

**OBSERVATION AND IMPLICATIONS OF IODINE (WITH IODINE-129) ASSOCIATED WITH PRESOLAR XENON COMPONENTS IN METEORITIC NANODIAMONDS.** J. D. Gilmour<sup>1</sup>, G. Holland<sup>1</sup>, G. Turner<sup>1</sup>, A. B. Verchovsky<sup>2</sup>, A. V. Fisenko<sup>3</sup> and L. F. Semjonova<sup>3</sup>. <sup>1</sup>School of Earth, Atmospheric and Environmental Sciences, University of Manchester, Manchester M13 9PL, UK, <sup>2</sup>Planetary and Space Sciences Research Institute, Open University, Walton Hall, Milton Keynes MK7 6AA, Bucks, U. K. <sup>3</sup>Vernadsky Institute of Geochemistry and Analytical Chemistry RAS, Kosygin St. 19, Moscow 117975, Russia.

**Introduction:** Nanodiamonds [1] are the most abundant presolar material in primitive meteorites. They are known to contain three presolar xenon components, released at different temperatures in step heating experiments: Xe-P3, Xe-HL and Xe-P6 [2]. Low temperature Xe-P3 is near in composition to average solar system xenon (with subtle differences [3]) and intermediate temperature Xe-HL is enriched in the heavy and light isotopes by a factor of  $\sim 2$ . Xe-P6 is constrained to lie on a high temperature mixing line from Xe-HL, but its exact composition is otherwise poorly constrained [2].

We have previously argued that  $^{129}\text{Xe}$  from  $^{129}\text{I}$  decay may be associated with the P3 component [4]. Here we report the results of an I-Xe analysis that shows iodine also associated with the P6 component, and constrains the  $^{129}\text{I}/^{127}\text{I}$  ratios on closure to xenon loss. Our data use high resolution laser step heating. Isotope ratio measurements were made using the RELAX mass spectrometer [5].

In the I-Xe technique [6], samples are neutron irradiated, converting stable  $^{127}\text{I}$  to  $^{128}\text{Xe}$  via neutron capture and  $\beta$  decay. A xenon isotopic analysis can then determine the  $^{127}\text{I}/^{132}\text{Xe}$  ratio and the  $^{129}\text{I}/^{127}\text{I}$  ratio of the sample using a calibration based on co-irradiated samples of pyroxene from the anomalous enstatite chondrite Shallowater. Since the conversion efficiency from  $^{127}\text{I}$  to  $^{128}\text{Xe}$  is  $\sim 10^{-4}$ , the detection limit for iodine corresponds to  $^{127}\text{I}/^{132}\text{Xe} \sim 100$ , which is around two orders of magnitude higher than the solar system relative abundance [7]. Chronological interpretation of the  $^{129}\text{I}/^{127}\text{I}$  ratio relies on the assumption that iodine in the sample was evolving concordantly with that in the average solar system as sampled by Shallowater. In the case of presolar components this assumption must be considered dubious.

We report data from a 10  $\mu\text{g}$  irradiated sample of the ED12 coarse grain size separate of nanodiamonds prepared by ultracentrifugation of an acid residue from Efremovka [8]. Gas was extracted in each of 48 separate settings of the power density of the illuminating laser, which controls the temperature of the sample. Heavy and light isotope data are consistent with mixing trends previously reported in nanodiamond analyses [2,9] (Fig 1) except that the highest temperature data evolve first from HL towards the P6 composition, then back; similar behavior was observed in our analysis of an unirradiated aliquot [4] – Fig. 2.

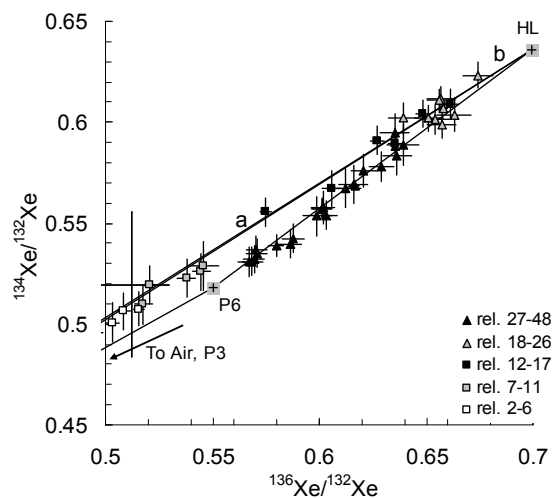


Fig. 1. Heavy isotope mixing. Symbols correspond to position in the release sequence during step heating. Labeled compositions are from [2].

