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

SSS032-01 Room:302 Time:May 24 14:15-14:30

Manganese concentration in the latest slip plane of the Neodani fault zone

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Occurrence, mineral assemblage and chemical composition of the fault gouges in the Neodani fault zone are studied to clarify the characteristics of the slip plane ruptured during the 1891 Nobi earthquake. Studied sites are Midori and Osso at Neo region of Motosu city in Gifu prefecture. Midori is at the site of 6m vertical displacement in the 1891 earthquake, and the trench site has been opened to the public as the Seismic faults observation and experience house. Samples collected from this site are studied. Osso is 1km away from the site (Naka) of 8m displacement in the 1891 earthquake, and probably ruptured during the 1891 earthquake from the trace of surface rupture. Fault exposure appeared by the road construction is studied. At both sites, fault plane is subvertical, and the Jurassic accretionary complex of Mino belt in the northeast side is bounded by the terrace deposit in southwest side. The accretionary complex of Mino belt contains the matrix of mudstone and blocks of greenstone and chert. At Midori, the surface displacement of the 1891 earthquake is equal to the displacement of the basement rocks, suggesting that the boundary of fault gouge and terrace deposit is slipped during the 1891 earthquake. At Osso, the fault gouge zone with a thickness of 3cm is developed, and divided into 3 different fault gouges based on their color. Brown fault gouge zone is inferred to be the rupture zone of the 1891 earthquake according to the cutting relationship.

X-ray fluorescence (XRF) and powder X-ray diffraction (XRD) analyses of 9 samples from Midori and 8 samples from Osso were performed. As enough amount of samples is collected at Osso, thin section observation, SEM observation and EPMA analysis are also performed. The results of XRF analysis shows MnO concentration at the fault gouge zones. At Osso, 3 kinds of fault gouges are divided into mudstone and greenstone origins based on SiO2, MgO and CaO contents. MnO content in the brown fault gouge of mudstone origin is 4 times greater than the origin of this fault gouge. The results of XRD show the precipitation of smectite and break down of plagioclase in the fault gouges. Manganese bearing minerals are not detected by XRD. Microstructure of the brown fault gouge shows that the fragments of quartz and greenstone are surrounded by brown material. These fragments with brown material are observed in section using SEM-EDX. SEM observation shows that manganese concentrates at the margin of fragments. EPMA analysis of these fragments clarified that Ba is concentrated with manganese, and Fe is not.

Generally, manganese is dissolved in the ground water, and is precipitated under oxidic condition. Basically, fault gouge is not permeable due to clay minerals. But the rupturing during earthquakes may temporally increase the permeability of fault gouges. If ground water flows from underground reductive condition to subsurface oxidic ones, manganese will be precipitated. Manganese concentration in the fault gouges may indicate fault gouges with manganese are ruptured recently. The occurrence of manganese is similar to the oceanic manganese nodules. But their growth rate is very slow (1mm/100 thousand year). Slip and/or frictional heating of fault may reflect to the manganese growth rate.

Keywords: Neodani fault, fault zone, latest slip plane, manganese concentration

Japan Geoscience Union Meeting 2011
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SSS032-02 Room:302 Time:May 24 14:30-14:45

Frictional property of earthquake rupture surfaces in soft basement rock

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Frictional properties of earthquake rupture surfaces were examined in laboratory experiments to obtain a fundamental data for probing causes of variability of surface slips on an identical active fault accompanied by repeated large earthquakes.

A surface slip of a few tens cm on an active fault was associated with the 2008 Mw 6.9 Iwate-Miyagi inland earthquake, while paleoseismic trench studies on the identical fault reveal past earthquakes with a substantially larger slip of about 2 m (Maruyama et al., 2010). The 2004 Mw 6.6 Mid-Niigata earthquake also showed such variability of surface slips: a small surface slip of about 20 cm on an active fault was associated with the 2004 earthquake, while a trench survey reveals a large slip of about 2 m with a past earthquake on the identical fault. Such a variability of surface slips on active faults poses a major issue in assessing earthquake hazard based on active fault evaluations, because the variability leads an underestimation of a repetition of past earthquakes.

Rock samples of lapilli tuff involving earthquake faults and intact rock samples from its hanging wall and footwall were hewed out from a trench wall exposed for the paleoearthquake study in the source region of the 2008 Iwate-Miyagi inland earthquake. A density, a porosity, P- and S-wave velocities of the these samples are about 1.6 g/cm^3, 50 %, 1.7 km/s, and 0.3 km/s, respectively. Box shear and triaxial compression methods were adopted to measure frictional coefficients (FC) and cohesive stresses (CS) of the earthquake faults and compressional strengths of the intact rock samples. Normal stresses and confining pressures for both the tests are given at 0.1-0.6 MPa and 0.1-0.4 MPa, respectively. Additionally, reciprocating slips were repeatedly applied to the earthquake fault sample in the box shear test in order to emulate a large slip up to 1 m of an actual earthquake.

Experimental results are summarized as follows:

1) FC and CS of the sample from earthquake faults are 0.27-0.38, and 14-64kPa, respectively. The frictional coefficients are much less than the standard FC 0.85 of hard rocks under low normal stresses (Byerlee, 1978).

2) FC and CS of the samples from both the hanging wall and footwall rocks are about 0.2 and 200 kPa, respectively. The cohesive stresses of these rocks are, thus, much larger than those of the earthquake fault.

3) Repeated sliding test for emulating a large slip suggests that frictional strength is not largely depend on the slip amount.

4) Compressional strengths of the hanging wall and footwall rocks are almost the same: Internal frictional coefficients (IFC) of both the rocks are about 0.8. A large difference of IFC and FC from the above result 2) is likely caused by a difference of fracturing mechanisms involved in the two different test methods.

Keywords: surface earthquake fault, variability of surface slip, frictional property, box shear test

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SSS032-03 Room:302 Time:May 24 14:45-15:00

Estimate of fault angle about Isehara fault by computer simulation which use CIP method

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Isehara fault is reverse fault which exist in north east shore of Tanzawa mountainous region.
Isehara fault is parallel with Fusinoki-Aikawa line which is a boundary of Pre Neogene and Neogene (Research Group for Active Faults of Japan 1991).
Isehara fault length is 20 km.
Isehara fault is concealed active fault and appearing flexure at ground surface.
Cover layer thickness from bed rock is 35m that is estimated by drill core data at Miyasita Isehara city near Isehara fault (Takeda et.al. 2003).
Most upper region of cover layer consist of loam and under region of cover layer consist of gravel and sand.
Assuming that connect fault scarp and fault surface that is confirmed by drill core, fault angle is about 40 degree.
But, Isehara fault angle is 50-60 degree that is estimeted by reflection seismic survey (Kanagawa prefecture 1996).
This difference is according to Isehara fault's fault angle become the smaller at near ground surface (Takeda et.al. 2003).

Therefore, Isehara fault's fault angel is uncertain.
In this study, we conduct two-dimensional computer simulations assuming that a covering layer on the bedrock
is cut perpendicular to the fault line, and we setimate the fault angle at bed rock for Isehara fault.
In this study, the covering layer is considered to be not an elastic medium but a Bingham fluid. Therefore, its consist of sand and gravel.
We use the constrained interpolation profile (CIP) method to calculate the Bingham fluid.
The CIP method is a type of difference method.
A function and differentiation of function use to advect function for CIP method.
As a result, CIP method succeed with reducing numerical diffusion that is fault of difference method.
The CIP method have advantages which is possible calculate large deformaton and division of layer by the faulting.

We attempt to simulations which is running by changing fault angle, maximum fault slip rate and unit displacements.
We surch parameters which can reproduce fault flexure of Isehara fault.
As a result, we discovered that fault angle is 30 degree, maximum fault slip rate is 0.5 m/s and unit displacements is 3.0 m.
This fault angle is different from previous study value.
This difference is according to Isehara fault's fault angle become the smaller at near ground surface (Takeda et.al. 2003).

Keywords: active fault, Isehara fault, fault flexure, simulation, CIP method, fault parameters

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SSS032-04 Room:302 Time:May 24 15:00-15:15

Late Holocene faulting along the Sarobetsu fault zone in northern Hokkaido, Japan

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Detailed mapping based on LiDAR by Ministry of the Environment, analysis of morpho-sedimentary units, and radiocarbon dating of the prograding beach-ridge complex of the Teshio Lowland in northern Hokkaido allow the differentiation of six prograding units. These are called: III-VII, 6000-4650 yBP; VIII, 4650-2190 yBP; IX, 2190yBP-Present. Theses units are deposited during periods of high relative sea level.

Longitudinal profiles of swales parallel to shoreline, show southward titling of the beach-ridge plain. The relative heights between the northern and southern end of the profiles are 6.5m (III-VII), 1.5-1.7m (VIII), and 1.4m (IX). These differences seem to be caused by coseismic coastal uplift due to the active blind thrust fault, the Sarobetsu fault zone.

Keywords: the Sarobetsu fault zone, late Holocene faulting, beach ridges

SSS032-05 Room:302 Time:May 24 15:15-15:30

Estimation of ground movement of the Iwate-Miyagi Nairiku Earthquake 2008, from the Geomorphic Image Analysis of LiDAR D

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In the previous work, authors developed the new method to estimate the ground deformation of 1m order quantitatively and easily used high resolution periodical DEM, applied the technique of the image matching analysis - Patent No.4545219. And we showed the result of measurement of displacement of the mass movement due to the earthquake with high accuracy by using this technique. In the present study, we applied the same technique to the area of about 20km2 where the surface rupture appeared due to Iwate - Miyagi Nairiku Earthquake 2008, and tried the extraction of wide area ground deformation.

