AGE OF A15 NORITES; E.J.Dasch, NRC/NASA JSC, Houston, TX 77058 and Oregon State University, Corvallis, OR 97331; L.E.Nyquist, SN4/NASA JSC, Houston, TX 77058; G.Ryder and A.M.Steele, Lunar and Planetary Institute, 3303 NASA Road One, Houston, TX 77058 ; and H.Wiesmann, B.M.Bansal, and C.-Y.Shih, Lockeed/EMSCO, 2400 NASA Road One, Houston, TX 77058.

Despite their importance in understanding the early differentiation of the moon, few well documented samples of plutonic rocks from the lunar crust (pristine plutonic lunar rocks, or PPLR) have been dated unequivocally (1). Isotopic information on these rocks and their minerals commonly have been interpreted by careful (but not necessarily systematic) criteria of data selection. For Rb/Sr and Sm/Nd internal (mineral) isochrons, the common problem is significant departure from the best-fit isochron by one or more data points. Additionally, the dating systems may yield markedly different "ages" for the same rock. In an analysis of isotopic data from selected PPLR, Nyquist (1) compiled a histogram of ages which shows that the oldest dates were mainly determined by Rb/Sr techniques. The data are few, however, and it is not clear if this interpretation is correct, or, if it is, why Rb/Sr ages should be greater than, say, Sm/Nd ages on the same rock. The principle chronologic question (3-11) is the age of the Mg-suite of PPLR--particularly the norites and troctolites--relative to the apparently earliest lunar ages of ferroan anorthosites, and the much younger, better defined age of 3.9-4.0 Ga for the formation of several of the large lunar basins (eg. about 3.9 Ga ($^{39}Ar/^{40}Ar$) for anorthositic norite 15455; D.D.Bogard, pers. comm.).

We are continuing an isotopic study (cf. 1,2) of two PPLRs on which a considerable amount of isotopic information has been collected --an anorthositic norite clast (15455,265) and a norite clast (15445,247)--samples of the A15 "black and white" rocks.

Anorthositic norite 15455,265 (and 15455,228).

This rock is described by Ryder (12) and has been analyzed by Nyquist et al.(2). The available data (Fig. 1) indicate an ancient age equal to the age of the moon, within analytical uncertainties ($T=4.58 \pm 0.12$ Ga; $I(Sr)=0.69900 \pm 7$ ($\lambda(^{87}Rb)=0.0139$ $(Ga)^{-1}$). Inclusion of the WR data for 15455,265 (this study) yields a slightly older age and greater uncertainties. However, we have not been able to confirm this age by Sm/Nd or $^{39}Ar/^{40}Ar$ techniques; discordance within the Rb/Sr system and between dating methods has prompted us to continue this work.

Norite 15445,247 (and other samples of clast B;12).

