AGE AND PETROGENESIS OF PICRITIC SHERGOTTITE NWA 1068: Sm-Nd AND Rb-Sr ISOTOPIC STUDIES. C.-Y. Shih[1], L. E. Nyquist[2], H. Wiesmann[1], and J. A. Barrat[3], [1]Mail Code C23, Lockheed-Martin Space Operations, 2400 NASA Road 1, P.O. Box 58561, Houston, TX 77258-8561, chi-yu.shih1@jsc.nasa.gov, [2]Mail Code SR, NASA Johnson Space Center, Houston, TX 77058, l.nyquist@jsc.nasa.gov, [3]Université d'Angers, 2 bd Lavoisier, 49045 Angers Cedex, France.

Introduction: NWA 1068 is a 577g picritic shergottite found in the Moroccan Sahara in 2001[1]. The meteorite resembles several other picritic shergottites, e.g. EETA79001B, DaG476, SaU005 and Dho019, in major-element chemistry and mineralogy, but it differs significantly from these meteorites in REE distribution pattern. It has a slightly LREE-depleted pattern commonly shared by some olivine-free basaltic shergottites, e.g. Shergotty, Zagami and Los Angeles, but not QUE94201. Detailed geochemical and mineral-petrological studies were given in [1]. We performed Rb-Sr and Sm-Nd isotopic analyses on this rock to determine its crystallization age and to study the petrogenetic relationship between this meteorite and other basaltic and pricritic shergottites.

Samples: An aliquant sample of 1.62 g was allocated for isotopic studies at JSC. For this study, we processed 1.0 g of the interior of the meteorite. The whole rock samples were taken after the sample was coarsely crushed to <149μm. Then the sample was further crushed and sieved into finer 74-149μm and <74μm splits. The mineral separates - pyroxene, olivine and plagioclase - were obtained from these finer size fractions by magnetic and heavy-liquid density separations. So far, we have not obtained enough pure plagioclase for Sm-Nd analyses. Since the meteorite has been exposed to the severe desert environment, acid-washing was used to get rid of terrestrial alteration products for all the samples analysed. For cleaning whole rock and olivine samples, we used 2N HCl with sonication. For pyroxene samples, an additional step of 3N HF etching was used. Both acid-residue (r) and acid-leachate (l) were analyzed. The whole rock isotopic results were presented earlier [2].

Sm-Nd results: Sm-Nd isotopic results for bulk rock and pyroxene samples are shown in Fig. 1. The acid-washed olivine sample had too little Nd for good isotopic measurements. The unwashed whole rock and four acid-leachates of whole rock and mineral samples are clustered together. These five samples and three HF-washed pyroxenes form a linear array corresponding to an age of 185±11 Ma using the Williamson fit program [3]. The errors were ±14 Ma and ±16 Ma for the York [4] and Isoplot [5] programs, respectively. The datum for the gently HCl-washed WR(r) sample plots significantly above the isochron and may still contain some alteration products because it lies on a probable terrestrial alteration line (broken line) defined by the acid-washed samples, the desert caliche from Los Angeles shergottite [6] (square) and river aeolian particulates [7,8] (diamonds). If the isochron defined by leachates and pyroxenes represents the age of the meteorite, it certainly is consistent with the ages reported for several other shergottites [9] that have not been exposed to severe terrestrial weathering, e.g. Shergotty, Zagami, EETA79001A&B, ALHA 77005, LEW 88516. The corresponding initial ε_{Nd} value for this meteorite is –7.0±0.2, also in good agreement with values for some of these less altered shergottites.

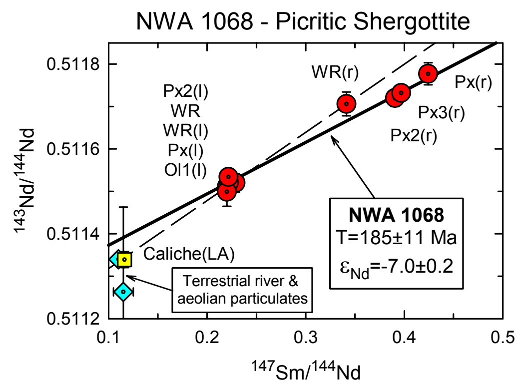

Figure 1. Sm-Nd isochron for NWA 1068.

Rb-Sr results: Rb-Sr results for whole rock and mineral separate samples are shown in Fig. 2. The Rb-Sr isotopic system for this meteorite is highly disturbed. A reference isochron for the Sm-Nd age of 185 Ma through the acid-washed plagioclase, Plag(r), gives a good estimate of the initial $^{87}Sr/^{86}Sr$ (~0.72230), since the plagioclase has the largest Sr budget of the rock, making isotopic alteration less noticeable. All four acid-washed samples plot close to this reference isochron. However, the acid leachates and unwashed bulk rock samples lie considerably lower than the isochron and trend towards the present seawater value of $^{87}Sr/^{86}Sr$~0.7090, strongly suggesting that the hot-desert environment had a severe effect on the Rb-Sr system of the meteorite. This alteration effect has been commonly observed in a number of Martian and lunar meteorites found in hot-deserts e.g. DaG 476, Dho019, Los Angeles and Dho287A [6,10-12]. Complete elimination of the terrestrial alteration products from minerals of hot desert meteorites remains a serious challenge for geochronologists.

