MINI-RF BISTATIC OBSERVATIONS OF CABEUS CRATER. G. W. Patterson[1], D. B. J. Bussey[1], A. M. Stickle[1], J. T. S. Cahill[1], P. Spudis[2], and the Mini-RF Team. [1]Johns Hopkins University Applied Physics Laboratory, Laurel, MD (Wes.Patterson@jhuapl.edu), [2]Lunar and Planetary Institute, Houston, TX.

Introduction: Observations of the south polar crater Cabeus indicate anomalous scattering behavior associated with crater floor materials (behavior not observed with monostatic data). We interpret this behavior as consistent with the presence of water ice. It is probable that the incidence angle at which the data was acquired plays a role in the differences observed between bistatic images and with the monostatic data.

Background: Radar observations of planetary surfaces provide important information on the structure (i.e., roughness) and dielectric properties of surface and buried materials [1-4]. These data can be acquired using a monostatic architecture, where a single antenna serves as the signal transmitter and receiver, or they can be acquired using a bistatic architecture, where a signal is transmitted from one location and received at another. The former provides information on the scattering properties of a target surface at zero phase. The latter provides the same information but over a variety of phase angles. NASA's Mini-RF instrument on the Lunar Reconnaissance Orbiter and the Arecibo Observatory in Puerto Rico are currently operating in a bistatic architecture (the Arecibo Observatory serves as the transmitter and Mini-RF serves as the receiver) in an effort to understand the scattering properties of lunar terrains as a function of bistatic (phase) angle. This architecture maintains the hybrid dual-polarimetric nature of the Mini-RF instrument [5] and, therefore, allows for the calculation of the Stokes parameters (S_1, S_2, S_3, S_4) that characterize the backscattered signal (and the products derived from those parameters).

Previous work, at optical wavelengths, has demonstrated that the material properties of lunar regolith can be sensitive to variations in phase angle [6-8]. This sensitivity gives rise to the lunar opposition effect and likely involves contributions from shadow hiding at low phase angles and coherent backscatter near zero phase [1]. Mini-RF bistatic data of lunar materials indicate that such behavior can also be observed for lunar materials at the wavelength scale of an S-band radar (12.6 cm). Among the terrains observed thus far, we have found the response of materials associated with the floor of the crater Cabeus to be particularly interesting.

Observations: A common product derived from the Stokes parameters is the Circular Polarization Ratio (CPR),

$$\mu_C = \frac{(S_1 - S_4)}{(S_1 + S_4)} \quad (1).$$

CPR information is commonly used in analyses of planetary radar data [1-4], and is a representation of surface roughness at the wavelength scale of the radar (i.e., surfaces that are smoother at the wavelength scale will have lower CPR values and surfaces that are rougher will have higher CPR values). High CPR values can also serve as an indicator of the presence of water ice [9].

