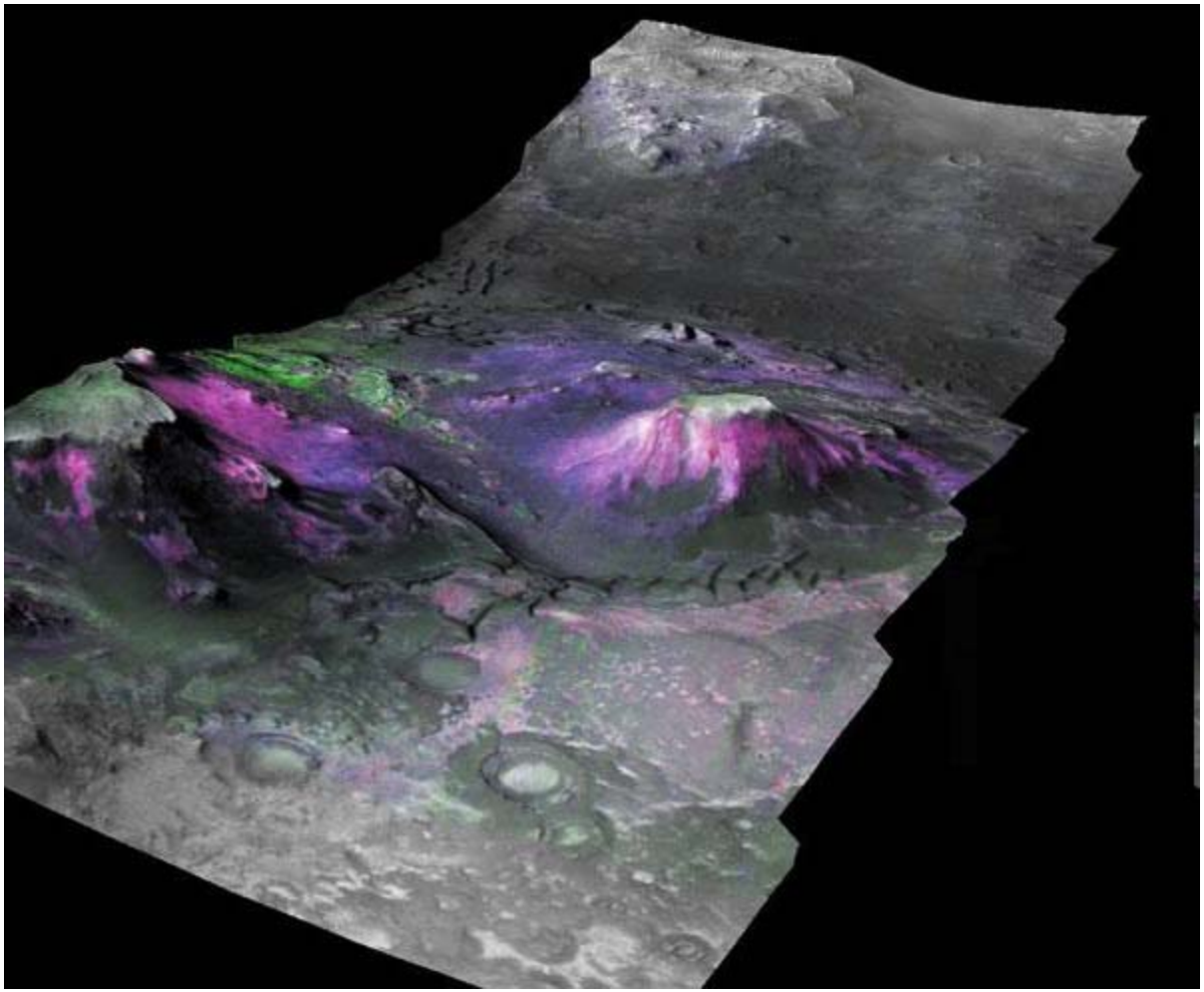
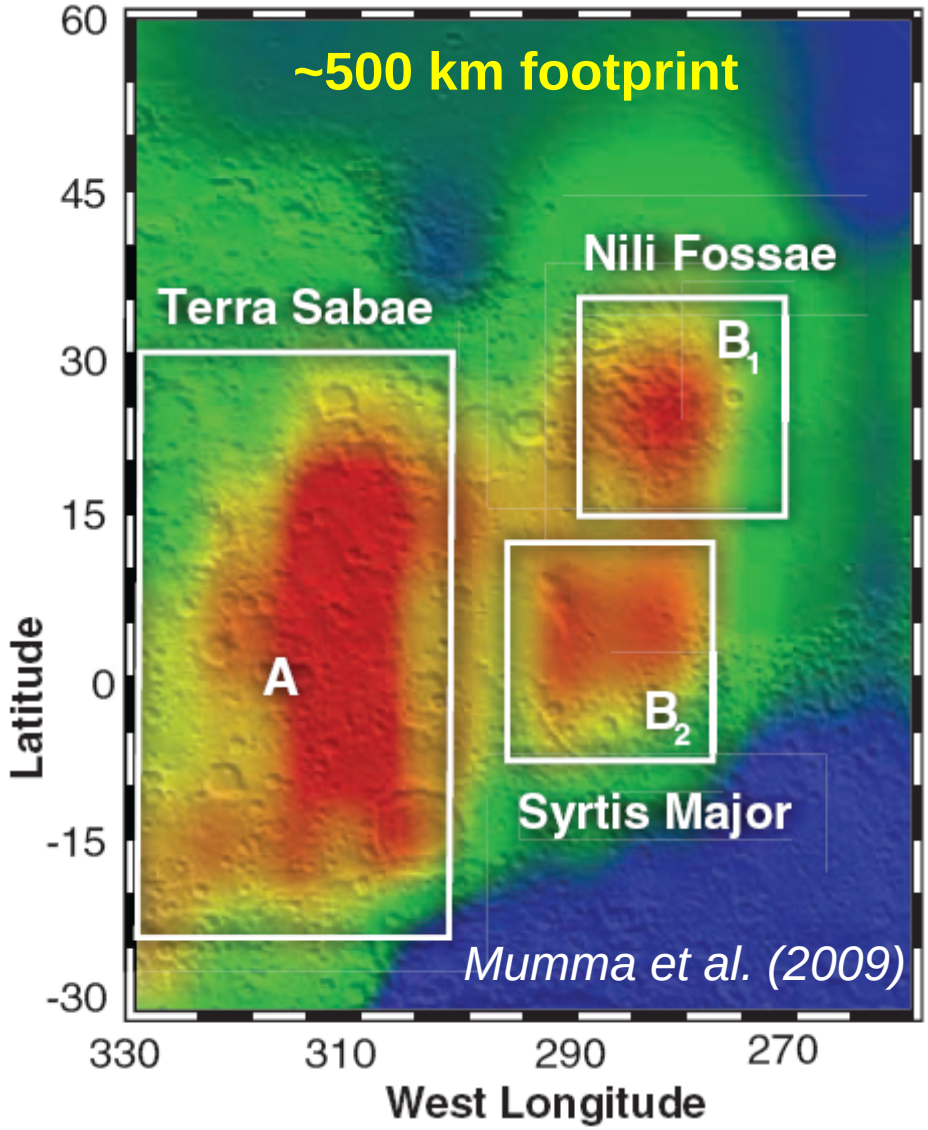
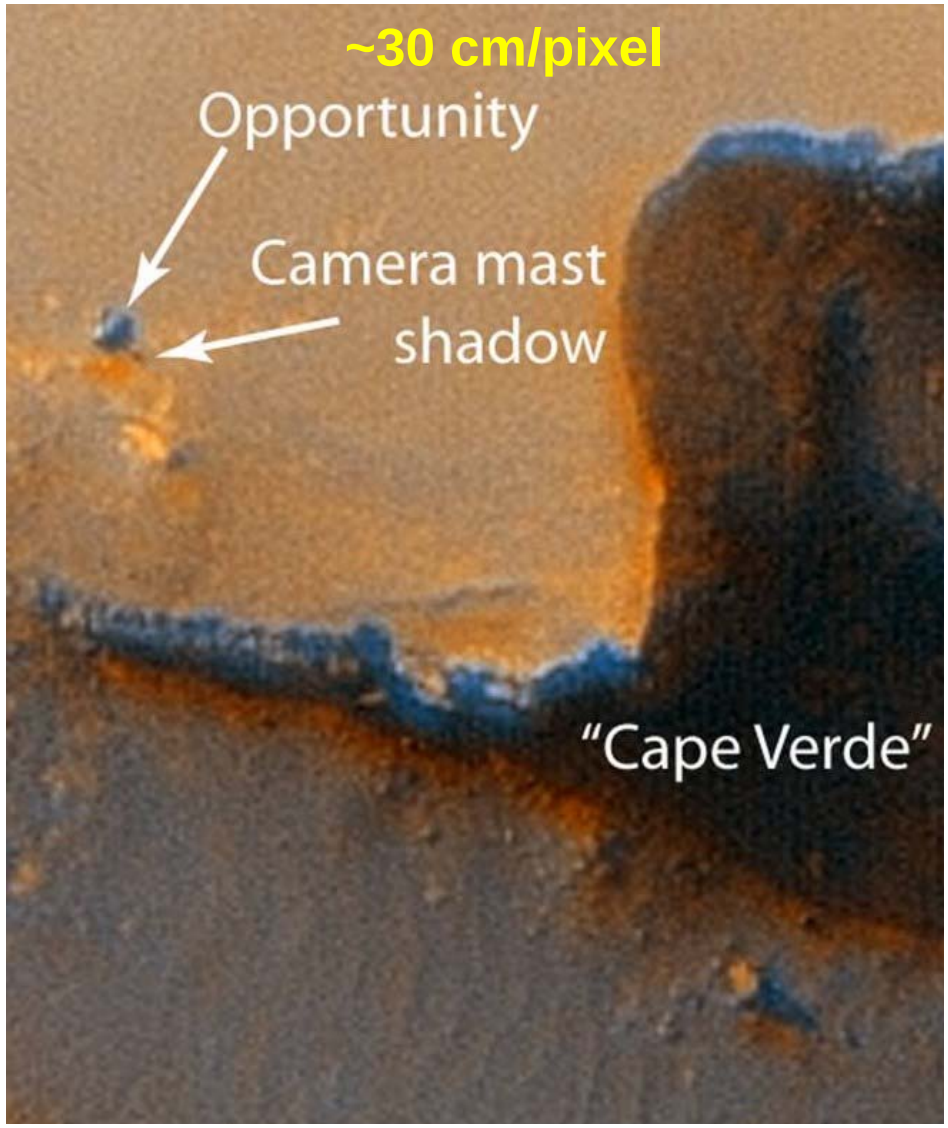
Morphology and mineralogy of methane source regions



James Wray (Cornell University)
and
Bethany Ehlmann (Brown University)

Apples to oranges?

