EVALUATING HANDHELD X-RAY FLUORESCENCE (XRF) TECHNOLOGY IN PLANETARY EXPLORATION: DEMONSTRATING INSTRUMENT STABILITY AND UNDERSTANDING ANALYTICAL CONSTRAINTS AND LIMITS FOR BASALTIC ROCKS. K. E. Young[1], C. A. Evans[2], and K. V. Hodges[1], [1]School of Earth and Space Exploration, Arizona State University, P.O. Box 871404, Tempe, AZ, 85282, [2]Astromaterials Acquisition and Curation Office, NASA Johnson Space Center, Houston, TX.

Introduction: While large-footprint X-ray fluorescence (XRF) instruments are reliable providers of elemental information about geologic samples, handheld XRF instruments are currently being developed that enable the collection of geochemical data in the field in short time periods (~60 seconds) [1]. These detectors are lightweight (1.3kg) and can provide elemental abundances of major rock forming elements heavier than Na. While handheld XRF detectors were originally developed for use in mining, we are working with commercially available instruments as prototypes to explore how portable XRF technology may enable planetary field science [2,3,4]. If an astronaut or robotic explorer visted another planetary surface, the ability to obtain and evaluate geochemical data in real-time would be invaluable, especially in the high-grading of samples to determine which should be returned to Earth. We present our results on the evaluation of handheld XRF technology as a geochemical tool in the context of planetary exploration.

Previous Work:

Basic Instrument Capabilities: In several previous reports [2,3,4], we detailed our efforts to calibrate handheld instruments with several well-characterized sample standards. All samples were homogenous, fine-grained basalts selected to minimize lithologic and crystallographic inconsistencies. We collected the data on smooth, unweathered surfaces. Data obtained using a Delta *Innov-X* handheld instrument were compared to published laboratory values. Using our suite of empirically-derived calibration curves, we also analyzed a set of lunar reference samples to demonstrate instrument capability. We obtained good analytical results for most elements heavier than Na (for example, see Titanium, in Fig. 1). These results indicate that, under ideal conditions using our established analytical protocols, a properly calibrated handheld instrument produces reliable analytical data.

Instrument Response with Sample Distance: Determining the necessary operating conditions for an instrument that could be used on an extravehicular activity (EVA) is important, especially due to limited time and mobility an astronaut will have on a planetary surface. If it is not time-efficient for an astronaut to operate this instrument, perhaps a robotic assistant is better equipped to collect the data and relay it to the astronaut. In either case, we need to determine how important it is for the instrument to have direct contact with the sample it is analyzing. Young et al. (2011, [4]) evaluated the effect of distance between the sample and the detector on data return (Fig. 2). In a laboratory setting (either terrestrial or planetary) [5], direct contact is easily achievable, but in the field, the data demonstrate that non-contact analyses are possible with proper calibration but that the results are not directly equivalent to those obtained in direct-contact mode. Any non-contact analyses must be performed at a fixed, repeatable distance from the sample surface in order to use a single calibration curve.

Additional Instrument Assessments: We continue to evaluate operational constraints and optimal protocols for interpreting data from a handheld XRF instrument.

Surface roughness: One of the most important considerations for field-based applications of this technology is to understand how surface roughness impacts analytical data. If astronauts plan to use this instrument on an outcrop in a planetary exploration context, we need to determine how much sample preparation will be necessary. Within the context of these studies, we compare and interpret data collected on both constrained surface geometries (sawed surfaces) as well as rough surfaces without any surface preparation.

Instrument Stability: In our efforts to establish the utility of this technology, we seek to ensure the minimization of any internal inconsistencies in the handheld XRF itself. Using a set of standards (discussed in [4]), we have run a series of repeat measurements with the same instrument over a total of two weeks, one in November of 2010 and one in August of 2011. Each sample standard was run at least a dozen times in each week, and we will present our standard curves produced from these data in this poster. Initial findings indicate high measurement reproducibility of each sample standard on different dates. Instrument stability would minimize the need for painstaking calibration on each occassion of utilizing the instrument, making it more user-friendly, especially in a planetary exploration environment.

Trace Element Analyses: In previous studies, we have devoted time to studying major element, whole-rock analyses of basaltic rocks, common both on Earth and on other planetary bodies. Because our initial major element assessments indicate that interpretable whole rock data can be achieved with the handheld XRF, we are expanding our analytical assessment to include some of the key trace elements found in basaltic rocks that are established markers for basaltic evolution, such as Zr, Ni, and Cr [6,7]. If reasonable and reliable trace element abundances can be gleaned from the rapid analysis protocols that are a hallmark of the handheld XRF technologies, the utility of such a tool for field-based geochemical reconnaissance is amplified.

Conclusions: In previous studies, we have established the handheld XRF device as a reliable and quick way to obtain real-time geochemical data in the field. There are many potential applications of this method, and we contend that planetary surface exploration is one area that could benefit from such a technology. In terms of practical field applications of the handheld XRF, we argue that sample preparation and operating conditions (such as the distance between the sample and the detector) appear to be critical in obtaining precise and accurate data. The effects of surface roughness and sample heterogeneities are poorly constrained as yet, but are a focus of current research. We are also evaluating the role of instrument drift in limiting the efficiency of data collection, especially in lieu of the constrained time available for astronaut explorers to conduct investigations. Finally, since trace elements play such an important role in evaluating geochemical evolutionary trends in basaltic magmas, we are working to establish which trace elements are most amenable to handheld XRF study.

Planetary field geology is greatly enhanced by the availability of real-time geochemical data to augment observations in the field. The handheld XRF provides a way to readily obtain such data. If minimal sample preparation and instrument calibration are needed, this technology could prove invaluable to planetary explorers.

Figures:

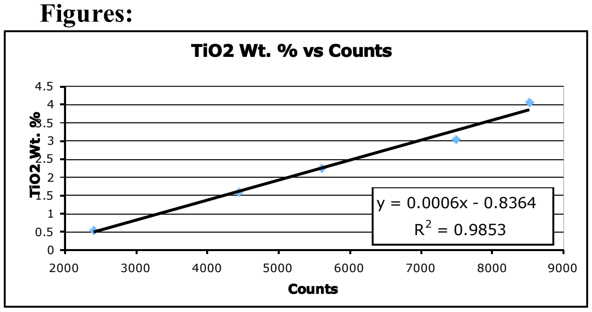

Figure 1: Results comparing data from the handheld XRF (shown as counts) to those obtained with laboratory instruments (shown as wt. %) demonstrate the reliability of the handheld device.

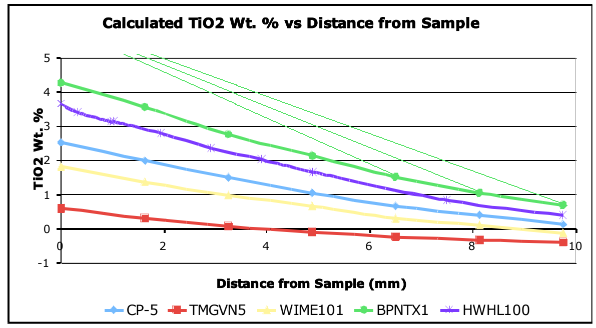

Figure 2: As the distance between the sample and the detector increases, the ability of the handheld XRF to provide reliable data dramatically decreases. Effective sample preparation and presentation is therefore very important when using this technology.

References:

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