ANALYSIS OF THE LUNAR POLAR LIGHTING CONDITIONS, AS SEEN BY CLEMENTINE. D. Ben J. Bussey[1], Paul D. Spudis[2], Stu Nozette[3], and Chris L. Lictenberg [4] 1. ESA/ESTEC Code SO, PO Box 299, 2200 AG Noordwijk, The Netherlands; bbussey@estec.esa.nl 2. Lunar and Planetary Institute, Houston, TX 77058 3. Lawrence Livermore National Laboratory, Livermore CA 94550 4. Naval Research Laboratory, Washington DC 20375

The lunar poles are of great scientific interest for a number of reasons [1]. The discovery of permanently shadowed regions inside craters close to the poles which may contain water ice has important ramifications for a human return to the Moon. Similarly if regions exist that receive large amounts of near-constant solar illumination, then a lunar base could be supported solely by solar power without the need of a RTG. The location of the south pole, just within the rim of the giant South Pole-Aitken basin [2], is of immense geological interest because of the potential presence of lunar mantle material either on, or close to the surface.

Clementine has provided, for the first time, a digital data set with which to analyse the lunar poles at high resolution (~250 m/pixel) and contiguous, consistent coverage. In addition, a control grid for the Clementine data has been produced by the USGS Flagstaff meaning that the actual position of the poles of the Moon is now known to an accuracy of one pixel. It is therefore now feasible to investigate how the lighting conditions at the lunar poles varies over the course of a lunar day. Data are available for a little more then two lunar days making it possible to examine how the lighting varies over the seasonal change for part of a lunar year (for the south pole, from winter solstice towards the vernal equinox).

The first stage of our polar research was the production of mosaics of both polar regions using the new Clementine cartographic control grid. These are shown in Figures 1 and 2; each mosaic covers an area from 80° to 90° in latitude at a resolution of 500 m/pixel. These mosaics were produced by averaging all available images and thus give a first order impression of the lighting conditions at the poles. The next part of the study involved the production of a movie showing how illumination changes throughout a lunar day. We initially completed this for the south pole because of its higher scientific value, but we will also be doing one for the north pole. Each orbital strip covering the south pole was made into a single image. All such consecutive images were then combined into a Quicktime movie. Of particular interest are regions that experience lighting extremes. Both areas which appear to be in constant darkness as well as regions which are illuminated for more than the nominal 50% of the lunar "day." Additional analysis of the data will permit us to create illumination maps of each pole.

We have also undertaken a comparison of a Clementine visual image and an Arecibo radar image [3]. Arecibo data has the advantage that it is able to "see" into the permanently shadowed regions surrounding the pole. Recently, Stacy et al. [3] reported on their attempts to identify areas near the poles that may contain deposits of water ice. They concluded that, contrary to the findings of Nozette et al. [4], areas of high radar backscatter near the south pole are probably not water ice because many of the identified zones of high backscatter occur in sunlit areas [3]. We analysed an Arecibo image of the south pole [5] that contains regions which have high radar backscatter (boxes C and D; Fig. 4), consistent with the presence of either zones of high surface roughness [3] or water ice [4]. Because Stacy et al. [3] claim that many of the high backscatter zones occur in illuminated areas, we match-pointed a controlled Clementine image mosaic of the south polar region with the Arecibo radar image to evaluate this relation. This allowed us to reproject the Clementine image so that it was co-registered with radar picture. Overlaying the radar backscatter image on top of the Clementine polar illumination image (Fig. 4) shows that areas C and D (regions of high backscatter identified in [3,5]) lie within the permanently shadowed regions surrounding the pole (Figures 3,4). Clearly some areas are likely to be roughness related; one zone of high backscatter (area B; [5]) occurs on an Earth-facing slope, suggesting that it is related to surface reflectance properties. However, other zones identified as possessing anomalously high backscatter, including the promising candidates occurring within the walls and floor of the crater Shackleton (20 km diameter, near the pole--Fig. 3), occur within zones that are permanently dark on the Clementine mosaic (Figs. 3, 4). Stacy et al. [3] assert that the rim of Shackleton is in sunlight, but this illuminated zone occurs *above* the areas of high backscatter C and D and both these zones are in darkness. Stacy et al. [3] used an early, uncontrolled image mosaic of the south pole [7] for their lighting analysis; our analysis used the new, updated lunar control, which displays surface positions accurately to within about 250 m. Stacy et al [3] use the supposed solar illumination of these areas as *a priori* evidence of surface roughness, rather than ice. We contend that both backscatter mechanisms are viable and that the Arecibo data *are* consistent with the results of the Clementine bistatic radar experiment [4].

Whilst scientifically interesting in its own right this research will be useful if the neutron spectrometer on Lunar Prospector confirms the presence of ice at the lunar south pole as we will be able to show where exactly this ice is to a high degree of accuracy.

