3023

PRE-BOMBARDMENT CRYSTALLIZATION AGES OF BASALTIC CLASTS FROM ANTARCTIC HOWARDITES EET87503 AND EET87513.

L.E. Nyquist, NASA Johnson Space Center, Houston, TX 77058; C.-Y. Shih, H. Wiesmann, and B.M. Bansal, Lockheed Engineering and Science Co., 2400 NASA Road 1, Houston, TX 77258.

Abstract: Igneous clasts of basaltic eucrites are found in both howardites and polymict eucrites. We have studied the Rb-Sr and Sm-Nd isotopic systematics of a number of such clasts, of metamorphic grades 1-6, using the classification of Takeda and Graham [1]. Here, we report Rb-Sr, ^{147}Sm-^{143}Nd, and ^{146}Sm-^{142}Nd studies of clast ,53 from Antarctic howardite EET87503. Although there is no evidence of disturbance of trace element systematics by Antarctic weathering [2], the Rb-Sr and conventional Sm-Nd isotopic sytematics are severely disturbed, which we ascribe to thermal metamorphism. The Ar-Ar age spectrum shows ages ranging from ~3.85-3.55 Ga in an unusual "down stairstep" [3]. The ^{146}Sm-^{142}Nd systematics, however, show the presence of live ^{146}Sm ($t_{1/2}$ = 103 Ma), with $^{146}Sm/^{144}Sm = 0.0061\pm0.0007$ at the time of crystallization. This result is very similar to that previously obtained for basaltic clast ,18 from howardite EET87513 (paired with EET87503), which has concordant Rb-Sr and Sm-Nd ages of ~4.5 Ga [4]. Thus, the two clasts are nearly the same age, and we conclude further that the EET87503,53 clast crystallized within 33±19 Ma of the LEW86010 angrite by comparing initial $^{146}Sm/^{144}Sm$ to that of the angrite [8,9]. We suggest that disturbances in the isotopic systematics of EET87503,53 are consanguineous with pyroxene homogenization.

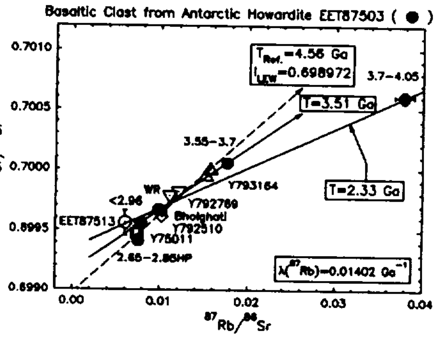

Figure 1. Rb-Sr data for whole rock and density-separated minerals of EET87503,53. Whole rock data for other eucrite clasts and matrix are shown for comparison.

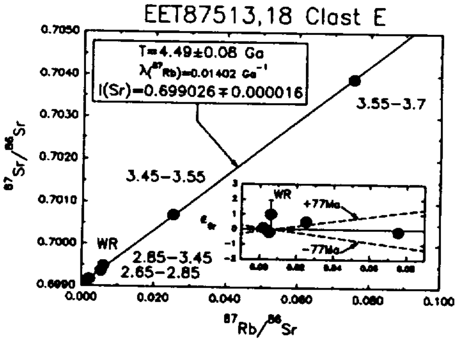

Figure 2. Rb-Sr isochron for density-separated minerals from EET87513,18 (clast E).

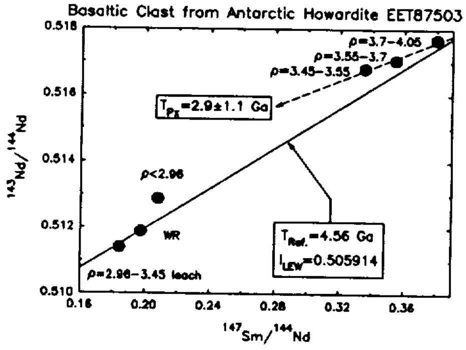

Figure 3. Sm-Nd isochron diagram for EET87503,53.

Rb-Sr Data: Rb-Sr data for EET87503,53 are shown in Fig.1. The whole rock (WR) data are typical of a number of eucrite clasts previously studied in our laboratory, and of eucrites in general. The Rb-Sr systematics of mineral phases also are similar to those of the "large" eucrite clast from the Bholghati howardite [5] except for unusually low Sr in plagioclase-enriched separates. However, they are spectacularly different from those of EET87513,18 (Fig. 2). The Rb-Sr data for EET87503,53 suggest an isotopic disturbance ~2.3-3.5 Ga ago, whereas the EET87513,18 data determine a well-fit isochron corresponding to an age of 4.49±0.08 Ga. The Rb-Sr systematics of eucritic pyroxenes are commonly disturbed [6], and when apparently well defined Rb-Sr ages near ~4.56 Ga are found, they often rely on the presence of a highly radiogenic mesostasis. The pristine clast Y75011,84B is exceptional in having undisturbed Rb-Sr systematics for both pyroxenes and mesostasis [7].

Sm-Nd Data: Figure 3 shows the Sm-Nd data in a conventional Sm-Nd isochron diagram. The WR datum plots on a 4.56 Ga reference isochron for initial $^{143}Nd/^{144}Nd$ equal to that measured for the LEW86010 angrite [8,9], consistent with the absence of weathering disturbance. However, density-separated mineral phases plot distinctly off the reference isochron. All mineral phases were leached in 1 N HCl to remove phosphates, which, if present, could dominate the Sm-Nd systematics. The leachate of mixed mineral phases of intermediate density (2.96-3.45 g/cm^3)

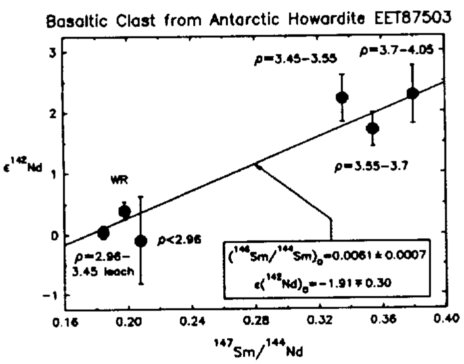

Figure 4. ^{146}Sm−^{142}Nd formation interval diagram.