The topographical data used in this research is two times of 2mDEM by the Airborne laser survey immediately after the disaster in June 2008, and September 2006. The slope angle map where the angle of gradient in the grid point had been shown by gray- scale was used for the digital geomorphological image used for the image analysis. The software improved to use MPIV described with MATLAB for three dimensional analyses was used for the image matching. When 2mDEM is used, the displacement magnitude that can be extracted by the digital geomorphological image matching is about the 1/10 grid size or more.

As a result of the investigation, 0-0.8m upheaval tendency to the rise on the west side was admitted in the entire region. And, the tendency of horizontally shortening of the surface by displacement for the eastward and for the westward was admitted. Moreover, a lot of small area where the direction of the movement was different was found, and the displacement magnitude in each small area was 0.2- 1m. The sites where the ground surface displacement was found by existing investigations are corresponding to the places where the direction and the magnitude of displacement of the ground change suddenly. Especially, the site Okayama where low cliff of westward up was formed is located in the collision zone of the displacement of the direction of east and west. In addition, the direction of displacement is greatly different in both shores along Ubusume River.

In conclusion, it is presumed that surface of the ground had been divided into the small blocks, and each block moved independently and minutely due to the earthquake. It is thought that the shape of the each block reflects the geological structure of underground. And it is thought that remarkable deformation of ground surface appeared in the zone where the direction and magnitude of displacement change suddenly. In the future, an unconfirmed surface deformation may be discovered in the area where a big distortion is assumed.

Keywords: active fault, DEM

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SSS032-06 Room:302 Time:May 24 15:30-15:45

Late Holocene fault scarps and activity of the Kozu-Matsuda fault

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We show new evidence for active tectonics of Tokyo metropolitan area by use of actively deforming landforms, Quaternary stratigraphy, and shallow to deep seismic reflection data tied with these stratigraphic constraints, resolving otherwise elusive blind thrust structures beneath highly urbanized areas. At the leading edge of the subducting Philippine Sea plate beneath the Kanto region, most significant active structures are recognized as active folding and/or faulting of Holocene and late Pleistocene fluvial and marine deposits above emergent splay thrust faults extending from a subduction megathrust that generated the 1923 Kanto earthquake (M7.9). In particular, fault scarps above the splay fault are interpreted as formed during historic earthquakes based on stratigraphy and trench excavations.

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SSS032-07 Room:302 Time:May 24 15:45-16:00

Coseismic subsidence recorded in the Holocene of the Nobi plain and activity of the Yoro fault system

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The Nobi plain has been tilting down toward the west, subsiding at mean rates of 1 m/kyr, as the result of faulting on the Yoro fault system, fringing the margin of the plain (Sugai and Sugiyama, 1999).

The upper Holocene of the Nobi plain is represented by a prograding delta sequence formed on the footwall side of the Yoro fault system. On the basis of analyses of six drilling cores and 46 ^{14}C ages from the Nobi plain, vertical changes of sedimentary facies, grain size distribution and Electronic Conductivity (EC) value of sediment samples suggest that temporal relative sea-level rise occurred around 500, 1200, 1000 to 4300, 4000, and 4700 to 5600 years ago(Niwa et al., 2009; 2010). Niwa et al. (in press) also detected river channel change to west and temporal relative sea-level rise about 1600 to 2700 years ago based on analyses of uppermost Holocene sequence of the Nobi plain and 35 14C ages. Synchronicity of events and trend of relative-sea level lowering during middle to late Holocene to the influence of eustasy and hydroisostasy indicates that cause of these relative sea-level rise events can be coseismic subsidence along the Yoro fault.

The above-mentioned subsidence events broadly correspond with previously known faulting events at the Kuwana fault to the south of the Yoro fault. These results are consistent with the notion that the Yoro and Kuwana faults comprise a behavioral segment in the Yoro fault system (Sugai et al., 1999).

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Keywords: Holocene, coseismic subsidence, Nobi plain, Yoro fault system, ^{14}C age

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SSS032-08 Room:302 Time:May 24 16:00-16:15

Analyses of GPR and bed-distribution discontinuity along the Wadamisaki fault in the mouth of the Togagawa River, Kobe

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Active faults are well known in the northern Osaka Bay and the Rokko Mountains. However, the fault linkage between the two areas is not yet known, except for the Gosukebashi fault. Hitherto, we analyzed the bed-distribution discontinuity for the marine Ma 13 bed (Holocene) using the database, Kobe JIBANKUN (Kobe City), in order to grasp a hidden fault in the mouth of the Togagawa River, Kobe. In addition, we curried out the ground-penetrating radar (GPR) investigation along three survey lines in the mouth of the Togagawa River, Kobe, showing the discontinuity of the Ma13 bed.

Detection of an anomalous reflector was found along the three GPR survey lines in the mouth of the Togagawa River. This result is well consistent with that from discontinuity analysis of the Ma13-bed distribution. This anomalous part distributes along two lines; one corresponds to the Wadamisaki fault, and the other can be interpreted as a hidden fault branching from the Wadamisaki fault. Therefore a combined use of the GPR and discontinuity analysis of bed distribution is very useful for grasping a hidden fault in the urban area of a mega-city.

Keywords: Ground-penetrating Radar Survey, discontinuity analysis of bed distribution, hidden fault, Wadamisaki faut, Ma13 marine bed (Holocene), Togagawa River, Kobe

SSS032-09 Room:302 Time:May 24 16:30-16:45

Acoustic prospecting for the seaward extension of Kurehayama faults in Toyama Bay, central Japan

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The southern Kurehayama fault-belt depicts the east margin of Imizu Hill and the central and northern parts are located on the Kurehayama hill which divides Imizu plains and Toyama plains (narrow sense). The latter hill is regarded as a tectono-morphological features by the Pleistocene fault-related fold of the Kurehayama fault (Yasuda Anticline). It is an asymmetric anticline with a low angle limb on the northwest, although the anticlinal axis and its southeast limb are eroded out by Ida-gawa and Jinzu-gawa rivers in the central belt. According to the previous data from geophysical exploration, the anticline is buried beneath the downtown Toyama city in Toyama plain. It was expected that the fault belt extends into the Iwase spur in front of Iwase and Mizuhashi towns, coastal Toyama Bay (Toyama Prefecture 1997).

The sea-bottom sounding was executed in the Toyama Bay aiming to acquire information on the grasp of an accurate position, shape and activity of the in the seaward section of the Kurehayama fault belt as part of consignment business ”Active fault survey in the nearshore waters” from the Ministry of Education, Culture, Sports, Science and Technology to National Institute of Advanced Industrial Science and Technology.

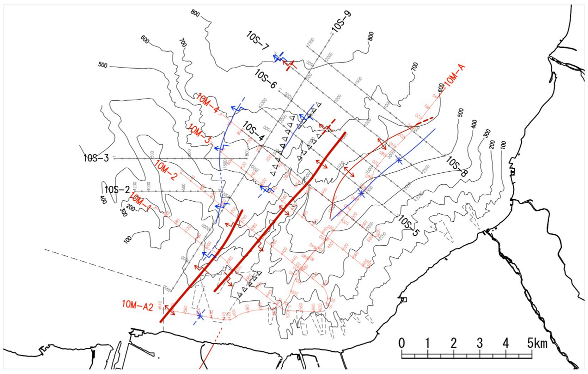
The target area is located in front sea area put from Toyama City to Uozu City, and the profiling lines were arranged in order to locatie the northernmost tip of the fault and to specify the strike of the assumed extension part, that is the Hamakurosaki spur, in a parallel and an orthogonal directions. The offshore operation including the trial run conducted 8 single channeled lines and 6 multichanneled lines from July 30 to August 7, 2010, acquiring seismic profiles of about 80km in the total extension.

In the prospecting line 10M-1 along the coast, the westerly dipping high-angle reverse fault of 700m in depth is presumable and also a buried fault-scarp in the shallower depths was interpreted. In addition, an anticline exists adjacent to the fault west side in this line, and is traceable to the entire Hamakurosaki spur (From 10M-A2 to 10M-4).

Based on discontinuity of the reflectors, a reverse fault more than 45 degrees in the dip angle, parallel to the west side of the anticlinal axis, is admitted from 10M-1 to 10S-4. Such a fault is also recognized to the north of10S-5. However it dips at 20 degrees or less, and is thought to be a surface phenomenon with no indication of the deeper fault. However, it is thought that the activity of this surface fault is new because the sea-bottom on the hanging wall to the west seems upheaved in 10S-6.

As for the seaward extension of the Kurehayama fault belt, the tectonic deformation by the fault is assumed in the area south of10S-6, and it is pointed out that length from the coastline is about 9.5km, and the dip of the fault becomes gentle while going to the north. Since the anticlinal structure of the Neogene (layer-N) is probably unconformable with the overlying layers at the horizon of reflector-d, it is possible that fault-related folding with the Kurehayama fault has been ceased already.

The previous surveys of the reflection method of land areas reveals the shallow structures of the Kurehayama fault less than 500m in depth. Acoustic prospection was done up to depth 1-2km in half of survey lines in this sea area, and the main Kurehayama fault was located on the just extension of the land fault trace. It can be especially said that the Kurehayama fault is characterized by accompanying asymmetric anticline structure in both regions in land and sea, and that the fault belt is a buried one whose displacement is expressed as flexures in the district from the downtown Toyama City through the coast up to the Hamakurosaki spur (south of line 10M-4).



Keywords: submarine active fault, acoustic prospecting, reflection method, Toyama Bay, Kurehayama fault, fault related fold

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SSS032-10 Room:302 Time:May 24 16:45-17:00

Fault distribution and activity in the offshore extension of the eastern margin fault zone of the Fukui plain

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We carried out active fault investigation by the request from Ministry of Education, Culture, Sports, Science and Technology in the offshore extension of the eastern margin fault zone of the Fukui Plain. We want to clarify the five following matters about the active fault based on this results. (1)Fault continuity of the land and the sea. (2) The length of the active fault. (3) The division of the segment. (4) Activity characteristics.

