Preliminary report on the sedimentary record of SCORE Site C9035 of Tokai, Nankai Trough, southwest Japan

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Abstract

Chikyu Shallow Core Program (SCORE) is a short and shallow ocean drilling program arranged by Japan Drilling Earth Science Consortium (J-DESC), Japan. SCORE provides opportunities for scientific ocean drilling test and project which can complete in a short period of time by using the ocean drilling vessel D/V Chikyu except for IODP expedition period.

Japanese historical documents reveal that Mw 8 class earthquakes have occurred every 100–150 years along the Nankai Trough since the 684 Hakuho earthquake. However, historical document and shore geological records are not enough longer to confirm the recurrence intervals of Tokai segment, Nankai Trough. Therefore, we propose to unravel the earthquake recurrence times of the Tokai segment using a long marine sediment record. A primary objective is to determine whether "enigmatic recurrence" observed in the historical record is found in the geological record. The title of this project is "Enigmatic recurrence pattern of Tokai earthquake in Nankai Trough, southwest Japan: the link between great earthquakes and ridge subduction". The aim is to investigate the past earthquake occurrence from a continuous sedimentary sequence at a local tectonic basin (i.e., Kanasunose Trough) in Nankai Trough, southwest Japan. Expedition 912 was conducted by D/V Chikyu sailing from Shimizu to Sasebo, Japan from 4 January - 15 January 2020. The Leg 1 of Expedition 912 (X912-Leg1) was cored Hole A and B in Site C9035 which are located in 34°05.7'N, 138°08.03'E with 2442 meters of water depth in the Kanasunose Trough, Tokai, Nankai Trough. Hydraulic Piston Coring System (HPCS) of the ocean drilling vessel (D/V) Chikyu helped to obtain an excellent long and continuous sedimentary record to unravel the earthquake recurrence pattern of this study area. The Penetration depth at site C9035 is 80.19 meters with HPCS drilled from 5 January to 8 January 2020.

The shipboard measurements of whole-round core samples involved X-ray computed tomography scanning and Physical properties. After splitting, the visual core description (VCD), smear slides, split surface image, Natural Remanent Magnetisation (NRM), penetration strength, and moisture and density (MAD) measurements, and Vane shear test were conducted. The sedimentary succession is dominated by silty sediments with numerous coarse-grained (coarse silt–very fine sand) layers and some volcanic ash layers and spots. Two lithological units (Litho-Unit I and II) can be distinguished on the basis of sedimentary facies. In the Litho-Unit I in the upper 40-m layer, we found an interval that contained approximately 200 turbidites. Based on the sedimentation rates suggested in previous studies, the period recorded by these 40 m spanned 40,000–50,000 years. As approximately 200 turbidites were found, the average turbidite depositional interval was approximately 200 years. This is the first time that turbidite sequences, which are considered to form during earthquakes, have been collected for such a long period of time (40,000—50,000 years).

Keyword: Tokai earthquake, Nankai Trough, Paleoseismology, seismo-turbidite.

