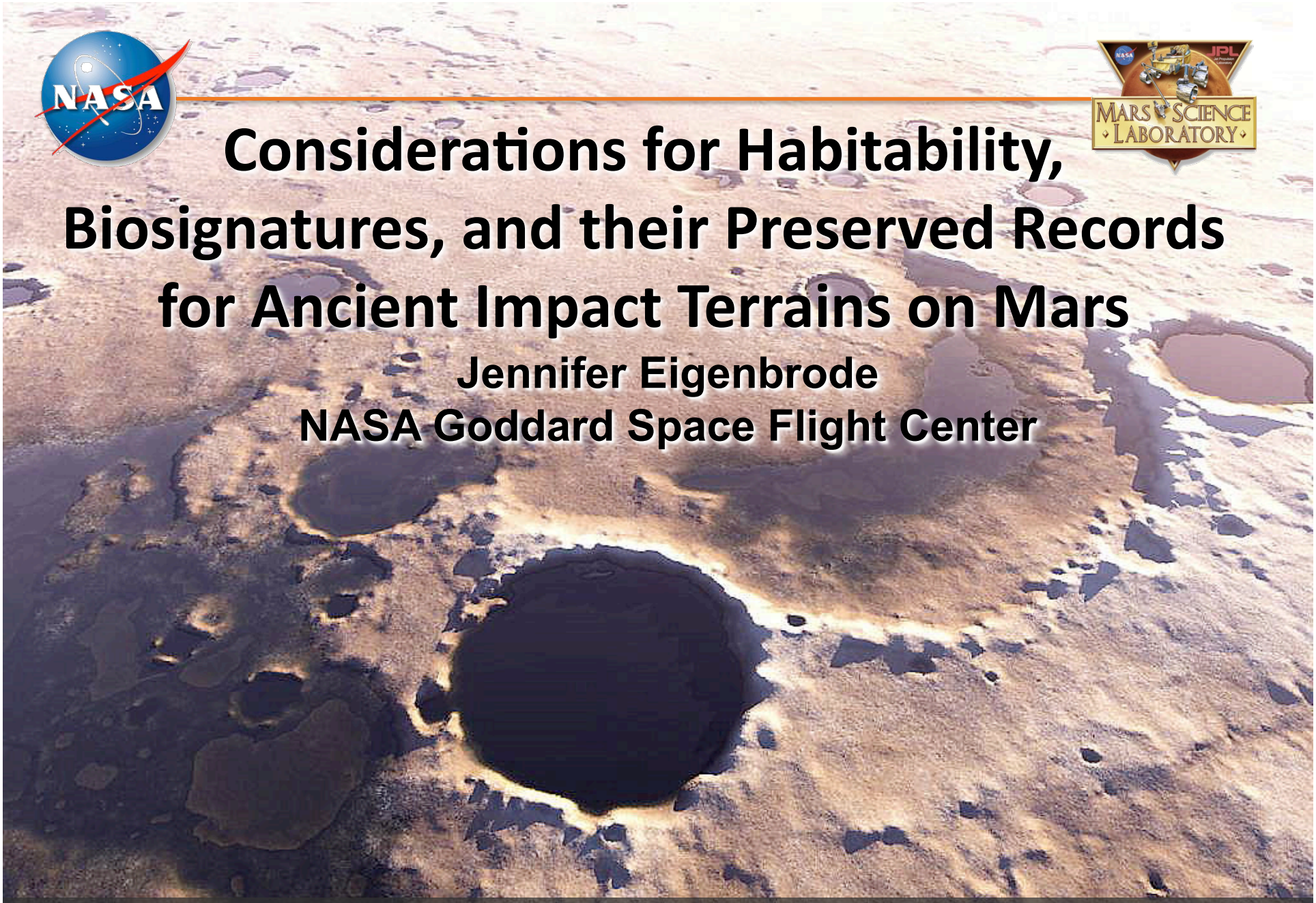
Considerations for Habitability, Biosignatures, and their Preserved Records for Ancient Impact Terrains on Mars

