6th Internat. Conf. on Mars Polar Science & Exploration
presented at MEPAG Meeting 33

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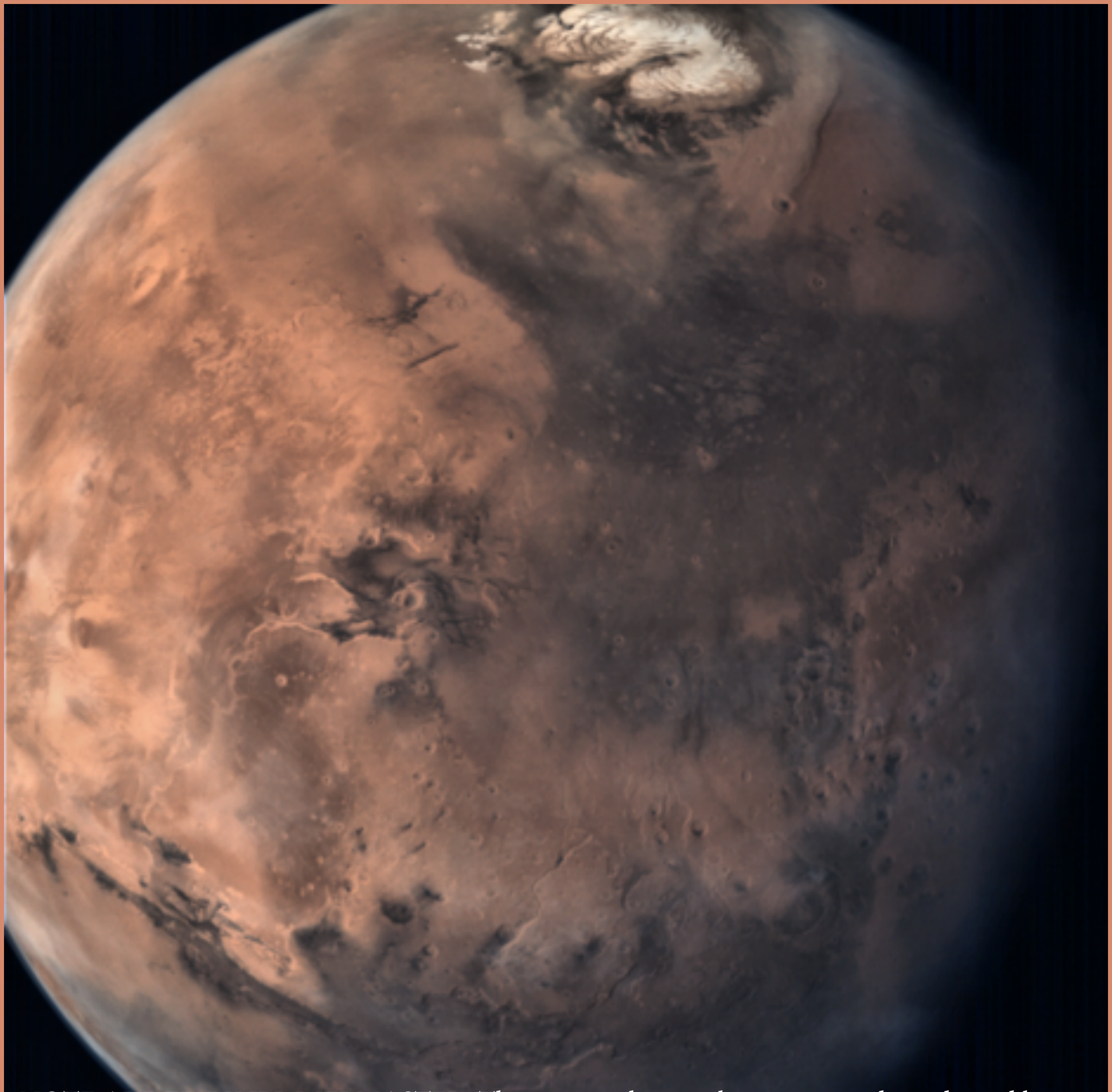


Smith, I.B., D. Beaty, T. Thorsteinsson (in press) Meeting Report, 6th International Conference on Mars Polar Science and Exploration, *EOS.*

Smith, I.B., S. Diniega, D. W. Beaty, T. Thorsteinsson,P. Becerra, A. M. Bramson, S. M. Clifford, C. S. Hvidberg,G. Portyankina, S. Piqueux,A. Spiga, T. N. Titus (in review), Introduction to the Special Issue on Mars Polar Science and Exploration: Conference Summary and Five Top Questions, *6th Mars Polar Conference Special Issue, Icarus*

