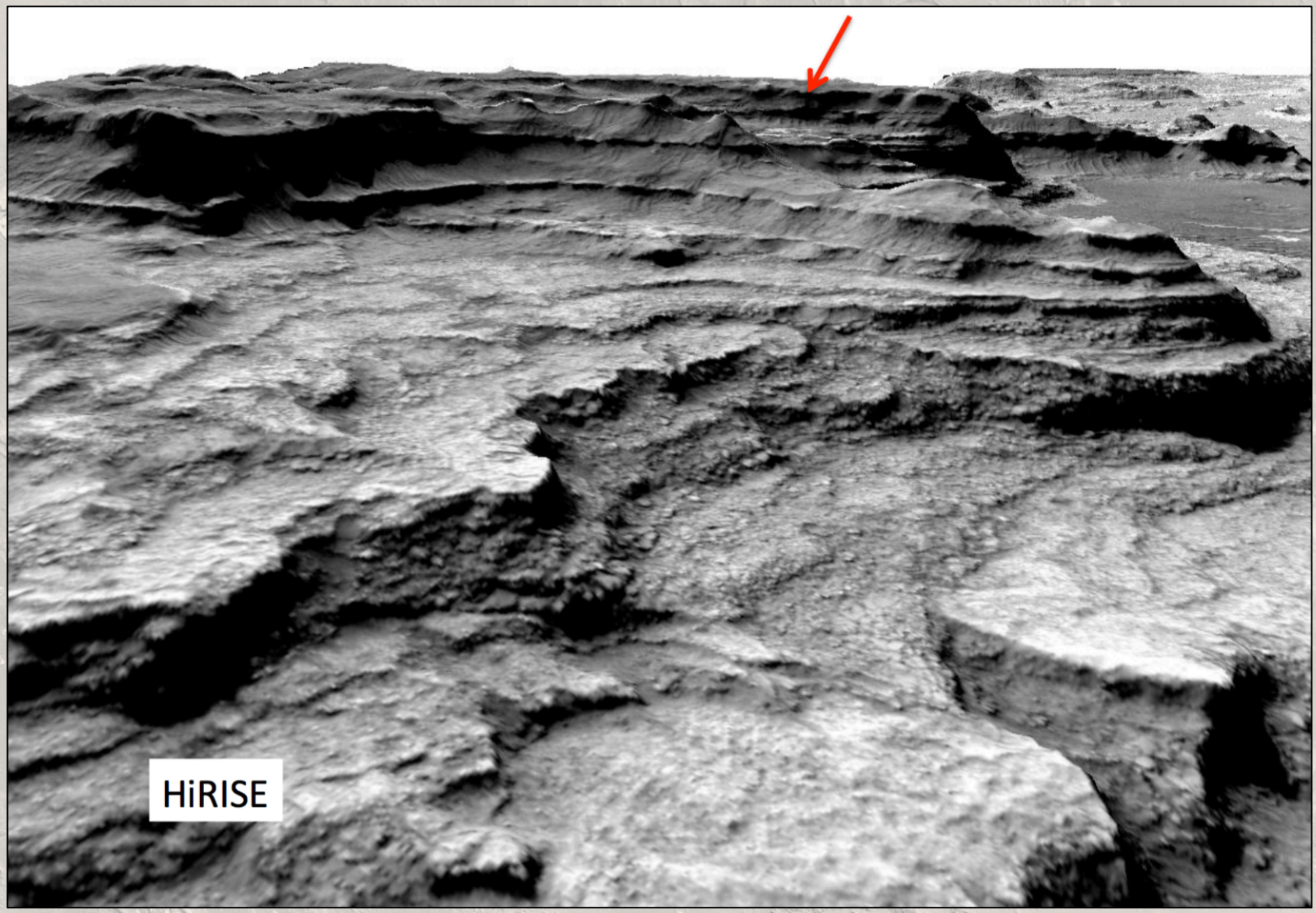


- **"Erosion bays" are where the delta sediments have been most recently-exposed**
- **Outcrop exposures at these locations may have the highest potential for organic preservation**

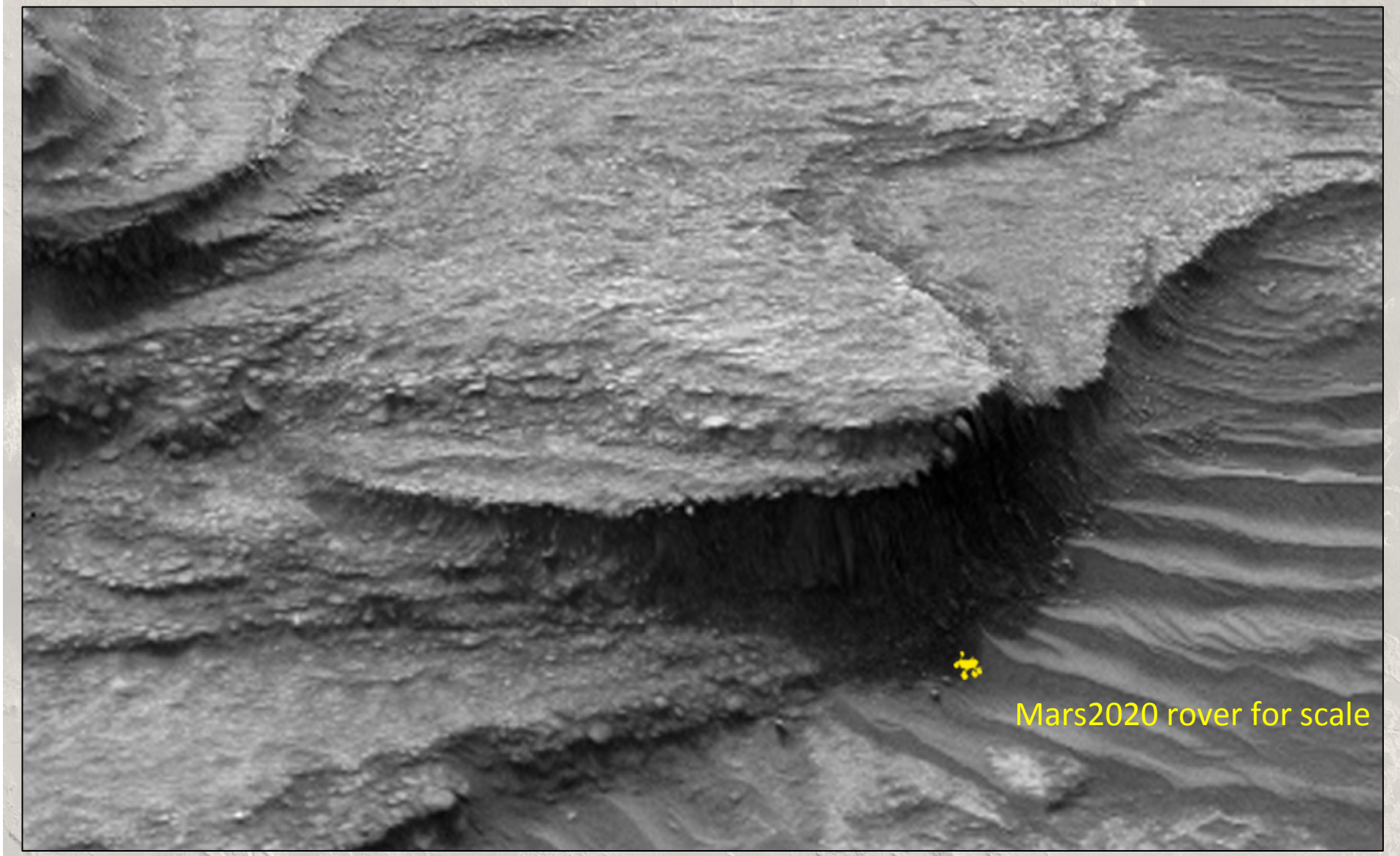
Overhanging ledges and variations in polygonal fracture patterns indicate variations in grain size and differences in cementation

A variety of sedimentary facies to sample at the delta, likely including coarse sandstones higher in the stratigraphy



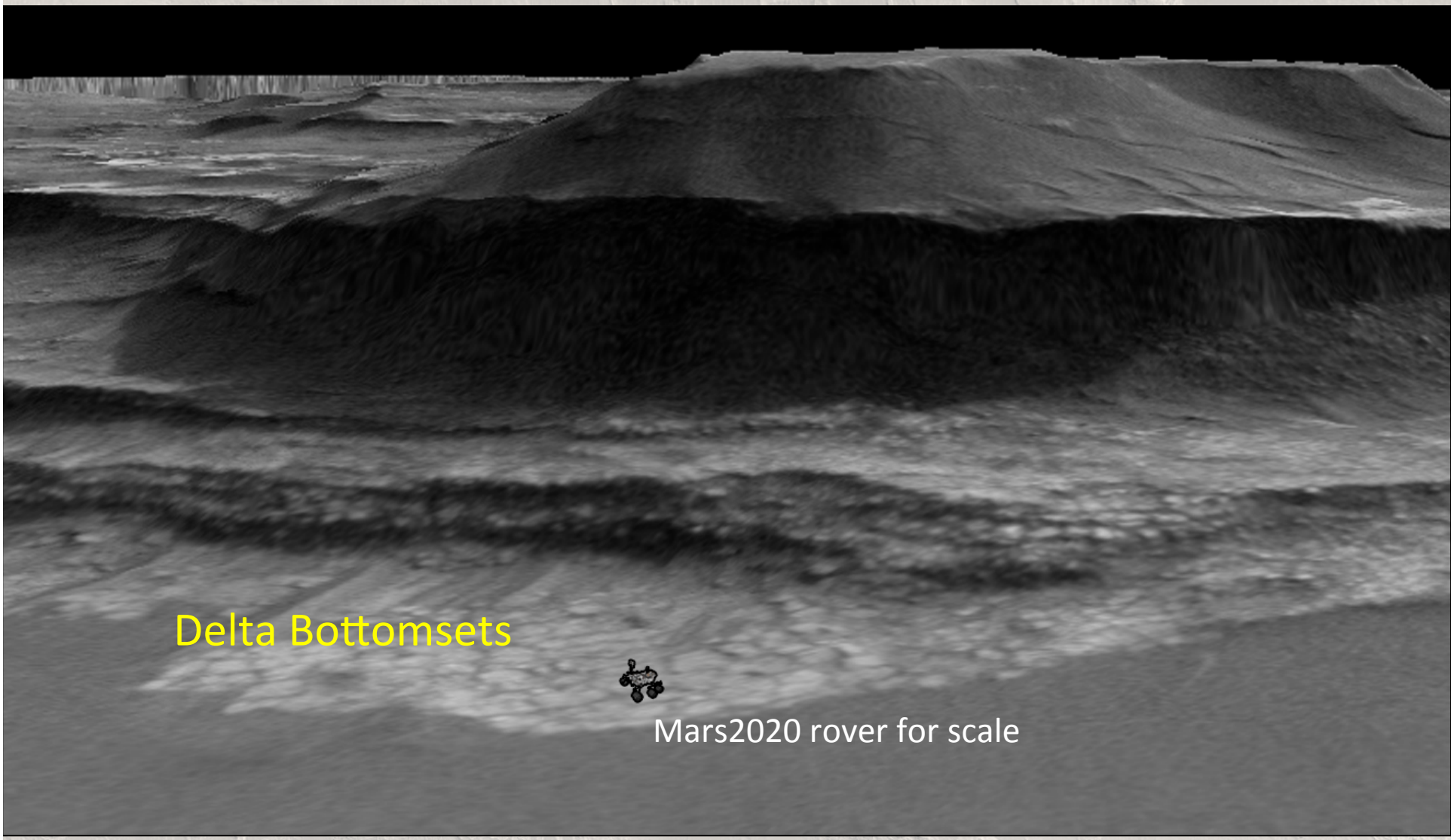
NO vertical exaggeration

Overhanging ledges shedding boulders indicates that erosion may be ongoing at the delta front



