ETH Zurich,
D-EAPS

Scaling Analysis on the Lunar Strong Magnetic Anomalies

Xi Yang[1], Anna Mittelholz[1]
[1]Department of Earth and Planetary Sciences, ETH Zurich, Switzerland

1 Introduction

Portions of the lunar crust acquired remanent magnetization, leading to pronounced magnetic anomalies detectable from orbit [1–3]. Constraining the structure of magnetized sources that generate these observed magnetic anomalies is key to understanding the evolution of the crust and the internally generated dynamo.

2 Method

Point source approximation: The magnetic field (T) follows a simple power law fall-off function with altitude (z)

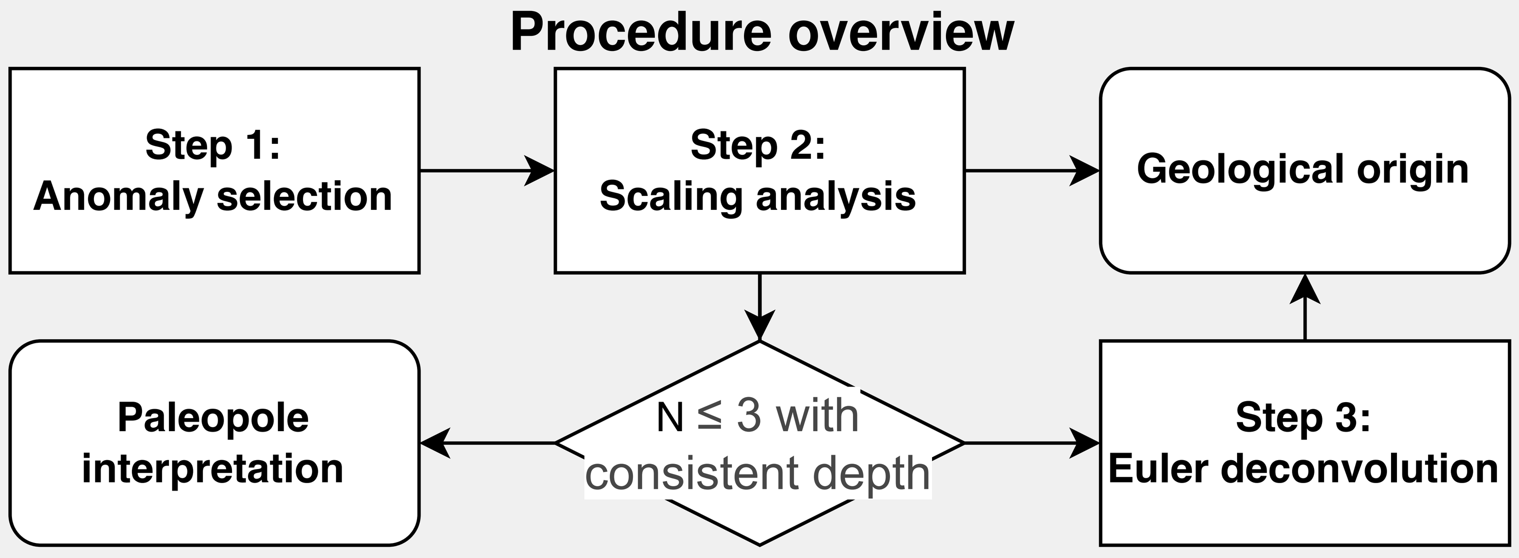
$$T = \frac{C}{(z+z_0)^N}$$

N: Scaling index

z_0: Source depth of magnetized body

Goal: Using N and z_0 to constrain geometries and magnetization and further constrain. their **geological origin and lunar dynamo**.

Procedure overview



3 Data

We focus on isolated strong magnetic anomalies (Fig.2) that show similar geometries in the recent lunar magnetic field models [1–3].

