CRYSTALLIZATION, RECRYSTALLIZATION, AND IMPACT METAMORPHIC AGES OF MONOMICT EUCRITE Y792510; L.E. Nyquist[1], H. Takeda[2], D.D. Bogard[1], C.-Y. Shih[3], and H. Wiesmann[3]; [1]Code SN41, NASA Johnson Space Center, [2]Chiba Institute of Technology, 2-17-1 Tsudanuma, Narashino City, Chiba 275, Japan; Lockheed-Martin Engineering and Sciences Co., 2400 NASA Road 1, Houston, TX 77258.

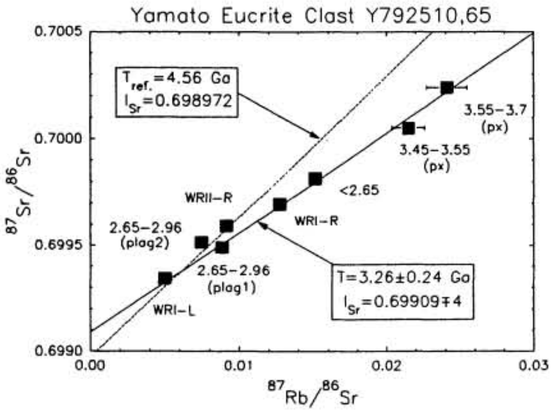

Figure 1. Rb-Sr isochron diagram for Y792510,65.

Y792510 is a monomict eucritic breccia of Takeda-Graham [1] metamorphic grade 6, the highest metamorphic grade. In a companion abstract [2], Y792510 is interpreted as a metamorphosed version of Y75011,84, a pristine, unmetamorphosed basalt clast in polymict eucrite Y75011. Y75011,84 is characterized by areas of dark glassy mesostasis. Interstitial areas in Y792510 texturally equivalent to mesostasis in Y75011,84 contain a recrystallized mineral assemblage. Homogenized pyroxenes contain augite exsolution lamellae up to ~8μm in width. Additionally, Y792510 contains granoblastic augite and K-, Na-rich inclusions in plagioclase [2]. For Y75011,84 concordant Rb-Sr and Sm-Nd ages of ~4.5 Ga [3] and an ^{39}Ar-^{40}Ar age of ~4.0 Ga [4] are easily interpreted as giving the times of crystallization and impact-related Ar-outgassing, respectively. ^{39}Ar-^{40}Ar ages of subsamples ,62 and ,65 of Y792510 are 3.40±0.16 and 3.60±0.04 Ga (2σ), respectively, and also record late impact metamorphism. However, the Rb-Sr age of Y792510,65 is only 3.26±0.24 Ga (2σ, revised from [5]). It probably records impact metamorphism also, because it is determined by the Sr-isotopic composition of apatite and pyroxene, minor Sr reservoirs in this eucrite. A conventional ^{147}Sm-^{143}Nd age of 4.56±0.06 Ga (2σ) is determined from the Sm-Nd data of the same minerals, which are major reservoirs of REE, but the Sm-Nd systematics of other mineral phases are disturbed. The ^{146}Sm-^{142}Nd formation interval of Y792510 relative to angrite LEW86010 is 99±30 Ma [5]. New Mn-Cr isotopic data of several samples of Y792510,65 show excesses of ^{53}Cr relative to a terrestrial standard. An ilmenite-enriched sample with the highest Mn/Cr ratio also has the greatest ^{53}Cr excess. Although the Mn-Cr data do not rigorously define an isochron, they confirm crystallization of Y792510 occured within a few million years of solar system formation. We identify the ^{146}Sm-^{142}Nd formation interval with pyroxene homogenization, or possibly mesostasis recrystallization, since the latter appears to post-date the former. Impact metamorphism ~3.5 Ga ago is recorded in the most easily reset radiometric systems and mineral phases.

