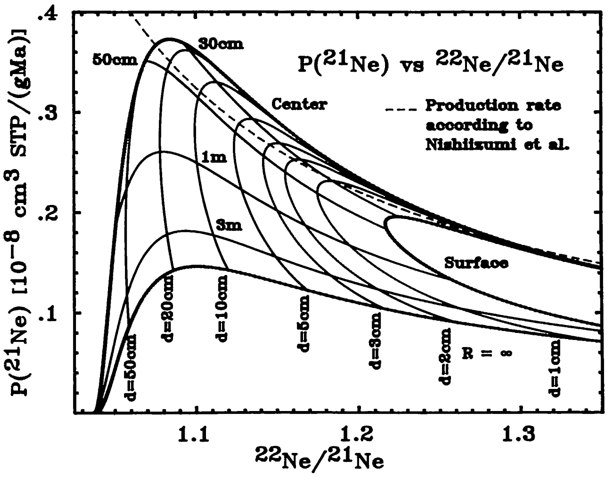
SWN. However, overlapping combustion of spallogenic nitrogen implies that $\delta^{15}N$ of the 900 °C step is an upper limit for the $\delta^{15}N$ of ancient SWN. Calculation of $N/^{36}Ar$ ratio using the nitrogen concentration of the 900 °C step yields a value close to that derived from lunar studies (3).

In contrast to lunar breccias, over 60% of the total nitrogen inventory in Fayetteville is released below 500 °C. After allowing for atmospheric contaminants, the low temperature nitrogen is shown to have $\delta^{15}N$ *ca.* $-20 \pm 10‰$, much lighter than $\delta^{15}N$ of meteoritic organic matter (4, 5), and also of common terrestrial contaminants (6). The nature of this component is not understood, but it is weakly bound by comparison with the putative implanted SWN. References: (1) Schultz and Kruse (1983) MPI (Mainz) Data Compilation. (2) Becker *et al.* (1976) *PLPSC* **7th,** 441–458. (3) Geiss and Bochsler (1982) *GCA* **46,** 529–548. (4) Robert and Epstein (1982) *GCA* **46,** 81–95. (5) Becker and Epstein (1982) *GCA* **4,** 97–103. (6) Heaton (1986) *Chem. Geol.* **59,** 87–102.

Shielding and Size Corrected Exposure Ages of Chondrites. Th. Graf, P. Signer and R. Wieler. ETH-Zürich, 8092 Zürich, Switzerland.

To deduce reliable exposure ages from chondritic samples from unknown positions in meteoroids of unknown size, the depth dependence of the production of cosmogenic nuclides should be well known. To this goal, we measured He, Ne, Ar and ^{10}Be in adjacent samples from the L5 chondrite Knyahinya as a function of sample position (1). With this data base we determined the free parameters in the production equation used to model the production of cosmogenic nuclides in iron meteorites (2). The validity of the model was tested by comparing the predictions with experimental data on Keyes (3), St. Severin (4, 5) and ALHA78084 (6). The exposure ages based on ^{21}Ne, ^{22}Ne and ^{38}Ar agree within 5% for each of the meteorites.

Figure 1 shows the production rates of ^{21}Ne versus the $^{22}Ne/^{21}Ne$ ratios for spherical meteoroids of various radii and the line corresponding to the shielding correction of the ^{21}Ne production rate according to Nishiizumi *et al.* (7).



As in iron meteorites, the model does not allow deduction of meteoroid size and sample position from the noble gases in a given sample only (8). Because we also modeled the ^{10}Be production, this situation is remedied. Since the 3-isotope correlation between the ratios of the production rates of $^{10}Be/P(^{21}Ne)$ and $^{22}Ne/^{21}Ne$ is linear (8), it can be used to compute size and shielding corrected exposure ages in chondrites:

$$\frac{t}{1 - \exp(-4.33*10^{-7}*t)} = \frac{(^{10}Be/P(^{21}Ne))\{1.11\} + (0.053 \pm 0.030)(^{22}Ne/^{21}Ne - 1.11)}{(^{10}Be/^{21}Ne)\{m\}}$$

The production rate ratio $(^{10}Be/P(^{21}Ne))\{1.11\}$ is given in atoms/atom and for a $^{22}Ne/^{21}Ne$ ratio of 1.11 and the index $\{m\}$ denotes the measured ratio. With an exposure age of Knyahinya of 40 Ma according to Nishiizumi *et al.* (7), we determined $(^{10}Be/P(^{21}Ne))\{1.11\} = 0.141 \pm 0.002$.

