Japan Geoscience Union Meeting 2013
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SCG62-01 Room:103 Time:May 20 09:00-09:15

Activity style of nonvolcanic tremor in southwest Japan

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In some subduction zones like as Nankai and Cascadia, slow earthquakes composed of slow slip event and non-volcanic tremor occur between the transition zone between the locked zone and downdip stable sliding zone. This slow earthquake source region ranges with a length of 600 km in southwest Japan or 1200 km in Cascadia; however, the region is divided into some segments based on their activity style. In each segment, the tremor episode recur at a certain interval with clear migration. Sometimes, the migration is observed across the different neighbor segments. Such activity style of tremor is very similar to that of megathrust earthquake because the tremor episode frequently occur. Therefore resolving the key factor that controls the activity style of tremor episode may contribute to understanding the occurrence mechanism of megathrust earthquake. Therefore, we investigate the detail activity style of tremor based on the clustering catalog (Maeda and Obara, 2009, Obara et al., 2010) because the tremor is well-detected and determined compared to other slow earthquakes.

The epicentral distribution of tremor is not uniform within the narrow belt-like zone. The tremor belt-like zone includes some aseismic portions. Some large aseismic portions in Ise Bay and Kii Channel is considered as the segment boundary because many tremor episodes stop at or start from the edge of the aseismic portion. However, the tremor activity in the central and eastern Shikoku clusters occurs continuously in space and time on both sides of a small aseismic portion. This indicates that the slow slip might propagate through the aseismic portion without tremor activity (Obara et al., 2011). The segment is defined as the rupture area of recurrent tremor episodes with a certain recurrence interval. However, sometimes the segment is divided into some small episodes with short time interval. These small episodes are not overlapped and finally cover the whole region of the segment. Therefore, the rupture area of the coming small episode is predicted in advance based on the occurrence style of previous small episodes. The rupture initiation point of the tremor episode is frequently away from the stop point of the previous tremor episode. This suggests that the effect of the stress concentration caused by the rupture propagation of the slow slip event is not so significant, but anyplace in the segment is ready to rupture and the rupture starts from the most weak point. These small episodes sometimes occur at the same portion within the segment. This might be defined as a sub-segment. The sub-segment boundary usually corresponds to the continuous tremor active spot. This spot also coincides to the rupture initiation discussed above. Therefore, the inhomogeneous spot on the plate interface may control rupture initiation and termination of slow slip event.

Keywords: non-volcanic tremor, slow earthquake, subduction zone, source migration, segmentation

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SCG62-02 Room:103 Time:May 20 09:15-09:30

Spatial dependency of migration velocities of non-volcanic low frequency tremor active area at southwest Japan

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Non-volcanic low frequency tremors (NVTs) on a subduction zone in southwest Japan roughly migrate with about 10km/day along strike direction of Philippine Sea plate (e.g., Obara, 2010). Although the migration pattern can be categorized into several groups (Obara, 2010, Obara et. al., 2011), it is not always simple if we look at a small spatial scale.Previous studies suggest that these complexities are related to frictional properties on plate boundary (Ando et. al., 2012, Gosh et. al., 2012). In other words, there is a possibility that we can infer the frictional properties from the spatial distribution of NVT migration velocity.

Based on, In this study, we estimated along-strike migration velocities of NVT activities that occurred after July 2008 using LFT catalogue determined by the envelope correlation method and summarized their spatial dependency. The results suggest that the migration velocity is similar if we chose an arbitrary small segment and migration direction.

References:

Ando, R., N. Takeda, and T.Yamashita (2012), Propagation dynamics of seismic and aseismic slip governed by fault heterogeneity and Newtonian rheology. J. Geophys. Res., 117, B11308, doi:10.1029/2012JB009532.

Gosh, A., J. E. Vidale, and K. C. Creager (2012), Tremor asperities in the transition zone control evolution of slow earthquake. J. Geophys. Res., 117, B10301, doi:10.1029/2012JB009249.

Obara, K. (2010), Phenomenology of deep slow earthquake family in southwest Japan: Spatiotemporal characteristics and segmentation. J. Geophys. Res., 115, B00A25, doi:10.1029/2008JB006048.

Obara, K., T. Matsuzawa, S. Tanaka, T. Kimura, and T. Maeda (2011), Migration properties of non-volcanic tremor in Shikoku, southwest Japan, Geophys. Res. Lett., 38, L09311, doi:10.1029/2011GL047110.

