SILICA-RICH MAGMATISM IN THE EARLY SOLAR SYSTEM: U-Pb AND Al-Mg CHRONOLOGY AND Cr ISOTOPES OF UNGROUPED ACHONDRITE NORTHWEST AFRICA 11119. M. H. Huyskens[1], M. E. Sanborn[1], Q.-Z. Yin[1], and C. B. Agee[2], [1]Dept. of Earth and Planetary Sciences, University of California-Davis, One Shields Avenue, Davis, CA 95616, [2]Institute of Meteoritics, University of New Mexico, 221 Yale Blvd. NE MSC03 2050 Albuquerque, NM 87131, (mhuyskens@ucdavis.edu)

Introduction: The ungrouped achondrite Northwest Africa (NWA) 11119 is only the second meteorite ever discovered with an intermediate composition [1, 2]. Thus, it provides a unique opportunity for insight into differentiation and the generation of “andesitic” crusts on asteroidal bodies. NWA 11119 is a porphyritic sub-volcanic rock composed mainly of pyroxene (px), plagioclase (plag), silica (tridymite, cristobalite and minor quartz) with minor occurrences of oxides and sulfides [1]. The bulk rock is andesitic-dacitic in composition, although it has rather low alkalis compared to its terrestrial counterparts [1]. Oxygen isotopes suggest that NWA 11119 and the ungrouped achondrite NWA 7325 most likely formed within the same region of the protoplanetary disk and may even originate from the same parent body [1]. NWA 7325 is a mafic achondrite with a very different mineralogy compared to NWA 11119. However, these two meteorites share a few similarities as well. Both are depleted in alkali elements and contain Cr-rich px [1]. In this study, we investigated U-Pb and Al-Mg chronology to determine the timing of the volcanism that formed NWA 11119. In addition, we use nucleosynthetic anomalies in ^{54}Cr to place constraints on its origin and relationship to known parent bodies of other meteorites.

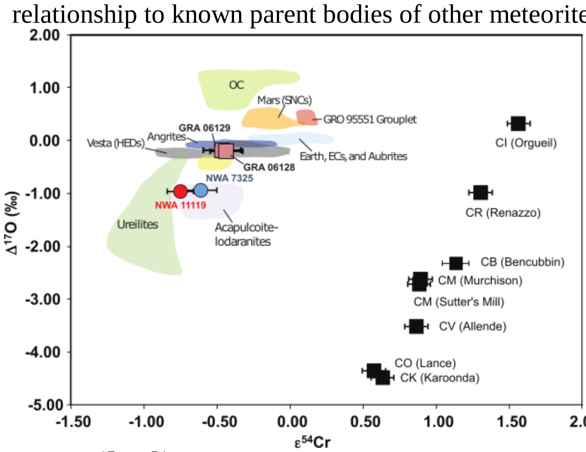

Fig. 1: Δ^{17}O-ε^{54}Cr diagram showing NWA 11119 and NWA 7325 with other meteorite groups. Literature data are from [3-5] and references therein.

Methods: Two px and one plag fraction (9-17 mg) were picked for U-Pb chronology. All fractions were subjected to 0.5 M HNO_3 wash (W1) followed by 6 M HNO_3 wash (W2) and 6 M HCl wash (W3) prior to dissolution in conc. HF+HNO_3 (R). Separation of U and Pb and analytical protocol are similar to [6].

For Al-Mg chronology four fractions were analyzed: px, pure plag, plag mixed with silica, and one whole rock (WR) powder. Each fraction weighs between 4-7 mg. Samples were dissolved in conc. HF+HNO_3, dried down and redissolved in 6 M HCl and dried down prior to dissolution in 1 M HNO_3. At this point a 5% aliquot of the sample was taken for ^{27}Al/^{24}Mg determination. Purification as well as ^{27}Al/^{24}Mg ratio and Mg isotope determination followed the procedures described in [7].

For Cr isotope analyses of material paired with NWA 11119 (provided by A. Irving), we followed a previously established procedure [5, 8].

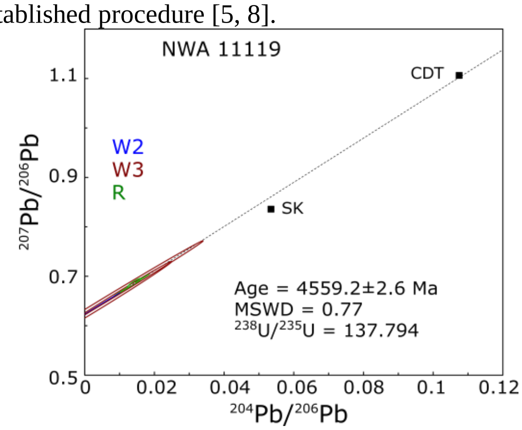

Fig. 2: Pb-Pb isochron for leachates and residues of px and plag of NWA 11119. Only fractions used for the regression and age calculation are shown. SK: Modern terrestrial Pb [9]; CDT: primordial Pb [10].

Results: The ε^{54}Cr isotopic composition determined for NWA 11119 is -0.75±0.09, which is within error to that measured for NWA 7325 [5] (Fig. 1).

Similar to NWA 7325, NWA 11119 has a very low U concentration (2.4-4 ppb). The measured blank-corrected ^{206}Pb/^{204}Pb ratios range between 25 and 300 with the highest ratio measured for one of the W2s. The ^{206}Pb/^{204}Pb ratios for the residues range from 60-95. All samples with a ^{206}Pb/^{204}Pb ratio above 50 fall on a regression line in a ^{204}Pb/^{206}Pb - ^{207}Pb/^{206}Pb diagram and define a date of 4559.4±2.6 Ma, assuming ^{238}U/^{235}U of 137.794 [11] (Fig. 2). Direct measurement of the ^{238}U/^{235}U ratio is not feasible, given the low U concentration of the sample.

