Synthesis of Oceanic Crustal Structure from Two-Dimensional Seismic Profiles

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We carried out a new synthesis of oceanic crustal structure from high-quality two-dimensional seismic refraction profiles. Our compilation includes 120 velocity-depth functions from 55 publications, with ages varying from 0-171 Ma, and spreading rates from 7-102 mm/yr half-rate. Average crustal thickness in our dataset is 6.15±0.93 km. Layer 2 has an average thickness of 1.84 km, but is thicker for young slow-spreading crust (2.06 km) and thinner for superfast-spreading crust (1.36 km). The layer 2/3 boundary likely corresponds with the lithologic boundary between dikes and gabbros for young fast- and superfast-spreading crust. At slow-spreading centers the layer 2/3 boundary is well above the imaged AMC reflector, and is interpreted to mark a change in porosity with depth within the dikes. At intermediate-spreading centers the layer 2/3 boundary corresponds to different lithologies (within dikes or at dike-gabbro boundary) depending on the magma supply. Layer 3 thicknesses approximately display the opposite trend with spreading rate as layer 2 thicknesses, resulting in a similar crustal thickness across all spreading rates.

Velocities at the top of layer 2 increase rapidly from ~3.0 km/s at 0 Ma to 4.6 km/s at 10.5 Ma, with a slower increase to 5.0 km/s at 170 Ma; however, some of this velocity increase may be influenced by sediment thickness. The rapid increase in velocity at young ages is attributed to crack closure by precipitation of hydrothermal alteration products; the increase at older ages suggests that this process may continue as the oceanic crust continues to evolve. High velocities at the top of layer 2 are associated with regions of thick sediment; velocities approaching or reaching laboratory measured values of 5.8-5.9 km/s are observed with a sediment thickness of 4.0-4.3 km. Pressure from the thick sediment will close microcracks and may also collapse large-scale features such as lava tubes and fractures.

Average velocities at the top of layer 3 are substantially lower (6.12-6.19 km/s) for young (<7 Ma) slow-spreading and intermediate-spreading crust than fast-spreading and superfast-spreading crust of this age (6.50-6.67 km/s). The low velocities at the slower spreading rates for young oceanic crust are likely associated with faults and fissures that are more prevalent and extend to greater depths at these spreading rates. Average velocities at the top of layer 3 are 6.67 km/s for older (>7 Ma) oceanic crust at all spreading rates.

Keywords: ocean crust, crustal thickness, spreading rate