The eastern margin fault zone of the Fukui Plain consists of the main part fault and the west part fault including sea area. Based on an existing fault evaluation, main part length is 45km, and the west part length is 33 km. In this area, the Fukui earthquake occurred in 1948. Kaga-shi offshore fault and Mikuni-cho offshore fault have been described in existing material concerning sea area fault. The length of the fault is 7km and 5km respectively based on the map.

In this investigation, 12 lines of high-resolution multichannel seismic reflection survey were carried out to recognize the detailed structure of a shallow stratum. In addition, we carried out standard type of multichannel seismic reflection survey for deep geological structure. The high accuracy topography survey was executed in the coast region where the rock was exposed. Furthermore, the sampling with the vibrocoring to get information of the sedimentation age was carried out.

The reflection profiles of the active faults were extremely clear. The fault displacement of sea floor and the deformation of Holocene epoch layer were recognized in the offshore extension of the fault zone though the displacement of sea floor was not identified in the coast area where rock was exposed. And another faults were recognized to the southwest side of the main part fault. It is interpreted that northern terminal of main part fault has diverged.

Because the displacement of sea floor or the deformation of the layer of Holocene epoch were confirmed, it is thought that they are active faults on which it acted at the latter term of Quaternary Era in both the main part and the west part.

Keywords: Fukui earthquake, Fukui plain, sea area, active fault, seismic reflection survey, lateral fault

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SSS032-11 Room:302 Time:May 24 17:00-17:15

Identification of Active Faults in the Western Seto Inland Sea

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There are little seismic surveys on active faults in some areas of Suo-nada Sea and Iyo-nada Sea, which are the part of the Western Seto Inland Sea. We tried The Multi-Channel Seismic Survey in this sea area. The purpose of the survey is to reveal the geological structure, and clarify the formations of active faults in the Sea. The survey was conducted by high-resolution sonic method using boomer source, deep seismic reflection profiling using water gun and air gun.

As the result of this survey, we could find some faults which strikes NE-SW same as the Median Tectonic Line (MTL) active fault system in this sea area. Some fault displacements including pull-apart basin and depression with negative flower structure were figured out on the obtained seismic reflection profiling. These displacements are a little but represent the geological features of the movement of right lateral strike-slip fault. These faults action continues after Pleistocene.

In addition, the width of the active faults seem to become wide with disperse toward offshore. At present, we think that we can divide these faults into geometrical segment which is based on the extensional jog.

Although the relationship between these active faults and the MTL active fault system has not been clarified completely, the result of this survey implies their formation under the same tectonic situation.

Keywords: western seto inland sea, active fault, acoustic exploration, lateral fault

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Creeping deformation along the Longitudinal valley fault at Yuli area in Taiwan estimated by the photogrammetric method

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The purpose of this study is to establish the deformation pattern and the distribution across the Longitudinal Valley Fault in Tongli (south of Yuli) area, based on the photographic method.

The Longitudinal Valley Fault (LVF), 150 km long and NNE-SSW striking, passes through the eastern Taiwan, and represents the obvious surface expression of the collision boundary between the Philippine Sea plate and the Eurasian continental plate. The southern of LVF segment is observed to be high speed creeping based on the creep meter and leveling survey etc. Owing to such a high deformation rate, many earthquakes have occurred along the LVF. The 1951 earthquake sequence represents a good example. It is shown that LVF has been displaced both co-seismically and inter-seismically. Murase et al. (2009, 2010, and 2011) established about 30 km leveling route from Yuli to Changbin to detect the vertical deformation across the LVF for two years. As a result, the vertical displacement is 1.7 cm in 200 m across the LVF and 2.7 cm in 1000 m, referred to the west end of our route. In addition, a synclinal deformation is detected on the hanging wall side of the fault.

We compared to the air-photographs which are taken at different age (1978 and 2007). If the creeping on the fault has continued for 30 years, the accumulation of displacement reaches about 1m, which is significantly?distinguishable by photogrammetric method. We decided and measured the GCP for the 2007 year air-photograph in the field. We oriented the 2007 air-photograph and then we apply the old-time coordinates of the triangulation point to 1978 air-photograph. We measure profiles across the fault on 1978 and 2007 air-photograph by photogrammetric system respectively. The comparing result is shown that the northern area has creeping but the southern area has undetectable creeping in Tongli. About this result, we think two possibility; one is the creeping is not uniformity along the fault, second is the photogrammetry has not enough quality. We should actually check the creeping or not. We made three new leveling survey lines in last year.

Keywords: Active fault, Photogrammetry, Creeping, Longitudinal valley fault, Taiwan, tectonic geomorphology

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SSS032-13 Room:302 Time:May 24 17:30-17:45

Recurrent morphogenic earthquakes in the past millennium along the strike-slip Yushu Fault, central Tibetan Plateau

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The magnitude (Mw) 6.9 (Ms 7.1) Yushu earthquake occurred on 14 April 2010 in a high mountain region in the Yushu area of the central Tibetan Plateau, resulting in approximately 3000 fatalities (including 270 missing) and widespread damage. Field investigations reveal that the earthquake produced a ˜33-km-long surface rupture zone along the pre-existing Yushu Fault of the strike-slip Ganzi?Yushu Fault Zone (Lin et al., 2011a). The Yushu earthquake provides us with a rare opportunity to understand the rupture mechanism and process of a large-scale strike-slip fault related to eastward extrusion of the Tibetan Plateau. The primary features of the seismogenic fault upon which the 2010 Yushu earthquake occurred are now understood, but details of its seismotectonic behavior, e.g., recurrence interval, slip rate, and maximum magnitude of morphogenic earthquakes, are largely unknown despite their importance in terms of assessing the seismic hazard in high mountain regions around the Yushu area on the central Tibetan Plateau.

Here, we present geological evidence regarding the occurrence of
paleo- and historical earthquakes that ruptured the strike-slip Yushu Fault of the Ganzi?Yushu Fault Zone during the past millennium, based on field work and observations of an excavated trench and outcrop in July 2010, after the 2010 Yushu earthquake (Lin et al., 2011b). Field surveys and analyses of an excavated trench and outcrop reveal that three morphogenic earthquakes have occurred on the Yushu Fault in the past millennium. Paleoseismic evidence, historical records, and radiocarbon age data show that (i) the penultimate large-magnitude earthquake occurred during the past 400 yrs, corresponding to the 1738 M 7.1 earthquake; and (ii) the third most recent event occurred between AD 650 and AD 1100, suggesting a recurrence interval of 300-400 yrs for morphogenic earthquakes on the Yushu Fault in the past millennium. An average slip rate of ˜4-5 mm/yr is estimated for the Yushu Fault. These results are consistent with those obtained from long-term geological evidence and GPS observations. Our findings reveal that most of the strain energy on the Ganzi?Yushu Fault Zone, caused by northeastward motion of the Tibetan Plateau to accommodate north?south shortening of the plateau due to ongoing northward penetration of the Indian Plate into the Eurasian Plate, is released as seismic slip.

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Keywords: Yushu earthquake, strike-slip Yushu Fault, Tibetan Plateau, morphogenic earthquakes, Paleoseismicity, Tibetan Plateau

SSS032-14 Room:302 Time:May 24 17:45-18:00

Active faulting in southern Bhutan Himalaya and its application for active tectonics

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Introduction

The on-going collision between Indian and Eurasia plates has caused uplift of the Himalayan range, appearance of dense distributed fault system and also outbreaks of mega earthquakes in the past 100 year along the Himalayan front. Because active faults generate large and shallow earthquakes (over M6.5), detailed information on distribution and sense of active faulting is fundamental data for not only study on active tectonics, but also planning for seismic mitigation. Geological and geomorphic knowledge about active faulting of Pakistan, northwestern India and Nepal is collected by numerous works, but limited works such as Nakata (1972) and Yagi et al. (1992) has only done to understand that of Bhutan and northeastern India at present. In this presentation we show the preliminary result regarding to distribution and sense of the active fault in southern Bhutan Himalaya and discuss about relationship between active faulting and structural tectonics, comparing with active faulting in southern Nepal Himalaya.

Method and material

We interpreted air photos by stereo-view to identify the typical tectonic landform such as a series of stream offset on same line and fault scarp on terrace or fan surfaces as geomorphic evidence for active faulting. We used air photos of both Bhutanese government institutions: Department of Geology and Mines (DGM), Ministry of Economic Affairs and Department of Survey and Land Record, Ministry of Home Affairs. The air photos are vertical, gray color scale with a scale of 1:12,500, 1:15.000 and 1:25,000 taken in 1989 and 1991. Information on the tectonic landforms and surface trace of active fault were mapped in topographical maps with a scale of 1:50,000. The air photos of some areas closing to the border to India are not available. We concentrated to interpret the area south of N27 in Bhutan where active faults may be distributed densely according to other Himalayan area.

Characteristics of active fault in southern Bhutan Himalaya

The result we interpreted are shown below:

1. There are many fault traces with E-W striking, parallel to the Himalayan range.

2. No single fault traces run from east to west entirely in the southern Bhutan, but the fault traces less than 30 km long are recognized generally, overlapped with five to six traces in part.

3. Regarding to vertical displacement on the E-W striking fault traces, that on the traces along the footwall of the Himalayan range shows north up-thrown, that inside the Himalayan range shows both directions between south up-thrown or north up-thrown.

4. The NE-SW and NW-SE striking fault traces are visible inside the range, oblique to the general trending of the range. We observed the left-lateral strike-slip along the NE-SW striking fault trace, the right-lateral strike-slip along the NW-SE striking fault trace. Some of those may run toward north out of mapping area.

