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Constraints on the lunar magnetic sources location using orbital magnetic field data

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Orbital magnetic field observations of the Moon show several magnetic anomalies distributed heterogeneously across its surface. These observations and results from paleomagnetic studies on lunar rocks corroborates that the lunar crust is locally magnetized. The origin of these magnetic field anomalies is still debated, as most of them are not related to known geological structures or processes. Some of the current suggestions to explain the origin of the anomalies sources include contamination from impactors that could deliver iron-rich material to the lunar surface, and heating associated with localized magmatic activity that could thermochemically alter rocks to produce strong magnetic carriers. Both hypotheses need however an inducing field to magnetize the lunar crust, and strong evidence from previous studies argues in favor of this being a global magnetic field generated by a core dynamo.

In this work, we aim to elucidate the origin of the magnetic anomalies by constraining the location and shape of the underlying magnetization. We do so by inferring the magnetization geometry from orbital magnetic field measurements using an inversion scheme that assumes unidirectional magnetization while making no a priori assumptions about its shape. This method has been used up to now to infer the direction of the underlying magnetisation but it has not yet been used to infer the geometry of the sources. We test the performance of the method by conducting a variety of synthetic tests using magnetized bodies of different geometries such as basins, dykes, and lava tubes, each corresponding to a different possible origin scenario for the observed magnetic anomalies. Results from our synthetic tests show that the method is able to recover the location and shape of the magnetized volume. We explore how different input parameters, such as shape, depth, thickness, and field direction influence the method's performance in retrieving the characteristics of the magnetized volume. Such an analysis can be performed on many lunar magnetic anomalies, including those which are not related to swirls or impact craters, i.e., the mechanisms that have been most studied up to now. This will help elucidate the geological history of the Moon and key features of the lunar dynamo evolution.