Preliminary Pb-Pb and U-Pb isotopic results of four separates from lunar dunite 72415 indicate an age between 4.37 and 4.52 Ga, and derivation from a high $^{238}\text{U}/^{204}\text{Pb}$ ($\mu$) source, similar to those for troctolite 76535 and norite 78235.

In our ongoing quest to understand the magmatic evolution of the early Moon, we have begun a penta-systematic (U-Th-Pb, Rb-Sr, and Sm-Nd) isotopic study of lunar dunite 72415. This rock is one of several that are considered pristine, monomict plutonic rocks [1] that may provide us with early lunar Pb isotopic compositions and U/Pb ratios. These isotopic signatures will hopefully provide some useful information with regard to the earliest stages of lunar evolution, including a magma ocean and/or subsequent differentiation stages [2]. Lunar dunite 72415, dominated by a cataclastic texture of large (up to 10 mm) pale-green olivine crystals set in a fine-grained, granulated matrix, consists of ~93% olivine, ~4% plagioclase, ~2% low-Ca pyroxene, minor amounts of high-Ca pyroxene, Cr-spinel, Fe-Ni-Co-Cr metal alloy, and trace amounts of troilite, whitlockite, and Zr-Cr armalcolite [3]. Thus far in our investigation, four separates of 72415,70 have been analyzed for Pb isotopes, including two whole-rocks, an olivine separate (OLIV), and a magnetic mineral mixture (MAG) that consists mainly of both pyroxenes and the spinel. The first whole-rock (WR-1) is leftover material from handpicking the olivine separate from the +100 mesh (>150 μm) fraction, and the second whole-rock (WR-2) consists of the entire unseparated -100 mesh (<150 μm) fraction. These separates were first treated with a water-alcohol wash and very dilute acids in order to remove secondary Pb components [4]. The remaining Pb in the residues should ideally represent initial Pb incorporated during cumulate formation as well as radiogenic Pb that has since accumulated from the in situ decay of U and Th.

The Pb isotopic data from the residues of leached separates (solid circles) are shown in the figure below, and are compared with our laboratory Pb composition (blank Pb, small asterisk) and the primitive Pb composition of troilite from the Canyon Diablo meteorite [5]. The Pb from all 72415 residues is radiogenic ($^{206}\text{Pb}/^{204}\text{Pb} > 100$), plotting near the ordinate, but unfortunately our data do not form a linear trend. Because these separates contained so little sample Pb (0.3 to 2.1 ng), our laboratory Pb contribution (blank) from processing the sample was a significant component in each. Our measured blank Pb (78 pg) was too large to correct the MAG data (correction for the measured blank produced a negative $^{204}\text{Pb}$ amount), so this analysis is shown as several along a dotted trend toward blank Pb with corresponding blank Pb amounts indicated. A near-maximum blank value of 70 pg places the MAG in a most improbable spot very near the ordinate, whereas a probable minimum blank value of 20 pg does not reach a chord defined by the OLIV and WR-1 analyses. A "best guess" blank value of 40 pg places MAG between these extremes, and a tie-line (dashed line) with OLIV defines a "best guess" minimum Pb-Pb age of 4.37 ±0.23 Ga for these two separates and dunite 72415 as well. WR-2, which does not plot with WR-1, lies along a trend (dotted line) between WR-1 and our blank Pb composition or CDT, indicating that WR-2 probably contains some amount of uncorrected non-radiogenic Pb (above the blank Pb) from one of these sources. Olivine is the most radiogenic, and plots very near the ordinate at a $^{207}\text{Pb}/^{206}\text{Pb}$ age of ~4.55 Ga. The most reliable data, OLIV and WR-1, define a line (solid) that indicates a Pb-Pb age of 4.52 ±0.06 Ga. This age would seem a bit too old, but is within error limits of a Rb-Sr age of 4.45 ±0.1 Ga [6]. In order to reconcile these two ages and the non-linear behavior of the three different separates from 72415, we must assume that the two whole-rock separates contain some significant amounts of non-radiogenic Pb above the correction for blank. However, it requires an overcorrection of WR-1 by 100% and WR-2 by ~400% of the measured blank value to align these whole-rocks with OLIV and MAG (20 pg blank) to yield a Pb-Pb isochron age ~4.43 Ga. These corrections are far too great to be explained by our chemistry and
therefore force us to consider contamination prior to sample preparation, either during sample collection or possibly by meteoritic contamination.

Fig. 1: Pb-Pb correlation diagram showing the behavior of residues from analysis of lunar dunite 72415. The residues of two whole-rocks (WR-1 & WR-2), an olivine separate (OLIV), and a magnetic separate (MAG) do not form a linear trend. However, the age of this rock can be constrained between 4.37 and 4.53 Ga (dashed and solid lines). Regardless of the corrections for any analyses, the data indicate that dunite 72415 was derived from a high-μ (>500) source, similar to other lunar highland samples, troctolite 76535 and norite 78235.

Regardless of these analytical problems, we can constrain the Pb-Pb age of 72415 to between ~4.37 and 4.52 Ga, the extremes allowed by the different combinations, assuming OLIV data are relatively unmovable. Perhaps of greater significance is the fact that the data clearly indicate derivation from a high-μ (>500) source, very similar to results from norite 78235 (μ = 508) and troctolite 76535 (~600) [7,8].

Preliminary U-Pb isotopic data using the OLIV and MAG separates also indicate a high-μ source for this dunite. Assuming primitive initial Pb isotopic compositions similar to CDT (206Pb/204Pb = 9.3; 207Pb/204Pb = 10.3), the two analyses do not define a possible array, and exhibit 207Pb/206Pb ages in excess of 4.55 Ga. These initial Pb values and ages are clearly not possible. Using initial Pb values similar to those used for 76535 (206Pb/204Pb = 71; 207Pb/206Pb = 119), corresponding to single stage Pb evolution from a source with μ ~1600 at an age ~4.44 Ga (assuming an age of 4.56 Ga for a Moon with near-primitive initial Pb values), the two-point chord intersects concordia at ~4.45 Ga.

Presently, we are analyzing the U and Th from all the residues, washes, and leaches as well as Rb-Sr and Sm-Nd on the residues of 72415 in order to better define the age(s) of crystallization.