THE INVENTORY OF LUNAR IMPACT BASINS FROM LOLA AND GRAIL. G. A. Neumann[1], F. G. Lemoine[1], E. Mazarico[2], D. E. Smith[2], M. T. Zuber[2], S. Goossens[1,3], J. W. Head[4], J. Andrews-Hanna[5], M. H. Torrence[6], K. Miljkovic[7], M. A. Wieczorek[7]. [1]NASA GSFC, Code 698, 8800 Greenbelt Road, Greenbelt MD 20771, [2]Massachusetts Institute of Technology, Cambridge MA 02139, [3]CRESST, University of Maryland Baltimore County, Baltimore MD 21250, [4]Brown University, Providence, RI 02912, [5]Colorado School of Mines, Golden, CO 80401, [6]Stinger Ghaffarian Technologies, Greenbelt, MD 20770, [7]Institute de Physique du Globe, 75205 Paris, FR.

Introduction: Previous analyses [1, 2] of the Moon's gravity field have revealed that virtually all lunar basins exhibit positive internal mass anomalies arising from mantle uplift and (in many cases) volcanic loading resulting in positive Bouguer anomalies in their centers. Bouguer gravity resulting from the Lunar Orbiter Laser Altimeter (LOLA) [3] and the Gravity Recovery And Interior Laboratory (GRAIL) [4,5] mission datasets have revealed several new gravity anomalies on the Moon that resemble those of traditional lunar basins, and confirmed others regarded as questionable. Conversely, the lack of circular positive Bouguer anomalies casts doubt on the existence of several pre-Nectarian basins [6] described as uncertain. The high-resolution GRAIL data in particular extend the recognition of impact basins to structures whose diameter is smaller than 300 km, some whose topographic expression has nearly vanished. However, the resulting inventory does not indicate a more extensive history of large impacts as has been previously suggested [7].

Methods: The gravity spectrum of model GRGM0420A [8, 9] is shown in Figure 1. The gravity predicted [10] by an LRO-LOLA topographic model assuming a uniform-density crust matches the observed gravity at high degrees but exceeds it at low degrees, indicating partial compensation. The GRAIL primary mission tracking data exhibits coherence >0.9 with topography from degree l=50 to l=~390 which indicates that a great deal of the gravity signal arises from topography and can be removed to reveal internal density variations. The Bouguer residual is minimized at short wavelengths at a crustal density [11] of 2550 kg m^{-3}. The residual can be modeled by variations in crustal thickness or deformation of the lunar mantle as well as by density variations arising from the impact process.

We examine candidate regions for circular Positive Bouguer Anomalies (PBA) indicating thinned crust and denser uplifted mantle, using catalogs obtained from analysis of topographic maps [12, 13]. Only those with rim crests or circular PBAs are retained.

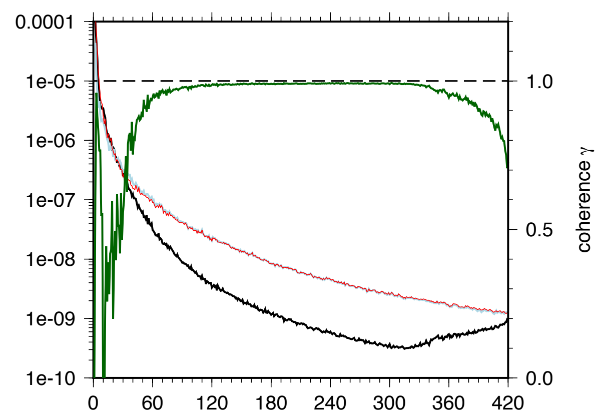

Fig. 1: Gravity spectrum (blue), coefficient amplitude predicted by topography (red), Bouguer residual anomaly (black), and correlation with topography (green).

Results: A Bouguer map (Figure 2) bandpassed from degree l=6 to l=384 reveals many circular positive anomalies of impact origin. Peak ring basins exhibit positive Bouguer anomalies lying within the innermost ring [14]. The largest anomalies are expressed from degree 1-6 and represent a nearside-farside asymmetry and the South Pole-Aitken impact.

The Bouguer anomaly reveals even further the buried impact history of the Moon. Several conjectured basins on the farside are revealed by gravity highs ringed by circular lows, as well as new basin-scale craters with diameters in the range of 180-320 km. A nearly-buried Sinus Asperitatis impact structure is resolved, whose 600+ km diameter and inner rings are likely buried beneath the mare. Many of the newly identified impact structures are topographically obscure, but are clearly revealed by gravity, such as that shown in Fig. 3 south of Lorentz. Taking into account both confirmed and questionable basins, a cumulative plot fit to a negative 2 power low yields a retention density N(300) = 1.05 to 1.34 x 10^{-6} km^{-2}, consistent with earlier work [15] but inconsistent with values nearly twice as great obtained prior to GRAIL [7, 16].

