Seismicity and its implications for fluid movement in the northern and central Hikurangi subduction zone, New Zealand

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Introduction

Beneath the North Island of New Zealand, the Pacific plate is subducting under the Australian plate along the Hikurangi Trough, forming the Hikurangi subduction zone. In the Hikurangi subduction zone, some recent studies suggest that fluid movement from the oceanic crust to the plate boundary or into the Australian plate impacts various seismic activities such as SSEs (slow slip events), tremors, and earthquake swarms. Tateiwa et al. (2022, JpGU) relocated earthquakes in the northern Hikurangi (37S –39.5S) and classified them into those occurring within the Australian plate (AUS), within the Pacific plate (PAC), or at the interplate (INT). They found that PAC, INT, and AUS earthquakes were active during the pre- and co-SSE period, co-SSE period, and post-SSE period, respectively, which indicates fluid movements before and after the SSE. In this study, we extend the study area to the central Hikurangi (39.5S-41S), classify earthquakes into AUS, INT, or PAC, and investigate the relationship between earthquakes and SSEs.

Data and Method

We selected all earthquakes in the GeoNet catalog of M > 3 occurring between 2003 and 2020 in the northern and central Hikurangi and shallower than 150 km for analysis. The number of earthquakes used was 7,616. Data from GeoNet broadband (HH) and short-period (EH) seismometers were used for the study. The classification into AUS, INT, and PAC mainly consists of the three steps: (1) classification based on the re-determined hypocenters by this study, (2) classification based on the focal mechanisms from the P-wave polarity, and (3) classification based on the cross-correlation of the waveforms. The number of earthquakes classified in each step was 3,269 in the first step, 260 in the second step, and 244 in the third step. To find the occurrence of SSEs, we used all GNSS stations by the GeoNet within the same region as used in the relocation analysis. We defined the occurrence timing of SSEs as the timing that the GNSS transient eastward displacement occurs based on linear function fitting. We also defined the 20-day period, from 30 to 10 days before the transient displacement appeared, as the pre-SSE period, from 10 days before to 10 days after the transient displacement as the co-SSE period, and from 10 to 30 days after the transient displacement as the post-SSE period.

Result and Discussion

PAC earthquakes were distributed widely, while AUS and INT were distributed locally. Many AUS earthquakes in the northern Hikurangi were where the extensional areal strain was observed (Dimitrova et al., 2016), indicating that the extension increases the permeability of the crust and makes it easy for fluid-related earthquakes to occur. INT earthquakes were at the periphery of the SSE source regions. In and around the shallow SSE source region, AUS earthquakes were active during the post-SSE period, INT earthquakes were active during the co-SSE period, and PAC earthquakes were slightly active during the pre- and co-SSE period. This is the same as in the Northern Hikurangi (Tateiwa et al., 2022, JpGU). This characteristic temporal relation with SSE dependent on earthquake location can be explained by fluid movement. That is, fluid movement from the oceanic crust to the plate boundary or upper plate, as proposed by Nishikawa et al. (2021), may have triggered SSEs, tremors, and AUS or INT earthquakes.