FORMATION AND IMPACT-METAMORPHIC AGES OF MONOMICT TYPE 6 EUCRITE Y792510.

L.E. Nyquist[1], H. Takeda[2], D. D. Bogard[1], B.M. Bansal[3], H. Wiesmann[3], and C.-Y. Shih[3], NASA Johnson Space Center, Houston, TX 77058; University of Tokyo, Hongo, Tokyo 113, Japan; Lockheed Engineering and Science Co., 2400 NASA Road 1, Houston, TX 77258.

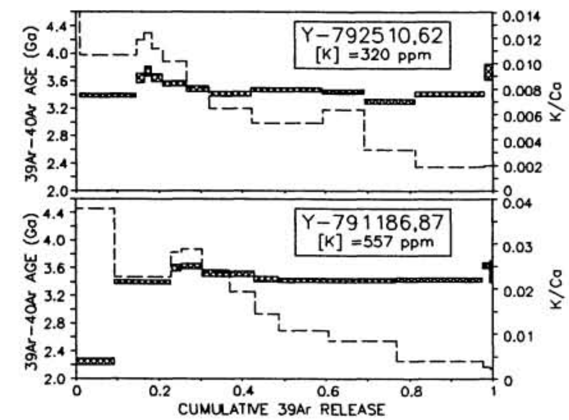

Figure 1. 39Ar-40Ar age spectra for Y792510,62 and paired eucrite Y-791186,87.

Abstract: Monomict eucrite Y792510 is a highly weathered specimen [1] of metamorphic grade 6, the highest on the Takeda-Graham scale [2]. Preliminary mineralogical and isotopic studies of clast Y792510,62 have been reported [3,4]. Nearly identical ^{39}Ar-^{40}Ar age spectra were found for Y792510,62 and for the paired eucrite Y791186 (Fig. 1). The age spectra are flat and give well-defined Ar-out-gassing ages of 3.45$\pm$0.05 Ga with almost no evidence of older ages. Rb-Sr and Sm-Nd ages of Y792510,62 were poorly defined, but indicated older ages up to ~4.4 Ga [4]. We report additional Rb-Sr and Sm-Nd isotopic studies of an interior clast Y792510,65. The new data confirm an old crystallization age for ,65 of 4.64$\pm$0.22 Ga by the ^{147}Sm-^{143}Nd technique and 4.45$\pm$0.03 Ga by the ^{146}Sm-^{142}Nd technique. The Rb-Sr data give a completely reset internal isochron age of 2.85$\pm$0.33 Ga. Whether the reset ages are related to the high metamorphic grade of Y792510 is presently unclear. The possibility of a causal relationship between chronometer resetting and the growth or presence of volumetrically significant augite exsolution lamellae deserves further investigation.

Rb-Sr Data: Rb-Sr data for Y792510,65 are compared to earlier data for Y792510,62 for samples of low Rb/Sr ratio in Fig. 2. Two samples of ,62 with densities <2.65 g/cm^3 ("trydymite") and >3.6 g/cm^3 ("ilmenite"), respectively, have higher Rb/Sr ratios and model ages of ~4.1 Ga and ~1.3 Ga, and are not shown in the figure. They were probably influenced by the ~3.45 Ga thermal event and/or Antarctic weathering [4]. Here we emphasize data for the major minerals, especially pyroxene. The data for pyroxene from ,62 (density 3.4-3.6 g/cm^3) are displaced to the left of a 4.56 Ga reference isochron, whereas both pyroxene samples from ,65 (densities 3.45-3.55 and 3.55-3.7 g/cm^3, resp.) are displaced to the right of the reference isochron, and with other subsamples of ,65 define an apparent age of 2.85$\pm$0.33 Ga. We attribute the ,62 pyroxene data to Rb-volatilization due to impact-generated heating locally exceeding ~800°C [5]. Clast ,65 apparently was locally closed to Rb-loss, so the time of thermal metamorphism was recorded through re-equilibration of the Sr-isotopic composition in the major mineral phases.

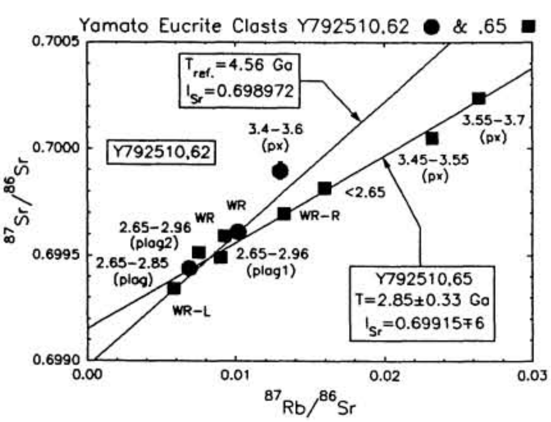

Figure 2. Rb-Sr isochron diagram for eucrite clasts Y792510,62 and Y792510,65.

Sm-Nd Data: Sm-Nd data for the two clasts are shown in a ^{147}Sm-^{143}Nd evolution diagram in Fig. 3. The pronounced difference in Sm/Nd ratio of the pyroxene separates is attributed to leaching the ,65 pyroxenes in 1N HCl prior to analysis, which removed a high-REE, low-Sm/Nd phase (phosphates and/or exterior grain surfaces). The Nd concentration measured for 3.4-3.6 g/cm^3 pyroxene of ,62 was twice that for the 3.45-3.55 g/cm^3 pyroxene of ,65, whereas the Sr concentration was ~30% less. This easily soluble phase was partially isotopically

FORMATION AND IMPACT-METAMORPHIC AGES OF Y792510: Nyquist L. E. et al.

