Identifying seismic gap and quiescence by monitoring spatio-temporal changes in seismic energy releases and recurrence patterns

Yuzo Toya[1], Minoru Kasahara[2]

[1] Earth and Planetary Sci., Hokkaido Univ., [2] ISV, Hokkaido Univ

This study presents a technique to graphically illustrate seismic gap and seismic quiescence in the space-time history of seismicity, and to examine their relationships to large earthquake occurrence for last 100+ years along some of the major tectonic boundaries near Japan. Quantitatively identifying such patterns is an essential step in the development of a reliable earthquake-forecasting algorithm. Spatio-temporal distribution of cumulative seismic energy release was mapped to identify spatial 'gaps' in seismicity, while at the same time, space-time distribution of inter-event time (or elapsed time since last event) for given magnitude-class events was mapped to delineate zones of on-going apparent seismic quiescence. Importantly, the sampling window size and shape used for mapping a tectonic boundary segment was decided in reference to known fault dimension of a recent local maximum earthquake (or 'characteristic earthquake'). The employed simple but systematic mapping scheme allowed successful identification of some spatio-temporal 'gaps' in seismicity preceding large events (M ge. 7.0) that were previously indicated by other researchers. Furthermore, other forms of seismicity patterns became apparent in result for some cases, such as migration of epicenters and nearly periodic occurrence of seismic quiescence. For example, a few clear southward migration episodes of mostly moderate size events (M ge. 5) could be observed along the tectonic boundary of the eastern Japan Sea. Following the episodes, large earthquakes along the same boundary appeared to migrate northward. Also, in the case of southern Kurile trench near Hokkaido, quasi-periodic occurrence of seismic quiescence episodes in M ge. 7 events were noticed dividing the studied plate boundary into approximately four equal-size segments. Each separate tectonic segment is apparently moving with its characteristic recurrence period in tune with its neighbors. At the same time, M ge. 7.5 class events along the boundary in southern Kurile appear to occur by filling the gap at the SE Nemuro Pen. Oki. These seismicity patterns observed in southern Kurile may imply the existence of variations in the local 'strength' along the plate boundary, i.e., 'asperities' or some near-permanent features on the contact zone, together with the existence of a regional nested structure of asperities with a large scale 'asperity' that is presumably a source for future gap filling event(s). Finally, the above results from seismicity pattern analysis need to be compared with other factors controlling the boundary tectonics to obtain more accurate estimate of the deficiency in seismic energy release. Much of the effect from those other factors is hopefully revealed in the observations of geodetic strain. For the case of southern Kurile, the SE Nemuro Pen. Oki plate segment is geodetically shown to be coupled as well, and the strain is being accumulated there. Accordingly, the segment is likely to host large gap-filling earthquake(s) (M ge. 7.5) in the near future. The introduced method works well in identifying some regular patterns in seismicity, although further improvements are feasible.

(Note: 'ge.' = greater than and equal to)