I-Xe and Other Xe Isotope Systematics in Irradiated GRA 06129

I-Xe AND OTHER XENON ISOTOPE SYSTEMATICS IN IRRADIATED GRA 06129. J.L.Claydon[1], S.A. Crowther[1], C.K. Shearer[2] and J.D. Gilmour[1], [1]School of Earth, Atmospheric and Environmental Sciences, University of Manchester, Oxford Road, Manchester, M13 9PL, UK. jennifer.claydon@postgrad.manchester.ac.uk, [2]Institute of Meteoritics, Dept. of Earth and Planetary Sciences, Univ. of New Mexico, Albuquerque, NM 87131, USA.

Introduction: Graves Nunataks 06128 & 06129 (referred to hereafter as GRA 8/9) are ungrouped achondritic meteorites that have been paired by their proximity and petrographic description [1, 2]. GRA 8/9 are thought to originate in the crust of an asteroid and are dominated by Na-rich plagioclase (48.86 wt%) [1]. Diopside (19.24 wt%), nepheline (11.69), olivine (7.48), pyrite (4.88), orthoclase (1.48), apatite (0.44), ilmenite (0.13) and chromite (0.01) are also present [1].

Melting on the GRA 8/9 parent asteroid occurred early in the solar system, as shown by an Al-Mg age of 4565.9 ± 0.3 Ma [1]. All previous samples from asteroid crust have been basaltic in nature. GRA 8/9 provides evidence that the chemistry of asteroid crustal materials is more varied than previously thought and that crustal processes other than basaltic magmatism, occurred in the early solar system.

The decay products of short-lived isotopes, alive during the first 100 Ma of the solar system, can be used to calculate precise ages of early solar system materials. ^{129}I decays to ^{129}Xe with a half-life of 16 Ma and has been shown to be a reliable chronometer [3, 4]. A correlation between ^{129}Xe and ^{127}I (a stable isotope) during step-heating of a sample indicates the ^{129}Xe is derived from iodine. By measuring the ratio of excess ^{129}Xe and ^{127}I the relative age of the material can be determined. This is then referenced to a standard of a known age (usually the meteorite Shallowater) to calculate an absolute age.

Results presented in [5] give a relative I-Xe age for GRA 9 of 75 ± 5 Ma after Shallowater. This corresponds to an absolute age of 4487.3 ± 5.02 Ma using the re-evaluated Shallowater age of 4562.3 Ma given in [6], and an initial ^{129}I/^{127}I ratio of ~4×10^{-6}.

Our previous analysis of unirradiated GRA 9 samples [1] showed excess ^{129}Xe from decay of ^{129}I, either *in situ* or inherited, and $^{131\text{-}136}$Xe from fission of ^{244}Pu. After correction for a contribution to ^{132}Xe from fission, the maximum observed ^{129}Xe/^{132}Xe ratio was 2.05 ± 0.088. Concentrations of iodogenic xenon (excess ^{129}Xe over trapped xenon with the composition of Q-Xe [7]) varied between the samples (10^8 – 10^{10} atoms g^{-1}) with 70% of iodogenic xenon in one sample released in a single step suggesting it was hosted in a minor phase.

Here we present first results from one of 5 irradiated whole rock (3.56 mg) samples of GRA 9.

Methods: Whole rock fragments of GRA 9, along with the irradiation standard Shallowater, were included in irradiation MN10a at the SAFARI-1 reactor in Pelindaba, South Africa. Samples were loaded into a sealed tube and exposed to thermal neutrons (~10^{19} n cm^{-2}) to convert the stable isotope ^{127}I to ^{128}Xe. This allows simultaneous measurement of the ^{129}I decay product (^{129}Xe) and a stable iodine isotope (^{127}I via ^{128}Xe), since neutron irradiation produces ^{128}Xe from iodine. In addition, ^{131}Xe is produced from Ba or Te and ^{131}Xe, ^{132}Xe, ^{134}Xe and ^{136}Xe are produced from neutron-induced fission of ^{235}U.

Following irradiation the samples were laser step-heated and xenon isotopes analysed using the resonance ionization mass spectrometer RELAX (Refrigerator Enhanced Laser Analyser for Xenon) [8, 9]. Absolute amounts of gas were calculated, and a sensitivity correction made, by reference to measurements of terrestrial air interspersed throughout analyses. The blank of the instrument was also monitored over the time of the analyses. The ^{128}Xe*/^{129}Xe* ratio for the associated Shallowater standards was 0.95 ± 0.04 (where * indicates production from iodine).

Results and Discussion: Laser step-heating of the sample produced 114 consecutive releases. In a graph of ^{136}Xe/^{132}Xe and ^{134}Xe/^{132}Xe (not shown) mixing was observed between a trapped component (terrestrial air or Xe-Q) and a fission signature isotopically consistent with either ^{244}Pu or n-induced fission of ^{235}U modified by n-capture on ^{135}Xe [e.g. 10]. A correction based on ^{130}Xe is ambiguous in distinguishing between the two possible fission components. However, it is expected that the fission component will be dominated by ^{235}U in samples that have experienced neutron fluences this high, and this has been assumed to be the case here.

Releases 1-50 contained significant trapped ^{132}Xe and iodine-derived ^{128}Xe*. This is consistent with terrestrial contamination during the sample's sojourn in the Antarctic [10, 11]. Releases 50-70 exhibited essentially mono-isotopic ^{128}Xe*. These data challenged the dynamic range of the instrument and are still being examined. They are not discussed further here, where we focus on releases 85-114, after the major release of ^{128}Xe*.

