THE ROLE OF WATER WITHIN FAULT ZONES

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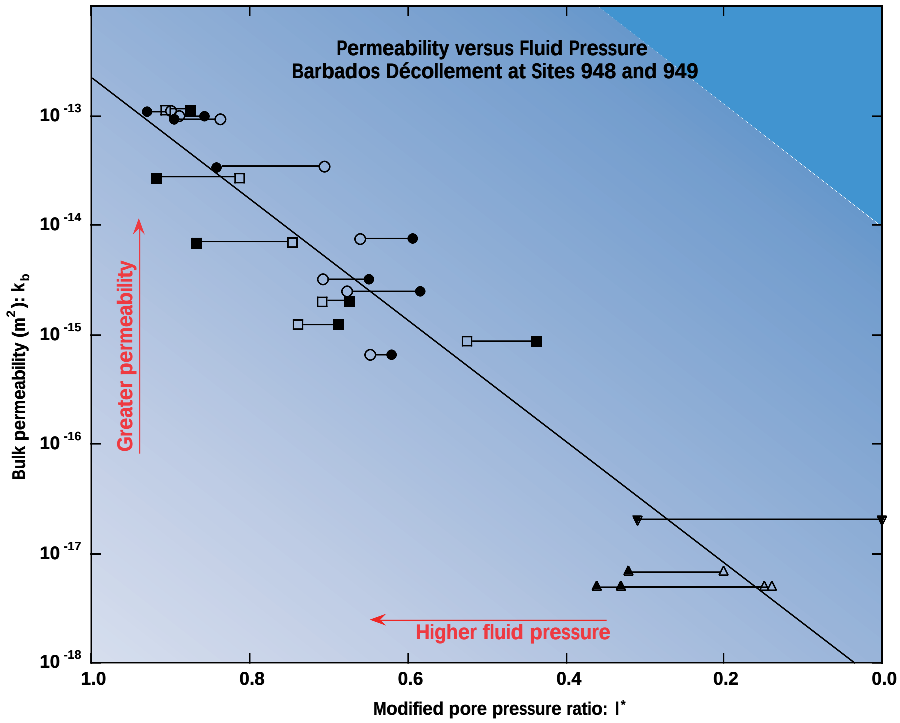
Geologists have long been aware that water plays an important role in enabling Earth's tectonic plates to slide past one another. When water is present along a fault, it may help lubricate the fault surface. When water is under pressure within a fault, it may bear some of the load of the overlying sediments and rock, and allow these materials to glide past each other over long distances. This motion takes place with or without earthquakes.

Scientists have examined the roles of water within fault zones in many settings. One area subjected to particularly intense research is the boundary between the North American and Caribbean plates, northeast of Barbados, where the two plates are moving towards each other at a rate of several centimeters per year. As these plates collide, and the North American plate is thrust under the Caribbean plate, a large wedge of sediment is scraped off and piled into a thick wedge. The island of Barbados is the tip of this sediment wedge, or "accretionary complex."



Effective bulk permeability versus pore-fluid pressure along the décollement of the Barbados accretionary complex. These are results from borehole aquifer tests during ODP Leg 156 (circles and squares used for two different kinds of tests) at Sites 948 and 949, and from CORK tests conducted during a subsequent submersible expedition to Site 949. The range of values shown for each permeability (closed and open symbols joined by a line) indicate the range in fluid pressures during each test. The modified pore pressure ratio is fluid pressure normalized to the weight of the overlying sediment; using this value rather than absolute fluid pressure allows data from the two sites to be combined. The line through the data illustrates the apparent relation between permeability and fluid pressure in this setting.

Two geologic properties of great interest to scientists working in this area are fault permeability and fluid pressure below the accretionary complex, along the fault that separates the wedge from the underlying plate. Permeability is a measure of the ease with which fluid can move through rock. It has been hypothesized that the fault below the Barbados wedge is very permeable and that the fluids within the fault are under great pressure.

The first direct measurements of permeability and fluid pore pressure along this fault were completed at two sites during ODP Leg 156 in 1994. These measurements suggest that: (1) fluid pressures are high along the fault, (2) permeability is also relatively high along the fault, and most interestingly, (3) permeability varies with fluid pressure within the fault [*Fisher and Zwart,* 1996 and in press]. Leg 156 test results are also consistent with a variety of independent, but less direct estimates based on chemical and thermal observations and modeling.

These Leg 156 data were complemented by additional information collected from a long-term borehole seal and instrument package that was left in one of the holes during the ODP expedition [*Screaton et al.,* 1997]. This hole was visited by submarine 18 months after the drilling expedition to retrieve the long-term data and to conduct additional hydrologic tests. The long-term record confirms that fluids within the fault below the sediment wedge are under great pressure, and the new tests are consistent with the idea that permeability varies with fluid pressure. These results should help scientists better understand how these kinds of faults work, and how fluid pressures influence tectonic and earthquake cycles.

References:

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