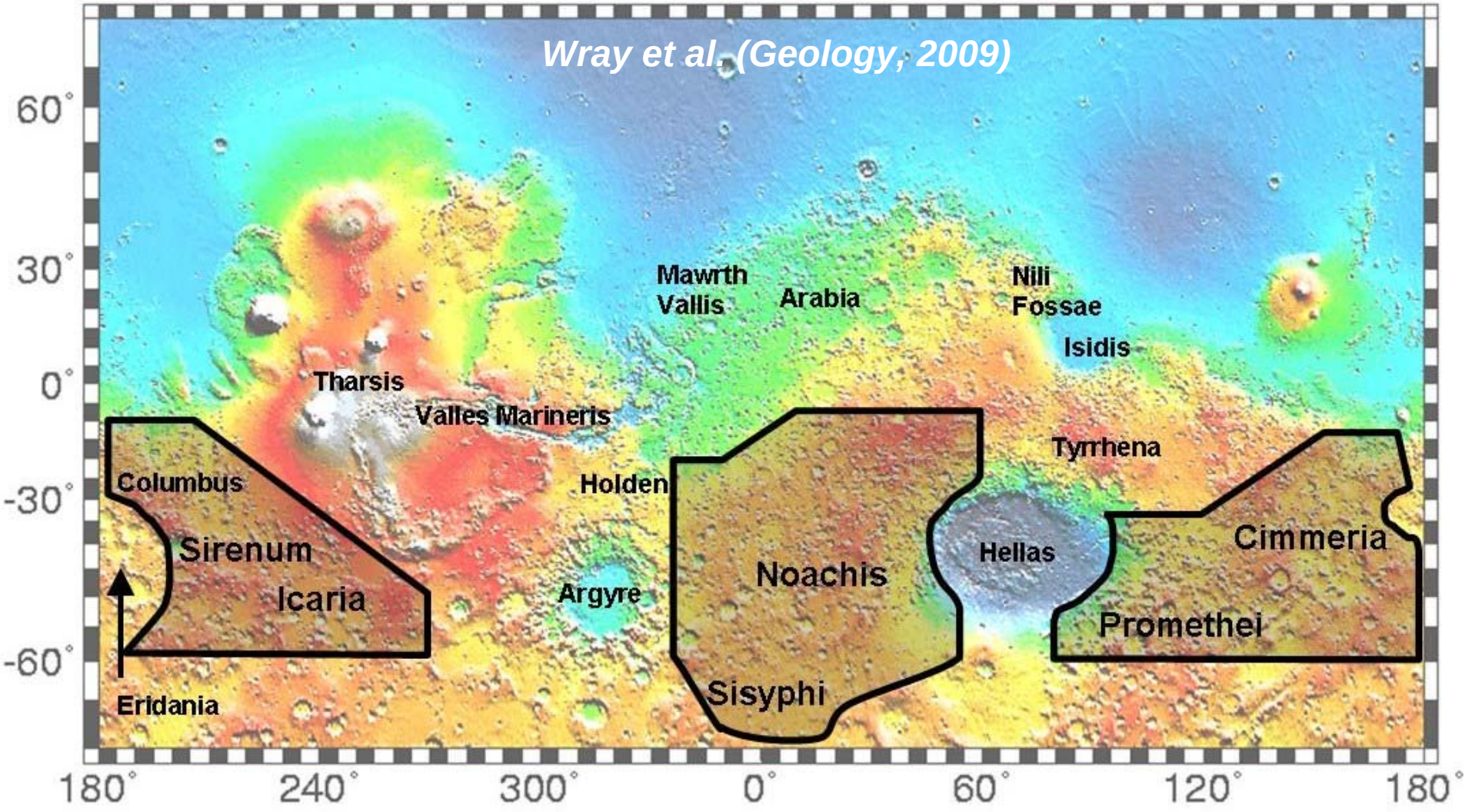




• Nevertheless, localized methane sources imply connection between methane production/release mechanism(s) and regional geology

Focus areas: Nili Fossae and Terra Sirenum

- Nili region may be among the best exposures of Noachian crust (*Mustard et al., JGR, in press*)
- Sirenum (SW of Tharsis) is the portion of southern highlands observed to date

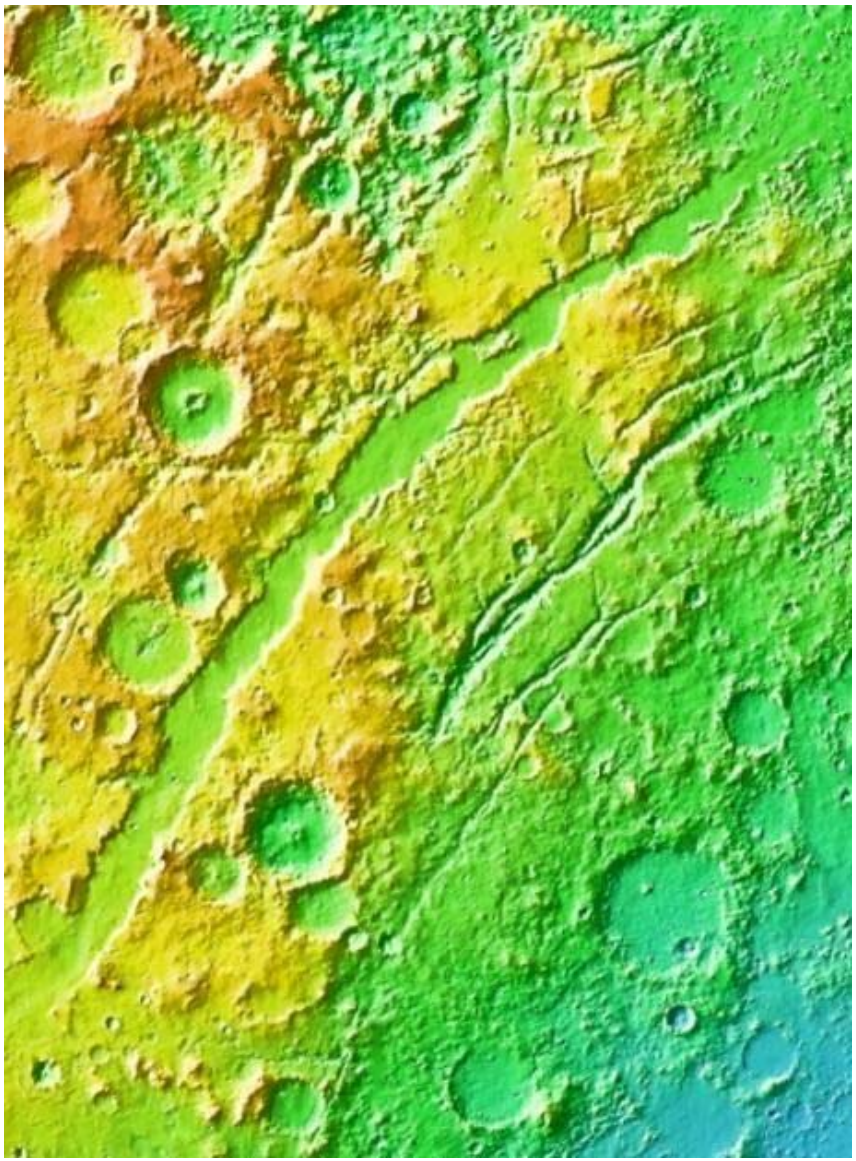


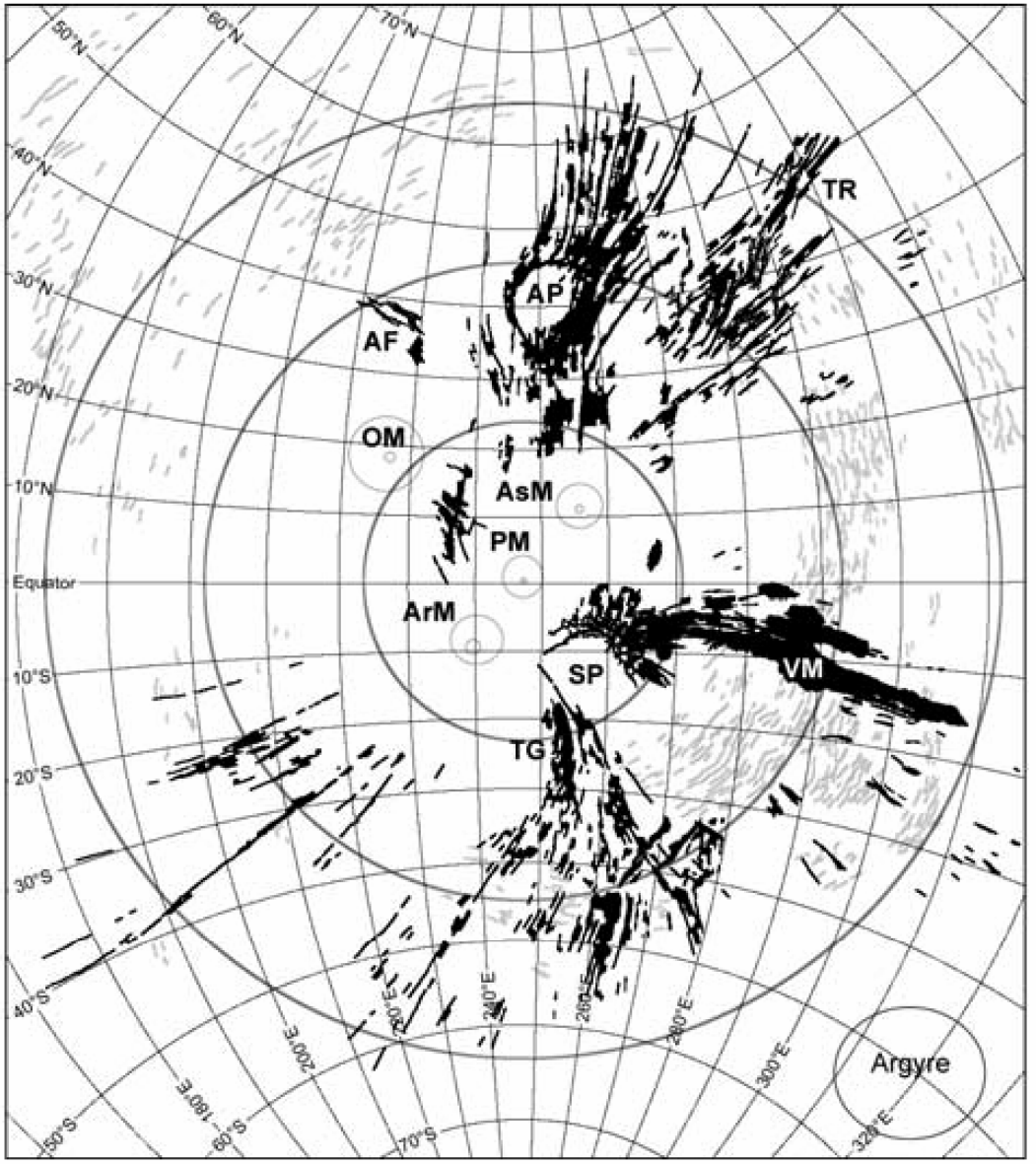
Some characteristics of Nili Fossae and Terra Sirenum

1. Fissures
2. Megabreccia
3. Serpentine, other hydrated minerals
4. Evidence for groundwater

Even if none of these actually has anything to do with methane, they exemplify the types of features one can look for.

