

# Geology of Earthquakes: the breakthrough in the last and next decades

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The Headquarters for Earthquake Research Promotion published the long-term evaluation of the Rokko-Awaji Island fault zone shortly before the tenth anniversary of the 1995 Kobe (Hyogoken-Nanbu) earthquake. The evaluation is based on the separation of two sub-events, one characteristic event on the Nojima fault in Awaji Island and the other non-characteristic smaller event under Kobe. The innovative project of the probabilistic earthquake hazard maps, the acceptance of the idea of the characteristic slip, and recent severe damages from intermediate-sized non-characteristic earthquake stimulate the study of the geology of earthquakes and urge improvements. The great Sumatran earthquake of December 2004 also demonstrates the success and problems remain for the discipline. Before the Kobe earthquake, a lot of data on the active faults had been accumulated but they were not shared by the public and the majority of seismologists. Only the researchers inside the community and nuclear safety designers shared the information. At that time in California, the SCEC Phase II project was about to complete the probabilistic seismic hazard map of California. The map was very much appreciated by the hazard and reinsurance communities. The 1995 Kobe earthquake coincided with the establishment of the methodology and techniques for the probabilistic hazard assessment. Therefore, the new national project in Japan on the PHA was initiated immediately after the disasters. The intra-plate earthquakes like Kobe earthquake recur in a time period of a few times to more than 10 times longer than the coverage of historic records. It was impossible to forecast these earthquake without geomorphic and geologic information. The geology of earthquakes increases our knowledge about earthquake hazards drastically. At the same time, the earthquakes that do not leave signature on the surface of the earth are far beyond the ability of the geological studies. This inability, however, does not reduce the value of the methods.

The sub-event under Kobe in 1995 ruptured only a small and deeper portion of the Rokko faults and geology and geomorphology could never study the faulting. Some active fault researchers still claim that there are possibilities that the Quaternary fault under the intensity 7 zone ruptured on January 17, 1995. But there is no evidence at all to demonstrate the surface faulting on that very day. Geodetic data and seismological inversion rule out the possibility of surface faulting. However, we do not know much about the exact location of the ruptured fault plane notwithstanding the great efforts for aftershock monitoring and all geophysical exploration. We know very little about actual faulting under Kobe. The January 2005 evaluation pointed out the possibility of a characteristic event on the Rokko faults together with the East Awaji faults as large as M 7.9. The probability is calculated but chronological constraints of past events are not good enough.

The intermediate-sized earthquakes with intense ground shaking occurred repeatedly in this decade. Geological research cannot supply us with quantitative and time-dependent information on these earthquakes. Probabilistic hazard assessment is not applicable for these earthquake. However, seismologists should find the way to supplement the PHA with those geologic information on smaller but hazardous earthquakes.