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Keywords: Non-volcanic low frequency tremor, migration, subduction zone, fault heterogeneity

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SCG62-03 Room:103 Time:May 20 09:30-09:45

Spatial variation in size distribution of deep non-volcanic tremor in southwest Japan

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Magnitude-frequency distribution of ordinary earthquake satisfies the Gutenberg-Richter (GR) relation, indicating the size-frequency distribution satisfies the power law. The slope of semi-log graph of the GR law, b-value, is considered to reflect the stress state in earthquake source region. Size of deep non-volcanic tremor is estimated by the reduced displacement (RD) (Aki and Koyanagi, 1981) and their frequency distribution satisfies the exponential law (Hiramatsu et al. 2008). The slope of semi-log graph of this exponential law is very important when considering the friction property in the tremor source region on the subducting plate interface. In this study, we have investigated spatial variation in the RD-frequency distribution of tremor in southwest Japan. The result shows that the slope of RD-frequency distribution varies strongly from cluster to cluster. In each of the segment in western Shikoku, eastern Shikoku and Kii Peninsula, there exists a negative correlation between the observed slopes of RD-frequency distribution and the recurrence intervals of tremor activity: the larger the slope is, the longer the activity interval. In laboratory experiments, it has been shown that contact patches on friction surface grow and combine with time. The observed correlation might suggest time variation in the distribution of tremor patch size on the plate interface.

Keywords: non-volcanic tremor, size distribution

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SCG62-04 Room:103 Time:May 20 09:45-10:00

A New Method to estimate the tremor depth accurately

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To understand the mechanism of tectonic tremors, which have been discovered in many subduction zones and transform faults mainly around Pacific, it is important to determine the precise location of tremors, especially depth to know whether they occur on the plate boundary, in the oceanic crust, or in the upper plate. However, very weak and ambiguous signals of tremors prevent us to detect them and determine their hypocenters by popular location methods used for ordinary earthquakes, i.e., by reading P- and S- wave arrival times for each event. Therefore other methods are applied to detect and locate tremor, such as an envelope correlation method (e.g., Obara, 2002) and a matched filter analysis (e.g., Shelly et al., 2007). However, the accuracy of locations is not sufficient for detailed investigation.

In this study, we develop a new technique to determine tremor depth precisely by obtaining S-P times from tremor signals. S-P times are measured by comparing a vertical velocity seismogram with a synthetic moment rate function. The synthetic moment rate function is approximated by the energy rate function, which is proportional to the squared ground velocity. This technique will also provide us the information about the focal mechanism of tectonic tremors, because this method has a potential to reveal the green function of tectonic signals at each station.

Keywords: Subduction Zones, Tectonic Tremors, S-P times

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SCG62-05 Room:103 Time:May 20 10:00-10:15

Non-volcanic tremor characteristics in Taiwan and their stress interaction with local earthquakes

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Recent findings of tremor in Taiwan have shown it to be an ideal region in which we can study the relationship between tremor and earthquakes. Although several studies (Chao et al., GJI, 2012; Chao et al., SSA Meeting, 2011) have identified triggered and ambient tremor beneath the southern Central Range of Taiwan, a number of fundamental characteristics of tremor in Taiwan remain unclear. In this study, we auto-detected eight-year (2004˜2011) continuous seismic waveforms and obtained tremor episodes under the southern Central Range using the Waveform Envelope Correlation and Clustering (WECC) method and a spatio-temporal clustering criterion. We also quantified tremor activity before and after the local 4 March 2010, Mw6.3 Jiashian earthquake, the hypocenter of which is located about 30 km away from active tremor sources, and the 2010 Mw8.8 Chilean earthquake, which occurred six days before the Jiashian mainshock. This special dataset provides a means of studying the relationships among ambient tremor, triggered tremor, and local and regional earthquakes.

Analysis of the data shows that ambient tremor in the southern Central Range of Taiwan is characterized by frequent recurrence of short duration (5˜24 min. per day); however, unlike other subduction environments, the Nankai tremor zone exhibits a continuous occurrence of tremor episodes from a period of hours to days. The analysis also shows that ambient tremor in Taiwan surrounds an active triggered tremor source and that its spectrum is similar to that of triggered tremor, but with lower amplitude, which confirms the theory that triggered tremor is a sped-up result of ambient tremor. We found that background noise in this region during the local daytime period exhibits larger amplitude than that of ambient tremor, implying that if we employ borehole seismometers in the study region, we should be able to detect more tremor episodes. Our findings also show that maximum tremor activity occurred within ten days after the Jiashian mainshock, indicating a static stress interaction between the tremor rate and locally occurring earthquakes, and that tremor rate gradually returned to its previous status six months after the mainshock. Although the dynamic stress from the Chilean earthquake exceeded the tremor-triggering threshold of 8-9 kPa in Taiwan, it neither triggered tremor nor influenced local seismicity. The study found no evidence that significant change in tremor activity correlated with that of the Chilean earthquake or local seismicity. Finally, we examined potential slow slip events in nearby regions with geodetic observations from GPS data and found no direct evidence of a connection between the GPS observations and tremor episodes. Our investigation of ambient tremor in Taiwan can lead to more thorough understanding of tremor-generated zones and geological structures in this region.

