LEAD-LEAD ISOTOPE SYSTEMATICS AND TERRESTRIAL AND EJECTION AGES OF EARLY AMAZONIAN DEPLETED SHERGOTTITE NORTHWEST AFRICA 7635. R. Andreasen[1], M. Righter[1], T. J. Lapen[1], A. J. Irving[2], K. Nishiizumi[3], A. J. T. Jull[4], and M. Caffee[5]. [1]Department of Earth and Atmospheric Sciences, University of Houston, 312 Science & Research Building 1, Houston TX 77204 (randreas@central.uh.edu) [2]Department of Earth and Space Sciences, University of Washington, Seattle WA. [3]Space Sciences Laboratory, University of California, Berkeley, Berkeley CA. [4]Department of Geosciences, University of Arizona, Tucson, AZ. [5]Department of Physics, Purdue University, West Lafayette IN.

Introduction: Northwest Africa 7635 is the most evolved depleted shergottite discovered to date. It is unique among shergottites in (a) its mineralogy with the presence of maskelynite phenocrysts and apparent absence of phosphate minerals [1] (b) its ~2.3 Ga age which is about four times older than any of the other depleted shergottites [2] and (c) its source Sm-Nd and Lu-Hf compositions, which are the most depleted yet identified for shergottites [2]. The extremely depleted source composition and young terrestrial age (see below) of NWA 7635 make it a well-suited sample for investigating the Pb-Pb isotope systematics of the depleted shergottite source, given the inferred very low time-integrated U concentration.

Methods: Cosmogenic radionuclide concentrations were measured by accelerator mass spectrometry at Purdue University (^{10}Be and ^{26}Al, $t_{1/2}$ 1.36 Myr and 0.705 Myr, respectively) and at the University of Arizona (^{14}C, $t_{1/2}$ 5,730 yr). The concentrations were ^{10}Be 9.7±0.1 dpm/kg, ^{26}Al 70±5 dpm/kg, and ^{14}C 46±1 dpm/kg. The terrestrial age is calculated to be 2.8±1.3 kyr and the space exposure age is 1.0±0.1 Myr, based on the chemical composition of the measured subsample (2.28 % Mg, 5.49 % Al, 6.06 % Ca, 3100 ppm Mn, and 16.4 % Fe) and model production rates.

For Pb isotopes a 94 mg split of whole rock powder (B) from an interior 1.1 g piece crushed by hand with agate mortar and pestle was dissolved by sequential dissolution, first by ultrasonification three times in 0.5 M HNO_3 for 10 minutes (L1), followed by leaches with room temperature leach 1 M HCl (L2), warm 6 M HCl (L3), room temperature 6 M HCl – 0.2 M HF (L4), warm 6 M HCl – 2 M HF (L5), and a final step of 7 M HNO3 – 14 M HF (R). Splits of 84 mg and 92 mg, respectively, of the more magnetic (M1) and less magnetic (M2) 200-325 mesh size fractions from a ~1 gram interior piece crushed with alumina mortar and pestle for mineral separation were dissolved in similar fashion, except that the second leaching step was omitted, and the smaller sample was completely digested at the second to last step. Lead was isolated through a two-step anion exchange column chemistry and analyzed for lead isotopic composition by MC-ICP-MS with thallium added for instrumental mass bias correction [3] on the University of Houston Nu Instruments Plasma II. Based on ion beam intensities of the 6 bulk rock powder fractions, the calculated Pb concentration of NWA 7635 is ~1.1 ppm, similar to that measured in [1]. For NWA 7635 ~40-60% of Pb is released during the first leaching step suggesting some but fairly limited Pb contamination. Apart from the 1 M HCl leach of the bulk rock powder all the remaining fractions contain 7-30% of the sample Pb (5-30 ng) allowing for precise determination of their Pb isotopic composition. Procedural Pb blanks are around 40 pg, resulting in blank corrections of 0.1-0.8%. NIST Pb standards 981 and 982 were measured interspersed with samples to monitor instrument accuracy and stability.

Results: The Pb isotopic compositions of all fractions of NWA 7635 are unradiogenic with ^{206}Pb/^{204}Pb and ^{207}Pb/^{204}Pb values ranging from 10.52-10.77 and 11.26-11.40, respectively, for the strong HF containing leaches, and up to 11.5 & 12.0 and 11.9 & 12.1, respectively for the first leaches of mineral grains and rock powder. ^{207}Pb/^{206}Pb ratios rare 1.06-1.07 for the strong leaches and as low as 1.01 for the early leaches. A regression on all datapoints gives a scatterchron with an age of 4441±16 Ma (MSWD=292). Separate regressions on the weak and strong leaches instead give much better constrained subparallel trends (Fig. 1) with apparent ages of 4414±11 Ma (MSWD = 51) for the weak acid leaches, and 4390±16 Ma (MSWD = 1.5) for the strong leaches. The μ-value (^{238}U/^{204}Pb) of NWA 7635 is low but not well constrained at this point given the low U concentration; it is likely ~1±1.

