Sm-Nd AGE OF A PRISTINE NORITE CLAST FROM BRECCIA 15445; C.-Y. Shih, B.M. Bansal and H. Wiesmann, Lockheed Engineering and Science Co., 2400 NASA Road 1, Houston, TX 77058; E.J. Dasch, NASA Headquarters and Department of Geology, Oregon State University, Corvallis, OR 97331-5506; L.E. Nyquist and D.D. Bogard, NASA Johnson Space Center, Houston, TX 77058.

Sm-Nd isotopic results are reported for a lunar norite sample ,15445,17, from the large white lithic clast of breccia 15445 which was collected near Spur Crater on the Apennine Front. The white clast is petrographically and chemically similar to norite 78235 (1,2). It also has very low siderophile element abundances (3) and hence probably represents a pristine norite. Chunks totaling 2.07 g of the 15445,17 norite clast were chipped from the E surface of the large white Clast B and were originally allocated to a consortium led by P.W. Gast in 1972. REE abundances were determined by mass spectrometric isotopic dilution as part of the consortium study (1). Rb-Sr isotopic data were not published mainly because the isotopic system was severely disturbed. Later, a Sm-Nd isotopic study was attempted using the JSC-NBS 12" mass spectrometer but the Nd isotopic precision was unsatisfactory because of the low Nd contents of the samples. The current Sm-Nd isotopic studies were performed on material remaining from these studies. The whole rock sample (WR) was taken from the <149μ size fraction. Three density separates, ρ<2.85 g/cm^3, ρ=2.97-3.3 g/cm^3 and ρ>3.3 g/cm^3, were obtained from the 74-149μ size fraction using heavy liquids of bromoform, tetrabromomethane and methylene iodide. The samples were spiked with a new ^{150}Nd-^{149}Sm spike and analysed with the JSC Finnigan-Mat 261 mass spectrometer. The Sm concentration data were corrected for effects of lunar neutron irradiation using the measured Sm isotopic composition of a sample from the 44μ size fraction.

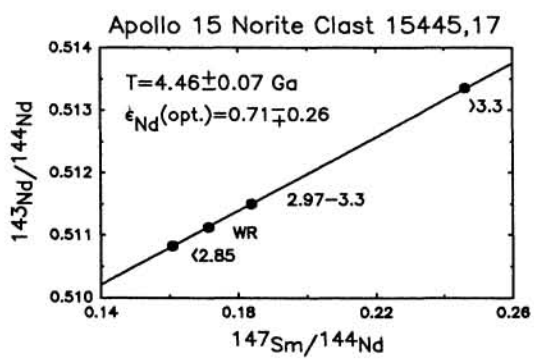

Figure 1. Sm-Nd internal isochron

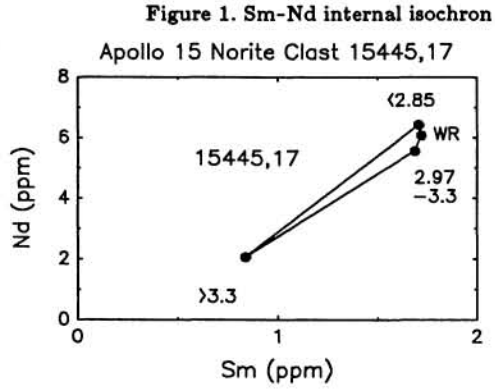

Figure 2. Sm-Nd correlation

Sm-Nd isochron: Sm-Nd isotopic data for the whole rock and mineral separates of this pristine norite clast, presented in Fig. 1, yield a line corresponding to an age of 4.46±0.07 Ga for $\lambda(^{147}Sm)$= 0.00654 Ga^{-1} and an initial ϵ_{Nd} value of 0.71±0.26 relative to the CHUR parameters of (4). The isochron age and initial ϵ_{Nd} value were obtained using the York (5) program. Uncertainties are 2σ. The uncertainty of the ϵ_{Nd} value was optimised following the procedures described in (6). Uncertainties of the data are smaller than the symbols. Sm and Nd abundances in samples of whole rock and mineral separates are shown in Fig. 2. The non-linear distribution of the Sm and Nd data strongly suggests that the linear Sm-Nd isotopic relationship in Fig. 1 is a well-defined isochron and probably represents the crystallization age of the norite. Comparably old Sm-Nd ages were also reported for norite 78236 (7) and ferroan anorthosite 60025 (8). The age of norite 15445,17 marginally overlaps the Rb-Sr ages for other pristine crustal rocks; *e.g.*, troctolite 76535 (9), dunite 72417 (10) and anorthositic norite 15455,228 (11). Rb-Sr isotopic data for the 15445,17 norite confirm the earlier result that the Rb-Sr system was disturbed and no meaningful Rb-Sr age was obtained.

