Relationship between alteration intensity and elastic wave velocity of gabbroic rocks from ICDP Hole CM1A, Oman Drilling Project Phase II

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The mafic to ultramafic rocks suffer metamorphism and metasomatism by the seafloor hydrothermal activities. These alterations can influence the elastic wave velocity due to the change of mineral assemblages during the ocean floor metamorphism. However, most previous studies have measured the elastic wave velocity of relatively unaltered samples. In this study, we measured elastic wave velocity of the altered gabbro from the Semail ophiolite collected from the Oman Drilling Project Phase II in order to estimate the effect of ocean floor metamorphism on the elastic wave velocity.

Gabbro samples were collected from CM1A site that is reported to be a layered gabbro sequence. Total seven samples those have different alteration intensity were measured. We use intra-vessel deformation and fluid flow apparatus at Hiroshima University to measure elastic wave velocity under confining pressure up to 200 MPa. Elastic wave velocity was measured by the pulse transmission method, with the amplitude and the frequency of a trigger wave of 5 V and 2 MHz, respectively. After measurements under dry condition, measurements under wet conditions injecting pore water were performed (P_P = 10 MPa). Alteration intensity is recognized by the relative abundances of the secondary minerals.

On the basis of the petrography, alteration group could be divided into four types. First type is almost fresh, olivine altered to serpentine and chlorite partially with less green minerals present. Second type has saussuritized plagioclase dominantly and also some sample shows alteration of clinopyroxene to amphibole. In the third type amphibolitization of clinopyroxene is dominant, and also saussuritization of plagioclase occur. Fourth type is the most altered sample showing alteration halo along the veins. Almost of the minerals are changed to prehnite except a few relict clinopyroxene. This type has higher porosity than other types.

Sample density ranges from 2.77-3.08 g/cm^3, and porosity ranges from 0.02-0.22% except ca. 1% from halo alteration sample. Data from these samples show a trend that elastic wave velocities (V_P and V_S) increase with increasing the confining pressure from 20 to 200 MPa. V_P increases from 5.68-6.80 to 6.16-6.91 km/s, V_S slightly increases from 3.65-3.97 to 3.69-3.99 km/s and V_P/V_S is almost constant ranging between 1.56-1.86 to 1.64-1.88 under dry condition, and on the other hand, V_P increases from 6.08-6.82 to 6.31-6.93 km/s, V_S slightly increases from 3.64-3.98 to 3.69-4.00 km/s and V_P/V_S is almost constant 1.67-1.86 to 1.68-1.87 under fluid-saturated condition, respectively. This result is mostly consistent with the layered gabbro occur in a normal oceanic crust (e.g. White et al., 1992; Shinohara et al., 2008).

At 200 MPa and under dry condition, V_P moderately decreases with increase in alteration intensity. About 0.75 km/s decreases in response to the increase in alteration intensity from 10 to 80 %. Comparing dV_P (difference in calculated and measured values) from the back-calculated original mineral assemblages of gabbro and peridotite reveled that the decrease in dV_P for the former is less than the latter. Moreover, both the curves of V_P and impedance change cross-over each other for gabbro and peridotite after nearly 50% of alteration.

From the above results, we suggest that if both gabbro and peridotite suffer more than 50% alteration, reversal of seismic velocity and impedance occurs, which effectively would affect the determination of geophysical Moho.

Reference: White et al. (1992) J. Geophys. Res. 97, 19,683-19,715. Shinohara et al. (2008) Phys. Earth Plan. Inter., 170, 95-106. Christensen (2004) Inter. Geol. Rev., 46, 795-816.

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