Extreme Lighting Conditions at the Lunar Poles

Ben Bussey and Paul Spudis
The Johns Hopkins University Applied Physics Laboratory
11100 Johns Hopkins Road
MP3-E128
Laurel MD 20723

Phone: 240 228 6163
Fax: 240 228 0386
Email: ben.bussey@jhuapl.edu

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Introduction. The Moon's spin axis is nearly perpendicular, inclined at 1.5°, to the ecliptic plane which can result in unusual lighting conditions at the lunar poles. Areas which have low elevation, such as the floors of impact craters, may never see the Sun, i.e. they are permanently shadowed, whilst regions of high elevation, relative to the local terrain, may be permanently illuminated.

Illumination Extremes. Areas of extreme insolation are interesting for both scientific and operational reasons. Permanently shadowed areas are likely cold enough to represent cold traps for any water molecules entering. It has been modeled that the temperature in these cold traps is less than 100 K. Thus over a period of time, water molecules reaching the Moon, from cometary and asteroid impact, could produce a sizable deposit. Both the Clementine and Lunar Prospector missions identified probable ice deposits at the lunar poles. Obviously the presence of water ice at both poles has huge implications for the possibility of supporting a manned infrastructure on the Moon.

Areas of constant illumination are valuable for two reasons. Firstly they represent places which would permit abundant solar energy generation, possibly negating the need for RTGs. Secondly it has been modeled that the temperature in a region with constant grazing illumination is approximately 220 K ± 10 K, a benign thermal environment relative to the rest of the Moon.

Current Knowledge. An analysis of the lunar south polar lighting using Clementine image data revealed some interesting illumination conditions (Figure 1). No place appears to be permanently illuminated. However several regions exist which are illuminated for greater than 70% of a lunar day in winter. Two of these regions, which are only 10 km apart, are collectively illuminated for more than 98% of the time.

Modeling simple impact craters has revealed that there is a lot more permanent shadow, associated with these features, surrounding both lunar poles than previously thought, at least 7500 km^2 and 6500 km^2 at the north and south poles respectively. Additionally permanent shadow can exist in craters more than 10° latitude away form a pole (Figure 2). There is therefore the potential for more cold traps and volatile deposits.

Regions of extreme illumination conditions exist, and their presence has ramifications for a return to the Moon.

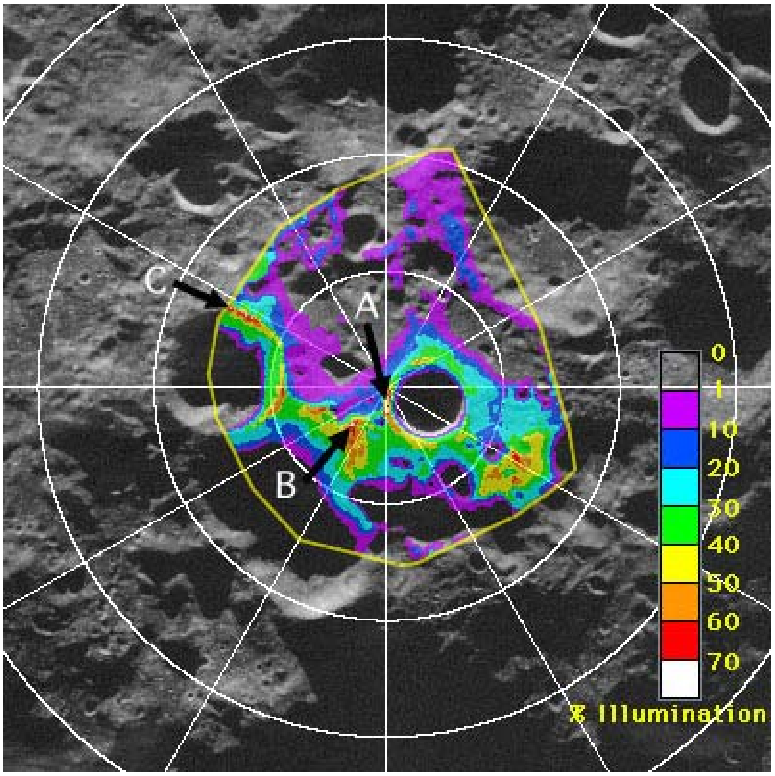

Figure 1. The illumination map for the lunar south pole showing what percentage of a lunar day that a point on the surface is illuminated. The three most illuminated regions are labeled A,B, & C. A & B are only 10 km apart and collectively are illuminated for more than 98% of the time.

From Bussey et al., Illumination conditions at the lunar south pole, Geophys. Res. Lett., 26, No. 9, 1999.

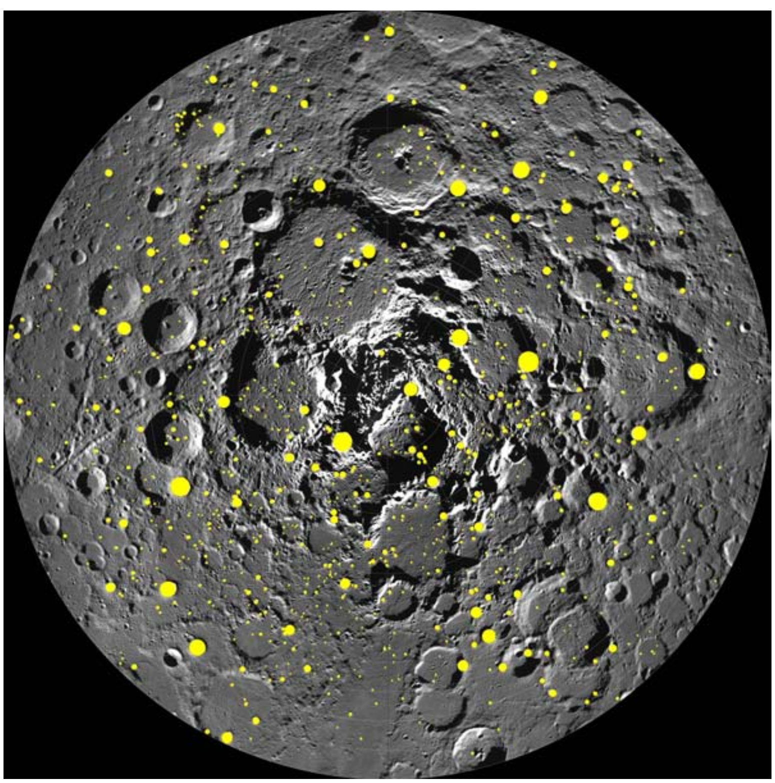

Figure 2.. A map of the northern lunar polar region showing the location of simple craters that contain permanent shadow. The total area of permanent shadow in simple craters within 12° latitude of the pole is 7500 km^2.

From Bussey et al., Permanent Shadow in simple craters near the lunar poles, Geophys. Res. Lett., 30, No. 6, 2003.