NO vertical exaggeration

Delta bottomsets are easily accessible and may have been recently-exposed via scarp retreat



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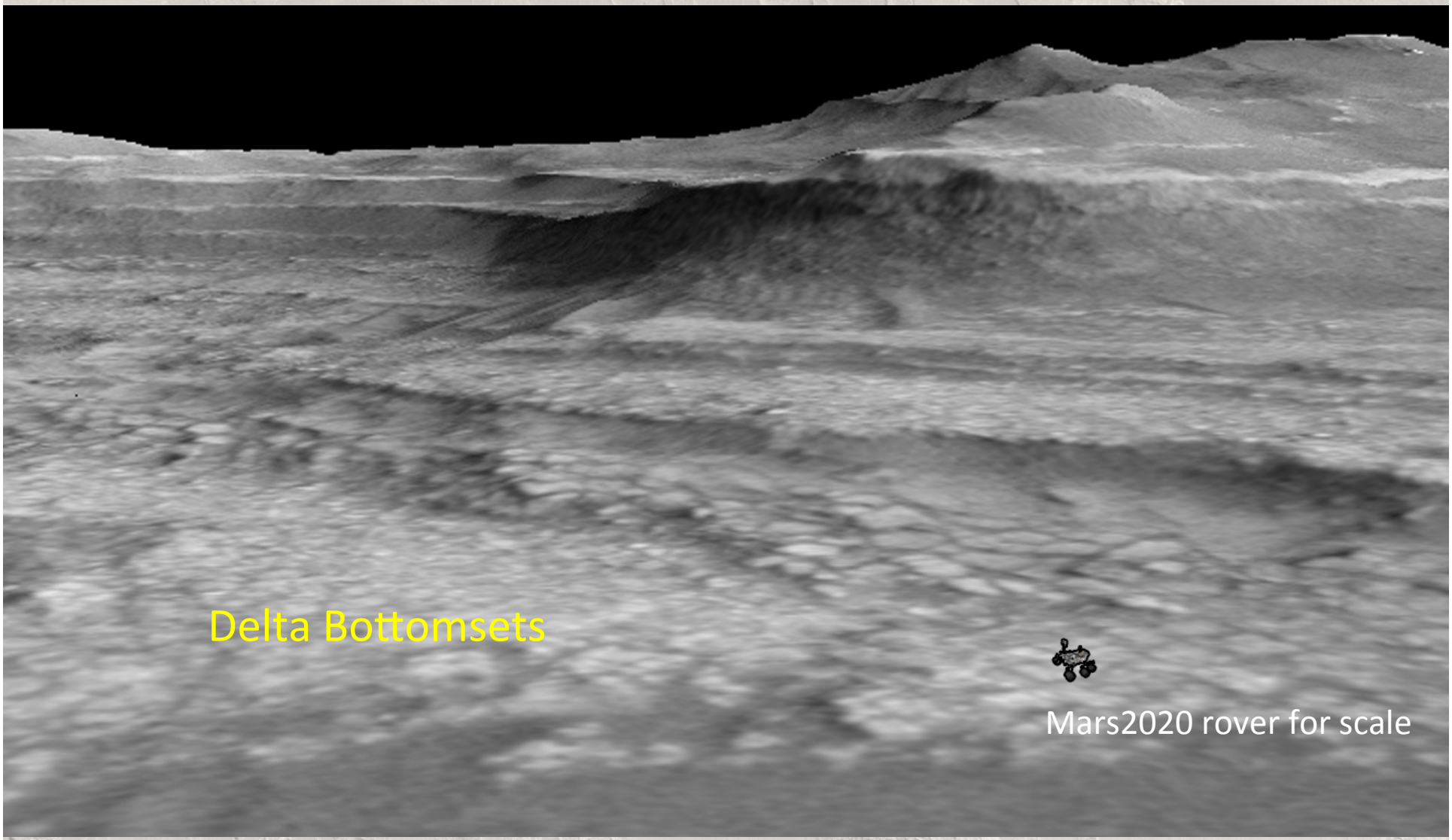

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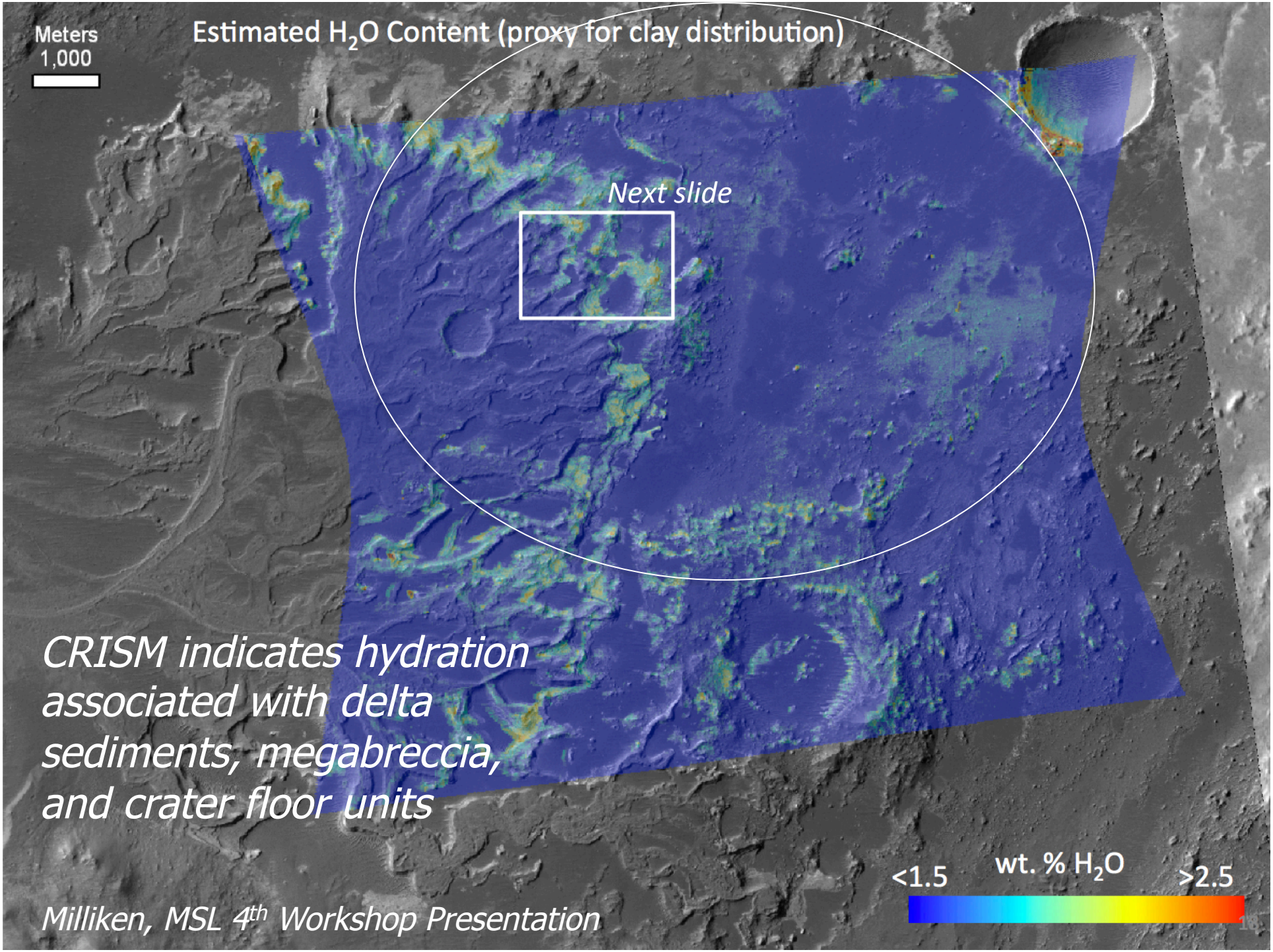
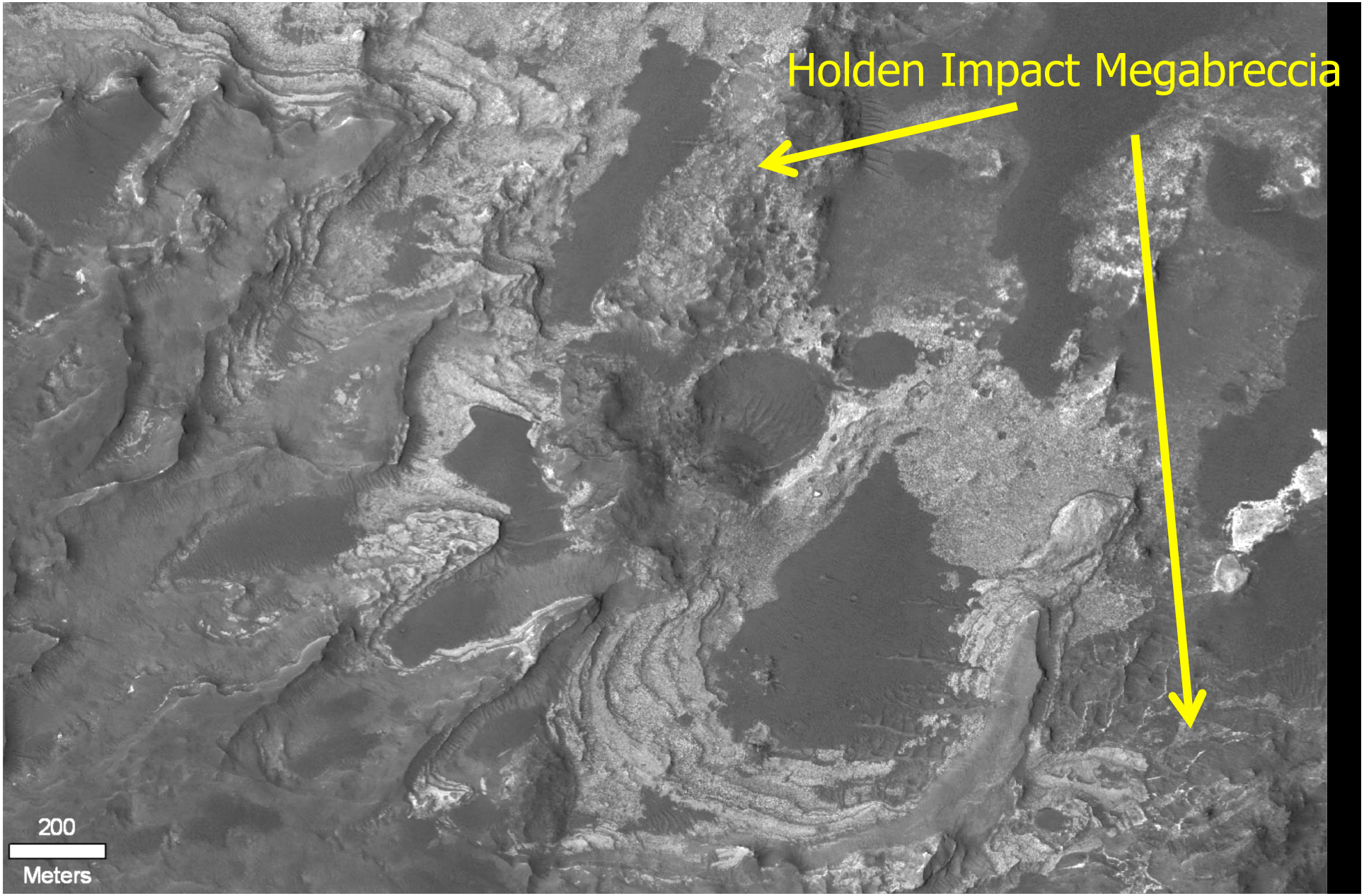