5. Eastward from Tshoki, density of fault traces is less than other part, also the E-W trending traces concentrate within 1 km width.

Relationship between structural geology and distribution of fault

The active fault we identified in the southwestern Bhutan are almost distributed widely not only along the Main Boundary Thrust (MBT), but also over the Lower Himalaya between the MBT and the Main Central Thrust (MCT). However in south-eastern Bhutan east of Tshoki the traces of active fault is almost single along the MBT in map view. In Nepal the surface traces of active faults follow the main geological boundaries such as the MBT and MCT, and the density of active faults in the Lower Himalaya is very low. The difference reflects the difference of type of long-term collision tectonics. Principal axes of horizontal strain based on slip sense and striking of the faults is N-S, which is suitable for the direction of plate motion.

This research was supported by Grant-in-Aid for Young Scientists (B) and JST-JICA, SATREPS.

Keywords: Bhutan, Himalaya, active fault, tectonic landform

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

SSS032-P01 Room:Convention Hall Time:May 25 16:30-17:30

A new method for evaluating fault activity based on fault gouge properties -Occurrences and colors of fault gouges from

Yukari Miyashita[1*], Kenta Kobayashi[2], Atsushi Kamei[3], Jun'ichi Itoh[4], Mitsuo Manaka[5], Keisuke Fukushi[6]

[1]Geological Survey of Japan, AIST, [2]Niigata University, [3]Shimane University, [4]Geological Survey of Japan, AIST, [5]Geological Survey of Japan, AIST, [6]Kanazawa University

In order to develop a new method for evaluating fault activities, we have analyzed a relationship between fault activities and fault gouge properties. In particular, we focused on the colors, clay minerals and chemical compositions of fault gouges.

We report occurrences of fault gouges in the western part of Tottori Prefecture, southwest Japan, particularly attentive for the colors of fault gouges derived from granite. Many minor faults accompanying fault gouges are distributed in the area. The fault gouges from the aftershock area of 2000 Tottori-ken Seibu earthquake are characterized by pale-green, white and yellowish brown. In contrast, gouges from the Nichinanko lineament and Komachi-Ohdani lineament area are characterized by yellowish brown, orange and pink. On the $a*$-$b*$ diagram, these two area are clearly distinguished. The difference of fault gouge color might be corresponding to the difference of fault activity.

Keywords: fault gouge, fault rocks, 2000 Tottori-ken Seibu earthquake, active fault, fault activity

Japan Geoscience Union Meeting 2011
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SSS032-P02 Room:Convention Hall Time:May 25 16:30-17:30

A new method for evaluating fault activity based on fault gouge properties-Comparison of fault gouges in the aftershock

Mitsuo Manaka[1*], Keisuke Fukushi[2], Yukari Miyashita[1], Kenta Kobayashi[3], Atsushi Kamei[4], Jun'ichi Itoh[1]

[1]AIST, [2]Kanazawa University, [3]Niigata University, [4]Shimane University

We compared to examine mineralogical and geochemical studies of fault gouges in the aftershock area and the neighborhood of 2000 Tottori-ken Seibu earthquake, to establish a new method for evaluating fault activity of low activity faults. The fault gouges were conducted by powder X-ray diffraction analysis, sequential selective extraction tests and color measurements. As the results, the fault gouge in the aftershock area is mainly composed of illite and chlorite, and the gouge in the neighborhood is mainly composed of halloysite. Iron in the gouge in the aftershock area is mainly contained in illite, and iron in the gouge in the neighborhood is mainly contained in amorphous and crystalline iron oxide. Results of color measurements showed that negative $a*$ values from the gauge in the aftershock area indicated the presence of chlorite, and that positive $a*$ values from the gouge in the neighborhood indicated the presence of crystalline iron oxide. These results indicated that mineralogical and geochemical characteristics can distinguish clearly the fault gouges in the aftershock area and the neighborhood of 2000 Tottori-ken Seibu earthquake and that color measurements can be effective to distinguish these gouges.

Keywords: 2000 Tottori-ken Seibu earthquake, fault gouge, powder X-ray diffraction analysis, sequential selective extraction test, color measurement, crystalline iron oxide

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

SSS032-P03 Room:Convention Hall Time:May 25 16:30-17:30

A new method for evaluating fault activity based on fault gouge properties - Color measurement of fault gouges -

Kenta Kobayashi[1*], Yukari Miyashita[2], Mitsuo Manaka[2], Atsushi Kamei[3], Keisuke Fukushi[4], Jun'ichi Itoh[2]

[1]Dep. Geol., Fac. Sci., Niigata Univ., [2]AIST, [3]Shimane Univ., [4]Kanazawa Univ.

We measured colors of fault gouge zones to estimate the fault activities. First, we made powder containing hematite and/or goethite which have been weighed correctly, and measured colors of the powder. Second, the colors were compared with those of the fault gouge zones along the Nichinan-ko SE lineament and with those in the epicentral area (aftershock zone) of the 2000 Tottori-ken Seibu earthquake (Mj 7.3). Dark-red gouge zones along the Nichinan-ko SE lineament contain 0.1-0.5 % of hematite. Precipitations of the hematite are observed along the margins of the gouge zones, may have formed in the inter-active period.

Keywords: Tottori Prefecture, fault gouge, color, active fault, fault activity

SSS032-P04 Room:Convention Hall Time:May 25 16:30-17:30

Estimation of causative faults producing crustal upwarping in the Nishi-tsugaru Coast, Northeast Japan

Yuumi Ogata[1*], Takahiro Miyauchi[1]

[1]Earth Sci. Dept., Chiba University

The Nishi-tsugaru Coast, Northeast Japan, has experienced co-seismic shoreline uplifts associated with two historic earthquakes (either M6.9)which occurred in 1704 AD and 1793 AD (Imamura,1920; .Usami,2003). Although each offshore causative fault model was proposed to explain the height distribution of co-seismically emerged abrasion platforms by Nakata et al. (1976) and the small tsunami generation (Sato, 1980), neither models did not coincide with active tectonic structures and topography. Re-recognizing Holocene emerged tidal topography and their dating, we aim to estimate actual causative faults of which movements match the upwarping of paleoshoreline features and active geologic structure in the surrounding submarine areas. Based on the concordance among the deformation modes indicated by co-seismic records and late Quaternary marine terrace records, the causative fault of 1793 earthquake is assigned to the Kita-kanegasawa fault developing the Odose anticline described in the geological map by Hirayama and Kamimura(1985) , and similarly that of 1704 earthquake is likely the Omagoshi fault in Osawa (1963). In addition, the most northeast area of this coast has been probably up-warped by the active movement of Ajigasawa fault, and the Henashi peninsula in the central part of the coast by that of a submarine active fault which is estimated below the steep tectonic scarp several kilometer offshore

Keywords: emerged shoreline topography, upwarping, cosesimic uplift, causative fault, Nishi-tsugaru Coast

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

SSS032-P05 Room:Convention Hall Time:May 25 16:30-17:30

Offshore source fault modeling using late Quaternary paleoshoreline records, Northeast Japan

Takahiro Miyauchi[1*]

[1]Earth Sci. Dept., Chiba University

The eastern margin of Japan Sea is a tectonically active zone of Northeast Japan back-arc and a fold and thrust belt under compressive stress field in Quaternary, which is characterized by inversion tectonics succeeding to the middle Miocene opening of the sea. The differential uplift showing tilting and warping of late Quaternary marine terraces along a 500 km long coast of this eastern margin is understood due to offshore causative fault movements and related large earthquakes. Holocene terrace morphology with steps, historically documented coastal uplift at large earthquakes along the Japanese coast, and harmonious displacement patterns among MIS 5e and Holocene paleoshoreline heights, indicate the occurrence of intermittent and repeated coastal uplift produced by co-seismic distinctive crustal movements. Shallow submarine reverse fault segments with either west dip or east dip, close to the coastlines, are undoubtedly responsible for coastal uplift and accumulative marine terrace tilting and warping demonstrated as fault-related fold structures. Calculating co-seismic displacement distribution to be best fit to marine terrace records, by the use of crustal dislocation model, individual fault parameters range in length from 20-60 km, in dip angle from 30-50 degrees, in slip from 2-7 m (in uplift from 1-3 m), suggesting earthquake magnitude in the range of Mw7.0-7.5 and recurrence time of 1000-4000 years. This implies that the eastern marginal coastal areas of Japan Sea have high probability of large magnitude earthquakes accompanied by coastal uplift, which will happen somewhere in near future. Particularly in the area where present abrasion platforms widely develop, the next large earthquake seems imminent.

Keywords: Late Quaternary, paleoshoreline records, dislocation, source fault modeling, Japan Sea-eastern marginal tectonic zone

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

SSS032-P06 Room:Convention Hall Time:May 25 16:30-17:30

Seismic reflection profiling survey across the Tengmori-Dedana Faults, the southern Kitakami lowland fault zone

Kohei Abe[1*], Dai Nobuoka[2], Yoshikazu Matsubara[2], Kyoko Kagohara[3], Hideki Kosaka[4], Takanobu Kamataki[2], Toshifumi Imaizumi[5]

[1]M. T. Brain Co.,Ltd., [2]Oyo Co., [3]AFERC, AIlT, [4]Kankyo Chisitu Co.,Ltd., [5]Tohoku Univ.

