

# U-Pb Chronology of Lunar Meteorite NWA 4472

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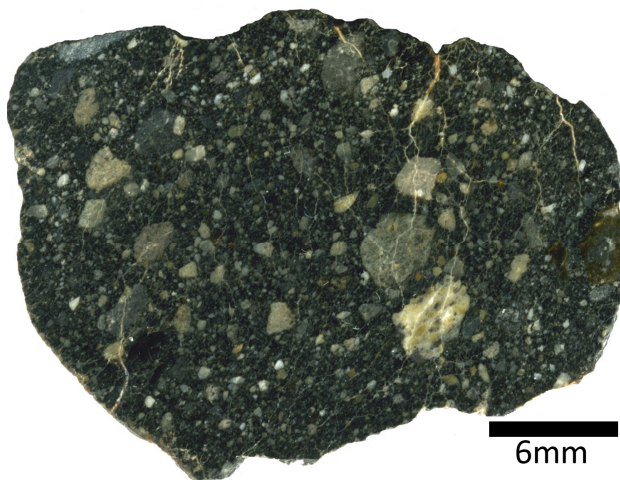
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## Introduction

Lunar meteorites provide geological samples of the Moon from regions that were not sampled by the US Apollo and Soviet Union Luna sample return missions. These important samples are providing vital new information about the thermal and magmatic history of the Moon.

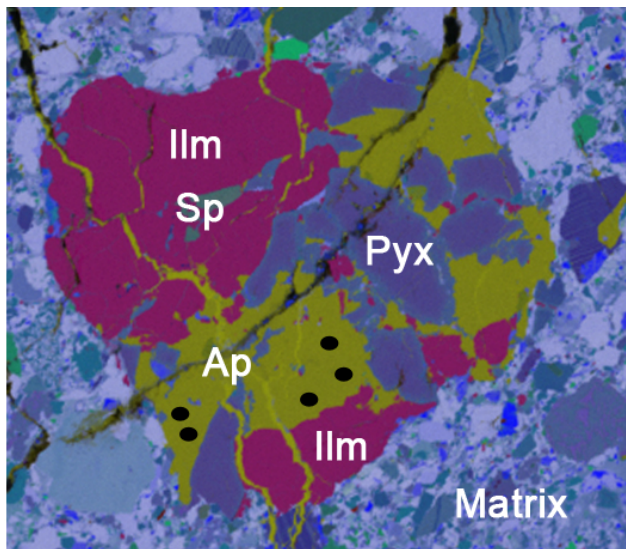
## The Meteorite: NWA 4472



North West Africa (NWA) 4472 is a heterogeneous lunar meteorite breccia that was collected in Algeria in 2006. The sample comprises a mixture of rock and mineral fragments (Fig. 1 [2]), which were derived from different bedrock environments and were fused together in the lunar soil or regolith. Part of this clast inventory includes several basaltic rock fragments that originate from several compositionally distinct lava flows and mantle source regions. This study was designed to investigate the crystallisation ages of these basalts, and to relate their chronological and petrological history to the Apollo, Luna and lunar meteorite sample collection [1].

## Figure 1:

False colour X-ray map of a basalt clast in NWA 4472 showing mineral phases and compositions.



300 microns

Locations of the ion probe measurements made by this study are denoted by black spots

