Japan Geoscience Union Meeting 2012
(May 20-25 2012 at Makuhari, Chiba, Japan)

SSS33-01 Room:302 Time:May 22 15:45-16:00

Detailed hypocentral distribution associated with the 2011 Boso Slow Slip Event

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The slow slip events (SSEs) recur every 5-7 years off the Boso Peninsula. The latest event occurred from October to November in 2011, with the shortest recurrence interval in the last 29 years. In association with this event, significant crustal deformations caused by the SSE were clearly observed by high-sensitivity accelerometer (tilt meter) operated by the NIED. The Boso SSE has a significant feature that it accompanies seismic swarms. During the 2011 SSE, numerous swarms also occurred and clear migration was observed. Its spatio-temporal distribution agrees well with slip migration estimated from crustal tilt data for each characteristic period. Focal mechanisms from the NIED Hi-net and AQUA catalogue for major earthquakes are thrust type with slip vectors consistent with the relative motion between the Japanese island arc and the Philippine Sea plate. Repeating earthquakes also occurred during the period of significant crustal deformation. Since repeating earthquakes at the plate subduction zone reflect interplate quasi-static slips (Kimura et al., 2006), these repeating earthquakes associated with the Boso SSE also can be regarded as interplate earthquakes triggered by the SSE slip. In this study, we determined high-precision hypocentral distribution to investigate the SSE activity in detail.

The Kanto plain is covered with thick sedimentary basin and this is a critical issue in the hypocenter determination. In other words, seismic wave velocities of the sediments are approximately Vp~1.9km/s and Vs~0.7km/s, and affect arrival time of seismic wave greatly, and surface ground noise is very large due to human activity. To avoid these issues, the NIED have constructed deep borehole stations. At the Boso peninsula, seven 1000m-class borehole stations have been constructed. In these stations, seismographs are installed at the bottom of the boreholes, where effect of low velocity sediments is small. We relocated hypocenters by using five 1000m-class or deeper borehole stations. When arrival time data is available for four or more stations, we determined hypocenter by using hypomh (Hirata and Matsu'ura, 1987). By using these results as initial hypocenters, we determined high-precision hypocenters by Double Difference (DD) method. For comparison, we also determined high-precision hypocenters by DD method by using the NIED Hi-net hypocenter.

Compared to the latter results, hypocentral depths in the former results are 2.0 km shallower on average below the eastern coast of the Boso peninsula and 2.1km deeper below the southeastern coast. As a result, the former results exhibit clear planar distribution gently dipping northward. Earthquakes along this plane have thrust type focal mechanisms. Repeating earthquakes are also distributed along this plane. These results indicate that this plane corresponds to the interface of the interplate shearing. In the 2007 SSE, more seismic swarms occurred off the eastern coast of the Boso peninsula and more swarms occurred below the southwestern coast in the 2011 SSE. The above results indicate that such difference of the swarm activity corresponds to difference of the SSE slip.

Keywords: Slow slip event, Boso Peninsula, high-precision hypocenter distribution, repeating earthquake

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SSS33-02 Room:302 Time:May 22 16:00-16:15

Seismotectonics beneath Kanto: A review of recent seismological studies

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The Kanto region, surrounding the Tokyo metropolitan area, has been hit by disastrous M8-class earthquakes and numerous intensely damaging M7-class earthquakes throughout recorded history (e.g., Utsu, 1979, 1999; Usami, 2003). For example, the 1923 Kanto megathrust earthquake (M7.9), which occurred along the upper surface of the Philippine Sea slab (Figure 1b), was one of the most destructive earthquakes of the 20th century, causing severe damage to the Tokyo metropolitan area and resulting in 105,000 fatalities. Earthquake Research Committee (2004) evaluated the probability of the occurrence of an M7-class earthquake beneath southern Kanto, based on the assumption that the five most recent M7-class earthquakes since 1885 occurred randomly as a Poisson process. The evaluation revealed a 70% probability that such an earthquake will occur in the next 30 years.

Here we review our recent seismological observations in Kanto and present geometries of the Pacific and Philippine Sea plates, the lateral extent of a contact zone of the two plate, relationship between heterogeneous structure in the Philippine Sea plate and three of the five M7-class earthquakes (1921, 1922, and 1987 earthquakes) used in the evaluation of Earthquake Research Committee (2004).

Keywords: Kanto asperity, serpentine, slab contact zone

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Classification of Magnitude 7 Earthquakes in Tokyo Metropolitan Area since 1885

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We estimated the source regions of five earthquakes which occurred in southern Kanto region since 1885 (i.e., the 1894 Meiji Tokyo, 1895 and 1921 Ibaraki-Ken Nambu, 1922 Uraga channel and 1987 Chiba-Ken Toho-Oki earthquakes) and classified them into intraplate or interplate earthquakes by analyzing collected data (Ishibe et al., 2009a, 2009b; Murotani et al., 2011) and comparing with seismic velocity model (Nakagawa et al., 2011). The 1894 Meiji Tokyo Earthquake was a slab earthquake within the Philippine Sea plate (PHS) or an interslab earthquake between PHS and Pacific plate (PAC). The 1895 Ibaraki-Ken Nambu Earthquake was a slab earthquake within PAC. The 1921 Ibaraki-Ken Nambu, 1922 Uraga Channel and 1987 Chiba-Ken Toho-Oki Earthquakes were slab earthquakes within PHS with strike-slip fault mechanisms.

Significant changes in both hypocentral locations and focal mechanisms have been observed after the 2011 off the Pacific coast of Tohoku earthquake (e.g., Hirose et al., 2011; Kato et al., 2011). The same situation would be expected for the Kanto earthquakes and understanding the spatio-temporal changes in stress field during a seismic cycle might be a key to time-dependent evaluation of earthquake occurrence probability. For example, the association between the 1923 Kanto Earthquake and two preceding slab earthquakes within PHS is interesting (e.g., Nakajima et al., 2011).