Jennifer Eigenbrode
NASA Goddard Space Flight Center

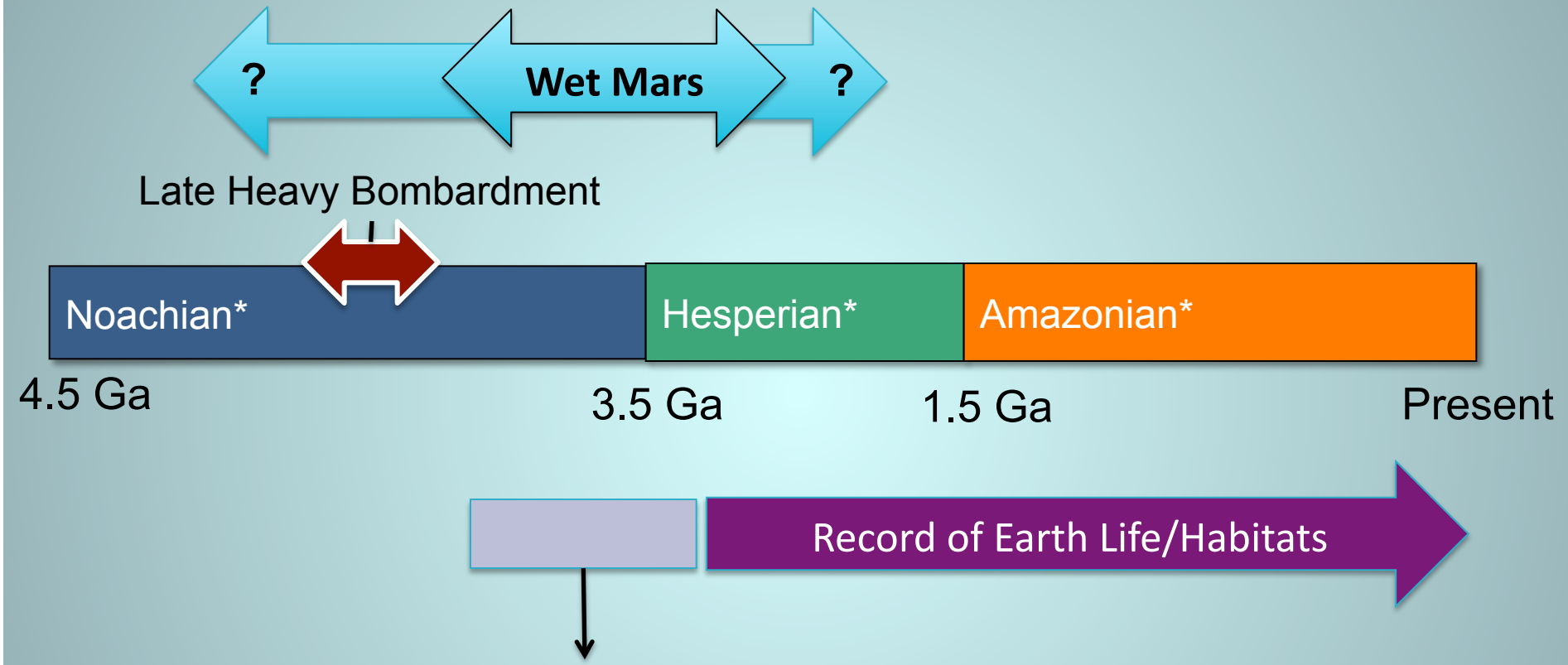


Artist's rendition of ancient Meridiani based on MOLA observations. Credit: Space4case.

How do impact events influence habitability records and the MSL investigation?

More specifically, how do impact events influence the MSL objective to "... assess the biological potential of at least one target environment by determining the nature and inventory of organic carbon compounds"?

Ambiguous record of Earth life and habitats for comparable timeframe of ancient Mars



Earth -- ambiguous biosignatures, environments difficult to identify

*Working model for Mars history by Bibring et al., 2006

How do impact events influence habitability records and the MSL investigation?

