MICRO-XRF: FAST, HIGH SPATIAL RESOLUTION ANALYSIS OF ROCK AND SOIL ELEMENTAL CHEMISTRY *IN SITU*.

A.C. Allwood[1], L.A. Wade[1] and R. Hodyss[1], [1]Jet Propulsion Laboratory, California Institute of Technology, Pasadena, CA. Abigail.C.Allwood@jpl.nasa.gov

In situ analysis of rock chemistry is a fundamental tool for geological exploration of planets and moons. However, the current generation of flight instruments provides either spatially homogenized elemental data across a relatively large area (17mm diameter circle: Alpha Proton X-ray Spectrometer [APXS] on Mars Science Laboratory [MSL]) or single spot analyses from a mast-mounted camera up to several meters from the target ('ChemCam' on MSL). While these instruments provide valuable data, they may provide limited information about the relationship of rock composition to small scale textures, fabrics and structures in the rock—relationships that can be crucial for resolving many critical planetary science questions, particularly those important to astrobiology and sedimentology. To that end, a true chemical microanalysis capability is being developed: an arm-mountable, Micro X-ray fluorescence (Micro-XRF) instrument that will provide high spatial resolution measurements of the elemental chemistry of rocks and soils (**Fig. 1**).

The instrument uses state of the art X-ray focusing technology to produce a narrow X-ray beam (100 to 200 micrometer diameter) with extremely high fluorescent X-ray count rates (several hundred thousand counts per second). The combined small spot size and high count rate enable rapid, sensitive analysis of small target areas on rocks and soils.

Science rationale: The ability to ascertain the composition of small scale geological features plays a crucial role in determining the identity, origin and significance of mineral assemblages; as well as detecting and interpreting cryptic chemical patterns and signatures, including potentially biogenic ones. For example, in order to understand the relevance of hydrated minerals to habitability on Mars, it is vital not only to detect the minerals, but also to understand the residence of minerals in relation to small scale geological features such as detrital grains, cements, concretions, laminae, crystals etc: this is required in order to (for example) determine whether the minerals formed in standing bodies of surface water, or in the subsurface long after the rocks were buried.

The science value of micro-scale elemental analysis has been validated through studies of diverse rock types, including ~3.5 billion yr-old rocks containing the oldest evidence of life on Earth. Raster maps of the micro-scale distribution of elements in these rocks reveal mineralogy and key aspects of rock fabrics that constrain paleoenvironmental conditions, habitability and biogenicity in Early Archean stromatolites [1]. Whereas true raster mapping is likely too massive to be accommodated on upcoming potential missions, we envision collection of multiple point spectra along transects with (e.g.) millimeter-scale spacing, coupled with accurate visual alignment. This approach can achieve similar science results with very low mass, power, complexity and data volume.

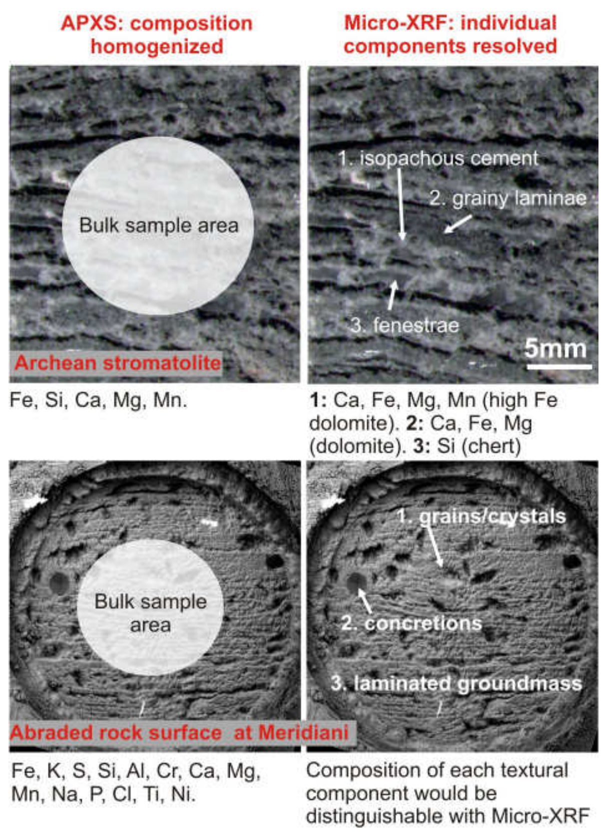

Figure 1: Comparison of analyses performed by APXS (left) and Micro-XRF (right). Top: Micro-XRF reveals the composition of important, separate components of an Archean stromatolite. Bottom: Bulk elemental data leaves significant unresolved questions about the geologic history of this martian rock (lower image courtesy Caltech/JPL).

Preliminary results: A breadboard instrument is currently being assembled and tested at JPL. The instrument consists of commercially available components, including a miniature X-ray tube (**Fig. 2**), Amptek X-ray detectors (silicon drift detectors, SDD) and electronics,. Preliminary testing yielded excellent spectra of metal (stainless steel: **Fig. 3**) and rock samples (dolomite-chert) within 10 seconds. A systematic calibration plan is being developed, along with an imaging system to visually document the location of the measurements.

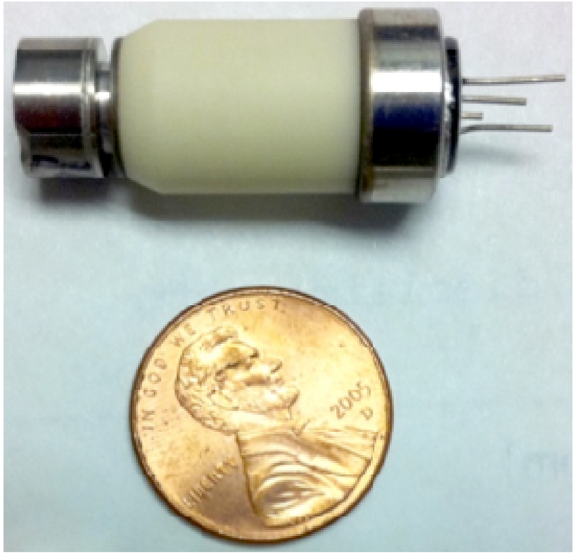

Figure 2: Moxtek miniature X-ray tube (image credit: Kris Kozaczek/Moxtek, Inc.)

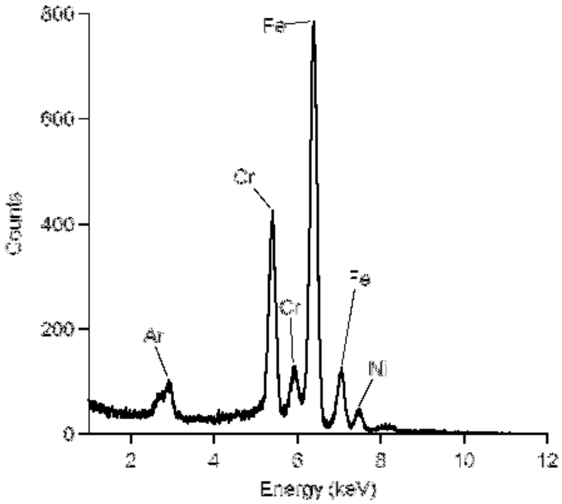

Figure 3: Spectrum of stainless sample, acquired with the Micro-XRF breadboard instrument.

References: [1] Allwood, A.C., Grotzinger, J.P., Knoll, A.H.., Burch, I.W., Anderson, M.S., Coleman, M.L., Kanik, I. (2009) *PNAS*, *106*, 9548-9555