SM-ND, LU-HF AND U-PB SYSTEMATICS OF NORTHWEST AFRICA 11509 SHERGOTTITE.

M. Righter[1], T. J. Lapen[1], A. J. Irving[2] and B. Hoefnagels, [1]Dept. of Earth & Atmospheric Sciences, University of Houston, TX, USA (mrighter@uh.edu), [2]Dept. of Earth & Space Sciences, Univ. of Washington, Seattle, WA, USA.

Introduction: Northwest Africa (NWA) 11509, a fresh 500 gram stone found in Mali, is a relatively coarse grained olivine gabbroic shergottite containing shock-melted intercumulus zones [1]. It consists of relatively equant grains of clinopyroxene (51 vol.%) and olivine (17 vol.%) with vesicular, plagioclase-rich interstitial regions. NWA 11509 exhibits unique shock features including the complete melting and recrystallization of plagioclase as well as olivine grains that are recrystallized into aggregates of fine-grained polygonal subgrains [1]. Among the 134 unpaired Martian meteorites now recognized, only a few (e.g. NWA 6342 [2]) exhibit such extreme shock features. In addition to these unique shock features, NWA 11509 shows unique isotopic/geochemical characteristics. The rare earth element abundances of NWA 11509 are similar to those for intermediate shergottites. However, the measured bulk Nd and Hf isotopic compositions show that NWA 11509 falls in between the established fields for intermediate and enriched shergottites. Here we present preliminary results of Sm-Nd and Lu-Hf isotopic analyses, plus phosphate U-Pb systematics, and place these new data in the context of existing data for shergottites with the aim of identifying similarities and potential source affinities.

Samples and analytical procedures: Clean, representative dust produced by cutting a sample portion on an IsoMet saw using a Cu alloy plated stainless steel blade was used to conduct whole rock analysis. An intact interior fragment of NWA 11509 (~0.1 g) was also analyzed. A ~2.4 g aliquot of NWA 11509 was crushed in an aluminum oxide mortar and pestle, and pyroxene grains were hand-picked under a microscope. Both "whole rock" fractions and the pyroxene fraction were spiked for Lu-Hf and Sm-Nd analyses. All chemical separation procedures were carried out in clean laboratory facilities at the University of Houston (UH), and Sm, Nd, Lu and Hf isotope analyses were conducted using the Nu Instruments *Nu Plasma II* MC-ICP-MS at UH.

In situ U-Pb isotopic analysis on a polished thick section was carried out with a Photon Machines Excite coupled to a Varian 810 quadrupole ICPMS at UH. Each spot analysis was conducted with 85μm in diameter laser bean at 15 Hz repetition rate, a fluence of 4 J/cm^2, 20s on-peak blank, 30s ablation time. Operating conditions for the samples and standards were exactly matched for each analysis. Yates Mine and Madagascar phosphates were used as the external calibration standards and Bear Lake phosphate as the internal standard.

Results: The Sm-Nd analyses of NWA 11509 whole rock (*dust*) gave a measured $^{147}Sm/^{144}Nd = 0.2651$ and a present-day $\varepsilon^{143}Nd = +6.67$, which plots between the established fields for intermediate and enriched shergottites. The handpicked pyroxene fraction yielded a present-day $\varepsilon^{143}Nd = +6.63$, which is essentially the same as the value for WR-dust. The Lu-Hf analyses of whole rock (*dust)* gave a present-day $\varepsilon^{176}Hf = +3.60$ and a measured $^{176}Lu/^{177}Hf = 0.01742$. The other whole rock (*chunk*) gave a present-day $\varepsilon^{176}Hf = +5.77$ and a measured $^{176}Lu/^{177}Hf = 0.01669$. The whole rock (*dust*) and the pyroxene define a slope corresponding to a Lu-Hf age of 820 ± 84 Ma for $\lambda(^{176}Lu) = 1.865 \times 10^{-11}$ yr^{-1} with an initial $^{176}Hf/^{177}Hf$ value of 0.283542 ± 0.000031 using the Isoplot regression program [3]. The whole rock (*chunk*) and the pyroxene define a slope corresponding to a Lu-Hf age of 518 ± 88 Ma. The modeled source $^{176}Lu/^{177}Hf$ and $^{147}Sm/^{144}Nd$ isotope ratios were calculated using a two-stage model, assuming a differentiation age of 4.513 Ga [4] and the CHUR parameters of [5] for both 820 Ma and 518 Ma. The calculated source $^{176}Lu/^{177}Hf$ and $^{147}Sm/^{144}Nd$ compositions are 0.03797 and 0.1957 for 820 Ma, 0.03727 and 0.2008 for 518 Ma, respectively. These calculated source compositions are in good agreement in spite of the apparent age differences. The source compositions of NWA 11509 suggest that it is derived from Martian mantle mixtures that are somewhat similar to those that produced other known intermediate shergottites, but further extend the observed range in intermediate source compositions for both Lu/Hf and Sm/Nd isotopic systems.

Eight phosphate grains were analyzed for U-Pb systematics by LA-ICP-MS. All results plot on discordia between common Pb compositions and values for very recent materials (within about 12 Ma). These very young U-Pb ages of phosphates, as well as the existence of completely recrystallized plagioclase observed throughout NWA 11509, suggest that this shergottite experienced relatively high levels of shock metamorphism in comparison to other shergottites to recrystallize plagioclase and phosphates after extensive melting, likely caused during the recent (3 Ma ago [1]) energetic ejection of this specimen from Mars.

References: [1] Irving A. J. et al. (2018) *LPS* XLIX, Abstract #2279. [2] Kizovski T. V. et. al. (2019) *Meteoritics & Planetary Science* 54, 768-784. [3] Ludwig K. R. (2003) *Berkeley Geochronology Center Spec. Pub.* 1a, 59. [4] Borg L. E. et al. (2003) *GCA* 67, 3519−3536. [5] Bouvier A. et al. (2008) *Earth Planet. Sci. Lett.* 280, 285−295.