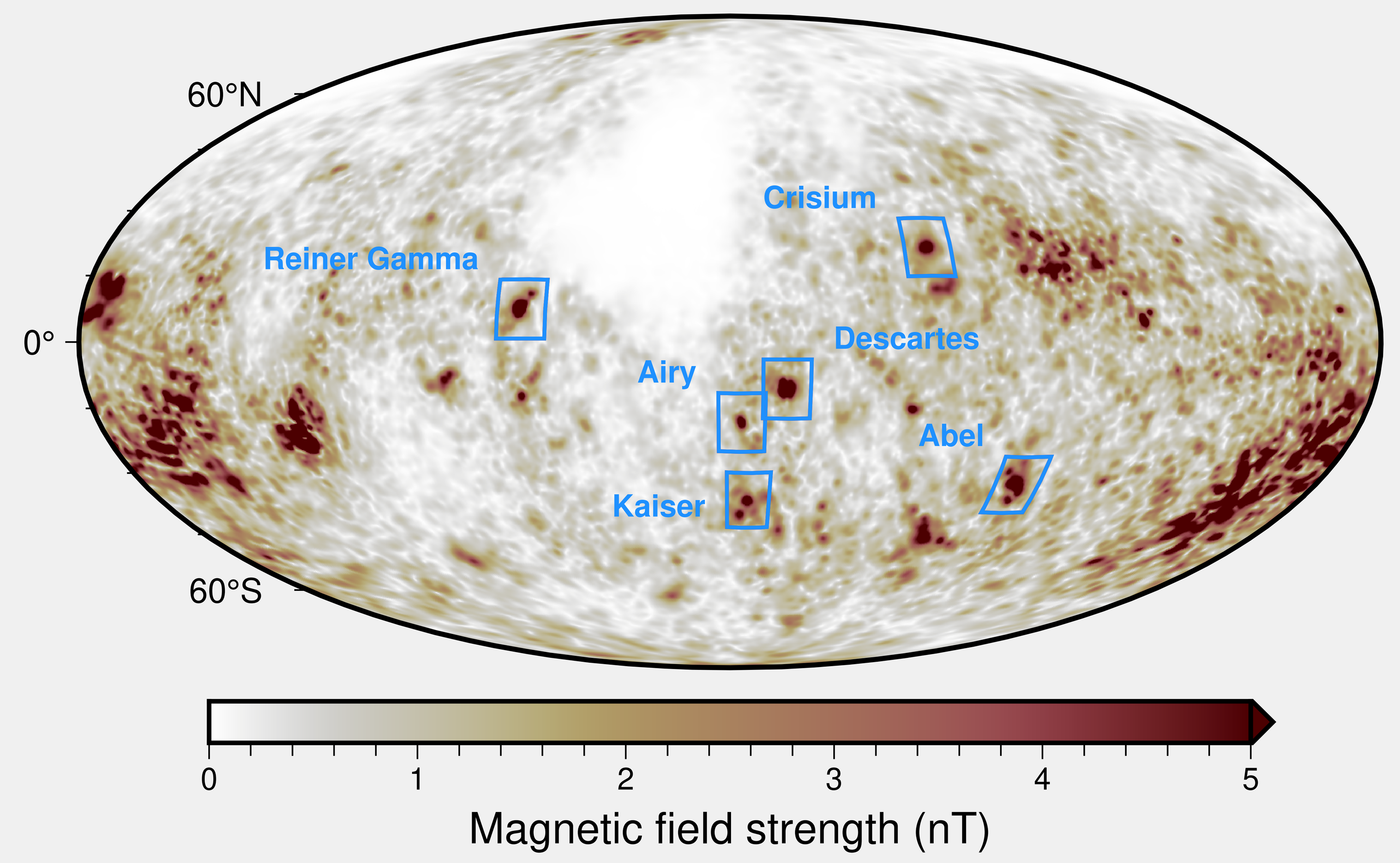


Figure 2. The studied lunar magnetic anomalies with magnetic field strength at 30 km altitude from the model of [1]

Radial field strengths of the strongest anomalies in 27–33 km altitudes and 37–43 km altitudes are used to derive best-fit N and z_0.

How well can we recover the source?
Synthetic tests show that a buried dipole with a depth exceeding about 10 km can be reliably recovered given current model resolution.

Results from primary [1] and supplementary [2] models are overall consistent.

4 Results and Discussion

- *Simple:* A single, uniformly magnetized source with simple geometry.
- *Complex:* Nonuniformly magnetized and/or distributed sources.