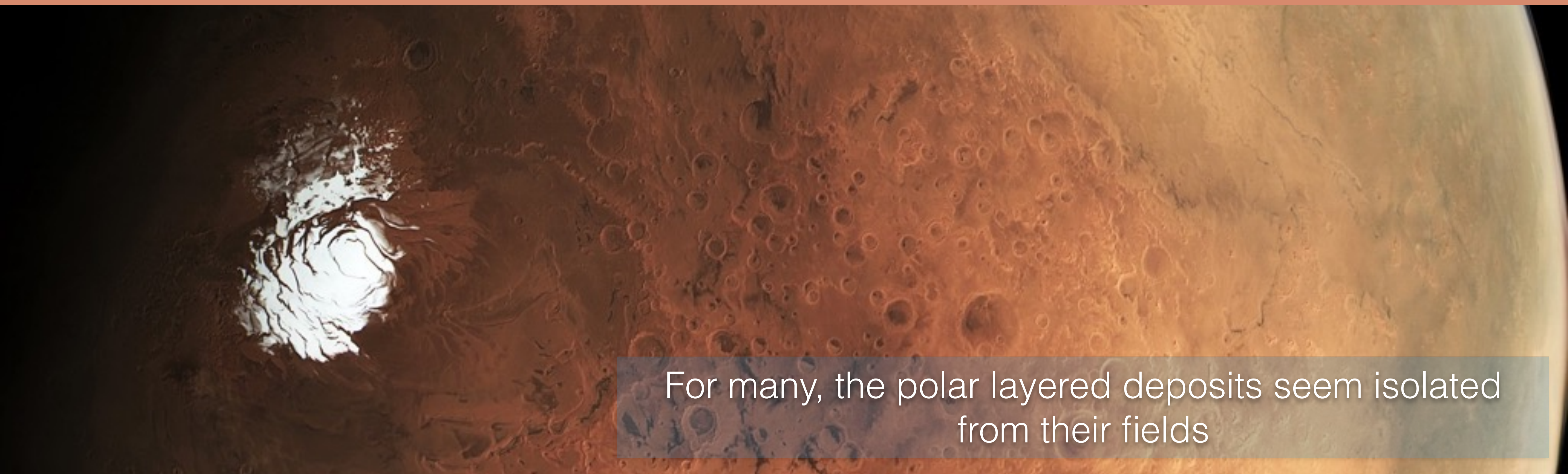
9 **articles** already submitted to special issue, at least 12 more promised

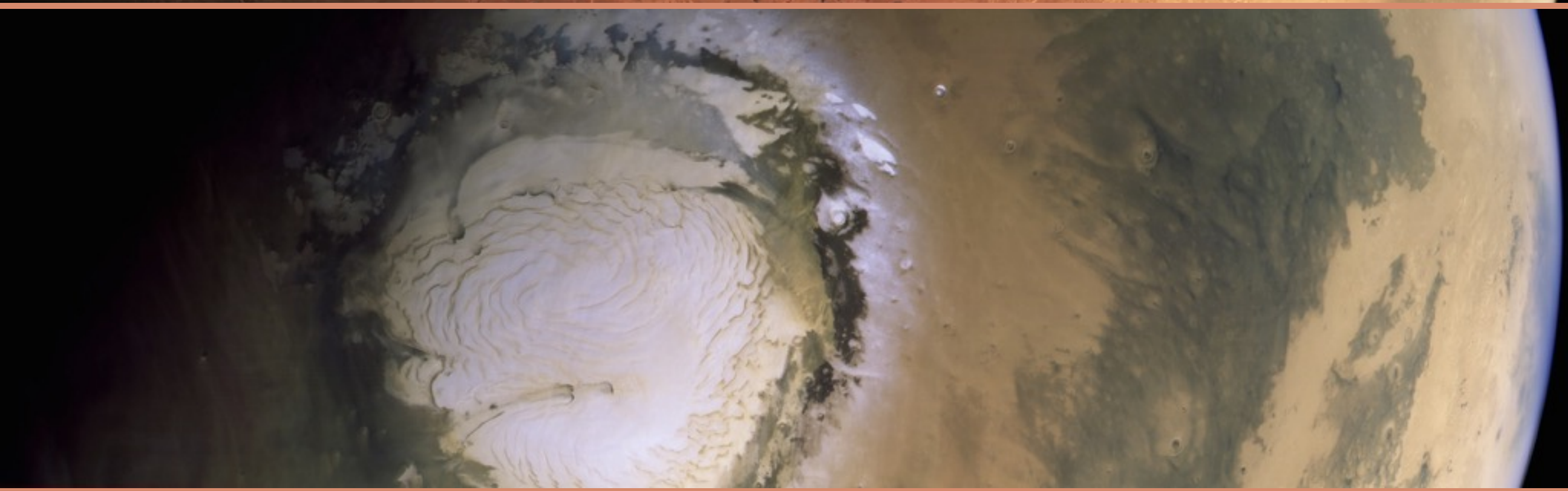
Held at University of Iceland in Reykjavik, September 5-9

