I-Xe DATING OF INCLUSIONS FROM IAB IRON METEORITES. S. Niemeyer,
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The iron meteorites have been resolved into a number of distinct genetic
groups via Ge- and Ga-Ni systematics (1). Meteorites in the two groups IAB
and IIE contain chondritic silicate inclusions and are believed to have formed
non-ignobly; the IAB meteorites in particular seem to have accreted as solids
after metal-silicate fractionation in the solar nebula. We have attempted to
define the time scale for the fractionation process which produced the large
variations in the concentrations of some of the siderophile elements by I-Xe
dating (2) of four IAB iron meteorites and one (Mundrabilla) anomalous IAB
meteorite. We report now on I-Xe analyses of samples composed primarily of
silicate which were extracted from all five IAB meteorites, and on troilite
samples from two of these meteorites (representing the first attempted I-Xe
dating of this mineral). Some of the preliminary results are shown in Table 1.

Ages are given relative to Bjurböle, using the convention that a negative age
indicates formation prior to Bjurböle. The errors on the ages do not include
the normalization error. The flux calibration was provided by analyses of
Bjurböle, St. Severin, and a KI salt. Unfortunately the mediocre correlations
obtained for both meteorites yielded rather discrepant values for the neutron
flux. The KI analysis provided an intermediate flux value, so a simple average
of all three calibrations has been used, and an additional error of 2.5 m.y.
should be included when the listed ages are compared to samples separately
irradiated. The four silicate analyses which provided good high-temperature
correlation lines fall within a narrow 6 m.y. age range. The oldest IAB meteorite
studied has an age similar to carbonaceous chondrite magnetite (3), and the
younger IAB irons are contemporaneous with the older stone chondrites (2).

The trapped $^{129}Xe/^{132}Xe$ ratios for the most part fall in the range defined by
the stone chondrites. The outstanding exception is Landes where the deviation
from the solar ratio is almost an order of magnitude greater than the highest
ratio previously reported. This indicates that the history of Landes is unique
in some way. The amounts of trapped Xe are similar, excluding perhaps Pitts,
and are consistent with the Xe concentrations found for the ordinary
chondrites.

One of the primary objectives of this study was to investigate whether the
ages of the silicate inclusions correlated with the fractionation sequence
found in Ga, Ge, and Ni of the metal phase. Figure 1 is a plot of the Ni-
content of the metal phase vs. the I-Xe age of the silicate inclusion. The
points representing the four IAB samples with well-defined ages define a con-
vincing correlation. This is the first instance of a systematic relationship
between any property of a meteorite class and the I-Xe ages—the stone chon-
drites fail to show such a relationship. The only previously analyzed IAB
meteorite, El Taco (3), lies just within 1$\sigma$ of this correlation, but the error
is quite large due to the uncertainty in the flux calibration. At the present
time we interpret the correlation between the Ni content and the silicate age
as a real effect which provides new constraints on the history of the IAB
class. The extremely good correlation over a narrow age range rules out previ-
ous proposals that involved implanting old silicates into relatively much
younger Fe-Ni bodies. It seems quite improbable that the metal and silicate
I-Xe DATING OF IRON METEORITES

S. Niemeyer

Phases in these meteorites could have formed at much different times and/or nebular regions and still recorded such a correlation. We also note that this observed correlation provides support for the implicit assumption of isotopic homogeneity for iodine, at least for the region in which these meteorites formed. This is especially important in light of the increasing evidence for some isotopic inhomogeneity in the early solar nebula.

The analyses of Pitts silicate have not been included in the above discussion because of the absence of conventional high-temperature correlation lines. The first Pitts silicate sample was obtained using physical methods only, i.e. acids were not used to destroy other phases. The "etched" Pitts silicate was obtained by a density separation in Clerici solution and subsequent treatment in hot HCl and HNO3. The unetched sample defined a good line for the five temperature steps between 1100°C and 1375°C, in which about 80% of the trapped Xe was released, but the steps above 1375°C lie well above (i.e. high $^{129}$Xe/$^{133}$Xe) this line. The etched silicate is strikingly different: the steps between 1000°C and 1350°C define a good line with a significantly greater slope; the trapped gas content was drastically reduced by the treatment while the amounts of excess $^{128}$Xe and $^{129}$Xe were not greatly affected. In both samples, though, the higher temperature points lie above the intermediate-temperature correlation line. These anomalous points may be explained in two ways: presence of at least two different mineral assemblages which have different ages (one of which is older than the ages defined by the intermediate temperature lines), or alternatively, presence of a component which has a very high $^{129}$Xe/$^{133}$Xe ratio with relatively little $^{127}$I (stardust?). In any case, the presence of these anomalous points and the differing results for the two samples make it precarious to ascribe chronological significance to the Pitts silicate analyses.

Silicate from one other meteorite, Mundrabilla, was also treated in acids, and the analysis revealed a striking pattern in which all the points except the first at 600°C lie on the correlation line. This is the first instance of an I-Xe analysis in which essentially all (99.7%) of the $^{128}$Xe is correlated with $^{129}$Xe. In this case we can certainly rule out the disconcerting possibility that in some way the outgassing at low temperatures of uncorrelated $^{128}$Xe may have affected the correlation line. Yet this sample participates in the Ni-age correlation so most likely the other three silicate correlation lines are similarly unaffected by the uncorrelated $^{128}$Xe. Possibly the high degree of correlation for Mundrabilla was partially due to the treatment in acids which may have removed $^{127}$I not associated with excess $^{129}$Xe.

