Combined Remote Mineralogical and Elemental Measurements From Rovers. F. P. Seelos[1], R. C. Wiens[2], D. A. Cremers[2], M. Ferris[2], J. D. Blacic[2], and R. E. Arvidson[1], [1]Department of Earth and Planetary Sciences, McDonnell Center for the Space Sciences, Washington University, St. Louis, MO 63130, seelos@wunder.wustl.edu, Tel: 314 935 4888, Fax: 314 935 4998, [2]Los Alamos National Laboratory, Los Alamos, NM 87545.

The FIDO/K9 Year 2000 Mars Prototype Rover field trials at the Lunar Crater Volcanic Field, Blackrock Summit, NV provided the opportunity for the tandem acquisition of Laser Induced Breakdown Spectroscopy (LIBS) data and VISIR reflectance data from select geologic targets in a non-laboratory environment [1]. The LIBS data were acquired by the LANL LIBS instrument mounted on the Ames Research Center K9 rover [2], and the VISIR reflectance data were acquired with an ASD Full Range portable spectrometer. The ASD instrument has a wavelength range of 350 to 2500 nm and a spectral resolution of 3 to 10 nm.

LIBS is focused on the determination of the elemental composition of a target, whereas VISIR reflection spectroscopy is more useful in inferring the mineralogy. By acquiring both types of data in tandem from rovers, a more complete characterization of the target can be obtained.

The samples that were measured in the field are pictured in Figure 1. It should be noted that sample A11/A14 is a single target separated into two pieces. In addition, the reflectance data for sample A04 proved to be unreliable so analyses are not included in this report. These considerations reduce the number of samples in the analysis to ten.

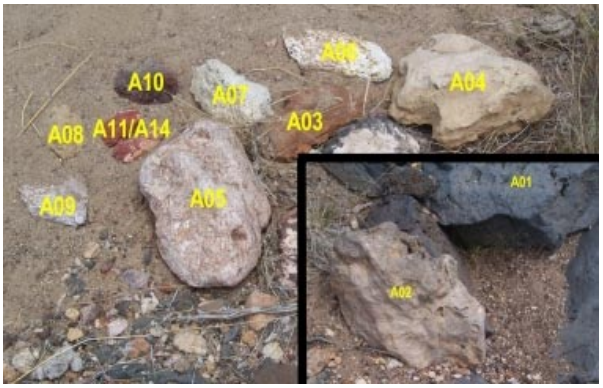

Figure 1 - Samples measured in the field with both the LIBS and reflectance instruments. Sample A05 is approximately eight inches long.

Analyses of the reflectance spectra led to the separation of the samples into four distinct groups. These groups are defined as follows: Group 1, Basalt endmember; low and generally featureless reflectance spectra. Group 2, Goethite endmember; characteristic goethite Fe^{3+} spectral features in the range of 0.50 to 0.85 microns. Group 3, Kaolinite endmember; diagnostic spectral doublet with minima at 2.17 and 2.21 microns. Group 4, Dolomite endmember; carbonate feature at 2.32 microns. It should be noted that many of the samples in Group 3 also exhibit the goethite spectral features, and that the lone sample in the dolomite group has a strong kaolinite doublet in its reflectance spectrum as well. Table 1 gives a summary of the results of the classification, and Figure 2 exhibits representative spectra from each group.

Group No.	Endmember	Member Samples
1	Basalt	A01; A10
2	Goethite	A03; A11/A14
3	Kaolinite	A05; A06; A07; A08; A09
4	Dolomite	A02

Table 1 - Groups determined from VISIR spectra.

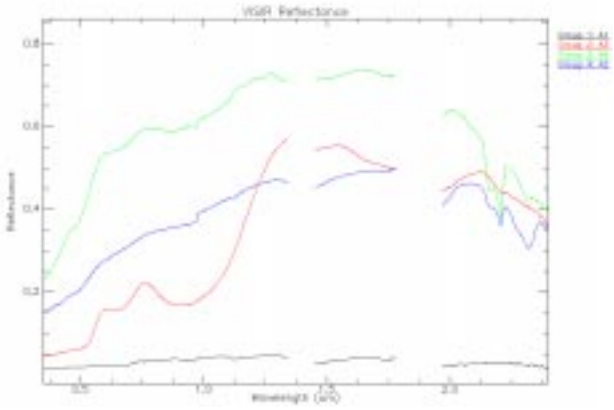

Figure 2 - Representative VISIR reflectance spectra.

The LIBS instrument operates by briefly illuminating a target with a powerful laser pulse that converts a small quantity of the target material to a plasma. This can be done from stand-off distances up to several tens of meters. The plasma that is created radiates in the visible spectrum, and is measurable with a spectrometer. From the spectroscopic data, the elemental composition of the target can be inferred [3].

Due to time constraints, the data acquired by the LIBS instrument in the field consisted only of single shot measurements that were effective over a wavelength range of 370-450 nm. In contrast, the preferred method of data acquisition consists of stacking multiple shots taken from the same target. Also in the

interest of time, no in-field composition calibrations were performed. Nevertheless, a great deal of information regarding the abundance of common rock-forming elements was recovered. In all cases, the LIBS data gave relative elemental abundances consistent with the endmembers that were identified from the VISIR reflectance spectra. The LIBS results are given in Table 2. It should be noted that the LIBS analysis was performed without any knowledge of the results from the VISIR spectra.

Combined VISIR/LIBS measurements thus allow for a much more accurate reconstruction of the chemistry and mineralogy of the samples than could be obtained by the analysis of either data set independently. A combined system could be used to great advantage during a rover mission to Mars, remotely acquiring mineralogical and elemental data for a large number of targets during traverses.

	Si	Ca	Fe	Ti	Mg	Al	Sr	Na/ Ca
	Group 1: Basalt							
A01	M	M-H	H	H	H	M-H		M-H
A10	M	M-H	M	M	M-H			M
	Group 2: Goethite							
A03	L	L	H					H
A11	L-M		H		H	L	H	M
A14	L	L	VH		M			
	Group 3: Kaolinite							
A05	VL	M-H			M	L	T	L
A06	VL	M-H			M	L	T	L
A07	M-H		L-M	M-H		M-H		H
A08	M			T		M-H		H
A09	M			T		M-H		H
	Group 2: Dolomite							
A02	VL	M-H			M	L	T	L

Table 2 - Relative elemental abundances from LIBS data. (VH: Very High, H: High, M: Moderate, L: Low, VL: Very Low; T: Trace)

References:

[1] Arvidson R. E. et al. (2000) . [2] Wiens R. C., et al. (2000) LPS XXXI, 1468. [3] Cremers D. A. and Radziemski L. J. (1986) in Laser Spectroscopy and its Applications (L.J. Radziemski, et al., eds), Chapter 5, Marcel Dekker, New York.