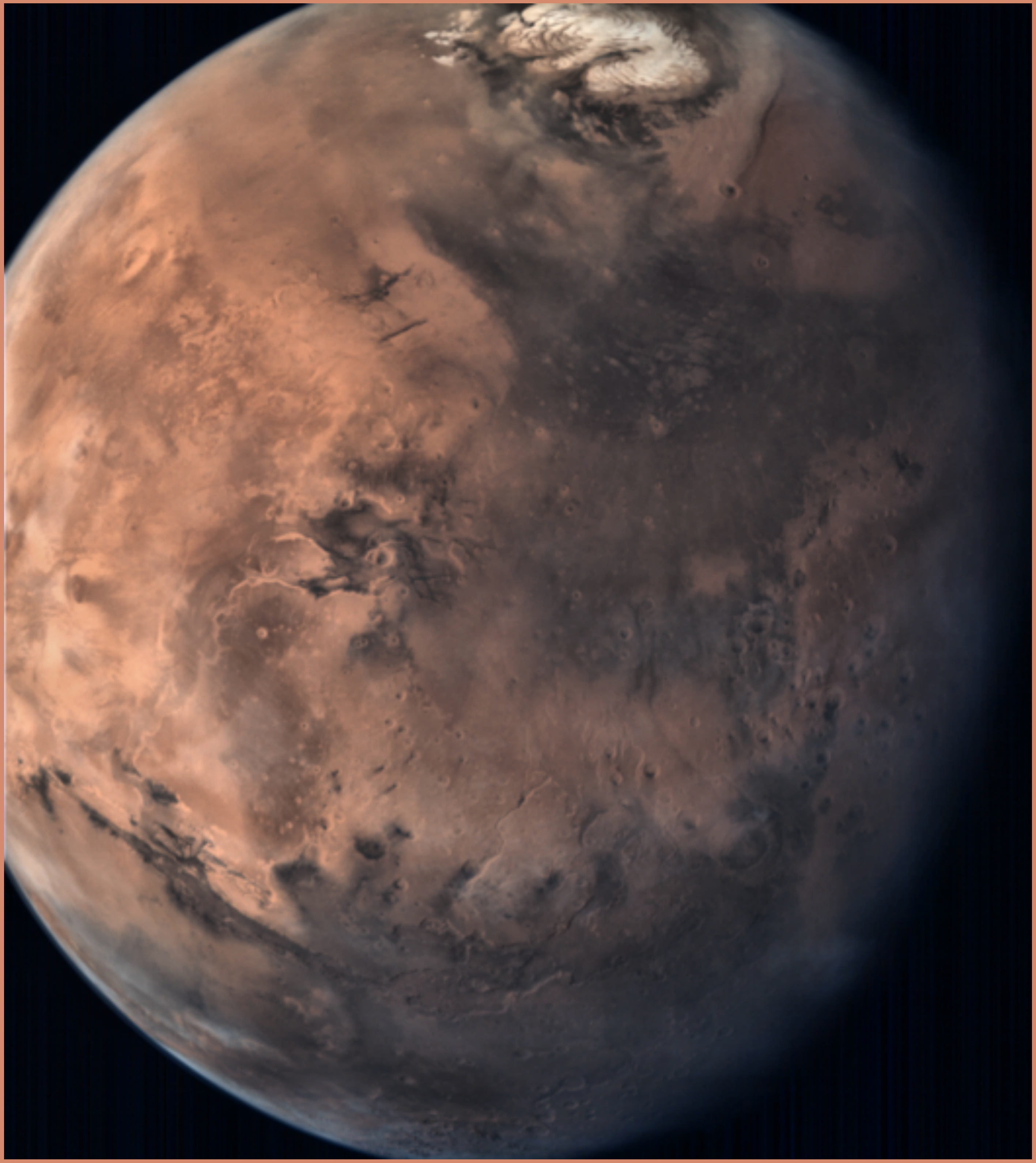
- **102 attendees from 11 countries**, >140 indications of interest
- 22 student presenters (12 students with financial support)
- 16 oral technical sessions followed by 15 minute discussion
  - Almost all oral requests were honored
  - Widespread engagement in discussion
- 3 simultaneous poster sessions
- 9 institutional sponsors
- 7 field trip options, including 3 options for mid-conference

Technical Sessions

- Present Polar Atmosphere: Dynamics
- Present Polar Atmosphere: H_2O and CO_2
- Volatiles and Diurnal or Seasonal Cycles
- Surface Activity
    1. CO_2 ice as a geomorphologic agent
    2. Surface Expression of Seasonal Processes
- Terrestrial Analogs
- The Martian Climate Record
    1. Polar Cap Edition
    2. Ancient and Modern Ground Ice
- Polar Geology
    1. Glaciers and Ground Ice
    2. Polar Geochemistry and Mineralogy
    3. Polar Structure
- Glaciology and the Physics of Ice
- Future Exploration of Mars Polar Regions


For many, the polar layered deposits seem isolated from their fields





The poles are a record of past climate, and polar processes drive current climate.

The poles influence:
movement of sand in dunes,
dust in the atmosphere,
isotopic ratios,
availability of volatiles,
melting point and stability of liquid water

- through time

no priority order, put together by designated synthesis team

Our primary questions (1 of 5)

Polar Atmosphere: What are the dynamical and physical atmospheric processes at various spatial and temporal scales in the polar regions, and how do they contribute to the global cycle of volatiles and dust?

