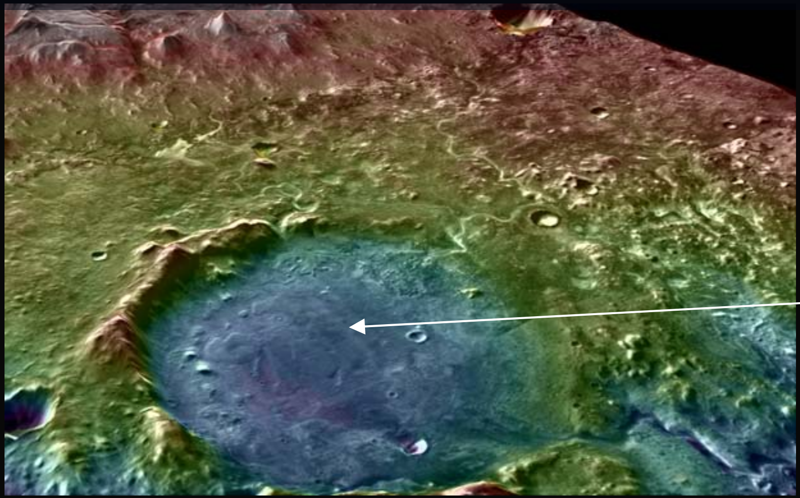
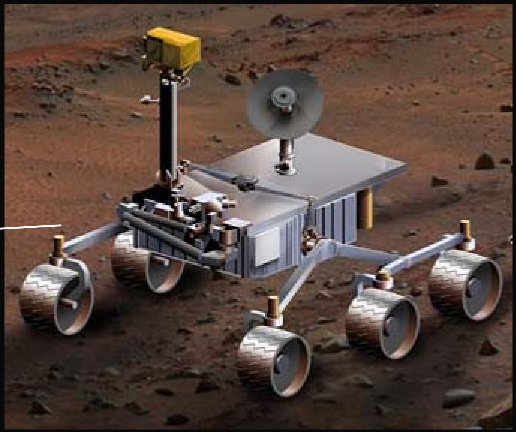
Jezero Crater Lake: Phyllosilicate-bearing sediments from a Noachian valley network as a potential MSL landing site





Caleb Fassett, Bethany Ehlmann, Jim Head, Scott Murchie, Jack Mustard, Sam Schon

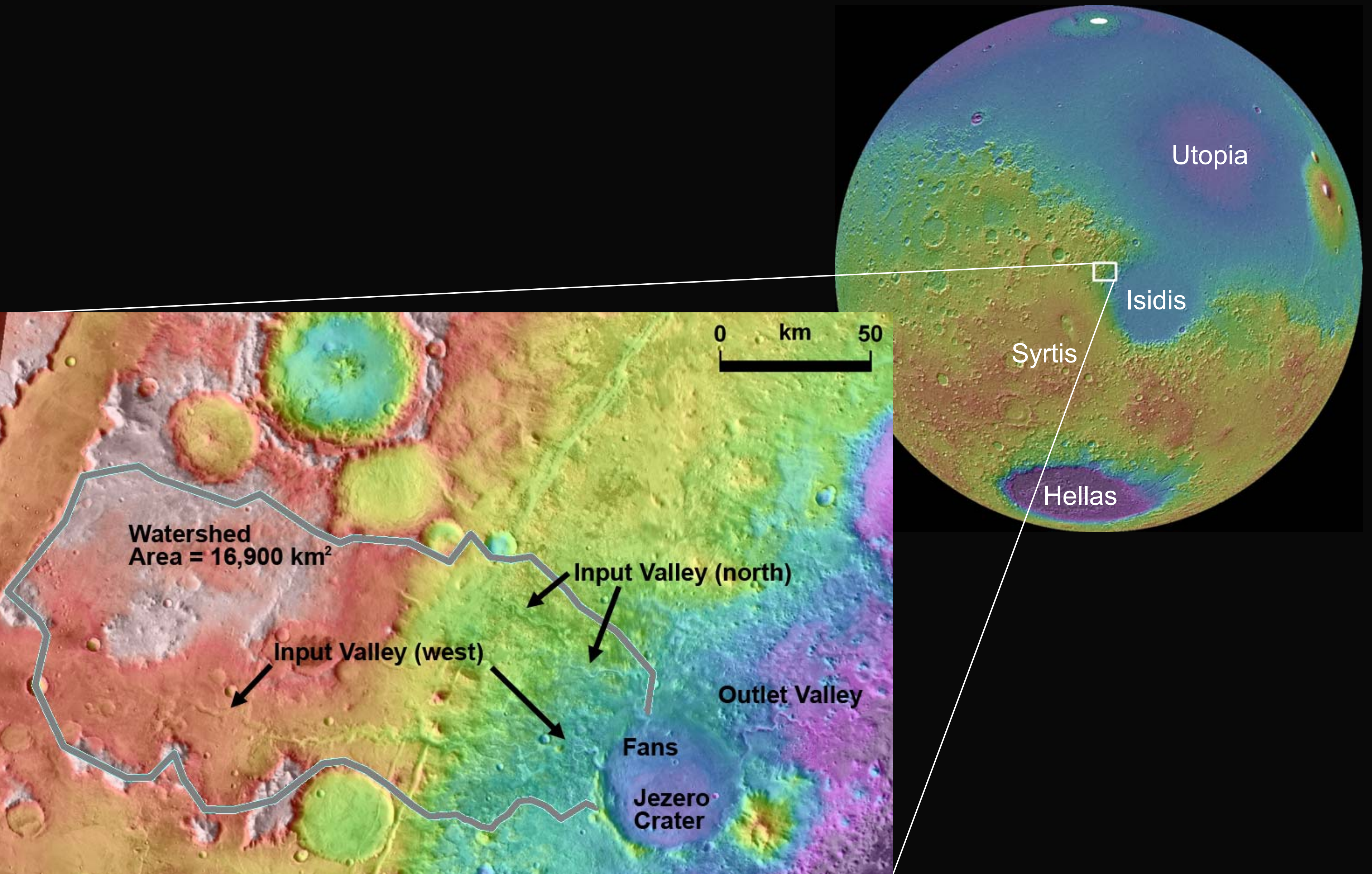
Proposed by Jay Dickson (et al.), Ralph Harvey, and Jim Rice

