ZERO-TOPOGRAPHY GRAVITY ANOMALY OF THE MOON. N. K. Zhe[1], D. Kobayashi[1], and K. Sprenke[2], [1]Department of Earth Sciences, SUNY Brockport, Brockport, NY 14420. nzhe1@brockport.edu; dkobayashi@brockport.edu, [2]Department of Geological Sciences, University of Idaho, Moscow, ID 83844. ksprenke@uidaho.edu.

Introduction: Surface gravity on planetary bodies is controlled mainly by the topography and near-surface internal structures, as well as density contrasts. There is a strong association between surface gravity and elevation on the Moon [1], suggesting the gravitational variation is dominated by anomalies associated with surface shape, such as the near side/far side dichotomy, craters, basins, and ejecta piles. Gravity anomalies not connected in any way with surface shape might better reveal, compared to regular Bouguer gravity maps, details of uncompensated subsurface structures not previously resolved. This study is the first to present a lunar gravity map showing only disturbances in the free air gravity field that have no correlation, positive or negative, with topographic relief.

Data: We use the Bouguer gravity data collected by NASA's Gravity Recovery and Interior Laboratory (GRAIL) mission. The topography model (i.e., Bouguer reduction per unit density) is back-calculated from the Bouguer gravity and gravity disturbance data retrieved from the same source to ensure the consistent reference frame and linear relationship between the gravity and elevation data sets.

Method: The non-topographic anomalies are located by applying a concept in structural geology. First, we apply a 2-D smoothing of 300 km radius three times to filter out spherical harmonic degrees above L=18, avoiding short-wavelength artifacts [2]. For each data point on the map, both gravity field and elevation surface are viewed as planes. The apparent dip of the gravity plane in the direction of the strike of the elevation plane provides the dip direction and dip angle of a gravity component that has no association with the elevation. The collection of the horizontal derivatives of gravity anomaly is then integrated to construct the map of non-topographic gravity anomaly, which points out the presence of hidden subsurface structures and density contrasts on the Moon.

Results and Discussion: The resultant zero-topography gravity anomaly is shown in Figure 1. Zero topography gravity anomalies on the Moon could possibly arise from one of the following processes: (1) sedimentation in the form of ejecta deposition over pre-existing compensated topography, (2) erosion by mega-impact of a pre-existing compensated internally loaded crust, (3) subsurface density anomalies that developed after a rigid lithosphere formed, and (4) pre-existing irregularities on the crust-mantle boundary (e.g., a fossil equatorial bulge). In all cases, a zero-topography gravity anomaly indicates the presence of a mass concentration hidden beneath the surface, unless it is revealed by lithology or albedo changes on the surface.

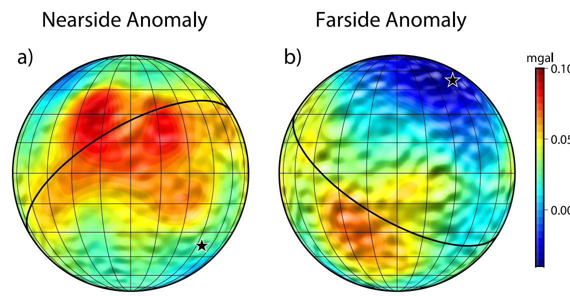

Fig 1: Orthographic view of the zero-topography gravity anomaly of the Moon with smoothed topography shading. The black line represents the best-fit great circle tracking the highest gravity anomaly with the associated poles at 52°N, 230°E indicated by stars. Nearside and farside labeling refers to the modern-day lunar positioning.

Figure 2 shows the location of hidden geologic structures. Linear positive anomalies or "ridges" suggest a planer intrusive body, such as a dike, and "valleys" suggest a potential fault zone. Lines of inflection points suggest a lithologic contact of a fault. "Hills" suggest the presence of subsurface mass concentrations (mascons), and "depressions" suggest an area of density deficit.

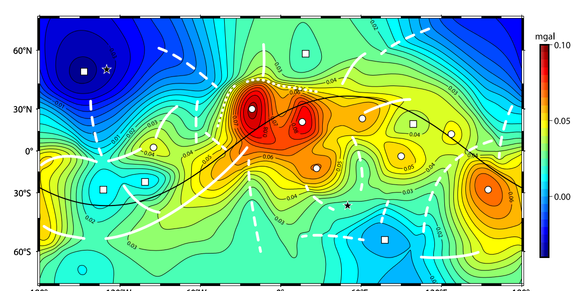

Fig. 2: Zero-topography gravity anomaly on a Mercator projection. White solid line traces a linear positive anomaly or "ridge," dashed line a "valley," and dotted line an inflection line. White circles and squares indicate areas of positive and negative anomalies, respectively.

Our zero-topography gravity anomaly map also suggests a paleo-equatorial bulge. We find the great circle that passes over more subsurface mass on the Moon than any other great circle and its pole at 52°N, 230°E (Figures 1 and 2). If this is the actual paleo-equator, then the excess map associated with the fossil equatorial bulge is in fact resulting in uncompensated gravity anomalies below a now resurfaced topography. If so, the Moon's internal density distributions, as opposed to its outer figure, once controlled the lunar moments of inertia. Our proposed paleopole is about 1366 km (~45°) west of the previously proposed pole [3].

Acknowledgments: The figures were produced using the Generic Mapping Tools (GMT) software.

References: [1] Zuber, M.T. et al. (2012). Gravity Field of the Moon from the Gravity Recovery and Interior Laboratory (GRAIL) Mission. *Science*. [2] Smith, S.W. (1999). *The Scientist and Engineer's Guide to Digital Signal Processing*, 2e. [3] Garrick-Bethell, I, Perera, V., Nimmo, F., and Zuber, M.T. (2014). The tidal–rotational shape of the Moon and evidence for polar wander. *Nature*.