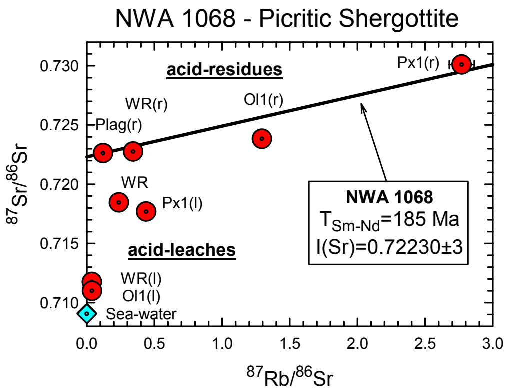

Figure 2. Rb-Sr isochron for NWA 1068.

Initial ε_{Nd} and mg-values of shergottites: Fig. 3 summarizes the mg-values and the initial ε_{Nd} values for basaltic (circles) and picritic (squares) shergottites. Shergottites may have come from three distinct mantle reservoirs. QUE94201, Dho019, DaG476 and SaU005, were derived from a highly depleted mantle source(s). NWA 1068, along with Shergotty, Zagami and Los Angeles, could have come from an enriched mantle reservoir with distinct negative initial ε_{Nd} values. EETA79001A & B could have come from a moderately depleted mantle. The large variations of mg-value found within each shergottite group are probably due to either crystal fractionation or pyroxene- and olivine-accumulation during the crystallization of their respective parental magmas near the Martian surface. Our isotopic data are consistent with the formation of NWA 1068 by olivine accumulation [1], however, the olivine probably did not come from peridotitic shergottites like ALHA77005 and LEW88516.

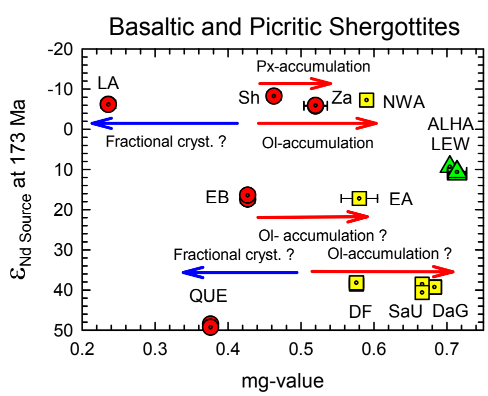

Figure 3. mg-values for Martian meteorites.

Sr and Nd isotopic constraints on shergottite sources: Fig. 4 summarizes the initial $^{87}Sr/^{86}Sr$ ratios and their corresponding initial ε_{Nd} values for basaltic (circles) and picritic (squares) shergottites. Nyquist et al. [2,6] showed that shergottites from the enriched source (e.g. Shergotty-type) and moderately depleted source (EETA) may have assimilated small amounts (~20% and ~7%, respectively) of Martian crustal components during ascent of a QUE-type parent magma. Alternatively, all shergottite parent magmas originated from distinct mantle sources. Shergotty-type and EETA-type sources can be produced from a highly depleted DaG-type source by including small amounts (<10%) of trapped KREEPy liquid during early Martian magma ocean differentiation [13]. An alternative mantle metasomatism calculation using a non-KREEPy liquid component seems to give a better fit for the Sr and Nd isotopic signatures of shergottite sources. In this case, we assumed that the highly depleted cumulate source for the DaG-type shergottite has 0.5xCI of Sr and 0.1xCI of Nd and the trapped liquids have 20xCI of Sr with $^{87}Sr/^{86}Sr$=0.73 and 7-33xCI of Nd with ε_{Nd}=-20. The results (curves in Fig. 4) show that the EETA and Shergotty-type sources can be produced from the DaG-type source by adding ~1% and 6-8%, respectively, of a metasomatic fluid, perhaps came from a fertile mantle reservoir, with evolved Sr and Nd isotopic compositions but a modest Nd abundance. Shergottite parent magmas could be 5-10% partial melts of their respective sources.

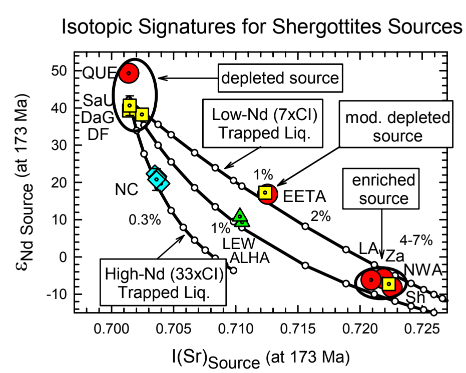

Figure 4. ε_{Nd} vs. I(Sr) for Martian meteorites.

References: [1] Barrat J.A. *et al.* (2002) *GCA* **66**, 3505-3518. [2] Nyquist L.E. *et al.* (2002) *Unmixing the SNCs*, LPI Cont. 1134, 43-44. [3] Williamson J.H..(1968) *Can. J. Phys.* **46**, 1845-1847. [4] York D. (1966) *Can. J. Phys.* **44**, 1079-1086. [5] Isoplot by K. Ludwig using York D.(1969). [6] Nyquist L.E. *et al.* (2001) *LPS XXXII*, abs. #1407. [7] Goldstein S.L. *et al.* (1984) *E&PSL*, 70, 221-236. [8] Albarede F. & Brouxel M (1987) *E&PSL*, **82**, 25-35. [9] Nyquist L.E. *et al.* (2001) *Chronology and Evolution of Mars*, **96**, 105-164. [10] Borg L. *et al* (2000) *LPS-XXXI*, CD-ROM #1036. [11] Borg L. *et al* (2001) *LPS-XXXII*, CD-ROM #1144. [12] Shih C.-Y. *et al.* (2002) *LPS-XXXIII*, CD-ROM #1344. [13] Borg L. (2002) *Unmixing the SNCs*, LPI Cont. 1134, 9-10.