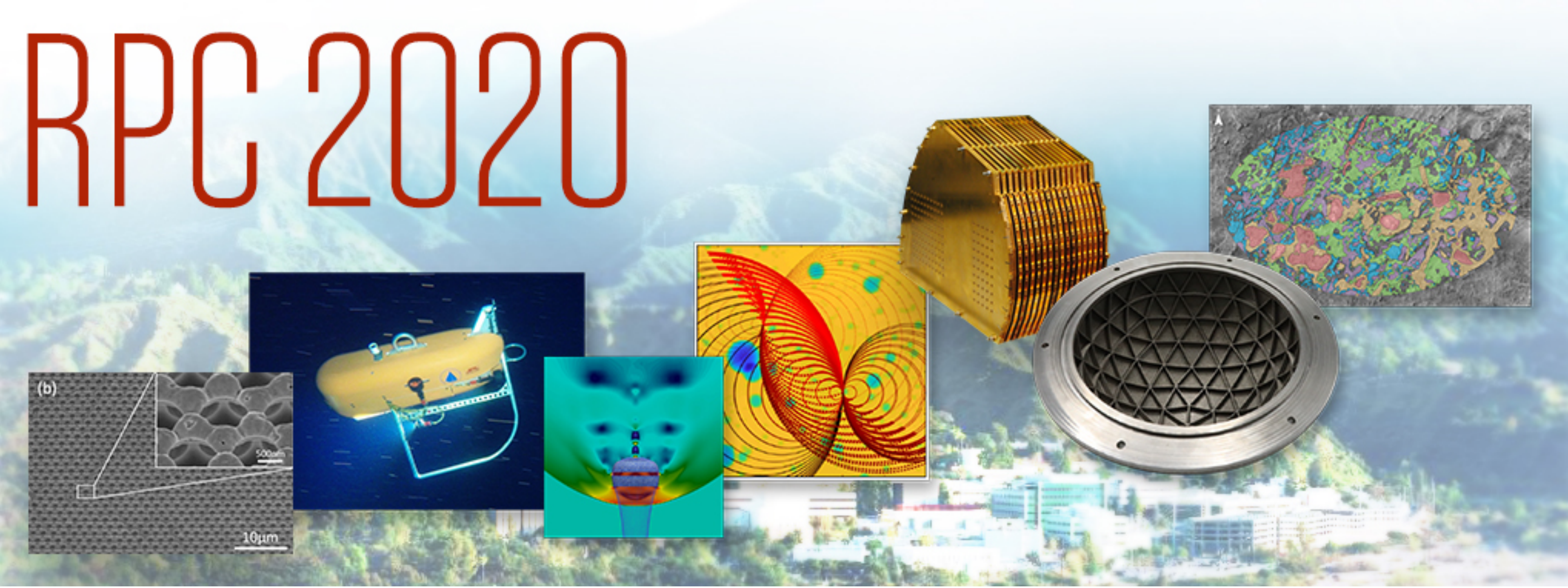


Virtual Research Presentation Conference

Analog Mars Sample Return Science

Principal Investigator: Kenneth Williford (3225)
Co-Is: Michael Tuite (3227)
Program: Strategic Initiative