Polar Atmosphere	
	Quantify the interplay of local, regional, and global circulations in the polar regions, including polar vortex, katabatic winds, transient eddies, among others
	Characterize the transport of volatiles and dust aerosols into and out of the polar regions
	Understand and predict the condensation of H_2O and CO_2 ice clouds and their impact on the thermal structure and atmospheric circulation
	Estimate the amount of CO_2 and H_2O frost deposited and lost at the surface via precipitation or sublimation
	Determine dust deposition patterns over the PLD and the specific mechanisms enabling dust lifting

no priority order, put together by designated synthesis team

Our primary questions (2 of 5)

Polar Ices: What do physical characteristics of the Martian PLD reveal about their formation and evolution?

Perennial Polar Ices	
	Determine the energy and mass balance of the polar ice reservoirs, and characterize volatile fluxes (i.e., seasonal deposition and removal, long term accumulation vs. erosion, when and where, at what rates)
	Characterize current/recent perennial ice landforms such as the south polar residual cap and associated features (i.e., distribution, variety, composition, and evolution) and their relationship with seasonal processes
	Quantify the role and efficiency of dust and sand as agents promoting the preservation of buried volatiles
	Determine the vertical and horizontal variations of composition and physical properties of the materials forming the polar layered deposits
	Identify and quantify the differences and similarities between the NPLD and SPLD
★	*Identify where and hypothesize as to why ice flow model predictions do not match observations*

★ We have absolutely no idea

no priority order, put together by designated synthesis team

Our primary questions (3 of 5)

Past Climate: How has the Martian (polar) climate evolved through geologic history, and what record exists of past-states?

Past Climate (Polar) Record	
	Determine and characterize the link between orbital forcing and resultant climate parameters to layer properties at the PLD and non-polar deposits, and then invert to derive polar and global martian history
	Further test the current hypothesis that NPLD formation began at ~4 Ma
★	*Estimate the climatic conditions that could have formed the SPLD, especially given that current and recent climates are predicted to be unfavorable for accumulation and that the surface age may be greater than 30 Myr*
	Determine if the SPLD H_2O ice units (AA_1 and AA_2) were deposited in one or multiple periods of favorable climate
	Characterize the processes and timing that led to the buried CO_2 ice reservoirs at the south pole
★	*Determine how the SPLD expanse relates to the much larger southern polar deposits in terms of age and climate epochs that are recorded. Specifically, does the Dorsa Argentea Formation (DAF) have origins in an ancient climate and what can DAF presence tell us about that climate?*
★	*Determine the climate forcing that allowed for the development of the south polar residual cap (SPRC), and how it remains in its present-state given that models predict it to be unstable. Also estimate its absolute age*

no priority order, put together by designated synthesis team

Our primary questions (4 of 5)

Non-polar ice: What is the history and present state of the mid- and low-latitude volatile reservoirs?

Non-polar Ice	
	Inventory and characterize the non-polar volatile reservoirs at the surface and near-surface
	Determine the accessibility of H_2O ice deposits as a resource for future human exploration, in particular the conditions and lowest latitude under which water-ice reservoirs can be found
	Determine under which conditions the non-polar volatile reservoirs accumulate and persist
	Determine how different chemistries (salts) influence the movement of volatiles and their impact on habitability
	Investigate if liquid water exists or has existed in locations associated with mid- and lower-latitude ice deposits. Could these have provided habitats for, or preserved evidence of, past or present life?

no priority order, put together by designated synthesis team

Our primary questions (5 of 5)

Present day surface activity: What are the roles of volatiles and dust in surface processes actively shaping the present polar regions of Mars?

Present Day Surface Activity	
	Determine the processes by which seasonal CO_2 (alone, or in conjunction with other surface materials) acts as an agent of geomorphic change for: gullies/alcove-aprons, dunes, and araneiform terrain, on various time scales
	Quantify the amount of CO_2 needed for the observed geomorphic processes to occur. Characterize what form (snow or direct deposition), when, and where that CO_2 is deposited/accumulated seasonally
	Determine the present rate of activity and the time needed to produce the existing surface features. Detect changes in environmental conditions as recorded within these landforms
	Observe the distribution of seasonal and diurnal H_2O and CO_2 frost deposited each year, from within the seasonal cap down to the lowest latitudinal-extent
	Characterize inter-annual variability in polar surface processes and determine their relationship to volatile cycles, dust cycles, and weather
	Determine the present-day role and extent of seasonal polar deposits of H_2O within surface changes

