Evaluation of spatio-temporal seismicity change

Akio Yoshida and Kohji Hosono

Seismology and Volcanology Department, Japan Meteorological Agency 1-3-4, Otemachi, Chiyoda-ku, Tokyo 100-8122, Japan (e-mail: akio.yoshida-a@hq.kishou.go.jp; phone: +81-3-3212-8341; fax: +81-3-3212-2807).

Appearance of seismic quiescence before a large earthquake around the focal region was first pointed out by Inouye for the 1964 Niigata earthquake with a magnitude of 7.5 (Inouye, 1965[1]). Since then, many papers have reported observation of seismic quiescence before large earthquakes. However, variety and vagueness are seen in the definition of quiescence as to threshold magnitude of earthquakes for which the quiescence is observed, length of the time period and extent of the region where the quiescence appears. In some cases quiescence area almost coincides with the focal region, while in other cases it is reported that quiescence is observed in the far more extended areas. In order to evaluate quantitatively the time period and extent of precursory seismic quiescence some techniques have been proposed so far; e.g., a method using z-map (Wiemer, 1996[5]; Wyss and Habermann, 1988[6], et al.), a statistical method (Ogata, 1992[3]), a CHASE plot (Yoshida and Takayama, 1992[8]) and so on. Further, some ideas have been suggested about the mechanism of quiescence (Scholz, 1988[4], Kato et. al, 1997[2]). In spite of those efforts towards the objective and unified evaluation of seismic quiescence it seems that contradictory arguments still exist whether the phenomenon is significant and practically useful for the prediction of large earthquakes or not. We consider that detection of seismic quiescence is a promising way for selecting a site where a large earthquake is expected to occur in the near future, if some attentions are paid properly.

It is well known that foreshocks are very likely to be observed for earthquakes in some specific tectonic regions, but they do not necessarily occur for all earthquakes. Similarly it is well expected that pattern of appearance of seismic quiescence is greatly affected by the tectonic situations of the site. Inhomogeneity of the medium and complexity of stress accumulation process are probable main causes of the variety. Thus we should consider that variability of spatio-temporal characteristics of precursory seismic quiescence is an intrinsic property of the phenomenon. It does not indicate insignificancy of the phenomenon, but it is rather to be taken to show us a clue to understand state of stress in and around the focal region of earthquakes just before their occurrence.

The second point of which we should take note is that appearance of quiescence is not necessarily succeeded by an occurrence of a large earthquake. One of the conspicuous examples is a quiescence which was observed in an extended area to the west of Suruga Bay, southern coast of central Japan, during the 1988-89 period (Yoshida et. al., 1998[7]). The quiescent area included the northern part of the focal region of the anticipated Tokai earthquake, where a dense observation network of seismographs, borehole volume strainmeters, extensometers, tiltmeters, underground water monitors has been deployed in order to detect precursory phenomena immediately prior to a large earthquake. So that, when the quiescence appeared, we paid much attentions to it, but, not a large earthquake occurred afterwards. Although the quiescence has turned out not to have had been a short-term precursor of a large earthquake, it was found that subsidence in the northern coastal area of Suruga Bay had accelerated coinciding with the appearance of the quiescence. We think the latter fact shows that the seismic quiescence was somewhat related to the decrease of seismogenic stress in that region probably due to change of coupling state between the Philippine Sea plate and the Eurasian plate.

As above-pointed out, seismic quiescence is not necessarily a precursor of a large earthquake. We can say, however, that decrease and increase of seismic activity is an indication of change of regional stress. Consequently it is expected that we can utilize observation of spatio-temporal change of seismicity for estimating increase or decrease of regional stress as well as propagation or diffusion of tectonic stress. In doing the estimation, an effective way to find correlation of seismicity changes in different regions is to calculate CHASE for both regions. CHASE stands for CHAnge of SEismicity and the value is calculated by taking difference of number of earthquakes occurred in successive two periods (Yoshida and Takayama, 1992[8]). By choosing appropriate lengths for the preceding and succeeding periods, we can investigate change and correlation of seismicity in different lengths of time. Using this method, we found out that the seismic activities in the three adjacent areas of the Kinki Triangle, a triangular tectonic block delineated by conspicuous active faults in the Kinki District, southwestern Japan, are well correlated. It is also found that the seismic activity in the eastern region has a tendency to precede about three years that in the western region (Yoshida and Takayama, 1994[9]).

References

[1] Inouye, W., 1965, *On the seismicity in the epicentral region and its neighbourhood before the Niigata earthquake,* Quarterly Journal of Seismology, **29**, 139–144 (in Japanese).

[2] Kato, N., Ohtake, M., and Hirasawa, T., 1997 *Possible mechanism of precursory seismic quiescence: Regional stress relaxation due to preseismic sliding,* Pure and Applied Geophysics., **150**, 249–267.

[3] Ogata, Y., 1992, *Detection of precursory relative quiescence before great earthquakes through a statistical model,* Journal of Geophysical Research, **97**, 19845–19871.

[4] Scholz, C. H., 1988, *Mechanisms of seismic quiescences,* Pure and Applied Geophysics, **126**, 701–718.

[5] Wiemer, S., 1996, *Analysis of seismicity: new techniques and case studies,* Ph.D. Dissertation, University of Alaska, Fairbanks, Alaska.

[6] Wyss, M. and Habermann, R. E., 1988, *Precursory seismic quiescence,* Pure and Applied Geophysics, **126**, 319–332.

[7] Yoshida, A., Hosono, K., Wiemer, S., and Noguchi, S., 1988, *Re-examination of the seismic quiescence observed in western Suruga Bay during the period 1988–1989,* Abstracts, J. Earth Planet. Science Joint Meeting, **307**.

[8] Yoshida, A. and Takayama, H., 1992, *Correlation of seismic activities in the circumferential areas of the Kinki Triangle and its tectonic significance,* J. Geography, **101**, 327–335 (in Japanese with English abstract).

[9] Yoshida, A. and Takayama, H., 1994, *Change of seismic activity in an extensive area before and after the 1953 Boso-oki earthquake and the 1972 Hachijojima-toho-oki earthquake,* J. Geography, **103**, 696–705 (in Japanese with English abstract).