The Moon's Near Side Megabasin. Charles J. Byrne, Image Again, 39 Brandywine Way, Middletown, NJ 07748, charles.byrne@verizon.net.

Introduction: The Moon, like Mars, has strong hemispheric asymmetry. In the Moon's case, the near side is very different than the far side [5], while for Mars the northern hemisphere is different than the southern hemisphere [1, 13]. In each case, the more common alternative explanations are large impacts or a spontaneous overturn of an early magma ocean.

This abstract proposes that much of the Moon's asymmetry can be explained by a single, very large impact on the near side which threw its massive ejecta partly into lunar escape and partly onto the far side, thickening the crust there. The Near Side Megabasin of the Moon was proposed [2, 4, 5] on the basis of comparing the topography of the Moon to a generalized model of an impact basin that was large in respect to its target body [3, 8, 10). Subsequently, consideration of a geophysical model of crustal thickness has resulted in a realization that the Near Side Megabasin, like the South Pole-Aitken Basin, has undergone full isostatic compensation. As a result, the estimated vertical dimensions of the initial apparent basin and its ejecta have been increased by a factor of 6.0 [4, 5, 7] over the vertical dimensions that correspond to the current topography. This brings the topographic and crustal thickness evidence in agreement with the proposed model of the Near Side Megabasin.

Current Topography: The current topography of the Moon is shown in Figure 1.

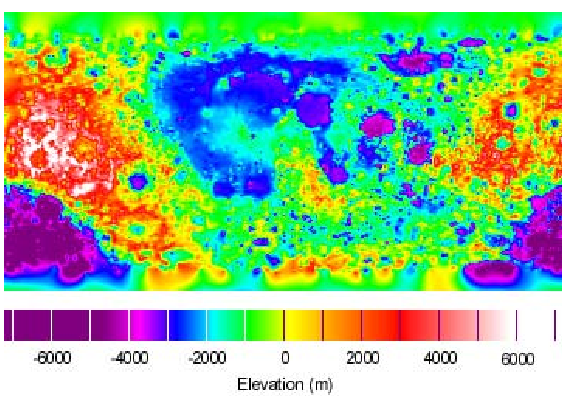

Figure 1: Digital elevation map (geographic coordinates), based on Clementine LIDAR data [14, 15]. The standard deviation of the topography is 2135 m [4].

Models of impact features: Figure 2 shows the Moon with the South Pole-Aitken Basin and about 50 other basins and large craters modeled according to the principles of dimensional analysis and measurements of the individual features. Mare fill is included. The specific methods are described in [4]. The South Pole-Aitken Basin has thrown ejecta into the area of the far side bulge, but not nearly enough to produce the current topography there. It has also produced a peak at its antipode (now under Mare Frigoris), which would have been relatively subdued by kinetic effects, since the ejecta would have landed at a 45º angle, the same as the ejection angle.

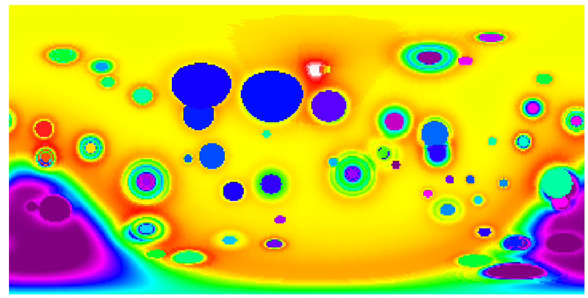

Figure 2: Model of the current topography of the Moon, including the South Pole-Aitken Basin [6], and 50 smaller basins and large craters [4], combined by superposition. Many of the basins are filled with mare to their current measured elevations. The model of the South Pole-Aitken Basin also has a level fill, although remote sensing data shows this to be mostly crustal material. The standard deviation of the residual topography after subtracting this model from the the topography is 1832 m.

A comparison of Figures 1 and 2 shows that a large depression covering the near side and a mound on the far side are missing in the model.

One More Basin: The addition of a model of the proposed Near Side Megabasin produces Figure 3.

