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Seismic structure and heterogeneity of the oceanic crust

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Most of our knowledge about the oceanic crust is based on petrological and seismic properties of ophiolites and core samples from deep ocean drilling boreholes. The three-layer model of a normal oceanic crust only represents an idealized ophiolite sequence from abyssal plains (Fig. 1) [1,2]. It is characterized by a 3-10 km thick crust covered by pelagic and turbidite sediments. However, previous studies have found significant variations in crustal thickness and seismic structure throughout the ocean basins. For example, the crustal thickness is ~30 km and ~20 km in mature and immature island arcs, respectively, but exceeds 35 km in oceanic plateaus. The extremely thin oceanic crust is observed near fracture zones and beneath active mid-ocean ridges, while moderately thick crust (10-15 km) occurs beneath aseismic mid-ocean ridges.

Based on a summary of seismic velocity measurements on ophiolites and core samples, the dependence of P-wave velocity (Vp) and S-wave velocity (Vs) on pressure, temperature, porosity, and density was established for major lithologies. Distinct seismic structure of the oceanic crust were interpreted in terms of lithology, porosity, alteration, serpentinization, and spreading rate at the mid-ocean ridges. The results indicate that although the oceanic crust predominantly consists of igneous rocks of basaltic composition, each layer thickness may vary without sharp velocity change. Intraplate magmatism and fracture zones have locally modified structure and composition of the oceanic crust. Serpentinization can cause remarkable decrease in velocities and density of peridotites, which will reduce reflectivity of the crust-mantle boundary. The abundance of serpentinites in the oceanic crust was estimated based on velocity-density relationship. Therefore, recycling rate of the oceanic crust into deep mantle cannot be stable due to the lateral variations in structure and composition.

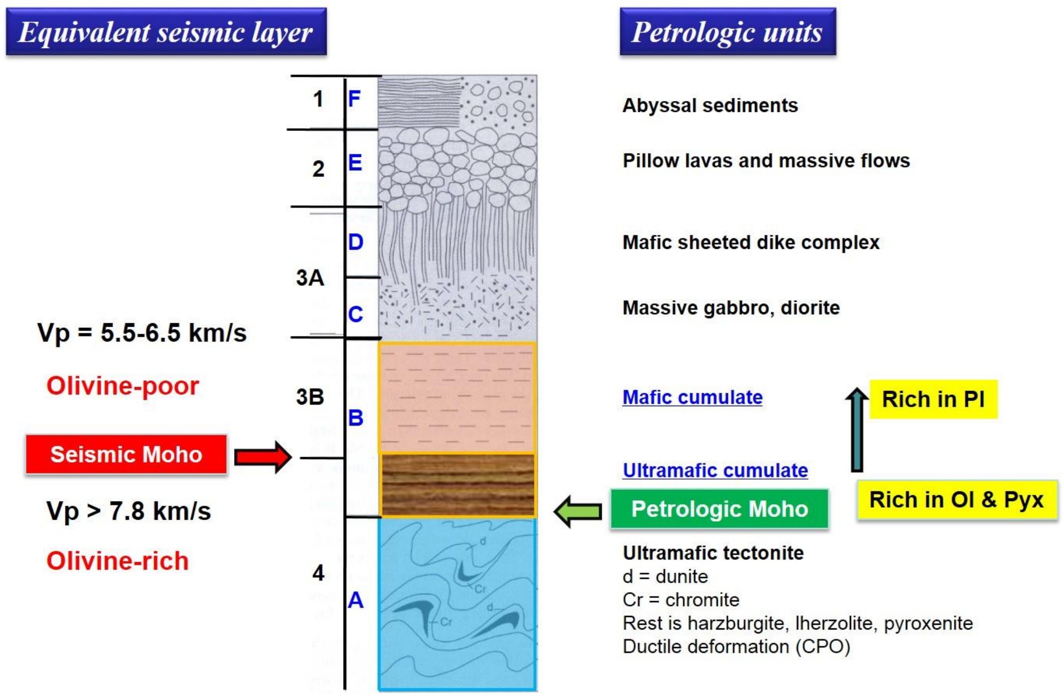

Figure 1. A model of the oceanic lithosphere with lithological interpretation of seismic layers (modified after Moores, 1982). Note the discrepancy between the seismic Moho and petrologic Moho.

References:

[1] Christensen & Salisbury (1975). Reviews of Geophysics and Space Physics 13, 58-86.

[2] Moores (1982). Reviews of Geophysics 20, 735-760.