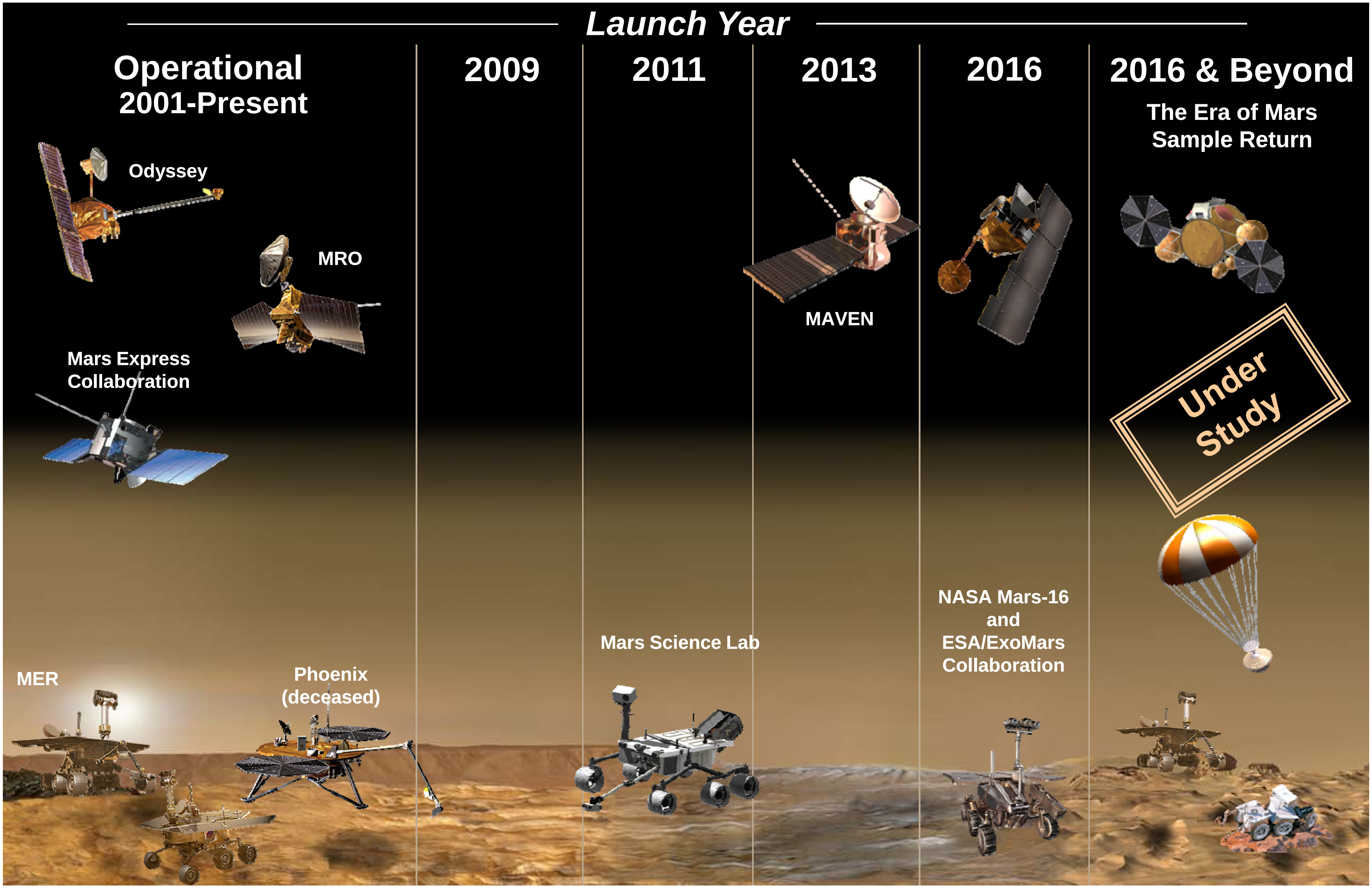
Mars Program Planning

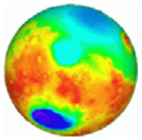
April 2, 2009

David Beaty

The Exploration of Mars

Where to From Here?





What have we discovered?

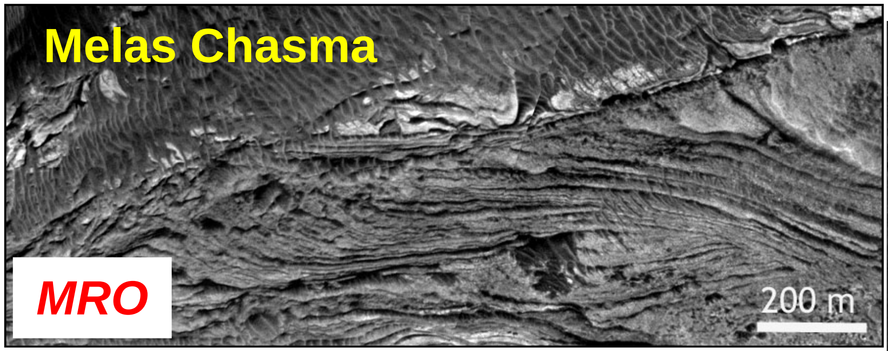
The 2003 projection of where our discoveries might take us

- **Search for Evidence of Past Life**
  - **Keys: Understand stratigraphy, biologic preservation potential**
  - **Low scientific risk: sedimentary targets are very large**
- **Explore Hydrothermal Habitats**
  - **H-t environments considered highly prospective for life**
  - **Can be pursued using in-situ missions**
- **Search for Present Life**
  - **Explore active aqueous areas**
  - **Need to access specific targets (small?, subsurface?); major PP issues; MSR required.**
- **Explore Evolution of Mars**
  - **Science in first decade significantly changes the questions to be asked**
  - **Need for planet-wide recon through second decade**

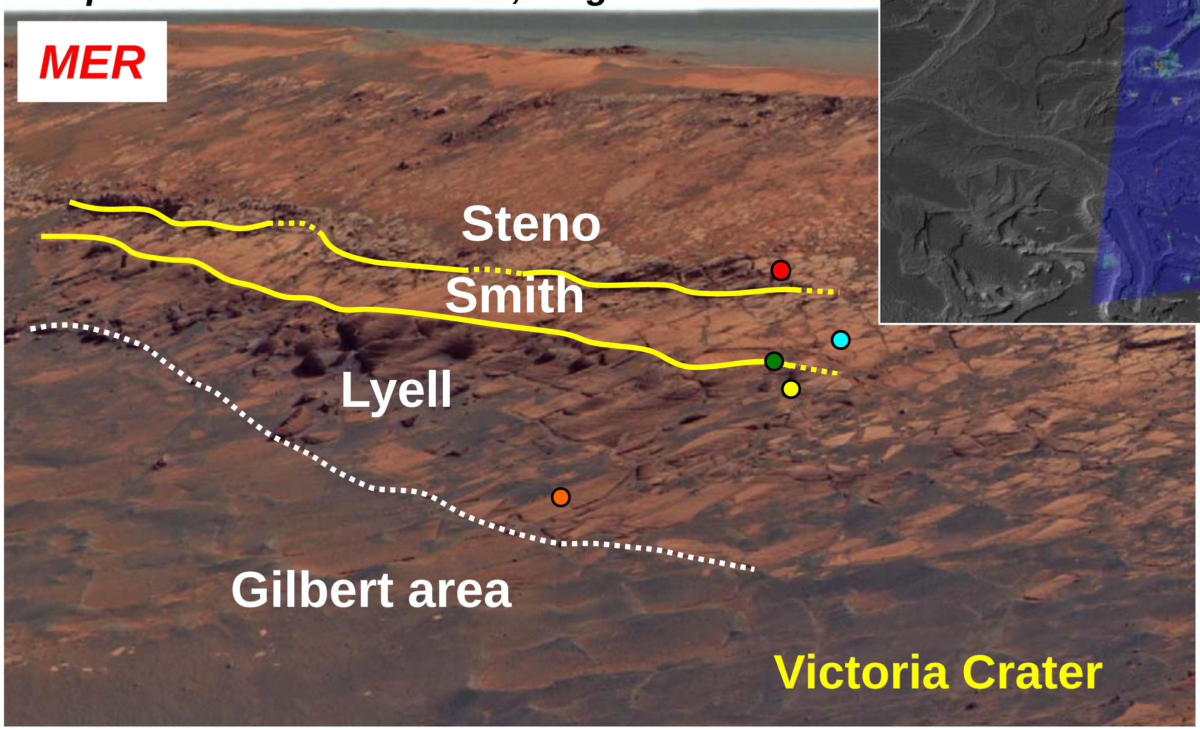
WHAT HAVE WE FOUND?

