

ISOTOPIC PROVENANCE OF ALUMINOUS MARE BASALTS FROM THE FRA MAURO FORMATION; E. J. Dasch NRC/NASA Resident Associate (Johnson Space Center) and Department of Geology, Oregon State University, Corvallis, OR 97331-5506; C.-Y. Shih, B. M. Bansal, and H. Wiesmann, Lockheed/EMSCO, 2400 NASA Road 1. Houston, TX 77058; and L. E. Nyquist, SN4/NASA JSC Houston, TX 77058.

Fragments of aluminous mare basalts from the Apollo 14 site, especially from breccia 14321, have been studied extensively (1-3). Despite similarities in petrographic features and major element chemistry, at least five chemical groups of mare basalts are well defined by their trace element abundances (1). We are continuing our Rb-Sr isotopic studies of these rocks in an attempt to constrain their magmatic history and petrogenetic relations. New data reported herein are from a combined sample of several small group 1 basalts (14321; 93 mg) and a "group 0" basalt (14321. 1383; 472 mg). The samples were crushed in a boron carbide mortar and pestle and sieved with nylon screen. After obtaining whole rock samples, plagioclase- and pyroxene-enriched subsamples were separated magnetically; additional subsamples of different densities were obtained by heavy-liquid separation.

14321 - Group 1 Basalt: The Rb-Sr isochron diagram for this rock is shown in Figure 1. The five data points define an isochron yielding an age of  $4.12 \pm 0.08$  b.y. for  $\lambda(^{87}\text{Rb})=0.0139$  (b.y.)<sup>-1</sup> (or  $4.03 \pm 0.08$  b.y. for  $\lambda(^{87}\text{Rb})=0.0142$  (b.y.)<sup>-1</sup>).  $I(\text{Sr})=0.69939 \pm 4$  -- similar to initial ratios found in other A-14 mare basalts, e.g., 14053 (4). The rock does not appear to be shocked or otherwise disturbed; thus, we believe this age to be the crystallization age of the basalt.

14321, 1383 - "Group 0" Tridymite Ferrobasalt: The Rb-Sr isochron diagram for this rock is shown in Figure 2. The three data points define an isochron age of  $4.05 \pm 0.05$  b.y. for  $\lambda(^{87}\text{Rb})=0.0139$  (b.y.)<sup>-1</sup> (or  $3.96 \pm 0.05$  b.y. for  $\lambda(^{87}\text{Rb})=0.0142$  (b.y.)<sup>-1</sup>).  $I(\text{Sr})=0.69972 \pm 8$ , significantly higher than for most A-14 mare basalts. Again, lack of textural disturbance leads us to believe that this date represents the crystallization age of the volcanic rock.

T-I(Sr) Relations and Petrogenesis: T (age) vs. I(Sr) data for internal (mineral) isochrons of A-14 basalts are displayed in Figure 3. Literature data for a group 3 basalt (4), for an A-14 olivine basalt (5), and for A-14 KREEP basalts (6) also are included. Basalt representative of group 4 has yet to be analyzed at a precision comparable to the graphed data. Aluminous mare basalts at the A-14 site are much older than those found at the A-12 (7) and Luna-16 sites (8). Our continuing data indicate that the A-14 basalts represent the oldest mare basalts recovered from the Moon. The age data show mare basalt activity from 3.96 to 4.33 b.y. in the Fra Mauro Region. The chemically grouped A-14 aluminous mare basalts are mainly distinguishable from each other in terms of their T and I(Sr) parameters and represent at least three rock units, consistent with the chemical classification of (1). The tridymite ferrobasalt, informally referred to as a "group 0" rock owing to its enriched REE concentrations (9), and the olivine basalt (5), do not appear to be related to the five groups of (1) with respect to T-I relations. I(Sr) values for the rocks plotted fall into three readily distinguishable categories: highest I -- the tridymite ferrobasalt; intermediate I -- basalt from groups 1-3; and lowest I -- group 5 basalt and the olivine basalt. Viewed as a coherent chemical set of rocks, however, it is noteworthy that the groups of rocks proposed by (1) have a well defined time-averaged  $^{87}\text{Rb}/^{86}\text{Sr}$  ratio of about 0.06, similar to the whole-moon value proposed by (10). These groups of basalt thus could have evolved from a common,

