CRYPTOMARE DEPOSITS REVEALED BY 70-CM RADAR. B.A. Campbell[1] and B.R. Hawke[2], [1]Smithsonian Institution, PO Box 37012, MRC 315, Washington, DC 20013-7012 (campbellb@si.edu), [2]HIGP, University of Hawaii, 2525 Correa Road, Honolulu, HI 96822 (hawke@higp.hawaii.edu).

Introduction: Cryptomare deposits represent ancient basalts that have been subsequently buried by and (to some degree) incorporated into highland-dominated basin or crater ejecta. Past work has identified cryptomaria on the basis of iron and titanium signatures within highland terrain, and by the presence of craters with optically dark haloes formed by mafic material excavated from depth. We present new 70-cm wavelength radar data that penetrate to depths of 10's of m to reveal a large expanse of cryptomaria between Orientale and Oceanus Procellarum.

Cryptomaria: In some regions, early mare basalts have been mantled by or incorporated into ejecta from basin- or crater-forming impacts. Such deposits have been identified on the basis of two criteria: (1) small craters that excavate the buried basalt, creating a characteristic dark halo in visible images [1, 2]; (2) Fe and/or Ti enhancements in the multi-spectral signature of highland terrain, indicating that pre-existing mare material has been incorporated into the basin ejecta [3]. Such techniques have been used to identify cryptomaria W of Oceanus Procellarum, NW of Mare Humorum, in the Schiller-Schickard region, in the Balmer basin, and within Australe Basin [2-6]. Radar observations, particularly at longer wavelengths, offer the opportunity to probe much greater depths of the lunar regolith than is possible with multi-spectral analysis.

Radar Data: We are collecting a new 70-cm wavelength map of the lunar nearside, using the Arecibo and Greenbank telescopes. The data are processed with a "patch focusing" method that avoids smearing of the resolution cells due to differences in the motion of points on the surface during an integration period. The best spatial resolution in range and azimuth is ~450 m x ~320 m at the limbs, and the range resolution is ~900 m for areas at 30^{o} incidence angle (closer to the center). The radar data are collected in both senses of circular polarization, and are calibrated to off-Moon noise for each "look".

Orientale-Procellarum: Fig. 1 shows a 70-cm, SC-polarization radar map and matching Clementine visible image of the region E of Orientale. The radar echo is generally low in areas covered by basalts, such as Mare Humorum, Oceanus Procellarum, Cruger crater, Grimaldi basin, and small post-Orientale mare flows. Hummocky, striated, or pitted terrain, and smoother "light plains" surrounding Orientale (the inner facies of the Hevelius formation [7]), are typically radar and optically bright. Surrounding Cruger crater and extending E toward Procellarum, however, there is a region of low radar return that is associated with high visible surface albedo. This area generally corresponds to the outer facies of the Hevelius formation [7]. Outlying radar-dark regions are also observed (e.g., surrounding Rocca P; Fig. 2).

