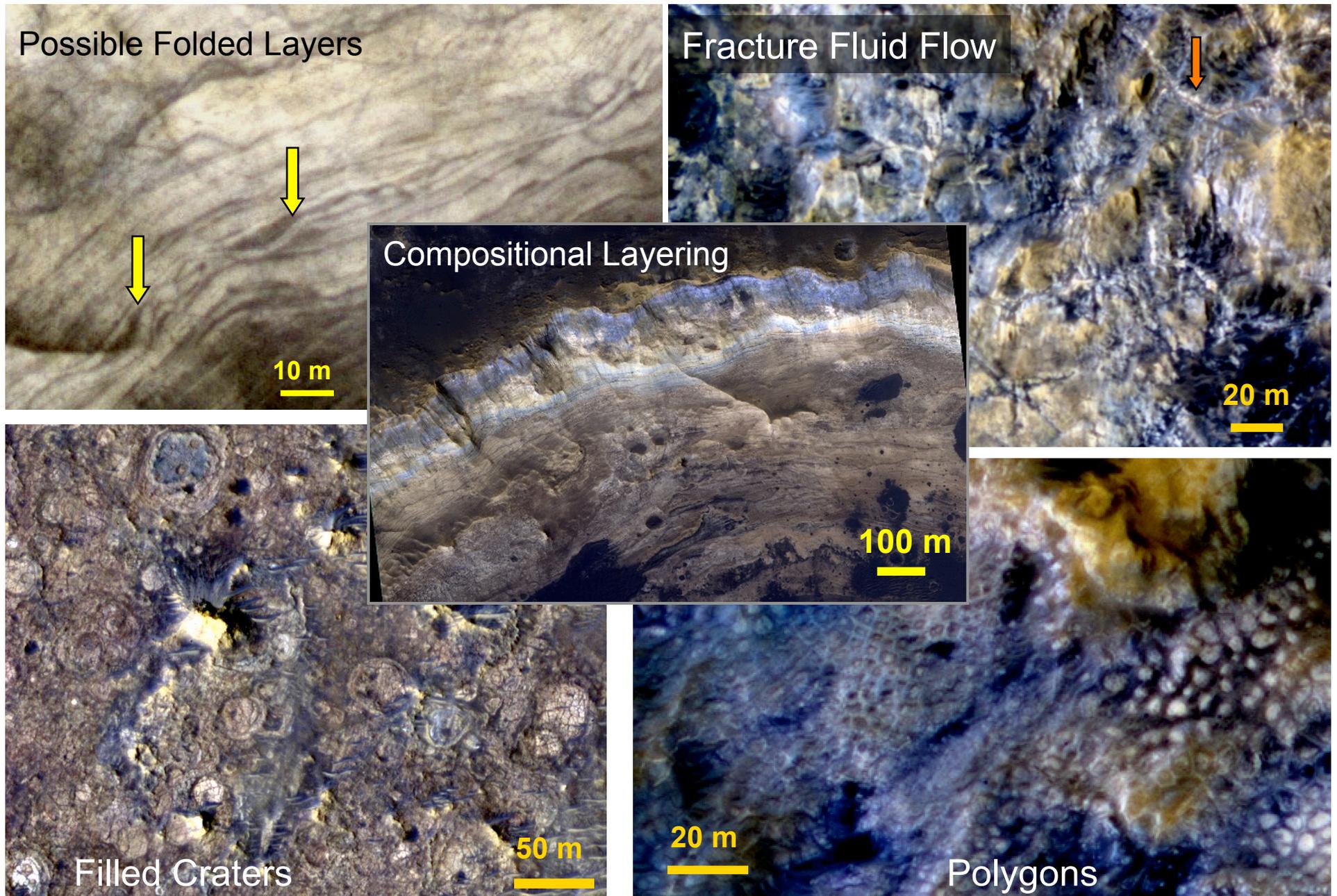
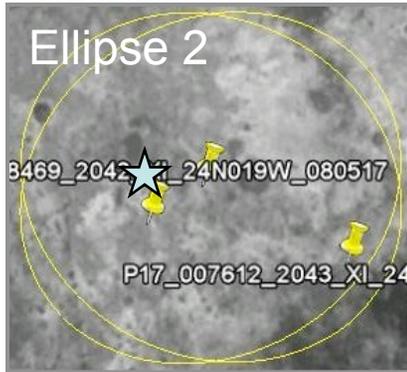


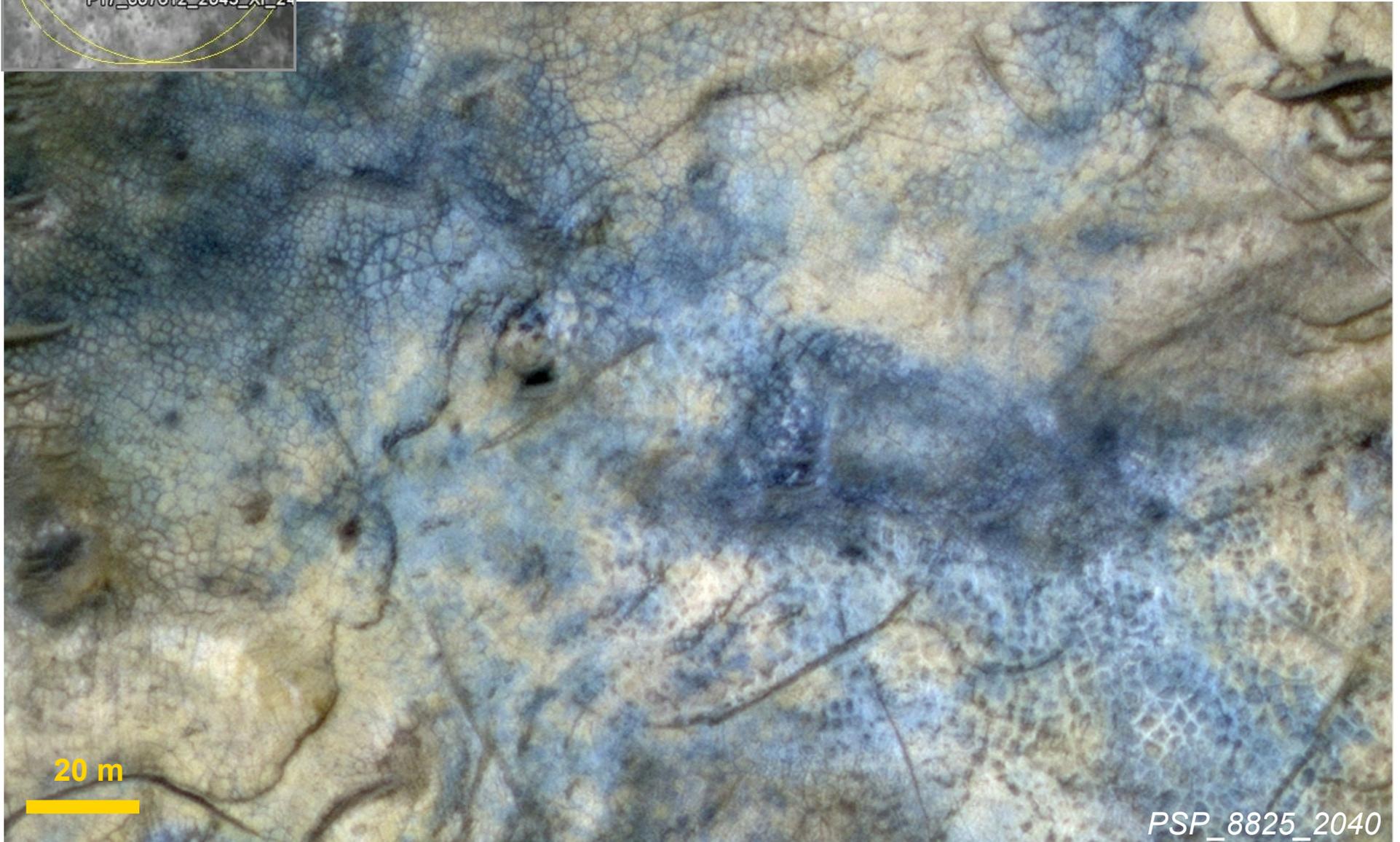
# Morphology and Stratigraphy from HiRISE

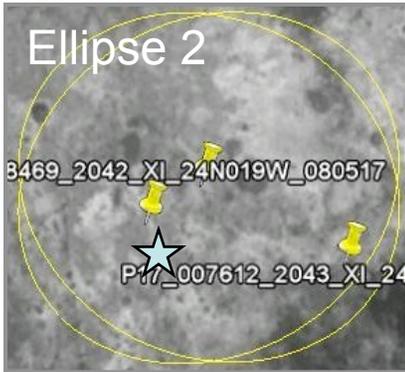




## Polygons at the landing sites

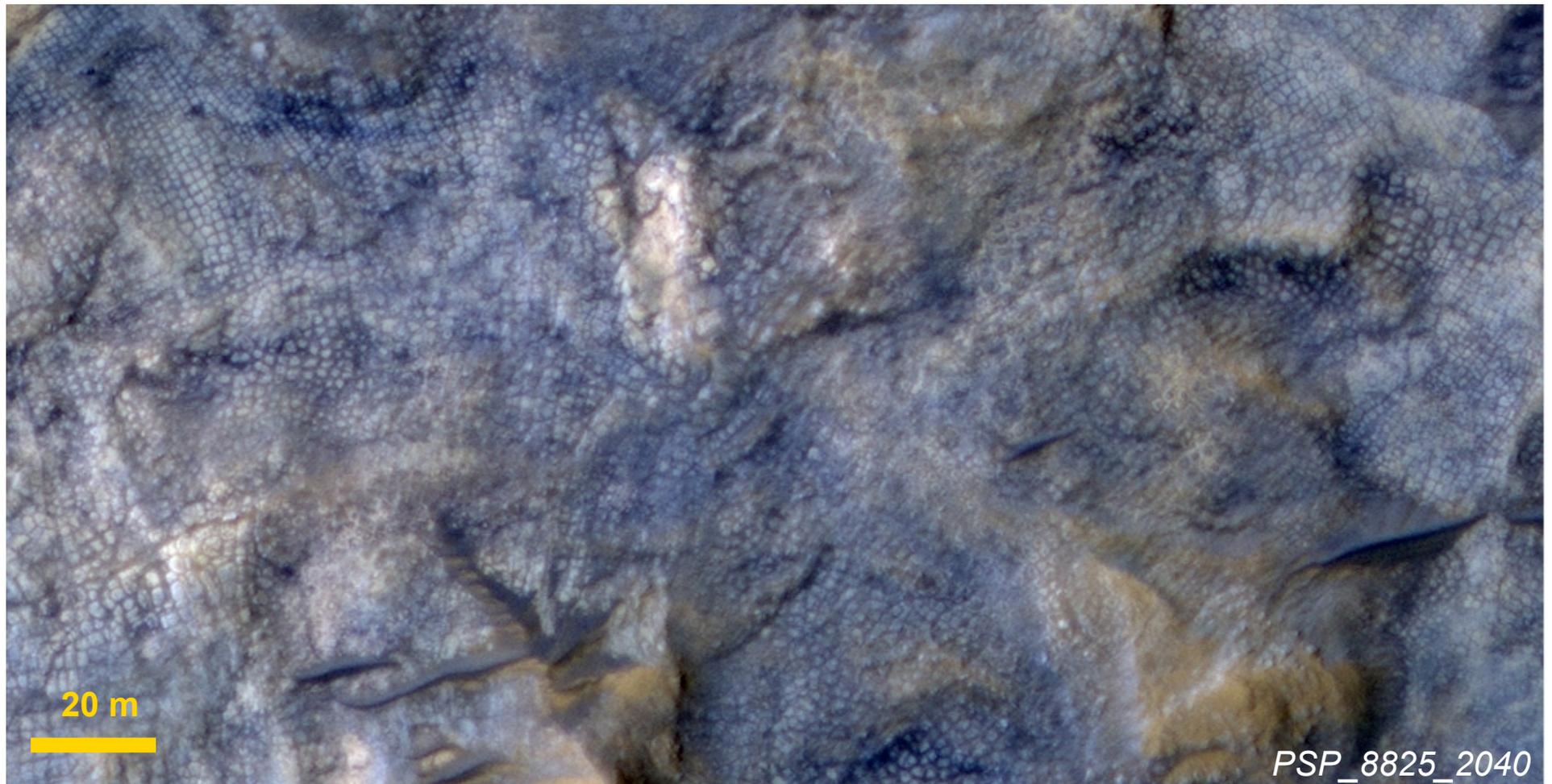
- Varied sizes, bright and dark rims within 100 m span – *why?*
- NOT a rectilinear joint pattern (here)