Meters
1,000
Estimated H_2O Content (proxy for clay distribution)
Next slide
CRISM indicates hydration associated with delta sediments, megabreccia, and crater floor units
<1.5
wt. % H_2O
>2.5
Milliken, MSL 4th Workshop Presentation

Fe/Mg phyllosilicate signatures in delta front also vary with stratigraphy. Megabreccias also contain Fe-rich clays



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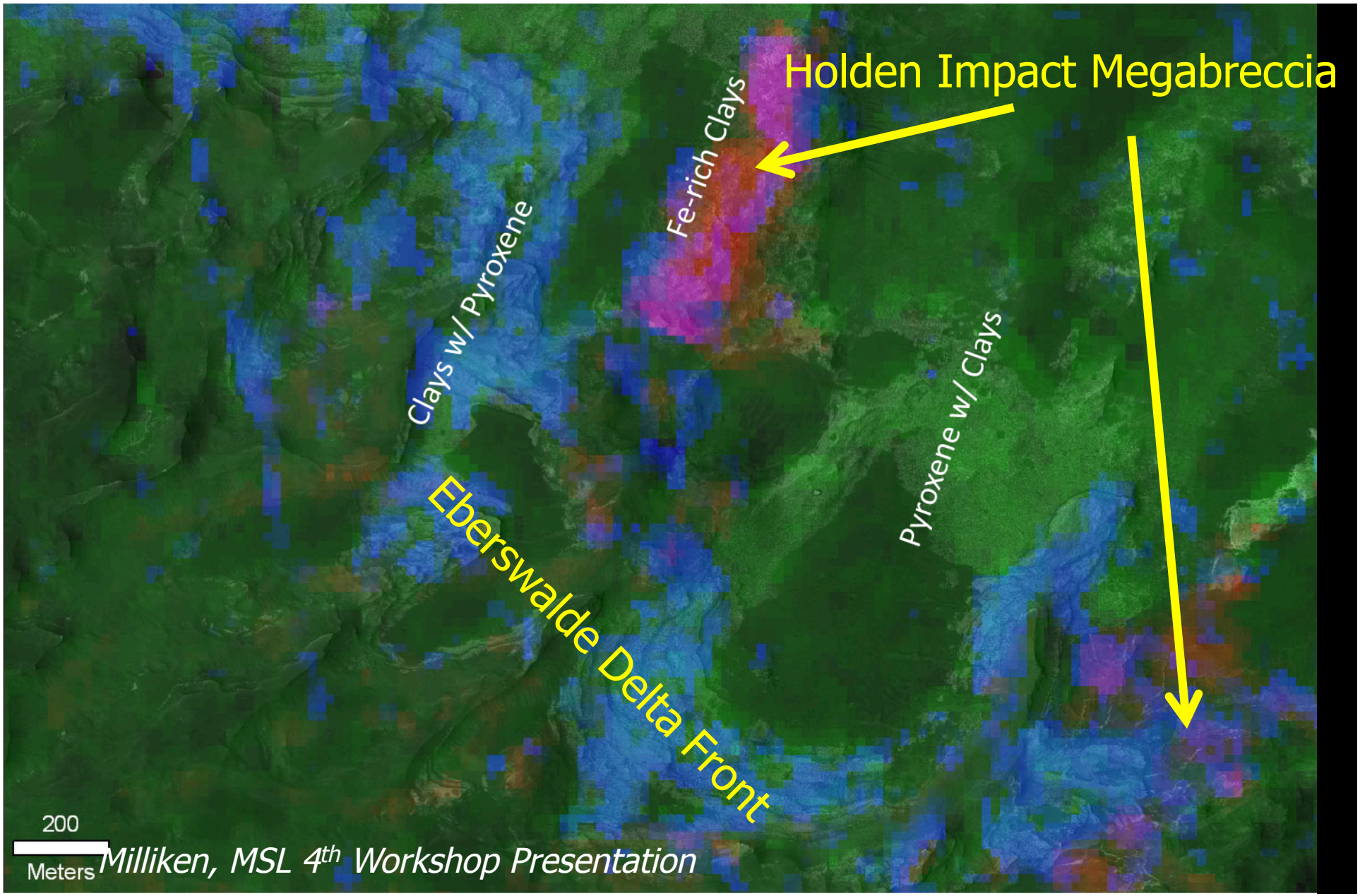
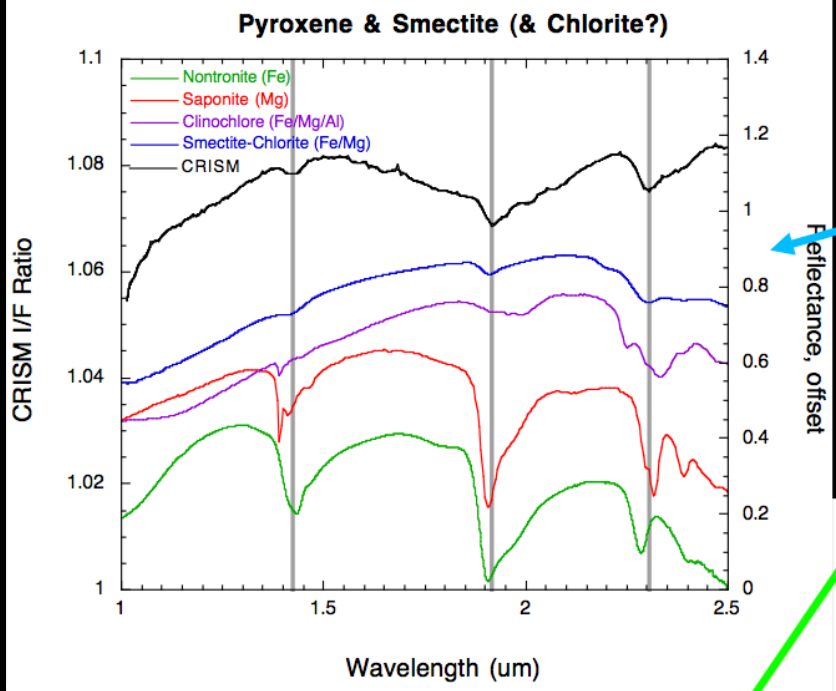
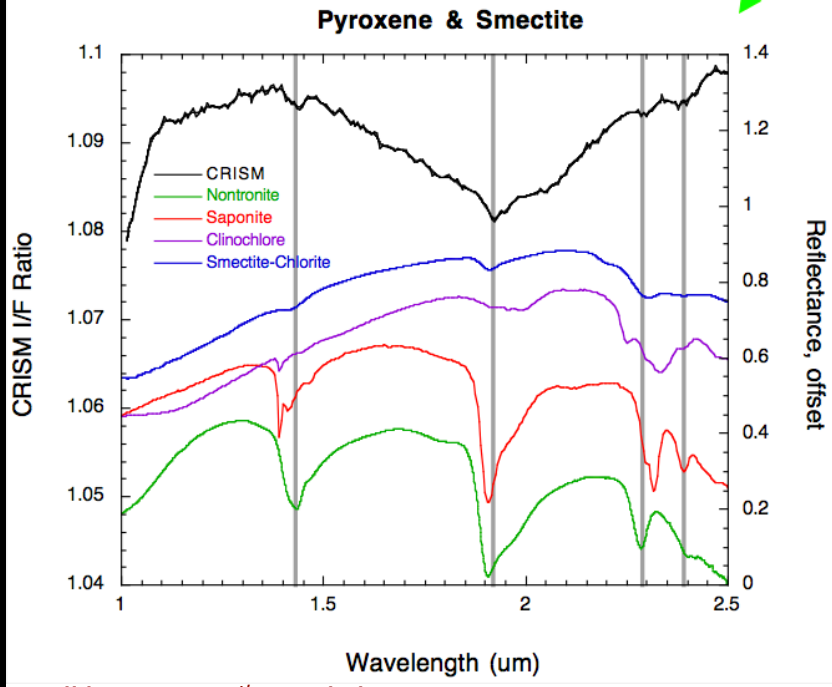




