

Permeability healing of clay-rich sedimentary rocks from the Hikurangi margin: a possible mechanism to explain slow-slip event recurrence

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Abstract

The northern part of the Hikurangi margin (HM) regularly experiences shallow slow-slip events (SSEs), possibly extending into the thrust faults of the sedimentary prism. For example, offshore Gisborne SSEs occur every 1-2 years and can last several weeks, during which 5-30 cm of slip may be accommodated. Understanding what controls the timing of such events will help the comprehension of HM deformation and earthquake mechanics in general. One hypothesis for a slow slip mechanism is that the low permeability of the HM prism rocks and the large fluid volumes dragged deep into the subduction zone cause over-pressures along the megathrust and prism splay faults. Overpressure induces SSEs that locally increase permeability. After an SSE, swelling clays and ductile deformation reduce permeability within months, resetting the conditions for developing overpressure. We tested such a hypothesis by measuring the hydraulic permeability of fractured sedimentary rocks making up the core of the accretionary prism. Tests were performed using a newly developed X-ray transparent pressure vessel mounted inside a micro-computed tomography scanner (mCT) that allowed in-situ observation of fracture evolution as a function of confining pressure, time, and exposure to water. The tested rocks were probably subducted to ~7.5 km and are calcareous-glaucinitic fine-grained sandstones with a silty matrix from the Late Cretaceous-to-Paleocene Tinui Group containing ~15% vol% of clay minerals. After exposure to high confining pressure and water, the samples regained pre-fracture permeability in tens of days. mCT imagery suggests that fracture clogging, possibly due to clay expansion, controls healing. We propose that slow slip events in the northern HM open fault fractures and allow drainage at the beginning of the slip cycle, followed by fracture clogging due to swelling clays and ductile deformation, with the duration of the cycle regulated by the interplay of these processes.

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