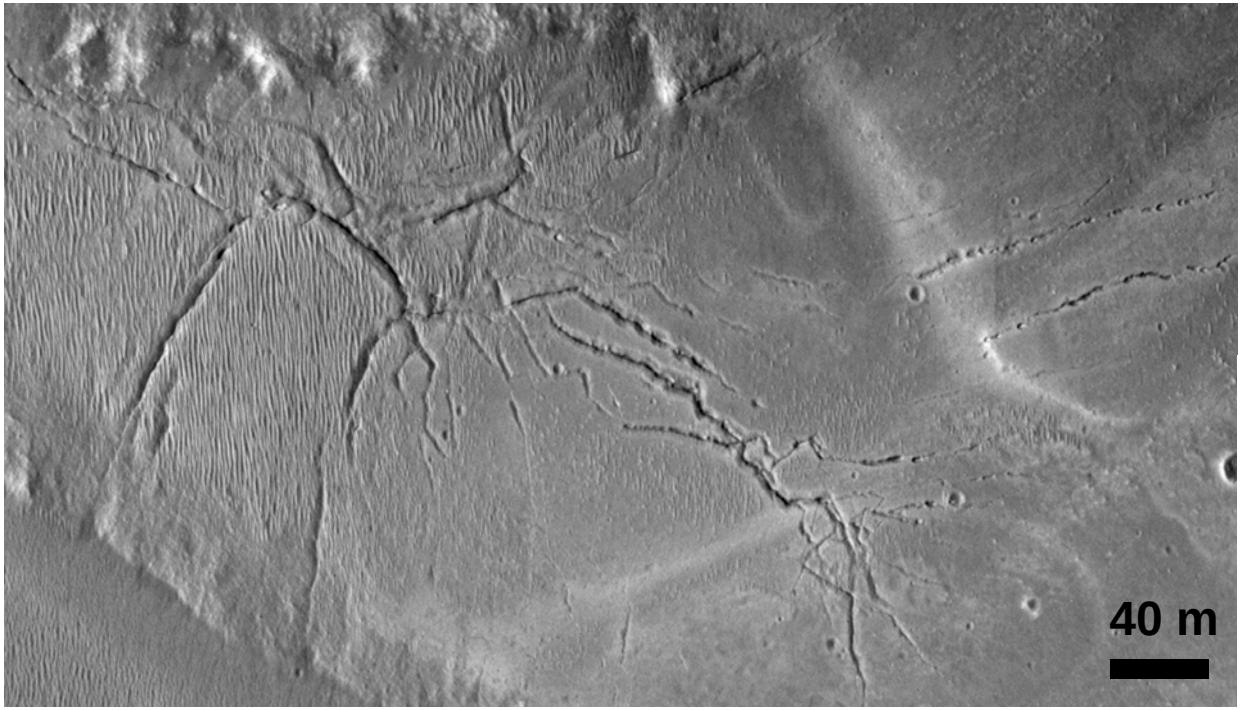
Large fissures in Nili Fossae and Terra Sirenum

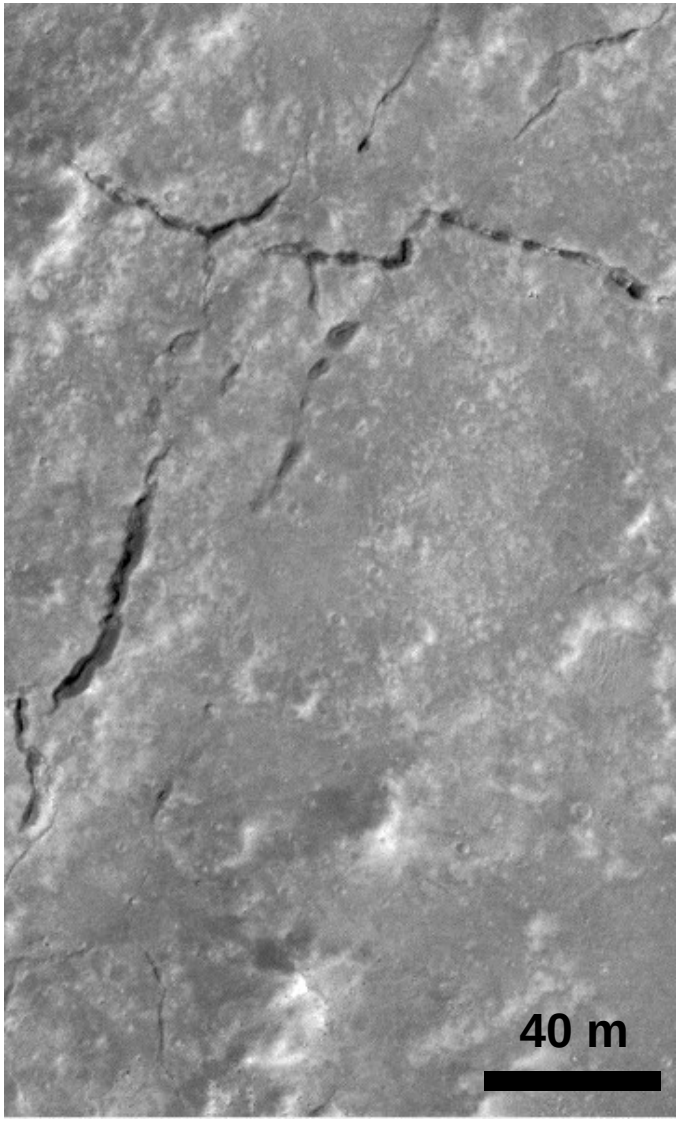


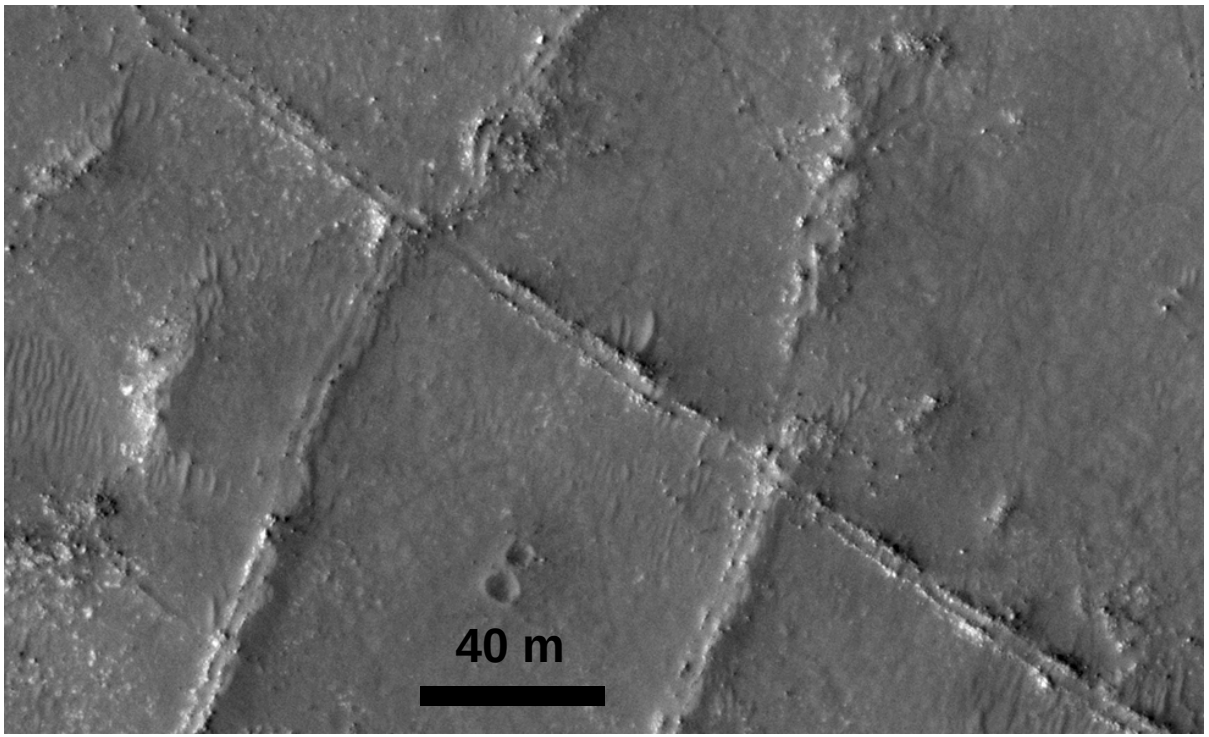


Hauber & Kronberg (JGR, 2005)

