EARLY DIFFERENTIATION OF CARBONACEOUS ACHONDRITE PARENT BODIES: NEW INSIGHTS FROM NORTHWEST AFRICA 10132

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Introduction: The rapidly increasing number of achondrites originating from planetesimals with carbonaceous chondrite type isotopic affinities (e.g., [1-6]) have provided a unique opportunity to trace differentiation and crystallization processes and their associated timescales across a diverse number of parent bodies across solar nebula settings. Recently, we reported on four unique achondrites, Northwest Africa (NWA) 6704/6693 and NWA 7680/6962, that originated from a carbonaceous reservoir, most similar to CR chondrites [1-6]. These meteorites along with the carbonaceous achondrite NWA 2976/011 [7] show that differentiation activity was widespread around 4562.7-4563.7 Ma in a region of the solar nebula (carbonaceous chondrite forming region) believed to be originating from outside Jupiter that was previously suggested to have minimal magmatic activity inferred by the typical undifferentiated nature of carbonaceous chondrites observed prior to recent discoveries.

Here, we report on another achondrite, NWA 10132, that bears strong similarities to NWA 6704/6693. As with NWA 6704/6693, this sample is predominantly composed of orthopyroxene and olivine with minor amounts of plagioclase and chromite and has similar oxygen isotopes [8,9]. However, reported textural differences and the absence of vesicles in NWA 10132, which are present in NWA 6704/6693, means that a direct pairing is implausible [9]. Rb-Sr systematics [10] also point towards variations among these meteorites with relatively low Rb concentrations in NWA 6704 ($^{87}Rb/^{86}Sr$ <1), but rather high Rb and low Sr ($^{87}Rb/^{86}Sr$ as high as 7) in NWA 10132 and NWA 6693 with corresponding highly radiogenic $^{87}Sr/^{86}Sr$ approaching 1.2. If these two rocks are originating from the same parent body, then coupling the petrologic and chronology information will enable a better picture of differentiation on this carbonaceous planetesimal and in the early Solar System. To this end, we report the $\varepsilon^{54}Cr$ isotopic composition of NWA 10132, as well as age constraints for its formation age utilizing the ^{53}Mn-^{53}Cr and Pb-Pb isotopic systems. ^{26}Al-^{26}Mg measurements are currently in progress and will be presented at the meeting.

Results and Discussion: The $\varepsilon^{54}Cr$ isotopic composition of NWA 10132 is indistinguishable from that of NWA 6704/6693 within uncertainty. A common Cr isotopic composition, along with the previously reported oxygen isotopes [9], indicates a common source reservoir for both meteorites, potentially on the same planetesimal. Cr isotopic measurement of individual mineral separates (pyroxene and olivine) and the bulk rock yield a well-defined isochron with an initial $^{53}Mn/^{55}Mn$ that translates to an age of 4562.76±0.41 Ma (anchored to D'Orbigny). Lead isotopic analysis of pyroxene residue after extensive multi-step leaching likewise provides a well-defined isochron. The regression through all pyroxene residues provides an age of 4562.71±0.19 Ma, calculated using a $^{238}U/^{235}U$ value measured for NWA 6704 [11].

Multiple lines of evidence (mineralogy, Cr and O isotopes) support a common source for NWA 10132 and NWA 6704/6693. As such, all three meteorites could be referred to now as a grouplet. We suggest that these two distinct rocks are providing a snapshot of petrogenetic processes on the same carbonaceous parent body. The ages for NWA 10132 provided using the ^{53}Mn-^{53}Cr and Pb-Pb systems are contemporaneous with that of NWA 6704/6693, including the ^{26}Al-^{26}Mg age of NWA 6704/6693. Identical mineralogy and contemporaneous formation poses the possibility that NWA 10132 and NWA 6704/6693 originated from a common magmatic source. Identical Rb-Sr isochron among the three samples may indicate NWA 6704 represent a surface sample with more significant Rb loss, whereas NWA 6693/10132 indicate a deeper-seated sample with less Rb-loss [10]. The consistency in the ages indicates that the NWA 10132/6704/6693 grouplet parent body experienced widespread melting and crystallization at 4562.7 Ma within 200 kyr interval and that cooling was not protracted given the consistency among chronometers with differing closure temperatures (Pb-Pb, Mn-Cr, Al-Mg, Rb-Sr) and between samples that sampled crystallization conditions (e.g., textural evidence such as vesicles and variations in volatile content) on the parent body (NWA 10132 vs. NWA 6704/6693). Previous time constraints for carbonaceous achondrite formation have utilized single examples of their respective parent bodies [5,7]. The NWA 10132/6704/6693 grouplet provide a unique opportunity to investigate timescales of formation under various petrogenetic conditions on a single, carbonaceous achondrite parent body, an ability previously limited to non-carbonaceous planetesimals (e.g., angrites and HEDs).

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