Tsunami modeling by marine landslides and reduction of disasters

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The marine landslides due to large earthquakes caused much larger tsunamis than that expected from the magnitudes of the earthquakes. One example is the large tsunami along Aleutian Inlands due to the 1946 Aleutian earthquake (Ms7.2). The maximum tsunami height was about 40 m. The marine landslide is believed to be the main cause for this large tsunami near the source area. The other example is the 1929 Great Banks tsunami due to the earthquake of Ms7.2. The earthquake itself was caused by the marine landslide which cut the ocean bottom cables. Therefore, the large tsunami was completely generated by the marine landslide. We try to model the tsunami by our numerical simulation of marine landslide and tsunami to find volume of the landslide.

The marine landslides due to the volcanic eruptions also caused large tsunamis. Landslide during the 1741 eruption of Oshima-Oshima volcano in Hokkaido, Japan, occurred in the Japan sea generated a large tsunami. The tsunami caused severe damage along the coast of Hokkaido. We numerically simulated the landslide and tsunami generated by the 1741 Oshima-Oshima eruption using an improved two-layer model to explain the depositional area of the landslide, the tsunami heights written in historical records, and the distributions of tsunami deposits. Areas of erosion and deposition by the 1741 landslide were estimated from the bathymetric data on the northern slope of Oshima-Oshima volcano. From the bathymetry difference before and after the landslide, the volume of collapsed material was estimated at 2.2 km^3. Based on those data, the landslide and tsunami were numerically simulated by solving equations of an improved two-layer model that incorporates Manning's formula in the bottom friction terms of the lower layer. An apparent friction angle of 2.5 and a Manning's roughness coefficient of 0.15 were selected to explain the area of deposition estimated from the bathymetry analysis and distributions of tsunami deposits. The thickness distribution of the computed landslide mass fits relatively well with the depositional area. Computed tsunami heights match those from historical records along the coast. Computed tsunami inundation areas cover most of the distributions of tsunami deposits identified along the coasts.

No tsunami forecast method for those tsunamis generated by marine landslides exists.

It is needed to be developed for the tsunami disaster mitigation. Because a dense cabled observation network, called the seafloor observation network for earthquakes and tsunami along the Japan Trench (S-net), was installed in Japan recently, those ocean bottom pressure data should be used to forecast tsunami heights along the coast for landslide tsunamis. We developed a tsunami numerical simulation method by assimilating those ocean bottom pressure data as a tsunami forecast method (Tanioka and Gusman, 2018). The method was tested for tsunami generated by earthquakes, but it should be used for landslide tsunamis, too.

Reference

Tanioka, Y. and A.R. Gusman, (2018) Near-field tsunami inundation forecast method assimilating ocean bottom pressure data: A synthetic test for the 2011 Tohoku-oki tsunami, Phys. Earth Planet. Int., 283, 82-91, https://doi.org/10.1016/j.pepi.2018.08.006

Submarine slides and tsunamis: a review

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In this paper, I review the general characteristics of submarine slides, and their trigger mechanisms in short- and long-terms and marine geohazards due to the submarine slides. Submarine slides have been reported in various sedimentary environments.

From their geometry, submarine slides are generally zoned into three domains from their geometry; headwall, translational and toe domains. Even in the very initial deformation stages, these domains can be distinguished; i.e. the headwall domain includes fissures, the translational domain includes asymmetric deformation structures due to shear deformation, and the toe domain is dominated by pressure ridges.

Most of the slip surfaces correspond to clayey layers, but sand layers could also be such surfaces under undrained conditions as reported in the Nankai Trough. Geological record of past 20 ka suggest that large submarine slides have not occurred from 5 ka to present, but it is uncertain because of the lack of data.

The trigger mechanism would more likely be related to the consequence of earthquakes, such as an abrupt increase in ground acceleration and increased pore fluid pressure. The precondition includes many factors, such as gradual increase in pore pressure by decomposition of methane hydrate due to climate change, increase in pore pressure by high sedimentation rate, ground deformation due to subduction/collision of seamounts, and/or slope steepening due to volcanic activities.

Case study of submarine landslides, liquefactions, injections by past earthquakes: Guidance of field trip for Miura Peninsula on 24th May

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Recent study on geohazardous phenomena in the past and present subduction zones were summarized to suggest the submarine and on-land geology offers best comparison for understanding the geohazard history, process and mechanism. They involve volcanic activities and associate sedimentation of an island arc, large subduction type earthquakes and related tectonic movement. They used to be associated with large submarine sliding and tsunamis. In these years the critical comparison of both field geology on land and by submersibles in and around the Japanese trench areas are the strongest method (Kawamura et al., 2008; Ogawa, 2011; Ogawa and Yanagisawa, 2011). For the best comparison, we chose the type areas around the Izu arc collision zone in central Japan, particularly along the Sagami trough subduction zone, where geologically and historically known activities have been well analyzed since the middle Miocene to the modern ages, when the Boso triple junction came to the present areas (Mori and Ogawa, 2020). Several tracts of accretionary prisms from early to middle Miocene to Pliocene represent the total history of sedimentation and deformation of Izu arc-derived volcaniclastics (Ogawa and Taniguchi, 1988; Ogawa et al., 2008; Muraoka and Ogawa, 2011; Mori and Ogawa, 2019).

On land geology is well exposed on the continuous coastal benches in the Miura-Boso peninsulas, which have been repeatedly uplifted by subduction type large earthquakes (M ~ 8) with recurrent years of 400 to 2000 (Shishikura, 2014). The syn-sedimentatary deformation under semi-lithified conditions are analyzed by means of application of the soil and rock mechanical viewpoints (Ogawa, 2019). We will observe the representative outcrops on the southern tip of the Miura Peninsula, 60 km SW of Tokyo during the post-meeting field trip. The outcrops show liquefaction, mud diapir, vein structure, some are during large earthquakes, which also triggered large landsides and possibly tsunamis. Some debris flow and turbiditic deposits and chaotic injection bodies may be the products of such geohazardous phenomena. We will have good discussion on the causes and results between these phenomena, by learning the present submarine geology of the Sagami trough plate boundary as well.

(References)

Kawamura, K., et al. 2009, GSABull, 121, 1629-1646.
Mori, S. and Ogawa, Y. 2019, JGSJapan, 125: 737–757.
Mori, S. and Ogawa, Y. 2020, GS London SP, (in press).
Muraoka, S. and Ogawa, Y. 2011, GSA SP, 480, 233–247.
Ogawa, Y., 2011, Springer book, vol. 8, 39-52
Ogawa, Y. 2019, Gondwana Research, 74, 31-50.
Ogawa, Y., et al., 2008, GSA SP, 436, 155-170.
Ogawa, Y.; and Taniguchi, H. 1988, Modern Geology, 12, 147-168.
Ogawa, Y. and Yanagisawa, Y., 2011, Springer book, vol. 8, 53-73.
Shishikura, M., 2014, Episodes, 37, 246-257.