Estimating topography before the volcanic sector collapses using tsunami survey data with numerical simulations

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Large sector collapses and landslides have the potential to cause significant disasters. Estimating topography and conditions such as volume before the collapse are thus important for analyzing behaviors of moving collapsed materials and hazard risks. This study considers three historical volcanic sector collapses in Japan that caused tsunamis: the collapses of Komagatake Mountain in 1640, Oshima-Oshima Island in 1741, and Unzen-Mayuyama Mountain in 1792. Numerical simulations of the tsunamis generated by each event were first carried out based on some assumed collapse-scenarios. Presenting concrete conditions relating to the topography before the events based on those results and tsunami survey data is the primary objective of this study.

The Oshima-Oshima Tsunami, which is the subject of many previous studies, was first simulated to evaluate how tsunami heights changed during the simulation as the topographic conditions changed. It was found that tsunami height was especially sensitive to the collapsed volume and frictional acceleration acting on the collapsed material; however, observed tsunami heights could be reproduced with high accuracy using proper conditions of frictional acceleration for the scenarios even they were not exact. A minimum requirement for the collapsed volume of the observed tsunami height was introduced and quantitatively evaluated using the results of numerical tsunami simulations. The requirements for the collapses of Komagatake Mountain and Unzen-Mayuyama Mountain, for which there is not much quantitative data or many previous studies, were estimated to be approximately 1.2 and 0.3 km^3, respectively.

Keywords: sector collapse, topography, tsunami , numerical simulation

High resolution subbottom survey of submarine landslides on the western slope of Daini-Atsumi Knoll

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Submarine landslide is regarded as one of the significant marine geohazards because it causes tsunami destructive to coastal area when the scale is large. Although most landslides are small in the Nankai Trough area, a relatively large landslide stretching about 7 km east to west and 10 km north to south is developed in the Daini-Atsumi Knoll. Because the seismic reflection profile crossing this landslide exhibits large depth differences between methane hydrate BSRs and the landslide body, possibility of landslide along the base of methane hydrate zone is denied (Nagakubo et al., 2009, Chigaku Zasshi). Deep-towed subbottom profiler (SBP) survey using ROV NSS successfully obtained high resolution sedimentary and deformation structures of the shallow part of the landslide during the R/V Hakuho-maru cruise KH-15-2.

The landslide of this study exhibits a horseshoe-shape facing west at the western slope of the Daini-Atsumi Knoll. One SBP survey line crosses this landslide in an east-west direction. Large scarps are developed at water depth from 1240 to 1440 m with a fall of 200 m and from 1580 to 1710 m with a fall of 130 m. Normal faults are distributed at the upper slopes of these large scarps suggesting extensional deformation. In contrast, gentle undulations developed at the lower slopes of the scarps suffer from compressional deformation due to downward movements of landslide bodies. There are, moreover, acoustically transparent features subvertically intruded from the lower layers. Similar structures are reported from the northwestern slope of the knoll 7 km west of our survey area and interpreted as sliding blocks under the cover sequence (Shimura et al., 2016; Suzuki et al. , 2016, JpGU abstract). Sliding blocks are also found below the thin cover sequences in the downstream region although any deposit derived from landslide is not recognized on the Anoriguchi canyon floor located at the distal part of the landslide. We concluded that the landslide occurred recently because there is no thick sedimentary sequence covering the undulations due to compressional deformations and landslide blocks.

Keywords: deep-tow subbottom profiler, landslide, Nankai Trough, outer ridge

A research plan for Submarine landslides and their influence to the benthic environment associated with the Hinagu fault zone in Yatsushiro Sea, off Kumamoto

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The 2016 Kumamoto Earthquake was sourced from a part of active faults of the Futagawa-Hinagu fault zones. The southern part of the Hinagu fault zone (Yatsushiro-sea segment) consists of submarine active faults in the Yatsushiro sea, off west Kyushu. We present a planned sampling project in the Yatsushiro sea by a research vessel for evaluating earthquake-induced submarine landslides/mass movements and associated tsunami potential and influence to the benthic environment.
Many active faults trending NNE-SSW to NE-SW off Ashikita to off Izumi are reported based on the subseafloor structural study using a high resolution multichannel seismic reflection (Kagohara et al., 2011). Submarine active faults in the northern part of the Yatsushiro-sea segment show apparent displacement of right lateral slip and are ascribed to activity of twice in Holocene.
Sediments in the Minamaba bay in the southern Yatsushiro sea contain mercury originated in the industrial pollution in 1950s. Tomiyasu et al. (2014) reported an irregular decrease or increase in mercury concentration in the surface sediments out of the data obtained in 2002~2010, which implies a possibility of secondary mass movement (redeposition).
In our project, we plan to conduct sampling of sediments in the area where the submarine active faults develops in the southern Yatsushiro sea, integrated analysis of geology, analytical chemistry and ocean biology for the purpose of the evaluation of submarine landslides and benthic environmental dynamics.
To complete the above objectives, the Yatsushiro sea is the most suitable and opportune target because of the Kumamoto earthquake and the existence of a felicitous tracer of mercury. The probability of earthquake occurrence of the Yatsushiro-sea segment within 30 years was evaluated as 0-16% (Headquarters for Earthquake Research Promotion, 2013), which was the highest value among the Futagawa-Hinagu fault zones. Nevertheless, the 2016 Kumamoto earthquake occurred in the other segments, leading to tensed occasion in the Yatsushiro sea area and requiring urgent investigation. By examining the record and frequency of submarine landslides, we are capable of evaluating risks of tsunami, burial of benthic marine products and transfer of mercury-contained sediments associated with the future earthquakes in the Yatsushiro sea.

Keywords: submarine landslide, 2016 Kumamoto earthquake, mercury, Yatsushiro sea, Minamata bay

Control of submarine landslide as the trigger of tsunami

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A tsunami generally results from a big earthquake. More specifically, 82% of tsunamis is estimated to be caused by tectonic deformation on the ocean floor, while 6% by submarine landslide. However, evidenced by the 1972 Unzen earthquake and tsunami disaster, called “Shimabara erupted, Higo affected”, an on-land landslide triggered a tsunami. In the case of the Unzen earthquake, an “on-land” landslide was routed along a stream to the sea causing a tsunami; this approximates the same mechanism that generates a tsunami by submarine landslide. Based on an analysis of seismic and geodetic data, together with recorded tsunami waveforms of the Tohoku tsunami of March 11, 2011, Tappin et al. (2014) proposed that, while the primary source of the tsunami was the vertical displacement of the seafloor due to the earthquake, an additional tsunami source is required. They further proposed that the most likely additional tsunami source was a submarine mass failure (i.e., a submarine landslide). The best method to prevent a huge tsunami is to remove its cause, which is typically submarine sediments that otherwise can become mobile in the form of a submarine landslide following an earthquake; such is our plan to mitigate tsunami disasters. The highest priority of this operation is given to the area off the Kumano-nada Sea. The Nankai Trough is considered extremely dangerous with elevated potential to cause a huge submarine landslide and resulting devastating tsunami, especially when a big earthquake occurs in this region.

Keywords: control of tsunami disaster, submarine landslide

