MINERALOGY AND PETROGRAPHY OF LUNAR FELDSPATHIC BRECCIA NORTHWEST AFRICA 11460. H. J. Cao[1], Z. C. Ling[1*], J. Chen[1] and X. H. Fu[1], [1]Shandong Provincial Key Laboratory of Optical Astronomy and Solar-Terrestrial Environment, Institute of Space Sciences, Shandong University, Weihai, 264209, P. R. China. (zcling@sdu.edu.cn).

Introduction: Lunar meteorites are rocks ejected from random and unknown source regions on the lunar surface [1]. They represent alternative mineralogies and lithologies, contributing to understand and constrain lunar crustal and geological evolution [2,3]. Northwest Africa (NWA) 11460 is a new lunar meteorite found in 2017, classified as feldspathic breccia and contains ~1 cm sized basaltic and gabbroic lithic clasts [4]. Here we present preliminary results on the mineralogy and petrography of NWA 11460, focusing on the shock metamorphism and potential source of individual lithic clasts.

Methods: Raman point-counting measurements were performed on a thin section of NWA 11460 via the state-of-art inVia® Raman system (Renishaw Company) in Shandong University, Weihai. Backscattered electron (BSE) imaging and energy dispersive spectrometer (EDS) compositional mapping (Na, Mg, Al, Si, S, Ca, Ti, Fe) for local areas were performed on a thick section via Zeiss Supra 55 Scanning Electron Microscope (SEM) at the National Astronomical Observatories of the Chinese Academy of Sciences (NAO, CAS) and FEI Nova NanoSEM 450 at Shandong University, Weihai, respectively. Spot electron probe microanalyses (EPMA) was done via JEOL JXA-8230 electron microprobe at NAO, CAS.

Results and Discussion:

Modal mineralogy. Raman point-counting measurements [5] (n=400) were done at ~1000 μm intervals within an area of ~3.2 cm × 1.6 cm. Modal mineralogy of NWA 11460 is shown in Table 1. Plagioclase (about 61.6 vol.%, $An_{71.1\text{-}91.1}$) is the most abundant mineral phase with minor irregular fracture [6]. Olivine ($Fo_{40.3\text{-}90.9}$, based on method of [7]) is the second abundant (about 28.3 vol.%) mineral phase of NWA 11460. Pyroxene (10.1 vol.%, $Fs_{0.4\text{-}44.1}Wo_{2.6\text{-}13.6}En_{35.8\text{-}85.3}$) is less abundant and composed of orthopyroxene (6 vol.%), clinopyroxene (3.8 vol.%), and disordered pyroxene (0.3 vol.%) [8]. Accessory minerals including ilmenite, spinel, troilite, and Fe-Ni metal are also found in this meteorite.

Petrography: Cross polarized light (XPL) and BSE images of the sections of NWA 11460 show that various sized lithic and mineral clasts in fine-grained matrix. Here we studied 14 mineral/lithic clasts and they are subdivided into three main types based on mineral composition and texture (Figure. 1).

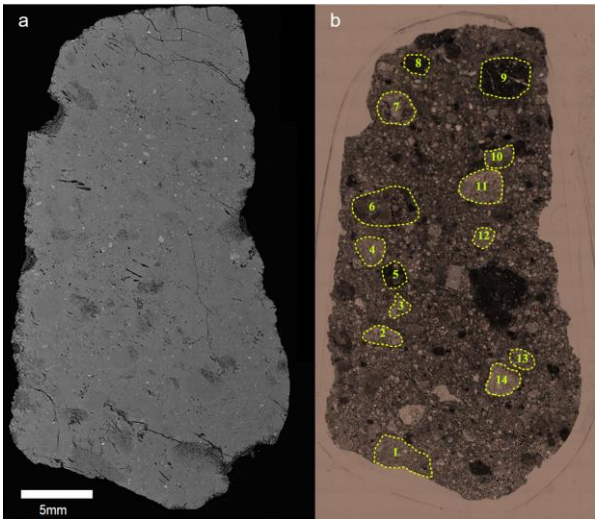

Figure 1. a) BSE mosaic image of NWA 11460 thick section. b) XPL montaging image of NWA 11460 thin section labeled with 14 lithic/mineral clasts.

Table 1. Modal mineralogy of NWA 11460 by Raman point-counting method.

Minerals	Proportions (vol.%)
Plagioclase	61.6
Olivine	28.3
Orthopyroxene	6.0
Clinopyroxene	3.8
Disordered pyroxene	0.3

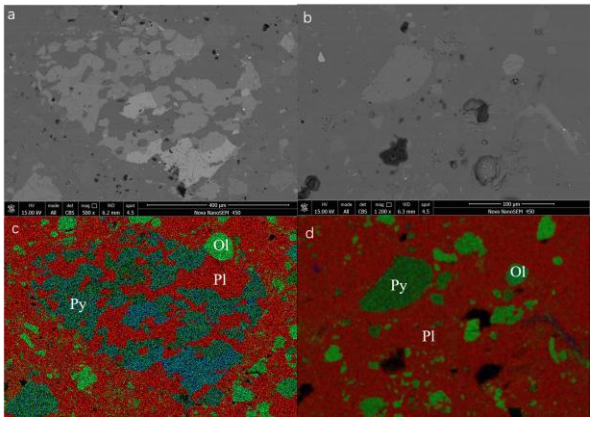

Figure 2. BSE and X-ray composite (red-Al, green-Mg, and blue-Fe) images of two areas in NWA 11460. Pl = plagioclase, red. Ol = olivine, light green. Py = pyroxene, dark green. a) a mafic clast. b) a pyroxene grain exhibiting exsolution lamellae. c) X-ray composite image of a) image with Fe-rich pyroxene. d) X-ray element map of b) image.