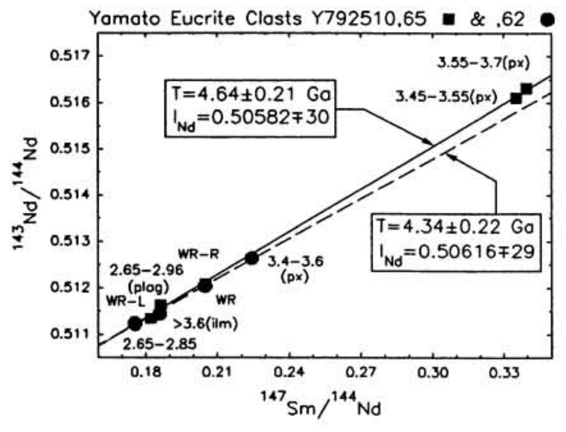

Figure 3. ^{147}Sm-^{143}Nd isochron diagram for eucrite clasts Y792510,62 and Y792510,65.

equilibrated by the late thermal event, since the apparent Sm-Nd age of the ,62 clast is 4.34$\pm$0.22 Ga. The apparent age of the ,65 clast is 4.64$\pm$0.21 Ga. The comparatively large uncertainties in these ages are due to "noise" in the low Sm/Nd data. There is an interesting complementarity between ages calculated from the leached- and unleached-pyroxenes for the two samples, with the suggestion that thermal metamorphism has slightly lowered the Sm/Nd ratio of pyroxene while raising that of adjacent easily soluble phases. Combining the data for both clasts gives an apparent age of 4.64$\pm$0.15 Ga, but this approach may be of doubtful validity.

Fig. 4 shows the Sm-Nd data for ,65 in a ^{146}Sm-^{142}Nd evolution diagram. (Precise $^{142}Nd/^{144}Nd$ measurements were not made for ,62.) These data define $^{146}Sm/^{144}Sm$ = 0.0039$\pm$0.0008, similar to values found previously for clasts from polymict eucrites and howardites [6]. Assuming $(^{146}Sm/^{144}Sm)_o$ = 0.008 for angrite clast LEW86010 [7] at 4558 Ma ago [8] leads to a formation interval of 107^{+34}_{-28} Ma, and a formation age of 4451^{+28}_{-34} Ma. This formation age is similar to that for LEW85300,55 and possibly the Bholghati clast [6] as determined by the ^{146}Sm-^{142}Nd technique, but appears to be slightly younger than that of the EET87513,18 and EET87503,53 clasts [9].

Conclusions: The utility of the ^{146}Sm-^{142}Nd method for determining reliable ages in the presence of impact-generated metamorphism severely affecting the other chronometers is again demonstrated. Values of initial $^{87}Sr/^{86}Sr$ calculated for the ,65 and ,62 clasts at the ^{146}Sm-^{142}Nd formation age are 0.698971$\pm$0.000059 and 0.698997$\pm$0.000031, consistent with initial $^{87}Sr/^{86}Sr$ found for angrites and other eucrites, but are relatively uncertain due to isotopic disturbance of the Rb-Sr system. There is as yet no evidence of differential evolution of $^{87}Sr/^{86}Sr$ in the source regions for eucritic basalts. Finally, there is a hint that the high degree of pyroxene metamorphism represented by the high metamorphic grade of Y792510 may be connected in some manner to the completeness of resetting of the Rb-Sr chronometer, and to the apparent partial resetting of the Sm-Nd chronometer. This connection may arise either through contemporaneity of impact metamorphism and chronometer resetting, or by facilitated isotopic equilibration of pyroxenes because of the presence of volumetrically significant high-Ca exsolution lamellae up to 10 µm in width in Type 6 eucrites.

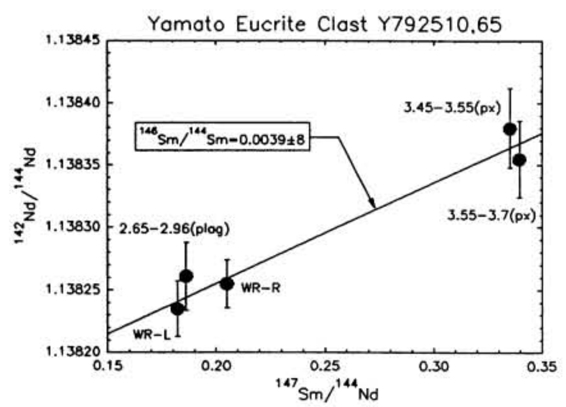

Figure 4. ^{146}Sm-^{142}Nd isochron diagram for eucrite clast Y792510,65.

REFERENCES: [1] Photog. Cat. Ant. Met. (1987) NIPR, p. 124. [2] Takeda H. and Graham A.L. (1991) *Meteoritics* **26**, 129-134. [3] Takeda H. et al. (1988) *Meteoritics* **23**, 304. [4] Nyquist L. et al. (1988) *Meteoritics* **23**, 295. [5] Nyquist L.E. et al. (1991) *LPS* **XXII**, 985-986. [6] Nyquist L.E. et al. (1992) *LPS* **XXIII**, 1009-1010. [7] Nyquist L.E. et al. (1994) *Meteoritics* **29**, 872-885. [8] Lugmair G.W. and Galer S.J.G. (1992) *GCA* **56**, 1673-1694. [9] Nyquist L.E. et al. (1994) *LPS* **XXV**, 1015-1016.