MAFIC ANOMOLIES IN THE LUNAR HIGHLANDS. T. A. Giguere[1,2], B. Ray Hawke[1], G. A. Smith, G. Jeffrey Taylor[1], D. T. Blewett[1], P. G. Lucey[1], and P. D. Spudis[3], [1]Hawai'i Inst. of Geophys. and Planetology, University of Hawai`i, 2525 Correa Rd., Honolulu, HI 96822, [2]Intergraph Corporation, 2828 Pa'a St. Ste. 2150, Honolulu, HI 96819, [3]Lunar and Planetary Institute, Houston, TX 77058.

Introduction

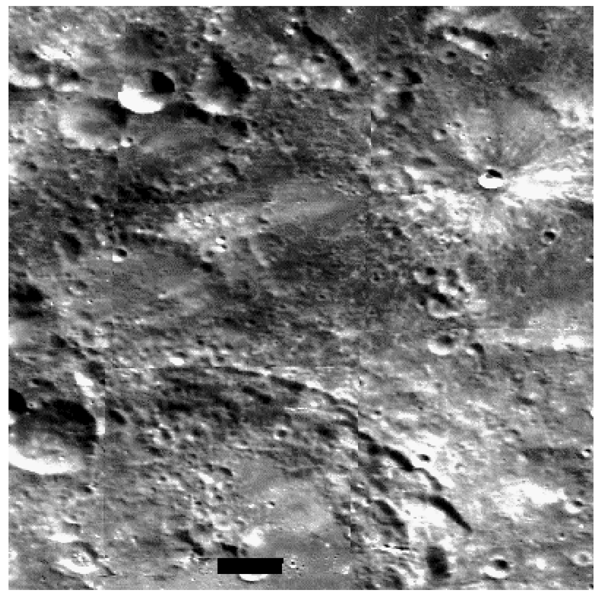
Ancient mare basalts deposits that have been hidden or obscured by superposed higher albedo material are referred to as cryptomaria [1, 2, 3]. They represent a record of the earliest mare volcanism. Earlier remote sensing and geologic studies have provided evidence for the distribution of ancient mare volcanism. Schultz and Spudis [4] studied the distribution of dark-haloed impact craters in the lunar highlands. They suggested that basaltic volcanism predated the last major basin-forming impacts and that early mare volcanism may have been widespread. Hawke and Bell [5, 6] used near-IR spectra to demonstrate that many dark-haloed impact craters excavated ancient mare units buried by basin and crater ejecta. Studies of the Apollo orbital geochemical data sets [7, 8, 9, 10] have shown that mafic geochemical anomalies on the east limb and farside of the Moon are commonly associated with light plains deposits that exhibit dark-haloed craters. The ages of these plains units indicated that the extrusion of mare basalt was a major process well before 4.0 b.y. More recent studies have used both Earth-based and spacecraft remote sensing data to characterize selected lunar cryptomaria [2, 3, 11, 12, 13, 14, 15]. Yet, many questions remain. We have utilized maps of FeO and TiO_2 abundances and maturity produced from Galileo and Clementine multispectral images as well as Prospector data to investigate the nature and origin of ancient buried mare basalts. The purposes of this study include the following: 1) to investigate the nature and origin of mafic anomalies in the highlands, 2) to determine the compositions of buried mare units, 3) to study the composition of surface units in and around each cryptomare region, 4) to investigate the processes responsible for cryptomare formation, and 5) to perform a global examination to locate previously unidentified cryptomaria.

Methods

Clementine UVVIS and Galileo SSI images as well as Prospector data were utilized in this study. The techniques described by Lucey et al. [16, 17] and Blewett et al. [18] were applied to calibrated Galileo SSI images to produce FeO and TiO_2 abundance maps for the lunar nearside. These maps have a resolution of 1-2 km. Global Clementine FeO, TiO_2, and maturity maps with a variety of resolutions (1-35 km) were also used to locate and investigate mafic anomalies. Clementine images with a resolution of 125 m were utilized to study selected cryptomare.

