TESTING THE ANTIPODAL EJECTA MAGNETIZATION HYPOTHESIS: CLUSTERED MAGNETIZATION DIRECTIONS OF THE LUNAR GERASIMOVICH MAGNETIC ANOMALIES

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Summary

- We infer the magnetization directions of the Gerasimovich and Crisium crustal magnetic anomalies.
- We compare the magnetization directions of both sets of anomalies to infer formation mechanisms
- The magnetization directions at the southern trio of Gerasimovich anomalies is compatible with acquisition of TRM at the Crisium antipode, but the magnetization directions for the northern duo remain unexplained.

Introduction: Lunar Magnetic Anomalies (LMAs) provide evidence for an early global lunar magnetic field, but the mechanism for generating such a field is currently unknown [1,2]. LMAs can provide clues to the strength and geometry of the dynamo at the time of formation [3].

Source Formation Mechanisms
- Iron-rich impact material [5]
- Volcanic Intrustions [6]

Magnetization Mechanisms [4]
- Thermal Remanent Magnetism (TRM)
- Shock Remanent Mangetism (SRM)

Some LMAs are nearly antipodal to large basisns, suggesting these anomalies could be formed by SRM as a result of ejecta in the presence of a dynamo or plasma-amplified field [4]. The Gerasimovich anomalies are nearly antipodal to the Crisium basin [7], which has a known age of 3.8–3.9 Ga [1,8].

GOAL: Constrain the strength of the dynamo field at the time of formation of Crisium by determining the formation mechanism of the Gerasimovich anomalies.

Observations: We define the Gerasimovich anomalies to be the five anomalies seen in Fig. 1. We describe the anomalies as the southern trio (Fig 1b-d) and northern duo (Fig 1e-f). There are three craters in this region: Gerasimovich, Houzeau, and an unnamed crater. The Crisium antipode is nearest to Houzeau crater. Lunar swirls (not shown) can be found in the Southern Trio where the magnetic field is strongest.

Methodology: We use Parker's Method [9-11] and the spherical harmonic dataset from [12] to determine the best-fit magnetization direction and source location. Figure 3 describes Parker's Method and our synthetic testing to ensure it is working correctly.

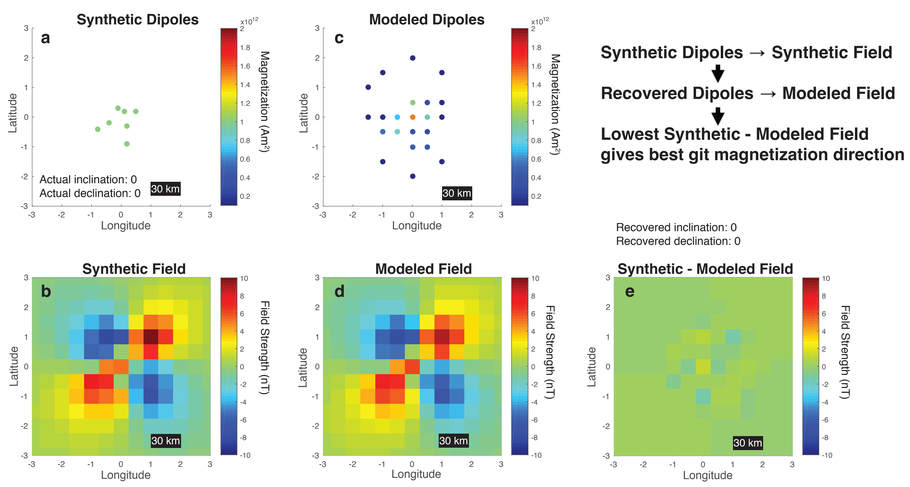

Figure 3. Visual Representation of Parker's Method and "synthetic data" testing. We start with a set of random dipoles (a) and the magnetic field (only east component is shown) produced by these dipoles (b). Parker's Method uses the data (b) to find the best-fit location and strength of the resulting dipoles (c) for a specific magnetization direction, and test over all possible directions. The field produced by the resulting dipoles (d) is compared with (b) as seen in (e). The direction used to produce the lowest RMS value in (e) is taken to be the best-fit magnetization direction.

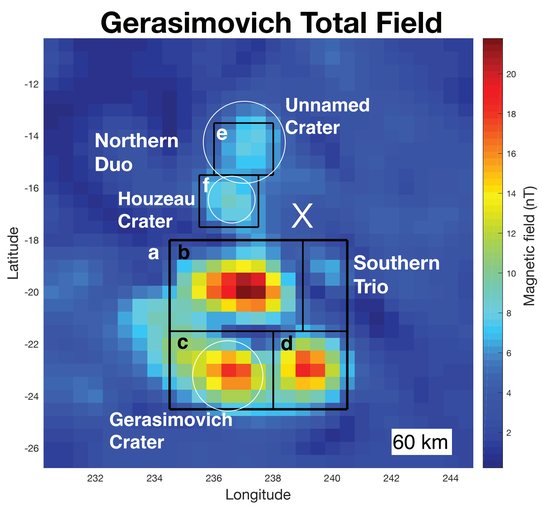

Figure 1. Magnetic field of the Gerasimovich anomalies at 30 km. The southern trio is labeled as (a) and the northern duo as (e-f). Within (a), there are three individual anomalies (b-d). Field map based on spherical harmonic dataset from [12]. The Crisium antipode is marked with an X.

