

howardites, several types of eucrites (including over 50 pieces), two or more enstatite chondrites, many ordinary chondrites and many pieces of rare or new meteorites. However, there are many specimens that have not been processed initially and examined in detail in the National Institute of Polar Research, Tokyo.

ON THE ORIGIN AND COMPOSITION OF HYDROGEN AND CARBON IN METEORITES

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As a continuation of our previous studies (Yang and Epstein, 1982; Robert and Epstein, 1982), 19 bulk meteorites and 40 acid treated meteorites of all types were analyzed for their concentration and isotopic composition of hydrogen and carbon. Bulk samples show terrestrial δD values with some exceptions. There is no relationship between δD and hydrogen or carbon content, $\delta^{13}C$, class, etc. However, we find that there are positive relationships between δD in acid residues and hydrogen or carbon content. These correlations seem to be independent of meteoritic class or petrologic types.

The acid residues are more resistant to oxidizing reagents than was found by Robert and Epstein (1982) and residues resemble those which contain anomalous noble gases (Lewis *et al.*, 1975). The suggested interstellar origin of these residues whose hydrogen has high D/H finds further support in: 1) the positive relationships between δD and hydrogen or carbon content, 2) the high δD values of hydrogen in residues from both carbonaceous and noncarbonaceous meteorites, 3) the presence of anomalous noble gases in these residues (Yang and Anders, 1982).

Good relationships exist between δD and $\delta^{13}C$ in acid residues. Primitive meteorites have a strong inverse relationship between δD (between -500 and $+2000$ ‰) and $\delta^{13}C$ (between -22 and -12 ‰). Residues from meteorites which suffered metamorphism show a larger variation in $\delta^{13}C$ (-31 to -15 ‰).

We attempted to isolate phases containing hydrogen of high D/H ratio by several techniques: 1) Magnetic separation of bulk Carraweena and Abee. 2) Density and magnetic separation of Orgueil HCl-HF residue. 3) Treatment with organic solvents (CCl_4 , C_6H_{14} , Acetone, C_6H_6 , CH_3OH) on Semarkona acid residue. 4) three size separations of Semarkona acid residues. Only experiment four produced an effect. Fine grains show higher δD values and higher hydrogen concentrations (1065 ‰; 2200 μ moles/g) as compared to coarse grains (156 ‰; 890 μ moles/g). Also the fine grains showed a higher $\delta^{13}C$ and carbon concentration (-19 ‰; 8.0% carbon/g) than did the coarse grains (-31 ‰; 2.8% carbon/g).

An HCl-HF residue of Murchison was treated by H_2O_2 for one aliquot and by HNO_3 for the other aliquot. The δD for the former residue was 1800 ‰ and for the latter 940 ‰. The H_2O_2 oxidation reduced the hydrogen and carbon content by 60 to 80%. This partial oxidation increased to δD from 1100 ‰ to 1800 ‰.

In our extraction procedure where we pyrolyze our samples, we found that the δD values became generally more positive with higher temperatures. When both H_2O and H_2 are produced, δD values of H_2O are higher than δD values of H_2 gas. Semarkona bulk however, showed very different release patterns. For example, 54 μ moles/g of H_2 gas gave a δD value of 3600 ‰, whereas, 156 μ moles/g of H_2O extracted at the same temperature range gave a δD value of 2150 ‰. Moreover one bulk sample released H_2 gas with a δD value of 5300 ‰. A sample of acid residue of Semarkona gave total hydrogen of $\delta D = 440$ ‰, a considerable lower δD value than for bulk sample. A simple material balance calculation shows that the acid soluble phases contained total hydrogen of $\delta D = 1700$ ‰. This D/H ratio (0.002) is similar to that of interstellar molecules (Wannier, 1980). Spallation origin may be ruled out since it should also produce unheard of quantities of 6Li , 3He , ^{21}Ne , ^{131}Xe , etc.

A very low δD value of -500 ‰ was obtained from a yield of 3600 μ moles/g of hydrogen from HCl-HF residue of Abee (E4).

Lewis, R.S. *et al.*, 1975. *Science* **190**, 1251.

Robert, F. and S. Epstein, 1982. *GCA* **46**, 81.

Wannier, P.G., 1980. *ARAA* **18**, 399.