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

HDS004-01 Room:103 Time:May 27 10:45-11:00

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.

Keywords: landslide, cyclone, glacial disaster, earthquake, natural damming, disaster management

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HDS004-02 Room:103 Time:May 27 11:00-11:15

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.

Keywords: GLOF, natural hazard mitigation, risk evaluation, field survey, disaster map

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HDS004-03 Room:103 Time:May 27 11:15-11:30

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

Keywords: Postseismic deformation, active fault, slip rate

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HDS004-04 Room:103 Time:May 27 11:30-11:45

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.

Keywords: Geodetic observation, West Java, Strain Accumulation

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HDS004-05 Room:103 Time:May 27 11:45-12:00

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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HDS004-06 Room:103 Time:May 27 12:00-12:15

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

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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.

Keywords: Bromo volcano, Phreatic Eruption, Magmatic, Volcanic earthquake, Tremor

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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 SO_2 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 (HCO_3^-), chloride (Cl), sulphate (SO_4), 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

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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.

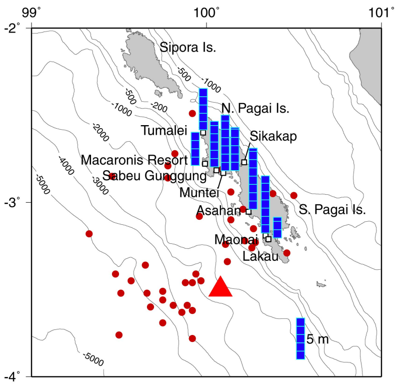
2. This earthquake was a tsunami earthquake, which produced weak shaking but large tsunamis. While initial magnitude was 7.2, analysis of long period seismic wave indicated the long duration and larger seismic moment (Mw 7.8), hence a possibility of large tsunamis. Such broadband seismic analysis of 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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HDS004-10 Room:103 Time:May 27 14:30-14:45

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.

Keywords: sedimentology, tsunami deposits, grain size, foraminifera, Mentawai

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Reconstruction of past tsunami disasters: Evidence from radiometric dating of Porites coral boulders in Southern Ryukyus

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It is important for future disaster mitigation to evaluate the recurrence period and/or frequency of extreme geohazard events such as earthquakes, tsunamis and severe storms. In this study, We focused on fossil coral boulders cast ashore by paleo-tsunamis. A large number of massive coral boulders, locally called Tsunami-ishi, are widely scattered both along the shore and on the reef all over the Southern Ryukyu Islands, Japan. When corals were cast ashore by large tsunamis, their growth should stop at that time and the date of the tsunami event could be confirmed by radiometric dating of well-preserved surface parts of these coral boulders.

Several previous studies reported ^{14}C ages of tsunami boulders. However, in previous studies there were some problems such as selection of samples for dating and conversion of ^{14}C ages to calendar ages, hence previous studies concluded that confirming historical tsunami events were difficult. In this study, unlike reef rock boulders, We focused on *Porites* coral boulders that can be used to determine the exact ages of past events because the age of the coral surface should indicate when the boulder cast ashore by the tsunamis. To determine the exact ages of past disaster events, we also used a high-precision and accurate dating of well-preserved surface parts of massive *Porites* coral boulders cast ashore.

This is the first report that high-precision U/Th dating has been applied to tsunami deposits in Japan. The results confirmed that several *Porites* boulders in Ishigaki Island were cast ashore both by the 1771 Meiwa tsunami, one of the largest tsunami disasters in Japan, and by the 1625 historical tsunami event of unknown cause.

^{14}C dating of 125 samples collected from Southern Ryukyu Islands was also conducted and its dates were converted to calendar ages by using appropriate correction methods. Some huge *Porites* boulders were newly identified as the Meiwa tsunami origin, which are useful for numerical transport model of the boulders and lead to calculate hydraulic values of the Meiwa tsunami. We also newly found several Meiwa-tsunami-derived *Porites* corals in various geological settings on several islands. These results could help to constrain source fault models of the Meiwa tsunami, and lead to specify the location of source fault of the tsunami, which has still been controversial.

