OLD AGE OF FORMATION FOR A DISTINCT VARIETY OF A17 HIGH-TITANIUM MARE BASALT. J. Dasch¹, G. Ryder², Y. Reese¹, H. Wiesmann³, C.-Y. Shih³, and L. Nyquist⁴, ¹Code FE, NASA Headquarters, Washington, DC 20546, j.dasch@hq.nasa.gov, ²Lunar and Planetary Institute, 3600 Bay Area Boulevard, Houston, TX 77058, ³Lockheed-Martin, Code C-23, 2400 NASA Road 1, Houston, TX 77058, ⁴Code SN21, NASA Johnson Space Center, Houston, TX 77058.

High-titanium mare basalts and volcanic glasses collected at the Apollo 17 landing site that have been analyzed chemically probably are not part of a single eruptive event. They constitute at least three basaltic groups (e.g. [1]) which have been interpreted as being related through partial melting or fractionation processes, or both, of a primary magma, melts of heterogeneous provenance, or some mix of these possibilities. Ryder [2] described a possible new type (D) of high-titanium mare basalt (79001, 2161) from an A17 drive tube which sampled the rim of Van Serg crater, a young impact crater. Ryder based his conclusion on the rock’s more primitive bulk chemistry, its subophitic texture, the order of appearance of minerals formed, and their grain sizes and textures. We report Rb-Sr and Sm-Nd isotopic analyses which show that 79001, 2175 is the oldest high-titanium basalt reported from the moon, and is distinctly older than previously reported ages for A17 basalts, and has more calcic plagioclase feldspar. The rock has a bulk chemistry that is more primitive than other mare basalts collected at the A17 site (higher MgO, Mg#, higher Co and Cr, but lower TiO₂ and much lower incompatible elements (though similar REE pattern). Collectively, these textural and chemical features led Ryder to conclude that the rock has a composition close to that of a magma and that they define a new and distinct group of A17 high-titanium mare basalts.

The basalt sample 79001,2175 weighing ~0.8 g was allocated for our isotopic studies. The sample was crushed to pass a 100 mesh (149 µm) nylon sieve. A sample of ~0.2 g was taken for whole rock samples (WR) used in the present study and for ⁴⁰Ar-⁴⁰Ar analysis by Donald Bogard at JSC. The remaining sample of ~0.6 g was sieved into 149-74 µm, 74-44 µm and <44 µm size fractions. From the two coarser size fractions, three pure mineral separates of plagioclase (Plag), pyroxene (Px) and opaque minerals (Opaque) were prepared using a Frantz magnetic separator, heavy liquids and handpicking. The isotopic measurements were made using a multi-collector Finnigan-MAT Model 261 mass spectrometer. The Sr isotopic compositions were normalized to ⁸⁸Sr/⁸⁶Sr=8.37521 and ⁸⁷Sr/⁸⁶Sr=0.710250 for NBS 987 Sr standard.

Rb-Sr Data: Rb-Sr isotopic analysis of this core fragment (Figure 1) yields an internal (mineral) isochron age of 3.92 ± 0.10 Ga (λRb=0.01402 Ga⁻¹), with an initial ⁸⁷Sr/⁸⁶Sr, Iₛ₈ = 0.699284 ± 34. This formational age is distinctly older than previously reported ages for A17 and most of the A11 titanium-rich mare basalts, which range in age from about 3.6 to about 3.8 Ga (e.g. [4, 5]). The age of this basalt is just within error limits of the 3.83+0.02 Ga age of the oldest A11 mare basalt, group B2 (e.g. [5]).

The dark matrix contains tiny plagioclase laths, not interlocking, intergrown with clinopyroxene. Unlike other A17 basalts with subophitic textures, this sample contains phenocrystic, subhedral, and anhedral matrix olivine. Additionally, 79001 contains early pigeonite rather than augite, oxide minerals which appear later in the crystallization sequence than in other A17 basalts, and has more calcic plagioclase feldspar. The rock has a bulk chemistry that is more primitive than other mare basalts collected at the A17 site (higher MgO, Mg#, higher Co and Cr, but lower TiO₂ and much lower incompatible elements (though similar REE pattern). Collectively, these textural and chemical features led Ryder to conclude that the rock has a composition close to that of a magma and that they define a new and distinct group of A17 high-titanium mare basalts.

Figure 1. Internal (mineral) isochron (⁸⁷Sr/⁸⁶Sr vs. ⁸⁷Rb/⁸⁶Sr) for high-titanium mare basalt 79001, 2175. Plag = plagioclase feldspar, WR = whole rock, Px = pyroxene, and Opaque = ilmenite and other opaque phases. The best-fit line of York [3] for all the points yields an age (T) of 3.92 ± 0.10 Ga with an initial Sr isochron (Iₛ₈) of 0.699284 ± 34. Insert shows the displacements of measured ⁸⁷Sr/⁸⁶Sr values from the isochron in parts in 10⁴.

Sample and analyses: Mare basalt 79001 is a fine-grained basalt and has an olivine phryic, subophitic texture distinct from other high-titanium volcanic rocks.
basalts except the young high-K mare basalts at the Apollo 11 site. A two-stage model yields $^{87}\text{Rb}/^{86}\text{Sr} \sim 0.032$ for the 79001 basalt mantle source.

**Sm-Nd Data:** Sm-Nd isotopic analyses for constructing an internal (mineral) isochron for 79001 are in progress. So far, only the whole-rock sample has been analyzed. The Rb-Sr isochron age for the sample and the WR Sm-Nd data, however, allows calculation of the initial isotopic composition of Nd ($\epsilon^{143}\text{Nd}$, or $I^{143}\text{Nd}$) of about $+4.2 \pm 0.6 \epsilon$ units. The $\epsilon^{143}\text{Nd}$ and age data for high-Ti mare basalts are shown in Figure 3. The initial Nd isotopic ratio also is high for its old age. It implies that the basalt came from a highly depleted mantle source of $^{147}\text{Sm}/^{144}\text{Nd} = \sim 0.243$, assuming the mantle source was established very early at ~4.56 Ga ago. In this case, the Sm/Nd ratio did not change much during the basalt-forming process at 3.92 Ga.

**Discussion:** The Rb-Sr isochron age of 79001, 2175 of 3.92 ± 0.10 Ga will be more closely constrained with the completion of Sm-Nd isotopic analyses. Additionally, a split of the WR sample was reserved for $^{39}\text{Ar}-^{40}\text{Ar}$ analysis. Within the analytical uncertainties, however, our Rb-Sr age indicates that 79001, 2175 is the most ancient of the A17 (and A11) high-titanium mare basalts. Supporting Ryder’s earlier conclusion [2] that 79001 constitutes a new group (D) of A17 titanium-rich basalts, our $I^{143}\text{Nd}$ point for this rock has a position that is distinct from the fields of other A17 and A11 high-Ti mare basalt groups in $I^{143}\text{Nd}$ space. The mare basalt volcanism represented by 79001,2175 seems to have been nearly contemporaneous with the Serenitatis event (e.g. [6-9]).

**REFERENCES:**