THE IMPORTANCE OF LRO OBSERVATIONS TO THE LCROSS MISSION. 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 the presence of water (Fig. 3) [2].

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 impact 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 [3], 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.

LRO Targeting

LRO's targeting of the impact site, both before and after the impact, will be critical to achieving the LCROSS mission. Targeting before impact will aid both with target selection and target characterization. Because the final impact site can be tweaked a small amount up to 30 days before impact, data received early from LRO could allow us to optimize the impact site to avoid previously undetected hazards or to impact in a site that is more likely to harbor H_2O.

Furthermore, pre-impact LRO data will allow the impact site to be well characterized prior to impact. Estimates of preexisting regolith depth, rockiness, and small scale slopes, as seen by LRO, will be helpful in interpreting the impact's ejecat plume and resulting crater.

Finally, data taken by LRO post-impact will allow us to better understand impact cratering processes. The resulting impact flash, the crater depth/diameter ratio, the crater morphology, and the ejecta pattern will all be analyzed given all the known parameters of the impactor (mass, shape, density, impact velocity, impact angle.) We expect the Centaur crater to be 20-25 meters across and 3-4 meters deep. The crater that will form when the shepherding spacecraft impacts crater will be 13-15 meters across and about 2 meters deep.

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:

[1] Feldman W.C., Maurice S., Binder A.B., Barraclough B.L., et al. (1998) *Science*, *281* 1496–1500.
[2] Elphic R.C., Eke V.R., Teodoro L.F.A., Lawrence D.J., et al. (2007) *Geophys Res Lett*, *34* L13,204.
[3] Campbell B.A. and Campbell D.B. (2006) *Icarus*, *180* 1–7.
[4] Margot J.L., Campbell D.B., Jurgens R.F., and Slade M.A. (1999) *Science*, *284* 1658–1660.

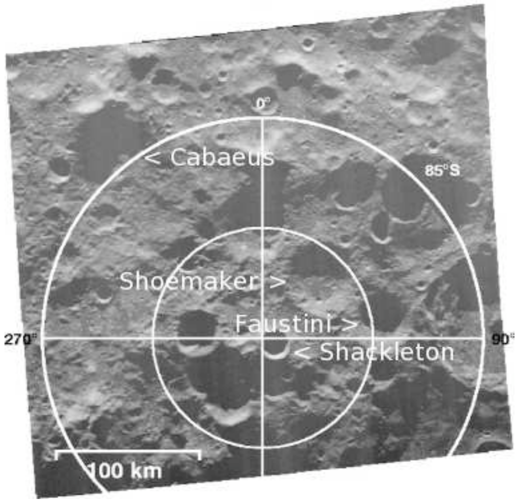

Figure 1: South Pole: Illustration of the location of candidate impact locations for LCROSS, superimposed on a radar backscatter map of the lunar south pole from [4].

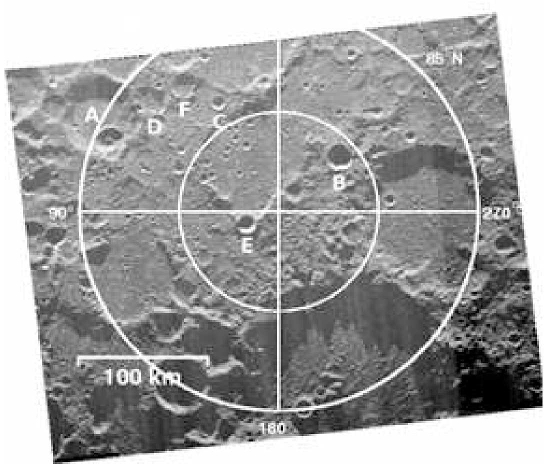

Figure 2: North Pole: Illustration of the location of candidate impact locations for LCROSS, superimposed on a radar backscatter map of the lunar north pole from [4]. Labels B-F are placed directly beneath the corresponding crater.

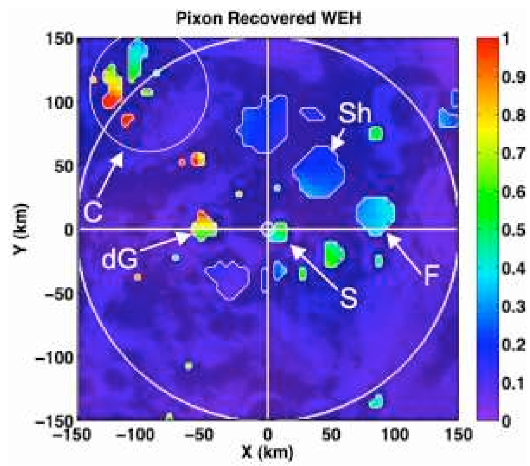

Figure 3: Water-equivalent hydrogen (WEH) in wt% corresponding to the epithermal count rates. Large circle denotes 85S. *C* = Cabaeus, *Sh* = Shoemaker, *dG* = de Gerlache, *S* = Shackleton, *F* = Faustini. From [2].