Fracture permeability in active hydrothermal systems: Observations from downhole measurements

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Active hydrothermal systems have become areas of increasing multidisciplinary scientific interest because of their biological diversity, economic ore deposits and fundamental physical and chemical processes associated with crustal accretion along oceanic spreading centers. In these areas, hydrothermal circulation is dominated by fluid flow through permeable portions of the crust and upper mantle as localized high temperature and lower temperature diffuse flow is discharged at the seafloor [*Davis, Mottl, Fisher, et al.,* 1992; *Fisher, et al.,* 1996; *Humphris, Herzig, Miller, et al.,* 1996; *Fouquet, Zierenberg, Miller, et al.,* in preparation]. Downhole and long-term borehole experiments conducted during ODP Legs 139 and 169 have shown the presence of numerous structural features which seem to have a significant role in controlling fluid flow and the precipitation of hydrothermal deposits [*Davis and Becker,* 1994; *Davis and Fisher,* 1994; *Fouquet, Zierenberg, Miller, et al.,* in preparation].

Because of the low core recovery in the Middle Valley, logging data from Hole 856H located in the Bent Hill area were of primary importance for the accurate delineation of the lithological units and structures identified from the core observations. Good borehole conditions, compositional variability and changes in physical properties between the different formations allowed a clear identification of distinct logging units and subunits (Figure A). The recovered core and Formation MicroScanner (FMS) images also showed that the formation is intensely but unevenly veined with a high level of fracturing which includes the presence of hydrofractures and disseminated sulfides within the feeder zone (Figures B & C). These findings suggest that fluid flow through the sediments and changes in fluid pore pressures have a significant effect on the precipitation of sulfide minerals and other ore deposits.

A succession of steeply dipping and uniformly striking fractures within the sedimentary units also suggests a tectonic influence in the area (Figure D). These features which overlay the sediment-sill complex and basaltic flows (Figure E) may provide larger conduits for hydrothermal circulation. FMS images (Figure D) in combination with low resistivity and high porosity measurements suggest the presence of a fault at 250 mbsf which may be a primary contributor to the location and formation of this active hydrothermal system.

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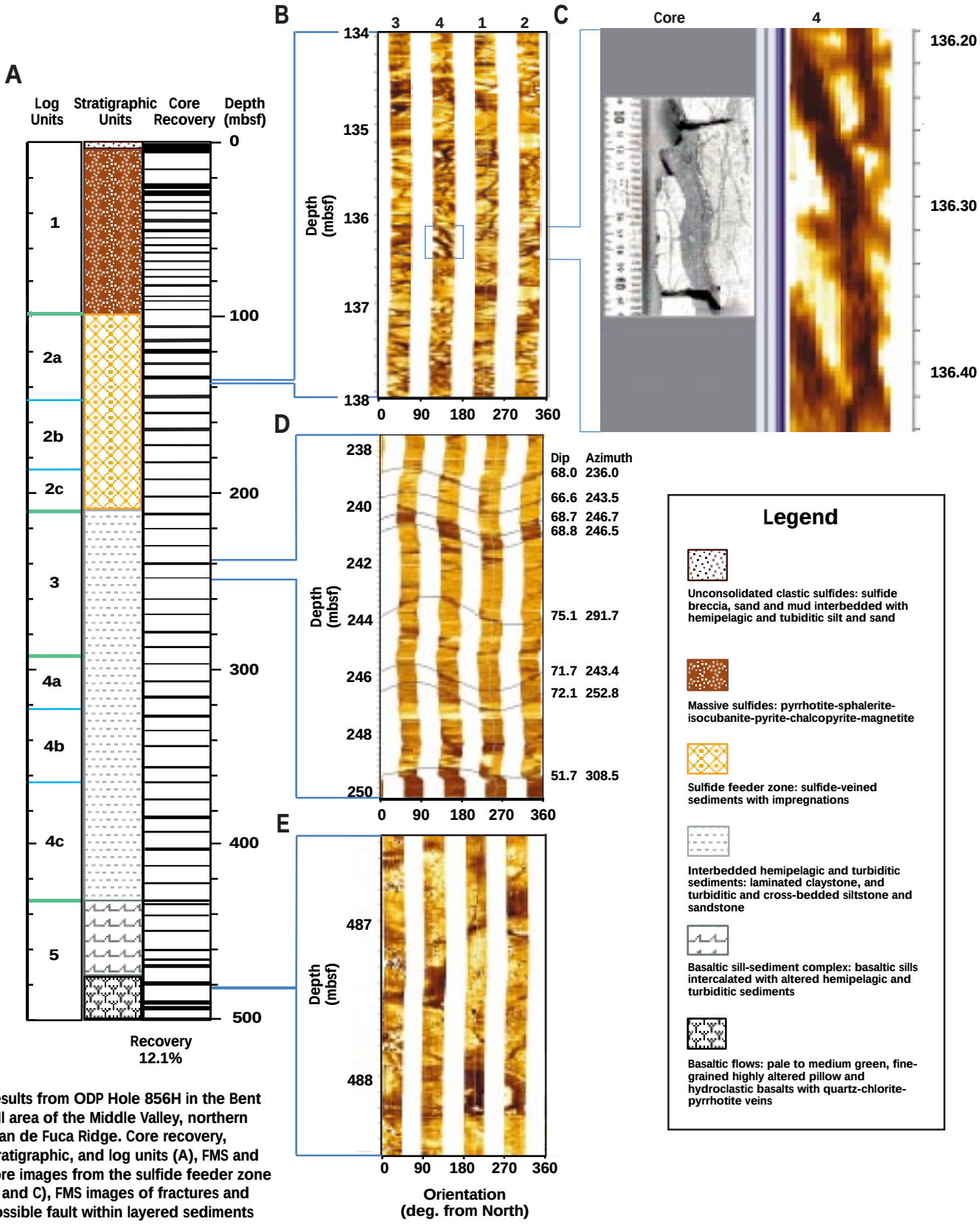

Results from ODP Hole 856H in the Bent Hill area of the Middle Valley, northern Juan de Fuca Ridge. Core recovery, stratigraphic, and log units (A), FMS and core images from the sulfide feeder zone (B and C), FMS images of fractures and possible fault within layered sediments (D), and the underlying pillow basalts (E).