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

HDS004-01 会場:103 時間:5 月 27 日 10:45-11:00

ブータンの自然災害
Natural disaster in Bhutan

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Natural disasters intensively took place in Bhutan in 2009. For instance, unusual outflow from debris covered glacier, floods and natural damming of a river induced by a cyclone, watery mishap in the river recreation and earthquake struck the country as abrupt and unexpected events. Furthermore, slope failures interrupted the highway traffics, because of steep and geologically fragile slopes. These climatic and geo-hydrologic disasters revealed various risks and issues of the natural hazard in Bhutan.

The authors have been involved in the research project of glacial lake outburst floods (GLOFs) in JICA/JST program since 2009. On the basis of the project, over view of the disaster information and further advisement to the focal sections and persons are necessary.

As for the revealed issues, establishment of weather and seismographic observation network and its information spreading throughout the society are particularly required. Documentation and mapping of experienced various disasters in and around Bhutan are essential. It is also important to mention that technical development and awareness creation regarding hazard mitigation should be enhanced at the national and local governments and community level.

キーワード: 地すべり, サイクロン, 氷河災害, 地震災害, 河道閉塞, 災害管理
Keywords: landslide, cyclone, glacial disaster, earthquake, natural damming, disaster management

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ブータンヒマラヤの氷河湖決壊とその危険性
Glacial lake outburst and hazardous lakes in the Bhutan Himalaya

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In our country has been threatened by glacial hazard such as glacial lake outburst flood (GLOF) as well as the other high mountain region. In order to assess the possibility of GLOF hazard in the Bhutan Himalaya, we observed 27 lakes in the northern Bhutan under the JICA/JST project. In this presentation we will introduce the history of the GLOF hazard in Bhutan and summery of the preliminary result of the GLOF hazard assessment. The field surveys for the evaluation were carried out in/around the lakes in 2009 and 2010 by the authors and tenth other Japanese and Bhutanese researchers. Especially, bathymetric survey achieved to obtain more reliable information for assessing the stability of the moraine dame and flood analyses. Glacial lakes in the researched area show relatively stable at the moraine dam and surrounding slope. However, we need make plans continuous monitoring using satellite data and field observation in the future.

キーワード: 氷河湖決壊洪水, 減災, 危険度評価, 現地調査, 災害実績図
Keywords: GLOF, natural hazard mitigation, risk evaluation, field survey, disaster map

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ESTIMATION OF SLIPRATE AND LOCKING DEPTH ON ACTIVE FAULT BASED ON GPS SURVEY IN ACEH PROVICE

ESTIMATION OF SLIPRATE AND LOCKING DEPTH ON ACTIVE FAULT BASED ON GPS SURVEY IN ACEH PROVICE

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The potential seismic hazard along the Sumatran fault after the Great Sumatra Earthquake of 2004 was influenced by the factors such as: distribution of coseismic and postseismic activity following the 2004 earthquake, and the coulomb stress change caused by postseimic and coseismic displacement. These factors have increased the likelihood of an earthquake of magnitude more than 5 Mw occurring in the north segment of Sumatra Fault.

Campaign and Continuous GPS observations were made to monitor the crustal deformation caused by the 2004 Aceh earthquake. Data processing results show that the postseismic deformation activity is still ongoing in Aceh. Displacement due to postseismic deformation is 0.6 m in the EW direction at the point of ACEH. Estimation of slip rate for the Aceh segment of the Sumatra Dault is 2 mm / year, that of the Seulimum segment is 2 mm / year, and of the Tripa Segment is 3.5 mm/year, with about 10 km of locking depth

キーワード: Postseismic deformation, active fault, slip rate
Keywords: Postseismic deformation, active fault, slip rate

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Five Years Geodetic GPS observation in the West of Java Island
Five Years Geodetic GPS observation in the West of Java Island

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West of Indonesia is region of the plate boundary between the Australia plate and Sunda plate is seismically highly active. Subduction of great tectonic plates continues further south and east/southeast along the great Sunda Trench. The normal subduction below Java is characterized by the development of typicalfore-arc basins while oblique subduction beneath Sumatra results in partitioning of the convergent motion into thrust and strike-slip faulting. Along the arc, the age and thickness of the lithosphere increase considerably from west to east; from 49?96 Ma below Sumatra to the west to 96?134 Ma below Java. Subduction of great tectonic plates

The activity of local fault can be inferred from six time GPS campaign observation in West Java, 2006 (December), 2007 (August), 2008 (August), 2009 (June and August) and 2010 (August) as a sinistral motion of Cimandiri fault and dextral Lembang fault control the deformation pattern in West Java. Using simple elastic half-space model we estimate geodetic slip-rate of Cimandiri fault is 6mm/yr and 3mm/yr for Lembang fault. This result also suggest that the interplate coupling is very weak or if any it only extend at very shallow portion (less than 10 km) which is very diffult to be detected by inland GPS network that located 250 km away from the trench.

キーワード: Geodetic observation, West Java, Strain Accumulation
Keywords: Geodetic observation, West Java, Strain Accumulation

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A10絶対重力計によるインドネシアでの地盤沈下・地殻変動モニタリング（第２報）
Application of A10 absolute gravimeter for monitoring land subsidence and crustal movement in Indonesia (the 2nd report)

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In many of the urbanized cities in Indonesia, one of the urgent problems is land subsidence mainly due to excess pumping of groundwater. In Jakarta, for instance, the recent GPS surveys conducted by ITB have revealed the significant subsidence along the northern costal area with the rate of more the 10 cm/yr. It has been also reported that more than 10 cm/yr land subsidence is in progress in some areas in Bandung. In West Java, there are some active faults (e.g. Lembang fault) whose tectonic activities may cause crustal movements. These land movements can be measured by present-day space geodetic techniques, such as GPS and InSAR. In addition, precise gravity measurements can provide useful information to understand the mechanism of the movements, because they reflect the underground density changes or mass movements.

In order to detect the gravity changes associated with the land movements in West Java, we have been conducting gravity measurements with a field type absolute gravimeter, Micro-G LaCoste Inc. (MGL) A10 since 2008. The outline of the absolute gravity measurements and the survey areas have already been reported at the 2010 JpGU meeting. In this paper, we reports the surveys conducted in 2010 and some results obtained so far.

The gravity measurements in 2010 have been conducted from July 15th to August 5th. Practically the measurements in Jakarta and Bandung have been carried out from July 22 to 25 and from July 31 to Aug 3, respectively. We employed both A10-07 and a Scintrex gravimeter for the measurements as same as before. In addition, we tried to occupy the same points as many times as possible to confirm the repeatability of the measurements. A note is that some of gravity points in Jakarta were lost mainly due to road construction. We therefore set up a couple of new points, in particular near the coastal area where large subsidence has been observed. The GPS measurements, on the other hand, have successfully been carried out by the ITB team from late June to the end of July.

During the survey before 2009, we experienced several technical problems on the absolute gravity measurements, particular on the field measurements in high temp and humid condition. We suspected these problems are mainly due to voltage drop of the DC batteries and thermal effects on the computer system for control and data acquisition. Therefore, this time, we directly used the car battery with the engine on during the measurements and tried to keep the computer cool with a PC cooling pad. All these efforts almost overcome the problems so far, and we could get the data as good as those obtained in normal condition. On the other hand, we found some offsets or drifts in the absolute gravity values obtained. This means that the absolute values need calibration, and we corrected the values afterwards by comparing the reference values measured in Japan.

The result of the GPS measurements in Jakarta show the same subsidence pattern as before, i.e., more than 10cm/yr subsidence along the northern coastal area. The gravity measurements show the same tendency, although the number of available gravity points are limited. The comparison between the height changes and the gravity changes shows more like the gradient of water density. However the uncertainty is still large and we need further data accumulation for more precise conclusions.

The gravity changes in Bandung also show the similar spatial pattern with the GPS data. However the quantitative comparison is still difficult. One of the reason is that many of the gravity points are not completely same points as the GPS points. This should be considered in the future surveys.
Keywords: absolute gravimeter, land subsidence, crustal movement, GPS, Indonesia

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タラン火山の活動と周辺の構造性地震との関係
Relation of volcanic activity of Talang volcano with tectonic earthquakes

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Talang volcano is located in Solok district, West Sumatera, Indonesia. It consists of North and South craters and rises to 2597 m above sea level. Eruptions in 19th century were characterized by magmatic eruptions after the first historic record in 1833 with black ash plume and glowing lava emerging near Jantan peak. Magmatic eruptions repeated in 1843, 1845, and 1883. After dormant period in 20th century, eruption style of the volcano has changed to phreatic eruption in 21th century. The eruption occurred at Gabuo atas crater and formed hot spring pond. Phreatic eruption then repeated in 2003, 2005, and 2007. Relation of eruption of the volcano with large tectonic earthquakes was firstly recognized by a phreatic eruption on April 12, 2005 at the volcano. The eruption occurred 2 days after Mentawai earthquake (Mw 6.7) with epicenter distance about 147 km from the volcano. Increase in volcanic activity repeated after occurrence of large tectonic earthquakes in surrounding area of Talang Volcano, such as Padang earthquake (Mw 7.6) on September 30, 2009. Deep volcanic earthquake increased up to 79 events and shallow one increased up to 40 events. Interaction of large tectonic earthquake with volcanic activity at Talang volcano was shown by increasing seismicity or eruption. The hypocenters of the tectonic earthquakes were located near West Sumatera subduction zone or Great Sumatera fault. The increase in volcanic activity was triggered by tectonic earthquake with intensity more than III on MMI scale at the Talang volcano. Intensity of Talan's ground motion by Mentawai earthquake (Mw 6.7) 2 days prior to phreatic eruption on April 12, 2005 was V on MMI scale. Intensity of ground motion of Padang earthquake (Mw 7.6) on September 30, 2009 was VI on MMI scale at the volcano. In contrast, Talang volcano showed no increases in seismicity and eruptivity after the Mentawai Earthquake (Mw7.7) on October 25, 2010. The MMI scale at the volcano was only III. It was suggested that volcanic activity of Talang volcano was affected by large tectonic earthquake with intensity more than III on MMI scale.