Keywords: non-volcanic tremor, dynamics and static triggering, Taiwan, tectonic tremor

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SCG62-06 Room:103 Time:May 20 10:15-10:30

Linear stability of plane Poiseuille flow in infinite elastic medium and volcanic tremors

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We investigate linear stability of a plane Poiseuille flow of a compressible fluid sandwiched between two semi-infinite elastic media, focusing on application to excitation mechanism of volcanic tremors. Previous studies have shown that, in the even mode, where the fluid-layer thickness becomes wider and narrower symmetrically, the flow speed needed to destabilize the system could be infinitesimally small when the wavelength of the wave-type fluid and solid motion is very long (Balmforth et al., 2005; Dunham and Ogden, 2012). We show that a similar instability occurs in the odd mode, where the width of the fluid layer does not change very much regardless of the fluid and solid motion. The odd-mode instability occurs with a slower flow speed than in the even mode, and the wave-type motion propagates oppositely to the basic flow. We calculate the critical Mach number for instability of the compressible Poiseuille flow for various dimensionless parameters and conclude that the odd mode is more possible to account for excitation of volcanic tremors than the even mode.

Keywords: fluid dynamics, dynamics of elasticity, flow-induced vibration, elastic surface wave

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SCG62-07 Room:103 Time:May 20 10:30-10:45

Long-term seismic quiescence caused by partial decoupling of the plate boundary prior to the 2011 Tohoku earthquake

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Katsumata (2011) found that a long-term seismic quiescence started 22 years before the 2011 off the pacific coast of Tohoku earthquake (M=9.0) by analyzing an earthquake catalog compiled by Japan Meteorological Agency (JMA). A detailed analysis of the earthquake catalog between 1965 and 2010 using a gridding technique (ZMAP) shows that the 2011 Tohoku earthquake is preceded by a seismic quiescence anomaly that starts in the middle of 1989, and lasts about 22 years, until the occurrence of the main shock. The quiescence anomaly area is located around the deeper edge of the asperity ruptured by the main shock. The seismicity rate clearly decreases from 3.0 to 1.5 events/year (a drop of 50%). On the other hand Ozawa et al. (2012) found that a time-dependent analysis indicates aseismic slip offshore of Miyagi and Fukushima prefectures from 2004 based on global positioning system (GPS) data. They suggested that the aseismic slip is a precursor to the Tohoku earthquake. In this study I point out that the seismic quiescence area found by Katsumata (2011) overlaps almost exactly with the aseismic slip area found by Ozawa et al. (2012), suggesting that the seismic quiescence is caused by the aseismic slip.

Katsumata, K., A long-term seismic quiescence started 23 years before the 2011 off the Pacific coast of Tohoku Earthquake (M = 9.0), Earth Planets Space, Vol. 63 (No. 7), pp. 709-712, 2011.

Ozawa, S., T. Nishimura, H. Munekane, H. Suito, T. Kobayashi, M. Tobita, and T. Imakiire (2012), Preceding, coseismic, and postseismic slips of the 2011 Tohoku earthquake, Japan, J. Geophys. Res., 117, B07404, doi:10.1029/2011JB009120.

Keywords: 2011 Tohoku earthquake, seismic quiescence, slow slip

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SCG62-08 Room:103 Time:May 20 11:00-11:15

Objective detection and catalog of short-term SSE

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Geological Survey of Japan (GSJ), National Institute of Advanced Industrial Science and Technology (AIST) constructed integrated observatories in and around Shikoku, Kii Peninsula and Tokai. In these observatories, we are observing groundwater, strain, tilt and earthquake. In addition to these data, using the tilt data of National Research Institute for Earth Science and Disaster Prevention (NIED) Hi-net and strain data of Japan Meteorological Agency (JMA), we are monitoring short-term slow slip events (SSE). At present, the occurrence of short-term SSE is determined by visual inspection with reference to the tremor. Therefore, it is considered that there is oversight of the short-term SSE.

