

ABOUT THE GEOCHEMICAL ORIGIN OF LIFE

Issue 3 of *Elements* provides excellent reviews of a variety of geochemical and mineralogical approaches to the origin of life on Earth. Collectively, however, these papers reveal that two very important factors affecting Earth's primordial environment continue to be essentially ignored by origin-of-life researchers. One of these is the widely accepted view that the Archean deep oceans were saturated in the dissolved hydrothermal ferrous iron necessary to (a) fuel the banded iron formations (e.g. Holland 1973) and (b) explain the positive europium anomalies in their oxide facies (Klein and Beukes 1992). This is important because if the early deep oceans were saturated in dissolved ferrous iron, then the concentrations of dissolved sulfides would necessarily have been extremely low (Walker and Brimblecombe 1985; Towe 1991). This awkward geochemical situation places severe restrictions on the applicability of various proposals mentioned (e.g. Wächtershäuser 1990) regarding early world oceans, leaving such reactions relegated to special places...sulfide oases?

The other important factor that is routinely ignored is the enhanced UV flux that would have been provided by the young Sun to primordial surface environments (Canuto et al. 1982). This situation would have been exacerbated by the absence of even a moderate ozone screen in those computer-model atmospheres that require very low values for free molecular oxygen (e.g. Kasting 1993). An intense early flux of UVB radiation to the Earth's surface makes hypotheses relying on the development and growth of primordial organic molecules through wetting and drying in tidal ponds, with or without mineral surface catalysis (Usher 1977; Smith 2005), difficult to support. In addition, the very early development and establishment of photosynthetic life (Rosing and Frei 2004) would also be difficult to understand. Even a moderate ozone screen would be helpful (Towe 1996). At the moment, there is no internally consistent scenario for prebiotic synthesis leading to life's origin. Many laboratory experiments continue to be routinely done without any simulated prebiotic UV radiation flux and are carried out under our ambient 21% oxygen levels. J.V. Smith (2005) is correct when he writes, "Most scientists...search for an *integrated* geological/biochemical basis that allows biological evolution to begin on Earth using scientific features testable in a chemical laboratory, and perhaps even observable in geologic specimens." His emphasis on the



We received several letters in response to the articles published in the last two issues. We sincerely hope this forum of discussion will continue.

The editors

word "integrated" is appropriate. However, if origin-of-life researchers continue to overlook or ignore some of the important constraining environmental parameters for the early Earth, meaningful progress in this field will remain slow.

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RESPONSE FROM THE GUEST EDITOR: Ken Towe's welcome comments to *Elements* issue #3 underscore the uncertainties in any geochemical model for life's origins. For every hypothesis there are objections and counterarguments. Was the concentration of ferrous iron too high to sustain the presumed concentrations of dissolved sulfides? Perhaps, as Towe notes, local hydrothermal environments provided "sulfide oases." Was the sun's UV output too intense? Perhaps rocky overhangs or north-facing shorelines (in the Northern Hemisphere) provided an early form of sunblock.

And, indeed, there is no one successful "integrated" scenario for life's origins, primarily because few researchers accept the notion of a one-step origin. Rather, the prevailing view of life's origins on Earth and elsewhere in the universe relies on a sequence of emergent processes, each of which added a degree of complexity and structure to the emerging biochemical world (Hazen 2005). In this view, many environments played important roles – hydrothermal vents, atmospheric aerosols, UV-irradiated ponds, porous subsurface rocks, and more. To be sure, realistic experimental constraints are vital for relevant studies of any of these environments. But meaningful, steady progress in the field is being made, not by restricting our purview, but rather by embracing a diversity of ideas and experimental protocols.

Robert M. Hazen

Hazen, R. M. (2005) *Genesis: The Scientific Quest for Life's Origins*. National Academy of Sciences, Joseph Henry Press, Washington, DC

RADIUM-COLORED DIAMONDS

The March 2005 issue of *Elements* included a fascinating paper by James Shigley on treatments to change the color of diamonds; such treatments were noted to have begun on a commercial scale in the 1930s. As treated diamonds are valued much less than diamonds of natural color, the "origin of color" is today part of the quality assessment done at gemological laboratories (Shigley 2005). Of historical interest are some of the earlier, precommercial investigations on diamond coloration related to the radium industry of the early twentieth century (Landa 1987). A radium-colored green diamond was previously on display at the Smithsonian Institution's National Museum of Natural History, and such diamonds are occasionally encountered by jewelers and gemologists today.

Probably the first laboratory experiments using ionizing radiation from radium salts to induce color changes in diamonds were carried out by Sir William Crookes circa 1904 (one of his treated diamonds is in the collection of the British Natural History Museum). Around 1920, the radium research group headed by Samuel C. Lind of the US Bureau of Mines (USBM) began work on the coloring of diamonds by direct contact with radium salts and by exposure to radon gas (Lind 1972; Lind and Bardwell 1923). Low-value yellow diamonds were converted to a green color rarely seen in nature. The sale of these artificially colored stones became a concern to the Jeweler's Protective Association, who sought to ensure the value of natural diamonds. Lind had a stormy meeting with mineralogist George Kunz (for whom the mineral kunzite—a pinkish, light-violet, or



Radium-treated green diamond in a ring. © GEMOLOGICAL INSTITUTE OF AMERICA. REPRINTED BY PERMISSION.

within the jewelry industry was associated with his exposure of such scams. Kunz died in 1932 (Hadden 1999). Ironically, kunzite also changes color when exposed to ionizing radiation, and specimens of it, as well as of sapphire and diamond, were experimentally exposed (without result) during the testing of the atomic bomb at Bikini Atoll in the Marshall Islands in 1946 (Pough and Schulke 1951) presumably with the idea of using color-change measurement as a radiation dosimetry tool.

Diamonds suspected of having been radium treated continued to attract the attention of gemologists into the 1930s, with Sir William Bragg and others offering opinions on detection methods. Attention in the 1940s shifted to cyclotron-irradiated diamonds. Discussions with Dr. Shigley during the preparation of this letter are gratefully acknowledged.

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ABOUT HOWARD EVANS

I enjoyed your piece about Howard Evans. He was also a structural chemist of some ability, and did some fine work on ionic complexes in solution. I was his branch chief for some years, and sometimes it was a challenge to explain the relevance of his research to the higher-ups in the Survey. It would be an impossible task in today's world.



Let me point out that the chemists as well as the physicists are concerned with their history. Check out the Center for the History of Chemistry (Chemical History Foundation) in Philadelphia.

Priestley Toulmin, Alexandria, Virginia

lilac-colored transparent gem variety of spodumene—is named) at Tiffany & Co. in New York. This strong opposition from the jewelry industry ended any thought of future experiments by the USBM scientists.

Lind, who studied with Madame Curie prior to joining the USBM, died in 1965 after a distinguished career in radiochemistry at the University of Minnesota and Oak Ridge National Laboratory (Landa 1987). Kunz worked at both the US Geological Survey (USGS) and also at Tiffany & Co as their first "gem expert." He regarded artificially colored gemstones as frauds, and much of his fame



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