Ilm = ilmenite  
Pyx = pyroxene  
Ap = apatite  
Sp = spinel

Colours represent concentration of different element where

Si = blue  
Al = white  
Mg = green  
Fe = red  
Ca = yellow  
Ti = pink

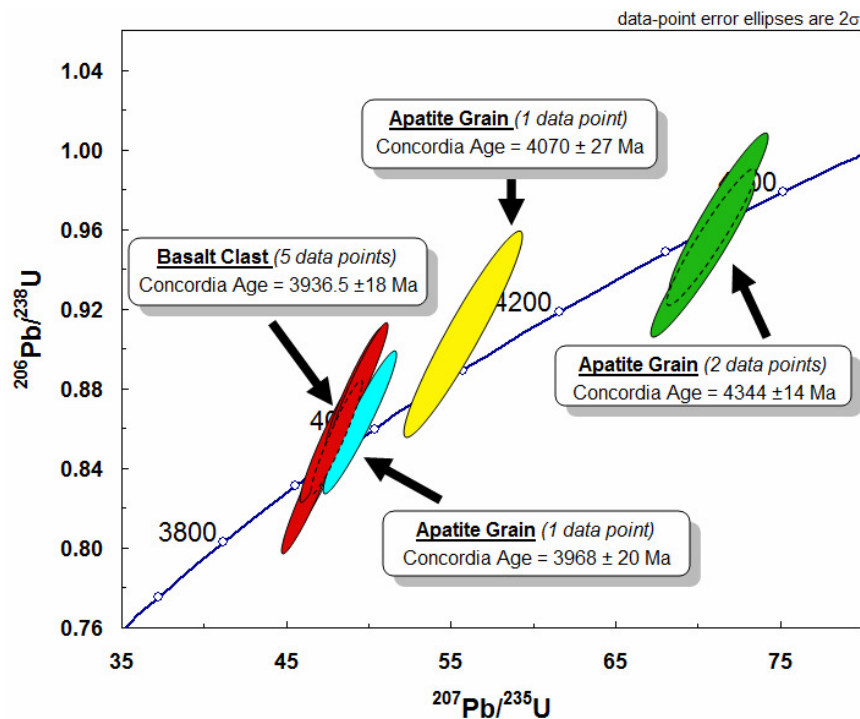
## Results:

U-Pb and Pb-Pb isotope data was obtained from the phosphates, Apatite ( $\text{Ca}_5(\text{PO}_4)_3\text{F}$ ) and Merrillite ( $\text{Ca}_{18}\text{Mg}_2(\text{PO}_4)_{14}$ ), located in three sub-sections of NWA 4472 [3]. In both cases the U/Pb standard used was a terrestrial fluorapatite (UWA-1) supplied by John Valley (University of Wisconsin) and analysed by Dan Condon (NIGL, Keyworth) and Larry Heaman (University of Alberta) for the U/Pb age.

## Apatites:

The Apatites were analyzed in both discrete mineral grains within the NWA 4472 matrix, and in polymict mare basalt clasts such as the clast shown in Fig. 1. The results are illustrated in Fig. 2, are described in [3], and are summarized below:

- Five points analyzed in zoned fluorapatite grains within the basalt clast shown in Fig. 1 yielded an average  $^{207}\text{Pb}/^{206}\text{Pb}$  age of  $3931 \pm 18$  Ma ( $2\sigma$ ) and have a U-Pb concordia age (Fig. 2: red ellipses) of  $3937 \pm 18$  Ma ( $2\sigma$ ).
- Two analyses within a discrete matrix fluorapatite grain gave an average  $^{207}\text{Pb}/^{206}\text{Pb}$  age of  $4345 \pm 24$  Ma ( $2\sigma$ ) and have a U-Pb concordia age (Fig. 2: green ellipses) of  $4344 \pm 14$  Ma ( $2\sigma$ ).
- An analysis of a second matrix apatite grain gave a  $^{207}\text{Pb}/^{206}\text{Pb}$  age of  $4070 \pm 18$  Ma ( $2\sigma$ ) and has a U-Pb concordia age (Fig. 2: yellow ellipse) of  $4070 \pm 27$  Ma ( $2\sigma$ ).
- An analysis within a third matrix fluorapatite grain gave a  $^{207}\text{Pb}/^{206}\text{Pb}$  age of  $3966 \pm 12$  Ma ( $2\sigma$ ) and has a U-Pb concordia age (Fig. 2: blue ellipse) of  $3968 \pm 20$  Ma ( $2\sigma$ ).



