Great earthquakes in Japan and Kuril Trenches and eruption of three volcanoes in Southwest Hokkaido in 17th century

*Kenji Satake[1]

1.Earthquake Research Institute, University of Tokyo

Great earthquakes with M~8 repeatedly occur with recurrence interval of ~ 70 years along the Kuril Trench off Hokkaido. Studies of tsunami deposits (e.g., Nanayama et al., 2003, Nature) indicate that the size of earthquake and tsunami occurred in the 17th century was much larger. Three volcanoes in southwest Hokkaido also erupted in the 17th century; Komagatake in 1940 and 1694, Usu in 1663 and Tarumai in 1667 and 1739. The tsunami deposits are usually found beneath these volcanic tephra layers, at 20 m altitude on the coast (Hirawaka, 2012, Kagaku) and inland up to several km from the coast.

The mechanism of the 17th century earthquake was studied by tsunami numerical simulations from interplate earthquake models (two different depths down to 50 km and 85 km) and tsunami earthquake model near the trench axis (Satake et al., 2008, EPS). Comparison of computed inundation areas with the distribution of tsunami deposits shows that the best model of the 17th century earthquake is a 300 km long, 100 km wide fault at a depth range of 17 to 51 km, with slip of 10 m off Tokachi and 5 m off Nemuro. This model may represent a simultaneous rupture of Tokachi-oki and Nemuro-oki earthquakes. The maximum coastal tsunami height from this Mw = 8.5 earthquake model was about 10 m. Recently, Ioki and Tanioka (2016, EPSL) modified the above fault model to include near-trench subfault (tsunami earthquake fault with 25 m slip along the trench axis) and showed that the coastal tsunami heights can be more than 20 m and able to explain both tsunami heights and inundation. Moment magnitude of this model is Mw = 8.8.

Tsunami deposits were also found from older earthquakes along the Pacific coast of Hokkaido. Another tsunami layer was found between tephra layers of the 17th century and 10th century. Three or four more tsunami layers were identified between the 10th century tephra and that of 2500 year BP (Nanayama et al., 2003). From the long core samples, Sawaii et al. (2009, JGR) showed that recurrence interval of 15 tsunamis in the last 6000 years varies from 100 to 800 years with an average of 400 years.

The three volcanoes in southwest Hokkaido belong to Honshu arc rather than Kuril arc, hence the earthquake related to these eruptions may be the one along Japan Trench rather than Kuril Trench. Along the northern Japan Trench, an earthquake in 1611 (Keicho earthquake) caused devastating tsunami damage and casualties similar to those of 2011 in Sendai plain and Sanriku coast. However, no damage due to ground shaking was recorded, hence it is considered as a ‘tsunami earthquake’. If it was similar to other ‘tsunami earthquakes’ such as the 1896 Sanriku earthquake, with the fault motion limited near the trench axis, then it is unlikely that such a shallow slip would affect volcanic eruptions. The 1611 Keicho earthquake may be the 17th century earthquake that brought tsunami deposits in Hokkaido. If so, the slip must be three times larger than the above models, in order to reproduce the tsunami heights and inundation areas in Sanriku and Sendai coasts (Okamura and Namegaya, 2011, GSJ). Annual bands of lacustrine deposit in Harutori-ko (Kushiro) suggest that the 17th century earthquake occurred in 1636 (Ishikawa et al., 2012, JpGU meeting). In northern Tohoku such as Morioka and Hirosaki, official daily records of clans should have recorded ground shaking from an earthquake in Kuril Trench (Satake, 2004, Annals Geophysics).

When the relation between the giant earthquakes and volcanic eruption is discussed, it must be considered that near-simultaneous eruptions occurred only in the 17th century during the several thousand years, while the giant earthquakes that leave tsunami deposits have recurred at 500 years

interval.

Keywords: great earthquakes, volcanic eruption, Kuril Trench, Japan Trench, tsunami