The large uncertainty of the coefficient of the $^{22}Ne/^{21}Ne$ ratio reflects the comparatively large uncertainties of the Be determinations. Improvements of the counting statistics as well as interlaboratory calibrations of ^{10}Be and the noble gas determinations would reduce this uncertainty. Exposure ages of St. Severin and ALHA78084 derived by this method agree to 5% with those based on noble gas profiles mentioned above. References: (1) Graf *et al.* (1988) in prep. (2) Signer and Nier (1960) *JGR* **65,** 2947. (3) Wright *et al.* (1973) *JGR* **78,** 1308. (4) Schultz and Signer (1976) *EPSL* **30,** 191. (5) Tuniz *et al.* (1984) *GCA* **48,** 1867. (6) Sarafin *et al.* (1985) *EPSL* **72,** 171. (7) Nishiizumi *et al.* (1980) *EPSL* **50,** 156. (8) Voshage (1984) *EPSL* **71,** 181.

^{244}Pu Abundance in Ordinary Chondrites. B. Hagee,[1] T. J. Bernatowicz,[1] F. A. Podosek,[1] D. S. Burnett,[2] M. L. Johnson[2] and M. Tatsumoto.[3] [1]McDonnell Center for the Space Science, Washington University, St. Louis, MO 63130 USA. [2]Geological Sciences, Cal Tech, Pasadena, CA 91125 USA. [3]U.S.G.S., Federal Center, Denver, CO 80225 USA.

The cosmic abundance of ^{244}Pu is an important parameter in models of nucleosynthetic chronology and as a reference value in studies of solar system chronology. Experimental determination of this abundance is a long-standing problem which has still not been fully solved. Two different approaches have been used, both based on measuring ^{244}Pu via its fission product Xe, but in two different classes of meteoritic material. One class consists of samples relatively rich in Pu and relatively poor in Xe components, especially trapped Xe, which interfere with identification of fission Xe. Such materials, *e.g.,* achondrites, phosphates, refractory inclusions, are, however, chemically fractionated, and lacking a stable or long-lived isotope of Pu the ^{244}Pu measurements must be translated to cosmic abundance by assuming geochemical coherence with another element, typically Nd. By this approach the best estimate (1) of cosmic ^{244}Pu abundance, stated relative to co-produced (r-process) ^{238}U, is $^{244}Pu/^{238}U = 0.004$. The other class of material is bulk chondrite, believed to be an unbiased sampling of non-volatile elements. We believe that this is the best approach to determining the cosmic abundance of ^{244}Pu, since assessing whether Pu is geochemically coherent with Nd or another element requires independent knowledge of the unfractionated abundance of ^{244}Pu. The whole-rock chondrite approach is experimentally difficult, however. For some time the best estimate of ^{244}Pu abundance by this approach was $^{244}Pu/^{238}U = 0.015$, based on an analysis of the LL6 chondrite St. Severin (2). More extensive and sophisticated analyses of St. Severin (3, 4) led to an improved estimate $^{244}Pu/^{238}U = 0.007$, sharply lower than the previous value but still substantially higher than the value based on differentiated samples.

While it is important to determine ^{244}Pu abundances in whole-rock chondrites other than the single meteorite St. Severin, previously available data on other meteorites have not been usefully precise. We have determined fission Xe concentrations (Table) by stepwise heating analysis of a group of (unirradiated) ordinary chondrites selected to facilitate identification of fission Xe. Isotope dilution measurements of U, Th, Nd and Ce on aliquots of the samples used for gas analysis are under way. These samples were prepared from alternating cut slabs; the remaining slab faces have been examined for general petrological characterization and for distribution of phosphates, the principal hosts of Pu. The data available so far indicate fission Xe concentrations and $^{244}Pu/^{238}U$ ratios consistent with those in St. Severin.

