

NON-ATMOSPHERIC NOBLE GASES FROM CO₂ WELL GASES; M.W. Caffee¹, G.B. Hudson¹, C. Velsko¹, E.C. Alexander, Jr.², G.R. Huss², and A.R. Chivas³,
¹Lawrence Livermore National Laboratory, Livermore, CA 94550, ²Dept. of Geology and Geophysics, Univ. of Minn., Minneapolis MN 55455, ³Research School of Earth Sciences, Australian Natl. Univ. Canberra, A.C.T. 2601, Australia

A handful of terrestrial samples show small excesses of ¹²⁹Xe relative to the isotopic composition of atmospheric Xe (e.g. Phinney et al., 1978; Allegre et al., 1983). These ¹²⁹Xe excesses were first noted by Butler et al. (1963) in CO₂ samples from Harding Co., New Mexico. Similar ¹²⁹Xe excesses have also been observed in Mid-oceanic-ridge-basalts (Allegre et al., 1983). These excesses of ¹²⁹Xe are almost certainly due to the decay of ¹²⁹I, a nuclide present in the early solar system.

Phinney et al. (1978) observed excesses of fission-derived Xe in the CO₂ and attributed most of this fission-derived Xe to ²³⁸U. They also observed ³He/⁴He and ²⁰Ne/²²Ne ratios greater than air, although the errors in the latter ratio were large.

We have analyzed CO₂ samples from three locations: two from Colorado, from the McElmo Dome and Sheep Mtn. deposits, and one from Australia, from the Caroline deposit (Chivas et al., 1987).

In all three samples there are noticeable excesses of ¹²⁹Xe. To determine the Xe fission spectra we must subtract out all the Xe not produced by fission. As a first attempt we will assume that the underlying component is atmospheric in composition, and that all the ¹³⁰Xe is due to this component, and subtract it out. Table 1 shows the isotopic composition of the remaining Xe for the Caroline sample after this subtraction. It is apparent that although ²³⁸U is favored, there are excesses at ¹²⁸Xe and deficits of ¹³¹Xe and ¹³²Xe. Mixing Pu-derived Xe with ²³⁸U-derived Xe only makes matters worse. Alternatively, we could presume that the underlying composition of this Xe is not atmospheric. Phinney et al. (1978) observed that the best fit to the Harding Co. Xe could be obtained by subtracting off a mixture of atmospheric Xe and SUCOR Xe. Based on the ¹²⁸Xe/¹³⁰Xe ratio (Fig. 1) we can estimate the fraction of non-atmospheric Xe to mixed with atmospheric Xe. We obtain a mixture of 5-10% meteoritic-like Xe with the remainder being atmospheric Xe.

Table 1 also shows the remaining Xe isotopic composition after subtracting the appropriate mixture of atmospheric and meteoritic Xe. The remainder of the Xe appears to be a mixture of Pu- and U-derived fission Xe. Based on the ¹³¹⁻¹³⁴Xe/¹³⁶Xe ratios we conclude that 15% of the fission-derived ¹³⁶Xe could be attributed to ²⁴⁴Pu decay (see Fig. 2). The similarity between the Caroline and Harding Co. CO₂ is striking. The simplest interpretation of this data is that the ¹²⁹Xe excesses are due to a mantle component and that the Xe observed in these samples is a mixture of this mantle component and crustal contamination (Fig. 3) (c.f. Staudacher, 1987).

