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Evidence of Partial Differentiation and a Metallic Core on the CV Chondrite Parent Planetesimal

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We have conducted a new paleomagnetic study on the Allende CV carbonaceous chondrites, one of the best paleomagnetically studied rocks in history. It has long been known that the meteorite Allende and other CV carbonaceous chondrites contain a natural remanent magnetization. This record has been difficult to interpret because the age and setting of magnetization acquisition were poorly understood. Carbonaceous chondrites have traditionally been thought to samples bodies that have not undergone large-scale differentiation. The bulk chemical composition and aggregational texture of chondrites demonstrate that they are not the products of planetary melting processes. Thus, we need to determine the nature and acquisition time for the magnetization in Allende in order to distinguish between the possible magnetic field sources. Therefore, we conducted high resolution demagnetization analyses compared to shock remanent magnetization acquisition, absolute paleointensities, and a variety of rock magnetic measurements. We also investigated magnetostatic interactions and viscous demagnetization. Using recent geochemical, petrologic, and isotopic datasets, we demonstrate that the unidirectional magnetization in Allende must have been acquired following accretion of the parent body, likely over several million years (Ma) during metasomatism on the CV parent planetesimal $\sim$8-10 Ma after solar system formation. Therefore, the magnetization in Allende is apparently too young and was acquired over too long a time period to have been produced by early external protoplanetary disk or solar magnetic fields. Moreover, our determinations of Allende's paleointensities are in the range expected for core dynamos in early planetesimals. A simple interpretation of Allende's paleomagnetic record is therefore that CV chondrites are derived from the outer, unmelted layer of a differentiated body with a convecting, liquid metallic core and core dynamo. Thermal modeling of early planetesimals heated by ^{26}Al decay indicates that dynamos were likely generated in convecting metallic cores lasting for $\geq$11 Ma after solar system formation. Because such bodies melt from the inside out, some may preserve an unmelted, relict chondritic surface which could be magnetized during metasomatism in the presence of a core dynamo.