Small fissures near Nili Fossae







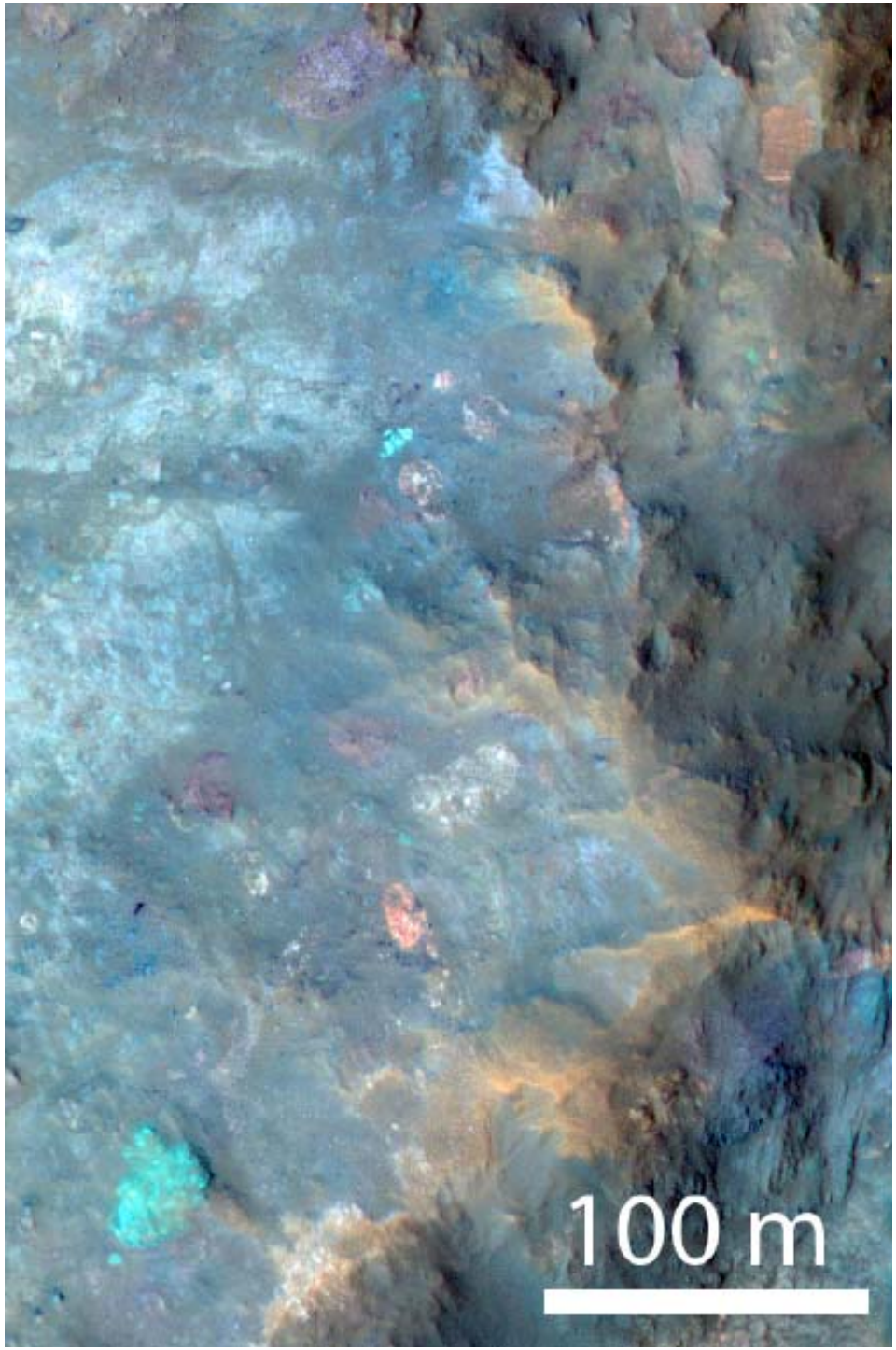
Megabreccia on Mars

- Large (10s-100s of meters) blocks of diverse lithologies cemented in a matrix

- Likely formed from heavy impact bombardment

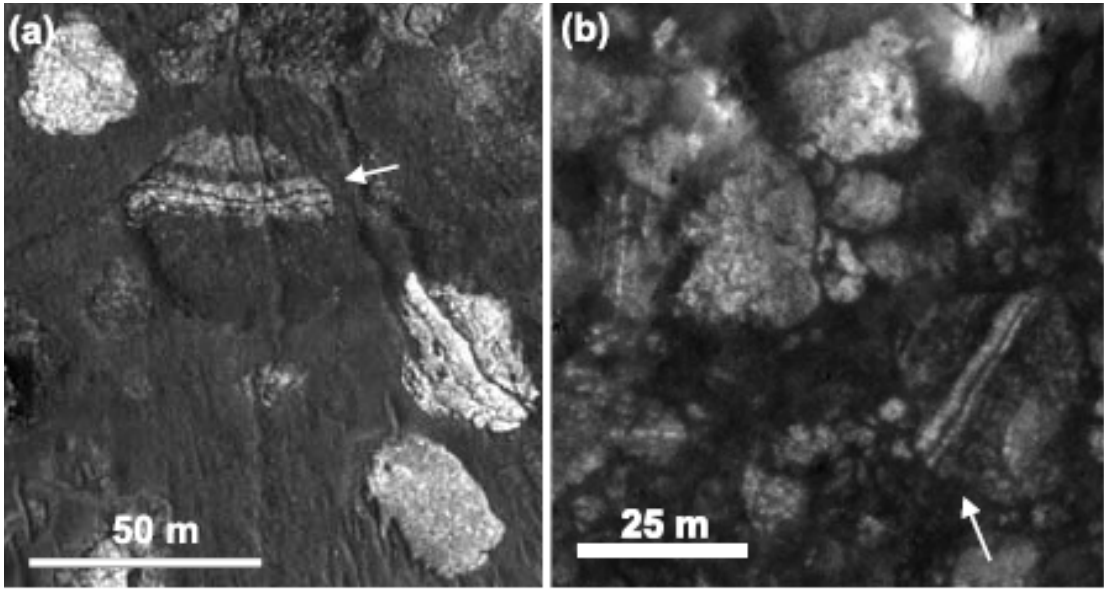
- Found in crater central uplifts, Valles Marineris (deep exposures)

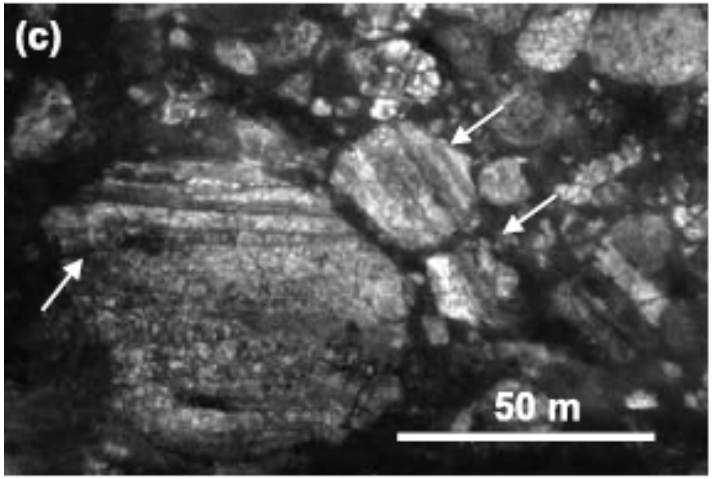
- Possibly occupies a globally widespread subsurface layer (*McEwen et al., EPSC 2009*)

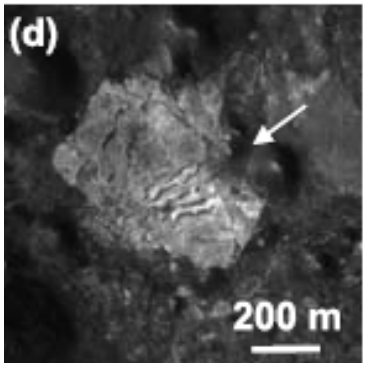


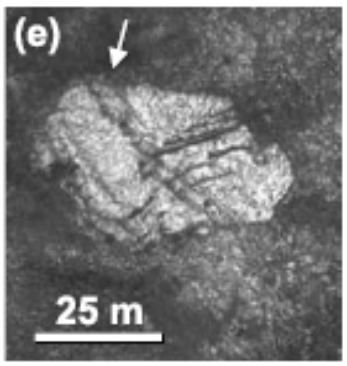
Mega-breccia

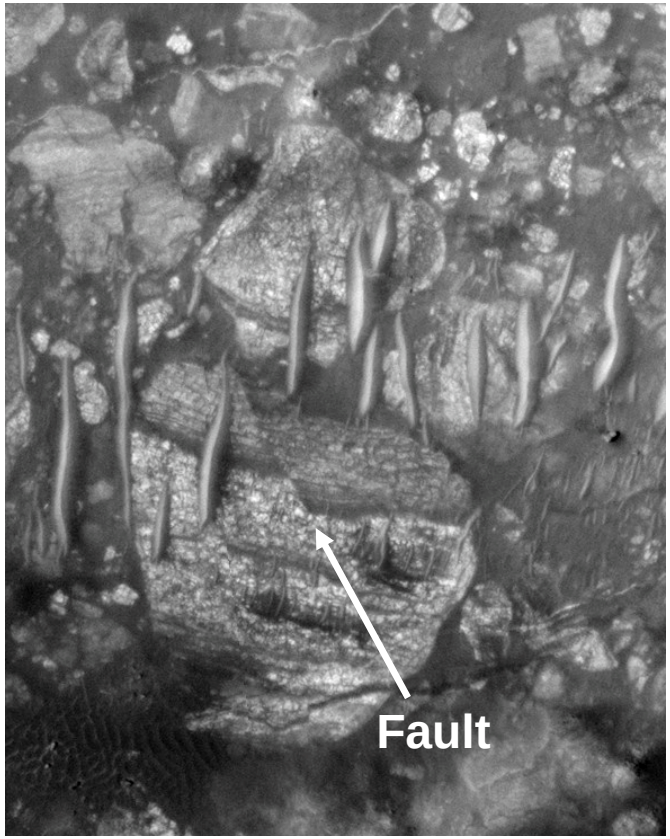
- Uniquely broad distribution in Nili Fos.

