GEOCHRONOLOGY OF NWA 1195 BASED ON Rb-Sr AND Sm-Nd ISOTOPIC SYSTEMATICS. S. J. Symes[1], L. E. Borg[2], C. K. Shearer[2], Y. Asmerom[3], and A. J. Irving[4], [1]Department of Chemistry, University of Tennessee-Chattanooga, Chattanooga, TN, 37403, Steven-Symes@utc.edu, [2]Institute of Meteoritics and [3]Department of Earth and Planetary Sciences, University of New Mexico, Albuquerque, New Mexico 87131, [4]Earth & Space Sciences, University of Washington, Seattle, WA 98195.

Introduction: The shergottite meteorites comprise a diverse array of igneous samples from Mars. They are classified into three groups including basalts, lherzolites, and olivine-bearing porphyritic (olivine-phyric) rocks. All have roughly basaltic compositions, yet the trace-element and isotopic compositions cover an enormous range [1]. Many of the shergottites share a common crystallization age of ~175 Ma, while others have ages between ~330 – 575 Ma.

Northwest Africa 1195 (NWA) is a recently identified shergottite that was found in the Safsaf region of eastern Morocco [2]. It petrographically resembles other olivine-phyric shergottites such as DaG 476, SaU 005, Dhofar 019, and NWA 1068. In order to determine its relationship to other shergottites and to better understand the composition of shergottite source regions, we have determined its Rb-Sr and Sm-Nd isotopic compositions.

Northwest Africa 1195: NWA is a coarse-grained olivine-phyric shegottite containing large olivine phenocrysts (up to ~2mm) in a coarse-grained matrix of pyroxene and maskelynite. The pyroxenes are light brown and relatively fresh, whereas the olivines are dark brown and stained, and often contain calcite as a result of terrestrial alteration. Olivines are euhedral and zoned from Fo_{81} cores to Fo_{60} rims indicating the parent magma was relatively mafic; Mg# = 59 [3].

An 845 mg split of NWA was crushed in a mortar and pestle. Prior to sieving, a whole-rock fraction (Wr-1) was set aside. Then large olivines were hand-picked. The remainder was sieved at 74-150 μm, and 44-74 μm, and <44 μm. A second "whole-rock" fraction (Wr-2) was obtained from the <44 μm fines. Minerals were hand-picked from the two largest sieve fractions after passing through a Frantz isodynamic separator. All fractions except Wr-1 and Olivine were leached in warm acetic acid and 1 N HCl prior to digestion. Element separations utilized HCl and methyllactic acids and cation specific resins. All samples were analyzed statically using a multi-collector Micromass Sector 54 thermal ionization mass spectrometer with Nd and Sm run as oxides.

Sm-Nd systematics: The $^{147}Sm/^{144}Nd$ and $^{143}Nd/^{144}Nd$ isotopic data are presented in Fig. 1. Five mineral separates (two pyroxene, two whole-rock, and an olivine fraction) define a crystallization age of 348±19 Ma for $\lambda(^{147}Sm)=0.00654$ Ga^{-1} and yield an initial ε_{Nd}^{143} value of +40.1±0.3. Acid-washed residues from two maskelynite fractions lie significantly below the isochron. This could be related to laboratory blank considerations or due to analytical uncertainties resulting from very low abundances of Nd in these fractions. The Mask 1 (R) fraction contained 400 pg Nd and Mask 2 (R) contained 740 pg Nd. However, these hypotheses are not supported by low Nd blanks (~7 pg) and the observation that the third pyroxene fraction, Mg-Px 2 (R), is almost within error of the isochron yet contains only 640 pg Nd. Terrestrial weathering is an unlikely explanation for shifting the Mask fractions off the isochron as well since 1) the Sm-Nd isotopic system is resistant to weathering [4], and 2) weathering will be different for QUE 94201 (Antarctica) and NWA (hot desert) yet the maskelynite fractions from both meteorites are shifted the same direction.

Interestingly, the maskelynite fractions from QUE also do not plot on the Sm-Nd isochron [5]. This suggests that the Sm-Nd isotopic systematics of the maskelynite in these samples are disturbed by the shock event(s) that generated them. The maskelynite must

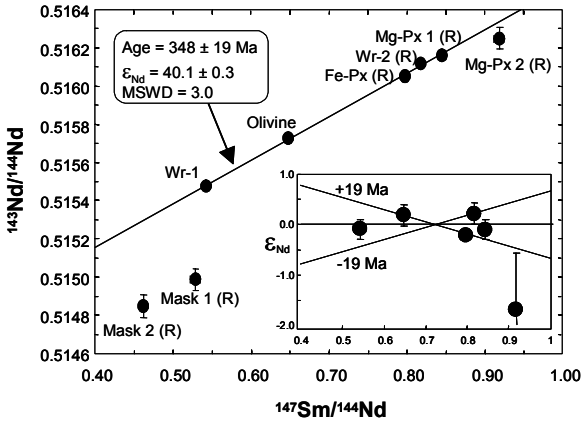

Figure 1. Sm-Nd isochron plot for whole-rock and mineral fractions from NWA 1195. Five mineral separates define an age of 348±19 Ma. R denotes residue left after leaching in acetic/HCl.

contain a component characterized by low $^{147}Sm/^{144}Nd$ and $^{143}Nd/^{144}Nd$ ratios, and is therefore probably derived from a LREE-enriched source that could have been added during the formation of maskelynite as suggested for QUE [5]. Despite aggressive leaching, the contaminant is still present in the analyzed frac-

tions suggesting it is incorporated into the maskelynite as opposed to being adsorbed along grain surfaces.