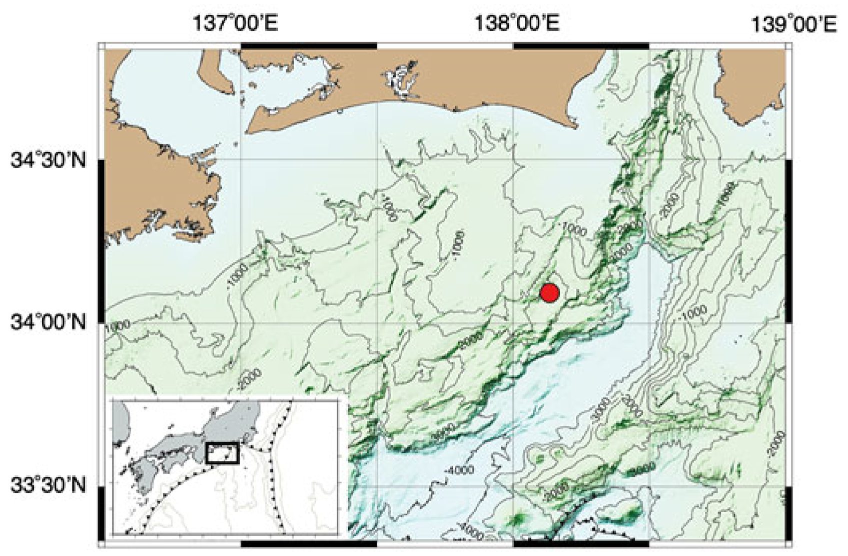

Figure 1. In tectonic setting, the Nankai Trough is a subduction zone that is caused by the subduction of the Philippine Sea Plate beneath Japan, part of the Eurasian Plate. Earthquakes along Nankai Trough have occurred repeatedly, and the next occurrence is expected to be imminent since the last Nankai Trough Earthquake in 1946. The underlying Nankai megathrust is the source of the Nankai megathrust earthquakes. Enshunada Basin is a semi-individual basin of the Kanasunose Trough in between Tokai Fault and the Frontal Thrust of Nankai Trough. The core of the Enshunada Basin is expected to reconstruct the record of past-earthquakes. Therefore, we focus on the study area (red solid circle), Tokai (black inset in the lower left) of Nankai Trough for understanding the occurrence of past-earthquakes.

