MapX – An *in situ,* full-frame X-ray spectroscopic imager for the biogenic elements

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Microbial life exploits microscale disequilibria at boundaries where valence, chemical potential, pH, Eh, etc. vary on a length scale commensurate with the organisms themselves - tens to hundreds of micrometers. These disequilibria can exist within cracks or veins in rocks and ice, at inter- or intra-crystalline boundaries, at sediment/water or sediment/atmosphere interfaces, or even within fluid inclusions trapped inside minerals. The detection of accumulations of the biogenic elements C,N,O,P,S at appropriate concentrations on or in a mineral/ice substrate would constitute permissive evidence of extant life, but context is also required. Does the putative biosignature exist in a habitable environment? Under what conditions of P, T, and chemical potential was the host mineralogy formed?

MapX is an arm-deployed contact instrument that directly images the biogenic elements C, N, O, P, S, as well as the cations of the rock-forming minerals (Na, Mg, Al, Si, K, Ca, Ti, Cr, Mn, Fe) and important anions such as Cl, Fl. The instrument provides element images having ≤100 μm lateral spatial resolution over a 2.5 cm X 2.5 cm area, as well as quantitative XRF spectra from ground-selected or instrument-selected Regions of Interest (ROI) on the sample. Quantitative XRF spectra from ROI can be translated into mineralogies using ground- or instrument-based algorithms. Either an X-ray tube source (X-ray fluorescence) or a radioisotope source such as 244-Cm (α-particle and γ-ray fluorescence) can be used, and characteristic X-rays emitted from the sample are imaged onto an X-ray sensitive CCD through an X-ray MicroPore Optic (MPO). As a fluorescent source, 244-Cm is highly desirable in a MapX instrument intended for life detection since high-energy α-particles are unrivaled in fluorescence yield for the low-Z elements. The MapX design as well as baseline performance requirements for a MapX instrument intended for life detection / identification of habitable environments will be presented.