

# Opaline Silica Occurrences in the Columbia Hills of Mars: A Case Study in the Hunt for Biosignatures

A scale-integrated comparison of the opaline silica  
next to Home Plate and silica sinter forming in hot  
spring discharge channels at El Tatio, Chile

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Arizona State University  
(manuscript in revision)



1 cm

Opaline silica outcrops in Gusev crater  
Pancam approximate true color image



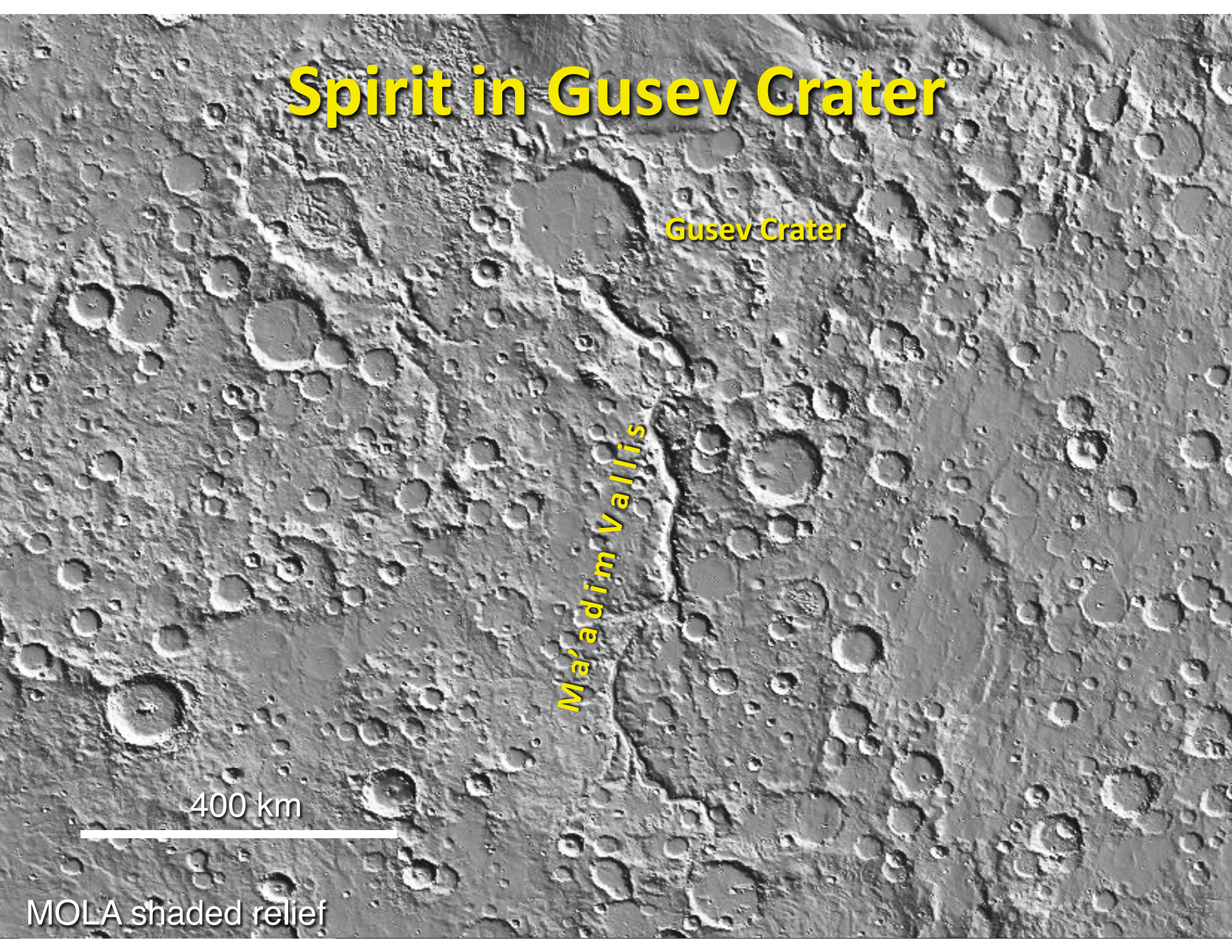
# Spirit in Gusev Crater

Gusev Crater

Ma'adim Vallis

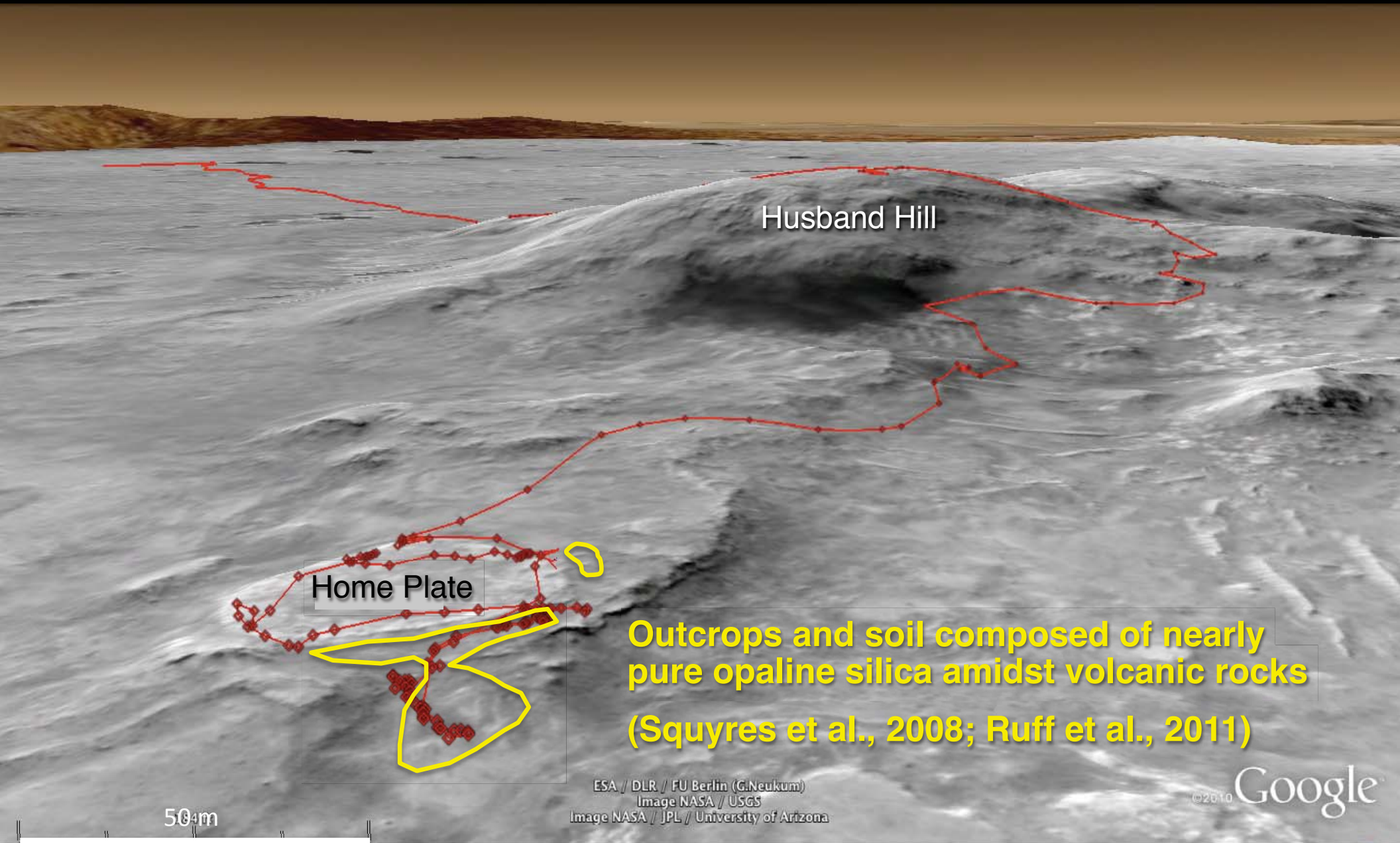
400 km

MOLA shaded relief





# Gusev Crater Silica Discovery



Husband Hill

Home Plate

Outcrops and soil composed of nearly pure opaline silica amidst volcanic rocks  
(Squyres et al., 2008; Ruff et al., 2011)

ESA / DLR / FU Berlin (G.Neukum)  
Image NASA / USGS  
Image NASA / JPL / University of Arizona

