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

David Blake, Philippe Sarrazin, Kathy Thompson and Thomas Bristow

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, F1. The instrument provides element images having \( \leq 100 \mu m \) 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 (\( \alpha \)-particle and \( \gamma \)-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 \( \alpha \)-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.