Crustal Structure and Evolution Along the Juan de Fuca Ridge Flanks

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An extensive multi-channel seismic investigation of the Juan de Fuca Ridge was carried out in 2002. Here we focus on flank profiles crossing the Endeavour, Northern Symmetric, and Cleft ridge segments. These profiles are a few hundred km-long, extend out to crust about 5 my old, and provide detailed structural information giving insight into crustal evolution.

We observe spatial variation in sedimentary cover, tectonic activity, layer 2A thickness, depth to the axial magma chamber and Moho structure. Whereas the western ridge-flank appears to be tectonically stable, normal faults are imaged within the thick sediment section of the eastern flank indicating recent tectonic activity well beyond the axial region. Fault offsets gradually diminish upsection suggesting growth faulting caused by long-term slip within the basement structure. In places, imaged fault planes extend through the sediments and crust to the Moho. Reflections from crustal gabbros are not likely unless the rocks are serpentinized at fault planes, which is indicative of fluid flow deep into the crust. Anomalously bright Moho where the deep faults plunge into the upper mantle suggests that fluid exchange may extend even below the crust.

The reflection images show that the western and eastern ridge flanks are evolving in a markedly different way. We believe that the main causes for differential flank evolution are distinct sedimentation and tectonic histories. Massive sediment accumulation on the eastern flank strongly affects the hydrothermal fluid flow regime and the evolution of layer 2A. Faulting profoundly affects the crust by providing new pathways for fluids

trapped in the upper crust. Bending of the oceanic slab due to nearby subduction is a likely driving force for the observed faulting. The density and magnitude of faulting do not monotonously decrease away from the trench, as would be expected from pure slab bending, indicating that other factors contribute to the faulting process. Magnetic and bathymetry data tie the faulted areas to propagator wakes. The crust formed at ridge propagators may be weaker than that formed under normal spreading conditions, and thus may be the first to be faulted as the crust approaches a subduction zone.