The lunar dynamo: paleomagnetism and power sources

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Paleomagnetic studies of Apollo samples and spacecraft measurements of crustal magnetism indicate that the Moon generated a core dynamo magnetic field that commenced by ~4.25 Ga. The field peaked in intensity during the period between ~3.85 Ga and ~3.56 Ga, reaching values of ~35-120 μT that rival the modern Earth's dynamo [1]. By ~3.3 Ga, surface fields declined to ≤~15 μT. The dynamo further persisted (either continuously or intermittently) in a weakened (~5 μT) state until at least ~2.5 Ga [2]. It is unclear when the dynamo ultimately ceased, but recent work hints it might have been prior to ~1 Ga. We review studies that investigate not only the paleointensity evolution and duration of the lunar dynamo field [1-2], but also its potential structure [e.g., 3].

Determining the paleointensity evolution and lifetime of the lunar dynamo helps constrain its power source(s). The dynamo may have been driven by thermal convection, thermochemical convection sustained by core crystallization, mechanical stirring of core fluid by impacts or mantle precession, or a combination of the aforementioned processes [1]. Even if implausibly high radiogenic element abundances are included in the lunar core, convective dynamos are likely incapable of producing even the minimum paleointensity that has been determined for the entire high-field period between ~3.85 and 3.56 Ga [4]. However, thermochemical convection could power a constant, weak (~2 μT) dynamo until ~200 Ma [4]. Therefore, the lunar dynamo was probably powered by a combination of power sources operating at different times in lunar history (i.e., mechanical stirring of the core prior to ~3.56 Ga and thermochemical convection afterward).

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