THE DISTRIBUTION OF MARE AND CRYPTOMARE IN THE SOUTH POLE-AITKEN BASIN: NEW PERSPECTIVES FROM MULTIPLE DATASETS. R. N. Clegg-Watkins[1,2], B. L. Jolliff[1], N. E. Petro[3], and S. J. Lawrence[4], [1]Department of Earth & Planetary Sciences and the McDonnell Center for the Space Sciences, Washington University in St. Louis, 1 Brookings Dr., St. Louis, MO 63130, [2]Planetary Science Institute, Tucson, AZ, [3]NASA GSFC, Planetary Geodynamics Laboratory, [4]School of Earth and Space Exploration, Arizona State University, Tempe, AZ. (rclegg@levee.wustl.edu)

Introduction: The South Pole-Aitken Basin (SPA) has long been recognized as a high-priority location for scientific studies and exploration [1-5]. Several areas of mare are identified within the basin, but other areas occur in the interior of SPA that are not obviously basaltic surfaces. These surfaces are relatively smooth, indicating basalt may lie under observed surface materials in the form of cryptomare [6] – ancient volcanic deposits obscured by overlying crater and basin impact ejecta. These overlying ejecta deposits are extensive (covering hundreds of square km [7]) and are of interest as potential landing sites in the SPA interior because they are fairly smooth. These deposits are important for assessing the mixture of materials in the regolith. Samples from these areas would be valuable because they will reveal what materials are present within the basin interior [7-9] and because they are expected to contain impact melt and breccias from the SPA event as well as from subsequent large impacts within SPA. In addition, samples from SPA will provide critical ground truth for SPA remote sensing data.

Here we integrate data from the Lunar Reconnaissance Orbiter (LRO) Narrow Angle Cameras (NACs), Wide Angle Camera (WAC) [10], and derived Clementine FeO [11] to assess potential cryptomare deposits in the interior of SPA. We use these data sets to investigate the topography, reflectance, and composition of several potential cryptomare deposits: an area east of Bhabha crater, an area south of Stoney crater, and Mafic Mound, a local topographic high south of Bhabha [12] (Fig. 2). For comparison to a mare surface, we analyzed an exposed mare unit in Bose A crater, north of Bhabha. WAC topographic data was used to assess the topographic expression and smoothness of these areas. NAC imagery and photometry, coupled with Apollo, Luna, and Chang'e-3 soil data and Clementine FeO data, were used to investigate the compositional variations of the putative cryptomare deposits.

Methods: The LRO WAC DTM (GLD100) [13] was used to assess the roughness of each area in terms of the Terrain Ruggedness Index (TRI), which is the mean elevation difference between adjacent pixels in the DTM [14, 15]. Large topographic deviations attributable to secondary processes, such as craters or wrinkle ridges, were excluded from the TRI calculations.

Reflectance (*I/F*) data for each site were extracted from NAC images spanning a range of phase angles, and we used a Hapke photometric function to fit the data and to normalize *I/F* to a common phase angle (30°) [16-18]. Hapke modeling was used to solve for the single scattering albedo, *w*, which is dependent, in part, on composition. Our previous photometric studies of spacecraft landing sites, coupled with returned sample compositions, have shown a strong inverse correlation between *w* and mafic content when comparing mature soils [16, 17] (Fig. 1). We used Clementine-derived FeO estimates of the SPA mare and possible cryptomare areas, and compared these results with variations in albedo (Fig. 1).

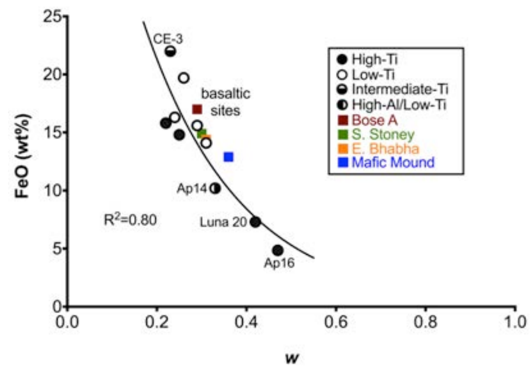

Fig. 1: Empirical relationship between single scattering albedo (*w*) and FeO for landing sites and SPA areas.

Results: The exposed mare in Bose A was the smoothest of the areas we analyzed, with a TRI of 1.6. The mare unit also has the highest estimated Clementine FeO content, 17.0 wt%, and the lowest *I/F* (0.053) and *w* values (0.29). The regions E. of Bhabha and S. of Stoney, both of which were identified as cryptomare in previous studies [7, 19], have similar topographic variations, with TRIs of 5.1 and 5.9, respectively. These two areas also have very similar *I/F*, *w*, and FeO contents. The area E. of Bhahba has *I/F* and *w* values of 0.058 and 0.31, and an estimated FeO content of 14.4 wt%. The region S. of Stoney has an *I/F* of 0.055, a *w* of 0.30, and an estimated FeO content of 14.9 wt%. Mafic Mound has the highest TRI, 12.7, as well as the highest *I/F* (0.068) and *w* (0.36) values, but has

Table 1: Reflectance, elevation, and FeO for SPA cryptomare and mare study areas

Site	*Type*	*I/F*(30°)	*w*	TRI	FeO* (wt%)
Bose A	Mare	0.053	0.29	1.6	17.0
S. of Stoney	Cryptomare	0.055	0.30	5.9	14.9
E. of Bhabha	Cryptomare	0.058	0.31	5.1	14.4
Mafic Mound	Nonmare	0.068	0.36	12.7	12.9

