CONTRIBUTION OF MAJOR BASINS TO THE LONG-WAVELENGTH SHAPE OF THE MOON FROM THE LUNAR ORBITER LASER ALTIMETER (LOLA).

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Introduction: The long-wavelength shape of a planetary body can be used to infer information on spin state and orbital evolution [1]. The long-wavelength gravity field provides a measure of the shape of the gravitational potential that is in equilibrium with the rotation. But since the present-day gravity field need not have any correspondence with that at the time that the body cooled enough to "freeze in" its shape [2], the topography field may provide a more suitable proxy for the original long-wavelength structure. Applying this thought process to the Moon, we recognize that there are many long-wavelength contributions to the lunar topography, particularly difference in crustal thickness between the near and far sides [3] and most notably, major impact basins. In this study we begin to characterize the contribution of the largest lunar basins to the long-wavelength lunar shape using new observations from the Lunar Orbiter Laser Altimeter (LOLA), an instrument on the Lunar Reconnaissance Orbiter (LRO), as well as consideration of gravity.

LOLA Observations: LOLA [4] is a 5-beam laser altimeter that ranges to the Moon continuously in the LRO mapping orbit at a rate of 28 Hz. The instrument has a precision of ~10 cm and the accuracy depends on orbit determination. Currently LOLA data processing is using mostly navigation orbits and the accuracy is at the few tens of meters level. Precision orbits of order 1 m should be achievable, with the help of the LRO laser ranging investigation, which consists of Earth-based laser ranging the LRO when the spacecraft is in view of Earth [5]. By long-wavelength standards the Moon is well sampled topographically, with the current map (cf. Fig. 1) containing nearly 800M observations as of December 2009 [6].

Lunar Basin Contributions: Major impact basins have imparted significant stochastic variations on the lunar shape. Since the depths of many major basins exceed the magnitude of the flattening [7] it is important to ascertain the extent that the flattening may be corrupted by impact-related signatures. The largest impact basin on the Moon, the 2200-km diameter South Pole-Aitken Basin (Fig. 1), is a degree 5 feature, indicating it can be represented adequately by a degree and order 5 spherical harmonic expansion [8]. SP-A occupies about 9% of the lunar surface area and is prominently placed between the south pole and the equator and centered at approximately 191 E longitude. The present volume of SP-A [8] is of order 10^{17} m^3 which, if filled with lunar crustal material (ρ=2650 kg m^{-3}) would increase the mass of the Moon by about 0.5%. It is possible that SP-A's position on the Earth-Moon line is not an accident of history but a result of the impact's displacement of material that moved the crater toward the pole and the adjacent highlands toward the equator, possibly helping to stabilize the orientation of the moon in the Earth-Moon system. Fig. 1 shows the relationship of SP-A and the lunar highlands.

Today, the gravity signature of SP-A is relatively benign for its size indicating that the basin topography is largely compensated [9]. Many other lunar basins contain mare fill, and many of these basins appear to be in an overcompensated state [3]. Table 1 shows some representative basins that contain mare fill, along with the radial dimensions of their estimated mare plug and sub-isostatic ring [10]. From the standpoint of topographic power these basins contribute markedly through approximately degree 10 and the separate and collective contribution of the near side basins will be quantitatively evaluated.

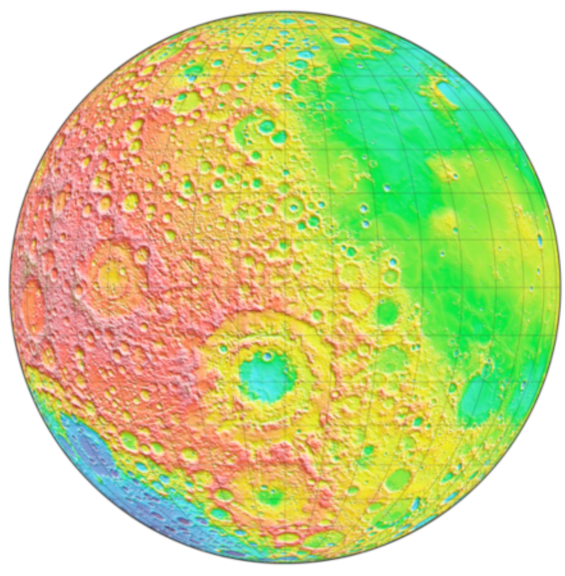

Fig. 1. Far side (left) of the Moon showing the South Pole-Aitken basin (in dark blue) and the lunar highlands in red as mapped by LOLA [1]. Near side (right) is dominated by mare basins.

Table 1. Selected lunar mare basins [10]

Basin	Radial Extent*, km
Imbrium	300, 650
Serenitatus	275, 530
Crisium	200, 440
Nectaris	200, 420
Humorum	160, 350
Smythii	140, 400
Fecunditatus	140, 500
Orientale	130,385

*Outer boundary of mantle plug and subisostatic ring.

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