In this region there are four distinct releases (Figure 1), each of which exhibits ^{131}Xe* (assumed to have been produced from Ba rather than Te), ^{134}Xe* (assumed to have been produced from U rather than Pu), iodogenic ^{128}Xe* and trapped ^{132}Xe. Each group of

releases exhibits a distinct range of I/Ba and U/Ba ratios (Figure 2) suggesting releases from host phases of similar but distinct composition that evolve to lower I/Ba and U/Ba with increasing release temperature. These four releases account for 1.8% of total I, 93% of total Ba, 6.3% of trapped Xe and 27% of total U. The estimated total Ba concentration is in the range 10-100 ppm, consistent with that previously reported for this meteorite [1], suggesting that ^{131}Xe* at least is sourced from plagioclase, the major Ba carrier [1]. Variable iodine and uranium concentrations implied by the varying ratios of daughter xenon isotopes to Ba in the 4 groups may reflect the presence of varying concentrations of inclusions rich in these incompatible elements.

Data from these releases are plotted in a conventional iodine-xenon isochron diagram, where they are compared to previous analyses of this meteorite (Figure 3). Data from G2 have approximately the maximum ^{129}Xe/^{132}Xe ratio previously reported [1] and lie on the reported isochron [5], but the groups in general do not form an isochron suggesting greater complexity than simple mixtures of an evolved xenon component with varying proportions of iodine with a well defined ^{129}I/^{127}I ratio. The data of G2 correspond to a model I-Xe age of ~45 Ma after Shallowater, but chronological interpretation should be made with extreme caution in the absence of an isochron.

References: [1] Shearer C.K. et al. (2010) *GCA,* 74, 1172-1199. [2] Day J.M.D. et al. (2009) *Nature* 457, 179-183. [3] Brazzel R.H. et al. (1999) *GCA,* 63, 739-760. [4] Gilmour J.D. et al (2006) *Meteoritics & Planet. Sci.,* 41, 19-31. [5] Bajo K. et al. (2010) *Meteoritics & Planet. Sci.,* 45, A5089. [6] Gilmour J.D. et al. (2009) *Meteoritics & Planet. Sci.,* 44, 573-579. [7] Busemann H. et al (2000) *Meteoritics & Planet. Sci.,* 35, 949-973. [8] Gilmour et. al. (1994). *Rev. of Sci. Inst.* 65, 617-625. [9] Crowther S.A. et al. (2008) *Journal of Analytical Atomic Spectrometry,* 23, 921-1044. [10] Crowther S.A. et al. (2009) *Meteoritics & Planet. Sci.,* 44. 1151-1159. [11] Schwenzer S. P. et al. (2009) *Polar Sci,* 3, 83-99. [12] Cartwright J.A. et al. (2010) *Meteoritics and Planetary Science*, 45, 1359–1379.

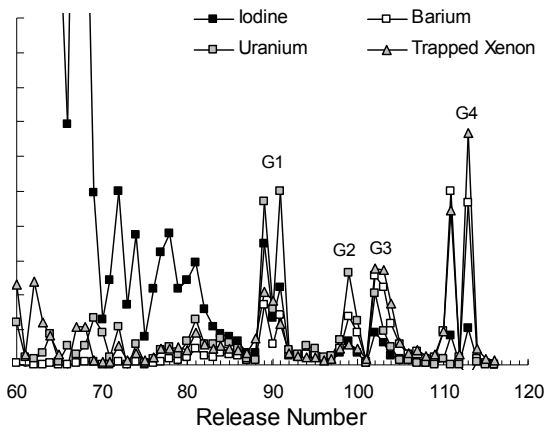

Fig. 1. Release patterns at high temperature of xenon isotopes produced from the elements indicated during irradiation, and of trapped xenon (arbitrary units).

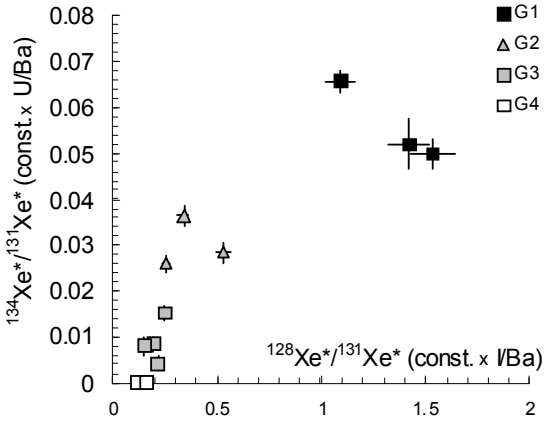

Fig. 2. Relative abundances of uranium, iodine and barium corresponding to releases labeled in Fig. 1.

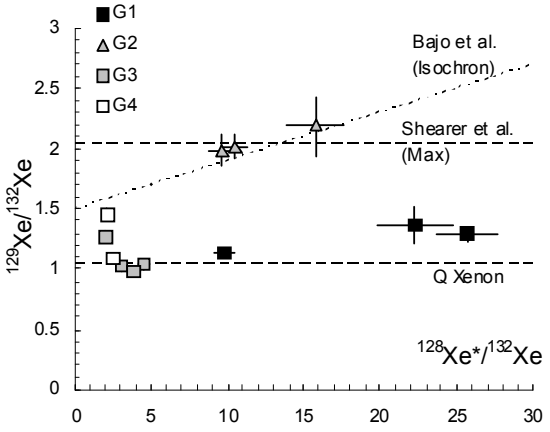

Fig. 3. I-Xe "isochron" diagram for the releases labeled in Fig. 1. G2 data are consistent with the maximum ^{129}Xe/^{132}Xe ratio reported by Shearer et al. [1] and lie on the isochron of Bajo et al. [5], but the data in general do not exhibit isochronous behaviour.