AGE OF A15 NORITES, CONTINUED ; E. J. Dasch[1], C. -Y. Shih[2], B. M. Bansal[2], H. Wiesmann[2], and L. E. Nyquist[3] ([1]Department of Geology, Oregon State University, Corvallis, OR 97331-5506; [2]Lockheed/EMSCO, 2400 NASA Road 1, Houston, TX 77058; and [3]SN, NASA-Johnson Space Center, Houston, TX 77058).

In a continuing isotopic study of Apollo 15 pristine noritic clasts (1-3), we have presented Rb-Sr data for a noritic clast (,247) from breccia 15445 (4). The Rb-Sr isochron for the rock indicated an ancient age $T \geq 4.6$ Ga and primitive $I(Sr)=0.69903 \pm 0.00020$, but with unacceptably high scatter of the data. We interpreted the high "age" and partly discordant data as resulting from either isotopic disturbance owing to natural contamination during impact cratering on the lunar surface, artificial contamination or preferential leaching of Rb during mineral separation using heavy liquids, or to some combination of these possibilities. Herein we report new Sm-Nd data obtained for the same samples of the norite for which we did the Rb-Sr isotopic measurements previously.

Fig. 1.

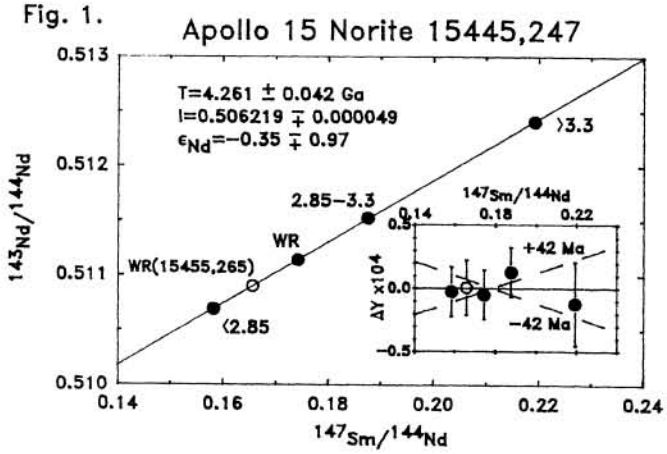
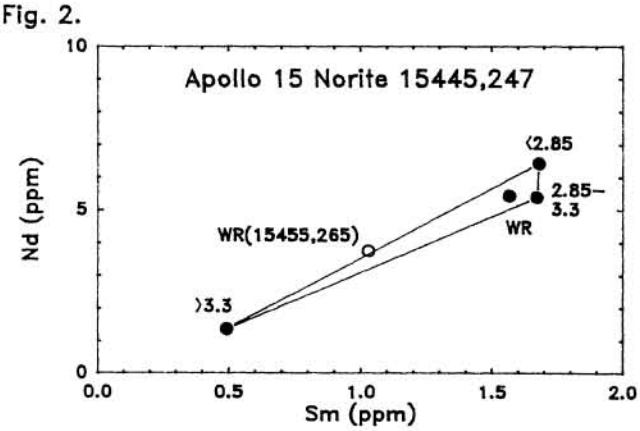


Fig. 2.



The Sm-Nd isotopic data for the noritic clast are presented in Figure 1. Mineral separates were obtained using heavy liquids. The lightest fraction (<2.85 g/cm^3) consists mainly of plagioclase whereas the densest fraction (>3.3 g/cm^3) is enriched in pyroxene. Typical analytical uncertainties in $^{143}Nd/^{144}Nd$ were ~20 ppm except for the >3.3 g/cm^3 fraction for which the uncertainty was ~30 ppm. In contrast to Rb-Sr isotopic data for these samples, all four data points define an isochron. The data were regressed by the conventional York (5) method and yield an age of 4.261 ± 0.042 Ga for $\lambda(^{147}Sm)=0.00654$ Ga^{-1} and an initial $^{143}Nd/^{144}Nd = I(Nd) = 0.506219 \pm 0.000049$ normalized to $^{148}Nd/^{144}Nd = 0.24308$, which corresponds to an initial ϵ_{Nd} of -0.35 ± 0.97 using the notation and chondritic parameters of (6). Regression of the data using the Williamson (7) method yields nearly identical results and error limits. The Sm isotopic data were corrected for lunar neutron irradiatiom using the measured Sm isotopic composition for 15445,247. The datum for a WR sample of an anorthositic noritic clast (,265) from breccia 15455 are also plotted in the figure for comparison and clearly shows that these two noritic clasts are isotopically very similar.