*Clementine data

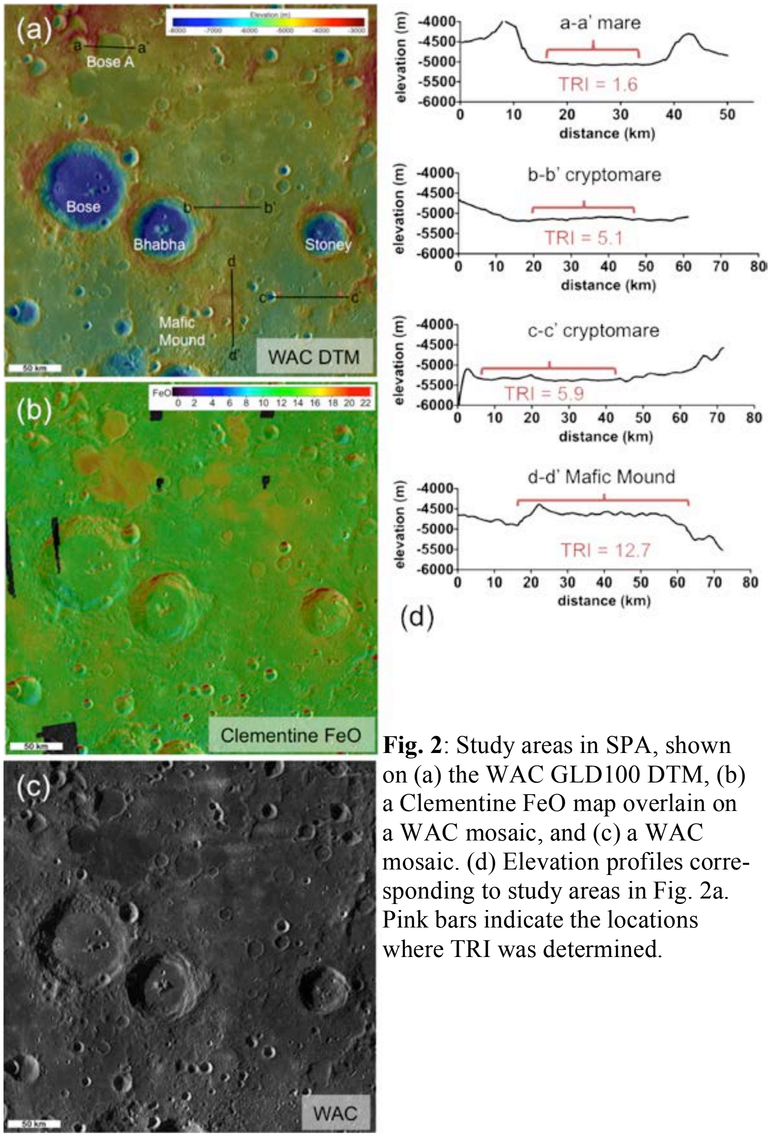

Fig. 2: Study areas in SPA, shown on (a) the WAC GLD100 DTM, (b) a Clementine FeO map overlain on a WAC mosaic, and (c) a WAC mosaic. (d) Elevation profiles corresponding to study areas in Fig. 2a. Pink bars indicate the locations where TRI was determined.

the lowest estimated FeO content (12.9 wt%). Values for each of the areas analyzed are listed in Table 1.

Discussion: The SPA mare units we analyzed are smooth and flat, with TRIs <2. The estimated FeO content for Bose A mare falls where expected based on the relationship between *w* and FeO determined for landing site soils (Fig. 1). Other nearby mare units also have similar FeO values, between 17–18 wt%. Potential cryptomare areas are also relatively smooth, with TRIs ranging from ~2–6. As expected, the cryptomare are not as low in reflectance or as high in estimated FeO as exposed mare units. The regions E. of Bhabha and S. of Stoney have intermediate *w* and Clementine FeO values, consistent with their slightly higher reflectance. The higher reflectance and lower FeO at these sites may indicate the presence of basalt that has been covered and/or mixed with overlying materials (also discussed in a companion abstract [20]).

Mafic Mound (MM) is an enigmatic feature in SPA, with asymmetric elevated topography, lower reflectance, and lower mafic content than nearby exposed mare surfaces [11, 21]. WAC topography indicates MM has higher elevation and is rougher than cryptomare deposits, falling close to the TRI range measured for nearby non-mare units (~15–22). It is possible that MM was a topographic feature that existed before the emplacement of basalts, and that the level of flow was too low to cover MM.

Mafic Mound has the highest reflectance and the lowest estimated FeO of the sites analyzed, but is not as reflective or iron-poor as feldspathic landing sites (Apollo 16 and Luna 20). Moon Mineralogy Mapper (M^3) spectra of MM suggest that the feature is similar in pyroxene composition to, but more reflective than, nearby mare and cryptomare materials [12]. It has been suggested that the increased reflectance is caused by an elevated abundance of high-albedo components such as plagioclase [12].

Conclusions: Integrating lunar datasets allows us to quantitatively determine where cryptomare deposits are located. Truly understanding the composition and variety of materials within SPA requires returning samples from the surface or analyzing them *in-situ*, and the smooth topography of these central SPA regions is favorable for future landings. However, as described here (and [20]), not all smooth surfaces represent the ancient floor of SPA, as some surfaces likely contain ancient volcanic materials.

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