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Gravity aspects from recent gravity field model GRGM1200A of the Moon and analysis of magnetic data

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ABSTRACT

The gravity aspects for the Moon (the gravity disturbance, the Marussi tensor, two gravity invariants, dimensionality ratio, the strike angles, and the virtual deformations), all combined with magnetic anomalies and detailed surface topography, allow new views of specific locations on the Moon. Using these new gravity quantities, we hypothesize the following for several features on the Moon. A dike-like intrusion (exceeding ~100 km in length) from inside to outside of the Clavius crater likely solidified at the time of the existence of lunar dynamo. Mare Crisium analyses show a specific distribution of faulting across the mare. The same size impacts, Crisium and Clavius, present the dilatational deformation that is smoother for Crisium, while Clavius is under variable concentric compression due to an uplift of denser rock. Mare Orientale deformation not only confirmed the prior finding of the near surface faults, but also reveals a nature of the faulting (expansion vs compression blocks). Magnetic analyses of related lunar anomalies constrain mascon extent under the Copernicus structure and outline contraction areas from cooling of the upwelled mantle material. Mare Imbrium impact event has demagnetized regolith along with the Copernicus crater using a novel mechanism of shock propagation while plasma demagnetization. Clavius' magnetic field reveals magnetization that is likely more than four billion years old. Mare Crisium impact has a unique magnetization signature by impact related transient field. Mare Orientale showed, for the first-time, rippling-like effect of the Moon's mantle. This process of upwelled rippled mantle allows efficient demagnetization of the Orientale basin. For the first time, the application of the gravity aspects has been extended from the Earth to the Moon. This approach opens a new and inspiring field of planetary studies and point to otherwise hardly detectable phenomena. More detailed studies should follow.

1. Introduction

A knowledge of the gravity and magnetic field provides information about celestial bodies for various applications including boundary constraints for studies to infer about their interiors, geological history, etc. The gravity (and/or magnetic anomalies) and/or their second radial derivatives are frequently used. For the Moon, these data are derived from orbiters, not ground-based measurements. For example, among others, Andrews-Hanna et al. (2012, 2013) or Zuber et al. (2016b) studied crust and upper mantle structure or compensation state and ring structures of lunar basins from a combination of recent gravity data (GRAIL, Gravity Recovery and Interior Laboratory, Wieczorek et al., 2013) and topography data (LOLA, Lunar Orbiter Laser Altimeter, Chin et al., 2007; Smith et al., 2010 and Smith et al., 2017) using Bouguer gravity anomalies and gravity gradients (that reveal the distribution of mass in the subsurface). Recent global magnetic field models are mostly based on Lunar Prospector and Kaguya orbital data (see below). GRAIL data allow estimating the bulk density fluctuating around 2550 kg/m^3, much less than was previously assumed. This difference is due to an average porosity of 12% down to depths of a few kilometres. While

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