The ^{27}Al/^{24}Mg ratios range between 0.08 and 50 and the measured δ^{26}Mg* between 0.02 and 0.58 ‰ (Fig. 3). The ^{26}Al/^{27}Al at the time of last isotopic closure determined from the ^{26}Al-^{26}Mg isochron is $(1.61\pm 0.07)\times10^{-6}$ (MSWD=1.3) with a corresponding initial δ^{26}Mg* of 0.017±0.004‰. Anchoring to an ^{26}Al/^{27}Al ratio of 3.93×10^{-7} for the angrite D’Orbigny and the corresponding U-corrected Pb-Pb age [12-16] results in an date of

4564.77±0.37 Ma. This is in good agreement with a previous report for this meteorite [17]. Relative to the canonical $^{26}Al/^{27}Al$ [18], NWA 11119 formed 3.54±0.05 Ma post CAIs. Its absolute age is 4563.78±0.42 Ma relative the Pb-Pb age of [19]. The discrepancy between the two timescale is a known problem and remain to be resolved in cosmochemistry community.

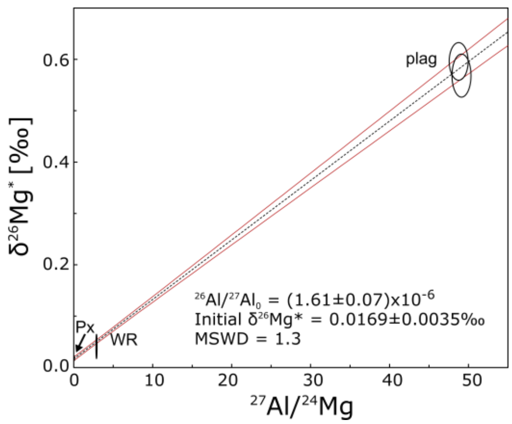

Fig. 3: Al-Mg systematics of NWA 11119.

Discussion: The two known "andesitic" meteorites (NWA 11119 and GRA 06128/9) do not share the same parent body, based on their $\Delta^{17}O$-$\varepsilon^{54}Cr$ composition (Fig. 1) [1, 2, 4] and different alkali elements abundance [1]. A similarly old age has been reported for a few other differentiated meteorites (e.g. Brachina, Asuka 881394), suggesting that volcanism was commonplace in the early Solar System. However, these meteorites are the result of different magmatic processes. Brachina (4564.8±0.5 Ma) is very olivine rich (~80%) and is thought the be the residue from low amounts of partial melting [20-22]. Asuka 881394 (4564.95±0.53 Ma) is a coarse grained anomalous eucrite [23, 24].

For NWA 11119, the U-Pb and Al-Mg dates are discrepant, with the Al-Mg date recording an earlier event. The dates are different outside of uncertainty by 5.0±2.6 Myr. Both dates utilized the same mineral phases (px and plag) from the same fragment of the meteorite, thus minimizing any systematic sampling bias. However, the Al-Mg age is likely controlled by plag, whereas Pb-Pb age depends on px. Closure temperatures of Pb in px and Mg in plagioclase will need to be compared closely [25, 26]. Another possibility for the discrepancy is the assumption of the average Solar System $^{238}U/^{235}U$ ratio for the Pb-Pb age calculations. However, it is unlikely that the age difference for the Al-Mg and U-Pb systems is a result of this assumption. The $^{238}U/^{235}U$ ratio would have to be ~3‰ higher, which is outside the typically observed variations. The major difficulty with U-Pb chronology of this meteorite is the low U concentration and the unradiogenic Pb composition. The resulting larger uncertainties make it difficult to ascertain if all terrestrial Pb was effectively removed. However, the resulting regression line does extend to primordial Pb (Fig. 2). We take this as an indication that terrestrial Pb was effectively removed and the Pb-Pb date is robust.

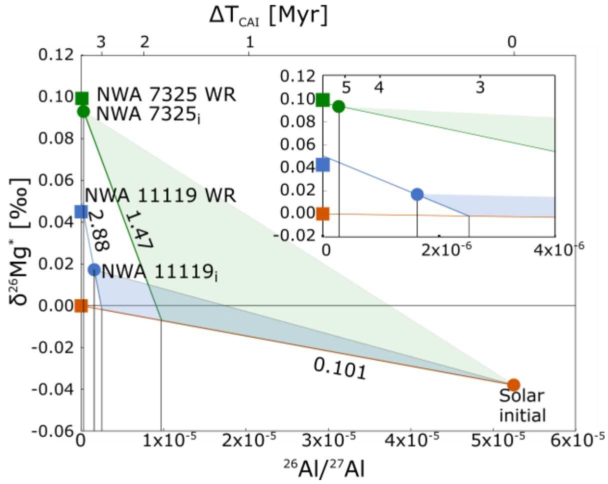

Fig. 4: Mg isotope evolution diagram from solar initial [18] for NWA 11119 (this work) and NWA 7325 [27]. Shaded regions show permissible pathways of precursor reservoir evolution (blue for NWA 11119, green for NWA 7325).

NWA 11119 is 1.68±0.45 Myr older than NWA 7325 based on their Al-Mg ages. Both show elevated initial $\delta^{26}Mg^*$, with NWA 7325 much higher than NWA 11119 (0.093‰ compared to 0.017‰). Based on the initial $\delta^{26}Mg^*$ of NWA 7325, its parental magma source reservoir differentiated no later than 1.72 Myr after the formation of CAIs [27]. Similarly, NWA 11119's parental source reservoir fractionated from the solar reservoir 3.08 Myr at the latest after CAI formation (Fig. 4).

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