SHADOW DEPTHS AND OTHER CHARACTERISTICS OF POTENTIAL LCROSS IMPACT SITES. G. D. Bart[1], A. Colaprete[2], [1]*University of Idaho, Department of Physics, PO Box 440903, Moscow, ID 83843, USA. (gbarnes@uidaho.edu)*, [2]*NASA Ames Research Center, M/S 245-3, Moffett Field, CA 94035, USA..*

The LCROSS Mission: LCROSS, the Lunar CRater Observation and Sensing Satellite, will be launched on the same rocket as the Lunar Reconnaissance Orbiter (LRO) later this year (`http://lcross.arc.nasa.gov`).

The LCROSS scientific objectives are: (1) Confirm the presence or absence of water ice in a permanently shadowed region on the Moon. (2) Identify the form/state of hydrogen observed by at the lunar poles. (3) Quantify, if present, the amount of water in the lunar regolith, with respect to hydrogen concentrations. (4) Characterize the lunar regolith within a permanently shadowed crater on the Moon. The presence of water ice is hypothesized based on evidence found by the Lunar Prospector neutron spectrometer for hydrogen in permanently shadowed regions at the poles [1].

The LCROSS spacecraft will set the rocket's Centaur Earth departure upper stage (EDUS) on an impact trajectory with the Moon. Once the trajectory is set, the spacecraft will release the EDUS, which will then impact the Moon in a permanently shadowed region characterized by high concentrations of hydrogen according to the Lunar Prospector neutron spectrometers. Following four minutes behind the EDUS, LCROSS will fly through the impact plume, using its 5 cameras (1 visible, 2 Near IR, 2 Mid IR), three spectrometers (1 visible, 2 NIR), and one photometer to search for water ice.

Impact Site Candidates: Four south-pole regions are currently candidates for the LCROSS impact (Fig. 1): Shoemaker crater (88.1 S, 44.9 E, 50.9 km diameter), Shackleton crater (89.9 S, 0.0 E, 19 km diameter), Faustini crater (87.3 S, 77.0 E, 39 km diameter), and Cabaeus (85 S, 35 E) (Fig. 1). Several north pole craters are currently under consideration as well (A-F, Fig. 2).

Site Criteria and Characterization:

Target selection will be key to the success of this mission. The constraints on the impact site selection are: (1) The ejecta plume must be observable by ground-based and orbital observatories. (2) The ejecta must be illuminated by sunlight, since the instruments primarily measure reflected light. (3) The target should have known surface properties (low roughness and slopes, deep regolith cover.) (4) The target should be in a permanently shadowed region with an observed concentration of increased hydrogen, which could indicate presence of water [3].

The first two criteria depend on the angles between the moon and the earth, and the moon and the sun, respectively. These criteria are set by the orbital motion of the bodies, and thus are determined at any given site by the impact date and time. Some impact dates will not provide acceptable viewing and lighting conditions for any impact sites. Other dates will provide acceptable viewing and lighting conditions for some sites and not others.

The third criteria, characterizing the expected terrain within the crater, is more challenging to achieve because the target im-

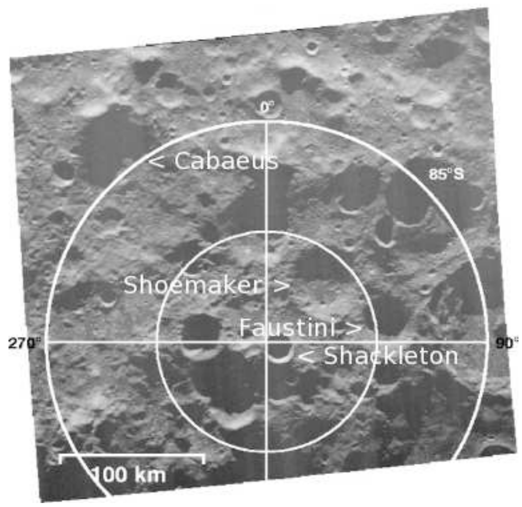

Figure 1: South Pole: Illustration of the location of candidate impact locations for LCROSS, superimposed on a radar backscatter map of the lunar south pole from [2].

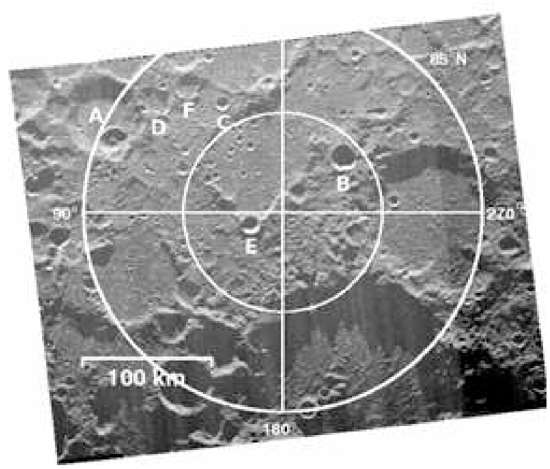

Figure 2: North Pole: Illustration of the location of candidate impact locations for LCROSS, superimposed on a radar backscatter map of the lunar north pole from [2]. Labels B-F are placed directly beneath the corresponding crater.