Similarly to Talang volcano, Guntur volcano is located near active faults (Cimandiri, Lembang, and Baribis faults) and subduction zone. Subduction zone at southern part of Guntur volcano was a source of destructive earthquakes. On July 17 2006, Pangandaran earthquake (Mw 7.7) occurred and was felt at Guntur volcano with intensity III on MMI scale, however it was followed by increase in neither seismicity nor eruptivity. Similarly there was no change of seismicity when Tasikmalaya earthquake (Mw 7.0) struck south region of West Java with MMI III on September 2, 2009.

Talang volcano is more susceptible triggered by tectonic earthquakes than Guntur volcano. Active geothermal systems beneath the volcanoes become important factor for triggering phreatic eruption. However, magmatic systems of the volcanoes may still in normal stage. Intensity of the ground motion caused by the large tectonic earthquakes and previous condition of the volcanoes take important role in triggering increase in seismicity or eruption of volcano.

Keywords: Talang volcano, volcanic activity, tectonic earthquake, MMI

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The 2010-2011 Eruption of Bromo Volcano, East Java, Indonesia
The 2010-2011 Eruption of Bromo Volcano, East Java, Indonesia

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As one of active volcanoes in East Java, Bromo volcano located at Tengger Caldera which administratively belongs to Probolinggo Regency. Based on the historical eruptions, the volcano was dominated by phreatic eruption. The eruptions were generally preceded by volcanic tremor as happened in 1995 and 2004. After the eruption in 2004, the volcanic activity was only showing gas emission from the crater.

The precursor changed when the volcanic activity of Bromo volcano started to increase in November 2010. Initially, the color of emission changed from thick whitish to grayish on November 8th. One hour later number of volcanic earthquakes gradually increased. The first phreatic eruption occurred on November 20th. On November 23rd, two eruptions took place which were also accompanied by tremor. The alert level of Bromo volcano was increased to level III (SIAGA) and 7.5 hours later the level was upgraded to the level IV (AWAS). The rapid upgraded was caused by enlarging in amplitude maximum of tremor from 5 mm until 30 mm. The intensity of the eruption gradually decreased and CVGHM decided to downgrade the status to the level III (SIAGA) on December 6.

The eruption is still ongoing until now. The seismograf has recorded tremor with the maximum amplitude varying between 5-40 mm. Until the middle of December, the crater ejected thick grey-brownish ashfall ranges from 400-2000 meter height. Late December, incandescent volcanic material that visually observed was emerged from the crater and pumice that was also ejected. That event indicates that the eruption of Bromo became magmatic. However, the alert level is still in level III (SIAGA). CVGHM has recommended not entering the danger zone with 2 km in radius from the crater.

キーワード: Bromo volcano, Phreatic Eruption, Magmatic, Volcanic earthquake, Tremor
Keywords: Bromo volcano, Phreatic Eruption, Magmatic, Volcanic earthquake, Tremor

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EVALUATION OF OF SINABUNG VOLCANO ERUPTION AUGUST- SEPTEMBER 2010

EVALUATION OF OF SINABUNG VOLCANO ERUPTION AUGUST- SEPTEMBER 2010

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Sinabung Volcano located at Karo District, Province of North Sumatera, geographically its summit lies at 03deg 10min North and 98deg 23,5min East. The peak has elevation of 2400 m.asl. The eruption history of Sinabung Volcano does not known well. On August 27, 2010, phreatic eruption occurred. It was a first eruption that continued by another eruption series on August 28, August 29, August 30, September 3 and September 7, 2010. The eruption produced volcanic ash and 1-5 km height of eruption column.

Some methods were conducted to monitor the volcanic activity of Sinabung Volcano such as seismic, geochemistry and deformation using EDM (Electronic Distance Measurement) and Tiltmeter. Seismic monitoring conducted continuously from 4 (four) seismic stations. Three stations use 1 component seismometer while other use 3 components.

The recorded seismic event consist of : Tectonic earthquakes, Local Tectonic earthquakes, Deep-Volcanic earthquakes, Shallow-Volcanic earthquakes, Emission earthquakes and Tremor earthquakes. Hypocenter distribution before eruption on September 7 separated below the crater and north part of Sinabung Volcano with depth of 1-6 km from the summit. After the eruption, it was concentrated precisely below the crater with 1-5 km depth. At the time when volcanic activity decreases (end of September ? October 2010), earthquakes accumulated at Northeast part with depth of 1-9 km. This indicated that the source of earthquakes not only from the volcano itself, but also possible influenced by local tectonic activity that occurred at Northeast highland of Sinabung Volcano.

Flux of SO2 that was measured simultaneously with the eruption showed sizeable and high pressured volcanic degassing. Result of water chemistry analysis from some water samples around Sinabung Volcano showed high concentration of bicarbonate (HCO3-), chloride (Cl), sulphate (SO4), and natrium (Na). This indicated the presence of hydrothermal system below the conduit of Sinabung Volcano and also minor magmatic supply.

Tiltmeter measurement noted that there was no significant changes on both radial and tangential components during August-September 2010. It was assumed that pressure equilibrium changes gradually and as implication of this condition, the emission activity at the crater is still ongoing intensely.

Distance measurement with EDM showed slight correlation between slope distance changes and time. From this result, it was assumed that rate of energy release occurred gradually and will take a long time. Deformation at Sinabung Volcano not only as implication of internal energy release but also sensitive to regional tectonic activity, mostly for earthquake that has magnitude more than 5 Mw.

The activity of Sinabung Volcano is getting down this time. Visual observation, seismic activity and deformation monitoring show decreasing activity. However, phreatic eruption and lahar flow is still potentially occurr. Some mitigation efforts conducted to antisipate the future eruption, such as establishment The Observatory Post of Sinabung Volcano that full equipped with monitoring equipment, construction of Geologycal map and Volcano Hazard map, distribution of information and coordination with Local Government.

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Urgent multi-disciplinary survey for the effects of tsunami from the Mentawai, Indonesia, earthquake on 25 October 2010

Urgent multi-disciplinary survey for the effects of tsunami from the Mentawai, Indonesia, earthquake on 25 October 2010

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We carried out field survey of tsunami from the 25 October Mentawai, Indonesia, earthquake in North and South Pagai Island. It was a multi-disciplinary survey supported by ongoing collaboration project between Indonesia and Japan, titled as Multi-disciplinary Natural Hazard Reduction from Earthquakes and Volcanoes in Indonesia. The main objectives of the survey were to measure physical aspects of tsunami, such as tsunami heights, inundation distances and characteristics of tsunami deposits, summarize human and property damage, and interview human and social reaction to the tsunami, i.e., if the tsunami warning messages reached to coastal community and how people reacted. The main findings of the survey was summarize as follows.

1. The tsunami heights were measured at eight localities on the west coast of North and South Pagai Islands. Thirty-eight measurements range from 2.5 to 9.3 m, but mostly 4 to 7 m. The tsunami inundation was more than 300 m at three locations.

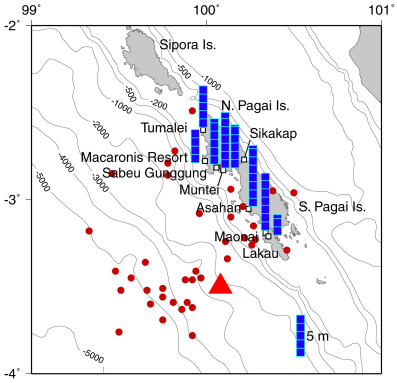
2. This earthquake was a tsunami earthquake, which produced weak shaking but large tsunamis. While initial magnitude was 7.2, analysis of long period seismic wave indicated the long duration and larger seismic moment (Mw 7.8), hence a possibility of large tsunamis. Such broadband seismic analysis of should be included in the tsunami warning system.

3. The tsunami deposits sampled at 4 to 6 sites along transects at three locations are described. The deposits are mostly coarse to medium sand, 5 to 26 cm thick, and composed of 2 to 5 units. Many units show normal grading and moderate sorting. The thickness is variable along profiles affected by local topography, but grain size generally shows finer landward.

4. Residents felt and many were awaken by earthquake, but they reported that the ground shaking was weaker than the 2007 Bengkulu or 2009 Padang earthquake. Because these earthquakes did not cause tsunami damage, many residents did not expect tsunami. Many people heard loud sound of tsunami, and escaped to inland.