Unlike Earth, recycling of surface by tectonics, not a big issue

Consequences of impact events:

- bedrock excavation, disruption, and redistribution
- delivery exogenous material
- abiogenic organic products (?)
- **HEAT!**

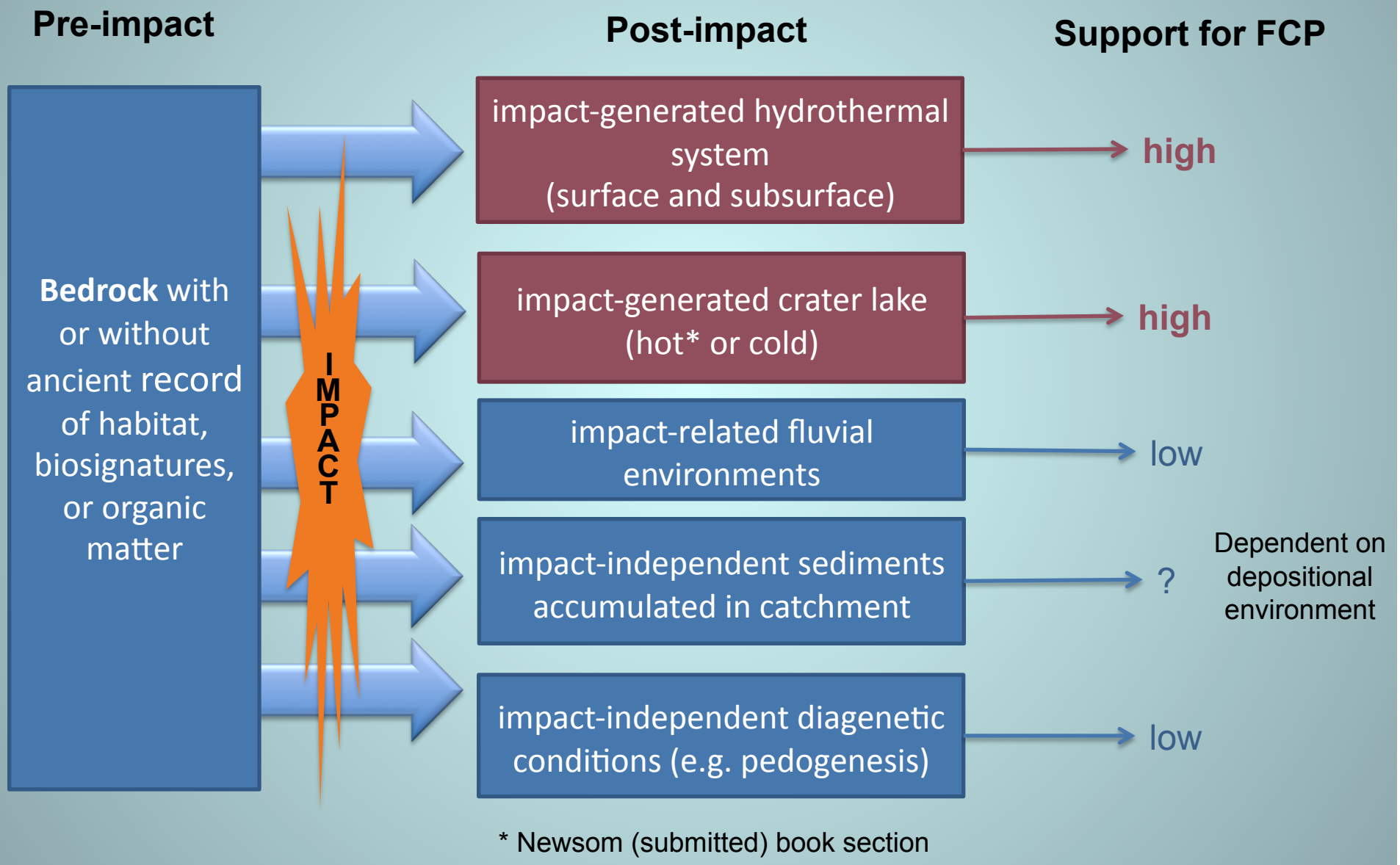
  - can linger for 1000's to 10,000's years (more?)
  - water, chemical energy, nutrient cycling to fuel life