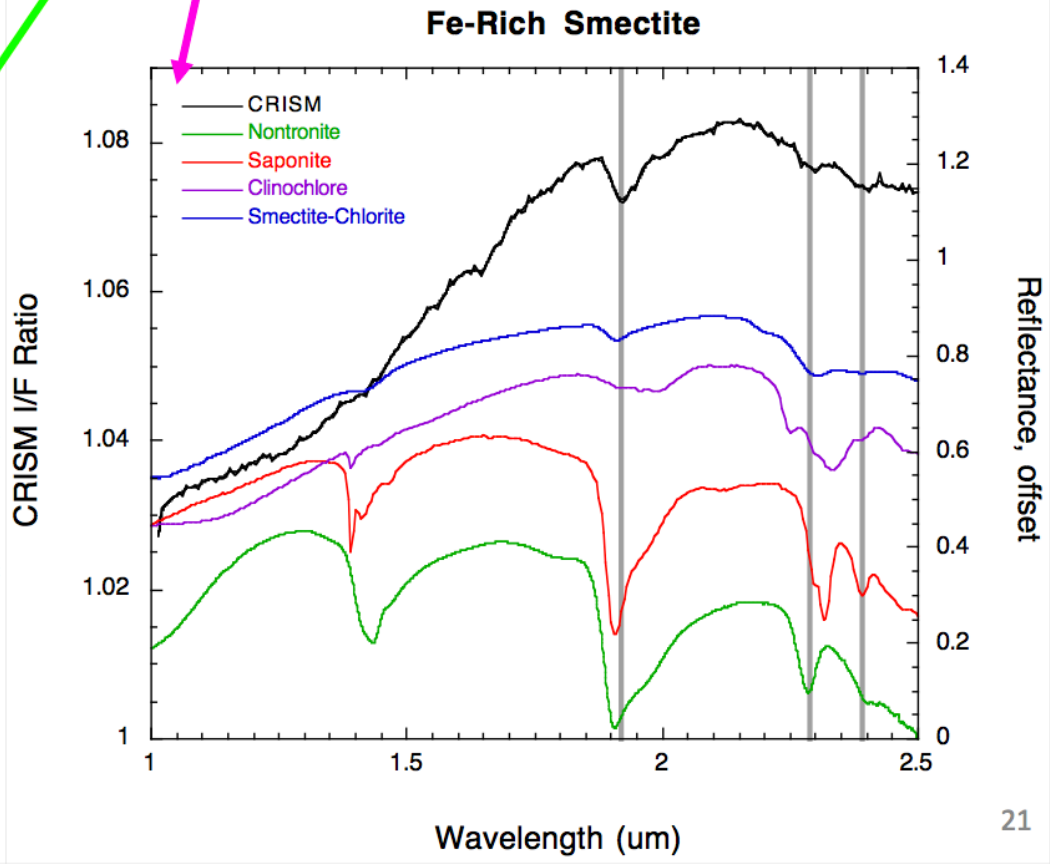


There are at least 3 distinct units:

