Abstract

The Elastic and Transport Properties of Hikurangi Margin Rocks as a Function of Stress, Saturation, and the Presence of Fractures

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Stress, saturation, and the presence of fractures impact the elastic properties and permeability of rocks and subsurface domains, in general. The Hikarungi margin of New Zealand displays different fault slip behavior, with a transition from aseismic creep in the north to coseismic slip in the south. The different modes of slip along the margin may be related to different rock physical properties. For example, the low permeability (<100 μD) of clay-rich mudstones might control the occurrence of fluid overpressures at depth. We perform geomechanical experiments on outcrop samples from the Raukumara Peninsula region to explore how the elastic behavior and permeability of Hikurangi margin mudstones vary with terrane and confining pressure. In particular, we present data for Miocene-aged mudstones, which represent recently accreted sediments forming the outer prism, as well as Cretaceous-aged mudstones that are analogous to the inner prism and modern-day backstop of the margin. We use a NER AutoLab 1500 pressure vessel equipped with a saturation fluid circuit to generate a range of confining pressures and to saturate the samples. We measure shear and compressional velocities for confining pressures ranging 0-200 MPa for dry and saturated samples. We measure static Young's moduli for one Miocene sample (4.36 GPa) and one Cretaceous sample (6.13 GPa) and estimate the sample compaction mimicking the compaction experienced by sediments dragged at depth along the subduction zone. We measure the permeability of intact and fractured clay

bearing mudstones using the pressure transient method. Low permeability estimates for a Cretaceous mudstone sample (<100 µD) suggest that the studied lithology would be capable of acting as an impermeable barrier and influencing overpressures at depth. On the other hand, the high permeability of Miocene mudstone samples (~100 mD to ~1 mD) suggest that such a lithology could promote focused fluid flow. We explored how fracturing and subsequent healing influence the permeability of such impermeable barriers, discovering that these clay-bearing lithologies tend to heal rapidly, regaining the low initial permeability. Such experimental observation suggests that in the Hikurangi margin, subducted and overriding rocks should remain fractured to allow the fluid flow inferred by many authors. We propose that slow-slip events and earthquakes promote fracturing, as suggested by modeling and theoretical studies. This experimental framework could be applied to additional rocks from the Hikurangi margin. Ultimately, these results will help constrain hydraulic conductivity of the overriding plate, mechanisms of overpressure generation, and the influence of fluid pressures on seismic velocities.