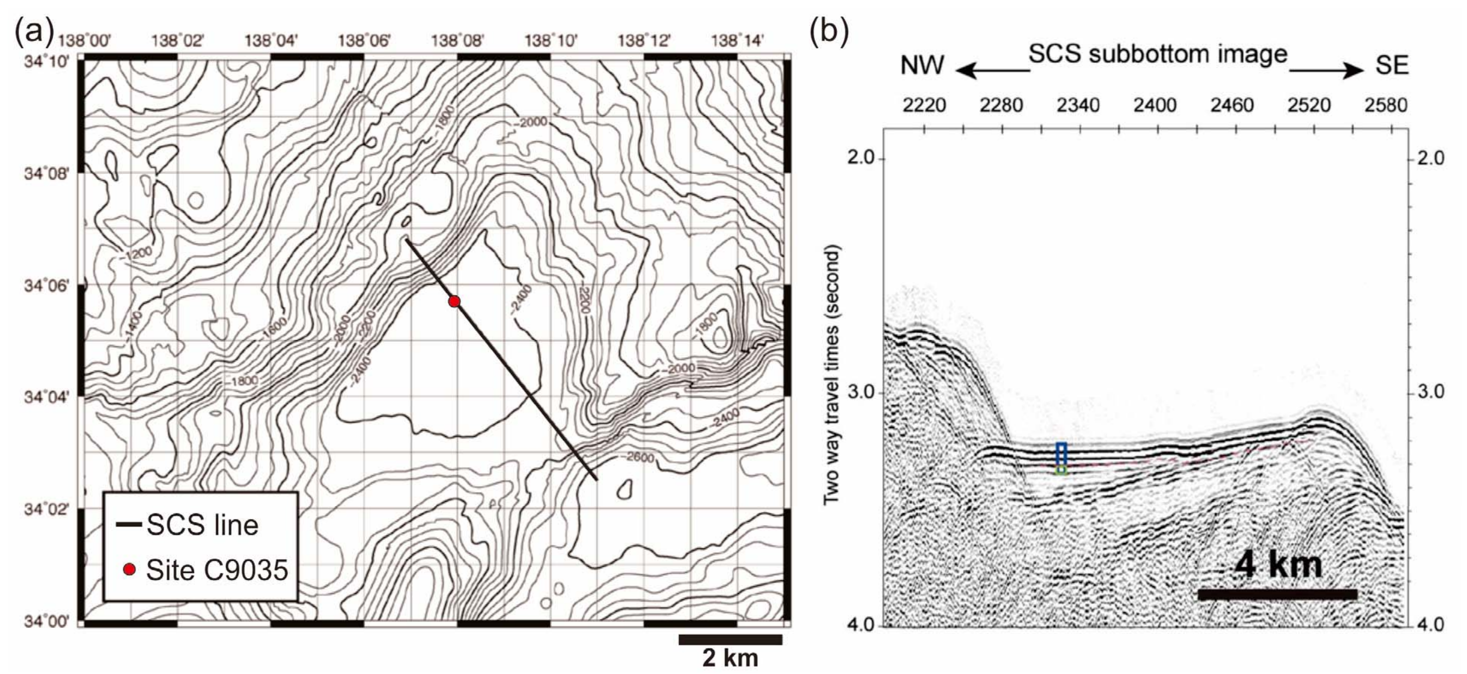

Figure 2. (a) The detailed bathymetry in the Enshunada Basin, Nankai Trough. The location of site C9035 is marked in the red solid circle. One single-channel seismic (SCS) line (solid line) is across the site C9035 (https://gbank.gsj.jp/marineseisdb/Tokai/index_Tokai.html). (b) Sub-bottom image. The primary target of the sub-horizontally stratified sequence (blue border) has approximately a 75-m interval. Additional 20-m coring (green border) is planned to understand the timing of local tectonic events. The sub-seafloor depth is estimated using a velocity of 1500m/s.

Table 1. Hole summary of C9035 of X912-Leg1.

Site	Hole	Location	Water depth (mbsl)	Number of cores	Total cored interval (m)	Initial core recovery (%)
C9035	A	34° 5.7000'N, 138° 8.0300'E	2413.5	1	9.5	105.3
	B	34° 5. 6962'N, 138° 8.0346'E	2414.0	12	80.0	104.7

Lithostratigraphy

The sedimentary succession recovered at Site C9035 is dominated by silty sediments with numerous coarse-grained (coarse silt–very fine sand) layers and some volcanic ash layers and spots. The section is divided into two major lithological units (Litho-Unit I and II), distinguished on the basis of sedimentary facies.

Litho-Unit I consists of bioturbated silt and layered coarse silt–very fine sand with massive silt. Numerous intercalations of coarse silt–very fine sand layers characterize this unit. Most basal contact of each layers are sharp and grades upward into massive silt. Litho-Unit I interval includes 0 – 42.10 m CSF-B in C9035B and whole C9035A (0 – 10.00 m CSF-B).

Litho-Unit II is characterized by matrix-supported gravelly mud–muddy gravel. Angular mudstone gravel is predominant. Large (>a few tens cm) siltstone blocks with distorted layer or bedding are found. Litho-Unit II interval includes 42.10 – 80.19 m CSF-B in C9035B. Some coring disturbances such as flow-in and fall-in are observed.