©2010 Google

50m

14°36'00.24" S 175°31'35.39" E elev = 6304 ft

Eye alt = 5946 ft

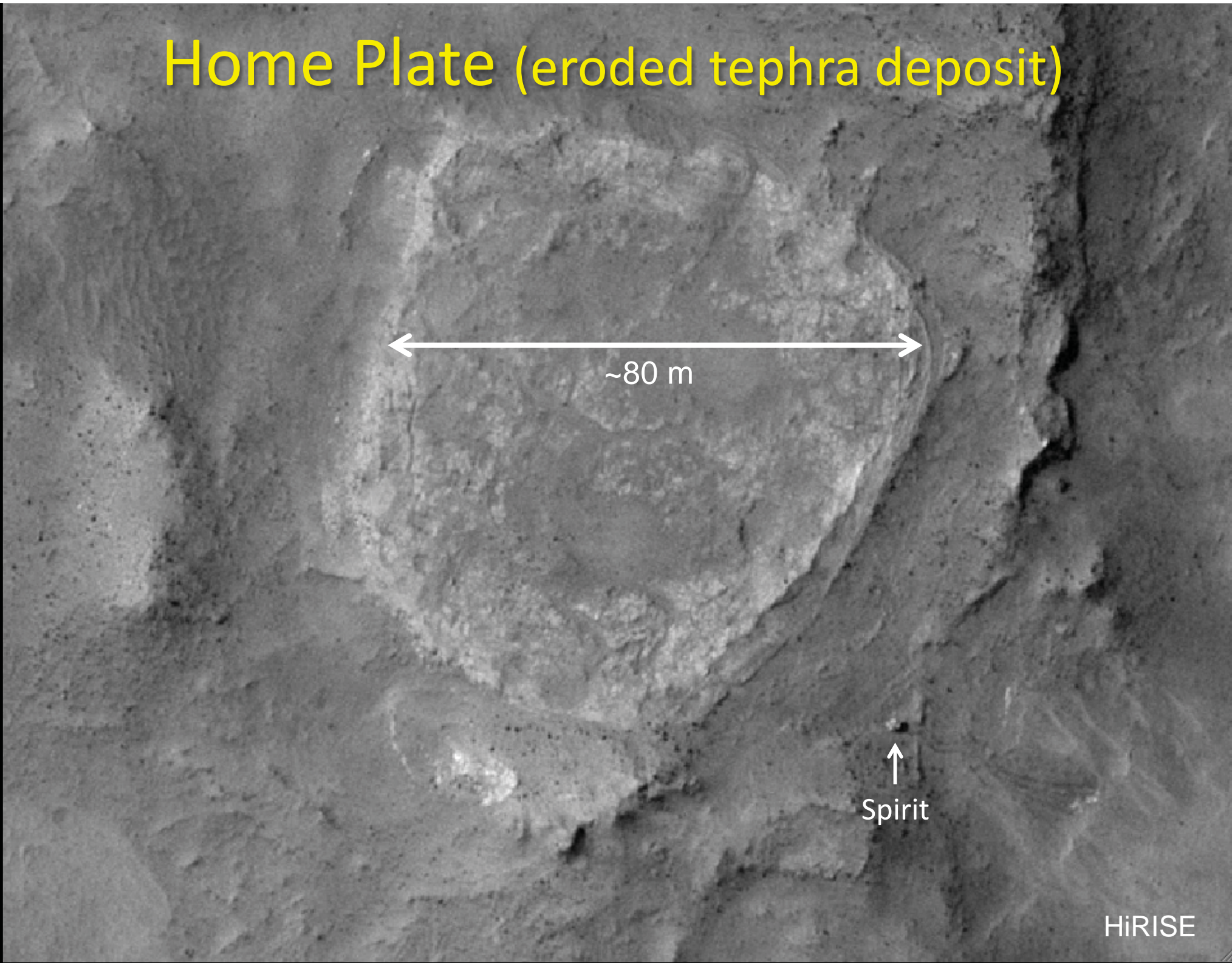


# Home Plate (eroded tephra deposit)

← ~80 m →

↑  
Spirit

HiRISE





# Silica at Home Plate

APXS:  
 $\text{SiO}_2$  90%

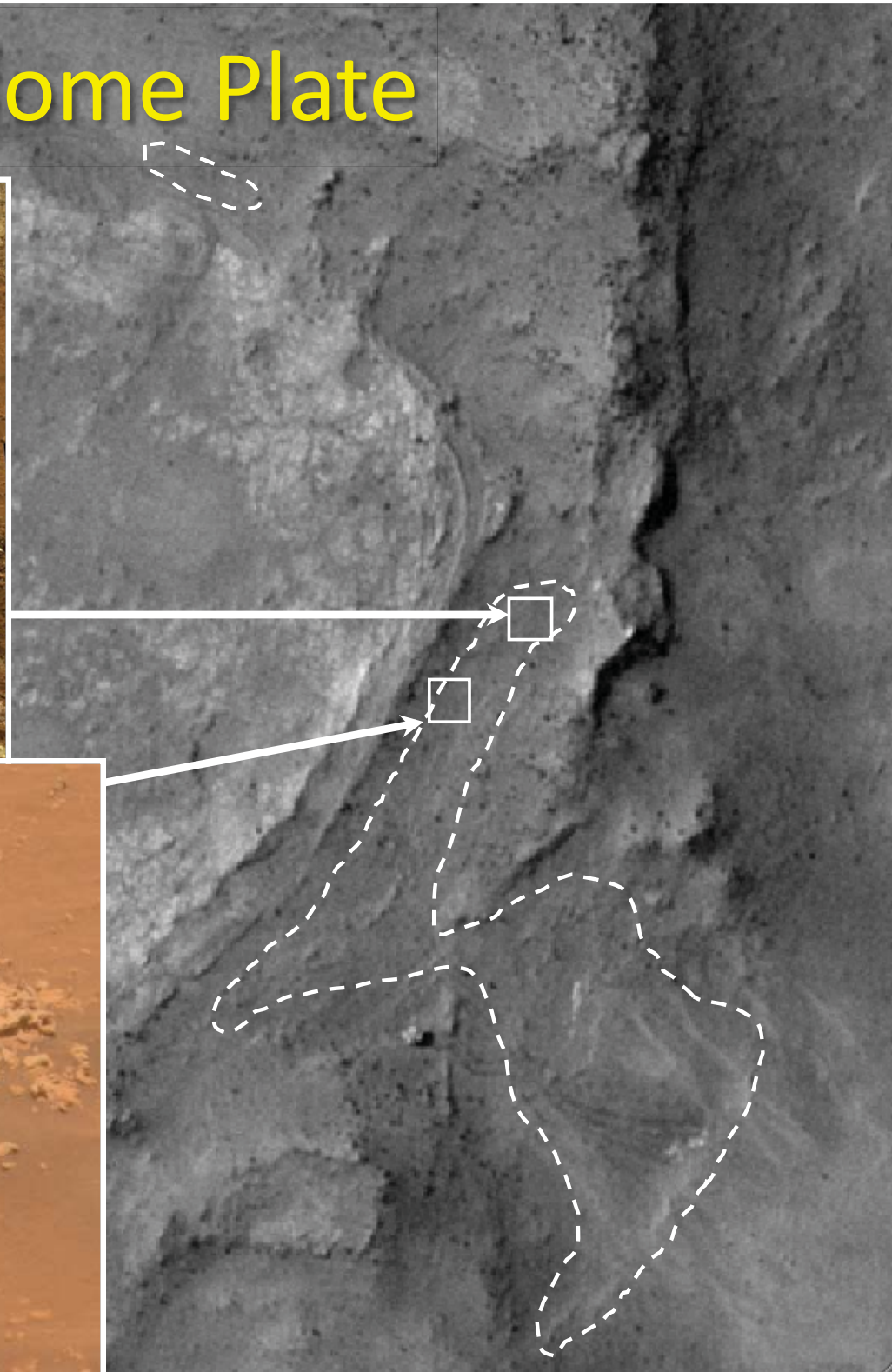
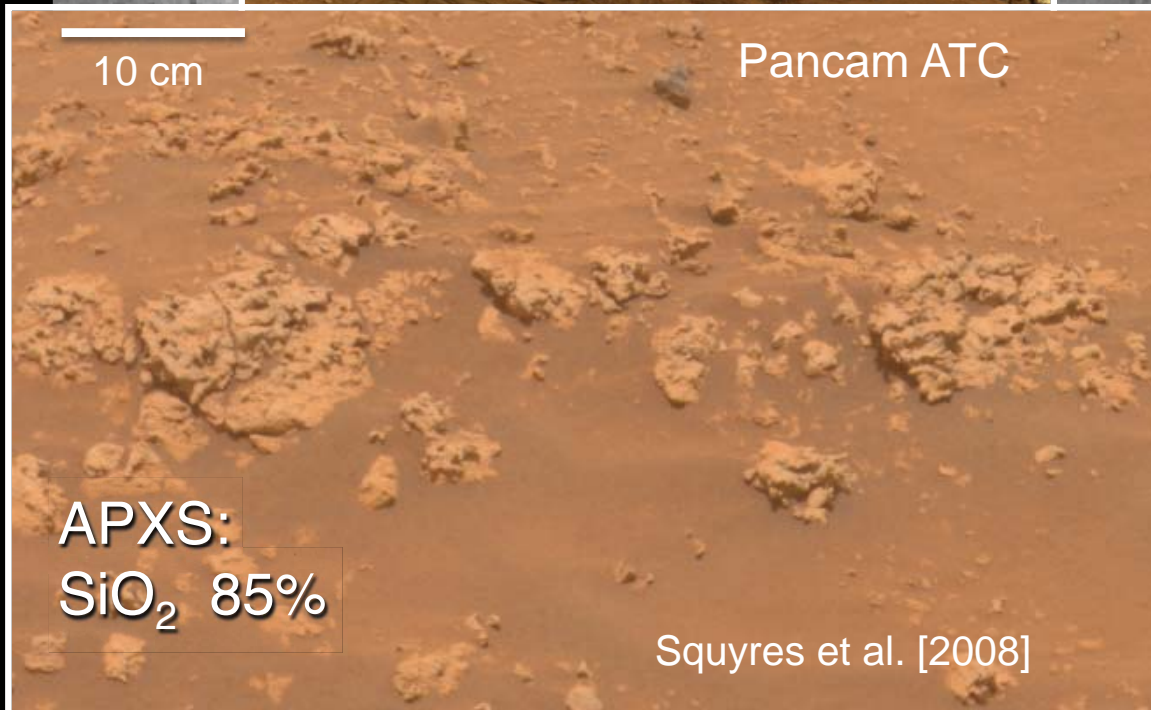


10 cm

Pancam ATC

APXS:  
 $\text{SiO}_2$  85%

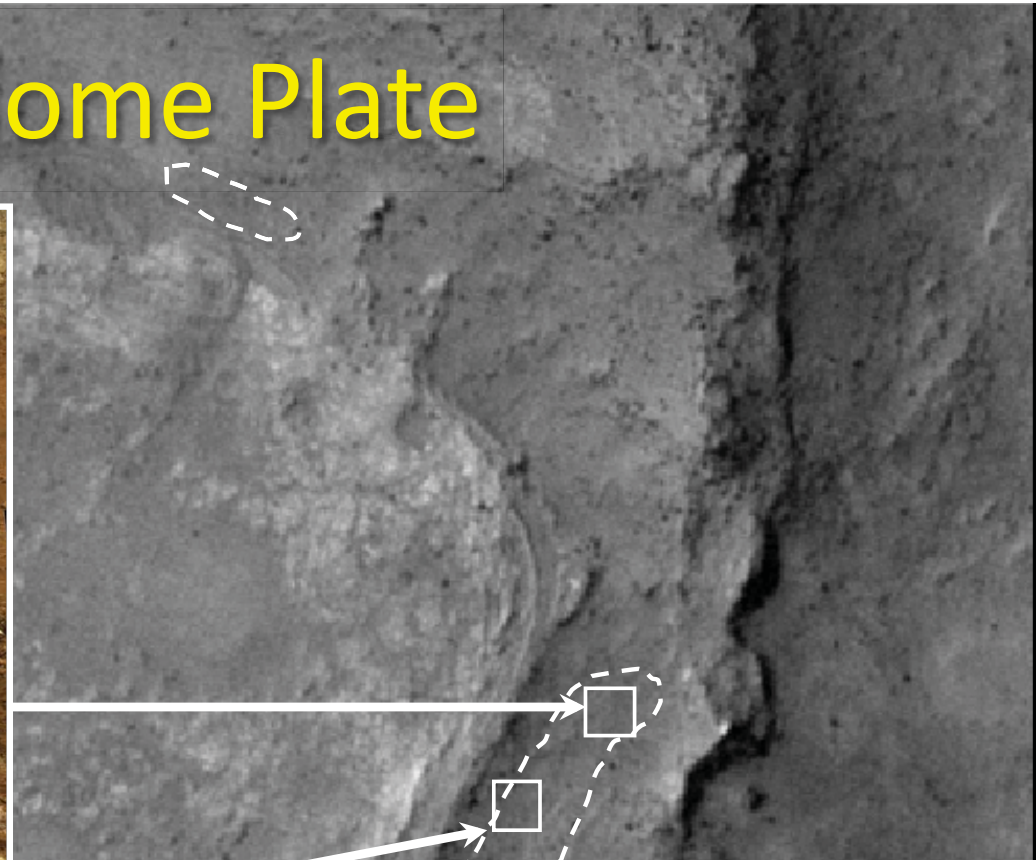
Squyres et al. [2008]





