ENHANCING EXPERIENTIAL LEARNING IN ASTROBIOLOGY AT HISPANIC-SERVING INSTITUTIONS WITH HAND-HELD XRF INSTRUMENTATION. E. B. Melchiorre[1], A. Covorrubias[2], M. DeHoyos[2], D. Terry[2], C. Sheets-Harris[2], and W. Buckley[2], [1]Geology Department, California State University, 5500 University Parkway, San Bernardino, CA 92407 emelch@csusb.edu, [2]Geology Department, California State University, 5500 University Parkway, San Bernardino, CA 92407.

Introduction: Experiential learning through classroom activities, laboratory exercises, travel, field work, and internships is the key to reaching many students. Studies with students demonstrate that those who perform and participate in research as an undergraduate have strong correlation with several positive student outcomes which include increased educational retention, persistence to graduation, higher GPA, and increased probability of acceptance into graduate school [1] [2]. Undergraduates who have meaningful research experiences are observed to have positive changes in psychosocial profiles, higher self-confidence and morale, and independence [3] [4].

Hand-Held XRF Instrumentation: A generous grant by the W.M. Keck Foundation in 2014 permitted the geology department at CSUSB to acquire four state of the art NITON hand-held x-ray fluorescence instruments. Recent advances in miniaturization of electronics and detectors have enhanced hand-held XRF technology into a serious quantitative tool. The XRF detectors have four internal filters and can reliably measure the abundance of elements Mg through S to the tenths of a weight percent, and Cl through U to the 10-100 ppm level. Some transition metals have detection limits as low as a few ppm. The instruments obtained have on-board GPS that may be synchronized to a lap-top computer or tablet to permit real-time examination of geochemical data within Google Earth or similar mapping platforms.

Meteorite Studies: Five undergraduate students traveled with faculty to the Lunar and Planetary Laboratory at University of Arizona to test the utility of hand-held XRF technology for meteorite classification. Over 200 analyses (44 elements each, 8,800 unique data points) were performed on a range of meteorite samples, including pallasites, chondrites, irons, lunar meteorites, and a Martian meteorite.

A preliminary discovery is a “polishing effect” where iron meteorites experience slight chemical alteration when high-speed polishing is used to produce the slabs of material we examined. This polishing is known to produce substantial heat and in some cases differential polishing, which is believed to produce this effect. This effect was noted when performing duplicate analyses on the polished fronts and unpolished backs of the same samples.

Glass Studies: The effectiveness of hand-held XRF detectors for chemical classification of impact glass (tektites) was evaluated in spring of 2014 with a research trip to the Missouri University Research Reactor facility (MURR), with extensive testing of 40 samples of obsidian (natural volcanic glass). All of these obsidian samples have extensive elemental characterization by neutron activation and ICP-MS work, and are used as laboratory reference standards. This work determined that the new XRF instruments produce excellent results for some elements (e.g., Calcium and Zirconium), and poorer results for others (e.g., Aluminum and Potassium). Plots of XRF values vs accepted standard values indicate a correlation coefficient of more than 0.95 for many elements, down to the low ppm level. The huge database generated during this visit to the Missouri laboratory (40 samples, 44 elements, 6 analyses, 10,560 data points) and later analyses for tektite samples (4,218 data points) is being processed by faculty and students, with a goal to produce a “glass XRF reliability chart,” with each element color-coded to indicate the reliability of the data fit from this study.

Conclusions: The effectiveness of hand-held XRF chemical characterization is dependent upon correcting to standards and knowing the limitations of the instrument. The characterization work performed by undergraduate students on meteorites and natural glass has established analysis protocol and determined limitations for analysis of these materials. Non-destructive, *in-situ* chemical analysis has great potential for testing museum specimens, and materials in National Parks or other setings where it is desired that they remain undisturbed. But most significantly, students have gained personal confidence and a passion for science through mastery of a sophisticated instrument that produces rapid results.

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