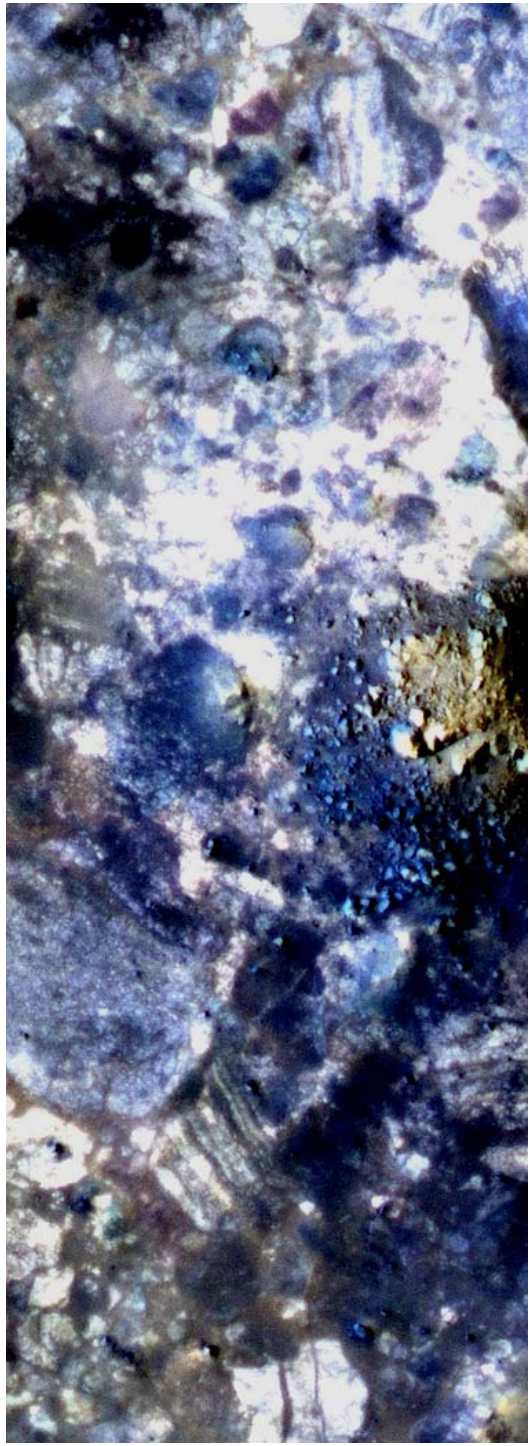












Serpentine

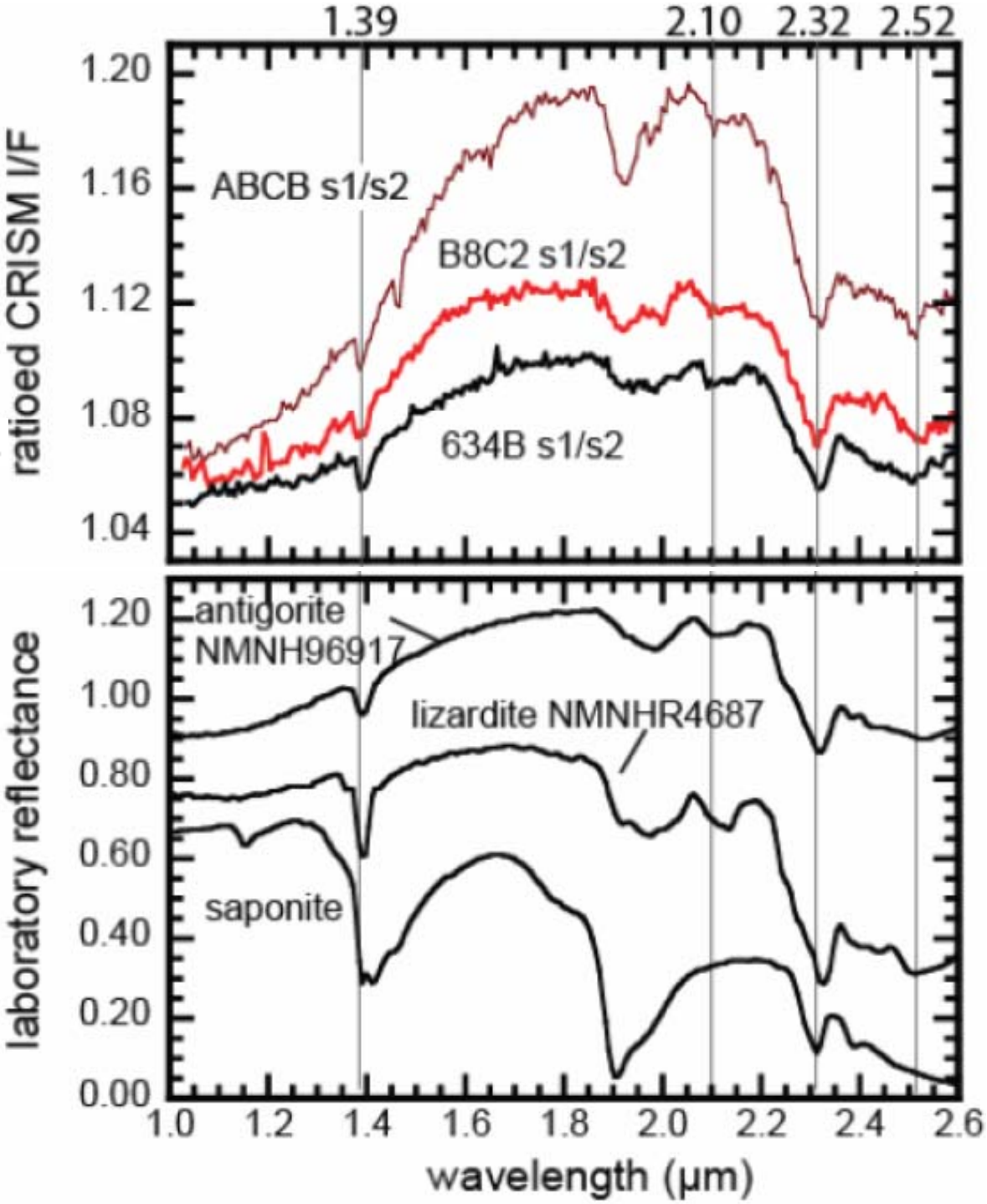
- Forms in reactions that can also form methane, e.g. (*Oze & Sharma, GRL, 2005*):

$$24Fe_2SiO_4 + 26H_2O + CO_{2(aq)} = 12Fe_3Si_2O_5(OH)_4{}^{a} + 4Fe_3O_4 + CH_4$$

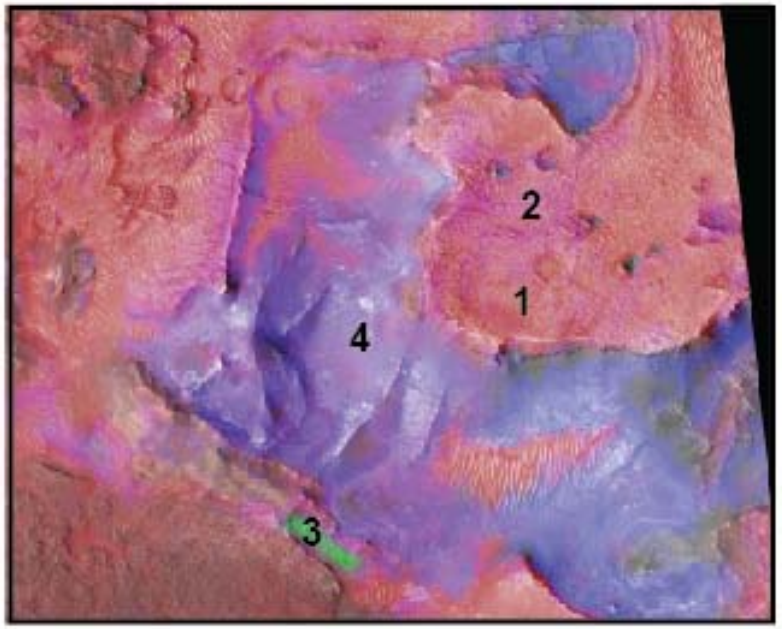
- Requires olivine-rich precursor

- Mg-serpentine in Nili Fossae and south of Tharsis (*Ehlmann et al., LPSC 2009*)

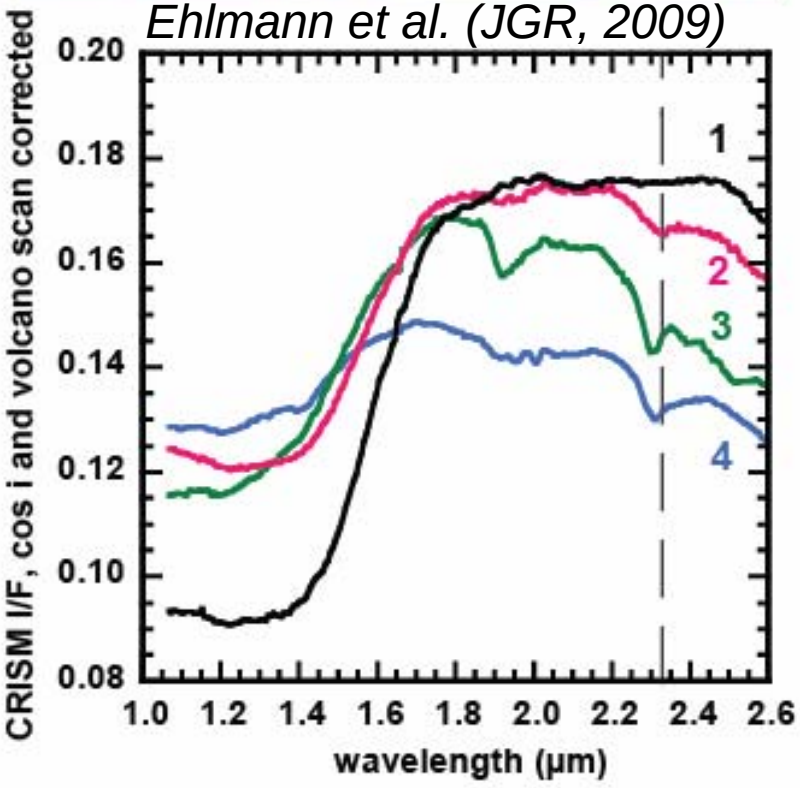
- Distinguished from clay or carbonate by 1.39, 2.10 µm bands



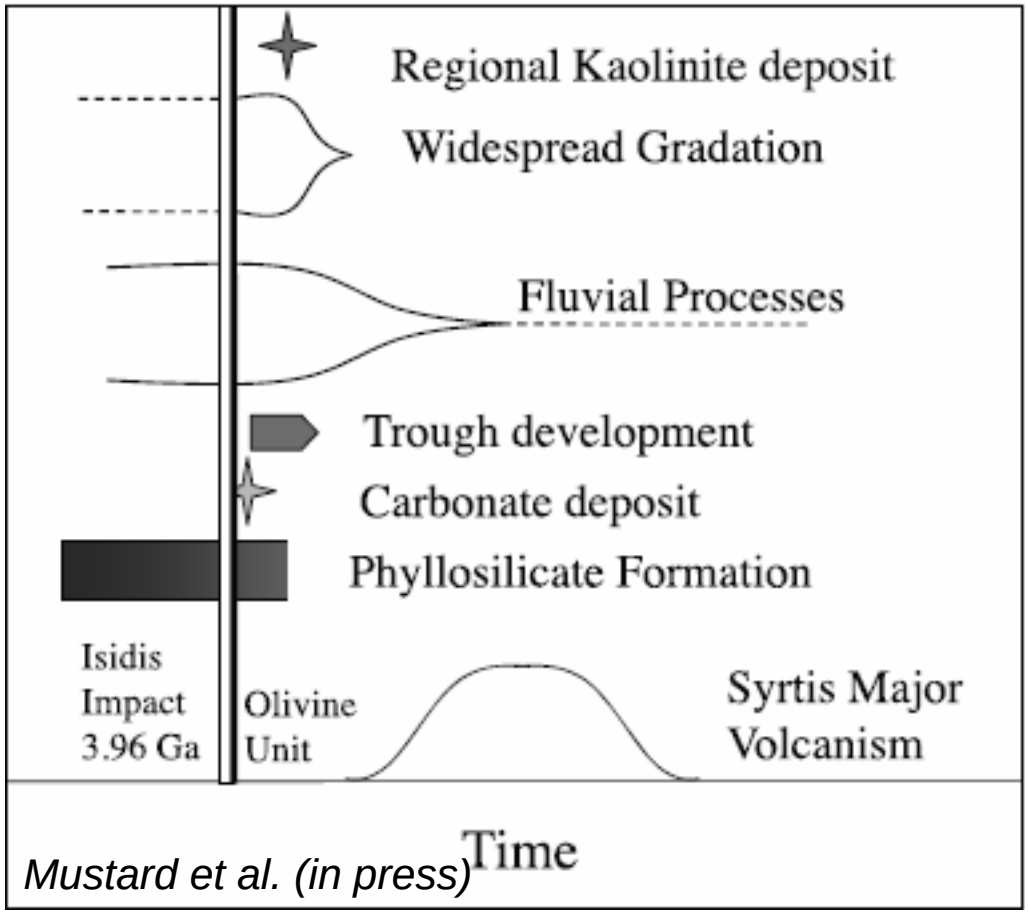
Nili serpentine from Mid-Late Noachian olivine