Formation, Concentration, and Preservation (FCP)*

* from report by Biosignature Taphonomy Working Group

Formation	→ i.e., potential habitability environments the may sustain energy gradients (redox gradients), nutrients, and water to fuel ecosystems
Concentration	→ increases our chances of a detectable and interpretable record… minimize the needle in the haystack search
Preservation	→ i.e., preservation of both the "target environment", the biosignatures of that environment, including syngenetic organic materials

Evaluation of support for FCP for impact-related rocks



* Newsom (submitted) book section

Evaluation of support for FCP for impact-related rocks

Impact craters provide access to bedrock

Pre-impact

Bedrock with record of habitat, biosignatures, or organic matter

Post-impact

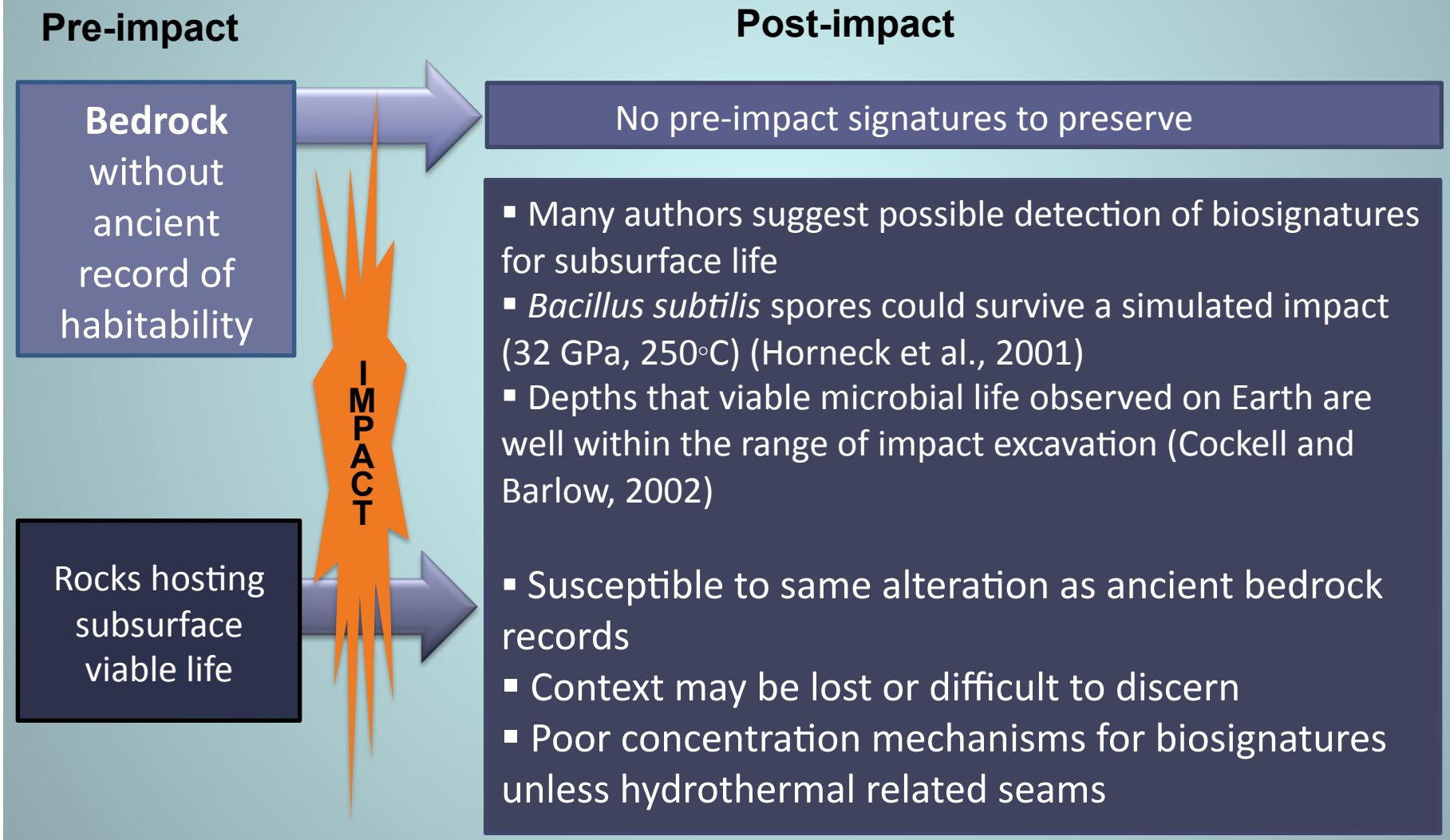
- Biosignatures in sedimentary rock that are excavated from or proximal to impact craters are susceptible to alteration/destruction by:
  - impact erosion, subsequent oxidation and weathering
  - shock metamorphism*
  - hydrothermal alteration*
  - redistribution*
  - overprinting by later life*
- Context for biosignatures in the pre-impact record is at best complicated and at worst lost.
- Framework for understanding past habitability at multiple scales may be lost.
- Difficulty in reconstructing depositional environment.