-Clay-bearing unit with pyroxene

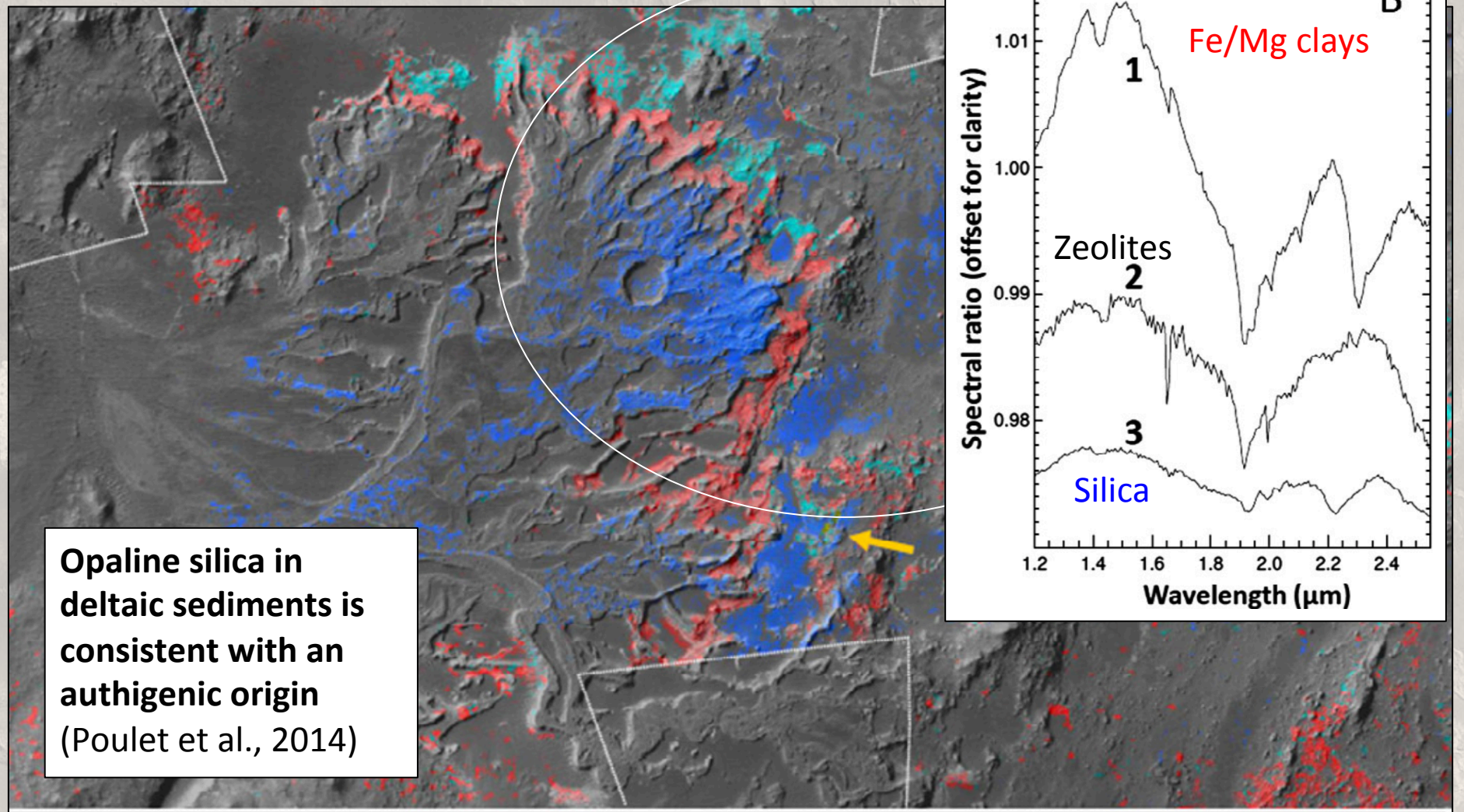
- Pyroxene unit with clays

- Fe-rich clay unit

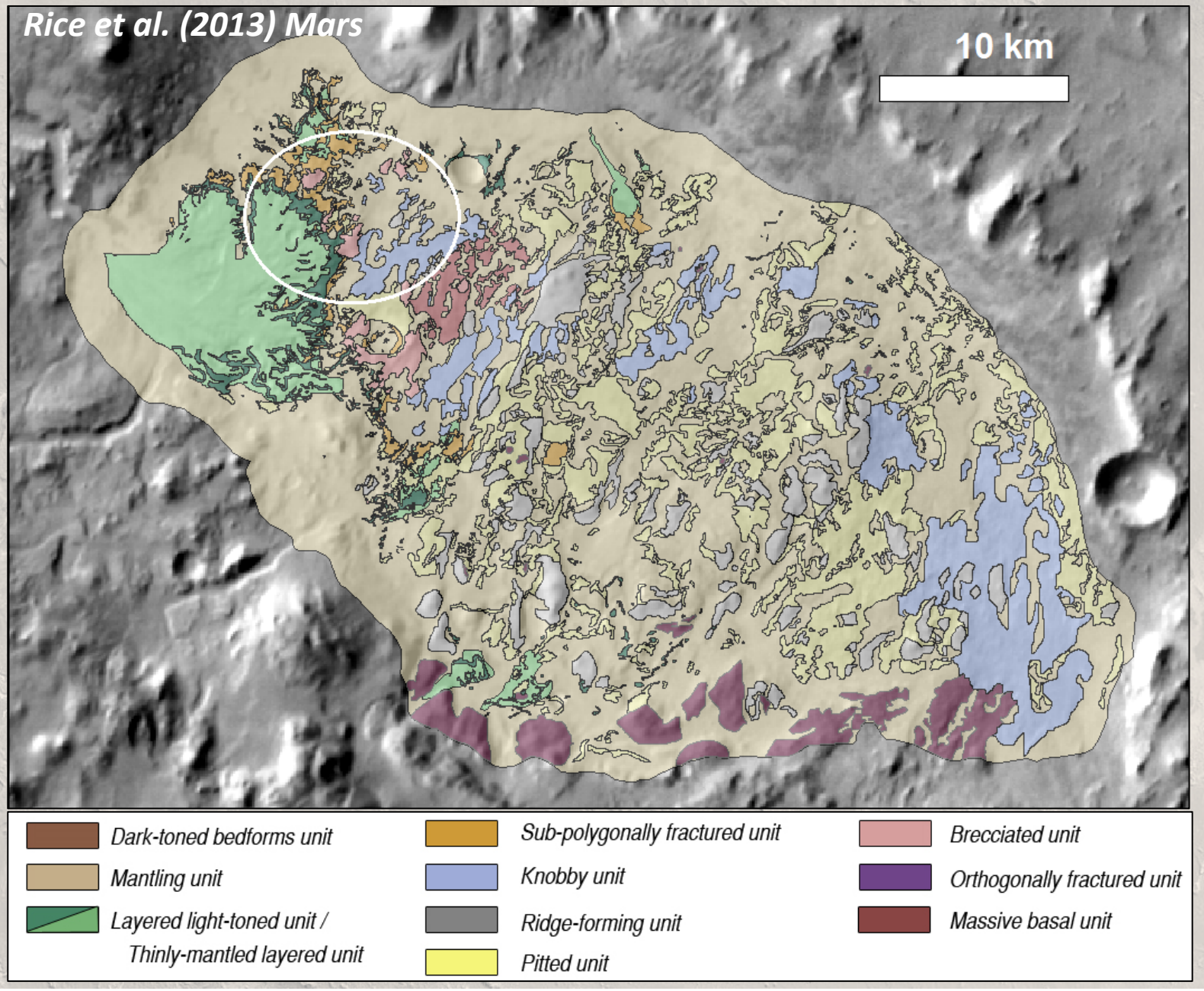


Milliken, MSL 4th Workshop Presentation

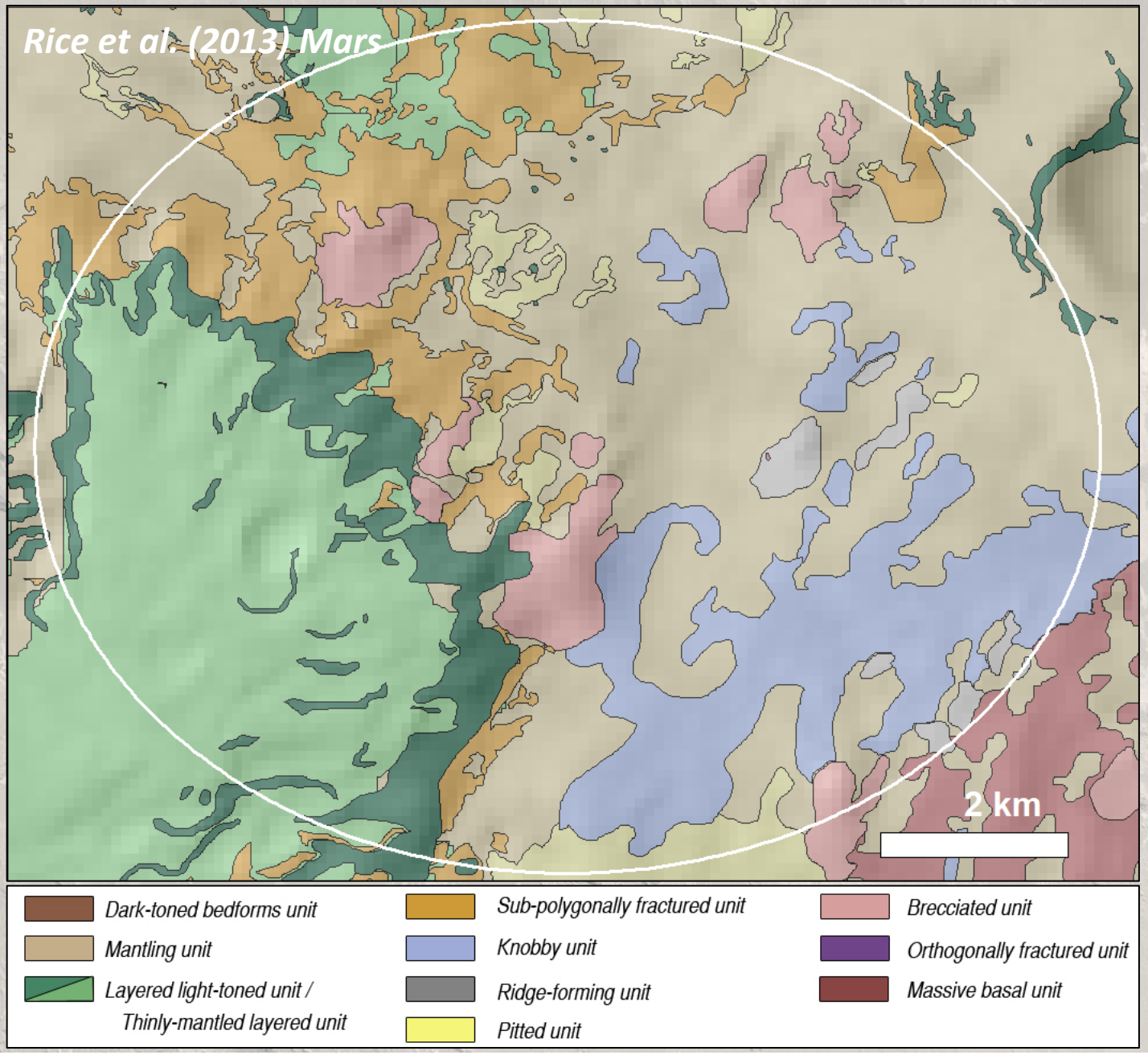
Opaline silica detected in the delta sediments and other crater floor units (Poulet et al., 2014)