Ehlmann et al. (JGR, 2009)



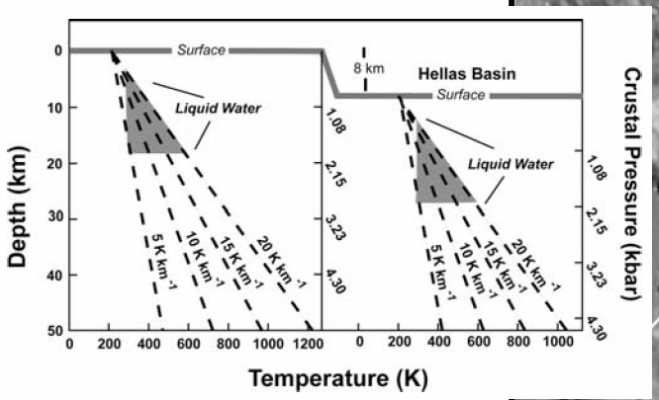
- Nili hosts largest exposure of olivine on Mars (early Syrtis lavas or Isidis impact melt?)
- Partially altered to Mg-carbonate, serpentine



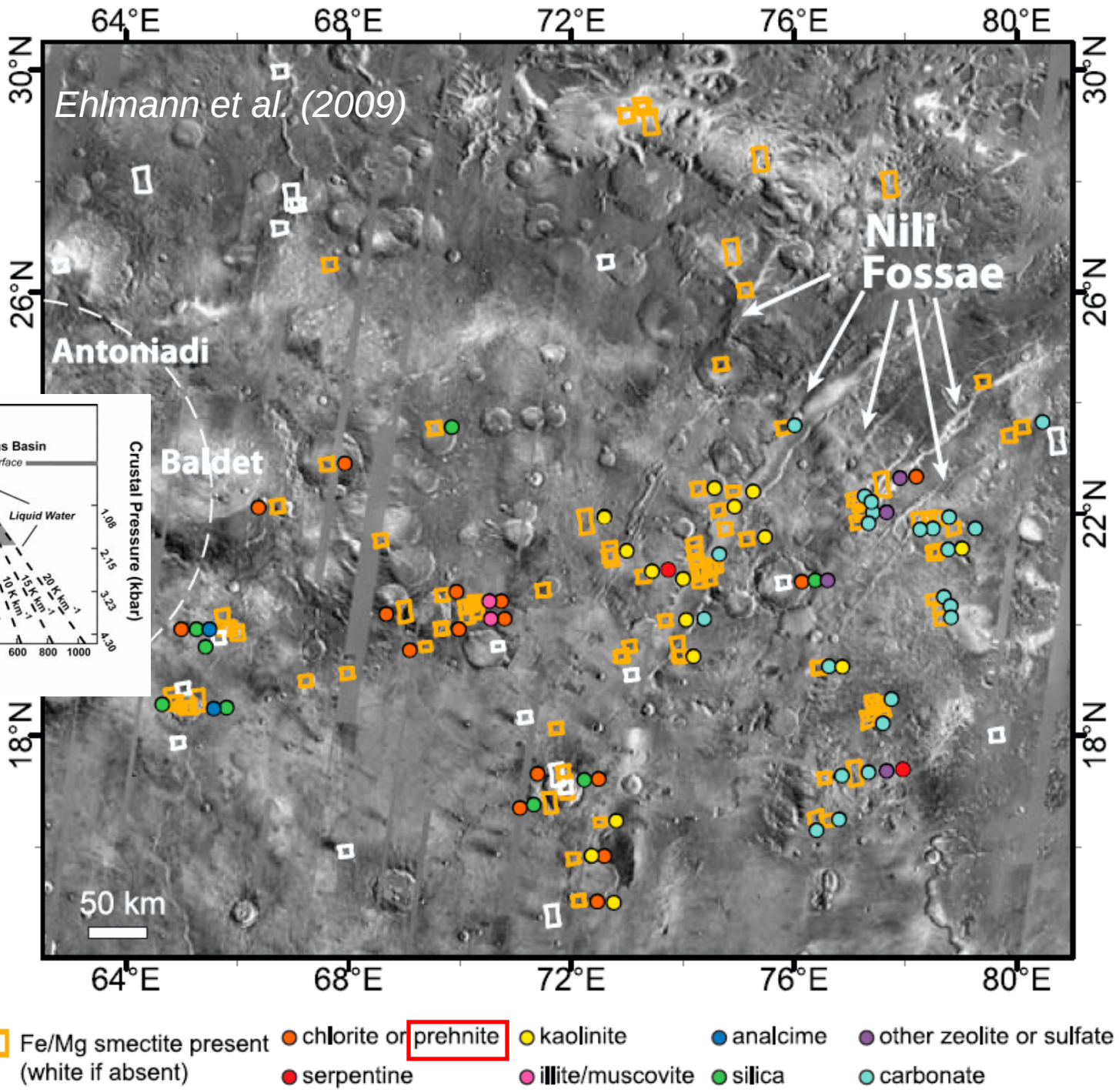
Mustard et al. (in press)

Nili Fossae mineral zoo

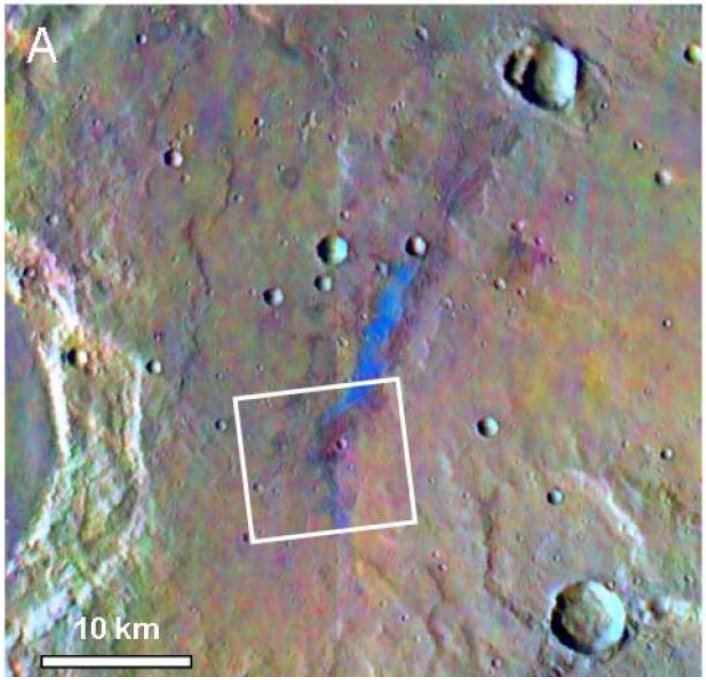
Prehnite forms at 200–350°C, <3 kbar, low pCO_2



Oze & Sharma (2005)

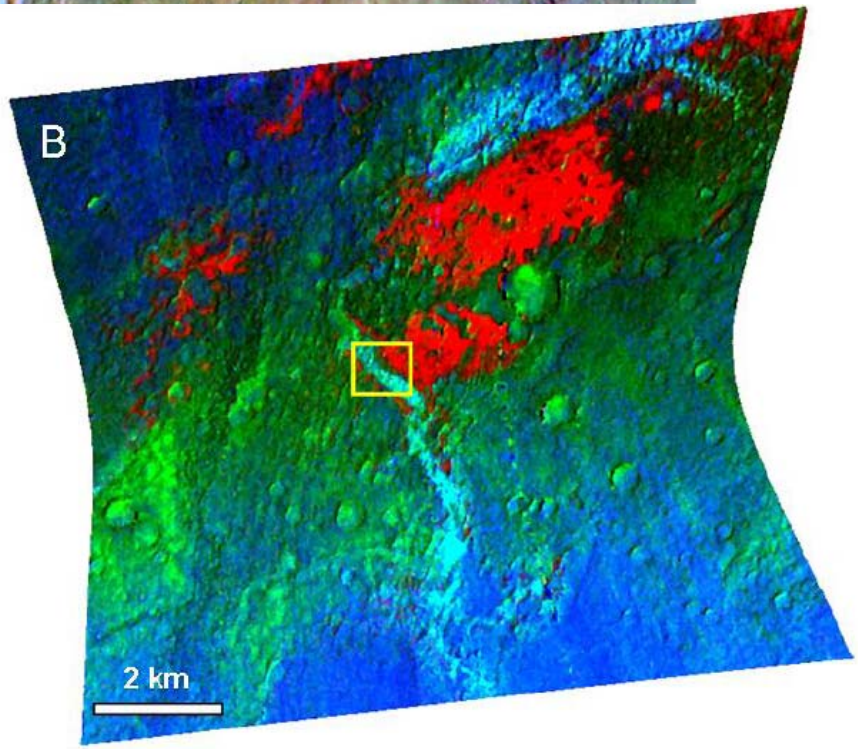


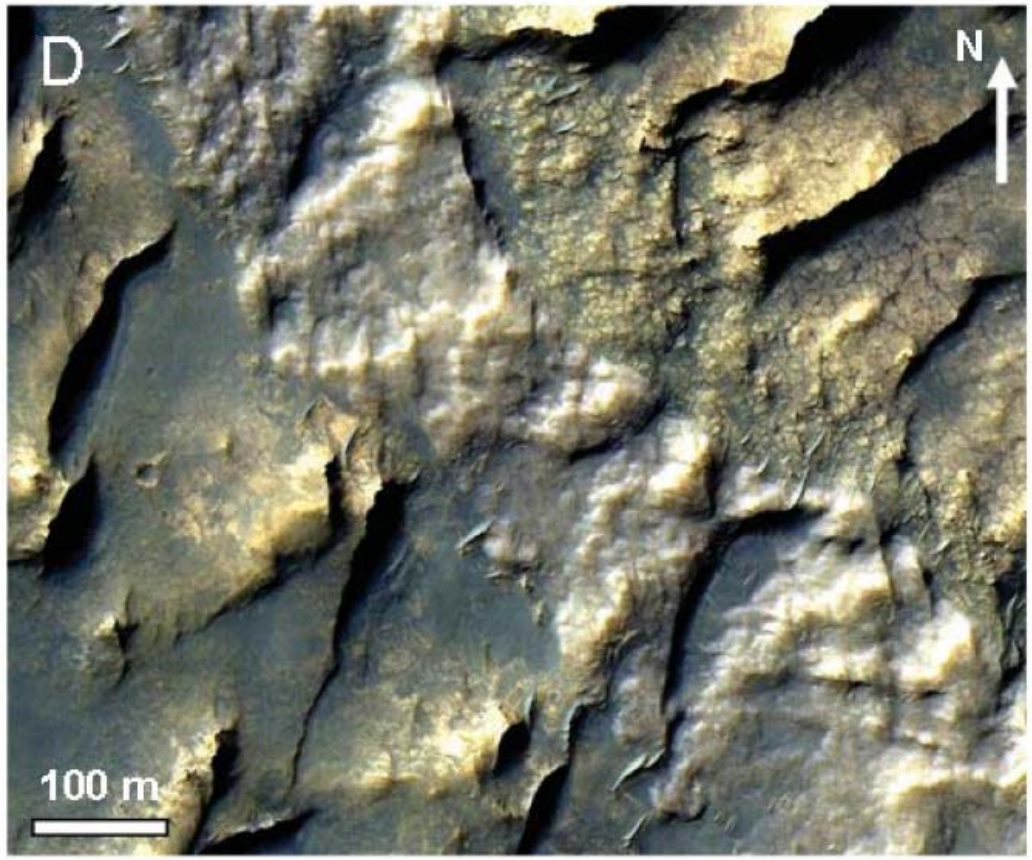
Sirenum clay+salt plains deposits



- Unique thermal IR phase consistent with chlorides (*Osterloo et al., Science, 2008*)

