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Final Technical Report

Project Title: "Observations and Modeling of the Transient General Circulation of the North Pacific Basin"

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The objective of this study was to clarify the role that interstellar-cloud chemistry played in forming the population of organic molecules presently found in carbonaceous meteorites. This goal was to be achieved by means of defining the isotopic components present in organic and related phases in the meteorites and thereby identify the processes and source reservoirs involved in organic synthesis in the early solar system.

Isotopic analysis of separated amino acids from the Murchison meteorite yielded results that are complex and not fully interpretable at this time. Substantial inter-acid variability in D/H ratio was observed, some but not all of which could be attributed to exchange with terrestrial hydrogen. Pronounced, though smaller, variability was also found for $^{15}N/^{14}N$ ratios. For both D/H and $^{15}N/^{14}N$ data, observed meteoritic values were substantially greater than found in terrestrial materials, providing a robust constraint on degrees of possible terrestrial contamination. Also, $^{13}C/^{12}C$ ratios, though falling within the range of data found on earth, significantly exceeded those characteristic of naturally occurring terrestrial amino acids. Inter-acid variability in $^{13}C/^{12}C$ ratios was muted relative to that observed for D/H and $^{15}N/^{14}N$ but still lay well outside of experimental uncertainty. No systematic relationship could be observed between variations in H, C and N isotopes.

Two anomalous components were also found during the course of this study. A highly (>6% relative to terrestrial) ^{15}N-depleted, N-rich compound, which has not yet been identified, co-eluted with some amino acids. Clearly the Murchison meteorite sampled nitrogen from a number of highly diverse isotopic reservoirs. In fact, from this and related studies, it is now apparent that the distribution of nitrogen isotopes in the primitive solar system was extremely inhomogeneous.

The second anomalous result obtained in the present study was for an extract of "ammonia" from Murchison. It should be noted that this sample consisted of ammonia that was probably derived from a number of different compounds present in the meteorite itself, possibly including amines and amides, as well as ammonia sensu strictu and ammonium slats. However, the significance of this analysis is that the $^{15}N/^{14}N$ ratio measured was much lower than those found for the meteoritic amino acids (+2% vs around + 9% relative to terrestrial). This raises an important question concerning the source of the ammonia that was involved in synthesis of the amino acids. This issue needs to be explored further.

In addition to carrying out the research summarised above, the PI served during the grant period as chair of the Origins of Solar Systems Review panel, and as vice-chair of the Gordon Conference on Origins of Solar Systems. (In 1997, he also served as chair of the Gordon Conference.)

Patents or Inventions Resulting

None

Publication:

A number of publications drew upon results from the present study: They include:

Origins of organic matter in meteorites

In: Proc. NIPR Symposium on Antarctic Meteorites, #6, P.293(193)

Origins of amino acids in the early solar system

In: Advances in Space Research, vol. 15, p. 107 (1993)

What can meteorites tell us about nebular conditions and processes during planetesimal accretion?

In: Icarus, vol. 106, p. 135 (1993)

Nitrogen and its isotopes in the early solar system

In: Volatiles in the Earth and Solar System, p. 167 (1995)

Interstellar material in meteorites

In: Formation and Evolution of Solids in Space, in press (1997)