A diversity of geologic units mapped across the crater floor



A large subset of crater's geologic diversity is sampled in the ellipse



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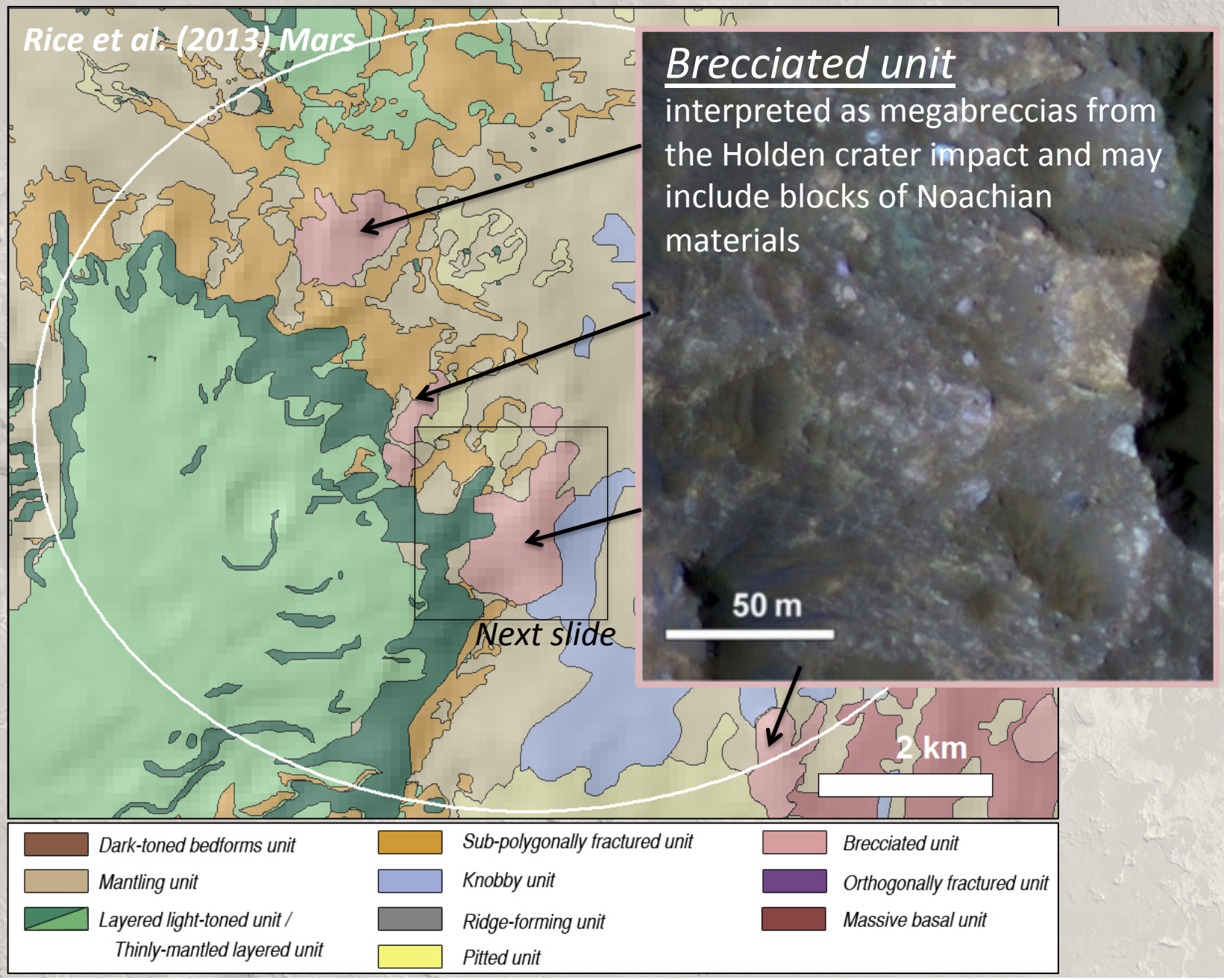
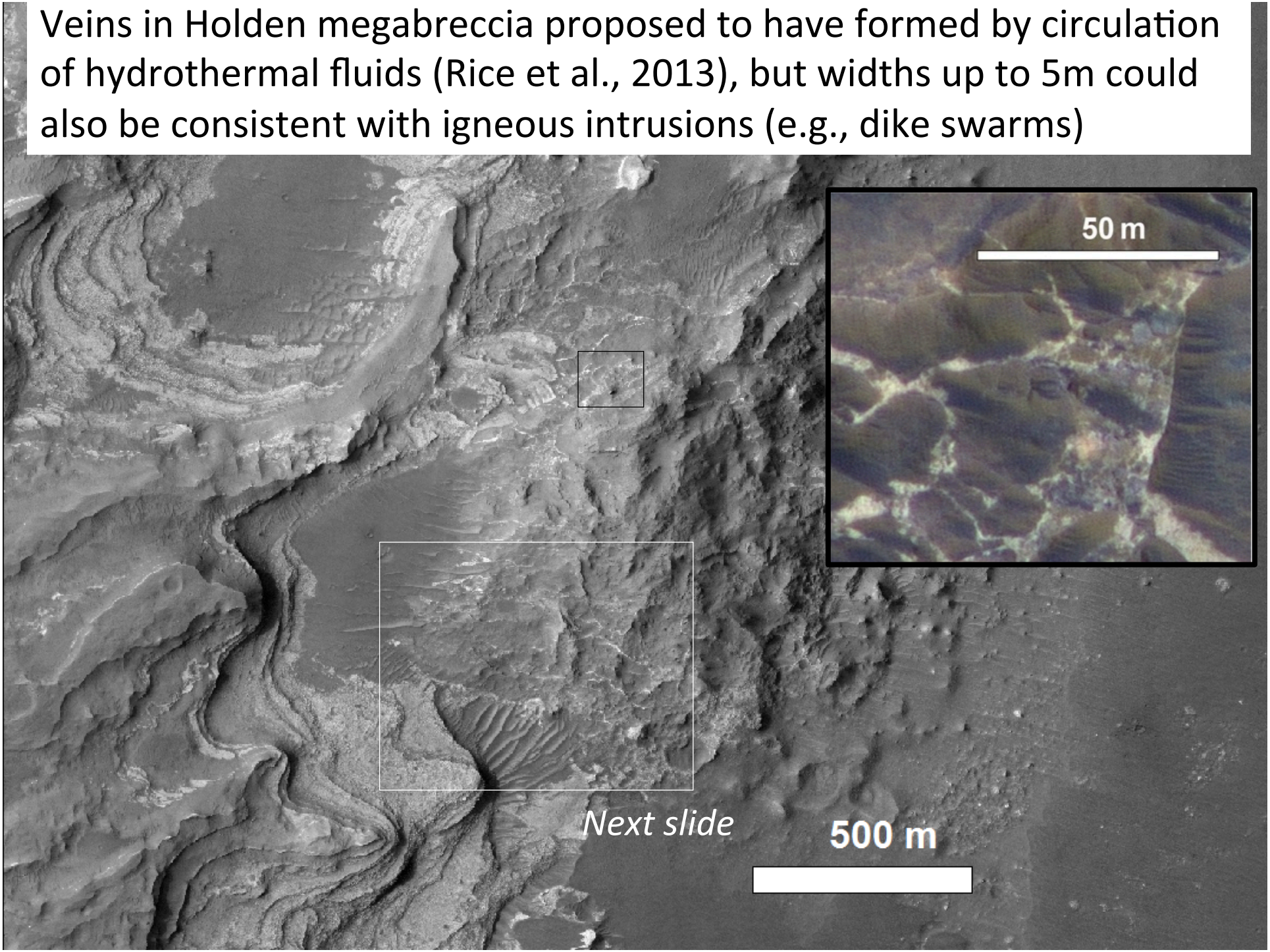
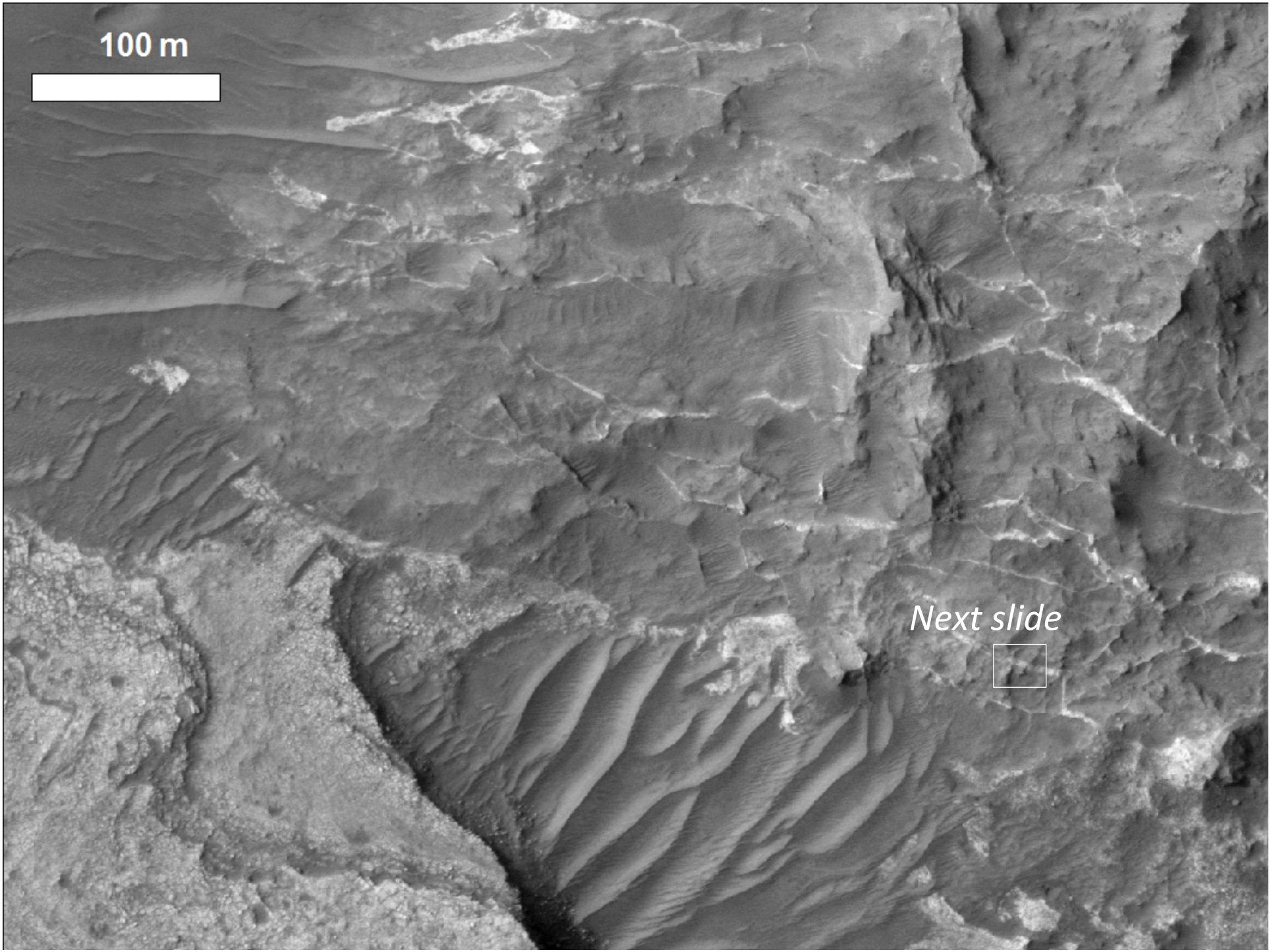
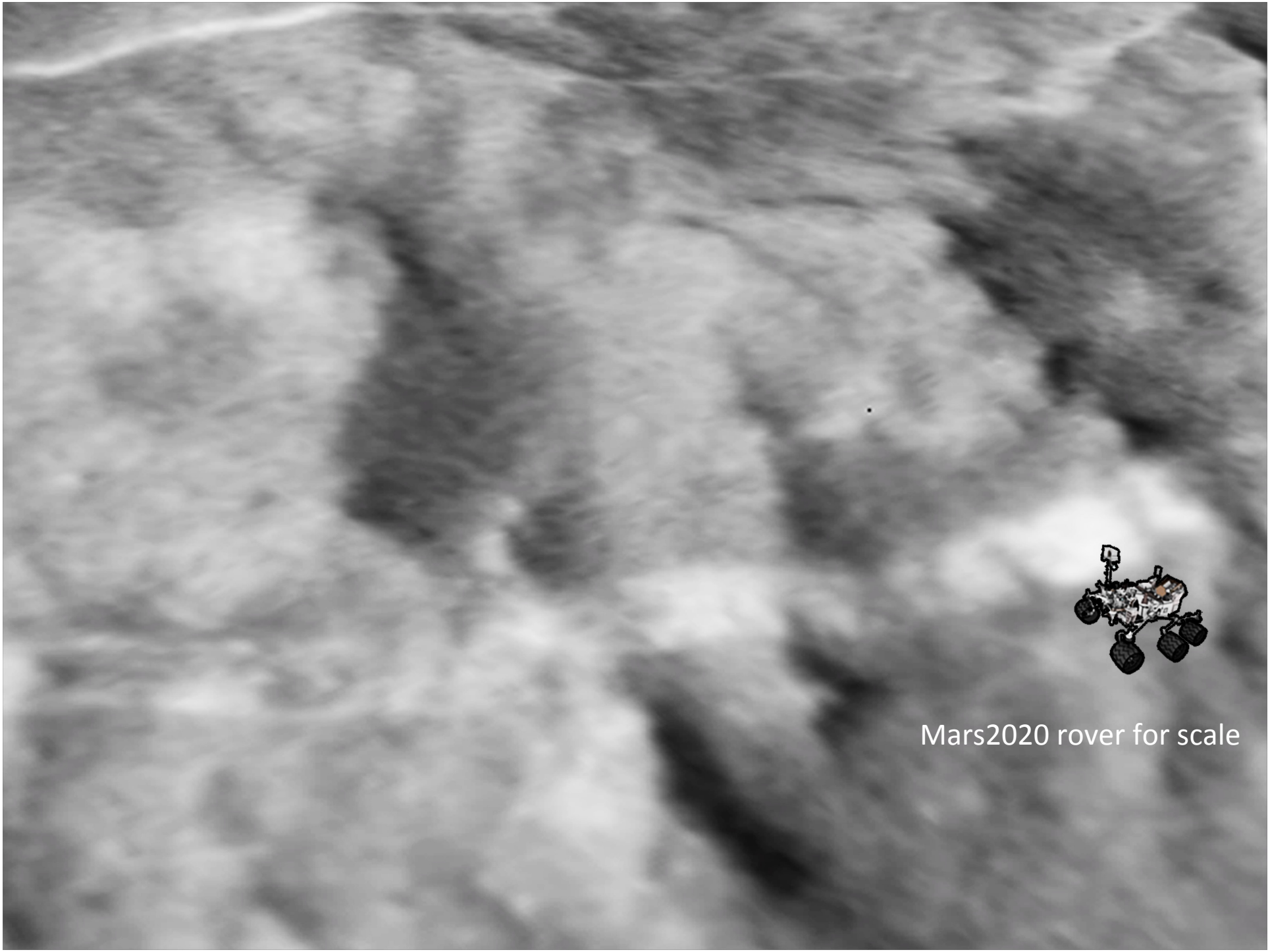