Special thanks to CRISM, CTX, HiRISE, HRSC, MOC, MOLA, OMEGA and THEMIS teams

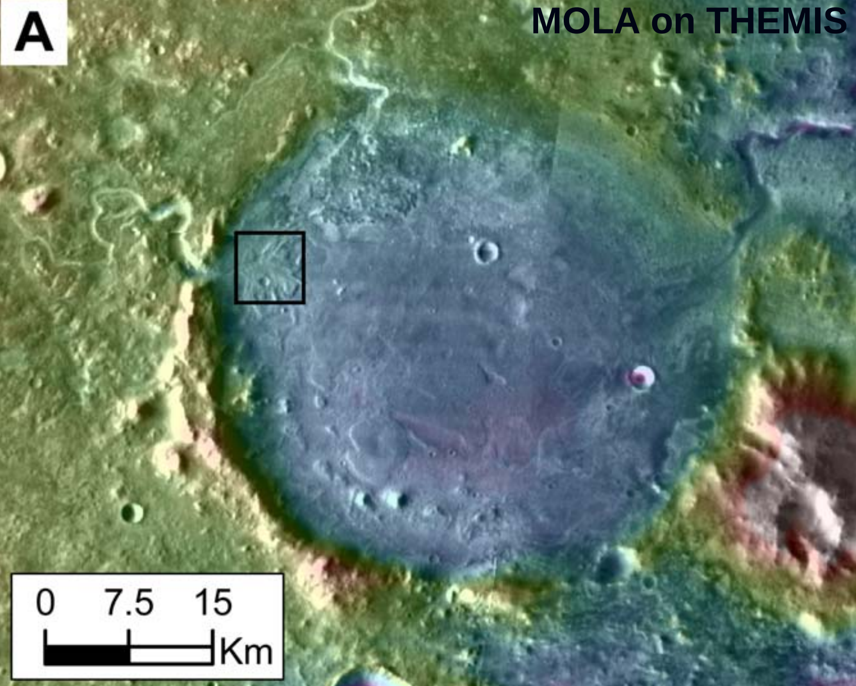
Outline

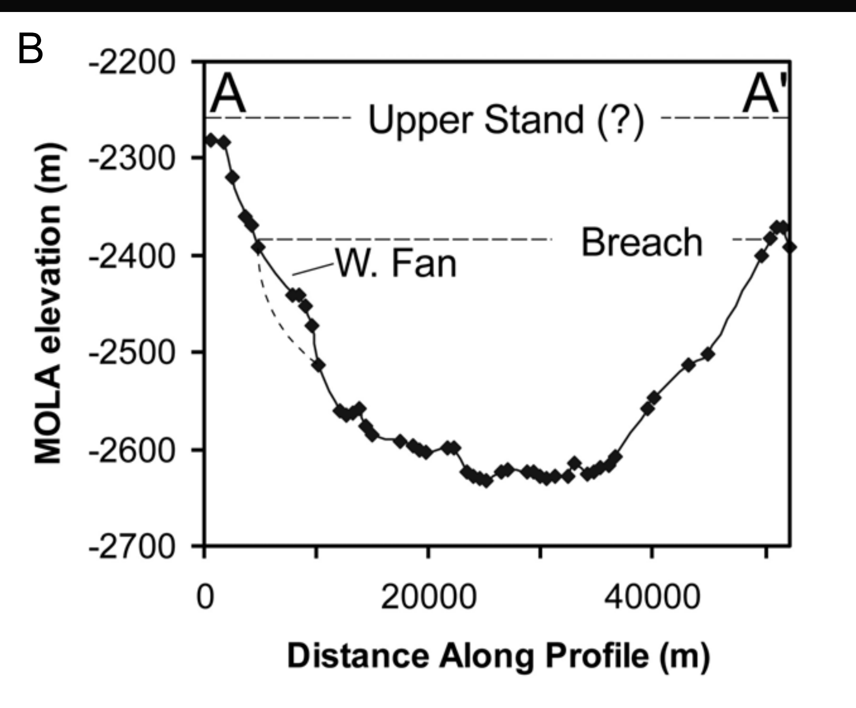
- Geology:
  - Geological setting (CTX, THEMIS, HRSC, OMEGA, MOLA)
  - Outcrop scale mineralogy, morphology, and geology from CRISM and HiRISE
- Jezero Crater and MSL:
  - Meeting Mission Science Goals
  - Preliminary look at landing site safety