## Polygon Puzzles

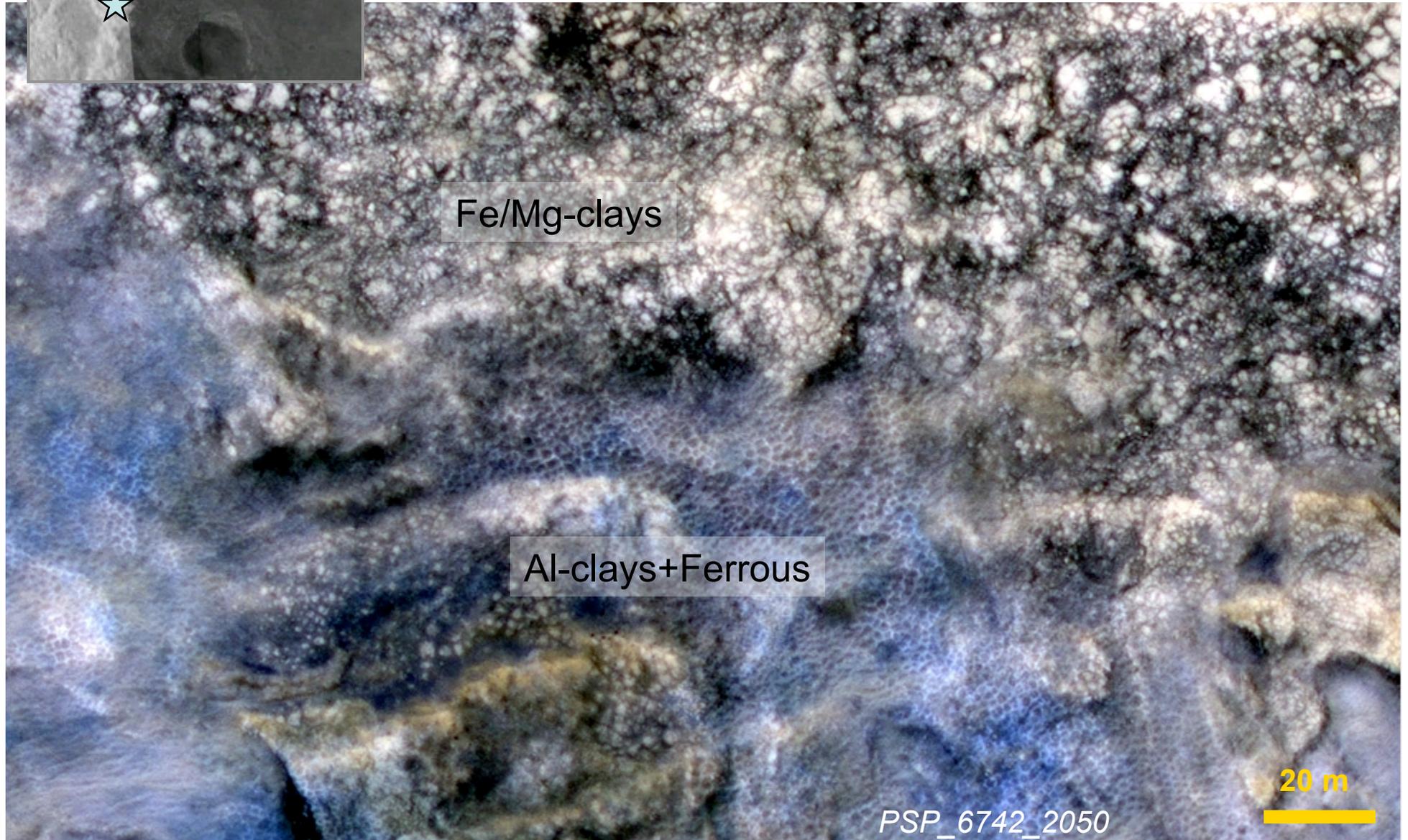
- Formed by desiccation (loss of pore water)? Mineral dehydr[oxyl]ation? Weathering? Periglacial at high obliquity?
- Ancient or relatively recent?
- Lab desiccation expts: polygon width varies w/ composition, depth, layer thickness, substrate roughness – *all measurable*





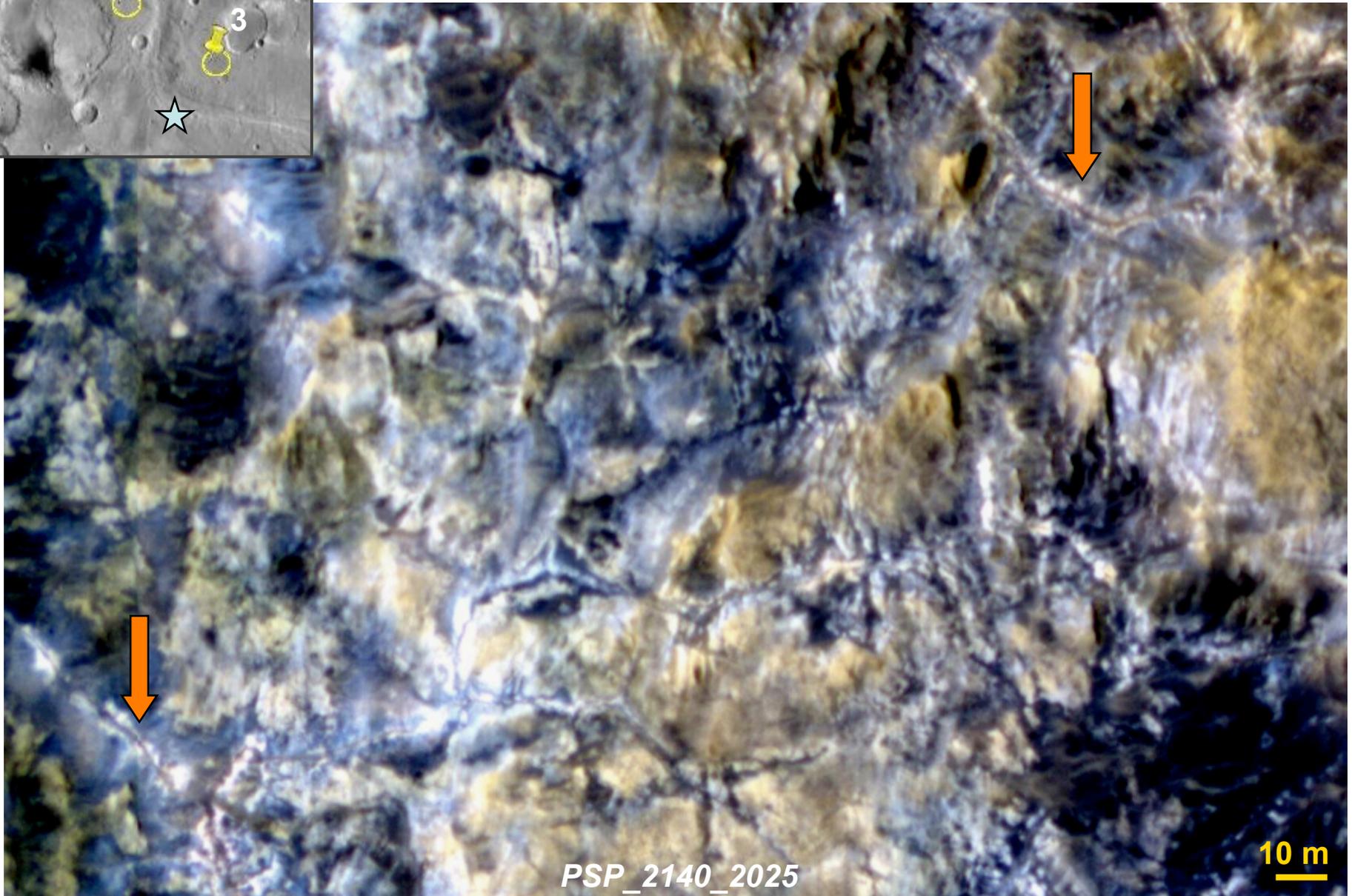
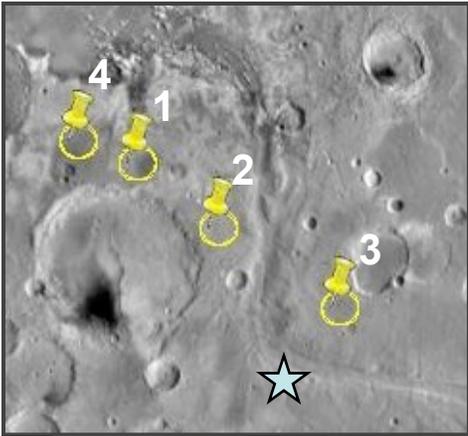
# Polygons compared to compositions

- Fe/Mg-clay-bearing units have “less ordered” fracture patterns



# Halo-bounded fractures

- Type examples in Fe/Mg-phyllo unit South of channel

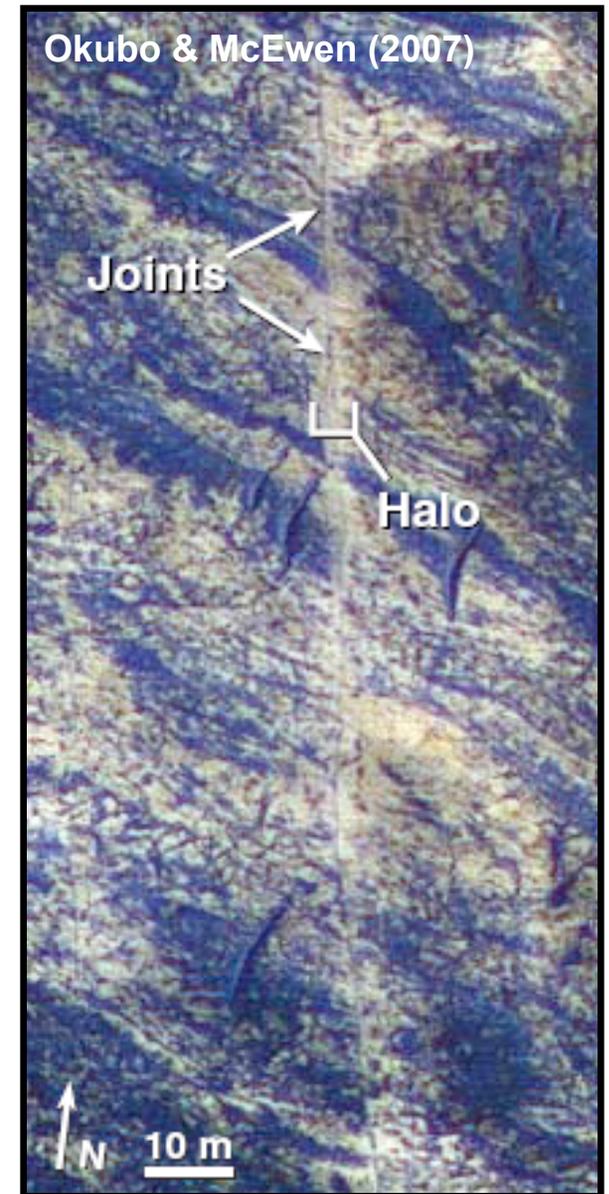


# Halo-bounded fractures on Earth and Mars

- Possible analogs on Earth form when reducing fluids (often groundwater) flowing through fractures remove Fe-oxide grain coatings
- Dark halos can form via precipitation of Fe-oxides

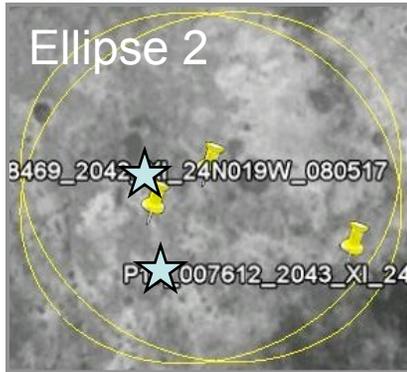


Jurassic Entrada Sandstone, SE Utah (courtesy C. Okubo)