We attempted to test in a more direct manner the relationship between the metal and silicate by dating troilite and silicate from the same meteorite; presumably the troilite postdates the metal since the troilite usually appears to have formed in situ. The Mundrabilla troilite temperature steps above 900°C define a very good line; and the troilite appears to be associated with the correlation line since the bulk of the troilite decomposed at 1050°C and the 1000°C and 1050°C steps contained the greatest amounts of Xe. Nevertheless, the corresponding age requires that the troilite formed about 12 m.y. before silicate from the same meteorite, an unexpected result. One possible important source of error is the production of $^{129}$Xe from neutron capture by $^{128}$Te during
I-Xe DATING OF IRON METEORITES

S. Niemeyer

irradiation in space, an effect which should be larger in Mundrabilla than in most other meteorites (4). The possible extent of this interference was monitored by a stepwise heating of an aliquot of unirradiated Mundrabilla troilite. We estimated the extent of this interference by the following procedure: the difference between the natural neutron energy spectrum and that employed in the reactor was estimated from the relative amounts of excess $^{129}\text{Xe}$ and $^{131}\text{Xe}$ in the irradiated and unirradiated samples. We then calculated a production ratio for $^{131}\text{Xe}/^{132}\text{Xe}$ of $\sim 1.3$, which taken with the unirradiated sample data, allows an estimate of the total amount of interference $^{129}\text{Xe}$. This amount is then partitioned among the temperature steps of the irradiated sample by means of the measured $^{131}\text{Xe}/^{132}\text{Xe}$ ratios. The data thus corrected defines a fairly good correlation line above 900°C yielding an age about 2 m.y. younger than the age listed in Table 1 for the uncorrected data. We now believe, with minor reservations, that the troilite is 10-12 m.y. older than the silicate, but we do not at this time propose an explanation for this surprising result.

Pitts troilite was also analyzed, but it did not yield a good correlation line; indeed the data may define two different lines. Since the 950, 1000, and 1050°C points best define a line, we have listed the corresponding age in Table 1. Due to the anomalous results for the Pitts silicate samples, we cannot clearly define an age difference between the silicate and troilite. It seems fairly evident, though, that the troilite is younger than one of the phases in the silicate samples. We note that in contrast to Mundrabilla troilite, which shows evidence for only light shock, Pitts troilite has suffered enormously from shock (5) which may account for its relatively much younger age.

References:

Table 1. Xenon data for IAB iron meteorites*  

<table>
<thead>
<tr>
<th>Sample</th>
<th>Relative Age</th>
<th>$^{129}\text{Xe}/^{132}\text{Xe} \times 10^{-15}$ cm$^3$/g</th>
</tr>
</thead>
<tbody>
<tr>
<td>Landes silticate</td>
<td>$+2.4 \pm 0.4$</td>
<td>$3.60 \pm 0.4$</td>
</tr>
<tr>
<td>Copiapo s.</td>
<td>$+1.0 \pm 0.6$</td>
<td>$0.86 \pm 0.10$</td>
</tr>
<tr>
<td>Mundrabilla s.</td>
<td>$-0.3 \pm 0.4$</td>
<td>$1.30 \pm 0.12$</td>
</tr>
<tr>
<td>Woodbine s.</td>
<td>$-3.7 \pm 0.3$</td>
<td>$1.23 \pm 0.06$</td>
</tr>
<tr>
<td>Pitts s.</td>
<td>$(-0.6 \pm 0.2)$</td>
<td>$1.10 \pm 0.02$</td>
</tr>
<tr>
<td>&quot;Etched&quot; Pitts s.</td>
<td>$(-2.4 \pm 0.6)$</td>
<td>$1.05 \pm 0.04$</td>
</tr>
<tr>
<td>Pitts troilite</td>
<td>$+17.4 \pm 2.5$</td>
<td>$1.01 \pm 0.02$</td>
</tr>
<tr>
<td>Mundrabilla tr.</td>
<td>$-12.3 \pm 0.5$</td>
<td>$0.96 \pm 0.01$</td>
</tr>
<tr>
<td>Pitts troilite</td>
<td>$-17.4 \pm 2.5$</td>
<td>$1.01 \pm 0.02$</td>
</tr>
</tbody>
</table>

*Relative ages are with respect to Bjurböle (20). The absolute flux calibration error is not included in the listed errors. Amounts of $^{132}\text{Xe}$ have relative lo errors of -5%, and absolute amounts require an additional error of 10%.

The ages for the Pitts samples in parentheses are defined by intermediate temperature correlation lines which do not have true chronological significance (see text).

†Trapped $^{129}\text{Xe}/^{131}\text{Xe}$ ratios are determined assuming the AVCC ratio for trapped $^{129}\text{Xe}/^{131}\text{Xe}$ except for samples marked by † for which air composition is used.

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