Deep Reaching Gas-permeable Tectonic Faults of the Early Earth as Habitats for the Origin of Life

UNIVERSITÄT DUISBURG ESSEN

Open-Minded

[1]U. Schreiber and [2]C. Mayer

[1]University Duisburg-Essen; Faculty of Biology, Department of Geology; [2]University Duisburg-Essen, Faculty of Chemistry, Institute of Physical Chemistry

1 Introduction

The worldwide discussion on the origin of life encounters difficulties when it comes to estimate the conditions of the early earth and to define plausible environments for the development of the first complex organic molecules. Until now, the role of the earth's crust has been more or less ignored.

2 The Model

First continental crustal cores may have been developed some tens to hundreds of million years after formation of earth. Due to tectonic stress the proto continents were sheared by vertical strike-slip faults at an early stage. In our opinion, deep-reaching open, interconnected tectonic fault systems may provide possible reaction habitats ranging from nano- to centimetre and even larger dimensions for the formation of prebiotic molecules.

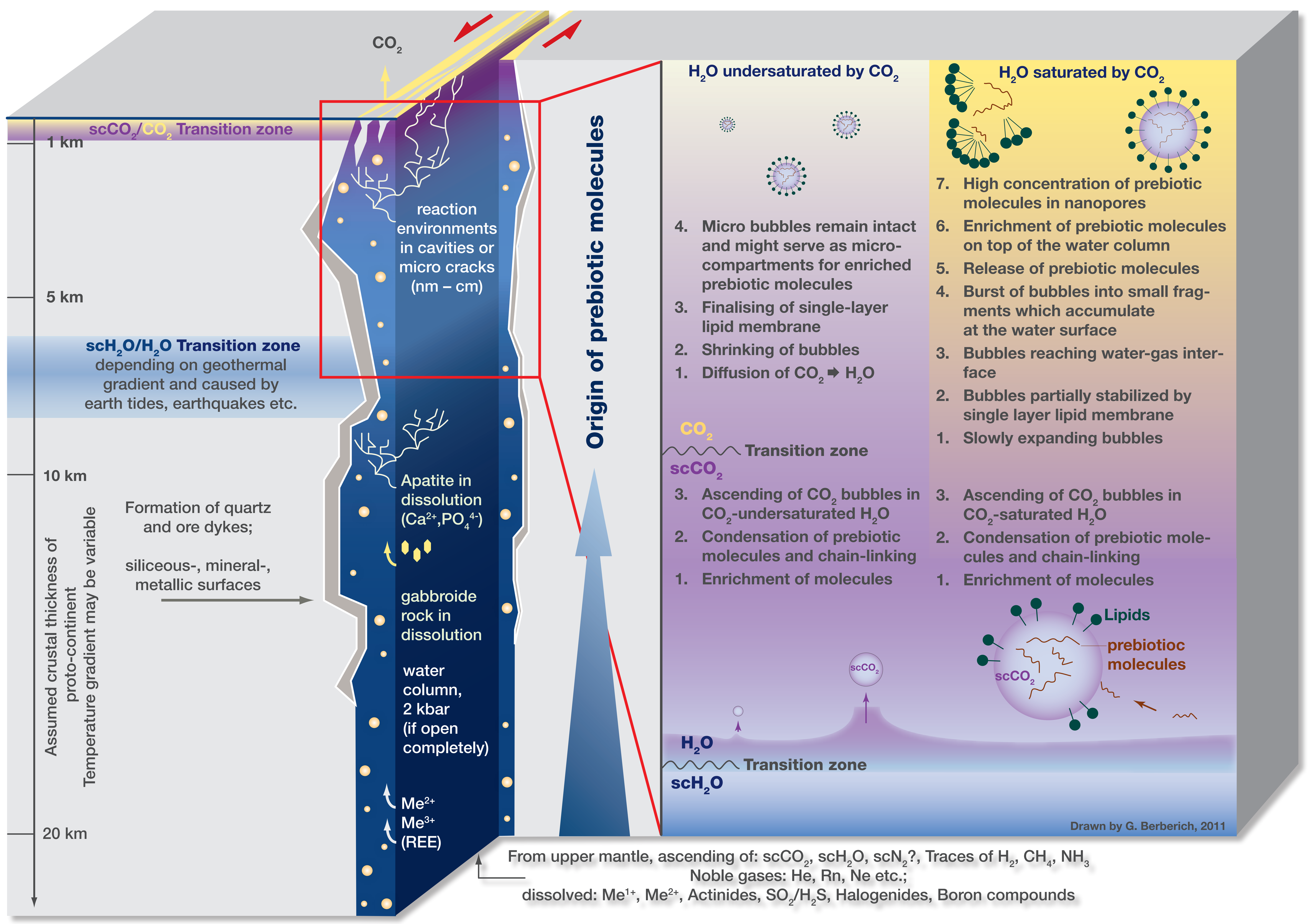

Fig. 1 Detailed section of the crust profile relating to the postulated development of prebiotic molecule enrichment processes (from: Schreiber et al. 2012)

Their fillings consist of supercritical and subcritical waters and supercritical and subcritical gases. Here, all necessary raw materials including phosphate for the development of prebiotic molecules exist in variable concentrations and in sufficient quantities. Furthermore, there are periodically changing pressure and temperature conditions, varying pH-values, metallic surfaces, clay minerals and a large number of catalysts. While cosmic and UV-radiation are excluded, nuclear radiation intervenes the chemical evolution of the molecules inside the crust.

Inside strike-slip faults, a two-phase system formed by supercritical CO_2 ($scCO_2$) in liquid water provides the environment for condensation and polymerisation of hydrogen cyanide, nucleobases, nucleotides and amino acids.

In addition to the presence of all necessary raw materials including phosphate, as well as variable pressure and temperature conditions, we suggest that supercritical $scCO_2$ as a nonpolar solvent could have played an important role.

Under variable pressure and temperature conditions and the influence of periodically changing conditions (extreme earth tides played an important role for cyclic variations within the fluid-water-interface and for the development of gradients), the reaction products can be transferred into a neighbouring aqueous environment. Based on this, prebiotic molecules could have been condensed to long-chained molecules, from which first cell structures could have been formed by chemical evolution.

