

Stability of amino acids and peptides during diagenesis on the early Earth

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We hypothesize that sub-seafloor sedimentary environments, where sediments are dehydrated at moderate temperature and pressure (e.g. 150°C, 200 MPa) during diagenesis, are much more feasible locations for the polymerization of amino acids [1], rather than sea-floor hydrothermal environments (e.g. [2]). This is because pressure applied in sub-seafloor environments could have stabilized amino acids and peptides even at high temperature conditions. To test the hypothesis, we conducted a series of amino acid polymerization experiments using a belt-type press. In each experiment, ~150 mg of amino acid powders (glycine, alanine, or valine) were placed under high pressure (1 – 5.5 GPa) and temperature (180 – 400°C) conditions for 2 – 24 hours. After the experiments, we analyzed yields of residual amino acids and produced peptides and elemental ratios of the experimental products.

The results showed that all three amino acids were polymerized up to 5-mer without any catalysts under the experimental conditions. At a fixed temperature (e.g. 250°C), increasing pressure increased the yields of peptides as well as residual amino acids. This indicates that amino acids and peptides were prevented from decomposing to gaseous species (e.g. CO₂, NH₃) at higher pressures. However, increasing temperature from 250 to 400°C at a fixed pressure and elapsed time (e.g. 2.5 GPa, 2 hours) significantly decreased the yield of amino acids and peptides, indicating that peptide and amino acids may not persist under such high temperature conditions, even when high pressures were applied. Elemental analyses of the experimental products showed that products with a low yield of the residual amino acid had significantly decreased N/C ratios, suggesting that NH₃ was released during the decomposition of amino acids. Thus, deamination may be a key process when determining the stability of amino acids and peptides.

[1] Nakazawa *et al.* (1993) *Viva Origino* **21**, 213–222.

[2] Imai *et al.* (1999) *Science* **283**, 831–833.

Xenon: Some unsolved problems

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Isotopes in earth science are often compared to DNA in biological sciences because both are used as tracers. Noble gases are ideal for use as tracers due to their chemical inertness and rarity. The heaviest noble gas, xenon, is a particularly excellent tracer due to its nine isotopes, five of which contain radiogenic components. The extrasolar isotope was first identified in xenon in a meteorite by Reynolds (1), which opened a new discipline named Xenology. Here, I discuss some topics in which I have been interested for decades. I hope that some of you may contribute to solving these fascinating unanswered problems.

Xe in carbonado: Some polycrystalline diamond carbonado contains enormous amounts of U-derived spontaneous fission Xe (¹³⁶Xe_{sf} = 2.5 × 10⁻⁸ cc/g) (2), which indicates that the carbonados originated in highly U-enriched environment, likely in the crust (3).

Xe in the Earth: Very early atmospheric evolution has been suggested on the basis of Xe isotopes, but in order to quantify this precisely it is essential to identify the pristine mantle isotopic composition, which is still not well understood.

Xe in the solar system: Because of multiple isotopic composition, xenon offers fundamental constraints in resolving solar evolution. The question on primordial Xe in the solar system that was first raised independently by Takaoka (4) and Pepin (5) is still unsettled.

[1] Reynolds (1963) *J. Geophys. Res.* **68**, 2939. [2] Ozima *et al.* (1991) *Nature* **351**, 472. (3) Kaminsky (1987) *Dokl. Akad. Nauk SSSR*, **294**, 439. (4) Takaoka (1972) *Mass Spectrometry* **20**, 287. (5) Pepin & Phinney (1978) *Space Science Center Report*, University of Minnesota.