EVALUATING THE EVIDENCE FOR MAGNETIC DYNAMOS IN CHONDRITIC PARENT BODIES.

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Introduction: For small, early-forming planetesimals such as the meteorite parent bodies, the detection of a core dynamo implies an ample internal heat budget powered by short-lived radionuclides, which in turn places strong constraints on the timing of accretion and the subsequent distribution of heat in the deep interior. Among chondrite groups, previous paleomagnetic studies have revealed evidence for magnetic fields with between <10 and 60 μT intensity on the CV and H parent bodies [1-3]. The high intensity, late apparent age, and long acquisition times of these magnetizations have been used to argue for a dynamo origin instead of solar wind [4], nebular [5], or impact-induced [6] alternatives, respectively. Despite these suggestions for the existence of core dynamos on chondritic parent bodies, several predictions of the dynamo hypothesis have not been fully tested. First, inferred accretion times of chondritic parent bodies [7] implies that many should have lacked magnetic dynamos. However, due to the pervasive aqueous alteration [8] and the poor magnetic recording fidelity of most chondrites [9], interpretable records of ancient dynamos may not persist in meteorite samples whether or not they were exposed to dynamo magnetic fields. As such, reliable evidence for the *absence* of dynamo activity on meteorite parent bodies has proven elusive. Second, the uniformity and long duration of dynamo magnetism predicts that consistent remanent magnetizations should be observed in different meteorites from the same group. Likewise, all ferromagnetic components of a meteorite dating from the time period of the active dynamo should record a comparable magnetic field.

Paleomagnetic Experiments and Results: To further evaluate the chondrite parent body dynamo hypothesis, we present paleomagnetic experiments on the Semarkona LL3.0 chondrite and the Kaba CV3.1 chondrite. For experiments on the Semarkona meteorite, we extracted eight chondrules containing dusty olivine grains. We then subjected seven chondrules to progressive alternating field (AF) demagnetization up to at least 290 mT and conducted thermal demagnetization up to 780˚C on one chondrule. Because metal grains in dusty olivines are a primary nebular product and did not undergo secondary alteration on the LL parent body [5], these samples are expected to preserve a reliable record of the ambient magnetic field on the parent body during metamorphic heating to 200-260˚C [10]. Although all eight isolated chondrules we measured carried at least one identifiable component of magnetization, we observed no coherent magnetization direction expected from a dynamo magnetic field. Magnetizations from different chondrules at similar AF unblocking intervals uniformly pass the paleomagnetic conglomerate test, indicating consistency with randomized magnetization directions. Furthermore, in the thermally demagnetized chondrule, we observed no coherent decay of magnetization between room temperature and 400˚C, which is expected to contain any magnetization imparted during parent body metamorphism. Anhysteretic remanent magnetization (ARM) acquisition experiments in an AC field of 260 mT and bias fields between 2 and 50 μT indicate that 3 out of 4 tested dusty olivine-bearing samples are capable of recording an ambient magnetic field between 5 and 10 μT. As such, our observed lack of unidirectional magnetization suggests that LL ordinary chondrite parent body did not host a magnetic dynamo with surface field intensity >5 μT during the time of peak metamorphism, which is expected to occur during the time of highest heat flux when a thermally-driven dynamo is most active.

Our preliminary high-resolution magnetic imaging of the Kaba polished section using the quantum diamond magnetometer (QDM) shows that veins of secondary minerals in the chondrite carry a remanent magnetization. Ongoing analysis aims to establish the origin of this magnetization and evaluate its consistency with remanent magnetization observed in other samples of Kaba [11] and Allende (CV3.6). If the magnetization of secondary veins is consistent in strength and direction with that of surrounding materials, the acquisition of magnetization must have postdated the compaction and secondary alteration of the matrix. This would imply that rapid heating during impact compaction is unlikely to be responsible for the magnetization event [6], thereby favoring acquisition in a long-lived dynamo instead of an ephemeral impact-generated field.

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