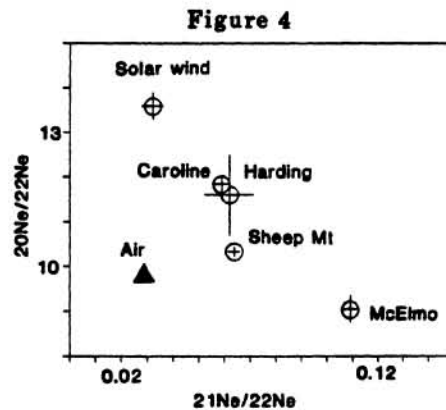
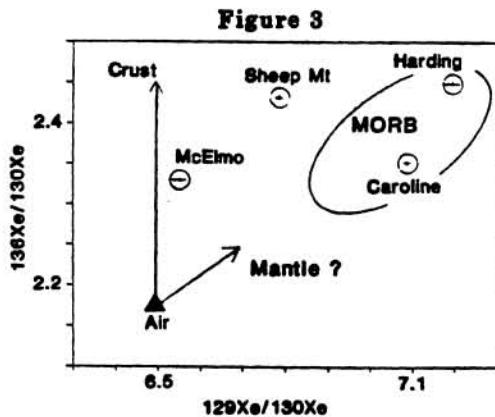
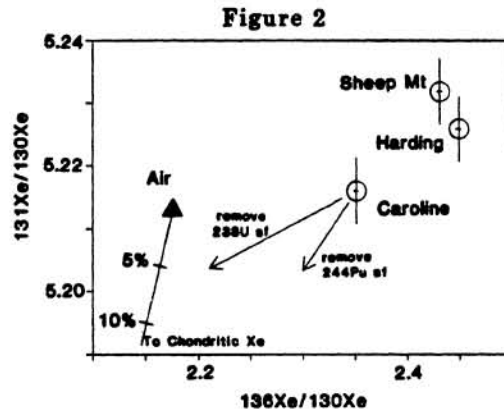
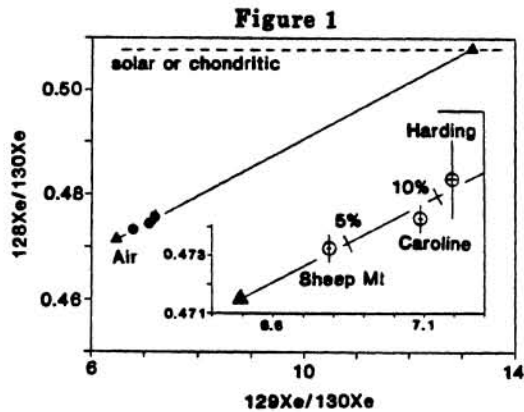
Figure 4 shows the Ne isotopic data for the CO₂ samples. Both Caroline and Harding Co. samples have elevated ²⁰Ne/²²Ne ratios. Similar effects have been observed in other mantle-derived samples. Producing ratios this high by mass-fractionation is difficult, so a solar-like Ne component is suggested.

In summary, based on the ubiquitous occurrence of ¹²⁹Xe excesses in CO₂ wells it seems reasonable to conclude that this Xe has a mantle origin. Based on the additional excess of ¹²⁸Xe and its correlation with ¹²⁹Xe it is plausible that the mantle component has some contribution from meteoritic-like Xe. Assuming this to be the case the remaining fission-derived Xe is mostly due to the decay of ²³⁸U, however it is plausible that there is a real contribution from ²⁴⁴Pu decay.

Table 1. Summary of Caroline Fission Xe

	124Xe	126Xe	128Xe	129Xe	130Xe	131Xe	132Xe	134Xe
					(136Xe = 1.0)			
Caroline Xe minus air Xe								
	0.002	0.003	0.016	3.37	0.0	0.017	0.478	0.830
+ -	0.002	0.002	0.006	0.09		0.040	0.041	0.024
Caroline Xe minus 91% air Xe and 9% chondritic (Kenna) Xe								
	-0.001	0.003	-0.003	3.04	0.0	0.099	0.635	0.846
+ -	0.002	0.002	0.005	0.07		0.036	0.037	0.021
			238U fission			0.088	0.568	0.828
					+ -	0.003	0.010	0.012
			244Pu fission			0.248	0.893	0.930
					+ -	0.015	0.013	0.005
			fraction of 136Xe due to 244Pu fission			0.07	0.22	0.17
					+ -	0.22	0.11	0.21

References:
Allegre et al. (1983) Nature, 303, 762-766;
Butler et al. (1963) J. Geophys. Res., 68, 3283-3291; Chivas et al. (1987) Nature, 326, 587-589; Phinney et al. (1978) J. Geophys. Res., 83, 2313-2319; Staudacher (1987) Nature, 12, 605-607.



This work was provided under the auspices of the U.S. Department of Energy by Lawrence National Laboratory under contract W-7405-Eng-48.