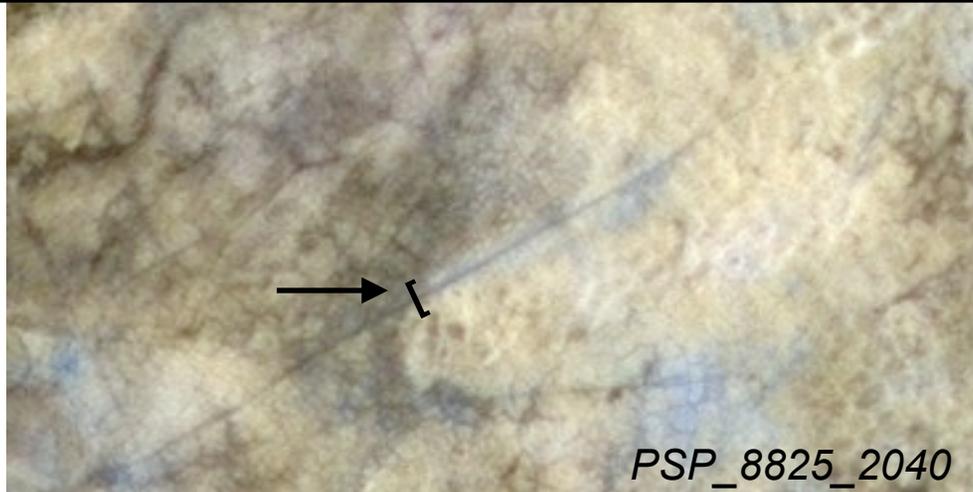
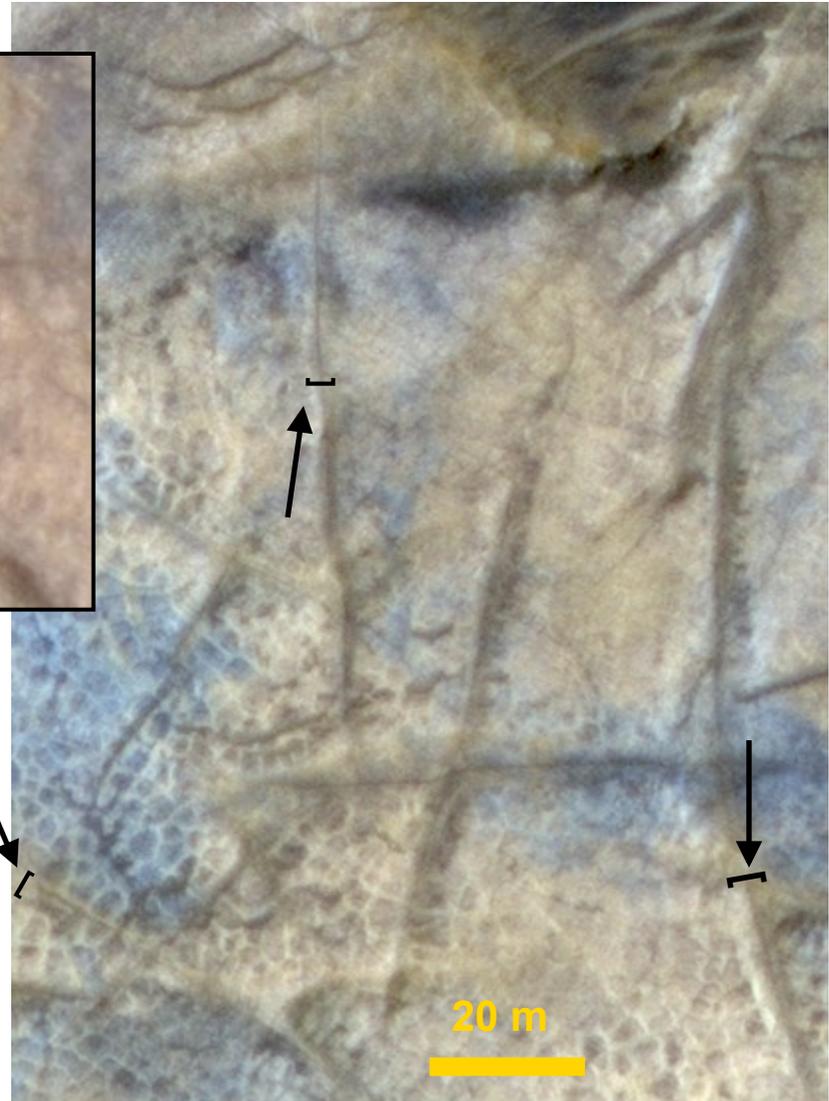
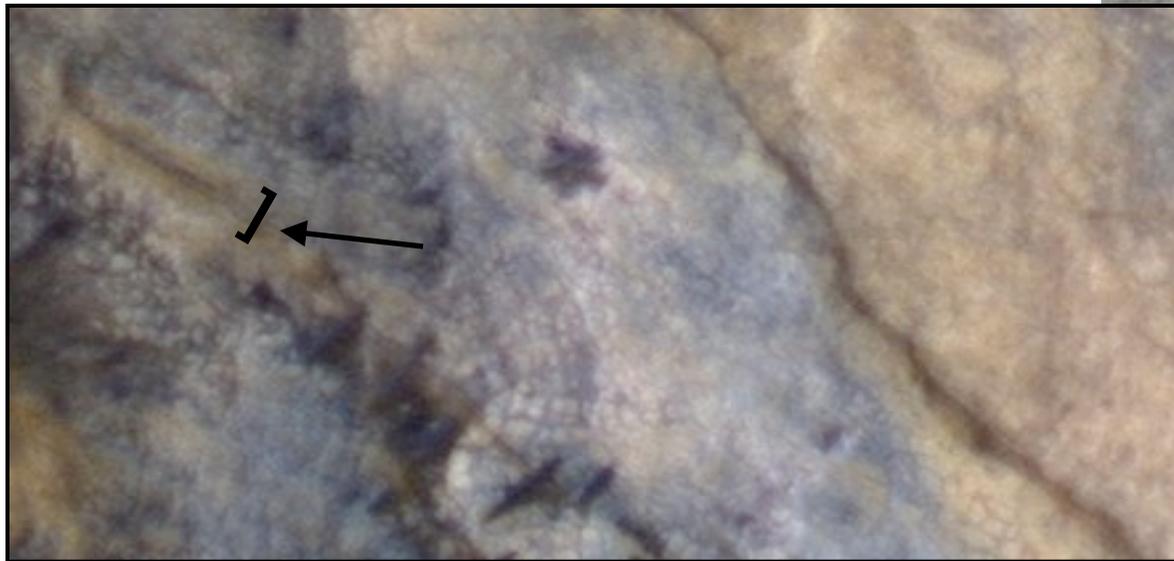
Okubo & McEwen (2007)

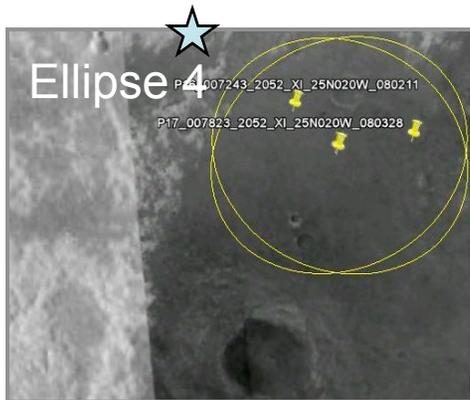
Candor Chasma, Mars



# Halo-bounded fractures

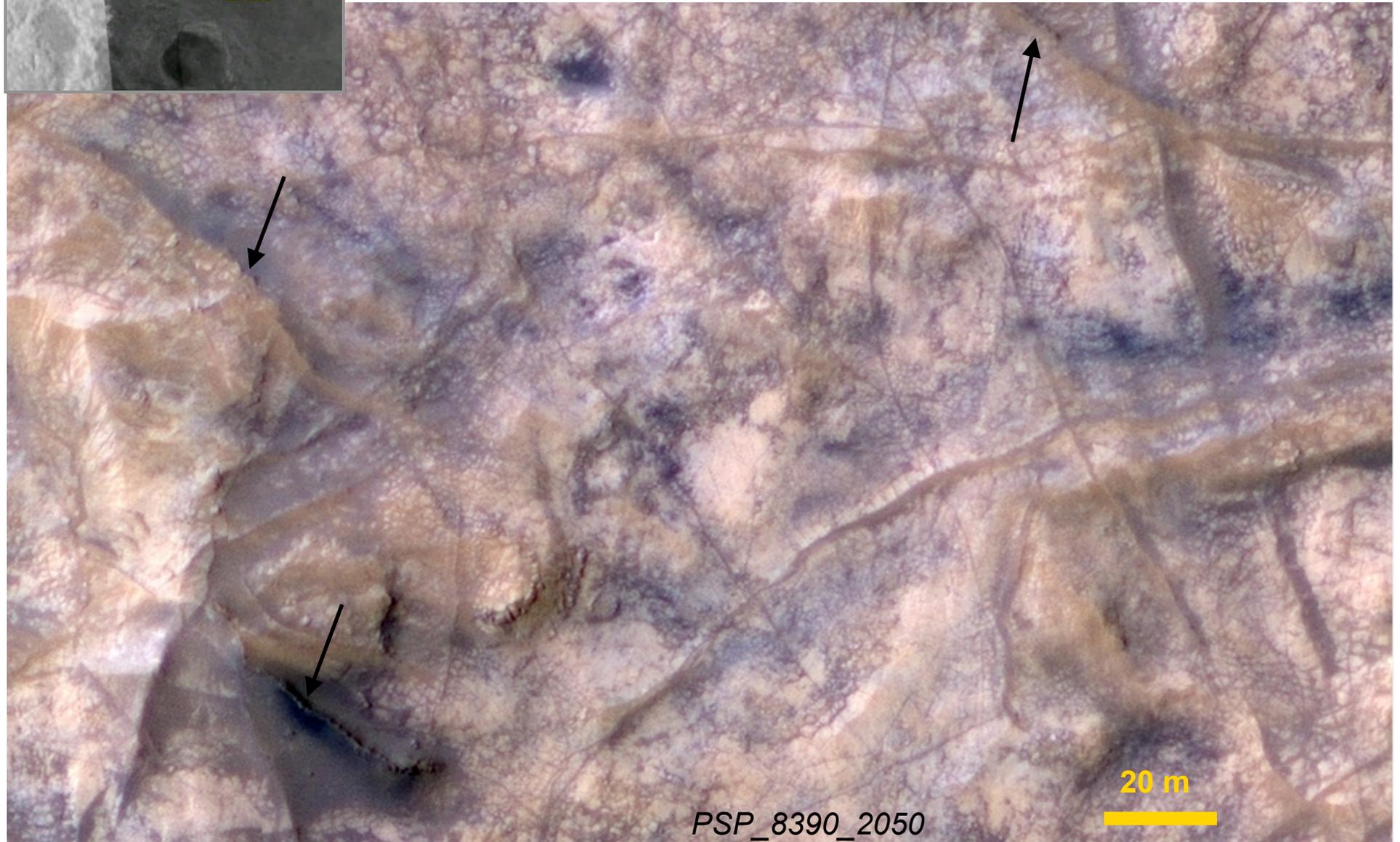
- Some fractures appear relatively high-standing—cemented?
- High/low albedo halos bounding fractures could be due to chemical and/or textural changes resulting from fluid flow





## “Inverted” fractures??

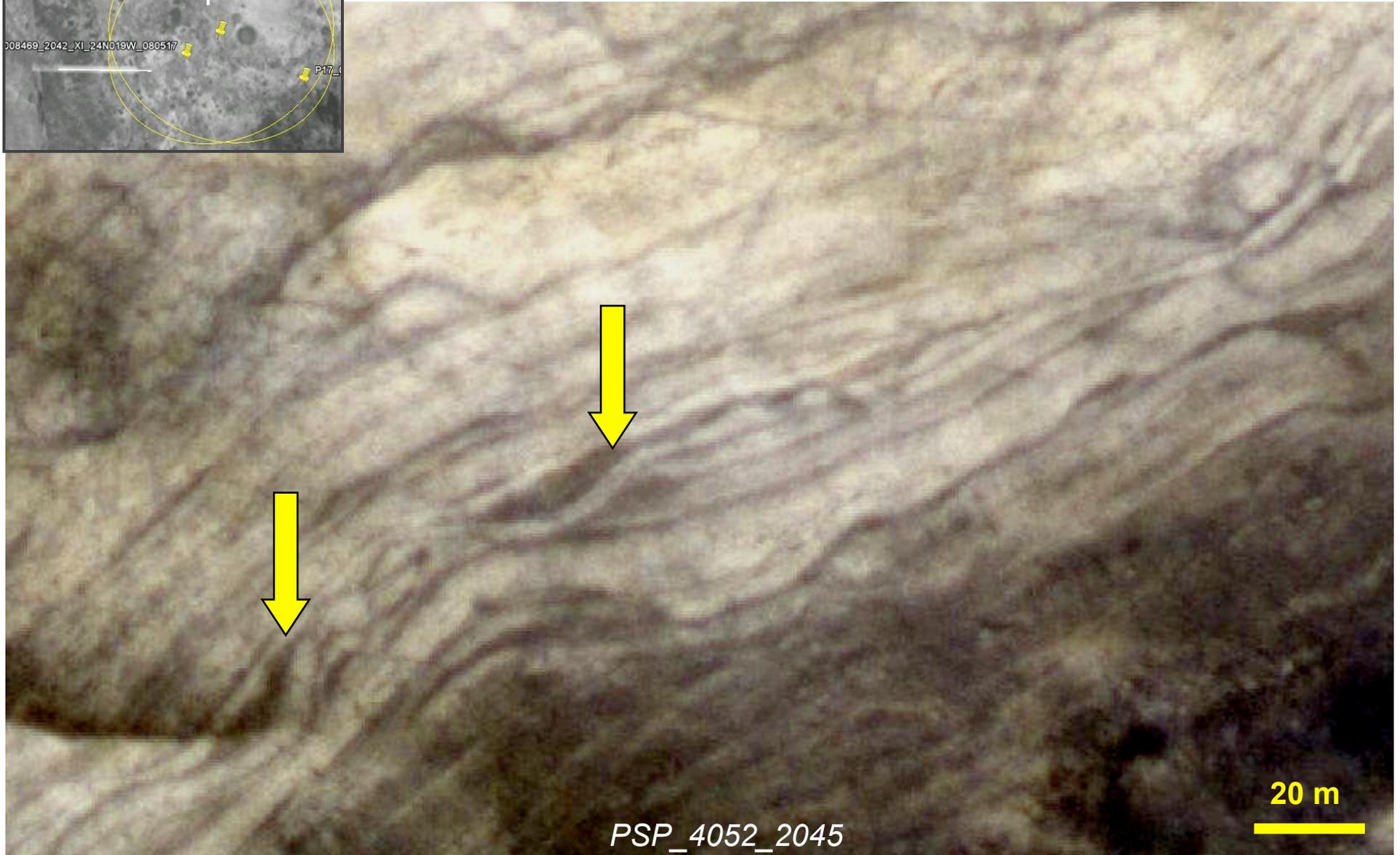
- Dikes? Resistant Fe-oxide fracture fill? (Some darkening could be sand, but note rocky appearance at arrows.)