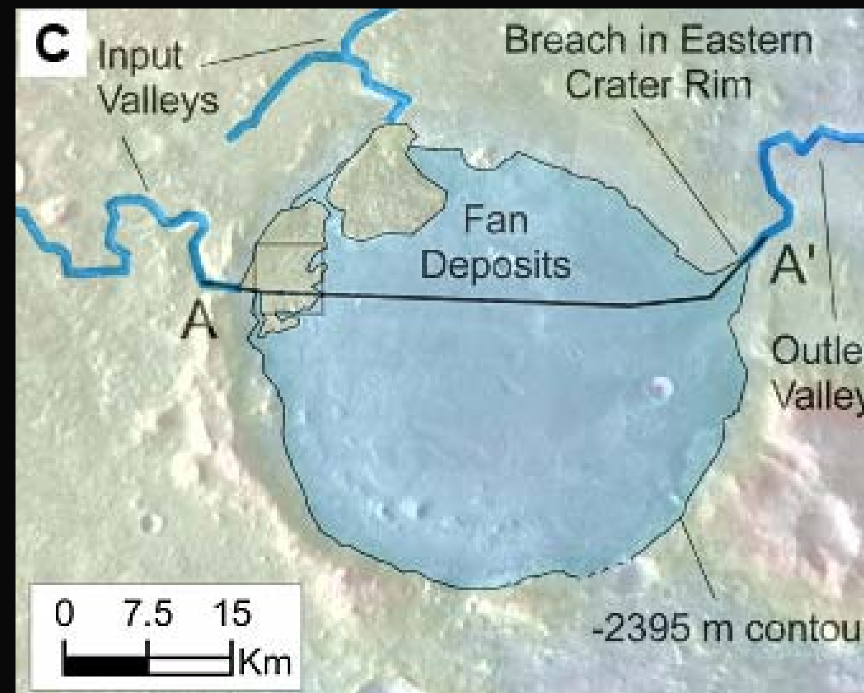
Jezero Crater, Regional View



Jezero Crater Lake







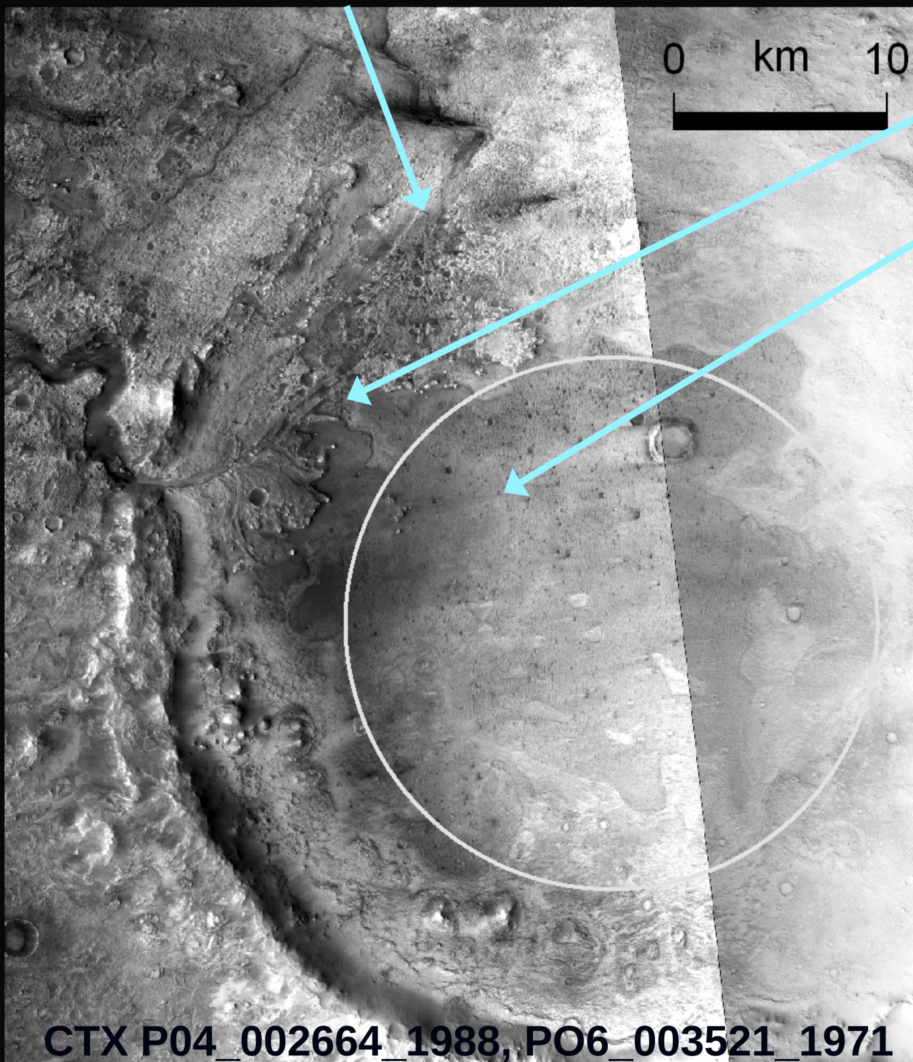
Fassett and Head, 2005

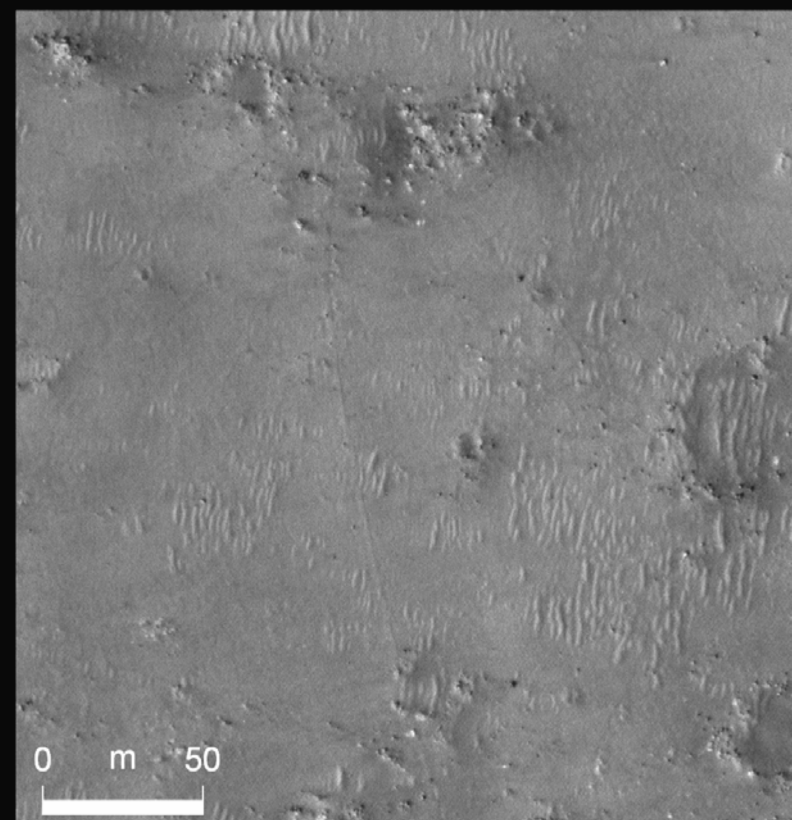
Jezero Crater from MRO

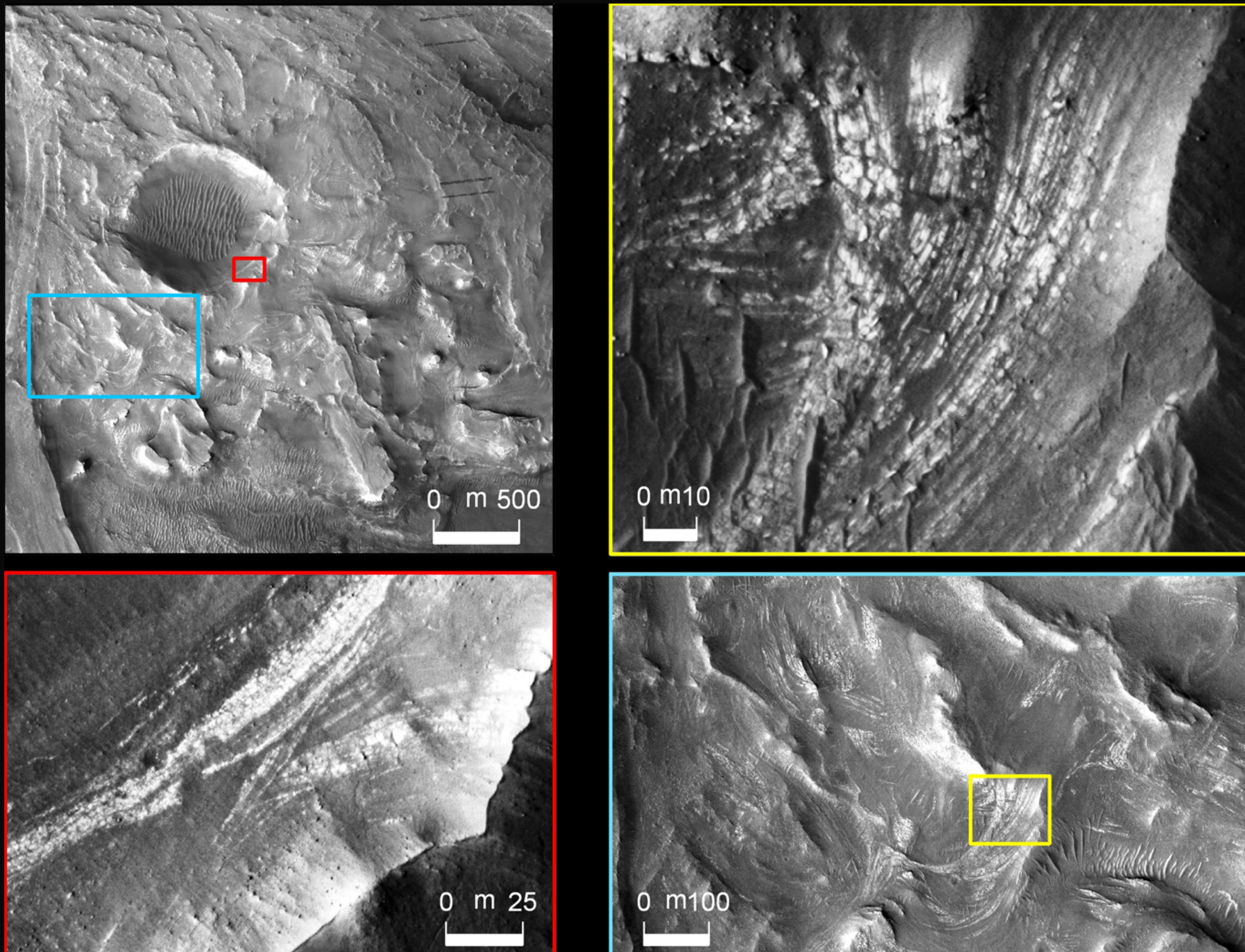
Northern Fan

Western Fan (primary target)

'Smooth' Unit (likely volcanic origin)