Name	30 km altitude		40 km altitude		Type
	z_0 (km)	N	z_0 (km)	N	
Reiner Gamma	15	3.3	13	3.2	Complex
Abel	16	2.3	16	2.2	Simple
Airy	32	3.3	28	3.1	Complex
Descartes	28	3.5	20	3.0	Complex
Crisium	49	3.0	47	3.0	Simple
Kaiser	33	2.8	25	2.4	Complex

Origin: The Crisium anomaly can be explained by an impact melt deposit; others are more plausibly associated with magmatic activities

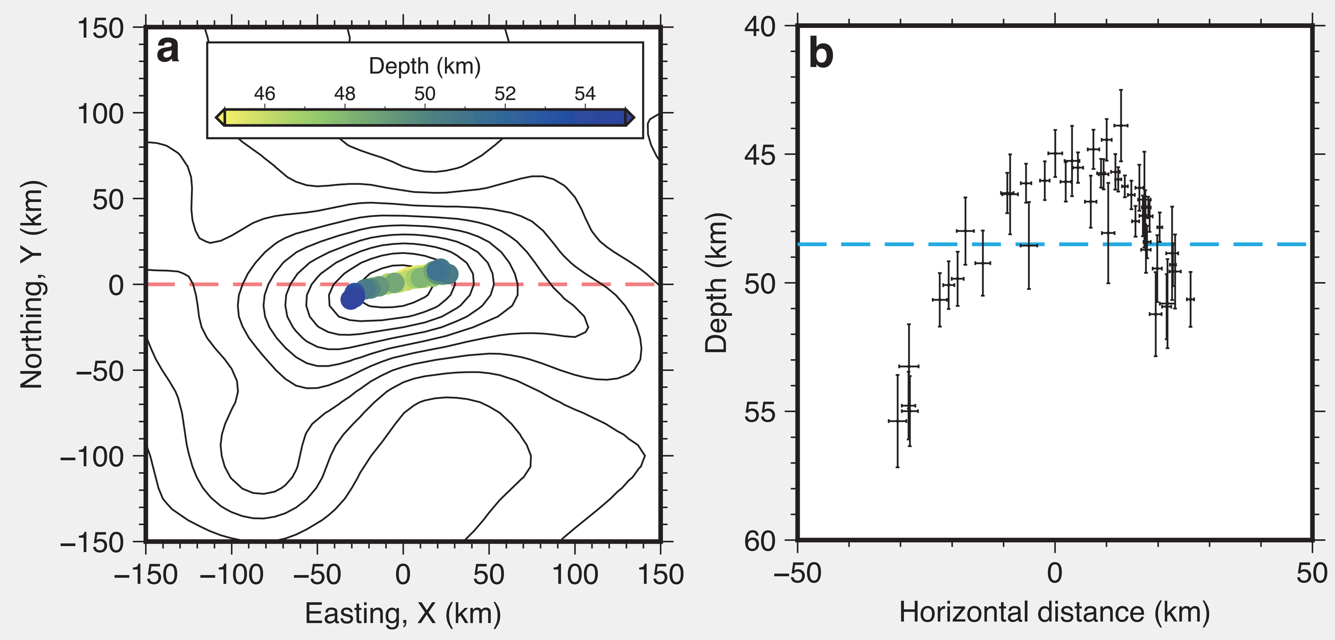


Figure 3. Source distributions of the Crisium anomaly derived from Euler deconvolution.

Paleopole: Simple anomalies that support paleofield interpretation indicate a substantial change in the orientation of the dynamo field