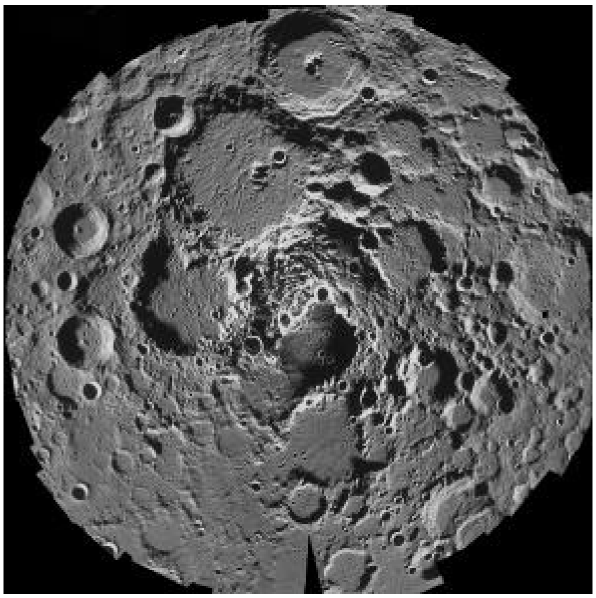

Figure 1. North pole mosaic.

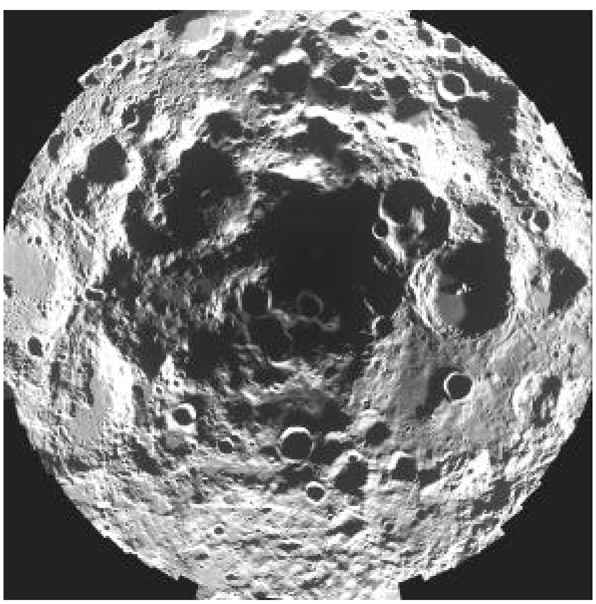

Figure 2. South pole mosaic.

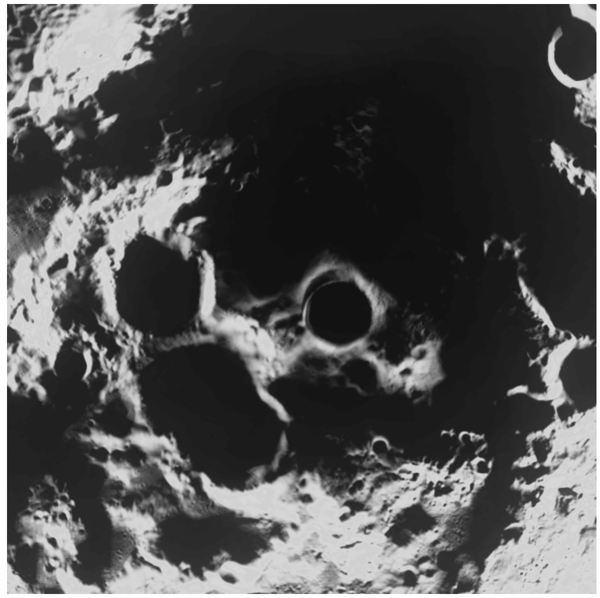

Figure 3. High resolution Clementine image showing the average illumination conditions at the south pole during one lunar day.

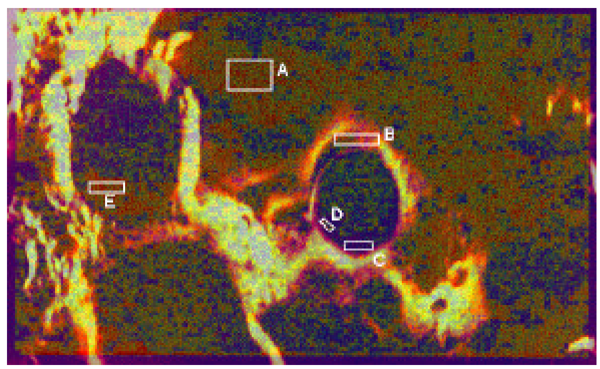

Figure 4. This image was produced by overlaying a colourised version of Figure 3 on top of the radar backscatter image [5]. The boxes D and C indicate regions where high radar backscatter is consistent with the presence of water ice. Four of the five areas are within permanently shadowed regions.

References [1] Spudis P.D., Bussey D.B.J., and Stockstill K.R. (1997) *Meteoritics* **32**, 4, A123. [2] Spudis P.D., Reisse R.A., and Gillis J.J. (1994) *Science* **266**, 1848-1851. [3] Stacy N. J. S. et al. (1997) *Science* **276**, 1527-1530. [4] Nozette S. et al. (1996) *Science* **274**, 1495-1498. [5] Stacy N.J.S. (1993) Ph.D. Thesis, Cornell Univ., Ithaca NY. [6] Stacy N.J.S. et al. (1997) *Science* **278**, 145. [7] Shoemaker E.M. et al. (1994) *Science* **266**, 1851-1854.