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The Mars Astrobiology Probe (MAP) Instrument for ExoMars

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The search for extinct or extant life on Mars is the major objective of several future Mars missions. Looking for key organic compounds, that are essential for biochemistry as we know it, or that are indicative of extraterrestrial organic influx, is the primary goal of the Mars Astrobiology Package (MAP). The MAP experiments are designed to address in a robust and comprehensive manner one of the primary goals of the ExoMars mission, which is “to search for traces of past and present life on Mars”. It achieves this goal by isolating and identifying key organic compounds, amino acids/amines and PAHs, directly on the surface of Mars. MAP consists of four separate major components: a subcritical water extractor (SCWE); the Mars Organic Detector (MOD): a novel lab-on-a-chip micro-capillary electrophoresis (CE) system; and the Mars Organic Reactor Suite (MORS). SCWE is used to extract the target compounds from samples provided by the ExoMars sample distribution system. MOD next uses sublimation at Mars ambient pressure to extract, purify and concentrate organic compounds from the SCWE extract. MOD then assesses presence of two target classes of compounds, amines/amino acids and polycyclic aromatic hydrocarbons (PAHs), by measuring the fluorescent response on a MOD capture cold finger. In the case of amino acids, fluorescence is generated by their reaction with a dye, fluroescamine,

which is highly specific for primary amines and was shown to occur in the dry state, thus eliminating the use of solvents. PAHs are naturally highly fluorescent so they can be detected directly. To permit the simultaneous detection of both target compounds, half of the cold finger is coated with the fluroescamine reagent, while the other half is uncoated. With the MOD fluorescence analyzer, the target compounds can be readily detected at the sub-parts-per-billion (ppb) level. If either amines/amino acids or PAHs or both are detected in the MOD-based screening of a sample this means that other organic compounds are also likely present in the sublimate. Thus, other organic detection instruments selected for ExoMars may want to interrogate the sublimed material to characterize these compounds. If an amine/amino acid signal is detected in the MOD-based analyses, the microfabricated chip-based CE separation device with integrated reaction chambers, pumps, and capillary sipper is used to gather the sublimate from the fluroescamine coated portion of the MOD cold finger and determine the amino acid composition and chirality in order to evaluate their origin. Of particular importance would be the finding that the amino acids are present as a non-racemic mixture (non-equal amounts of the D- and L-isomers), which could be suggestive of a biotic origin. The SCWE/MOD/CE suite combines with the MORS component that is used to determine the oxidative characteristics of the samples in order to provide data on the role of oxidation reactions in the survival of organic compounds in the Martian regolith. These oxidant data will be of particular significance if a negative result (no fluorescent signal above background is detected) is obtained by the MOD.

MAP has the potential of performing the first successful detection of organic compounds on Mars. The instrument is currently at TRL 5-6, and a prototype of the integrated MAP instrument has been extensively field tested in the Atacama Desert and the Panoche Valley region of California.