ELECTRON-INDUCED LUMINESCENCE AND X-RAY SPECTROMETER (ELXS) SYSTEM FOR LIFE DETECTION. S.R. Jurewicz[1], J.Z. Wilcox[1], T. George[1], A. Chutjian[1], J. Feldman[1], S. Douglas[1] and J.M. Hanchar[2] ,[1] Jet Propulsion Laboratory, California Institute of Technology, 4800 Oak Grove Drive, 302-231, Pasadena, CA 91109 (stephen.r.jurewicz@jpl.nasa.gov), [2]The George Washington University, Dept. of Earth and Environmental Sciences, 2121 Eye Street N.W., Washington, DC 20006.

Introduction: The question of life on Mars continues to be a significant topic of debate in the planetary science community since the observations in ALH84001 were published [1]. Although the scientific data presented to date appears equivocal, it has sparked considerable public interest in the search for extra-terrestrial life and promoted a new direction for future pace missions. NASA has developed guidelines for these missions and their affiliated research [2]. A primary theme of these guidelines is the link between the possibility of extraterrestrial life and the past or present existence of liquid water. Hence, the search for water and related mineralogy plays a pivotal role in the search for life.

The search for signatures of life/water on planetary bodies, like most planetary exploration, proceeds on a series of reducing scales from global to a few centimeters. Although planetary observing satellites can look at the big picture, it will be up to small roving vehicles carrying carefully selected instrument packages to probe the planets surface.

Instrument Description: The ELXS concept is a novel, portable, micro-instrument targeted for the detection of mineralogic signatures of past water and extinct life on the surface of planetary bodies such as Mars. The ELXS is designed to perform rapid (minute-scale), in-situ spectroscopy consuming extremely low energy (~50J) per measurement. The measurements include x-ray fluorescence for elemental composition determination and cathodoluminescence (CL) spectroscopy. The instrument also includes a visual light camera capable of imaging the area being analyzed in both ambient light and CL modes. The spatial resolution of the measurements can be varied from approximately one centimeter to a few hundred microns. Juxtaposing these analysis techniques should enhance the ability to detect water-deposited minerals such as carbonates, which commonly exhibit CL. As suspected in ALH84001, carbonates may contain biogenic material and may possibly yield a biogenic signature. CL also occurs in minerals that are not associated with aqueous deposition. The elemental composition information can be used distinguish between minerals that may suggest biogenesis (carbonates and phosphates) from those that probably do not (e.g. pyroxenes). In addition, CL may identify characteristic morphological features such as potential relic textures embedded within a rock or soil matrix.

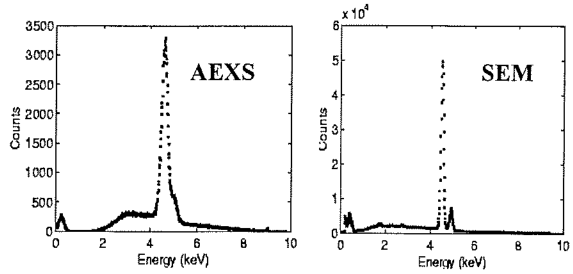

Fig. 1. X-ray fluorescence spectra obtained from a pure Ti target in **(a)** air using the AEXS test setup and **(b)** SEM, operated at 10 keV. The two Ti peaks are not completely resolved in **(a)** due to the resolution (~200 eV) of the X-ray detector, and the background counts are also higher due to the increased scattering of the electron beam.

Although optical spectrometers and x-ray fluorescence instruments have had a long heritage in previous in-situ exploration missions, CL measurements have never been attempted. The proposed ELXS builds on the JPL-pioneered concept of electron-induced x-ray fluorescence from samples in their pristine state in ambient atmosphere [3]. The proof-of-principle device was the Atmospheric Electron X-ray Spectrometer (AEXS). The device contained a miniature electron source that was vacuum-isolated with a microfabricated, electron-transmissive membrane [4]. The device demonstrated rapid, in-situ, x-ray fluorescence spectrum collection as illustrated in Figure 1. The ELXS development extends this previous effort by taking advantage of the fact that electrons may also excite CL spectra.

Mars Meteorites and Mars Exploration: Detectable CL in Mars meteorites including ALH84001 is mentioned in the literature [5]. In addition, some evidence suggests that CL in Mars meteorites may be relatively common [6]. The mineralogic identification of the CL producing species in these studies is not well documented but include glass and clinopyroxene. Chemical analysis of carbonate grains in ALH84001 show considerable variation and include essentially Fe-free members [7]. The presence of Fe-free carbonates makes CL for these minerals more plausible.

The EXLS instrument is envisioned to perform on either freshly exposed rock surfaces or soil grains as follows. First, the selected sample area will be darkened by a small cover and then bombarded by the broad (1cm) electron beam. It is hoped that the electron beam will exite CL in the exposed minerals. In particular, hydrothermally deposited minerals (carbonates) have the highest possibility for fluorescence. Once the spatial distribution of the minerals is determined, a smaller area can be selected for more detailed analysis. The electron gun can be moved into the desired position and the electron beam focused down to a few hundred microns. The smaller spot size enables a more detailed chemical and CL analysis within the limit of the beam size. This technique provides both a rapid rough estimate of the bulk chemical composition and CL exciting elements on two scales. Then, if the results appear interesting, additional points may be sampled or other more precise and energy consuming instruments may be employed. If nothing warranting a more precise investigation is found, the device can be moved to a new location with minimal loss of time.

The authors are aware that the lack of sample preparation of the exposed surface will result in electron scattering and that will degrade the resulting EDS analysis. In addition, the presence of dust coatings must also be considered when attempting to analyze soils and rocks [8]. However, we still believe that enough data can be gathered to allow for approximate mineral identification.

Biogenic Signatures: Current evidence for past bacterial life on Mars focuses around zoned carbonate globules in ALH84001. Thus detecting similar features in Martian rocks is a logical place to begin the search for life. CL imaging may be a useful guide to illuminating similar features on exposed rock surfaces. Although major chemical analyses can tell us the identity of a mineral, CL spectra may have the potential for suggesting a possible biogenic origin. The potential of CL in this area has yet to be determined. One of the main goals of this project is investigate any possible variations in CL spectra between carbonates formed or altered by biogenic activity and those formed through abiotic processes. Current plans include studies of CL spectroscopy in carbonates associated with cyanobacteria and chemolithotrophic thermophiles from hydrothermal deposits and fossilized stromatolites. Most importantly, CL is widely used for the illumination of various textures in sedimentary rocks and may be useful in illuminating features that would be over looked in ambient light conditions.

References: [1] McKay D.S. et al. (1996) *Science, 273,* 924--930. [2] Morrison D. and Schmidt G.K. eds. (1999) Astrobiology Roadmap, conf. proc. [3] George T. (1997) NASA New Technology Report NPO-20335. [4] Feldman J. et al. (1998) NASA New Technology Report NPO-20463. [5] Protheroe W.J. and Stirling J. (1998) *LPS XXIX,* abst.# 1569. [6] Protheroe W.J. (1998) Senior Thesis, Univ. Houston Clear Lake. [7] Treiman A.H. and Keller L.P. (2000) *63rd Annual Meteoritical Society Meeting,* Abst.#5279. [8] Bridges N.T. and Crisp J.A. (2001) *JGR, 106,* 14621-14665.