Rb-Sr systematics: The $^{87}Rb/^{86}Sr$ and $^{87}Sr/^{86}Sr$ isotopic data are presented in Fig. 2, but yield no age information. Regression of the data for five of the mineral separates gives a slope corresponding to an age of 6.0 Ga for $\lambda(^{87}Rb)=0.01402$ Ga^{-1}. This indicates that the Rb-Sr system is disturbed, most likely as a result of terrestrial weathering in the hot desert. A similar disturbance of the Rb-Sr system was found for other hot desert finds such as NWA 856 [6] and DaG 476 [4]. Modern seawater and Libyan desert sandstones have $^{87}Sr/^{86}Sr$ values of ~0.709 and ~0.712, repectively, indicating that terrestrial Sr could shift all of the fractions to higher values. The Mask 2 (R) fraction appears to be the least affected by contamination so an estimate of the initial $^{87}Sr/^{86}Sr$ ratio of 0.701614±16 is obtained for NWA by regressing a 348 Ma reference line through this fraction. This is likely an upper limit as alteration is expected to increase this ratio.

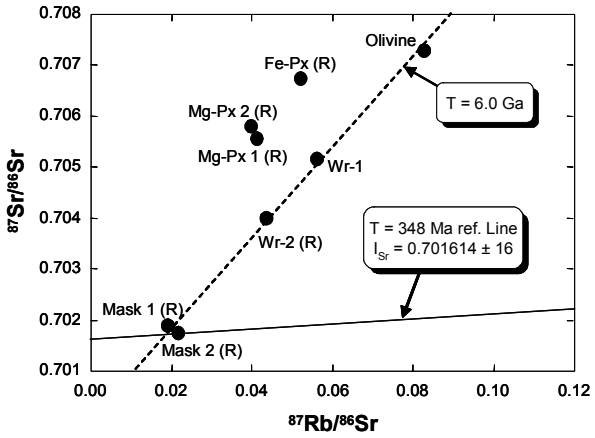

Figure 2. Rb-Sr isochron plot of mineral and whole-rock fractions from NWA 1195. The Rb-Sr system is disturbed. Error bars are smaller than the symbols. R denotes residue left after leaching.

Comparison to QUE 94201: The Sm-Nd age for NWA overlaps with that of basaltic shergottite QUE 94201 [5] suggesting a link between these meteorites. Table 1 compares ages with initial Sr and Nd isotopic compositions for the respective source regions and indicates that these meteorites are not isotopically related, but could represent separate flows produced contemporaneously.

Table 1. Sm-Nd ages and initial isotopic compositions of source regions for NWA 1195 and QUE 94201.

Meteorite	Age (Ma)	I(Sr)	ε_{Nd}^{143}
NWA 1195	348 ± 19	0.701614 ± 16	40.1 ± 0.3
QUE 94201	327 ± 19	0.701298 ± 14	47.6 ± 1.7

Like QUE, the low value of I(Sr) for NWA is consistent with the high initial ε_{Nd}^{143} value and indicates that this meteorite was derived from an incompatible-element-depleted source region. The observation that NWA (Mg# = 59) is compositionally less evolved than QUE (Mg# = 38) and yet isotopically more evolved indicates these samples cannot be related by crustal assimilation processes.

Frequency of magmatic events: The shergottites display a greater range of ε_{Nd}^{143} values than all known terrestrial rocks (Fig. 3). There is a profound difference in initial ε_{Nd}^{143} values between the pre-300 Ma samples and the ~175 Ma samples indicating that the older samples are derived from more LREE-depleted sources. Age and isotopic data from NWA 1195 reinforce this apparent division. Moreover, the source region(s) for the older (>300 Ma) shergottites show comparatively little isotopic diversity, whereas the ~175 Ma rocks span an enormous range in initial Nd isotopic ratios. Thus, the martian meteorites appear to represent numerous contemporaneous, but compositionally distinct, magmatic events.

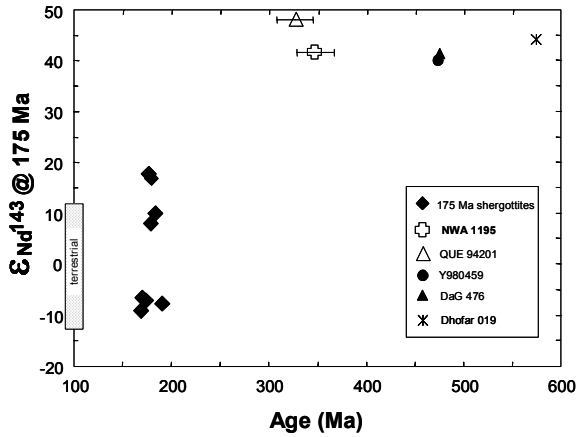

Figure 3. Plot of initial ε_{Nd}^{143} values, recalculated to a common age of 175 Ma, against crystallization age for shergottites. The range of ε_{Nd}^{143} values for shergottites is much greater than the entire range of known terrestrial rocks (stippled region).

Conclusion: NWA 1195 has a crystallization age of 348±19 Ma. It has a lower initial ε_{Nd}^{143} than the only other ~330 Ma shergottite (QUE 94201) and must derive from a less LREE-depleted source. In general, older (>300 Ma) shergottites appear to derive from extremely LREE-depleted source region(s). The abundance of meteorites with contemporaneous ages, but derived from different sources suggests frequent martian magmatism.

References: [1] Borg L. et al. (2002) *GCA*, **66**, 2037-2053 [2] Irving A. et al. (2002) *MAPS*, **37**, A69 [3] Irving A. et al. (2004) *LPS XXXV,* #1444. [4] Borg L. et al. (2003) *GCA,* **67***,* 3519-3536. [5] Borg L. et al. (1997) *GCA,* **61**, 4915-4931. [6] Brandon A. et al. (2004) *LPS XXXV,* #1931.