# Opaline Silica at Home Plate

APXS:  
SiO<sub>2</sub> 90%



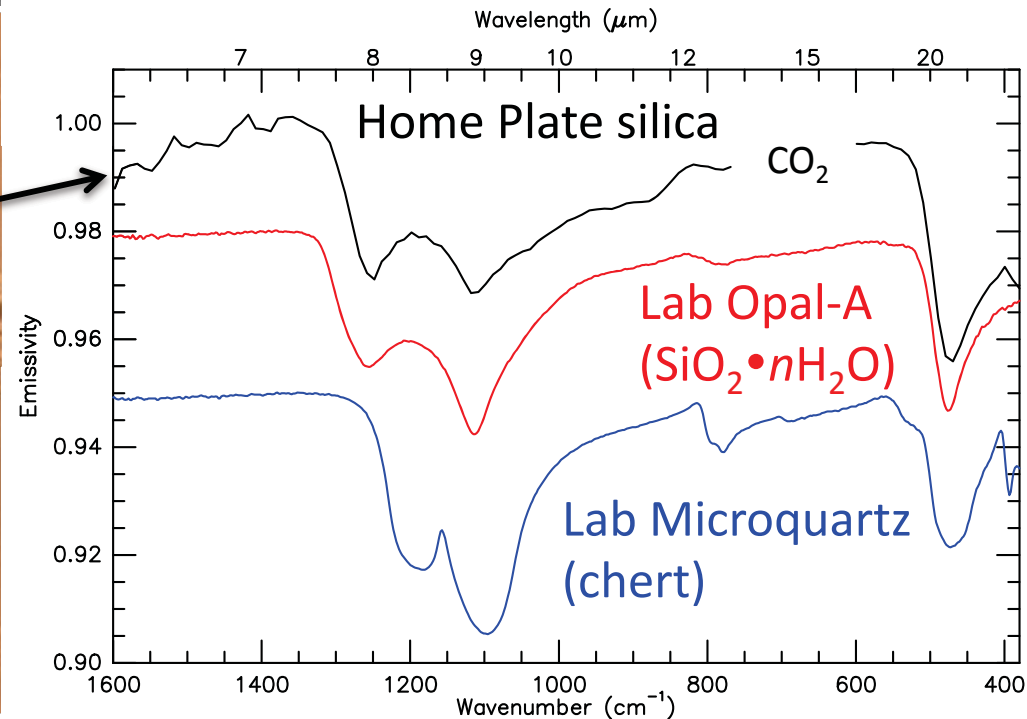
10 cm

Pancam ATC

Mini-TES  
observation

APXS:  
SiO<sub>2</sub> 85%

Squyres et al. [2008]





# Competing Hypotheses

**Fumarolic silica residue:**  
opaline silica outcrops are  
country rock altered by acid-  
sulfate steam condensates;  
**independent of stratigraphy**

Sulphur Banks, Hawaii



Yellowstone National Park



**Hot spring sinter:**  
opaline silica outcrops  
are primary precipitates  
from silica-rich fluids;  
**stratiform**



# Home Plate Analog: El Tatio, Chile (Atacama) Hydrothermal System

- 4300 m elevation
- <100 mm/yr precipitation
- Diurnal freeze-thaw (Nicolau et al., 2014)
- Silica precipitation dominated by evaporation
- Fluids evaporate to dryness; halite precipitation is final product
- Extreme UV radiation (Cabrol et al., 2014)



# Yellowstone Grand Prismatic Spring



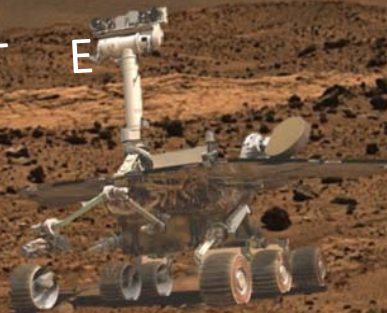






H U S B A N D H I L L

H O M E P L A T E



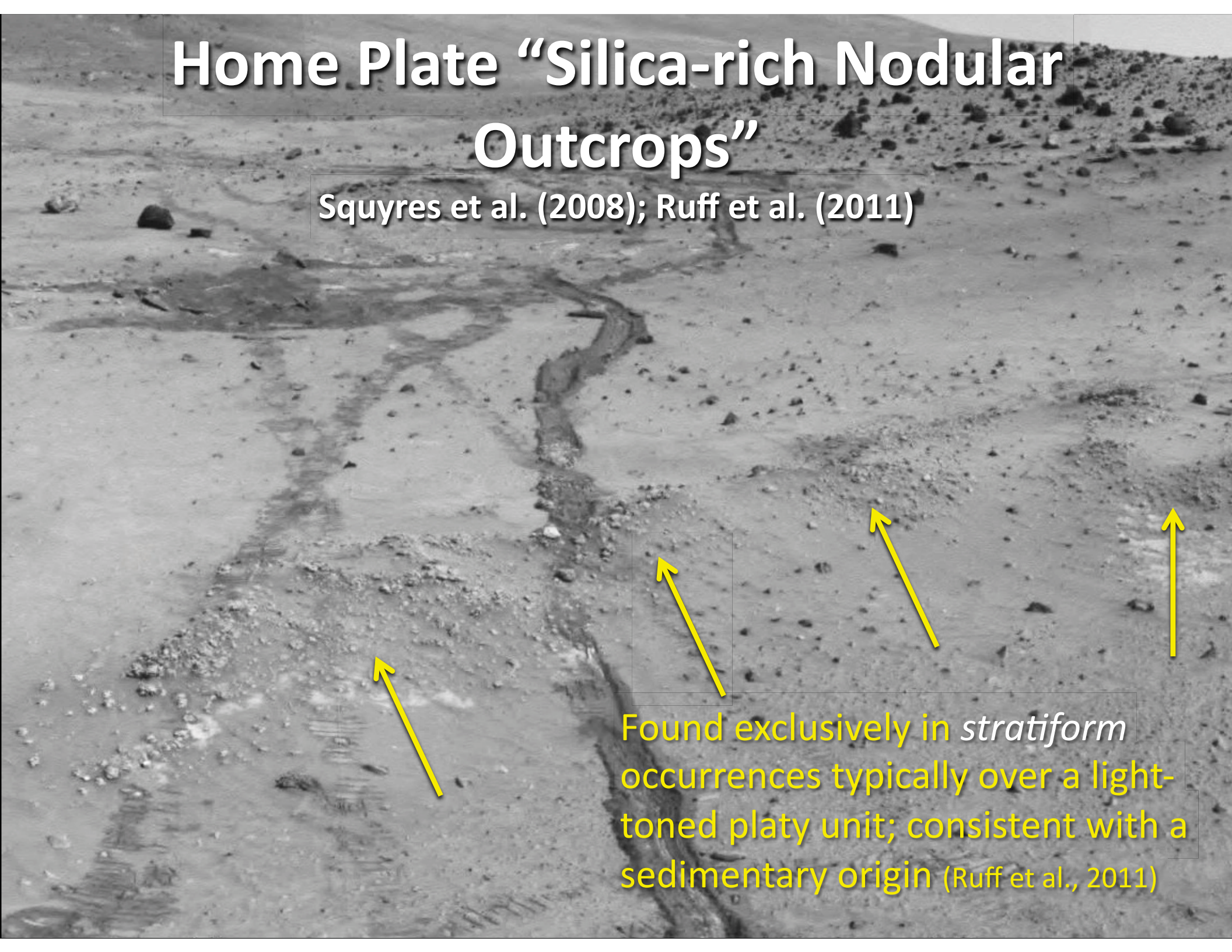
Example of opaline silica occurrence

Eastern Valley of Home Plate, Gusev crater      Pancam approximate true color



# Home Plate “Silica-rich Nodular Outcrops”

Squyres et al. (2008); Ruff et al. (2011)