Discoveries: Major Sedimentary Record

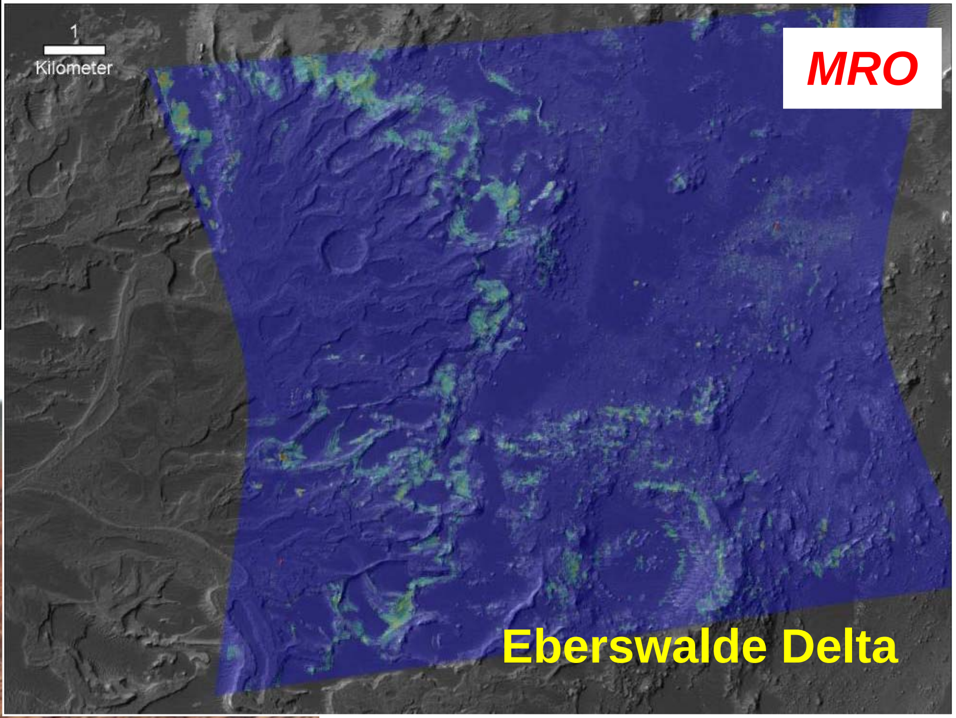
Large-scale sedimentary structures

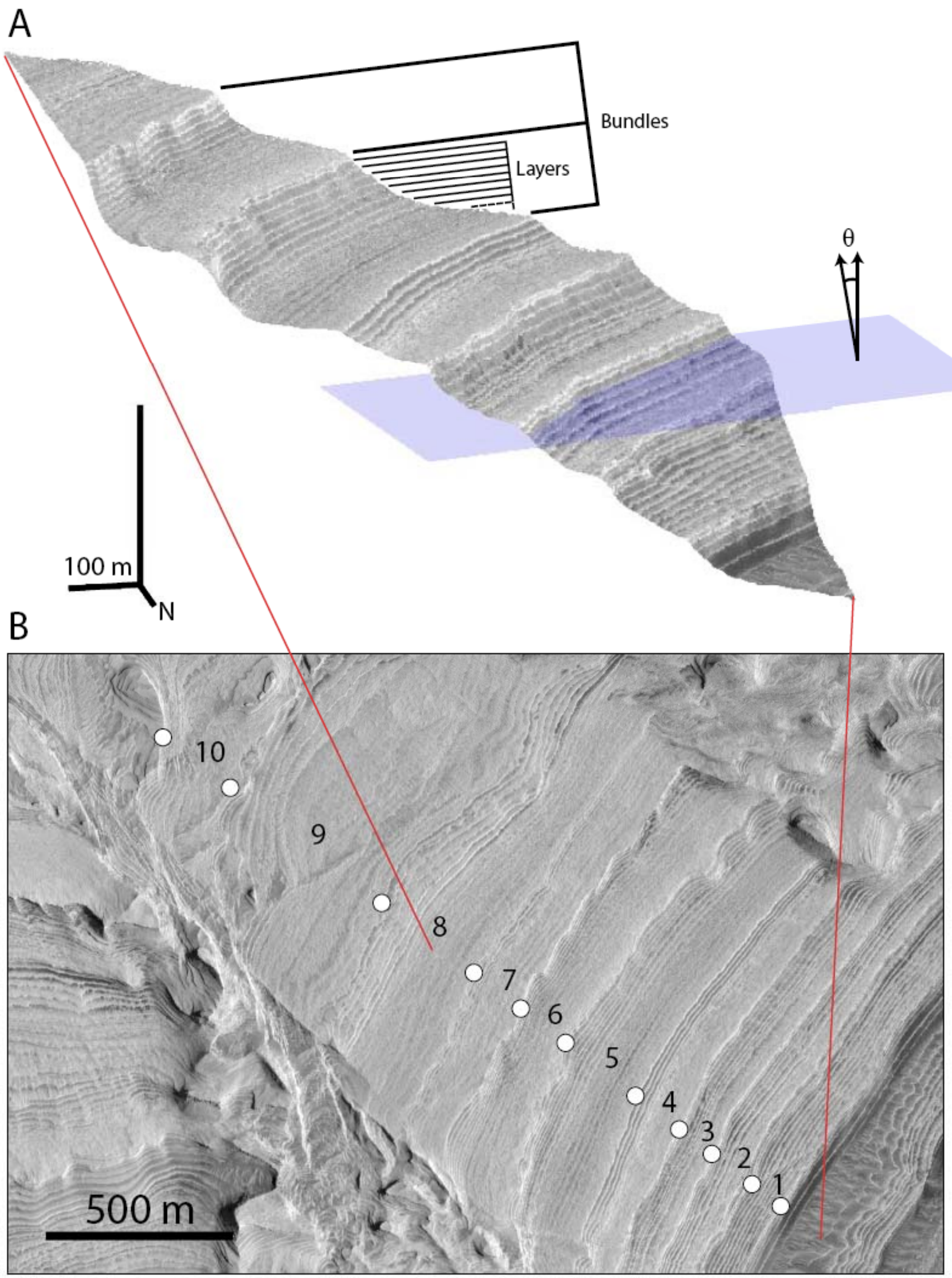


Hesperian subsurface water, diagenesis



Delta, showing phyllosilicate layers



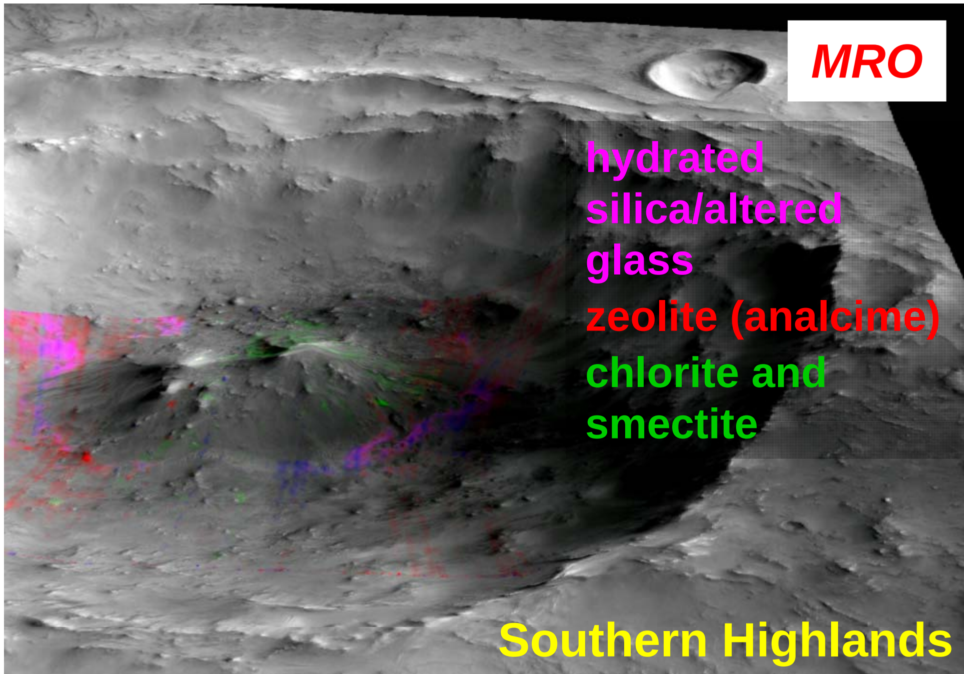


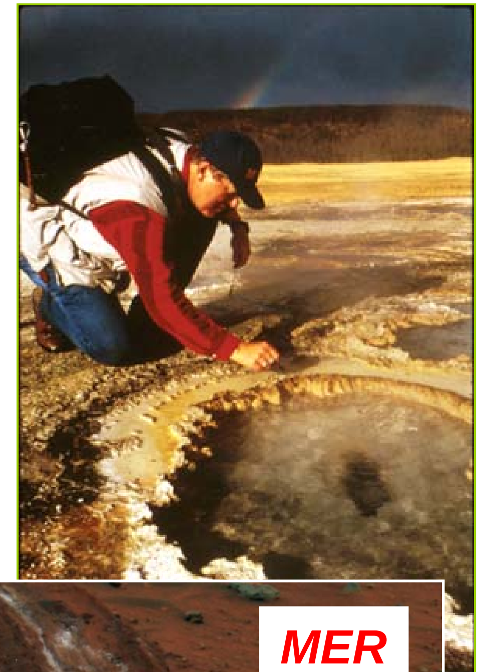
Quasi-Periodic Layering in the Sedimentary Rock Record of Mars. *Science* 5 Dec. 2008

