I-XE AGES OF INDIVIDUAL BJURBOLE CHONDRULES,

Caffee M.W., Hohenberg C.M., Hudson B. and Swindle T.D., McDonnell Center for the Space Sciences and Department of Physics, Washington University, St. Louis, MO 63130 USA.

Relative formation ages for individual chondrules from the Bjurbole meteorite have been determined by I-Xe methods. The chondrules, ranging in size from a few mg to a few tens of mg, along with 47 mg of "whole rock" were sealed in a single quartz vial and irradiated at the University of Missouri Research Reactor (designated the SLC-6 irradiation). The irradiation container was water flooded to minimize thermal problems and constantly rotated to minimize flux gradients. After irradiation the xenon was extracted in stepwise heating and analyzed statically in an ion-counting mass spectrometer system (1). Extraction temperatures refer to the coil only, as determined with an optical pyrometer, and consequently significantly overstate the true temperature of the sample. Isotopic data obtained for the chondrules, and for "whole rock" Bjurbole, irradiated simultaneously, are shown in Figs. 1-5. Error limits rarely exceed the symbol size. Where the limits are visible the correlated uncertainties [2] sometimes result in non-orthogonal error bars.

As is usual in I-Xe systematics these samples released neutron-produced ^{128}Xe in the lower temperature fractions that was uncorrelated with the natural radiogenic ^{129}Xe, indicating prior loss of xenon from these sites (or superficial iodine contamination). Xenon released above 1300 C in all samples contained ^{128}Xe in constant proportion with the ^{129}Xe, as evidenced by the conventional linear I-Xe "isochron." Figure 1 displays the high temperature (correlated) data for all the samples run in a plot of ^{129}Xe/^{132}Xe versus ^{128}Xe/^{132}Xe. Note here the span covered by the 35 data points and the expanded insert showing data for the whole rock sample. Excepting the uppermost point the data all appear to lie on a single straight line. In the conventional I-Xe interpretation such a linear array suggests two-component mixing between a common trapped component and a single radiogenic component of constant ^{128}Xe/^{129}Xe ratio. This implies that a constant ratio of 17 m.y. ^{129}I and stable ^{127}I must have characterized all of the mineral sites represented here. That is, all of these objects must have begun retaining xenon at the same time with a precision given by the quality of fit to the single straight line shown in Fig. 1.

This interpretation is misleading, however, because Fig. 1 does not display the data in the most illuminating manner. Figure 2 shows data for the correlated release of pile-produced ^{128}Xe and radiogenic ^{129}Xe in a graph of ^{128}Xe/^{129}Xe versus ^{132}Xe/^{129}Xe for two different Bjurbole chondrules. Here the radiogenic component lies at the ordinate intercept and the trapped component to the lower right. Two component mixing is evidenced by linear arrays between these two end members with the chronometrically meaningful parameter (the ^{128}Xe/^{129}Xe ratio of the radiogenic component) provided by the intercept. This ratio is directly proportional to the ^{127}I/^{129}I ratio at xenon retention (the neutron capture ratio being the constant of proportionality). The advantage over Fig. 1 can be seen in the clearly resolved difference in the radiogenic components of these two chondrules. The usual interpretation of I-Xe dating is that the two chondrules began with the same iodine isotopic composition but chondrule 1 began the quantitative retention of xenon 1.8 m.y. before chondrule 2, although the initial iodine composition could as well have been affected by local isotopic inhomogeneities in the solar system.

Figure 3 shows the whole rock isochron, which is also indicated in Fig. 2 (dashed line). The trapped component T was computed by adjusting ^{129}Xe in AVCC to fall on this line, giving a ^{129}Xe/^{132}Xe ratio of 1.045. As evidenced by the different intercepts, three different formation times are indicated. The whole rock sample postdates chondrule 1 by 920,000 years but predates chondrule 2 by about the same amount. Data for chondrule 3 (not shown) show somewhat more scatter but are bounded by the whole rock and chondrule 2 isochrons. The story becomes more complex, however, when chondrules 4 and 5 are considered. Figure 4 shows the data for chondrule 4 (open circles) and chondrule 5 (filled circles) along with the three isochrons previously determined. It is interesting to note that while neither chondrule forms a convincing linear isochron all the data points lie on two of the existing isochrons. Moreover, the release pattern for chondrule 4 (Fig. 5) shows a distinctly bimodal behavior, with all of the radiogenic ^{129}Xe released from the first phase contemporaneous with chondrule 1. The more refractory phase released nearly pure radiogenic xenon of constant isotopic composition corresponding to an initial ^{129}I/^{127}I ratio identical to that of the whole rock (hatched area of Fig. 5 and two superimposed points in Fig. 4 lying on the whole rock line). Nearly two thirds of the total radiogenic ^{129}Xe was released in the 1600 C fraction, suggesting that this second release peak corresponds to the melting of a single major iodine-bearing phase. Chondrule 5 follows the same pattern in that the point lying on the lower line (chondrule 1 isochron) is the low (1400 C) temperature fraction and the higher temperature fractions (1500, 1600 and 1700 C) lie on the whole rock isochron.

It is apparent that the individual chondrules of Bjurbole must be considered as individual samples of the primitive solar system, each preserving its own individual isotopic record. I-Xe formation ages can be obtained for these objects with a precision of about 100,000 yr. At least three distinct iodine isotopic compositions are evident among the six samples examined in this initial study. If these differences are due to differences in the xenon retention times, some of the chondrules predate the matrix and some postdate it, indicating that the apparent I-Xe formation time of the matrix is not the compaction time of the meteorite.

