Sudden decrease in elastic wave velocity of a natural rock of plagioclase aggregate without H2O fluid and partial melting

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Low velocity anomalies in mid-to-lower crust have traditionally been considered to reflect the storage or transportation of H2O fluid or magma. However, we observed sudden decrease in compressional (Vp) and shear (Vs) wave velocity of a natural rock of plagioclase aggregate (An49-53) under dry and no partial melting conditions. It is possible to cause some of the low velocity anomalies without H2O fluid and partial melting. Here we report the results of Vp and Vs up to 900 C and 1 GPa measured with pulse reflection technique. The uncertainty of Vp and Vs is up to 0.35 %. Details of our ultrasonic measurement in Yokohama National University are described in Kono et al. (2004). The plagioclase aggregate shows sudden decrease in Vp and Vs at higher temperatures. Vp measurement between 25 C and 700 C (Run No.P700) show slight decrease in Vp below 300 C and sudden decrease in Vp above 400 C with increasing temperature. P700 shows excellent reversibility in Vp during both (first and second) heating and cooling cycle. In contrast, Vp measurements between 25 C and 900 C (Run No.P900) show irreversible change in Vp and Vs. In the first cycle of P900 between 25 C and 700 C, we observed a comparable Vp value at a given temperature during heating and cooling same as P700. In contrast, Vp values show irreversible change in the second cycle between 25 C and 900 C. In the second cycle, Vp slightly decreases up to 300 C and markedly decreases above 400 C during heating same as P700. But, during cooling, Vp values linearly increase from 900 C to 25 C with keeping higher temperature derivative in Vp. Temperature derivative of Vp increase from -1.99x10-4 km s-1 C-1 (25-300 C) to -4.41x10-4 km s-1 C-1 (400-900 C) in the first cycle and during heating of the second cycle, and is -4.24x10-4 km s-1 C-1 (25-900 C) during cooling of the second cycle. Vs values (Run No.S900) also show sudden decrease above 400 C same as Vp. Similarly to P900, S900 shows reversible Vs change in the first cycle between 25 C and 700 C and irreversible Vs change in the second cycle between 25 C and 900 C. Temperature derivative of Vs increase from -1.11x10-4 km s-1 C-1 (25-300 C) to -2.73x10-4 km s-1 C-1 (400-900 C) in the first cycle and during heating of the second cycle, and is -2.45x10-4 km s-1 C-1 (25-900 C) during cooling of the second cycle. In order to clarify the cause of sudden decrease in Vp and Vs above 400 C, we studied these run products with optical microscope, SEM-EDS and X-ray diffraction analysis. Optical microscope and SEM-EDS analysis show that observed sudden decrease in Vp and Vs is not attributed to dehydration reaction and partial melting because of no glass and no reaction products in the run products. In X-ray powder diffraction analysis, the starting material and run product of P700 show lower values of lattice angle gamma, comparable to 'low' (ordered) plagioclase (e.g. Kroll & Ribbe, 1980). In contrast, run products of P900 and S900 show higher values of lattice angle gamma, which correspond to 'high' (disordered) plagioclase. We therefore consider that the order-disorder transition of plagioclase cause a sudden increase in temperature derivative of Vp and Vs at around 400 C. Our results suggest that the 'high' plagioclase shows 2.2-2.5 times higher temperature derivative of Vp and Vs than the 'low' plagioclase. As a result temperature derivative of Vp and Vs above 400C has stronger negative effect than positive pressure derivative of Vp (1.63x10-1 km s-1 GPa-1) and Vs (0.69x10-1 km s-1 GPa-1) at higher geothermal regions than 65mW/m2 surface heat flow. Stronger decrease in Vp and Vs with depth would occur in high-temperature mid-to-lower crust.