^{14}C measurements of 77 *Porites* boulders also suggest that these boulders cast ashore by not only 1771 Meiwa tsunami but also other various paleo-tsunamis during more than last 2,000 years. By stacking probability distributions of calibrated ^{14}C ages of these boulders, some tsunami peaks including 1771 Meiwa tsunami and 1625 historical tsunami were detected. This result indicates that past tsunamis struck Southern Ryukyu Islands in cycles of about 150 to 400 years. Moreover, these peaks also confirmed paleo-tsunamis not described in historical documents but only told as regional legends. This is the first scientific evidence of legend tsunamis.

This study demonstrated that historical and prehistorical tsunamis could be confirmed by accurate dating of *Porites* coral boulders. The methods we developed in this study demonstrate an important application of these boulders for paleo-geohazard studies.

Keywords: Tsunami boulders, Porites spp. coral, U/Th dating, Radiocarbon dating, Paleo-tsunamis, Southern Ryukyu Islands

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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.

Keywords: Earthquake, Tsunami, Pacific Ocean

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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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HDS004-14 Room:103 Time:May 27 15:30-15:45

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

We would like to express our deep appreciate to the Ministry of Education, Culture, Sports, Science and Technology (MEXT) and JST-JICA (Peru) for the Financial support throughout the study. Also our gratitude to La Punta municipality and residents, and Callao Regional Government through its Civil Defense Office and members.

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Keywords: human behavior, risk perception, tsunami evacuation, tsunami modeling

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HDS004-15 Room:103 Time:May 27 15:45-16:00

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.

Keywords: Tsunami casualty model, evacuation, tsunami casualty index

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

HDS004-16 Room:103 Time:May 27 16:00-16:15

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 Room:103 Time:May 27 16:30-16:45

Disaster vulnerability revealed by the 2010 Mentawai tsunami earthquake in Indonesian society

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[1]ERI the University of Tokyo, [2]BPPT Indonesia, [3]Asian Disaster Reduction Center

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.

Acknowledgement: This survey was supported by SATREPS by JST, JICA, RISTEK and LIPI.

Keywords: tsunami earthquake, disaster vulnerability, education, early warning system, emergency relief, Indonesia

Japan Geoscience Union Meeting 2011
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HDS004-18 Room:103 Time:May 27 16:45-17:00

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.

Keywords: existing structures, seismic resistant, strength evaluation, seismic code, structural analysis

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HDS004-19 Room:103 Time:May 27 17:00-17:15

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

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[1]Indonesian Institute of Sciences (LIPI), [2]Indonesian Institute of Sciences (LIPI)

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).

Keywords: Local Wisdom, Community, Survival strategy, Local institutions, Earthquake, Disaster

Japan Geoscience Union Meeting 2011
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HDS004-20 Room:103 Time:May 27 17:15-17:30

Comparing community functions for the post-disaster reconstruction in Aceh and Yogyakarta Regions of Indonesia