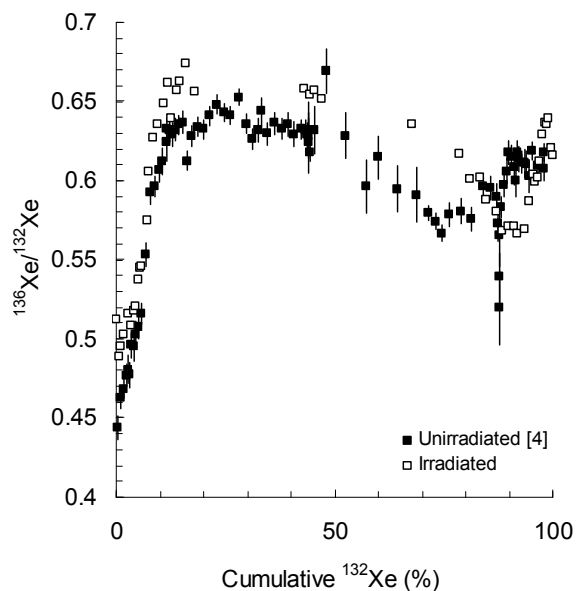


Fig. 2. Analyses of irradiated and unirradiated aliquots of coarse Efremovka nanodiamonds show similar variation with temperature. After release of Xe-HL the composition evolves first towards Xe-P6, then back towards Xe-HL (Fig. 1).

**Results:** In simple terms, those components with more “normal” (lower)  $^{136}\text{Xe}/^{132}\text{Xe}$  appear to have higher  $^{127}\text{I}/^{132}\text{Xe}$  ratios (above the detection limit of  $\sim 100$ ) and non-zero  $^{129}\text{I}/^{127}\text{I}$  ratios (Figs 3, 4). At low temperature, there is clear evidence of an association

between Xe-P3 and iodine with  $^{129}\text{I}/^{127}\text{I} \approx 0.40 \times 10^{-4}$  at last closure to xenon loss. Since the concentration of Xe-P3 in nanodiamond separates was affected by processing in the early solar system, this demonstrates that  $^{129}\text{I}$  was alive at this time in similar sites in the diamond structure to Xe-P3. At higher temperatures, the data suggest that iodine with  $^{129}\text{I}/^{127}\text{I} > 2 \times 10^{-4}$  was present when the P6 carrier closed to xenon loss.

**Discussion:** The more “normal” isotopic signatures of the P3 and P6 components suggest that they have sampled a mixture of multiple nucleosynthetic sites, and might be expected to have originated in a reservoir with  $^{127}\text{I}/^{132}\text{Xe}$  ratios close to the galactic average (assumed to be close to the solar ratio of  $\sim 1$ ). The observation that they are associated with  $^{127}\text{I}/^{132}\text{Xe}$  ratios two orders of magnitude higher suggests either a trapping process that favored incorporation of iodine (adsorption during grain growth?) – or thermal processing that removed xenon from nanodiamonds where it had been trapped as efficiently as iodine (e.g. by implantation).

The variable P3 concentrations of meteoritic nanodiamonds suggest that Xe-loss played a significant role in setting the I/Xe ratio observed at low temperature. In contrast, Xe-P6 is lost only at high temperature and there is no evidence for loss of xenon from this component during the formation of the solar system. Scenarios might be devised in which the  $^{127}\text{I}/^{132}\text{Xe}$  signature of the P6 component is set by degassing in the interstellar medium without affecting Xe-HL (released at lower temperature), but it seems simpler to account for the observation as resulting from a trapping process sensitive to the different chemistries of iodine and xenon. If excess  $^{129}\text{Xe}$  in Xe-P6 is calculated over the  $^{129}\text{Xe}/^{132}\text{Xe}$  ratio observed in Xe-HL, the  $^{129}\text{I}/^{127}\text{I}$  ratio recorded in this component is higher than that of the Early Solar System (ESS – Fig. 4), but consistent with variations in well mixed galactic material.