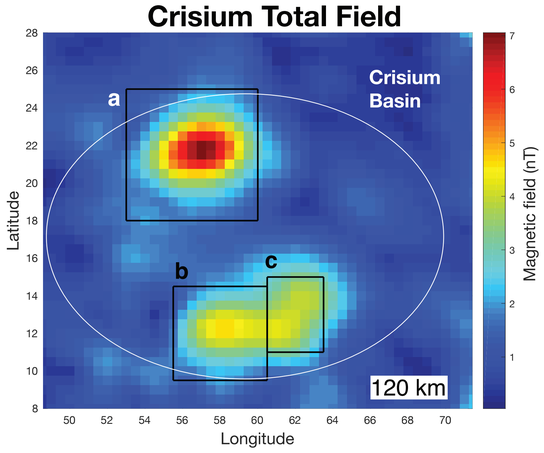

Figure 2. Magnetic field of the Crisium anomalies at 30 km. The three main anomalies are identified as North (a), South (b), and West (c). Field map based on spherical harmonic dataset from [12].

Results	Interpretations	Reasoning
Southern trio radially magnetized	TRM	Strong anomalies with coherent magnetization
Weaker northern duo has different directions	TRM or SRM	TRM: different source formation times SRM: disorganized magnetic material creates weaker anomalies with dissimilar directions
Northern Crisium anomaly magnetized in different direction than southern anomalies (also seen by [15])	TRM from different formation mechanisms	1. Possibly different thicknesses of impact melt could record different directions 2. One anomaly could originate from magnetized melt, the other from volcanic activity

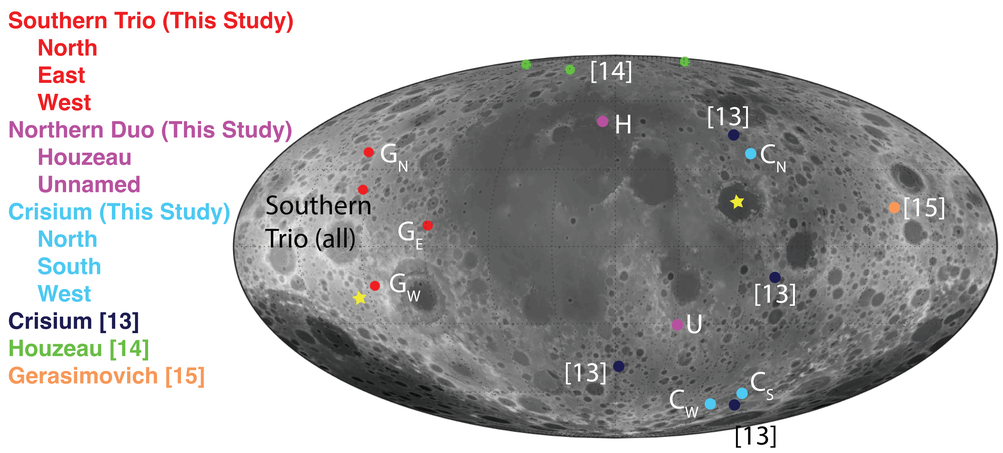

Figure 4. Paleopole locations based on inferred magnetization directions (Southern Trio, Northern Duo, and Crisium) and work from previous authors [13-15]. Mollweide projection over LOLA topographic data. Stars indicate locations of Crisium Basin and Gerasimovich crater.

Conclusion

- The southern trio of anomalies are magnetized radially (TRM) → Determine directional uncertainty associated with southern trio (see Fig. 5)
- The anomaly at the unnamed crater is magnetized similarly with the southern Crisium anomalies (TRM or SRM) → Determine direcional uncertainties and compare the unnamed crater anomaly with southern Crisium anomalies
- The Northern Crisium anomaly is magnetized in a different direction than those in the south (TRM) → Consider differing formation mechanisms for the anomalies at Crisium.

Future Work

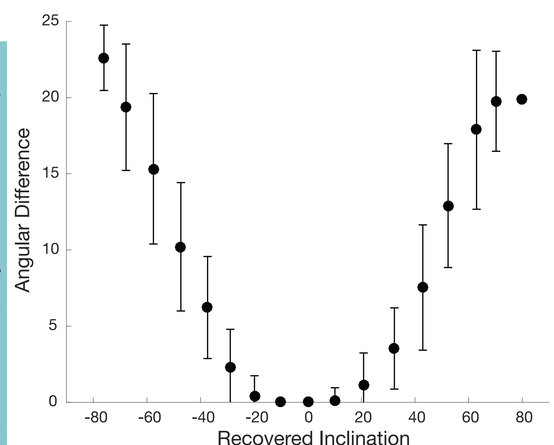

Figure 5. Preliminary uncertainty work. Average angular difference between the actual magnetization direction and the recovered magnetization direction plotted against recovered inclination.

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