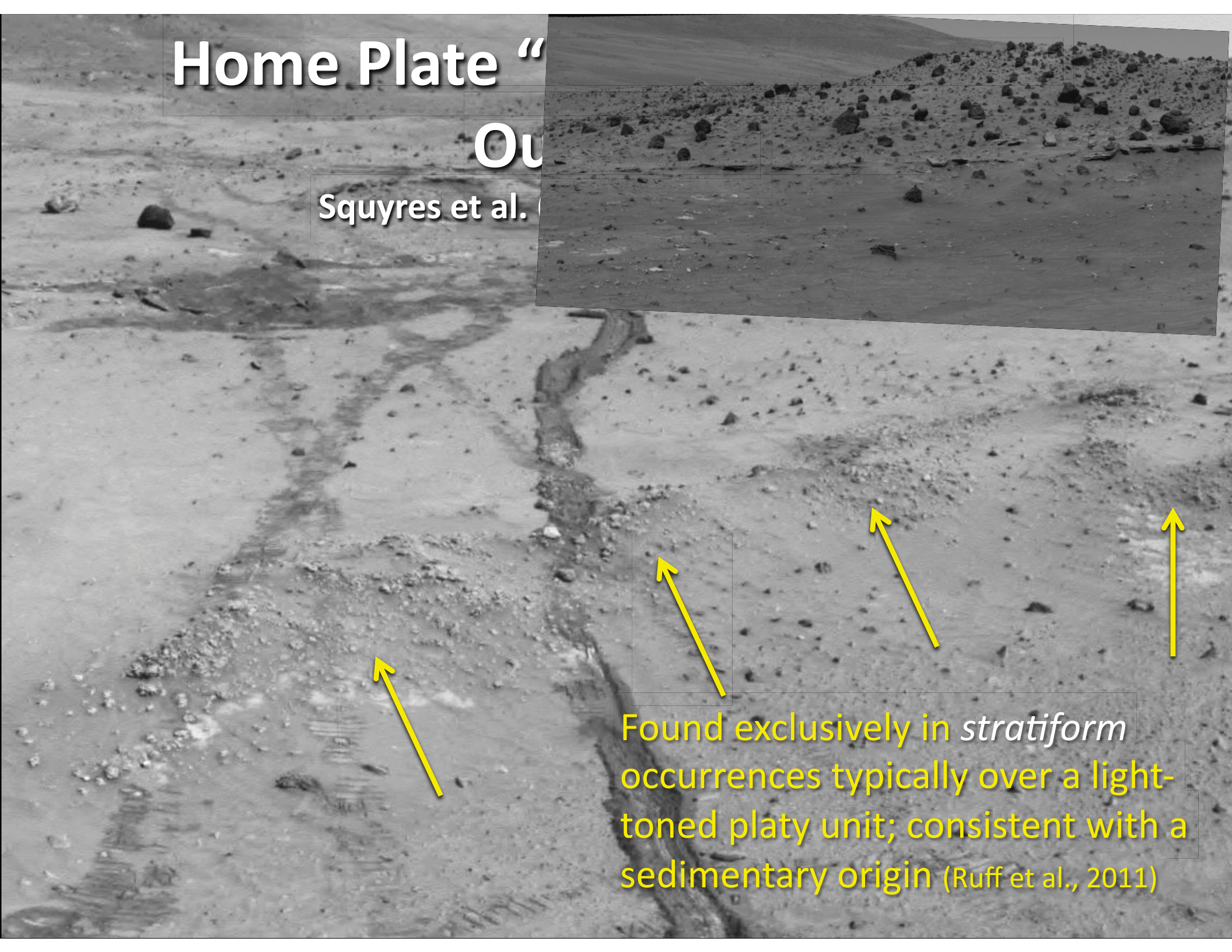
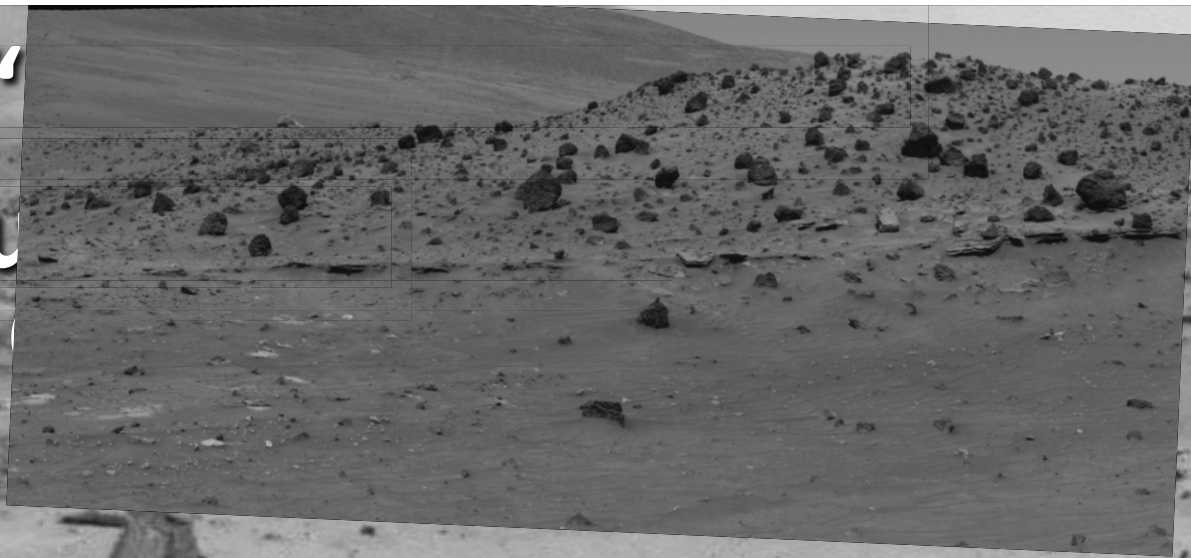
Found exclusively in *stratiform* occurrences typically over a light-toned platy unit; consistent with a sedimentary origin (Ruff et al., 2011)



# Home Plate “

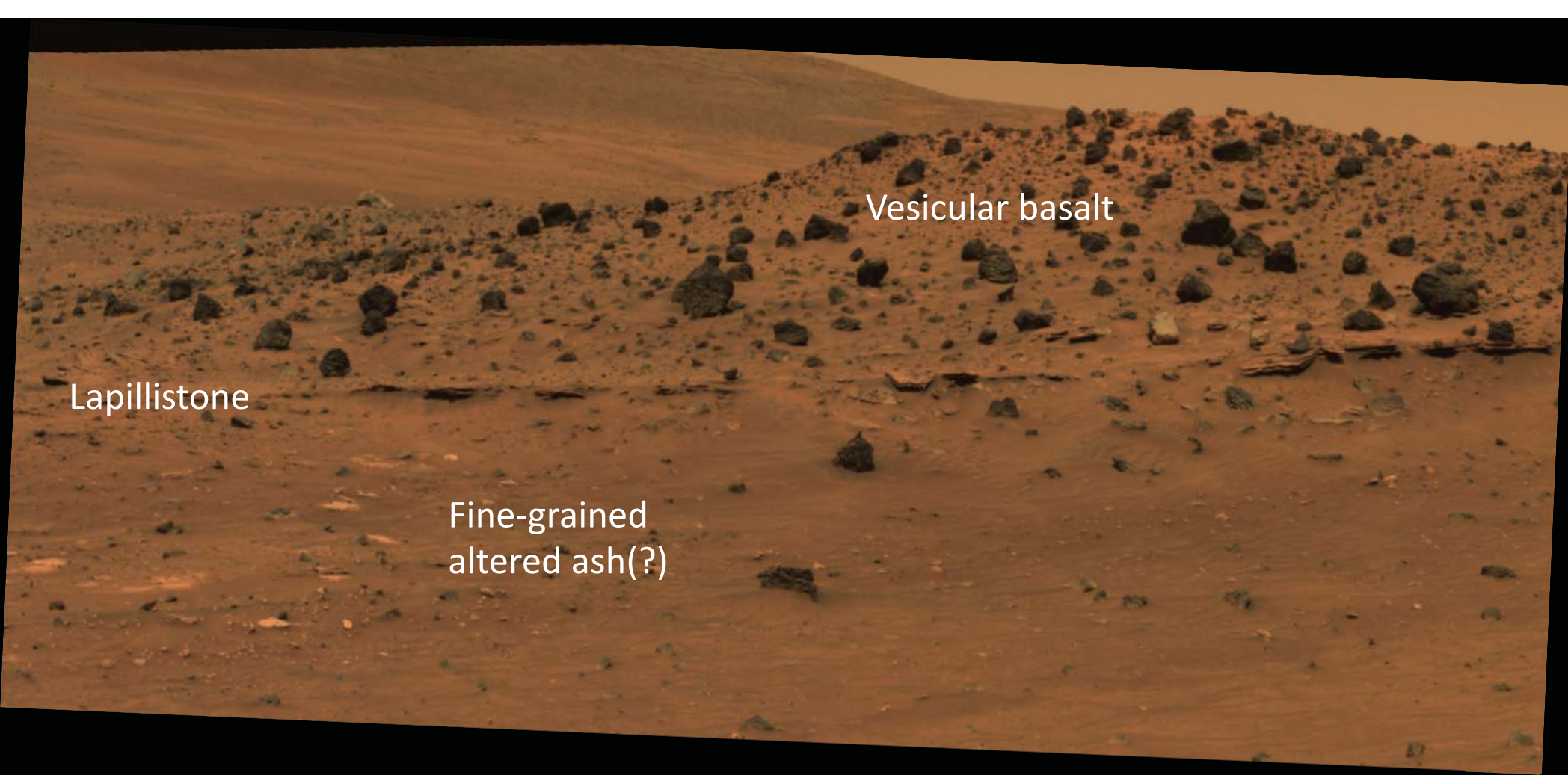
Out

Squyres et al.



Found exclusively in *stratiform* occurrences typically over a light-toned platy unit; consistent with a sedimentary origin (Ruff et al., 2011)





Vesicular basalt

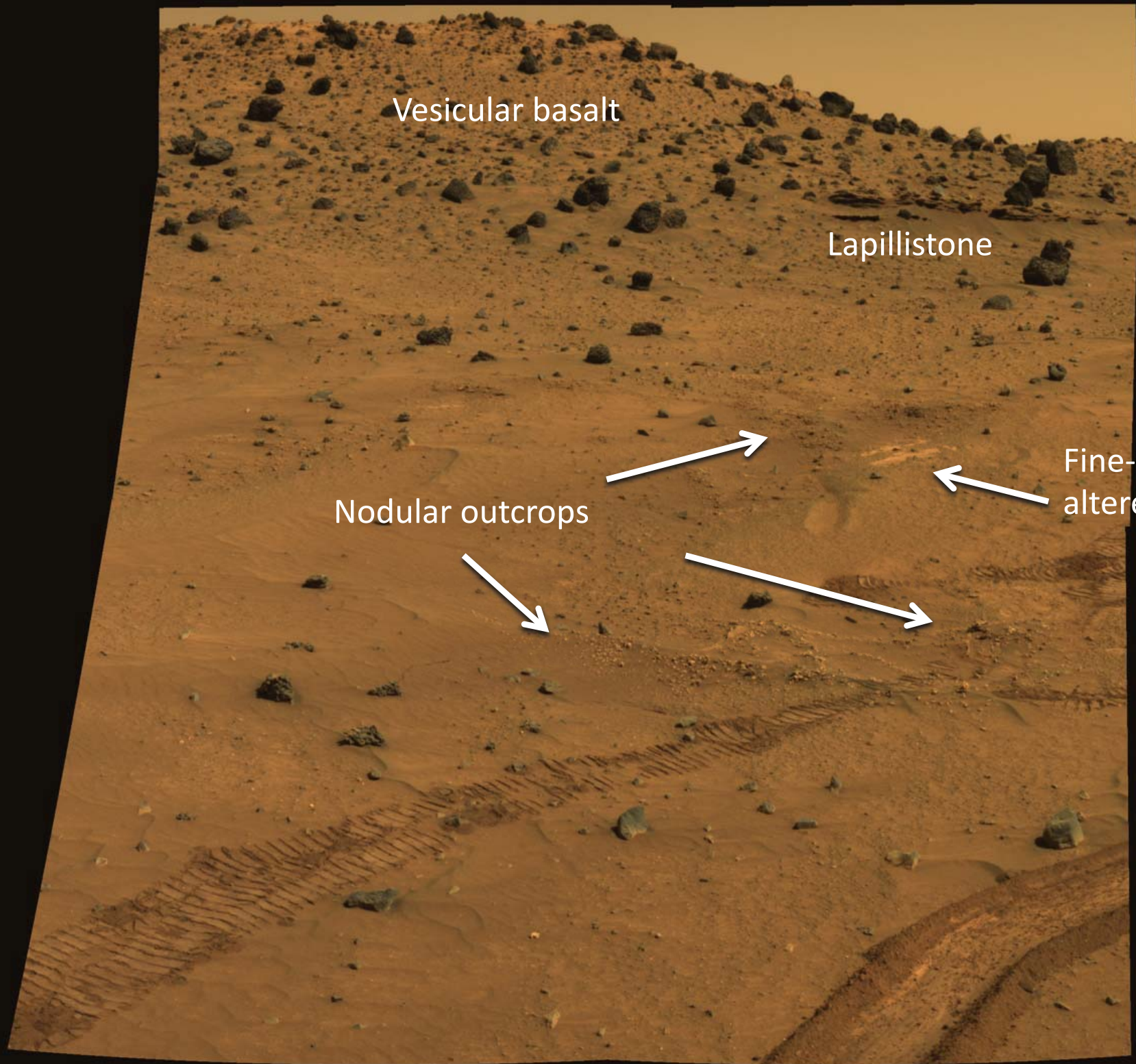
Lapillistone

Fine-grained  
altered ash(?)