Discussion: The very tight correlation in ^{207}Pb/^{204}Pb and ^{206}Pb/^{204}Pb seen for the strong leaches of NWA 7635 may represent a mixing line between undradiogenic Pb indigenous to NWA 7635 and a Martian or terrestrial contaminant, or it could represent an isochron dating the formation of the mantle source of the depleted shergottites, or perhaps dating the time of crystallization of NWA 7635, if the Sm-Nd age represent later disturbance. If age significance is attributed to the 4390 ± 16 Ma Pb-Pb age it is clear that NWA 7635 must come from a mantle source with a much higher μ-value than other depleted shergottites. Relative to other depleted shergottites such as DaG476 [4], NWA 1995 [5], and QUE 94201 [6], NWA 7635 has a higher $^{207}Pb/^{206}Pb$ ratio and much less radiogenic $^{204}Pb/^{206}Pb$ ratios. In figure 2 variation in $^{207}Pb/^{206}Pb$ and $^{204}Pb/^{206}Pb$ for NWA 7625 is shown together with best-fit regression lines for depleted shergottites Dag 476, NWA 1195, and QUE 94201 and intermediate/enriched shergottites, nakhlites, and ALH 84001 [4-7]. The regression line for NWA 7635 intersects the growth curve with μ=2 (depleted shergottite source [4]) at ~4.15 Ga, significantly younger than its 4.4 Ga Pb-Pb age. NWA 7635 intersects a growth curve with μ=5 (intermediate & enriched shergottite source [4]), it is however difficult to reconcile such a high μ-value in the source with a very low μ-value in the rock. Alternatively NWA 7635 intersects a growth curve with μ-value 1.1 around 2.5±0.5 Ga, consistent with the Sm-Nd age [2] and easier to reconcile with the low μ-value in the rock. If this is the case, then the Pb-Pb 'age' of NWA 7635 most likely is an artifact of mixing indigenous Pb with younger Pb either from a Martian or terrestrial source (fig. 2) as has been suggested previously [6,7]. The sub-parrallel $^{207}Pb/^{206}Pb$ vs. $^{204}Pb/^{206}Pb$ patterns and similar Pb-Pb ages, but very different inferred μ-values for the depleted shergottites NWA 7635, QUE 94201, NWA 1195, and Dag 476 are consistent with mixing of a depleted shergottite source to variable degrees with younger Martian high $^{206}Pb/^{204}Pb$, low $^{207}Pb/^{206}Pb$ lead. This mixing may to some extent be obscured by additional terrestrial contamination with low $^{204}Pb/^{206}Pb$ and intermediate $^{207}Pb/^{206}Pb$ for depleted shergottites that plot close to the terrestrial Pb field.

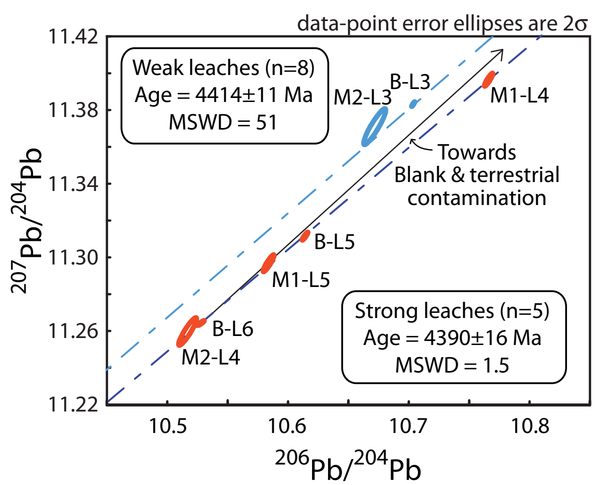

Figure 1: $^{207}Pb/^{204}Pb$ vs. $^{206}Pb/^{204}Pb$ and regressions for refractory strong leaches and labile weak leaches (most points not shown).

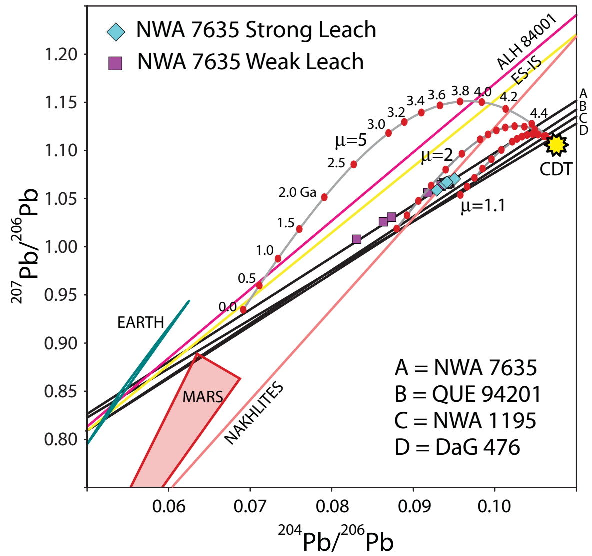

Figure 2: $^{207}Pb/^{206}Pb$ vs. $^{204}Pb/^{206}Pb$ for NWA 7365 and best-fit regression lines for other Martian meteorites [4-7]. Growth curves based on Canyon Diablo Troilite (CDT) [8]. Fields for terrestrial common Pb [9] and young Martian Pb [10] are also shown.

Conclusions: Northwest Africa 7635 has the most unradiogenic Pb measured so far for a depleted shergotitte. Unradiogenic $^{206}Pb/^{204}Pb$ and relatively radiogenic $^{207}Pb/^{204}Pb$ ratios suggest either early formation from a high-μ source or late formation from a low-μ source. Given the low μ-value and depleted Sm-Nd and Lu-Hf source compsition of NWA 7635 [2] the latter scenario is preferred. The launch age of 1.0±0.1 Myr which is similar to those for 10 other depleted shergottites [11,12] suggests that NWA 7635 may have been launched in the same event as many of the other much younger depleted shergottite specimens, implying prolonged magmatic activity from the depleted shergottite mantle source over a relatively restricted area.

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