Pb-ISOTOPIC AND INITIAL Sr AGES OF THE ACHONDRITE NWA 4587. Y. Amelin[1], E. Rydeblad[1,2], P. Koefoed[1,3], E. Krestianinov[1], M. H. Huyskens[4], and Q.-Z. Yin[4]. [1]Research School of Earth Sciences, The Australian National University, Canberra ACT 2601, Australia (yuri.amelin@anu.edu.au), [2]Dept. of Earth Science and Engineering, Imperial College London, UK, [3]Dept. of Earth and Planetary Sciences, Washington University in St. Louis, USA, [4]Dept. of Earth and Planetary Sciences, University of California-Davis, CA 95616, USA.

Introduction: Modern petrologic and isotopic (O, Cr, Ti, Mo etc.) studies suggest that the known population of achondrites represents at least 35 asteroids [1], each having potentially different history of accretion and melting. A majority of achondrites are isotopically similar to non-carbonaceous chondrites, the Earth and Mars, but there is a growing number of achondrites that have isotopic similarity to carbonaceous chondrites [2, 3]. Knowing the time of accretion and magmatism of achondrites that were derived from various parent bodies with different isotopic affinities allows us to compare the evolution of different domains in the solar protoplanetary disk.

Here we report Pb-isotopic, $^{238}U/^{235}U$, and Sr-isotopic data for Northwest Africa (NWA) 4587, an achondrite with "carbonaceous chondrite" isotopic affinity that is paired with NWA 011 and NWA 2976. Pb-isotopic age for NWA 2976 was previously reported [4], but there is a disagreement outside analytical uncertainty between two determinations of $^{238}U/^{235}U$ ratio [4, 5]. To the best of our knowledge, Rb-Sr systematics of these meteorites have not been reported.

Materials and Methods: NWA 4587 is a basaltic achondrite that is mainly made of pyroxene and plagioclase and minor silica and oxides [6]. Seven pyroxene fractions of various quality (from best clear inclusion-free grains to bulk pyroxene fractions) were picked for U-Pb and Rb-Sr analyses at the ANU, and processed in two batches. In the batch A126, four fractions were leached in 0.5M HNO_3 with ultrasonication (W1), hot 7M HNO_3 (W2), and hot 6M HCl (W3). Residues of the two largest fractions were split it halves (A126 11a-R, 11b-R, 12a-R, 12b-R), thereby increasing the total number of residue analyses to nine. Leaching protocol for the second batch (A144) was similar, but the leachate W2 and W3 were combined as W2. No HF leaching has been used in this study.

Procedures for U-Pb, Rb-Sr and $^{238}U/^{235}U$ analyses follow those described in [7]. Rb/Sr ratios and Sr isotopic compositions were measured in residue and first wash fractions after separation of Pb and U. A whole rock fraction was analysed in three repeat sessions for $^{238}U/^{235}U$ at UC Davis.

Results: Three U isotope analyses yielded consistent results with the weighted average $^{238}U/^{235}U$= 137.784±0.010. This value is consistent with $^{238}U/^{235}U$ of 137.787±0.011 measured in NWA 2976 by Connelly et al. [5], but is higher than 37.751±0.018 reported by Bouvier et al. [4]. The $^{238}U/^{235}U$= 137.784±0.010 is used in all Pb-isotopic age calculations below.

All Pb-isotopic analyses are plotted in the isochron diagram in Fig. 1.

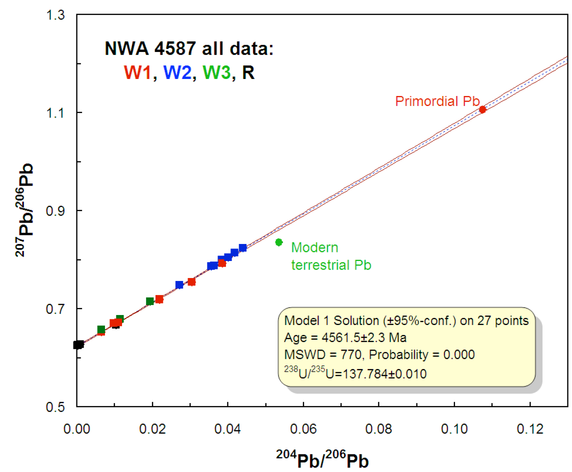

Fig.1. Pb-isotopic data for all leaching steps and residues of seven pyroxene fractions of NWA 4587.