# Volcanic Stratigraphy

(Decameter to meter scale context)





Vesicular basalt

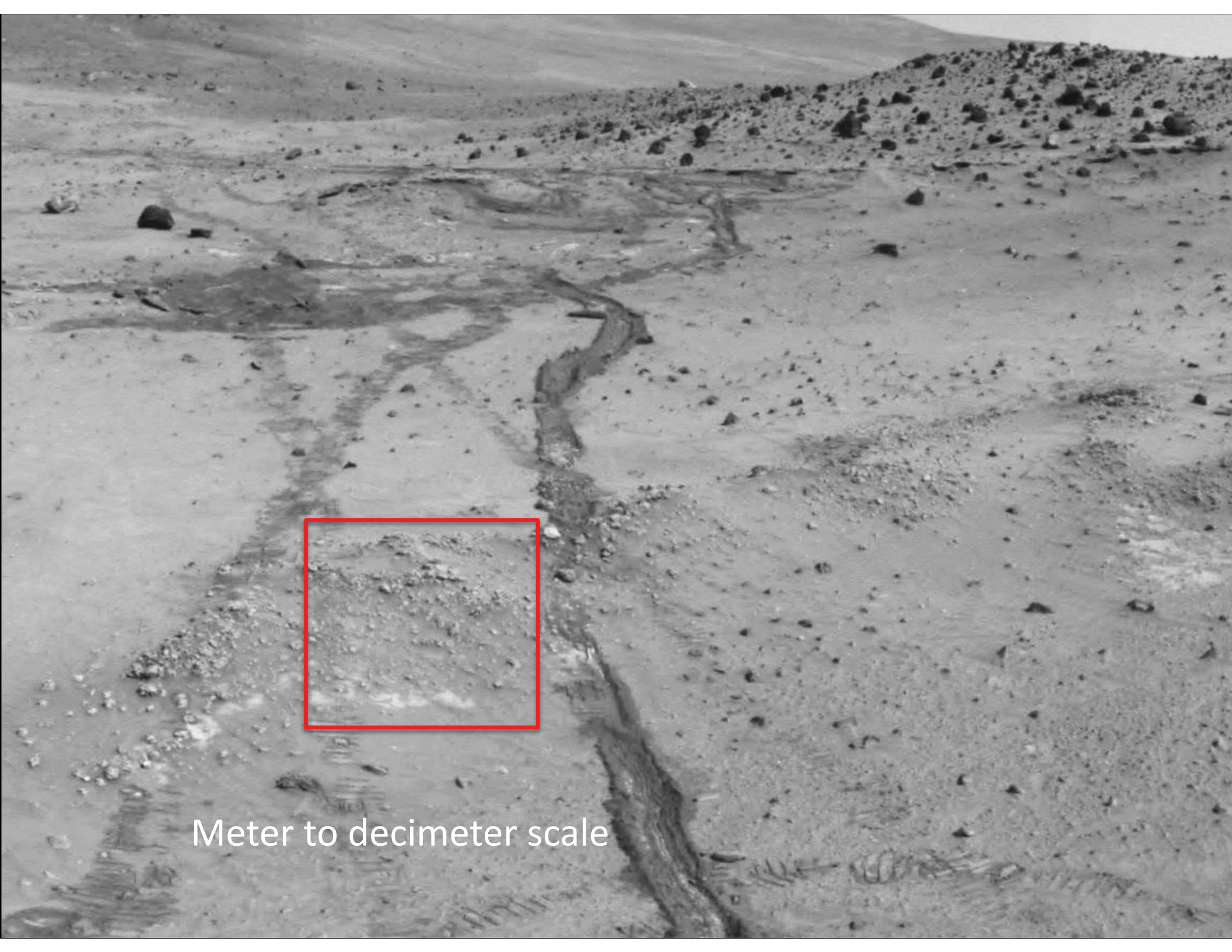
Lapillistone

Nodular outcrops

Fine-grained altered ash(?)







Meter to decimeter scale



Sol 778 Pancam approximate true color





El Tatio, Chile hot spring discharge apron





El Tatio hot spring discharge channel



Nodular Masses with Digitate Structures



El Tatio hot spring discharge channel



# Nodular Masses with Digitate Structures

Sol 778 Pancam approximate true color



Sol 1160 Pancam ATC Elizabeth Mahon

# Digitate Structures

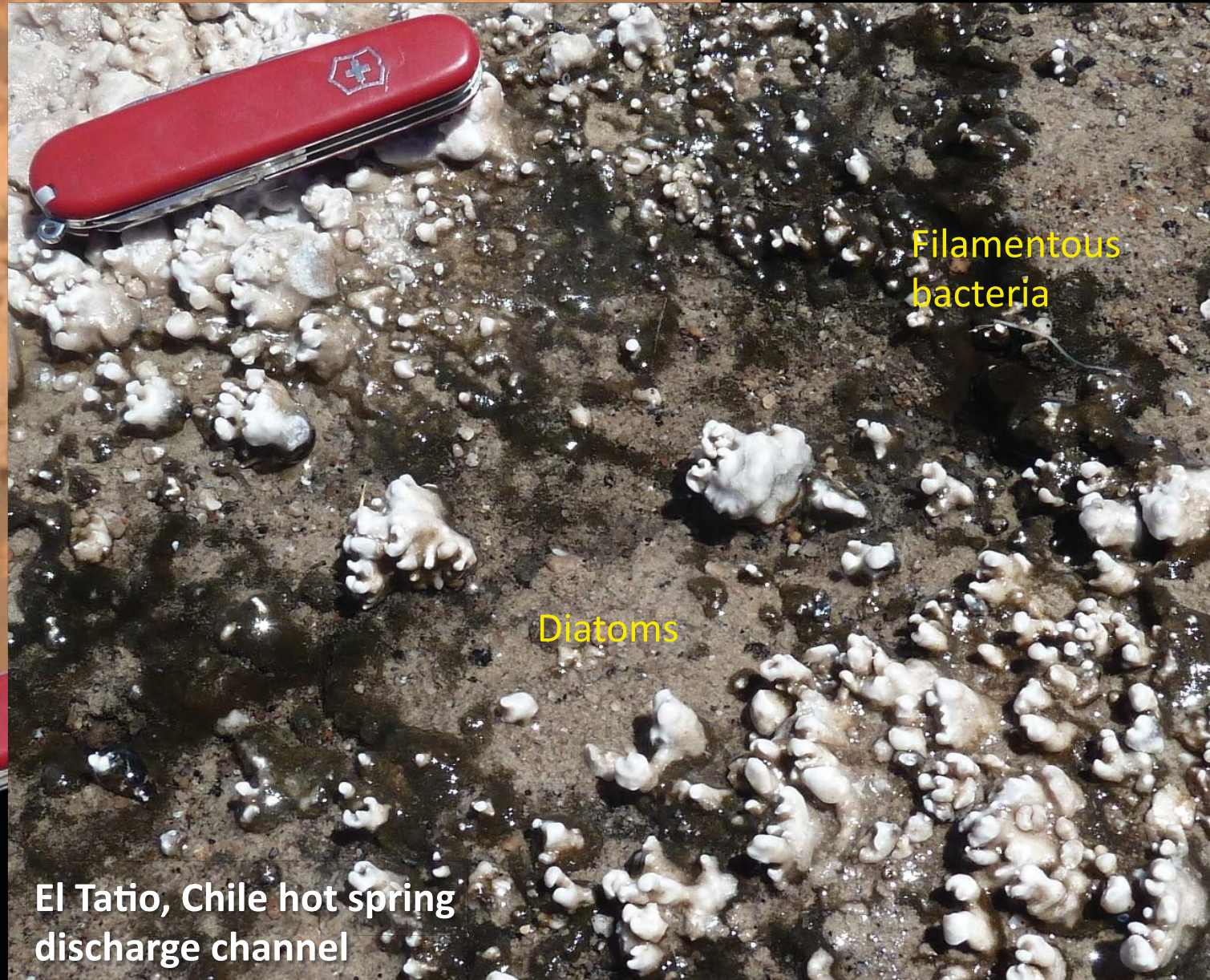
Centimeter to  
millimeter scale





Sol 1160 Pancam ATC Elizabeth Mahon

# Digitate Structures



El Tatio, Chile hot spring discharge channel



Sol 1160 Pancam ATC Elizabeth Mahon

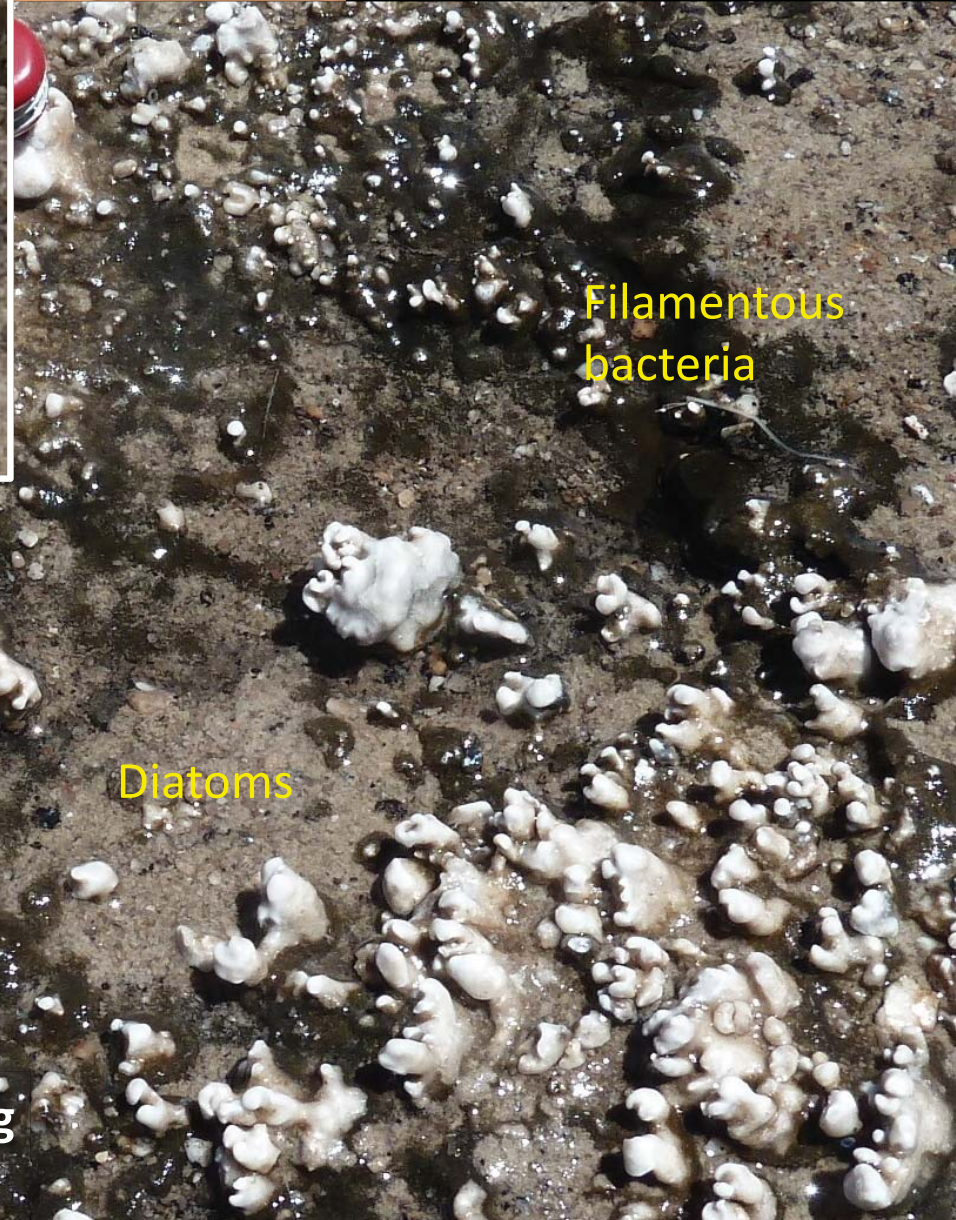
# Digitate Structures



Primary feature  
Microbially mediated?



