Geophysical Research Abstracts
Vol. 15, EGU2013-7712, 2013
EGU General Assembly 2013

Pre-biotic organic molecules in hydrothermal quartz veins from the Archaean Yilgarn province, Australia

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According to a model recently published by Schreiber et al. (OLEB 2012), pre-biotic organic molecules as earliest markers for a chemical evolution have been formed in tectonic faults of the first Archaean cratons. These faults are often documented by quartz- and other hydrothermal vein mineralization. During the growth of these quartzes, small portions of hydrothermal fluids are enclosed which conserve the chemical composition of the given fluid medium. According to our model, the preconditions for the geochemical formation of organic molecules are a suitable carbon source (e.g. carbon dioxide), varying P/T conditions, and catalysts. This given, rising hydrothermal fluids such as mineral-rich water and supercritical carbon dioxide in deep faults with contacts to the upper earth mantle offer conditions which allow for reactions similar to the Fischer-Tropsch synthesis. So far, the inclusions which possibly have conserved the products of these reactions have not been analyzed for possible organic constituents.

First analytical results of a Mesozoic hydrothermal quartz vein from central Germany (Taunus) reveal that several organic compounds are found in fluid inclusions. However, the true origin of these compounds is unclear due to possible contamination by adjacent Corg-rich metasediments. Therefore, we have extended the study to hydrothermal quartz veins from the Archaean Yilgarn craton, to impact-generated quartz veins of the Shoemaker-Crater as well as to hydrothermal quartz boulders from a 2.7 to 3 billion years old conglomerate near Murchison (Western Australia). In one of the samples from the conglomerate, a wide spectrum of organic compounds such as bromomethane, butane, isoprene, benzene, and toluene have been detected. The time interval between the quartz formation, its erosion and its sedimentation is unknown. Possibly, the analyzed quartz sample was formed in a hydrothermal vein long before any living cells have existed on earth. In this case, the given result would be the first indication for pre-biotic organic chemistry.

In contrast, almost no organic compounds have been detected inside fluid inclusions from impact-generated quartz veins of the Shoemaker-Crater (its geological age is estimated between 1.6 and 1.0 Ga), even though they partially have formed in stromatolite-bearing sedimentary rocks. Some of them occur in Precambrian gneisses. We interpret the absence of organic compounds as a consequence of the different genesis of the quartzes near the Shoemaker-crater: the impact-induced hydrothermal system had no connection to the Earth′s mantle and hence, no contact to rising volcanic fluids.

Our analytical results prove the presence of complex organic molecules in fluid inclusions trapped in quartz veins from the Archaean Yilgarn craton in Australia. They allow a more detailed understanding of the synthetic processes which have occurred in rising hydrothermal fluids in the upper crust of the earth and which may have led to the formation of early pre-biotic organic molecules. Based on the findings, laboratory experiments will be designed to reproduce these processes and to yield further understanding on their mechanism. Furthermore, they should yield a collection of possible products which may have formed the basis for the first biomolecules in Earth's history.