Subseafloor "Rivers" of Fluid and Heat

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Fluids are present throughout Earth's crust and move vast quantities of heat and chemicals between oceanic and lithospheric reservoirs. Fluids contribute to production of continental crust, generation of explosive volcanism, lubrication of plate boundary faults, formation of hydrates and mineral resources, and development and support of biological communities. Some of the greatest challenges in marine hydrogeology are resolving the depths and distances over which flow occurs, and determining the nature of formation properties and driving forces that cause this flow. To meet this challenge, ODP scientists recognized the value of monitoring conditions within the seafloor, and developed technology to install observatories in a wide range of settings.

Several observatories have been installed at a seafloor spreading center in Middle Valley in the Pacific Ocean, off the western coast of North America (Figure 1). This is a place where new seafloor is created, so the observatories allow monitoring of "zero-age" crust. Two holes were drilled, cased and sealed in Middle Valley during ODP Leg 139, establishing the first long-term borehole observatories in the seafloor. Hole 858G was drilled in the Dead Dog vent field, within a few tens of meters of several clusters of active chimneys discharging fluids at temperatures up to 280 °C (Figure 2). Another hole (857D) was drilled 1.6 km south of the Dead Dog vent field through sediments and sills ("hydrothermal basement"). Geophysical and hydrogeological experiments were completed, and both holes were sealed with observatories (including temperature sensors, fluid samplers, and pressure gauges) and left to equilibrate. The observatories were visited by submersible and remotely-operated vehicles over several years, and reinstrumented during ODP Leg 169.

Pressure records downloaded from the observatories after 14 months suggested that, after correcting for differences in fluid density, the difference in fluid pressure between basement fluids in Hole 858G relative to fluids in Hole 857D was very small, equivalent to about 1-2 atmospheres of pressure. This small pressure difference is responsible for driving rapid flow of water to the vent field from the surrounding formation. This observation requires that hydrothermal basement below the vent field at this spreading center is extremely permeable (Figure 3).

Determining that basement permeability is very high is important because it means that small changes in pressure can travel long distances, and that fluids can move freely within the crust, greatly influencing the chemistry, biology and physical properties within the seafloor.

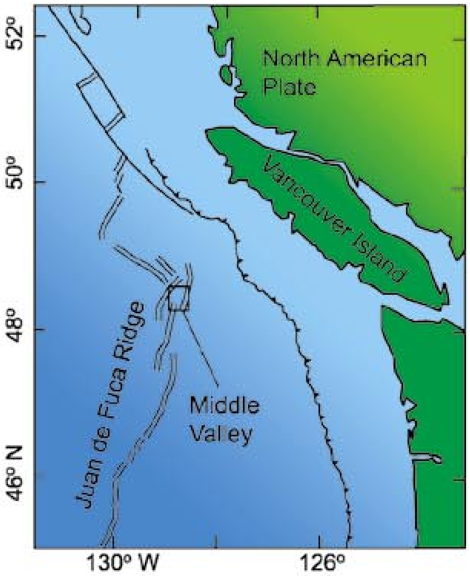

Figure 1

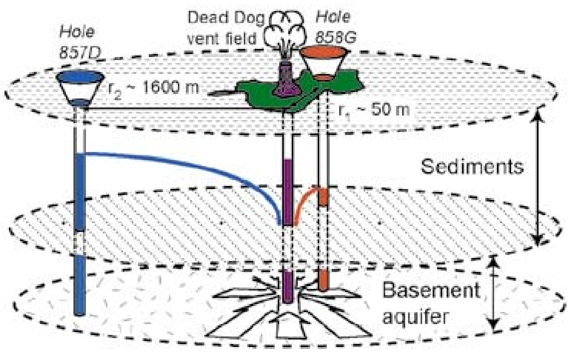

Figure 2

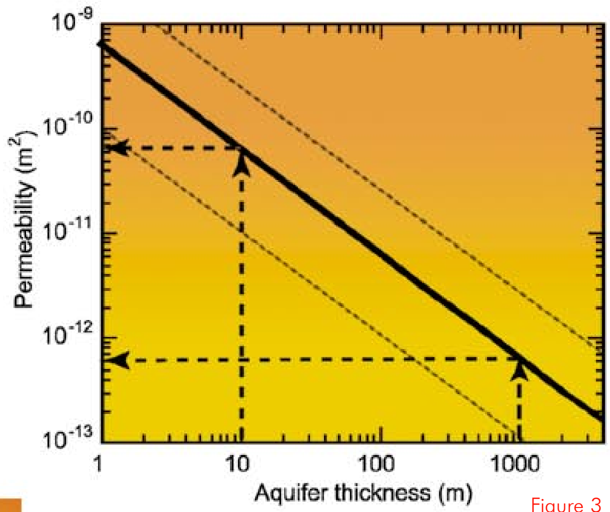

Figure 3