PETROLOGIC AND ISOTOPIC CHARACTERIZATION OF OLIVINE-PHYRIC DEPLETED SHERGOTITTE NORTHWEST AFRICA 6162. S. E. Suarez[1], M. Righter[1], A. Udry[2], T. J. Lapen[1], A. J. Irving[3], [1]Department of Earth and Atmospheric Sciences, University of Houston, Houston, TX (sesuare2@uh.edu) [2]Department of Geoscience, University of Nevada at Las Vegas, Las Vegas, NV, [3]Department of Earth and Space Sciences, University of Washington, Seattle WA.

Introduction: Shergottites, the most abundant class of martian meteorites, are mafic to ultramafic igneous rocks that have a wide range of crystallization ages that span over 2 billion years [1]. Their mineralogy, textures, trace element and radiogenic isotope compositions can provide information about early planetary differentiation, evolution of mantle reservoirs, and magmatic processes that occur in the curst and upper mantle.

Shergottites are classified petrographically by their textures and geochemically by rare earth element and radiogenic isotopic compositions. Igneous textural types are distinguished as basaltic, olivine-phyric, gabbroic, and poikilitic while geochemical groups are distinguished as enriched, intermediate, or depleted with respect to incompatible to compatible trace element ratios. Olivine-phyric shergottites are characterized by olivine phenocrysts set in a finer-grained groundmass composed of pyroxene, maskelynite, olivine, and minor phases including chromite, ulvöspinel, and ilmenite [2]. Based on the texture and trace element abundances, Northwest Africa (NWA) 6162 is characterized as an olivine-phyric depleted shergottite [3] that was found in 2010 near Lbirat, Morocco. NWA 6162 is the focus of this study because the specimen experienced little terrestrial alteration [3] and is launch-paired with other depleted shergottites [1].

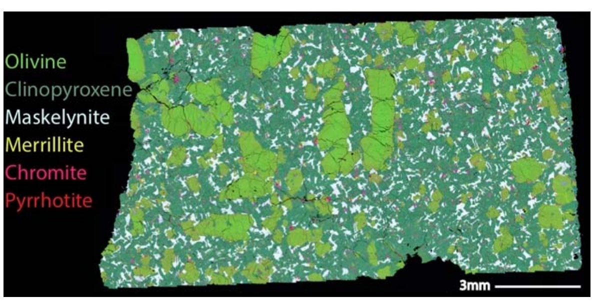

Figure 1. Composite X-ray elemental map (Al = white, Ca = yellow, Fe = red, K = cyan, Mg = green, Si = blue, Ti = pink)

NWA 6162, along with at least 20 other depleted olivine-phyric shergottites, share an ejection age of 1.1 Ma and exhibit a range of crystallization ages from 347 Ma to 2403 Ma [1]. Studying these specimens gives a rare opportunity to understand a volcanic succession that is inaccessible to current instrumentation on Mars.

In this study we report element compositions of phases including pyroxene, olivine, and chromite and oxygen fugacity (fO_2) of phenocryst and groundmass assemblages to further clarify the petrologic history of this sample and for potential comparisons with other olivine-phyric shergottites with and without shared ejection ages.

Methods: A polished thin section of NWA 6162 was prepared for this study. A JEOL 7600F analytical field-emission SEM (FE-SEM) was used to obtain elemental mapping for initial characterization, followed by quantitative spot analyses using a JEOL 8530F field emission EPMA at NASA Johnson Space Center. Microprobe conditions were 15 kv, 30 nA. To calculate oxygen fugacity, methods from [4] were used. A bulk rock powder of NWA 6162 was analyzed for Lu-Hf and Sm-Nd isotopes by a NuPlasma II multiple-collector inductively-coupled plasma mass spectrometer at the University of Houston.

Results: The Hf and Nd isotope composition of whole rock indicate that the specimen is derived from incompatible element depleted mantle sources (Fig. 2). Mineral compositions measured are shown in Figure 3.

Pyroxene:	$\mathbf{En_{61.7-71.2}\ Wo_{5.9-11.7}}$
Olivine in groundmass:	$\mathbf{Fo_{64.6-65.4}}$
Olivine phenocryst:	**Core to Rim** $\mathbf{Fo_{71.4-67.7}}$
Chromite:	$\mathbf{Chr_{39-77}Ulv_{2-50}Sp_{12-41}}$

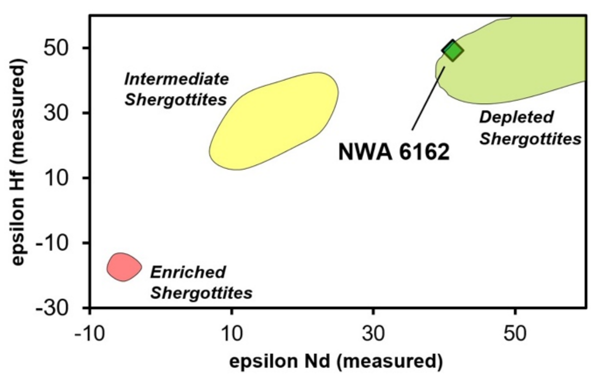

Figure 2. Nd and Hf data for whole rock of NWA 6162 compared to literature compilations [1].

