NORTHWEST AFRICA 10985: A NEW LUNAR GABBRO? J. Chen[1], B. L. Jolliff[2], R. L. Korotev[2], K. Wang[2], A. Wang[2], P. K. Carpenter[2], H. Chen[2] and Z. Ling[1*], [1]Institute of Space Sciences, Shandong University, Weihai, 264209, China (merchenj@mail.sdu.edu.cn, zcling@sdu.edu.cn), [2]Department of Earth & Planetary Sciences and the McDonnell Center for the Space Sciences, Washington University in St. Louis, 1 Brookings Drive, MO 63130, USA.

Introduction: Northwest Africa (NWA) 10985 is a recently discovered lunar meteorite and contains a prominent gabbro lithology within a fragmental breccia [1]. Gabbroic lithologies previously recovered in a group of lunar meteorites are proven petrogenetically related according to bulk and mineral compositions [e.g., 2-3]. These meteorites (i.e., NWA 773 clan) provide a unique opportunity to study both plutonic and volcanic lithologies derived from an assumed lunar crustal magma chamber [4]. In this work, we studied compositional and mineralogical characteristics of NWA 10985, to address whether this new gabbro-rich sample is another member of the NWA 773 clan.

Methods: Pure gabbro subsample of NWA 10985 (~0.719 g) was ground and about 14 mg was weighed for bulk compositional analyses. The major and trace elemental compositions were analyzed using a Thermo Scientific iCAP Q ICP-MS at Washington University in St. Louis (WUSTL) except SiO_2, which was calculated by the difference.

A polished thin section of NWA 10985 was characterized using BSE (backscattered electron) imaging (Figure 1), X-ray compositional mapping, and spot electron probe microanalyses (EPMA) with the JEOL JXA-8200 electron microprobe at WUSTL.

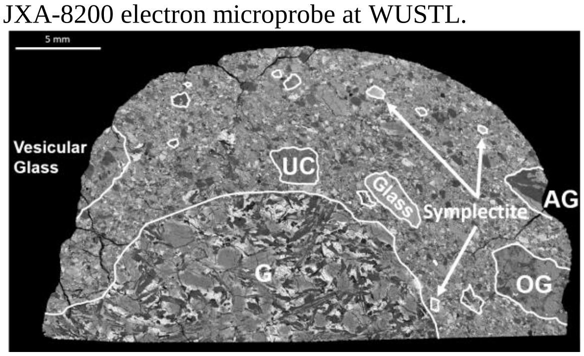

Figure 1. BSE mosaic image of the NWA 10985 thin section showing distribution of prominent lithic clasts.

Results: NWA 10985 samples four intrusive lithologies (ultramafic cumulate (UC), olivine gabbro (OG), anorthositic gabbro (AG), and gabbro (G)).

Bulk composition. The gabbro lithology in NWA 10985 has higher TiO_2, Al_2O_3, Na_2O, and lower FeO, MgO, Mg# than those ferroan gabbro (FG) and olivine phyric basalt (OPB) in NWA 773 clan (Table 1). That indicates an origin from more evolved melt than FG and OPB of NWA 773 clan in terms of major elements (Table 1). However, the incompatible trace elements (ITE) concentrations in NWA 10985 gabbro are lower than those in the FG and OPB of NWA 773 clan (Table 1 and Figure 2).

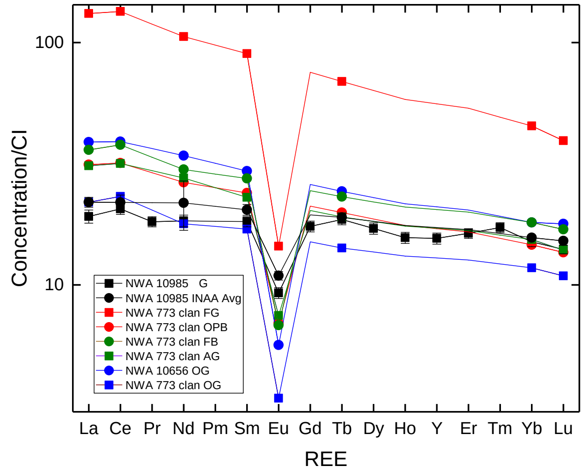

Figure 2. REE patterns of NWA 10985 gabbro, compared with other lithologies of NWA 773 clan.

Mineral composition. Olivine and pyroxene compositions of OG and AG in NWA 10985 fall into the range of OG and AG in NWA 773 clan (Figure 3). UC in NWA 10985 presents more magnesian olivine and pyroxene compositions out of the range of OG corresponding to an earlier crystallization stage. Pyroxene in NWA 10985 gabbro exhibits large-scale core to rim normal magmatic zoning from pigeonite and augite to pyroxferroite composition, covering the whole range from OG to FG in NWA 773 clan.

