Supporting Information for *Geochemistry and petrography of martian meteorite Northwest Africa 11115: A rare earth element-enriched olivine-phyric shergottite closely linked to Northwest Africa 1068*

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1 Comparison between previously reported bulk chemistry data and superseding new analyses

A chip of NWA 11115 (*Sample-FMNH*) was homogenized by using an agate mortar and pestle, yielding approximately 31 mg of powder. The powder was fluxed with $LiBO_2$ and fused and quenched into five glass beads. The beads were mounted in an epoxy on one sample holder and polished. NIST Standard Reference Materials (SRM) 610 and 612 were used for measurement calibration. NIST SRM 610 followed by two blanks was used for bracketing unknowns. We carried out a total of 24 repeat analyses of the sample. Data were reduced using the SILLS software (Guillong et al. 2008).

The bulk composition of *Sample FMNH* was analyzed at the Field Museum of Natural History (Chicago) using Laser Ablation Inductively Coupled Mass Spectrometry (LA-ICP-MS). The LA-ICP-MS setup at the Field Museum's Elemental Analysis Facility is a ThermoFisher Scientific iCAP Qc Quadrupole ICP-MS Spectrometer coupled to a New Wave UP213 UV laser ablation system. For this study a laser aperture resulting in a 100 µm spot size was used.

The LA-ICP-MS analyses carried out at the FMNH resulted in some anomalous values, some of which (including previously unknown K/Th ratios for the martian meteorites and surface) were reported in Melwani Daswani et al. (2017). Because some dubious element abundances were obtained, we carried out electron probe microanalyses (EPMA) of the glass sample prepared for the FMNH to test its compositional homogeneity and whether the unusual analyses were caused by the instrument. EPMA analyses confirmed that the K concentration of the sample was low, but there were significant differences in the concentrations of other elements (Supplementary Table 1).

The EMPA analysis of FMNH-beats were performed using a JEOL 8200 electron microprobe (WDS: 15 kV; 5 nA; beam defocused to 20 µm) interfaced with the Probe for EPMA program from Probe Software, Inc. Standards for these analyses were synthetic fayalite (FeKα), Shankland forsterite (MgKα), synthetic Mn2SiO4 (MnKα), synthetic anorthite (AlKα, SiKα, CaKα), Amelia albite (NaKα), Asbestos microcline (KKα), synthetic TiO2 (TiKα), and synthetic Cr2O3 (CrKα). Quantitative elemental microanalyses were processed with the CITZAF correction procedure (Armstrong 1995). Nominal ~85% percent of $LiBO_2$ is added in Probe Software to correct for matrix effect and achieve near 100% oxide wt% total. The $LiBO_2$ was later excluded for reporting the composition of FMNH-beats (supplementary Table 1).

As a result of the discrepancies between the analytical results of the same sample, and the unusual element mass ratios (especially the low relative potassium: K/Th, K/La), we performed a separate LA-ICP-MS analysis at the University of Bern (*Sample-UniBern*), which is described in the Main Text, and we include the calibration measurements and 27 spot analyses in the Supplementary Spreadsheet File S1. In addition, we back-calculated the bulk rock chemistry from the modal mineralogy, and obtained a composition that was significantly closer to *Sample-UniBern* (calculations shown in Supplementary Spreadsheet File S1, and summarized results shown in Supplementary Table 3). Thus, we consider that the results from *Sample-UniBern* supersede the *Sample-FMNH* analyses.

Supplementary Table 1. Whole rock chemistry of two samples of NWA 1115. Oxides are reported in wt. %, and individual elements in µg/g.

	Sample-FMNH						Sample-UniBern		
	LA-ICP-MS			EPMA Caltech			LA-ICP-MS		
	n	Mean	±2σ	n	Mean	±2σ	n	Mean	±2σ
SiO_2	24	52.56	2.78	8	44.74	1.09	27	47.90	1.09
TiO_2	24	0.96	0.03	8	0.45	0.75	27	0.74	0.28
Al_2O_3	24	8.08	1.00	8	10.16	0.87	27	6.53	0.97
FeO_T	24	16.27	4.25	8	22.32	1.72	27	20.97	1.43
MnO	24	0.50	0.03	8	0.72	0.41	27	0.51	0.03
MgO	23	8.72	1.14	8	11.36	0.84	27	12.27	0.74
CaO	24	10.15	1.39	8	8.66	0.45	27	8.67	0.48
Na_2O	24	0.84	0.13	8	0.66	0.25	27	1.30	0.18
K_2O	24	0.03	0.02	8	0.02	0.05	27	0.18	0.04
P_2O_5	20	0.78	0.02				27	0.73	0.21
Li							27	4.34	0.50
Be	16	0.78	0.39				27	0.37	0.15
B							27	3.66	0.98
Cl	18	415.54	313.22						
Sc	20	52.04	1.22				27	44.69	4.23
V	24	244.17	19.23				27	232.17	41.30
Cr	24	2555.65	200.91	8	2188.82	742.72	27	2348.05	1560.64
Co	24	45.83	4.13				27	47.00	4.04
Ni	24	143.14	30.72				27	138.03	20.90
Cu	20	28.67	31.77				27	15.44	4.62
Zn	20	42.32	8.69				27	91.22	13.44
Ga	20	15.21	1.22				27	14.79	2.52
Ge							27	0.80	0.12
As	24	bdl[a]	nd[b]				27	0.19	0.04
Rb	22	2.35	7.26				27	6.86	2.91
Sr	24	77.31	6.72				27	56.13	6.77
Y	24	19.04	2.01				27	17.55	5.46
Zr	24	79.15	9.11				27	57.27	22.97
Nb	24	5.29	0.60				27	3.84	1.80
Mo	24	3.28	0.66				27	0.13	0.04
Ag	4	0.26	0.24				27	0.01	0.01
Cd	12	0.36	0.72				26	0.04	0.02
In							27	0.03	0.01
Sn	23	0.71	0.95				27	0.30	0.08
Sb	17	0.72	0.88				21	0.01	0.01
Cs	22	0.28	0.50				27	0.46	0.22
Ba	20	110.09	5.52				27	62.47	7.77
La	20	4.16	0.53				27	2.92	1.00
Ce	23	6.64	1.18				27	6.82	2.45
Pr	24	1.06	0.36				27	0.94	0.35
Nd	24	4.81	0.74				27	4.68	1.70
Sm	24	1.92	0.42				27	1.76	0.63
Eu	23	0.82	0.27				27	0.67	0.20
Gd	24	2.96	0.65				27	2.72	0.97
Tb	23	0.64	0.29				27	0.48	0.15