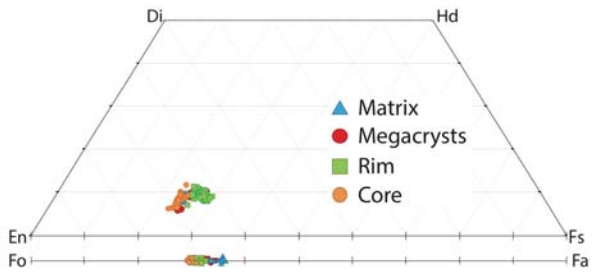

Figure 3: Pyroxene quadrilateral and olivine major element compositions for NWA 6162. Compositions overlay with other olivine-phyric shergottites.

Olivine-pyroxene-spinel oxybarometry was applied to early and late stage assemblages to calculate oxygen fugacity (fO_2) and crystallization temperatures. Phenocryst and finer-grained groundmass areas were selected for appropriate mineral assemblages with the analyzed phases in close proximity. Minerals analyzed for the calculations are pyroxene, olivine, and chromite. The fO_2 calculations were performed on all combinations of the analyzed data from each associated mineral assemblage. Criteria for early and late stage assemblages were defined by [5]. Early stage assemblages were comprised of chromites with a high Cr#, olivine with a high Mg# and clinopyroxenes with low Wo while late stage assemblages had high Ulv#, low Mg# and high Wo. In one assemblage, compositional and image data from a chromite grain showed exsolution; the compositions of this composite grain were mathematically reintegrated prior to fO_2 calculation.

Three phenocrysts have a range of oxygen fugacity relative to FMQ of -3.91 to -4.17, averaging at -4.05 with a standard deviation of 0.4. Calculated temperatures range from 949 to 1054°C. Four matrix areas have a range of oxygen fugacity relative to FMQ of -2.63 to -4.18 and an average of -3.44 with a standard deviation of 0.6 (Fig. 4). Calculated temperatures for this assemblage range from 843 to 1067°C.

Discussion: The isotopic compositions, trace element abundance ratios, and calculated fO_2 are all consistent with parental melt for NWA 6162 derived from mantle sources that are depleted in incompatible elements and relatively reduced. The fO_2 determined for the phenocryst assemblages are -4.0 relative to FMQ while the groundmass assemblage yielded a more oxidized composition (-3.4 relative to FMQ). This difference is attributed to late stage oxidation of the magma [e.g. 4,6]. The relatively low calculated fO_2 for this specimen is lower than most other

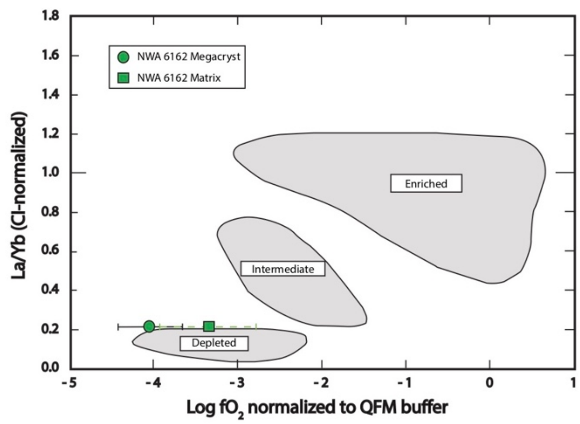

Figure 4. Oxygen fugacity of phenocryst (megacryst) and matrix in NWA 6162 relative to QFM buffer versus REE enrichment. Modified after [4].

depleted shergottites [e.g. 6], but most overlap within uncertainty.

Since this sample is likely derived from a pile of stacked igneous rocks from a single meteorite ejection site, this specimen is important for building a picture of the lithologic and mantle source variations recorded from a single location on Mars. If significant mantle source variations are recognized from the volcanic center(s) that produced the stacked igneous rocks from ~300 to 2400 Ma, then constraints on the heterogeneity of mantle in a melting plume head can be assessed.

Future Work: Future work will include Lu-Hf, Rb-Sr, and Sm-Nd analyses to decipher precise source compositions and igneous crystallization age. Other paired olivine-phryic shergottites will also undergo petrologic and isotopic analyses for comparison. These age data will further assess timing and duration of volcanism and magmatism at this volcanic center.

References:
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