Introduction: Apollo 16 sample 63545 was initially described as one of a group of 19 generally rounded, fine-grained, crystalline rocks that were collected as rake samples [1]. This 16 g “rocklet” was collected at Station 13 on the ejecta blanket of North Ray Crater at the foot of Smoky Mountain [2]. Originally classified as a Very High Alumina (VHA) basalt on geochemical grounds [3], it was later argued to be an impact melt rock [4]. Here we report a Rb-Sr and Sm-Nd isotopic study that shows that some portions of the rock failed to reach isotopic equilibrium on last melting in agreement with the impact melt rock interpretation. Nevertheless, by omitting mineral fractions that are discordant with the majority of the data, we arrive at the time of last melting as 3.88±0.05 Ga ago. This age is in agreement with the $^{143}Nd/^{144}Nd$ plateau age of 3.83±0.23 Ma [5], if the latter is adjusted for the ~1.4-1.8% revision in the age of the hornblende monitor [6]. This investigation was undertaken in part as proof-of-concept for SPA-basin sample return.

Petrology, Sampling, Sm and Nd Abundances: Rock 63545 was one of the rocks originally considered by Hubbard et al. [3] to constitute a group of Very High Al$_2$O$_3$ (VHA) “basalts”. The major element composition of VHA rocks is characterized by Al$_2$O$_3$ in the range ~20-24% and FeO in the range ~5-8% [3]. REE abundances are characterized by La in the range ~50-70 X chondritic. A more comprehensive compositional study [7] placed 63545 into sub-group 2M, “low-Sc VHA”, or as an aluminous variant of 2NR. Texturally, it was classified as a “subophitic-ophitic-intersertal (clast-free) impact melt rock” [8] and placed into the “aluminous subophitic group by [5]. Photomicrographs of 63545 [4] show a subophitic texture like 63549 [5], but also a fine-grained, recrystallized anorhostitic clast.

Compositional “VHA basalts” are grossly similar to KREEP basalts like 15382 and 15386, but characterized by higher Al$_2$O$_3$ and lower REE abundances. (cf. Fig. 1). Because in a melting experiment Delano [5] found plagioclase to be absent from the liquidus of a 63545 composition he concluded that its negative Eu anomaly could not be a result of petrogenesis via partial melting. Delano [4] thus favored an origin via impact-fusion of highlands components, in agreement with modern consensus on the origin of VHA basalts.

Although 63545 is not endogenously igneous in origin, its subophitic texture makes it amenable to mineral separation procedures routinely used to study basalts. A finely powdered sample (258 mg) retained from previous studies was sieved into 200-325 (115 mg) and <325 mesh size fractions. Each size fraction was “washed” in 2N HCl and the wash retained as “Leachates”. As for basalts, the leachates were greatly enriched in both Sm and Nd compared to the whole rock, showing LREE-enrichment (Fig. 1). A plagioclase-enriched fraction (Plag(r)) was floated from the 200-325 mesh fraction in heavy liquid of density $\rho = 2.85$ g/cm$^3$. A pyroxene-enriched fraction (Px(r)) sank at $\rho = 3.32$ g/cm$^3$. An intermediate density fraction with $2.85<\rho<3.32$ g/cm$^3$ is designated Plag+Px(r). REE abundances of Px(r) were lowest among the fractions and LREE-depleted as expected for pyroxene. Unexpectedly, REE in Plag(r) were greater than in Px(r), and also LREE-depleted compared to the whole rock (WR), suggesting incomplete removal of pyroxene.

Delano [4] described pink spinel, plagioclase, olivine, pyroxene, interstitial glass, minor oxides, and metal in 63545. No electron probe studies were available to him, and we know of none. Phosphates were not described, but are likely contributors to the leachates and should be sought in this rock and in others like it.

Sm-Nd Data: Sm and Nd isotopic data of several fractions do not satisfy an isochron relationship (Fig. 2), implying the mineral grains in them did not come to complete isotopic equilibration. However, WR (unleached, <325 mesh), the two leachates, and Px(r) are collinear within 1 $\varepsilon$-unit and define an age of 3.91±0.10 Ga, and $\varepsilon_{Nd} = -0.44±0.4$ consistent with derivation from LREE-enriched parental materials.

Rb-Sr Data: Whole rock $^{87}$Rb/$^{86}$Sr ~ 0.06 is high compared to lunar mare basalts. In contrast to lunar
Reimold et al. [10] analysed the more coarsely crystalline 67747 obtaining an age of 3.91±0.04 Ga adjusted to \(\lambda^{87}\text{Rb} = 1.402 \text{ Ga}^{-1}\) and initial \(^{87}\text{Sr}/^{86}\text{Sr} \text{I}_\text{S} = 0.69952±0.00010\) in agreement with the present results for 63545. Fig. 4 shows Rb-Sr data for VHA rock 60335 (also group 2M [7]) combined with those for 63545. The combined data yield an isochron age of 3.90±0.07 Ga and \(\text{I}_\text{S} = 0.699547±0.000052\) refining the \((T, \text{I}_\text{S})\) parameters for VHA melt rocks first reported by [14] from a whole rock isochron.

**Conclusions**: The weighted average Rb-Sr ages of of VHA melt rocks 67747 and 63543 of 3.90±0.04 Ga agrees with the Rb-Sr ages of Apollo 15 KREEP basalts (e.g., 3.88±0.04 for 15434,73 [15]) as well as that of Apollo 16 KREEP-rich impact melt rock 65015 (3.89±0.01, adjusted, [12]) and also the Sm-Nd age of 63545. Furthermore, VHA rocks bear the characteristic REE pattern of KREEP (Fig. 1). Thus, we tentatively identify the age of this sample group with the Imbrium basin. That this ~3.90 Ga exceeds the widely accepted age of 3.85±0.02 Ga [16] by ~1.3% may be explainable by a necessary revision of the age of the Mnhb-1 monitor by 1.4-1.8% [6].