Simulation of earthquake generation cycle and its problems to be solved in the future for earthquake prediction

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In order to realize earthquake prediction, especially for great interplate earthquakes, we aim at obtaining the present and past status of interplate coupling and then predicting how the coupling status changes until the occurrence of earthquakes. I will introduce recent studies on simulation of earthquake generation cycles that is necessary to predict changes in status of interplate coupling and then mention some related problems for earthquake prediction.

Interplate earthquakes and coupling status is now modeled by dislocation distribution on a boundary that is in elastic (and viscoelastic) medium. In order to simulate spontaneous changes in coupling status, a fault constitutive relation and a tectonic loading model are necessary. Fault constitutive relations are derived not from observation but from rock experimental data. Tectonic loading is modeled by dislocation with a constant rate on the boundary, which represents steady plate motion.

For simulation of interplate earthquake generation cycle, it is necessary to set geometry of plate boundary, rheological parameter of the medium, spatial distribution of parameters for the fault constitutive relation, and plate convergence rate. Most of the values can be estimated from various observation data, except for the constitutive parameters. If you choose constitutive parameters properly, simulation can reproduce a spatio-temporal pattern of interplate coupling similar to that estimated from observation. In order to achieve such a similar pattern, however, plenty number of simulations with different parameter sets are necessary. It cannot be done for a large-scale simulation that needs the Earth Simulator.

One of the important problems, which should be solved in the near future for prediction of changes in interplate coupling, is to develop a system of data assimilation that can optimize fault constitutive parameters for observation data. Some studies of optimization of fault constitutive parameters have done for seismic rupture propagation. For afterslip of interplate earthquakes, estimation of the relation between stress and slip velocity has been done recently. Based on the results, it is possible to estimate constitutive parameters and to test how simulation can reproduce the afterslip pattern with the parameters. The improvement of constitutive relation is also another problem. Data assimilation system can be used in order to check if the fault constitutive relation used is good. Material science using core from the plate boundary and in situ observation in the deep-sea borehole in the near future may also give important information for fault constitutive relation. Additionally, the observation data on the ocean bottom and in the deep-sea borehole are necessary for interplate earthquakes, which mainly occur off shore in Japan.