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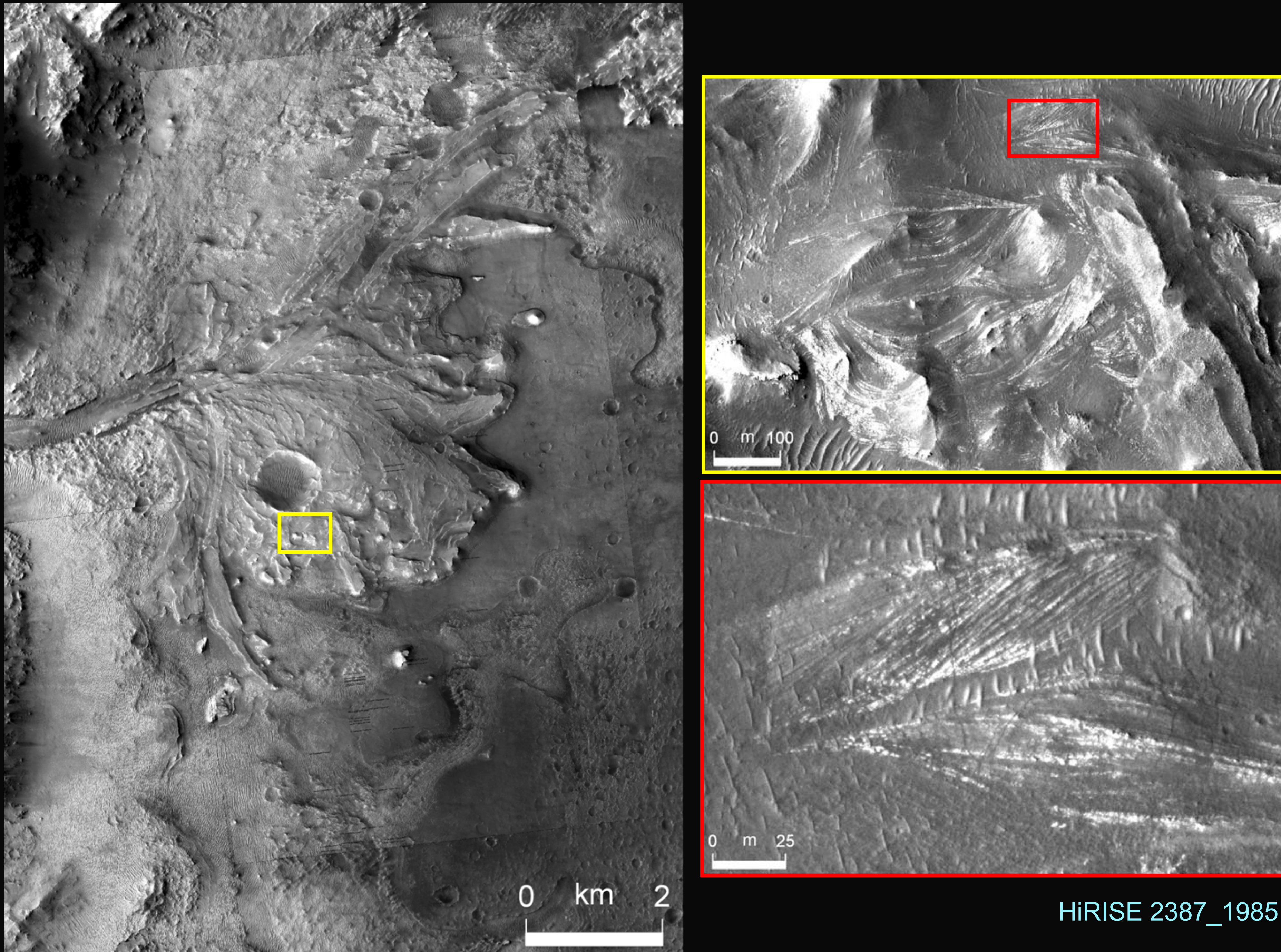
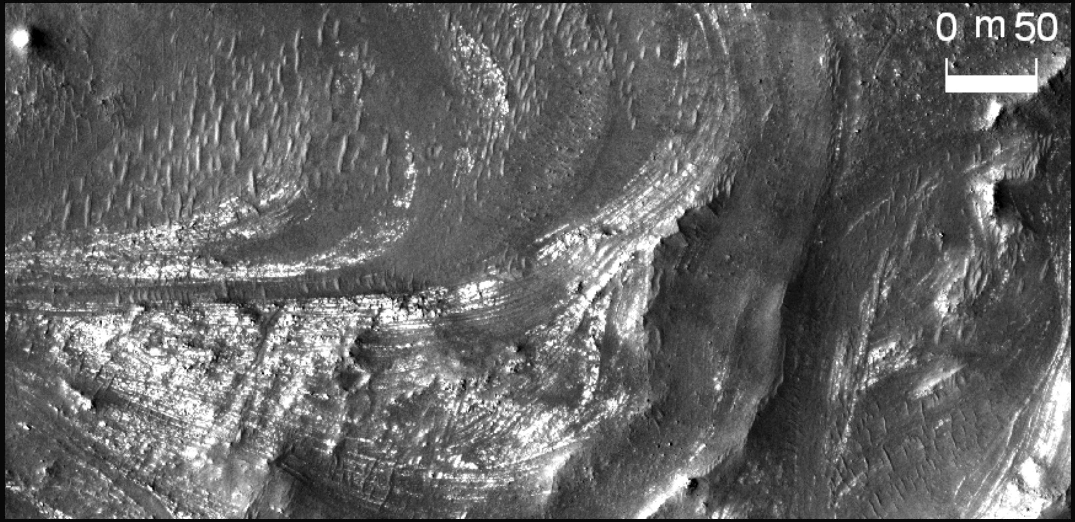
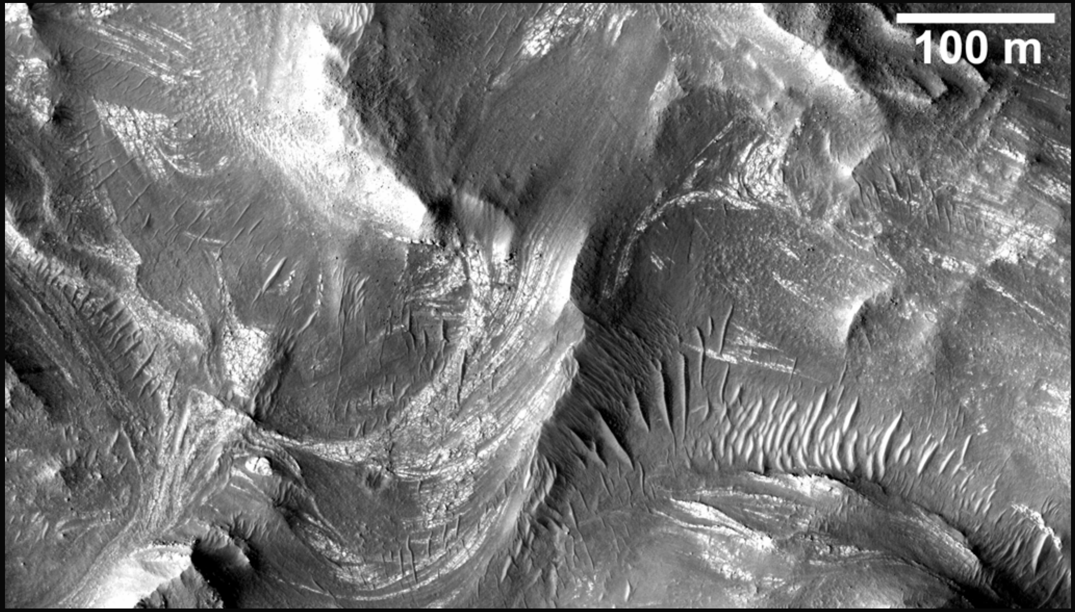


HiRISE 2387_1985

Meanders/Lateral Accretion

ASTER Image, Songhua River China





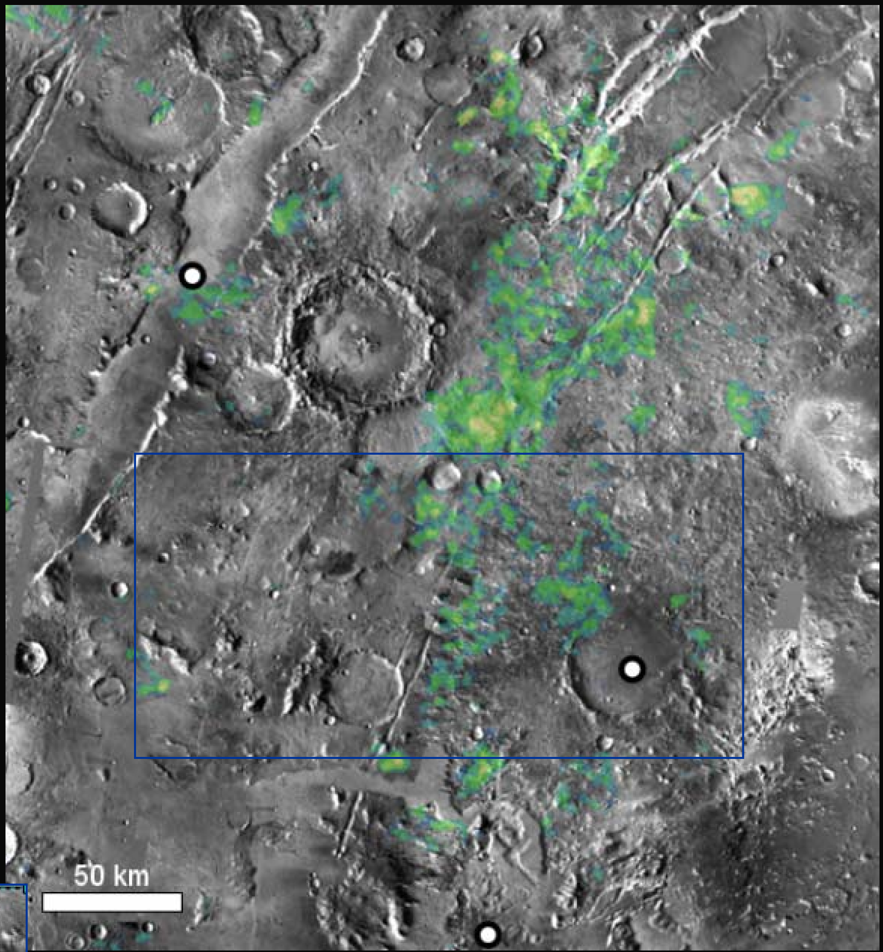
Regional phyllosilicates

Iron-Magnesium rich smectite clays are spread over >100,000 km^2 in the Nili Fossae Npl terrain