5. The official tsunami warning from BMKG reached the Mentawei regency office, but did not reach coastal communities because of lack of communication tools. However, some coastal residents were watching TV and saw running text of tsunami warning (5 to 18 min after the earthquake, according to BMKG summary). Therefore, early warning message through television should be enhanced.

6. Numbers of casualties dramatically vary from place to place. Nearly a half of villagers lost their lives at some communities, but a few at other communities. Tsunami education, repeated drills, proximity to high ground, and a three-story tower seem to make the dramatic difference.



Keywords: Tsunami, field survey, Mentawai, tsunami earthquake, tsuami deposit, Indonesia

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Sedimentological Characteristics Of The October 25, 2010, Mentawai Tsunami
Sedimentological Characteristics Of The October 25, 2010, Mentawai Tsunami

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On October 25, 2010, at 9:42 pm local time, an Mw7.7 earthquake occurred off Mentawai islands, about 120 miles W of Bengkulu, Indonesia. The earthquake generated tsunami and caused severe damage at the coasts of the islands, and killed more than 450 people. From November 6 to 9, we carried out a post-tsunami field survey, as a part of SATREPS project 'Multi-disciplinary natural hazard reduction from earthquakes and volcanoes in Indonesia' supported by JST and JICA. The survey team consisted of four Japanese and five Indonesian scientists, and was led by Prof. Kenji Satake. We visited nine sites located along the western coast of North and South Pagai Island, and revealed that the tsunami heights are mostly between 4 and 7 m there. Here, we report result of our sedimentological study of the tsunami deposits at four sites in Pagai Islands: Sabeu Gunggung, Muntei Barubaru, Macaronis resort, and Tumalei. At each site, the thickness and sedimentary characteristics of the tsunami deposit were measured and observed along transect and samples for laboratory analysis were collected. The tsunami deposits at Sabeu Gunggung, Macaronis resort and Tumalei are mainly composed by medium to coarse sand-sized fragments of corals, shells of mollusca and foraminifera. At Muntei Barubaru, the tsunami deposits are mostly composed by very coarse sand and gravel-sized deposits. Thickness of the tsunami deposits are ranging from 5 to 26 cm. The tsunami deposits consist of two to five units, and the units show both fining upward and coarsening upward trends, with fining upward dominating. Cross bedding structures are present at Tumalei transect. Mud clasts are found at the most landward points at Macaronis resort. Local topography noticeably affects the thickness, number of layers, and distribution of tsunami deposits along transect. The tsunami deposits do not show consistent landward decrease in thickness, but the grain size shows finer landward. Erosion features widely occurred at Sabeu Gunggung and Muntei Batubaru. At all sites, Amphistegina lesonii and Neorotalia calcar dominating the foraminifera content. These two species live at the shallow depths of less than 30 m. These two species indicate that the tsunami likely entrained most of the sediment in shallow depth. The foraminifera assemblage and diversity varies at each point, along transect and at each transect. Thus, the Mentawai tsunami deposits show complex characteristics. Understanding of these modern tsunami deposit characteristics will improve the clue to the recognition of paleotsunamis.

キーワード: sedimentology, tsunami deposits, grain size, foraminifera, Mentawai
Keywords: sedimentology, tsunami deposits, grain size, foraminifera, Mentawai

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南琉球列島の津波災害史の復元 -津波石ハマサンゴの放射年代測定によるアプローチ-
Reconstruction of past tsunami disasters: Evidence from radiometric dating of Porites coral boulders in Southern Ryukyus

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過去の津波災害がいつ・どの程度の規模で起こったか、またどの位の周期で襲来したのかを知ることは、現在の防災対策および将来予測を行う上で重要である。そこで本研究では、琉球列島の海岸に広範囲に分布している『津波石』と呼ばれる、過去の津波で打ち上げられた化石サンゴに注目した。サンゴは打ち上げられた際に死んで成長が止まるため、津波で打ち上げられた化石サンゴの新鮮な表面を採取し年代測定を行うことで、化石サンゴが打ち上げられた年代、つまり過去の津波イベントの年代を求めることができる。

いくつかの先行研究にて津波石の ^{14}C 年代値が報告されているが、年代測定用のサンプル選定や ^{14}C 年代値の暦年代への較正方法などに関して問題点が多かった。そのため、古文書記録に記載されている複数の浸水イベントのうちどの歴史津波で津波石が打ち上がっているかの推定は困難であった。本研究では津波石の中でも、同心円状に成長するため群体最上部が打ち上げられた時期に一致するハマサンゴ群体に着目した。また、津波石ハマサンゴに対して高精度かつ高確度な年代測定法を適用することで、正確にどの歴史的高波イベントで津波石が打ち上がっているかを決定した。

まず、現在サンゴ試料に対して最も精度の高い年代測定法である U/Th 年代測定法を、ハマサンゴ津波石という日本の津波堆積物に初めて適用した。その結果、1771 年に発生した明和津波で津波石が打ち上がっていたことを実証するとともに、1625 年に発生したとされる原因不明の高波イベントの痕跡を初めて科学的に発見した。

また、125 個の津波石ハマサンゴ試料の ^{14}C 年代測定を実施し、新たに求めた較正データを用いて正確な暦年代較正を行った。その結果、複数の巨大な津波石ハマサンゴが明和津波起源であることを明らかにした。この結果は、明和津波の水理量を推定するのに有用な巨礫移動モデルを適用するのに役立つ。さらに、様々な場所で新たに明和起源の津波石を発見した。これらの発見は、現在でも未解明な明和津波の波源や原因を解明する上で必要である、津波波源モデルに制約を与える事ができる新しい知見である。

77 個の津波石ハマサンゴの ^{14}C 年代測定結果から、1771 年の明和津波や 1625 年の古津波イベントだけでなく、2000 年以上前から様々な年代で打ち上げられていることがわかった。この ^{14}C 年代値の確率分布の総和をとることで、古津波イベントがどのタイミングで起きているかを検証した。その結果、1771 年や 1625 年以外にも複数の津波イベントが確認でき、南琉球列島において約 150-400 年の周期で津波石を打ち上げている高波イベントが発生していることがわかった。また、1460 年代頃や 1200 年前後の津波イベントは古文書記録にも記載されていない地元の言い伝えによる伝説の津波と一致し、その他にも有史以前のピークも検出できた。今回の結果は、伝説の津波に関する初めての証拠である。

このように、津波石ハマサンゴに放射年代測定法を用いることで、歴史津波だけでなく、有史以前の津波も認定できることがわかった。また、過去の津波災害研究に対して津波石ハマサンゴを使うという有益な方法を開発することができた。

キーワード: 津波石, ハマサンゴ, U/Th 年代測定法, 14C 年代測定法, 古津波, 南琉球列島
Keywords: Tsunami boulders, Porites spp. coral, U/Th dating, Radiocarbon dating, Paleo-tsunamis, Southern Ryukyu Islands

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HDS004-12 会場:103 時間:5 月 27 日 15:00-15:15

Tsunamigenic Rate of the Pacific Ocean Earthquakes
Tsunamigenic Rate of the Pacific Ocean Earthquakes

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Pacific Ocean is the location where three?fourth of the total number of tsunami had occurred. Countries surrounding this Pacific basin suffered from many tsunamis and killed great number of life. Problem occurs when earthquake information has issued, for example, what is a potential of a tsunami generation for such an earthquake magnitude or focal depth is known? This study proposed Tsunamigenic Rate (TR) which is defined as the ratio between the number of earthquake?generated tsunamis and the total number of earthquake occurred.

This study considers the NGDC database which contains earthquake event of 200 B.C. to present (from year -193 to 2010). The earthquake event excludes an event that the epicenter located longer 50 km from a shoreline. Total number of tsunami associated event is 743 and tsunami was not associated event is 735 leads to the total number of 1,478 events. Consequently, the Tsunamigenic Rate (TR) is calculated from earthquake event of the magnitude varies from 5.0 to 9.0, focal depth is as deep as 200 km and sea depth is as deep as 7,000 m. The Pacific Ocean is geographically divided into 9 regions namely, New Zealand?Tonga (NZT), New Guinea?Solomon (NGS), Indonesia (IND), Philippines (PHI), Japan (JAP), Kuril?Kamchatka (K?K), Alaska?Aleutians (A?A), Central America (CAM) and South America (SAM).

Results support that greater earthquake magnitude and shallow focal depth has high potential to generate tsunami with high tsunami height. The average TR in Pacific Ocean is 0.50 where TR for each region varies from 0.35 (CAM) to 0.68 (NGS). TR for each region was calculated and shows the relationship with the three influence parameters namely, earthquake magnitude, focal depth and sea depth. The Tsunamigenic Rate will help ascertain one decision for a tsunami generation of each earthquake event based on a statistical basis of the historical data and decision support tool during an early tsunami warning stage.

キーワード: Earthquake, Tsunami, Pacific Ocean
Keywords: Earthquake, Tsunami, Pacific Ocean

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チラチャップ（インドネシア）での想定巨大地震による津波数値計算と津波災害リスク評価
Tsunami simulations for expected great earthquakes and risk evaluation of tsunami disaster at Cilacap in Indonesia

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As a part of the JST-JICA project,"Multi-disciplinary Hazard Reduction from Earthquake and Volcanoes in Indonesia", tsunamis from expected great earthquakes are computed and a risk of disaster from those tsunamis at populated areas along the coast are planned to be evaluated.