The fission Xe calculations require assumption of trapped Xe composition and are sensitive to this assumption. The tabulated fission concentrations are minima in that they assume trapped $^{130}Xe/^{136}Xe$ equal to the highest observed value. The trapped $^{130}Xe/^{136}Xe$ ratios for all these meteorites are similar and, as previously noted for St. Severin (4), are significantly different (higher) from AVCC. References: (1) Marti

	Sample	$^{136}Xe_f$ (10^{-13} cc/g)	U (ppb)	$\frac{^{244}Pu}{^{238}U}$
LL5	Olivenza	7.1 ± 2.9	10.88	0.006
L6	Barwell	7.6 ± 4.2	9.24	0.006
H5	Pultusk	12 ± 7		
H6	Guarena	20 ± 8		
LL6	Marion	6.9 ± 2.6		
LL6	St. Severin (3, 4)	6.9 ± 0.6		0.007

K., Lugmair G. W. and Scheinin N. B. (1977) *Lunar Planet. Sci.* **8,** 619–621. (2) Podosek F. A. (1972) *Geochim. Cosmochim. Acta* **36,** 755–772. (3) Hudson G. B., Kennedy B. M., Podosek F. A. and Hohenberg C. M. (1982) *Lunar Planet. Sci.* **13,** 346–347. (4) Hudson G. B., Kennedy B. M., Podosek F. A. and Hohenberg C. M. (1988) *Proc. Lunar Planet. Sci. Conf.* **19th,** in press.

Trojan Asteroid Lightcurves: Continuing Work.

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Last year, Hartmann, Tholen, Cruikshank, and Goguen (1) reported the unexpected discovery that Trojan asteroid lightcurves appear to contain more high amplitudes than among main belt asteroids. This result is important because it may imply information about Trojans' origins and histories. We hypothesized that because of the low collision frequency among the Trojans, more primordial bodies may be preserved, and they may have more irregular shapes. This work has now been published by Hartmann, Tholen, Goguen, Binzel, and Cruikshank (2).

Further observations are underway to attempt to confirm these results. Coordinated, complimentary work is being done by our group and by Linda French and co-workers. Figure 1 shows the status of our current set of data. This new figure includes recent three additional asteroids observed by Tholen, subsequent to our earlier work. More observations are needed to enlarge the sample, but the peculiarity of the Trojan-Hilda sample remains prominent. We need to understand its cause! References: (1) Hartmann W., Tholen D., Cruikshank D. and Goguen J. (1987) *Meteoritics* **22,** 399–400. (2) Hartmann W., Tholen D., Goguen J., Binzel R. and Cruikshank D. (1988) *Icarus* **73,** 487–498.

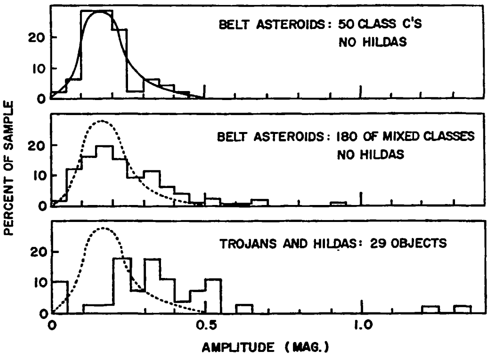

FIG. 1. Comparison of distributions of maximum observed amplitudes among belt asteroids (top, center) and Trojans and Hildas (bottom). All samples are for the same diameter range, 42–188 km. Dotted lines repeat the distribution sketched in the top figure, for reference.

Comparison of Volatiles Released from Carbonaceous Chondrites and IDPs with the Halley Cometary Volatiles.

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The volatile contents in primitive extraterrestrial materials are important to the understanding of the origin and subsequent evolutionary histories of the organogenic elements (H, C, N, O, S, and P). Equally important is the comparison of the volatile compositions of interplanetary dust particles (IDPs), carbonaceous chondrites, and cometary dust. We are carrying out direct analysis of volatiles associated with IDPs and individual fragments of carbonaceous chondrites and comparing their abundances and distributions with the data returned from the Halley encounters.

