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Archean Fluid Inclusion of Hydrothermal Quartz Minerals - Archives of Prebiotic Chemistry on Early Earth?

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The composition of fluid inclusions in minerals such as quartz which have grown in the hydrothermal environment of continental crust during the Archean period might provide important information about the first organic molecules formed by hydrothermal synthesis.

We present evidence for organic compounds which were preserved in fluid inclusions of Archean quartz minerals from Western Australia. Samples from a quartz dyke north of Jack Hills and >3 Ga old quartz pebbles from a conglomerate of the Jack Hills in Western Australia (a region where the oldest zircons, with an age of more than 4.3 Ga, were found) were analyzed.

With comprehensive two-dimensional gas chromatographic analysis a variety of organic compounds were found which unambiguously show that simple and even more complex prebiotic organic molecules have been formed by hydrothermal processes. Depending on the chemical composition, all compounds determined, except for those containing nitrogen, can be assigned to four classes: aliphatic hydrocarbons, halocarbons, alcohols, and aldehydes.

Stable-isotope analysis results for CH_4 clearly indicate that the CH_4 found in the inclusions of Australian quartz samples was formed from abiotic precursors such as carbon dioxide or elemental carbon and makes a biogenic (e.g. from microbes) or thermogenic origin (decomposition of organic matter) highly unlikely. Obviously, the liquid phase in the continental Archean crust provided an interesting choice of functional organic molecules. We conclude that these organic substances could have made an important contribution to prebiotic chemistry which might eventually have led to the formation of the first living cell.

The first prebiotic chemistry and the formation of protocells could have occurred in the hydrothermal environment of tectonic fault zones in the upper continental crust, and could undergo complex reactions in a two-phase environment formed by hot water and supercritical carbon dioxide.

References:

References: [1] Schreiber U, Locker-Grütjen O, Mayer C (2012) Origins of Life and Evolution of Biospheres 42: 47-54. [2] Mayer C, Schreiber U, Dávila MJ (2015) Origins of Life and Evolution of Biospheres 45:139-148. [3] Mayer C, Schreiber U, Dávila MJ (2017) Life 7:3. [4] Schreiber U, Mayer C, Schmitz OJ, Rosendahl P, Bronja A, Greule M, Keppler F, Mulder I, Sattler T, Schöler HF, PLOS One, in review.