Japan Geoscience Union Meeting 2013
(May 19-24 2013 at Makuhari, Chiba, Japan)

SSS27-P01 Room:Convention Hall Time:May 22 18:15-19:30

Relation between Temporal Variation of b-value and Recurring Slow Slips off Boso Peninsula: Part 2

Fuyuki Hirose[1]*, Kenji Maeda[1]

[1]Meteorological Research Institute

Hirose & Maeda (2012, JpGU) investigated a relation between temporal variation of b-value of the G-R law (Gutenberg and Richter, 1944, BSSA) and stress change associated with slow slip events (SSEs) around Boso peninsula. They interpreted their result as follows by considering the inverse correlation between b-value and stress obtained in laboratory experiments (Scholz, 1968, BSSA):

1) Because a coupling rate is low in the period of no SSEs in the area where swarm earthquakes occur, stresses applied to the region becomes also low. Therefore, b-value becomes large.

2) Seismicity activates at the north edge of the SSE area because stresses increase around the SSE area according to an occurrence of SSEs. In this situation, b-value decreases because of high stress.

3) After that, because SSEs converge within a week or 10 days, stresses applied to adjacent area around SSEs decrease gradually. A b-value increases gradually with decrease of stresses and has a peak value before next SSE.

They used JMA catalogue in the period of 1990/1/1 ? 2011/12/31 with M ? 1.5 and Depth ? 40 km, and relocated hypocenters by Double-difference (DD) method (Waldhauser & Ellsworth, 2000, BSSA). And they calculated temporal changes of b-value using events that may occur near plate boundary.

On the other hand, we obtained seismic waveform data after August, 2002. We will relocate hypocenters precisely using both methods of waveform cross-correlation and DD and retry to calculate temporal changes of b-value. We will report our result in the session.

Keywords: Boso peninsula, slow slip, b-value, stress, temporal change, waveform cross-correlation

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Earthquake Observation in the Suruga Trough Using Ocean bottom Seismographs-Preliminary Report-

Hisatoshi Baba[1*], Kenji Hirata[2], Hiroaki Tsushima[3], Tatsuya Miyagawa[1], Tsuyoshi Matsumoto[1], Kazuya Inamura[1], Akio Katsumata[3], Hiroshi UENO[3], Shigeki Aoki[3], Kenji Maeda[3], Takashi Yokota[3], Toshiyasu Nagao[1]

[1]Tokai University, [2]National Rsearch Institute for Earth Science and Disaster Prevention, [3]Meteorological Research Institute, JMA

Tokai Univ. and MRI, are carrying out the single station earthquake observation near the Suruga Trough axial region, east end of a possible near-future Tokai Earthquake, using pop-up type OBSs from October, 2011 to July 2012. After the single-station observation, we are conducting tripartite observation of three OBSs. Deployment and recovering of the OBSs are repeatedly conducted every three months using small work boat with about 20 ton ages of Tokai Univ. In the Suruga Trough axial region, seismicity became active since-years ago; moderated-size earthquakes occurred there (M6.5 in 2009 and M6.1 in 2012).

Although those are believed earthquakes occurred in the subducting Philippine Sea Plate, from land network observation, depth of these moderated-size events may not be necessarily constrained well because of lack of observation within the Suruga Bay.

We report a preliminary result about single-station observation to examine local seismicity in the Suruga Trough axis in terms of frequency and S-P time distribution.

From January 2012 to July 2012, the following results were found.

(1) During this time, the single OBS observation detected 11,539 events.

(2) About 5,000 events show S-P time of less than 5sec. About 1,100 events show those of less than one second.

(3) The earthquakes with S-P time of less than one second are considered to occur in the Philippine Sea plate, not in the land plate.

By the second stage observation from August 2012, we installed OBSs in three sites around Suruga Trough. In our presentation, we would like to mention some preliminary results of the tripartite observation.