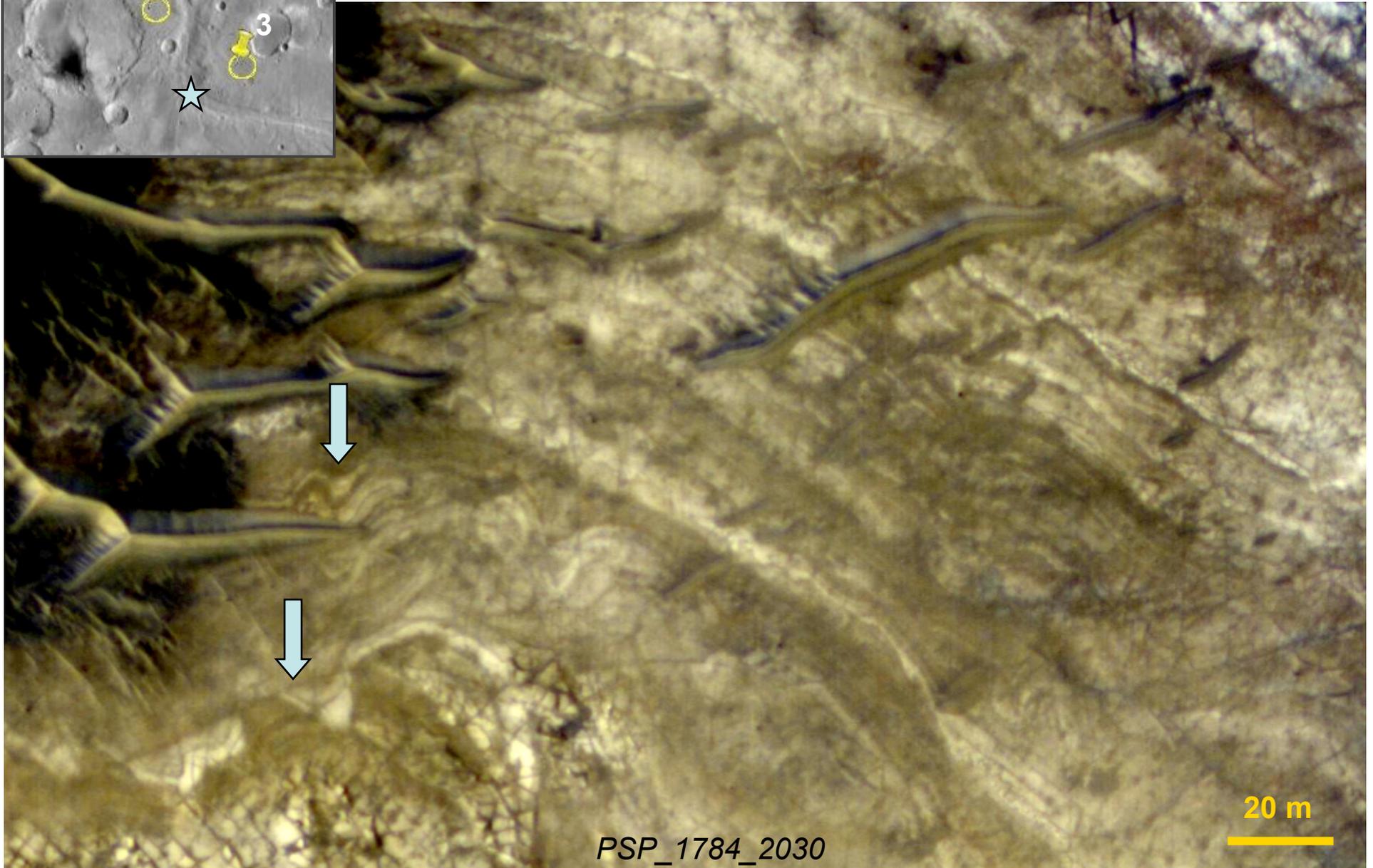
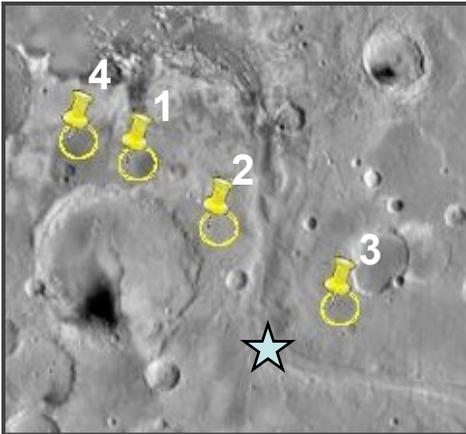
## Possible folds in nontronite-bearing layers

- Morphology consistent w/ (but not diagnostic of) soft (i.e. wet) sediment deformation

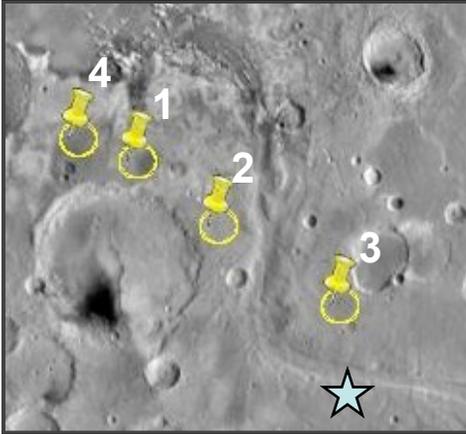


## Possible folds in nontronite-bearing layers

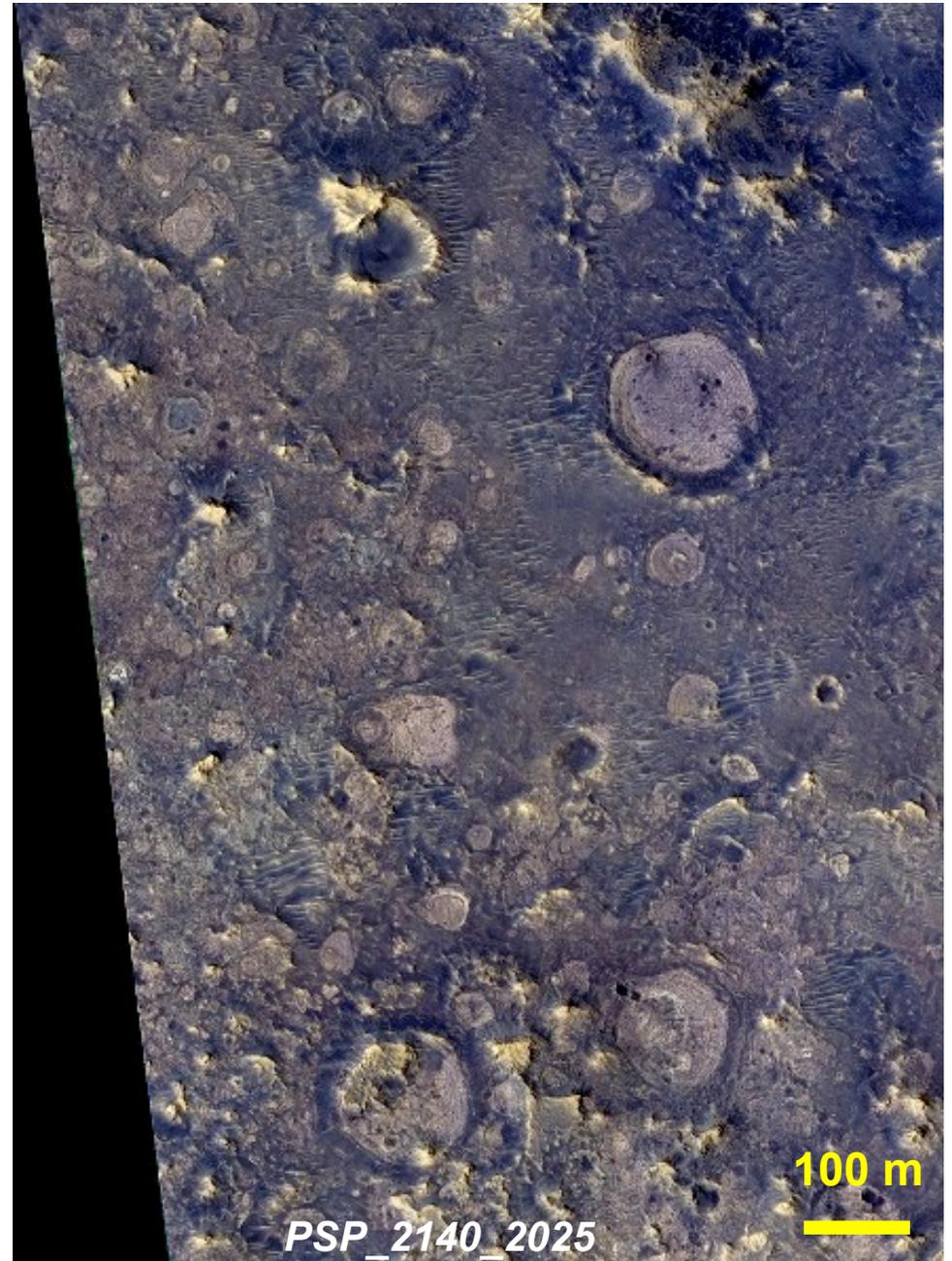
- Not yet seen in landing ellipses; resolution insufficient?



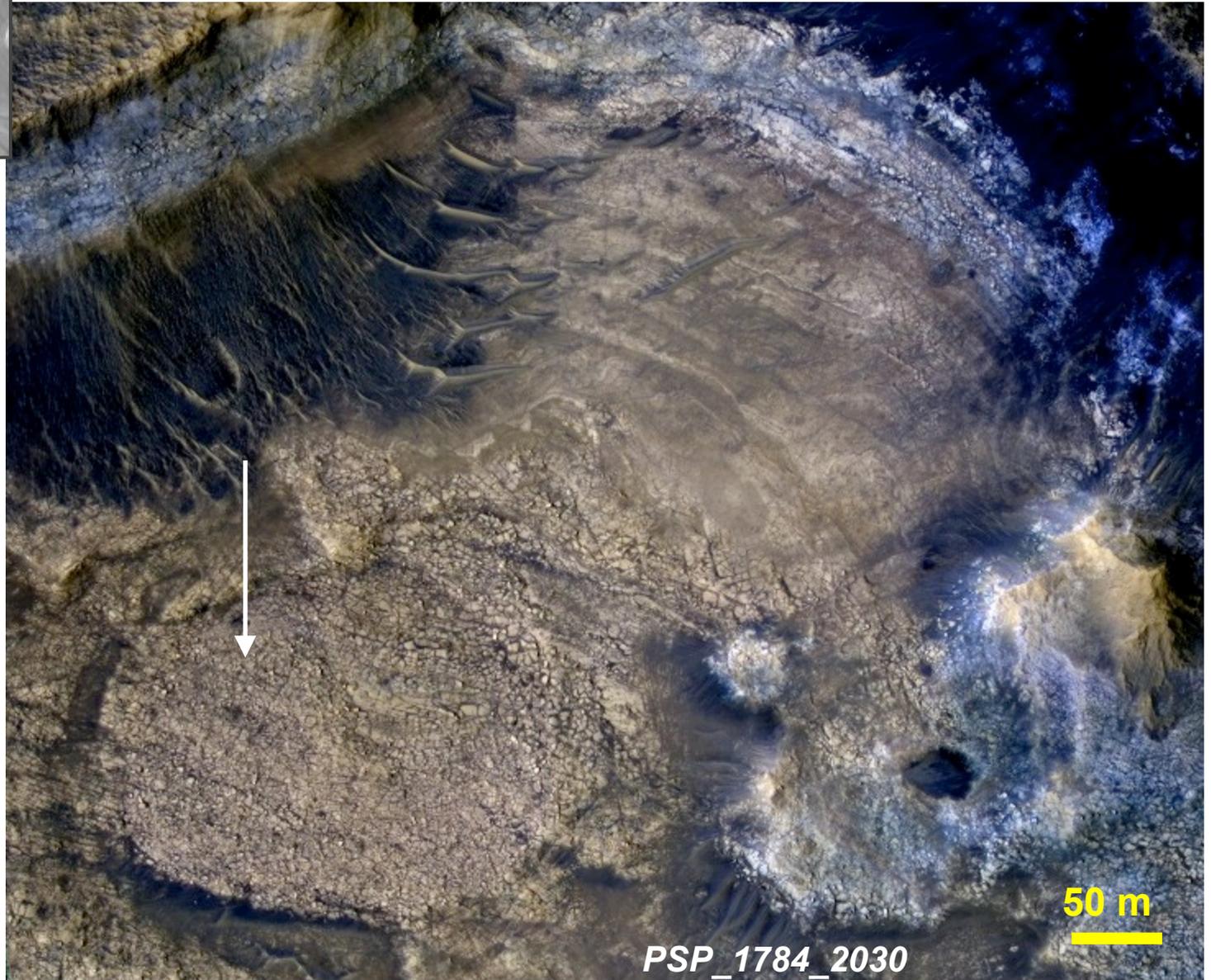
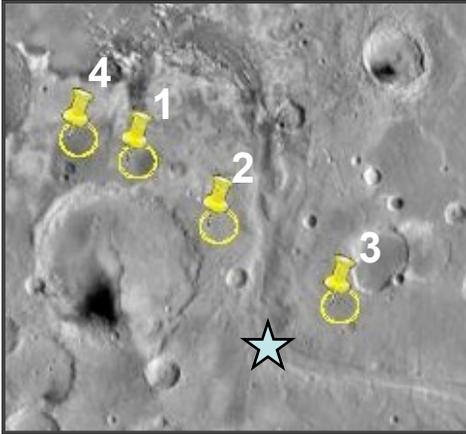
## Filled craters in nontronite-bearing unit

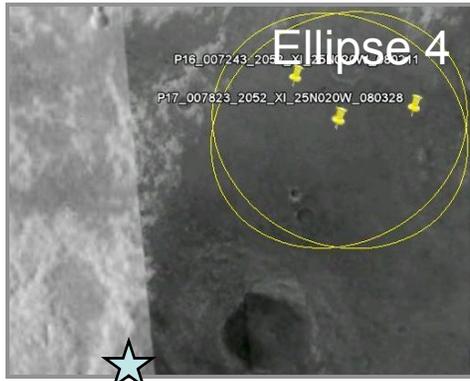


- Quasi-circular color/albedo features of varied size
- Unique to nontronite-bearing materials
- Colors match the layers (tan) that overlie this unit (brown)
- Suggest deposition of this unit over an extended period of time, and/or hiatus in deposition

