Spatial heterogeneity of physical properties along the Barbados plate-boundary fault

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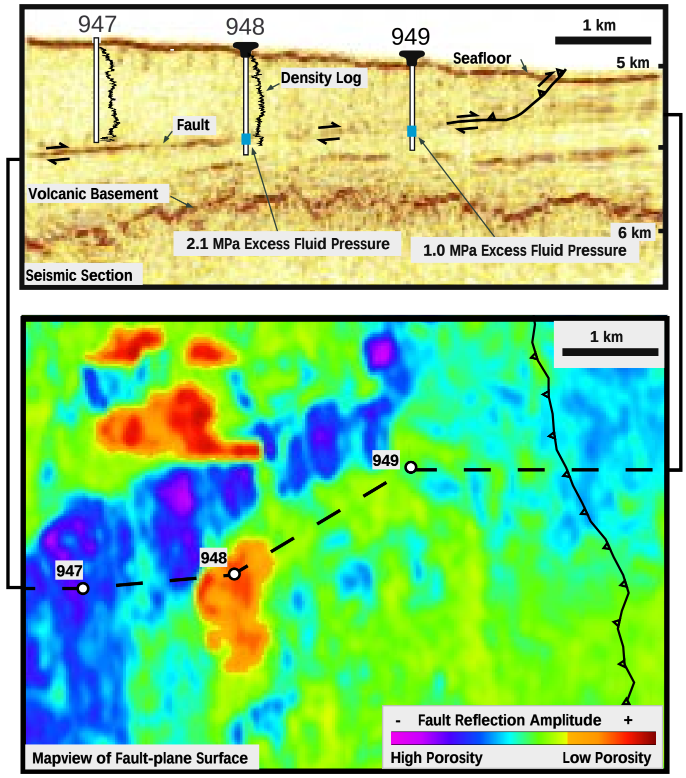
In the last decade, observations of seafloor water seeps in subduction zones have placed renewed emphasis on the relationship of fluids and fault behavior. This is particularly important in subduction zone toe-of-slope regions where forced tectonic dewatering produce exceptional rates of porosity reduction and fluid expulsion. The location of fluids and how they propagate controls the distribution of low-shear-strength fault zones. There is mounting evidence that fluids reach pressures far higher than hydrostatic, causing localized weakening, faulting and even dilation. Multiple crosscutting sets of veins indicate crack generation and mineralization induced by cyclic lithostatic fluid pressures and fluid flux. Seismic reflection cross-sections often detect a coherent mappable reflection associated with the fault including off Costa Rica, SW Japan, Oregon and Barbados. Off Barbados where the North America plate is subducting beneath the Caribbean a 3D study yielded a map-view of fault-plane-reflection peak amplitude constructed from 204 adjacent seismic sections [*Shipley et al.,* 1994]. This map spurred speculation concerning the heterogeneity of porosity, fluid pressure, fluid flow, and even strength and stress associated with plate-boundary thrusts.

ODP Leg 156 was as an opportunity to calibrate the seismic map to the geology of the fault zone at three localities with cores, logging-while-drilling, and long-term measurements of temperature and pressure in the sealed boreholes. *In situ* densities as low as 1.4 - 1.6 gm/cm^3 were discovered at subbottom depths of 575 to 560 m in layers 1-to-14 m thick [*Moore et al.,* 1996] and 2.1 MPa and 1.0 MPa overpressures were measured within the fault zone [*Foucher et al.,* 1997; *Becker et al.,* 1997]. These results suggest that the map of the reflection amplitudes (really waveforms) relate the magnitude of the reflection with the fluid content of the usually 12-14 m thick layer. Thus, the negative purple and blue portion of the map almost certainly are compartments of the fault plane of particularly low-density and, thus, higher porosity and permeability. Positive orange-reds values are higher density and lower porosity, and are probably higher-strength regions on the fault surface. The widespread negative polarity patches are high-pressured, low-strength areas. These patterns suggest analogies to asperities presumed to be active in the seismogenic zone.



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