Ar-Ar and Rb-Sr Data: Ar-Ar data for Y792510,62 and Y791186,87, paired with Y792510 [6], were presented previously [5]. Their Ar-Ar ages average 3.43±0.10 Ga (2σ). New data for Y792510,65 give an Ar-Ar age of 3.60±0.04 Ga (2σ) for this subsample. These data suggest two different impact events, assuming that radiogenic Ar was completely outgassed during impact metamorphism. The Rb-Sr data of Y792510,65 (Fig. 1, revised from [5]) define an isochron age of 3.26±0.24 Ga (2σ). Within the uncertainties in the methods, it is possible that the Ar-Ar and Rb-Sr ages were determined by a single event ~3.5 Ga ago. The data clearly indicate that impact-related metamorphism can cause Sr-isotopic equilibration. The Rb-Sr isochron age is determined by data for a whole rock leach (mostly mesostasis-derived apatite), a sample of density <2.65 g/cm^3 (probably mostly mesostasis-derived silica), and two pyroxene separates of density 3.45-3.55 and 3.55-3.7 g/cm^3, respectively. The Rb/Sr ratios of the plagioclase separates (2.65-2.96 g/cm^3) were higher than expected, apparently due to inclusions of pyroxene and K-, Na-rich feldspar [2].

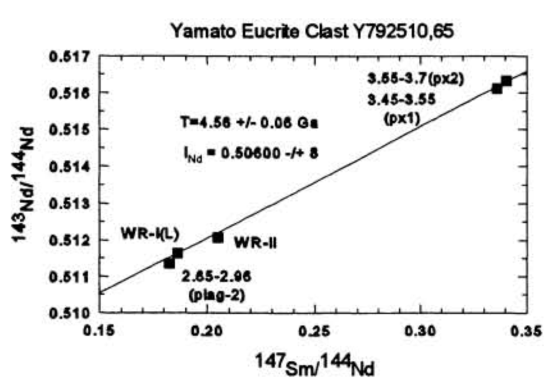

Figure 2. Sm-Nd isochron diagram for Y792510,65.

Because the Rb-Sr isochron age is determined by pyroxene and mesostasis-derived phases, it may be associated with pyroxene homogenization and mesostasis recrystallization. Alternative interpretations which decouple isotopic equilibration from observable mineralogical and textural effects also may be permitted because the minerals which most influence the isochron age contribute only a minor fraction of the total Sr inventory, and would be easily affected by Sr migration.

Sm-Nd Data: Fig. 2 (revised from [5]) shows the ^{147}Sm-^{143}Nd data for Y792510,65 with a 4.56±0.06 Ga (2σ) isochron fit to the WR-I(L) (apatite) and pyroxene data. Data for the WR-II and Plag-2 samples (2.65-2.96 g/cm^3) are omitted from the fit because they are unleached and are susceptible to contamination and/or Antarctic weathering. Such effects would be minimized for the pyroxene (leached) and apatite (high REE concentration) samples. An isochron fitted to all the data gives an apparent age of 4.64±0.21 Ga (2σ) [5]. $^{142}Nd/^{144}Nd$ data give $^{146}Sm/^{144}Sm$ = 0.0039±0.0008 [5] at the time when pyroxene closed to Nd-isotopic equilibration. This value is lower than for the LEW86010 angrite [7,8], and for most eucrites studied in previous investigations. Consequently, it suggests either "late" crystallization of Y792510, or post-crystallization equilibration of the Nd-isotopic composition before complete decay of ^{146}Sm ($t_{1/2}$ = 103 Ma). The uncertainties in the Sm-Nd data do not allow these two possibilities to be distinguished.

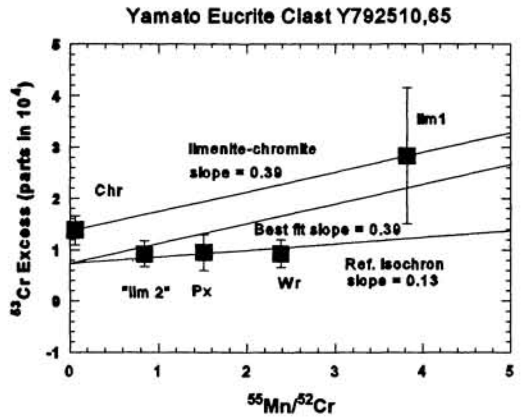

Figure 3. Mn-Cr data for Y792510,65.

