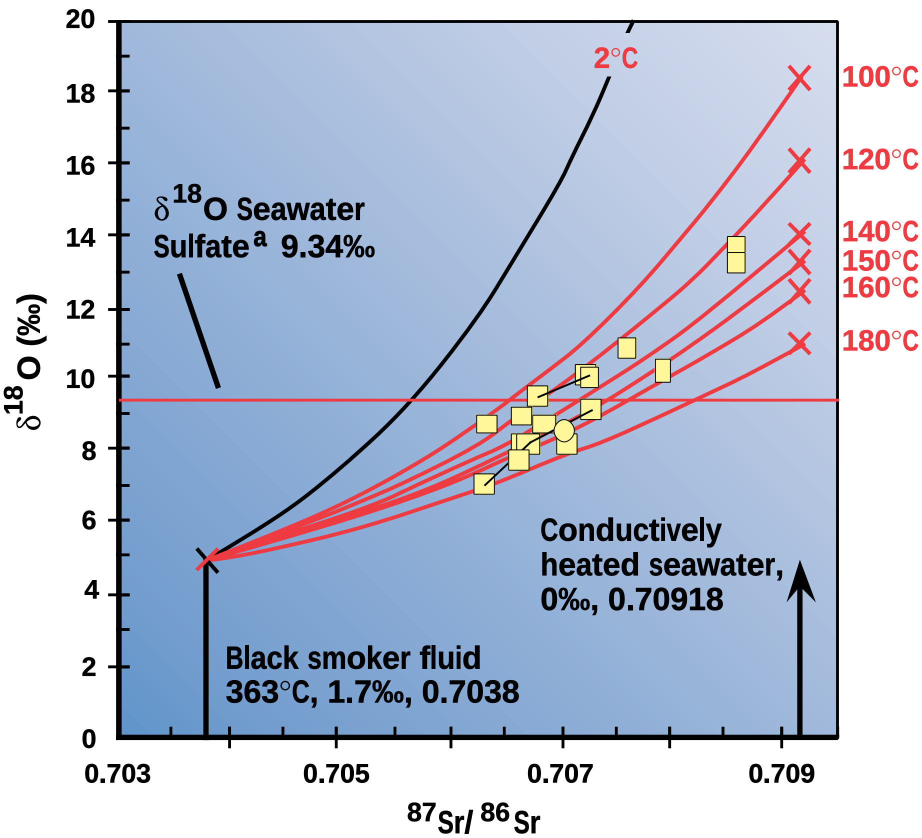
Dissecting an active hydrothermal deposit

Damon A.H. Teagle and Jeffrey C. Alt, Geological Sciences, University of Michigan,
Hitochi Chiba, Kyushu University, Japan, and
Susan E. Humphris, Woods Hole Oceanographic Institution

Strontium- and oxygen-isotopic measurements of samples recovered from the Trans-Atlantic Geotraverse (TAG) Hydrothermal Mound during Leg 158 of the Ocean Drilling Program provide important constraints on the nature of fluid-rock interactions during basalt alteration and mineralization within an active hydrothermal deposit.

The development of a silicified, sulfide-mineralized stockwork within the basaltic basement follows a simple paragenetic sequence of chloritization followed by mineralization and growth of a quartz + pyrite + paragonite stockwork cut by quartz-pyrite veins. Initial alteration involved the development of chloritic alteration halos around basalt clasts by reaction with a Mg-bearing mixture of upwelling, high-temperature (>300°C), black smoker-type fluid with a minor (<10%) proportion of seawater. Continued high-temperature (>300°C) interaction between the wallrock and these Mg-bearing fluids results in the complete recrystallization of the wallrock to chlorite + quartz + pyrite. A quartz + pyrite + paragonite assemblage replaces the chloritized basalts, and developed by reaction at 250°-360°C with end-member hydrothermal fluids having $^{87}Sr/^{86}Sr \approx 0.7038$, similar to present-day vent fluids. The uniformity of the $^{87}Sr/^{86}Sr$ ratios of hydrothermal assemblages throughout the mound and stockwork requires that the $^{87}Sr/^{86}Sr$ ratio of end-member hydrothermal fluids has remained relatively constant for a time period longer than that required to change the interior thermal structure and plumbing network of the mound and underlying stockwork.



$^{87}Sr/^{88}Sr$ vs. $\delta^{18}O$ for anhydrite from the TAG hydrothermal mound. Trajectories are calculated for the Sr- and oxygen-isotopic composition of anhydrite precipitated from mixtures of hydrothermal fluid with seawater that has been conductively heated to the labeled temperatures before mixing.

Precipitation of anhydrite in breccias and as late-stage veins throughout most of the mound and stockwork, down to at least 125 mbsf, records extensive entrainment of seawater into the hydrothermal deposit. $^{87}Sr/^{86}Sr$ ratios indicate that most of the anhydrite formed from ≈2:1 mixture of seawater and black smoker fluids (65% ± 15% seawater). Oxygen-isotopic compositions imply that anhydrite precipitated at temperatures between 147°C and 270°C and require that seawater was conductively heated to between 100°C and 180°C before mixing and precipitation occurred.