Mineral compositions and source lithologies of clasts: Clasts 1, 6, and 14 are dominated by plagioclase and olivine, classified as troctolitic anorthosite. Olivine ($Fo_{75.5-82.6}$) and plagioclase ($An_{86.8-89.2}$) (from multiple Raman point-counting analysis) exhibit the euhedral morphology (Figure 3b and 3c). Based on the Mg# vs. An plot (Figure 4), clast 1, 6, and 14 might come from Mg-suite lithologies [9].

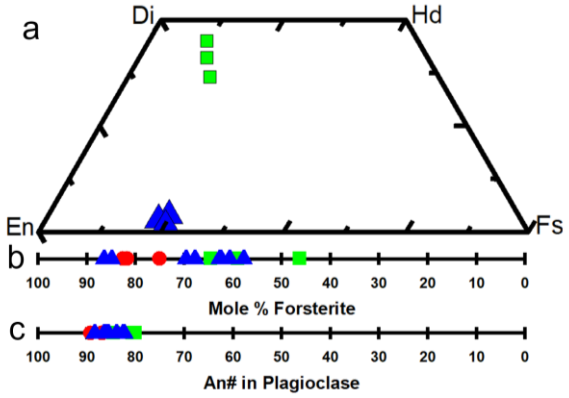

Figure 3. Mineral compositions from EPMA. a) pyroxene. b) olivine. c) plagioclase (An contents). Red circle: clasts 1, 6, and 14; Green square: clasts 5, 9, and 10. Blue triangle: clasts 2, 3, 4, 7, 8, 11, 12, and 13.

Clasts 5, 9, and 10 are troctolite, composed of mostly plagioclase and olivine, minor pyroxene and accessory minerals. Olivine ($Fo_{46.3-64.5}$) has generally intermediate Mg# value and high-Ca pyroxene ($Fs_{11.8-16.8}Wo_{36.4-45}En_{43.1-45.2}$) grains are enclosed in the plagioclase (Figure 3a). Plagioclase has relatively low An value ($An_{80-84.5}$). Based on Mg# vs. An plot (Figure 4), these clasts may originate from alkali-suite lithologies.

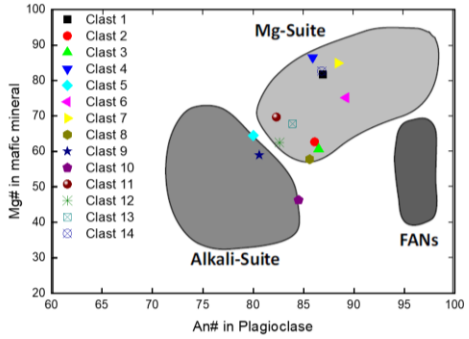

Figure 4. Pyroxene/Olivine Mg# versus plagioclase An content plot of 14clasts in NWA 11460.

Clasts 2, 3, 4, 7, 8, 11, 12, and 13 contain abundant plagioclase (>75 vol.%) corresponding to noritic/troctolitic anorthosite. Olivine ($Fo_{57.8-86.5}$) present euhedral morphology ranging from 10s to 100 μm. Low-Ca pyroxene ($Fs_{23.1-25.2}Wo_{1-4}En_{71.2-73.7}$, Figure 3a) has minor fracture, exhibiting exsolution lamellae which are ~1 μm thick (Figure 2b). Plagioclase grains have low An contents ($An_{82.3-88.4}$). We infer that these clasts probably originated from Mg-suite lithologies via Mg# vs. An plot (Figure 4).

Shock metamorphism: There are some shock features in NWA 11460. No maskelynite was observed in BSE image and Raman point-counting measurements, indicating a shock pressure less than 20–30 GPa [10,11]. Pyroxene grains generally exhibit nominal Raman peaks with less fractures except minor disordered pyroxene grains. Olivine grains also present fractures but no distorted olivine are found. These characteristics suggest that NWA 11460 could experience moderate shock pressure (<30 GPa).

Conclusions and Future work:

The mineral compositions of anorthositic clasts in NWA 11460 are consistent with those of Mg-suite, exhibiting large compositional variation. Troctolite clasts of NWA 11460 are similar to alkali-suite. It suggests that this meteorite may originate from Mg-rich lunar highland regions. Future work includes determination of the bulk composition to constrain its origin and potential relationship to Apollo Mg-suite or alkali-suite lithologies.

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