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undepleted source and extruded at different times, early in the history of mare basalt volcanism. The variations of trace element abundances in the basalts could be due to slight differences in the degrees of partial melting. However, the low I(Sr) olivine basalt evolved in a low  $^{87}\text{Rb}/^{86}\text{Sr}$  environment ( $\sim 0.03$ ) similar to the A-11 and A-12 mare basalts, suggesting cumulate sources for these low I(Sr) rocks. [Young aluminous mare basalts such as 12038 and L-16 B-1 were derived from sources of even lower  $^{87}\text{Rb}/^{86}\text{Sr}$  ratio ( $\sim 0.01$ )]. The isotopic data indicate that the high I(Sr) tridymite ferrobasalt was not generated from the same source material from which the lower I(Sr) basalts were derived. However, the isotopic data do not rule out the production of the tridymite ferrobasalt and the intermediate I(Sr) group basalts by assimilation of existing KREEPy source rock into a low I(Sr) basaltic magma.

Fig. 1

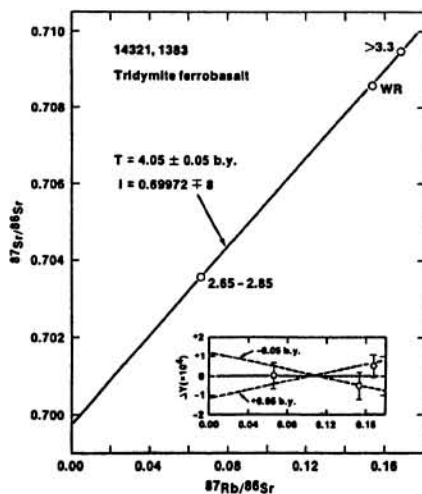


Fig. 2

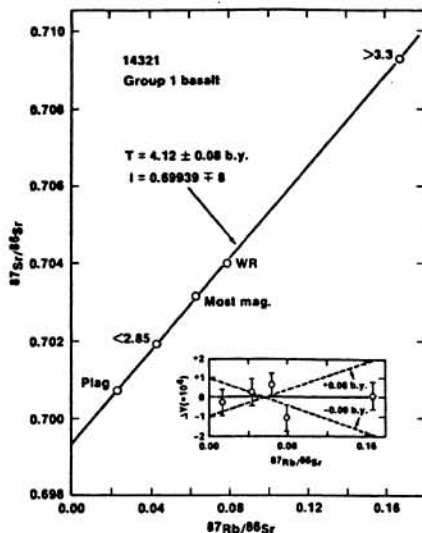
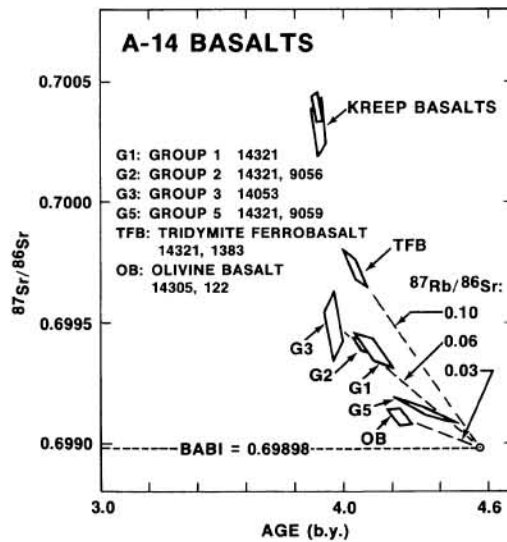


Fig. 3



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