1. Introduction

The determination of precise and accurate isotopic ages of lunar impact melt rocks is crucial for calibrating the lunar crater chronology function [1]. The $^{176}$Lu-$^{176}$Hf system promises to be a powerful tool for dating the crystallization of lunar impact melt rocks because it has a high closure temperature [e.g., 2] and strong elemental fractionation results in a large range in Hf among minerals, potentially allowing higher precision on internal isochrons as compared to Sm-Nd. Additionally, it is possible to simultaneously analyze other geochemical systems such as $^{147}$Sm-$^{143}$Nd and $^{87}$Rb-$^{87}$Sr on the same sample.

Additionally, it is possible to simultaneously analyze other geochemical systems such as $^{147}$Sm-$^{143}$Nd and $^{87}$Rb-$^{87}$Sr on the same mineral fractions. However, both Lu-Hf and Sm-Nd can be heavily affected by neutron capture (NC) effects, which need to be properly corrected [3, 4] for accurate dating.

2. Sample and Method

Sample 14310 is a holocrystalline, clast-free impact melt rock with a fine-grained, subophitic texture [5, see also Poster #3]. Its long exposure on the lunar surface (210 to 347 Myr, [5]) means that it was subjected to significant neutron fluxes. Five mineral fractions (63-125 µm, separated from a ~1 g split: using magnetic and density methods) and a bulk fine fraction were spiked and processed through a modified version of the chemical separation scheme of [6] (cation column separation of HFSE, Lu, LREE; Ln-Spec column separation of Hf from other HFSE; HDEHP Kel-F column to separate Sm from Nd). The isotope compositions of Lu, Hf, Sm, and Nd were measured on a Neptune Plus MC-ICP-MS. An unspiked aliquot of the ‘bulk fine’ fraction was also analyzed to characterize the neutron fluence for this sample.

3. Results

Lu-Hf: The analyzed fractions contain 0.16-4.3 ppm Lu and 1.2-41 ppm Hf. The uncorrected $^{176}$Lu/$^{177}$Hf and $^{176}$Hf/$^{177}$Hf data of five of the six fractions yield a 4036 ±59 Ma (MSWD = 0.84) isochron. Plagioclase fraction #2 lies above the isochron. The neutron fluences that affected the sample were calculated using the Hf and Sm isotopic composition of the ‘bulk fine’ fraction. Correcting for NC effects changes the date to 4011 ±59 Ma (MSWD = 0.87).

Sm-Nd: The analyzed fractions contain 2.5-43 ppm Sm and 8.9-156 ppm Nd. The uncorrected $^{151}$Sm/$^{144}$Nd and $^{151}$Nd/$^{144}$Nd data of four fractions (excluding plag #1 & #2) yield a 3.8 ±1.1 Ga (MSWD = 3.9) date. Correcting for NC effects changes this date to 3.75 ±0.26 Ga (MSWD = 2.6).

4. Discussion and Conclusion

Our $^{176}$Lu-$^{176}$Hf data yield the oldest date reported for sample 14310. Owing to the high resistance of Lu-Hf to later (shock-induced) heating events [19], this date is more likely to represent the actual crystallization age of this sample than $^{40}$Ar/$^{39}$Ar or Rb-Sr dates. Our $^{151}$Sm-$^{144}$Nd date is indistinguishable from the Lu-Hf date. To improve the precision of the former, the Eu/Sm of the plagioclase has to be determined to improve the correction for NC effects on Eu.

According to [20], 14310 pre-dates the Imbrium event. On the basis of the young Rb-Sr and $^{40}$Ar/$^{39}$Ar ages of the sample, those authors argued for a young age (3770 ±20 Ma) of the Imbrium event. The older Lu-Hf date from our present study allows for a significantly older age of the Imbrium event of up to ~4 Ga.

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