A GEODETIC APPROACH TO ESTIMATE THE CONTRIBUTION OF IMPACT CRATERS AND BASINS TO THE MOON'S LOW-DEGREE GRAVITY FIELD. D. E. Smith[1], V. Viswanathan[2,3], E. Mazarico[3], S. Goossens[3], J. W. Head[4], G. A. Neumann[3] and M. T. Zuber[1], [1]Massachusetts Institute of Technology, Cambridge, MA, USA (smithde@mit.edu), [2]University of Maryland Baltimore County, Baltimore, MD, USA, [3]NASA Goddard Space Flight Center, Greenbelt, MD, USA, [4]Brown University, Providence, RI.

Introduction. The lunar gravity field preserves a record of bombardment history visible in its gravity anomalies. These anomalies constitute an important part of the lunar gravity field (*i.e.*, the degree-2 coefficients in spherical harmonic representation) that largely dictate the Moon's equilibrium orientation in space and its global gravitational flattening (C_{20}). By extracting the gravity anomaly of an individual crater we can provide an estimate of the lunar gravity field prior to a given impact and calculate its contribution to true polar wander and the degree-2 gravity. The largest known impact on the Moon is the South Pole-Aitken (SP-A) basin-forming impact and it is estimated to be the largest single contributor to the Moon's C_{20} component. Because of its large size and substantially compensated state, estimates of its contribution to the low-degree gravity are uncertain. Here we present estimates of the contribution to the lunar gravitational flattening (C_{20}) of 29 craters and basins smaller than SPA but greater than 200 km in diameter (D).

Methodology. We developed a new geodetic approach that sequentially extracts the gravity field of a crater or basin from the GRAIL lunar gravity field (GRGM1200B [1]) based upon the location and size of the crater in the lunar topography [2]. The free-air gravity anomaly of each crater is sampled and averaged along azimuthal directions up to twice the crater radii to obtain the crater signature. The background gravity obtained by averaging the values for r>1.25R is subtracted from the radial average to prevent any discontinuity in the surroundings of the crater after it is removed. This is then repeated in a sequential manner for a given list of craters. Our primary interest is in the C_{20} coefficient as it represents the gravitational flattening. We obtain the gravity coefficients through spherical harmonic transforms [3].

Fig. 1 shows the individual unnormalized values of C_{20} estimated for 29 of the largest impact craters and basins (excluding SP-A) with $D \geq 200$ km, in decreasing diameter order.

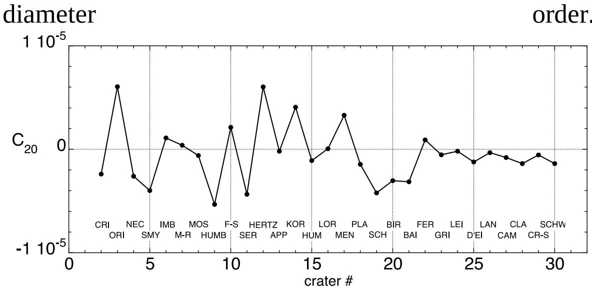

Figure 1. Values of the C_{20} coefficient for 29 lunar impact basins and craters with $D \geq 200$ km in decreasing diameter order. A slight trend suggests C_{20} decreases with decreasing crater diameter.

We note that [2] indicates that there are nearly 70 craters with D>200 km; our list of 29 enables the results to be compared with [4].

Fig. 2 is a comparison of the C_{20} coefficient with [4-5] for the same craters and basins; error bars indicate uncertainties at 3-σ. The figure indicates that all but one of the results presented are within the 3-σ error bars of [5]; this validates the ability of our geodetic method to provide individual estimates nearly equivalent to the method described in [4-5].

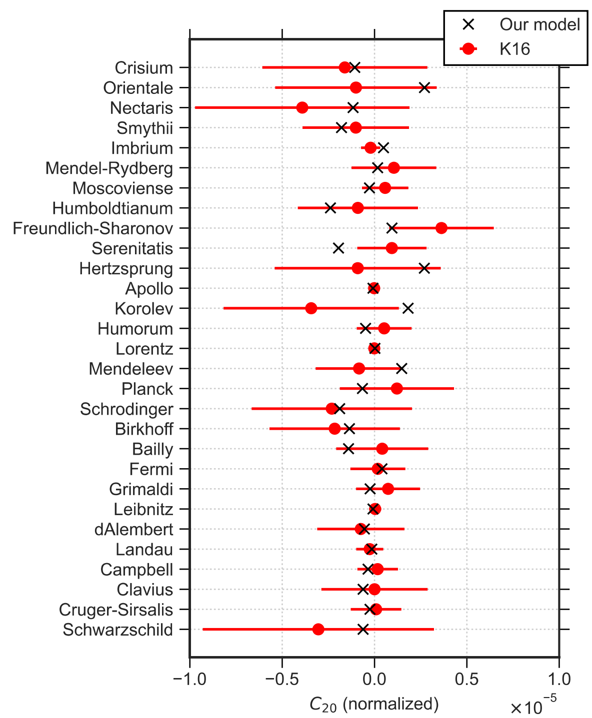

Fig 2. Comparison of C_{20} estimates using our fitting approach and those from [4-5] (rotated back to their geographic location). Values are 4π-normalized [3].

Our modeling approach also takes into account the cratering chronology as compared to a simultaneous crater extraction. The relatively younger craters are modeled and removed first from the global gravity field before proceeding to older craters. This sequential modeling technique enables a more precise determination of their individual gravitational contributions to the global lunar gravitational flattening, particularly for overlapping features.

Equally important as agreement of individual values is their cumulative effect. All of these craters and basins are believed to be some of the oldest lunar craters dating from the early Imbrian to the pre-Nectarian period [6] and their cumulative effect could indicate their contribution during early bombardment to the gravitational flattening. Ages based on crater counting are available [6] and all these craters have an assigned geological age [7]. We have placed all 29 craters in geological age order and within each age class in order of decreasing diameter. Fig. 3 shows the accumulated values of C_{20} for the 29 craters, all >200km.

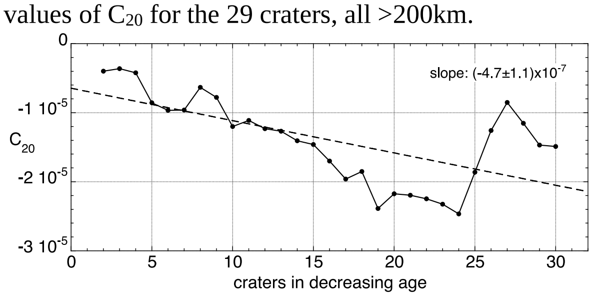

Fig 3. Cumulative values of C_{20} for the smallest 29 anomalies in decreasing age.

We can apply the method to all craters for which a gravity signature is resolved. Our database [2] contains nearly 5000 craters larger than 20 km, all of which exhibit gravity anomaly signatures.

Conclusions. We demonstrate that geodetic estimation of the gravity field of individual craters and basins based upon information in the topography compares favorably with complex geophysical models [5]. We find the accumulation of C_{20} coefficients suggests the lunar gravitational flattening has increased (C_{20} becomes more negative) as a result of impacts during the pre-Nectarian to early Imbrian period. Our future work will extend the study to smaller craters.

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