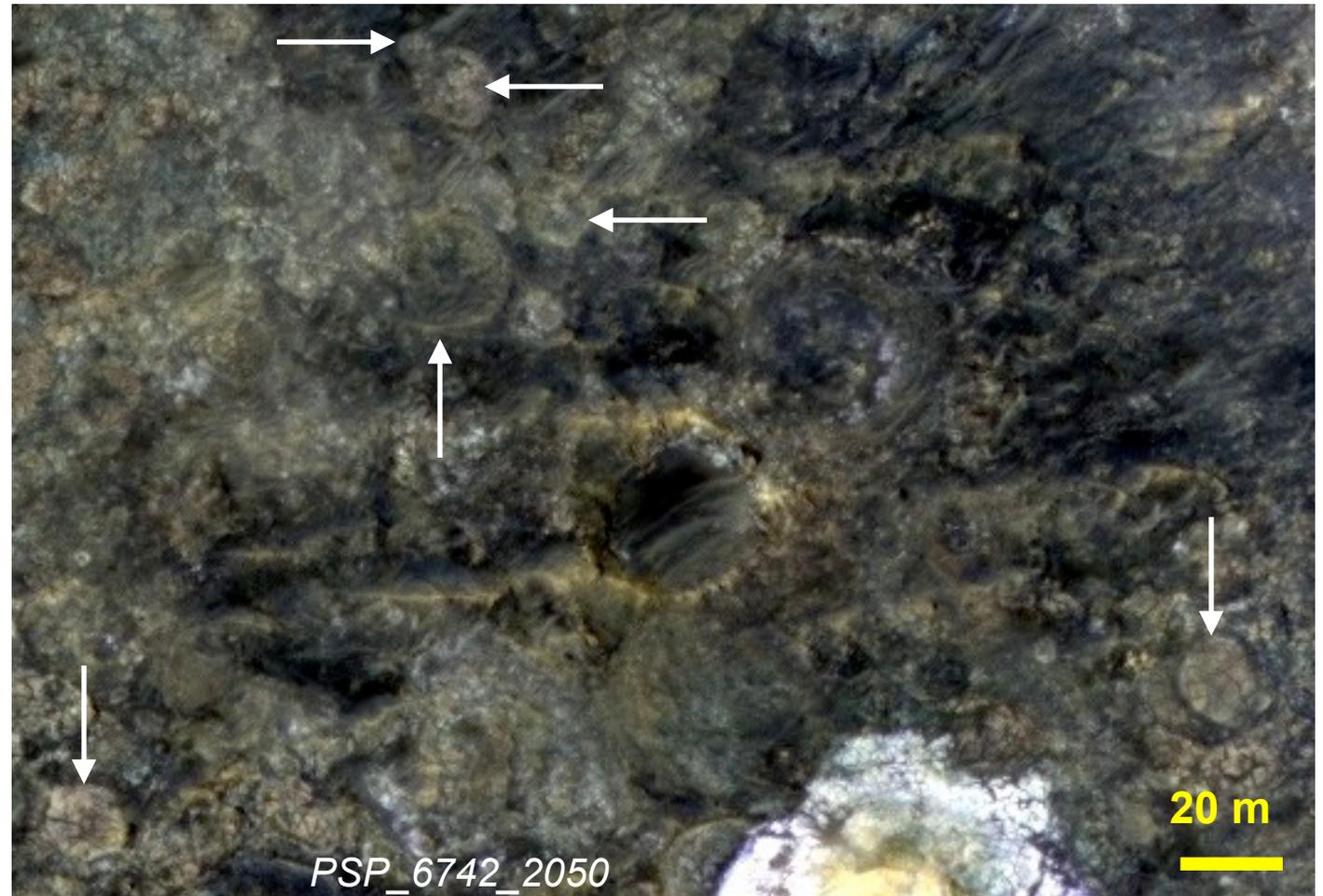


# Filled craters in *layered* nontronite-bearing unit

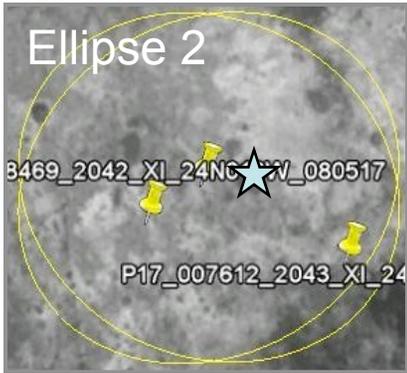




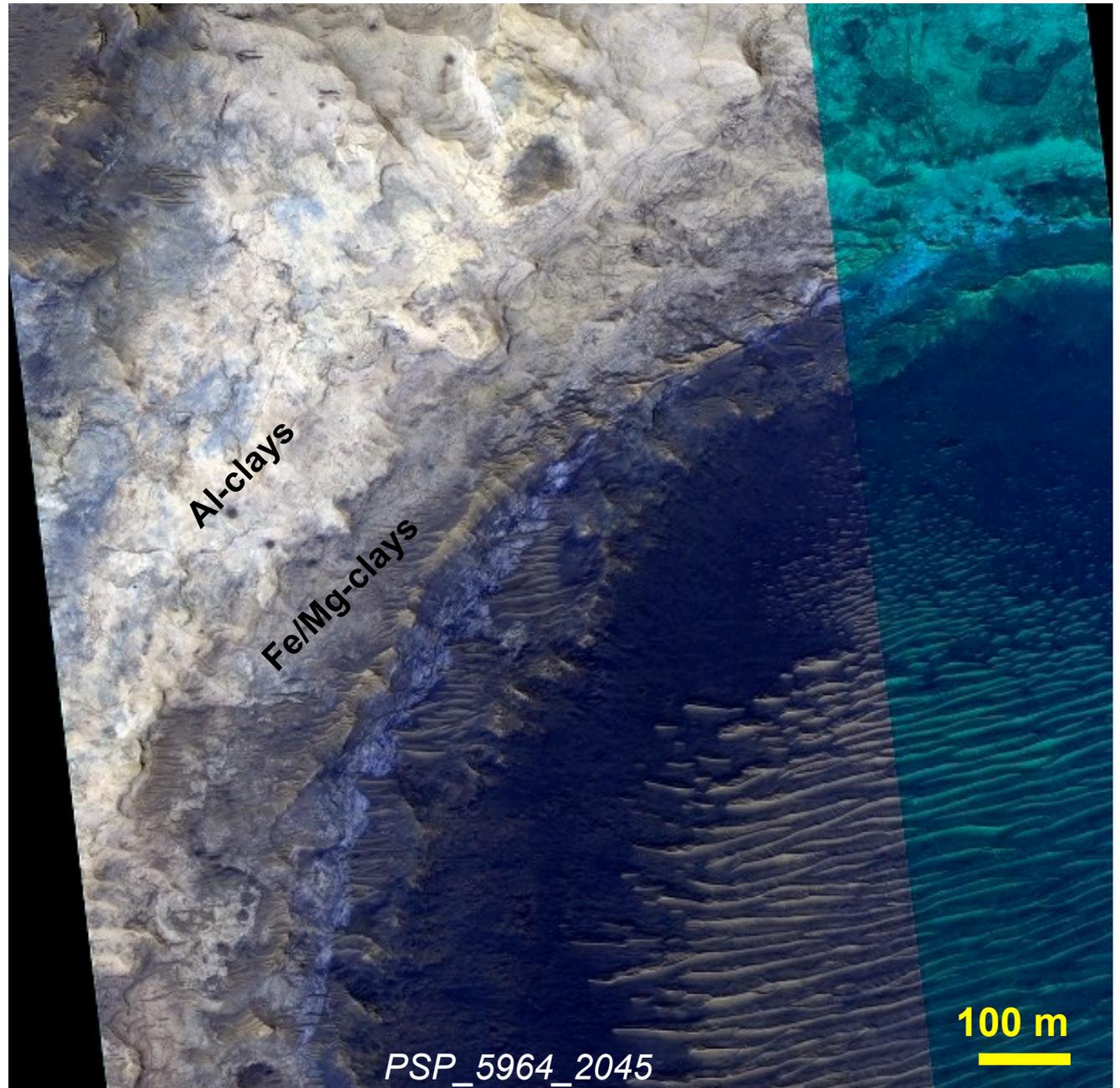
## Filled craters in nontronite-bearing unit – near landing ellipse



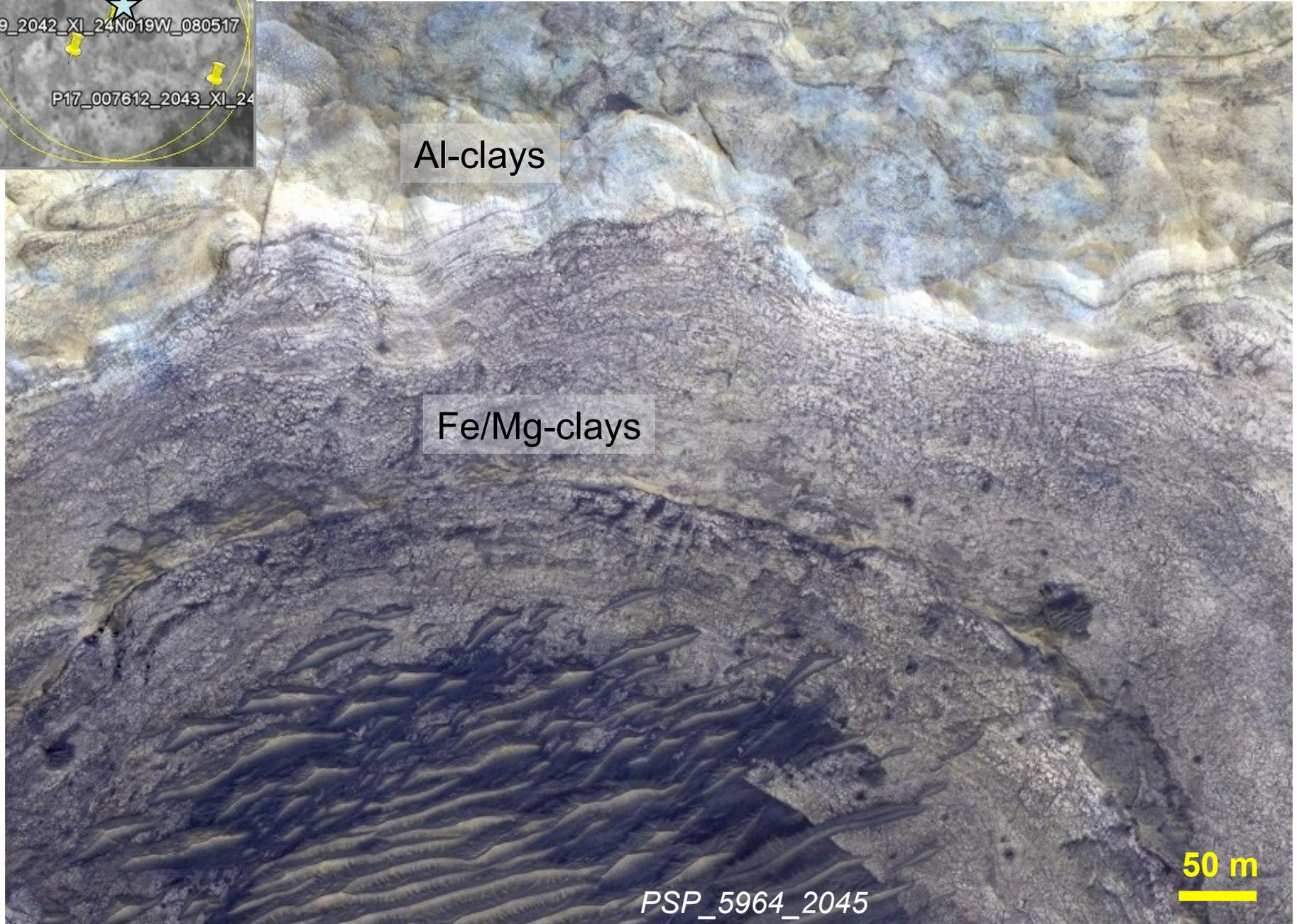
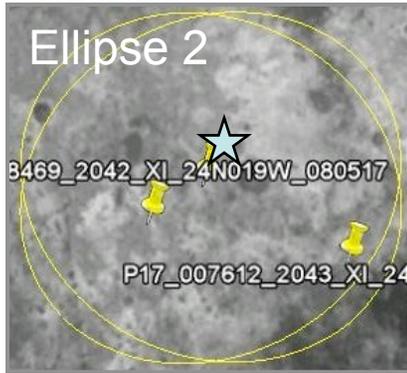
# Compositional layering

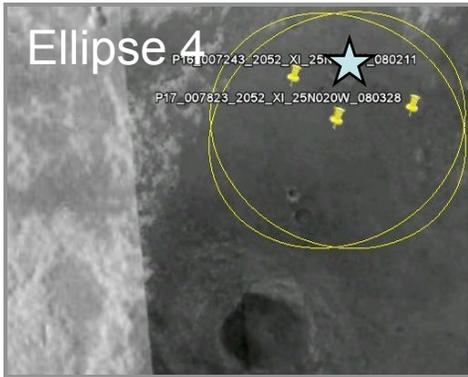


- Al-clay to Fe/Mg-clay transition (and more) exposed in wall of D~2 km crater *near center of ellipse!*
- Ellipse 3 has comparable exposures



