

**NOBLE GAS CHARACTERISTICS OF INTERSTELLAR DIAMONDS AS A FUNCTION OF METEORITE CLASS AND THERMAL HISTORY.** Gary R. Huss and Roy S. Lewis, Enrico Fermi Institute, University of Chicago, 5640 S. Ellis Ave, Chicago, IL 60637-1433.

Interstellar diamonds, the carriers of exotic Xe-HL and associated He, Ne, Ar, and Kr, have now been found in primitive members of every chondrite class [1]. The abundances of diamonds (and SiC) vary with the abundance of matrix (the likely site of diamonds) and with the meteorite's metamorphic history [1]. It was known before diamonds were identified that Xe-HL in CM chondrites is accompanied by isotopically normal Xe released at low temperatures [2]. Its carrier, C<sub>2</sub> [3], was apparently inseparable by chemical means [3,4]. However, this component (Xe-P3 [4]) is not present in Allende (CV3) diamonds [3,5]. Early stepped heating experiments on Allende diamonds revealed subtle Xe isotopic variations that apparently require the existence of an additional Xe component of unknown composition [5]. There have also been several reports that Xe-H and Xe-L are separable under some experimental conditions [e.g., 6], although most were subsequently been discounted [e.g., 7]. This study was undertaken to identify the isotopically distinct noble gas components in diamond separates, characterize their carriers, and determine the distribution of these components as a function of meteorite class and metamorphic history.

Diamond separates were prepared from 15 meteorites representing 8 meteorite classes (LL, L, H/L, E, CI, CM, CV, and CO) in the hope that nature has separated some of the components. The procedure of [8] was modified to minimize contamination from coarse components and to achieve complete diamond recovery. Noble gases were measured by stepped pyrolysis using ~200 C steps. Only Ne, Kr, and Xe were measured for early samples, but He and Ar were also measured for later samples.

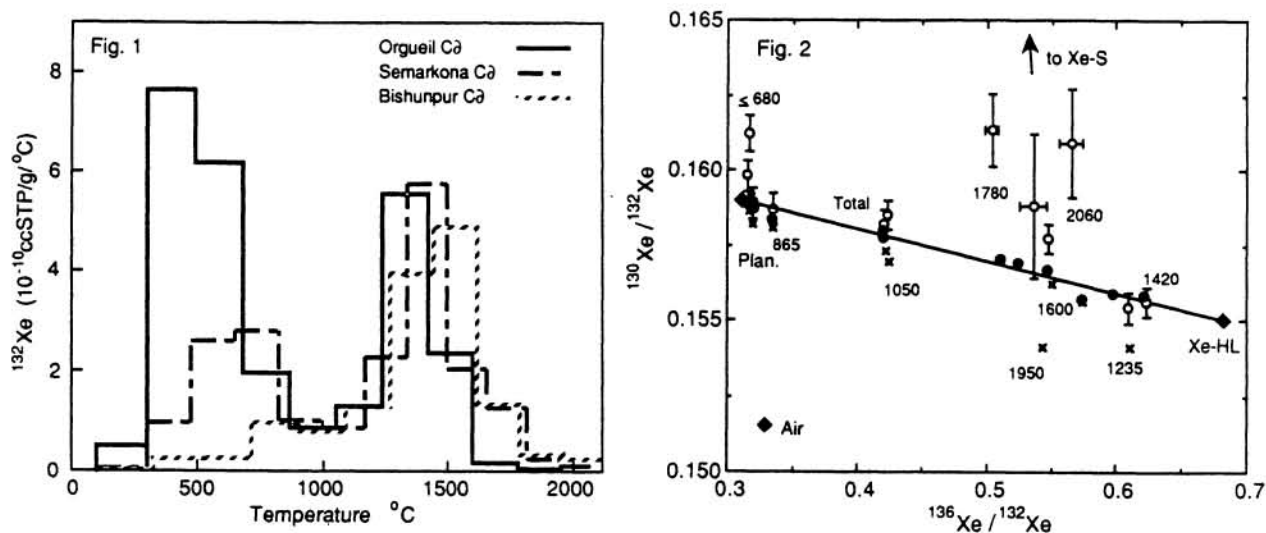
**Results** As observed previously [2,8], stepped pyrolysis reveals two major gas releases in diamond separates (Fig. 1), one between 300 C and 900 C consisting of Ar, Kr, and Xe of 'normal' isotopic composition accompanied by very little He and Ne, and another between 1100 C and 1800 C consisting of Xe-HL and associated He, Ne-A2, Ar, and Kr-H. The low-T, 'normal' component has higher Ar/Xe and Kr/Xe than does the exotic, high-T component, and is reminiscent of the 'normal' component in 'Q' that is removed by oxidizing acids.

