Japan Geoscience Union Meeting 2012
(May 20-25 2012 at Makuhari, Chiba, Japan)


SSS35-P01 Room:Convention Hall Time:May 22 18:00-19:30

# Color analysis of a fault rock aiming at the new dating method of a fault

MURAKAMI, Masaki[1*], SATO, Fumi[1], MARUYAMA, Michiko[1], Kanae Kaida[2], Takafumi Uzawa[2], Shotaro Sezaki[2], Jun-ichi Uchida[3], Yoko Michiguchi[3], Hideaki Tsutsumi[3]

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Color analysis of rocks was first performed by Nagano and Nakashima (1989) in order to measure degrees of weathering on the surfaces of granitic rocks. Because color change depends on degree of alteration, color analysis has been applied in studies of landslides, weathering in borehole samples, and so on. Miyashita et al. (JPGU, 2011) applied color analysis to fault rocks in Tottori-ken Seibu area, and found the differences of color trend in the a∗-b∗ color maps between two linearments in the area. They presumed that the differences depended on the activity of faults. In this study, color analysis was performed in four fault zones (Awaji, Goumura, Yamasaki and Kego-Nishiyama) in Japan. As a result, distributions of obtained color data were different among four fault zones.

Keywords: fault rocks, dating, color analysis

**Japan Geoscience Union Meeting 2012**
(May 20-25 2012 at Makuhari, Chiba, Japan)


SSS35-P02 Room:Convention Hall Time:May 22 18:00-19:30

# Surface fault traces of isolated short faults and their subsurface structure

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Length of active faults are one of the important parameters for the evaluation of the size of earthquakes. In some case, longer seismogenic faults may exist beneath the isolated short faults. Here ”Isolated short fault” is defined as 1) separated from other active faults $>$ 5 km and 2) its length is shorter than 15 km. Affected faults are picked up from the active faults maps of Japan published by the Research Group for Active Fault of Japan (1991) and Nakata and Imaizumi (2002). We checked the surface fault trace using large scale airphotos and the relationships in the length between the surface trace of active faults (Ls) and subsurface structures inferred from the geological faults (Lgl) and the gravity anomaly distributions (Lgv). Based on the surface trace analysis, 47 faults could be elongate than those in previous maps and average of ”Extended Ratio” is calculated as 1.64. About the subsurface structures, average of ”Extended Ratio” is 1.69 (Lgl/Ls) and 2.01 (Lgv/Ls), respectively. These value means average ratio of the part of the indistinct surface fault trace along the isolated short faults. This study was apart of the project supported by JNES in 2010FY.

Keywords: active fault, isolated short fault, subsurface structure, size of earthquake, active fault evaluation

Japan Geoscience Union Meeting 2012
(May 20-25 2012 at Makuhari, Chiba, Japan)


SSS35-P03 Room:Convention Hall Time:May 22 18:00-19:30

# Geological evidence of development of fault related fold in and around Horonobe hill

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[1]JAEA Horonobe unit

Evaluation of effect of fault zone is one of the important issues in the geological isolation of high-level radioactive wastes. Based on the result of the geological data in and around the northern Hokkaido Horonobe hill, the outline is examined about changes of the depositional environment in the past about 3 million years, and the relation with the development process of a fault related fold is considered.

Keywords: fault related fold, facies, fault and fold zone, anticline, syncline

Japan Geoscience Union Meeting 2012
(May 20-25 2012 at Makuhari, Chiba, Japan)


SSS35-P04 Room:Convention Hall Time:May 22 18:00-19:30

# Paleoseismological survey on the seaward extension of the active fault along the western margin of the Hakodate Plain

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Active reverse fault zone including the Oshima-Ono Fault and the Tomikawa Fault locate between the Kamiiso Hills and Hakodate Plain. Late Quaternary marine terraces in several levels are distributed along the southwest coast of the Hakodate Plain. Their heights of marine terraces show the amount of uplift since the late Quaternary. We have conducted an integrated survey of the coastal area of Hakodate Bay, as a part of the 2011 offshore active fault survey project funded by MEXT, in order to understand distribution and paleo-seismicity of offshore active fault and fold in Hakodate Bay. The survey comprises high-resolution multichannel sonic survey, ultra-high-resolution single-channel sonic survey and paleoseismological vibro coring. The stacked time sections show that the submarine active faults with west-side-up extend NW-SE to NS trend in the Hakodate Bay. These characteristics of the submarine active faults suggest that the faults are southern extension of the Tomikawa Fault. Precise interpretation of the sonic profiles tied with core leads to an inference that the paleoseismic event occurred during the Holocene.

