Ar-Ar, Rb-Sr, AND Sm-Nd STUDIES OF EUCRITIC CLAST LEW85300,55; L.E. Nyquist, D.D. Bogard, NASA Johnson Space Center, Houston, TX, 77058; B.M. Bansal, H. Wiesmann, and C.-Y. Shih, Lockheed ESC, Houston, TX, 77058.

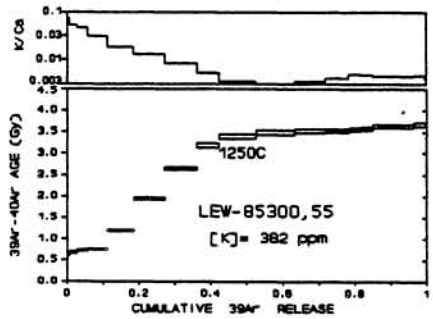

Figure 1. Ar-Ar data for LEW85300,55.

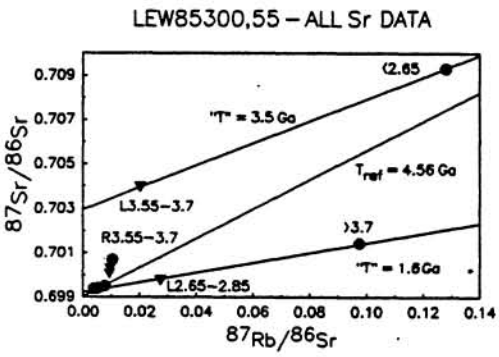

Figure 2. Rb-Sr data for all samples of LEW85300,55. Inverted triangles, L: leachates; filled circles, R: residues and unleached samples.

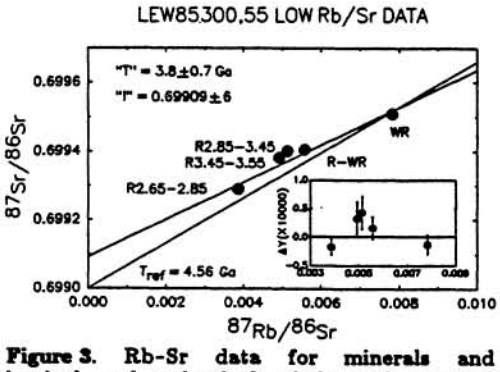

Figure 3. Rb-Sr data for minerals and leached and unleached whole rock samples having low Rb/Sr ratios.

Eucritic clast LEW85300,55 was studied as part of the Lewis Cliffs 85300-03 consortium led by R. Hewins. LEW 85300 is an impact breccia containing dark glassy matrix and numerous igneous and brecciated clasts (1,2,3). Chemical studies of several of the clasts have found positive Ce anomalies suggesting the possibility that trace element abundances have been affected by Antarctic weathering (4). LEW85300,55 was selected for Rb-Sr and Sm-Nd studies because trace element analyses showed that of the LEW85300-03 clasts allocated to us it was least affected by weathering (D. Mittlefehldt, pers. comm.). Ar-Ar and whole rock Rb-Sr and Sm-Nd studies of the clasts also showed that LEW85300,55 was most appropriate for further detailed isotopic study.

The Ar-Ar data show complete degassing of the clast ~3.5 Ga ago and no evidence of an older crystallization age (Figure 1). The ~3.5 Ga age is shown only by phases of low K/Ca ratio. Phases of higher K/Ca have lost radiogenic Ar either continuously since ~3.5 Ga ago or possibly in a younger event ≤0.75 Ga ago. Petrographic studies (1,3) show that tridymite is present in the LEW85300-03 clasts and it is probably the high K/Ca phase since a phase of low density similar to that of tridymite was also found to have a high Rb/Sr ratio.

A portion of the sample was crushed and sieved to a grain size of 44-74μm for the Rb-Sr and Sm-Nd studies. Fractions of density <2.65, 2.65-2.85, 2.85-3.45, 3.45-3.55, 3.55-3.7, and >3.7 g/cm^3 were prepared using heavy liquids. The intermediate fractions having densities in the range 2.65-3.7 g/cm^3 were individually leached in 1N HCl for 10 minutes at room temperature.

The Rb-Sr data are strongly disturbed (Figures 2 and 3). The major minerals have low Rb-Sr ratios and most plot near a 4.56 Ga reference isochron. The 3.55-3.7 g/cm^3 low-Ca pyroxene residue plots along a mixing trend between the whole rock and 3.55-3.7 g/cm^3 leachate (Figure 2). This trend also includes the leachates of the 3.45-3.55 g/cm^3 high-Ca pyroxene and the 2.85-3.45 g/cm^3 fraction, which was composed of a mixture of phases. The Sr concentration in the low-Ca pyroxene was low, 5 ppm, and apparently still contained a contribution from phosphates. The Rb-Sr data for the leachate of this fraction probably most closely approximates values for pure phosphate. A tie line between this leachate and the <2.65 g/cm^3 fraction (tridymite?) of high Rb/Sr ratio corresponds to an apparent age of 3.5 Ga, suggesting that Sr isotopic equilibration was achieved between tridymites and phosphates at the time of major Ar degassing. The >3.7 g/cm^3 ilmenite fraction and the leachate of the

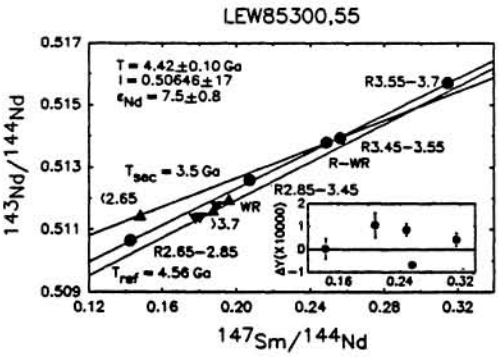

Figure 4. Sm-Nd data for major minerals and the leached whole rock of LEW85300,55 show a correlation yielding an apparent age of 4.42±0.10 Ga.

