PETROGENESIS OF NORTHWEST AFRICA (NWA) 8686, A NEW OLIVINE-PHYRIC SHERGOTTITE.

R. W. Nicklas[1], J. M. D. Day[1], A. Udry[2] and Z. Vaci[3] [1]Scripps Institution of Oceanography, University of California, San Diego, La Jolla, CA 92093, USA. Email: rwnicklas@ucsd.edu, [2]Department of Geoscience, University of Nevada, Las Vegas, Las Vegas, NV 89154, USA [3]University of New Mexico, Albuquerque, NM 87131, USA

Introduction: Shergottites are a class of martian meteorites that are basaltic to picritic in bulk composition and make up the vast majority of meteorites from Mars. Olivine-phyric shergottites are a subclass of the shergottites characterized by large macrocrysts of olivine set in a finer grained groundmass of pyroxene and shocked plagioclase [1]. As they are generally thought to be among the most primitive melt-like of martian meteorites, olivine-phyric shergottites are valuable for constraining the major element systematics and temperatures of partial melts, and offer important chemical and thermal constraints on the evolution of the martian mantle. In recent years, the increasing availability of meteorites from the African Sahara has greatly increased the number of identified martian samples, offering insight into the diversity of magmatic processes on Mars [2]. NWA 8686 was found in the Sahara in 2014 and identified as an olivine-phyric shergottite with a $\Delta^{17}O$ value of 0.228, but little mineral and no bulk rock data have been reported on this sample, and no constraints are available on its parental melt composition.

Methods: A small chip of NWA 8686, along with ~0.5 g of whole-rock powder was obtained from the Institute of Meteoritics, University of New Mexico. The chip was mounted in epoxy and polished for *in situ* analysis. Back-scatter electron (BSE) images, element maps and quantitative analyses of all phases were performed using the *JEOL* JXA-8900 at the University of Nevada, Las Vegas. *In situ* trace element analyses were performed at the *Scripps Isotope Geochemistry Laboratory* (*SIGL*) by LA-ICP-MS. Bulk rock major and trace element data were performed on the bulk rock powder using an iCAPq quadrapole ICP-MS at the *SIGL*. Osmium isotopic and highly siderophile element (HSE) systematics of NWA 8686 were determined on the remaining powder by digestion with isotopic spikes in sealed Carius tubes at the *SIGL*. Os was separated by extraction and micro-distillation and analyzed by TIMS and the remaining HSE were separated by ion-exchange chromatography and analyzed by ICP-MS.

Results: Bulk rock major and trace element abundance data are listed in **Table 1**, and average olivine, maskelynite, augite and pigeonite compositional data are listed in **Table 2**. The mount shows ~25% olivine, ~40% pyroxene and 35% maskelynite with accessory phosphates, oxides and sulfides. Bulk rock rare earth element (REE) pattern shows a strong depletion in both LREE and HREE relative to MREE (**Figure 2**). The bulk rock HSE abundances are relatively high at 13.9 ppb total, reflecting its high MgO and olivine content. The sample has a relatively unradiogenic measured $^{187}Os/^{188}Os$ ratio at 0.1260 and a flat chondrite-normalized HSE pattern, with a small enrichment in Re that may be the result of terrestrial hot desert alteration.

Table 1: *Bulk rock abundances of selected major and trace element abundance in NWA 8686; oxides are in wt. %, trace elements are in ppm.*

SiO_2	44.15	**La**	1.39
CaO	6.57	**Ce**	3.88
Al_2O_3	5.14	**Pr**	0.48
FeO	22.85	**Nd**	2.96
MgO	18.20	**Sm**	1.81
TiO_2	0.71	**Eu**	0.72
MnO	0.52	**Gd**	2.91
K_2O	0.02	**Tb**	0.56
Na_2O	0.67	**Dy**	3.86
P_2O_5	1.18	**Ho**	0.79
V	97.2	**Er**	2.14
Cr	3116	**Tm**	0.29
Co	61.8	**Yb**	1.82
Ni	127.1	**Lu**	0.25

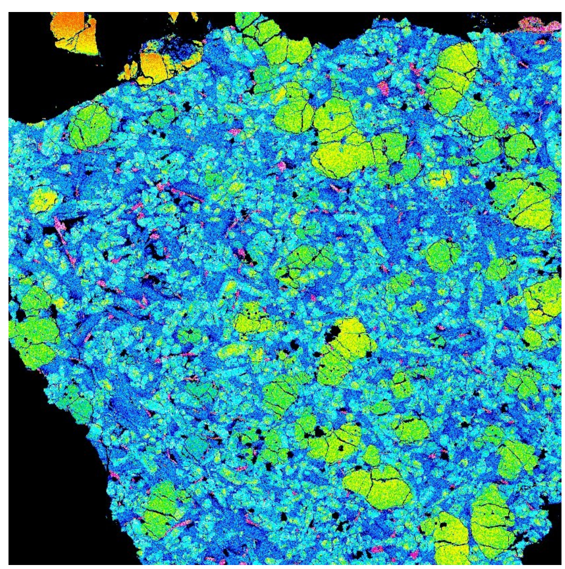

Figure 1: *Semi-quantitative Ca-Mg x-ray map of the NWA 8686 mount. Mount is ~0.5 cm in diameter.*

Large green-yellow phases are the olivine macrocrysts. Dark blue is maskelynite pyroxene, light blue-green groundmass is pyroxenes. Pink is merrillite, black spots are spinels and other oxides. Top right hand corner linear pink feature on the edge of mount is a calcite crust, likely terrestrial. High-Mg orange phase in the top left is a Mg rich olivine that is also likely terrestrial contamination.