It is difficult to obtain clean, pure mineral separates of this monomict breccia. Although larger mineral grains, especially pyroxene, are evident, much of the rock is a very fine-grained "dust", ostensibly a result of impact granulation. Because fine dust (FD) hampered mineral separation by sieving and magnetic means, we rinsed the crushed WR sample in freon (low dielectric constant and, presumably, low propensity for chemical leaching), decanting the freon and FD in several rinses. Mineral-enriched separates then were obtained by magnetic means, handpicking, and heavy liquids. A Rb/Sr isochron diagram for seven samples of this rock is shown in Fig. 2. It is obvious that, similar to the results for several other PPLR, the samples do not form a closed system with a well defined age; at least some components of the rock have disturbed Rb/Sr properties, either from natural (impact mixing) or artificial (contamination, chemical leaching, analytical) reasons. Only the WR sample was obtained entirely mechanically (M). The WR (FD), Px, and Plag were treated with freon; the remaining samples (L) were treated with heavy liquids, water, acetone, or freon (ie. possibly leached). We consider the most likely problems to be: (1) leaching of components (especially the pyroxene, >3.3 point) by heavy liquids (see 13); and (2) unintentional inclusion of fragments of matrix melt rock. Other problems, such as possible inclusion of other exotic components, leaching of phases by water, acetone, and perhaps freon also may contribute. Regression of all the data, excepting the 3.3 point, yields T=4.93 Ga, though isochron uncertainties incorporate the age of the moon. Although the Px and >3.3 g/cc fractions are both enriched in pyroxene, the Rb and Sr concentrations in the >3.3 g/cc fraction are only 25% and 36%, respectively, of those in the Px fraction. The overall depletion of Rb and Sr in the >3.3 g/cc fraction is probably due to exclusion of trace element rich mesostasis present in the magnetically separated sample. However, the use of methylene iodide appears to have preferentially leached Rb as well, as evidenced by the pronounced departure of the >3.3 g/cc datum from the regression line for the other data. This effect casts suspicion on all separates of this rock for which liquids were used in sample preparation prior to dissolution. A reference isochron of 4.56 Ga, drawn through the WR(M) point, also is shown, and all data for which liquids were used in sample preparation are seen to depart from it in the direction of Rb loss.

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This largest clast of norite 15445 (clast B; 12) has been sampled several times and analyzed by Nyquist and associates (eg. 2). Many of these data are unpublished. Fig. 3 is a Rb/Sr isochron plot showing data for all WR samples for which no liquids were used in sample preparation. The WR age is T=4.48±0.29 Ga with I(Sr)=0.69905±0.00014. Like the individual chip just described (15445.247), other fragments of this monomict breccia yields subsamples that show scatter on Rb/Sr isochron plots (not shown). Again it is unclear what combination of natural and preparation factors have contributed to the isotopic discordance in these samples. Like 15445,247, we believe that chemical leaching by liquids during sample preparation, prior to dissolution, and perhaps inadvertant inclusion of impact-melt material have caused at least part of the scatter.

We are continuing work on these rocks, to understand better the causes of discordance and to obtain more precisely determined ages of crystallization. For now we provisionally conclude that these norites crystallized during earliest lunar history, at a time indistinguishable within analytical uncertainties from the ages of pristine lunar anorthosites, as evidenced by their similar initial $^{87}Sr/^{86}Sr$ ratios.

Fig. 1

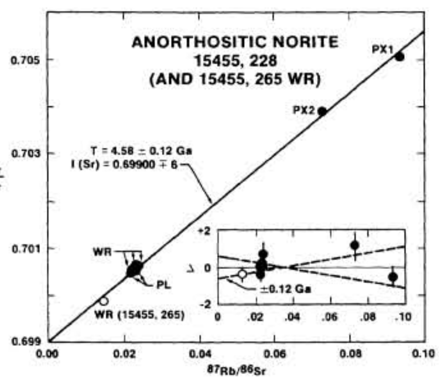
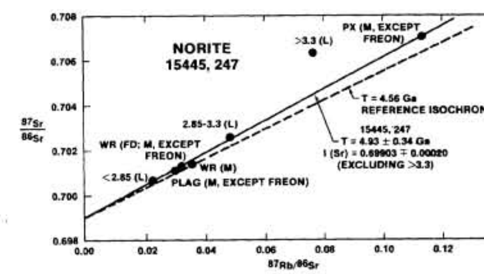


Fig. 2



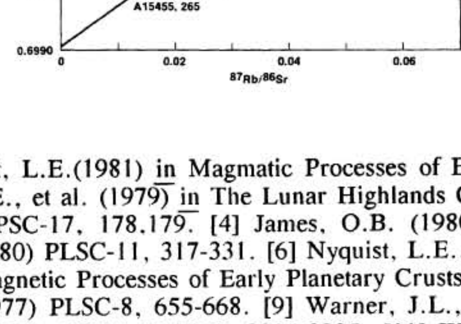


Fig. 3

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