Found in the **lowermost stratigraphic layer,** beneath olivine and LCP and cut by the fossae

(Bibring et al., 2005; Poulet et al., 2005; Bibring et al., 2006; Mangold et al., 2007; Poulet et al., 2007; Mustard et al., 2007)

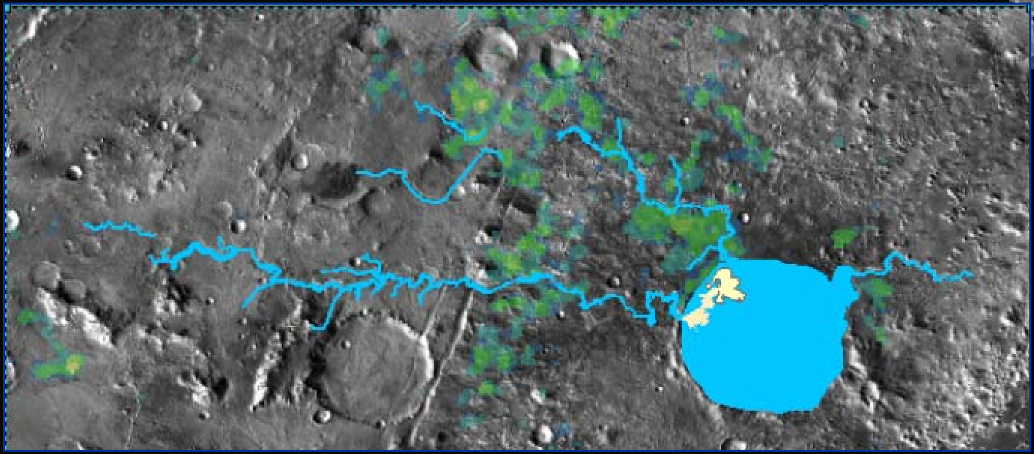
OMEGA D2300 parameter on THEMIS



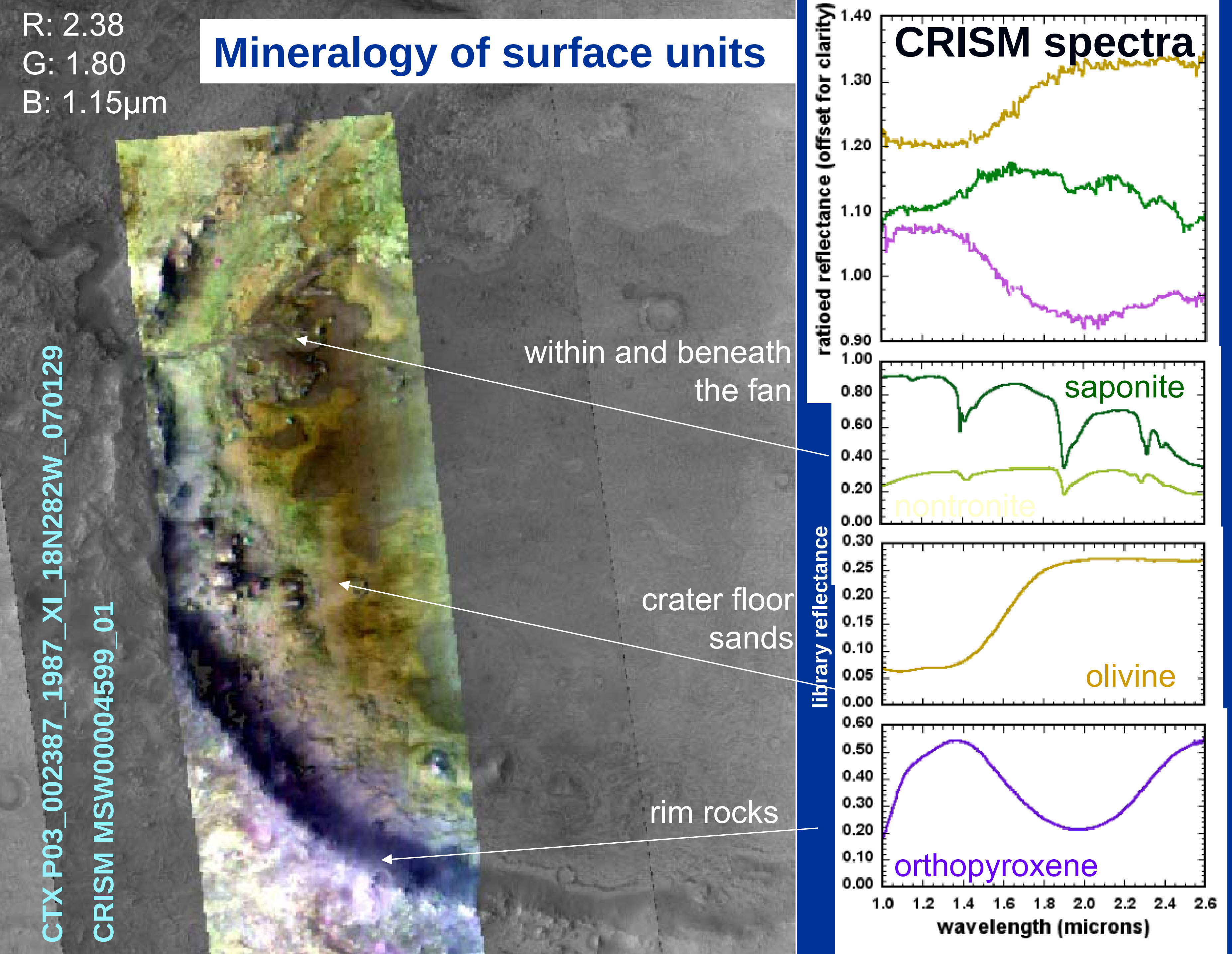
Phyllosilicate band strength

0.01 *D2300* *0.05*

Jezero crater watershed



Mineralogy of surface units

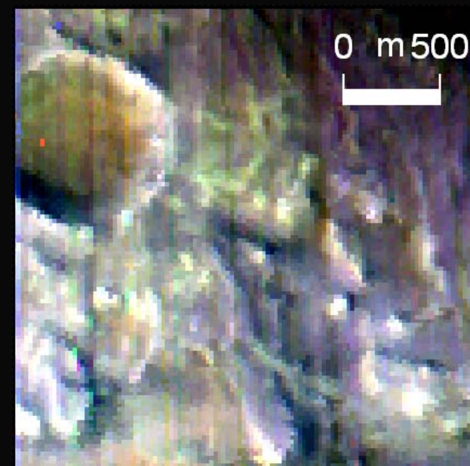


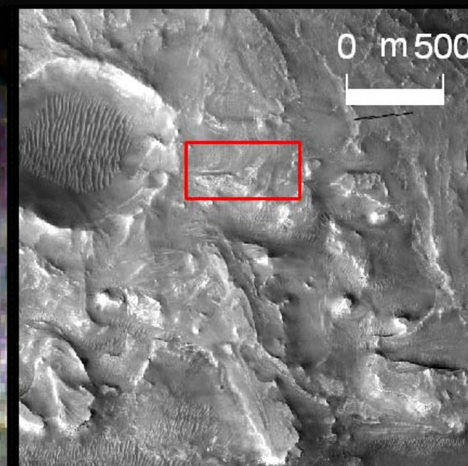
CRISM

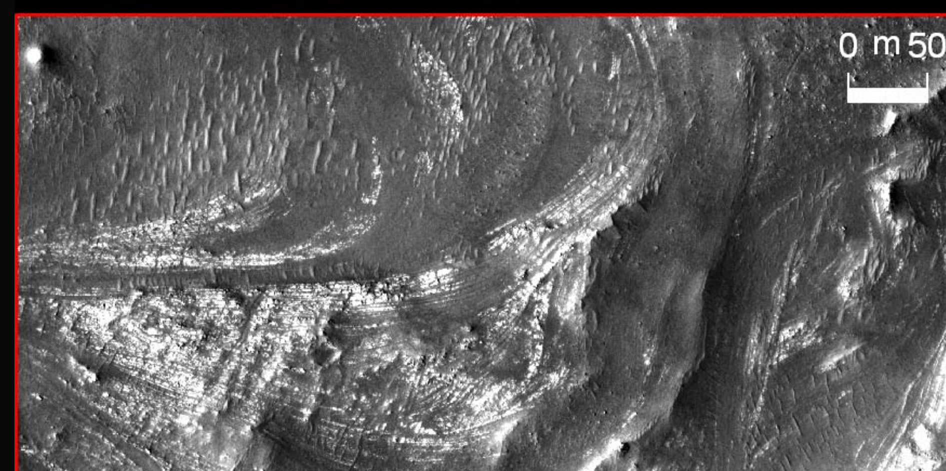
Spectra imply phyllosilicate in fan material (and surroundings); on fan surface these appear to be transported valley network sediments

R: 2.38 µm, G:1.8 µm, B: 1.15 µm
Orange: Olivine; Green: Phyllos;
Purple: Neutral or weak bands

Ehlmann et al., 2007 (in prep.)



