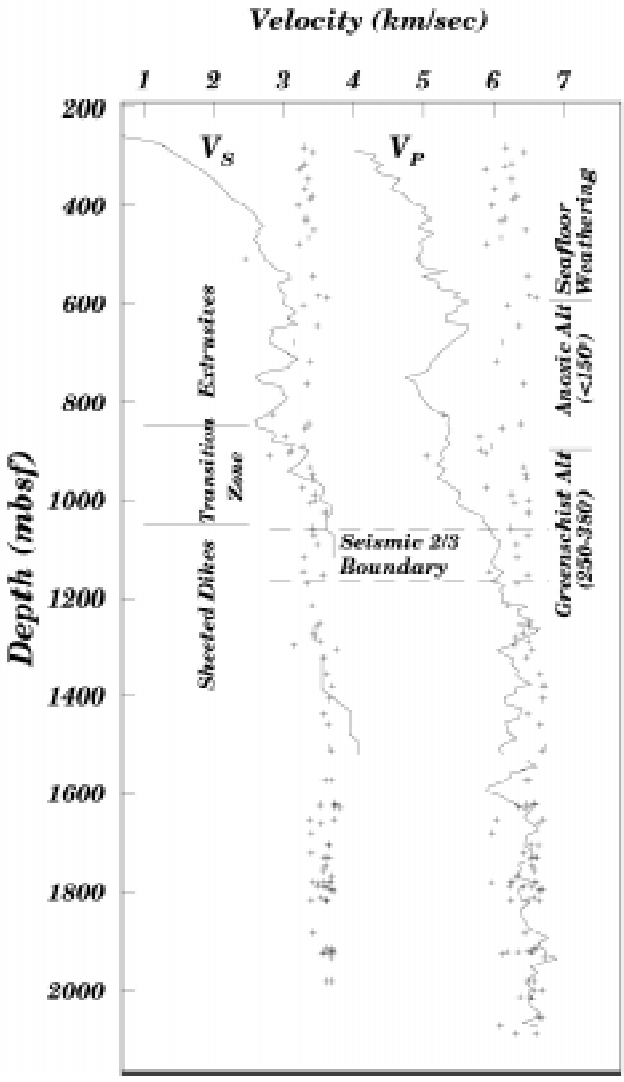
The velocity structure in upper ocean crust at Hole 504B from vertical seismic profiles

Stephen A. Swift, Ralph A. Stephen, D. Lizarralde, and Hartley Hoskins, Woods Hole Oceanographic Institution



VSP seismic velocities show exceptionally low values in the upper 300 m of basement and increase to the base of the lithologic transition zone. In contrast, velocities measured on Hole 504B samples in the laboratory at 100 MPa (+ ; [*Wilkens et al.,* 1983]; [*Christensen and Salisbury,* 1985]; [*Christensen et al.,* 1989]; [*Iturrino et al.,* 1995]; [*Salisbury et al.,* 1996]) show relatively little variability with depth. The trends in velocity with depth are determined by porosity changes which are related to lithologic zones [*Cann et al.,* 1983] and, through changes in permeability, to zones in alteration mineralogy [*Honnorez et al.,* 1983].

The vertical seismic profiles (VSP) obtained on Ocean Drilling Program Legs 111 and 148 in Hole 504B provide the first opportunity to directly correlate seismic velocity structure to the lithology and physical properties of upper ocean crust providing a baseline for comparison with seismic measurements elsewhere. In the VSP velocity profiles, the change in slope marking the layer 2/3 boundary coincides with the base of the lithologic transition zone. Seismic layer 2 is comprised of extrusives and the transition layer in which extrusive flows and dikes interfinger, and seismic layer 3 begins at the depth where dikes constitute 100% of the section. Even in these normal incident VSPs, several second arrivals are observed with apparent velocities corresponding to vertically polarized shear energy. The travel times of these arrivals suggest scattering from discrete point-like diffractors within the upper 110 m of basement. Compressional to shear wave conversion near the seafloor occurs by scattering from surface roughness and volume heterogeneities and does not depend on angle of incidence as predicted by a plane boundary transmission coefficient analysis. This implies that the velocity structure at the top of basement cannot be inferred from amplitude versus offset analysis based on a plane interface geometry. The shear waves generated in this normal incidence experiment can be used to measure Poisson's ratio *in situ* at seismic frequencies in the upper ocean crust. There is little difference between vertical compressional velocities from the VSPs and horizontal velocities obtained from the oblique seismic experiment on Leg 92. Compressional wave velocities in a transversely isotropic model vary by less than 10%.

References:

Cann, J.R., M.G. Langseth, J. Honnorez, R.P. VonHerzen, and S.M. White, *Init. Reports of the DSDP, 69,* 1983.

Christensen, N.I., and M.H. Salisbury, Seismic velocities, densities, and porosities of layer 2B and 2C basalts from Hole 504B, edited by R.N. Anderson, J. Honnorez, and K. Becker, *Init. Reports of the DSDP, 83,* 367-370, 1985.

Christensen, N.I., W.W. Wepfer, and R.D. Baud, Seismic properties of sheeted dikes from hole 504B, ODP Leg 111, edited by K. Becker, and H. Sakai, *Proc. of the ODP, Sci. Results, 111,* 171-176, 1989.

Honnorez, J., C. Laverne, H.-W. Hubberton, R. Emmermann, and K. Muehlenbachs, Alteration processes in layer 2 basalts from Deep Sea Drilling Project Hole 504B, Costa Rica Rift, edited by J.R. Cann, M.G. Langseth, J. Honnorez, R.P. Von Herzen, and S.M. White, *Init. Reports of the DSDP, 69,* 509-546, 1983.

Iturrino, G.J., N.I. Christensen, K. Becker, L.O. Boldreel, P.K.H. Harvey, and P. Pezard, Physical properties and elastic constants of upper crustal rocks from core-log measurements in Hole 504B, edited by J. Erzinger, H.J.B. Dick, and L.B. Stokking, *Proc. of the ODP, Sci. Results, 140,* 273-291, 1995.

Salisbury, M.H., N.I. Christensen, and R.H. Wilkens, Nature of the layer 2/3 transition from a comparison of laboratory and logging velocities and petrology at the base of Hole 504B, edited by J.C. Alt, H. Kinoshita, L.B. Stokking, and P.J. Michael, *Proc. of the ODP, Sci. Results, 148,* 409-414, 1996.

Wilkens, R.H., N.I. Christensen, and L. Slater, High pressure seismic studies of leg 69 and 70 basalts, edited by J.R. Cann, M.G. Langseth, J. Honnorez, R.P. Von Herzen, and S.M. White, *Init. Reports of the DSDP, 69,* 683-686, 1983.