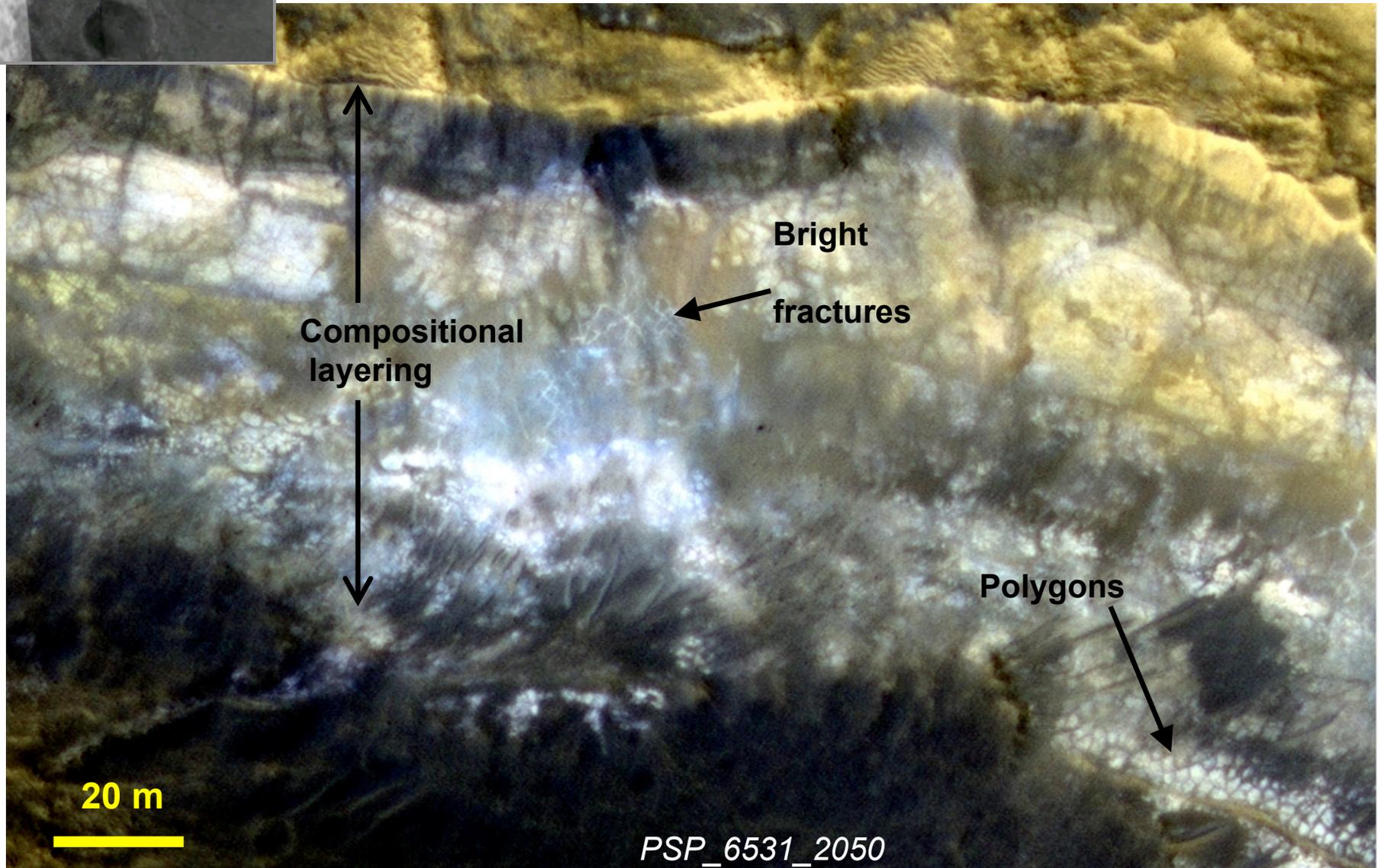
# Layering in another crater (D~1 km)

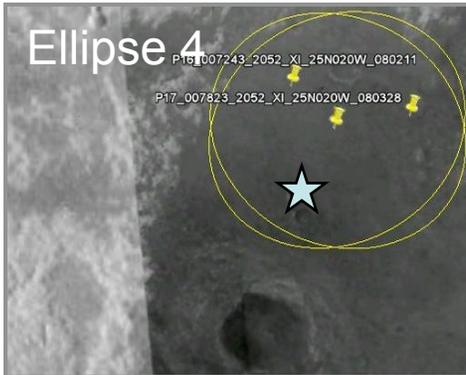




## Compositional layering *in* ellipse 4

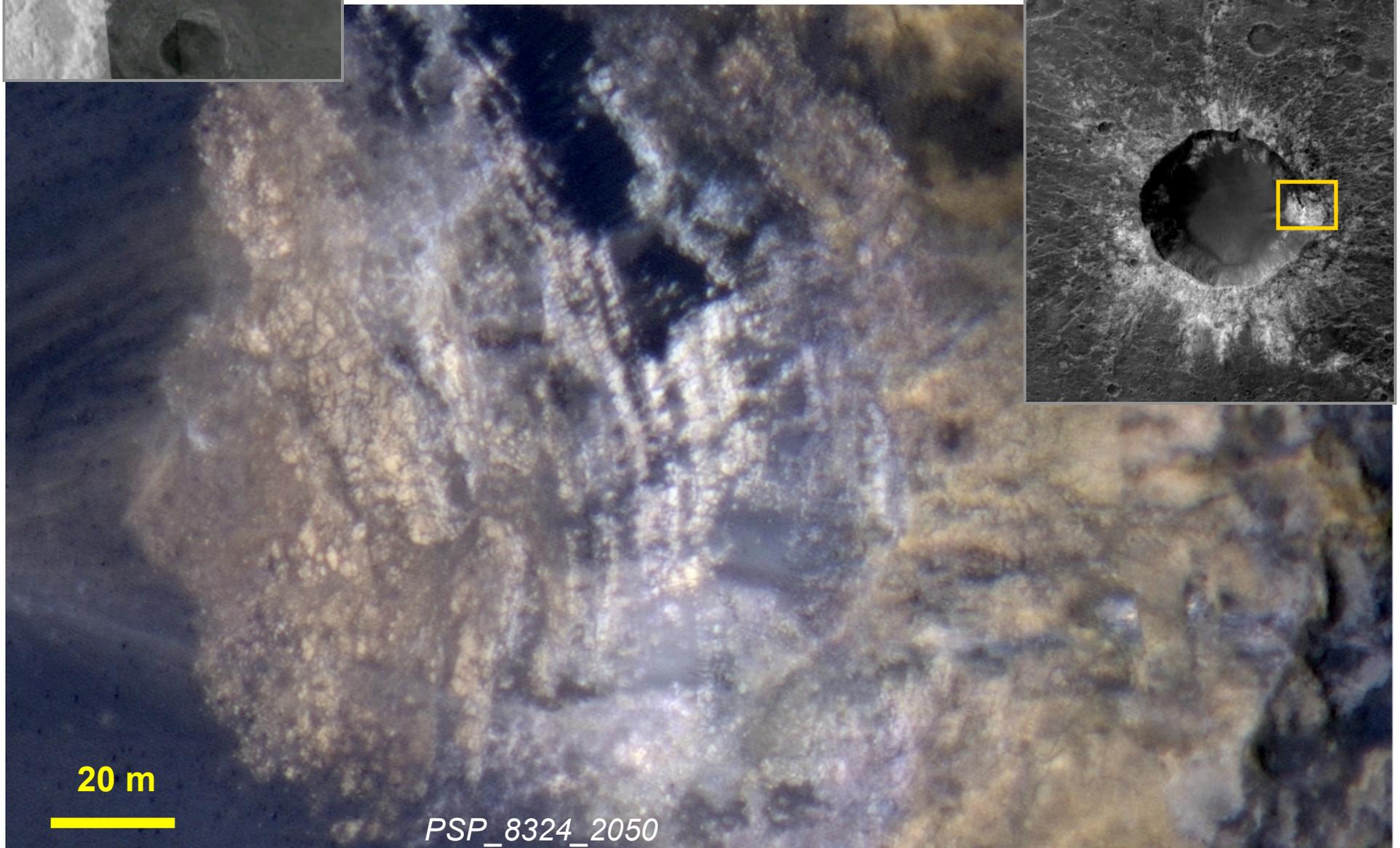
- Fe/Mg (image) and Al-clays exposed by D~2.5 km crater
- *Smaller* exposures of light-toned materials are numerous



