Comparative study of slope failure-origin sediment characteristics for earthquake hazard mitigation

Ken Ikehara (Geological Survey of Japan, AIST), E-mail: k-ikehara@aist.go.jp

Abstract

To evaluate marine active faults and earthquake and to mitigate tsunami hazard, most primitive information is 1) location and morphology of an active fault, 2) recurrence intervals of an active fault, and 3) age of the last earthquake event. Although the location of the submarine faults can be detected by seismic surveys, recurrence intervals and age of the last event can be known only by sediment records. Because submarine slope failures have been triggered by several mechanisms, the integrated studies for total knowledge about from the origin of slope failures at slope area to the resulted deposits at basin area are essential for the hazard mitigation. Furthermore, it is very important to understand the trigger mechanism at the individual slope from the monitoring of pore fluid pressure change by the events. To complete the study on both material science and monitoring, the shallow ocean drilling is a unique method.

Overall eight questions:

What are the major hypotheses and unanswered questions in your topic? Describe the global relevance of those questions.

Major hypothesis

Characteristics of gravity flow deposits record the trigger process of the slope failure which originates the gravity flow deposits. Slope failure occurs according to increasing of pore pressure of sediment interstitial water. Factors to make submarine landslides are thought to be shaking by the earthquakes, wave loading, tides, floods, abrupt sedimentation, gas, glaciation, erosion, diapers and sea-level lowering. There are several ideas to distinguish the trigger processes to form the gravity flow deposits. However, the variability of the characteristics of the deposits in the variable geologic, tectonic, sedimentologic, and climatic settings has not yet been understood. To understand the source to sink of each gravity flow deposits gives us the better understanding of the

sedimentary processes including the trigger processes. Therefore, the strategy for the understandings is the coupled drilling from slope to basin through the base-of-slope. Furthermore, the continuous monitoring studies using bore holes in slope areas are significant to understand the trigger of the increasing pore fluid pressure to form the gravity flow deposits. Comparative studies among the different settings both sediment characteristics and monitoring give us the variability of the gravity flow deposits which have relation to the various kinds of natural hazards. If we obtain the relationship between the origin of slope failures and the characteristics of the slope failure-related deposits, we will estimate the recurrence intervals of the particular hazards in a particular area.

Major unanswered questions

What is a major trigger of submarine slope failures?
What is a controlling factor of size of the slope failures?
How is variable of the sediment characteristics of the particular origin of slope failure?
Can we estimate the recurrence intervals of the natural hazards from the sediment records?
How large events could preserve in the sediments?

Which of these represent the highest research priorities that can realistically be archived in the next decade ?

To understand relationship between trigger mechanism of submarine slope failures and the resulted slope failure deposits, and their variability is essential to answer the above-mentioned unanswered questions. To specify the trigger mechanism and degree of pore pressure increasing by each geological and/or climatic event, it is important.

What drilling, sampling, experimental and site characterization strategies are required to archive your goals ?

Total understanding from slope deposits to basin deposits is essential for the study. Installing sensitive pore fluid pressure sensor in the bore holes at the slope sites is necessary for understanding the trigger mechanism. Target depths for setting the measurement tools may be mostly less than 1000 mbsf.
A target area for the primary study might be in the Nankai area, where the drilling,

2D/3D seismic surveys, submersible observations, and the detailed bathymetric surveys are already performed. However, Sagami Trough is another target area because both the large earthquakes at the plate boundary and the small earthquakes by the other mechanisms have occurred, and is the most important area for the Japanese society because the area locates just near the Tokyo metropolitan area which has large population. Response of the slope to the degree of shaking for the failures of the slope is essential.

Drilling is essential to resolve the unanswered questions, because comparison of gravity flow deposit (turbidite) records with the historical earthquakes indicates that the turbidite records are incomplete. Gravity flow deposits with coarse grain size and large thickness might deposit near the base-of-slope. As smaller gravity flows might move shorter distance, the base-of-slope is the best place to obtain the complete earthquake records. In general, it is difficult to take a long core sample with thick coarse sediments by normal piston corer. Drilling is a unique method to obtain long core from such an environment. For the hazard mitigation by the submarine large earthquakes, numerous drillings (even shallow) are essential to clarify the above-mentioned objective.

What are your platform and technology needs ?

Any kinds of platform are acceptable. For the comparative studies, to use of multi-platform is better for this study. Technology to measure the pore fluid pressure continuously is important to understand the relationship between the sediment characteristics and the degree of the trigger mechanisms.

What mix of long-term projects and single expeditions will best answer those questions ?

It needs single expedition. However, to complete the comparative study, it is essential to have a series of single expedition which has the potential area of the slope failures of any origin and any kinds.

How can the future drilling program interact with other science programs and with industry to achieve your goals ?

1) To evaluate marine active faults and earthquake and to mitigate tsunami hazard, most primitive information is 1) location and morphology of an active fault, 2) recurrence

intervals of an active fault, and 3) age of the last earthquake event. Acoustic imaging surveys have clarified the distribution of submarine active faults. However, it is hard to understand the precise history of fault activities only from the acoustic imaging. There are several studies on the seismo-turbidites to understand the recurrence intervals of plate boundary earthquakes using short piston cores. The results indicate that the turbidite is a potential tool for past earthquake detection. Estimation of the grade (magnitude) of the earthquakes is another important issue. Especially, knowledge on maximum grade is quite useful for the hazard mitigation. Because of the limited records on the instrumental observations and historical documents, knowledge on size distribution of possible earthquake from a submarine fault is very poor. Combination of several kinds of phenomena recorded in the marine sediments such as slope failures, turbidite and debrite depositions, surface ruptures, and submarine liquefactions, and their spatio-temporal distribution might give us useful information on the grade of the possible earthquakes.

2) To distinguish earthquake- and/or flood-related sediment slope failures are essential. This distinction is important for the measure for hazard mitigation, because earthquake and flood has completely different method for the hazard mitigation. Even so, it is essential for the hazard mitigation to know the kind and origin of the natural hazards.

3) Submarine slope failures have break the submarine cable in place, Modern societies have been keep by international communications. Also, tsunami is formed by the submarine slope failures. Therefore, knowledge on submarine slope failures and their recurrence intervals is very important for hazard mitigation.

What hot topics can be highlighted to be used for outreach and raising the public's interest ?

Recurrence of large earthquakes is an important topics for the countries and peoples facing to the subduction zones. To protect the life and infrastructures, the knowledge on earthquake itself and it related tsunami is essential for mitigation of disasters. It is a social consensus that tsunami and large earthquake disaster damage significantly in coastal areas.

How are your science goals relevant to society ?

When we understand the relationship between the slope failures and deposition of

gravity flow deposits, it would be a science goal in the next decade. If size, timing and location of future earthquakes and the related submarine slope failures are expected from the sediment records, it would be a final goal.