A SPECTACULAR NITROGEN ISOTOPE ANOMALY IN BENCUBBIN;

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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 nitrogen has two stable isotopes: ^{15}N and ^{14}N. On earth, the relative abundances of these isotopes are fairly uniform, with the ratio of the number of ^{14}N atoms to ^{15}N atoms averaging 270, and ranging from about 258 to 274. The variations are due to small differences in the chemical properties of the two isotopes. Earlier studies of the isotopes of nitrogen in iron and stony meteorites revealed a considerably greater range in the abundance ratio, from about 230 to 300. Furthermore, the

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abundance ratio of nitrogen in the solar wind (as measured in solar atoms implanted into surfaces of solid grains in the lunar surface soil) has varied over geologic time from at least 320 in the past to 270 today. Clearly there are processes in the sun and solar system that are much more effective in separating or producing isotopes of nitrogen than any processes acting on earth. Whether these are predominantly chemical reactions or nuclear transformations remains to be resolved.

The new result reported here is an isotopic measurement on an unusual stony-iron meteorite named Bencubbin, which was found in Western Australia in 1930. Nitrogen from both the metallic and stony parts of the meteorite was analyzed, and in both materials large excesses of ^{15}N were found, resulting in values of the $^{14}N/^{15}N$ abundance ratios as low as 137. That is, ^{15}N is enriched in Bencubbin by about a factor of two relative to terrestrial nitrogen. This is by far the largest ^{15}N enrichment of any known natural material. The effect is so large that chemical processes are probably inadequate to account for it, and one looks, therefore, for possible nuclear reactions. The isotopes of nitrogen are known to play an important role in the main energy-production processes in many stars, through a series of nuclear reactions known as the CNO cycle (involving the elements carbon, nitrogen, and oxygen). However, in the normal CNO cycle, ^{14}N is produced and ^{15}N is destroyed, which is in the opposite direction to what we see in Bencubbin. In face, radio astronomers observe enhancements of ^{14}N in parts of our galaxy due to the operation of this cycle in stars. An alternative possibility is the production of ^{15}N in the explosive stellar phenomenon known as a nova. Nova explosions have previously been called upon to explain the production of ^{26}Al, a radioactive isotope that was present in the early solar system when the meteorites were formed.

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Additional studies of Bencubbin, in search of isotopic anomalies in other elements, may reveal whether the postulate of a nuclear origin is supported.