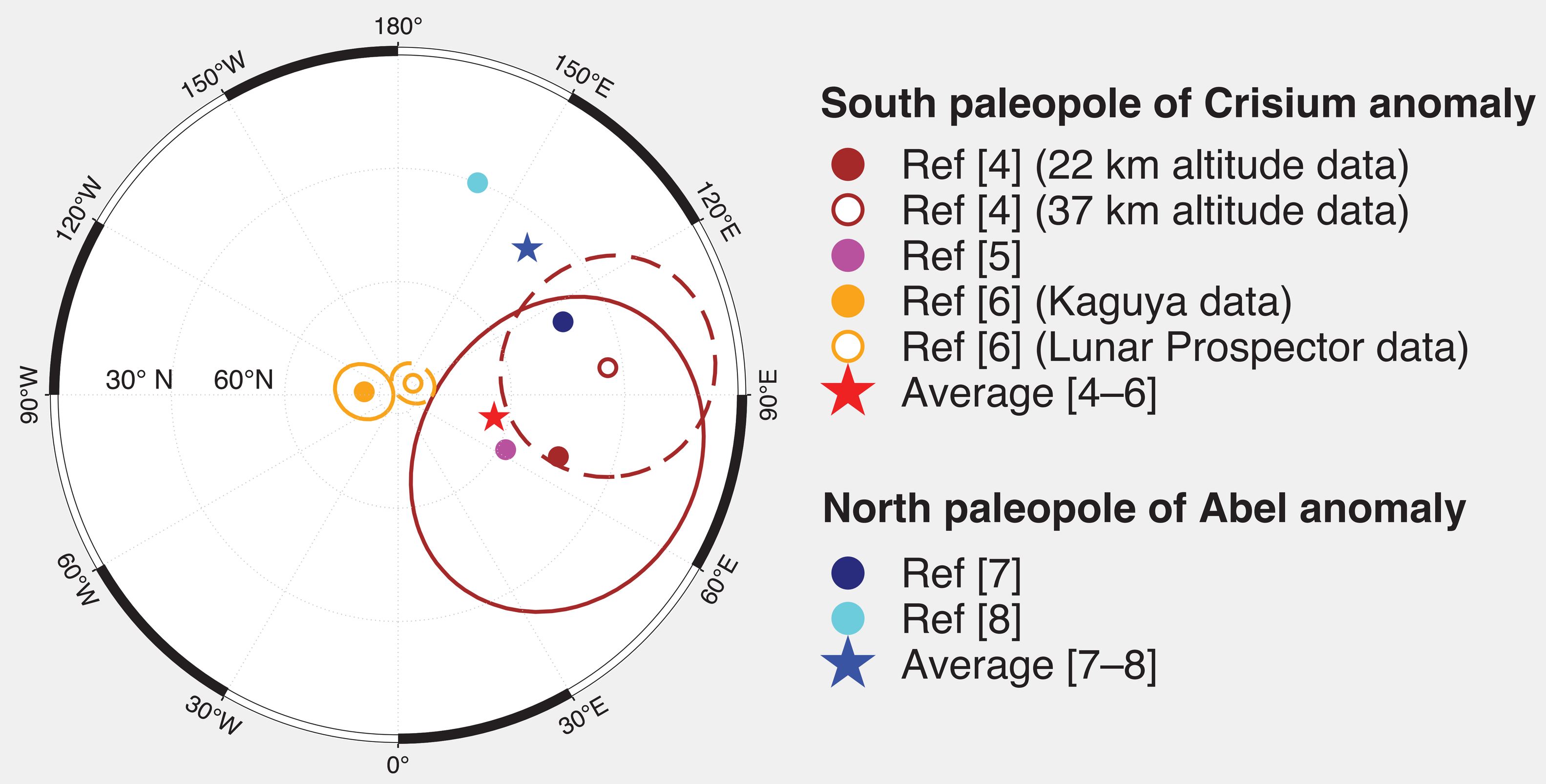


Figure 4. Lunar paleopoles associated with the Crisium and Abel anomalies from [4–8]

5 Conclusion

- Altitude-dependent decay of field strength helps constrain **source properties and geological origins** of lunar magnetic anomalies.
- Crisium and Abel are consistent with **uniformly magnetized sources with simple geometry**, supporting **a substantial change in paleopole position**.
- Reiner Gamma, Descartes, Airy, and Kaiser have **non-uniformly magnetized** or **complexly distributed** sources.

References

[1] Tsunakawa et al. (2015), *JGR: Planets*, 120, 1160–1185. [2] Ravat et al. (2020), *JGR: Planets*, 125, e2019JE006187. [3] Hood et al. (2021), *JGR: Planets*, 126, e2020JE006667. [4] Baek et al. (2019), *JGR: Planets*, 124, 223–242. [5] Hood et al. (2021), *JGR: Planets*, 126, e2020JE006668. [6] Takahashi et al. (2014), *Nature Geoscience*, 7, 409–412. [7] Oliveira and Wieczorek (2017), *JGR: Planets*, 122, 383–399. [8] Arkani-Hamed and Boutin (2014), *Icarus*, 237, 262–277.