Assigned Presentation # RPC-083

Jet Propulsion Laboratory
California Institute of Technology

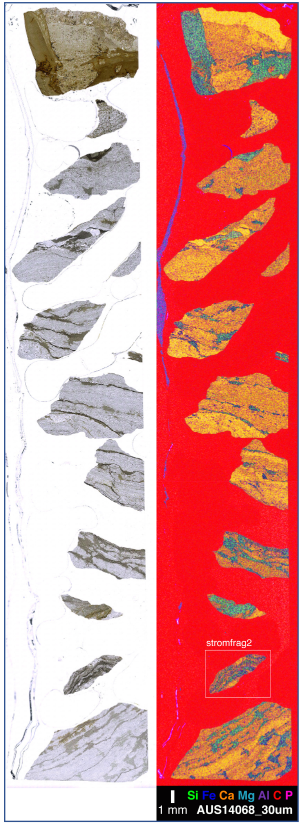
Introduction

ABCLAB
ASTROBIOGEOCHEMISTRY LABORATORY
SAMPLING THE SOLAR SYSTEM FOR SIGNS OF LIFE

Abstract

Mars Sample Return (MSR) is among the most ambitious and potentially transformative scientific and technical endeavors in human history, and JPL leads its design and execution for NASA. With sample selection and collection by Mars 2020 beginning in February, 2021 and follow-on missions envisioned to launch as early as 2026, returned sample analysis could begin as early as 2031. Participation in the scientific fruition of MSR – via competition for access to returned samples – will be no doubt be limited to those institutions demonstrating a technical infrastructure and science team with a unique and sustained record of achievement that stretches the bounds of possibility.

The JPL Astrobiogeochemistry Laboratory (abcLab) operates as an institutional resource to develop the techniques and interpretive contexts required to detect signs of life and planetary evolution in samples one day returned from Mars. We pursue a program of Analog Mars Sample Return Science (AMaSRS) studying the formation, preservation and detection of signs of life and environment in geologic samples using a field-portable Mars 2020 analog drilling system to collect, curate and analyze core samples from analogs for the Mars 2020 exploration area in and around Jezero crater, while simultaneously addressing compelling questions in Earth science.



Transmitted light image and elemental map of AMaSRS core sample of a stromatolite from the ~2.7 Ga Tumbiana Fm

Problem Description

With the *Perseverance* rover on its way to Mars and potential follow on missions currently in formulation, JPL leads the effort to select, collect, and return the first samples from another planet. In an effort to cultivate the potential for continued scientific participation in the crucial final stage of MSR – the analytical phase after samples return to Earth – JPL has maintained strategic investment in the technical infrastructure, institutional knowledge and human capital that would eventually be required to compete for scientific access to these extraordinarily precious returned samples.

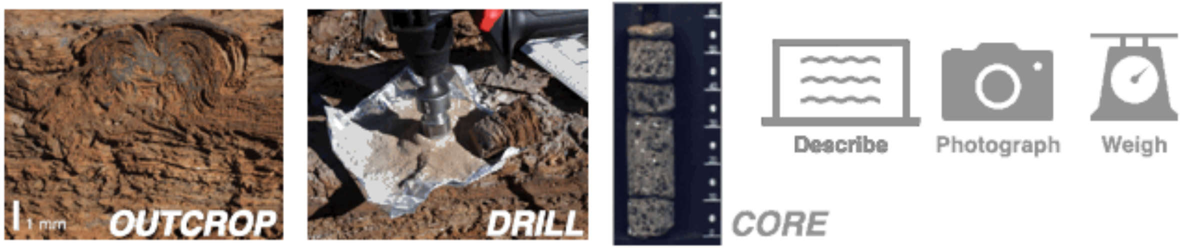
Strategic investment by JPL in the Astrobiogeochemistry Laboratory has resulted in a state-of-the-art facility for the analysis of diverse biosignatures in Mars analog Earth rocks and the development of analytical workflows that could be applied to returned samples. Our Strategic R&TD program establishes the framework for a sample analysis facility and scientific team that, if sustained and enhanced over the next decade, would be among the finest in the world. We envision that such a facility and team, constructed in intimate co-evolution with technical execution of MSR, would be extraordinarily competitive when Mars samples become available to the scientific community.

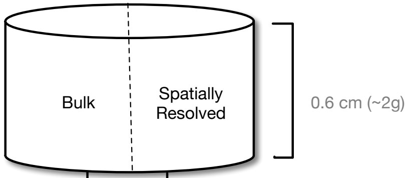
Methodology

We couple Mars 2020 flight-like coring with state-of-the-art sample handling, preparation, and analysis in an innovative workflow.

Each core sample is collected together with its surrounding rock (hand sample) for further contextual analysis in the abcLab.