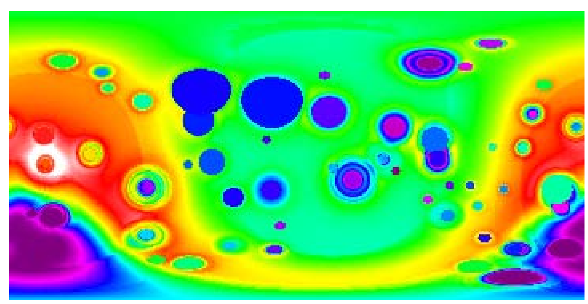

Figure 3: A model with one more impact feature, the proposed Near Side Megabasin, has been added. In this figure. The model is circular, with the only parameters being its apparent diameter (3163 km), apparent depth (3500 m), and the latitude and longitude of its center (8.5º S and 22º E) [4]. The model has a flat floor, like that of the South Pole – Aitken Basin (see Figure 6). The standard deviation of the residual topography is reduced to 1114 m.

A comparison of Figure 3 with Figure 1 shows that all the large scale features of the topography are well-modeled by the addition of this single impact feature, using the same model as the others. The shape of its ejecta is unfamiliar because this basin is so large relative to its target. Most of the ejecta has been driven to escape velocity and the remainder, following elliptical trajectories, has formed the giant mound around the antipode. This mound was later modified by the South Pole-Aitken Basin.

In Figure 4, two changes were made to the model of the Near Side Megabasin to make a better fit to the topography.

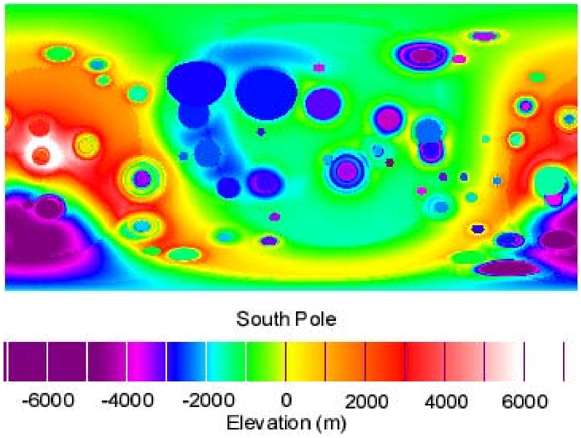

Figure 4: The model of the Near Side Megabasin has been improved by allowing the basin to be elliptical (eccentricity 0.42 and major axis rotated 53º W of N).Also, a model of the depression in Oceanis Procellarum has been added. The standard deviation of the residual topography is reduced to 1077 m.

Figure 5 shows Lambert equal-area views centered on the Near Side Megabasin and its antipode.

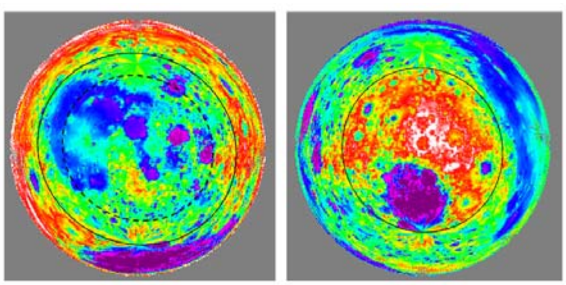

Figure 5. Lambert equal area projections (150º range) centered on the Near Side Megabasin and its antipode. The solid line is the inside edge of the rim and the dashed line is the edge of the flat floor.

Crustal thickness and isostatic compensation: The gravity field of the Moon is determined by tracking the orbits of spacecraft. Variations in topography or density cause corresponding variations in the gravity field, but at large scales, such variations are much lower than the topography would produce. This implies that the current large-scale topography is in isostatic equilibrium [11]. Hikida and Wieczorek [7] have produced a crustal thickness map using density assumptions of 3.361g/cm^3 mantle density and 2.8 g/cm^3 crust density, implying an isostatic compensation ratio of 6.0. Thus the original apparent depth of each giant basin would have been 6 times their current apparent depth.

