

will consist of actual observations, rather than simulated sequences generated from a shape model. They will enable the viewer to see all the details of the topography, morphology, and distribution of compositional units as the viewing and illumination geometries change. Several different video sequences of Geographos are anticipated, including separate sequences for each imaging system and merged datasets. The LIDAR will provide the highest spatial resolutions (in four colors), the thermal-IR detector will provide nightside imaging, the UV/VIS camera will provide the highest resolution of the entire visible and illuminated surface during the 75 s before and after closest approach, and the UV/VIS plus near-IR detectors will map the mineralogy.

SOURCES SOUGHT FOR INNOVATIVE SCIENTIFIC INSTRUMENTATION FOR SCIENTIFIC LUNAR ROVERS.

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Lunar rovers should be designed as integrated scientific measurement systems that address scientific goals as their main objective. Scientific goals for lunar rovers are (1) to develop a more complete understanding of the stratigraphy, structure, composition, and evolution of the lunar crust by close examination of the geology and geochemistry of multiple, wide-spaced landing sites on the Moon; (2) to improve the understanding of the lunar regolith and history of solar system events that have affected the lunar surface; (3) to improve the understanding of the lunar interior and set constraints on planetary evolution using geophysical techniques; and (4) to identify and characterize potential lunar "resources" that could be utilized by future human missions.

Teleoperated robotic field geologists will allow the science team to make discoveries using a wide range of sensory data collected by electronic "eyes" and sophisticated scientific instrumentation. Rovers need to operate in geologically interesting terrain (rock outcrops) and to identify and closely examine interesting rock samples. Analytical instrumentation should measure the maturity of soils and the chemical composition (major, minor, and trace) and mineralogy of soils and fresh surfaces of rock samples. Some ingenious method is needed to obtain fresh rock surfaces. Manipulator arms are needed to deploy small close-up cameras and lightweight instruments, such as alpha backscatter spectrometers, as "stethoscopes" to the clasts in boulders. Geoscience missions should also deploy geophysical packages.

Enough flight-ready instruments are available to fly on the first mission, but additional instrument development based on emerging technology is desirable. There are many interesting places to explore on the Moon (i.e., the lunar poles) and it is highly desirable to fly multiple missions with continuously improved instrument sets. For example, there are needs for (1) *in situ* reflectance spectroscopy measurements (with high spectral resolution TBD) to determine the spectra (~0.3-2.5 μm) and mineral contents of rocks and soils in a manner analogous to what is done from a distance by Earth-based telescopes or from lunar orbit; (2) Mössbauer spectroscopy to determine soil maturity and mineralogy and relative abundance of iron-bearing phases; (3) close-up images by a "field-lens" electronic camera with artificial lighting and good depth focus (autofocus?) allowing scientists in the control room to have the

ability to make discoveries and document what has been analyzed by the analytical instruments; (4) precise and accurate analytical measurements of the chemical composition of soils and rocks—especially the critical determination of the Fe/Mg ratio and one or more of the large ion lithophile elements; (5) cryogenic systems to cool solid-state detectors such as infrared sensitive CCD arrays, Si(Li) X-ray or Ge gamma ray detectors; (6) multispectral imagery by CCD cameras including telephoto, metric, or panoramic; (7) bore-sited laser range-finding equipment with gimbals that read out angles for precise site survey; and (8) thermally evolved gas analysis.

DRILL/BORESCOPE SYSTEM FOR THE MARS POLAR PATHFINDER. D. A. Paige, S. E. Wood, and A. R. Vasavada, Department of Earth and Space Sciences, University of California, Los Angeles CA 90024, USA.

The primary goals of the Mars Polar Pathfinder (MPP) Discovery mission are to characterize the composition and structure of Mars' north polar ice cap, and to determine whether a climate record may be preserved in layers of ice and dust. The MPP would land as close as possible to the geographic north pole of Mars and use a set of instruments similar to those used by glaciologists to study polar ice caps on Earth: a radar sounder, a drill/borescope system, and a thermal probe. The drill/borescope system will drill ~50 cm into the surface and image the sides of the hole at 10-μm resolution for compositional and stratigraphic analysis.

Several uncertainties have guided the development of this instrument. It is presently not known whether the surface at the north pole consists of solid ice or packed snow, or how difficult it will be to drill. In order to more quantitatively investigate design and power requirements, we built a thermal chamber for testing the drill/borescope instruments under Mars-like conditions with complete remote control. To minimize the number of mechanisms and moving parts, an integrated drill/borescope system would be desirable for the MPP. However, for these initial tests we used separate off-the-shelf components: a Hilti model TE-10A rotary percussion drill, and an ITI 26-in rigid borescope attached to a Sony XC-999 cigar-type color CCD camera. The drill rotates at about 500 rpm while hammering at about 50 Hz, using about 150 W. Using a 1-in continuous-flute drill bit, it is able to drill through 12 in of -80°C solid ice in about two minutes, with no down-force applied except for its own weight. A talus pile of the low-density shavings forms around the surface, but the hole is left clear after the drill is retracted. The borescope is a hard-optics right-angled device with fiber-optic illumination at its tip. It is able to focus from near contact to infinity. The borescope has a 13° vertical field of view, which amounts to about 3 mm of vertical distance at the viewing distance in our 1-in-diameter holes. This equipment, and high-resolution vertical scans of two boreholes, are part of a videotape. We prepared three types of samples: pure ice, ice with dust layers, and snow with dust layers. To make the ice/dust sample we successively poured and froze a suspension of 2-μm cinder particles in water. The dust settles as the water freezes, and forms layers between clear ice. The first close-up images of the inside of a hole were taken in the solid ice/dust sample with the borescope as it is lowered slowly to the bottom. The ice in these images appears almost black, and the dust layers are reddish

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one of the instruments

Various instruments that are now to be developed for later missions will be described