Results and Discussion

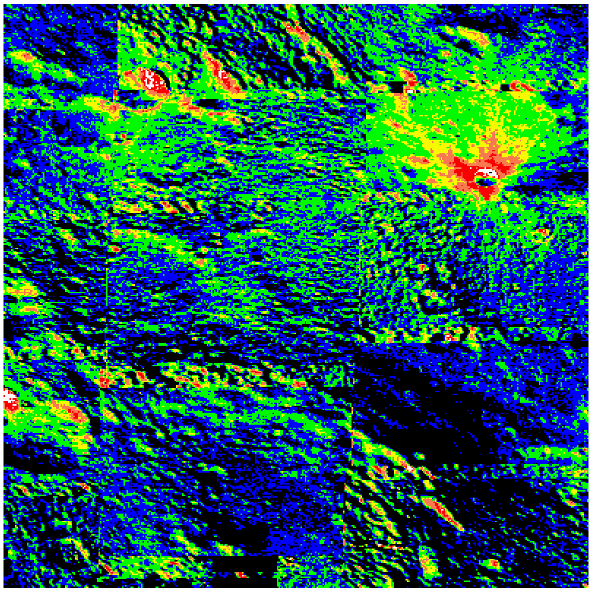
Southern Central Highlands. Most of the southern portion of the lunar central highlands exhibit FeO values that range between 5 and 9 wt. % and TiO_2 values less than 1 wt. %. However, a small area with anomalously high FeO values has been identified near the 114 km Maurolycus crater at the crater Buch B. Maurolycus is located at 14.0° E, 41.8° S and Buch B is located at 17.0° E, 39.9° S.



Albedo image (0.75 µm) of the highlands area around Maurolycus and Buch craters. Clementine high-resolution image (125 m/pixel).

The highest FeO values (13-15 wt. %) are centered on the dark-rayed crater Buch B (dia. = 6 km) which is located on the rim and wall of Buch C. The maturity image indicates that both the dark and bright portions of the Buch B ejecta deposits are very immature. The low-albedo areas of the ejecta blanket exhibit the highest FeO values (~14-15 wt. %). Slightly enhanced TiO_2 values (1-2 wt. %) are exhibited by portions of the ejecta deposit.

Lesser FeO enhancements are associated with the dark-rayed crater Maurolycus A (dia. = 15 km) and Barocius M (dia. = 17 km) which excavate dark material. These craters are not located in a light plains deposit, which is a formation often found associated with cryptomare deposits. The local geologic setting as well as regional geochemistry suggests that Buch B and the other dark-haloed craters did not excavate cryptomare material. Perhaps mafic intrusions were excavated from depth by these dark-rayed craters.



Buch B FeO distribution. Clementine high-resolution image (125 m/pixel). Scale in FeO wt. %: Black <7, Blue 7-10, Green 10-12, Yellow 12-14, Orange 14-16, Red 16-18.

Northeast Nearside (NEN) Region. Dark-haloed impact craters occur on the extensive light plains deposits on the northeastern portion of the lunar nearside. Hence, ancient mare volcanism may have occurred in at least some parts of the NEN region. The Galileo iron map shows enhanced FeO values associated with Gartner D and other nearby impact craters. A light plains unit was mapped in the area south of Hercules and Atlas craters by Grolier [19]. It appears that this light plains unit was produced by the contamination of a mare deposit with highlands-rich ejecta from Hercules and Atlas craters [20].

South Pole-Aitken (SPA) Basin. A mafic geochemical anomaly is associated with the interior of this giant basin [21]. The origin of this mafic anomaly is uncertain and it has been suggested that cryptomaria may play at least some role in producing the elevated FeO and TiO_2 values displayed by SPA interior deposits. We have identified a few relatively small cryptomare deposits in the basin floor. One is exposed by a 25 km diameter dark-halo impact crater located at ~39°S, 157°E. A circular zone of high TiO_2 and FeO values is centered on the crater and correlates with the dark halo [21]. Another crypto-mare is associated with Davisson crater (80 km diameter, 38°S, 175°W).

Cruger Region. Numerous small impact craters have excavated a FeO-rich subsurface unit in the region east of Cruger crater (46 km diameter, 17°S, 67°W). The cryptomare in this region appears to be very thin and discontinuous.

Balmer Region. Balmer cryptomare exhibit elevated FeO and TiO_2 values relative to the surrounding highlands. In addition, Lunar Prospector GRS data indicate that a small Th enhancement is associated with the interior of Balmer basin.

Terrain North of Taruntius Crater. The FeO values are elevated in the light plains units to the north and northeast of Taruntius crater. A dark-halo impact crater on the rim of Taruntius crater combined with the elevated iron values associated with the light plains suggest that an ancient mare basalt deposit was later contaminated by variable amounts of highland material as a result of Taruntius and other impacts.

Schiller-Schickard Region. The Galileo FeO map shows that iron values vary from 11-15 wt. % in the Schiller-Schickard (SS) cryptomare. These results support previous suggestions that ancient mare basalts were excavated from beneath plains units emplaced by the Orientale impact event. In addition, it appears that the light plains deposits in the SS region contain a major component of mare basalt.

Lomonosov-Fleming Region. This farside basin contains light plains which exhibit dark-halo craters that expose FeO-rich mare material. TiO_2 values associated with these craters range up to of 2.5-3.5 wt. % [20]. These are the highest of any cryptomare deposits on the Moon.

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