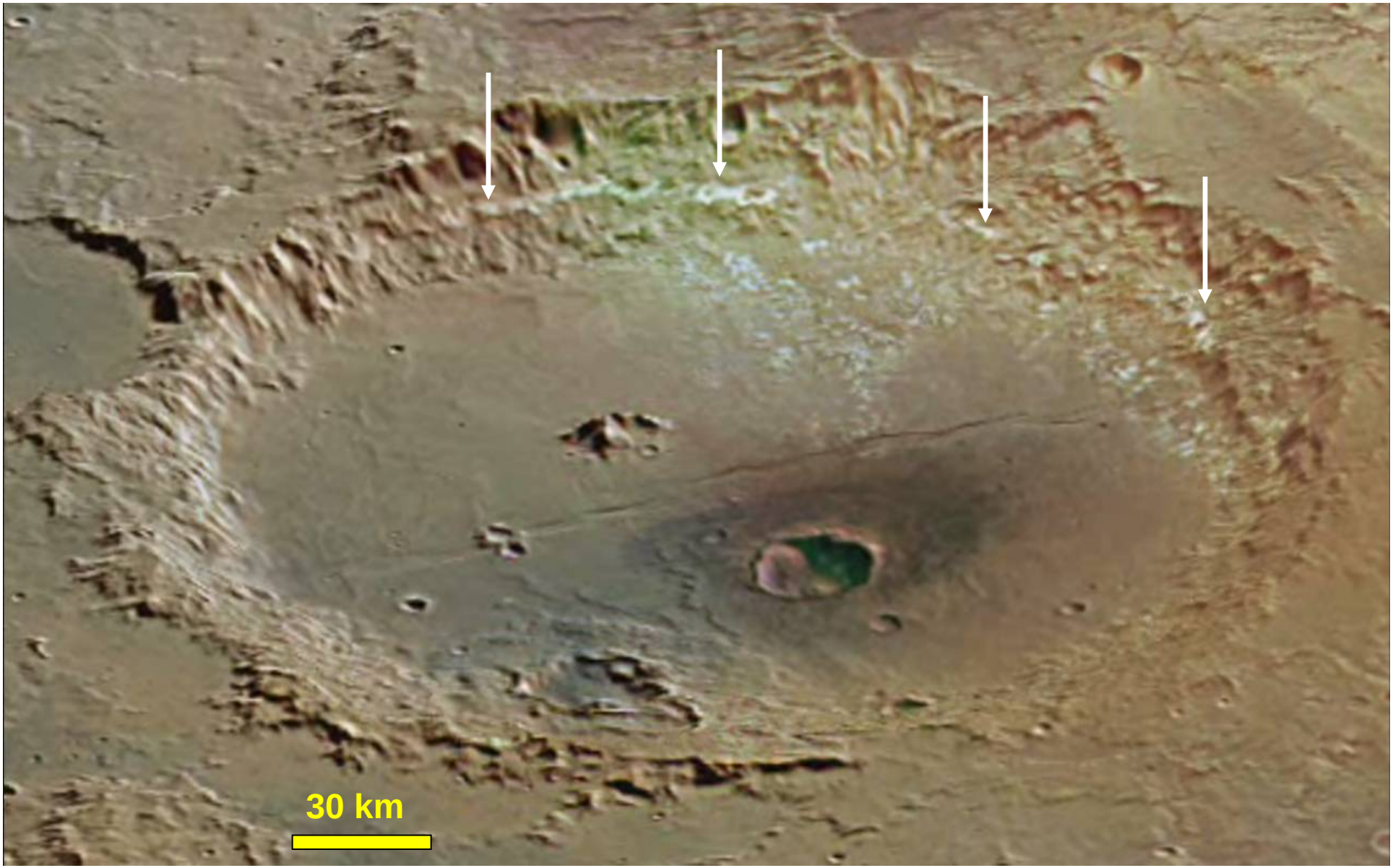
- This phase commonly coexists with Fe/Mg-clays (*Murchie et al., JGR, 2009* and *Wray et al., Geology, 2009*)



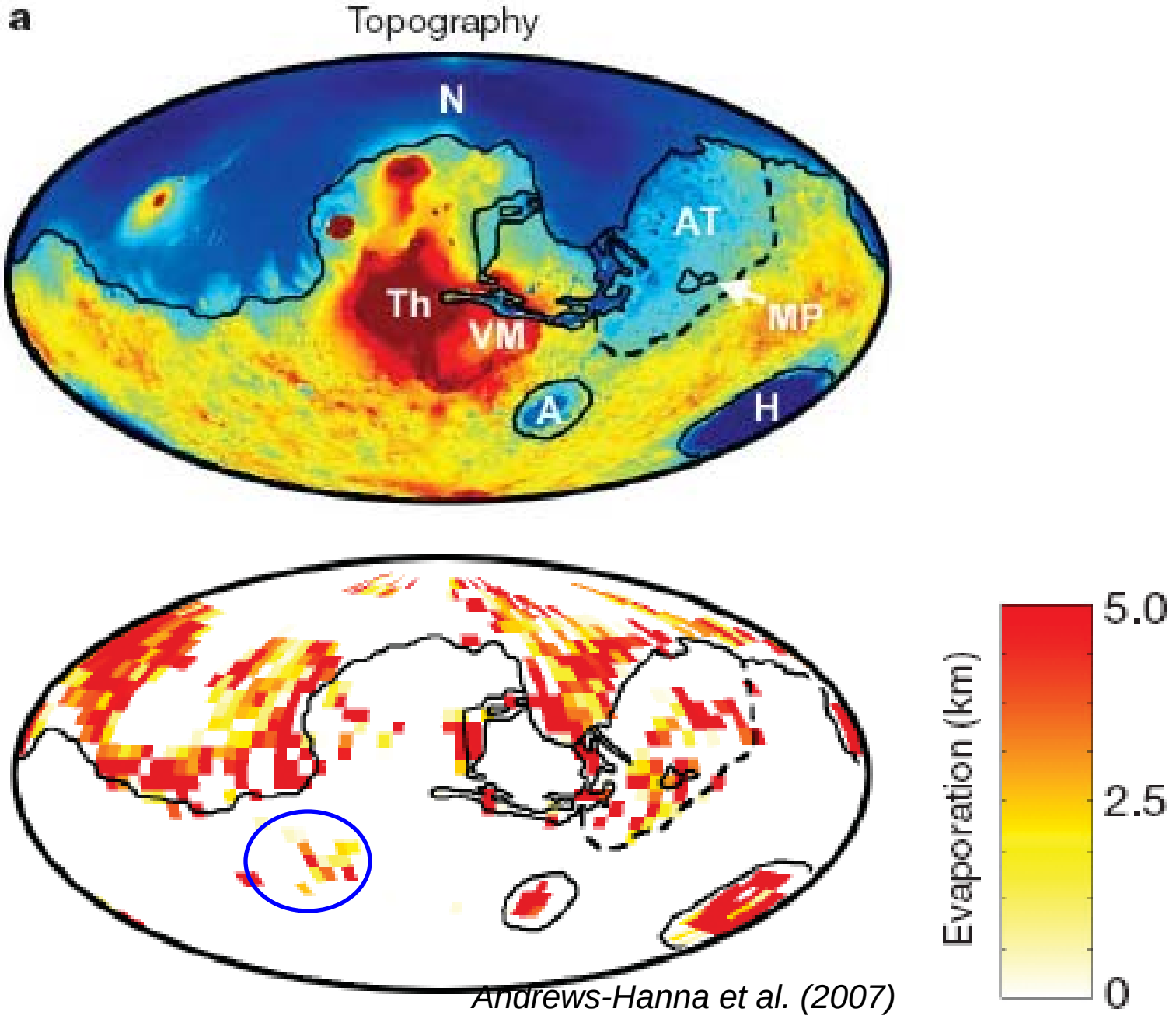


Columbus crater, Terra Sirenum

- 10 adjacent craters have Late Noachian layered deposits of Al-clays and salts
- Columbus crater has sulfate “bathtub” ring (*Wray et al., 2009 LPSC and AGU*)



