PETROGRAPHY AND MINERALOGY OF NORTHWEST AFRICA (NWA) 4884 WITH RAMAN SPECTROSCOPY.
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Introduction: Apollo and Luna sample studies have provided valuable data on the lunar volcanism and impact history [1-3], however, these samples only represent a limited lunar surface area (~ 4.7%) [4]. Lunar meteorites come from random surface regions of the Moon far away from previous sample-return sites, thus they represent alternative mineralogy and lithologies, contributing to understanding and constraining lunar evolution [5, 6].

Northwest Africa (NWA) 4884 is classified as a mingled basalt-rich breccia and likely originating from the southern Lacus Veris (20.5° S, 84.5° W) within Orientale basin and the western mare unit (45.3°N, 151.3°E) of Campbell crater [7]. NWA 4884 has gone through extensive shock [8]. Thus its petrography and mineralogy are valuable for studying its petrogenic and brecciation history, and verifying potential source regions.

This work reported preliminary characterization of petrography and mineral chemistry of NWA 4884 by backscattered electron (BSE) imaging and Raman spectroscopy.

Experimental methods:

NWA 4884 thick section was carbon coated and its backscattered electron (BSE) images were obtained by Nova NanoSEM 450 at Shandong University, Weihai. Laser point-counting Raman spectroscopic measurements of NWA 4884 were conducted using the state-of-art inVia® Raman system (*Renishaw Company*) in Shandong University, Weihai. The green laser (532 nm) was used for excitation, and the Raman shift range of 100~1400 cm^{-1} was measured with a spectral resolution better than 1 cm^{-1} and spectra repeatability of ±0.2 cm^{-1}. A Si wafer with a Raman peak at 520.5 cm^{-1} was used as the wavelength calibration standard. The spatial resolution of the laser spot is better than 1 μm. We measured 100 positions within an area of ~3.6 mm ×3.6 mm at an interval of ~400 μm.

Petrography and mineral chemistry of NWA 4884

BSE image of NWA 4884 is shown in Fig. 1. According to Raman spectra obtained, NWA 4884 mainly contain minerals include plagioclase, olivine, pyroxene and large-scale shock-induced maskelynite, etc. Based on their characteristic Raman spectra [9-11], as shown in Fig. 2, olivine is identified by sharp Raman doublet peaks at 819 and 850 cm^{-1} and Raman peaks at 330 and 669 cm^{-1} are from pyroxene. Plagioclase has prominent Raman peaks at 504 cm^{-1}, indicating anorthite endmember or bytownite. Maskelynite also has similar Raman peaks to crystalline plagioclase, but its Raman peaks are much wider due to the disorder of plagioclase crystals.

We preliminarily divided the whole thick section into five areas (Fig. 1) for detailed analysis as follows.

Area 1: The minerals in this area are all maskelynite. It might indicate that previous plagioclase clast of area 1 went through intense shock.

Area 2: Pyroxene and olivine are the main mineral in this area. Pyroxene host presents numerous fractures. We have observed olivine with various (Fo=50-90) in area 2 (Fig. 3). Compared to pyroxene, olivine exhibits more fractures and contains pyroxene and oxide inclusions.

Area 3: There are an amount of sub-mm melt glass spherules interspersed surrounding mixture of olivine, pyroxene and plagioclase. Their look like polyhedral or ellipsoidal clasts, being not similar to irregular dent. We considered that they could come from parental magma. Raman analysis indicates that it mainly contains high-Ca pyroxene (Wo>46).

Area 4: Compared to areas above, area 4 is a vast mixture of olivine, pyroxene and plagioclase, containing part of maskelynite and other monomineralic fragments (e.g., iron-nickel metal).

Area 5: This region has much complicated mineral composition by Raman and EDS analysis. It is different from other regions because of abounding fine brecciated fragments. Raman analysis indicates that main minerals include olivine, pyroxene and minor maskelynite, distributing scattered plagioclase surrounding matrix. Meanwhile, we also have observed ilmenite, ulvöspinel, troilite, iron-nickel metal.