Keywords: offshore active fault, Hakodate Bay, high-resolution sonic survey, coring, Paleoseismicity

Japan Geoscience Union Meeting 2012
(May 20-25 2012 at Makuhari, Chiba, Japan)


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# Active fault segmentation and structural development of the eastern flank of the Ou Backbone Range, northeast Japan

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The Kitakami Lowland fault zone (KLFZ) is an active reverse fault zone that extends for more than 70 km in length. KLFZ can be classified into south and north areas, bordering around the Waga River. In the north area, active faults developed along the eastern flank of the Ou Backbone Range (OBR). In the south area, active faults are divided into along the eastern flank of the OBR and in the Kitakami Lowland. Several deep seismic profilings have proved structural development intersect at right angles to the arc. But structural development direction parallel to the arc has been little investigated.

In light of recent E-W trend stress field since Pleistocene time in the northeast Japan arc, geomorphological and geological maps showing the detailed distribution since Pliocene time are keys to show the changes of the structural development. In order to connect geomorphic and geologic data to crustal deformation, it is important that the shallow branched fault is investigated, in that many active reverse fault zones form branched fault in the shallow depth and a variety of surface deformation. The objectives of this thesis are: 1) investigation geomorphology and Geology at the surface of several active fault traces consisting the active fault zone, 2) estimation of subsurface structure and its development associated with active fault trace, and 3) discussion of the difference of crustal deformation between the north and the south area.

Active faults were mapped on the basis of geomorphological and geological maps. Investigation of tectonic geomorphology and fault outcrop provided a variety of surface deformation and activity of the active faults. Subsurface geological structure and its development of the active faults were interpreted, based on shallow seismic reflection profiling, gravity survey in some location. Subsurface geometry of fault model was constructed from amount of shortening and shape of deformation using area balancing method. Strike, location and range of the fault model were inferred from tectonic geomorphic and geologic structure.

As a result, KLFZ and active fault around it are consisted two categories in the north area and four categories in the south area. Location and structure of the fault models should be studied further, but the results of subsurface structure and its development indicate that consecutive active fault zone of the surface is composed by several fault formed by different structural development.

1) In comparison with those (shortening: $<$0.5 km/2 Ma, length: 10-15 km) in the Kitakami Lowland, amount of shortening and length of the fault model below the OBR (shortening: 1-2 km/2 Ma, length: 10-20 km) are large. This different indicates that displacement due to faulting along the volcanic front (OBR), have accumulated at a rate of 101 orders than that of the Kitakami Lowland.

2) In comparision with those in the south area, amount of shortening and length of the fault model in the north area are large. It should be noted that the largest fault model (Uwandaira fault group and Yokomoriyama fault, 1896 Rikuu Earthquake; M7.2) is located the area which the Quaternary volcano is not distributed in the volcanic front.

3) Main active fault is distributed along a steep Bouguer anomaly gradient, northern part of the Morioka-Shirakawa tectonic line, and in and around the low velocity zone of the lower crust by seismology.

Structural development difference between the north and south area, seismogenic fault of historic earthquake, Bouguer anomaly map, distribution of Quaternary volcano, and crustal heterogeneity suggest that development of active fault is controlled by basement structure, distribution of Quaternary volcano, and crustal heterogeneity. It is suggested that segment of active fault of the surface is controlled by these factors.

Keywords: Kitakami Lowland fault zone, seismic reflection profiling, area balancing method, slip rate, amount of shortening

Japan Geoscience Union Meeting 2012
(May 20-25 2012 at Makuhari, Chiba, Japan)


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# Long-term activity and paleoseismicity of the Warikurayama fault along the southeastern foot of the Mahiru Mountains, no

AWATA, Yasuo[1*], Masahiro Miyawaki[2], Masaru Saito[2]