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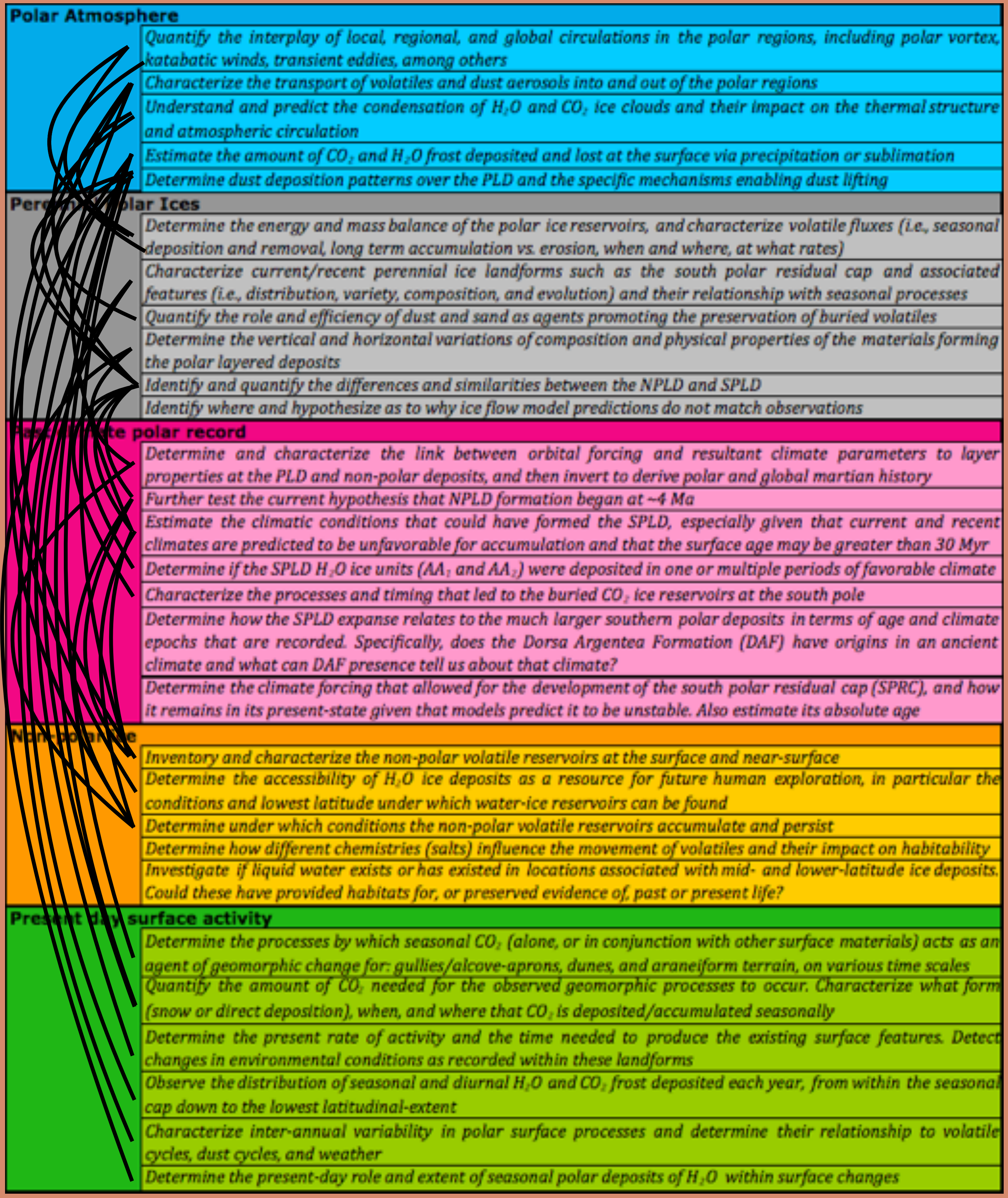
This is the Amazonian!

Our goals are frequently linked and inseparable. As examples:

The atmosphere affects the perennial ices, non-polar ice, and present day surface activity.

The climate record is stored within the materials of the perennial and non-polar ices.



This is the Amazonian!

Our questions, overlap the MEPAG's current document

★ (red) Nearly exact same goal

★ (yellow) Overlap with existing goals

Notice:

Many polar studies are required to get at MEPAG's current list but are underrepresented by the goals document.

Because polar is part of climate and part of geology, it is often overlooked

A3.2. Characterize surface-atmosphere interactions as recorded by aeolian, glacial/periglacial, fluvial, lacustrine, chemical and mechanical erosion, cratering and other processes.