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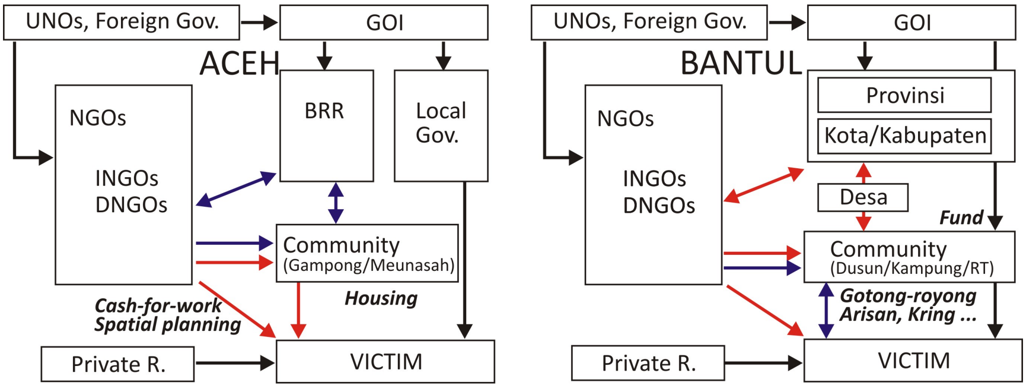
In this paper, we present some discussion about what roles and how a local community plays for the post-disaster reconstruction in the context of developing countries, in particular Indonesia, through comparing the cases of Aceh and Yogyakarta. The information was mainly acquired by the questionnaire surveys that we conducted targeting the community leaders at 200 Gampong in Banda Aceh and Aceh Besar, Province of Nangguroe Aceh Darussalam in December 2010 and, at 161 Dusun in District of Bantul, Special Province of Yogyakarta in August 2010, respectively. Indeed, the central government formally declared Aceh and Yogyakarta to finish the reconstruction works from the 2004 Indian Ocean Tsunami, and from the 2006 Java Earthquake, respectively. However, we have no enough discussion about what kind of problems occurred during the longer-term reconstruction process, and about each actor's efforts to tackle them. According to our preliminary observation for example about the housing reconstruction, there was much difference especially in the aid flow, also the roles of local community and their relationships with the governmental sectors being different from each other (see the figure above). In most if not all underdeveloped regions, the government, whether local or national, has limits to activity in the disaster response, rehabilitation, reconstruction and preparedness for various reasons. Instead, social capital/network based on community, kinship and so on is increasingly emphasized, and it is of growing importance to involve such informal or non-governmental mechanisms appropriately into the formal/governmental sector. For this, we discuss what socio-geographically conditions the community-based, or grassroots disaster managements, by analysing the results of the questionnaire on the community functions, paying special attention to the difference in the type and magnitude of hazard, and in locality social structures between the two regions.



Keywords: community function, post-disaster reconstruction, grassroots disaster management, social capital, Indian Ocean Tsunami, Java Earthquake

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

HDS004-21 Room:103 Time:May 27 17:30-17:45

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

Irina Rafliana[1*]

[1]The Indonesian Institute of Scinences

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.

Keywords: Natural Disaster, Mitigation, Education

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HDS004-P01 Room:Convention Hall Time:May 27 09:00-10:45

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).

Keywords: Philippine fault, paleoseismology, active tectonics, recurrence interval

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HDS004-P02 Room:Convention Hall Time:May 27 09:00-10:45

Enhancement of Earthquake and Volcano Monitoring and Utilization of Disaster Information in the Philippines: Part 2

Hiroshi Inoue[1*], Hiroyuki Kumagai[1], Fumiaki Kimata[2], Toshiyasu Nagao[3], Renato Solidum[4], Bart Bautista[4]

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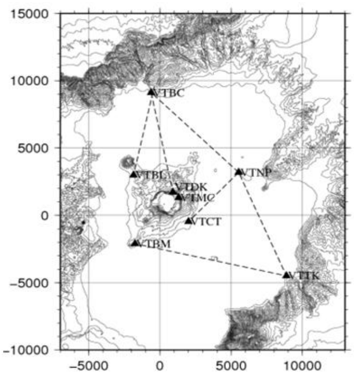
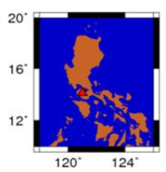
We started a five year (2010-2014) project of Enhancing Earthquake and Volcano Monitoring Capabilities and Promoting Effective Utilization of the Disaster Information in the Philippines, under SATREPS (Science and Technology Research Partnership for Sustainable Development) program. In this project we (1) install broadband seismometers, seismic intensity meters, and an automated source analysis system to promptly estimate ground shaking and damage, (2) evaluate earthquake generation potential by GPS measurements and geological survey, (3) install broadband seismometers, infrasonic sensors, GPS receivers and electro-magnetic sensors at Taal and Mayon volcanoes, and (4) develop an earthquake-volcano disaster information portal site and promote its effective utilizations.