Cilacap is one of the most populated towns in the Indian coast of Java. Recently, the 2006 West Java earthquake (Mw7.7) occurred as a tsunami earthquake and generated large tsunamis and caused the severe tsunami disasters at Pangandaran. Fortunately, the tsunami at the city of Cilacap was small, about 2m, because Nusa Kambangan Island protected the city of Cilacap from the large tsunami came from southwest. In this paper, the tsunami inundation heights and areas estimated at the city of Cilacap from several expected underthrust earthquake models along the Java subduction zone are presented.

For this research, available bathymetry data (such as ETOPO1, navigation charts and detailed survey data) and topography data (such as SRTM data and topography data from Bakosurtanal) were first collected for the detailed tsunami computation. To get more detailed bathymetry data and topography data, including building classification, near the populated areas at Pangandaran and Cilacap, the field surveys were conducted in 2010. The depths were continuously recorded by an echo sounder with GPS system installed in rented small boat. The navigation speed of boat was less than 10 km/h. At Pangandaran, we have collected the bathymetry data in the west coast area (3 km x 2 km) along almost 8 track lines. Each track line is about 2 km long and the direction is north-south perpendicular to the coast line. At Cilacap, we have collected the bathymetry data in the east coast area (4 km x 3 km) along 7 track lines. Each track line is about 4 km long and the direction is east-west perpendicular to the east coast.
The non-linear shallow water equations were numerically solved on a staggered grid system using a finite difference method applying a moving boundary condition. Nested grids were also used for the tsunami computation. To make a realistic source model, we first study tsunami generated by the 2006 West Java earthquake. We estimate the best source model which explains the inundation heights along the coast of Pangandaran Based on the source model of the 2006 West Java earthquake, several fault models off Cilacap along the Java subduction zone are assumed.

Preliminary tsunami numerical computation using the assumed fault model off Cilacap with a moment magnitude of 8.5 indicates that many houses in the city of Cilacap are flooded by the tsunami.

Keywords: Cilachap, Tsunami numerical simulation, Tsunami disaster, Large earthquake

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Tsunami Risk Perception in Questionnaires and its use for the Modeling of Start Time Evacuation Behavior

Tsunami Risk Perception in Questionnaires and its use for the Modeling of Start Time Evacuation Behavior

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Questionnaires are a popular and fundamental tool for acquiring information on human behavior, public knowledge and perception of risk [2]. There is a lack of research in tsunami human behavior [1] specially on the start time decision for evacuation, even though a great improve on technology for early warning has been achieved, still some people decide not to evacuate from tsunami [4,5]. Most of survivals who did not evacuate give as a reason, the fact that the sea did not retreat, no information or warning confirmation came, or they considered themselves in a safe place already, etc. [3]. It is true that, if we do not consider cognitive aspects of the human being during the process of evacuation, the results provided by such models might be far from reality [6]. In this study, Risk Perception (RP) was the key for the construction of the model of start evacuation decision. RP is a subjective judgment of a risk, an idea of how risk could be the situation. It was treated as a dynamic level, from a moment of no threat through a decision stage in which an alteration of the environment is perceived and risk perception rises until the individual has to consider an action (e.g. evacuate or not), this, based on experience, social or external sources of influence and time pressure; and finally enters a last stage of risk recognition where the decision becomes a protective action. For this, a Tsunami Evacuation Behavior Questionnaire was conducted in La Punta, Peru. Risk perception level was calculated for each individual and a risk perception framework for evacuation decision was integrated into a model and verified with actual data from questionnaires. Reference Risk, Prospect Reference Theory, Subjective Judgment Matrices and Bayesian Learning were used as tools to construct this Risk Perception Framework for Tsunami Evacuation Decision. An improvement on predicted times for the sample group was obtained in comparison with traditional models [7]. The proposed risk perception model of decision shows consistency and a promising future in human behavior modeling for tsunami events.

Acknowledgments
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キーワード: human behavior, risk perception, tsunami evacuation, tsunami modeling
Keywords: human behavior, risk perception, tsunami evacuation, tsunami modeling

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Improvement on tsunami casualty model and its application as the basic approach to design tsunami evacuation route

Improvement on tsunami casualty model and its application as the basic approach to design tsunami evacuation route

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An improvement of tsunami casualty model by utilizing better description of human body based on anthropometry data was conducted to obtain better understanding about human ? flow interaction that lead to tsunami casualty. The absence of the model verification from previous researches is now fulfilled. The proposed model is applied in Padang city, Indonesia, to assess the feasibility of roads that will be used for tsunami evacuation. The city is under threat of possible giant tsunami in the future due to the existing seismic gap in Mentawai fault zone. The term of Tsunami Casualty Index (TCI)is used to express the ratio of the time of tsunami inundation that lead to a dangerous situation to human, with the total time of the tsunami inundation. The roads with TCI more than 50% obtained from the model should be considered to be avoided during evacuation. In such areas, additional tsunami evacuation shelter may be needed by the community the possibility of tsunami casualty in the respective areas.

キーワード: Tsunami casualty model, evacuation, tsunami casualty index
Keywords: Tsunami casualty model, evacuation, tsunami casualty index

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HDS004-16 会場:103 時間:5 月 27 日 16:00-16:15

The Influence of Mentawai Tsunami to Public Policy on Tsunami Early Warning
The Influence of Mentawai Tsunami to Public Policy on Tsunami Early Warning

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Tsunami hit Mentawai Islands on the night of October 25, 2011. All the affected are in Mentawai Municipality Administration which consists four main islands, Siberut, Sipora, Pagai Utara (North Pagai) dan Pagai Selatan (South Pagai). As the epicenter of the earthquake was south-west to the islands, the damaged areas concentrated on the west coast and became severe to the south.

From the prespective of tsunami warnings, on Mentawai event the requirements for an effective early warning were only partially fulfilled. In order for an early warning to save lifes, it should be (1) true and reliable, (2) timely and provide sufficient time evacuation, (3) able to reach every single individuals without exceptions, (4) clear and understandable, and (5) followed and obeyed. For Mentawai-case, first requirement was achieved. Some of the survivors even witnessed the running-text on television informing the potency of tsunami generating. Part of the second requirement was also effective, although due to geographical condition, time for evacuation were very limited. Unfortunately, the rest of warning requirements failed and live losses were more than 400 people.

There were two other important facts which confirmed by surveys carried out by experts shortly after the tragedy. Firstly, the earthquake was not felt very shaking, especially in comparison to nearby event on September 12, 2007 and November 30, 2009 where tsunamis were absent. This fact lead to the suprising existence of tsunami earthquake which was not recognised before in the west of Sumatera Island.

Secondly, it can also be seen in the event the absence of local wisdom in saving lifes. In the contrary to Aceh tsunami, December 2004 when local wisdom saved many lifes at Seumeulue Island, there is no such mechanism can be observed in Mentawai.

The facts above then provided important inputs for policy making process. The process was initiated by defining policy environment, its key actors and target groups and how all of these elements inter-related. Before it is formulated, the dynamics of the public policy was also considered to reduce the contradiction with the existing one. It is clear that root of the problems are the poverty in the areas which leads to high vulnerability. Therefore, government institutions are encouraged to set-up plans within their own mandates to overcome the problems should tsunami hit again in the future. A formal legal basis in the form of President's Instruction was then urgently needed to underline and emphasize the synergy among institutions to strengthened tsunami early warning in Indonesia.

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HDS004-17 会場:103 時間:5 月 27 日 16:30-16:45

メンタワイ津波地震で露呈したインドネシア社会の災害脆弱性について
Disaster vulnerability revealed by the 2010 Mentawai tsunami earthquake in Indonesian society

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A tsunami earthquake occurred off the Mentawai Islands, Indonesia on 25 October 2010, and its tsunami claimed around 445 lives and devastated western coastal villages. The proximity of epicenter to Pagai Islands made a fast arrival of tsunami at a rainy night. According to BMKG (Metrological Climatological and Geophysical Agency in Indonesia), seismic wave magnitude was M7.2. However, the tsunami heights were 4 to 7m, lager than that expected from the magnitude.

As an emergency response to the disaster, a group of researchers from Japan and Indonesia carried out a collaborative survey in Pagai Islands. The objectives of the survey include to measure physical characteristics of the tsunami, to interview government and United Nations (UN) personnel for emergency relief situation, and to interview local refugees and residents for their reactions. We interviewed approximately 120 persons and distributed about 50 questionnaire sheets at 10 coastal villages. The questionnaire consists of 17 questions, including location, earthquake shaking, people's action before the tsunami, casualties, their opinions for many casualties and on a safer future against tsunami. Other important information not listed in the questionnaire was also obtained during the survey.

The interviews revealed that the first aid was late because of remote area, bad weather and high waves immediately after the disaster, limited transportations, and late recognition of the damage situation. For the first seven days, the main relief center was in Padang, west Sumatra, where the resources were gathered. Because South Pagai Island does not have harbor, space for plane/ helicopter landing, nor appropriate road system on land, transportation of relief was done by ships in high waves. After seven days, the government moved the center to Sikakap in South Pagai Island. The government added helicopter distribution to support sea transportation. Because the Merapi volcano erupted in east Java Island on 26 Oct 2010, emergency relief aid had to be divided to two locations in Indonesia. The cluster approach system for disaster, which has been initiated by UN, was not effective for the weather condition and remote area in Mentawai islands. Small NGOs could not charter ships and helicopters. Logistics had to depend on big organizations, especially Indonesian Red Cross, Indonesian army and UN. Many volunteers and some small NGOs stayed in Sikakap and returned without doing any activity.

