Spatially resolved biosignature analysis and the search for signs of ancient life in the solar system

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An approach to the search for signs of ancient life – or biosignatures – has emerged in recent years that combines micro- to nano-scale morphologic analysis by correlative microscopy with spatially resolved spectroscopy and mass spectrometry. The underlying logic holds that

1) spatially correlated chemical, isotopic, mineralogic and/or morphologic disequilibria,

2) observed in a context consistent with the known environmental limits of life,

may indicate the influence of life in the environment of formation. In order to determine whether observed features were indeed formed by life – that is, to test their biogenicity – various criteria are used that range in conservatism. One end of the spectrum requires that all abiotic formation mechanisms must be ruled out to accept biogenicity. Alternatively, a system of criteria may be used to evaluate whether a biotic or abiotic origin is more likely according to the principle of parsimony. This approach has been applied to biogenicity tests in Earth's oldest rocks, and its evolution is crucial to the search for extraterrestrial life.

Mars 2020 is the next NASA rover mission and the first step toward a possible Mars sample return effort whose successful completion would yield a diverse Mars sample collection providing transformative scientific dividends for generations. Mars 2020 will explore an ancient environment with a scientific payload designed to determine formation and alteration processes, detect possible signs of ancient life, and select locations with high biosignature preservation potential for in situ analysis and sampling. A newly developed sampling and caching system on the rover will prepare surfaces for correlative, spatially resolved morphologic and spectroscopic analysis and collect rock core and regolith samples. Core samples will be hermetically sealed and safely cached on the surface of Mars for possible future return.

In this presentation, perspectives on the state of ancient biosignature detection will be offered, including recent developments related to the early evolution of life on Earth. Scientific capabilities and emerging operational strategy for Mars 2020, possible architectures for Mars sample return, and a view for the future of the search for ancient life in the solar system will also be discussed.