Relationship between P wave velocity change and pore water pressure variation induced by the 2016 Kumamoto Earthquake

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We developed a compact seismic source suitable for high frequency underground survey with the use of the giant magnetostrictive actuator (GMA). This giant magnetostrictive seismic source is composed of a controller system and a vibration exciter driven by a GMA. The controller system generates driving current for a GMA with arbitrary wave form in synchronization with a GPS clock. The vibration exciter generates single force in vertical direction with maximum generating force of 91kgf. This system is currently used to observe mainly P wave velocity change of the bedrock (Toki granite) in 100-200Hz frequency range, because the sampling frequency of the A/D converter in the comprehensive borehole crustal activity observation device is 400Hz. Even at observation points 700m away from the seismic source, it is possible to observe changes in P wave travel time with accuracy of about 10μs by stacking for 1 day.
Stepwise travel time delay of the direct P wave, induced by the Kumamoto earthquake (April 16, 2016, Mj7.3), is observed at TGR 350 (distance 353m, about 25μs delay) and TRIES (distance 690m, about 60μs delay) shortly after the start of continuous transmission. These travel time delays are thought to be caused by the decrease in P wave velocity due to opening cracks in Toki granite. Coseismic and postseismic travel time change of the direct P wave detected at TRIES is consistent with the long-term fluctuation pattern of pore water pressure observed at STG200N in the shaft of the Mizunami Underground Research Laboratory (JAEA). The pore water pressure in the granite rose gradually after stepwise rising at the time of the earthquake, peaked at the beginning of June(about 30kPa), and then gradually dropped. Direct P wave travel time is delayed gradually after the stepwise delay on the day of the earthquake, delayed to about 90μs at the same time as the pore water pressure peak, and then gradually recovered. If the pore water pressure rise of 10kPa is converted into the travel time delay of 30μs, they coincide with each other within the margin of the travel time change estimated error over several months. This result indicates that the pore water pressure changes in the Toki granite controls the opening and closing of the crack and the P wave velocity changes.

Keywords: giant magnetostrictive seismic source, P wave velocity change, pore water pressure, crack, granite