The 2010 Mentawai tsunami earthquake revealed Indonesia's vulnerability for natural hazards. Countermeasures of tsunami were not enough. Tsunami early warning system has been developed by international society after the 2004 Indian Ocean tsunami. The official warning from BMKG reached the Mentawai regency office, but did not reach local communities due to lack of communication tools. Some residents saw running text of tsunami early warning on TV. However, the communities speak local dialect and some of them especially women cannot read characters. It was doubtful all of them could read the text of tsunami early warning. Education to mothers is necessary to protect their children against natural disaster.

The lesson from this survey is that the Indonesia and international societies have to prepare for complex disaster in different places, as well as disaster at remote areas. Therefore, a main relief center for emergency response need to be established close to disaster area as soon as possible. It is also time to change tsunami early warning system, correct education and emergency relief assistance to seamlessly reach vulnerable people.

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キーワード: 津波地震, 災害脆弱性, 防災教育, 早期警戒警報システム, 緊急救援, インドネシア
Keywords: tsunami earthquake, disaster vulnerability, education, early warning system, emergency relief, Indonesia

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Earthquake Safer Housings and Buildings: Strength Evaluation of Existing Structures
Earthquake Safer Housings and Buildings: Strength Evaluation of Existing Structures

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Important thing in seismic resistant structures is evaluating the seismic strength of existing structures. For important and expensive structures, structural health monitoring is applied by putting sensors capable of detecting any changes in the structures. Any changing in stiffness, mass, and damping of the structures is considered as symptoms. Fortunately, important structures are built with very strict supervising method so that the detail of the building is recorded in the as-built drawing.

For most developing countries, usually the drawing itself is not well kept. Even if it is kept in a safe place, the drawing and the actual building are usually not the same. Steel reinforcement inside the concrete makes it the source of in-appropriateness because it is hidden in the concrete. Building a structure that really follows the detailed engineering drawing is not usually the case for budget structures. For the sake of practicality, material availability, and rising cost, structures are usually built different from what it was stated in the engineering drawing.

Learning from that, it is important to apply a method that is capable of diagnosing the health of a structure. Methods for evaluating the strength of structure usually consist of two steps. First step is for obtaining data and second step is for making a numerical model based on the obtained data.

In this paper, experiences in carrying out strength evaluations of existing structures for seismic safety are shown and important findings are highlighted.

キーワード: existing structures, seismic resistant, strength evaluation, seismic code, structural analysis
Keywords: existing structures, seismic resistant, strength evaluation, seismic code, structural analysis

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The Roles of Local Wisdom in Times of Post Disaster:Lessons Learned from the Bantul Earthquake

The Roles of Local Wisdom in Times of Post Disaster:Lessons Learned from the Bantul Earthquake

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The District of Bantul, Yogyakarta, is geologically and geographically vulnerable to earthquake, indicated by the 2006 earthquake that caused a significant socio economic impact to its people. The community experienced difficulty in providing their basic needs, especially during critical conditions, the first three days after the earthquakes, when relief from the government and other donors had not been received. An assessment using a qualitative approach informed that local wisdom played an important role for the community survival strategies. The communities looked for and prepared their needs, particularly food, health care and shelter by themselves with other members of neighborhoods (RT) and/or the community groups (hamlet/Dukuh). Their activities were strongly supported by the existence of local wisdom, such as community self helpfulness (tolong menolong) and cooperation (gotong royong), and sense of togetherness in facing disaster, care about each other, mutual response and endeavor. Their emergency responses were assisted by local institutions, both formal (RT, RW, hamlets and villages) and non formal (kinship and paguyuban). The government, particularly district and provincial government, with their relevant policies and programs and the leadership of the head of the district and Sultanate of Yogyakarta, also had a high contribution to the community recovering process, such as in the provision of their basic needs (food, health care and shelter).

キーワード: Local Wisdom, Community, Survival strategy, Local institutions, Earthquake, Disaster
Keywords: Local Wisdom, Community, Survival strategy, Local institutions, Earthquake, Disaster

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HDS004-20 会場:103 時間:5 月 27 日 17:15-17:30

インドネシアのアチェおよびジョグジャカルタにおける災害復興に対するコミュニティ機能の比較検討
Comparing community functions for the post-disaster reconstruction in Aceh and Yogyakarta Regions of Indonesia

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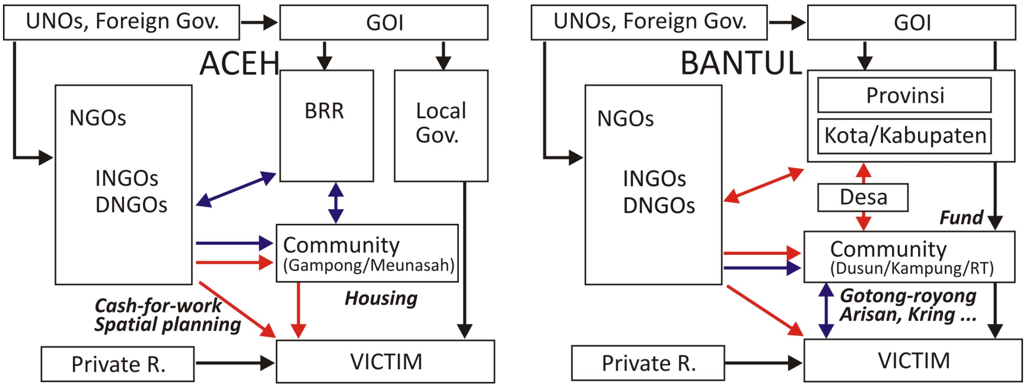
この報告では、アチェおよびジョグジャカルタの事例の比較研究を通して、開発途上国、特にインドネシアの文脈において、災害復興に対してコミュニティがどのような役割をどのように演じるかということについて議論する。主なデータソースは、2010 年 8 月にアチェ州バンダアチェおよびアチェベサールの 200 ガンポンを、2010 年 12 月にジョグジャカルタ州バントゥールの 161 ドゥスンをそれぞれ対象に行った質問紙調査である。インドネシア政府は、それぞれ両地域における 2004 年インド洋大津波と 2006 年ジャワ島中部地震からの復興事業の完了を宣言した。しかし、長期復興過程においてどのような問題が生じ、各主体がどれにどのように対処してきたかということに関する議論はまだ十分ではない。例えば、私たちの住宅復興に関する予察的調査によれば、両地域間にはとりわけ援助の流れに大きな違いがあり(上図)、地域コミュニティの役割や政府との関係についても異なっている。多くの開発途上地域においては、災害対応、復旧、復興、備えの活動に際して、政府の機能に限界がある。それに代わって、コミュニティや親族などを基盤とした社会関係資本ないし社会的ネットワークがますます強調されるようになっており、そうした非公式のメカニズムを政府部門に適切に組み入れることがいよいよ重要である。ここでは、コミュニティに立脚した、あるいは草の根の災害対応にとってどのような社会的・地理的条件があるのかということについて、それらの両地域におけるハザードの種類や規模、地元の社会構造の相違に注目し、質問紙調査の結果を分析することによって議論する。



キーワード: コミュニティ機能, 災害復興, 草の根の災害対応, 社会関係資本, インド洋大津波, ジャワ島中部地震
Keywords: community function, post-disaster reconstruction, grassroots disaster management, social capital, Indian Ocean Tsunami, Java Earthquake

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インドネシアの教育システムにおける災害教育のメインストリーミング化
Mainstreaming Disaster Risk Reduction into Indonesian Education System: The Long and Winding Road to a Better Prepared S

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Mainstreaming Disaster Risk Reduction into Indonesian Education System:
The Long and Winding Road to a Better Prepared Schools

Irina Rafliana ? Indonesian Institute of Sciences (LIPI)
Makoto IKEDA ? Asian Disaster Research Center
Asep Koswara ? COMPRESS LIPI
Indonesian Disaster Education Consortium

Indonesia is one of the most disaster prone countries known all over the world. Many works had been done, in the area of preparedness and public education. The Indonesian Institute of Sciences had developed key parameters in measuring community preparedness, including for schools. It relates with the preparedness of individuals, as to teachers and students, and also preparedness of schools as an institution. In developing a better prepared school community, the government of Indonesia and also numbers of non government organizations were looking into pursuing integrating disaster education into curriculum. In turned out, that curriculum integration does not necessarily form a better schools policy in reducing their risks. This was verified using the assessment tools developed by LIPI. It needs more than increasing knowledge through curricula, to ensure reduced loss of lives during school time.

The Consortium for Disaster Education (CDE) was formed in 2005, and now already consisted of more than 50 organizations in Indonesia, working hand-in-hand with specific work on disaster education issues, including education policies. The consortium had facilitated and prepared a national strategy paper for mainstreaming disaster education in Indonesia, and supporting Indonesian Ministry of Education when it established the Ministerial Circular Letter to all provinces and districts prone to disasters. The consortium continued supporting this national movement with the extensive process needed, taking into account the critical parameters of what is meant by School-based Preparedness for all schools in Indonesia to build their schools safer and prepared. Indonesian Institute of Sciences together with Japan-ADRC and Tsunami Disaster and Mitigation Research Center-Syiahkuala University had studied 5 schools in Banda Aceh and observing ways and manners which schools might adapt to build their preparedness plan systematically, but moreover, at most easiest and relevant to schools condition and daily activities.