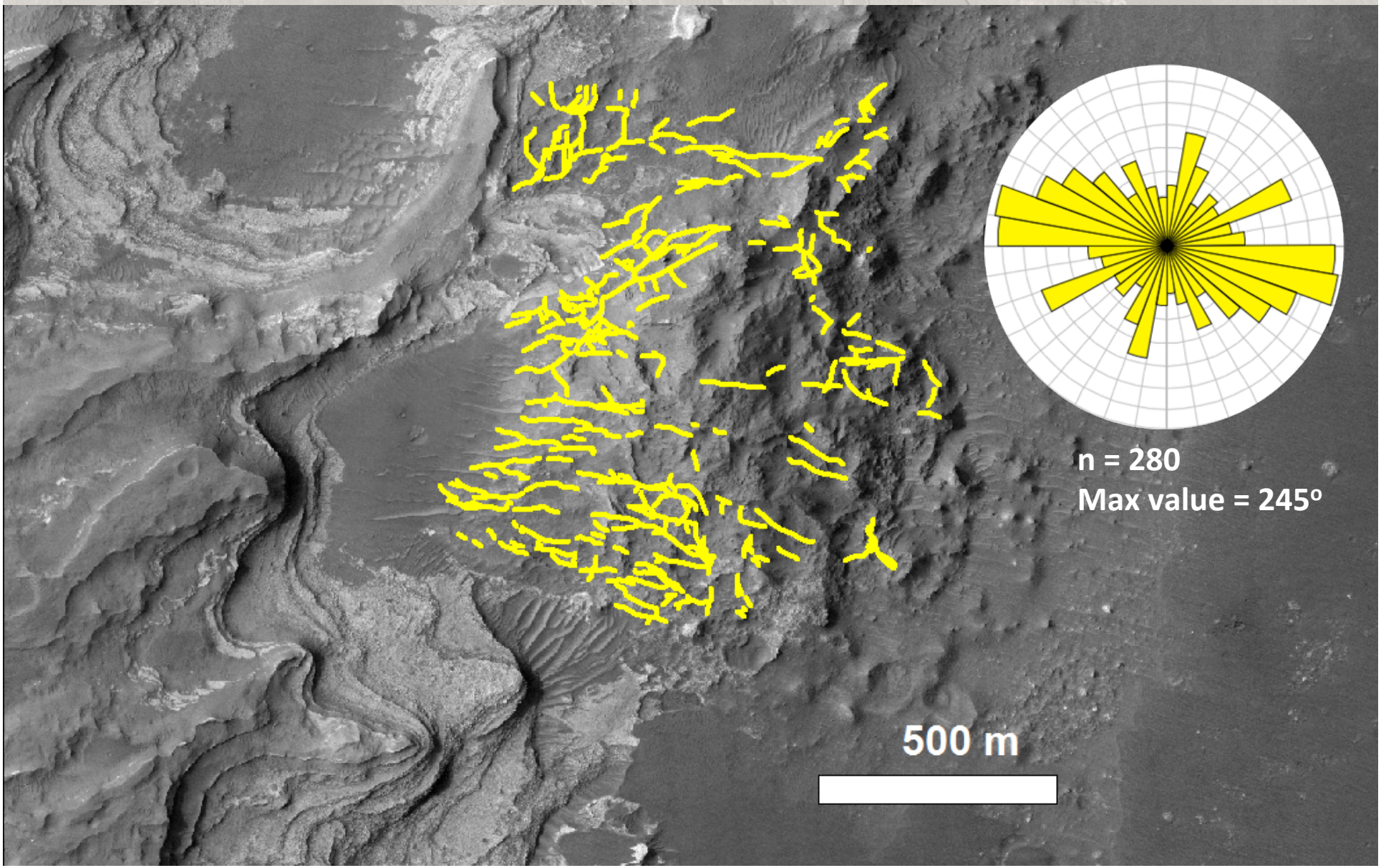
Veins in Holden megabreccia proposed to have formed by circulation of hydrothermal fluids (Rice et al., 2013), but widths up to 5m could also be consistent with igneous intrusions (e.g., dike swarms)



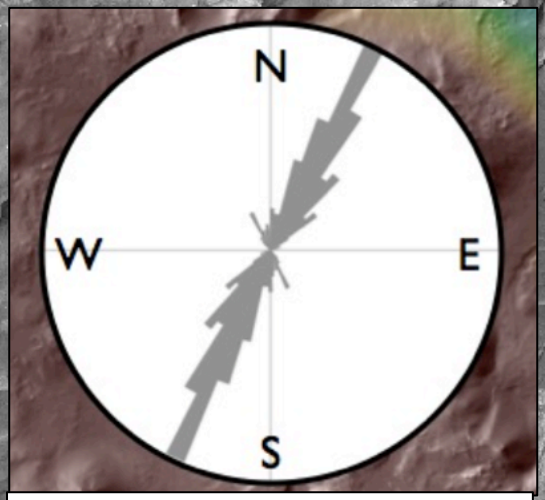

100 m
Next slide


Mars2020 rover for scale

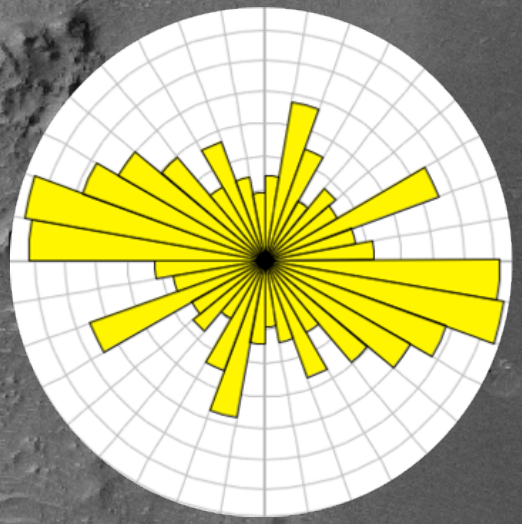
Largest megabreccia outcrop contains veins with a predominant WNW-ESE orientation



Orientation appears to be unrelated to other trends within crater (e.g., faults, other fracture-fill deposits), suggesting the possibility that veins either formed due to localized stresses and hydrothermal activity, or they pre-date the emplacement of the megabreccia (were carried into Eberswalde as an intact ejecta block)



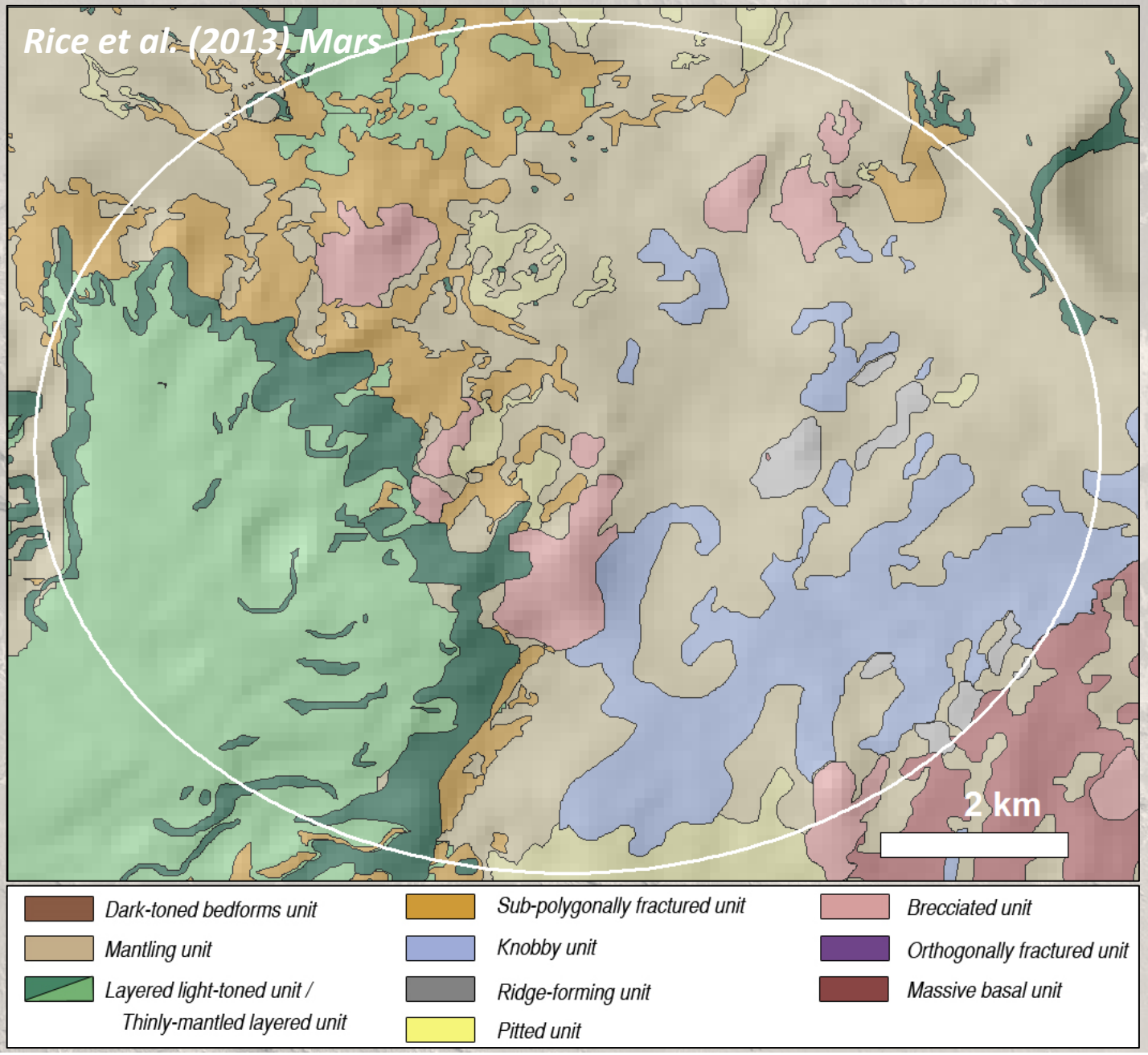
Orientations of faults mapped throughout Eberswalde crater
(Rice et al., 2011)