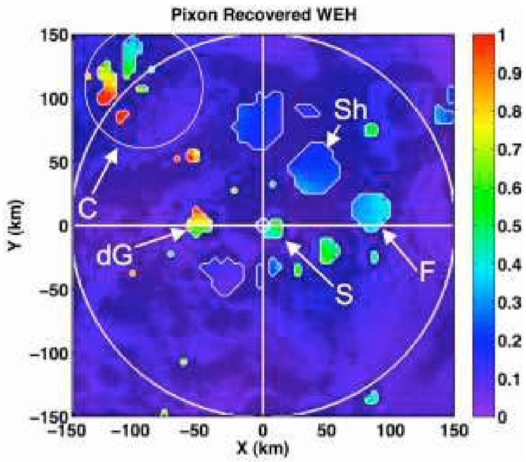

Figure 3: Water-equivalent hydrogen (WEH) in wt% corresponding to the epithermal count rates. Large circle denotes 85S. *C* = Cabaeus, *Sh* = Shoemaker, *dG* = de Gerlache, *S* = Shackleton, *F* = Faustini. From [3].

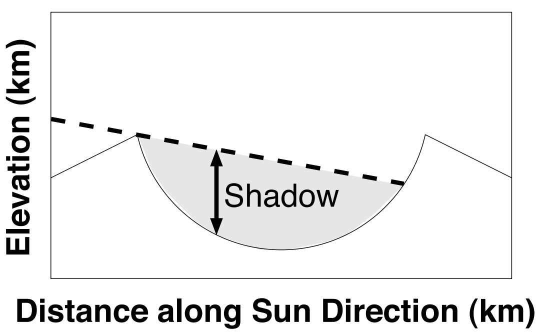

Figure 4: A schematic diagram of the crater profile and illumination angle, which gives us the shadow depth at points of interest within the crater.

pact site is required to be permanently shadowed. Because of lack of high resolution visible imaging at the poles, we use high resolution Earth-based radar data [4], which can directly observe some parts of the permanently shadowed regions. In addition, the "KAGUYA" (SELENE) team at JAXA has kindly provided us with some of their data for internal project use only. Once the tools and analysis methods are established, we will be ready to quickly assess new data provided by the instruments on LRO, which will begin taking data 2-3 months prior to the LCROSS impact.

Shadow Depths:

We have calculated the shadow depths at several potential impact sites. Shadow depths are important for predicting what will be seen at the time of impact both by the spacecraft as well as by earth-based observers. In addition, shadow depths will aid in predicting the development and expansion of the OH cloud. The shadow depths are controlled by the angle at which the sun is illuminating the target area (marked on Fig. 1 and 2).

In order to calculate shadow depths we were required to assume an impact date so that we could calculate the angle at which the sun would be with respect to the target location. The impact date depends largely on the launch date. As the launch and the impact dates approache and becomes more firm, these same methods can be used to predict more accurate shadow depths. Neither the target nor the impact date has yet been determined; nevertheless, we assume an impact date of Aug. 2, 2009, for the purposes of this calculation. We used the JPL Horizons system (`http://ssd.jpl.nasa.gov/horizons.cgi`) to determine the sun's position with respect to the moon. On Aug. 2, 2009, the solar longitude will be 47.45237 , and the solar latitude will be -0.26908 . The solar longitude determines the direction that the sun will shine across the crater, and the solar latitude determines how far above the horizon the sun will be.

Local topography data from the "KAGUYA" (SELENE) laser altimeter (LALT) data was kindly provided by JAXA for internal project use. First we determine topographic profiles across the craters through potential impact sites, along the sun direction. Then, taking into account both the solar latitude and the target's latitude, we determine the sun angle at that target location. Finally, we combine the profile and illumination angle to find the depth of the shadow at points of interest within the crater. See Fig. 4 for a schematic diagram of the results.

Conclusion:

This study is critical to providing the best scientific return from the LCROSS mission. Understanding the target as well as possible will both optimize the quality of data return and improve the analysis of the data.

Although this study is critical to the success of the LCROSS mission, it will also return scientific results relevant to:

- NASA lunar exploration initiatives
- Future landing site selection
- Understanding cratering processes
- Dry craters (Moon) vs. possibly wet craters (Mars)
- Ice deposits elsewhere, such as Mercury

References:

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