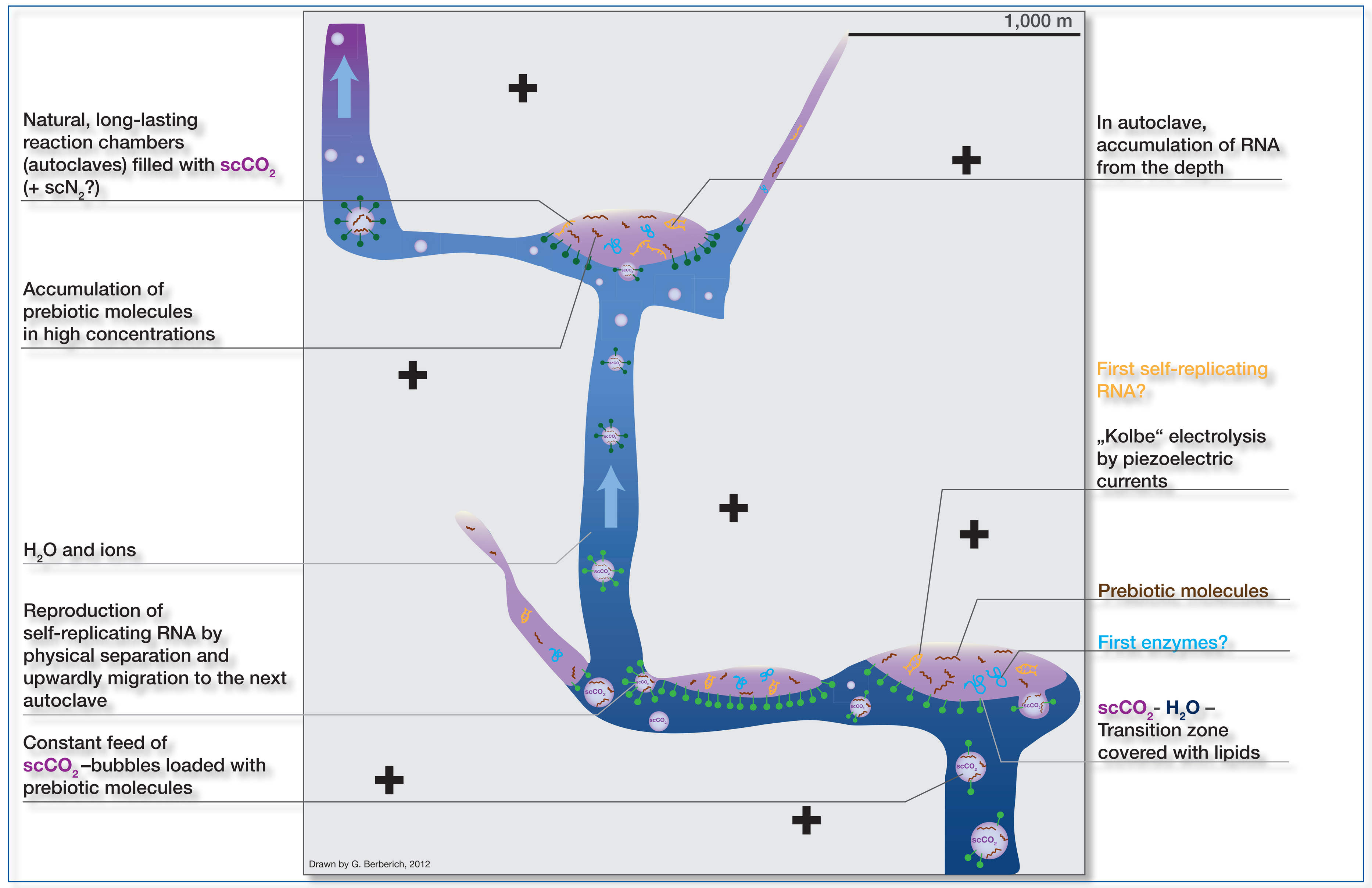

Fig. 2 Schematic representation of the hypothesized processes in a fault zone which provides possible reaction habitats ranging from nano- to centimetre and even larger dimensions for the formation of prebiotic molecules. Prebiotic molecules could have been condensed to long-chained molecules, from which first cell structures could have been formed by chemical evolution.

3 Further Activities

The proposed hypothetical model for the origin of life will be used to design crucial experiments for the model's verification. Because all proposed processes could still occur in tectonic faults at the present time, it may be possible to detect and analyse the formation of prebiotic molecules in order to assess the validity of the proposed hypothesis. A clear indication of the geological provenience of corresponding organic substances arises, if these substances appear in racemic mixtures (e.g. d- and l-alanin), making them distinguishable from similar molecules of biological origin. Additionally, their isotopic composition can help to exclude a possible biological origin. In addition to deep drillings using specific drilling fluids, the analysis of fluid inclusions of quartz dykes in former deep crustal regions are another possible approach.

