TERRESTRIAL KRYPTON AND XENON, ARE THESE FREAKS ? D. Heymann and R. Palma , Rice University, Houston, Texas, 77001.

Variations of the isotopic compositions of spallation-corrected Kr and Xe in the solar system have been called a Pandora's Box(1). The terrestrial Xe composition has been interpreted as mass-fractionated solar Xe or, alternatively, Ur-Xe plus Pu-244 fission(2). A major problem of these ideas is that terrestrial Kr and Xe cannot have been fractionated simultaneously by a simple process. One must invoke multi-step sequences involving the Earth during planetary times. This raises the following issue. Are terrestrial Kr and Xe freaks which nature has only generated once and only in one place of our galaxy, or are they not?

Xe with atmospheric composition has been found in a number of lunar rocks(3,4), but recent experiments suggest that this is terrestrial contaminationwhich occurs when lunar rocks are ground up in air(5). Interestingly, the rocks in which the purported lunar Xe with terrestrial composition has been found are all "banged up" to some extent on the moon. One may thus turn the argument around and posit that these rocks are prima facie evidence that the moon had a transient atmosphere with Xe of atmospheric composition.

It has long been known(6) that carbonaceous chondrites release Kr and Xe of atmospheric composition up to about 700^{o} C. This is quite general(2) and the amounts are significant, sometimes up to 20% of the total Kr and Xe in these meteorites. Recently(7) this has been blamed on adsorption on the ubiquitous layer-lattice silicates, followed by firmer trapping by some unknown process, i.e. again contamination from the air. However, the HF-HCl-resistant residue 3Cl of the Allende meteorite does not contain layer-lattice silicates(8). Upon etching with nitric acid, this sample loses much of its trapped Xe and Kr(8). The composition of the "removed" gas can be easily calculated by comparison with sample 3C2(8). It is not surprising that the Xe removed is depleted at masses 124-126 with respect to solar Xe. However, what is surprising is that the composition of the "removed" gas can be represented by the formula: 3 parts solar + 1 part atmospheric, except at mass 131. The discrepancy at this mass can be removed by assuming that about 0.1% of Xe-131 in the sun has been destroyed during the deuterium-burning phase(9).

There is, obviously, nothing sacred about the formula. One can represent the composition of the "removed" gas by any number of components, known or postulated, in appropriate proportions. However, one of the components must bear the hallmark of atmospheric Xe, i.e. it must be strongly depleted at masses 124-128 relative to solar Xe.

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The case for terrestrial Kr in meteorites is much weaker, principally because the difference between solar and terrestrial Kr is much smaller than that between solar and terrestrial Xe. Nevertheless, recent results on Orgueil(10) suggest strongly, that treatment of Orgueil residues "removes" Kr which is enriched at masses 78-82 relative to solar Kr, a hallmark of terrestrial Kr.

The evidence that Xe and Kr , atmospheric, or atmosphere-like(i.e. apparent mass-fractionation) occur not only on the earth, but on the moon and in the meteorites is not firm, but cannot be ignored either. One may posit that the lunar gases have been somehow transfered in the past from the earth to the moon, but this is very difficult to defend for the meteorites. If terrestrial Kr and Xe are not freaks, but occur elsewhere in the solar system, there are interesting consequences. One must find a fractionating process which has different signs for the isotopes of Kr and Xe. Onle one such process is known, namely thermal diffusion. Isotopic thermal diffusion factors change sign at a characteristic temperature T(k), which for pure gases is proportional to the critical temperature, according to the law of corresponding states. Thus the sign changes in Xe at higher temperatures than in Kr. However, the most likely pre-terrestrial environment where this could have happened is liable to have been hydrogen-rich, which makes the characteristic temperatures where the thermal diffusion factor changes sign almost identical.

If one cannot find suitable fractionation processes for the atmosphere-like gas, one must accept that the abundance variations at the neutron-poor isotopes of the two elements are due to nucleosynthesis(11). This raises the mesmerizing question why the processes, collectively called p-processes, have generated at some time the neutron-deficient isotopes of Xe quite effieciently, but those of Kr relatively inefficiently(strange Kr and Xe in meteorites), and have done just the opposite at some other time(atmosphere-like gases). In a sense this is reassuring, because the abundances of the neutron-deficient isotopes in solar Kr and Xe lie between those of strange and atmosphere-like. If the strange Kr and Xe represent a late, nearby supernova(12), then there must have been nucleosynthetic "styles" which generated the neutron-deficient isotopes of Kr and Xe in more atmosphere-like abundances.

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References: 1. Srinivasan, B., Gros, J. and Anders, E.(1977) J. Geophys. Res, 82,762; 2. Dr. R.O. Pepin has discussed these issues extensively with one of us;3. Lightner, B.D. and Marti, K.(1974) Proc. Lunar Sci. Conf. 5th,2023; 4. Leich,D.A. and Niemeyer, S.(1975) Proc. Lunar Sci. Conf. 6th,1953; 5. Niemeyer, S. and Leich, D.A. (1976) Proc. Lunar Sci. Conf.7th,587; 6. Reynolds, J.H. and Turner, G. (1964) J. Geophys. Res. 69,3263; 7. see Frick, U. and Moniot, R.K.(1977) Proc. Lunar Sci. Conf. 8th, 229; 8.Lewis, R.S.,Srinivasan, B., and Anders,E.(1975) Science 190,1251;9. see Cameron, A.G.W. (1963) Icarus 1,314; 10. Frick, U.(1977) Proc. Lunar Sci. Conf. 8th, 273; 11. see Manuel, O.K. and Sabu, D.D. (1977) Science 195,208; 12. Cameron, A.G.W. and Truran, J.W.(1977) Icarus 3o,447.