Dy	23	3.74	0.64	27	3.32	1.04
Ho	24	0.91	0.26	27	0.68	0.21
Er	23	2.29	0.55	27	2.01	0.58
Tm	24	0.40	0.18	27	0.26	0.07
Yb	24	2.00	0.41	27	1.76	0.42
Lu	20	0.41	0.17	27	0.25	0.06
Hf	24	2.49	0.37	27	1.69	0.60
Ta	24	0.39	0.27	27	0.18	0.09
W	24	1.97	0.84	27	0.50	0.15
Re	3	0.05	0.01	0		
Au	24	bdl	nd	0	-	-
Tl				27	0.03	0.01
^{206}Pb	14	1.26	1.42	0		
^{207}Pb	12	1.58	2.85	0		
^{208}Pb	14	0.76	0.74	27	0.70	0.33
Bi	17	0.19	0.33	20	0.004	0.003
Th	24	0.59	0.22	27	0.51	0.14
U	20	0.40	0.51	27	0.13	0.02
Mg#	23	58.24	3.30			

[a]At or below the detection limit. Values represent maximum concentration measured.

Supplementary Table 2. Element ratios used for provenance tests. Martian meteorite average ratios from Taylor (2013).

	FMNH LA-ICP-MS		Caltech EPMA		UniBern LA-ICP-MS		Martian meteorite average	
	Ratio	±2σ	Ratio	±2σ	Ratio	±2σ	Ratio	±2σ
Martian meteorite tests								
Fe/Mn	32.88	10.63	33.14	15.75	41.43	1.71	40.3	2.3
K/Th	464.29	308.80	-	-	2987.43	810.43	5300[a]	220[a]
Cl/Th	694.69	546.21	-	-	-	-	236.29	Nd
P/Yb	1694.51	457.88	-	-	1802.14	211.60	2065.27	Nd
Ga ppm/Al wt.%	3.47	0.28	-	-	4.28	0.62	4.067	Nd
Na/Al	0.15	0.04	0.09	0.04	0.28	0.02	0.247	Nd
MgO wt%/Cu ppm	0.37	0.16	-	-	0.81	0.24	0.611	Nd
Shergottite tests								

Rb/La	0.54	1.70	-	-	2.38	1.05	2.9066	Nd
Rb/K	0.01	0.03	-	-	0.005	0.001	0.0047	Nd
Cs/La	0.07	0.11	-	-	0.16	0.08	0.1805	Nd
Weathering tests								
Th/U	2.05	1.91	-	-	4.09	0.77		
Sr/Nd	16.13	2.34	-	-	12.26	3.53		
Ce/Ce^{*b}	0.78	0.12	-	-	1.01	0.04		
K/La	57.92	25.57	-	-	526.94	154.59		

[a]Global surface average from the Gamma Ray Spectrometer on Mars Odyssey (Taylor et al. 2006).

Supplementary Table 3. Back-calculation of the bulk chemical composition of NWA 11115 from the modal mineralogy, using the mean mineral compositions determined using spot analyses with the BSE SEM (see main text). Densities to derive the mass from the mode were obtained from the Handbook of Mineralogy (Anthony et al.). Since minor sulfide and silica phases were not analyzed, they are assumed to be pyrite and quartz for the purposes of recalculating the bulk composition. Slight discrepancies in the sum totals are due to rounding errors. Detailed calculation is found in the Supplementary Spreadsheet File S1.

	Olivine	Clinopyroxene	Plagioclase	FeCrMnMgAlTi oxides	Sulfides	Phosphates	Silica	Total wt. %
Normalized mode	14.36	50.60	30.62	1.91	0.30	2.11	0.10	100
Normalized mass	16.85	52.86	25.14	2.66	0.46	1.95	0.08	100
SiO_2	5.84	27.27	14.03	0.01	nd	nd	0.08	47.24
TiO_2	nd	0.12	bdl	0.04	nd	nd	nd	0.16
Al_2O_3	nd	0.81	6.81	0.18	nd	<0.01	nd	7.81
Cr_2O_3	nd	0.21	nd	1.43	nd	nd	nd	1.64
FeO_T	6.91	11.07	0.19	0.88	0.14	0.05	nd	19.23
MnO	0.13	0.36	nd	0.02	nd	nd	nd	0.51
MgO	3.83	9.83	0.05	0.08	nd	nd	nd	13.79

CaO	0.04	2.78	2.49	<0.01	nd	1.03	nd	6.35
Na_2O	nd	bdl	1.36	nd	nd	0.03	nd	1.39
K_2O	nd	nd	0.09	nd	nd	nd	nd	0.09
P	0.01	bdl	nd	nd	nd	0.91	nd	0.92
S	0.01	0.03	nd	nd	0.09	<0.01	nd	0.13

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