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Time-dependent consolidation and reduction in permeability of quartz aggregate due to pressure solution precipitation

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During diagenesis process, incohesive sediments are compacted, lose porosity and permeability, and gain resistance against deformation. Understanding of evolution in the hydrological and mechanical properties during diagenesis is of essential importance in considering deformation of a shallow part of the crust including accretionary prism. Pressure solution precipitation creep is one of the important mechanisms in diagenesis of sediments, and thus has been intensively studied. Previous studies have established microphysical models and the constitutive law during compaction creep [e.g., Shimizu, 1995; Niemeijer et al., 2002]. In the present study, we put our focus on the evolution in the permeability and storage capacity during consolidation due to pressure solution precipitation creep of quartz aggregate.

Recent studies [e.g., Noda and Lapusta, 2013] have pointed out the importance of hydraulic properties on the earthquake generation mechanisms. In particular, permeability plays a cardinal role in thermal pressurization of pore fluid due to frictional heating during high velocity fault slip. An important unknown is whether the host rock (or sediments) fractures with significant increase in the porosity and the permeability or not. Such a property would depend on the degree of consolidation or diagenesis, as well as confining pressure, temperature, and loading condition. In the present study, the focus is put on the effect of time-dependent consolidation or diagenesis on the mechanical and hydraulic properties.

The starting material is commercially available quartzite power the mean grain size of which is about 6 microns. We have prepared the specimens from slurry by sedimentation inside silver tubes which are used as jackets during compaction experiments with gas apparatus at Hiroshima University. The initial specimens have good repeatability in terms of permeability. Compaction experiments are performed with distilled water as pore fluid and at 200 MPa confining pressure, 100 MPa pore pressure, and temperature at most 550 degree C. Permeability and storage capacity are monitored continuously during compaction experiment by pore pressure oscillation technique [e.g., Fischer and Paterson, 1992]. The shortening of the specimen is measured by the hit-point method from time to time.

After the consolidation test, we performed triaxial deformation test at constant load point velocity at room temperature. It turns out that solution-precipitation process extend the elastic limit of the sediment pretty quickly. When the specimen is heated up to 500 degree C by about 100 degree C/ 10 min and cooled down by a similar rate as soon as the temperature reaches 500 degree C, the specimen shows peak strength about 300 MPa in terms of axial compressional stress applied in addition to the 100 MPa effective isotropic pressure. Note that an uncooked sample yields as soon as the axial compressional stress is added. In the present poster, the relations between the shortening and hydraulic properties will be discussed.

Keywords: Diagenesis, Deformation experiment, Fluid-flow experiment