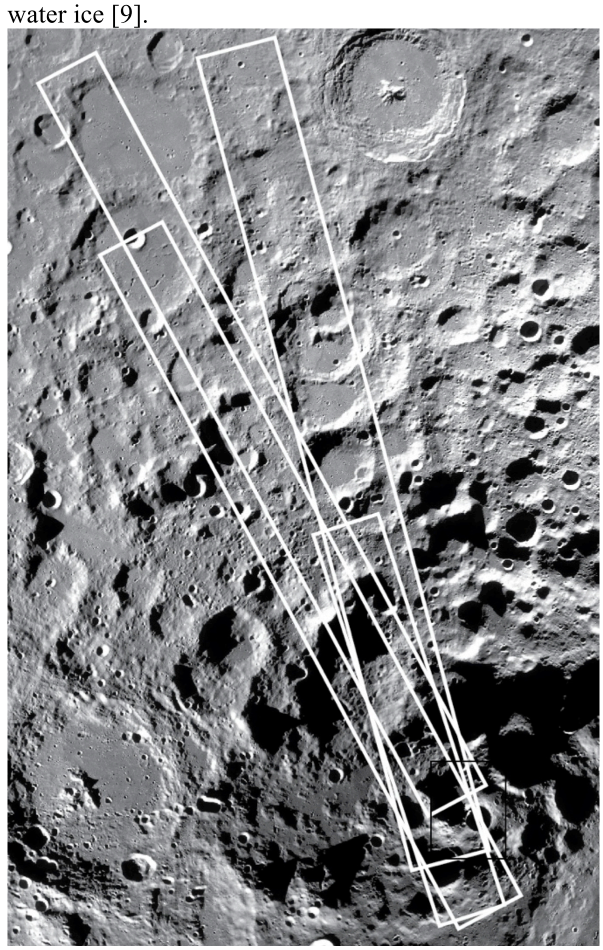


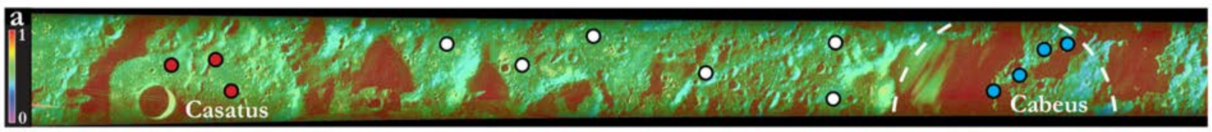
Fig. 1. Bistatic observations that include Cabeus crater (outlined in white).

Data for the south polar crater Cabeus has been acquired on four occasions (Fig. 1) and these data cover a phase angle range of 0° to 18°. When viewed at near zero phase (Fig. 2), the floor of Cabeus crater shows an enhancement in CPR with respect to surrounding materials. This is not apparent in data acquired of Cabeus crater when Mini-RF operated in a monostatic mode

[10]. Further, when viewed at phase angles of several degrees (Fig. 2), the floor of Cabeus crater shows a suppression of CPR with respect to surrounding materials.

Summary: The scattering behaviour of the floor of Cabeus crater indicates a clear opposition effect at low phase angles that is consistent with the presence of water ice [11-13]. We suspect that the difference in the scattering behaviour observed with a monostatic architecture is related to the grazing incidence (~85°) at which the region is viewed by Mini-RF when operating in a bistatic mode. This would suggest that the water ice observed would need to be confined to a relatively thin layer, near the surface.

References: [1] Campbell et al. (2010), *Icarus*, 208, 565-573; [2] Raney et al. (2012), *JGR,* 117, E00H21; [3] Carter et al. (2012), *JGR,* 117, E00H09; [4] Campbell (2012), *JGR*, 117, E06008; [5] Raney, R. K. et al. (2011), *Proc. of the IEEE*, 99, 808-823; [6] Hapke et al. (1998), *Icarus*, 133, 89-97; [7] Nelson et al. (2000), *Icarus*, 147, 545-558; [8] Piatek et al. (2004), *Icarus*, 171, 531-545. [9] Black et al. (2001), *Icarus*, 151, 167-180; [10] Neish et al. (2011), *JGR*, 116, E0100; [11] Hapke and Blewett (1991), Nature, 352, 46-47; [12] Mishchenko (1992), Astrophysics and Space Science, 194, 327-333; [13] Mishchenko (1992), Earth, Moon, and Planets, 58, 127-144.



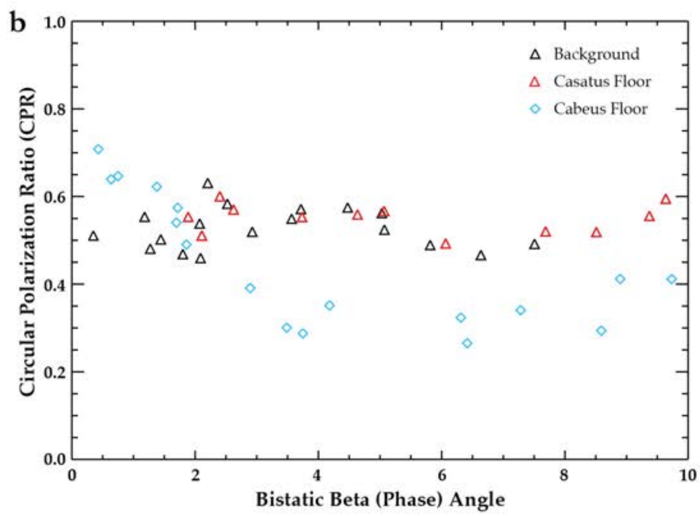


Figure 2. (a) Circular Polarization Ratio (CPR) data acquired on May 7, 2013 using the Mini-RF bistatic operational mode. North is to the left in the image. The crater Cabeus (84.9°S, 35.5°W, dia. 98 km) is outlined in dashed white and the crater Casatus (72.6°S, 30.5°W, dia. 111 km) is also observed. Circles indicate 90 km² regions of the surface where the CPR data was sampled and plotted against phase angle. (b) Plot of CPR versus phase angle for Casatus crater (red), Cabeus crater (blue), and surrounding terrain (white/black). Data from four Mini-RF bistatic collects of the region are included. Cabeus crater shows a clear opposition effect that is distinct from both the surrounding terrain and the nearby crater Casatus.