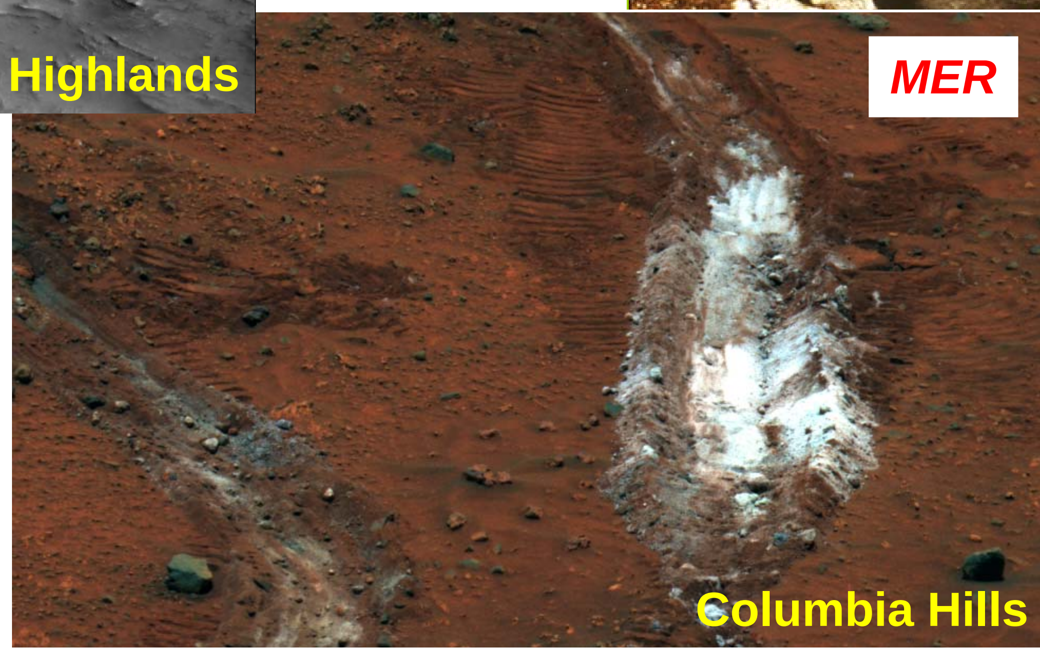
Kevin W. Lewis, Oded Aharonson, John P. Grotzinger, Randolph L. Kirk, Alfred S. McEwen, Terry-Ann Suer

With the tentative, but reasonable assumption that some water was required to lithify the Arabia deposits, the suggestion of orbital cyclicity implies that a hydrologic cycle may have been active at least intermittently over millions of years.

Discoveries: Past Hydrothermal Envir.





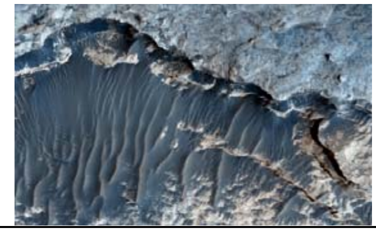
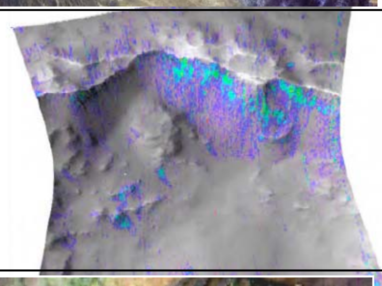
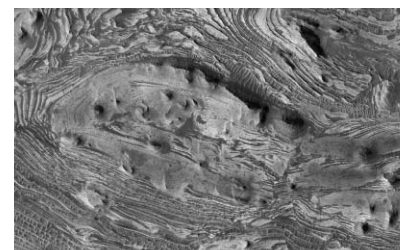
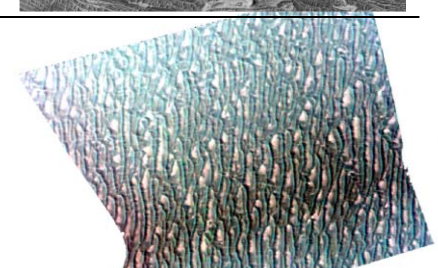
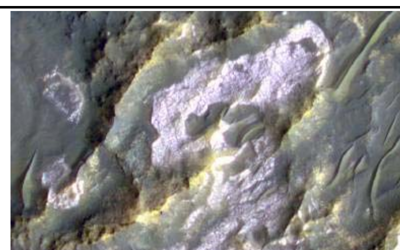
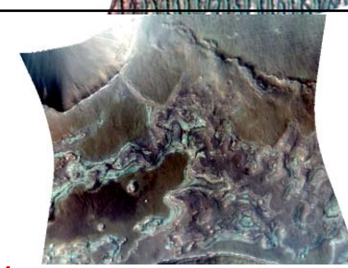


Widespread alteration, Southern Highlands

Ancient hydrothermal deposits

Discoveries: Diversity of Mars

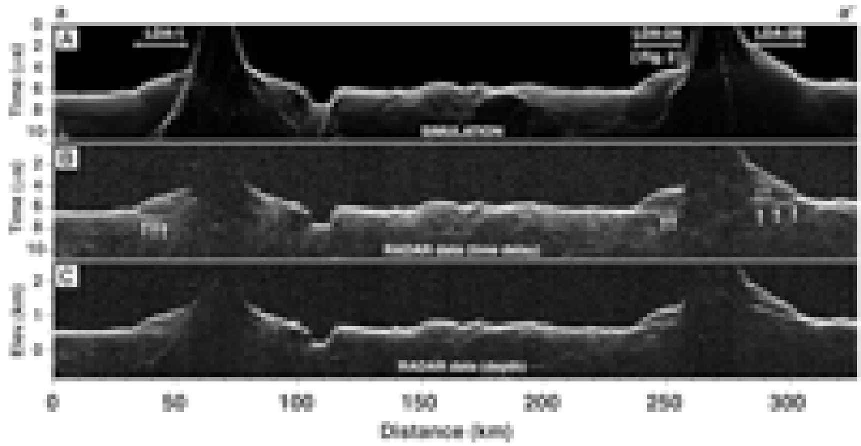
Mars' surface geology can be classified into a diverse number of different geologic terranes that formed in response to evolving planetary conditions.