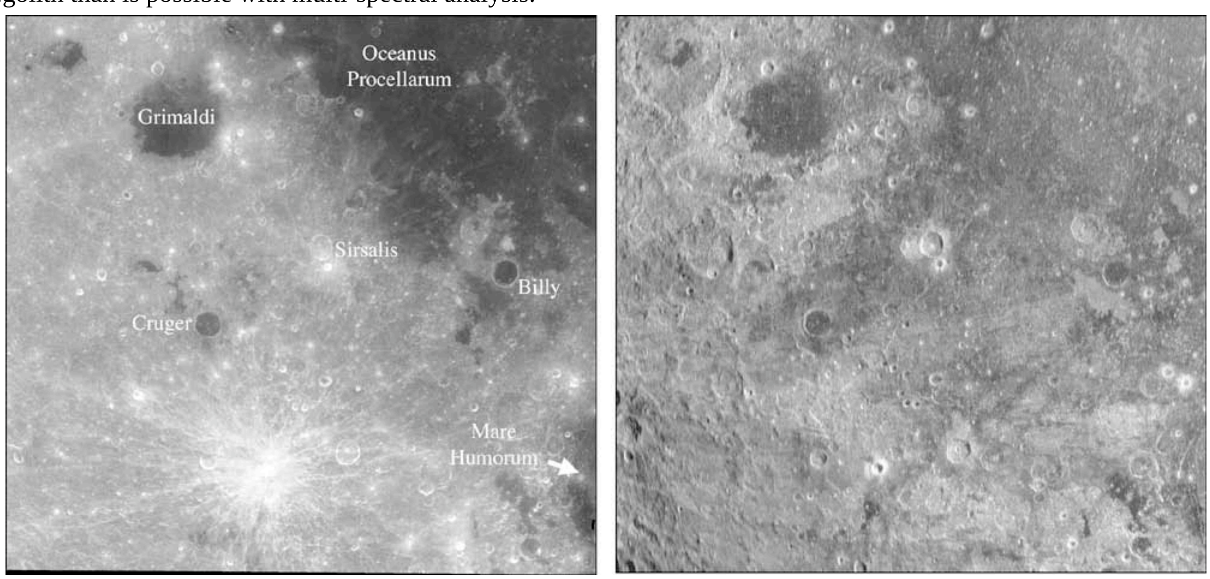

Fig 1. Optical (left; Clementine 1 μm) and 70-cm SC-polarization radar (right) images of the Orientale-Procellarum region. Note the low radar return from the area surrounding Cruger crater, and extending E to Oceanus Procellarum.

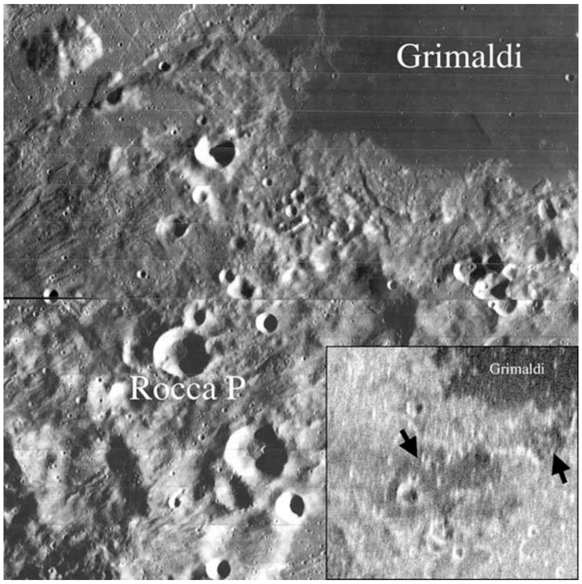

Fig. 2. Lunar Orbiter and 70-cm SC-polarization radar (inset) images of the region SW of Grimaldi. Note the low radar return in "highlands" material surrounding Rocca P crater, marked by the black arrows.

Radar and VIS-IR Correlations: In the region between Grimaldi and Procellarum, and along a relatively narrow band peripheral to the Procellarum basalts, lower radar returns are correlated with increases in the iron and titanium content of the regolith surface. This is consistent with the inference that cryptomaria underlie the western highlands margin of Procellarum [3], and previous observations of decreasing radar echo with increasing ilmenite content [8, 9].

The low radar echo associated with the area around Cruger crater, and in outcrops near Grimaldi and SE toward Humorum, is not correlated with a significant increase in the inferred FeO and TiO_2 abundance of the regolith. In essence, these areas appear to be "highlands" at optical and infrared wavelengths, but have 70-cm radar echoes ~5 dB (a factor of 3) lower than nearby terrae. Similar, though less dramatic, reductions in echo power are observed at 3.8-cm wavelength.

We propose that this reduced radar echo is due to the presence of a mixed mare/terra layer within the penetration depths of the 70-cm and 3.8-cm signals. The plausible depth of this layer depends upon the loss tangent of the overlying "pure" highland material. If the highlands have a loss tangent of 10^{-4}, as measured for some lunar samples [10], the mixed zone could occur at depths of 10's of m and satisfy the radar observations. A loss tangent value of 10^{-3} requires that the mixed zone be within 10 m of the surface.

It seems implausible that a mixed zone of mare and highland material exists at depths of only a few meters across such a large area, but never actually reaches the surface (where the multi-spectral signature would be evident). We thus propose that the highland loss tangent, at least for the ejecta of Orientale, has a value closer to 10^{-4}, and that the mixed zone generally lies at a depth of a few 10's of m.

Conclusions: The new radar data reveal an extensive ancient mare basalt province underlying at least the outer eastern ejecta facies of Orientale. The low radar signature appears to stop where the basin ejecta becomes very deep (the inner Hevelius formation [7]), so the full western extent of the original maria is uncertain. There is also good reason for assuming that loss tangents within the Orientale-excavated terrae are of order 10^{-4}. This has implications for our inferred depth of probing in areas such as the south polar highlands. Ongoing work will extend our mapping of cryptomare deposits across the nearside, including the Australe basin.

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