After sample collection and curation, a small (~1 cm^3) subsample of the core is further subdivided into one component for bulk geochemistry and another for spatially resolved analysis by the techniques shown at right.





homogenize

Mineralogy: XRD

(Trace) elements: ICP-MS

TOC/δ^{13}C, TN/δ^{15}N: NanoEA-irMS

Molecular composition
Bitumen: GC-MS, GC-QqQ-MS
Kerogen: Py-GC-MS

Compound specific C, H, N isotopes: GC-C-MS-irMS

impregnate with (labelled) epoxy, section, polish

Texture: Light microscopy & SEM

Elemental: SEM/EDS

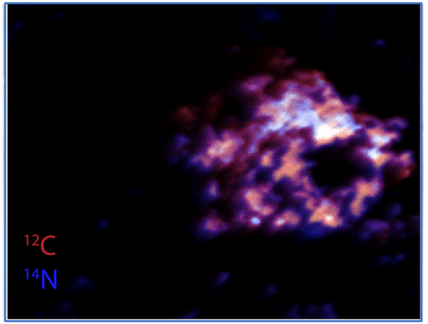
Mineralogy: Light microscopy, SEM & Raman

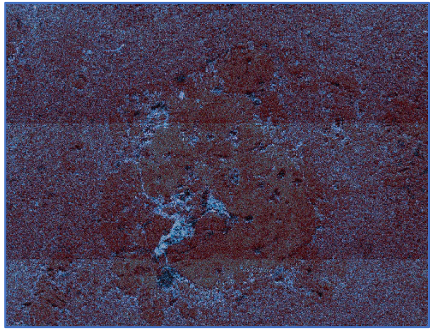
Nature, Distribution & Abundance of Carbonaceous Matter: NanoSIMS, ToF-SIMS
including δ^{13}C of kerogen and carbonates, δ^{34}S, Δ^{33}S of sulfides and sulfates

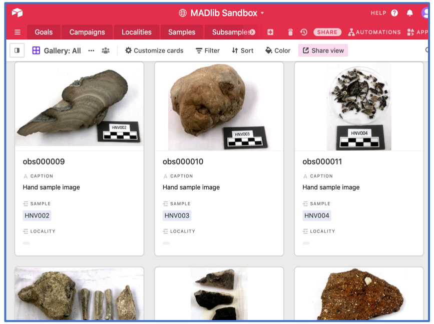
Isotopic Composition of Key Organic and Inorganic Phases: SIMS

By collecting a corresponding hand sample many times the mass of the core, we are also able to analyze the sample without mass constraints imposed by the small cores. This is important because it allows us to understand potential ambiguities introduced by core sample size limitations, and how these ambiguities may relate to different geologic contexts.

Results I







The Walker Lake sample collection represents an opportunity to test hypotheses about the preservation of diverse biosignatures in a lacustrine hydrothermal system.

A 10 x 10 μm NanoSIMS map of ^{12}C and $^{12}C^{14}N$ highlights organic matter preserved in the 3.47 billion year old Mt. Ada Chert. With these maps, we can investigate the preservation of some of the oldest organic matter on Earth.

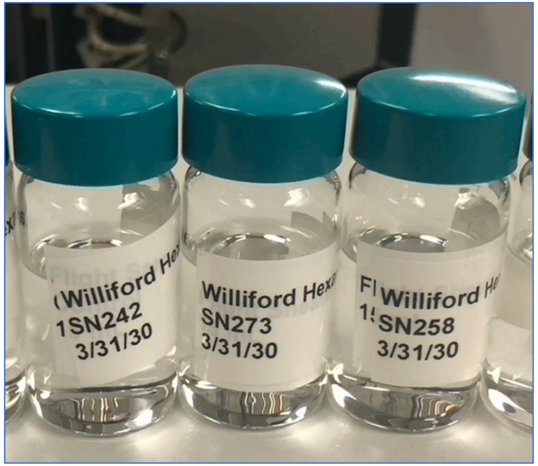
An SEM/EDS map of the Allende meteorite shows the distribution of organic carbon throughout the matrix of the meteorite. With our Mars analog workflow, we are able to analyze extraterrestrial materials.

The Mars Analog Data Library (MADlib) is an online repository for sample related data including location and observations. The MADlib is accessible to our wide network of collaborators.