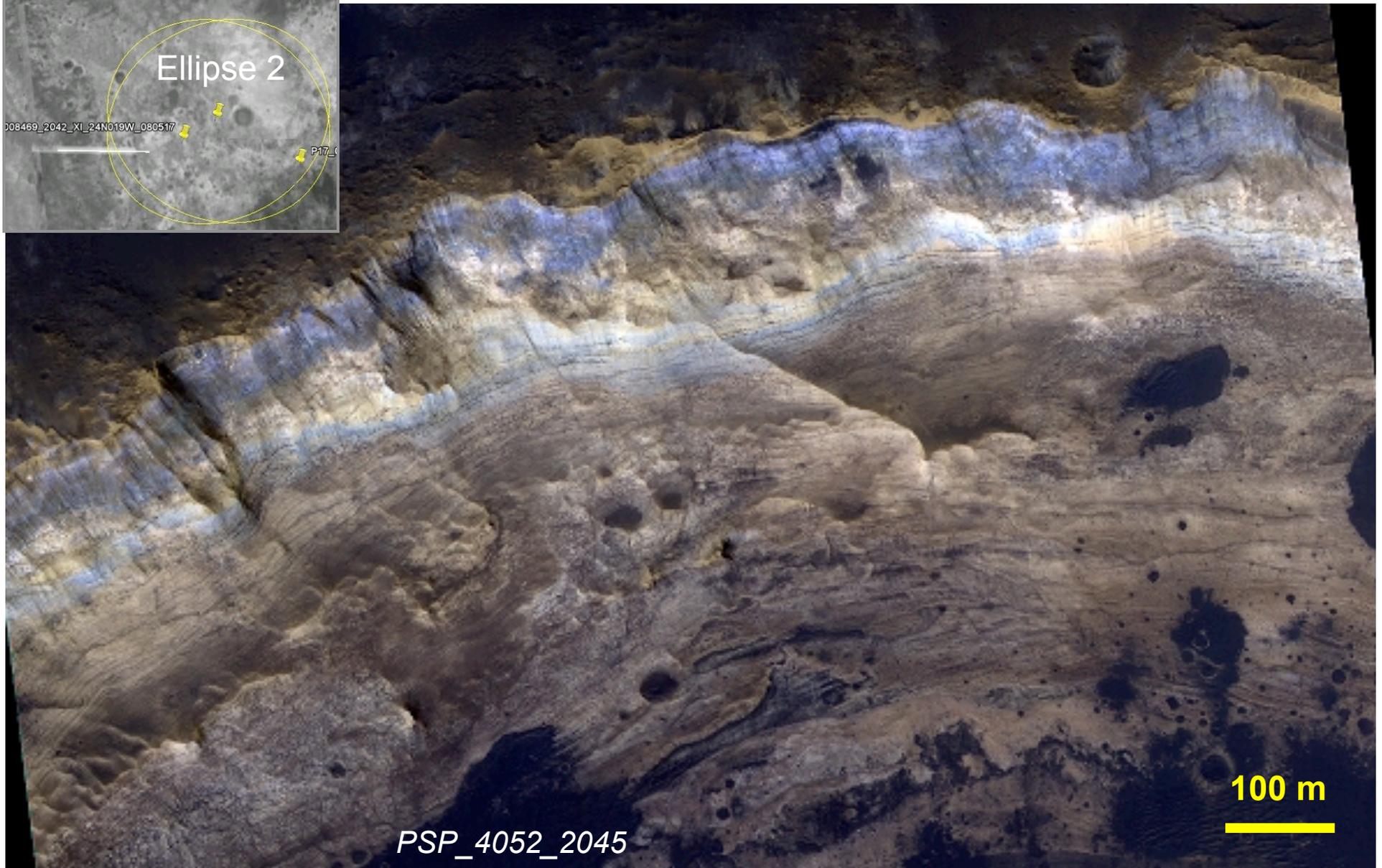


## Compositional layering *in* ellipse 4

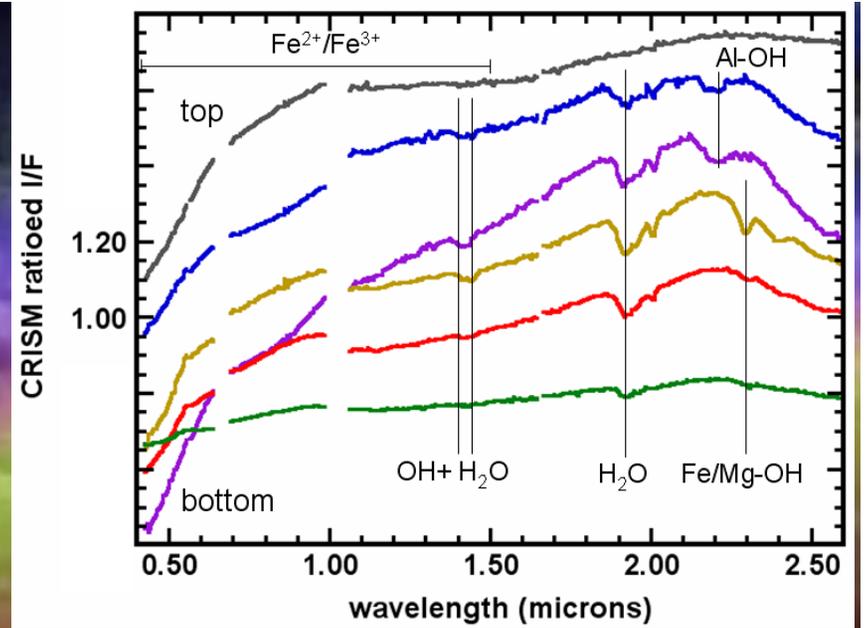
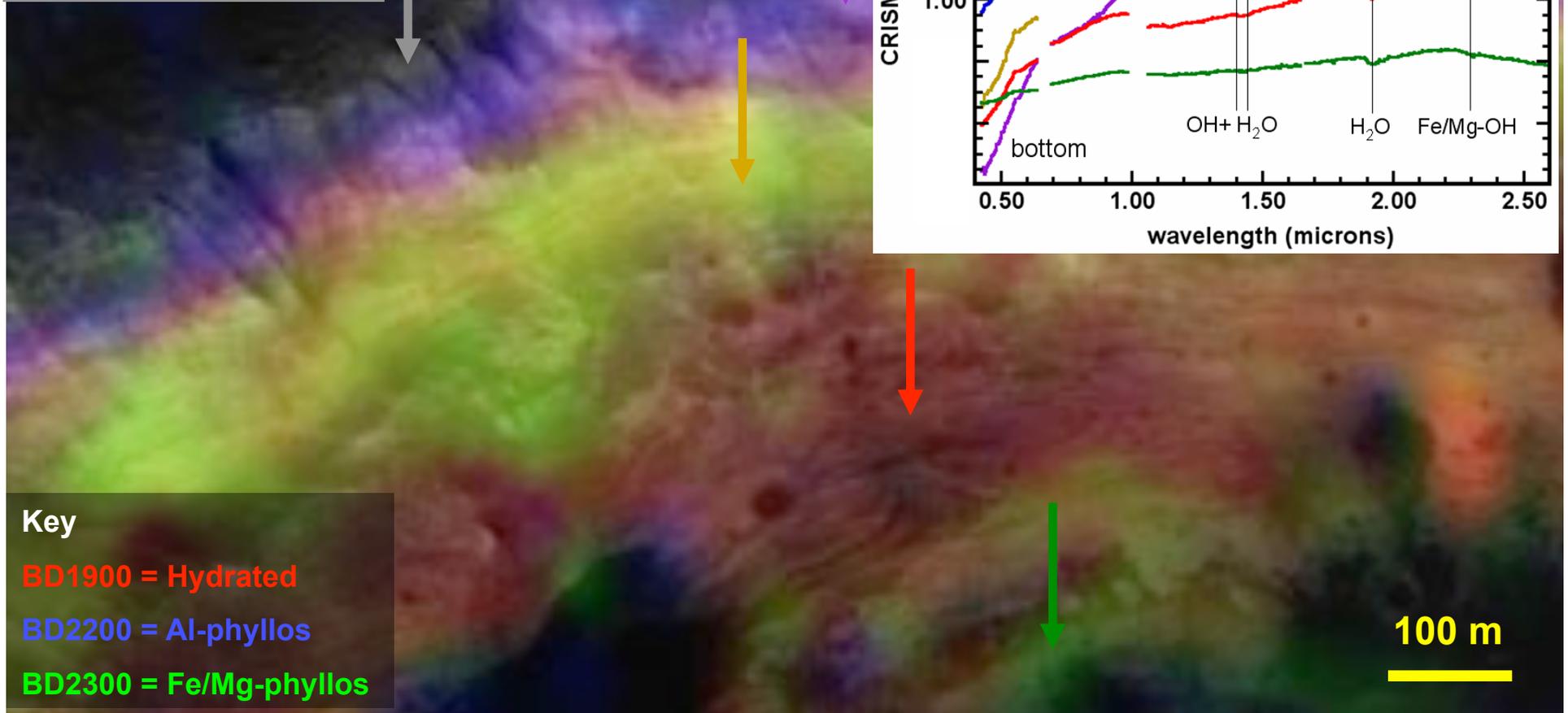
- Al (image) and Fe/Mg-clays exposed by D~800 m crater
- Could stop here on the way to targets SW of ellipse



# Color layering near ellipse 2...

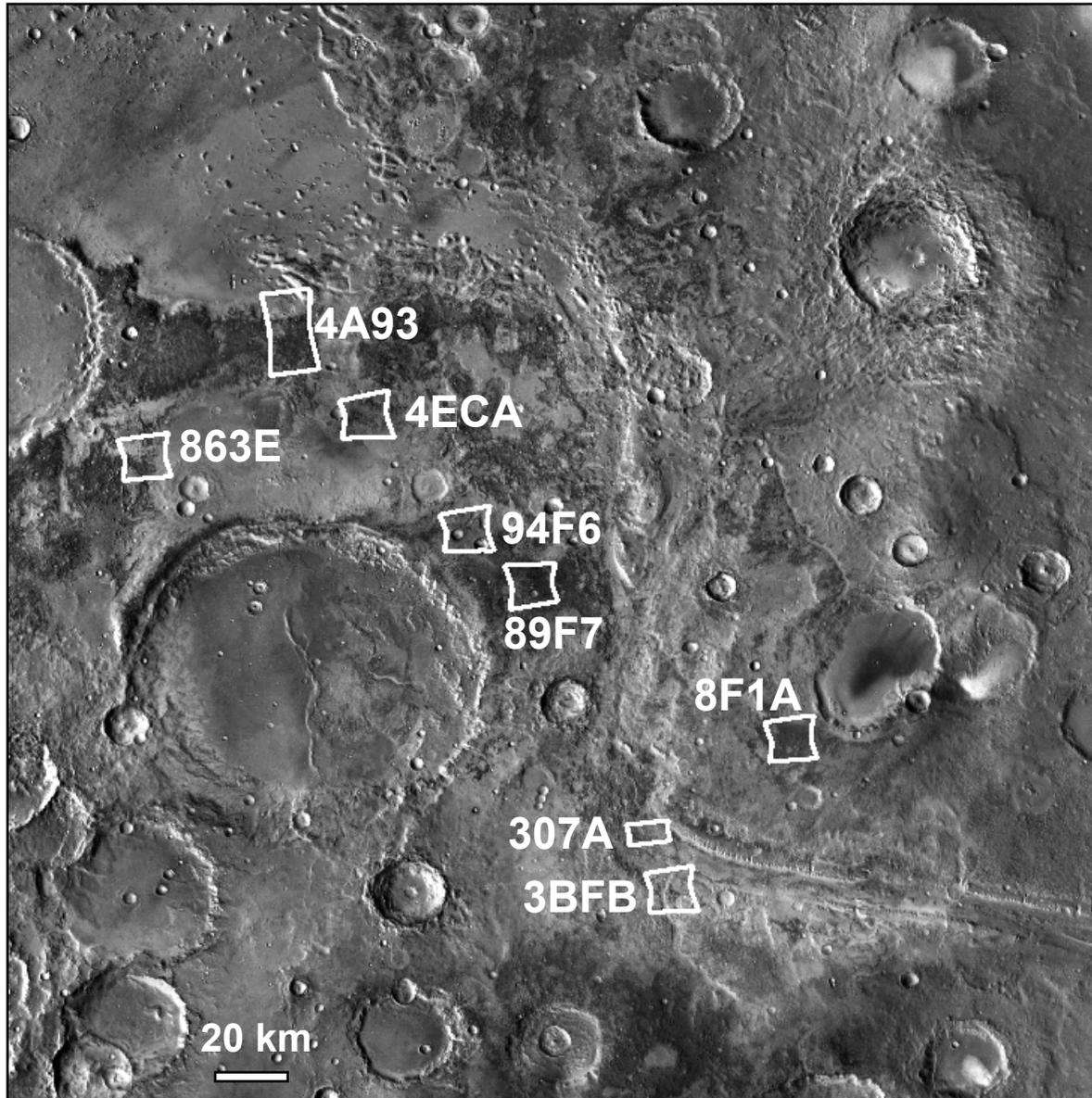


# = Compositional layering



CRISM data (FRT 94F6) from B. Ehlmann

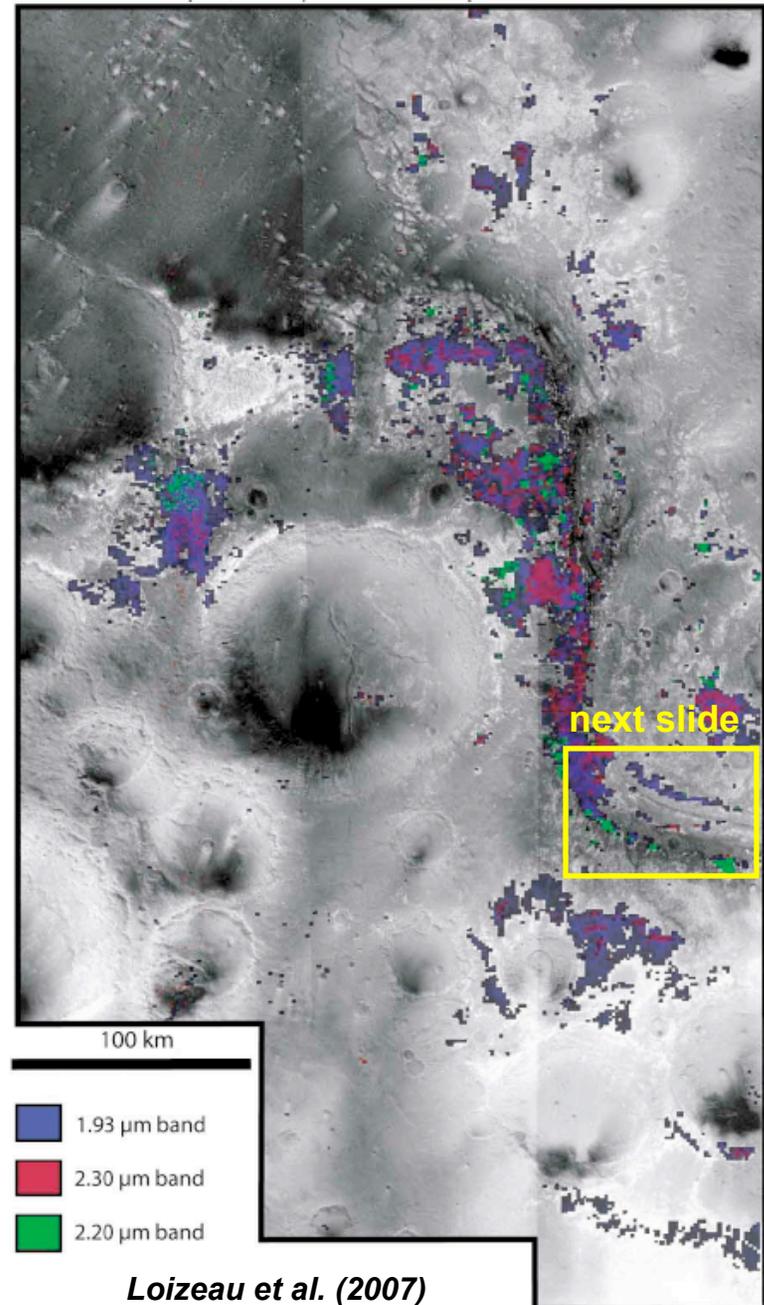
# Compositional stratigraphy: Insights into regional layer geometries

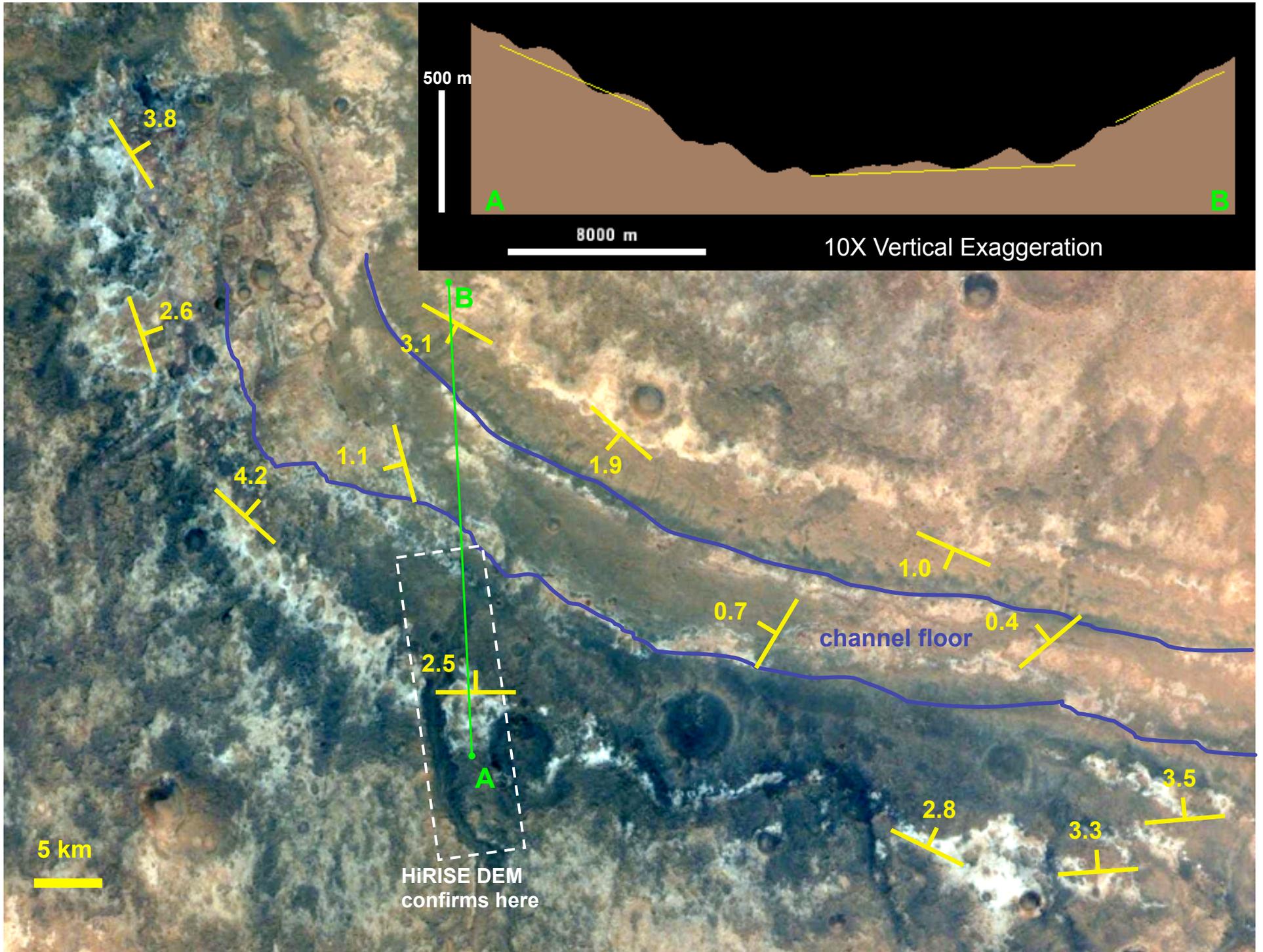


- Used CRISM to define compositional units, HiRISE to determine stratigraphic relations at 8 different sites
- Always the SAME result:
  - Dark, bland cap unit
  - Al-clay-bearing layers
  - Fe/Mg-clay-bearing layers (lowest)
- Stratigraphy same on both sides of outflow channel, *and* on channel floor
- *Are all Al-clay-bearing layers part of single unit (~40 m) that drapes the channel?*

# Testing with HRSC

- HRSC color used to trace contact b/w Al-clays (blue/white) and Fe/Mg-clays (tan/red)
- Strike and dip measured along contact in HRSC DTM (50-m post spacing)





# Al-clays: Interpretation of regional geometry

- **Observations:**

1. Al-clays overlie Fe/Mg-clays in every observation surveyed, on both sides of the channel and on its floor. No interbedding is observed in CRISM data. Also true beyond Mawrth region (Eldar's talk).
2. The contact b/w compositional units traces the regional topography, including across the channel.

