

Watching Plates Move with CORK Observatories

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Beneath much of the seafloor of the world's oceans, formation fluids circulate through the igneous crust and overlying sediments, transferring heat and chemicals between the interior and exterior of the Earth. CORK (Circulation Obviation Retrofit Kit) instrumentation was originally developed to document this flow through observations of temperatures, pressures, and compositions of formation fluids made well after drilling ends. Over the first decade of CORK monitoring experiments installed in a variety of ODP holes, a number of observations have been made that range well beyond the original objectives of understanding fluid circulation.

One particularly exciting aspect of CORK results is the unanticipated information provided about plate deformation (extension, compression, shearing, faulting, etc.) and associated earthquakes. CORK records show that fluid pressure and temperature respond to tectonic deformation, which often involves earthquakes but may also occur aseismically. Theory developed to account for how fluid pressure responds to seafloor tidal loading (another outgrowth of CORK observations) can be applied with little modification to explain the response to tectonic deformation. In fact, the observations of the former provide an excellent calibration for the latter. Data from CORKS have also shown that long-lasting changes in mechanical and hydrologic properties, inferred from changes in the formation-pressure response to seafloor tidal loading, result from plate strain, most notably at sites that are close to the location of earthquakes.

Changes in fluid pressure have been observed at sedimented ocean crustal sites as far as 120 km from relatively small earthquakes in the vicinity of the Juan de Fuca Ridge (Figure 1). They show that regional plate strain is observed to be greater than that which would be generated by seismic slip alone. During a series of small earthquakes on the ridge axis that began with a magnitude 4.6 earthquake, the strain observed at four CORK sites was equivalent to that which would have been produced by a much stronger, magnitude 6 event. Most of the displacement of the "spreading event" that was the cause of the plate strain and earthquakes must have taken place aseismically. Thus, research from CORKS is helping to explain the relationship between episodic plate motion and deformation and earthquake energy release.

CORK monitoring continues on the axis and flank of the Juan de Fuca Ridge (where a new swarm of seismic activity has taken place recently), the flank of the Costa Rica Rift, and the Nankai and Mariana subduction zones. New installations were just completed at the Costa Rica subduction zone. It is our hope that long-term hydrologic monitoring at all of these sites will provide new knowledge and understanding of earthquake rupture and plate strain processes, and the role of water in both.

Figure 1. Examples of pressure changes through time associated with seismic fault slip events in 1996 and 1999 (Stars). Pressures increase where the formation is compressed and decrease where it is extended, then return to unperturbed levels at rates that depend at each site on routes for hydrologic "drainage". Pressure and temperature changes associated with earthquakes have been observed in all of the instrumented holes shown.