Keywords: Earthquake Observation, Suruga Trough, Ocean Bottom Seismograph

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Earthquake Observation in and around Kumano Nada using Cable and Pop-Up type Ocean Bottom Seismographs

Hiroshi Sarukawa[1], Hisatoshi Baba[2*], Kenji Hirata[3], Akira Yamazaki[4], Hiroaki Tsushima[5], Akio Katsumata[5], Hiroshi UENO[5], Shigeki Aoki[5], Kenji Maeda[5], Takashi Yokota[5]

[1]Hannan Co., Ltd., [2]Department of Marine and Earth Science, Tokai Univ., [3]National Rsearch Institute for Earth Science and Disaster Prevention, [4]JMA, [5]Meteorological Research Institute, JMA

From October, 2008, JMA started earthquake observation offshore in the middle of the Nankai Trough using cable type Ocean Bottom Seismographs (OBSs) which has been installed from the Tokai-Oki area to Kumano Nada area. Then MRI and JMA installed twelve of pop-up type OBSs around the cable type OBSs from June, 2009 to September, 2009. Aim of this campaign observation is (1) examine the hypocenter determination ability of the JMA cable type OBSs, (2) to compare hypocenter distributions determined by only the cable type OBSs or a combination of cable type + pop-up OBSs with those by land seismic networks for understanding of feature or disposition of hypocenter distributions determined by different combination of offshore and land observation. During three months of the campaign observation, a combination data set of the cable and pop-up type OBSs detected 188 events, most of which were located around Nankai Trough axis. These hypocenters depth distribution are about 20 ? 50km, but decided by only cable type OBSs are tends to become relatively shallow. Comparison of hypocenters with those determined by the land network suggests that hypocenter distribution determined by both of cable and pop-up type OBSs shows the cluster form.

In this presentation, we further discuss feature and disposition of the hypocenter distribution estimated by the cable type OBSs as well as geographical feature if seismicity in this area.

Keywords: Earthquake observation, Ocean Bottom Seismograph, Tokai Oki, Kumano Nada, Comparison of the hypocenter

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Relationship between seismicity off Awashima inferred from Ocean Bottom Cabled Seismometers and 1964 Niigata earthquake

Takashi Shinbo[1*], Yuya Machida[1], Masanao Shinohara[1], Tomoaki Yamada[1], Kimihiro Mochizuki[1], Toshihiko Kanazawa[2]

[1]ERI, [2]NIED

The Niigata-Kobe Tectonic Zone (NKTZ) (Sagiya et al., 2000) is placed in the eastern margin of the Japan Sea, many large earthquakes occurred within NKTZ (e.g. 1964 Niigata earthquake, 2004 Chuetsu earthquake, and 2007 Chuetsu-oki earthquake). To understand the generation mechanism of these earthquakes and a formation of the NKTZ, it is important to obtain detailed hypocenter distribution around the NKTZ. It is difficult to locate hypocenters in offshore regions only land seismic stations and we cannot understand seismicity around NKTZ precisely.

We have been monitoring seismic activity by using Ocean Bottom Cabled Seismometers (OBCSs) from August 2010 off Awashima which the epicenter of the 1964 event is located. A seismic survey using airgun and these OBCSs was conducted to obtain seismic velocity structures around deployment of OBCSs. The data of the OBCSs enable us a precise location of hypocenters. In this study, we determine hypocenters occurred around Awashima and discuss relationship between these events and a mainshock fault plane of 1964 Niigata earthquake.

We determined 23 hypocenters using data from OBCSs. Most of these hypocenters occurred at depths ranging from 5km to 20km. These focal depths were shallower than focal depths determined by Japan Meteorological Agency. The hypocenter by OBCS form a plane dipping to the west and the dip of plane is estimated at 34 degree. The dip angle is smaller than one of the mainshock fault plane of 1964 event. We interpret that these events do not occur on the mainshock fault plane of 1964 Niigata earthquake. We need to accumulate data from OBCSs to reveal the relationship between seismic activity around Awashima recently and the fault plane of 1964 Niigata Earthquake.