The Kitakami lowland fault zone (KLFZ) is an active thrust zone that extends for about 70 km along the Quaternary volcanic front of the northeast Japan arc. The activity of the thrust zone after Quaternary is mostly recognized as a fault reactivation of Miocene normal faults in the area. Tengmori fault group which comprise the southern portion of the KLFZ is composed by several active faults. These faults deform late Quaternary fluvial terraces and debris flow deposits in Kitakami lowland. We present seismic reflection data acquired along the Kitakami - Kanegasaki profile, 12.8 km-long, to define the geological structure of the Tengmori fault group. In seismic lines, the vibrator truck (IVI ENVIRO VIB) is used as the seismic source. Source and geophone spacing are 10-m. Seismic reflection data was processed by using the standard CMP stacking method. The seismic profiles correlated with surface geologic mapping clearly.

Keywords: Tengmori-Dedana Faults, Kitakami Lowland, seismic reflection profiling, subsurface structure

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

SSS032-P07 Room:Convention Hall Time:May 25 16:30-17:30

Fault outcrop and tectonic landform of the western margin fault zone of the Kitakami lowland, northeast Japan

Hideki Kosaka[1*], Kohei Abe[2], Kyoko Kagohara[3], atsushi Miwa[4], Toshifumi Imaizumi[5], Yutaka Mamada[6], Jun-ichi Uchida[6]

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The western margin fault zone of the Kitakami Lowland (KLFZ) is a 70-km-long, reverse faults that consist of mulitiple faults that run parallel to mountain front of northeast Japan. The older paleoseismic events are difficult to explain by only a single trench investigation. Understanding the distribution and activity of the branched faults is important to identify the older paleoseismic events in the KLFZ. We describe paleoseismic events and distribution and activity of the branched faults based on two fault outcrops and the tectonic landform.

Paleoseismic events are identified in the first fault outcrop of the Uwandaira fault group (UFG). We identified at least 4 late Pleistocene-Holocene paleoseismic events, based on the upward termination of fault and angular unconformity, in the fault outcrop. Studies of tectonic landform of fluvial terraces indicate 8-20 late Pleistocene-Holocene paleoseismic events, assuming slip per event obtained from the fault outcrop and the minimum height of the scarplet. The pronounced disparity of paleoseismic events between the fault outcrop and tectonic landform suggests that multiple events have been recorded beneath each angular unconformity. The results imply that the study of the tectonic landform is indispensable to interpretation of paleoseismic events in the region where unconformities have been formed in the footwall of the active thrust.

Distribution and activity of the branched faults are identified in the second fault outcrop of the Nanshozan active fault group (NFG; F1 fault, F2 fault), based on geomorphic feature and surface geology (Plio-Pleistocene Siwa Formation), including the active reverse fault passing through the second fault outcrop (F3 fault). The Miocene strata have been thrust over the Siwa Formation along the mountain front (F1 fault). Distribution of fluvial terraces indicates that the F1 fault has been inactive. The F2 fault deforms fluvial terraces in the footwall of the F1 fault. Deformations of fluvial terraces and arrangement of valley spread of alluvial terraces provide that the F3 fault runs through east side of the hills on the footwall of the F2 fault.

Keywords: Paleoseismic event, angular unconformity, branched fault

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

SSS032-P08 Room:Convention Hall Time:May 25 16:30-17:30

Active fault traces along the Hanawa higashi fault zone, northeastern Japan

Masayoshi Tajikara[1*], Takashi Nakata[2], Toshifumi Imaizumi[3], Yasutaka Ikeda[4], Takahiro Miyauchi[5], Hiroyuki Tsutsumi[6], Hideaki Goto[7], Takashi Azuma[8], Tokihiko Matsuda[1], Tadaki Mizumoto[1], Ritsuko S. Matsu'ura[1]

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Hanawa higashi fault zone is a NS-trending, 19-km-long fault and is located along the eastern margin of the Hanawa Basin, northeastern area of the Akita prefecture. Based on detailed interpretation of air photographs, we mapped fault traces in the northern part of the Hanawa Basin where no active faults have been mapped, despite existence of clear topographic boundary between the Hanawa Basin and the Ou Backbone Range. As a result, length of the fault zone changed from 19 km to 26 km. This fact indicates that reevaluation of seismic hazard from the Hanawa higashi fault zone is needed.

This research was funded by grants from the Ministry of Education, Culture, Sports, Science and Technology.

Keywords: active fault, inland earthquake, Hanawa Basin, Hanawa higashi fault zone, air photograph interpretation

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

SSS032-P09 Room:Convention Hall Time:May 25 16:30-17:30

Tectonic Geomorphology of the southern part of eastern marginal fault zone of Aizu Basin, Northeast Japan

Tadaki Mizumoto[1*], Masayoshi Tajikara[1], Tokihiko Matsuda[1], Takashi Azuma[2], Hiroyuki Tsutsumi[6], Toshifumi Imaizumi[3], Yasutaka Ikeda[4], Takahiro Miyauchi[5], Ritsuko S. Matsu'ura[1]

[1]Earthquake Reserch Center, ADEP, [2]AFERC, AIST, [3]Tohoku Univ., [4]Univ. of Tokyo, [5]Chiba Univ., [6]Kyoto Univ.

At the eastern edge of the Aizu basin close to the foot of the Ou backbone range, several active faults constitute a fault zone trending north to south, named of the eastern marginal fault zone of Aizu Basin. These fault traces were found to prolong towards a mountainous area constituting a fault zone extending to about 49 km in length. In the mountainous area, the two faults, Ouchi-kuramura fault and Simogo fault constituting the southern part of the fault zone, are mapped by Nakata and Imaizumi (2002).

In the vicinity of Otokane, at the southeast part of Shimogo town, the Katodani River flows westward and forms several terraces along them. The fault produces westward facing scarps across the late Pleistocene terraces (probably formed in and around 17,000 years ago) to be displaced in flexure scarp facing the westward and having a vertical deformation of 5 m. At the opposite bank of the river, the lower terrace is also formed with a vertical component of 1.7 m. The progressive amounts of displacement on the late Pleistocene terraces suggest that at least two faulting events have occurred during past 17,000 years. This fault having a length of about 9 km trending north to south in the mountainous area where no active faults have been mapped are newly named to be Otogane fault and also constitutes a southern edge of the fault zone. The length of the fault zone is extended by 4km to southward including the new fault.

This research was funded by grants from the Ministry of Education, Culture, Sports, Science and Technology.

Keywords: Active fault, Aizu Basin, Simogo town, Otogane fault

Japan Geoscience Union Meeting 2011
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SSS032-P10 Room:Convention Hall Time:May 25 16:30-17:30

Quantitative analysis of tectonic landforms along the Nagamachi-Rifu fault segment by using LiDAR?based 2-m-grided DEM

Yasuo Awata[1*], Sakae Mukoyama[2], Hisashi Sasaki[2]

[1]Geological Survey of Japan, AIST, [2]Kokusai Kogyo Co., Ltd.

The location and slip-distribution of the Nagamachi-Rifu fault segment is quantitatively analyzed using 2-m-grided DEM that detected by airborne LiDAR. 0.5-2 m interval contour maps and 150 topographic cross sections generated from DEM permit identification and measurement of 13 river terraces and a 5-km-wide flexure and fault zone in and around the urbanized Sendai city.

The narrowly-defined Nagamachi-Rifu Line fault is a 22-34 km-long and 2.5-km-wide active flexure and fault zone, which consists of the right-stepping Miyagino and Nigatake flexures, and the Dainenji-yama back thrust. Each of flexures and fault displace the terrace surfaces and recent alluvial plain cumulatively. The Dainohara terrace of 100 ka or older has received a maximum 70 m vertical by the movement of the Miyagino and Nigatake flexures. The total deformation of the flexures consist of 70 % of uplifting relative to the alluvial plain. 30-50 % of uplifting of the flexures attribute the deformation by the Dainenji-yama back thrust.

The Yagiyama flexure is an active structure longer than 10km, which developed on the upthrown side of the Nagamachi-Rifu Line fault. A 1-1.5 km-wide asymmetric acticline of the terrace surfaces are newly recognized in the downtown of the city. A 2-km-long scarplet on the river terraces continues northward from 3-km-north of the Yagiyama flexure. The active Tsubonuma-Enda fault is located on the SW of the flexure.

The displacements of river terraces, normalized by the number of faulting event, depict the pattern of slip-distribution along the active fault and flexure with high clarity. The normalized displacements along the Nagamachi-Rifu Line fault are constantly large along the 15-km-long central part of the fault and gradually decrease toward the both ends. On the other hand, the displacement along the Yagiyama flexure increase in the southwestern part of the flexure seems continue to the Tsubonuma-Enda fault. When the 4.5 m of uplifting of lowest terrace has experienced 2 faulting events caused by the Nagamachi-Rif Line fault, the recurrence interval of the fault is estimated to be 5-6 ky or longer based on the age and cumulative displacement of the Dainohara terrace. This estimation is consistent with the paleoseismisity in Holocene revealed at the NE part of the fault.

Keywords: Nagamachi-Rifu Line fault, airborne LiDAR, DEM, tectonic landform, active fault, slip distribution

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

SSS032-P11 Room:Convention Hall Time:May 25 16:30-17:30

Fault geomorphology identified by the interpretation of stereoscopic images produced from digital elevation model

Hideaki Goto[1*], Tomohiro Tatemichi[1]

[1]Hideaki Goto

Detailed digital elevation model (DEM) data distributed from Geospatial Information Authority of Japan (GSI) has been stored steadily since the Basic Act on Promotion of Utilization of Geographical Information was published in 2007. We produced stereoscopic images from all files of 5m-mesh-DEM made by GSI, and interpreted fault topography on the fluvial plains. The small fault scarps are newly identified on the Kyoto basin, Toyama and Niigata plains. It shows that stereoscopic images from detailed DEM are applied materials for active fault research.

