RB-SR AND ^{40}AR-^{39}AR SYSTEMATICS OF THE ESTHERVILLE MESOSIDERITE

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In an earlier paper (1) the Rb-Sr internal isochron age (T) and the initial $^{87}Sr/^{86}Sr$ (I_{EST}) for the Estherville mesosiderite were shown to be 4.35±0.10 AE (2σ) and 0.69905±2 (2σ) respectively. With the new ^{87}Rb decay constant of 1.42×10^{-11} yr^{-1}, T is 4.26±0.10 AE (2σ). We report here additional studies of the Rb-Sr and ^{40}Ar-^{39}Ar isotopic systematics for this meteorite. The ^{40}Ar-^{39}Ar studies were on aliquots of samples used in the earlier Rb-Sr study; new Rb-Sr data include analyses of plagioclase and a mesostasis phase from a separate portion of the slab of Estherville. 4.3 mg of the mesostasis phase showed a Rb/Sr enrichment of 60 times relative to plagioclase and highly radiogenic $^{87}Sr/^{86}Sr \sim 0.713$. The present data together with results reported earlier allow a very precise definition of T = 4.24 ± 0.03 AE (2σ), and I_{EST} = 0.69904±2 (2σ) for this mesosiderite (Fig. 1).

The I_{EST} is identical to BABI when adjusted for interlaboratory bias. In the discussion below all Sr-isotopic measurements made in our laboratory are adjusted by -0.00006 to compare our data with CIT data (2). The Rb/Sr ratio in orthopyroxene suggests that the mesosiderite parent body (MSP) is an extremely Rb-poor early planetary body; $[Rb/Sr]_{MSP} \lesssim 0.005$. I_{MSP} is thus $\gtrsim$ 0.69894 if the MSP formed at 4.5 AE ago and differentiated at 4.3 AE ago. The evolution of the I values of Estherville and the MSP from the primitive I of the Allende meteorite must have occured in the solar nebula over a period of ∼ 9 m.y. I_{EST} could not have evolved in a condensed body, such as MSP, if T represents a lower limit to the age of this meteorite.

Stepwise heating ^{40}Ar-^{39}Ar data have been obtained from a plagioclase separate and from a "whole rock" sample (actually a sample of the silicate fraction without metal and troilite) of Estherville. The interpretation of these data are complicated by the presence of a third order, but non-trivial, trapped Ar component. Most of the ^{36}Ar and ^{38}Ar measured in the samples are spallogenic with $[^{36}Ar_{sp}/^{36}Ar]_{meas}$ ranging from 0.97 to 0.69 in the plagioclase and 0.97 to 0.31 in the whole rock sample. The errors associated with subtracting the major spallation component inevitably lead to large uncertainties in the residual trapped component.

Assuming the trapped component to be of terrestrial atmospheric composition, both the plagioclase and whole rock samples yield age spectra which start at ∿3.5 AE and rise smoothly, with no obvious plateau, to ∿ 4.5 AE. The 900 through 1300°C fractions of the plagioclase data (which contain 56% of the total ^{39}Ar) define a linear array in a $^{40}Ar/^{36}Ar$ versus $^{40}K/^{36}Ar_{tr}$ diagram. The slope of the linear array corresponds to an age of 3.550±0.096 AE ($\lambda^{40} = 5.543 \times 10^{-10}$/yr) and the intercept corresponds to a trapped $^{40}Ar/^{36}Ar$ ratio of 443±37. The use of that trapped $^{40}Ar/^{36}Ar$ value for the whole rock data results in negative ages for the 500°, 600°, and 1000°C fractions. There is no trapped composition which will result in a ^{40}Ar-^{39}Ar age which agrees with the very precise Rb/Sr age.

The $^{38}Ar_{sp}/^{37}Ar$ ratio is remarkably constant in the plagioclase data set and correspond to an exposure age of ∿80 M.y. using the production rate for ^{38}Ar given in (3). The $^{38}Ar_{sp}/^{37}Ar$ ratios in the whole rock data agree with the plagioclase data at low temperatures. This effect may be due to the influence of additional target elements in the nonplagioclase phases and/or to possible contributions from neutron capture reactions on ^{37}Cl in the reactor. The cosmic ray exposure age presumably dates the final disruption of the parent body which produced the meter scale Estherville object.