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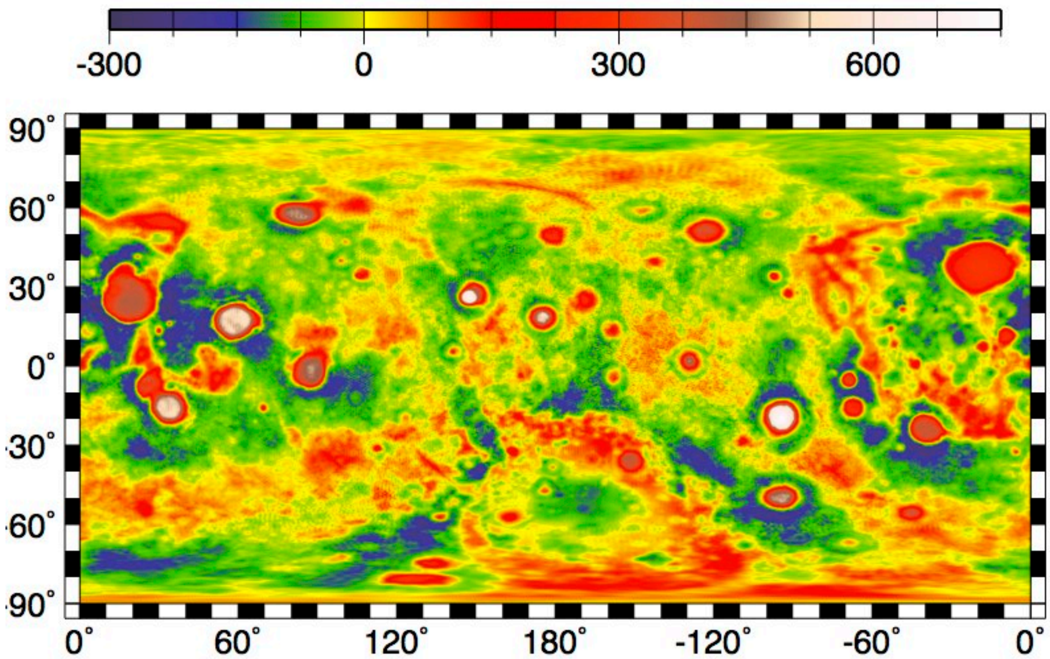

Fig. 2: Bouguer gravity anomaly bandpassed from degree l=6 to l=384 in cylindrical projection. Scale is in milli Galileos, (10^{-5} m s^{-2}).

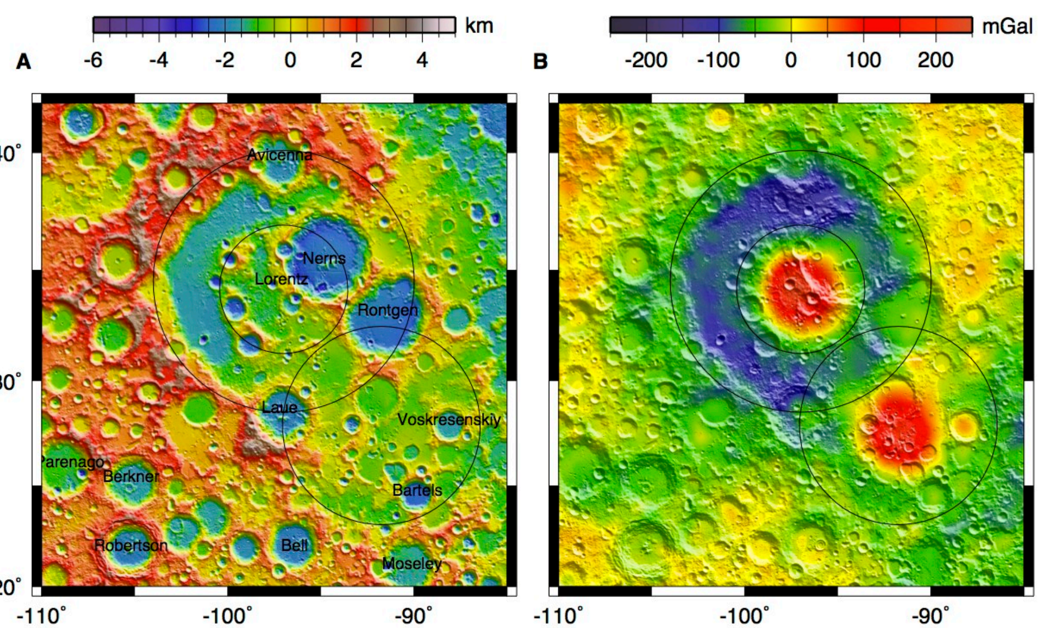

Fig. 3: Topography (A) and Bouguer gravity (B) of Lorentz, a 333-km diameter peak-ring basin, and a nearby unnamed impact feature with a Bouguer anomaly similar to that of Lorentz, in Mercator projection.