**Astrobiology and NASA’s Proposed Mars 2020 Rover**

**Strategy for Detecting Past Life on Mars**

To search for potential biosignatures, it is necessary to (a) identify sites that likely hosted past habitable environments, (b) identify high biosignature preservation potential materials to be analyzed for potential biosignatures, and (c) perform measurements to identify potential biosignatures or materials that might contain them.

Although it would be logical to assess habitability and biosignature preservation potential before seeking potential biosignatures, for practical considerations, evidence for all three would be sought concurrently during exploration at a particular rover location.

**Past Habitable Environments**

- **Habitability**
  - To assess the habitability of a past environment, the rover must be able to examine the geologic record of that environment and evaluate the following characteristics of that environment:

- **Preservation of the Evidence of a Prior Habitable Environment**
  - Evidence for the habitability criteria are preserved as geological or geochemical proxies, or may not be preserved at all.

- **Integrate Observations Across Kilometer to Millimeter Scales**
  - In order to explore and document geologic processes and history of a site, it is essential to integrate observations from orbital (regional) scales to microscopic (sub-millimeter) scales. The footprint and spatial resolution of measurements is critical for ensuring observations can be correlated across scales.

**Types of In Situ Observations and Measurements**

- **Full details of the required observations at a particular site cannot be predicted precisely. However, the types of observations that are likely to be critical are well understood, as shown by these examples among two broad rock classes.**

**Biosignature Preservation Potential**

- **Preservation of Biosignatures**
  - Certain minerals and rock types are more effective than others for enhancing the preservation of biosignatures in Earth’s geologic record.
  - An assessment of Biosignature Preservation Potential (BPP) should consider the minerals and rock types that might contain Potential Biosignatures (PBI).
  - If life existed in the past, biosignatures will exist today. Only if conditions were favorable for biosignature preservation.

**The Effect of Geologic Time**

Biosignatures must “run a gauntlet” of processes through geologic time that can either lower or elevate their BPP.

Assessing the potential for preservation of any given type of biosignature requires interpretation of past geologic environments and processes. This interpretation requires measurements of rock chemistry, mineralogy, oxidation state, and rock texture, morphology, and context.

**Geologic Time**

- Environment of PBS Formation
  - e.g., microenvironments degrade or recycle organic and mineral PBS, e.g., degrade PBS by microorganisms, hydration, radiolysis, dissolution, thermal degradation, impact deformation, chemical replacement due to ingressing fluids, etc.
  - CR preserve PBS by desiccation, segregation in impersistent host rock, fire, irradiation, and benign temperatures and pressures

**Initial Sequestration of PBS in a Geologic Deposit**

- e.g., degrade PBS by microorganisms, hydration, radiolysis, dissolution, thermal degradation, impact deformation, chemical replacement due to ingressing fluids, etc.
  - CR preserve PBS by desiccation, segregation in impersistent host rock, fire, irradiation, and benign temperatures and pressures

**Long-term Sequestration of PBS**

- PBS is released from the host rock, fire, irradiation, and benign temperatures and pressures

**Surface exposure to impacts, erosion and/or weathering of the host deposit**

- Some examples as those indicated for long-term sequestration of PBS

**Categories of Potential Biosignatures Hypothesized to Exist in Martian Rocks**

These hypothesized potential Martian biosignatures represent independently observable features.

The 2020 Mars Rover must have the capability to detect as many of these signatures as possible to have a credible chance to find evidence of past life on Mars, because:

1. We cannot anticipate which of those (if any) will be present or well-preserved...
2. ...therefore we cannot anticipate which categories will provide the most information.
3. Confidence in confirming biological origin(s) increases as more categories are detected.

**Potential Biosignature Assemblages**

- **Energy**
  - Chemical features that suggest biologic processing

**Finding and Recognizing Potential Biosignatures**

Strategies for detecting ancient PBS can involve a range of optical or analytical measurements. Yet not all measurement types have the same diagnostic potential. Some measurements, such as detecting organic carbon, are suggestive but not definitive. Other measurement types provide greater confidence as to whether the feature under investigation has been produced by biological activity. Features that provide intermediate levels of confidence include elemental ratios and molecular mass distributions of organic compounds. When multiple types of measurements are combined, the ability to establish the presence of any PBS improves.

For some features the probability of a non-biological origin is so remote that they represent single-point diagnostic characteristics. Complex biological molecular structures, e.g., oligomers or polymers, represent such highest confidence biosignatures.

**Mars 2020 Rover Science Strategy**

**Field Strategy**

Assessing habitability and preservation potential at a site with a record of an astrobiologically relevant ancient environment requires a rover that can navigate to the terminus and conduct lateral and stratigraphic surveys across multiple scales and targets.

**Cross-Cutting Instrument Suite**

The measurements that would be required to meet the geology and habitability, biosignatures, and caching objectives are similar. Thus, these three objectives are compatible and well-suited to be assigned to the same mission.

**Spatially Correlatable Measurements**

The ability to spatially correlate variations in rock composition with fine-scale structures and textures is critical for geological and astrobiological interpretations.

**Well-documented Samples**

Make a sufficient quantity, variety and quality of geologic observations to interpret past environmental conditions and understand spatial and temporal relationships in the geologic record.

**Preparation of a Returnable Cache**

Three attributes are essential to making a cache returnable:

1. The cache has enough scientific value to merit return.
2. The cache complies with planetary protection requirements.
3. The cache is returnable in an engineering sense.