キーワード: 自然災害, 防災, 教育
Keywords: Natural Disaster, Mitigation, Education

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

HDS004-P01 会場:コンベンションホール 時間:5 月 27 日 09:00-10:45

Paleoseismic studies along the Philippine fault zone, eastern Mindanao, Philippines

Paleoseismic studies along the Philippine fault zone, eastern Mindanao, Philippines

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The Philippine fault zone (PFZ) is one of the major strike-slip faults of the world that transects the entire length of the Philippine archipelago for more than 1,200 km from northwestern Luzon Island in the north to eastern Mindanao Island in the south. Consists of several segments, this arc-parallel, NW-SE trending, left-lateral fault zone is related to oblique subduction of the Philippine Sea plate beneath the Philippine island arc. This fault zone has been seismically active for the past 100 years with more than 10 earthquakes greater than M7. The most recent devastating earthquake was the 1990 Mw 7.7 Luzon earthquake that produced more than 120-km-long surface rupture along the Digdig fault with maximum horizontal slip of about 6m.

In Mindanao Island, the PFZ traverses its eastern portion for about 320km. It is characterized by fault parallel ridges, systematic deflection of stream and fluvial terraces, sag ponds and fresh tectonic scarps related to historical surface rupture. Historical documents also show possible surface-rupturing earthquakes such as the 1879 Ms 6.9 Surigao earthquake, 1891 Ms 7.2 Davao earthquake, and 1893 Ms 7.3 Monkayo earthquake. The fault trace in this island contains numerous geometric discontinuities such as en echelon steps and branching that may be used for segmentation of the fault zone. However, the timing of most recent earthquakes and recurrence intervals for these faults were poorly constrained. In order to reveal its paleoseismic activities, we have excavated multiple trenches across the different segments of the PFZ in Mindanao Island for the past two years.

Two sites were excavated across the Surigao fault located in the northern part of the island. Near vertical faults were identified on both sites and revealed evidence for at least two and probably three surface-rupturing earthquakes during the past 1,300 years that includes the 1879 Ms 6.9 Surigao earthquake. Prior analysis of aerial photographs and field observation along this segment also revealed fresh tectonic scarps and offset river terraces related to the surface rupture of the 1879 Surigao earthquake. In central part of eastern Mindanao, trench exposure in Compostela Valley across an east facing scarp that cuts an alluvial plain in an inter-valley mountain, exposed near vertical faults and contained evidence for at least two probably three or more surface-rupturing earthquakes for the 1,700 years that may include the 1893 Ms 7.3 Monkayo earthquake. Near the southern end of PFZ in Mindanao Island, trenching studies conducted north of Mati City showed a longer recurrence interval (> 1,000 years) compared to the other segments in this island. No historical earthquake (>M6) was documented in this area for the past 400 years.

Trench investigation conducted in this island revealed systematic variation of recurrence interval from 500-600 years in the northern part (Surigao segment), 500-1000 years in the central part (Compostela Valley) to > 1000 years along the southern end of the PFZ. This variation may be correlated to the southward decrease on slip rate along PFZ in this island from 24 mm/yr in the northern part (Surigao) to about 10 mm/yr in the south (Davao) derived from campaign type GPS survey (Aurelio, 2000, Island Arc).

キーワード: Philippine fault, paleoseismology, active tectonics, recurrence interval
Keywords: Philippine fault, paleoseismology, active tectonics, recurrence interval

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HDS004-P02　　会場:コンベンションホール　　時間:5 月 27 日 09:00-10:45

フィリピン地震火山監視強化と防災情報の利活用推進: その 2
Enhancement of Earthquake and Volcano Monitoring and Utilization of Disaster Information in the Philippines: Part 2

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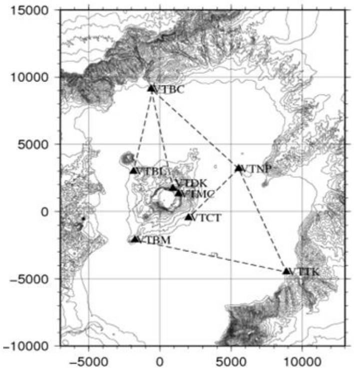
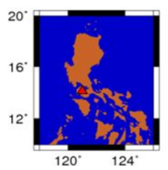
地球規模課題対応国際科学技術協力事業 (SATREPS) の研究課題「フィリピン地震火山監視能力強化と防災情報の利活用推進」(2010-2014) では、フィリピン火山地震研究所 (PHIVOLCS) と共同して (1) リアルタイム広帯域地震・強震・震度観測網と自動震源解析システムの導入による迅速で正確な震度分布と被害推定、(2)GPS 地殻変動および断層地質地形調査による大地震の発生ポテンシャル評価、(3) タール火山とマヨン火山のリアルタイム監視システムの構築、(4) 地震・火山情報ポータルサイトの構築とその利活用促進を行う。

初年度である 2010 年度は、(A) 全国５箇所の衛星テレメタ観測点 (ビラク、ルバング、ギマラス、バタラサ、パガディアン) への広帯域地震計・強震計の整備とマニラの PHIVOLCS への自動震源解析システム (SWIFT) の導入、(B) 震度速報システムのプロトタイプソフトウェア開発と PHIVOLCS における試運転、(C) ミンダナオ島における GPS キャンペーン観測と過去のデータの解析、および GPS 連続観測点（ミンダナオ島ブツアン、タンダグ）の整備、(D) タール火山における５箇所の広帯域地震計、２箇所の空振計、３箇所の GPS、３箇所の電磁気観測装置の整備とテレメタシステムの導入、を行いデータ取得と解析か開始された。また、(E) 防災科研（つくば）の大型振動台を用いて、フィリピンで一般的なブロック組積造ノンエンジニアド住宅の比較倒壊実験を実施した。さらに PHIVOLCS 職員による日本の地震火山観測体制の視察、ならびにマニラにおけるプロジェクトワークショップを実施した。

2011 年度は、更に５箇所の広帯域地震計・強震計の設置、自動震源解析システムの運用、震度速報システムのマニラ周辺での試験運用、地震発生ポテンシャル評価のための GPS キャンペーン・連続観測の継続、断層地質・地形調査、タール火山の活動の総合的監視、マヨン火山への地震計・GPS の整備、住宅の簡易耐震診断と地域の脆弱性評価手法開発のための調査・実験、ポータルサイトの設計、等を計画している。





station	BB	SP	IF	GPS	EM
VTBC	*	*			
VTNP	*		*		
VTBM	*	*		*	*
VTDK	*		*	*	*
VTCT	*	*		*	
VTMC		*			*
VTTK		*			
VTBL		V			

V: vertical component only

キーワード: フィリピン, 地震, GPS, 火山, 監視, 防災情報
Keywords: Philippines, earthquake, GPS, volcano, monitoring, disaster information

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フィリピン・タール火山の火山監視観測網の構築
New multi-parameter observation network at Taal volcano, Philippines

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Hiroyuki Kumagai[1*], Tadashi Yamashina[1], Yuta Maeda[1], Rudy Lacson[2], Mel Figueroa[2], Toshiyasu Nagao[3], Akihiro Takeuchi[3], Yoichi Sasai[3], Takeshi Hashimoto[4], Paul Alanis[2], Juan Cordon[2], Fumiaki Kimata[5], Takahiro Ohkura[6], Hirotaka Obata[7], Akira Wada[7], Agnes Aguilar[2], Jaime Sincioco[2]

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[1]NIED, [2]PHIVOLCS, [3]Tokai University, [4]Hokkaido University, [5]Nagoya University, [6]Kyoto University, [7]Hitach Zosen

Taal volcano is one of the most active volcanoes in the Philippines. After an exceptionally long dormant period since the last eruption in 1977, renewed volcanic activity began in April, 2010. We deployed a new multi-parameter observation network at Taal volcano in November, 2010. The network consists of seismic, electromagnetic, GPS, and infrasonic stations, and their real-time data are transmitted to the head office of the Philippine Institute for Volcanology and Seismology (PHIVOLCS) in Metro Manila. We installed broadband seismic sensors (Guralp CMG-40T: 0.02-60 s) and short-period seismic sensors (Kinemetrics SS-1: 1 s), and created a network of seven seismic stations (5 broadband and 2 short-period stations) at the volcano. Seismic data are digitized by either Kinemetrics K2 or Basalt 24-bit data logger with a sampling frequency of 50 Hz. We installed three Overhauser magnetometers with one fluxgate magnetometer on Volcano Island. Data from Overhauser and fluxgate magnetometers were digitized with sampling intervals of 10 and 0.1 s, respectively. Three GPS receivers (Trimble NetR5) with a sampling rate of 10 s were also installed on Volcano Island. We further installed two low-frequency infrasonic sensors (ACO TYPE7144/4144: 0.01-10 s). All these data are first telemetered to Taal Volcano Observatory by a local digital telemetry system using 2.4 GHz wireless LAN, and then transmitted to the PHIVOLCS head office through a satellite telemetry system in real-time. Seismic, magnetic, GPS, and infrasonic data are received and processed by four PCs and two cluster machines installed in the head office of PHIVOLCS. These real-time multi-parameter observation data are automatically processed to visualize their temporal variations through web systems. We are currently developing a seismic waveform inversion technique suitable for Taal volcano that holds lakes: Effects of water on Green's functions are investigated to properly estimate seismic source mechanisms using a waveform inversion approach. Systematic uses of quantitative analysis techniques to analyze the data from the network will be useful to detect possible precursors of eruptions and contribute to improved monitoring of Taal volcano.