Probability of large earthquakes with magnitude (M)˜7 during the next 30 years was estimated to be 70 % based on the above five earthquakes by the Earthquake Research Committee (2004). However, types of these earthquakes are not well known due to low quality of data. We tried to classify these earthquakes into intraplate or interplate earthquakes.

The focal depths of the 1894 Meiji Tokyo earthquake (M7.0; Utsu, 1979) from previous studies are variable due to the differences of s-p times. Our study also shows similar variation (7-10 s) obtained from waveforms at Hongo, the University of Tokyo. Seismic intensity map based on the Central Meteorological Observatory (1895) and Hagiwara (1972) indicates circular pattern. However, the seismic intensity distribution of the earthquake of October, 7, 1894 occurred in southern Kanto indicates isoseismals extended along the PAC. In Hongo, the s-p times of the Meiji Tokyo earthquake and earthquake of October, 7 are about 7.0 s and 17.0 s, respectively. This suggests that the discussion on the focal depth is possible based on seismic intensity distribution and that the Meiji Tokyo earthquake was not a slab earthquake within PAC.

The focal depth of the 1895 Ibaraki-Ken Nambu earthquake (M7.2) was estimated to be ˜80 km using s-p time at Tokyo (11.3 s) assuming epicenter by Utsu (1979). The s-p times read in this study are about 11 s and are consistent with the report of Omori (1899) although they show some variations.

The focal depth of the 1921 Ibaraki-Ken Nambu earthquake (M7.0) was estimated to be around 53 km using s-p times of seismograms or JMA reports. Seismic intensity distribution supports this result; anomalous seismic intensity distribution characterizing the PAC slab earthquakes is not recognized. Furthermore, initial motion focal mechanisms using modified HASH algorithm (Hardebeck and Shearer, 2002) are strike-slip types, even if the uncertainty of hypocenter locations is taken into account.

The hypocenter of the 1922 Uraga Channel earthquake was estimated in the southwestern Chiba at a depth of around 53 km from s-p times obtained from seismograms or JMA reports. The initial motions indicate either strike-slip or normal fault type focal mechanism if the hypocenter uncertainty is taken into consideration. The circular isoseismals suggests that this earthquake was not a slab earthquake within PAC.

Keywords: Tokyo metropolitan earthquake, Classification, intraplate earthquake

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Tsunami Deposits obtained from Long Geoslicer Survey in Koajiro Bay on the Miura Peninsula, Kanagawa, Japan

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We have conducted single channel acoustic reflection survey and Geoslicer survey at the Koajiro Bay, which locates in the southwestern part of the Miura Peninsula, in order to reveal preceding histories to the Genroku event in the great Kanto earthquake sequence. As a result, five event layers are identified at 0-2 m depth which deposited during past 1500 years. Among these, the upper three event layers can be correlated with tsunami deposits obtained at the head of Koajiro Bay. The result in this survey is consistent with Shimazaki et al. (2011), who suggested that the 1293 earthquake which caused destructive damage in Kamakura, the capital in those days, was the antepenultimate Kanto earthquake.

The great Kanto earthquakes (M~8) occurred in 1703 and 1923 between the continental plate and Philippine Sea plate. However, the occurrence time of the antepenultimate Kanto earthquake have not been revealed although some candidates are proposed based on geological or geomorphological surveys and/or historical documents (e.g., Ishibashi, 1991, 1994; Shishikura, 2003). Shimazaki et al. (2011) conducted handy Geoslicer survey at the head of Koajiro Bay and identified three tsunami deposit layers, probably due to the 1923, 1703 and antepenultimate Kanto earthquakes (1060-1400 AD). Single channel acoustic reflection profiling identified many continuously-distributed reflective layers, which suggests that tsunami deposits due to the previous Kanto earthquakes are probably preserved. Thus, we conducted long Geoslicer survey at the inner Koajiro Bay and obtained 6 cores (2 cores x 3 locations) with a length of 4-6 m.

From the observation, coarse layers, which consist of mixture of materials such as shell fragments, mud clasts, gravels, and coarse sandy sediments, are identified at 0-2 m depth. These coarse layers are significantly distinguishable from inner bay deposits which consist of fine sand, silt and clay. Five possible event layers were identified from the grain size analysis with an interval of 2 cm.

The uppermost event deposit locates at just below the seafloor. Palmer-sized gravel flatly deposited at the other core with the depth corresponding to the second event deposit. The radiocarbon (14C) age of 1560-1820 AD (2sigma, including calendar year calibration and marine reservoir correction) was obtained from barnacle attached at the upper part of the gravel. This is consistent with 14C ages of marine shells uplifted by the 1703 Kanto earthquake (Shishikura et al., 2007) and thus, barnacle possibly attached after the gravel has been conveyed by the 1703 Kanto earthquake tsunami. The 14C age of 1230-1400 AD and 1210-1280 AD were obtained from gamopetalous clam and wood within the third event deposit. These 14C ages indicate that the upper three layers can be correlated with tsunami deposits which were identified from handy Geoslicer survey in the head of Koajiro Bay. The occurrence time of antepenultimate Kanto earthquake estimated from this survey is after 1210 AD and it supports that the 1293 earthquake was the antepenultimate Kanto event.

The fourth event layer deposited 720-1280 AD based on 14C ages. It is difficult to identify corresponding historical earthquakes because of large uncertainty although some damaging earthquakes (e.g., the 818 and 878 earthquakes) are documented. The fifth event layer deposited 560-690 AD.

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Keywords: Kanto earthquake, Miura Peninsula, Koajiro Bay, Tsunami deposit, The 1293 Kamakura earthquake