Plastic flow: Both megabasins have flat floors similar to the maria flooding smaller basins. Remote sensing establishes that these floors are formed by refilling of crustal material. Figure 6 shows a simulation of an impact that is sufficiently energetic to soften the target material.

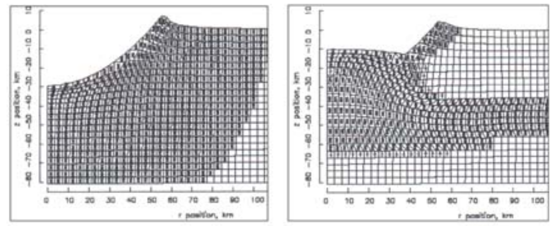

Figure 6: This figure is from an abstract by Turtle and Melosh [12]. The upper diagram shows a simulated large impact. The lower diagram shows refill of the material by plastic flow, forming a nearly flat surface. The plasticitiy of the target would have been induced by the heat energy released by the impact [9]

Summary: Addition of one new impact basin, the proposed Near Side Megabasin, provides a quantitative explanation for the major topographic and crustal thickness asymmetries of the Moon. The thickness of the pristine crust, 47 km [4], may have been uniform before the impacts that formed the two megabasins. The proposed Near Side Megabasin has many implications to the distribution of mineral anomalies, thermal history, and asymmetries of the Moon's moments of inertia and center of gravity. Additional topographic and geophysical measurements would refine the parameters of the Near Side Megabasin. The author is grateful to Hijima Hikida and Mark Wieczorek for sharing their crustal thicknesss data and to Greg Neumann, Paul Lucey, and Jay Melosh for suggestions and comments.

References:

[1] Andrews-Hanna, Zuber, M.T., and Banerdt, W.B., Global Structure of the Martian Dichotomy: An elliptical impact basin?, LPSC XXXIX, Abstract #1980, 2008. [2] Byrne, C.J. The Near Side Megabasin of the Moon, LPSC XXXVII, Abstract 1930, 2006. [3] Byrne, C.J., Effects of global target shape on impact cratering, In Bridging the Gap II, Effect of Target Properties on the Impact Cratering Process, p.27, LPI contribution No. 1360 Lunar and Planetary Institute, Houston (Abstract 8010. August, 2007). [4] Byrne, C.J., A large basin on the near side of the Moon, Earth, Moon, and Planets, 101: 153-188, 2007. [5] Byrne, C.J., "*The Far Side of the Moon: a Photographic Guide*," Springer, New York, 2008. [6] Garrick-Bethell, I., Ellipses of the South Pole - Aitken Basin: implications for basin formation, LPSC XXXV, Abstract 1515, 2004. [7] Hikida, S.H., and Wieczorek, M.A., Crustal thickness of the Moon: New constraints from gravity inversion using polyhedral shape models, LPSC XXXVIII, Abstract 1547, 2007. [8] Housen, K.R., Schmidt, R.M., and Holsapple, K.A., Crater ejecta scaling laws: fundamental forms based on dimensional analysis, JGR, Vol. 88, B3, 1983. [9] Ivanov, B.A., Lunar impact basins – Numerical modeling, LPSC XXXVIII, Abstract 2003, 2007. [10] Melosh, H.J., "*Impact Cratering, a Geologic Process*", Oxford University Press, 1989. [11] Neumann, G.A., Zuber, M.T., Smith, D.E., and Lemoine, F.G., The lunar crust: global structure and signature of major basins, JGR Vol. 101, No. E7, 1996. [12] Turtle, E.P., and Melosh, H.J., Modelomg of the role of plastic behavior in the collapse of large impact craters. [13] Wilhelms, D.E. and Squyres, S.W.T., The Martian hemispheric dichotomy may be due to a giant impact, Nature 309, 1984 [14] Zuber, M.T., Smith, D.E., and Neumann, G.A., The shape and internal structure of the Moon from the Clementine Mission, Science, Vol. 266, 1994. [15] Zuber, M.T., Smith, D.E., and Neumann, G.A. , Topogrd2, http://pds-geosciences.wustl.edu/missions/clementine/, 2004.