As shown in Fig. 3, we obtained the mineral chemistries of pyroxene and olivine using Raman spectroscopy [12]. It shows that Fo values of olivine are 50-90 and it is magnesium-rich. Pyroxene distribution of Fig. 3 shows that most pyroxene of NWA 4884 crystalized during high temperature and was Mg-rich (En~60-75). According to Wo value, they can be classified as augite besides a small amount of pigeonite [13].

Conclusion: Major minerals of NWA 4884 is plagioclase, olivine, pyroxene and maskelynite. And there are scattered maskelynite with infinitesimal plagioclase in margin. For whole meteorite, its edge regions have fine mineral fragments and brecciation, indicating that this meteorite have experienced intense impact events.

Future work: Raman point-counting and Raman imaging measurements on this meteorite will continue to be performed. Moreover, Compositional analysis will be conducted by using electron microprobe (EMP) for quantitative study. Moreover, shock pressure of maskelynite will be needed to estimate, studying its impact history.

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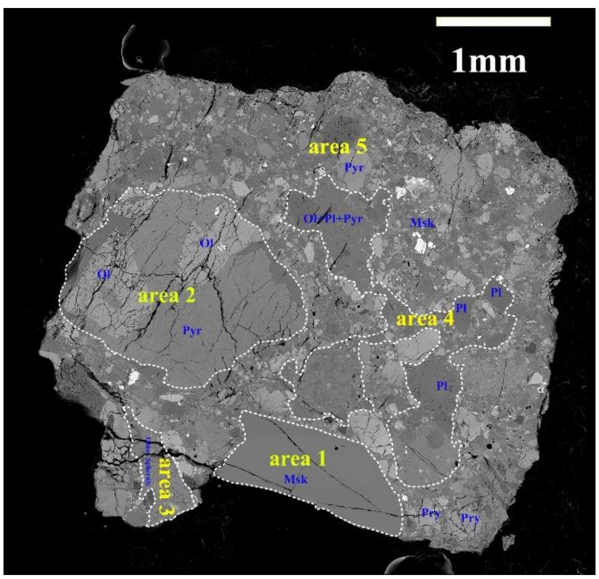

Figure 1. BSE Mosaic image of the NWA 4884 thick section.

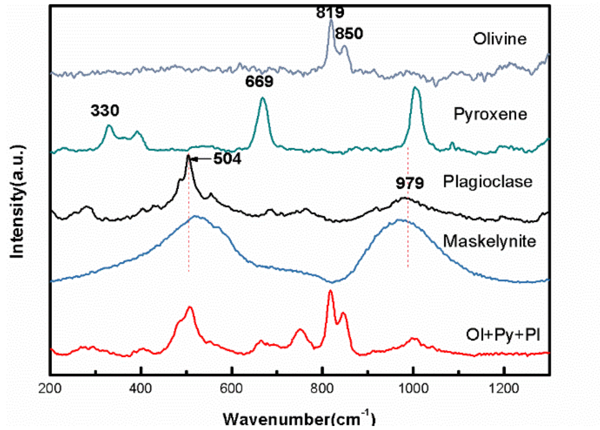

Figure.2 Typical Raman spectra of minerals within NWA 4884.

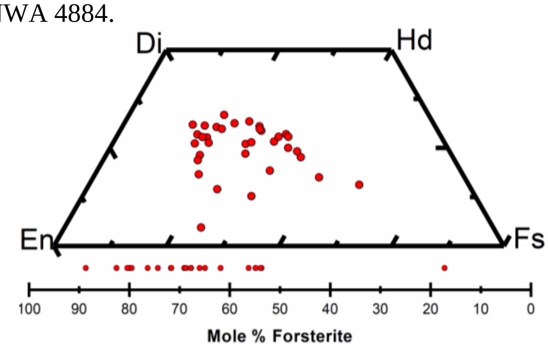

Figure. 3 Pyroxene and olivine chemistries of NWA 4884 by Raman.