Japan Geoscience Union Meeting 2011
(May 22-27 2011 at Makuhari, Chiba, Japan)

SSS033-01 Room:105 Time:May 23 14:15-14:30

Outline of the Kanto Asperity Project

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The Kanto region is one of the most densely populated urban areas in the world. Great earthquakes along the Sagami trough have repeatedly occurred. The 1703 Genroku and 1923 (Taisho) Kanto earthquakes caused severe damages in the Tokyo metropolitan area. Slow slip events (SSEs) have also repeatedly occurred in an area adjacent to the asperities of the great earthquakes, off Boso peninsula (e.g., Ozawa et al 2007).

The Kanto Asperity Project (KAP) proposes a drilling and long-term monitoring program in the southern Kanto region of southeastern Japan with the aim of determining the characteristics of the plate boundary in and around the source regions (asperities) of great earthquakes and SSEs.

Recent progress in the development of supercomputers has enabled the simulation of earthquake and SSE generation cycles, but the parameters are not based on scientific data, and are not sufficiently reliable to assess the hazards associated with future earthquakes. The establishment of a realistic earthquake-generation model is of crucial importance in mitigating the danger posed by earthquake geohazards.

We focus on three different types of seismic events occurring repeatedly at the almost same depth of the seismogenic zone along the Sagami trough (5-20 km)

(1) The 1923 M˜7.9 Taisho earthquake, located in Sagami Bay. Maximum slip is about 6 m, the recurrence interval is 200-400 yr, and the coupling rate is 80-100% ("coupling rates" = "slip amounts during earthquakes or slow-slip events" / ["rate of motion of the Philippine Sea Plate" - "recurrence interval"]) .

(2) The 1703 M˜8.2 Genroku earthquake, located in Sagami Bay, but also extending to the southern part of Boso Peninsula. Maximum slip is 15-20 m, the recurrence interval is ˜2000 yr, and the coupling rate at the southern part of the Boso Peninsula is 10-30%.

(3) Boso slow-slip events, located southeast of Boso Peninsula. Maximum slip is 15-20 cm over ˜10 days, the recurrence interval is 5-6 yr, and the coupling rate is 70-100%.

In the cases of Nankai and Cascadia, SSEs occur at deeper levels than the asperities, and the location can be controlled by temperature and pressure. The Boso SSEs occur at the same level as the asperities, raising the possibility that the conditions (materials, fluids, or surface roughness) in the Kanto region are different to those encountered at Nankai and Cascadia.

Our main objectives of the KAP are

Objective 1. to understand why the different types of events occur side by side at almost same depth (in same P-T conditions) and

Objective 2. to establish realistic earthquake-generation models using data on each step of the process of natural earthquakes.

We submitted one umbrella and two component proposals (Program A and B) in October 2010. Program A proposes ultra-deep drilling to intersect plate boundaries in the Boso SSE region and the Taisho asperity, in order to compare the geological materials at the two sites. Coring and logging at plate boundaries would also yield realistic frictional properties and effective normal stress, as derived from experiments on recovered materials and from measurements of pore pressure, respectively.

Program B proposes long-term monitoring (borehole observatories) for recording in detail crustal deformations and seismicity during 2-3 cycles of Boso SSEs, enabling testing of the hypothesis that SSEs can be used to assess the validity of earthquake generation models. Once Program B has yielded earthquake generation models from SSE ones, we can verify and improve the models by directly determining the values of parameters as part of Program A.

We have considered to submit one more new proposal. This will focus on the input materials on the Philippine Sea plate. One of our hypothesis on the Objective 1 is that the difference of input materials may cause the different type of slips. Saito et al. (this session) will describe the details of this hypothesis.

Keywords: asperity, slow slip, drilling, monitoring

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SSS033-02 Room:105 Time:May 23 14:30-14:45

Diversity of the Kanto earthquake suggested from paleoseismological data

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The Kanto earthquake generated from the interface between the Philippine Sea Plate and the North American Plate has been historically known as the 1703 Genroku earthquake and the 1923 Taisho earthquake. Reconstruction of the past Kanto earthquake before the 1703 event must depend on geological and geomorphological evidence because of lack of historical records. Although the past Kanto earthquake has been distinguished into two types of the Taisho type and the Genroku type based on evidence of marine terraces, recent paleoseismological data suggests it should be reevaluated.