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HDS004-P04 会場:コンベンションホール 時間:5 月 27 日 09:00-10:45

Ground deformation of Guntur, Sinabung and Merapi volcanoes, in Indonesia by continuous GPS observation

Ground deformation of Guntur, Sinabung and Merapi volcanoes, in Indonesia by continuous GPS observation

大倉 敬宏 [1*], 井口 正人 [2], Muhamad HENDRASTO[3], Umar ROSADI[3]
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Indonesia is the greatest volcano-country in the world, with 129 active volcanoes. Prediction of volcanic eruption and mitigation of volcanic hazards are urgently required. However, many active volcanoes are equipped with only one seismic station. For the mid- and long- term prediction and evaluation of post-eruptive activity, continuous observations of ground deformations are necessary. Therefore, we have recently installed GPS stations in Guntur , Sinabung and Merapi volcanoes.

Guntur volcano complex is located 35 km SE of Bandung city, West Java, Indonesia. Although Guntur volcano has been dormant in eruptive activity since 1847, seismicity of volcanic earthquakes is active and mid- and long-term prediction of volcanic eruption is required for reduction of volcanic hazards. On the other hand, ground deformation monitoring is important to evaluate post-deformation of eruption and/or transition of eruptive style.

Sinabung volcano in North Sumatra erupted on August 2010 after >400 years dormancy. The eruptive activity began with phreatic eruption and declined in September, however seismicity on and around the volcano was still high even after the eruptions. An explosive eruption occurred on October 26, 2010 at Merapi volcano in Central Java and the eruptive activity was followed by continuous occurrence of pyroclastic flow from the summit crater during the period from November 3- 5.

In October 2009, 3 stations were installed in the area surrounding Masigit-Parukuyan-Kabuyutan-Guntur craters of the Gntur volcano. Each station is equipped with a dual-frequency GPS receiver (Leica GRX1200+GNSS). A battery and a solar panel were used for power supply for the receiver. Similar observation systems were installed at Merapi volcano in December 2010 and at Sinabung volcano in February 2011. Receivers (Leica GR10) are installed at the flanks of these volcanoes. Continuous observation with a sampling rate of 1second is performed at all stations and GPS data are saved as RINEX file. At the Guntur volcano, observed data is retrieved via the WLAN installed between each station and the Guntur Volcano observatory (POST). We applied a PPP (precise point positioning) using GPS analysis software, GIPSY-OASIS II Ver.5.0. In the analysis, JPL precise ephemeris is used, and dairy coordinates are calculated in the frame of ITRF2005. From the obtained coordinates, we can calculate baseline among stations.

We compare the result in the Guntur volcano with a past leveling result. By precise leveling surveys during the period from August 1996 to November 1997, the uplift around the summit area was detected (Hendrasto et al., 1998). Using grid search assuming a Mogi source as the deformation source, location of the source and volume change were determined. The obtained source is located at a depth of 5 km beneath Mt. Masigit (Sadikin, 2008). With this position fixed, volume change between each leveling survey was calculated. Total volume of the pressure source increased by 1.5*10^6 m^3 during the period from August 1996 to December 2002 and volume increase rate is estimated to be 2.5*10^5 m^3/year(Sadikin, 2008). If we apply this average rate to the GPS observation period, we expect a inflation with a volume change of 2.75*10^5 m^3 which cases 0.5cm baselines change among GPS sites. Any significant changes can not be recognized in our GPS measurement. This means deformation rate at the Mogi source beneath Mt. Masigit was smaller than the average rate obtained by leveling data during the period from August 1996 to December 2002 when the seismicity of volcanic earthquakes of Guntur volcano was high.
Keywords: volcano monitoring, GPS, indonesia

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カリウム-アルゴン年代に基づくスンダ弧バリ・東部ジャワのカルデラ火山地域における火山活動の長期時空間分布の検討
Long-term distribution of volcanic activity around calderas in Bali and East Java, Indonesia, determined by K-Ar dating

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Kiyoshi Toshida[1*], Shingo Takeuchi[1], Ryuta Furukawa[2], Akira Takada[2], Supriyati Andreastuti[3], Nugraha Kartadinata[3], Anjar Heriwaseso[3], Oktory Prambada[3]

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インドネシアの Bali と東部 Java 地域には大規模噴火を繰り返した複数のカルデラ火山が分布するが，カルデラ形成に至る火山活動の長期変化は年代値が少なく未解明である．そこで，各カルデラ火山と周辺に分布する先カルデラ活動の火山岩類を主たる対象に，現地での地形解析と溶岩のカリウムーアルゴン年代測定を体系的・網羅的に実施している，

Bali には Batur, Bratan の 2 つのカルデラ火山があり，Agung 火山と共に活火山である． K-Ar 年代測定の結果，Bali 地域には 1.6Ma, 0.7-0.5Ma と 0.2Ma-現在の 3 つの活動期があり，Batur, Bratan カルデラ火山はともに，外輪山が 0.5Ma までに形成された古い火山と 0.2Ma よりも新しい火山から構成されることが明らかになった．各火山の形成時期は以下のとおりである．

(a) Batur の外輪山 Penulisan のうち北斜面にある開析された火山体底部・上部の各溶岩の年代がいずれも 0.5Ma で互いに一致した．

(b) Agung 火山東麓に分布する地形が開析された火山体（Tapis）の溶岩も年代が 0.5Ma であり，Penulisan の各試料と一致した．

(c) Penulisan に区分されてきた溶岩のうち，北東山麓の地形が相対的に開析されていない地域の溶岩から 0.2Ma の年代が得られた．また，Batur の外輪山東部の火山体 (Abang) の基底部溶岩から約 15 万年前と，上記の 2 試料よりやや新しく，誤差範囲で一致する年代が得られた．

(d) Batur, Bratan 火山の中間に分布する標高 706m の小規模な火山の溶岩からも 0.2Ma の年代が得られた．

(e) Bratan 火山北麓の開析された火山体から 0.5Ma の年代が得られた．

(f) Bratan 火山北部の台地を構成する Old Buyan Bratan の無斑晶質溶岩から 0.2Ma の年代を得た．

(g) Bratan 火山の南西側に位置する Batukau 火山の南西山麓に分布する溶岩からも 0.2Ma の年代が得られた．

(h) Bratan 火山北西方の Asah 近傍に分布する溶岩から 1.6Ma の年代を得た．この溶岩は新第三系 Djembrana 火山岩類に区分されてきたが第四系であることが明らかとなった．

東部 Java に位置する Tengger 火山は体積 1600km3 に及ぶカルデラ火山であり，その活動期は Ngadisari と Tengger の 2 回のカルデラ形成により区分されている．Tengger カルデラ内には活火山である Bromo がある．先カルデラ期の成層火山体 (広義の Old Tengger) は，Kukusan (400km3) とそれを覆う狭義の Old Tengger から成る．Tengger 火山周辺域の活動時期について，以下の各事項が明らかとなった．

(i) Tengger カルデラ形成噴火時の噴出物に挟在する溶岩から 0.3Ma の年代を得た．Tengger カルデラの形成時期は 30 万年前と考えられ，従来説と比べ大幅に遡る．

(j) カルデラ北西壁を構成するする溶岩の年代は，基底部・頂部とも約 0.45Ma で互いに一致した．これに対し，カルデラ南東壁の底部と火山体北西麓の溶岩の年代は約 0.3Ma で互いに一致した．よって，Tengger 火山は，成層火山体とカルデラが場所をずらしつつ，2 回形成されたと考えられる．

(k) Ngadisari カルデラ形成噴火・イントラカルデラ期の活動時期は，(i)(j) の各年代に挟まれる期間，すなわち 30-45 万年前に該当すると考えられ，既往値と比べ 2-3 倍古くまで遡ることになる．

(l) 北西部の Kukusan の溶岩から 1.7Ma の年代を得た．Kukusan は Tengger より古い火山であり，Tengger 火山地域の火山活動は 170 万年前まで遡る．

(m) Kukusan の馬蹄形凹地を埋める溶岩から 0.08Ma の年代を得た．これは Kukusan と比べはるかに新しく，後カルデラ期には北西山麓で側火口が形成された．

(n) 東部地域の火砕丘の火山弾の年代は 0.25Ma であり，Tengger カルデラの形成よりやや新しい．

(o) Tengger，Semeru 両火山の中間に分布する火山群では，溶岩について 2-4 万年前の年代が得られた．これは既往 14C 年代とも整合的である．この火山群は Semeru の古期ではなく新しい時期の活動と位置付けられる．

(p) Semeru 火山南麓にある最下位ユニットの溶岩は，0.5Ma である．Semeru 火山の活動は 50 万年前まで遡る．

なお，本研究の地質調査は，JST-JICA-RISTEK-LIPI の地球規模課題対応国際科学技術協力事業「インドネシアにおける地震火山の総合防災策」の一部として実施している．

キーワード: カルデラ, 火山, カリウム-アルゴン法, 第四紀, インドネシア
Keywords: caldera, volcano, K-Ar dating, Quaternary, Indonesia

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KH10-5 スマトラ北西沖調査航海概要ー高分解能 MCS 調査ー
High-resolution MCS survey during KH-10-5 Leg.1 off northwest Sumatra cruise

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A huge ocean-wide tsunami, with average heights of more than 20 meters along the west coast of the northern tip of Sumatra followed the 2004 Sumatra-Andaman earthquake (Mw9.2). Several working hypotheses have been proposed, but the generation mechanism for this tsunami remains unresolved. Most of these hypotheses suggest a possible coseismic slip on splay faults in the outer-arc-high off northwest Sumatra. Among these splay faults, the Middle Thrust (or possibly the Lower Thrust), can best account for features of the Indian Ocean tsunamis observed at regional and ocean-wide distances. To map fault traces and other geological structures that may be contributed by splay fault displacements, we conducted the KY09-09 bathymetry survey offshore northern Sumatra in 2009. The aim of that survey was to identify a fault trace that could be considered a candidate for the Middle Thrust (Hirata et al.,2010).

