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1. Geotechnical (e.g., soils, excavation, foundations, and use of *in situ* materials for shielding).

2. Mitigation of detrimental effects of the environment (e.g., dust, thermal, primary and secondary impacts of micrometeoroids, radiation, and vacuum). This area includes obtaining a better understanding of the dust and debris environments above and on the surface of the Moon.

3. Approaches to use in construction on the Moon (e.g., extravehicular activity, robotics, telepresence, assembly aids, connectors). The appropriate choices can be made only with adequate knowledge of the surface conditions and variability.

4. Contamination/interference control and restoration processes. May vary with chemistry and mineralogy.

5. Performance of optical and related systems and charge-coupled devices (CCDs) on the Moon. CCDs deserve particular attention with respect to shielding requirements against cosmic and solar flare radiation. Shielding will probably be with *in situ* materials requiring excavation and placement at desired densities.

6. Test and evaluation techniques for lunar observatory systems and construction approaches to validate approaches before returning to the Moon. Depends on devising appropriate simulation of lunar conditions.

We anticipate that the initial telescopes on the Moon will be small automated instruments that have already been shown to be feasible by existing Earth-based robotic telescopes. These early telescopes will not only establish the viability of telescopes on the lunar surface, but will also perform excellent extended observations during the long lunar night to test models of active stars and galaxies, and do all-sky CCD surveys in the ultraviolet and infrared using a Schmidt wide-field telescope to complement the important sky survey done at Mount Palomar. We conclude that attention must be given to instrumenting these small telescopes in innovative ways to obtain information that will help find answers to unknowns in the areas listed above. We suggest that there are excellent opportunities to use the early landers to investigate the behavior of the soil under load, determine the extent of dust movement (e.g., levitation) associated with the passage of the lunar terminator, and place bounds on disturbances associated with vehicle operations on the Moon. Creative uses of information obtained from many innovative approaches may be used to help make lunar-based telescopes a reality.

For example, ground-probing radar has many terrestrial applications (e.g., in assessing pavement layer thicknesses in highway engineering applications, in determining the location of fissures in the dry lake bed at the Edwards Air Force Base shuttle landing site, and at Meteor Crater, Arizona, in investigations of the ejecta blanket). We propose to use this technology on the Moon in conjunction with other techniques such as penetrometers, borings, and core recovery to ascertain needed subsurface soil and rock properties. The goal is to minimize the use of labor-intensive subsurface sampling required during site investigations on the Moon and to improve approaches to assessing *in situ* lunar construction materials.

References: [1] Johnson S. W. and Burns J. O. (1991) *Proceedings of the Common Lunar Lander Workshop*, NASA, Houston. [2] Johnson S. W. (1992) *Proceedings of Space 92*, American Society of Civil Engineers, New York. [3] Johnson S. W. and Wetzel J. P. (1992) *J. Aerosp. Eng.*, 5.

AN *IN SITU* TECHNIQUE FOR ELEMENTAL ANALYSIS OF LUNAR SURFACES.

K. Y. Kane and D. A. Cremers, CLS-4, Mail Stop J567, Los Alamos National Laboratory, Los Alamos NM 87545, USA.

An *in situ* analytical technique that can remotely determine the elemental constituents of solids has been demonstrated. Laser-Induced Breakdown Spectroscopy (LIBS) is a form of atomic emission spectroscopy in which a powerful laser pulse is focused on a solid to generate a laser spark, or microplasma. Material in the plasma is vaporized, and the resulting atoms are excited to emit light. The light is spectrally resolved to identify the emitting species.

LIBS is a simple technique that can be automated for inclusion aboard a remotely operated vehicle. Since only optical access to a sample is required, areas inaccessible to a rover can be analyzed remotely. A single laser spark both vaporizes and excites the sample so that near real-time analysis (a few minutes) is possible. This technique provides simultaneous multielement detection and has good sensitivity for many elements. LIBS also eliminates the need for sample retrieval and preparation preventing possible sample contamination. These qualities make the LIBS technique uniquely suited for use in the lunar environment.

LIBS has been demonstrated using several different types of samples at distances between 4 and 18 m. Analyzed samples include simulants of Apollo mission Moon rocks, Mauna Loa basalt samples, and rock powder reference standards. An example of the spectra obtained with this technique using an Apollo Moon rock simulant is presented in Fig. 1. The presence of several elements such as aluminum, calcium, iron, magnesium, silicon, and titanium is clearly evident.

A portable LIBS instrument has been field tested with good preliminary results. An exposed tuff face was interrogated by the laser spark at a distance of approximately 18 m in bright sunlight. Spectra obtained at this distance displayed very strong emission

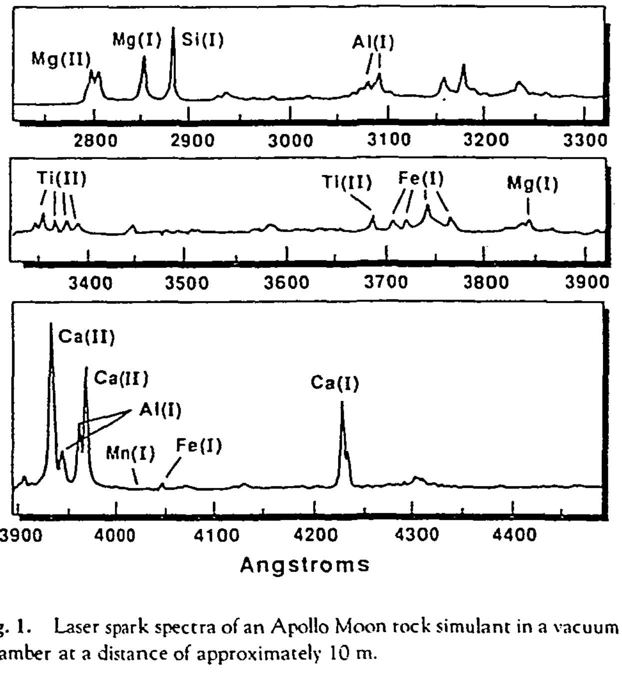

Fig. 1. Laser spark spectra of an Apollo Moon rock simulant in a vacuum chamber at a distance of approximately 10 m.