Asperity of the Taisho type extended from the northern edge of Sapgami Bay to Miura Peninsula has been ruptured at every 200-400 years. Recurrence of the Genroku type is inferred to 2000-2700 years, and its rupture area includes the Taisho asperity and extends to southeast off the Boso Peninsula. Mean slip rate of the Genroku asperity can be estimated to be 7 mm/year from inferred coseismic slip and recurrence time, but it is much smaller than the back slip rate (30 mm/year) estimated from GPS observations.

Timing of the Genroku type was inferred from emergence ages of the Numa terrace series along the southern part of the Boso Peninsula, which were Numa I: 7200 cal yBP, Numa II: 5000 cal yBP, Numa III: 3000 cal yBP, Numa IV: the 1703 Genroku. Recently we partly reevaluated them to be Numa II: 4400 cal yBP and Numa III: 2800 cal yBP by drilling survey in the Tateyama lowland. Uno et al. (2007) pointed out that the Numa terraces cannot be rigidly correlated with between the western coast (Uchibo side) and the eastern coast (Sotobo side) because the emergence ages of the terraces in the Sotobo side was dated to be Numa II: 5300 cal yBP and NumaIII: 4400 cal yBP. This fact suggests that the rupture event of the Genroku asperity can be identified to be not only the 1703 Genroku type but also another type of independent rupture so called the Sotobo type. If such type event exists, the contradiction of slip rate between geodetically estimated back slip and geomorphologically estimated recurrence would be solved.

Keywords: Kanto Earthquake, asperity, paleoseismology, marine terrace, Boso Peninsula, Miura Peninsula

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SSS033-03 Room:105 Time:May 23 14:45-15:00

Structural characteristics associated with seismogenesis Off Boso region investigating from MCS profiles

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Off Boso is located in the southeastern coast of Kanto region, subducted by the Philippine Sea and the Pacific Plates at the plate boundaries as Sagami Trough and the Japan Trench, respectively. Associated with the subductions, magnitude eight-class great earthquakes (e.g. 1703 Genroku, 1923 Taisho-Kanto events) had provided serious damages in this region. Moreover, slow-slip events have been observed off Boso region every 5-7 years since 1996, of which moment magnitude were equivalent to six (e.g. Ozawa et al., 2007). Slow-slip events are important for understanding the seismogenic cycles. Therefore, Off Boso is one of best region for the seismogenic study. Japan Agency for Marine-Earth Science and Technology (JAMSTEC) has conducted multi-channel seismic reflection (MCS) survey using R/V Kairei since 2008. The acquired MCS data is also contribute for site characterization of IODP proposal: Kanto Asperity Project. We reported the existences of seamounts at the plate boundary and splay faults connecting to major deep-sea channel from the MCS profiles along and across to the plate motion of the Philippine Sea Plate. Large amplitude and reverse polarity of reflection event at the plate boundary were also discovered in the slow-slip event area. We will report the structural characteristics around the slow-slip events especially for the seaward limit of the slow-slip events and northeastern edge of the Philippine Sea Plate using A5 line MCS data acquired in 2010. From A5 line data combined with previously acquired data, large amplitude reflection of the Philippine Sea Plate is distributed coincident with the slow-slip region. Landward trench slope of the A5 line data show that surface sediments and basement are not deformed near the trench axis but these are deformed landward region. The later can be caused by slumps of the trench slopes. These deformations may indicate the existence of deformation boundary as horst-graben structure of the Pacific Plate or northeastern edge of the Philippine Sea Plate. In this presentation, we will discuss tectonics and seismogenesis from the structural characteristics from MCS profiles.

Keywords: MCS, Off Boso, earthquake, Philippine Sea Plate, slow slip

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SSS033-04 Room:105 Time:May 23 15:00-15:15

