Open position at the PhD or Postdoctoral level (3 years)

Transition metals in modern microbes and hydrothermal vents: A missing link between early Earth and early life

Research group of W. Martin, Institute for Molecular Evolution, HHU Düsseldorf

We seek candidates who want to experimentally investigate the catalytic role of transition metals in early early evolution under hydrothermal vent conditions. The position is funded for 3 years and can be filled either at the PhD or postdoctoral level.

Applicants for the PhD position (payscale E13, 67%), requirements for application are an MSc degree in Chemistry, Biochemistry, Biotechnology or Chemical Engineering. Experience in basic analytical techniques such as NMR and/or HPLC would be advantageous but not required.

Applicants at the postdoctoral level (payscale E13, 100%), requirements for application are a PhD degree with experience in organic or inorganic chemistry. Experience in basic analytical techniques such as NMR and/or HPLC would be required.

The tasks of the successful candidate will be to design and perform experiments to characterize the catalytic properties of native metals and heterogeneous catalysts to promote H_2-dependent CO_2 reduction to biological pathway intermediates in the context of prebiotic chemistry in hydrothermal vents. Applications should be sent by e-mail to Prof. W. Martin (bill@hhu.de) and should include a curriculum vitae, the names of two potential references and a short personal statement (0.5 pages) describing your background and interest in the position. The position can be filled immediately, the starting date can be discussed.

Project summary:

Physiological and genomic evidence suggests that the first cells were H_2-dependent autotrophs that inhabited environments similar to modern serpentinizing hydrothermal vents. Today, spontaneous exergonic geochemical reactions at vents still generate H_2 from H_2O and small organic compounds from CO_2. Such exergonic reactions are broadly similar to segments of the acetyl-CoA pathway in acetogens and methanogens, which are primordial lineages by the measure of ancient genes. The midpoint potential of H_2 however requires anaerobes that reduce CO_2 with H_2 to use flavin based electron bifurcation, a complex mechanism involving proteins, to generate low potential reduced ferredoxins for CO_2 fixation. Electron bifurcation entails proteins, however, raising the central question of this proposal: How, where, and via what reductant did primordial CO_2 reduction occur, both prebiotically (before the existence of proteins) and at the onset of microbial metabolism? In the laboratory, Fe^0 reduces CO_2 inter alia to acetate, methane, and methanol, and hydrothermal vents harbour awaruite, Ni_3Fe, a natural compound of native metals. The project will investigate the abilities of nanoparticular awaruite, Ni_3Fe, and biologically relevant native metals (Ni, Co, W, Mo, Fe) alone and in combinations, to reduce CO_2 to CO and small organic compounds under hydrothermal conditions (100, 200 and 400 °C). We will test metals as reductants (without H_2) and catalysts (with H_2) with and without water. Some acetogens and methanogens can use Fe^0 as the sole electron donor. The project will open up fundamentally new perspectives for the investigation of early chemical evolution and its connections to the physiology of microbes that thrive in primitive habitats today.

The position is part of a collaboration with the group of Dr. Harun Tüysüz at the nearby Max Planck Institute for Coal Research in Mülheim/Ruhr. Dr. Harun Tüysüz (tueysuez@mpi-muelheim.mpg.de) also has an open position in this project to investigate for the synthesis and characterization of transition metal catalysts in CO_2 reduction.

References:

Weiss MC, Preiner M, Xavier JC, Zimorski V, Martin WF (2018) The last universal common ancestor between ancient Earth chemistry and the onset of genetics. PloS Genet 14: e1007518, doi: 10.1371/journal.pgen.1007518.

Sousa FL, Preiner M, Martin WF (2018) Native metals, electron bifurcation, and CO_2 reduction in early biochemical evolution. Curr. Opin. Microbiol. 43: 77–83, doi: 10.1016/j.mib.2017.12.010.

Preiner M, Xavier JC, Sousa FL, Zimorski V, Neubeck A, Lang SQ, Greenwell HC, Kleinermanns K, Tüysüz H, McCollom TM, Holm NG, Martin WF (2018) Serpentinization: Connecting geochemistry, ancient metabolism and industrial hydrogenation. Life 8: 41; doi: 10.3390/life8040041.