

Chemical transformations of soluble organic compounds delivered through impact events on the early Earth

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Understanding the prebiotic chemistry that gave rise to life critically depends critically on realizing how organic compounds are transformed in realistic early (i.e. Hadean) Earth environments, and on accurately replicating these conditions in a laboratory setting. Impact events were likely frequent during the Hadean, and could have contributed to the emergence of life via delivery of extraterrestrial organic matter and/or reduced minerals, regional impacts to the early crust, the addition of reduced gases to the local atmosphere, and the onset of local hydrothermal systems. These systems host a wide range of temperatures, pressures and mineral compositions that might contribute to the interaction and transformation of the soluble organic matter delivered by the impactor, which can be as high as 1% by mass in the case of carbonaceous meteorites. Some of these organic compounds, (e.g. glycine and other amino acids), have been invoked in many origins-of-life scenarios as widely available on the early Earth through impact delivery, but it is unclear if and how these compounds might be altered by the various physico-chemical conditions present in an impact-generated hydrothermal system. In this work, a set of organic transformation experiments were performed over ranges of plausible temperatures, pressures, salinities, mineral assemblages, and redox conditions. The most abundant soluble organic compounds found in carbonaceous meteorites (acetic acid, acetone, glycine, glycolic acid, methylbutanoic acid, propionic acid, acetaldehyde, propionaldehyde and butyraldehyde) were used as starting organic inventories present at plausible concentrations ($< 10 \mu\text{M}$), and subjected to a range of temperatures (50, 100 and 150 °C), subsurface elevated pressure (500 bar), and with dissolved hydrogen concentrations consistent with the presence of ultramafic (olivine), mafic (basalt) and felsic (granite) rocks. The results of these experiments provide a first estimate of the complex chemistry resulting from prebiotically-relevant chemical interactions and offer insights into the most effective ways to visualize and interpret mass spectra datasets resulting from non-targeted analyses, as well as bringing new perspectives on the organic inventory resulting from hydrothermal alteration of the soluble organic matter delivered to impact-induced hydrothermal systems.