Structure and fate of subducting Izu-Bonin Arc at Sagami Trough

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One of the primary objectives of Kanto Asperity Project (KAP) is to understand why three different type of asperities, Genroku, Taisho, and slow-slip events (SSE) off the east coast of Boso, are developed side by side in the same depth beneath Kanto district. A possible hypothesis is that the distribution of asperities is related to characteristics of upper part of subducted Philippine Sea plate. Unlike Nankai Trough where simple backarc basin is subducting, it is notable that the subducting plate at Sagami Trough is structurally complicated Izu-Bonin arc-forearc system. Distinct topographic, geologic, and geophysical features are identified along the eastern side of Philippine Sea plate. An along-arc zonal structure is well documented by magnetic anomalies (Yamazaki & Yuasa, 1998). Three major zones are composed of, from west to east, 1) Izu-Bonin volcanic front (low-K tholeite); 2) Izu-Bonin remnant arc composed of Paleogene volcanics (calc-alkaline, high-Mg andesite, and boninite), subducting beneath the southern part of Miura-Boso area; and 3) serpentinite seamounts subducting beneath off the east coast of Boso Peninsula. To verify a working hypothesis that the across-arc variation in crustal structure of the northern Izu-Bonin arc may control the distribution of different type of asperities beneath Kanto area, it is important to drill at the input area and recover volcanic basement rocks as initial materials to be delivered into the seismogenic zone. Characterization of rock mechanics and hydrologic properties of serpentinite may be a key to understand the mechanism of SSE.

Keywords: IODP, KAP, Izu-Bonin arc, Philippine Sea plate, Seismogenic zone

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SSS033-05 Room:105 Time:May 23 15:15-15:30

Systematic accretionary prism and slope basin system exposed in the Miura and Boso peninsulas, central Japan

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Geologic architectures in the southern Kanto region including the area where the Taisho-Kanto and Genroku earthquakes and Boso slow slip events occur show E-W or WNW-ENE trending geologic belt. Since the structure extends to the Miura and Boso peninsulas, on land geology in this area would provide a key to understanding geologic framework in the proposed drilling sites of Kanto Asperity Project. The Miura and Boso are composed of systematic accretionary prism and slope basin system. The former consists of two accretionary complexes: the early to middle Miocene Hota accretionary complex buried only 2-4 km, and the late Miocene to early Pliocene Miura-Boso accretionary complex buried less than 1 km. The latter uncomfortably overly the accretionary prism and tend to be younger to the south. These geologic systems were uplifted rapidly due to the Izu-Bonin island arc collision and therefore have never experienced deeper burial, thermal, and physical overprinting. In this presentation, we will show the geologic framework of accretionary wedge and overlying slope sediments in the Miura and Boso areas, corresponding characteristics on physical properties and deformation/fabrics, and comparison with modern-plate convergent margins in Kanto regions.

Keywords: accretionary prism, slope basin, OST, Boso, KAP

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SSS033-06 Room:105 Time:May 23 15:30-15:45

Physical properties, geologic age and magnetic fabrics of sediments collected from off Miura-Boso region

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Kanto, the capital region of Japan, is one of the large metropolitan areas in the world and is the central district of politics, economy and industry. We know great earthquakes will happen absolutely some day in the future and can imagine the extensive damage of the capital region.

The southeast of the Kanto located unique tectonic setting, the trench-trench-trench triple junction, which comprises the North America Plate, the Philippine Sea Plate and the Pacific Plate (Seno et al., 1987). The Philippine Sea Plate subducts beneath the North America Plate, moreover the Pacific Plate subducts beneath the Philippine Sea Plate (Seno et al., 1987). Thus, tectonic setting in the Kanto region is complicated, and large earthquakes occurred repeatedly a number of times in the past. During Japanese-French KAIKO project, various researchers obtained data of a lot of seismic prospecting, bathymetric surveys and piston cores so far in Sagami Bay and off Boso Peninsula (e.g. Nakamura et al., 1987), but we need to know more geological records of large earthquakes associated with such double plate subduction.

Many geologists, geophysicists and seismologists attempt to predict recurrent interval and magnitude of next large earthquakes by drilling from shallow to deep depths as an asperity horizon inducing large earthquakes. It is called as the Kanto Asperity Project. To know paleoseismic history in the Kanto region using shallow drilling cores is one of the main targets in this project.

In this study, we show physical properties, geologic ages and magnetic fabrics of deep-sea sediments collected from Sagami Bay and off Boso Peninsula, prior to drilling project to know whether paleoseismic records can decipher from the core sediments. 13 piston cores of about 4 m long were collected during JAMSTEC cruises KY07-14, KR09-10, and KT-10-10. The core sediments were mostly composed of hemipelagic clayey sediments interbedded with volcanic ash layers. Bathymetric surveys by seabeam mapping, sidescan SONAR investigation and subbottom profiling in the coring sites were also conducted during these cruises. Based on these data, we discuss sedimentation and erosional processes in Sagami Bay and off Boso Peninsula to decipher the paleoseismic records.