The regression through all data passes through the point of primordial Pb, suggesting low level of contamination with terrestrial Pb. First washes are generally more radiogenic than the second washes, probably because of dissolution of small crystals of U-bearing apatite or merrillite. All residue analyses except one contain very radiogenic Pb with $^{206}Pb/^{204}Pb$>1000.

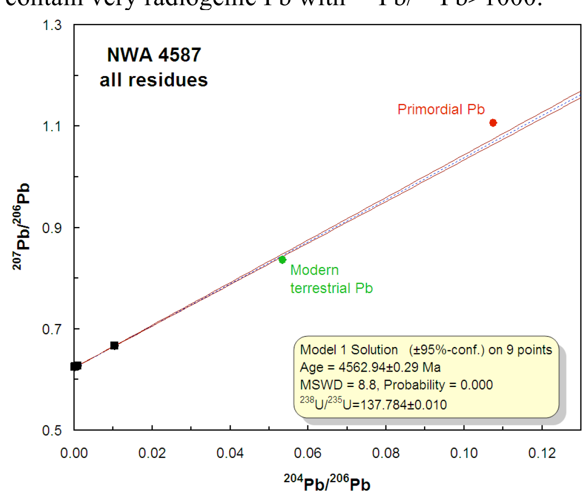

Fig. 2. Pb-isotopic data for all residues.

Regression of all residue analyses produces an isochron that yields a precise date, but passes through the point of modern terrestrial Pb. The slope of this isochron is strongly controlled by a single point with relatively non-radiogenic Pb (A126 32R , $^{206}Pb/^{204}Pb$= 96), which we interpret as containing some Pb introduced by weathering, or possibly a fragment of desert quartz, which are absent in other fractions. The date yielded by this isochron is thus unreliable.

Regression of the data for radiogenic residue analyses alone, and the exclusion of one point that plots below the main array (A126 32R, the point with low $^{206}Pb/^{204}Pb$), yields the age of 4562.5± 1.4 Ma, MSWD = 2.8. This age has little dependence on the composition of residual non-radiogenic Pb, but is relatively imprecise because of small spread of the isochron. In order to improve precision without compromising accuracy, we combined the residue data with data points of third washes, which are expected to contain the same residual non-radiogenic Pb as the residues, but smaller quantity of U and radiogenic Pb, thereby increasing the spread of $^{204}Pb/^{206}Pb$ ratios (Fig.3). The isochron passes, within uncertainty, through the point of primordial Pb.

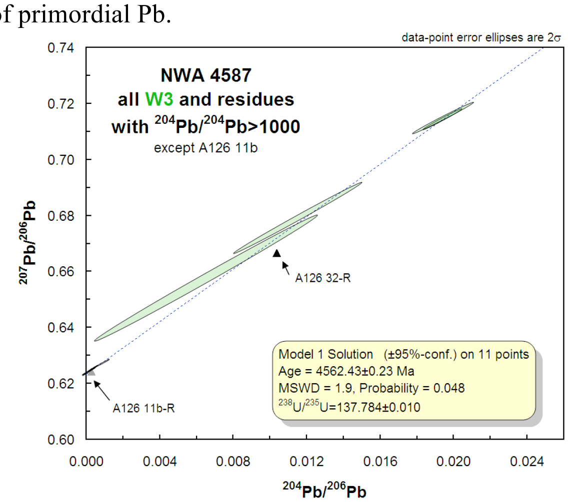

Fig. 3. Pb-isotopic data for residues and third leachates combined. Points A126 11b-R and A126-32R are excluded from regression.

