Tsunami generation due to large-scale submarine landslides induced by an earthquake

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Strong earthquake vibrations can liquefy sediments in the sea-floor slopes to induce large-scale (more than 1000 km^2 in area) submarine landslides, which generate tsunami waves. A submarine landslide (40x15 km^2), which took place in the slope at the Japanese trench off Sanriku, caused an abnormally high tsunami wave, which struck the central Sanriku coast, Japan on March 11, 2011[1]. The 2018 Palu earthquake, caused by the strike-slip movement of Palu-Kola fault, induce numerous number of submarine landslides in Palu bay to generate tsunamis struck the coasts of Palu city, Indonesia[2]. For the case of the 1923 Great Kanto earthquake in Japan, the changes in water depth more than 100 meters were reported after the earthquake in the entire region of Sagami bay and the mouth of Tokyo bay. This is the evidence of large-scale (100x50 km^2) landslide, running through the Sagami trough down to the Bando basin, which locates at the trench triple point. The landslide may cause the tsunami, which struck the coastline of Sagami bay, in particular Atami city. I will discuss the counter measurement to prevent the disaster by the landslide tsunamis.

1) Tappin D.R. et al., 2014, “Did a submarine landslide contribute to the 2011 Tohoku tsunami?”, Marine Geology, 357, 344-361.
2) A. Muhari, F. Imamura, T. Arikawa, A. Hakim, and B. Afriyanto, “Solving the Puzzle of the September 2018 Palu, Indonesia, Tsunami Mystery: Clues from the Tsunami Waveform and the Initial Field Survey Data,” J. Disaster Res., Vol.13 Sci. Comm., sc20181108, 2018.
3) Ebisuzaki, T., Maruyama, S., and Murata, K., 2020, “Tsunami disaster caused by submarine landslide, submitted to the annual report 2020 of the International Tsunami Disaster Prevention Society.