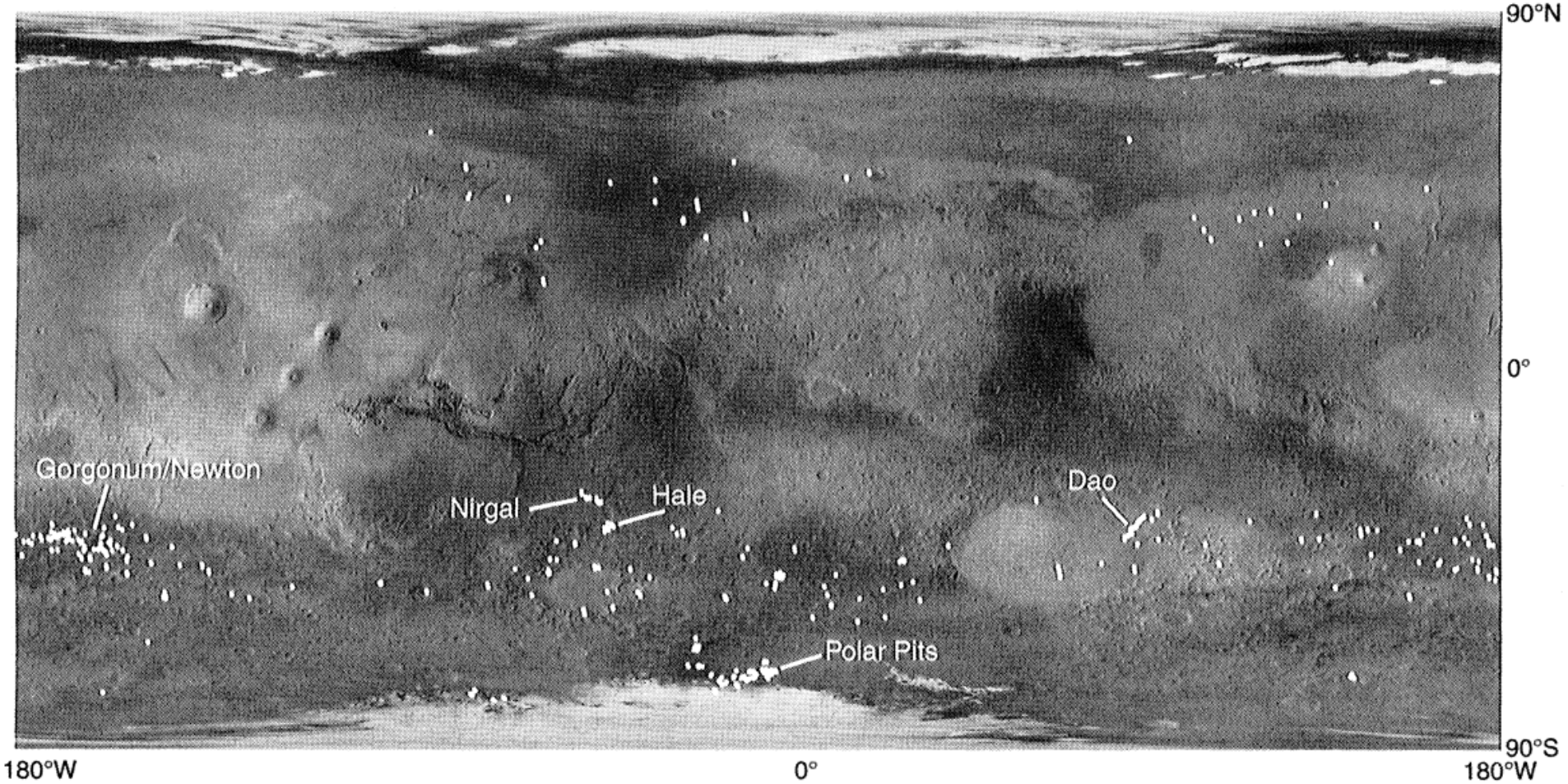
Groundwater upwelling in Terra Sirenum



Andrews-Hanna et al. (2007)

Gullies in western Terra Sirenum

- Concentration of gullies may reflect regional aquifer (*Malin & Edgett, 2001)*
- Several of these are **currently** active (e.g., *Dundas et al., AGU 2009*)
- Source(s) of water (ground, snowpack) remain hotly debated



Caveats and future directions

- Fissures, megabreccia, hydrated minerals, groundwater are intrinsically correlated; hard to know which (if any) is ***causally*** linked to methane

- SE Syrtis and Terra Sabaea source regions are different
  ➔ Simply due to poor exposure?

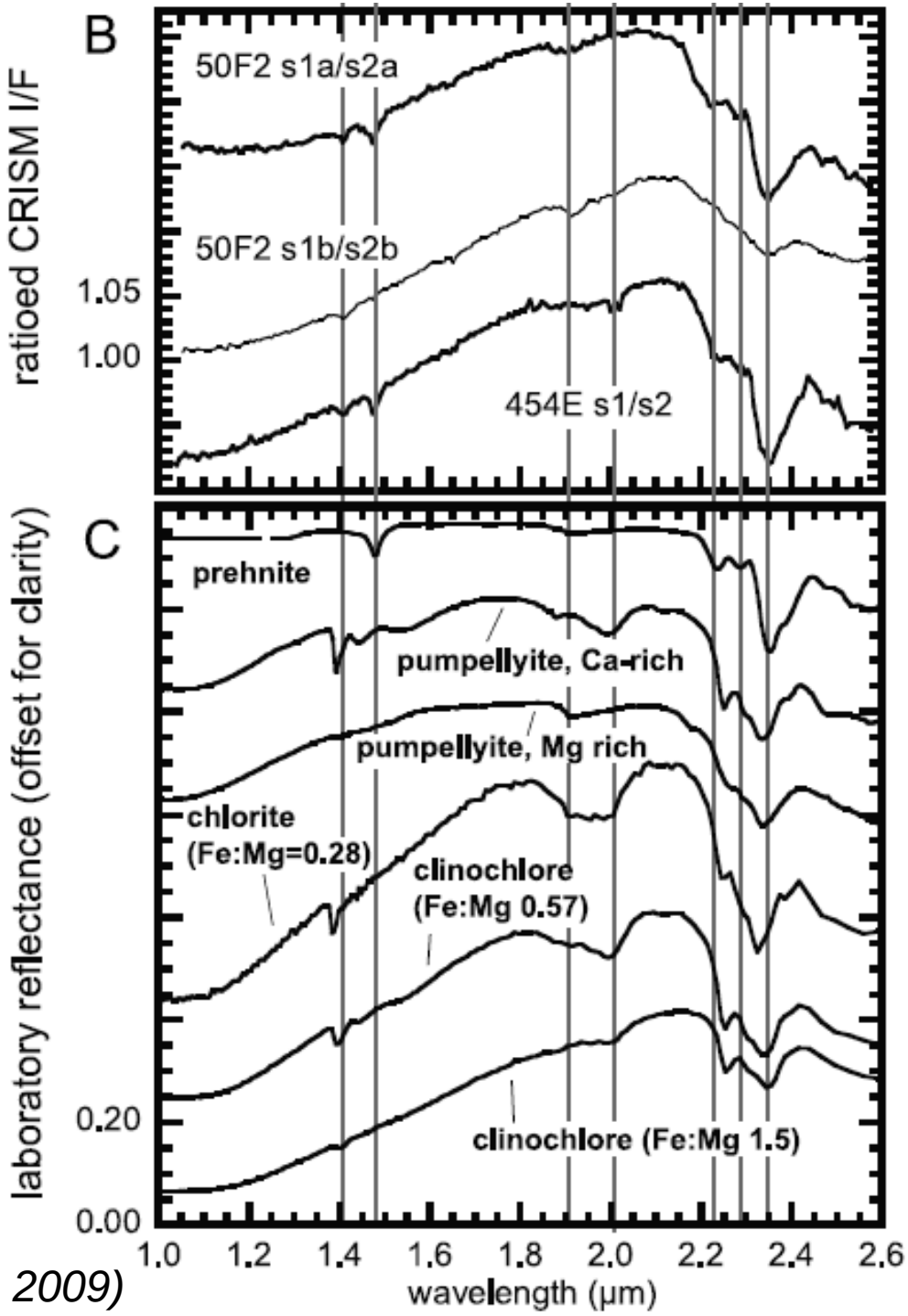
- **Global coverage** (spring/summer) is most critical to testing these trends

- Higher resolution methane maps will reduce uncertainties

Correlating methane to regional geology is a potentially powerful tool that we are just beginning to exploit…

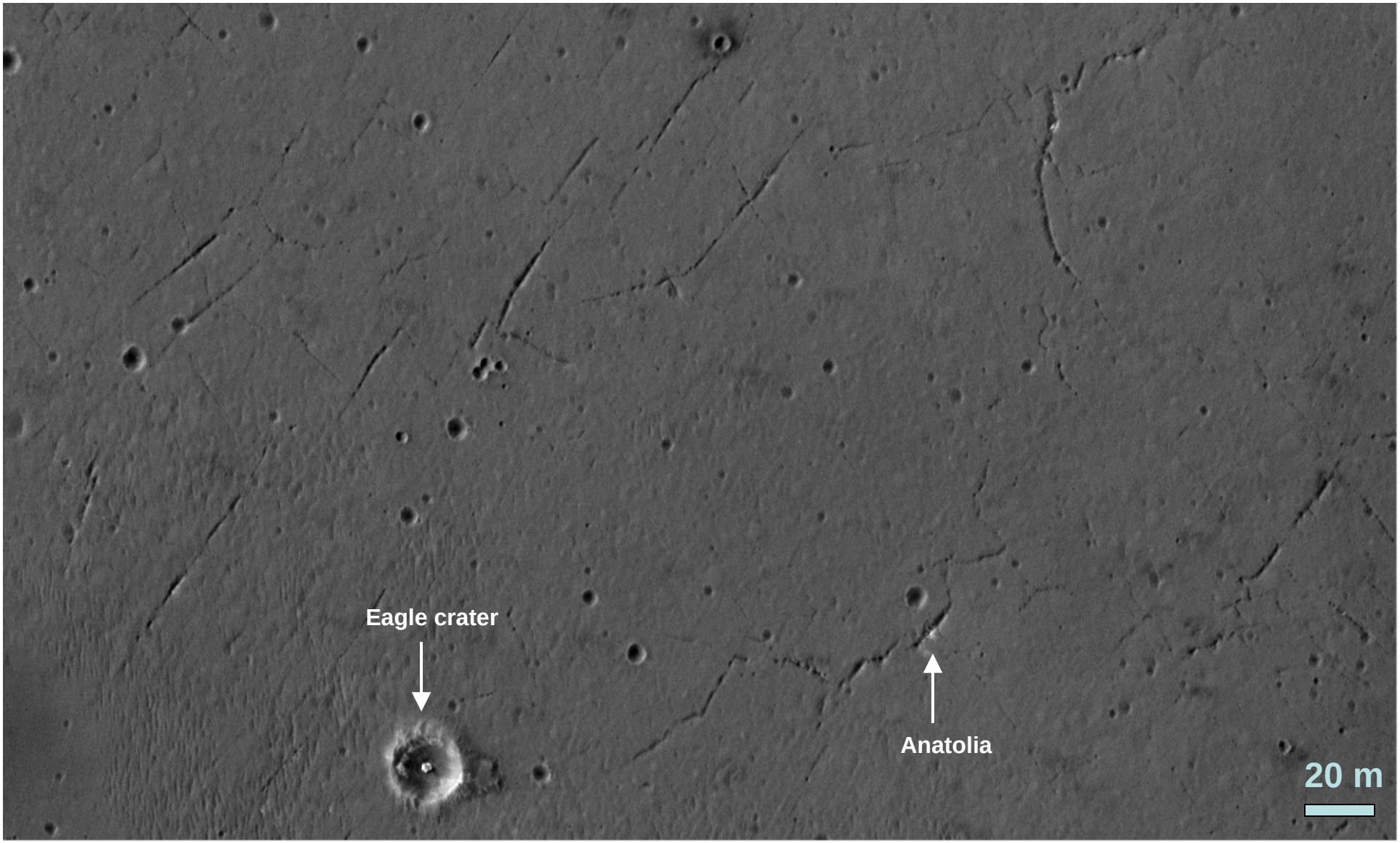
Extras

Identification of prehnite



Ehlmann et al. (JGR, 2009)

Aside: Anatolia trough and brethren



Features similar to small-scale Nili trough/pits abound at the Opportunity landing site; McLennan et al. (2005) have suggested sulfate-karst processes could be involved.