Keywords: active fault, digital elevation model, stereoscopic image, Kyoto basin, Isuguri Fault, Kakuda-Yahiko fault

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

SSS032-P12 Room:Convention Hall Time:May 25 16:30-17:30

Geologic structure in the epicentral area of the 2008 Iwate-Miyagi Nairiku earthquake

Keiichi Ueta[1*], Toshinori Sasaki[1], Daiei Inoue[1], Yasuhira Aoyagi[1], Kazuo Mizoguchi[1], Keishi Nunohara[2], Toshitaka Yokoyama[2], Osamu Hasegawa[3], Koichi Okuzawa[4]

[1]CRIEPI, [2]Techno Hase, [3]DIA Consultants, [4]CERES

We performed geologic reconnaissance in the epicentral area of the 2008 Iwate-Miyagi Nairiku earthquake to understand the relation between geological structure and the seismogenic faulting. Geologic mapping reveals that the Miocene Maekawa and Orose Formation form a monoclinal flexure-thrust belt and a fold belt trending NNE-SSW in the epicentral area. The Miocene strata thrust over the terrace deposits at outcrops within the fold and thrust belts.The monoclinal flexures and thrusts may have been developed during formation of the major folds propagating from the reverse basement fault, which corresponds to the source fault responsible for the main shock.

Keywords: Iwate-Miyagi Nairiku earthquake, Fold, Monoclinal flexure, Source fault

Japan Geoscience Union Meeting 2011
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SSS032-P13 Room:Convention Hall Time:May 25 16:30-17:30

Re-Examination of the 1762 Horeki Sado Earthquake

Hisashi Ishii[1*], Tomiichi Uetake[2], Tatsuo Usami[3], Hideki Nagumo[1], Ryoichi Nakamura[1]

[1]TEPSCO CO.,LTD.,, [2]TEPCO CO., LTD.,, [3]Tokyo Univ. Prof. Emeritus

Re-Examination of the 1762 Horeki Sado Earthquake
Hisashi Ishii1, Tomiichi Uetake2, Tatsuo Usami3, Hideki Nagumo1, Ryoichi Nakamura1
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We found new historical documents of the 1762 Horeki Sado earthquake and re-examined seismic intensity distributions. In this study, we reported new documents and estimation of the source location and magnitude.

The earthquake that occurred off Sado Island caused tsunami damages on the northern coast of Sado Island. The epicenter was estimated by Imamura(1947), Usami(1975,1987,1996,2003), Hatori(1990)and Kawauchi(2000).Usami(1996) estimated the magnitude as 7.0 ,whereas Hatori estimated as 7.2 from tsunami damages and the area of seismic intensity 5.

Seismic intensities were large at Sado Island and the coast of Niigata, Yamagata prefecture. Imamura (1947) estimated epicenter E off Sado Island, somewhere near the midway between Sado and Niigata.

Usami (1975, 1987, 1996) estimated epicenter E off Sado Island, 138.7deg E 38.1deg N and suggested 38.35deg N by the change possibility of disaster area (2003). Hatori (1990) drew refraction diagrams of the hypothetical tsunami to see the shoaling effects around Sado island and concluded epicenter was N off Sado Island, the northern peninsula Hajikizaki,138.3deg E 38.4deg N. Kawauchi (2000) inferred the epicenter W off Awashima Island off Sado Island,138.8deg E 38.6deg N. We investigated historical documents of Niigata, Yamagata and Akita pref. and found 5 new documents that were unpublished in the complied historical earthquake documents. With these new documents and published historical earthquakes, we tried to estimate the epicenter of this earthquake. The epicenter was estimated N off Sado Island.

Keywords: 1762 Horeki Sado earthquake, Historical earthquake

References: Tatsuo Usami, Materials for comprehensive List of Destructive Earthquakes in Japan. [416]-2001
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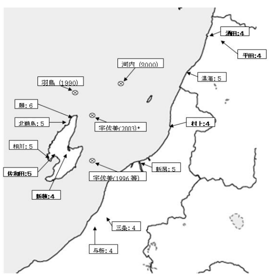

図-1 宝暦十二(1762)年佐渡地震の震央・震度分布

Fig1 The epicenter, Intensity distribution of the 1762 Horeki Sado Earthquake

ゴシック太字は新史料を示す。宇佐美（2003）*は、鵜島を北鵜島と考えたときの位置を示す。

Keywords: 1762 Horeki Sado Earthquake, Historical Earthquake

Japan Geoscience Union Meeting 2011
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SSS032-P14 Room:Convention Hall Time:May 25 16:30-17:30

Timing of the last faulting event on the Sekidosan fault of the Ouchigata fault zone, Central Japan

Takashi Azuma[1*], Nobuhiko Sugito[2], Hiroyuki Tsutsumi[3], Daisuke Hirouchi[4], Takashi Hosoya[5], Koji Magara[5], Taku Ito[5]

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Sekidosan fault is southeast dipping reverse fault with trending NE-SW, and bounding between the Sekido mountains and Ouchigata plain at the neck of the Noto Peninsula, Ishikawa Prefecture. Sugito et al. (2007) pointed out that the last faulting event had occurred between 850-250 cal.yrBP, whereas the Earthquake Research Committee recognized its timing as between 3200 cal.yrBP - 9 century (Earthquake Research Committee, 2005). We conducted trench excavation and drilling survey for the paleoseismological study at four sites, Mijiro, Sakai, Hongo and Shikinami, on Sekidosan fault in order to obtain the new data to identify the last faulting event of this fault. In this abstract we will show the result of survey and tentative interpretation to them.

A trench and 6 boreholes were excavated at Mijiro site. Trench is excavated on the foot of the flexure on the valley bottom. On the trench walls, humus, silt, sand and gravels deposited after 7000 cal.yrBP were observed. There was no fault in these sediments. Drilling core shows deformation of sediments below the trench floor.

At Sakai site, a trench was excavated on a small scarp on a fan, but this scarp was formed not by faulting, but by erosion. Sediments on the surface of the higher side of this scarp shows they were deposited in wetland. It indicates that trench site could be located on the up-thrown side of the fault concealed in the plain.

At Hongo site, 8 boreholes and a pit were excavated on the both sides of small scarp, which is located on the plain-side of the previous trench site. 2 boreholes were drilled with an angle of 45 degree and others are vertical. From the section and age data of sediments, this scarp could be formed by faulting, but more age data are required to identify the timing of it.

3 boreholes and a pit were excavated at Shikinami site. From the geological section of this site, the scarp was identified as formed by erosion. But existence of humic silt with age of around 7000 cal.yrBP and those elevation of 6-7 m above sea-level, indicate this site could be tectonically uplifted. Based on the age data from the pit, the last uplift event seems to be occurred in historical age.

Keywords: active fault, faulting history, paleoseismological trench excavation, drilling survey, Sekidosan fault, Ouchigata fault zone

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Paleoseismicity on the Kajiya, Sekigahara and Miyashiro faults in the Yanagase-Sekigahara fault zone, central Japan

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The Yanagase-Sekigahara fault zone truncating from Japan Sea to western Gifu prefecture, central Japan, is one of the major fault zones in Japan. The Earthquake Research Committee evaluated that the probability of the earthquake occurrence in the future on the southern part of this fault zone is unknown because of the luck of paleoseismological data. We carried out paleoseismological studies on the Kajiya, Sekigahara and Miyashiro faults in this fault zone to evaluate the rupture probability in the future of these faults, using the fund of the Ministry of Education, Culture, Sports, Science and Technology. A high-angle fault exposed on the trench walls at the Kajiya A site on the Kajiya fault. Radiocarbon dates indicate that at least one faulting event occurred in these 3,300 years. At the Kajiya B site, a fault cutting the bedrock and terrace deposit was observed, and radiocarbon dates indicate that the last faulting event occurred in these 1,000 years. At the Akiba site on the Sekigahara fault, the bedrock covered by the slope deposit and no fault was observed. On the Miyashiro fault, boring surveys show that the top of the Tokai Group and the bottom of young gravel layer are vertically displaced about 35 meters and 3 meters respectively.

Keywords: Yanagase-Sekigahara fault zone, Kajiya fault, Sekigahara fault, Miyashiro fault, trench excavation, paleoseismology

Japan Geoscience Union Meeting 2011
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SSS032-P16 Room:Convention Hall Time:May 25 16:30-17:30

Stress inversion method from fault slip senses and its application to active fault data

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Stress inversion methods from fault-slip data usually require to observe fault surface orientation, slip orientation and sense of shear. However, the descriptions of fault geometry made by many researchers are sometimes imcomplete for lack of slip orientations. In such cases, Andersonian fault model may be applied in spite of the existence of oblique slip faults. This presentation introduces a stress inversion method for imcomplete fault-slip data, which is applied to the active fault data compiled by Tsutsumi et al. (this meeting) in the Kinki and Chubu districts, central Japan.

The stress inversion method used in this study was developed by Sato (2006). A fault-slip datum has constraint on stress state through the assumption that a fault slips in the direction of resolved shear stress (Wallace-Bott hypothesis). The constraint can be expressed as a region in the deviatoric stress space which is geometrically the surface of five-dimensional unit sphere. If a datum is imcomplete, the area of constraint should be large. The inversion method superposes the constraint regions from all observed faults to compose a fitness distribution on the sphere. Since the deviatoric stress space is a metric space with the measure of difference between stress tensors (Yamaji and Sato, 2006), the area of constraint region can be used as the weights in the superposition process. Finally, the stresses which give the maxima of fitness are picked up as optimal solutions.

The active fault data set from about 200 locations were analyzed, and a reverse faulting stress with WNW-ESE compression was obtained. Although the data included no information about slip orientations, stress could be constrained in a small area in the deviatoric stress space (within 20 degrees around the optimal solution) due to the variation of fault surface orientations. Most of fault data are concordant with the optimal stress, while a small number of outliers deviate by only several degrees in the stress space. The fact that single stress can explain almost all of active fault slip senses shows the uniformity of stress state in the district.