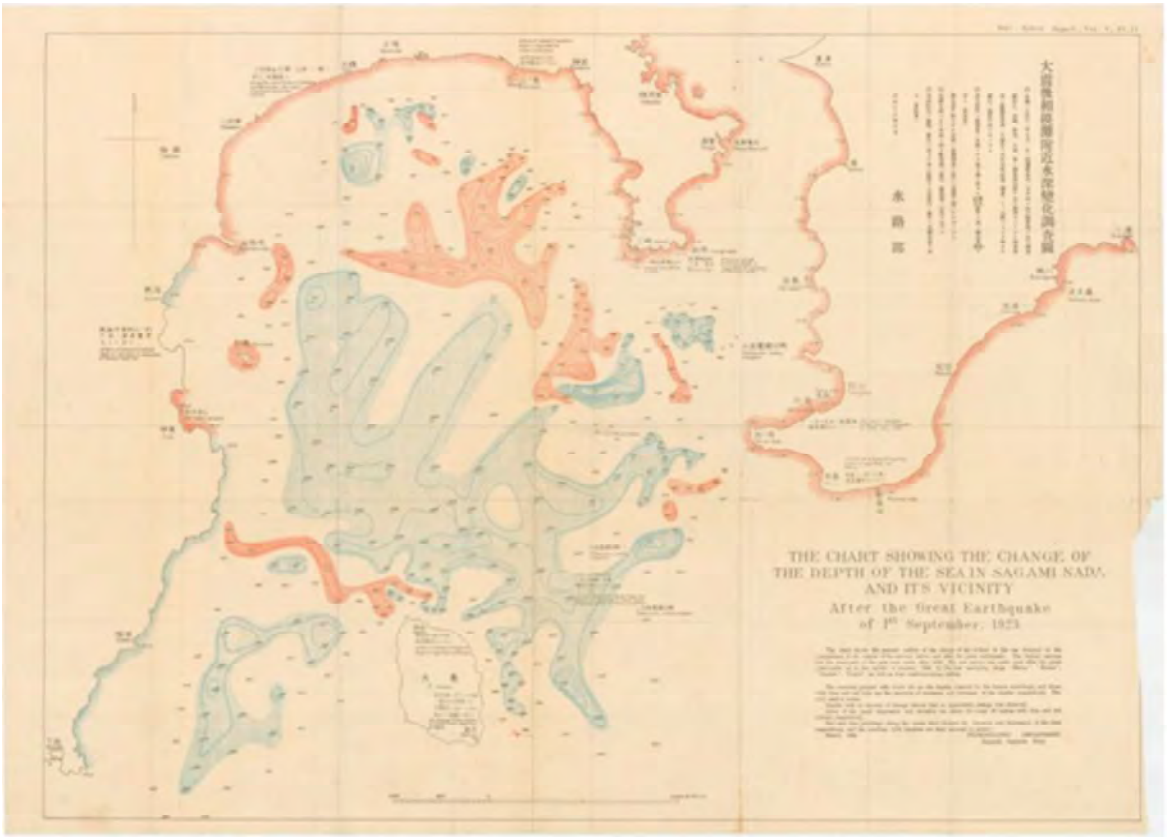

図 1. 大正関東地震前後の相模湾の水深変化，深くなった領域：青，浅くなった領域：赤（水路部 1924）

Geohazards on the Azores archipelago

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The Azores archipelago, located in the north Atlantic, is characterized by a complex geodynamic setting dominated by the triple junction where the North American, Eurasian and African lithospheric plates meet. This region is encompassed within a roughly triangular platform, delimited by the 2000 m isobath, characterize by a thicker oceanic crust associated with increased magmatism. Such evidence suggests that the area is controlled by the interplay between the distensive setting of the triple junction and a deep mantle plume.

The archipelago comprises nine volcanic islands aligned along a general WNW-ESE direction. The two most western islands emerge on the North American plate, in a more stable tectonic setting. The other seven islands are located along the boundary between Eurasian and African plates, in an area with intense seismic and volcanic activity.

Seismicity is typically associated to the main regional tectonic structures and is mostly of medium and low magnitude. Historical records, however, show that in nearly six centuries the islands have been stroke by 31 destructive earthquakes and seismic crisis that caused approximately 6500 fatalities and major social and economic losses.

During that period, at least 27 volcanic eruptions were documented at the archipelago, mainly along the same WNW-ESE direction as the seismicity. Presently there are 17

subaerial active volcanic systems and the geologic record shows a wide variety of eruptive styles and magnitudes. Historical eruptions range from effusive and mildly explosive events, such as hawaiian and strombolian eruptions, to more explosive surtseyan and subplinian events.

Along historical time, eruptions have caused several hundred victims and extensive damages. Last two eruptions on the archipelago, Capelinhos in 1957/58 and Serreta in 1998/2000, are examples with very different impacts. Capelinhos was a surtseyan eruption that caused massive damages and losses in Faial Island, whereas the submarine Serreta eruption had no impact in Terceira Island.

Another geohazard that frequently strikes the Azores are landslides. These are frequent phenomenon, triggered by different factors. At the archipelago, due to its subtropical oceanic climate, the most common trigger is intense rainfall. These phenomena are also highly potentiated by the young volcanic geomorphology and the friable nature of pyroclastic rocks. Large magnitude landslides had already occurred in the past, such as an earthquake-triggered landslide in 1522 that killed about 5000 people and destroyed an entire village in S. Miguel Island. Small and medium magnitude events are, however, much more frequent and recent years had shown that those smaller events are also responsible for tens of deaths and increasing losses.

Gas emissions are also a permanent geohazard in the islands and several villages are settled on high soil carbon dioxide degassing areas, with potential impact on the public health.

To cope with geohazards in the Azores, IVAR (Azores University) and the Regional Government constituted CIVISA, an operational association to run the seismovolcanic monitoring system of Azores and provide scientific advisory to civil protection authorities. This system integrates several networks, namely: seismic, geodetic, infrasound, geochemical, air quality, hydrometric, meteorological, landslide kinematic and geotechnical.

Improving the scientific and sociological understanding of geohazards in Sri Lanka

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After the Indian Ocean tsunami in 2004, the possibility of catastrophic disasters has realized, although Sri Lanka is not close to a plate margin. This catastrophic event highlighted that Sri Lanka as a country may not be able to cope with these major natural disasters, in addition to localized and frequent disasters such as landslides and floods, without an appropriate Disaster Management Plan. In the aftermath of the 2004 tsunami, the government of Sri Lanka developed a comprehensive Disaster Management Plan in consultation with international experts. This study examines Disaster Management Plan in Sri Lanka and examines the effectiveness of the existing management structure in revisiting the areas and communities affected by selected case studies in a coastal strip hit by the tsunami in 2004, recent catastrophic landslides and other disaters. Questionnaire surveys and field observations were used to collect data on the preparedness, availability of evacuation plans and pre-disaster alert systems. The results show the need to further improve the management of geohazards.