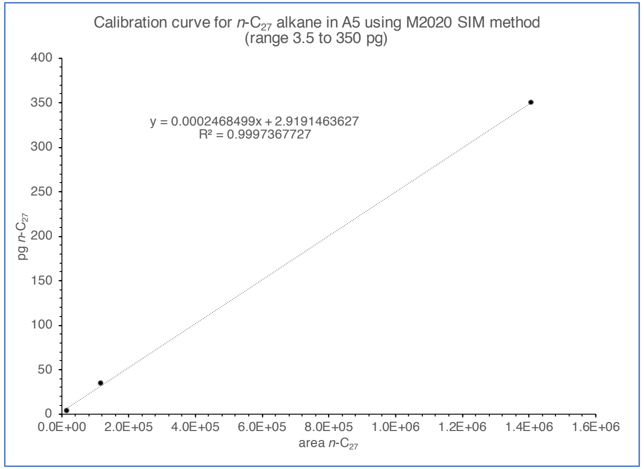
Despite laboratory access and travel restrictions imposed by the pandemic beginning mid-way through FY20, we made good progress toward our project objectives. We were able to make use of samples already in our collection, demonstrate our capacity to prepare samples without detectable molecular contamination, detect and characterize organic matter in the oldest rocks that contain evidence of life, handle and analyze extraterrestrial materials, and build a state-of-the-art data repository to securely store and explore our diverse data.

Results II

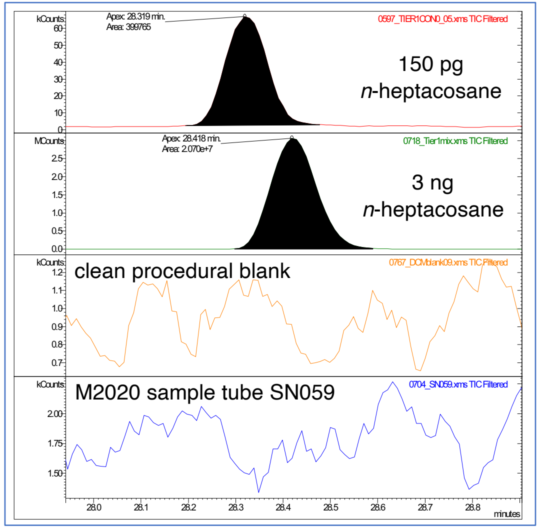
Two key AMaSRS tasks this year have been to determine and reduce levels of background organic contamination and levels of detection for organic compounds with scientific relevance to MSR. Because of our FY20 work in this area and prior strategic investment in the abcLab, we were able to assist Mars 2020 with the verification of sample tube cleanliness with respect to the so called “Tier 1” organic compounds – those of particular scientific importance for which contamination must be limited to less than 1 part per billion. Final sample tube rinsing and cleanliness verification occurred during the early days of the COVID-19 pandemic (four months prior to launch), and thus required a careful response by Mars 2020 to uncertain and rapidly changing circumstances.



a. Mars 2020 flight sample tube hexane rinses



b. abcLab GC-MS sensitivity calibration for M2020 Tier 1 compound *n*-heptacosane



c. Cleanliness verification for sample tube 059

Publications and References

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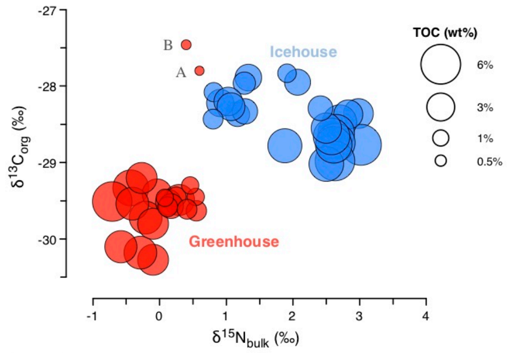

Figure 6

A figure from Tuite et al 2019 plots carbon and nitrogen isotope values from a stratigraphic suite of samples that span a transition from a greenhouse to an icehouse climate about 380 million years ago. The two distinct populations represent differences in the microbial ecology of a shallow ocean driven by climate. The same approach could be applied to returned Mars samples to interpret Mars climate and environmental history.