The relationship between recurrence interval and magnitude of repeating earthquakes occurring in and around the Raukumara Peninsula in the North Island, New Zealand

*立岩 和也[1]、Calum Chamberlain[2]、Laura Hughes[2]、Martha Savage[2]、岡田 知己[1]
*Kazuya Tateiwa[1], Calum John Chamberlain[2], Laura Hughes[2], Martha K Savage[2], Tomomi Okada[1]

1. 東北大学大学院理学研究科附属地震・噴火予知研究観測センター 、2. ヴィクトリア大学ウェリントン
1. Research Center for Prediction of Earthquakes and Volcanic Eruptions, Graduate School of Science, Tohoku University, 2. School of Geography, Environment and Earth Sciences, Victoria University of Wellington

Introduction

Analysis of repeating earthquake is expected to further the understanding of seismic activity and frictional properties of subduction zones. In particular, we showed that in northeast Japan, the parameter called "q-value", which evaluates the relationship between the recurrence interval *Tr* and the seismic moment M_0, was useful for evaluating the frictional properties of repeating patches (Tateiwa et al., 2020, JpGU). The q-value depends on the ratio of the velocity-weakening patch size r to the nucleation length h^*, and is negative when $r \tilde{} h^*$ and positive when $r>h^*$ (Chen et al., 2010).
Recently, repeating earthquakes have been detected in the North Island of New Zealand. To improve our understanding of the frictional properties of the northern Hikurangi subduction zone, we examine the q-value of repeating earthquakes occurring in and around the Raukumara Peninsula, the North Island of New Zealand. In order to discuss the frictional properties in addition to the q-value, we also investigate the ratio of the P-wave corner frequency *fc(P)* to the S-wave corner frequency *fc(S)*, which decreases with increasing rupture velocity.

Data & Method

In this study, we use the repeating earthquake catalog identified by Hughes et al. (in review) based on waveform correlation. This catalog contains 62 repeating earthquake sequences and 160 earthquakes. Based on focal mechanism and depth, each sequence is categorized into three groups: sequence occurring within the Australian plate, on the subduction interface, and within the Pacific plate.
For each repeating earthquake sequence, we examine the $\log Tr$-M_0 relation using the catalog origin time and seismic moment estimated from the low-frequency level of the spectrum. The slope of the regression line for the plot is defined as the q-value, and its spatial distribution is investigated. We adopt the spectral ratio method to estimate the corner frequencies.

Result & Discussion

Among earthquakes occurring at Tokomaru-Tolaga, q-values of repeating earthquakes occurring at the plate boundary (TT-int, at depths of about 13 km) and within the Australian Plate (TT-aus, just shallower than TT-int) both tend to be negative, and no significant difference is found. Many of them are located adjacent to the active seismic tremor zone in Tolaga Bay (Todd and Schwartz, 2016). The tendency of negative q-values for repeating earthquakes adjacent to the tremor zone is similar to those in the subduction zone in northeast Japan. The effective normal stress is expected to be low in the active tremor zone due to fluid, and therefore low in the repeating patches adjacent to the tremor zone. Since the h^* is inversely proportional to the effective normal stress, the low effective normal stress makes the q-value negative for TT-aus repeating earthquakes and especially for TT-int repeating earthquakes. Since h^* is proportional to the rigidity, if we assume that there exist sediments with low rigidity on the plate interface, the low rigidity acts to make the q-value positive. No significant difference of q-values between TT-int repeating earthquakes and TT-aus repeating earthquakes may be caused by high fluid pressure and low rigidity at TT-int. If lower effective normal stress and rigidity at TT-int than at TT-aus are the case, their effects on the h^* are canceled, making no significant differences of q-values. The low rigidity is expected to lead to a large ratio of rupture velocity *Vr* to shear wave velocity *Vs*, and therefore TT-int repeating earthquakes are to have larger *Vr/Vs* than TT-aus repeating earthquakes. We found that log*(fc(P)/fc(S))*, which varies inversely with *Vr/Vs*, has a value of 0.005 (±0.049) for TT-int and of 0.129 (±0.044) for TT-aus. From the result of Kaneko and Shearer (2015), this suggests larger *Vr/Vs* for TT-int than TT-aus, which is consistent with the assumption of low rigidity sediments at TT-int.

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