Geophysical Research Abstracts
Vol. 19, EGU2017-8080, 2017
EGU General Assembly 2017
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Hidden Earthquake Potential in Plate Boundary Transition Zones

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Plate boundaries can exhibit spatially abrupt changes in their long-term tectonic deformation (and associated kinematics) at triple junctions and other sites of changes in plate boundary structure. How earthquake behavior responds to these abrupt tectonic changes is unclear. The situation may be additionally obscured by the effects of superimposed deformational signals - juxtaposed short-term (earthquake cycle) kinematics may combine to produce a net deformational signal that does not reflect intuition about the actual strain accumulation in the region. Two examples of this effect are in the vicinity of the Mendocino triple junction (MTJ) along the west coast of North America, and at the southern end of the Hikurangi subduction zone, New Zealand. In the region immediately north of the MTJ, GPS-based observed crustal displacements (relative to North America (NAm)) are intermediate between Pacific and Juan de Fuca (JdF) motions. With distance north, these displacements rotate to become more aligned with JdF - NAm displacements, i.e. to motions expected along a coupled subduction interface. The deviation of GPS motions from the coupled subduction interface signal near the MTJ has been previously interpreted to reflect clock-wise rotation of a coastal, crustal block and/or reduced coupling at the southern Cascadia margin. The geologic record of crustal deformation near the MTJ reflects the combined effects of northward crustal shortening (on geologic time scales) associated with the MTJ Crustal Conveyor (Furlong and Govers, 1999) overprinted onto the subduction earthquake cycle signal. With this interpretation, the Cascadia subduction margin appears to be well-coupled along its entire length, consistent with paleo-seismic records of large earthquake ruptures extending to its southern limit. At the Hikurangi to Alpine Fault transition in New Zealand, plate interactions switch from subduction to oblique translation as a consequence of changes in lithospheric structure of the Pacific plate (without a triple junction). Here, the short-term, earthquake-cycle signal recorded by GPS shows a reduction in plate motion-directed displacements, which has been interpreted to reflect reduced coupling along the southernmost segment. However, this signal records both the subduction interface coupling effects related to the megathrust earthquake cycle and the shear deformation produced by the extensive right-lateral shear of the Marlborough Fault system (MFS). This superposition of deformation signals combine to mask a strongly coupled interface. The relevance of this effect is seen in the recent (November 2016) Kaikoura earthquake ,which appears to have both ruptured the megathrust interface and produced strike slip displacements on upper-plate crustal faults. These effects seen at these locations and elsewhere may cause misinterpretations of short-term deformation signals in terms of the longer term tectonic behavior of the plate boundary, missing a significant component of the earthquake potential.