Table 2*: Average electron microprobe data for Olivine, feldspar, augite and pigeonite. All oxide concentrations are in wt. %.*

Phase	Olivine	Feldspar	Augite	Pigeonite
SiO_2	34.60	54.99	51.74	52.14
TiO_2	0.03	0.06	0.31	0.20
CaO	0.18	10.08	12.95	5.24
Al_2O_3	0.04	27.32	1.46	1.10
FeO	40.72	0.83	15.41	19.69
MgO	24.42	0.10	17.12	20.77
MnO	0.77	0.02	0.59	0.68
Na_2O		5.30	0.19	0.11
K_2O		0.46	0.01	0.03
P_2O_5	0.07	27.32		1.10
Cr_2O_3	0.16		0.49	0.34
NiO	0.05	0.10	0.03	0.03
CoO	0.08			

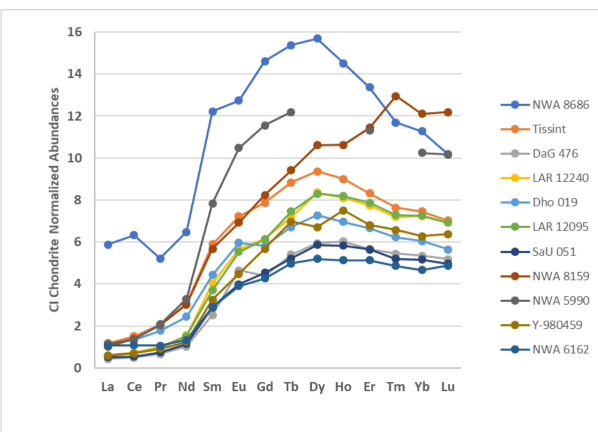

Figure 2*: Bulk rock REE normalized to CI chondrites in NWA 8686 and other depleted Shergottites from [3]*

Discussion: The texture of NWA 8686 greatly resembles other olivine-phyric shergottites, with large olivine macrocrysts set in a groundmass of pyroxene and feldspar. Feldspar is calcic (An_{67}) and pyroxene shows a bimodal distribution with both pigeonite and augite present. With the exception of a calcite rind in the upper right corner of **Figure 1**, no secondary alteration phases are evident in the mount. Sulfide is exclusively pyrrhotite, consistent with low levels alteration. Phosphates were found to be mostly merrillite, with only one apatite identified, indicating a relatively dry parental magma.

Olivine phyric shergottites rarely represent crystallized melt, but have accumulated olivines. Given the $K_D^{Fe\text{-}Mg}$ for martian lavas of 0.35 [4], the olivine in NWA 8686 is not in equilibrium with the bulk composition, with a $K_D^{Fe\text{-}Mg}$ of 1.33. Indeed, the macrocrysts are in equilibrium with a evolved melt (MgO ~4.8 wt. %, FeO 23 wt. %). No other olivine-phyric shergottites show such low MgO olivine, the closest being Dho 019, making NWA 8686 somewhat unique [4]. Given this observation, the olivines are therefore probably xenocrysts from a more evolved magma. It is this not possible to use them to constrain the parental magma composition of NWA 8686. NWA 8686 is probably the result of an evolved, basaltic shergottite-like melt acquiring ~20-25% xenocrystic olivine and is thus far removed chemically from its mantle source region.

With regard to trace elements, the bulk rock compositions is broadly similar to other depleted shergottites (**Figure 2**) with a chondrite normalized $(La/Yb)_N$ of 0.52. Contrary to other depleted shergottites [3], NWA 8686 is depleted in HREE relative to MREE with the pattern peaking at Dy and a $(Gd/Yb)_N$ of 1.39. It also has a lower $(Al_2O_3)/TiO_2$ ratio than other depleted shergottites [3]. These features could be the result of retention of garnet in the parental magmas source region, although the small size of Mars makes this signature rare in Martian samples.

The HSE abundances of NWA 8686 are similar to other high Mg shergottites [5]. Its unradiogenic Os isotopic signature, with a present day γ^{187}Os value of -2.8 is also within the range of other shergottites [5]. As there are no age data for NWA 8686 available, the initial Os isotopic composition is unknown. The unradiogenic Os isotopic signature may be derived from preferential assimilation of olivine, which is a very low Re/Os phase and will host unradiogenic Os signatures if the assimilated olivine is sufficiently old.

Our current model for the genesis of NWA 8686 suggests that it is the result of a deep melt that left garnet in its residue and then fractionated until it was basaltic in composition. It then assimilated fayalitic olivine and erupted at the surface where it cooled quickly. Given the unusual geochemical signatures of NWA 8686 future data to both date and constrain the origin of both its olivines and groundmass are forthcoming.

Funding: Support comes from the NASA Emerging Worlds program (JMDD).

References: [1] Goodrich C. A. (2002) *MAPS*, *37,* B31-B34. [2] Lapen T. J. (2019) *50th LPSC #2132.* [3] Udry A. et al. (2020) *JGR : Planets* 4] Filiberto J. and Dasgupta R. (2011) *EPSL, 304,* 527–537. [5] Tait K. T. and Day J. M. D. (2018) *EPSL, 494*, 99-108.