POLAR NIGHT VISION: THERMAL INFRARED IMAGING AT THE LUNAR SURFACE. P. O. Hayne[1], D. P. Osterman[2], B. T. Greenhagen[3], K. Donaldson Hanna[4], D. A. Paige[5], M. A. Siegler[6], T. Horvath[5], E. Jhoti[5] [1]University of Colorado Boulder (Paul.Hayne@Colorado.edu), [2]Ball Aerospace, [3]Applied Physics Laboratory, Johns Hopkins University, [4]University of Central Florida, [5]University of California, Los Angeles, [6]Southern Methodist University.

Introduction: Temperatures at the Moon's poles are largely controlled by insolation and shadowing. Without a substantial atmosphere to transport heat, extreme temperature gradients of 100's of degrees K per centimeter can persist in the insulating regolith across boundaries of shadow and light. In the shadows, volatiles such as water can be cold-trapped for geologically long timescales [1, 2, 3, 4]. Thermal conditions on the rough lunar surface are therefore largely independent of spatial scale, down to the ~1 cm scale where conduction effectively eliminates cold-traps (defined as < 110 K for water ice).

Given the anticipated prevalence of shadows at small spatial scales, thermal infrared imaging provides an effective way to identify cold-traps quickly and accurately. These cold-traps could then be investigated further by astronauts or rovers using instruments to determine the presence and abundance of ice. Furthermore, thermal IR imaging is necessary to establish the relationships between surface and subsurface temperature and the presence or absence of ice. Therefore, thermal IR imaging at the lunar surface could test hypotheses for the origins and supply/destruction rates of volatiles in the Earth-Moon system.

Proposed Instrumentation: Several space-qualified detector technologies are available for thermal IR imaging systems that could be deployed on the lunar surface. Here, we propose a low-cost, light-weight radiometer camera based on the Lunar Compact Infrared Imaging System (L-CIRiS) developed by Ball Aerospace and the University of Colorado's Laboratory for Atmospheric and Space Physics (LASP). L-CIRiS [5] uses a microbolometer detector array and a novel three-point calibration system for excellent radiometric accuracy for scene temperatures from < 100 K to >400 K. Spatial resolution of ~1 cm is possible with the standard optics from a distance of a few meters (Fig. 1).

With some modest technical development this or a similar system could be mounted on a mobile platform such as a rover or astronaut helmet. Alternatively, a handheld or wrist-mounted camera system could provide greater flexibility for astronaut operation and real-time decision making.

Importance for Polar Exploration: Astronauts exploring the lunar polar regions will need to make decisions based on data collected *in situ*. For example, shadow temperatures can span a large range, from < 30 K to >150 K [3, 6]; the warmer of these would be unlikely to contain ice, whereas the coldest might contain a wealth of useful and scientifically valuable volatiles. An astronaut with a thermal IR camera could therefore make informed decisions in real-time to locate the most promising sites for *in situ* resource utilization (ISRU). Besides ISRU, temperatures are also relevant to engineering constraints and astronaut safety.

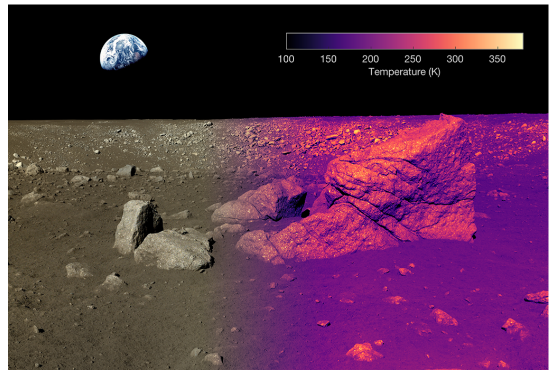

Figure 1: Simulated thermal infrared view at the Chang'e-4 landing site.

Importance for Lunar Science: Several important outstanding questions in lunar science can be addressed with thermal imaging from the surface. Among these is the supply rate and sources of volatiles to the Moon [7]. We propose to test the hypothesis that ice is currently accumulating at the lunar poles, by using temperature and compositional measurements of so-called "micro cold-traps". These features, from 1 cm to several meters, should have temperatures cold enough to support stable water ice, yet their small size should lead to more rapid destruction/modification of the ice by impact gardening. Based on established regolith modification rates [8, 9], we can establish the youngest micro cold-trap containing water, which places a relatively strong constraint on the present-day supply and destruction rates. These micro cold-traps could also be accessed within illuminated terrain (Fig. 2).

In addition to assessing volatiles, thermal IR imaging can be used to study surface composition and mineralogy [10, 11]. Based on these and other considerations, thermal infrared imaging from the lunar surface would enable a synergy between science and exploration.

Acknowledgments: This work was supported by the NASA Lunar Surface Instruments and Technologies Program, and the Lunar Reconnaissance Orbiter project.

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Figure 2: An illuminated peak sticks up from the deep shadows near the Moon's south pole. Shadowing of the lunar surface creates cold-traps for volatiles on spatial scales down to centimeters, which could exist within the illuminated region of this image. These cold-traps are ideal for testing hypotheses on the sources and supply of volatiles to the Earth-Moon system. (Credit: NASA/Lunar Reconnaissance Orbiter Camera)