Seismic reflection profiling of lacustrine deposits and discovery of an extremely large sublacustrine landslide in Lake Inawashiro, Fukushima, Japan

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Large landslides (larger than several hundred square meters) have been occurred in coastal and shallow water (shallower than about 100 meters) environments by historical big earthquakes. Possible mechanisms for landslides are related with liquefaction and destruction of water saturated materials induced by earthquakes. Although liquefactions have been frequently and widely observed as sand boils and ground failure by modern earthquakes in Japan, landslides in coastal and shallow water environments have been less recognized. Thus generation of large landslides should be related to a specific condition other than the sensitivity for liquefaction. In Lake Inawashiro in Fukushima, Japan, there are a number of topographic remnants of landslide along coastal areas. This suggests that the lake has been under the specific condition to generate landslides. To clarify the condition, the authors investigated the lake area geologically and geotechnically.

In 2015 and 2016, the authors carried out seismic reflection profiling by using 3.5 kHz Sub-bottom Profiler, scanned about 120 km in total distance of transects covering the entire Lake Inawashiro area. Comparison of seismic profile data with the sedimentary core (INW2012) sampled by Fukushima University in 2012 at the center of lake revealed the following results regarding to landslides and slope stabilities.

1) Seismic profiles shows the entire lacustrine sequences deposited after the lake formation in the southern half of the lake. Most of the profiles suggest simple layered structures. Some of the strong reflection layers within the structures correspond to known wide-spread tephra horizons observed in INW2012 core. A strong reflection layer of the bottom of the lacustrine deposit corresponds to the horizon of sand and gravels. Thus lacustrine deposit consistently has been deposited in the southern half of the lake. Whereas, sedimentary structures in profiles are not well recognized in the northern half of the lake. This is because that coarser (deltaic) sediment supply from Bandai volcano via the Nagase River probably affected the bottom of northern part of the lake and resulted in the acoustic waves reflected strongly and attenuated rapidly at the surface. The large landslides inferred from the present topography could be recognized underneath the coarse sediments.

2) Acoustically transparent facies, that indicates structureless sediments, is often observed across the lake. It suggests that soft sediment deformation by fluid or gas ejections have occurred in the lacustrine deposits, and also the lacustrine deposit has been affected by earthquakes repeatedly. In particular, the density of the facies is high in > 13 m below the lake bottom at the center of the lake. This horizon is about 1 m below the As-K tephra horizon (18,100 yrs. BP from Asama Volcano; Hirose et al, 2014). The age can be estimated as 20,000 years ago and infers an occurrence of a probable large earthquake affected this area at the time.

3) An extremely large subaqueous landslide structure was discovered. The length is 2.8 km and the

maximum thickness is about 25 m. The landslide structure is present beneath the horizon of about 20,000 years ago, and shows a massive body slid on a slope of 0.8 degrees. The distal end of the landslide consists of a number of thrusts and folds by compression. This study of landslide structure is important that clarified a whole process of sliding and a rupture surface. Further direct sampling from the rupture surface is necessary to understand the factors and condition of generation of landslides in coastal and shallow water environments.

<Reference>
Hirose, K., Nagahashi, Y., Nakazawa, N., 2014. Lithostratigraphy and dating of lacustrine sediment core (INW2012) from Lake Inawashiro-ko, Fukushima Prefecture, Japan. The Quat. Res., 53(3), 157-173.

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