In early November 2010, we have conducted another high-density survey of the likely source region for the tsunami. This survey consists of a MCS (GI-gun, G=45 cuin and I=105 cuin; true GI-gun mode shooting every 10 sec; a 1,200 m-long, 48 channel solid streamer cable) and a 3.5 kHz Sub-Bottom Profiler (automatic ping intervals depending on water depth). A MNBS bathymetry survey using the SEABEAM 2120, shipboard gravity measurement, and 3-component magnetic measurement have also conducted as well. The survey ship speed was set at averagely 4 knots relative to ground. We designed the acoustic survey lines to cross a series of ridges and troughs parallel to the local trench axis and hence to sample fault traces that are candidates of the Main Thrust, the Lower Thrust, the Middle Thrust, the Upper Thrust in the outer-arc high.

The primary objective of the KH-10-5 cruise are to image detailed deformation structure in the uppermost sediment layers, up to 1 second bsfl in TWT, that are plausibly related to deformation occurred along fault traces. Our final goals are (1) to understand the geological structures in the outer-arc high off northwest Sumatra and their deformation history and (2) to resolve the generation mechanism of the Dec 2004 huge tsunami.

Approximately 480 nautical miles of MCS and SBP data were acquired during the KH-10-5 cruise(Figure 1). During the survey, we produced band-pass filtered, single channel profiles as preliminary results for all the survey lines. We could obtain clear images down to about 1.5 sec (TWT) in the trench fill and a maximum of about 1 sec (TWT) in small troughs in the outer-arc high. In Lines 5 and 6, a kink folding and landward vergent backthrusts were identified near the trench. Many of the small basins on the outer-arc high show deformed sediment layer structures, indicating either folding or faulting. Many SBP profiles also show deformation pattern in the uppermost sediment layers that are consistent with deeper deformation imaged by single-channel data. But some of them seem inconsistent, suggesting a difference in deformation pattern between recent (uppermost) and old (substrata) sedimentation periods. In the region where the Middle thrust is postulated, we found abundant evidences of faulting and folding of the sediment within small basins, along lines 4, 5, 6, 8, 10, 11 and 12. But these results are based on onboard processing and are tentative. We are going to process the MCS data and then interpret detailed geological structure in the near future.

Figure 1
The survey lines (heavy black lines) during the KH10-5 cruise. Main structural features (dashed): WAF, West Andaman Fault; UT, Upper Thrust, ; MT, Middle Thrust; LT, Lower Thrust; M'T, Main Thrust. DF, Deformation Front. UT and LT, are depicted according to Sibuet et al. (2007); MT according to Hirata et al. (2010).

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キーワード: スマトラ, 海底, 調査, 反射法, サブボトム, 断層
Keywords: sumatra, seafloor, survey, reflection, subbottom, fault

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2010 年インドネシア，メンタワイ地震の津波波形インバージョン
Tsunami Waveform Inversion of the 2010 Mentawai, Indonesia Earthquake

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We performed a tsunami waveform inversion of the Mentawai, Indonesia earthquake (Mw 7.7, USGS) on October 25, 2010. The tsunami generated by this earthquake was about 4 to 7 m height and killed at least 445 on Mentawai Islands. Seismological analyses (e.g., USGS or NIED) indicate that this earthquake was tsunami earthquake with a long (˜ 100 s) duration. The tsunami was recorded at tide gauge and DART stations located in and around the Indian Ocean. We downloaded the tide gauge and DART data from WCATWC's, IOC's and NOAA's web sites and inverted the tsunami waveform data recorded at 9 tide gauges in Indonesia, Cocos, Sri Lanka, Maldives and a DART station located at southeast from the source region.

In order to estimate the slip distribution on the fault, 8 subfaults (4 along strike by 2 downdip) are assumed with the each subfault size of 50 km x 50 km. The focal mechanism is strike of 326 deg, dip of 12 deg and slip of 101 deg for each subfault from the USGS's Wphase moment tensor solution. The top depths of the shallower and deeper subfaults are 3 km and 13.4 km, respectively. Static seafloor deformation (Okada, 1985, BSSA) is calculated for each subfault model as an initial condition for the tsunami numerical computation. We adopted a constant rise time (or slip duration) of 30 s for each subfault. In order to calculate Green's functions from each subfault to the stations, the linear shallow-water equations were numerically solved by using a finite-difference method (Satake, 1995, PAGEOPH). For the far filed stations, we used a basic bathymetry grid of 2 arc-minute with finer grids of 24 arc-second around tide gauges, resampled from GEBCO_08 30 arc-second grid data. For the near field stations (Padang, Enggano, Tanahbalah and Telukdalam in Indonesia), an uniform grid of 12 arc-second was used, which was also resample form GEBCO_08.

The inversion indicates that large slips more than 2 m are located at the shallower subfaults near the trench, a feature similar to other tsunami earthquakes (e.g., Satake and Tanioka, 1999, PAGEOPH; Fujii and Satake, 2006, GRL). The total seismic moment is 4.3 x 10^{20} Nm (Mw 7.7) and the fault length is about 150 km. The synthetic tsunami waveforms generally agree with the observed ones. However, we found that the observed tsunami at Padang is not well reproduced, which is more sensitive to the solution of the slip distribution than the other stations. More detailed tsunami modeling may be required to estimate a reliable tsunami source model, by updating the bathymetry data with nautical charts and adopting a finer grid to express the complicated shorelines.

キーワード: 2010 年メンタワイ地震, 津波地震, 検潮所, DART, 津波波源, 津波波形インバージョン
Keywords: 2010 Mentawai Earthquake, Tsunami Earthquake, Tide Gauge, DART, Tsunami Source, Tsunami Waveform Inversion

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2006 年ジョグジャカルタ地震の震源断層と破壊過程
Source fault and rupture process of the 2006 Yogyakarta earthquake

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The Yogyakarta earthquake with a moment magnitude of 6.3 occurred in the central part of Java, Indonesia on 26 May 2006 at 22:54 UTC, causing severe damage to the densely populated area of the Yogyakarta region. About 6,000 people were killed, and 50,000 were injured. The Opak River fault, located along the damage area, was thought to be a possible source fault of the earthquake, whereas the aftershocks were distributed 10 - 20km east of the Opak River fault (Walter et al., 2007).

Therefore, to clarify the source fault geometry, we first analyzed SAR data. We obtained an InSAR image by comparing the data acquired before and after the earthquake (29 April and 14 June, 2006).

We derived the surface trace of the actual source fault from this InSAR image. We next located three point sources by performing the waveform inversions of Kikuchi and Kanamori [1991] at various positions along the derived fault trace. We chose 29 teleseismic stations at epicentral distances between 30 and 100 degree, and retrieved vertical components of broadband P-wave seismograms for these stations from the Data Management Center of IRIS.

Using the obtained locations and focal mechanisms of point sources together with the aftershock distribution,by Walter et al. (2007) and our InSAR image, we defined the two-segment fault plane and its larger segment was assumed to be bent. We next performed a finite fault inversion of the teleseismic data using the method of Kikuchi et al. [2003]. The Green' s functions were computed with the method of Kikuchi and Kanamori [1991]. In addition to the teleseismic data, we further included strong motion waveform data observed at the NIED stations called BJI and LEM, and performed a joint inversion of the both data using the method by Yoshida et al. [1996] with the revisions by Hikima and Koketsu [2005].

This study identifies the source fault of the 2006 Yogyakarta earthquake and derived its rupture process by the waveform inversions. The inversion results imply that the Yogyakarta earthquake consists of two subevents and the larger one occurred 20 s prior to the smaller one.

キーワード: ジョグジャカルタ地震, 震源過程
Keywords: Yogyakarta earthquake, source process

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レシーバ関数法を用いた浅い構造の推定：タブリーズ、イラン、の例
Receiver function method for estimation of the shallow structure: example for Tabriz, Iran

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キーワード: 浅い速度構造, レシーバ関数法, 強震動
Keywords: Shallow velocity structure, Receiver function, Strong ground motion