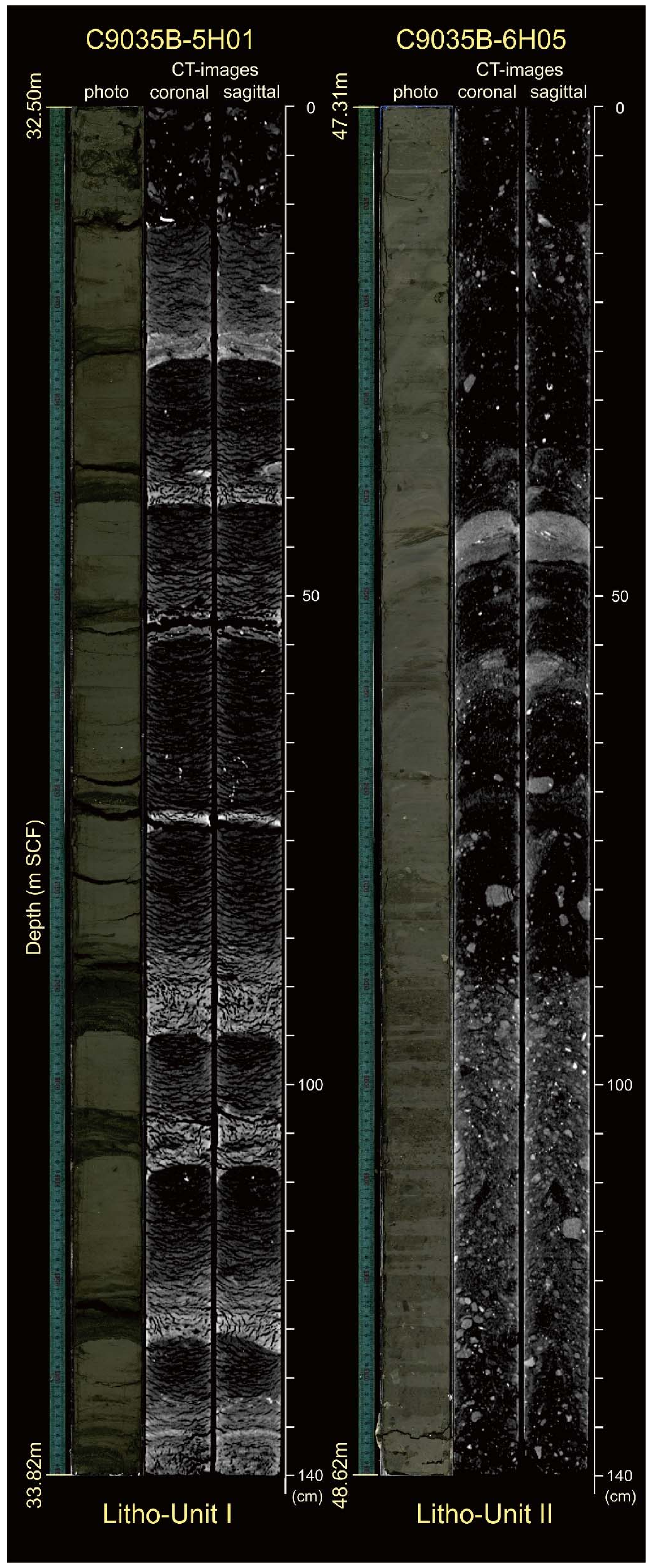

Figure 3. Photographs and X-ray computed tomography scan images (CT-images) in coronal and sagittal sections of sampled strata in C9035B-5H01 and C9035B-6H05. Black-and-white CT-images were processed using the software OsiriX DICOM viewer to adjust brightness and contrast. The bright part of CT-images represents high density. The three-dimensional CT-images of whole-round cores are helpful in the understanding of the orientations of layers or shapes of deformation structures. The photo shows the split-core faces which are in the same orientation as the coronal section of CT-images. Sections 5H01 and 6H05 can be considered as an example for Litho-Unit I and II in C9035, respectively. In section 5H01, the layered dark gray of core and bright interval of CT-images corresponded to the sandy parts of the turbidites can be determined. In contrast, section 6H05 is characterized by gravelly mud to muddy gravel. The individual particle size of gravel can be observed up to 3 mm in diameter. Depth (m CSF): meters core depth below seafloor.