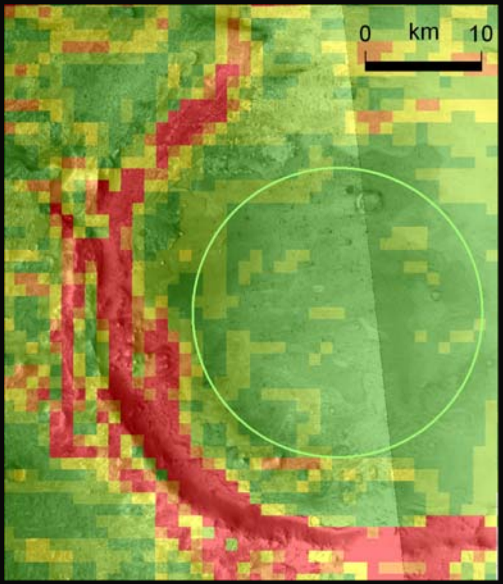




Geological History of Jezero

Early-Mid Noachian	Late Noachian	Hesperian to Amazonian
▪ Regional phyllosilicates formed ▪ Isidis impact: establishes regional topography and deposits extensive ejecta ▪ Jezero crater formed	▪ Two valley networks breach Jezero crater rim, deposit transported phyllosilicate-rich sediment and form lake	▪ Post-valley network activity of Nili Fossae ▪ ‘Smooth’ (probable volcanic) floor unit deposited embaying fan materials ▪ Aeolian deflation of fan sediments and exposure of fresh surfaces

Where to and how safely can we land?



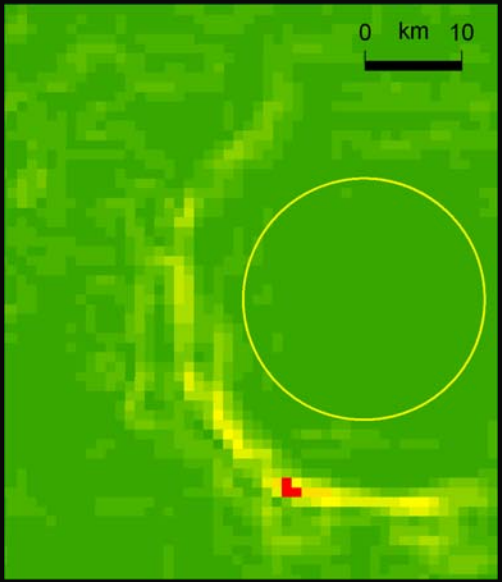
Slope Map of HRSC Orbit 988 DTM (75 m/px) at 1 km baseline (red regions are > 2.5°)

Elevation: ~ -2600 m

MOLA RMS shot roughness in landing ellipse: **1.23 m** (from *Neumann et al*., 2003 gridded data)

Meridiani = 0.8 m, Gusev =1.5 m

Slope Map of HRSC Orbit 988 DTM (75 m/px) at 1 km baseline (red regions are > 20°)



HRSC (75m) DTM, entire landing ellipse has slopes <2.5° at 1 km baseline (top left)

Also, entire LS + warning track < 20° at 2-10 km baseline (bottom left)

MSL Science Goals: Multiple Targets

1. Fan sediments (phyllosilicates, astrobiology, sedimentology, valley network characterization, etc.) (d~10-15 km)
2. Landing surface “smooth unit” (<30-m thick) interpreted as Hesperian volcanic flow (nature, chemistry) (d=0 km)
3. Olivine-rich sands accessible from traverse (characterization of regional material with distinct properties from remote sensing instruments) (d~5 km)
4. Access to ancient Noachian crustal materials from watershed and Jezero Rim (deeply excavated, LCP rich rocks) (d<20 km)

MSL Science Goals: Criteria

Ability to assess biological potential w/ MSL Payload

Evidence for Habitable Environment	✓	Lacustrine environment, Clays
Potential Preservation of bio-signatures	✓	Smectites: high preservation potential for organics Sediments: high preservation potential for textures

Ability to characterize

Geology, Geochemistry	✓	Minimal dust, clear outcrop exposures, wide variety of geochemical terranes
Context: Timescale and Stratigraphy	✓	Well Constrained