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Hypocenter distribution around the 2011 Tohoku-Oki earthquake by using Ocean Bottom Seismographic data

Kensuke Suzuki[1*], Ryota Hino[1], Yoshihiro Ito[1], Yojiro Yamamoto[2], Syuichi Suzuki[1], Yukihito Osada[1], Masanao Shinohara[3], Kenji Hirata[4], Akio Katsumata[4], Hiroaki Tsushima[4], Akira Yamazaki[5], Fujio Kusano[6], Yoshiyuki Kaneda[2]

[1]Research Center for Prediction of Earthquakes and Volcanic Eruptions,Graduate School of Science,Toho, [2]Japan Agency for Marine-Earth Science and Technology, [3]Earthquake Research Institute, University of Tokyo, [4]Meteorological Research Institute, [5]Japan Meteorological Agnency, [6]Sendai District Meteorological Observatory

A megathrust earthquake (M9.0), the 2011 off the Pacific coast of Tohoku earthquake (the 2011 Tohoku-Oki earthquake), occurred on Mar. 11, 2011 along the Japan Trench subduction zone. Its hypocenter and the area of major moment release are located in the Miyagi-Oki region, middle part of the Japan Trench area, where large interplate earthquake (~M7.5) have repeatedly occurred at about 40 years intervals. Since 2002, we have repeatedly deployed and retrieved pop-up type Ocean Bottom Seismometers (OBSs) to monitor the seismicity in the region. By using this OBS network, we could observe a sequence of the foreshocks, the mainshock and aftershocks of the 2011 Tohoku-Oki earthquake in their close vicinity.

Suzuki et al. (2012) relocated these hypocenters by using OBSs data. Although OBSs deployed in the area observed the series of earthquakes and their data provided with improved image of the hypocenter distribution, they relocated only early aftershocks occurred until 21 May 2011. In this presentation, we will report the aftershock distribution relocated by including the OBS data recovered in 2012 from the off-Miyagi region where large ($>$ 10 m) coseismic slip occurred at the 2011 Tohoku-Oki earthquake.

The mainshock hypocenter was relocated slightly westward from that reported by Japan Meteorological Agency (JMA), placing it near the intersection between the plate boundary and the Moho of the overriding plate. The foreshock seismicity mainly occurred on the trenchward side of the mainshock hypocenter, where the Pacific slab contacts the island arc crust. The foreshocks were initially activated at the up-dip limit of the seismogenic zone ~30 km trenchward of the largest foreshock (M 7.3, two days before the mainshock). After the M-7.3 earthquake, intense interplate seismicity, accompanied by epicenters migrating toward the mainshock hypocenter, was observed. The focal depth distribution changed significantly in response to the M-9 mainshock. Earthquakes along the plate boundary were almost non-existent in the area of huge coseismic slip, whereas earthquakes off the boundary increased in numbers in both the upper and the lower plates, including intensive aftershock activities of intraplate earthquakes with magnitude more than 7.

Keywords: Tohoku-Oki earthquake, OBS, Miyagi-Oki, seismicity

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SSS27-P06 Room:Convention Hall Time:May 22 18:15-19:30

Precise aftershock distribution of the southernmost rupture area of the 2011 Tohoku-oki earthquake by OBSs

Yuya Machida[1*], Masanao Shinohara[1], Kazuo Nakahigashi[1], Tomoaki Yamada[1], Kimihiro Mochizuki[1], Hajime Shiobara[1], Yoshio Murai[2], Ryota Hino[3], Toshinori Sato[4], Kenji Uehira[5], Hiroshi Yakiwara[6], Kenji Hirata[7], Shuichi Kodaira[8]

[1]ERI, Univ. of Tokyo, [2]Hokkaido Univ., [3]Tohoku Univ., [4]Chiba univ., [5]NIED, [6]Kagoshima Univ., [7]MRI, [8]JAMSTEC

The 2011 Tohoku-oki earthquake (MJMA = 9.0) occurred on the megathrust where the Pacific plate subducts below northern Japan arc on March 11, 2011. Many studies on slip distribution and source process of the main shock have been done, such as geodetic slip model [e.g. Ozawa et al., 2011], tsunami slip model [e.g. Fujii et al., 2011, Maeda et al., 2011], joint inversion of GPS, teleseismic, and tsunami observations [Simons et a., 2011] and rupture process [e.g. Yoshida et al., 2011]. They indicated the rupture area extends approximately 450 km in length and 200 km in width. The seismic experiment using airgun and Ocean Bottom Seismometers (OBSs) revealed that the southern end of the rupture of the 2011 main shock corresponds to the contact region of the Philippine Sea plate and the Pacific plate (Nakahigashi et al., 2012). Therefore revealing a crustal structure around the southern end of the rupture area is indispensable to understanding a seismogenic process. Furthermore, information about the Vp structures and Vp/Vs ratios is needed for a better understanding of large earthquakes that occur as a result of stress-concentration on the plate boundary.