Erosional or  
primary feature?



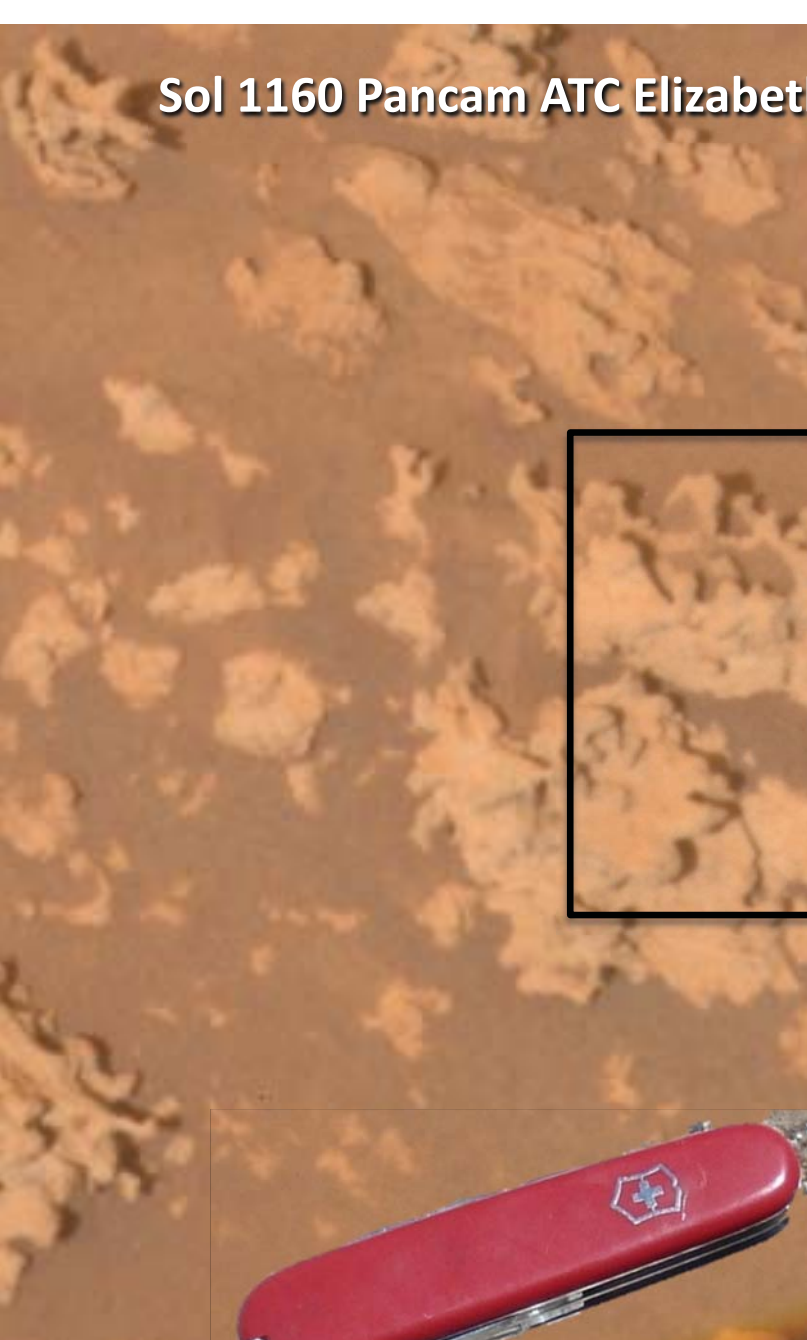
Filamentous  
bacteria

Diatoms

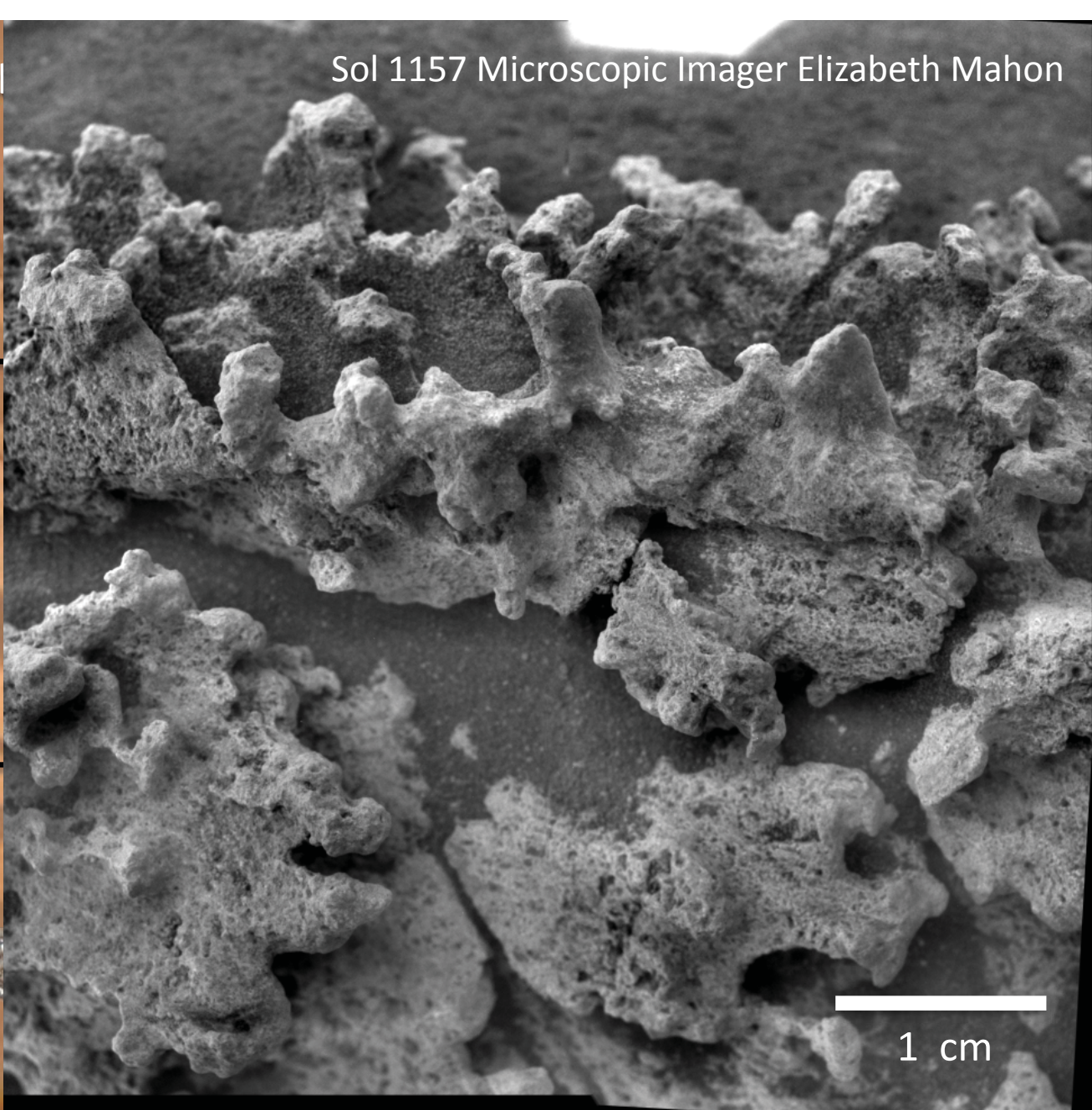
El Tatio, Chile hot spring  
discharge channel