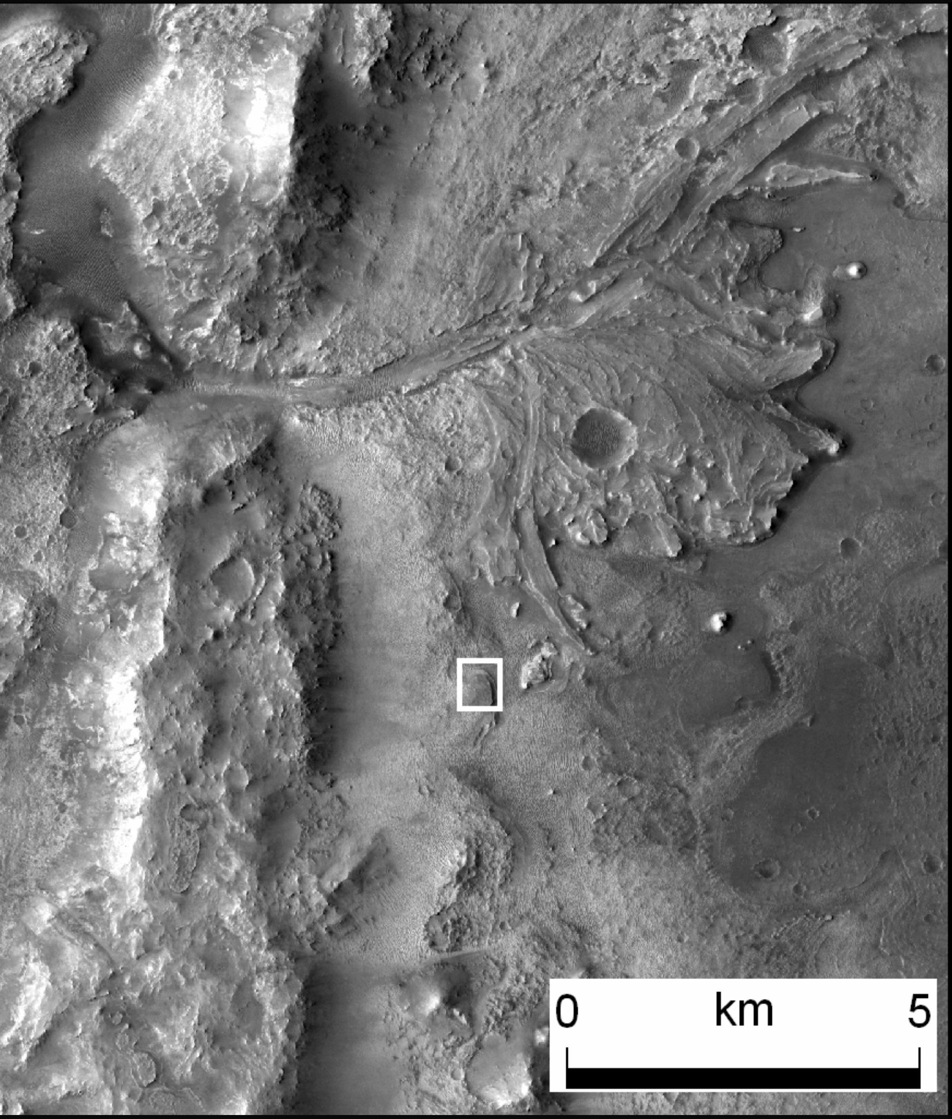
Summary

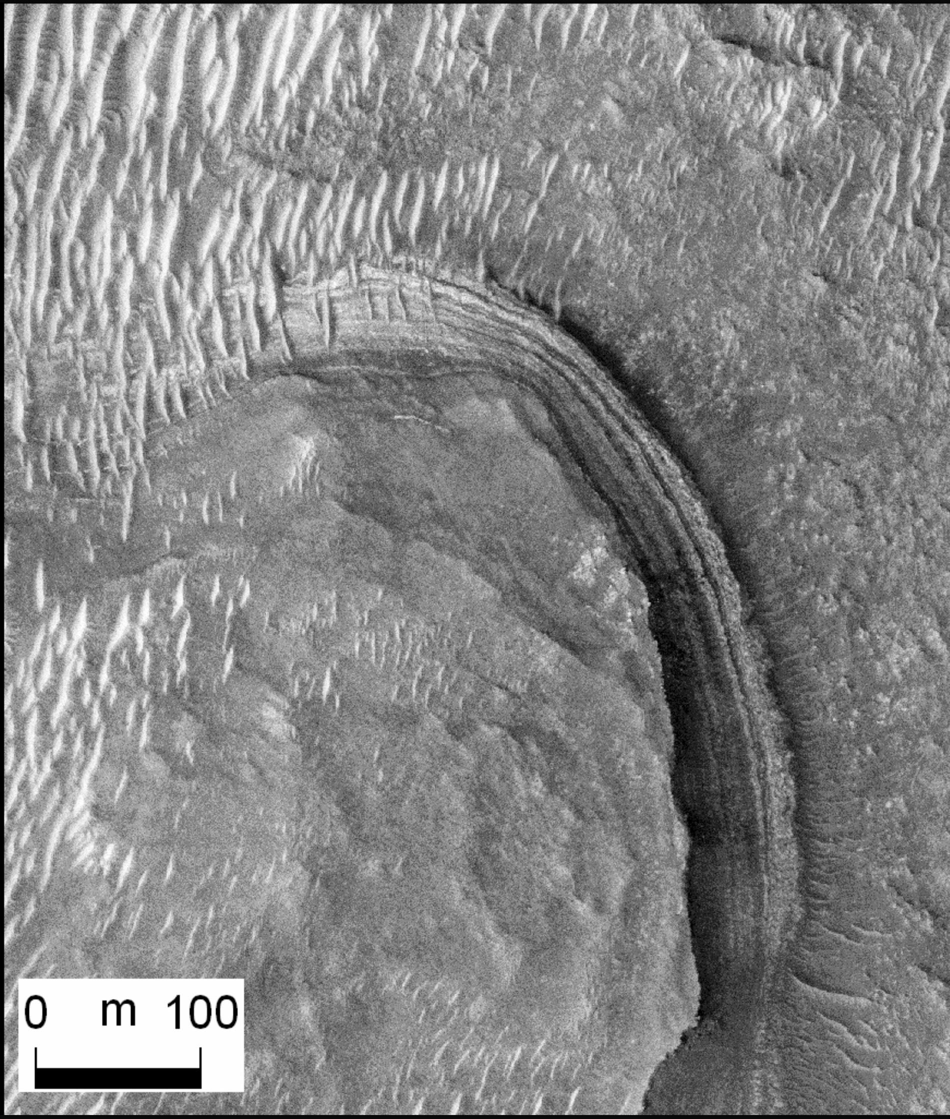
The Jezero Crater Landing Site is that it is compelling from a multitude of scientific standpoints:

- ***geomorphology and sedimentology***
- ***mineralogy and geochemistry***
- ***habitability and astrobiology***

Supplementals

Layering off the fan margin (paleo-shoreline?)

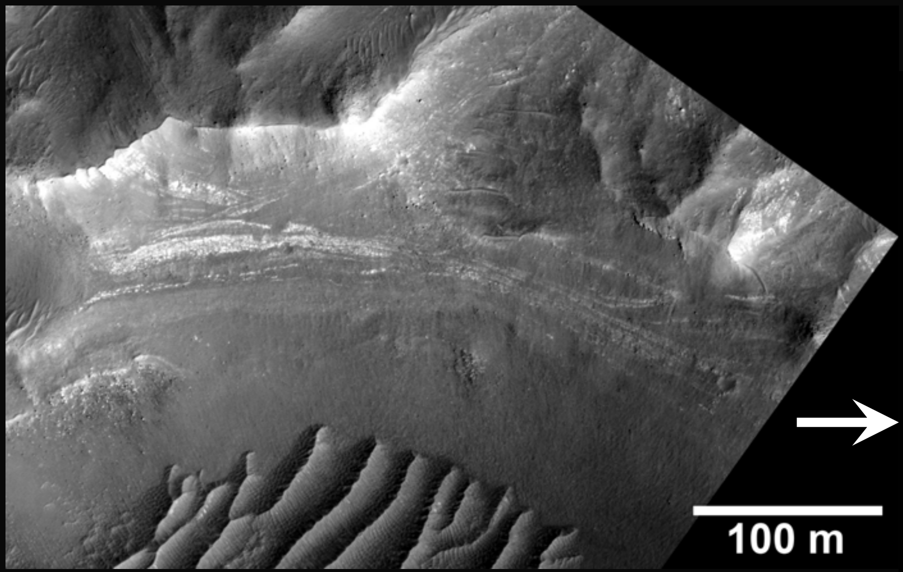


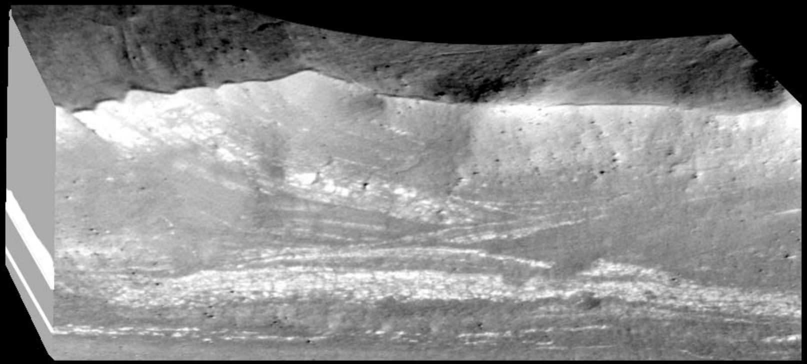


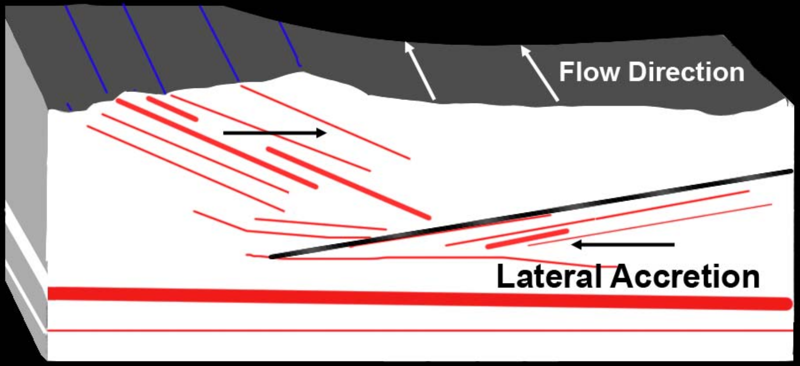
CTX Image P02_001820_1984

HiRISE, image PSP_003442_1985

Meanders/Lateral Accretion







Lateral Accretion deposits (courtesy Paul Heller, UWyoming)

Kayenta Fm., Jurassic, Colorado

Fassett et al., 2007 (in prep.)

