SOLAR-LIKE NOBLE GASES IN TERRESTRIAL DIAMONDS. M. Honda, P. McConville, J. H. Reynolds and E. Roeder*; Dept. of Physics, Univ. of California, Berkeley, CA; *U. S. Geological Survey, Reston, VA.

Motivated by exciting, but puzzling, noble gas results in terrestrial diamonds (e.g. high $^3\text{He}/^4\text{He}$ ratios close to the solar value from industrial class diamonds (1) and low $^4\text{He}/^4\text{Ar} (= 189$) from an Arkansas, USA diamond (2)), we undertook the study of noble gases in diamonds from different locations. We have measured 17 diamond samples: Premier type I; Finsch type I and II; DeBeers pool type I and II; Zaire; Arkansas [2 samples]; Australian [2]; Brazilian [3]; and industrial class diamonds, probably of South African origin [4]. One of the Arkansas diamonds (#1) was crushed and analyzed for Ar isotopes by Melton and Giardini but did not yield a publishable value for the ratio $^{40}\text{Ar}/^{36}\text{Ar}$. One industrial class diamond was successively heated for 30 min. at 1200, 1700, 2000, 2050°C. The fractional releases of $^4\text{He}$ were: 0.007, 0.027, 0.964, and 0.002 respectively, indicating that virtually all the He was released at the 2000°C graphitization of the sample. Noble gases are thus confirmed to be geologically immobile in diamonds. One of the gem class diamonds (Finsch type I) was cut in half, and one part crushed to 100 μm. He contents were measured in both the uncrushed and crushed samples. 40% of the He was observed to be lost during crushing. This suggest that noble gases are trapped in platelets and/or vesicles in diamonds together with $^2\text{N}_2$ (3).

Fig. 1 shows $^3\text{He}/^4\text{He}$ as a function of $^3\text{He}$ concentration, combined with values obtained at Tokyo by Ozima et al. (4). Our data points with arrows indicate upper limits for the measured $^3\text{He}$ contents. The $^3\text{He}/^4\text{He}$ ratios are characterized by a large spread (10^5), ranging from values below atmospheric to values in excess of the planetary, but not the solar ratio. There is no systematic correlation between the $^3\text{He}/^4\text{He}$ ratios and He concentration. Our results do not support the "calm" mantle evolution model in terms of the U-He system in diamonds (4). The highest $^3\text{He}/^4\text{He}$ value (1.57 ± 0.75; ±1) x 10^-4 was observed for an Australian colorless diamond composite, while the lowest (4.5 x 10^-8) was for an Australian colored diamond which, interestingly, came from the same kimberlite pipe. Two Arkansas diamond samples, possibly from the same pipe, also gave wide variations in $^3\text{He}/^4\text{He}$ and He content. These variations may reflect heterogeneity of the source region where diamonds formed. We found a $^{40}\text{Ar}/^{36}\text{Ar}$ of 670 ± 140 from the Arkansas #1 diamond, which conflicts with the result of Melton and Giardini.

The two samples, Australia colorless and Arkansas #2, with the highest $^3\text{He}/^4\text{He}$ ratios among our data set gave imprecise but intriguing $^{20}\text{Ne}/^{22}\text{Ne}$ ratios 12.6 ± 1.6 and 14.2 ± 2.1 respectively, which are close to the solar value (Fig. 2). Although we need confirmation of the Ne results, it appears so far as if the high $^3\text{He}/^4\text{He}$ ratio, close to the solar value, in diamonds is associated with solar-like Ne. An addition of other neon components, from spallation or nuclear reactions, to an atmospheric component cannot produce the elevated $^{20}\text{Ne}$/seen in the stones. To produce a $^{20}\text{Ne}/^{22}\text{Ne}$ ratio as high as 14 by mass fractionation of an initially atmospheric component (= 9.8), a 43% enrichment of $^{20}\text{Ne}$ relative to $^{22}\text{Ne}$ is needed. Such a large mass fractionation is hard to explain by any simple diffusive process.

If it is confirmed that some diamonds contain solar He and Ne, the following two origins could be considered: (i) primordial and (ii) sedimentary. Ozima et al. (5) speculate that the solar dust which later accreted to form the earth might have been subjected to intense solar wind radiation after the deuterium burning stage in the Sun. This would suggest
that diamonds are as old as the earth and, since their formation, have been completely isolated from other terrestrial materials. Alternatively, one can argue that diamonds were formed from sediments containing carbon on inclusions (4,5) and on carbon isotopes (6). A high $^4\text{He} / ^{12}\text{C}$ ratio (10$^{-4}$) has been discovered in sea sediments due to contamination by cosmic dust (4,5). Since solar wind-saturated cosmic dust contains 0.1 ccSTP/g of He with a solar ratio, only a 1 ppm contamination by cosmic dust in sediments can produce a measured $^4\text{He} / ^{12}\text{C}$ ratio higher than 1 x 10$^{-4}$, which presumably would be accompanied by solar neon. In other words, solar He and Ne in diamonds may originate in cosmic dust that was trapped in sediments that were precursory to diamond formation.