In the first Japanese fiscal year (JFY 2010), we carried out (A) installation of broadband and strong motion sensors at five VSAT seismic stations (Virac, Lubang, Guimaras, Bataraza, Pagadian) and the source inversion system(SWIFT) to PHIVOLCS in Manila, (B) development of a prototype software of real time seismic intensity measurement and its test operation in PHIVOLCS, (C) GPS campaign observation in Mindanao and analysis of existing data, and GPS continuous observations in Mindanao (Butuan, Tandag). We installed (D) five broadband seismic, two infrasonic, three GPS, and three electro-magnetic sensors and their telemetry at Taal volcano,. We carried out a (E) comparative shaking experiment of non-engineered concrete hollow block (CHB) masonry houses using a large-scale shaking table of NIED, Tsukuba. CHB is most common building material of residential houses in the Philippines. We also invited PHIVOLCS staff members to Japan for learning the current status of earthquake and volcano monitoring in Japan, and we held a project workshop in Manila.

In JFY2011, we will carry out installation of broadband and strong motion sensors at five more VSAT stations, continuous operation of SWIFT inversion system, test installation and operation of the intensity meter network in Metro Manila, campaign and continuous GPS measurements for evaluating earthquake generation potential, and integrated seismic, GPS, and EM monitoring of Taal volcano. We also plan to make survey and experiments for developing simple seismic diagnosis of residential houses and evaluation of vulnerability of towns, and designing a Web portal site of earthquake and volcano disaster information.





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

V: vertical component only

Keywords: Philippines, earthquake, GPS, volcano, monitoring, disaster information

Japan Geoscience Union Meeting 2011
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HDS004-P03 Room:Convention Hall Time:May 27 09:00-10:45

New multi-parameter observation network at Taal volcano, Philippines

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

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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$*$10ˆ6 mˆ3 during the period from August 1996 to December 2002 and volume increase rate is estimated to be 2.5$*$10ˆ5 mˆ3/year(Sadikin, 2008). If we apply this average rate to the GPS observation period, we expect a inflation with a volume change of 2.75$*$10ˆ5 mˆ3 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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Long-term distribution of volcanic activity around calderas in Bali and East Java, Indonesia, determined by K-Ar dating

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Long-term history of active calderas in Indonesia have not been well constrained due to the lack of chronological data. The ages of pre-caldera activities are mostly unknown. We therefore conduct comprehensive sample collection, K-Ar dating and topography analysis of volcanic rocks in Bali and East Java.

We have found three periods of volcanic activity in Bali. They are 1.6 m.y. BP, 0.7-0.5 m.y. BP, and 0.2 m.y. to present. The number of new volcanoes formed increased with successive active periods. Somma of both Batur and Bratan caldera volcanoes consist of multiple volcanoes that were formed at 0.5 Ma and 0.2-0.1 Ma. The calderas have been formed between the edifices.

(a) The ages of lavas from both the bottom and the upper part of Penulisan agree each other at 0.5 Ma. Penulisan is therefore formed at 0.5 m.y. BP.
(b) The age of lava from Tapis is also 0.5 Ma, and agrees with ages of Penulisan lavas.
(c) The ages of lavas at the base of Abang and the northern apron of Batur somma in Les waterfall area are 0.15-0.2 Ma. They are significantly younger than Penulisan.
(d) The age of lava from the small 706 m peak volcano between Batur and Bratan is also 0.2 Ma, and agrees with the age of lava from northern apron of Batur somma.
(e) The ages of lavas consisting the dissected ridges in the northern apron of Bratan are 0.5 Ma.
(f) The age of aphyric lava that forms plateau in the north apron of Bratan (Old Buyan Bratan) is 0.2 Ma.
(g) The age of lava in SW apron of Batukau volcano is also 0.2 Ma.
(h) The age of lava near Asah is 1.6 Ma. The unit belongs to Tertiary Djembrana volcanics, but the age is found to be Quaternary.

