
We have studied the Sm-Nd systematics of basalt 15065 and eucrite Moore County and the U-Pb systematics of some Apollo 15 mare basalts in an attempt to determine lunar mare basalt evolution history. Although the Sm/Nd fractionation among minerals separated from basalt 15065 was small, with the $^{147}{\text{Sm}}/^{144}{\text{Nd}}$ ratios ranging from 0.17 in the $\rho < 2.5$ fraction to 0.24 in the light-colored pyroxene (core), the Sm-Nd data of the basalt define an isochron which corresponds to $3.34 \pm 0.09$ (95% confidence) x $10^9$ yr and an initial $^{143}{\text{Nd}}/^{144}{\text{Nd}}$ of 0.50844±0.00011 using $\lambda_{^{147}{\text{Sm}}}=0.00654$ x $10^{-9}$ yr$^{-1}$ (Fig. 1). This Sm-Nd internal isochron age confirms the Rb-Sr internal isochron age of $3.28 \times 10^9$ yr reported for the rock by Papanastassiou and Wasserburg (1) as being the crystallization age, and confirms that Rb-Sr and Sm-Nd internal isochron ages do, in fact, agree when there has been no severe post-crystallizational disturbance to the Rb-Sr and Sm-Nd systems. We are now more confident that the $4.37 \times 10^9$ yr Sm-Nd and $4.36 \times 10^9$ yr Rb-Sr ages for norite 77215 (2) represent the crystallization age rather than the brecciation age. We also conclude that the $4.37 \times 10^9$ yr age represents the oldest reliable crystallization age yet obtained for lunar samples.

The $^{147}{\text{Sm}}/^{144}{\text{Nd}}$ ratios of the unbrecciated eucrite Moore County vary from 0.10 in plagioclase to 0.28 in pyroxene and the Sm-Nd data define a rather precise internal isochron which corresponds to $4.60 \pm 0.04$ (95% confidence) x $10^9$ yr and an initial $^{143}{\text{Nd}}/^{144}{\text{Nd}}$ ratio of 0.50676±0.00007. Although the Sm/Nd ratio of the whole-rock split of the eucrite differs from that of Juvinas, the initial $^{143}{\text{Nd}}/^{144}{\text{Nd}}$ ratio agrees with the Juvinas initial ratio reported by Lugmair et al. (3).

Using the eucrite initial ratio, the $^{147}{\text{Sm}}/^{144}{\text{Nd}}$ ratio for the source of basalt 15065 is calculated to be 0.1998 for a two-stage model. The ratio is large compared to the Juvinas value of 0.194 (3) but is still within the "chondritic" range of 0.195 ± 0.015. The use of Sm-Nd models for lunar basalt evolution with the "chondritic" Sm/Nd ratios appears to be quite speculative at this stage in assigning differentiation ages beyond the crystallization ages.

The efforts to precisely define the differentiation time for the source of Apollo 15 mare basalts from a U-Pb internal isochron have not been successful and merely gave $4.4 \pm 0.2 \times 10^9$ yr (model age) for the differentiation time. This uncertainty does not appreciably change even when all available Apollo 15 mare basalt data (4, 5) are included in the "isochron". The apparent scatter may reflect minor recent impacts (Elbow Crater?) which slightly disturbed the U-Pb systems of these basalts.
EVOLUTION HISTORY OF LUNAR MARE BASALTS

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REFERENCES

(1) Papanastassiou and Wasserburg (1973) E.P.S.L., 17, 324.
(5) Tatsumoto et al. (1972) The Apollo 15 Samples, p. 391.

FIGURE 1. Sm-Nd evolution diagram for basalt 15065. The data are for "cristobalite" (\(\rho < 2.5\)), plagioclase (\(\rho = 2.6-2.8\)), whole rock, pyroxene + ilmenite (\(\rho > 3.3\)), hand-picked dark pyroxene (rim), and hand-picked light pyroxene (core) fractions. The data define a line which corresponds to a 3.34 \(\pm 0.09\) x 10^9 yr age (2.77 \(\sigma\) at 95% confidence). The whole rock and \(\rho > 3.3\) fractions appear to deviate slightly from the line as can be seen in the \(\delta Y\) (in 10^4) vs. \(X\) plot in the insert.

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