

STABLE ISOTOPE VARIATIONS IN DEEP YUCATAN CENOTES.

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ABSTRACT

O, H, and S isotopic composition, conductivity, sulfur speciation, and pH, of two deep, water-filled karst sinkholes (known locally as cenotes from the indigenous Maya word tzonot = lake) in north central Yucatan, Mexico, were measured. These cenotes, Xcolac and Ucil, both extend through the regional fresh water lens which follow a trend: $\delta D = 8.11 \times \delta^{18}O + 10.4$, into an extensive salt water intrusion containing water isotopically indistinguishable from sea water.

Ucil and Xcolac Cenotes offer a unique opportunity to study bacterially mediated sulfur redox reactions in natural low temperature aqueous systems. Three factors make redox processes extremely important in the geochemistry of these cenotes: 1) density stratification that prevents turnover in the lower part of the system, 2) high concentration of sulfur species (that enter the system as sulfate) in the lower water layer (modified sea water), and 3) extensive tropical vegetation that falls into the cenotes to provide a rich source of carbon and trace nutrients for bacterial growth. One or more of the following characteristics distinguish deep cenotes from other aqueous environments of sulfate reduction such as fjords and marine caverns: 1) regeneration of the salt water column from the permeable aquifer system at the sides of the cenotes, 2) carbonate host environment, 3) lack of significant sediment at the bottom of the water column, 4) absence of base metal ions for metal sulfide precipitation, and 5) abundant vegetation and relatively high water temperature that are functions of the tropical environment.

Sulfate of the saline intrusion in both cenotes is strongly enriched in ^{34}S relative to sea water sulfate, from the action of sulfate-reducing bacteria. A difference in sulfur isotopic composition between sulfate and sulfide ($\Delta^{34}S$ up to 63.2 per mil) is observed at a depth of 80 meters in Xcolac Cenote and is consistent with this interpretation. This large sulfur isotope fractionation coupled with cycling between sulfate reduction and sulfide oxidation may indicate bacterial sulfur disproportionation. In contrast with sulfur isotope data from the cenotes, data from a deep (180 meter) observation well show that there is little variation in sulfur isotope composition as a function of depth. Both sulfur isotope and pH data indicate that specific processes occur within specific and sometimes narrow depth intervals.

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