At Tengger caldera, East Java, the age of the two caldera-forming eruptions are found to be older than 0.3 Ma., based on dating and stratigraphy of the different parts of somma edifice. The ages are found to be much older than previous studies.

(i) Caldera-forming eruption deposit of Tengger caldera at NW part of the caldera wall consists of alternating layers of pyroclastic fall and pyroclastic surge deposits as well as lava flow layer. The age of the lava is 0.3 Ma. Therefore, Tengger caldera was formed at 0.3 m.y. BP, which is much older than in previous study.
(j) At the NW wall of Tengger caldera, ages of lavas at the caldera rim and the bottom of the caldera wall agree at 0.45 Ma. The age of lava at the bottom of the SE wall and the age of lava from NW apron agree at 0.3 Ma. They are younger than age of NW wall lavas. It seems that Old Tengger (sensu stricto) consists of multiple stratovolcanoes.
(k) Based on the ages from (i)(j), we can estimate that Ngadisari caldera and the intra-caldera units were formed between 0.3-0.45 m.y. BP, which is 2-3 times older than in previous study.
(l) The age of lava from the dissected Kukusan volcano is 1.7 Ma. Kukusan is much older than Tengger. The volcanic activity in the Tengger-Bromo region has started by 1.7 m.y. BP.
(m) The age of lava that fill the depression of the Kukusan is 0.08 Ma. Parasite vent in the northwestern apron has therefore formed during post-caldera stage.
(n) The age of pyroclastic bomb from G. Garu is 0.25 Ma and is younger than Tengger caldera.
(o) The ages from Ayekayek-Ranu Pane area are 0.02-0.04 Ma, which are consistent with previous 14C age.
(p) The age of lowermost unit of Semeru in the southern apron is 0.5 Ma. Activity of Semeru dates back to 0.5 m.y. BP.

These results enable us to define long-term distribution of volcanoes leading up to caldera-forming activity in the range of 100 thousand to one million-year time scale.
Field surveys were conducted as a part of the project "Multi-disciplinary Hazard Reduction from Earthquakes and Volcanoes

in Indonesia", supported by SATREPS from JST, JICA, RISTEK and LIPI.

Keywords: caldera, volcano, K-Ar dating, Quaternary, Indonesia

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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).

Acknowledgement The KH10-5 cruise was conducted by using the R/V Hakuho-maru. We would like to express our gratitude to the Captain Takatoshi Seino and the crew for their cooperation and support during the cruise.

Keywords: sumatra, seafloor, survey, reflection, subbottom, fault

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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.

Keywords: 2010 Mentawai Earthquake, Tsunami Earthquake, Tide Gauge, DART, Tsunami Source, Tsunami Waveform Inversion

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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.

Keywords: Yogyakarta earthquake, source process

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Receiver function method for estimation of the shallow structure: example for Tabriz, Iran

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Receiver function method is widely used to estimate Earth crust and mantle structure. But to apply it to the estimation of weak low-velocity layers of shallow structure (1-5 km depth), which are important for prediction of earthquake strong ground motions for example, someone need to calculate receiver function at high frequencies, ˜3-8 Hz. High-frequency seismic waves are strongly scattered and calculation of receiver function in many cases become troublesome. To avoid this problem, we can use local small earthquakes. Receiver function approach is helpful to remove effects of source and path by deconvolution of the vertical component from the radial component. In its straightforward application receiver function is used to detect time delay of the Ps converted phases and then depths of the interfaces are estimated using a fixed velocity values in the layers. Instead, we use full waveform inversion of the receiver function into the velocity structure. We applied developed methodology to estimate shallow structures at a few sites in the region around the UNESCO World Heritage site Tabriz Baazar in Iran, constructed on about A.D.1400 or A.D.1500, with the purposes to estimate possible strong ground motions. Velocity of deepest layer was fixed according to the crustal structure. Receiver functions were inverted for velocity structure using Genetic Algorithm; propagator matrix algorithm was used to calculate theoretical receiver functions.

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Keywords: Shallow velocity structure, Receiver function, Strong ground motion