The abundance of the low-T, 'normal' component in diamond separates is apparently controlled by the thermal history of the meteorites. This component is present at 2 to 3 times the abundance of the exotic component in diamond separates from CI and CM chondrites. Among ordinary chondrites, its abundance decreases rapidly with increasing metamorphic subtype (Fig. 1) and is essentially gone in Ragland (LL3.4) and ALHA77214 (L3.4). In Leoville (CV3) and Vigarano (CV3) the low-T component is apparently present at around 5 % of the amount in Orgueil, but subtle differences in isotopic composition suggest that this gas may have a different origin. Low-T gas is essentially absent from Allende. The concentration of the exotic component in diamond separates increases by about 65 % as the low-T component is lost, suggesting that a carrier is removed with the low-T component. However, attempts to derive the gas content of the putative low-T carrier do not produce consistent results. Although the noble gases are apparently released from diamonds through chemical reaction with surrounding phases or the tantalum foil used to wrap them, the low-T component gives a clear signal of diffusive outgassing as well. Diffusive loss is also consistent with the increase in peak release temperature as the amount of low-T component decreases (Fig. 1). These observations suggest that the low-T component is not located in a separate carrier but instead in more labile surface or near-surface sites on the diamonds themselves. This hypothesis is supported by TEM and EELS analysis of diamond separates [9] which identified no additional carrier and showed no significant differences between Murchison (CM) and Allende (CV) diamonds.

The isotopic variation in diamond separates can be explained, in large part, by two-component mixing of a 'normal' and an exotic component (Fig. 2). The residual variation appears to be due to small amounts of SiC contamination from the host meteorite. To test this hypothesis, 9-isotope mixing calculations were performed in an attempt to match the measured Xe compositions using a 'normal' component, Xe-HL, and Xe-S as end members. The 'normal' component was derived from low-T steps from bulk and etched meteorite residues and is depleted in both Xe-S and Xe-HL compared to AVCC. It is somewhat depleted in Xe-S and Xe-HL even compared to measurements of bulk planetary gas by closed-system-etch of Allende and Murchison residues [10]. The Xe-HL composition was obtained from the most isotopically extreme temperature steps of the most enriched diamond separates. This composition is probably not pure Xe-HL, but its reproducibility suggests that no more than a small amount of extraneous 'normal' Xe has been included in the Xe-HL composition. A theoretical composition calculated by Gallino *et al.* [unpublished] was used for Xe-S. Mass fractionation of major components (to model diffusive loss either in nature or during extraction) was allowed if a fit could not otherwise be obtained.

Nine-isotope mixing calculations were remarkably successful in matching the observed compositions, strongly suggesting that mixtures of a 'normal' component, Xe-HL, and Xe-S, with some mass fractionation, are responsible for most of the Xe isotopic variations observed in diamond separates. The results are in accord with other observations as well. For example, the amount of Xe-S required by the calculation varies in concert with the bulk SiC abundance in the meteorite; e.g., enstatite chondrites which have lots of SiC [1] give high calculated Xe-S concentrations, while CV chondrites which have little SiC [1] have the lowest calculated Xe-S concentrations in the diamond separates. In addition, steps requiring large amounts of Xe-S also show evidence of Ne-E, as expected for SiC contamination. Furthermore, the mass fractionation corrections were significant only on those steps where massive loss of low-T gas has apparently occurred, in residual high-T steps, or in separates from meteorites which other data suggest have experienced extreme thermal histories (e.g., enstatite chondrites). No evidence was seen supporting the idea that Xe-H and Xe-L are separable.

A small amount of residual non-random variation remained unexplained by the three-component model. Variable excesses of  $^{129}\text{Xe}$ , often accompanied by excess  $^{128}\text{Xe}$ , occur in low-T steps of some samples and probably represent re-trapped gas from the host meteorite. In separates with small amounts of the low-T, 'normal' component, intermediate-T steps show apparent excesses of  $^{134}\text{Xe}$  at the 1 % level (vs calculated compositions) and high-T steps shows deficits in  $^{134}\text{Xe}$  and excesses of  $^{126}\text{Xe}$  (up to 2-3%). These variations were also observed by [5]. The magnitude of the high-temperature variation seems to roughly correlate with the abundance, relative to Xe-HL, of a 'normal' component released above 1400 C, so it is tempting to assign the variation to this component. But since these variations appear as residuals in the calculation along with all random variation, it is not possible to derive a composition for this supposed high-T, roughly 'normal', component using present techniques.



Figures: 1) Xe release curves for diamond separates from Orgueil (CI), Semarkona (LL3.0), and Bishunpur (LL3.2). The isotopically 'normal', low-T component is increasingly less evident in meteorites which have experienced increasingly higher temperatures, and the temperature of its peak release increases. 2) Stepped pyrolysis data from Orgueil diamonds are shown with open circles and error bars. Even though the vertical scatter is enhanced by the expanded scale, it is evident that the data spread between the 'normal' planetary and Xe-HL (filled diamonds), the dominant components in the sample. The x's show the effect of removing the amount of Xe-S calculated from 9-isotope mixing. The filled circles show the additional effect of removing mass fractionation. (Related points scatter almost vertically on the plot). For these isotopes, a 'normal' planetary component, Xe-HL, Xe-S and minimal diffusive fractionation can explain the observed isotopic variation in Orgueil Cd.

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