Guided waves propagating in subducted oceanic crust

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[1] We use guided waves traveling updip along the surface of the Nazca slab to image subducted oceanic crust at the Chile-Peru subduction zone. Observed *P* onsets of intermediate depth events near 21°S in northern Chile reveal waveguide behavior: with growing focal depth, low-frequency energy (<2 Hz) becomes more and more dominant, and higher frequencies arrive delayed, sometimes resembling two distinct phases. To explain the observations, we employ two-dimensional finite difference (FD) simulations of complete *P-SV* wave propagation along an updip profile of the subduction zone. The FD calculations shed some light on several basic issues regarding crustal waveguides. The development of guided waves dependent on event focal depth is simulated. Further, we show that the observed guided wave energy must decouple from the waveguide near 100 km depth to reach the deployed stations and that the decoupling process is related to variations in subduction angle. Simulations also yield constraints on source locations relative to the low-velocity structure. Finally, the frequency content of *P* onsets is used to constrain the thickness of the waveguide. The results indicate that a structure of <4.5 km average width and 7% low-velocity remains seismically slow compared to the surrounding mantle down to a depth of at least 160 km. The layer is interpreted as the unaltered lower part of the subducted oceanic crust, suggesting that complete eclogite transformation in the Chile-Peru subduction zone is unlikely to take place until beyond the volcanic front. *INDEX TERMS:* 3210 Mathematical Geophysics: Modeling; 7220 Seismology: Oceanic crust; 7260 Seismology: Theory and modeling; 8150 Tectonophysics: Plate boundary—general (3040); *KEYWORDS:* subducted oceanic crust, guided waves, FD modeling, low-velocity layer, Chile-Peru subduction

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1. Introduction

[2] The fate of subducted oceanic crust at intermediate depths is of main contemporary interest for understanding the subduction processes and, in particular, the origin of intermediate depth earthquakes [*Meade and Jeanloz*, 1991; *Abers*, 2000; *Yuan et al.*, 2000]. Seismic waves from intra-slab earthquakes that probe the seismic velocity structures of slabs are a valuable source of information on the mineralogical and thermal structure of subducted lithosphere [e.g., *Davies and McKenzie*, 1969; *Kirby et al.*, 1996]. Seismic wave anomalies are used to infer seismic velocity structure of subducted lithosphere and ultimately information on slab mineralogy [*Mitronovas et al.*, 1971].

[3] Velocity contrasts are derived from observations of a variety of seismic signals that are influenced by the subducted plate. Travel times, for example, are easy to measure but only yield average velocities along ray paths [e.g., *Fukao et al.*, 1978]. Detailed velocity structure within the slab that gives evidence for mineralogical phase changes can thus not be imaged [*Mitronovas et al.*, 1971].

[4] Another widely used technique employs converted waves caused by the slab surface or layering within the subducted lithosphere. *Helffrich and Abers* [1997], for example, employed converted waves to investigate a low-velocity layer at the eastern Aleutian subduction zone. Studies at the Chile-Peru subduction zone in the western central Andes inferred a similar layer up to depths of 120–160 km from *P-S*-converted waves [*Yuan et al.*, 2000; *Bock et al.*, 2000]. The resulting velocity contrast is 15% with a thickness of 5–10 km. Likewise, investigations at the northeast Japanese subduction zone found undulating velocity contrasts between the accretional wedge and subducted crust at various depths which are interpreted as evidence of chemical phase changes of the gabbroic subducted crust [*Snoke et al.*, 1978; *Helffrich*, 1996].

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