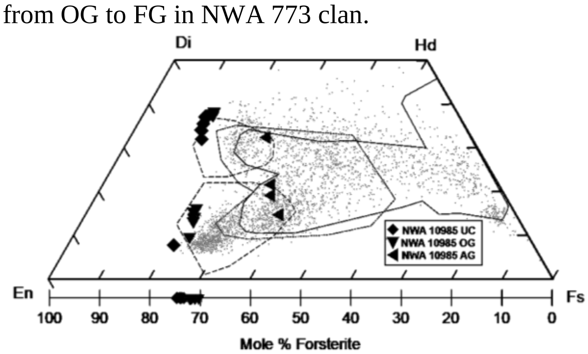

Figure 3. Pyroxene and olivine compositions of NWA 10985 UC, OG, AG, and G (gray) overlain on the compositional field of OG (dashed line), AG (dotted line), and FG (solid line) in NWA 773 clan.

Discussion: The bulk ITE concentrations of NWA 10985 gabbro do not fit into a simple evolution model of NWA 773 clan and require either a more complex crystallization regime or a distinct parental magma, although the mineral compositions of intrusive lithologies in NWA 10985 outline a similar petrologic relationship (UC→OG→AG→FG/gabbro) to NWA 773 clan.

Oscillatory zoning of a few pyroxene grains found in NWA 10985 gabbro (Figure 4) is indicative of more complicated formation of those pyroxene grains, which experienced specific processes in the magma chamber (e.g., convection or replenishment of primitive magma, [5]).

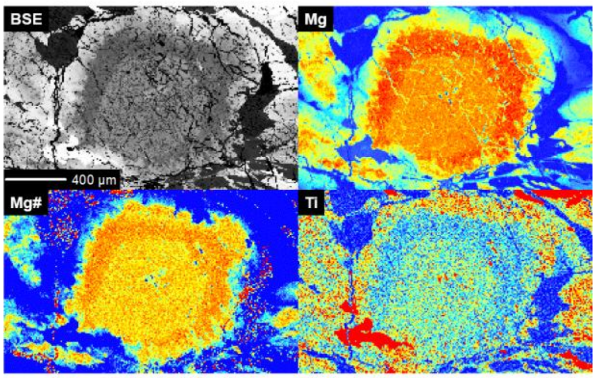

Figure 4. BSE image and X-ray maps of Mg, Mg# (molar Mg/[Mg+Fe]×100), and Ti of a pyroxene phenocryst in NWA 10985 gabbro.

Rb-Sr and Sm-Nd isotope analyses of the gabbro lithology are underway. Sr, Nd isotope data is expected to answer whether the NWA 10985 gabbro is derived from a different mantle reservoir from other gabbroic lithologies in NWA 773 clan.

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References: [1] Bouvier A. et al. (2017) *Meteoritics & Planet. Sci., 52, Nr 11,* 2411. [2] Jolliff B. L. et al. (2007) *LPS XXXVIII*, Abstract #1489. [3] Zeigler R. A. et al. (2007) *LPS XXXVIII*, Abstract #2109. [4] Valencia S. N. et al. (2019) *MAPS*, in review. [5] Elardo S. M. and Shearer C. K. (2014) *American Mineralogist, 99,* 355-368.

Table 1. Bulk compositions (oxides (wt.%) and selected trace elements (ppm)) of gabbro subsamples of NWA 10985, compared with FG and OPB in NWA 773 clan. Reference: (a) This study; (b) Mean concentrations of four subsamples, data from R. L. Korotev; (c) reference [4]. MR: Modal recombination. INAA: Instrumental Neutron Activation Analyses. na: not analyzed.

Sample	**NWA 10985 G**	**NWA 10985 G**	**NWA 10985 G**	**NWA 773 clan-FG**	**NWA 773 clan-OPB**
References	a	a	b	c	c
Method	ICP-MS	MR	INAA	Fused beads	Fused beads
SiO_2	48.3	47.0	na	47.5±0.22	45.4±0.19
TiO_2	2.57±0.09	3.20	na	1.07±0.05	0.85±0.03
Al_2O_3	8.81±0.14	9.85	na	6.91±0.25	8.01±0.16
Cr_2O_3	0.35±0.01	0.51	0.62±0.12	0.44±0.03	0.52±0.02
FeO	19.8±0.20	18.4	18.4±0.41	19.8±0.24	21.7±0.19
MnO	0.28±0.005	0.25	na	0.28±0.02	0.28±0.01
MgO	8.70±0.09	8.55	na	12.9±0.17	12.7±0.42
CaO	10.6±0.14	11.0	9.45±0.38	10.8±0.14	9.59±0.22
Na_2O	0.34±0.003	0.35	0.32±0.02	0.16±0.01	0.16±0.01
K_2O	0.11±0.001	0.10	na	0.15±0.01	0.02±0.003
P_2O_5	0.11±0.002	0.10	na	0.34±0.04	0.09±0.01
Mg#	44.0	45.3	na	53.7	51.0
Sc	37.9±2.0	na	48.7±1.52	42.5±2.1	39.4±1.6
Co	29.5±1.17	na	49.3±4.99	54±4	68±3
Ni	23.8±1.01	na	33.5±28.8	72±16	121±20
Zr	103±6	na	140±19.9	540±440	136±15
Hf	2.58±0.14	na	2.93±0.05	13±9	3.6±0.2
Th	0.85±0.05	na	1.12±0.11	6±4	1.47±0.07
U	0.23±0.02	na	0.32±0.20	1.6±1.2	0.37±0.05
Mass/mg	719	thin section	25–32	62	384