References

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Keywords: stress tensor inversion, fault-slip data, active fault, Hough transform

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SSS032-P17 Room:Convention Hall Time:May 25 16:30-17:30

Regional stress field across Kinki and Chubu regions derived from stress inversion analysis of active fault data

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We revealed regional stress field across Kinki and Chubu regions based on stress inversion analysis of active fault data. We complied fault slip data including fault plane orientation and sense of slip (right-lateral, left-lateral, reverse, normal and combination of strike-slip and vertical-slip). A stress field composed of WNW-ESE-oriented sigma1 with almost vertical sigma3 was detected by the analysis. This suggests that Kinki and Chubu regions have been under a fairly uniform stress field in the late Quaternary.

Keywords: active faults, fault slip data, regional stress field, stress inversion analysis

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SSS032-P18 Room:Convention Hall Time:May 25 16:30-17:30

Seismic reflection profiling across the Shufuji fault, Kinki district

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We present high-resolution seismic reflection profiling acquired by the hammer and 24-channnel recording system. A 1.0 meter source and geophone spacing give a 0.5 meter CMP spacing on the profile. The normal CMP stacking fold had 24 traces used by the same shot point. The location and continuity of active faults comprising a part of the Kinki region are clearly expressed in terms of topography. This area is the so-called Kinki Triangle. This study presents the results of seismic reflection surveys across the Fukurojou Maiseki Valley in the northern part of the Kinki Triangle. The subsurface configurations of the active faults are correlated with geomorphological fault trace and are related with the fault strikes.

Keywords: Seismic Reflection Survey, Shufukuuji Fault

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Tectonic topography and active fault outcrop in the eastern focal area of the 1943 Tottori Earthquake

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The magnitude (Mj) 7.2 Tottori earthquake occurred on 1943 in the Tottori Province of Japan, resulting in great damage throughout Tottori City urban area mainly. In the hill or mountain area west Tottori plane, there were two echelon surface ruptures called Yoshioka fault and Shikano fault associated with this earthquake known by previous studies (Tsuya, 1944). On the other hands, in the hill or mountain area east Tottori plane, surface rupture had not been confirmed.

Recently, the active fault was found by aerial photo investigation in this area (Takada et al., 2003), and there was not surface rupture because of the vertical slip distribution of this area was estimated to be deeper than the west area (Nakata, 2009). We have been studied geomorphological and geological survey for the purpose of seismic hazard assessment. In this presentation, we conclude the results of high resolution topographic investigation and active fault outcrop observation along the tectonic topography in the eastern part of the focal area.

Aerial photographic survey is using 1/20,000 scale (CG-75-2X) and 1/10,000 scale by U.S. military forces. We interpret DEM using shaded relief map and stereoscopic bird's-eye view made from 2m mesh topographic data which is obtained by airborne laser scanner of Kokusai Kogyo Co., Ltd. The outcrop survey and survey of the small trench excavated by man power are conducted by observation and sketch of the wall surface after the wall has been made flat and smooth.

As a result of topographic survey, we found consecutive tectonic topography which is right lateral displacement of several ridge and valley lines along the ENE-WSW lineament in the mountain area from Momodani, Tottori city to Kujira, Fukube town. We interpret four other relatively short lineaments which are parallel in this lineament east of Tottori City urban area. These short lineaments are composed of cols and rectilinear valleys, and we found an active fault outcrop (Takiyama outcrop) along the southernmost part of the short lineament. Takiyama outcrop have the active fault which cut the layer of DKP (Daisen-Kurayoshi tephra: 55ka) which apparent vertical displacement is ca.90cm, and we confirm that the fault has been repeatedly moved during late Quaternary. A small trench is excavated to study the latest event in focus just behind the outcrop in the col topography. As a result of this survey, the age of the latest event is limited between before depositional age of K-Ah (Kikai-Akahoya tephra: 7.3ka) after AT (Aira-Tanzawa tephra: 26-29ka).

Keywords: 1943 Tottori earthquake, tectonic geomorphology, active fault outcrop, DEM investigation, aerial photo investigation

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SSS032-P20 Room:Convention Hall Time:May 25 16:30-17:30

Study on Late Pleistocene to Holocene activity of the eastern part of Shinji Fault

Shuji Hirokane[1*], Kohei Kurooka[1], Yuji Ito[1], Junji Fujiki[2], Shuji Hata[2], Takenobu Tanaka[3]

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We investigated the eastern part of the Shinji Fault to clarify the activity during Late Pleistocene to Holocene by arrayed boring and trenching surveys at the Shimoubeo in Matsue city.

A fault is confirmed by one of arrayed borings crossing the extended line of the lineament based on our geomorphological study. It is presumed that the fault deformed the layer considered to be MIS7 or older, which is weathered and distributed below the layer that contains grains originated from the Daisen Matsue Pumice (DMP), and not deformed upper layer.

Another fault confirmed on the trench wall crossing the active fault shown on Nakata et al.(2008) deforms "layer A" considered as MIS6 or older that based on tephla and pollen fossil analysis shows some time gap with "layer B" contains grains originated DMP.

The activity after the fall of DMP is not confirmed on both faults at the site.

Keywords: Shinji Fault, trenching survey

Japan Geoscience Union Meeting 2011
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SSS032-P21 Room:Convention Hall Time:May 25 16:30-17:30

Study on Late Pleistocene to Holocene activity of the western part of Shinji Fault

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We investigated the western part of the Shinji Fault to clarify the activity during Late Pleistocene to Holocene by arrayed boring survey at the Sadahongo-Sakoya in Matsue city.

The result of survey shows systematic vertical displacement on the Daisen Matsue Pumice (DMP) layer and the upper layers.

The vertical displacement of key beds is estimated to be 1.3m at about 25,00014C yBP, 0.8m at about 10,00014C yBP and 0m at 7,000 to 10,00014C yBP.

The latest faulting event is presumed to be between 10,00014C yBP and 25,00014C yBP.

The degree of activity on the western part of Shinji fault is lower than previous studied sites located at the Minamikoubu, Kashima town along the central part of the Shinji fault.

Keywords: Shinji fault, displacement of fault, arrayed boring

Japan Geoscience Union Meeting 2011
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SSS032-P22 Room:Convention Hall Time:May 25 16:30-17:30

Seaward extension of the Nishiyama Fault Zone off Fukuoka, western Japan

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The Nishiyama Fault Zone is an active left-lateral strike-slip fault existing between Fukuoka City and Kitakyusyu City and is estimated to make a M7.3(Richter scale) earthquake (the Headquarters for Earthquake Research Promotion, 2004). This fault zone has been rated an overland fault. The Off O-shima Fault was discovered in the northwest extension sea area of the Nishiyama Fault Zone, but it had not seemed a sequence of the Nishiyama Fault Zone because they were away by 5 kilometers. On the other hand, the Kego Fault is 20 kilometers southeast of the Nishiyama Fault Zone and also had seemed to be an overland fault. But the 2005 West Off Fukuoka Prefecture Earthquake (M7.0 in Richter scale) happened in the northwestern extension sea area of the Kego Fault and the fault seemed to extend to the northern sea area. In response to this, Abe et al.(2010) conducted reflection seismic survey and vibratory coring and revealed that the Nishiyama Fault Zone extended to the northwest sea area, too. Then, Japan Coast Guard conducted accurate topographic survey in the same area and discovered tectonic reliefs on the seafloor. In this study, the fault distribution is investigated by these survey analyses. Survey vessel and multibeam echo sounder used by Japan Coast Guard are ”Kaiyo” and EM302, respectively.

The depth of this sea area is between 60 and 100 meters and northern area is deeper. Sand waves with long frequency and gentle slope are found in southern area and sharp and small-scale reliefs are distributed in northern area. This geomorphological difference is caused by the agglomeration degree of sediments. The new and soft sediments with sand waves cover the old and hard bed.

Lineament composed of channels and bulges in direction of northwest-southeast was found in the northwestern extension sea area of the Nishiyama Fault Zone and the Off O-shima Fault. The bulges are formed by the old and hard bed uplifted by the faults of both sides and crop out in the new and soft sediments. The maximum relative elevation is 5 meters. The channels deform both new sediments and old bed. The maximum depth is 2 meters. The flower structure is found in the seismic profile under the channels and this shows that the channels were formed by a lateral strike-slip fault. The main lineament runs for about 30 kilometers from O-shima to Oki-no-shima and extends further north. Some short faults are shown in the seismic profiles and on the seafloor and indicate that the fault is splitting toward north.

The surveyed sea area was a land in the Last Glacial Maximum about 20,000 years ago. The soft sediments with sand waves laid down after the submergence.

Keywords: Nishiyama Fault Zone, active fault, lateral fault, sea area, seafloor topography, seismic reflection survey

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Extension position and continuity of the Nishiyama fault in Chikuzen-Oshima Island, Fukuoka Prefecture

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The Nishiyama fault, a left-lateral strike-slip fault, locates from Fukutsu City to Iizuka City(Pref. Fukuoka, 1996). In the nearby Genkainada Sea, the 10-km long Off Oshima fault, was identified in Genkainada Sea, where is the offshore northwestern extension of the Nishiyama fault (e.g. Iwabuchi, 1996). Tsutsumi et al. (2008) suggested, on the basis of geomorphology, that the Off Oshima fault belonged to the Nishiyama fault zone. In August 2010 the Japan Coast Guard re-surveyed the Off Oshima fault and identified a 30-km long northwesterly extension.