Dependence on nature of impact and substrate

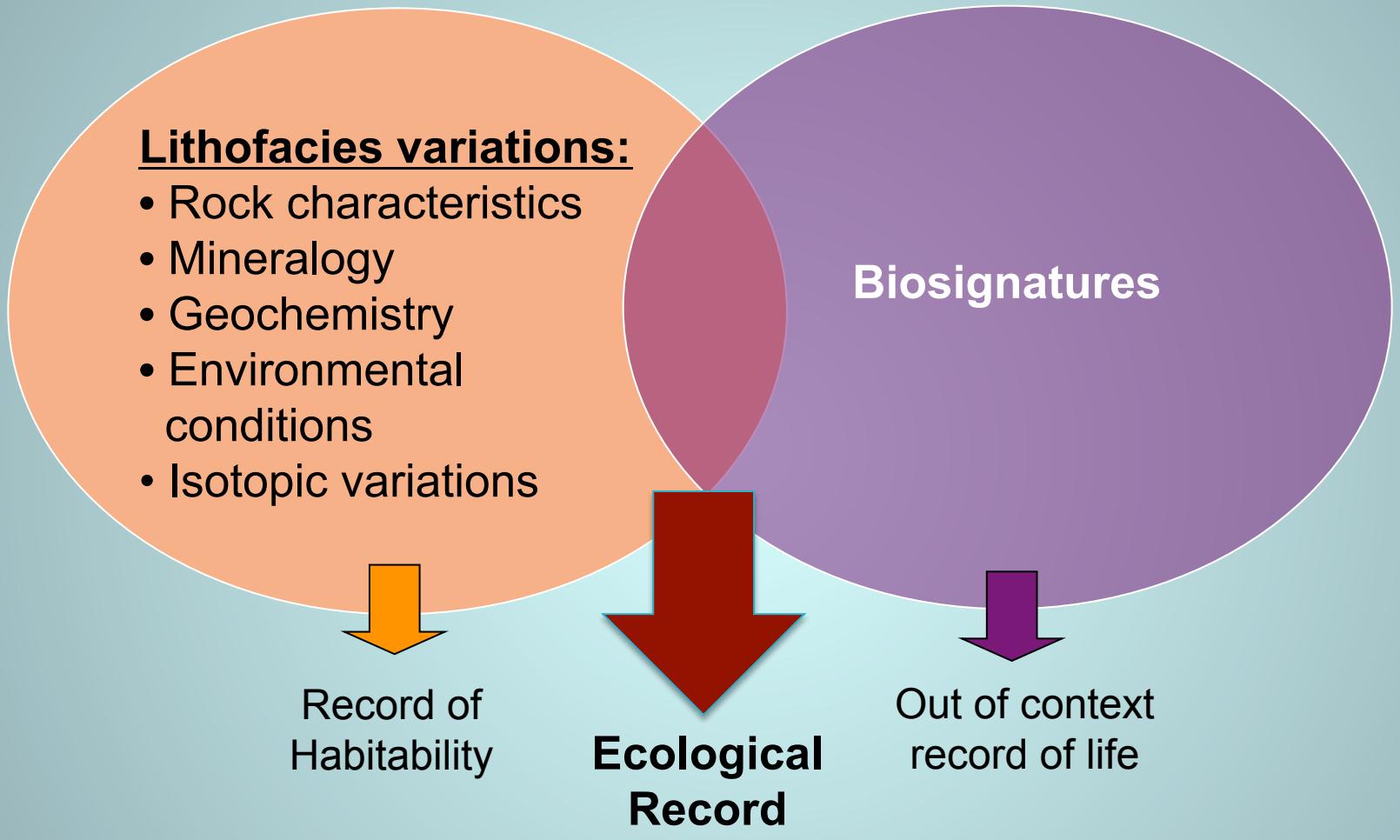
* As in Haughton Crater; Parnell, Lee, Osinski, Cockell, 2005, Meteoritics & Planetary Science