Aftershock observations using OBSs was carried out immediately after the occurrence of the 2011 Tohoku-oki earthquake, and precise aftershock distribution over the whole source area was estimated (March 15th-June 18th, 2011) [Shinohara et al., 2012]. In this study, we estimate precise hypocentral distribution around the southern end of the rupture area using additional date (June 28th-Sep. 13th, 2011) obtained by the aftershock observation by OBSs, and understand a source process of the 2011 Tohoku-oki earthquake.

This study is partly supported by the Spatial Coordination Funds fo the Promotion of Science and Technology (MEXT, Japan) titled as the integrated research for the 2011 off the Pacific coast of Tohoku Earthquake.

Keywords: 2011 Tohoku-oki earthquake, aftershock activity, Ocean Bottom Seismometers (OBSs), crustal structure, Philippine Sea plate, Pacific plate

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Triggered seismicity in Northern Nagano region at short times after the 2011 M9.0 Tohoku-Oki earthquake

Kengo Shimojo[1*], Bogdan Enescu[2], Yuji Yagi[2], Tetsuya Takeda[3]

[1]Graduate School of Life and Environmental Sciences, University of Tsukuba, [2]Faculty of Life and Environmental Sciences, University of Tsukuba, [3]NIED

The changes in seismicity after the 2011 Tohoku-Oki earthquake can be explained in most cases by the Coulomb static stress transfer mechanism (Toda et al., 2011). However, one exception seems to be the seismicity activation in a few inland regions of northeast Japan. Given the compressional tectonic regime in northeast Japan, the seismicity in such areas, after the megathrust event, should have been inhibited rather than activated, if we assume the Coulomb failure criterion. Thus the static stress transfer from the Tohoku-Oki earthquake cannot explain this seismicity increase. It may be possible to relate such activation with dynamic stress changes caused by the passage of surface waves from the 2011 Tohoku-Oki earthquake.

In this study we investigated the possibility of dynamic earthquake triggering in the northern Nagano region, where the seismicity was clearly activated following the 2011 Tohoku-Oki earthquake. An Mw6.2 event occurred here after about 13 hours from the Tohoku-Oki earthquake. According to the Japan Meteorological Agency (JMA) earthquake catalog, there was no recorded earthquake in this region in the first 7 hours after the 2011 Tohoku-Oki event. However, in many cases after large events, the seismicity immediately after the mainshock is incompletely recorded in earthquake catalogs (Kagan, 2004). We used event-waveform data and continuous waveform data recorded at Hi-net stations in Nagano region and apply the Matched Filter Technique (Peng and Zhao, 2009) to detect as many earthquakes as possible in the first hour after the Tohoku-oki earthquake. As a result, we have detected new events (i.e. events that are not in the JMA earthquake catalog) occurring in the first hour after the Tohoku-Oki earthquake. Some of these events are located close to the hypocenter of the Mw6.2 Nagano earthquake (which occurred about 13 hours after Tohoku-Oki earthquake), some others locate to the south, in an area where an Mw5.4 earthquake occurred about one month later. The analysis of F-net Centroid Moment Tensor (CMT) focal mechanism solutions shows that the majority of earthquakes from 2001 until the occurrence of the Tohoku-Oki earthquake differ from those after the M9.0 event. In detail, the thrust fault events are predominant in the region before the Tohoku-oki earthquake, while the dominant mechanism becomes strike-slip after the M9.0 event. The Coulomb failure stress changes cannot explain the focal mechanism changes. Note that the "anomalous" focal mechanisms in the triggered areas are consistent with a fluid-driven seismicity activation (Terakawa et al., 2012).

Based on the above results, we can speculate that the passage of surface waves from the Tohoku-oki earthquake caused enhanced fluid transport and pore pressure changes. These fluid-related changes may have modified the Coulomb failure function in such a way that the effective normal stress is decreased sufficiently to trigger failure (e.g., Cocco and Rice, 2002). We can further speculate that the seismicity occurred at early times after Tohoku-Oki earthquake in the Nagano region contributed through dynamic stress transfer to the occurrence of the nearby Mw6.2 Nagano earthquake.

