

The Giant off Tohoku earthquake of 11 March 2011

Kenji Satake (Earthquake Research Institute, University of Tokyo)

The earthquake occurred last week off the Pacific coast of northern Honshu was a plate boundary rupture along Japan trench, where the Pacific plate is subducting beneath northern Honshu. Its size (magnitude $M = 9.0$) was the largest in Japan's history and the fourth largest in the world in the last century. This giant earthquake produced strong ground shaking (maximum acceleration near 3 g) and large tsunami (most coastal tide gauges stopped after recording the maximum height of 7 m). From aerial observations and photographs, the tsunami inundation seems to exceed 5 km from the coast. The continuous GPS stations indicate that coast near Sendai moved more than 4 m horizontally and subsided about 0.8 m. The subsidence made the coastal inundation even after the tsunami wave retreated. We still do not know the final number of casualties, but it may exceed 10,000. The earthquake also caused serious damage to nearby nuclear power plants, which forced to limit electricity in other regions; many trains and traffic lights were shut down in Tokyo metropolitan area.

The source area of this earthquake is estimated 400 to 500 km long with maximum slip of 20 m, from aftershock distribution, GPS and seismographic data. Near the epicenter, or rupture start point, an $M 7.3$ earthquake occurred two days before. Around this region, Miyagi-oki, recurrence of $M \sim 7$ earthquakes made Earthquake Research Committee (ERC) of the Japanese government forecast of next earthquake with 99 % probability in the next 30 years. The 2011 earthquake, however, ruptured the neighboring regions with similar forecasts, hence the magnitude of earthquake and tsunami was much larger.

Occurrence of similarly great earthquake in AD 869 (called Jogan earthquake) was recorded in a Japanese historical document, which mentioned that large earthquake killed thousands of people and tsunami inundated kilometers. Studies of tsunami deposits have clarified that the AD 869 and older tsunami deposits were distributed a several kilometers from the present coast, and recurrence interval of such event was estimated as 450 to 800 years.

My reconnaissance observation from airplane indicates that the tsunami inundation areas from this earthquake are very similar to those of the Jogan earthquake. While we were in the process to understand the earthquake source model of the AD 869 and older earthquake, it seems to be interpreted as supercycle of earthquake recurrence. Earthquake cycle to release the accumulated strain at subduction zones is typically a few to several decades in most subduction zones. However, once in a few to several hundred years, giant earthquakes seem to have occurred for example in Indonesia or Chile, and known as supercycle.