Evaluation of rock evolution process in seismogenic fault: Dynamic wave propagation modeling to the digitalized fault rocks

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Abstract

To understand the characteristics of the Nankai seismogenic fault in the plate convergent margin, we calculated the P- and S-wave velocities (*Vp* and *Vs*) of digital rock models constructed from core samples of an ancient plate boundary fault at Nobeoka in Kyushu Island, Japan. We first constructed 3D digital rock models from micro-CT images and identified their heterogeneous textures such as cracks and veins. We replaced the cracks and veins with air, water, quartz, calcite, and other materials with different bulk and shear moduli. Using the Rotated Staggered Grid Finite-Difference Method, we performed dynamic wave propagation simulation and quantified the effective *Vp, Vs*, and the ratio of *Vp* to *Vs* (*Vp/Vs*) of the 3D digital rock models with different crack-filling minerals. Our results demonstrate that the water-saturated cracks considerably decreased the seismic velocity and increased *Vp/Vs*. The *Vp/Vs* of the quartz-filled rock model was lower than that in the water-saturated case and in the calcite-filled rock model. By comparing the elastic properties derived from the digital rock models with the seismic velocities (e.g., *Vp* and *Vp/Vs*) around the seismogenic fault estimated from field seismic data, we characterized the evolution process of the deep seismogenic fault. The high *Vp/Vs* and low *Vp* observed at the transition region from aseismic to coseismic regimes in the Nankai Trough can be explained by open cracks (or fractures), while the low *Vp/Vs* and high *Vp* observed at the deeper coseismic fault zone suggests quartz-filled cracks. The quartz-rich fault zone characterized as low *Vp/Vs* and high *Vp* in this study could partially relate to the coseismic behaviour as suggested by previous studies, because quartz exhibits slip-weakening behaviour (i.e., unstable coseismic slip).

Key words: Digital rock, wave propagation simulation, fracture-filled materials, and earthquake fault