Keywords: The 2011 M9.0 Tohoku-Oki earthquake, Northern Nagano seismicity, dynamic triggering, cross-correlation, focal mechanism data

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Spatio-temporal occurrence patterns among the foreshocks preceding the 2007 Noto Hanto earthquake

Issei Doi[1*], Hironori Kawakata[1]

[1]College of Science and Engineering, Ritsumeikan University

Foreshocks are a key for understanding the preparation and generation processes of the mainshock. In rock failure experiments, it is well known that acoustic emissions occur prior to the major failure (e.g. Scholz, 1968; Lockner et al., 1992). Recently, analyses of seismograms recorded by a dense seismic observation network have revealed new insights of foreshocks through studying uncataloged smaller foreshocks. Clustered foreshocks adjacent to the mainshock hypocenter with identical seismograms were found for the 1999 Izmit inter-plate earthquake in Turkey (Bouchon et al., 2011) and the 2008 Iwate-Miyagi Inland crustal earthquake in Japan (Doi and Kawakata, 2012). In this study, we try to make it clear how common the clustered foreshock occurrence and to grasp whether other foreshocks occur in total mainshock rupture volume. Focusing on the 2007 Noto Hanto Earthquake with JMA (Japan Metrological Agency) magnitude (Mj) of 6.8, we estimated the spatio-temporal clustered seismicities of the foreshocks in the source region.

By analyzing continuous seismograms that recorded activity in the 25 days before the earthquake, we detected 36 small seismic events around the mainshock hypocenter that classified as members of mainly three clusters. Two clusters included more than ten events and occurred some distance from the mainshock fault, indicating that the clusters did not relate to the mainshock event. The cluster located along the mainshock fault was only the third one. Especially, this cluster was mapped in the same general vicinity as the rupture initiation point of the mainshock and consisted of four foreshocks in succession with identical seismograms. This cluster began twelve minutes before the mainshock and then ceased for period of quiescence for the last eight minutes. The occurrence pattern of this clustered foreshock sequence is similar to that observed in association with the 2008 Iwate-Miyagi Inland earthquake.

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Precursory seismicity change of the 1999 Chi-Chi, Taiwan earthquake revealed by the ETAS model

Masashi Kawamura[1*], Chien-chih Chen[1]

[1]Dep. of Earth Sciences and Graduate Inst. of Geophysics, National Central University, Taiwan

In order to investigate the preparatory process of the 1999 Chi-Chi, Taiwan earthquake and the statistical feature of its related seismicity, we applied the Epidemic-Type Aftershock-Sequences model (ETAS model) (Ogata, 1988) to the earthquake data in Taiwan region. By means of the ETAS analysis for Taiwanese earthquakes with magnitudes larger than 2.4, seismic quiescence was found over broader regions of Taiwan, while seismic activation was identified near the source areas of the Chi-Chi earthquake in the period from Jan. 1, 1998 to Sep. 20, 1999, which is just before the occurrence of the Chi-Chi earthquake. The assumption that this is due to precursory slip (stress drop) on the fault plane of the Chi-Chi earthquake is supported by previous researches such as a numerical simulation using rate- and state-dependent friction laws (Kato et al., 1997) and the observation of abnormal change in crustal displacement for a station of Taiwan GPS network near southern edge of the source area of the Chi-Chi earthquake (Hou et al., 2003).

Reference

Kawamura, M. and C.-c. Chen, Precursory change in seismicity revealed by the Epidemic-Type Aftershock-Sequences model: A case study of the 1999 Chi-Chi, Taiwan earthquake, Tectonophysics, accepted.