Rb-Sr data for residues and first leachates (Fig. 4) indicate substantial addition of terrestrial Sr that is most abundant in the first leachates, while we have no evidence for (or against) addition of Rb. The residues plot on a scattered array that yields an age broadly consistent with the age of the meteorite, and yields the initial $^{87}Sr/^{86}Sr$=0.699032±0.000047 (MSWD=16). The excess scatting of the residue array is probably caused by the presence of residual terrestrial Sr with high $^{87}Sr/^{86}Sr$. If this interpretation is correct, then the residue analyses with the lowest initial $^{87}Sr/^{86}Sr$ give the best estimate of the initial $^{87}Sr/^{86}Sr$ of the meteorite.

Four residue analyses yielded consistent initial $^{87}Sr/^{86}Sr$ with the weighted average of 0.6990252± 0.0000075 (Fig. 5).

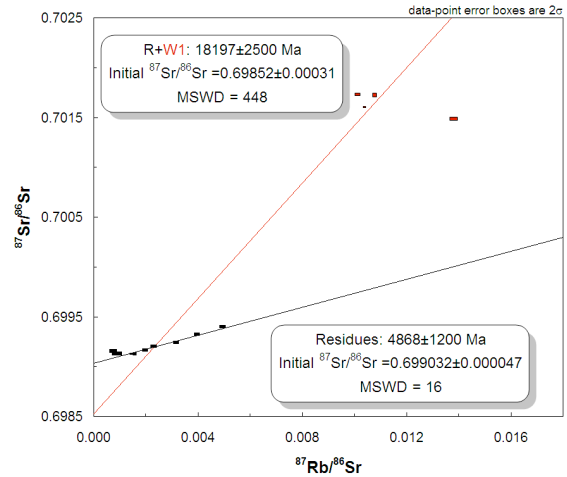

Fig. 4. Rb-Sr data for residues and first leachates.

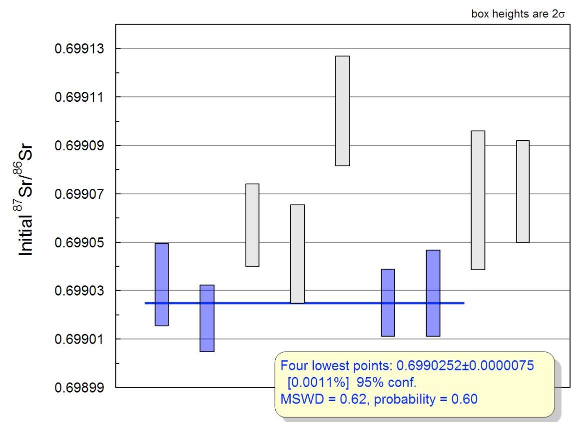

Fig. 5. Initial $^{87}Sr/^{86}Sr$ for the pyroxene residues.

Discussion: The Pb-isotopic age of NWA 4587 is 4562.43± 0.23 Ma. Its age is consistent with the age of NWA 2976 of 4562.89±0.59 Ma reported in [4], but becomes marginally younger if the age of NWA 2976 is recalculated with newly measured $^{238}U/^{235}U$. This age is discussed in the context of achondrite chronology in the companion presentation [3].

The timing of accretion of 3.7±0.7 Ma after CAI formation, or 4563.6±0.7 Ma, is estimated from the difference in initial $^{87}Sr/^{86}Sr$ between NWA 4587 and CAIs [8]. This age is also consistent with the Mn-Cr and Al-Mg ages of NWA 4587, and other ages summarized for the paired rock NWA 2976 and 011 in [3].

References: [1] Greenwood R.C. et al. (2017) *Chemie der Erde* 77, 1-43. [2] Sanborn M.E. and Yin Q.-Z., *LPS L* (this meeting). [3] Huyskens M.H. et al., *LPS L* (this meeting). [4] Bouvier A. et al. (2011) *GCA*, 75, 5310-5323. [5] Connelly J. N. et al. (2012) *Science* 338, 651-655. [6] Connolly Jr. H. C. et al. (2007) *MAPS* 42, 1647-1694. [7] Amelin Y. et al. (2019) *GCA*, 245, 628-642. [8] Hans U. et al. (2013) EPSL 374, 204–214.