X-RAY DIFFRACTION IN THE FIELD AND LAB ON THE MOON G. Jeffrey Taylor[1], David Blake[2], Jeffrey Gillis-Davis[1], Steve J. Chipera[3], David Bish[4], Julia Hammer[5], Paul Lucey[1], David T. Vaniman[6], and Philippe Sarrizin[7] [1]Hawaii Inst. of Geophys. and Planetology, Univ. of Hawaii, Honolulu, HI 96822 (gjtaylor@higp.hawaii.edu); [2]NASA Ames Research Center, Moffett Field, CA 94035; [3]Chesapeake Energy Corporation, 6100 N Western Ave., Oklahoma City, OK 73118; [4]Dept. of Geological Sciences, Indiana University, Bloomington, IN 47405; [5]Dept. of Geol. and Geophys., Univ. of Hawaii, Honolulu, HI 96822; [6] Los Alamos National Laboratory, EES-6, MS D462, Los Alamos, NM 87545; [7] inXitu, Inc., 2551 Casey Avenue, Suite A, Mountain View, CA 94043.

Introduction: The CheMin X-Ray diffraction/X-Ray fluorescence (XRD/XRF) instrument has been chosen to fly on the 2009 MSL mission to Mars [1]. A similar instrument would add significant capability to lunar surface measurements on robotic missions and at a lunar outpost. We have measured the mineralogy of lunar soil samples a using newly developed field-portable version of the flight instrument, called *Terra* (sold commercially by inXitu, Inc.). The results indicate that Terra can determine the abundances of minerals and glass in lunar soil samples. Similar instruments could be used on robotic missions to the Moon, as an aid to human field work for resource exploration and scientific mapping, and for use as a screening device in a surface laboratory. Developoment of such highly automated instrumentation is called for in Objective 1A-5, Investigation 2 (*Provide sample analysis instruments and protocols on the Moon to analyze lunar samples before returning them to Earth*) in the LEAG Goals [2]. The LEAG document specifically notes: "Analytical instruments at a lunar base will allow us to choose the optimal samples to return to Earth, hence making the best use of cargo space and mass. It also allows astronauts to receive preliminary data on samples collected to help in planning additional field observations. Automation is required so that astronauts do not have to spend significant amounts of time analyzing rocks and soils."

Procedures. Apollo regolith samples with grain sizes of < 150 µm and weighing ~50 mg were placed inside the mini-CheMin sample holder and exposed for about 4 hours each. The resulting diffraction patterns were quantified using Rietveld refinement, a structurally based full-pattern fitting technique. This allowed us to determine the abundances of minerals present at levels greater than about 1 wt% and the abundance of silicate glass.

Results: To date we have measured phase abundances in 11 lunar regolith samples from Apollo 11, 12, 14, 16, and 17. We compare our results with those obtained by point-counting [3,4] using scanning electron microscopy in Fig. 1. Although the agreement is not perfect at this stage of our research, the results are promising. There is scatter, but in general our results are within 10% of those obtained by the elaborate and time-consuming point-counting procedure used by L. A. Taylor and his colleagues [3,4]. A linear fit to the data in Fig. 1 gives a slope of 1.09 and R^2 of 0.903. A more extensive dataset for lunar mineral and glass separates will greatly improve the results.

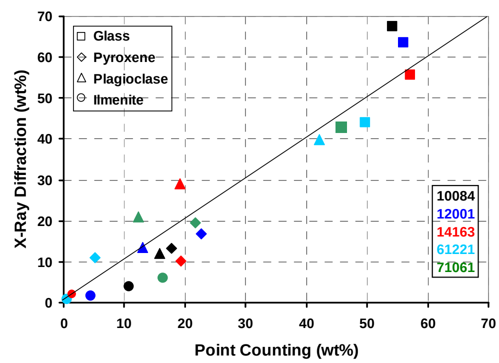

Fig. 1. Comparison of pointing counting using SEM (3,4) with our results using CheMin.

Implications : Terra is a robust instrument that would be extremely valuable for use in exploring the lunar surface. Instruments based on this design can be used on a rover making independent surveys of the surface (including highly automated surveys) or on a rover accompanying a human field party. Qualitative identification of all major phases in lunar soil samples can be achieved in 1-5 minutes of analysis time. Its ease of use would make it an ideal part of a lunar-surface laboratory suite designed to improve field studies and decrease sample-return mass, thus meeting an important LEAG objective. The instrument would take little astronaut time, requiring only ~5 minutes to prepare a sample sieved to <150 µm and load it into the instrument. The rest of the operation is fully automated.

References : [1] P. Sarrazin et al. (2005). *Powder Diffraction* 20, 128-133. [2] *Exploring the Moon in the 21st Century: Themes, Goals, Objectives, Investigations, and Priorities (2008)* (draft document). [3] Taylor, L.A. et al. (2001) *J. Geophys. Res.*106,27985-27999. [4] http://web.utk.edu/%7Epgi/data.html).