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We conducted geological and topographical surveys of the Warikurayama fault along the southeastern foot of the Mahiru Mountains in northeast Honshu, Japan, to examine its structure, long-term activity and palesoseismicity. We confirmed that the fault is a reverse fault of 17 km-long. The fault having a 5 km-long south-central section, which is predominant in reverse fault component, and 9 km-long northern and north-central, and 3 km-long southern segments predominant in flexure component. A cumulative vertical displacement along the fault shows bow-shaped distribution up to 1,100 - 1,400 m since the late Pliocene or early Pleistocene. Terrace surfaces in the middle to late Pleistocene and Holocene are also cumulatively deformed and faulted along the 11 km-long central section of the fault. Terrace surfaces of 20 ka and 30-35 ka show about 4 m of vertical offset, and terraces younger than 3 ka show about 2 m of vertical offset. We conclude that the Warikurayama fault is a single behavioral segment, which has ruptured twice since 20 ka with 2 m of vertical slip per event. The most recent event of the fault probably occurred after 3 ka, and possibly in 16th century or later. An average slip rate of the fault since the late Pliocene or early Pleistocene is 0.5 to 0.9 m/ky or larger, whereas the slip rate since 30-35 ka decreases at 0.1m/ky.

Keywords: Mahiru-sanchi Toen fault zone, active fault, long-term slip rate, slip per event, paleoseismicity, 1896 Rikuu earthquake

**Japan Geoscience Union Meeting 2012**
(May 20-25 2012 at Makuhari, Chiba, Japan)


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# Source fault model of Northern Honshu, Japan

SATO, Hiroshi[1*], ISHIYAMA, Tatsuya[1], IMAIZUMI, Toshifumi[2], KATO, Naoko[1], TAKEDA, Tetsuya[3], KOSHIYA, Shin[4], TSUTSUMI, Hiroyuki[5], TOYOSHIMA, Tsuyoshi[6], KUDO, Takeshi[7], YAMAKITA, Satoshi[8]

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Constructing source fault model is significant for estimation of strong ground motion and evaluation of crustal activity, including seismicity and crustal deformation. Surface ruptures and crustal deformation associated with large earthquakes produces tectonic geomorphology and geologic structure. Thus, using active fault and fold data, we can estimated seismogenic source faults. However, in some cases, no surface ruptures are observed associated with large earthquakes. Particularly, in the fold-and-thrust belt of Northern Honshu, the existence of shallow detachment in the Neogene post rift mudstone, makes the relationship between deep sited seismogenic source fault and near surface active fault complicated due to thin-skinned deformation processes. Present days geologic structure is strongly controlled by old geologic structure. In case of Northern Honshu, Miocene rifting associated with the opening of the sea of Japan, strongly controlled the geometry of sesimogenic source fault. It is indicative by the recent result of the deep seismic profiling in the Niigata area and investigation of source fault associated with the 2003 Northern Miyagi earthquake. For constructing a source fault model, an integrated, multi-deciplinary approach is needed, including geologic and crustal architecture and seismicity. Here, we examined the active fault data, with geologic structure, gravity anomaly data, seismicity and constructed rectangular fault models in Northern Honshu. It is a first attempted to provide regional models by integrated way of approach. It is a very first version and it will be updated by the increased information in the future.

**Japan Geoscience Union Meeting 2012**
(May 20-25 2012 at Makuhari, Chiba, Japan)


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

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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. We renewed Quaternary paleoshoreline data and reconsidered their uplift processes. The obtained results are as follows.

(1) Warping of Holocene and Pleistocene shorelines is not necessarily concordant with that of historical coseismic uplifted abrasion platforms, and is accompanied with at least 6 upwarped units having short wavelength, bounded by height discontinuities. This suggests the accumulative process by activities of plural fault segments.

(2) Geologic faults exist at boundaries of warped units. This indicates that those fault activities is related to warping and height discontinuities. Especially, the deformation is possibly produced by the growth of fault-related fold.

(3) At least 7 reverse fault segments are required in and around coastal areas, to create warped units. Calculating the dislocation by each fault, paleoshoreline warping is nearly reproduced.

(4) Several A- and B- class active source faults are newly recognized in land and below the offshore sea bottom. Re-assessments and to those faults and the caution to next hazardous earthquakes are necessary.