Keywords: ETAS model, seismic quiescence, seismic activation, seismic activity, precursory slip, the 1999 Chi-Chi earthquake

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Shear fracture strength of faults (VI): Relation between GPS velocity fields and seismic activity

Kiyohiko Yamamoto[1]*

[1]none

INTRODUCTION: In this study, the following two problems will be discussed. First, GPS velocity represents the velocity at which constituents of the crust moves. Crustal movements are considered to be caused by the non-uniform motion of the crustal materials. The GPS velocity field is non-uniform even in the intra-plate. In the south Kanto district, the direction of the GPS velocity actually varies from SW to NW as the observation point becomes south. One of the purposes of this study is to discuss the depth where the driving force of the crust is acting. Next, after the 2011 off the Pacific coast of Tohoku Earthquake (2011/3/11, Mw9.0), the seismic activity is high in the east side of either of the lines, the NW-SE line passing through near Kinkazan and the NE-SW line passing through near Iwaki. The similar pattern of the seismic activity is observable off the Ibaraki prefecture and off the Boso peninsula, as well. The other purpose is to make the meanings of the boundary line clear.

THE METHOD AND ITS BACKGROUND: A model of fault zones proposed on the basis of the results of in-situ stress measurement suggests that the strength of a fault is about 10 MPa in the upper crust. This means that the strength is very small, or faults are weak. This implies that a fault plane is nearly parallel to one of principal planes of stress. The comparison of the orientation of the horizontal stresses with the direction of GPS velocity in GRS80 system has revealed that the direction of the largest or the smallest horizontal stress can be approximated by the direction of GPS velocity. Therefore, we can expect that the direction of a fault strike is nearly equal to that of GPS velocity, if one of the principal stresses lies horizontal.

On the basis of the above results, the strike direction of a fault will be compared with that of GPS velocity, using the earthquakes occurring at various depths. This is available for discussing the driving force of the crust. In order to make the meaning of the boundary line clear, it is the first step that the direction of the boundary line is compared with that of GPS velocity.

RESULTS AND CONCLUSION: Focal mechanism solutions have been preliminarily compared with GPS velocities. From this comparison, it is seen that at least one of strike directions and their perpendiculars determined as the focal mechanism solution is close to that of the GPS velocity (1997-2007), even at depths larger than the crust. This suggests that the crust moves together with the upper mantle.

The GPS velocity (1997~2007) lies in SW direction at the GPS stations between Kinkazan and Choshi along the coast of the Pacific Ocean. The boundary line passing through Iwaki is almost parallel to the GPS velocity, and the boundary line passing through Kinkazan is almost perpendicular to it. An earthquake (2011/4/11, Mw 7.1) occurred near Iwaki. Although the strike direction of the nodal plane is determined with wide variety, the direction is almost perpendicular to the GPS velocity. These enable us to think the direction of the GPS velocity as one of the principal directions of stress. The boundary line passing through Kinkazan is almost perpendicular to the GPS velocity (1997-2002) at OSIKA. These suggest that the boundaries of the seismic activity are the boundaries of the crustal structure like as a tectonic line.

The following data are used:
GPS Velocity; GSI, http://mekira.gsi.go.jp/project/f3_10_5/ja/index.html
Seismic activity; NIED, http://www.hinet.bosai.go.jp/
Focal mechanism solution, NIED, http://www.fnet.bosai.go.jp/event/search.php?LANG=ja, and USGS, http://earthq

Keywords: weak fault, GPS velocity, Seismic activity, focal mechanism,, direction of fault strike, tectonic line

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A numerical simulation of an aftershock activity with the rate-and-state friction model and secondary aftershock effect

Takaki Iwata[1*]

[1]The Institute of Statistical Mathematics

The model of seismicity rate with rate- and state-dependent constitutive law suggested by Dieterich [1994, JGR] (hereafter referred to as Dieterich model) successfully explains the decay rate of an aftershock activity following an inverse power law (Omori-Utsu law [Utsu, 1961, Geophys. Mag.]). The temporal decay of an earthquake sequence derived from the Dieterich model is asymptotically the same as the particular case of the Omori-Utsu law with the p-value equal to 1, but real aftershock sequences has a variety of the p-value. Some studies have already attempted to resolve this consistency, but it is difficult to reproduce the case of $p > 1$. For this issue, Dieterich [1994] suggests his model including secondary aftershock effect. In this framework, Marsan [2006, JGR] shows the variation on the decay of an aftershock activity with his numerical simulation, but did not discuss how the p-value changes.