- **Possible Interpretations:**

1. The Al-clay-bearing unit is a pyroclastic/sedimentary deposit draped over Mawrth Vallis (~Late Noachian) that was subsequently altered in place.
2. The Al-clay-bearing unit is a sedimentary deposit of pre-existing clays draped over MV; alteration occurred elsewhere.

*These rule out deposition into a closed basin, or that the unit is Chryse impact ejecta (since Chryse predates MV).*

3. All **layers** here predate MV, but alteration occurred much later via a top-down process (e.g., pedogenesis) with stronger leaching of near-surface horizons.

# Al-clays: Interpretation of regional geometry

- **Observations:**

1. Al-clays overlie Fe/Mg-clays in every observation surveyed, on both sides of the channel and on its floor. No interbedding is observed in CRISM data. Also true beyond Mawrth region (Eldar's talk).
2. The contact b/w compositional units traces the regional topography, including across the channel.

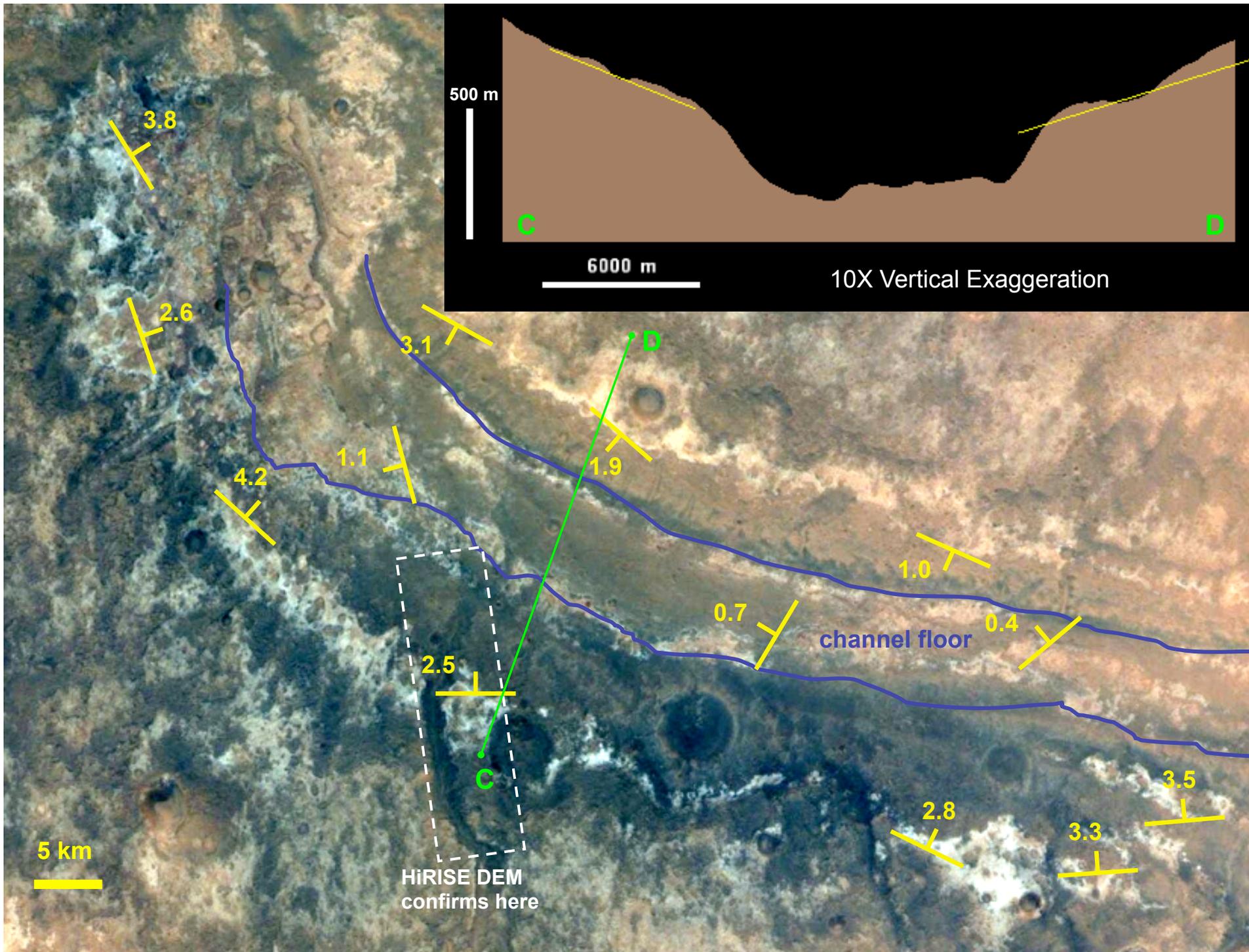
- **Alternative Interpretations:**

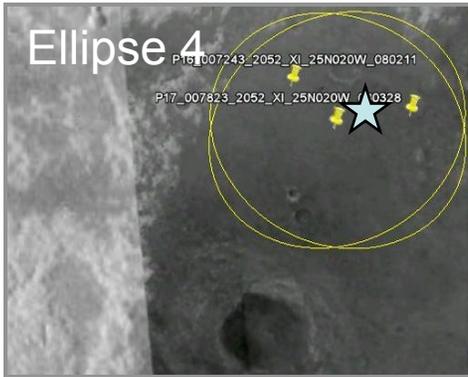
4. The Al-clay-bearing unit drapes a paleovalley at the location of MV, but the main MV flow(s) happened later and eroded the clay-bearing layers.
5. All clay-bearing layers were deposited as (sub-)horizontal beds, but regional tectonics produced a broad shallow syncline that was subsequently exploited by the MV outflow(s), eroding the clay-bearing layers in the process.

*In either case, the Al-clays on the channel floor would have been eroded from the valley walls and redeposited by the outflow(s).*

Fe/Mg clays cannot be similarly constrained, and may have a different story.

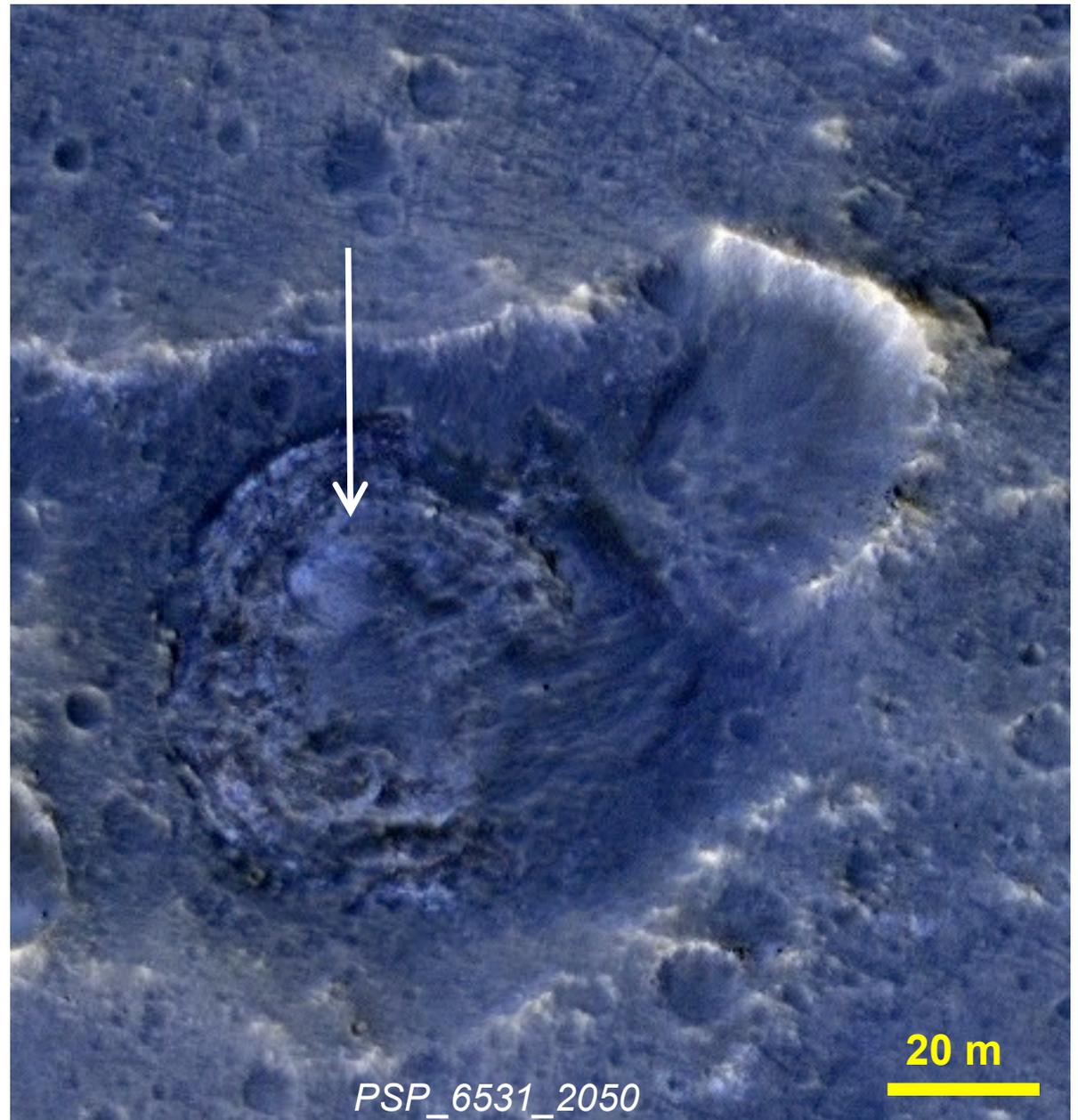
Extras





## Small exposures *in* ellipse 4

- Light-toned materials exposed in **many** small craters throughout the landing ellipse



# Fe/Mg-clays

- These show greater morphologic diversity, and we can't see anything lower (so we can't constrain the overall geometry of this unit)
- ➔ *Older, diverse sedimentary and altered igneous rocks? Analogous to Nili basement??*



Near Ellipse 2

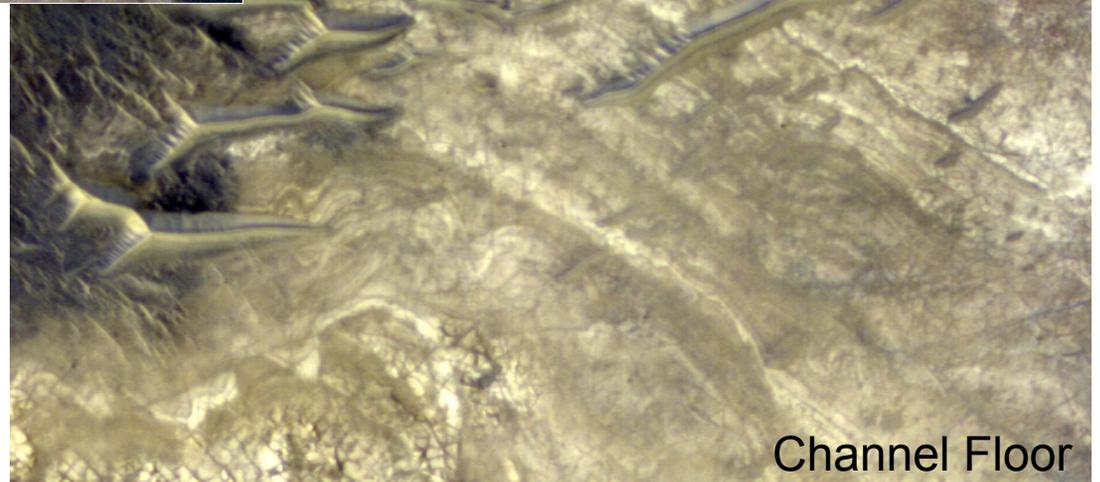


S. Valley Wall

50 m



Ellipse 2



Channel Floor