Polar Atmosphere		
	Quantify the interplay of local, regional, and global circulations in the polar regions, including polar vortex, katabatic winds, transient eddies, among others	★ (yellow)
	Characterize the transport of volatiles and dust aerosols into and out of the polar regions	★ (yellow)
	Understand and predict the condensation of H_2O and CO_2 ice clouds and their impact on the thermal structure and atmospheric circulation	★ (yellow)
	Estimate the amount of CO_2 and H_2O frost deposited and lost at the surface via precipitation or sublimation	
	Determine dust deposition patterns over the PLD and the specific mechanisms enabling dust lifting	
Perennial Polar Ices		
	Determine the energy and mass balance of the polar ice reservoirs, and characterize volatile fluxes (i.e., seasonal deposition and removal, long term accumulation vs. erosion, when and where, at what rates)	★ (yellow)
	Characterize current/recent perennial ice landforms such as the south polar residual cap and associated features (i.e., distribution, variety, composition, and evolution) and their relationship with seasonal processes	
	Quantify the role and efficiency of dust and sand as agents promoting the preservation of buried volatiles	
	Determine the vertical and horizontal variations of composition and physical properties of the materials forming the polar layered deposits	★ (yellow)
	Identify and quantify the differences and similarities between the NPLD and SPLD	
	Identify where and hypothesize as to why ice flow model predictions do not match observations	
Past climate polar record		
	Determine and characterize the link between orbital forcing and resultant climate parameters to layer properties at the PLD and non-polar deposits, and then invert to derive polar and global martian history	★ (red)
	Further test the current hypothesis that NPLD formation began at ~4 Ma	★ (red)
	Estimate the climatic conditions that could have formed the SPLD, especially given that current and recent climates are predicted to be unfavorable for accumulation and that the surface age may be greater than 30 Myr	★ (red)
