LUNAR METEORITE NORTHEAST AFRICA 003-A: A NEW LUNAR MARE BASALT.

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Introduction: Northeast Africa 003 (NEA 003) is a 124 g lunar meteorite found in November 2000 (6 g stone) and in December 2001 (118 g stone) in northern Libya in wadi Zam Zam area. This rock is a mare basalt and basaltic breccia. The lithology we designate Northeast Africa 003-A (NEA 003-A), which comprises the main portion (~75 vol.%) of the meteorite, is an unbrecciated mare basalt. Adjacent part, Northeast Africa 003-B (NEA 003-B), is basaltic breccia (~25 vol%) consisting of well consolidated glassy impact-melt matrix which contains scattered mineral fragments of chemical composition identical with composition of NEA 003-A and two larger clasts of low-Ti mare basalt lithologies.

Petrography and Mineral Chemistry: NEA 003-A is a coarse-grained low-Ti olivine-rich basalt (Fig. 1). Weathering grade is low, calcite and gypsum veinlets are present.

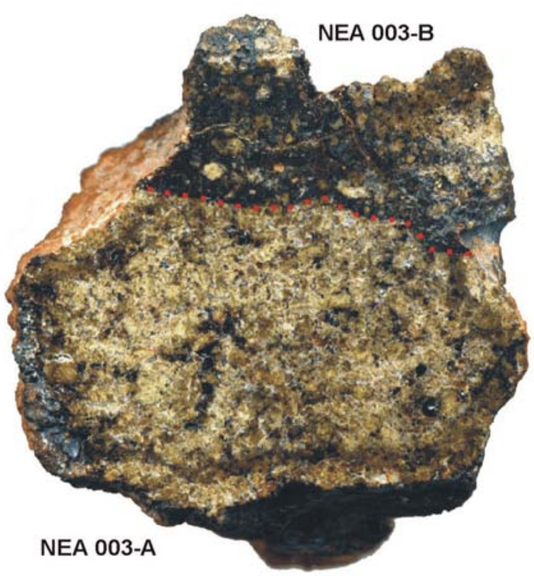

Figure 1. Photograph of 118 g specimen of Northeast Africa 003 lunar meteorite.

The rock is showing porphyritic texture of olivine (Fo_{73-19}), zoned pyroxene ($En_{5-71}Wo_{6-38}$) and plagioclase (An_{84-92}), (Fig. 4.). Majority of olivine crystals show normal symetrical zoning but number of olivine crystals show asymmetrical zoning with gradual iron enrichment. Pyroxene grains are often enclosing inclusions of olivine, chromite and ulvöspinel. Undulatory to mosaic extinction of olivine and pyroxene crystals indicate that these crystals have been deformed and presence of the numerous crack and fractures indicate the intensive shock processes. All plagioclase is totally converted to maskelynite.

The Fe/Mn atomic ratios in pyroxenes (Fe/Mn = 43-89 atom%) and olivines (Fe/Mn = 93-108 atom%) within the sample affirms the lunar origin. The Fe and Mn concentrations and composition of pyroxene and olivine are plotted in Fig. 2, after [1].

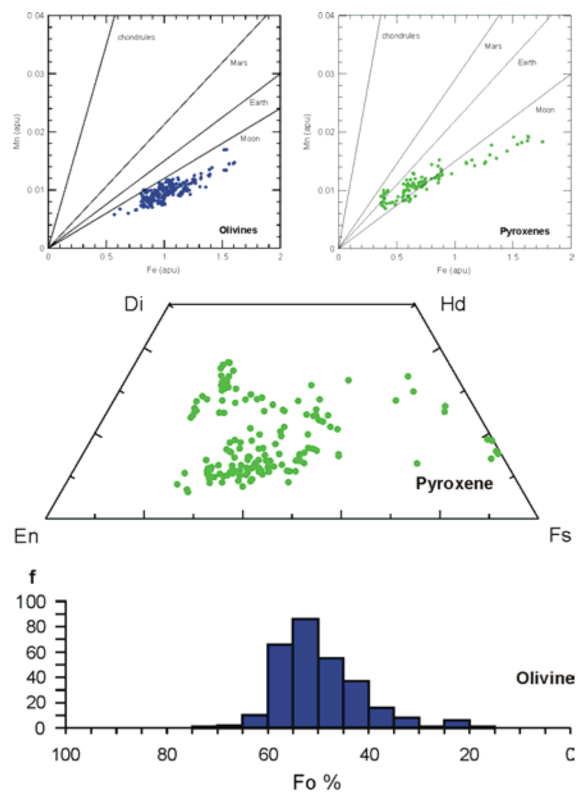

Figure 2. Olivine and pyroxene compositions of Northeast Africa 003-A.

The meteorite contains late-stage mesostasis composed of silica, Fe-rich pyroxene and pyroxferroite, plagioclase, ilmenite, troilite and apatite. Opaque phases include chromite, Ti-rich chromite, ulvöspinel, ilmenite, troilite and trace Fe-Ni metal. Shock veins and impact melt pockets are present throughout the sample. Mineral modes, determined by data processing from X-ray maps and BSE images, are (vol%): olivine = 17.5; pyroxene = 60.6; plagioclase = 18.2; ilmenite = 1.2; spinel = 0.8; mesostasis+impact melt = 1.8.

