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Crustal Thickness and Magnetization beneath Crisium and Moscoviense Lunar Impact Basins

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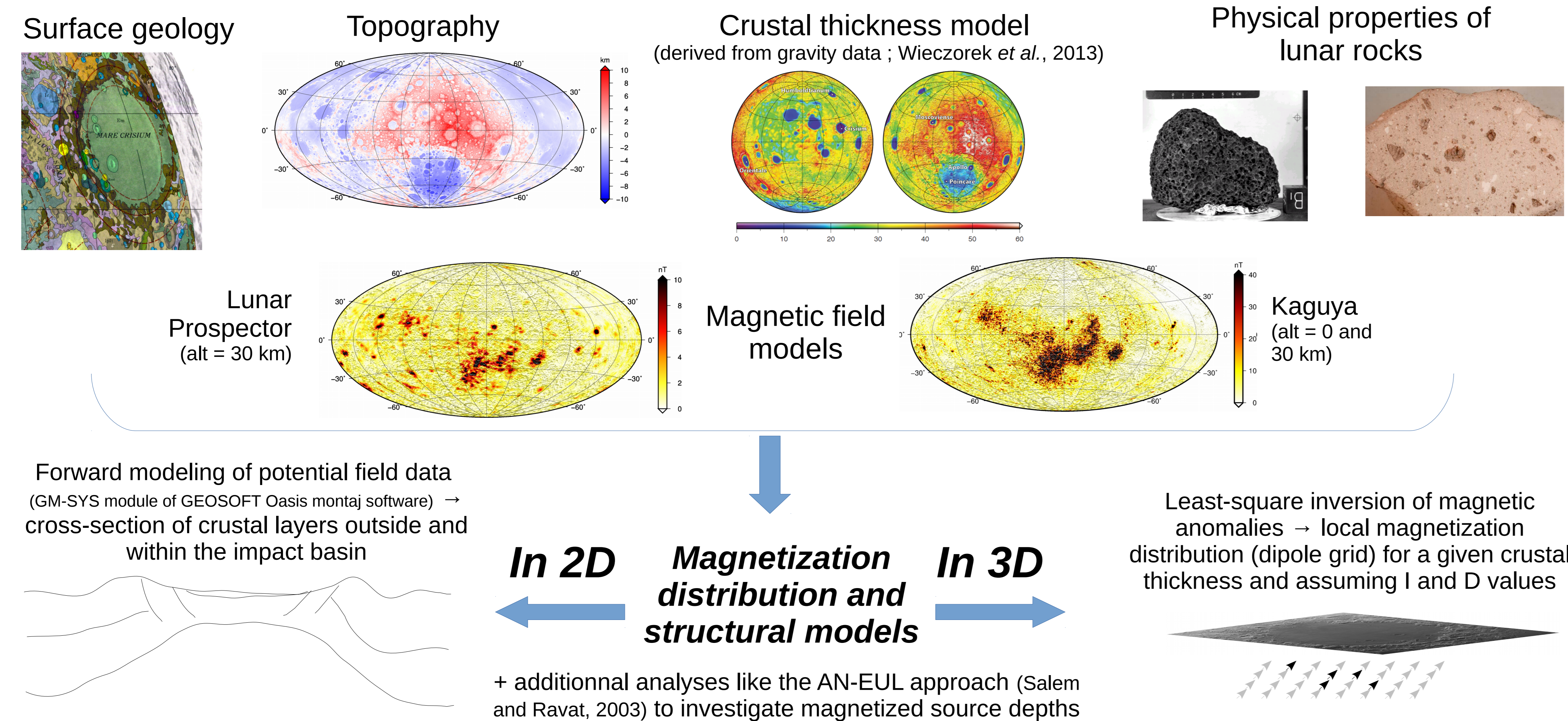
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ABSTRACT

