3次元分岐断層シミュレーションによる2014年長野県北部の地震の動的破壊過程
3D branching fault simulation for dynamic rupture process of 2014 Northern Nagano Prefecture Earthquake

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The 2014, M_w6.2, Northern Nagano Prefecture Earthquake broke the Kamishiro fault, which constitutes the northern end of the Itoigawa-Shizuoka tectonic line (ISTL). Associated with this earthquake, several characteristic phenomena indicate the complex configuration of this earthquake processes, as indicative of immaturity of the fault owing to low activity of ISTL at this end section. One of such is found in the surface ruptures, where the offsets were observed to be nearly 1 m for the southern half of the source area, while such surface ruptures were not identified for the northern half. This surface observation consists with the surface displacement distribution inferred from InSAR analysis, suggesting the large slip areas concentrated at near the ground surface on the southern half and at a deeper depth on the northern half, respectively. The surface break is suggested to be a temporally stable structure for a geomorphologic time scale overlapping preexisting fault scarps, and moreover, cumulative fault slip has found by trenching surveys. Another characteristic observation is that the first motion solution of the focal mechanism exhibits nearly pure strike slip faulting, while the centroid moment tensor does the reverse faulting with considerable a non-double couple component. The focal mechanisms of the foreshocks, aftershocks and the spatial distributions of them show the geometry of the source fault is composed of a dipping main-fault and a nearly vertical branch fault.
In this study, we consider this inferred complex fault geometry and carry out the fully dynamic 3 dimensional rupture simulation to understand the factors controlling the observed spatially and temporally heterogeneous features in the rupture process. We give the constraints of the applied stress based on the stress tensor inversion conducted for the focal mechanisms of small earthquake occurred in this region before this earthquake sequence; the maximum principle stress axis is determined to be horizontal oriented at ENE-WSW as the overall direction of the main-fault strike is nearly N-S. The determined stress ratio $(S_2-S_3)/(S_1-S_3)$ is also considered as a constraint together with the assumption of the vertical stress is in the lithostatic condition.
For the numerical simulation, we employed newly developed efficient algorithm for the 3D dynamic boundary integral equation method, called the First Domain Partitioning Method (FDPM) (Ando, 2016, submitted). This method allow us to fully consider the 3D fault geometry together with the ground free surface effect. Each run of the simulation is completed in a few minutes with 48 cores and 15 GB of memory for the following model size: element sizes ~0.5 km, number of elements ~2,000 and time steps ~ 400.
We performed a series of parameter studies over the stress states concerning its uncertainty in the dynamic rupture simulation. We found, under a certain range of parameter sets, the rupture initiated on the vertical branch fault and then propagated to the dipping main-fault. We further obtained the slip distribution, which is dominated by the strike slip component on the branch-fault and by the reverse components on the main-fault as expected from the orientations of the faults and the principle stresses. In these cases, the reverse faulting slip shows the maximum on the shallow part of the main-fault above the hypocenter, presenting the similarity with the emergence of the

observed surface break. The vertical branch-fault existing below the main-fault on the foot wall side seems to contribute the large slip at a depth on the northern half of the source area.

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