This study clarifies the effect of secondary aftershocks on the variety of aftershock decay through a numerical simulation. The approach used in this study is similar to that of Marsan [2006]. Probability distributions of stress changes caused by a mainshock and each aftershock are assumed, and random stress changes which follow the assumed probability distributions are given to a huge number of subfaults. Then, on the basis of the Dieterich model, we compute the seismicity rate with the given stress changes. While Marsan [2006] shows the expected decay of a seismicity rate, in this study earthquake sequences are generated from the computed seismicity rate and the p-values are estimated by fitting the Omori-Utsu formula to each of the generated sequences. The numerical simulation reveals that the p-value depends on the assumed probability distributions of stress changes and that in particular p-value is greater than 1 if the mean of the stress changes caused by aftershocks is positive.

Keywords: aftershock activity, Omori-Utsu law, p-value, rate- and state-dependent friction law, point process analysis, statistical seismology

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Temporary observation of micro earthquakes in the northern Ibaraki prefecture by using ready-made IC recorders

Keisuke Saito[1*], Kei Katsumata[1]

[1]Institute of Seismology and Volcanology, Hokkaido University

In order to obtain high quality focal mechanism solutions for earthquakes by using P-wave first-motion polarity data, a dense seismic observation network is required. In this study we propose a new seismic observation system to record a P-wave first-motion polarity. The system consists of a seismometer with a vertical component that price is approximately ten thousand yen and a commercially-supplied IC recorder that price is approximately ten thousand yen. According to the specification of the IC recorder, the recordable frequency band is from 60 to 3400 Hz, Katsumata and Okayama (2012) showed that the IC recorder is able to record seismic waves with a frequency as low as 10 Hz.

In this study, we conducted a temporary observation of micro-earthquakes for one month in the northern Ibaraki prefecture where is the high seismicity area, and addressed the effectiveness of the seismic observation system. The 29 seismic stations were deployed along a road so that it allows a deployment of many stations for a short time. Based on the P-wave first motion polarity, we estimated the focal mechanisms by using HASH program (Hardebeck and Shearer, 2002). In this study, we also use the polarity data recorded at the Hi-net stations that constructed by National Research Institute for Earth Science and Disaster Prevention. We estimated the four focal mechanisms for micro-earthquakes occurred in the study area. Focal mechanisms determined by both Hi-net and the temporary stations were compared with those determined by only Hi-net stations. As a result, we found that focal mechanisms including the temporary stations are more accurate.

For future study we research the frequency specification of the IC recorder in detail, and determine more focal mechanism solutions in the study area. The problems are whether most of them show the normal-faulting type, and whether the seismic observation system developed in this study is really valuable for the studies of focal mechanism.

Keywords: IC recorder

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On the distribution of seismic foci in the Japanese islands and neighborhoods- About the Wadati-Benioff zone

Hisao Adachi[1*], Yo Akamatsu[2], Yasumoto Suzuki[3], The Research Group of Deep Structure of Island Arcs[1]

[1]Tokyo University of Agriculture, [2]7-3-8 Tamadaira, Hino, Tokyo, 191-0062 Japan, [3]4-4-15 Sugano, Ichikawa, Chiba, 272-0824 Japan

In this presentation we examine features of distribution of seismic foci in the Japanese islands and neighborhoods, and show some examples of seismic units based on the Research Group of Deep Structure of the Island Arc(2009). We will do a few investigation about Wadati- Benioff zone (Wadati,1935; Usami et al.,1958; Utsu, 1974,1986 another).

The distribution of seismic foci in the Japanese islands and neighborhoods

In the area from west part of Kuril islands to Hokkaido the iso-depth focal contours run in the direction of ENE-WSW or NE-SW and get deeper to NW trend gradually. In the area of Honshu and surrounding area, and in the Japan sea, the iso-depth focal contours run in the direction of ENE-WSW or NE-SW and get deeper to NW trend gradually. In Kyusyu and in the Southwest islands and surrounding areas have a tendency to get deeper from the Ryukyu trench to N-W trend. The outline of the distribution of seismic foci is mentioned above, and by examining minutely we found that very often the iso-depth contours are displaced discontinuously. Displaced parts are straight or arc and its length are 10km or more. Units of the distribution of seismic foci are distinguished from the others on the displaced boundary.