Itaba *et al.* (2012) developed an objective detection method of tectonic crustal movement using redundant components of borehole strainmeter, and shown that it is effective for detection of short-term SSE in the Kii Peninsula. So, in this study, after tuning this method, we estimated the dislocation model of short-term SSE that detected tectonic crustal movement in more than one observatory.

In this presentation, we will introduce the detection results in some areas, the dislocation model and features of short-term SSE, and initiatives toward short-term SSE catalog.

Keywords: short-term SSE, strain, borehole strainmeter, tilt, groundwater, tremor

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SCG62-09 Room:103 Time:May 20 11:15-11:30

Detection of short-term slow slip events along Hyuganada and the Sagami trough using GNSS data

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Nishimura et al. (2012) detected tectonic offsets in GNSS time-series using the AIC and fault model estimation of short-term slow slip events (SSEs) on the subducting Philippine Sea plate along the Nankai trough. Here, we report results of detection and estimation of SSEs along Hyuganada and the Sagami trough using their method.

Daily coordinates of 314 GEONET stations in southwestern Japan were used to detect the deformation of SSEs along Hyuganada. We fitted a step function to the filtered daily coordinates to detect displacements in a direction of N135^{o}E which is opposite to the relative plate motion between the Philippine Sea plate and southwestern Japan. The candidate dates of the SSEs are determined if the significant displacements were detected. And three components (i.e., EW, NS, and UD) of the displacement were inverted to estimate a rectangular fault model. We finally recognized SSEs if the observed displacement were well reproduced by the fault model. The same procedure is applied for the analysis of SSEs along the Sagami trough. But we used 327 stations to detect displacements in a direction of N160^{o}E.

In the Hyuganada region, we estimated four M_w 6.0-6.1 SSEs near the border between Oita Prefecture and Miyazaki Prefecture. Number of SSEs in the southern region decreases around Miyazaki Prefecture but increases around the Osumi Peninsula and Tanegashima again. The SSEs near the Oita-Miyazaki border occur at a depth of ˜30 km and those near the Osumi Peninsula occur at a various depth between 10 and 50 km. It is interesting that SSEs with a depth of 30 km and shallower occur there, which have never been detected in the Shikoku region. Some SSEs accompanied with seismic activities along the Hyuganada. We also detected several episodes of SSE-related deformation along the Sagami trough. One of the largest SSEs occurs far east off the Boso Peninsula around April 14, 2007. The estimated moment magnitude ranges between 6.3 and 6.7.

In summary, many SSEs were found along Hyuganada and the Sagami trough, where significant activities of non-volcanic tremors are not observed. We found that some SSEs accompanied with seismic activities but that the others did not. Comparison among analyses for several neighboring regions revealed a problem that some false SSEs were detected by the present method because of a low signal to noise ratio. It is necessary to combine GNSS and strain/tilt data so as to improve the fault model estimation and estimate duration of SSEs.

Keywords: Slow slip event, GNSS, Crustal deformation, Subduction zone, Hyuganada, Sagami Trough

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SCG62-10 Room:103 Time:May 20 11:30-11:45

Development of a short-span strainmeter for observation of deformation of slow slip events

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Crustal deformations, such as strain and tilt changes, have been observed associated with deep low-frequency tremors occurring below the Kii peninsula and Shikoku. Strain measurements by an extensometer at Kishu operated by DPRI, Kyoto University, for example, show that the closer sources with epicentral distance of 30 - 40 km, have large deformations with strain changes of 10^{-9} to 10^{-8} occurring within several days. Although the traditional extensometer observations can these detect strain changes, it is difficult to make interpretations because of the limited number of stations

An instrument that is inexpensive and is easy to install will make possible strain array observations. We designed a short-span extensometer that is 1.5 - 2 m-long measure. The measure is made from a metal with a small temperature expansion constant and hanging by a thin string at one end. A linear variable differential transformer (LVDT) is used to detect displacement. Strong coupling of the instrument to the ground is important for stable observations, so three anchor bolts fixed to the base of the instrument are cemented into a 30-cm-deep hole.

As a test example, we constructed a one component short-span extensometer and installed it in a tunnel of Donzurubou observatory, Nara prefecture. Earth tides and strain oscillation caused by a teleseismic event are clearly observed by the short-span extensometer. We expect that the crustal deformation associated with deep low-frequency tremors can be observed by an array of these short-span extensometer, that have a length of 1.5-m.