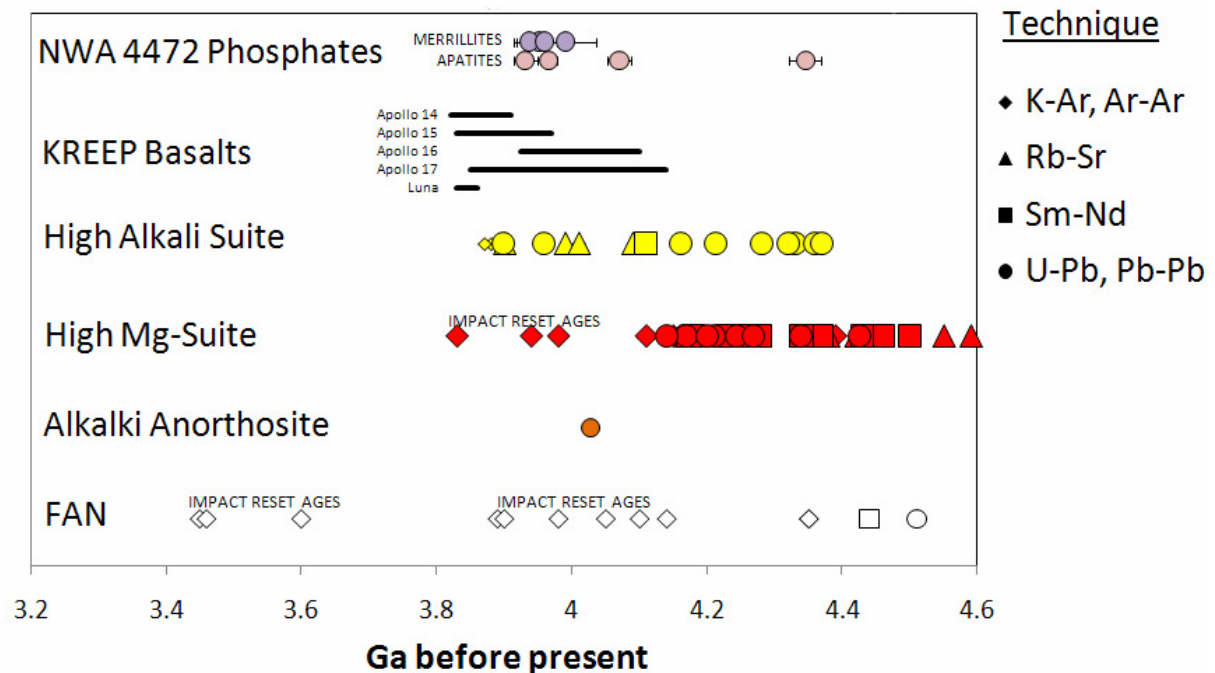
**Figure 2: Apatite U-Pb Concordia Plot.**

Apatite results are shown for the KREEP basalt clast shown in Fig. 1 (red coloured ellipse) and three isolated matrix apatite fragments. Solid ellipses represent analyzed data and dashed ellipses are Isoplot concordia ages.

## Merrillite:

The majority of the merrillite grains analyzed in this study were isolated fragments within the NWA 4472 matrix (i.e. they were not associated with any other mineral phase). The results are illustrated in Fig. 3 and are summarized below:

- Two merrillite grains yielded  $^{207}\text{Pb}/^{206}\text{Pb}$  ages of  $3936 \pm 22$  Ma ( $2\sigma$ ) and  $3936 \pm 18$  Ma ( $2\sigma$ ), which is consistent with the dates (3.93-3.94 Ga) of apatites within the basalt clast shown in Fig. 1.
- Two other merrillite grains gave similar slightly older  $^{207}\text{Pb}/^{206}\text{Pb}$  ages of  $3951 \pm 16$  Ma ( $2\sigma$ ) and  $3956 \pm 18$  Ma ( $2\sigma$ ) that cannot be specifically correlated with any of the apatite age dates.



### Figure 3: Merrillite and Apatite Ages

NWA 4472 phosphate crystallization ages dates measured in this study (Pb-Pb ages with  $2\sigma$  error bars) compared with the literature age dates of lunar crustal rocks (ferroan anorthosite [FAN], High Mg-Suite and High Alkali Suite) and volcanic KREEP basalts [1].

### Lunar Science Implications:

Results of this study indicate that NWA 4472 has sampled a range of lunar Pre-Nectarian period ( $>3.92$  Ga) lunar volcanic (KREEP basalts) and plutonic lithologies. We interpret that the ages determined by this study to represent the crystallization ages of various lithic components within the NWA 4472 regolith [2, 3]. The evolved mare basalt fragment (Fig. 1) dated to be 3.93 - 3.94 Ga, and the matrix apatite and merrillite grains (3.94 - 4.07 Ga) are consistent with the ages of Apollo 15, 16 and 17 KREEP (incompatible trace element rich) mare basalts (Fig. 2). We suggest that the older apatite grain, dated to be  $\sim 4.34$  Ga, might represent the crystallization date of a rare granitic (lunar High Alkali Suite) clast component.

It has been proposed [2] that the meteorite probably originated from the nearside of the Moon from an area around the periphery of the large Imbrium impact basin [2]. Therefore the KREEP basalt volcanism dated by this study ( $>3.93$  Ga; Fig. 2 [3]) must have predated the formation of Imbrium ( $\sim 3.85$  Ga) and associated subsequent basin-filling mare basalts ( $<3.85$

Ga). This conclusion has interesting implications for understanding the magmatic history of the Moon.

**References:**

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