A laser microprobe-quadrupole mass spectrometer system has been used to extract volatiles from individual grains of Orgueil along with fragments of the Murchison, and Allende (1) carbonaceous chondrites, and 2 IDPs [W7013B13 and 4 fragments of W7013B17 (2)]. The individual particles have been "zapped" with a Q-switched, Nd-glass laser (energy input of 0.1-1 J) to extract the volatiles from the samples. The released volatiles are analyzed with a benchtop quadrupole mass spectrometer and detected by an electron multiplier.

The major volatiles released from the carbonaceous chondrites include (m/z): C (12), N (14), O (16), H_2O (18), C_2H_2 with minor CN (26), CO with minor N_2 (28), O_2 (32), H_2S (34), hydrocarbons (39 and 41), CO_2 (44), COS (60), CS_2 (76), and C_6H_6 (78). Allende contained less H_2O than Murchison and Orgueil, and as expected the CI Orgueil released a factor of approximately 2.0 and 4.0 more volatiles than the CM Murchison and CV Allende meteorites, respectively.

The W7013B17 particles released CH (13), N (14), O (16), m/z = 20, O_2 (32), H_2S (34), HCl (36), hydrocarbons (23, 51 and 77), mass 61 and 74 possibly related to C_2H_5S or $C_2H_5O_2$ and C_3H_6S or $C_3H_6O_2$, respectively, and Silicon oil (132). The W7013B13 IDP particle released similar volatiles, however, W7013B13 released an order of magnitude more N than W7013B17 and its spectra also contained NH_3 (17), hydrocarbons (27, 39, 41, 49, 51, 55, 56, 62, and 67), COS (60), and CS_2 (78). The volatiles released from the IDPs varied widely in composition and abundance.

The spectral information obtained from the analysis of volatiles associated with the IDPs suggests that the compositions are related to those of carbonaceous chondrites and data returned by Vega 1 in its encounter with Halley. From the available information on the analysis of IDPs in the laboratory it is clear that the compositions and abundances of organogenic elements and their simple compounds vary over a wide range. Analysis of additional IDPs in the laboratory should further assist with the characterization of the CHON compositions associated with IDPs. References: (1) Blanford G. E. and Gibson, Jr. E. K. (1988) *LPS* **19,** 98. (2) Blanford G. E. and Gibson, Jr. E. K. (1988) *LPS* **19,** 100.

Relative Abundance of Different Types of Meteorites and the Quality of the Antarctic Meteorite Sample.

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Traditionally the relative abundances of different types of meteorites have been modeled from the Modern Falls. With the inclusion of the collection of meteorites from Antarctica, has the concept of expected relative abundances changed?

The Antarctic finds are comparable to the Modern Falls because they are easily recognized as meteoritic, and have not been highly weathered. The collections differ in two important ways. On one hand, the Modern Falls represent a larger collection area; on the other, the Antarctic finds represent a longer collection time. Both collections are thus important, but in different ways, because they represent samples integrated over different variables: time and space. The Allan Hills Main Icefield is the only Antarctic meteorite collection site which has been thoroughly searched and from which all the meteorites have been systematically removed and examined. This icefield also shows no strong evidence of being affected by single fall events (1). If we assume that these meteorites are a good sample of what has fallen onto the Antarctic icesheet, we can compare these directly to the Modern Falls. A good test of the similarity of the two samples is the relative abundance of different broad compositional classifications of the meteorites.

Two things must be done in order to compare the relative abundance of different types of meteorites between the Modern Falls and the Antarctic Finds from the Allan Hills Main Icefield. First, we must compare masses, not numbers. There is a strong surplus in number of H chondrites in the Allan Hills population. In addition, this relieves us of the burden of estimating the number of falls represented by the Antarctic Finds (2). Second, we must remove some of the extremely large meteorites from the Modern Falls collection. This is done because they are much larger specimens than would be expected to have fallen over the collection area and time represented by this collection.

When this comparison is made, the relative abundances of different types do not match within reasonable confidence levels, even at very broad classifications. Thus we have two distinct samples which can be used to model the meteoritic populations which come to the Earth. Since we conclude that the two samples are not equivalent, we have to choose which is more representative; integration over time, or integration over geographical area. The choice between the two has bearing on studies of current and ancient meteorite influx rates and size distributions. References: (1) Harvey R. (1988) *Meteoritics* **23,** this volume. (2) Harvey R. (1987) *Meteoritics* **22,** 403.