n = 280
Max value = 245°

500 m

A diversity of other geologic units within the landing ellipse



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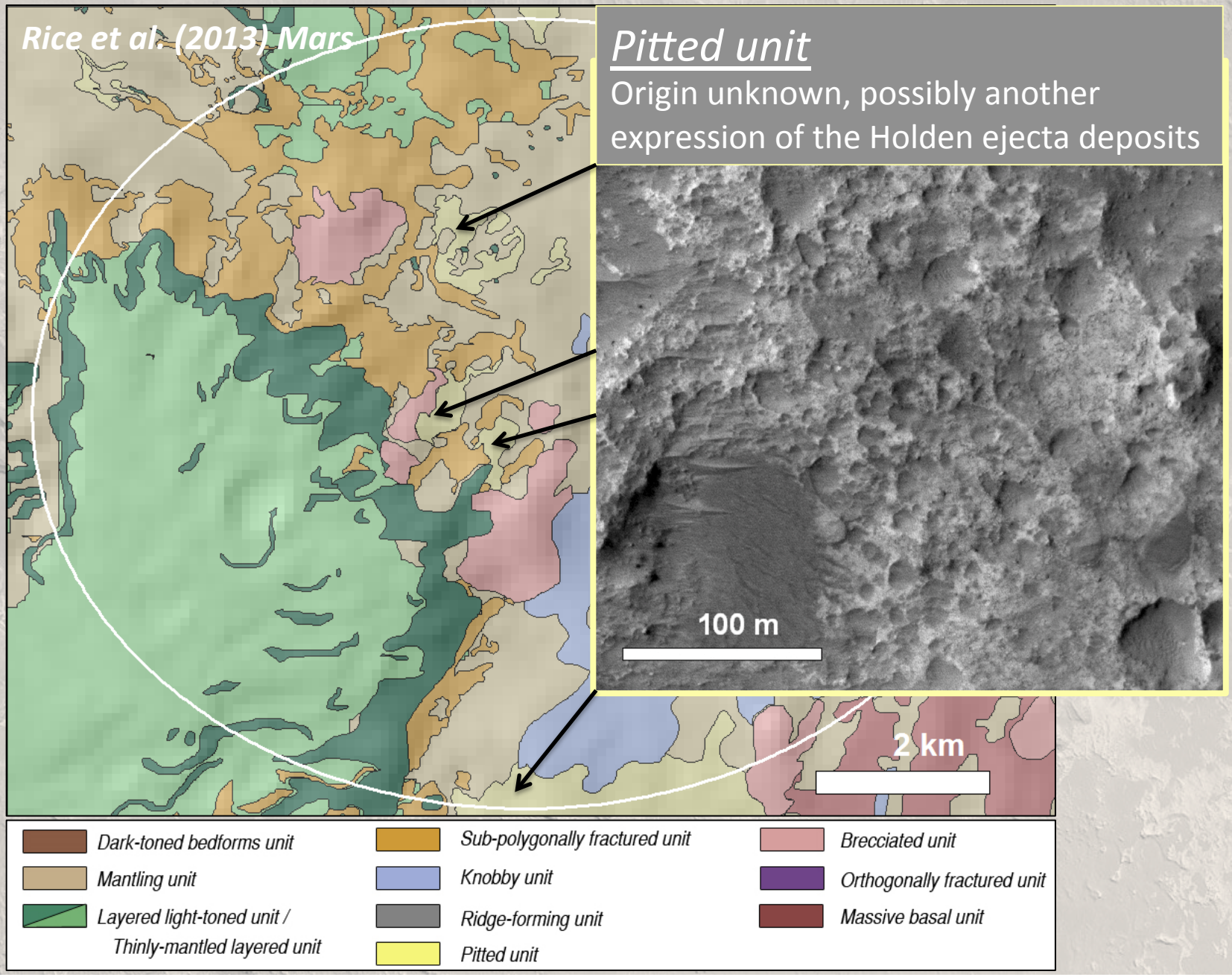
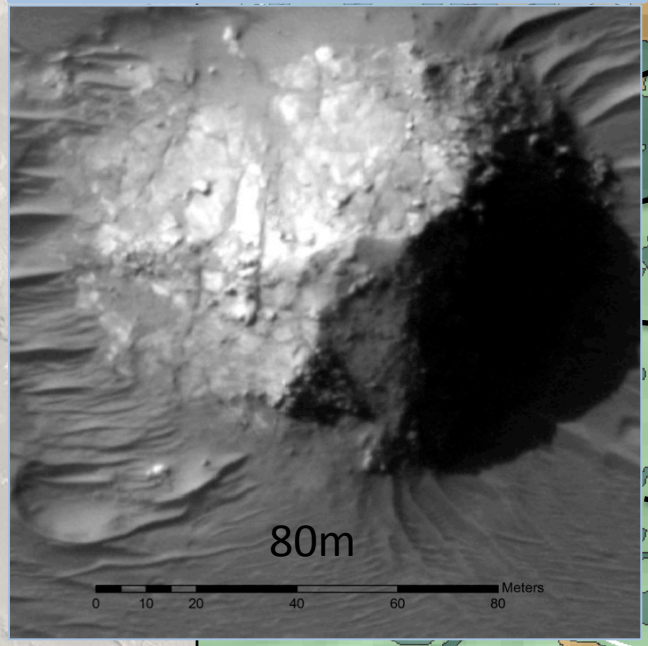


A diversity of other geologic units within the landing ellipse

Knobby unit

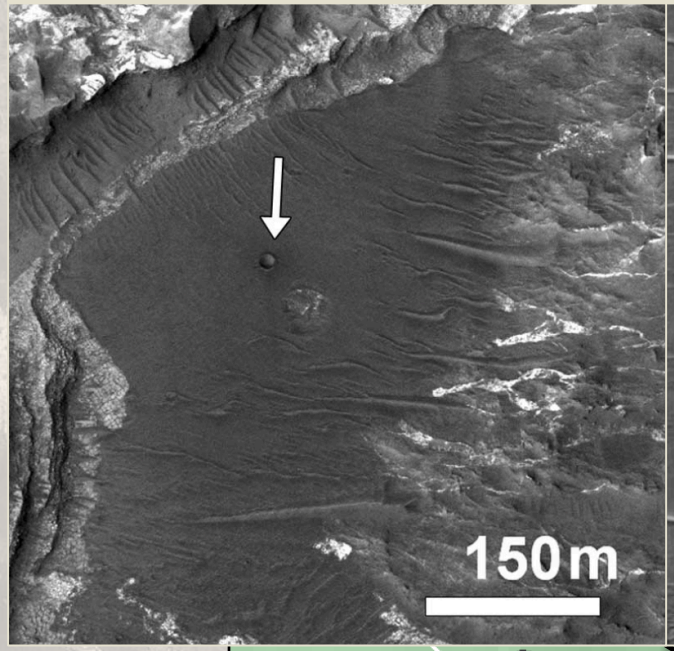
Contains light-toned, polygonally-fractured hills and mesas that may be remnants of more extensive lacustrine deposits *(Pruiett et al., GSA2016)*

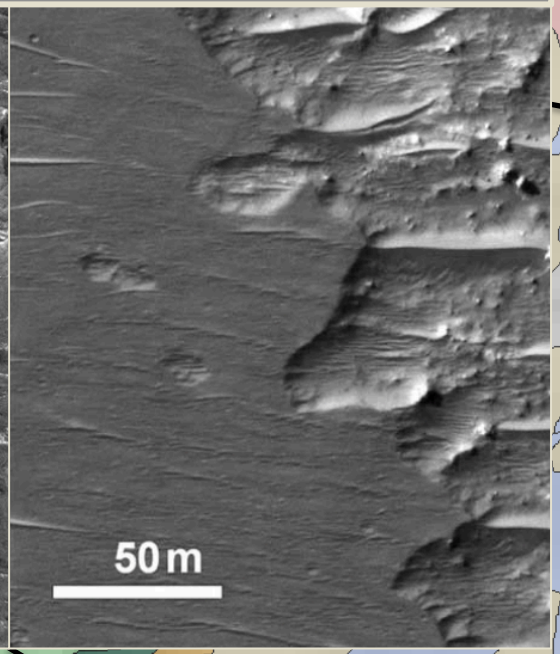


A diversity of other geologic units within the landing ellipse

Mantling unit

Observed regionally and interpreted as an airfall deposit. Retention of small craters and scarps suggests some degree of induration.





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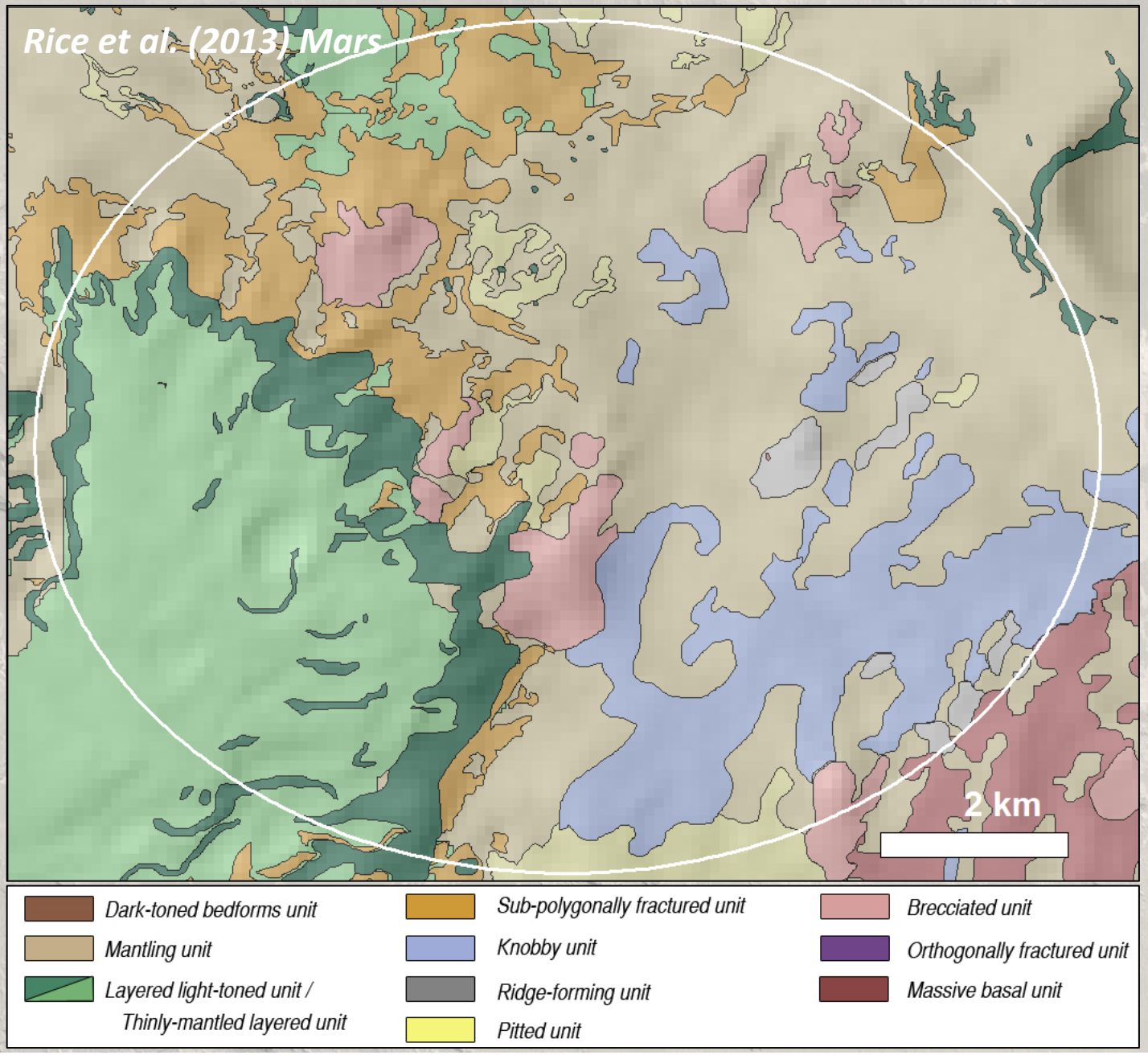

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- An opportunity to examine how **potentially long-lived** lacustrine systems were able to survive under changing global climate conditions in the early to mid Hesperian

- **Megabreccias** from the Holden crater impact and **giant veins** are also located in the **center of the ellipse**

- The **"compact diversity"** in the center of the Eberswalde ellipse, and the clear geologic context, would make for an **efficient sampling mission** with the potential for **fundamental scientific discoveries**