Chemical Composition

The selected whole-rock major, trace and rare earth elements are presented in Table 1. The concentrations of major elements were obtained using XRF and ICP-MS analyses. Trace elements and REEs were analyzed using INAA. The Fe/Mn ratios: (6 g stone, Fe/Mn= 85, 118 g stone, Fe/Mn=81).

Majors	wt%	Traces+REEs	ppm
SiO2	44.72	Sc	50.8
TiO2	1.34	Co	50.5
Cr2O3	0.52	Ni	84
Al2O3	8.02	Sr	117
FeO	21.83	Ba	252
MnO	0.27	La	3.0
MgO	13.59	Ce	8.5
CaO	9.16	Nd	4.5
Na2O	0.31	Sm	1.69
K2O	0.1	Eu	0.60
Total	**99.86**	Tb	0.46
		Yb	1.94
		Lu	0.28
		Hf	1.1
		Ta	0.15
		Th	0.43
		U	0.29

Table 1. Chemical composition of major and trace elements of Northeast Africa 003-A lunar meteorite.

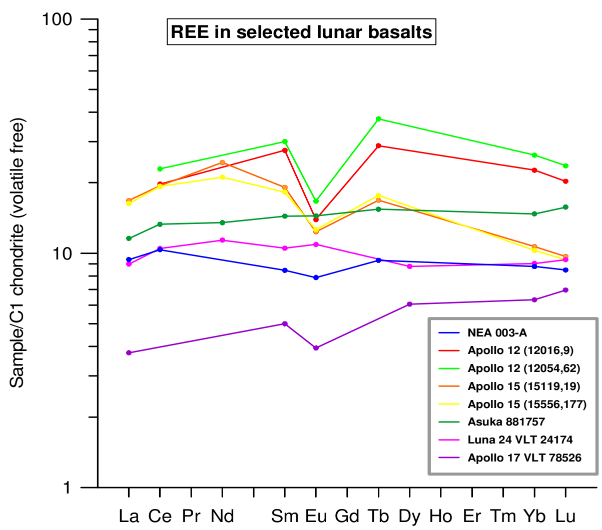

Figure 3. Volatile-free, chondrite-normalized plots of REEs in Northeast Africa 003-A and selected lunar basalts. REE concentrations are normalized to values of [2] multiplied by the factor 1.36. Data source for other selected lunar basalts is [3].

Discussion

When we compare NEA 003-A with other crystalline lunar basaltic meteorites, NEA 003-A is different in terms of texture, high modal abundance of olivine (17.5 vol.%) and mineral chemistry. The only lunar basaltic meteorite that have comparable amount of olivine is Dhofar 287A (20.6 vol%) [4]. Petrographically, NEA 003-A has similarities to Apollo 12 and 15 olivine basalts. Compositionally, however, is NEA 003-A different from the other basaltic lunar meteorites and Apollo and Luna mare basalts. The whole-rock MgO of NEA 003-A is the highest and TiO_2 content is the lowest among lunar unbrecciated basaltic meteorites [5]. In terms of REE contents, NEA 003-A has the lowest and flattest chondrite-normalized REE pattern among all known mare-basalt meteorites. These features suggests that NEA 003-A represents a previously unsampled lithology with no exact match to any so far described lunar basaltic meteorite.

References: [1] Papike J.J. (1998) in Planetary Materials, *Reviews in Mineralogy, 36*, ch. 5, M.S.A.; [2] Anders E. and Grevessen N. (1989) *Geochimica et Cosmochimica Acta* 53:197-214; [3] Fagan T. J. et al. (2002) *Meteoritics & Planetary Science* 37: 371-394; [4] Anand M. et al. (2003) *Meteoritics & Planetary Science* 38: 485-499; [5] Korotev R. L. (2005) *Chemie der Erde* 65: 297-346.

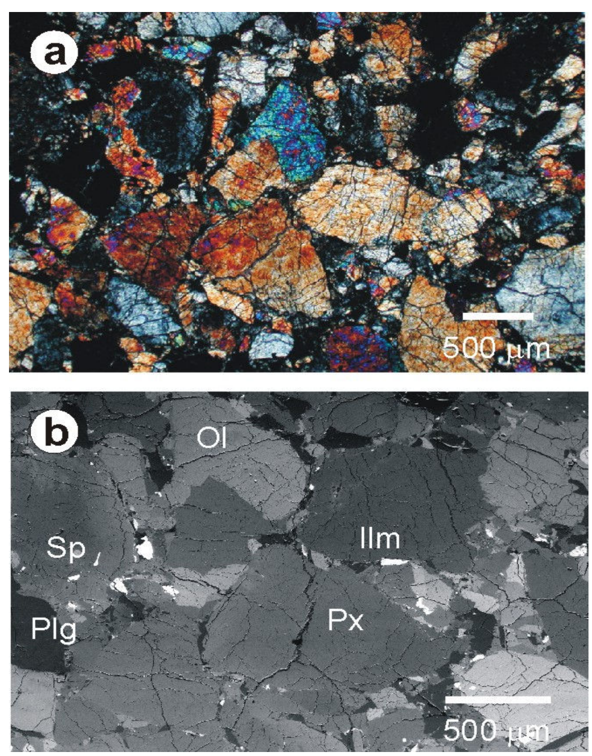

Figure 4. (a) Microscopic image in transmitted light (crossed nicols) showing a typical porphyritic texture of the rock, (b) BSE image of the meteorite`s texture - olivine (Ol), pyroxene (Px), plagioclase (Plg), ilmenite (Ilm) and spinel (Sp).