REFERENCES: 1) Hohenberg C.M. (1980) Rev. Sci. Instrum. 51, 1075. 2) Hudson G.B. (1981) Ph.D. Thesis, Washington Univ., St. Louis, 3) Hohenberg C.M. and Kennedy B.M. (1981) Geochim. Cosmochim. Acta 45, 251.

I-Xe AGES OF CHONDRULES

Caffee M., et al.

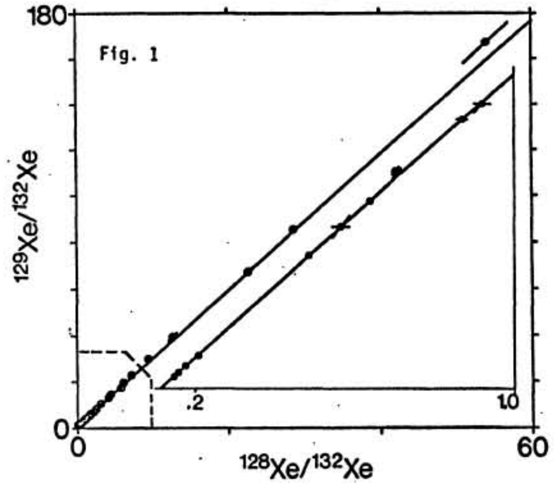
Fig. 1

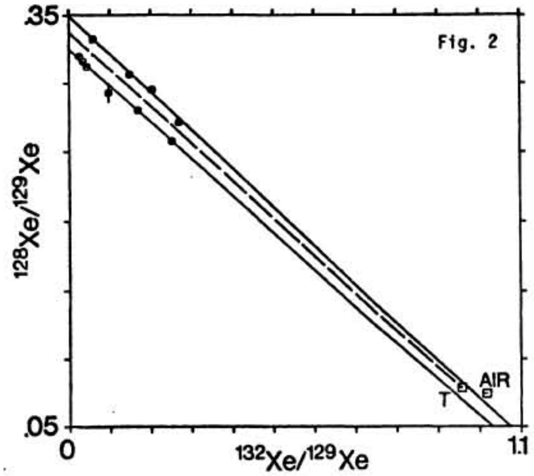
Fig. 2

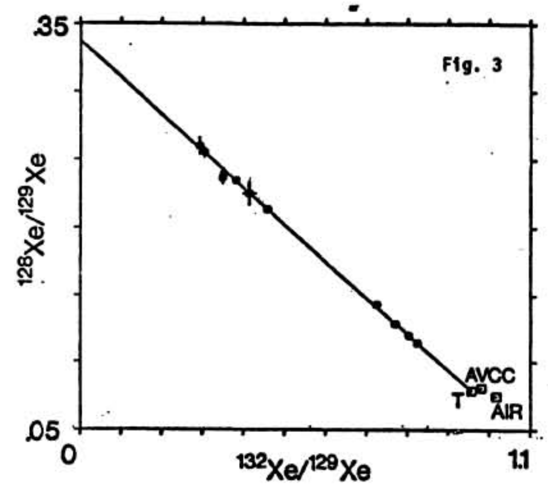
Fig. 3

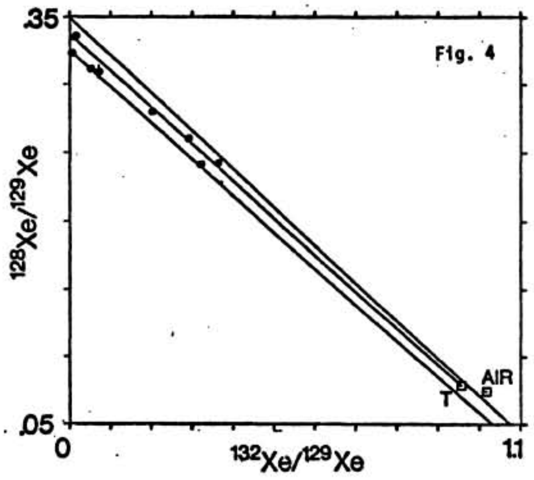
Fig. 4

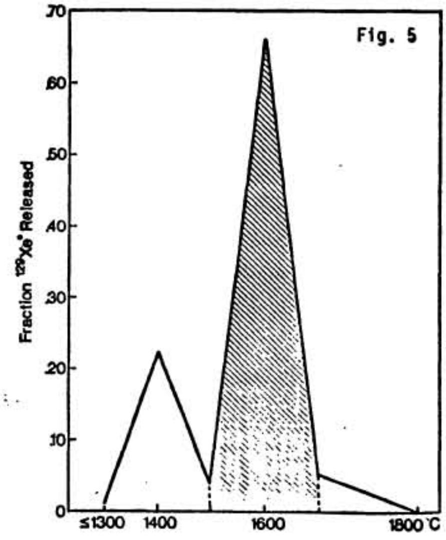
Fig. 5

TABLE 1

Sample	Wt.	[132]	[129*]	$\frac{^{129}Xe^*}{^{128}Xe^*}$	ΔT
Whole Rock	47.5	564.	226.	2.967 .016	≡ 0
Chondrule 1	13.3	31.	268.	3.078 .014	− 0.92
Chondrule 2	58.2	18.	84.	2.862 .021	+ 0.90
Chondrule 3	16.6	25.	90.	2.97^a .04	∼ 0^a
Chondrule 4	16.1	6.2	424.	b	b
Chondrule 5	17.5	30.	71.	b	b

Sample weights are given in mg; gas contents in units of 10^{-12}cc STP/g; and ΔT (age relative to whole rock) in m.y.

a) Isochron for chondrule 3 is not well defined, but consistent with the whole rock age.

b) Two different radiogenic components are suggested, one similar to the whole rock and one similar to chondrule 1 (see text).