The structure and chemistry of submarine hydrothermal systems revealed by deep ocean drilling

Jeffrey C. Alt, Department of Geological Sciences, The University of Michigan

The formation and cooling of oceanic crust provide heat that drives submarine hydrothermal systems, which significantly affect the compositions of both seawater and the crust. Deep drilling into the ocean crust has provided a view into the subsurface of these hydrothermal systems, enabling an understanding of their structure and evolution, and the chemical and isotopic exchange with the oceans [*Alt,* 1995; *Alt et al.,* 1996]. Seawater recharge at ridge axes evolves with depth in the volcanic section from cold oxidizing seawater to more reacted seawater solutions and higher temperatures (up to 100-150°C). The resultant alkali uptake from seawater decreases downward (see figure), but Mg is fixed in clay minerals veins throughout. At higher temperatures in the upper dikes (200-350°C) alkalis are leached, and Mg is fixed in secondary minerals in veins. Hydrothermal fluids entering the lower dikes and uppermost gabbros are highly reacted and leach metals and sulfide at high temperatures (≥400°C; see figure). These deep rocks altered at high temperatures are referred to as the "reaction zone," where the vent fluids acquire their final chemical characteristics. Hydrothermal fluids then move rapidly upward in discharge zones to form hydrothermal vents and sulfide deposits at the seafloor or in the shallow subsurface (such as in the transition zone of Hole 504B in the figure). Alteration of the volcanic section continues for up to tens of million years on ridge flanks at temperatures of 0 to 100-150°C, depending on age of the crust and amount of sediment. Formation of various secondary minerals results in significant uptake of alkalis, Mg, and CO_2 from seawater. The uptake of alkalis, CO_2, and ^{18}O on ridge flanks offsets their release at ridge axes, but for other elements (e.g., H_2O, $^{87}Sr/^{86}Sr$, Ca, Si, Mg, U), the chemical changes are essentially unidirectional during both axial and flank processes so the effects on the oceans and the crust are cumulative.

References:

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ODP Hole 504B, eastern equatorial Pacific