Keywords: paleoshoreline, warping, hisitorical earthquake, causative fault, fault-related fold, Nishi-tsugaru coast

Japan Geoscience Union Meeting 2012
(May 20-25 2012 at Makuhari, Chiba, Japan)


SSS35-P09 Room:Convention Hall Time:May 22 18:00-19:30

# High resolution seismic reflection profiling in Gotemba, central Japan

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We collected and processed shallow high-resolution seismic reflection data in Oyama Town and Gotemba City, Shizuoka Prefecture, in order to resolve structures andactivity of shallow blind thrust faults buried beneath thick volcaniclastics deposits derived from the Hakone and Fuji volcanoes. We deployed 200 seismic channels, 10-Hz geophones, and mini-vibrator as a seismic source along about 8-km-long seismic line. Common midpoint stacking by use of initial velocity analysis successfully illuminates subsurface geometries of active fault-related fold to 1-1.5 two-way time. Detailed seismic reflection analyses including refraction and residual statics, migration, deconvolution, and time-space variant bandpass filters, and depth-conversion by use of stacking velocities enable to obtain subsurface depth section of these thrust structures. The high-resolution depth section shows that Southwestern extension of the Tanzawa group is thrust over Pleistocene Ashigara Group and younger sediments buried between the Fuji and Hakone volcanoes. Upper tip of the thrust is located at ca 25 m deep beneath the Gotemba mudflow deposits and is possibly active during the late Quaternary. In addition, Ashigara Group is also thrust over the younger sediments (uQt) speculatively correlated with middle to upper Pleistocene Ikudo Formation, Suruga gravel deposits and undefined younger deposits. Angular unconformity between these units is recognized in the seismic section. Additionally upward-decreasing dips in the uQt over the forelimb indicates recent activity of this blind thrust fault during the deposition of the uQt.

Keywords: active fault, Izu collision zone, blind thrust fault, Fuji volcano, Hakone volcano, seismic reflection profile

**Japan Geoscience Union Meeting 2012**
(May 20-25 2012 at Makuhari, Chiba, Japan)


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# Numerical simulation of Kureha-hill formation by means of discrete element modeling

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The Kureha-hill is characterized by anticline structure and it is known that the hill formed by inversion tectonics of the Kureha-yama fault. The Kureha-yama fault is located at the eastern edge of the Kureha-hill and had acted as normal fault (middle Miocene) and reverse fault (Pleistocene). In the late Miocene, the fault had not acted and thick sedimentary layer was formed on its hanging wall. In this study, we employed the software PFC 2D (2 dimensional particle flow code) based on 2D discrete element method, and attempted to discuss the forming processes of the Kureha-hill given by geological studies from the viewpoint of mechanics.

As a soft sedimentary layer, we prepared the modeled layer that the particles (rigid disk) having density and radius of 2000kg/m$^2$ and of 9.0 - 9.75 m were packed with porosity of 0.1 in the area where width and depth are 4000 m and 400 m. We assumed Young's modulus of 161 MPa, Poisson's ratio of 0.28, compressive strength of 20 MPa, tensile strength of 1 MPa and shear strength of 2 MPa, as elastic constants and strength of the soft sedimentary layer. Thus, we set up the normal stiffness of 5 x 10$^7$N/m, the shear stiffness of 7 x 10$^8$N/m, the frictional coefficient of 0.6 and the contact bound of 1 MN. And we assumed that the bottom part of the sedimentary layer is basement and it behaves as rigid body. The Kureha-yama fault was modeled as a simple fault with constant dip angle of 50 degrees because it is found by previous geological survey and geophysical prospecting.

As a result, it was found the basic structures of the Kureha-hill could be restored by numerical simulation and that geological discussion on formation of the hill was correct mechanically. In addition, we found (1) top of the Kureha-yama fault would have reached at the surface when the fault had acted as normal fault, and (2) large deformation of the basement is required for forming anticline structure.

Japan Geoscience Union Meeting 2012
(May 20-25 2012 at Makuhari, Chiba, Japan)