	Determine if the SPLD H_2O ice units (AA_1 and AA_2) were deposited in one or multiple periods of favorable climate	★ (yellow)
	Characterize the processes and timing that led to the buried CO_2 ice reservoirs at the south pole	★ (yellow)
	Determine how the SPLD expanse relates to the much larger southern polar deposits in terms of age and climate epochs that are recorded. Specifically, does the Dorsa Argentea Formation (DAF) have origins in an ancient climate and what can DAF presence tell us about that climate?	
	Determine the climate forcing that allowed for the development of the south polar residual cap (SPRC), and how it remains in its present-state given that models predict it to be unstable. Also estimate its absolute age	★ (yellow)
Non-polar ice		
	Inventory and characterize the non-polar volatile reservoirs at the surface and near-surface	★ (yellow)
	Determine the accessibility of H_2O ice deposits as a resource for future human exploration, in particular the conditions and lowest latitude under which water-ice reservoirs can be found	★ (red)
	Determine under which conditions the non-polar volatile reservoirs accumulate and persist	★ (yellow)
	Determine how different chemistries (salts) influence the movement of volatiles and their impact on habitability	★ (yellow)
	Investigate if liquid water exists or has existed in locations associated with mid- and lower-latitude ice deposits. Could these have provided habitats for, or preserved evidence of, past or present life?	★ (yellow)
Present day surface activity		
★ (yellow)	*Determine the processes by which seasonal CO_2 (alone, or in conjunction with other surface materials) acts as an agent of geomorphic change for: gullies/alcove-aprons, dunes, and araneiform terrain, on various time scales*	
	Quantify the amount of CO_2 needed for the observed geomorphic processes to occur. Characterize what form (snow or direct deposition), when, and where that CO_2 is deposited/accumulated seasonally	
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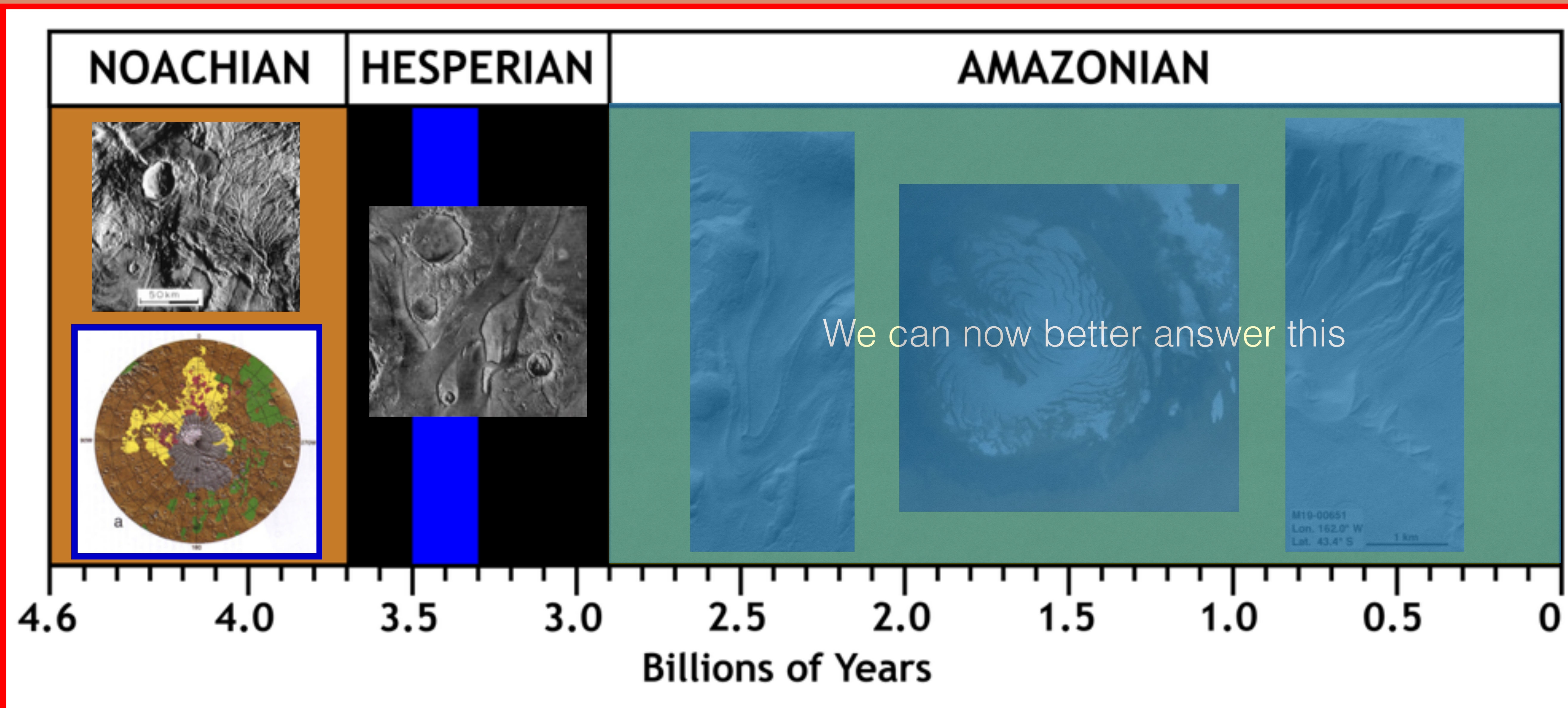
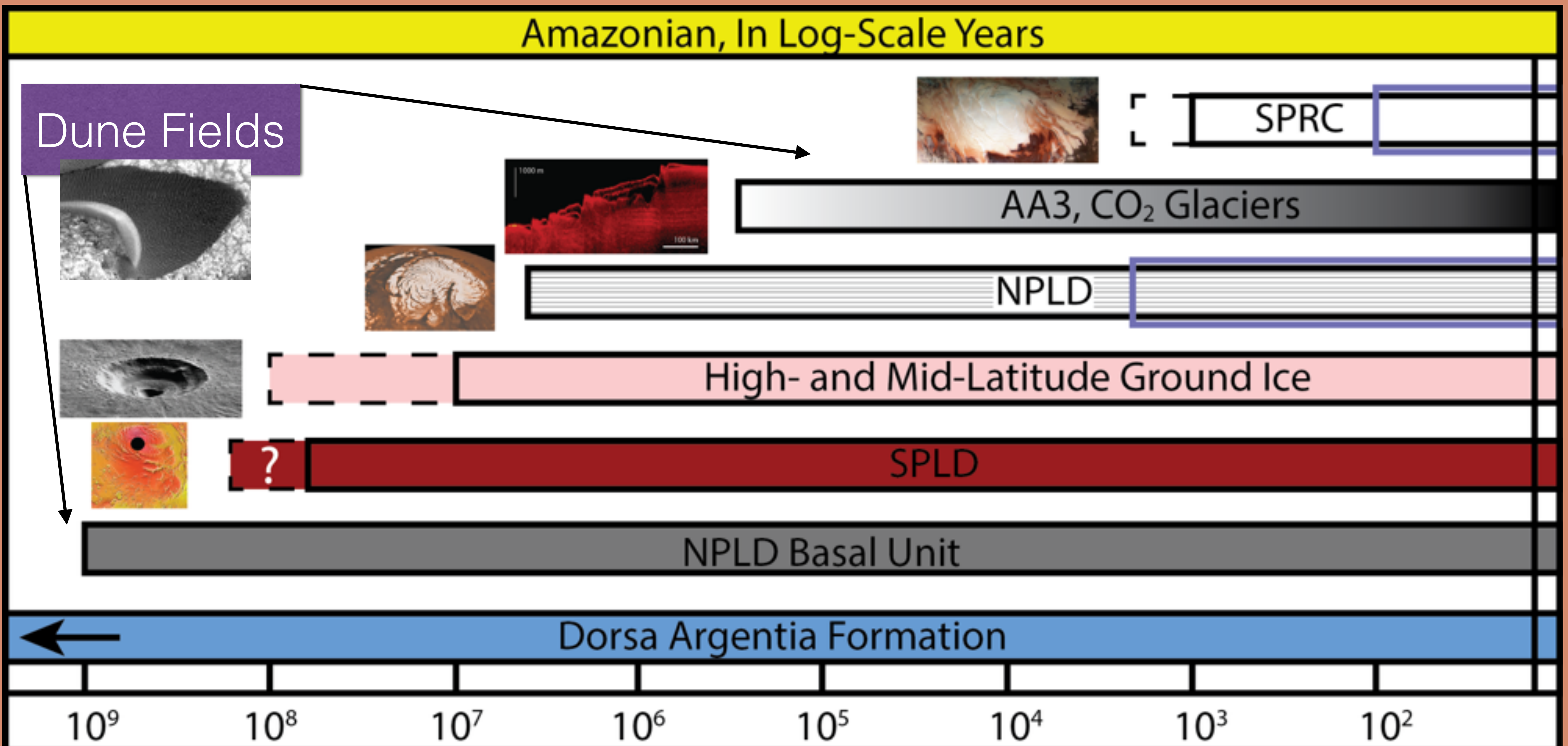
Mars Climate History: A Geological Perspective