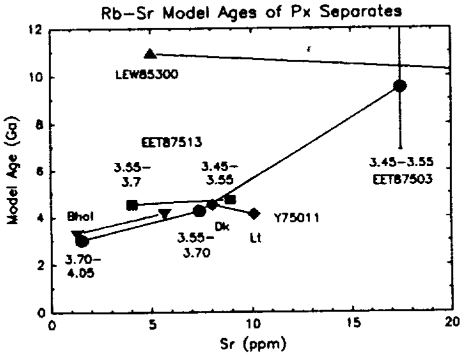

Figure 5. Rb−Sr model ages of pyroxene separates from basaltic clasts in howardites and polymict eucrites. Data from [4], [5], [7], and [10].

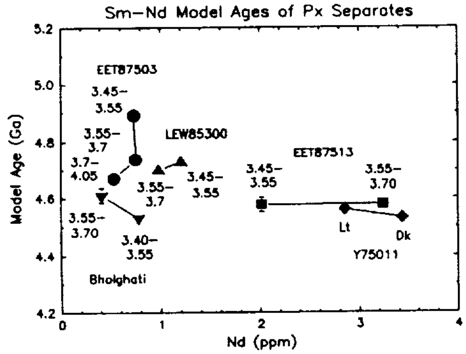

Figure 6. Sm−Nd model ages of pyroxene separates from basaltic clasts of howardites and polymict eucrites. Data from [4], [5], [7], and [10].

plots slightly below the reference isochron. The pyroxene separates progress from low to high density along a secondary isochron corresponding to an apparent age of 2.9±1.1 Ga, similar to that calculated from the Rb-Sr data of the WR and densest pyroxene (Fig. 1).

The ^{146}Sm-^{142}Nd systematics are shown in Fig. 4. In spite of disturbances in the conventional Sm-Nd systematics, these data define a line of slope corresponding to initial ^{146}Sm/^{144}Sm = 0.0061±0.0007, similar to 0.0066±0.0009 previously found for the EET87513,18 clast, establishing that the crystallization ages of the two basaltic clasts also are very similar.

Discussion: Why are the isotopic systematics of one howardite clast grossly disturbed, while those of another clast from a paired meteorite apparently undisturbed? We suggest the answer is linked to the differing degrees of pyroxene homogenization in the two clasts. Figure 5 summarizes Rb-Sr model ages, relative to initial $[^{87}Sr/^{86}Sr]_{LEW}$ = 0.69897 [8,9], of pyroxene separates from eucrite clasts analyzed in our laboratory; Figure 6 is an analogous summary of Sm-Nd model ages relative to initial $[^{143}Nd/^{144}Nd]_{LEW}$ =0.505914 [8,9]. Pyroxenes for each clast were separated by similar techniques, except for the Y75011 pyroxenes. The Y75011,84B clast is the least altered eucritic basalt and is classified as metamorphic grade 1 [1]. Clasts EET87513,18 and EET87503,53 are classified as grades 2-3 [11] and 5-6 [2], resp. For clasts of low metamorphic grade, the most Fe-rich, densest, pyroxene compositions are found at the rims of pyroxene grains, whereas clasts of high metamorphic grade are characterized by the presence of augite exsolution lamellae in host pigeonite or orthopyroxene of homogeneous composition [1]. Augite lamellae in EET87503,53 are ~10-20 μm wide and separated by ~60 μm [2]. Mineral separations were for material in the 44-74μm size range, thus, at least for this clast, significant fractionation of high- and low-Ca (high-and low-Sr) pyroxene should have been achieved. Both Rb-Sr and Sm-Nd model ages of the pyroxene separates from the two clasts of low metamorphic grade are ~4.5-4.6 Ga, i.e., the isotopic systematics of these clasts are undisturbed. However, the isotopic systematics of pyroxenes from clasts of high metamorphic grade in EET87503, Bholghati, and LEW85300 are disturbed, with low-density, Sr-rich, "pyroxene" separates having high Rb-Sr model ages, whereas high-density, Sr-poor "pyroxene" separates have low Rb-Sr model ages (Fig. 5). Less pronounced, but similar effects are shown by the Sm-Nd data (Fig. 6). We suggest trace element migration accompanied pyroxene exsolution and homogenization, presumably, during impact-related thermal metamorphism [1,7,12]. The ^{146}Sm-^{142}Nd systematics were little if at all affected, and preserve the pre-bombardment crystallization ages of the basalt clasts.

REFERENCES: [1] Takeda H. and Graham A.L. (1991) Meteoritics 26, 129–134. [2] D. Mittlefehldt, p. comm. [3] D. Bogard, p. comm. [4] Nyquist L.E. et al. (1992) LPS XXIII, 1009–1010. [5] Nyquist et al. (1990) GCA 54, 2195–2206. [6] Birck J.-L. and Allegre C.J. (1978) EPSL 39, 37–51. [7] Nyquist et al. (1986) JGR 91, 8137–8150. [8] Nyquist L.E. et al. (1991) LPS XXII, 989–990. [9] Nyquist L.E. et al. (1994) Meteoritics (submitted). [10] Nyquist L.E. et al. (1990) LPS XXI, 903–904. [11] P. Buchanan, p. comm. [12] Harlow G.E. and Klimentidis R. (1980) PLPSC 11, 1131–1143.