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Seismic quiescence and activation that precede large earthquakes and their source regions

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The authors have attempted to detect and to quantify the quiescence phenomena of seismic activity prior to large earthquakes, by using an analyzing method of seismic quiescence and activation (eMAP). They have shown that there are scaling laws of quiescent area and lead-time with respect to earthquake magnitude, which suggests the possibility of earthquake forecasting in intermediate time scales (Yoshikawa et al., 2014). As it is necessary to improve the accuracy for application of this method to the forecast, we have investigated in details the relationship between seismic quiescence and activation that precedes a large earthquake and the source region.

Our past investigation for 26 major earthquakes with the magnitude larger or equal to 6.7 (focal depths less than 200km) has shown that 15 cases of quiescence can be retrospectively detected before the earthquake, and revealed that there is a proportionality between the relative source distance (the distance from the rupture point to the center of quiet region) and the size of the quiescent area (the major axis). In the present study, we investigated the relationship between the source regions of earthquakes and the quiescent and activated areas for the above 15 cases. According to the result there were 12 cases where the seismically quiescent area is surrounded or neighbored by the seismically activated areas, which has been called as the doughnut pattern (Mogi, 1969). The result indicates that in most cases quiescence can be more easily identified by co-existence of the activated areas. In almost all cases the quiescent area did not fit to the whole source region of a future earthquake, but it overlaps only with a part of it. That is, the quiescent area does not determine the future source region. However, we could find that there are at least 9 cases where a source region overlapped with one of seismically activated areas when the doughnut pattern was formed. This possibly suggests that to detect the doughnut pattern can contribute to estimate a future earthquake source region.

As pointed by Mogi (1979), the first kind seismic gap is defined as an unbroken part to be considered as asperity in a seismic zone, whereas the second kind seismic gap is defined as a part of temporary seismic quiescence. That the seismic quiescent area described above does not fit to the whole source region means that seismic quiescence is not caused in the asperity but caused by decrease in seismic activity due to aseismic slip in the fault surface. On the other hand, the seismic activation in surrounding of the quiescent areas may be caused by seismic activity in asperity.

Keywords: seismicity, quiescence, earthquake forecast