Evaluation of support for FCP for impact-related rocks

Impact craters provide access to bedrock



At what point do we recognize signatures of habitability as signatures of an ecosystem?



Geological framework – the <u>larger, organized context</u> for understanding the source of biosignatures

MSL Investigation Pace

A traditional investigation of ancient habitats on Earth	vs.	MSL investigation of an ancient habitability on Mars
1. Survey area remotely (satellite or aerial)	→	Pre-mission remote observations
2. On-foot survey to get the big picture	→	Rover survey - cameras, ChemCam, et al. – draw from MER experience
3. Characterize the rocks: • In situ observations • Sampling	→	Major sink for mission time!
4. Sample return to lab 5. Lab sample preparation/analyses: • Mineralogy • Elemental and molecular compositions and spatial distributions • Physical parameters and morphologies	→	Major sink for mission time!

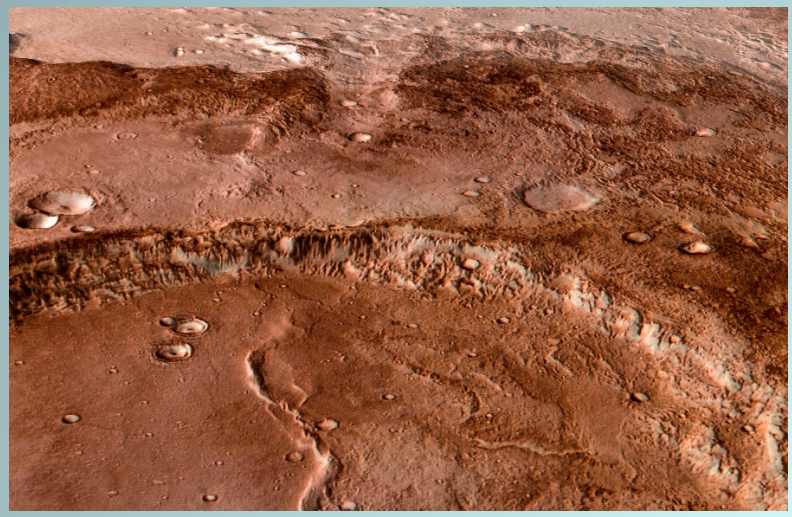
Take home message

What we don't know, but depend on for addressing the mission goal, adds potential risk to mission success.

