Deriving the ancient lunar pole path from impact induced gravity anomalies

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The large anomalies in the lunar gravity field are in most cases the result of large impacts that occurred more than 3 billion years ago. Today those anomalies provide the stability of the lunar rotation and if removed would cause a change in the position of the intersection of the spin pole with the lithosphere. Thus, extracting a gravity anomaly from today's gravity field can provide the approximate location of the pole of rotation prior to the impact that caused the anomaly. By removing the gravity field of each anomaly in order of age, youngest first, we can estimate the path of the lunar pole back 3 to 4 billion years, to the beginning of the time of heavy bombardment.

Starting from the GRAIL gravity model we selectively remove large gravity anomalies by first determining the center and dimensions of the anomaly from the Bouguer gravity and then deriving the average free air gravity for the Bouguer location and dimensions. The anomaly field is expanded into spherical harmonics and the degree 2 terms used to derive the change in pole position caused by the anomaly. Removing each anomaly in order of increasing age provides an estimate of the pole path from before the time of the first anomaly, SP-A. Since the pole path depends on the order of the gravity anomalies being created it is important to know when each impact induced anomaly occurred. The results suggest the reconstructed motion of the lunar pole of rotation is within approximately 10 degrees of the present pole.