

Composition and Seismic Properties of the Oceanic Lithosphere: A Synthesis of Ophiolites and Core Samples of the IODP



ZHAO Jiabin and WANG Qin*

State Key Laboratory for Mineral Deposits Research, School of Earth Sciences and Engineering, Nanjing University, Nanjing, Jiangsu 210023

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Abstract: Our knowledge of the oceanic lithosphere largely comes from analogy with ophiolite complexes and the direct scientific drilling of the present-day oceanic crust (e.g., Christensen and Salisbury, 1975, 1989; Smith and Vine, 1989; Dilek and Furnes, 2011, 2014). In this study, we summarized previous experimental results on seismic properties of oceanic lower crust and upper mantle according to different tectonic settings. The results are used to highlight the compositional heterogeneity and the nature of the oceanic Moho. Observation in different ophiolites reveal an ideal oceanic lithosphere profile with ideal petrologic units and seismic units (Dilek and Furnes, 2011, 2014). The lithospheric mantle beneath ocean basins is composed of tectonized peridotites, which include layered lherzolites and harzburgites and lenses of dunites with chromitites and nearly correspond to the seismic Layer 4. The overlying layered gabbros and mafic sheeted dike complex equal to the seismic Layer 3, as a result of crystallization from a magma chamber. The transitional unit between the former two petrologic units consists of layered ultramafic and mafic rocks, corresponds to the petrological Moho. The seismic Layer 2 and 1 are well defined by pillow lavas and massive flows, and the overlying abyssal sediments, respectively. Compared these results with the refraction seismic profiles, the oceanic crust and upper mantle show different composition and structure. The P-wave velocities of the Layer 3 gabbros varies from 6.7 to 7.0 km s⁻¹ and have low velocity gradients of <0.1 km s⁻¹. Although the gradual increase of P- and S-wave velocities with depth can be attributed to the increasing proportion of mafic minerals from the top to the bottom, prehnite-pumpellyite facies alteration of basalts, greenschist-facies metamorphism to epidote-amphibolite facies metamorphism of gabbros will decrease the velocities of the Layer 2 and Layer 3 (Christensen and Salisbury, 1975, 1989), because the P-wave velocities of chlorite and hornblende are 6.00 and 7.00 km s⁻¹, respectively, lower than those of plagioclase and pyroxene, respectively (Carlson, 2004). In addition, local velocity anomalies near the petrologic Moho can be related serpentinization of ultramafic rocks (Salisbury and Christensen, 1978; Carlson et al., 2009). In the Layer 4, the characteristic P-wave velocities of the upper mantle should fall in the range of 7.8 to 8.2 km s⁻¹. Poisson's ratios of chrysotile and lizardite, which are stable in oceanic crustal environments

according to the phase diagram, is 0.267 and 0.359, respectively, higher than those of olivine and pyroxene (Wang et al., 2013). Serpentinization will significantly decreased velocities and densities of peridotites and is the main reason for the variation of the Moho reflectivity beneath oceans.

Key words: ophiolite, seismic velocity, oceanic crust, serpentinization, Moho

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About the first author

ZHAO Jiabin, male, born in 1993 in Shanghai; Ph.D. student;

* Corresponding author. E-mail: qwang@nju.edu.cn

School of Earth Sciences and Engineering, Nanjing University, China. He is interested in seismic properties of the oceanic crust and upper mantle. Email: 825846646@qq.com; phone: 18800292569

About the corresponding author

WANG Qin, female, born in 1974 in Yili City, Xinjiang

Province; PH.D, graduated from Ecole Polytechnique de Montreal, Canada; professor of School of Earth Sciences and Engineering, Nanjing University, China. She is interested in structural evolution, rheology and physical properties of the lower crustal and upper mantle, as well as ultrahigh-pressure metamorphism and subduction zone processes. Email: qwang@nju.edu.cn; phone: 025-83596887, 13705171970.