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Effect of swelling cray minerals on permeability and occurrence condition of abnormal pore pressure

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The March 11, 2011, devastating Tohoku-Pacific Ocean Earthquake had its epicenter at the Sanriku coast as the Hokuriku plate tip had slipped significantly. However, it raises question on the traditional theory that plate tip never slips on a large scale. Geological survey in this area brings out the fact that, smectite, one of the swelling clay minerals, is present in 78% of the fault samples. Hence, smectite seems to be controlling the generation of the earthquake. In this study, it is hypothesized that swollen clay minerals reduced the permeability and caused the abnormal pore pressure. By measuring permeability of clay minerals, this hypothesis is validated and discussed about the earthquakes that occur in the plate boundary.

Permeability is measured using water and nitorogen gas as pore fluid by the constant differential pressure flow method. The method helps to determine the permeability based on the flow rate through the downstream in a state of constant pore pressure difference applied across the sample. The vessel deformation permeability testing machine is used in case of gas, whereas the syringe pump is used in case of water as pore fluid. During the experiment the confining pressure is controlled up to 10MPa, while pore pressure up to 5MPa. Two types of clay minerals i.e. illite, and montmorillonite are used as sample. At the beginning gas is used as the pore fluid, and then measured using water and compared for results.

Measurement results indicate that permeability of water is lower than the value measured using gas as pore fluid. Moreover, the decrease is 1.5 orders of magnitude in illite, while about 4.4 orders of magnitude in montmorillonite.

The reduction in permeability from gas to the water is due to water absorption and swelling of clay minerals. It decreases the gap between the clay particles reducing the flow paths. Montmorillonite has large decrease in permeability, leading to larger control of water effect. It is considered that a local presence of smectite will reduce the permeability in the underground. In addition, this result is applied to the abnormal pore pressure producing conditions. In case of illite, abnormal pore pressure does not occur to meet the condition. On the other hand, in case of montmorillonite the results satisfied the required condition, and there is a high possibility that abnormal pore pressure occurs when present locally in the subduction zone.