Mn-Cr Data: To resolve the ambiguity in crystallization age, Cr-isotopic analyses were made for a bulk sample and several mineral separates of Y792510,65. Mn and Cr concentrations were measured by graphite furnace atomic absorption spectrometry. The results are shown in Fig. 3. Ilm1 is the second step (12N HCl) of a selective dissolution of the >3.7 g/cm^3 density fraction, and is ilmenite-enriched. Chromite (chr) is the insoluble residue of this procedure. The first leach step (2N HCl) was enriched in troilite, had a high $^{55}Mn/^{52}Cr$ ratio (~14), but contained insufficient Cr for precise isotopic analysis. Ilm2 is a 12N HCl leach of the 3.55-3.7 g/cm^3 fraction without an initial 2N HCl leach; px was the residue. Data for the bulk (Wr), px, and ilm2 samples are consistent with a reference isochron slope of 0.13, as found for LEW86010 [7]. Both ilm1 and chr were more enriched in radiogenic ^{53}Cr than the other samples, so the combined data do not define an isochron. However, it may be significant that the slope of the best fit line through all the data is similar to the slope of the ilmenite (ilm1)-chromite tie line, and corresponds to an initial $^{53}Mn/^{55}Mn$ ratio of ~4.4×10^{-6}, similar to the value of ~3.6×10^{-6} for Chervony Kut [9].

Conclusions: Although the Mn-Cr data do not preserve an isochron relationship, they are consistent with the presence of live ^{53}Mn ($t_{1/2}$ = 3.7 Ma) during initial crystallization of Y792510. Their failure to define an isochron may be due to redistribution of radiogenic ^{53}Cr during recrystallization of the mesostasis and granoblastic areas. Mn is presently enriched in several mesostasis minerals relative to Cr, probably due to preferential incorporation of Cr into pyroxene during initial crystallization. Radiogenic ^{53}Cr subsequently produced in the original glassy mesostasis would be partitioned during recrystallization into newly formed host phases like ilmenite. High Mn/Cr ratios in such phases probably were changed during recrystallization, disturbing any pre-existing isochron relationship. The addition of radiogenic ^{53}Cr to phases with low Mn/Cr like chromite (produced in the granoblastic areas) would cause $^{53}Cr/^{52}Cr$ to plot above an original isochron as in Fig. 3. This explanation is consistent with the textural observations, since mesostasis recrystallization apparently post-dated pyroxene homogenization [2], and both probably occurred after complete decay of ^{53}Mn. Because the short-lived ^{146}Sm-^{142}Nd chronometer is likely to be reset by pyroxene homogenization, one interpretation, which we prefer, is that pyroxene homogenization occurred when $^{146}Sm/^{144}Sm$ was ~0.0039, i.e., 99±30 Ma after crystallization of the LEW86010 angrite. Because of the textural relations, recrystallization accompanied by formation of areas of granoblastic augite is inferred to have occurred later [2]. In this case it seems likely that recrystallization would have occurred at the time given by the Ar-Ar and Rb-Sr ages. Alternatively, recrystallization involving Ca migration also may have reset the ^{146}Sm-^{142}Nd chronometer, in which case pyroxene homogenization would have occurred even earlier. This possibility and possible heat sources for early processes on the parent body (Vesta?) are discussed mor extensively by [2].

REFERENCES: [1] Takeda H. and Graham A.L. (1991) *Meteoritics* **26,** 129-134. [2]Takeda H. et al., this volume. [3] Nyquist L.E., et al. (1986) *J. Geophys. Res.* **91,** 8137-8150. [4] Takeda H., et al. (1994) *EPSL* **122,** 183-194. [5] Nyquist L.E., et al. (1995) *LPS* **XXVI,** 1063-1064. [6]Nagao K. and Ogata A. (1989) *Mass Spectroscopy* **37,** 313-324. [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] Lugmair G.W., et al. (1994) *LPS* **XXV,** 813-814.