PRIMITIVE ACHONDRITE NORTHWEST AFRICA 11042: MELTING OF THE L CHONDRITE PARENT BODY

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Introduction: We report here the discovery of a new ungrouped primitive achondrite, Northwest Africa (NWA) 11042. A single 90.1 g stone was purchased from Abdelhadi Aithiba in Morocco in 2016. The stone is covered in black fusion crust and a broken surface displays a low degree of weathering.

Petrography: The rock is ultramafic and displays a phaneritic cumulate texture of olivine (Fo=75, 46 vol%), pyroxene (En=74 Fs=20, 38 vol%), maskelynite (Ab=83 An=12, 15 vol%), and chromite (1 vol%). Trace phases include troilite which is paired with kamacite and minor taenite, along with trace apatite. Plagioclase has been completely transformed to maskelynite. Shock-melt pockets that range in size from hundreds of µm to several mm are scattered throughout the groundmass and contain the high-pressure phase ringwoodite. A dark rim around the melt pockets is observed in backscattered electron imagery, and metal nanoparticles are observed exsolving from surrounding mineral grains, indicating that areas surrounding the pockets are being reduced by the melt.

Geochemistry: The oxygen isotopic composition of NWA 11042 plots within the range of the L chondrites ($\delta^{18}O$=4.46; $\delta^{17}O$=3.34; $\Delta^{17}O$=1.03). The whole-rock rare earth element (REE) composition displays a flat pattern that is ~2X CI chondritic [1]. Maskelynite displays a positive Eu anomaly, while pyroxenes display complementary negative Eu anomalies characteristic of igneous differentiation. $^{143}Nd/^{144}Nd$ and $^{147}Sm/^{144}Nd$ values for a whole-rock sample and olivine, pyroxene, and melt pocket separates were measured. The whole-rock, olivine, and pyroxene samples form a 3-point isochron with an age of 4100 ±160 Ma. The melt pocket separate plots off of this isochron at a much younger age.

Discussion: While the oxygen isotope composition of NWA 11042 matches that of the L chondrites, its composition is distinctly achondritic. It does not contain any relict chondrules and displays an igneous texture which is overprinted by shock features and thus not produced by them. The oxygen isotope composition of NWA 11042 resembles that of two other ungrouped achondrites, NWA 4284 ($\delta^{18}O$=4.22; $\delta^{17}O$=3.24; $\Delta^{17}O$=1.02) and NWA 6698 ($\delta^{18}O$=4.77; $\delta^{17}O$=3.74; $\Delta^{17}O$=1.23). NWA 4284 displays a similar igneous texture and mineralogy, but with higher modal pyroxene and plagioclase. Its plagioclase has been partially transformed to maskelynite and it does not contain shock-melt pockets or veins.

The flat REE pattern of NWA 11042 suggests that it is derived from L chondritic material as it plots very close to the ordinary chondrites. However, it is depleted in metallic Fe and siderophile elements relative to the ordinary chondrites which suggests that its parent body underwent a core formation event. Its Sm-Nd crystallization age is younger by several hundred Ma than any chondrite. This includes the highly metamorphosed L5 and L6 chondrites, which have younger ages due to being heated for longer by the decay of extinct radionuclides [2]. The young age of NWA 11042 could reflect contamination and incorporation of partially reset shock-melted material into the mineral isochron. Alternatively, if this meteorite represents a melt in the interior of the L chondrite parent body, it could have undergone an unusually long heating event for chondritic material and thus its Sm-Nd isotopic composition took longer to reach closure temperature.

The standard “onion shell” model of the L chondrite parent body [3] shows increasing thermal metamorphic gradient with increasing depth. The L3 chondrites form the outermost shell, followed by the L4, L5, and L6 chondrites with increasing depth. As temperature increases with depth, so does the minimum time required for material to cool past its closure temperature, and thus more metamorphosed chondrites are progressively younger. The existence of an L chondritic melt further raises the necessary temperatures and ages, and this would also raise the minimum size of the parent body since a larger size would be required to heat chondritic material past its melting point.

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