N85-26557

CARBON ISOTOPES IN BULK CARBONACEOUS CHONDRITES; Jérôme Halbout*, Toshiko K. Mayeda, and Robert N. Clayton, University of Chicago, Chicago, IL 60637. *Present address: Université de Paris, 75251 Paris Cedex 05, France.

At the present time, astronomers observe the formation of new stars as a consequence of gravitational contraction of "lumps" of gas and dust in large cold clouds within our galaxy. Our own sun and solar system may have formed in a similar fashion some 4.6 billion years ago. In order to learn more about the raw materials from which our solar system was formed, and also about the chemical and physical processes involved in its formation, we try to identify and study the most "primitive" matter accessible to us. Such matter has been found on a microscopic scale in a variety of meteorites: fragments of small solar system bodies that were never part of a large planet. This primitive matter has, in most cases, been identified by the presence of anomalous abundances of some isotopes of the chemical elements. These abundances are called "anomalous" if they cannot be accounted for by any known physical or chemical process occurring within the solar system. In some cases, the anomalies have been attributed to chemical reactions that took place in the cold cloud before formation of the solar system, at temperatures of -370°F or lower; in other cases the anomalies appear to result from nuclear reactions in exploding stars.

The element carbon has two stable isotopes: ^{13}C and ^{12}C. On earth, the relative abundances of these isotopes are fairly uniform, with the ratio of the number of ^{12}C atoms to ^{13}C atoms averaging 89, and ranging from about 88 to 94. The variations are due to small differences in the chemical properties of the two isotopes.

Of particular interest for carbon isotope studies are the primitive meteorites known as "carbonaceous chondrites." As their name implies, they are relatively carbon-rich (typically 1 to 3% by weight). Carbon is present in a variety of chemical forms, including graphite, carbonate minerals, and a large number of complex organic molecules. The presence of such an array of compounds attests to the primitive nature of these meteorites, since they could not have survived extensive heating. The carbonaceous chondrites are, therefore, prime candidates for the preservation of chemical substances that pre-date formation of the solar system.

Two previous studies, one at the University of Cambridge, the other at the California Institute of Technology, showed that the carbonaceous chondrite Murchison, which fell in Australia in 1969, contains a minute fraction of carbon with more than twice as much ^{13}C as terrestrial carbon. These studies were carried out on samples which were minor residues left after chemical dissolution of the main constituents of the meteorite. In our work, involving four other carbonaceous chondrites as well as Murchison, we have analyzed all of the carbon in the meteorites, using a selective oxidation technique to sort out the carbon contained in different chemical forms (graphite, carbonates, and organic matter). We confirmed the presence of the ^{13}C-rich component, and resolved additional carbon components with different, but characteristic, isotopic signatures.

Comparison can be made between the carbon isotope ratios in meteorites and the ratios observed in interstellar molecules by the techniques of radio astronomy. In interstellar molecules of carbon monoxide (CO) and formaldehyde (H_2CO), ratios of ^{12}C to ^{13}C range from about 20 to 100, with an average value of 67. The lowest $^{12}C/^{13}C$ (i.e., highest ^{13}C) ratios observed in meteorites are 42 (Cambridge and Chicago) and 36 (Caltech). It should be noted that the interstellar molecules and the meteorite samples represent two different times in the evolution of the galaxy, since the meteoritic materials have been locked up in mineral grains since their formation more than 4.6 billion years ago. The large variations in isotopic abundance in both the interstellar molecules and in the meteoritic materials are probably a consequence of nuclear reactions in stars, with subsequent ejection of matter from the stars into the interstellar medium.