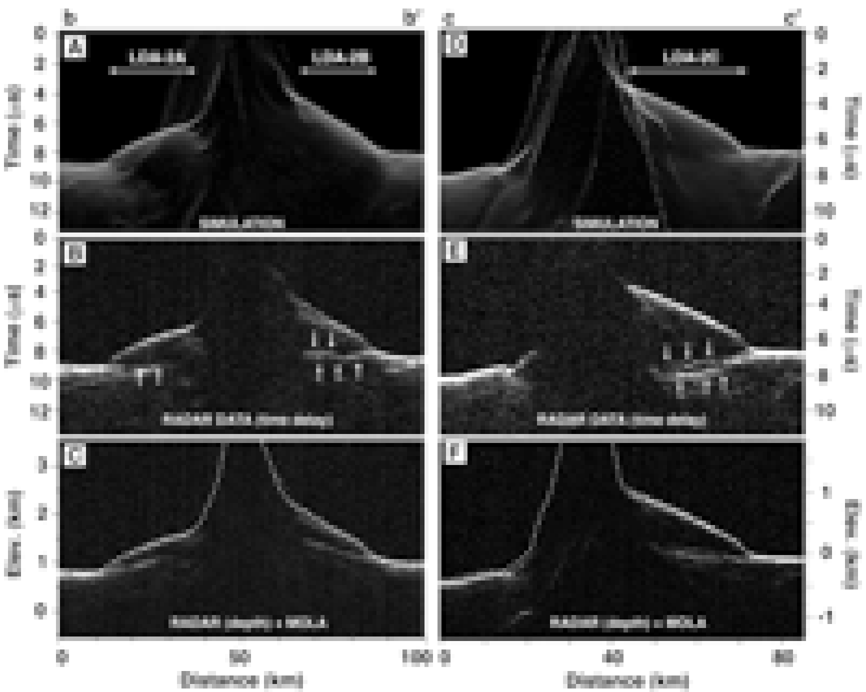
Noachian layered clays (type: Mawrth Vallis)		Noachian Meridiani-type layered deposits (type: Terra Meridiani)	
Deep Noachian phyllosilicates exposed in highland craters, chasma walls (type: Tyrrhena Terra)		Hesperian Valles-type layered deposits (type: Candor Chasma)	
Noachian intra-crater fans with phyllosilicate-rich layers (type: Jezero Crater)		Amazonian gypsum deposits (type: Olympia Undae)	
Noachian "glowing terrain" (type: Terra Sirenum)		Thin Hesperian layered deposits with hydrated silica (type: Ophir Planum)	

Issa Question: To what extent would having in situ access to more challenging sites impact our future science driven exploration of Mars?

Radar Sounding Evidence for Buried Glaciers in the Southern Mid-Latitudes of Mars.

Science. 21 Nov. 2008,
John W. Holt, et al.

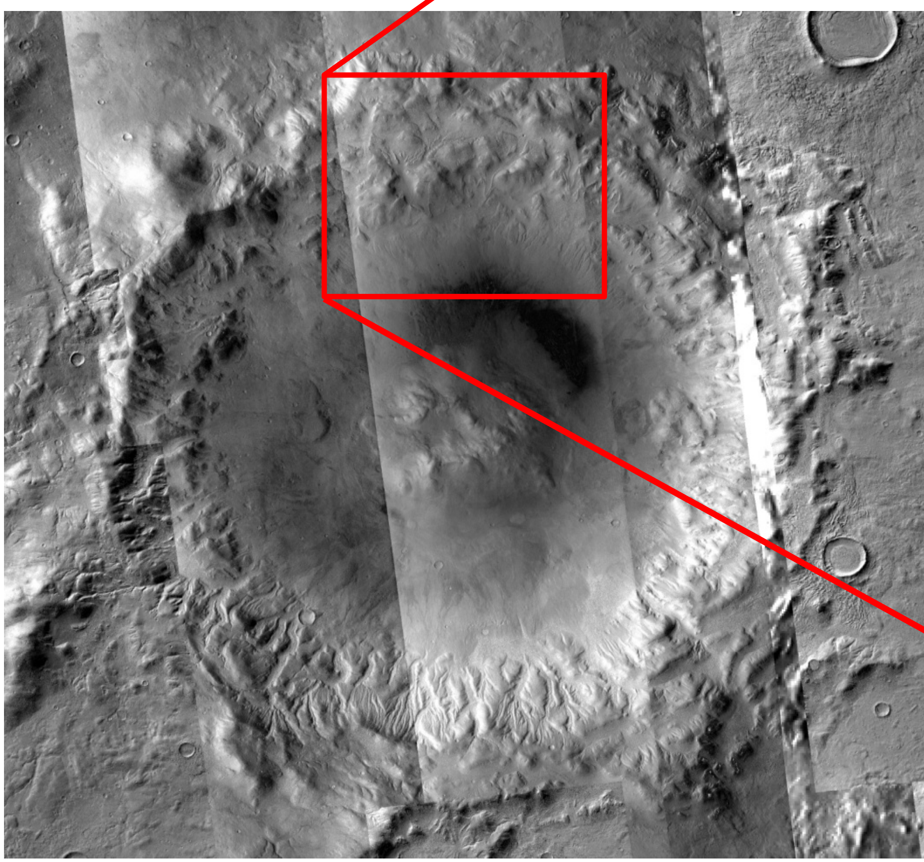


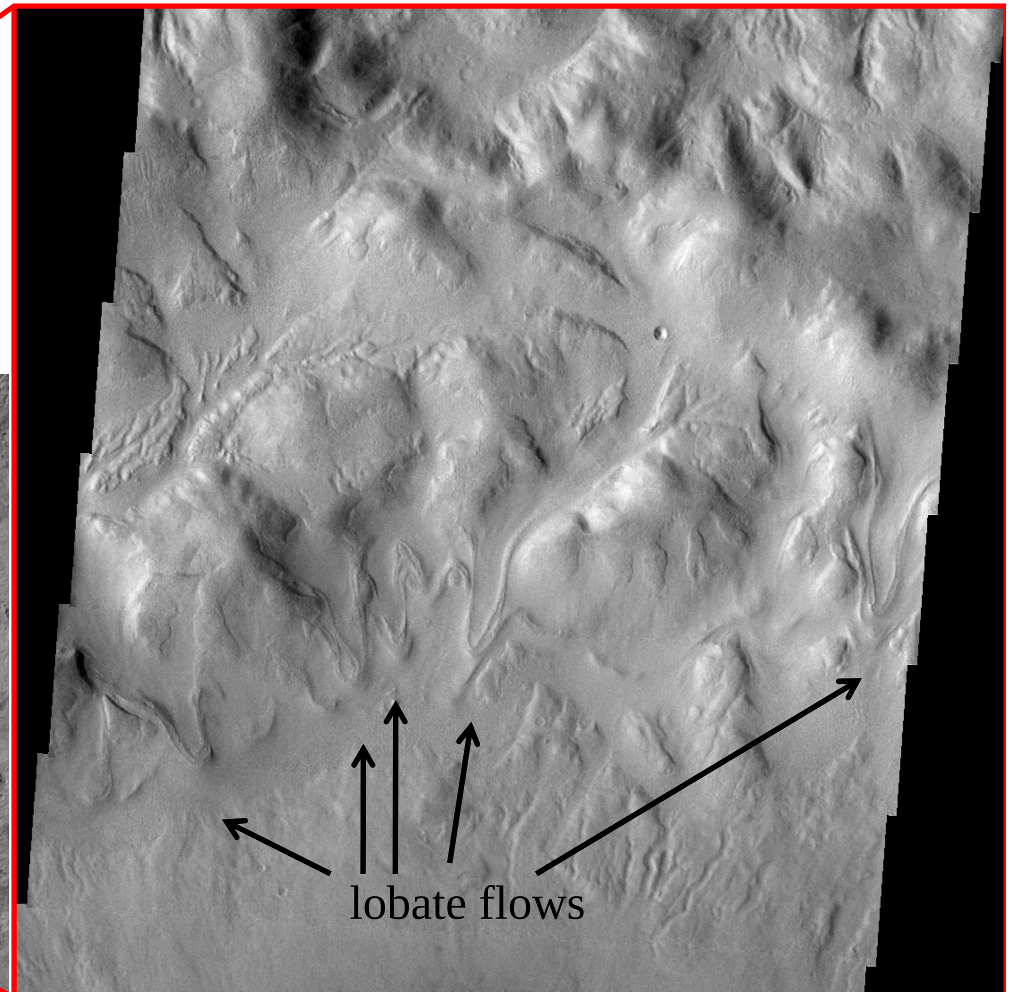


Soundings in eastern Hellas region by SHARAD reveal radar properties entirely consistent with massive water ice, supporting debris -covered glaciers. These results imply that these glaciers harbor large quantities of water ice derived from high-obliquity epochs, now concealed beneath a thin protective layer.

