LONG-LIVED MAGMATISM AND CORE DYNAMO IN VESTA.

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Introduction: Characterization of paleomagnetic fields of differentiated meteorites provides fundamental information on dynamo processes and thermal evolution on small bodies in the early solar system. Recent advances in paleomagnetic studies of meteorites have revealed strong paleofields requiring past dynamos in several asteroids, including angrites [1], pallasites [2], and the Howardite-Eucrite-Diogenite (HED) parent bodies [3], with the latter being most likely the asteroid 4 Vesta [4]. Solar and nebular fields could not be a source of these magnetization, because they should have dissipated within the first ~6 Ma of solar system formation [5]. However, the current evidence [3] for Vestan dynamo is indirect. It was inferred that a shock melted meteorite, ALHA 81001, which was interpreted to have cooled 3.69 billion years ago in the presence of a small field created by nearby crust that itself was magnetized in an ancient field while a dynamo was active [3].

Clearly, a direct reading of magnetic field strength of Vesta is needed. Diogenites are widely regarded as deep-seated rocks, magma ocean cumulates and/or crustal intrusive bodies of 4 Vesta [7], although harzburgitic and dunitic diogenites are also known [8]. Northwest Africa (NWA) 5480 is an olivine-rich diogenite (olivine-diogenite or harzburgite) with 57 vol.% and 42 vol.% olivine and orthopyroxene, respectively [8]. It is a pristine, low shock, unweathered rock. Its petrology and geochemistry has been studied in detail [e.g. 8,9]. Preliminary paleointensity data shows that NWA 5480 preserves a strong magnetic field of approximately 36 μT [10]. This implies a Vestan dynamo as the primary source since alternative sources are not expected to impart such a strong field [10]. Moreover, based on microstructural and fabric analysis of olivine and pyroxene grains it was inferred that NWA 5480 has undergone solid-state plastic deformation post-crystallization [11]. Observing plastic deformation is strong evidence that this diogenite recorded dynamic mantle convection occurring in the parent body 4 Vesta [11]. Olivine banding observed in this rock has been interpreted as evidence for magmatic flow in the mantle of 4 Vesta [8]. These features make NWA 5480 a particularly interesting rock as it may preserve a signal of past mantle convection.

While the presence of magnetized Vestan rocks implies it had solidified and cooled to below the Curie temperature during the presence of an early active dynamo [3, 10], it does present a thermal paradox for Vesta. If the current ^{26}Al-^{26}Mg age interpretations for diogenites are correct [12], early ^{26}Al decay results in a mantle initially hotter than the core, potentially inhibiting dynamo generation. All thermal models exclude such an early dynamo [13,14]. Therefore, constraining the age of diogenites in general, and NWA 5480 in particular, is of critical importance for better understanding the temporal context of dynamic mantle processes and the formation of core dynamo in the asteroid 4 Vesta.

We have recently applied the short-lived ^{53}Mn-^{53}Cr isotope system to constrain the timing of formation of NWA 5480 to be $\leq$ 4547.64 Ma [15], i.e., after > 19.68 Myr since the beginning of the solar system [15]. We additionally, used the observed isotopic anomalies in the stable ^{54}Cr isotope to investigate its relationship to other HEDs [15]. Here we explore U-Pb isotope systematics of NWA 5480 in order to further constrain its absolute age.

Results and Discussions: For an asteroidal dynamo to be active and generating magnetic fields that can be recorded in differentiated meteoritic minerals, a Goldilocks window of timing must be satisfied. (1) It must not be too early when heating from ^{26}Al (half-life = 0.73 Myr) results in a silicate mantle hotter than the metallic core and (2) It must also not be too late such that the metallic core has fully crystallized causing the dynamo to cease. Our new Mn-Cr age [15] and Pb-Pb age (to be reported at the meeting) imply that when NWA 5480 crystallized, ^{26}Al must have been completely decayed away. Together with the magnetic data [10] our new age also suggests that heat may have been removed by the Vestan silicate mantle.

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