Sol 1160 Pancam ATC Elizabeth



Sol 1157 Microscopic Imager Elizabeth Mahon

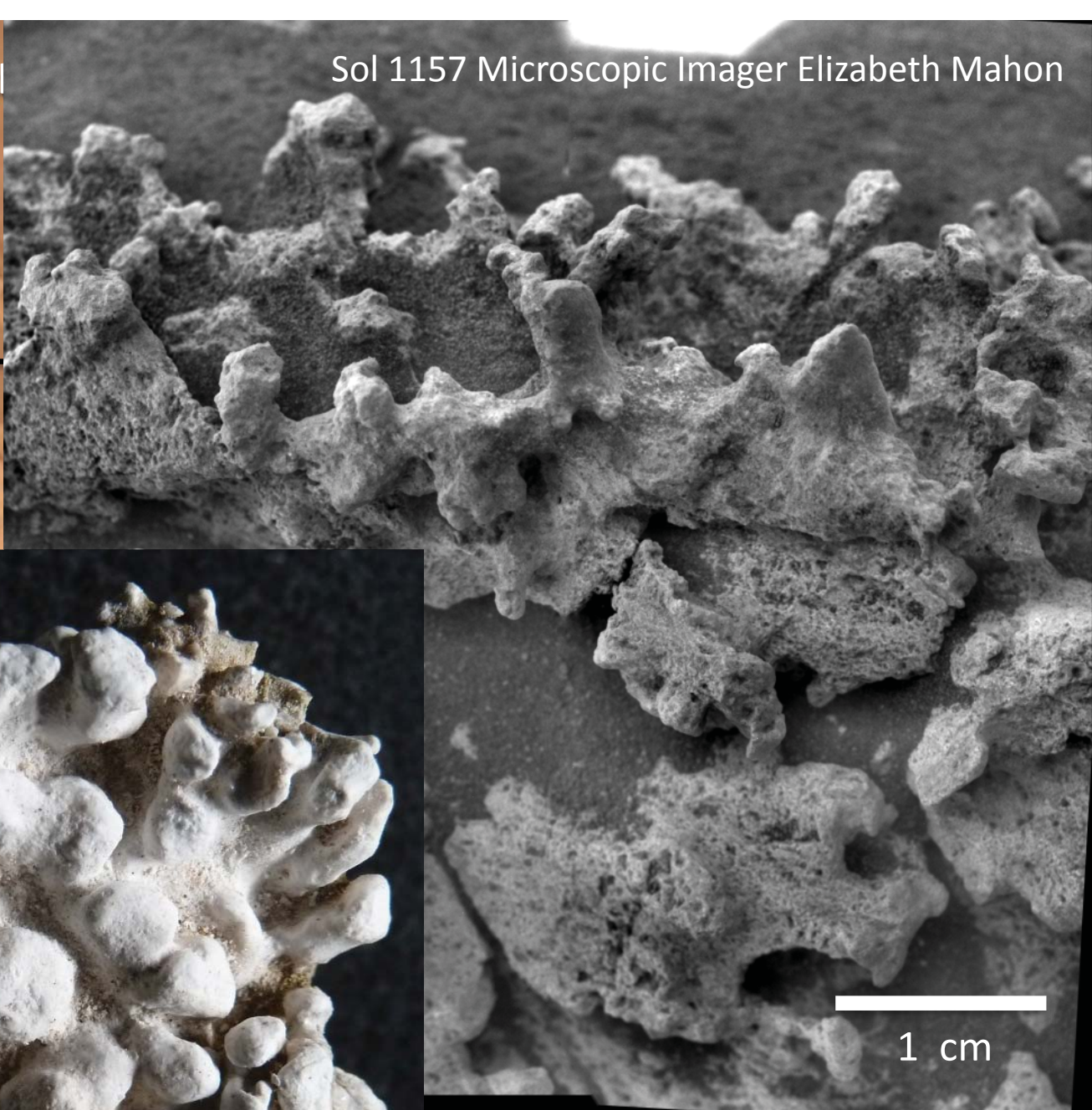




Sol 1160 Pancam ATC Elizabeth



Sol 1157 Microscopic Imager Elizabeth Mahon



El Tatio, Chile hot spring discharge channel sample

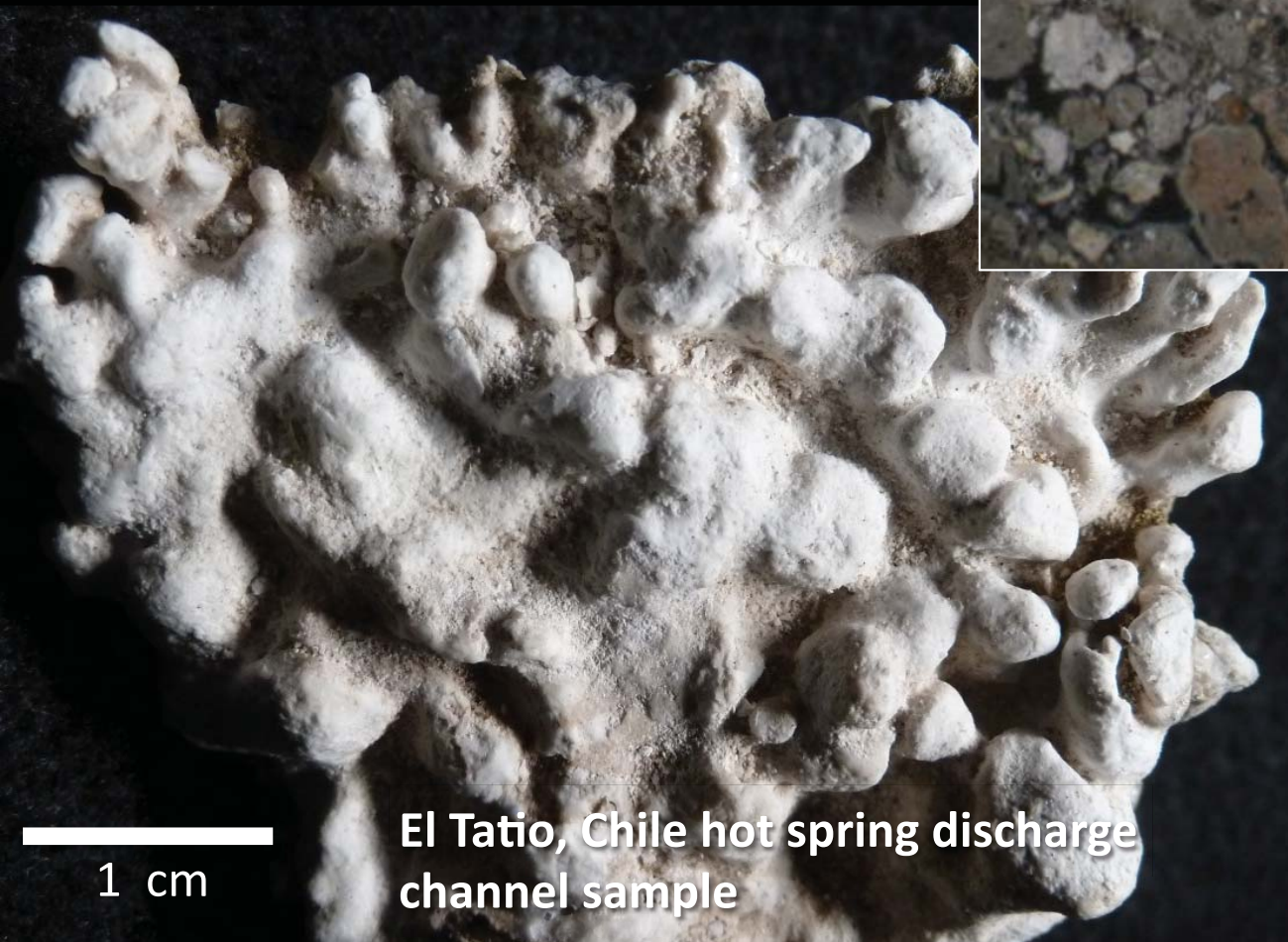


# Millimeter to micrometer scale

(not available from current Mars  
observations)

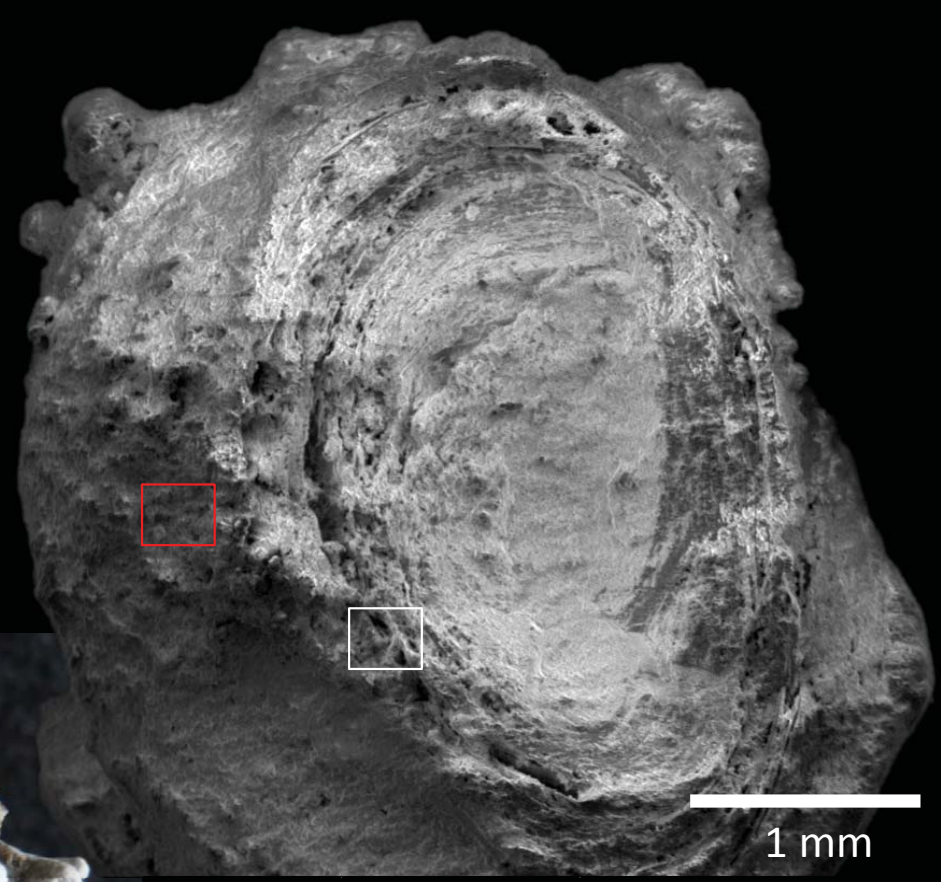
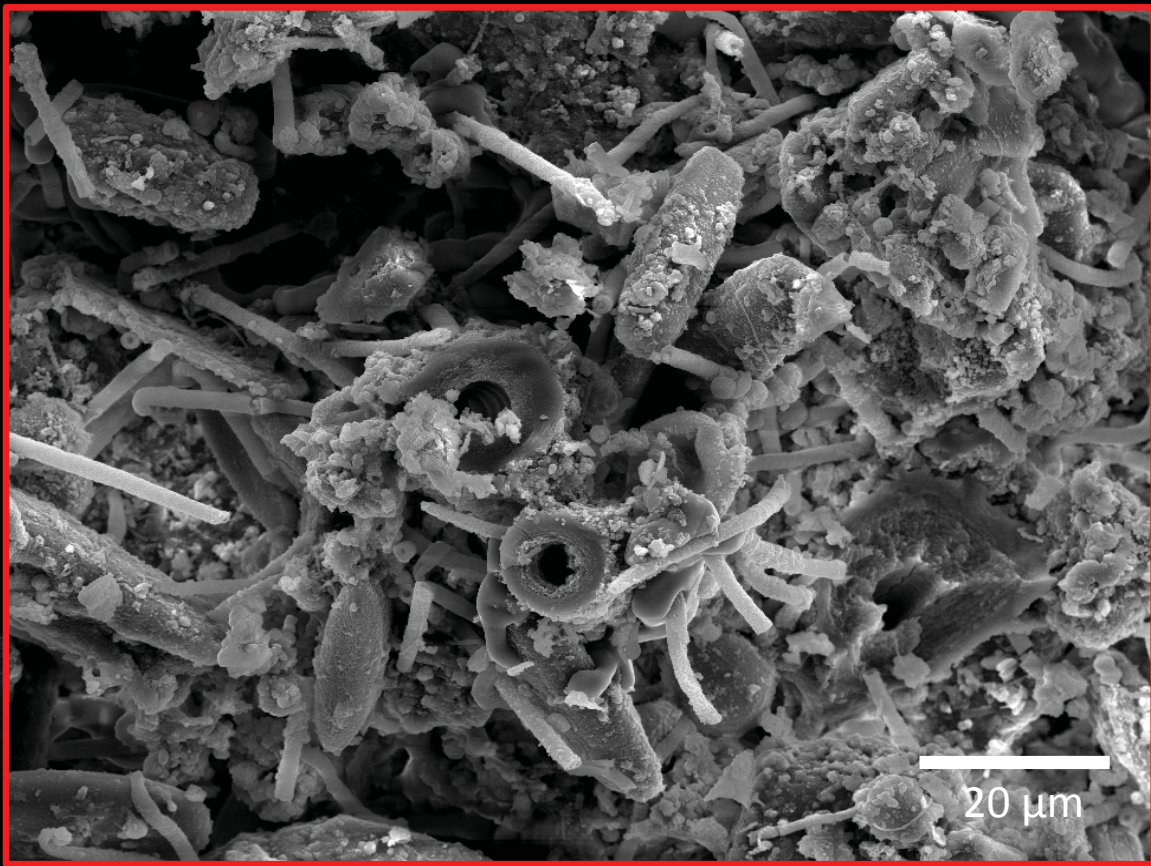


