

RB-SR AGES, TRACE ELEMENTS, AND SPECULATIONS ON LUNAR DIFFERENTIATION V. Rama Murthy, N. M. Evensen, Bor-ming Jahn, M. R. Coscio, Jr., Department of Geology and Geophysics, University of Minnesota, Minneapolis, Minn., 55455

The Rb-Sr internal isochron age of the Fra Mauro basalt 14310 is 3.93 ± 0.06 AE. The age of this sample resembles the high temperature ^{39}Ar - ^{40}Ar ages of low K mare basalts from the Sea of Tranquillity, but is significantly greater than those of the mare basalts collected from the Apollo 12 and 15 missions. The high initial $^{87}\text{Sr}/^{86}\text{Sr}$ ratio (0.70033 ± 0.00019) suggests either derivation from source material which had a high Rb/Sr ratio since near the time of the moon's formation, or contamination with highly differentiated Rb rich materials at the time of volcanism. The abundances of the trace elements K, Rb and Ba are also distinct from those of the known mare basalts. From the combined trace element data and Rb/Sr systematics, the most reasonable interpretation leads to the conclusion that lunar basalts are in general derived from source regions of low Rb/Sr ratio, but are contaminated in varying degrees with early formed materials containing high abundances of K, Rb, Ba and other incompatible trace elements.

Three soil samples from the Apollo 14 mission also show high abundances of these trace elements relative to the soils from earlier Apollo missions. However, model ages of the Apollo 14 soils range from 4.4-4.5 AE., in agreement with model ages for soils obtained from other sites on the moon. A detailed study of various size fractions from soil sample 14149 shows that this high trace element abundance pattern is common to all size fractions. The element abundances of K and Rb show a spread of ~20-50% but Sr and Ba vary by only about 10% in the various size fractions. From our leaching experiments and other studies of Apollo 11 and 12 soils, we had previously concluded that an exotic component containing highly radiogenic Sr and rich in K, Rb, Ba should be ubiquitously distributed in the lunar soils. This is confirmed in the case of the Apollo 14 soils. Further, this component is invariably present not only in different Apollo 14 soils, but in the various size fractions as well. If the exotic component had been transported over long distances and mixed with the soils, we would expect a grain size dependency, which in this case is not observed. A reasonable interpretation is that either a wholesale transport of material occurred in a collision event (Imbrium Basin excavation?) and that the soil was produced locally by lunar surficial degradation processes or that the exotic component was admixed into the Fra Mauro basalts at the time of their genesis and provided "in situ" source material for the formation of the soils.

A single sample of a mare basalt from the Hadley Rille site (15555) has

"Ages, trace elements"

V. Rama Murthy

P.572

been dated at 3.30 AE by both a Rb-Sr internal isochron and K-Ar dating on a plagioclase separate from the sample. Both the trace element pattern and the Rb-Sr systematics in this sample are highly reminiscent of the Apollo 12 basalts. It is clear that extensive volcanism leading to mare flooding occurred in widely separated regions of the moon between about 3.1 and 3.9 AE ago. We hypothesize that the mare basalts may be products of the internal thermal regimen of the moon, whereas the basalts at Fra Mauro may be melts produced or triggered by the collisional event associated with the excavation of the Imbrium basin. This would explain the high abundance of elements such as K, Rb and Ba in the Fra Mauro basalts as resulting from the fusion of trace element poor surface layers and underlying material rich in these elements. In a model of early lunar differentiation, we had earlier proposed that the outer regions of the moon became mineralogically and chemically stratified at a very early time, producing an outer layer of the moon which graded from Fe and Ti rich materials in the lower parts to residual material enriched in lithophile elements near the top, overlain by an anorthositic crust. A major collisional event such as that postulated for the Imbrium basin could result in excavation and melting of material down to the trace element rich layer, and thus produce materials having the composition of the Apollo 14 basaltic rocks, as well as the exotic component present uniformly in the soils from the Fra Mauro region. If the exotic component is tapped from the pre-mare basement only in a major impact event such as the Imbrium collision, a corollary of this hypothesis would be that the exotic component in the soils from Apollo 11, 12 and 15 should reside preferentially in the smaller size fractions, as a consequence of transport from a distant source. Experiments to test this are currently underway and will be reported.