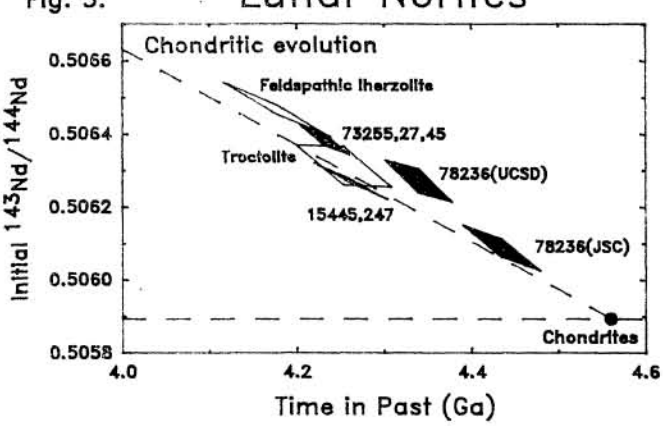
Sm and Nd abundances in whole rock and mineral separates from the norites are shown in Figure 2. The non-linear distribution of the data strongly suggests that the linear Sm-Nd isotopic relationship in Figure 1 is not a mixing line but a well-defined isochron. Thus the 4.26 Ga Sm-Nd isotopic age probably represents the solidification

age of the noritic clast, whereas the younger ~3.9 Ga $^{39}Ar/^{40}Ar$ age for an anorthositic norite clast from 15455 (8) represents a later event, perhaps impact brecciation. The Rb-Sr isotopic system for the clast was probably disturbed by this later event, contributing to the scatter in the Rb-Sr data.

The ages, T, and initial $^{143}Nd/^{144}Nd$ ratios, I(Nd), reported by the UCSD and JSC labs for the Mg-suite rocks (2, 9-11) are shown in typical error parallelograms (norites, in filled symbols; and others, in open symbols) in the T-I(Nd) evolution diagram (Figure 3). The data were renormalized to correspond to the CIT chondritic parameters (6). The T and I(Nd) values for the 15445,247 noritic clast are plotted within the field defined for the troctolite 76535 (11) and lie near the chondritic evolution line. Using a simple two-stage evolution model, the time-averaged $^{147}Sm/^{144}Nd$ in source material derived from the primitive chondritic I(Nd) at 4.56 Ga (6) is calculated to be ~0.188. This suggests that the parental magma for the A15 norite was slightly enriched in LREE. However, the A15 norite is well-resolved from the two A17 noritic samples, 78236 and 73255,27,45, in both T and I(Nd), indicating different sources for these norites.

The Mg-suite rocks are the most abundant rocks in the lunar crust and their ages vary from 4.18 Ga to 4.43 Ga. The old 4.43 ± 0.05 Ga age for the Mg-suite rocks was defined by the most retentive phases in the norite 78236 (2). The age is identical to the Sm-Nd age of 4.44 ± 0.02 Ga reported recently for the ferroan anorthosite 60025 (12) which belongs to the ferroan anorthosite suite of crustal rocks. Although most of the Mg-suite rocks appear to come from younger layered plutons within older anorthositic crust, the age data indicate that some were probably contemporary with the ferroan anorthosites and could have been produced by the early lunar differentiation event. The distinctly positive ϵ_{Nd} values for most of the Mg-suite rocks suggest that they crystallized from parental magmas derived by partial melting of depleted mantle sources, assuming that the moon was chondritic in Sm/Nd. Such depleted materials were also suggested to be sources for some of the A14 aluminous mare basalts (13). However, unusually large Sm/Nd fractionation (~50%) prior to the formation of Mg-suite rocks is required, which is not easy to explain by any near-surface igneous processes. This difficulty could be removed if the moon had an initially subchondritic Sm/Nd ratio, as suggested by (2), and also a slightly positive ϵ_{Nd} value (13).

Fig. 3. Lunar Norites



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