Recently Dasch et al. (12) reported Sm-Nd isotopic results for another norite sample, 15445,247, chipped from the same clast about 1 cm

from 15445,17. The 15445,247 clast yielded a significantly younger isochron age of 4.28±0.03 Ga. Fig. 3 clearly demonstrates significant differences between the Sm-Nd isochrons of these two norite samples. The Sm-Nd data indicate that Clast B is heterogeneous and contains at least two similar lithologies.

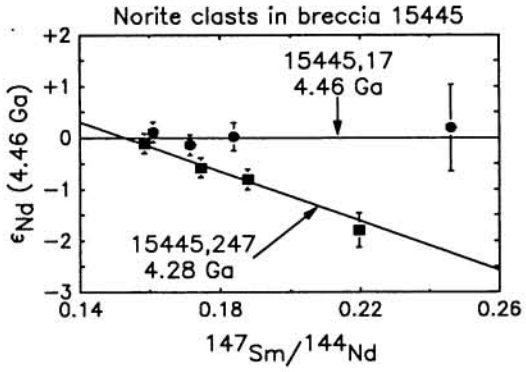

Figure 3. Sm-Nd isochrons for two norite clasts.

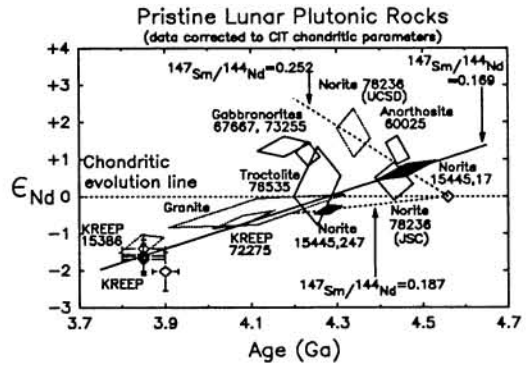

Figure 4. Ages and initial ϵ_{Nd} values

Ages and Initial ϵ_{Nd} values: Sm-Nd ages and initial ϵ_{Nd} ratios for pristine plutonic rocks including a ferroan anorthosite (8), a troctolite (13) and three norites (7,12), several KREEP basalts (14-16) and a granite (17), represented by error parallelograms, are summarized in Fig. 4. Apollo 15 norites 15445,17 and 15445,247 (in filled parallelograms), Apollo 17 norite 78236 (7,18), and two gabbronorites 73255,27,45 and 67667 (18,19) are clearly resolved from each other. Distinct parental magmas are required for the derivation of norites and gabbronorites, two major subgroups of the Mg-suite noritic rocks (20). In addition, norite 15445,247 and norites 15445,17 and 78236 crystallized from two parental magmas ~200 Ma apart. Noritic rocks have been generally accepted as layered plutons emplaced into the old ferroan-anorthositic crust which probably formed from a global magma ocean. Similarly old ages for norites and ferroan anorthosites implies that "serial magmatism" (21) or "multiple diapiric intrusions" (22) probably played a significant role in the genesis of lunar crustal rocks. Norite 15445,17 has a slightly positive initial ϵ_{Nd} value. Thus, sources for the parental magma to the norite had superchondritic $^{147}Sm/^{144}Nd$ =~0.252 assuming a two-stage evolution from a chondritic source at 4.56 Ga. The present $^{147}Sm/^{144}Nd$ value of the norite is ~0.171. A Sm/Nd fractionation of ~1.5 is required to produce norite from a LREE-depleted source. Such a large Sm/Nd fractionation is difficult to achieve under lunar crustal conditions (23). A more likely model is that norites were derived from LREE-enriched sources. Crustal rocks, *e.g.*, norites, troctolites, granites and KREEP basalts are all LREE-enriched and show a linear trend for their ages and initial ϵ_{Nd} values. They have been considered to be related to one another. A linear regression of ages and initial ϵ_{Nd} values for these rocks indicates a source of $^{147}Sm/^{144}Nd$~0.169. Such a subchondritic Sm/Nd (LREE-enriched) source is probably parental to a number of major lunar crustal rocks.

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