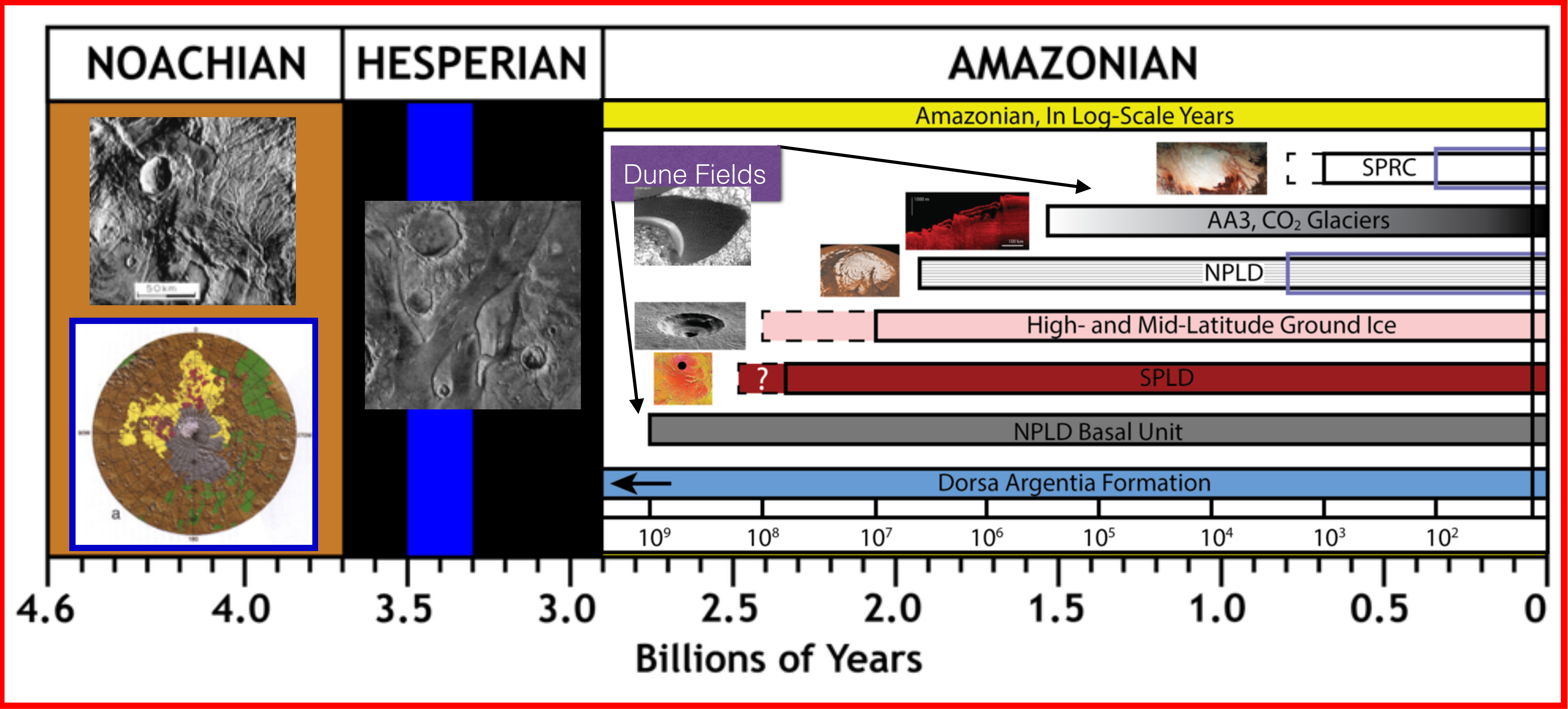
From Head et al, numerous conferences



With known ice deposits, we have climate information at various baselines and resolutions

MGS arrival

The Amazonian is nearly 2/3 of Mars history, and underrepresented



Recommendations for future Measurements, Modeling, and Field Work:

Flight Operations:

- Wind speeds, pressure, temperature near the polar caps between the surface and 10 km
- Surface observations of mass transport
- Surface observations of CO_2 precipitation and evolution
- Higher resolution vertical sampling of PLD and non-polar ice from orbital assets (top 10 m)
- *In situ* compositional sampling of the vertical stratigraphy of the PLD

Laboratory Experiments:

- Mars atmospheric chamber experiments involving interactions of CO_2, H_2O, and dust
- Wind tunnel experiments looking at dust and snow/frost movement and interaction

Terrestrial Analogs

- Gullies, patterned ground, dunes and ripples, and thermal cracks
- Unstable mid-latitude glaciers and buried ice deposits

Model Development

- Targeted and high-resolution modeling that incorporates atmospheric observations.
- Landscape evolution modeling that includes interactions between CO_2 frost and granular materials

Next Conference:

2020, not to interfere with academic year

Considering two places

- In discussions with people in Ushuaia, Argentina (Jan, 2020)
- Considering Tromsø, Norway (June, 2020)

Kvíarjökull (5705) is an outlet glacier from Öræfajökull, the 2110 m high glacier capped stratovolcano that forms the southernmost part of the Vatnajökull ice cap

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Askja Caldera, northern pre-conference field trip