Life at Hydrothermal Vents

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It is almost exactly 30 years ago that geologists found the first sign of abundant life at hydrothermal vents in the deep sea of the Pacific Ocean. Using the US research vessel "Atlantis" together with the submersible "Alvin" scientists from Woods Hole Oceanographic Institution (US) with Holger W. Jannasch as microbiologists made a number of exiting discoveries during the following years. The hydrothermal fluids are dramatically different in the chemical composition from sea water and enriched in chemically reduced molecules that can serve chemolithoautotrophic bacteria as energy sources. Life at the hydrothermal vents is dependent on these reduced substrates and on growth of these bacteria, which are the primary producers of the deep sea. They do not use light like plants and algae but chemically reduced inorganic molecules to gain energy for the fixation of carbon dioxide. We know now that not just one, but at least 4 different biochemical mechanisms have evolved in microorganisms to perform the fixation of carbon dioxide into organic molecules. Several of these are found in different representatives of the microbial communities at hot vents.

The hydrothermal fluids reach extremely high temperatures of more than 400^{o}C and on mixing with the ambient sea water (of only 2-3^{o}C) steep gradients of temperature and chemical concentrations are formed. Therefore, the energy available in these fluids, generated by geochemical processes deep below the surface of the ocean floor, is available for a great variety of microorganisms alongside the temperature gradient from maximum levels allowing life to occur down to those of ambient sea water. Most of these microorganisms are living attached to particles at or below the sea floor or suspended in the fluids, some live in symbioses with specifically adapted animals. It is exclusively the activity of these symbiotic bacteria and their primary production which allows these animals not only to live in the hydrothermal vent habitat, but also to accumulate very high levels of biomass, but also makes them strictly dependent on the continuous flow of these fluids. Indeed, the successful symbioses between bacteria and animals make hydrothermal vents to oases in the deep sea easily visible by eye.

Today a number of nations have manned or remote operated deep sea vehicles (also in Germany two of these are now in operation), to study deep sea hot vents and in particular their biology. Such vents occur all around the spreading axes in the oceans, where fluids seep out as diffuse emanations or as clearly visible vents. Our knowledge on the diversity of the different symbiotic associations and on the metabolic properties of the symbionts is steadily increasing, although we are still unable to cultivate these bacteria in the laboratory. Genetic approaches and genome sequences rapidly enlarge our knowledge on the diversity of bacteria and archaea freely living at hot vent habitats. Studies using clone libraries of natural hot vent DNA characterize the deep sea hot vents as unique habitats of hyperthermophiles and mesophiles. New groups of archaea were discovered at these vents and a recently discovered new group of proteobacteria was identified as major player in the biogeochemical reactions of hot vent systems.