The distribution of seismic foci and seismic unit

We will show the seismic unit on the Kuril basin, Izu-Ogasawara islands and adjacent area, and the central Honshu as a few examples.

The seismic unit around the Kuril basin. There is seismic unit shaped like a half basin getting deeper to the center of the basin and it keeps up with the unit of topography of the Kuril basin. The width of the units divided with displacement line like steps are 50-150km. We recognized these small rectangular units and large units. A large unit is formed with several small units.

The seismic unit around the Izu-Ogasawara Islands and neighborhoods. As a whole, in Izu, Ogasawara Islands and neighborhoods, the iso-depth contours show the direction of NS to NNW-SSE direction, but when some units are distinguished by ENE-WSW direction, the stepped displacement lines of EW direction, and the expanse of these units is number 10-200km.

The seismic unit around the center part of the Honshu. In the direction of iso-depth contour lines, ENE-WSW direction can distinguish some earthquakes area to have an expanse of 100-200km by these in NS to NNW-SSE direction in the Honshu central part whereas the general direction changes to the iso-depth contours in the Honshu central part greatly, and the direction of the iso-depth contours in northeastern Honshu.is displaced step-like after the line of NW-SE direction in NS to NNE-SSW direction.

On the Wadati-Benioff zone

The Wadati-Benioff zone is assumed as a board-shaped thing having the thickness that there is often, but it is divided into the small unit (earthquake area, earthquake sub-region, earthquake region; Adachi,2009) of some that was drawn a boundary with by a stepped displacement line near perpendicularly letting block structure. We want to really reexamine the significance of the Wadati-Benioff zone in future.

Members of the Research Group of Deep Structure of Island Arcs : Adachi H., Akamatsu Y., Harada Y., Iikawa I., Kawakita T., Kobayashi K., Kobayashi M., Koizumi K., Kubota Y., Miyakawa T., Murayama K., Ogawa Y., Sasaki T., Suzuki Y., Suzuki Yo. and Yamasaki K.

Keywords: earthquake, seismic foci, seismic unit, iso-depth contour, Wadati-Benioff zone, Japanese islands

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Wave Features Theory II of 2011, 2 NZ Earthquake Motion

Masaru Nishizawa[1]*

[1]none

Japanese only

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Ring-like arrangement of faults accompanied by shallow and deep earthquakes in central Honshu, Japan

Yasumoto Suzuki[1*], Hisao Adachi[1], Yo, AKAMATSU[1], Kensho, IIKAWA[1], Kazyhiro, KOBAYASHI[1], Masahiro, KOBAYASHI[1], Yoshiriro, KUBOTA[1], Keishin, MURAYAMA[1]

[1]4-4-15 Sugano, Ichikawa, Chiba, 272-0824 Japan

The ring-like arrangement of faults accompanied by shallow earthquakes in central Honshu are shown, and runs parallel to those of deep ones, and it must be due to the vertical deep roots of ring-like arrangement.

Asahi, Iide, Echigo and Abukuma Mountains mainly composed of granitic rocks are dormant in shallow and deep earthquakes, though the shallow earthquakes are active in the north part of the mountains. The general trends of faults accompanied by shallow and deep earthquakes encircle the granitic rocks, and suggest the deep vertical roots of those mountains. The faults deduced from the P-wave radiation pattern of shallow and deep earthquakes run parallel to the Quaternary volcanoes.

Hida, Kiso, Ryohaku, Suzuka, Nunobiki, Kasagi, Ikoma and Rokko Mountains composed of granitic rocks are about 400km in E-W direction and 200km in N-S direction. Central part is composed of Cretaceous Nohi rhyolite encircled by the granitic rocks. It is about 60km in N-S direction and about 40km in E-W direction. The boundary is cut by the deep faults accompanied by deep earthquakes. The deep earthquakes encircling the granitic rocks suggest the deep origin of granitic rocks

The general trends of faults accompanied by shallow and deep earthquakes run roughly parallel each other, so ring-like arrangement from shallow to deep is deduced.

Keywords: shallow earthquake, deep earthquake, earthquake mechanism, fault, ring-like arrangement