GRAIL data recently confirmed that the Crisium and Moscoviense large impact basins have the thinnest (< 5 km) crust of the Moon. Crisium also shows two localized intense magnetic fields located nearby its North and South borders, while Moscoviense shows a relatively-intense central magnetic field anomaly. In details, these magnetic fields are exactly located where the thinnest (<1-3 km) crust within these basins is predicted by the crustal thickness models. Here we investigate this apparent anti-correlation by modeling the sources of these potential field data using several approaches in 2D and 3D. Our results show that, beneath the very thin Mare basalt layer, a strongly-magnetized layer with laterally-varying thickness – but still thin (~2-3 km) – and density can be present. This layer may correspond to an impact melt sheet with large magnetization due to accumulation of iron-rich fluids during the impact event and/or to post-impact processes.

Constraints, Data and Method



Application to the Crisium impact basin

Geological background, GRAIL data Bouguer anomaly, Crustal thickness with crustal porosity of 12 % and mantle density of 3220 kg/m³, Total magnetic field (at 30 km)

Comparison between Northern Crisium anomaly observations and predictions at 30 km of altitude after LS inversion of a grid of dipoles located at 5 km depth

Best dipole grid solution with I=30°, D=180° (Hood, 2011)

Magnetization intensities up to 4 A/m at 5 km depth

Geological interpretation?

Physical parameters of each geological layer of the model

Rock type	Density (g/cm ³)	Magnetization* (A/m)
Anorthosites	2.4-3.0	0.001
Mare basalts	3.15	0.01
Impact breccia and ejectas	2.3-2.5	0.02-1
Impact Melt Rocks	2.7-2.9	2**
Mantle	3.22	0

*I ranges from 15° to 40° from South to North, as it could be by cooling in a global dipolar magnetic field
**Almost 1 order of magnitude larger than observed magnetization intensities on APOLLO IMR samples...

A possible Crisium basin cross-section fitting both gravity and total-magnetic field data, after slight modifications of crustal thickness, densities and magnetization intensities

Large magnetic field anomalies at Crisium may be due to strongly-magnetized pockets of dense impact melt rocks, thus possibly enriched in iron. Other impact breccia within and outside the basin are magnetized, but with standard bulk densities.

Application to the Moscoviense impact basin

Geological background, GRAIL data Bouguer anomaly, Crustal thickness with crustal porosity of 12 % and mantle density of 3220 kg/m³

A possible 2D forward model

Magnetic field (nT), Gravity Field (mGal), Depth (km)

A recent crustal model for Orientale Basin

→ Strongly-magnetized impact (melt) sheet beneath Mare basalts
→ Fracturation of anorthositic crust (or possibly mixed with impact breccia) occurs at depth below the 'inner' ring and the outer main ring, without significant magnetization

Conclusions and perspectives

→ the Crisium Basin magnetic field anomalies can be explained by a 2 km-thick crust assuming 'standard' lunar magnetizations plus some 'pockets' of local iron-rich impact (melt) rock, and a amagnetic mantle

→ the Moscoviense basin central magnetic field anomaly can be explained by a 2 km – thick layer of highly-fractured impact breccia (with standard relatively intense magnetizations), and fracturation/brecciation that also occurs at depths beneath and between the rings

→ both models agree with a recent local model of the crust/mantle density contrast beneath the Orientale Basin (Zuber et al., 2016), that requires larger crustal densities (impact melt sheet?) at center, as well as listric faults reaching the mantle (thus decreasing density):

→ further tests will be performed using joint inversion of gravity and magnetic field data, assuming different mantle density values, over some Nectarian impact basins associated with a magnetic anomaly

References: Hood, 2011, Icarus, doi:10.1016/j.icarus.2010.08.012; Salem and Ravat, 2003, Geophysics, doi:10.1190/1.1635049; Wiczcerek et al., 2013, Science, doi:10.1126/science.1231530; Yamamoto et al., 2010, Nature Geoscience, doi:10.1038/ngeo897; Zuber et al., 2016, doi:10.1126/science.aag0519

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