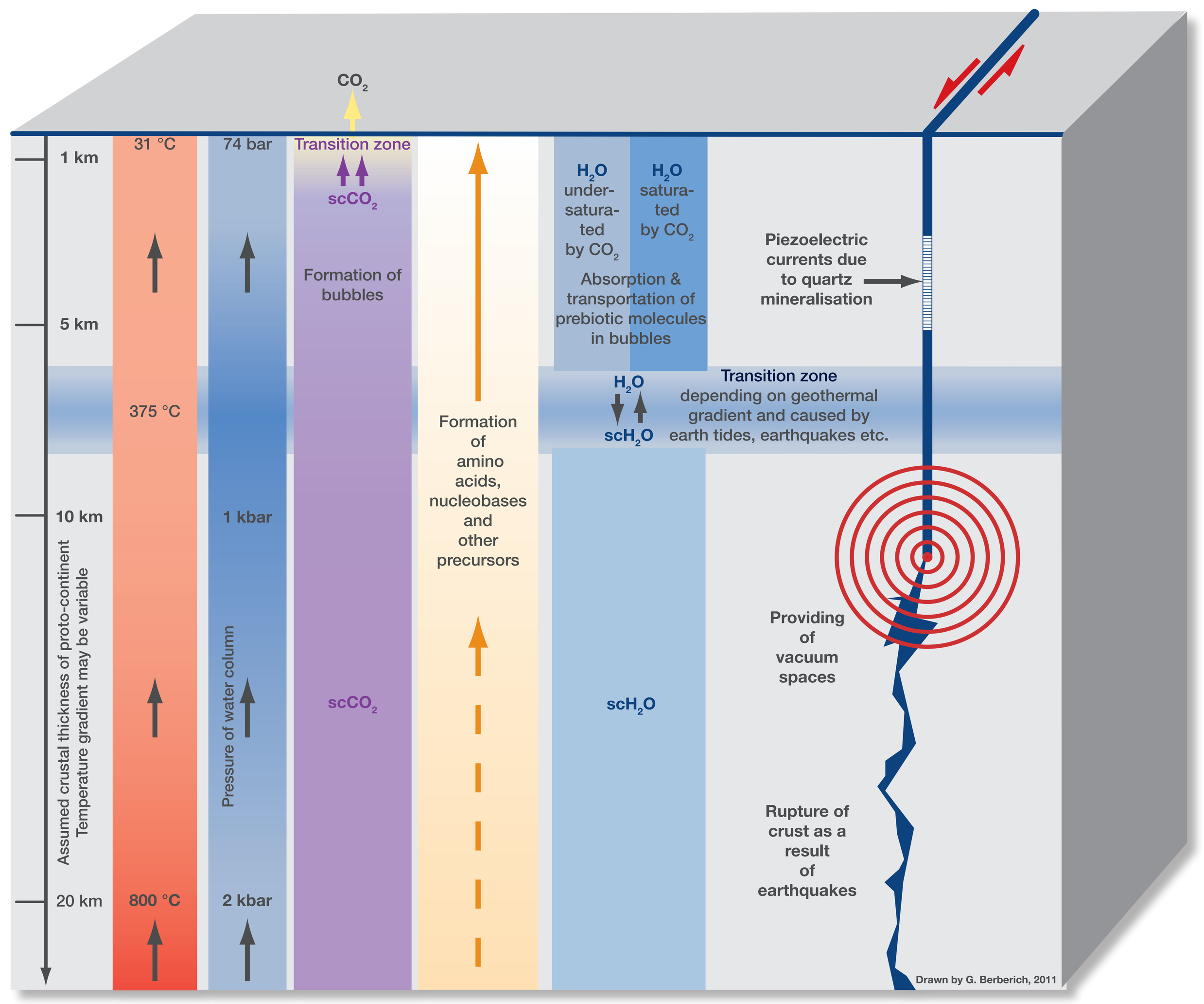

Fig. 3 Parameters of a hypothetical crust profile (from: Schreiber et al. 2012)

Fig. 4 Hydrothermal breccia, Rhenish Massif, found by: Thomas Kirnbauer

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References

Ulrich Schreiber & Oliver Locker-Grütjen & Christian Mayer (2012): Hypothesis: Origin of Life in Deep-Reaching Tectonic Faults. Orig Life Evol Biosph. DOI 10.1007/s11084-012-9267-4

Corresponding author: ulrich.schreiber@uni-due.de