Keywords: Porosity, Shear strength, 14C, Volcanic ash layer, Anisotropy of magnetic susceptibility, Bathymetric map

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SSS033-P01 Room:Convention Hall Time:May 23 10:30-13:00

Geological structures and active fault distributions in the Sagami Trough offshore Boso Peninsula

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Around the Boso Peninsula, the Philippine Sea Plate subducts beneath the Honshu Island at the Sagami Trough and the Pacific Plate subducts beneath the PHS Plate and the North American Plate at the Japan Trench. Especially, the offshore Boso Peninsula has very complicated geological histories by the influence of highly oblique convergence of the PHS Plate and collision of the Izu-Bonin Arcs from 15Ma. The geological body of this region is composed of the accretionary prism distributed in the Miura and the southern Boso peninsulas. Moreover, this area is the seismogenic zone in which the large-scale earthquakes called Kanto earthquake repeatedly occurred. The 1703 Genroku and 1923 Taisyo Kanto earthquakes have repeatedly occurred at intervals from about 200 to 300 years. Additionally, the tsunami and crustal movements occurred at the earthquake in this area, too. Tsunamis caused by earthquakes suggest that faults reach the seafloor. However, the distribution of active faults is unclear due to few studies. The objective of this study is to elucidate the subbottom structure and distribution of active faults offshore Boso area, especially Boso canyon (Boso escarpment), in the Sagami Trough using by the bathymetric map, IZANAGI backscattering image, and Multi-channel seismic (MCS) reflection profiles. MCS data using in this study was acquired by JAMSTEC during KR08-04 cruise in 2008 and bathymetric data was acquired by JAMSTEC and Japan Coast Guard.

Seismic reflection survey offshore Boso area provided very clear images of the upper Philippine Sea plate and the subbottom structures of trough fill sediments and the landward slope of the Sagami Trough. Some faults in the accretionary prism are recognized in this area. These faults interpreted as splay faults branched from the PHS plate boundary (Miura et al., 2010). Lineaments as fault topographies were recognized around the Boso canyon in high accuracy bathymetric map. The splay fault distribute under the Boso canyon by our bathymetric map and MCS profiles. This result suggests that the activity of the splay fault contributes to the development of the Boso canyon.

<Reference>

Miura, S., Yamashita, M., Takahashi, N., Nozaki, K., No, T., Kodaira, S., Kobayashi, R. (2010): Deep structural images off Boso region investigating with multichannel seismic reflection profiles. Japan Geoscience Union Meeting 2010, SSS023-05.

Keywords: Sagami Trough, Boso canyon, active fault, Kanto earthquake

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SSS033-P02 Room:Convention Hall Time:May 23 10:30-13:00

Slip distribution of the 1703 Genroku earthquake by using a curved fault model

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Great earthquakes along the Sagami trough, where the Philippine Sea slab is subducting, have repeatedly occurred. The 1703 Genroku and 1923 (Taisho) Kanto earthquakes (M 8.2 and M 7.9,respectively) are known as typical ones, and cause severe damages in the metropolitan area. The recurrence periods of Genroku- and Taisho-type earthquakes inferred from studies of wave cut terraces are about 200-400 and 2000 years, respectively (e.g., Earthquake Research Committee, 2004).

After we adopted an updated fault plane model (Sato et al. 2005), which is based on a recent model of the Philippine Sea slab, the asperity around the Miura peninsula moves to the north. Sato et al. (2005) presented the shape in inland part, but less information in oceanic part except for the Tokyo bay. Kimura (2006) and Takeda et al. (2007) presented the shape in oceanic part. In 2008-2010, multi-channel seismic (MCS) survey have been done off Boso peninsula and in the Sagami bay.

In this study, we compiled these slab models, and developed a new curved fault model. Kobayashi (2010, JpGU) inferred the slip distribution of the 1923 Kanto earthquake from geodetic data by using this fault model. In the present paper we infer the slip distribution of the 1703 Genroku earthquake from the geodetic data inferred from studies of wave cut terraces .

The curved fault plane was divided into 56 triangle subfaults. Point sources for the Green's function calculations are located at centroids of the triangles. At the present stage, we assume a 1-dimensional seismic structure model. The Green's functions are calculated by the frequency-wavenumber method of Zhu and Rivera (2002). Our preliminary results shows that a large slip area appears beneath the southern part of the Boso peninsula, which is consistent with our previous studies.

Keywords: asperity, the 1703 Genroku earthquake