Mid-Latitude Craters Show Evidence for Flow of Water/Ice on Mars

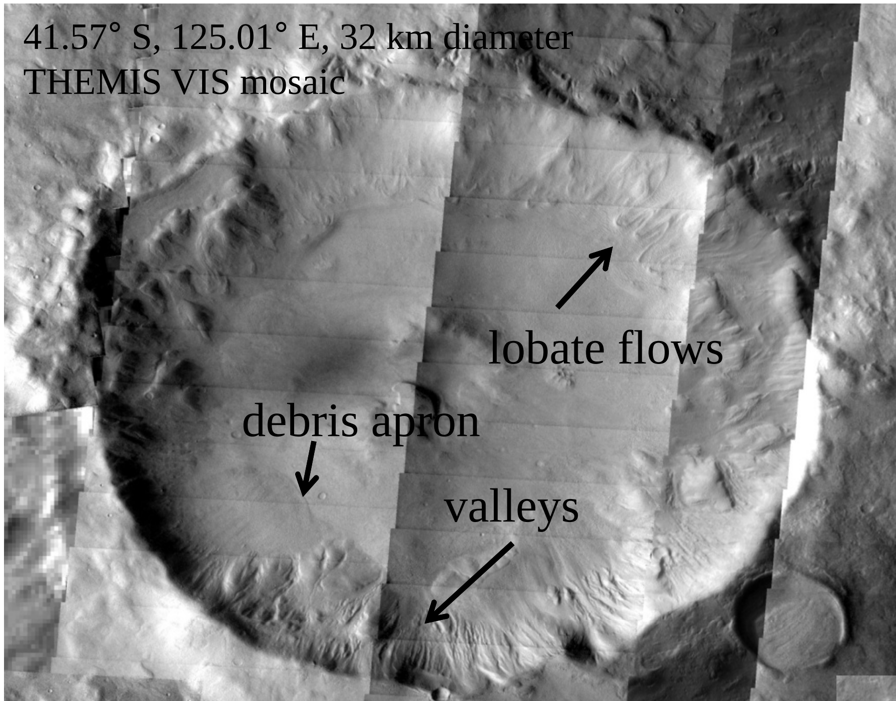
Icarus, 2009 Daniel C. Berman, David A. Crown, Leslie F. Bleamaster III





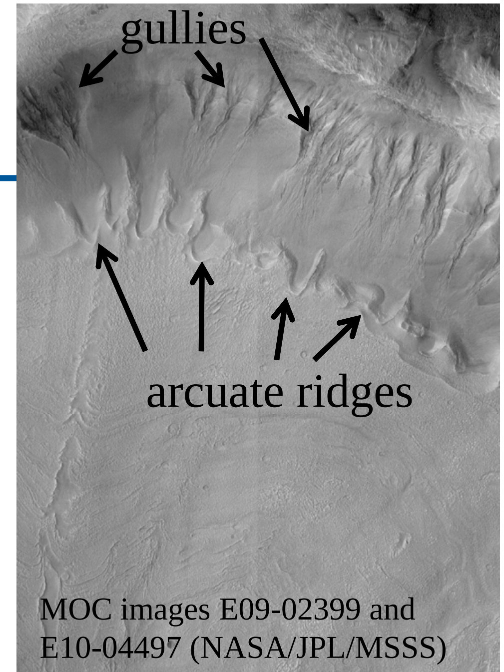
THEMIS VIS image V08298002
NASA/JPL/ASU

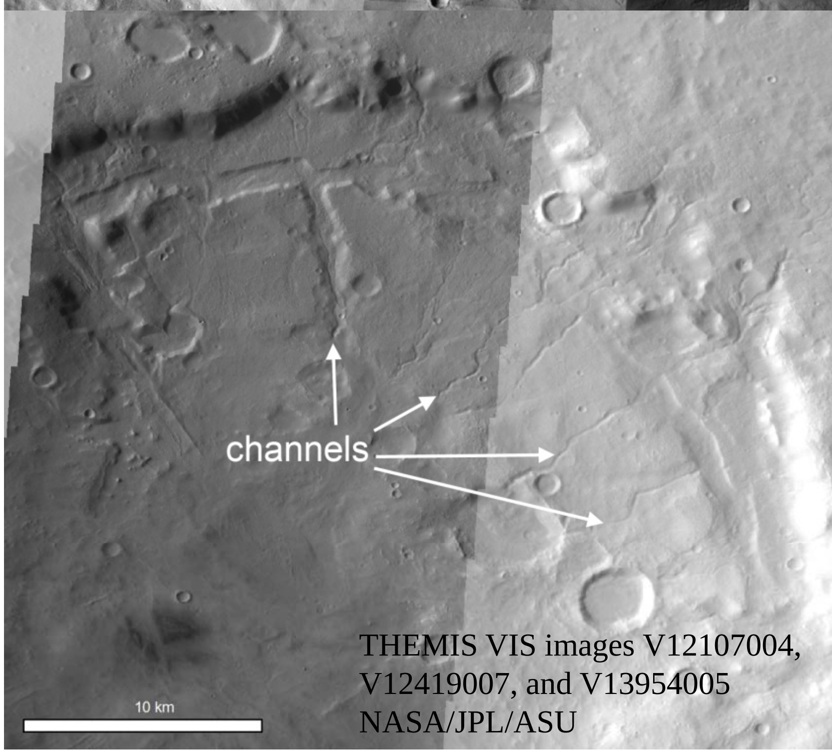
70 km diameter (39° S, 112.65° E)

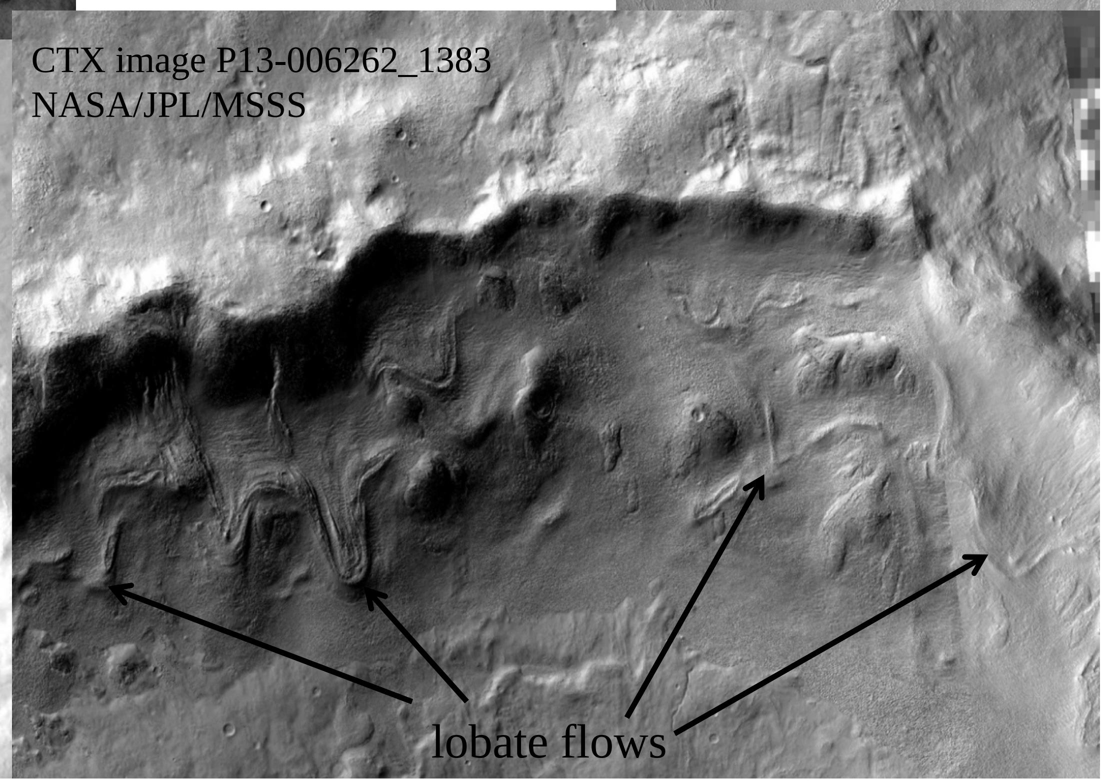


Flow features in Martian craters:

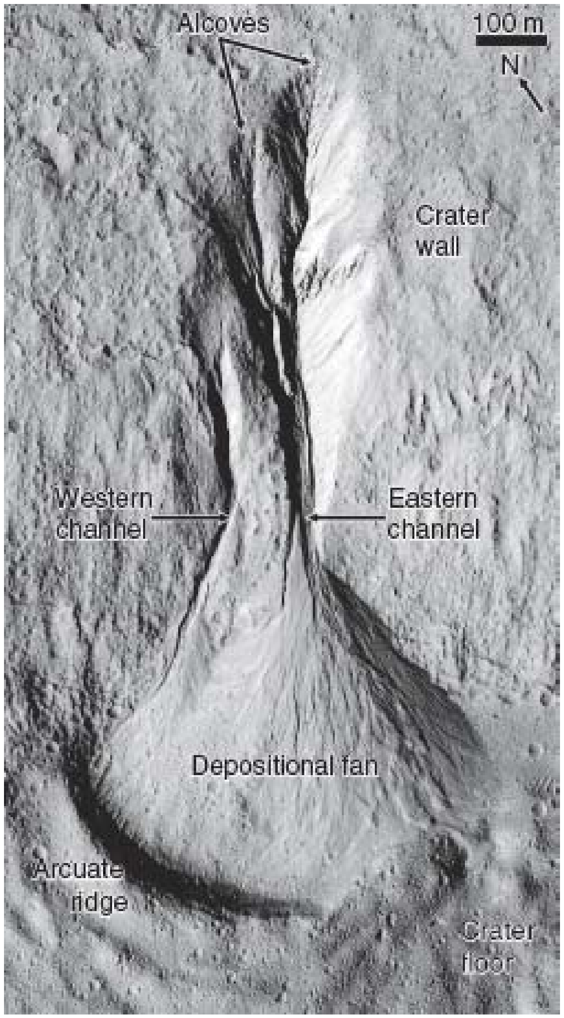
FEATURE	*Flow*
Lobate flows	ice
Channels	water
Valleys	ice
Debris aprons	ice
Gullies	water
Arcuate ridges	ice