**References:** [1] Lewis R. S. et al. *Nature* 326, 160-162. [2] Huss G. R. and Lewis R. S., (1994) *Meteoritics* 29, 791-810. [3] Gilmour J. D. (2009) *Geochimica Cosmochimica Acta* 74, 380-393. [4] Gilmour J. D. et al. (2005) *Geochimica Cosmochimica Acta* 69, 4133-4148 & Fisenko A. V. and Semjonova L. F. (2008) *Geochimica Cosmochimica Acta* 72 4177-4183. [5] Crowther S. A. et al. (2008) *Journal of Analytical Atomic Spectrometry* 23, 938-947. [6] Gilmour, J. D. et al. (2006) *Meteoritics and Planetary Science* 41, 19-31. [7] Anders, E. and Grevesse, N., (1989) *Geochimica Cosmochimica Acta* 53, 197-214. [8] Verchovsky, A. B., et al. (1998) *Science* 281, 1165-1168. [9] Huss, G. R. et al. (2003) *Geochimica Cosmochimica Acta* 67 4823-4848. [10] Gilmour J. D., et al. (2009) *Meteoritics and Planetary Science*, 44, 573-580.

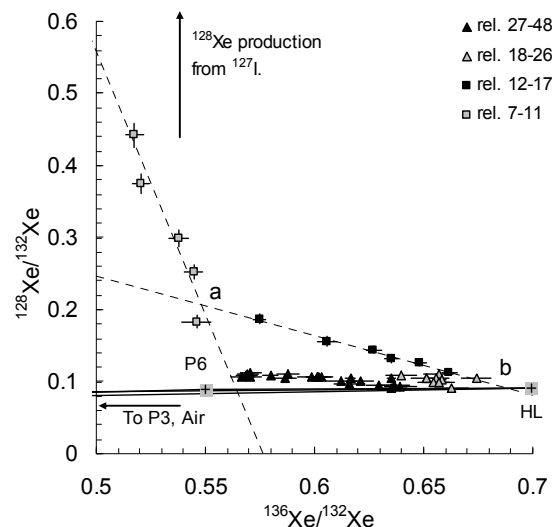


Fig. 3.  $^{127}\text{I}/^{132}\text{Xe} > \sim 100$  (the detection limit) is associated with xenon in components with  $^{136}\text{Xe}/^{132}\text{Xe}$  lower than that of Xe-HL (both Xe-P3 and Xe-P6). Lower temperature data (some not shown) exhibit higher  $^{127}\text{I}/^{132}\text{Xe}$  ratios.

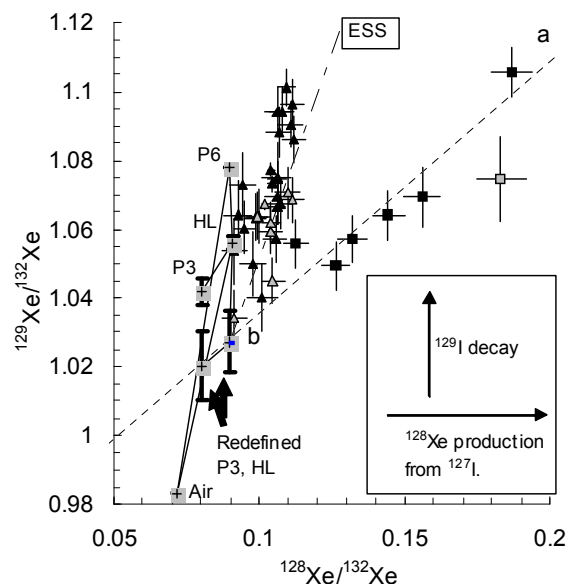


Fig. 4. An I-Xe diagram – lower temperature points have higher  $^{128}\text{Xe}/^{132}\text{Xe}$  ratios and are not plotted. The trend from a to b (see also Figs 1, 3) is from Xe-P3 to Xe-HL, leading to the identification of  $^{129}\text{Xe}^*$  from  $^{129}\text{I}$  decay in the previously reported composition [2] – a revised composition taking account of this is shown. The revised P3 composition is that of ref [3]. Higher temperature data suggest a contribution of  $^{129}\text{Xe}^*$  from iodine associated with Xe-P6. ESS denotes Xe-HL modified by iodine with the  $^{129}\text{I}/^{127}\text{I}$  ratio expected at the time recorded by  $^{26}\text{Al}$  in CAIs based on the calibration of [10].