We, therefore, interpret our results as recording three different events in the history of this meteorite. The well-defined event at 4.24±0.03 AE which set the Rb-Sr clock, a poorly defined event at ∿3.6 AE which partially reset the K/Ar clock, and the final breakup at ∿80 M.y.

The complex thermal history inferred from the ^{40}Ar-^{39}Ar systematics and the highly brecciated nature of this mesosiderite makes the interpretation of the Rb-Sr internal isochron age somewhat ambiguous. The age is controlled by the mesostasis phase. If the age refers to the crystallization of the mesostasis as a late-stage residual material in the parent body that melted at ∿4.5 AE ago, the radius of the parent body can be inferred to be in the

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range of 200-400 Km. Alternatively, the age may refer to the time of intense brecciation when the Rb-Sr isotopic system in the mesostasis has been reset.

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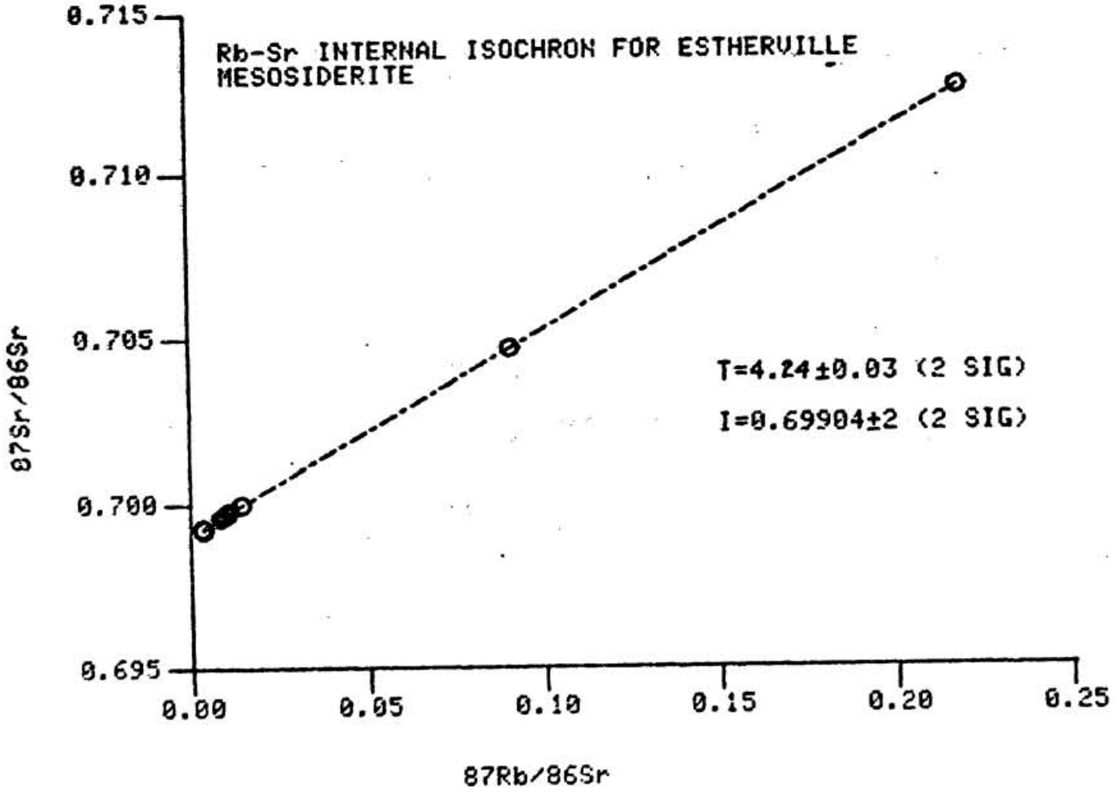

Fig. 1. Rb-Sr internal isochron for the Estherville mesosiderite.