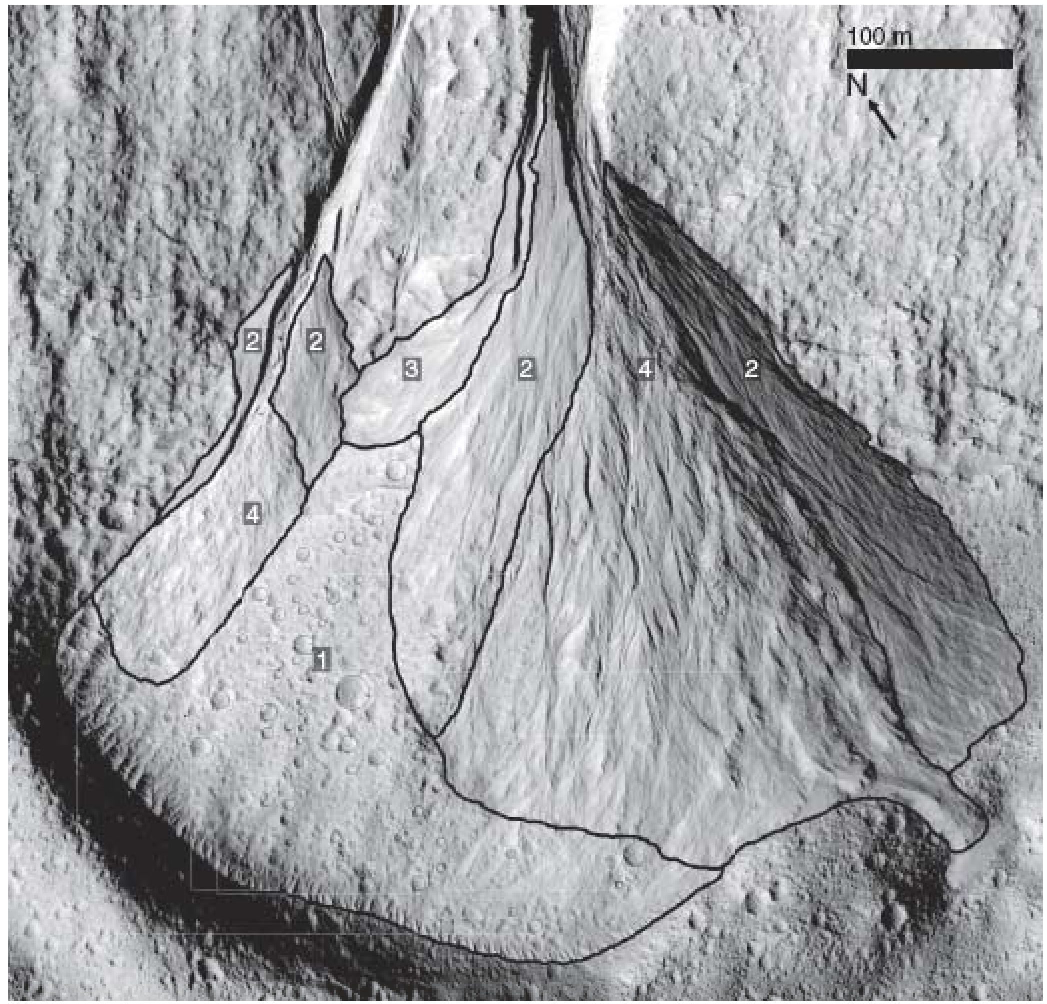




Unique chronostratigraphic marker in depositional fan stratigraphy on Mars: Evidence for ca. 1.25 Ma gully activity and surficial meltwater origin.*Geology* Mar. 2009



Samuel C. Schon, James W. Head, Caleb I. Fassett

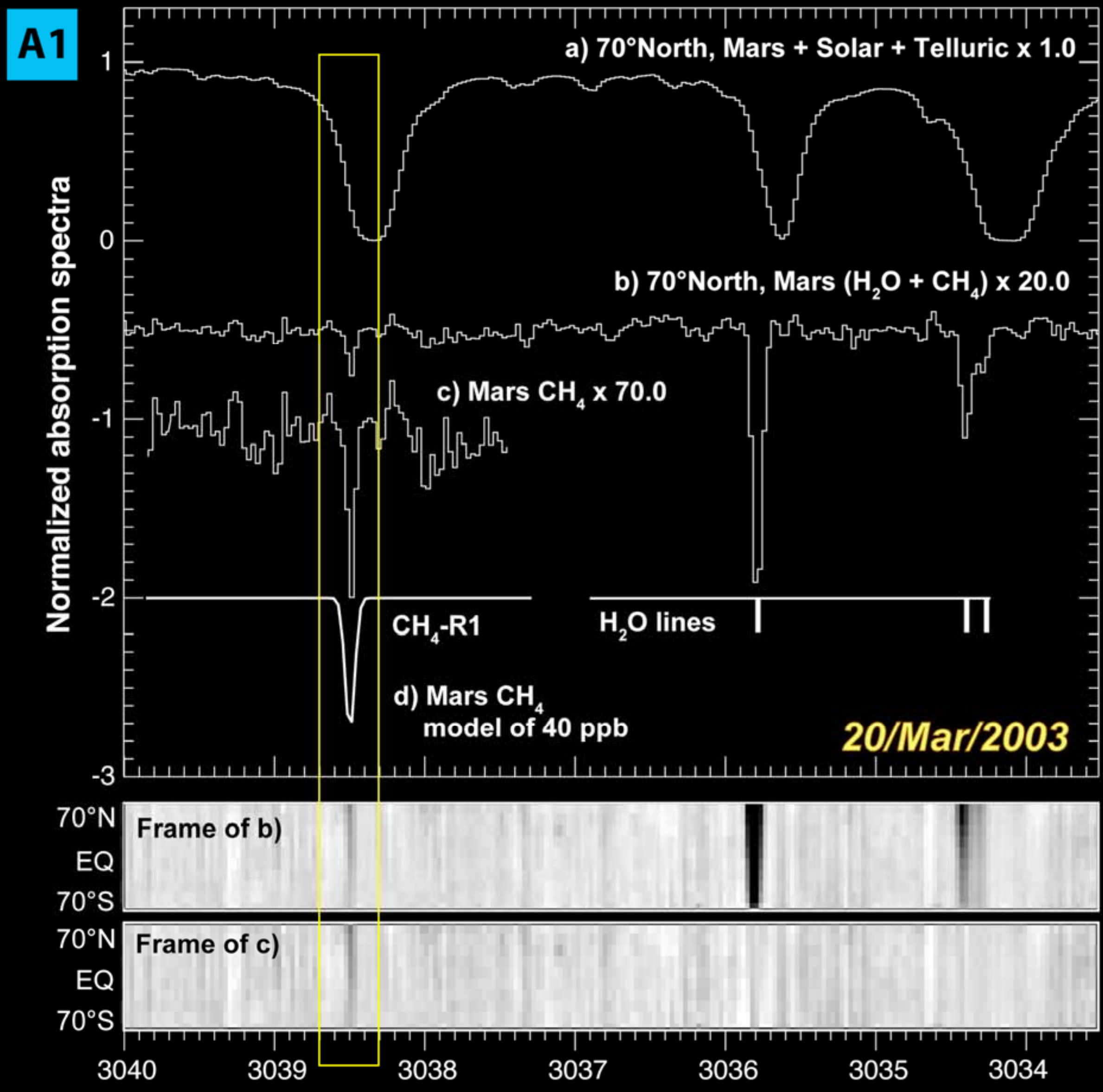


Eastern Promethei Terra Crater

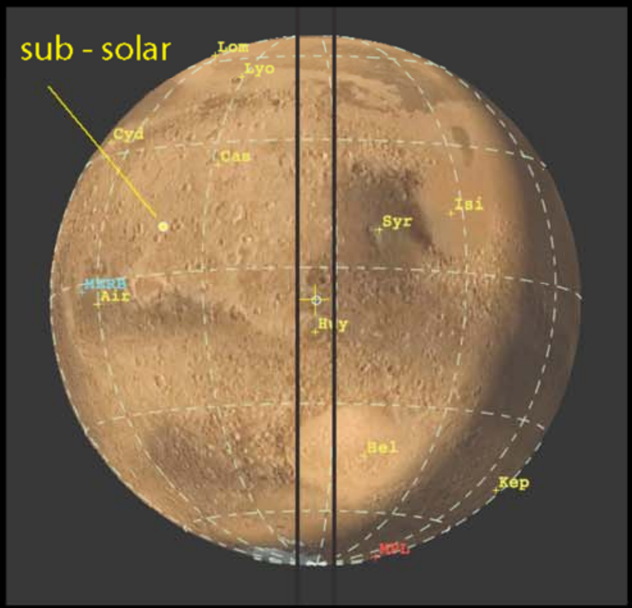
Issa Question: What would an in situ mission to such sites provide that we cannot get from orbit?