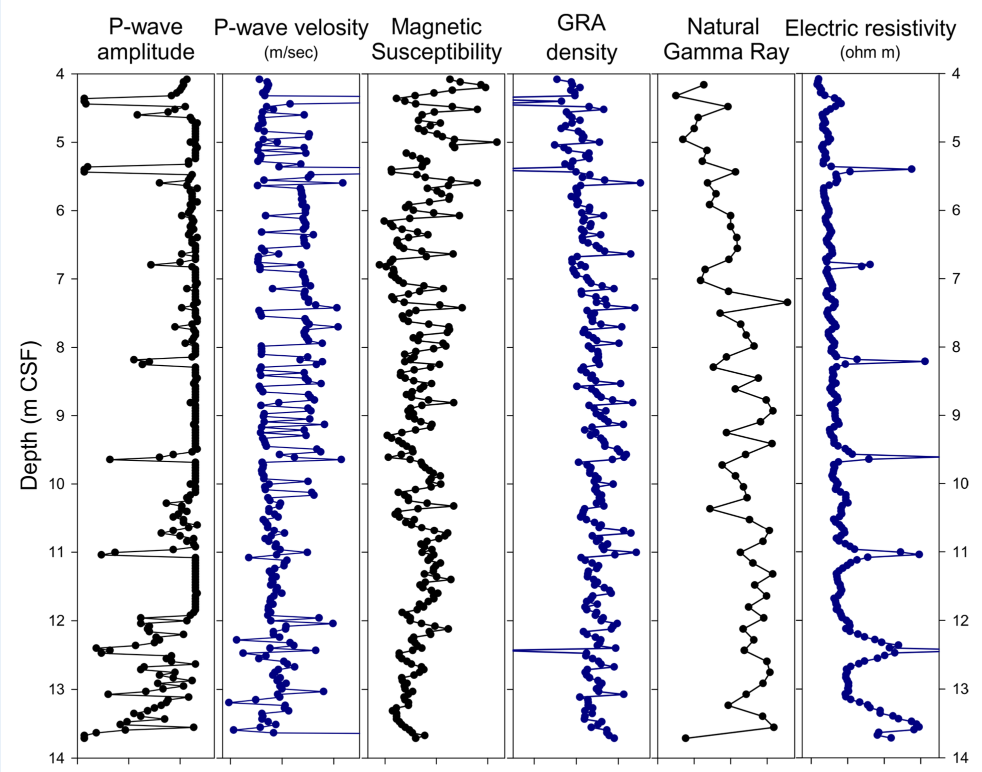

Figure 4. The measurements of Multi-Sensor Core Logger (MSCL) of C9035B-2H for example including P-wave amplitude, P-wave velocity, Magnetic susceptibility, GRA density, Natural gamma radiation, and resistivity. The jumping pattern in the P-wave velocity column can be regarded as machine errors. Magnetic susceptibility peaks roughly correspond to the sandy layers in the Litho-Unit I. The downhole variation of Natural gamma radiation shows gradually increasing downward which is similar to the trend of GRA density. The trend of electric resistivity also shows gradually increasing downward with minor fluctuation except for the section boundaries. Depth (m CSF): meters core depth below seafloor.

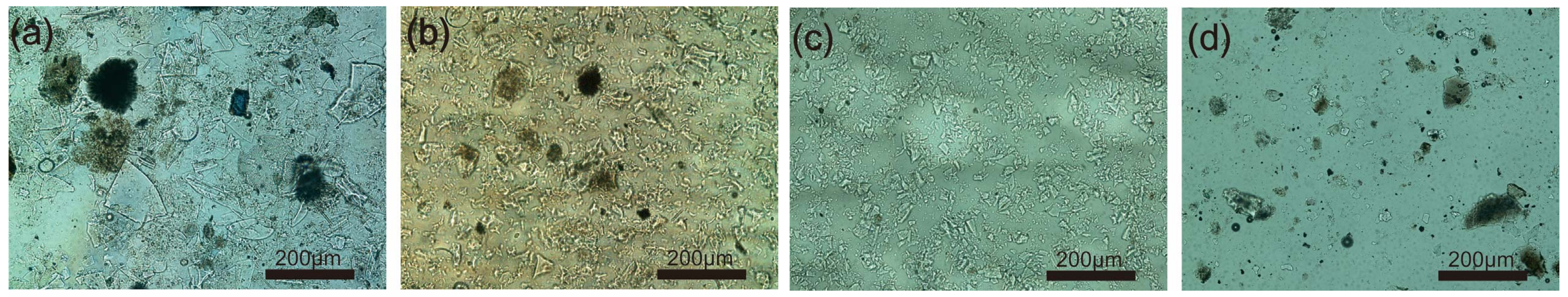

Figure 5. Several obvious ash layers and spots were found in C9035B. Four plane-polarized light microscopic images of C9035B includes clear glass fragments in each core depth: (a) 10.202 m, (b) 13.645 m, (c) 28.963 m, (d) 47.885 m.

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