However, there is a gap of longer than 10 km between the northern end of the Nishiyama fault and the southern end of the Off Oshima fault. Chikuzen-Oshima Island locates between these faults. The aims of this study are to identify the position of an active fault in Chikuzen-Oshima Island and the continuity of the Nishiyama fault and the Off Oshima fault.

Aerial photograph interpretation was carried out to identify tectonic geomorphology such as fault scarps or the displacement of valleys or mountain ridges. Geological and topographical field surveys were conducted.

The results were as follows. We revealed topographical features of recent fault activity in the central part of the island. We found two outcrops of a fault, low fault scarps and sinistral displacements of the valley and a mountain ridge. It was therefore concluded that this was an active fault. Tephra analysis of deposits of fluvial terrace, which is displaced 1.5 m vertically by the latest faulting, in the Tani district was carried out. It is clarified that these deposits contained Kikai-Akahoya tephra (K-Ah: 7.3ka yBP) and Aira-Tn tephra (AT: 26-29ka) tephras [Machida and Arai(2003)]. We concluded that this terrace age is younger than 7.3ka.

In conclusion, an active fault was identified in the central part of Chikuzen-Oshima Island and the Holocene terrace surface was displaced 1.5 m vertically by the latest faulting.

Keywords: active fault, Chikuzen-Osima Island, Nishiyama fault, Off Oshima fault

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Fault exposure along the west foot of the Kodaiji mountain, Munakata-City, Fukuoka Prefecture.

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In the Fukuoka Coastal zone, a new outcrop of reverse active fault was observed along the on the west foot of the Kodaiji mountain, Munakata-City, Fukuoka Prefecture. The strike and dip of the fault surface are N20W and 28W, respectively. In this outcrop, terrace gravels and Tertiary rocks were deformed and displacement of the bottom terrace gravels on this thrust fault is about 3.2m in the vertical component. Also, we reveal the nature of the active fault located the Fukuoka Coastal zone on the basis of fault outcrops and geomorpric features.

Keywords: active fault, fault expusure, Fukuoka Coastal zone, C class fault

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Tsunami deposit investigation in the Fukushima coastal area

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Jogan tsunami deposit which was caused by AD869 Jogan earthquake, is distributed in the Fukushima coastal area (from Sendai plain to Soma city: e.g., Sawai et al., 2007; Sugawara et al., 2002), and this information has been used to construct and verify the fault models (Satake et al., 2008). The detailed distribution of the Jogan Tsunami deposit, however, has been not clear. Therefore, in order to obtain the more detailed distribution of the Jogan tsunami deposit, we investigated in the five investigation points (south Matsukawaura, Urajiri, Hotokehama, Shimo-Asamigawa and Takaku) of the Fukushima coastal area. Here we report investigation results of the hand breaker boring core sample by geological and geochrological methods.

In south Matsukawaura, we found two tsunami deposits. The upper tsunami deposit is possibly thought to be ca. AD1500 tsunami deposit (Sawai and Shishikura, 2010), and the lower one is the Jogan tsunami deposit determined by the carbon dating. The run up height by the Jogan tsunami is possibly 0.5m above sea level.

In Urajiri, we found four tsunami deposits. These tsunami deposits were estimated to be AD1500 tsunami deposit, AD970 to AD1160 tsunami deposit, the Jogan tsunami deposit and BC730 to AD420 deposit, respectively. The run up height of the Jogan tsunami deposit is estimated less or equal 4m above sea level.

In Hotokehama, Shimo-Asamigawa and Takaku, we did not find the tsunami deposits.

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Paleo-sea depth changes and tsunami deposits due to the Kanto earthquakes in Ena Bay, south coast of Miura Peninsula

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Paleo-earthquake studies by geological and geomorphological surveys are important for earthquake forecast because they provide information not only of earthquake occurrence time and magnitude but also on environmental changes during co-seismic and inter-seismic intervals.

The recurrence interval of the great interplate earthquake along the Sagami Trough, Kanto earthquake, is estimated to be 200-400 years (Earthquake Research Committee, 2004). However, earthquake histories prior to the 1703 Genroku Kanto earthquake have not been revealed from historical literature. Miura Peninsula, which locates in northeastern part of the Sagami Trough, has been uplifted (Kanie et al., 1989) and tsunamis attacked along the coast of the Kanto region accompanied by the previous Kanto earthquakes (Hatori et al., 1973). Shimazaki et al. (2009) conducted Geo-slicer surveys in Koajiro Bay, Miura Peninsula and investigated histories of the previous Kanto earthquakes. As a result, they suggested that the 1293 earthquake causing destructive damage in and around Kamakura was the Kanto earthquake prior to the 1703 Genroku earthquake, as pointed out by Ishibashi (1991).

The purpose of this study is to reveal histories and identify tsunami deposits of previous Kanto earthquakes, and processes of uplift and subsidence from a reconstruction of paleo-sea depth using diatom and grain size analyses in Ena Bay, Miura Peninsula. In May and November, 2009, we conducted 3m length handy Geo-slicer surveys at Ena Bay, south coast of Miura peninsula. We have basically analyzed 3 cores (ENA-C, ENA-E and ENA-F).

As a result, three (ENA-E) or four (ENA-F) coarse layers including shell fragment and gravel are recognized. These event deposits erode a subsurface layer indicating that they accompanied with a strong current. Diatom analysis indicates an increase or a decrease of relative abundance of marine species, suggesting a change of sea depth. Namely, marine benthic species gradually decrease prior to the deposition of tsunami deposits indicating coastal uplift or sea level fall, and benthic species increase above tsunami deposits indicating coastal subsidence or sea level rise. It is revealed that Miura Peninsula uplifted about 1.5 m at the time of the 1923 Kanto earthquake and now subsides with a rate of about 3.7 mm/year from tide gauge record at Aburatsubo (Geospatial Information Authority of Japan, 2010). The characteristics of diatom analysis suggest that environmental changes corresponding to these co-seismic and inter-seismic crustal movements. This is consistent with the results in Koajiro Bay (Shimazaki et al., 2008). We concluded that these event layers are tsunami deposits accompanied with the previous Kanto earthquakes, named as T1, T2, T3, T4 and T5 unit from the top to the bottom, respectively.

The T1 unit is concluded as a tsunami deposit accompanied with the 1923 Taisho Kanto earthquake using Pb-210 dating. However, radiocarbon ages indicate that the T2, T3, T4 and T5 unit deposited about 2000 cal. yBP, 3000 cal. yBP, 3300 cal. yBP and 3700 cal. yBP, respectively. This is consistent with histories of previous Kanto earthquakes inferred from marine terraces in Boso Peninsula (Shishikura, 2003). Moreover, at least three coarse-grained layers are recognized between T1 and T2 at ENA-C. These layers are possibly identified as tsunami deposits from similar tendencies of grain size distribution and diatom species.

Keywords: Kanto earthquake, Tsunami deposit, Ena bay, Paleo-sea depth change, Diatom analysis

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Classifications of the earthquake type and the recurrence interval for the Kanto earthquake

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Classificaiton of past Kanto earhtquake is examined as follows.
A.1923-type; poorly known
B.1703-type; 950 to 2,500 years [Seno (1977)], 2,000 to 2,700 years [Shishikura (2003)].
C.1923-1703 combination-type; 800 to 1500 years [Matsuda et al. (1974, 1978)], 1,450 to 2,600 years [Nakata et al. (1980)].
D.1923-1703 addition-type; 260 to 320 years [Kanamori (1973)], 200 to 300 years [Ishibashi (1977)], 180 to 400 years [Seno (1977)], 470 to 1,143 years [Matsuda (1985)], 300 years [Kumaki (1982)], two patterns of ˜600 years and ˜900 years [Kumaki (1988)], 380 to 400 years [Shishikura (2003)].

Keywords: Kanto earthquake, earthquake type, recurrence interval, occurrence time, earthquake cycle, long term prediction

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SSS032-P28 Room:Convention Hall Time:May 25 16:30-17:30

Re-evaluation of the Thoen fault activity in the Lampang basin, northern Thailand

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We applied remote-sensing technique and geomorphic index analysis to a study of the NE-SW-striking Thoen fault, Lampang basin, northern Thailand. Significant morphotectonic landforms caused by normal fault in the Lampang basin are represented by fault scarps, triangular facets, wine-glass canyons and linear mountain front. Along the Thoen fault, the SL index indicates the steeper slope near the mountain front. These SL indices possibly relate to a normal fault system. Moreover, most of Vf and Smf values at Ban Mai and Sop Prap segments are low (0.44 to 2.75 of Vf and 1.11 to 1.82 of Smf). These geomorphic indices may indicate slightly active tectonic area that results from vertical slip on the normal fault. Geomorphological features and geomorphic indices of the study area envisage active normal faulting. However, stratigraphic units of trench at Ban Don Fai indicate no clear-cut evidence of any recent fault movement. At Ban Don Fai trench No. 2, AMS radiocarbon and OSL ages suggested that the sediments of the lowest unit were deposited between 960 to 910 years ago. Therefore, the last movement of the Ban Don Fai segment might have occurred earlier than 960 years ago. High resolution seismic survey data for coal investigation in the Mae Tha sub basin (adjacent to the present trenching site) reveal that the Thoen fault is a concealed fault. Thus, the Ban Don Fai segment of the Thoen Fault might be a concealed fault.

In the northern Thailand, there are six major faults that have been regarded as an active fault: Mae Chan, Mae Tha, Pua, Thoen, Mae Hong Son and Mae Ping faults. This study proved that the Thoen fault might be not so active at least during the latest several thousand years. More researches on the other active faults are necessary to evaluate the fault activity and very recent tectonics in northern Thailand.

Keywords: Thoen fault, Normal fault, Morphotectonic landforms, Geomorphic index analysis, OSL and AMS radiocarbon datings, Lampang basin, Northern Thailand