Mumma, Villanueva, Novak, et al. Science (submitted)

A detection theorem satisfied: CH_4 R1 and H_2O (3 lines) are detected



Mid - summer
(North, L_S= 155°)

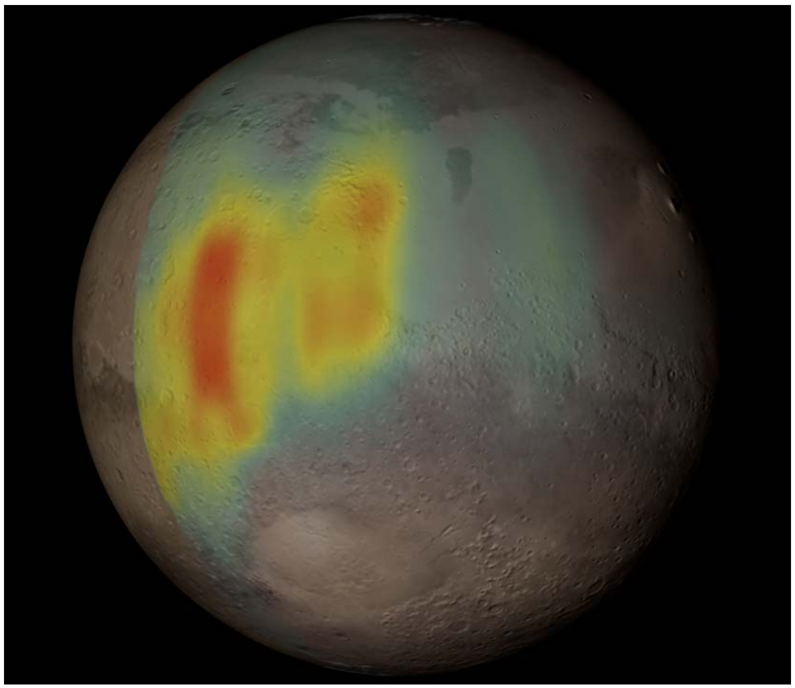


Both gases are enhanced in North

Strong Release of Methane on Mars in Northern Summer 2003

M.J.Mumma, G.L.Villanueva, R.E.Novak, T.Hewagama, B.P.Bonev, M.A.DiSanti, A.M.Mandell, M.D.Smith. ***Science*** Jan. 15, 2009

R1 &R0 methane lines are detected and mixing ratios vary from <3ppbv – 60ppbv



- ***Methane varies with location, source strength rivals terrestrial gas seeps***
  - ***A strong peaks are seen over Terra Sabae, Nili Fossae, and Syrtis Major (SE quadrant)***
  - ***The source strength > 0.6 kg/sec***
- ***Lifetime of methane is <4 years***
  - ***Methane lifetime from photo-chemical destruction is ~350 years***
  - ***Need new model for its destruction, perhaps oxidants on airborne dust***

The big question: Is methane produced biologically or geologically?

Either way, Mars must be active today

WHAT NEXT?
Where are our discoveries leading us?

Ancient life—potential has increased

- Lots of ancient liquid water, surface and ground
- Past geological environments that have reasonable potential to have preserved the evidence of life, had it existed.
- Understanding variations in habitability potential is proving to be an effective search strategy

⇒ SUMMARY: We have a means to prioritize candidate sites, and reason to believe that the evidence we are seeking may be preserved and is within reach of our exploration systems.

Modern life—possible

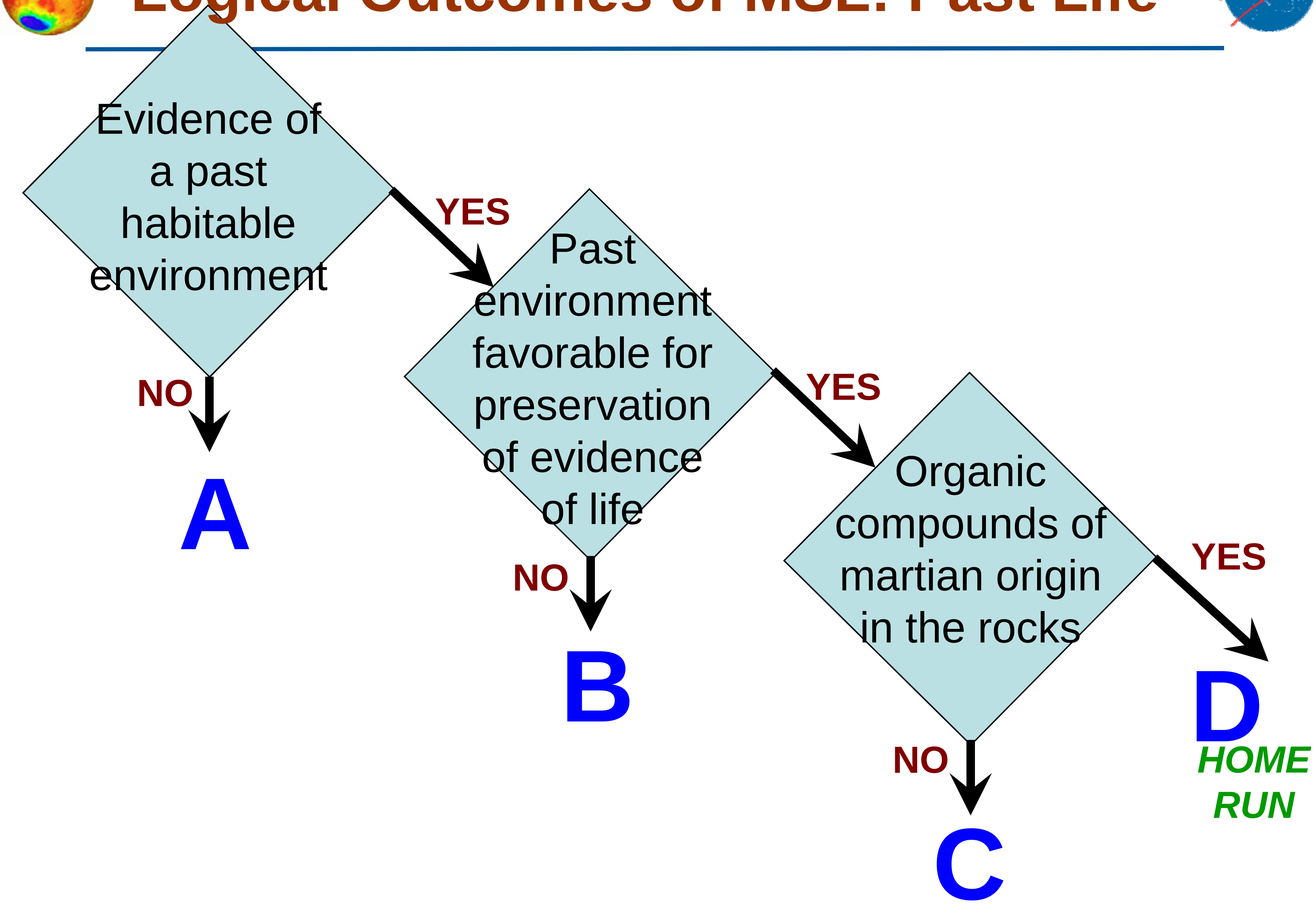
- Evidence of modern liquid water at surface is equivocal—probable liquid water in deep subsurface
- Methane may be a critically important clue to subsurface biosphere

⇒ SUMMARY: We have not yet identified high-potential surface sites, and the deep subsurface is not yet within our reach.