Keywords: strain meter, slow earthquakes, array observation

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SCG62-11 Room:103 Time:May 20 11:45-12:00

Anisotropic structures of oceanic slab and mantle wedge in a deep low-frequency tremor zone beneath the Kii peninsula

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Anisotropy is an important feature of elastic wave propagation in the Earth and can arise from a variety of ordered architectures such as fractures with preferential alignments or preferred crystal orientations. We studied regional variations in shear wave anisotropy around a deep low-frequency earthquake (LFE) zone beneath the Kii Peninsula, SW Japan, using waveforms of local earthquakes observed by a dense linear array along the LFE zone. The fast directions of polarization are subparallel to the strike of the margin for both crustal and intraslab earthquakes. The delay time of the split shear waves in intraslab earthquakes is larger than that in crustal earthquakes and shows a down-dip variation across the LFE zone. This indicates that anisotropy exists in the mantle wedge and in the lower crust and/or oceanic slab. We explain the observed delay time of 0.015˜0.045 s by suggesting that the mantle wedge consists of a deformed, 1˜15 km thick serpentine layer if the mantle wedge is completely serpentinized. In addition to high fluid pressures within the oceanic crust, the sheared serpentine layer may be a key factor driving LFEs in subduction zones.

Keywords: shear wave splitting, LFE, mantle wedge, serpentine, subduction zone, SW Japan

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SCG62-12 Room:103 Time:May 20 12:00-12:15

Slow earthquake associated with frictional healing of serpentinites

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Slow earthquakes occurred at subduction zone are distinct from regular earthquake in terms of their slip behaviors (e.g., Ide et al. 2007). We consider this difference to relate to localized hydration reactions at the plate interface that influence the frictional properties. The results of laboratory friction experiments indicate that simulated serpentine faults are characterized by a low healing rate and large slip-weakening distance compared with unaltered dry fault patches. These properties are consistent with the characteristics of subduction-related slow earthquakes, which exhibit a small stress drop and a relatively long duration. The results of numerical modeling suggest that slow slip events favor a large slip-weakening distance (e.g., Shibazaki and Iio 2003). These results may explain the slip mechanism of slow earthquake, suggesting that a locally serpentinized plate interface could trigger slow earthquakes assisted by pore pressure build-up, whereas unaltered dry patches that remain strongly coupled are potential sites of regular earthquakes.

Keywords: serpentinite, frictional experiment, frictional healing, slow earthquake

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SCG62-13 Room:103 Time:May 20 12:15-12:30

Geological and frictional aspects of very-low-frequency earthquakes in an accretionary prism

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Recent observations by on-land seismic networks and broadband ocean-bottom seismometers have identified the occurrence of very-low-frequency earthquakes (VLFE) along thrusts in accretionary prisms and near subduction plate boundaries at slip rates of 0.05-2 mm/s. However, the geological and frictional aspects of VLFE remain poorly understood. Here we show the characteristics of the thrusts in the Eocene Kayo Formation of the Shimanto accretionary complex exhumed from source depths of VLFE and the frictional velocity dependence of the thrusts materials. The host rock of the thrusts is quartz arenite that constitutes sandy turbidites. The thrusts are composed of quartz-rich fault rocks with or without clay foliations. The frictional slip in the thrusts is accommodated by the localized shear along quartz-coated slip surfaces or the distributed shear along clay foliations. Frictional velocity dependence of thrust materials was examined under wet conditions. At slip rates of 0.0028-0.28 mm/s, the powder sample from non-foliated rock show velocity-weakening behavior, while that from foliated fault rock exhibits velocity-strengthening behavior. All samples show velocity-strengthening behavior at slip rates of 0.28-2.8 mm/s. Microstructural analysis reveals that the velocity-weakening samples show a shear localization, while velocity-strengthening sample is marked by clay foliations oblique and parallel to shear zone boundaries. A frictional velocity dependence of the samples from quartz-rich thrust material, showing velocity weakening at 0.0028-0.28 mm/s but velocity-strengthening at 0.28-2.8 mm/s, is favorable for the occurrence of VLFE. The localized shear along quartz-coated slip surfaces in thrust may be the geological evidence of VLFE. However, when clay foliations develop in such thrust, thrust becomes frictionally stable as the samples with clay foliations shows velocity-strengthening behavior at 0.0028-2.8 mm/s. These results suggest that the quartz content and development of clay foliations along thrusts may be factors in controlling the occurrence and spatial distribution of VLFE in accretionary prisms.

Keywords: very-low-frequency earthquakes, accretionary prism, frictional velocity depenedence, fault zone structure