Yellowstone microbes, heated corals and their global connection

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A decade of coordinated Systems Geobiology research on Yellowstone hot springs and Caribbean and Pacific coral reef ecosystems indicates a host of striking scientific parallels. The spring water at Mammoth Hot Springs in northern Yellowstone is derived from rain and snowmelt runoff in the Gallatin Mountains that flows down along faults into the rock subsurface. This groundwater is then heated by the Yellowstone supervolcano to ~100°C (212°F), chemically dissolves deeply buried ~350 million year old marine limestone, and flows back up to the surface to emerge from vents at a temperature of 73°C (163°F). During this hydrologic journey, the Mammoth Hot Spring water evolves a salty chemical composition remarkably similar to that of seawater. Furthermore, the limestone rock (called travertine) that precipitates to form the classic meter-scale terraced steps of Mammoth Hot Springs are composed of a form of calcium carbonate ($CaCO_3$) mineral called aragonite. This is the same mineral that corals use to precipitate and grow their skeletons. In addition, several of the microbes that we have identified in the 73 to 25°C (163 – 77°F) hot-spring vent drainage patterns at Yellowstone are similar, and sometimes identical, to the microbes inhabiting coral tissues, coral mucus and seawater.

As a result, our field-based controlled experiments at Yellowstone are now being used to predict how corals will respond to future global warming. Heat-loving (thermophilic) microbes living at 65 to 71° C in Yellowstone are able to respond to shifts in water flow rate and temperature by changing the speed at which travertine rock (aragonite) is deposited on the floor of the drainage channels. Our biochemical analyses suggest that the microbes do this by producing different types of protein under different water temperature and flow conditions. We are now applying this mechanism derived from Yellowstone to form new interpretations of how density banding in the aragonitic skeleton of scleractinian corals (similar to tree rings) reflects coral response to changing sea surface temperature. Accurate interpretation of coral skeleton density banding is critically important for predicting future changes in sea surface temperature and thus plays a central role in shaping long-term policy strategies on global warming.

Tritium/Helium-3 dating of groundwaters around Chernobyl site

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Estimates of groundwater age allow geohydrologists to calculate recharge rates, assess aquifer's contamination risks, and calibrate complex flow models. The $^3H/^3He$ dating method offers a direct measure for the time since groundwater had its last gas exchange with the atmosphere.

The aim of this study is to bring temporal constraints to the radionuclide transport model in the Chernobyl test site. Samples have been collected in the exclusion zone, close to a trench filled with low-level wastes, both in the upper eolian sand layer and deeper in the alluvial deposit. CFCs and SF6 have been measured as well in order to compare dating methods. The $^3H/^3He$ results presented in Figure 1 clearly show increasing ages with depth (below groundwater table). This fully supports the groudwater stratification developed in the hydrogeological model of the area. The infiltration recharge rate is a sensitive key parameter of the model, and our data are consistent with a rate about 200mm/yr (maximum estimate).

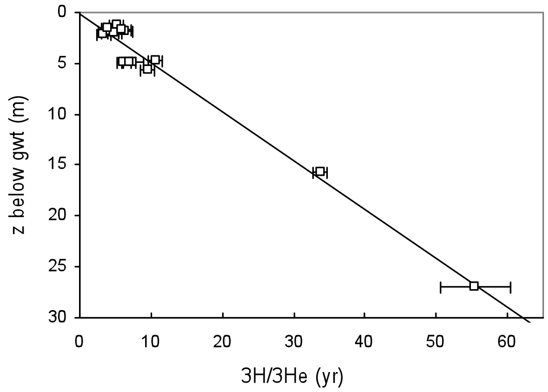

Figure 1: ^3H / ^3He ages versus depth below groundwater table.