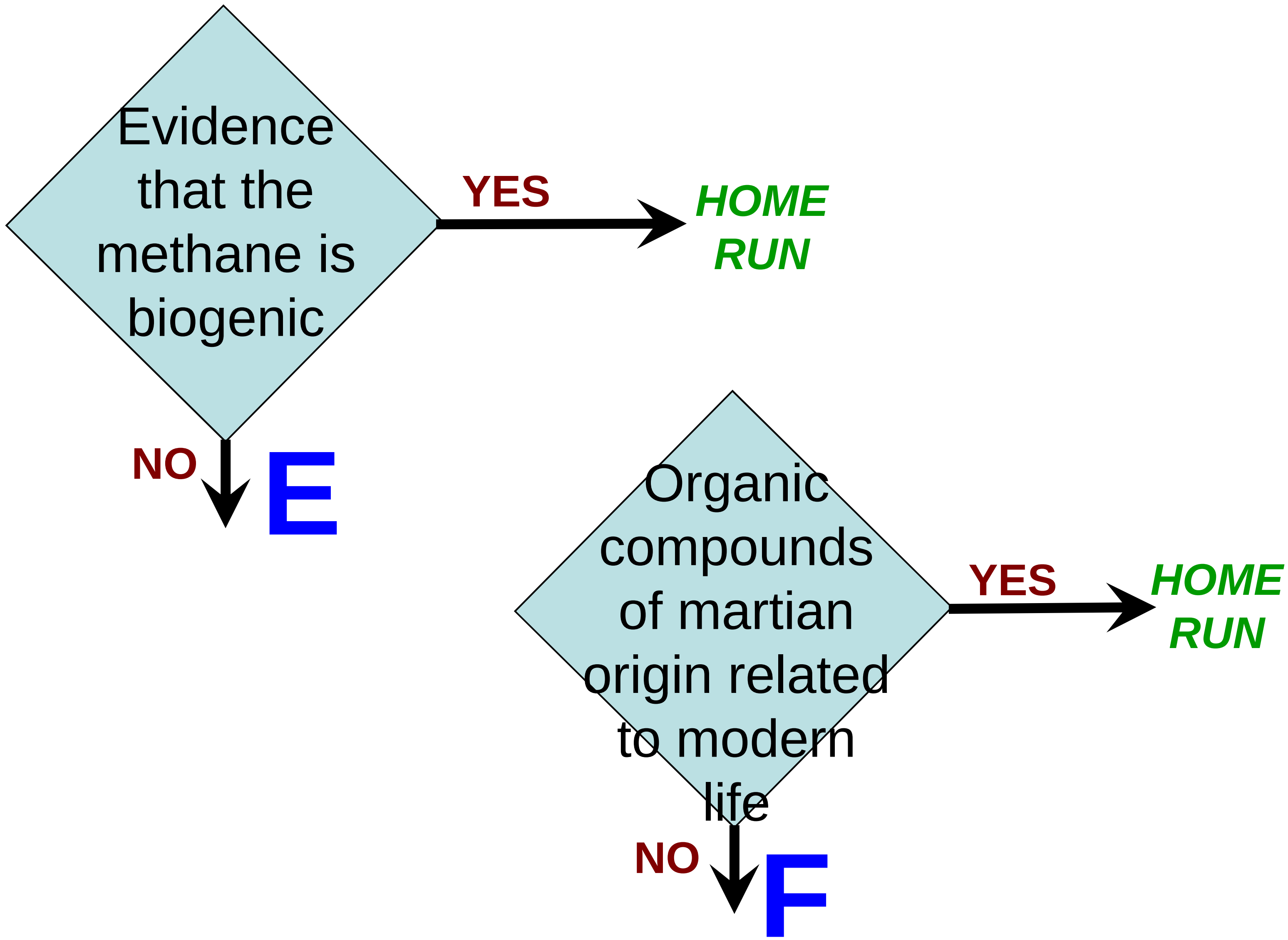
Mars is more diverse than previously thought

What are the primary logical outcomes from MSL?

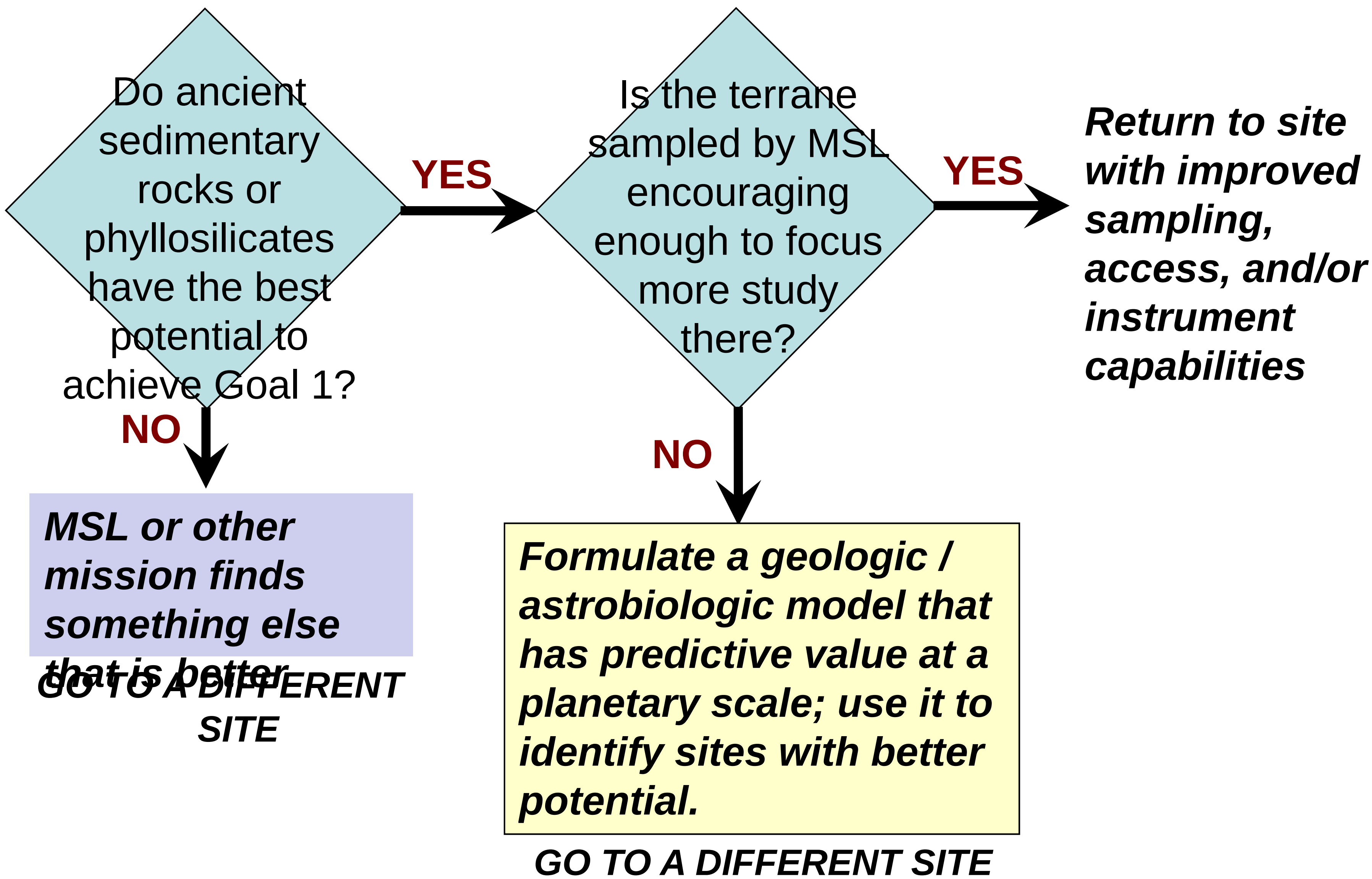
Logical Outcomes of MSL: Past Life



Logical Outcomes of MSL: Modern Life



MSL as a Test of MEPAG Strategies



Types of MSL outcomes and likely follow-up

MSL OUTCOME	FOLLOW-UP MISSION POSSIBILITIES			
	Rover to Same (S) or Different (D) Site	**Instrument (I) or Rover (R) capability upgrade**	**Vertical access**	**MSR**
Habitable past environments, no organics in rocks	D			
Past environments not good for preserving evidence	D			
Incomplete assessment of compelling deposits	S			M
Tantalizing interpretations but with ambiguity	S or D	I or R		
Interesting organic compounds in the soil but not in the rocks		I	V	M
Incomplete assessment of noncompelling deposits	D			
Instruments or rover/tools did not work as planned	S or D	I or R		

Possible Second Decade Mars Missions