Overview and recent progress of Earthquake Prediction Research in Japan

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In the 40 years of the history of earthquake prediction research and the 130 years of earthquake research in Japan, the progress in the last 10 years will be memorized impressively by the future researchers of earthquake sciences. Earthquake prediction research has been promoted by the government for the last 40 years for the purpose of earthquake disaster reduction. Many researchers devoted themselves to the pioneering findings of earthquake precursor phenomena. Due to their effort remarkable progress has been made on the observation system to record many phenomena related to crustal activities. In spite of the progress little is known about the precursors of earthquake occurrences.

The ‘New program for earthquake prediction research’, which is called new program started in 1999 based on the critical review of the previous program. The new program promoted the basic research of earthquake occurrence and the predictive simulation that collaborates with monitoring of crustal activity. The new program started under the policy of understanding the whole process of earthquake cycle to reveal the phenomena that are expected to occur at the final stage before earthquake occurrence, and aimed at earthquake prediction with high reliability. The 2nd new program has two principal subjects; (1) comprehensive research to clarify the activity in the earth's crust associate with preparation stage of earthquakes, (2) establishing predictive simulation for crust activity and the upgrading monitoring systems for crust activity. In the presentation, we summarize the principal results on earthquake prediction research in the period of new programs, and discuss the future direction of earthquake prediction research.

One of the principal results in earthquake prediction research during the period of the new programs is the establishment and successful verifications of physical model that is based on asperity hypothesis for the earthquakes in plate boundaries. For example, the main rupture area of 2003 Tokachi-oki earthquake was revealed to coincide with that of 1952 Tokachi-oki earthquake, supporting the idea of earthquake recurrence based on the asperity model. The asperity model is also able to explain the difference among the earthquakes in Miyagi-oki area that occurred in 1830's, 1978 and 2005. The potential focal area in Miyagi-oki is composed of three or more asperities, and the variation of the past earthquakes is explained by the difference in the combination of asperities that ruptures simultaneously. The simulation that considers realistic friction and fracture law and geometry of the plate boundary is able to reproduce the feature of the recurrence cycle of great earthquakes in the plate boundary in southwestern part of Japan.

The nation-wide, dense observation networks such as Hi-net (High Sensitivity Seismograph Network) and GEONET (GPS Earth Observation Network System) have been operated for about 10 years, providing very high-quality data set. Slow slip and the low-frequency tremor along the plate boundary are found in the data set. Now the low-frequency tremors are revealed to be the small vibration associate with slow slip along the plate boundary surface. These remarkable finding would open the gate to the new paradigm on the mechanism of earthquakes. The stress re-distribution processes in the preparation stage of earthquakes are being clarified.

These results show that the policy of the new program was basically correct, and should be continued. However, the physical model for the inland earthquake is still far from establishing and is qualitative stage for some specific region. The process of stress concentration to the fault region should be investigated as soon as possible. The research concerning the process immediately before earthquake has little advance during the period of the program. A comprehensive observation and study should be concentrate on the region where earthquakes are impending.