FIVE YEARS AT THE MOON WITH THE LUNAR RECONNAISSANCE ORBITER (LRO): NEW VIEWS OF THE LUNAR SURFACE AND ENVIRONMENT. N. E. Petro and J. W. Keller, NASA Goddard Space Flight Center, Greenbelt, MD 20771. (Noah.E.Petro@nasa.gov)

LRO Overview: The Lunar Reconnaissance Orbiter (LRO) has been orbiting the Moon for over five years. In that time, data from the seven instruments onboard the spacecraft have made significant advances in our understanding of the Moon and its environment. In September 2014 LRO completed its first Extended Science Mission (ESM) and began a second ESM (pending NASA approval). During the ESM and the second ESM, LRO has been in a quasi-stable, eccentric orbit of ~30 x 180 km with a periapse near the South Pole. This orbit enabled high-resolution measurements around the South Pole. LRO's seven instruments are operating nominally, and have experienced no significant degradation since beginning the ESM. The spacecraft has performed exceptionally well, with 98.4% uptime during the mission. LRO retains sufficient fuel so that its current orbit can be maintained for at least 8 years.

LRO's science teams have been extremely productive, focusing on the distribution of volatiles, evidence for early differentiation, measuring the lunar impact record, and the Moon's interactions with its external environment. Three of the most exciting findings by LRO have been the identification of LRO-era impacts, global tectonic features, and the transient nature of some volatiles at the surface. These findings will areas of focus for future LRO measurements.

LRO Data: LRO's data is released to the PDS every 3 months, as of August 2014 over 528.75 TB of data have been delivered by LRO. Many of the teams have delivered higher-level data products as part of their routine PDS deliveries (e.g., mosaics, maps, derived products). These products are intended to act as useful resources for the science and explorations communities (Figure 1).

Additionally higher-level LRO data products are of interest for future lunar landers. These products include illumination maps (Figure 2), meter-scale digital elevation models, roughness maps, and sub-meter per pixel images of possible landing sites. All of these products are available either from the PDS [1] or individual team websites [e.g., 2].

Tracking Lunar Volatiles: The LRO mission was initially conceived to identify the presence and abundance of volatiles in the lunar polar regions, specifically in permanently shadowed regions (PSRs), among other science questions related to lunar exploration [3]. In the five years of measurements from LRO, the paradigm for the distribution of lunar volatiles has significantly changed. Not only is there widespread evidence for volatiles both in and outside of PSR's, there is increasing evidence for temporal variability in the abundance of volatiles at and near the surface.

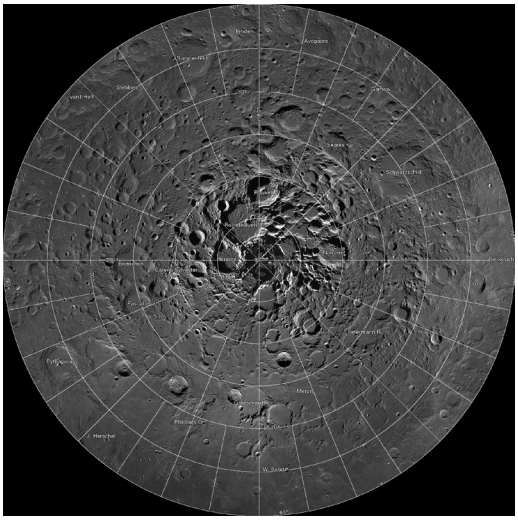

Figure 1. The LROC Northern Polar Mosaic (http://lroc.sese.asu.edu/images/gigapan), a 2-meter per pixel mosaic from 60º North to the pole.

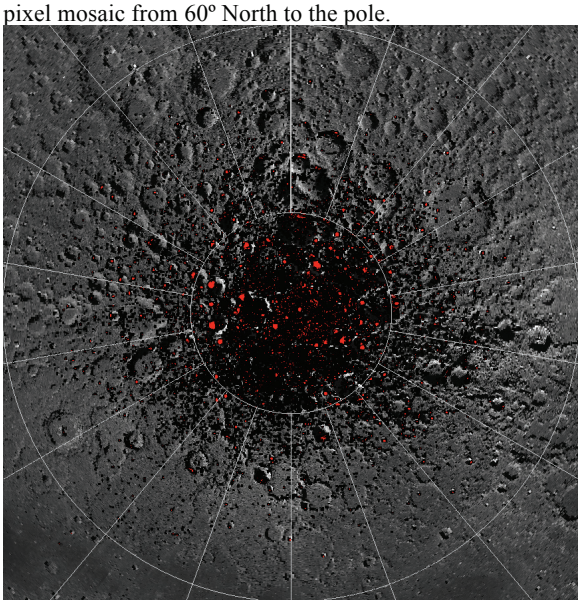

Figure 2. LOLA derived map of areas of permanent shadow at 240-meters per pixel (in red) for areas poleward of 65º North.

During LRO's second ESM there will be a focus on new measurements of the mobility and abundance of volatiles in the southern hemisphere. Taking advantage of not only 2 additional years of measurements to im-

prove statistics as well as the drifting of LROs periapse away from 90º South, additional measurements will:

- Identify the presence of transient surface frost in areas that are shadowed for a significant portion of the lunar day.
- Image the interior of PSR's to identify variations in regolith properties.
- Measure the temperature of the polar regions over a wider range of lunar time of day in order to improve models for subsurface ice stability.
- Constrain the role of small-scale cold traps (meter sized) in harboring volatiles.
- Make improved measurements of the distribution of volatiles outside of PSRs using multiple instruments.
- Make new targeted bistatic radar measurements of locations near the South Pole that may have buried ice deposits.

Data from LRO continues to refine our understanding of the unique environment at and near the lunar poles. Continued data from the mission will aid in measuring the scales (both temporal and spatial) that volatiles are found at and near the surface.

References:

[1]http://pds-geosciences.wustl.edu/missions/lro/default.htm

[2] http://imbrium.mit.edu/, http://diviner.ucla.edu/, http://lroc.sese.asu.edu/ , www.boulder.swri.edu/lamp/, http://lro.gsfc.nasa.gov/

[3] Vondrak, R., J. Keller, G. Chin, and J. Garvin (2010), Lunar Reconnaissance Orbiter (LRO): Observations for Lunar Exploration and Science, *Space Science Reviews*, *150*, 7-22.