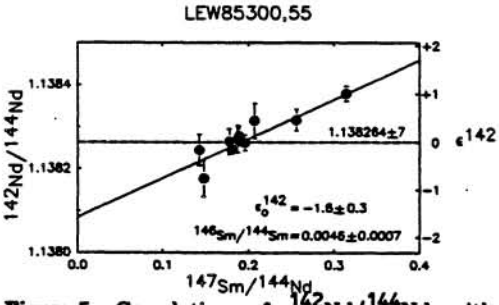

Figure 5. Correlation of $^{142}Nd/^{144}Nd$ with $^{147}Sm/^{144}Nd$ shows the presence of live ^{146}Sm at crystallisation.

2.65-2.85 g/cm^3 plagioclase fraction define a second trend line corresponding to an apparent age of ~1.6 Ga, suggesting that phosphates associated with plagioclase and ilmenite, respectively, were partially isotopically equilibrated at a later date, perhaps when the high K/Ca phase (tridymite?) lost radiogenic Ar. Low Rb-Sr data from the plagioclase, high-Ca pyroxene, 2.85-3.45 g/cm^3 mixed phase, whole rock residue (R-WR), and whole rock (WR) define a trend line and an apparent age of 3.8±0.7 Ga (Figure 3). Data for these phases lie within 0.4 ϵ-units of the best fit line, suggesting Sr-isotopic reequilibration between plagioclase and high-Ca pyroxene at the time of major Ar degassing. The whole rock datum lies on a 4.56 Ga reference isochron suggesting that the whole rock Rb-Sr system has remained closed since ~4.56 Ga ago.

Sm-Nd data for the plagioclase, high-Ca pyroxene, low-Ca pyroxene, and whole rock residue define a correlation line corresponding to an apparent age of 4.42±0.10 Ga (Figure 4). The <2.65 g/cm^3 "tridymite" lies off the correlation line but appears to have been in isotopic equilibrium with the leached whole rock (i.e., whole rock minus phosphates) ~3.5 Ga ago. The leachates (phosphates), ilmenite, and unleached whole rock also do not plot on the correlation line but lie instead along a 4.56 Ga reference isochron suggesting closed system behavior since ~4.56 Ga ago. Sm and Nd abundances in the leached and unleached whole rock samples, respectively, show that the phosphates contain ~78% of the REE inventory of the rock, accounting for the good agreement between the phosphate and unleached whole rock data. The displacement of the Sm-Nd data of the major mineral phases from that of the whole rock and phosphates and the failure of the data to define an isochron within analytical uncertainties suggests that the apparent isochron age only approximates the crystallization age and that the high initial ϵ_{Nd} = 7.5±0.8 has no petrogenetic significance.

In spite of disturbances in the correlation of $^{143}Nd/^{144}Nd$ to $^{147}Sm/^{144}Nd$, a good correlation exists between $^{142}Nd/^{144}Nd$ and $^{147}Sm/^{144}Nd$ showing the partitioning of live ^{146}Sm among the mineral phases when the clast crystallized (Figure 5). Initial $(^{146}Sm/^{144}Sm)_I$ = 0.0046±0.0007 is derived from the correlation, in good agreement with $(^{146}Sm/^{144}Sm)_I$ = 0.0032±0.0016 found for the Bholghati eucrite clast having a ^{147}Sm-^{143}Nd age of 4.51±0.03 Ga (5). The value of $(^{146}Sm/^{144}Sm)_I$ for the LEW85300,55 clast is also identical with $(^{146}Sm/^{144}Sm)_I$ = 0.0045±0.0005 reported by Lugmair et al. (6) for Allende, suggesting an age near 4.56 Ga. However, the younger age of 4.42 Ga obtained from the ^{147}Sm-^{143}Nd data of the major mineral phases is consistent with a solar system initial $(^{146}Sm/^{144}Sm)_o$ ~0.015, as suggested by Prinzhofer et al. (7). The disturbances of the long-lived parent-daughter isotopic systems is consistent with the suggestion that the LEW85300-03 suite was reheated to temperatures near 1000°C in an impact-generated ejecta blanket (8). Formation ages based on the short-lived ^{146}Sm-^{142}Nd chronometer may be more reliable for eucrites and other products of the HED parent body than are those based on the long-lived chronometers because of pervasive impact-associated reheating occurring on the parent body ~3-4 Ga ago.

REFERENCES: (1) Kosul J. and Hewins R. [1988]. LPS XIX, 645-646. (2) Kosul J. and Hewins R [1988] LPS XIX 647-648. (3) Hewins R., this volume. (4) Mittlefehldt D. and Lindstrom M. [1989] Workshop on Antarctic and Non-Antarctic Meteorites, LPI and Univ. Vienna, 38-40. (5) Nyquist L. E. et al. [1990] Age of a eucrite clast from the Bholghati howardite, submitted to GCA. (6) Lugmair G. et al. [1983] Science 222, 1015-1018. (7) Prinzhofer A. et al. [1989]. Ap. J. 344, L81-L84 (8) Batchelor J.D. et al. [1990] Metamorphism, brecciation and shock of the eucrite association meteorites, Meteoritics, in press.