Digitate Structure  
Cross section

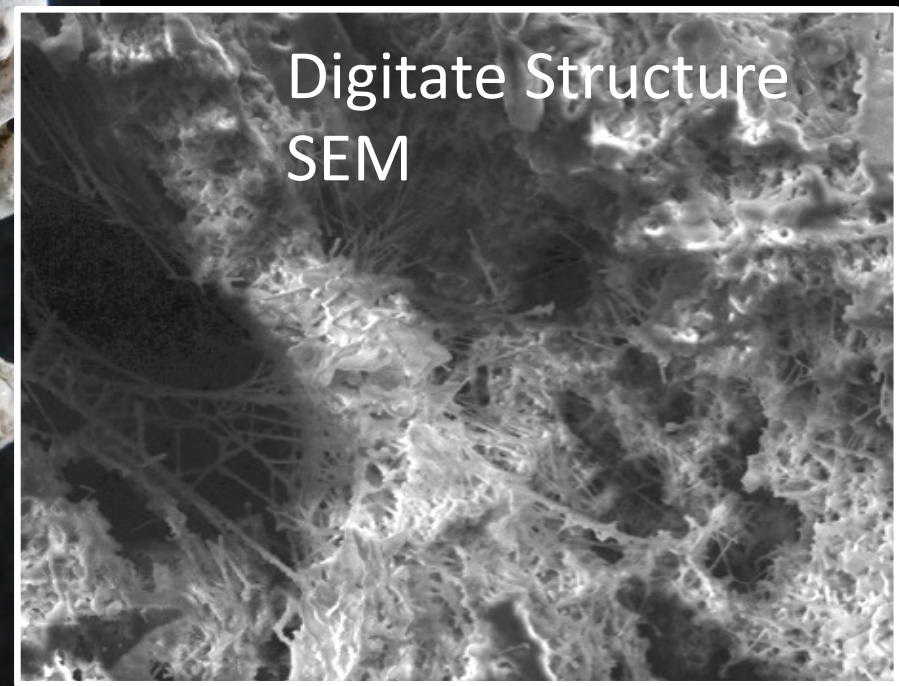


El Tatio, Chile hot spring discharge  
channel sample





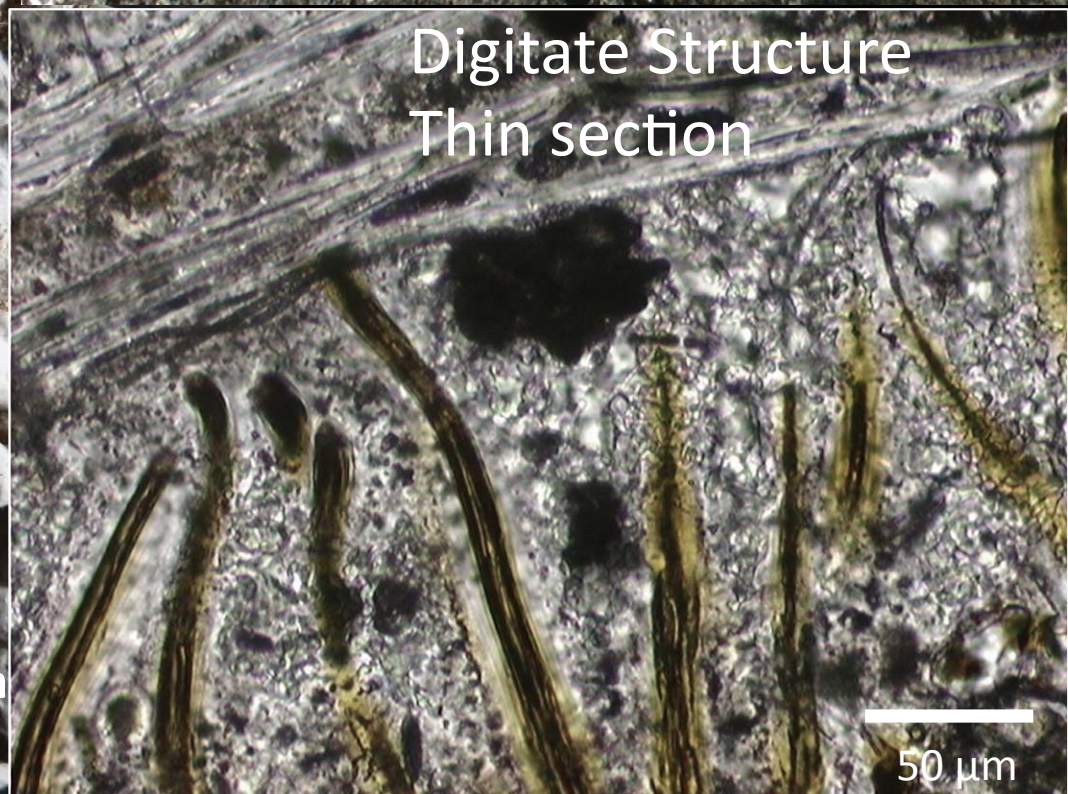
El Tatio, Chile hot spring discharge channel sample



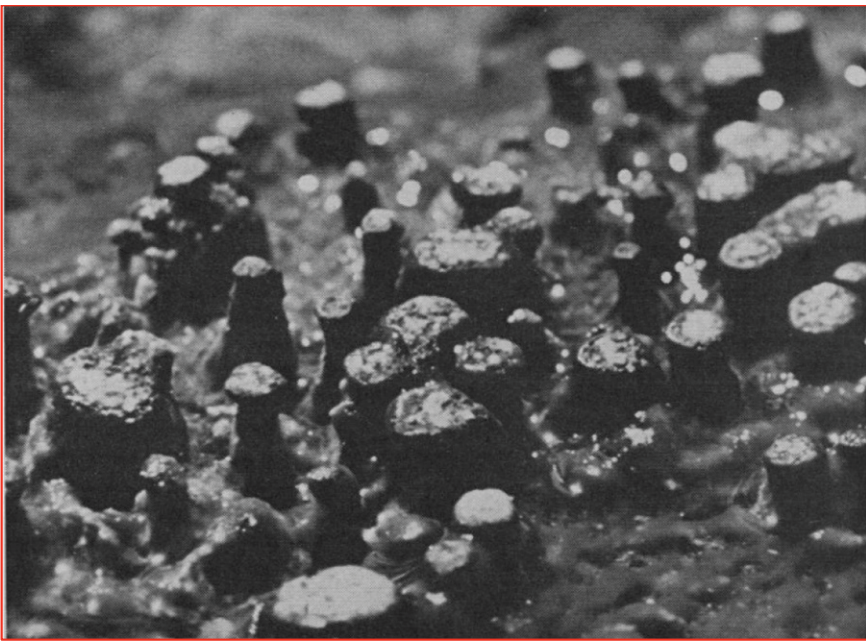


Millimeter to  
micrometer scale

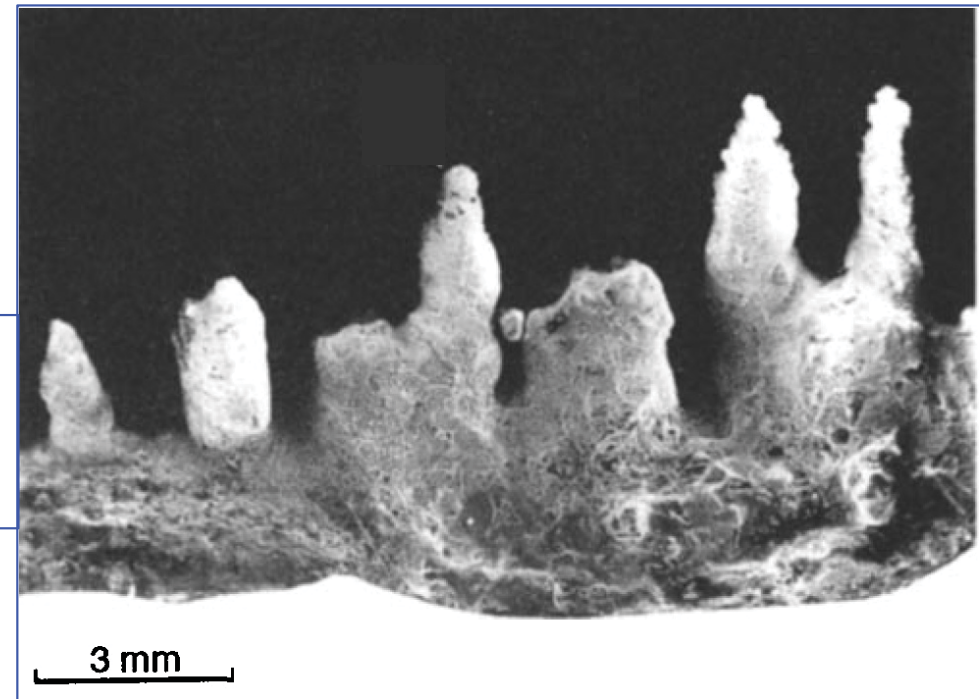
Microbially mediated  
microstromatolites







Siliceous Algal and Bacterial Stromatolites in Hot Spring and Geyser Effluents of Yellowstone National Park, Malcolm Walter et al., Science, 1972



Vertical Zonation of Biota in Microstromatolites Associated with Hot Springs, North Island, New Zealand, Jones et al., Palaios, 1997



Microbial-silica interactions in Icelandic hot spring sinter: possible analogues for some Precambrian siliceous stromatolites, Konhauser et al., Sedimentology, 2001



# Conclusions

- Opaline silica sinter produced by hot springs like at El Tatio can explain the morphologic characteristics of Home Plate opaline silica *down to millimeter scale*
- El Tatio sinter samples provide the best match yet to Mini-TES spectra, likely due to halite
- El Tatio digitate silica structures are biomediated microstromatolites; by analogy those beside Home Plate are *POTENTIAL biosignatures*



# Mars 2020 Science Definition Team Report

A **potential biosignature** is an object, substance and/or pattern that might have a biological origin and thus compels investigators to gather more data before reaching a conclusion as to the presence or absence of life.



# Other El Tatio Microstromalites(?)