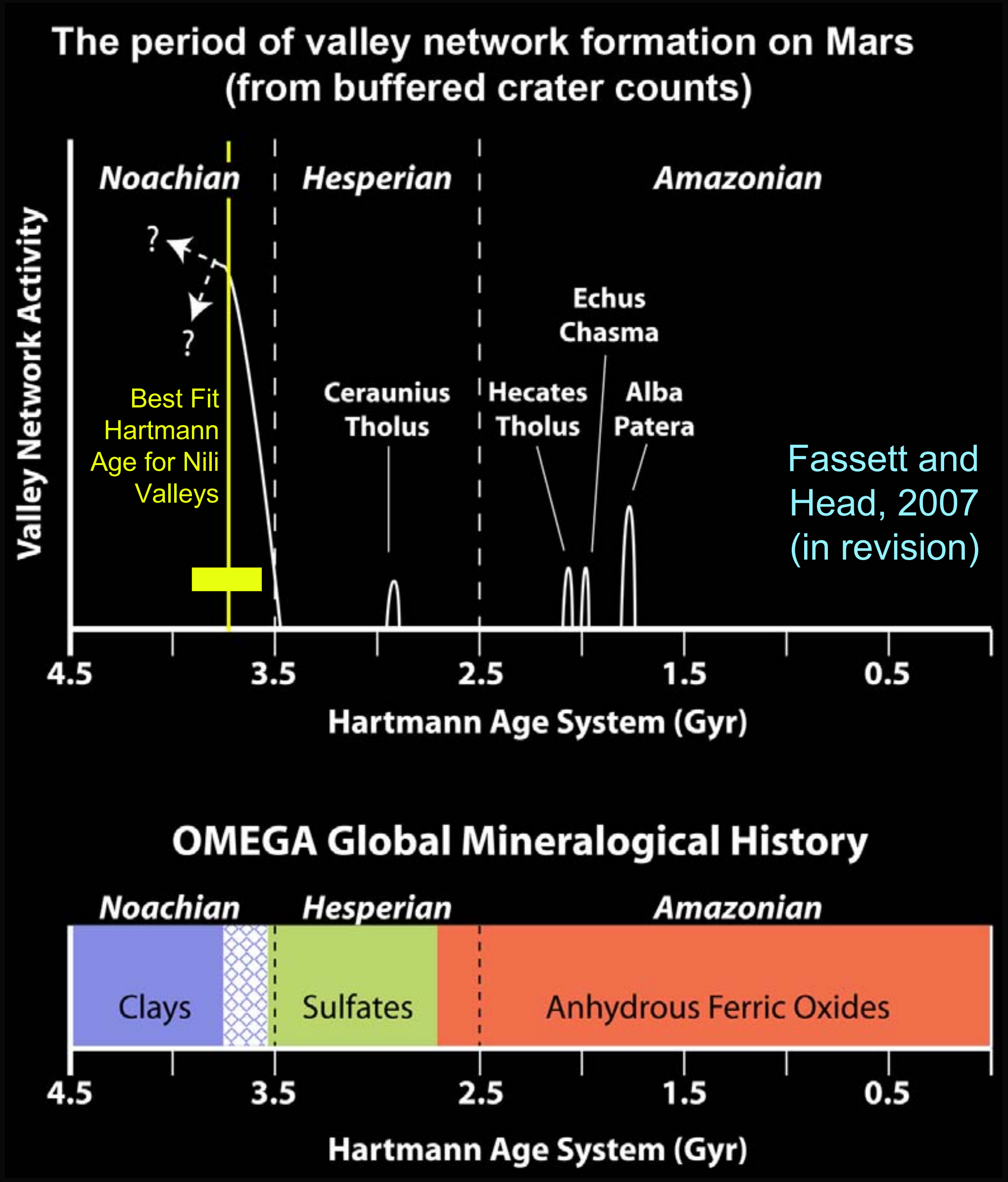
Age Constraints

Jezero crater deposits m*ust post-date:*

- Isidis
- Regional Phyllosilicate Formation

and *pre-date:*

- Strucutural activity of Nili Fossae graben
- Smooth floor unit deposition (likely Hesperian)



Bibring et al., 2006

Mafic Mineral Diversity

Pyroxene

Compositional transition from Npl to Hesperian Syrtis Major formation:

~60% (Noachian)

40% (Hesperian)

(Mustard et al., 2005; Thollot et al., 2007)

0.0 — 1.0

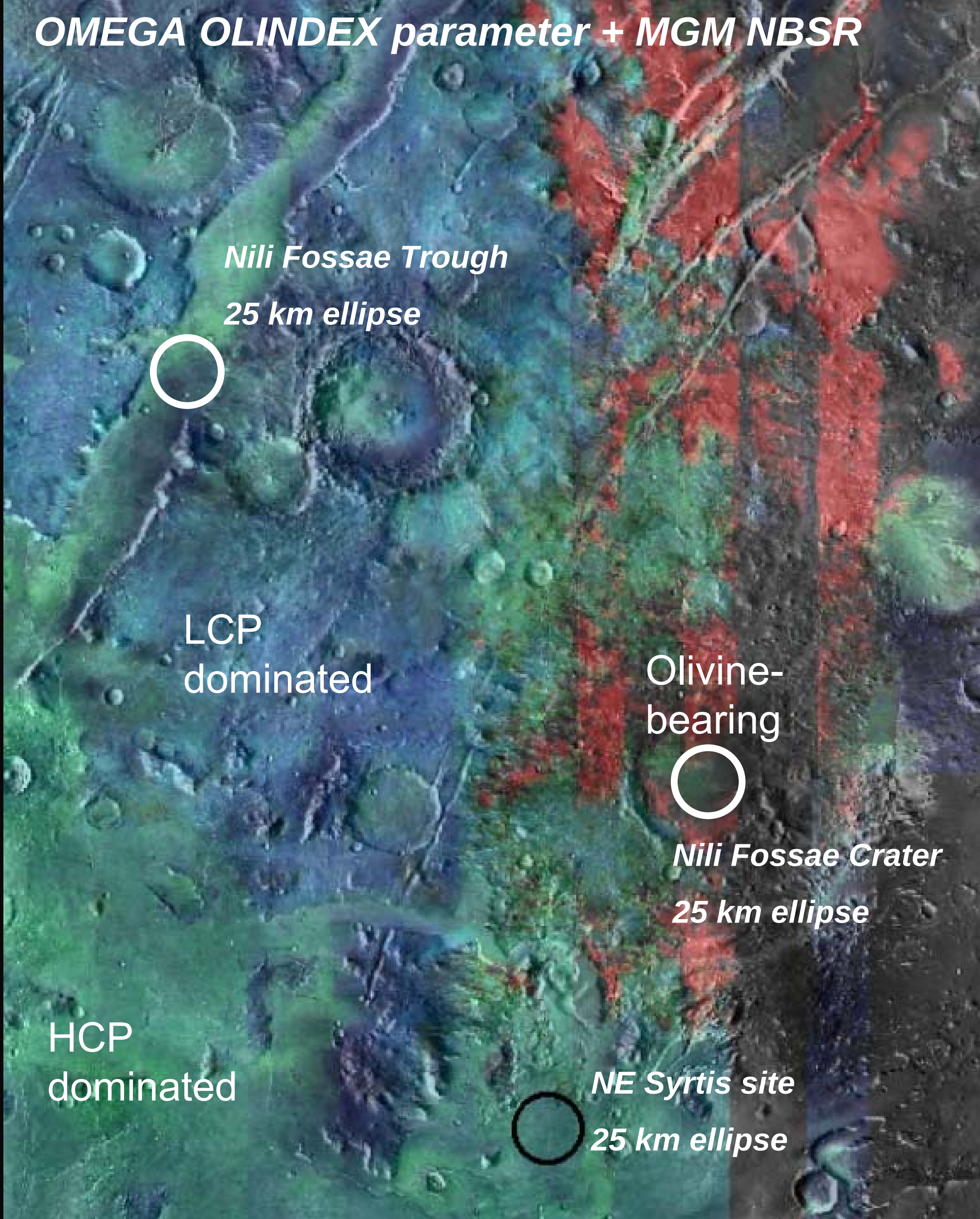
MGM band strength LCP/(LCP + HCP)

Olivine

Greatest concentration of olivine on the planet

(Hoefen et al., 2003; Hamilton and Christensen, 2005; Mustard et al., 2007)

OLINDEX > 0.015



Mineralogy of surface units – unratioed spectra