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# Geological structures controlling hydrothermal circulation system in the eastern flank of the Juan de Fuca Ridge

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Hydrothermal fluid in the ridge flank influences physical state and evolution of the crust and mantle. Global advective heat loss from ridge flanks is more than 3 times as large as that at the axis, and the ridge-flank mass flux is at least 10 times as large. To reveal hydrothermal fluid system in the ridge flank, intensive drilling operations (ODP Leg 168, IODP Exp. 301 and 327) were conducted in the eastern flank of the Juan de Fuca Ridge (Fisher et al. 2011). Before these drilling campaigns, we believed a largely 2D view of the dominant fluid-circulation pathways across the ridge flank. However, in the eastern flank of the Juan de Fuca ridge, the hydrothermal flow occurs largely parallel to the ridge (Hutnak et al., 2006). The basement outcrops could be fluid entry and exit points to and from the crust.

Drill string packer experiments in upper basement indicate a layered crustal structure with permeabilities of $10^{-12}$ to $10^{-11}$ $m^2$ (Becker and Fisher, 2008). Additional hydrogeologic analyses completed using the formation pressure response to the long-term flow of cold bottom seawater into basement at Site U1301 in the 13 months after drilling, as observed at Site 1027 (2.4 km away) (Fisher et al., 2008). The large-scale cross-hole tests indicate lower crustal permeability than smaller-scale single-hole tests. This result was unexpected because larger scale testing tends to give greater permeability values. The difference between these permeabilities may be reconciled by azimuthal anisotropy in basement hydrogeologic properties.

In this study, we extracted 3D structures of crust surface and faults distribution from seismic profiles in order to reveal geological structures controlling hydrological properties in the ridge flank. Three seismic surveys acquired over 100 seismic lines in the eastern flank of the Juan de Fuca ridge (e.g., Nedimovic et al., 2008). Although these seismic surveys were two-dimensional, the densely-distributed survey lines enable us to extract 3D subseafloor structures around the drill sites. By interpolating the horizons extracted on each profile, we constructed 3D geometry of the crust surface and fault planes. By considering anisotropic characteristics in the interpolation process, we clearly obtained geometry of crust surface. The detailed fault distribution as well as basement geometry can explain the permeability anisotropy observed by the hydrological experiments (Fisher et al., 2008).

When we compare the drilling results and seismic profiles, we can roughly distinguish the fractured zone vs. massive zone within oceanic crust on seismic profile; the lithology boundary seems to be consistent with the seismic characteristics (e.g., quality factor). From logging (e.g. borehole image) data, furthermore, the preferred fracture orientation can be estimated as ridge-parallel direction. By integrating seismic-logging-core data, we evaluate the permeability anisotropy as well as its scale-dependence.

Keywords: IODP Exp 327, Seismic reflection analysis, Eastern flank of Juan de Fuca plate, downhole logging