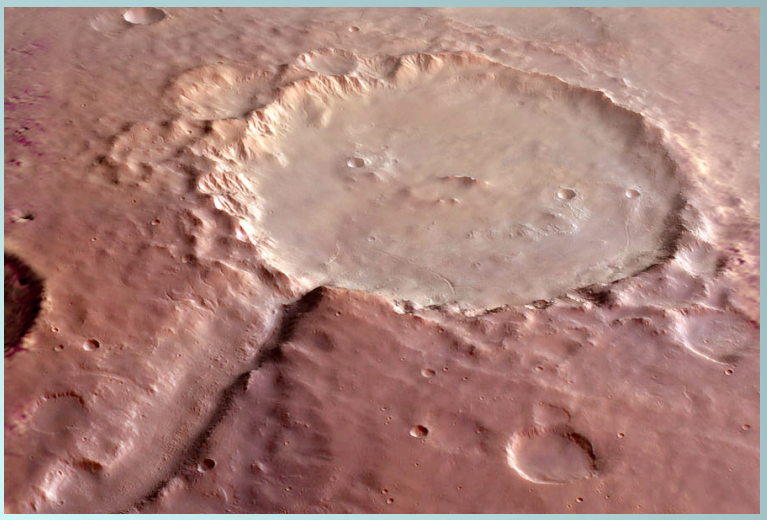
Complex histories, as scientifically intriguing as they are, are likely to increase the difficulty of addressing the mission goal.

Having a geological framework—or at least a good idea of what this might be—before landing allows for better strategic planning → supports efficiency and mitigates risk in mission operations

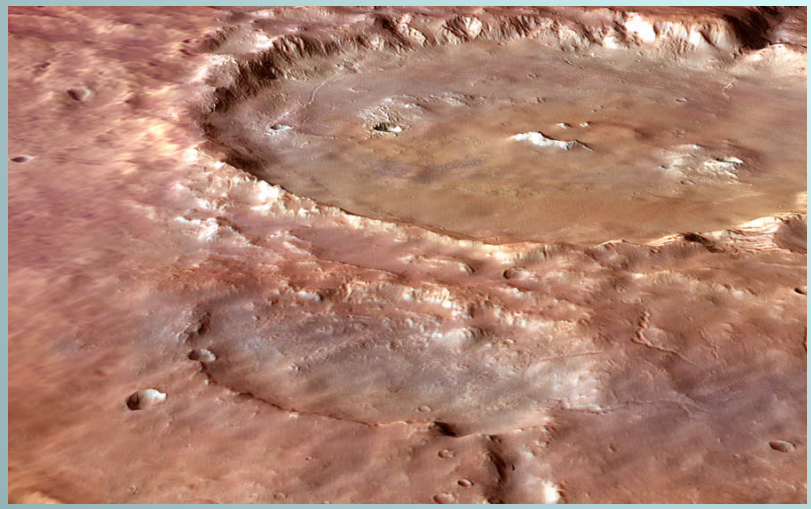
What does this mean for the candidate landing sites?



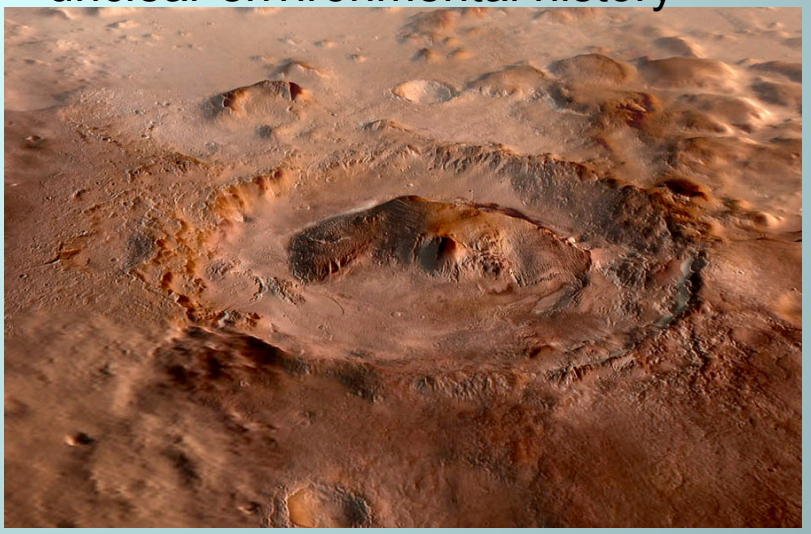
Mawrth: Complex history, unclear environment(s)



Holden: Complex framework, unclear environmental history



Eberswalde: Delta/lacustrine stratigraphic framework



Gale: Stratigraphic framework, unclear environment