Publications of the Institute of Geophysics, Polish Academy of Sciences
Geophysical Data Bases, Processing and Instrumentation
vol. 423 (C-112), 2018, pp. 111-112
DOI: 10.25171/InstGeoph_PAS_Publs-2018-057
16th Castle Meeting New Trends on Paleo, Rock and Environmental Magnetism, Chęciny, Poland, 2018

Constraining the Paleoinclination of the Lunar Dynamo

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Abstract

Paleomagnetic studies of lunar samples collected during the Apollo missions suggest the Moon had an active core dynamo for at least 2 billion years (Tikoo *et al*. 2017). The early lunar dynamo (4.25–3.56 Ga) was intense, recording paleointensities of 20–110 μT (Garrick-Bethell *et al*. 2009, Shea *et al.* 2012, Suavet *et al*. 2013, Weiss and Tikoo 2014). The lunar dynamo field subsequently declined to 5±2 μT at 2.5–1 Ga (Tikoo *et al*. 2017). The strength and longevity of this dynamo field is challenging to explain via a single mechanism. Thermal convection could not have driven a dynamo for such a sustained period of time, whilst thermochemical convection during core solidification is unlikely to have started so early (Christensen *et al*. 2009, Nimmo 2009). Alternative mechanisms of dynamo generation, such as mechanical stirring driven by gravitational coupling to the Earth may also be plausible (Dwyer *et al*. 2011).

There is also debate surrounding the dipolar nature of the lunar magnetic field. A recent study of lunar crustal magnetization found paleopoles oriented with both the rotation axis and the equator (Oliveira and Wieczorek 2017). On the other hand, evidence has also been found to support the presence of a dipolar field on the Moon oriented along the present day rotation axis (Cournède *et al*. 2012).

Providing a robust constraint on the direction of the lunar magnetic field over time is essential for establishing: (a) the mechanism by which the lunar dynamo was driven, (b) whether the magnetic field underwent reversals, and (c) whether the Moon experienced true polar wander.

Here we present results for the paleoinclination of the lunar magnetic field recorded 3.8 Ga (Kirsten *et al*. 1973) by sample 75055, collected during the Apollo 17 mission. This sample, along with samples 75035 and 75075 were collected from the Camelot crater. They were sampled from boulders which are thought to represent an overturned flap formed dur-

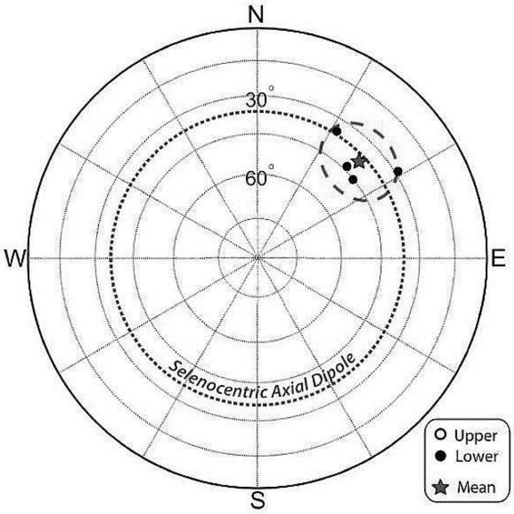

Fig. 1. Preliminary data for sample 75055 suggest that 3.8 Ga, the lunar magnetic field was dipolar and aligned along the Moon's rotation axis (Getzin *et al.* 2018).

ing impact cratering, or may represent in-place subfloor basalts exposed by recent mass wasting (Schmitt *et al.* 2017). Sample orientations were reconstructed in lunar coordinates using astronaut photographs from the Apollo 17 mission and personal correspondence with astronaut H.H. Schmitt.

At the latitude of the Camelot crater (20.19 °N), a dipolar field aligned along the rotation axis should return a paleoinclination of 36.3°. Preliminary results (Getzin *et al.* 2018) (Fig. 1) support this hypothesis, suggesting the Moon had a dipolar, dynamo-generated field that was stable for extended periods of time, undergoing reversals less frequently than the geodynamo.

Keywords: Moon, paleoinclination, dynamo, Apollo 17.

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