



# Sample Analysis at Mars (SAM) and Mars Organic Molecule Analyzer (MOMA) as Critical In Situ Investigation for Targeting Mars Returned Samples

Caroline Freissinet, Daniel P. Glavin, P.R. Mahaffy, Cyril Szopa, Arnaud Buch, Fred Goesmann, Walter Goetz, Francois Raulin

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**SAMPLE ANALYSIS AT MARS (SAM) AND MARS ORGANIC MOLECULE ANALYZER (MOMA) AS CRITICAL *IN SITU* INVESTIGATIONS FOR TARGETING MARS RETURNED SAMPLES.** C. Freissinet<sup>1</sup>, D. P. Glavin<sup>2</sup>, P. R. Mahaffy<sup>2</sup>, C. Szopa<sup>1</sup>, A. Buch<sup>3</sup>, F. Goesmann<sup>4</sup>, W. Goetz<sup>4</sup>, F. Raulin<sup>5</sup>, and the SAM and MOMA science teams. <sup>1</sup>LATMOS, UVSQ/UPMC/CNRS/IPSL, Guyancourt, France – caroline.freissinet@latmos.ipsl.fr, <sup>2</sup>NASA GSFC, Greenbelt, MD, USA, <sup>3</sup>LGPM CentraleSupélec, Gif-sur-Yvette, France, <sup>4</sup>LISA, UPEC/UPD/CNRS/IPSL, Créteil, France, <sup>6</sup>MPS, Göttingen, Germany.

**Introduction:** One of the biggest concerns for the detection of organics on extraterrestrial environment is the preservation potential of the molecules at the surface and subsurface given the harsh radiation conditions and oxidants they are exposed to. The SAM and MOMA instruments, respectively onboard NASA Mars Science Laboratory 2011 and joint ESA/RosCosmos ExoMars 2020, are both analytical laboratories that seek *in situ* organic molecules and potential biomarkers in the martian subsurface, and thus establish taphonomic windows of preservation of those molecules. This is critical for making a wise choice of Mars samples to return to Earth.

**Current and future *in situ* analyzers:** SAM has been analyzing Mars' regolith since 2012, with 16 scooped or drilled locations under investigation. SAM discovered chlorohydrocarbons indigenous to a mudstone drilled sample, Cumberland (CB) [1]. The discovery of chlorohydrocarbons in the martian surface means that reduced material with covalent bonds has survived despite the severe degrading conditions. Organic compounds in this ancient sedimentary rock could have formed on Mars from igneous, hydrothermal, atmospheric, or biological processes or, alternatively, delivered directly to Mars via meteorites, comets, or interplanetary dust particles. The implication of these results are twofold. Firstly, CB sample is composed of 20 % of smectite [2]. The detection of up to 300 part per billion of organic compounds in this sample suggests that clays are good candidates for accumulating and preserving organics over geological timescales. This has previously been postulated considering clays' high surface area, negatively charged interlayers and cation associated with water in the interlayers that retards water flow. Secondly, organics are prone to degradation under the high-energy radiation exposure through the thin Mars atmosphere. Preserved samples are thought to be buried < 2-3 m but the CB sample is only 65 mm-deep. The CB sample was found to have a surface exposure ages of 78 +/- 30 million years [3], which suggests recently exposed rocks could contain preserved organic matter and should be targeted for sample return.

The MOMA instrument onboard ExoMars 2020 should increase the detected abundance and diversity of organic molecules in Mars subsurface [4]; by drill-

ing a sample down to 2 meters, it will access more preserved area. The detection of oxychlorines at two very different locations (Phoenix: polar [5] and Curiosity: equatorial [6] sites) support the hypothesis that those compounds may be widely distributed at the surface of Mars. The drill cores of sedimentary rocks obtained and analyzed from the uppermost 2 m of the martian surface by ExoMars will thus be highly valuable to assess the unknown gradient of oxychlorine vs. depth within the martian regolith. Returning samples from a depth where oxychlorine is less abundant or even absent will provide the potential for better organic preservation and facilitate search for biosignatures in Earth-based laboratories.

**Feeds forward to Mars sample return:** The ability to detect organic compounds in martian sedimentary rocks is a function of their initial abundance and entrainment as the rock formed, the extent of subsequent degradation during diagenesis, exhumation and exposure to the surface and near-surface radiation - including the new conditions the sample is exposed to after caching and before returning it. *In situ* investigations provide significant progress toward mapping out potential windows of preservation for chemically reduced organic compounds, by providing important constraints on the types of rock samples (mineralogy, radiation exposure) to target for future examination and for sample return missions.

This view into ancient Mars begins to provide a context for habitable environments and is a first step toward understanding the presence and diversity of possible prebiotic or biotic molecular signatures. *In situ* investigation is a necessary first step before sample return. The current and future state of knowledge of simple and complex organics preservation, revealed by SAM and MOMA investigations, provide a critical source of information for understanding the returned samples that can be analyzed on Earth with the cutting-edge technologies available in our laboratories.

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