Simulation of the Recurrence of Long-term Slow Slip Events in the Tokai Region by assuming Locally Elevated Pore Pressure

Fuyuki Hirose[1]; Kenji Maeda[1]

[1] MRI

1. Introduction

A long-term slow slip event was reported to occur in the Tokai region, central Japan, from October 2000 to the middle of 2005 [GSI, 2007]. In addition, retrospective investigations reveal that long-term slow slip events have been observed beneath Lake Hamana with the recurrence period of about 10-30 years [Kimata et al., 2001; Kobayashi and Yoshida, 2004; NIED, 2004; Sagiya, 2007]. Hirose et al. [2007] tried to simulate them on the basis of the rate- and state-dependent friction law [Dieterich, 1979, 1981; Ruina, 1983] by introducing the spatial variation of friction parameters for asperity and other regions with taking the existence of subducting ridge off Tokai [Kodaira et al., 2004] into account. As a result, recurring slow slip events occur with the recurrence period of about 30 years beneath Lake Hamana and its western area when the plate convergence rate estimated by Heki and Miyazaki [2001] is used. However, the calculation region Hirose et al. [2007] covered is limited to the Tokai region and they did not include the effects from the asperity region of the Tonankai earthquake. In such a case, steady slip whose rate is same as plate convergence rate is assumed on plate boundary at everywhere outside of the calculated region including the Tonankai region. This unrealistic assumption might affect simulation results associated with the occurrence of slow slips. In this study, to avoid this problem we extend the calculation region to much wider area including the Tonankai and Nankai region.

2. Modeling Procedures

When hydrated minerals in the slab crust subduct into a great depth, they undergo a phase transformation and a large amount of water is liberated [Hacker et al., 2003]. Consequently, pore pressure on the plate boundary increases through dehydration reactions, which in turn decreases effective normal stress and weakens coupling on the plate boundary [Rice, 1992]. If the pore pressure increases on the plate boundary through dehydration reactions, a contact area between the continental plate and the Philippine Sea slab is expected to decrease. Therefore, it is appropriate to consider that the characteristic distance related to the contact area becomes smaller as well as effective normal stress in the regions where long-term slow slip events occur. In this study, we try to simulate the localized long-term slow slip events by introducing a locally small characteristic distance (L) as well as a locally elevated pore pressure, i.e., by setting effective normal stress smaller at northwest of Lake Hamana (10-30 MPa) than that in the rest of regions (100 MPa).

3. Results

The results show that great earthquakes in Tonankai and Nankai regions occur cyclically every about 150 years, and the new model can also simulate recurring local slow slip events at northwest of Lake Hamana. The recurrence periods of slow slip events are about 5 years for the effective normal stress of 10 MPa, 15 years for 20 MPa, and 20 years for 30 MPa, respectively. The recurrence periods for the second and third cases are consistent with the observation [Kimata et al., 2001; Kobayashi and Yoshida, 2004; NIED, 2004; Sagiya, 2007]. On the other side, slow slip events are inconspicuous with longer characteristic distance and higher effective normal stress. It is supposed that the effective normal stress and characteristic distance in the regions where long-term slow slip events occur is smaller than those in other regions.