Japan Geoscience Union Meeting 2014
(28 April - 02 May 2014 at Pacifico YOKOHAMA, Kanagawa, Japan)

SIT40-P01 Room:Poster Time:May 1 18:15-19:30

An overview of seismic coupling and crustal deformation on the basis of geofluid and shallow slow earthquakes

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Due to the use of broadband seafloor seismometers near the trench and dense inland networks of highly sensi-tive seismic stations, very low-frequency events (VLFEs) have been observed in the shallow transition zone near the trench of subduction plate boundaries as well as the deep one. Following the 2004 Sumatra Earthquake, the Japanese government has established the Dense Oceanfloor Network system for Earthquakes and Tsunamis (DONET) along the Nankai Trough. In the Tonankai district, M8-class megathrust earthquakes will probably occur in the near future; DONET-I has now operated since August 2011. In this study, we perform numerical simulations of multiscale earthquake cycles, including a megathrust earthquake and VLFEs, on a 3-D subduction plate boundary, in order to understand the change in VLFE activity after megathrust earthquakes and hydraulic pressure gauge data.

In our simulation, the motion equation for a subduction plate boundary is described by a quasi-dynamic equi-librium between the shear stress (due to reverse dip-slip on the discretized faults) and the frictional stress based on a rate- and state-dependent friction (RSF) law. To perform multiscale earthquake cycle simulations, we as-sumed single large asperity and numerous small asperities arranged along the strike direction, where the large asperity generates megathrust earthquakes and a chain reaction of numerous small asperities generate a migra-tion of slow earthquakes along the strike direction.

From our simulation results, we concluded as follows: (i) For a megathrust earthquake in which the coseismic slip penetrates to the trench, plate coupling in the postseismic stage will be strong in the region from the central part of the source region to the shallower part toward the trench, which will cause the shallow VLF after-events to be quiescent or to occur infrequently in isolation. On the outer rim, shallow VLF after-events will be reac-tivated earlier than they will be in the center because of weak plate coupling. (ii) Since leveling change due to slow earthquakes at DONET is expected to be local and incoherent in the same node because of the short dis-tance between their sources and the (DONET) receiver, it is useful to remove an average from original data in the same node in order to extract a signal.

Keywords: megathrust earthquake, subduction zone, seismic quiescence, high pore pressure, seafloor observation, rate- and state-dependent friction law