SSS35-P11 Room:Convention Hall Time:May 22 18:00-19:30

# Holocene surface faulting on the western segment of the Tonami-heiya fault zone, Toyama Prefecture

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Constraining the timing and characterizing the deformation style of individual past surface-rupturing earthquake events, particularly those of the recent events are important for better evaluating future probability of large earthquakes generated from inland active fault zone and for assessing seismic hazard. The western segment of the Tonami-heiya fault zone (active fault zone along the western margin of the Tonami Plain), which composed of two NNE-SSW-trending west-dipping reverse faults; the Horinji fault on the south and Isurugi fault on the north, is one of the major active fault zones in Hokuriku region. Late Quaternary faulting is delineated by tectonic geomorphic expression and Plio-Pleistocene stratal deformation, but its Holocene faulting behavior is poorly known. In order to clarify the Holocene activity we have conducted detailed geologic and tectonic geomorphic investigations at selected sites, including trenching and arrayed drilling helped by archeologists for age determination of pottery shards incorporated into strata. On the trench walls across the Horinji fault at Horinji site, Nanto City, distinct west dipping main thrust faults with a series of east-dipping back thrusts displacing late Pleistocene to Holocene strata were exposed. Principal deformation in the trench walls is incremental rotation and/or warping of strata on the hanging wall side of the main thrust associated with horizontal shortening. Multiple paleoseismic events were identified based on stratigraphic and structural evidence of paleoearthquake events such as angular unconformity and cross cutting relations of strata and faults. Cross cutting relations of two sets of oppositely dipping faults and radiocarbon dates from faulted strata suggest that the at least two paleoearthquakes occurred after ca 5.7 ky ago, which raises the possibility that this fault was responsible for the enigmatic 1586 Tensho earthquake. Detailed examination of back thrusts exposed in the trench walls at Kamimukuta site, Takaoka City, reveals first direct evidence of the late Holocene faulting on the Isurugi fault. One of three subparallel strands of back thrust displaces channel-fill sediments containing abundant pottery fragments and covered by black soil layer. Archeological examination and radiocarbon dating indicate that the latest faulting on this strand occurred between ca 4 ka and ca 2 ka. These new findings would contribute to refine evaluation of future probability of earthquakes generated from this fault zone. This research was conducted as an entrusted project from Ministry of Education, Culture, Sports, Science and Technology.

Keywords: paleoseismology, active fault, Holocene, Horinji fault, Isurugi fault, Toyama Prefecture

Japan Geoscience Union Meeting 2012
(May 20-25 2012 at Makuhari, Chiba, Japan)


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# Comprehensive research on the Uemachi fault zone (2)

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The Uemachi fault is running beneath the Osaka sedimentary basin, which is the secondary large populated area in Japan. Our research group has started to study the Uemachi fault zone in detail to get the information for developing the long-term earthquake evaluation and the strong ground motion prediction. Our research group consists of four sub-research groups for (1) research on detail trace for fault segments, (2) research on three-dimensional source fault and crustal velocity structure, (3) research on fault activity and average dislocation velocity, and (4) research on strong ground motion prediction. We introduce the research plan of this study for FY2010-2012 (SSJ fall meeting, 2011). Here we will show several research results till this period.

Keywords: Uemachi fault zone, active fault survey, long-term evaluation, strong motion evaluation

Japan Geoscience Union Meeting 2012
(May 20-25 2012 at Makuhari, Chiba, Japan)


SSS35-P13 Room:Convention Hall Time:May 22 18:00-19:30

# Preliminary results of tectonic geomorphological and geological researches on the Uemachi fault zone in Osaka, Japan

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We re-examined the distribution and shallow fault structure of the Uemachi fault zone. The Uemachi fault zone extends in the densely built-up area of Osaka and surrounding region, therefore, the long-term forecast of the future large earthquake and the strong ground motion prediction is necessary to evaluate various aspects for seismic hazards assessment. We conducted precise mapping of tectonic geomorphological features by tectonic geomorphological and geological survey including airphoto interpretations, geomorphological analysis using high-resolution LiDAR DEMs, extensive field work and re-evaluation of previous data. The newly-found evidence for tectonic geomorphic features is summarized as follows. Firstly, the high-resolution DEMs and related field works successfully revealed the distribution of uplifted delta relief along the northern portion of the Uemachi fault zone, which was estimated as concealed active faults in precious studies. The carbon 14 ages obtained from the top-set delta deposits, ~2500 y.B.P, probably postdate the timing of the most recent paleoearthquake. Secondly, previous studies mapped the distribution of the Sakuragawa flexure and the Suminoe flexure beneath the city central of Osaka as two blanching faults apart from the main Uemachi fault zone, however, we proposed these flexures are connected into single shallow structure as a sub-parallel frontal flexure zone along the main fault zone. The spatial distribution of flexures and the shallow fault structure are inferred from the borehole stratigraphy data as well as probable uplifted alluvial lowland shown in the high-resolution DEMs relief images. Thirdly, we re-examined the existence of the inferred active fault along the present coast line, extending far southwest from the southern termination of the Uemachi main fault zone. Along the estimated fault trace, the deformed fluvial/marine terraces are partly recognized as fault bulge or pressure ridge and back-tilt toward the mountain side. These tectonic geomorphic features support the existence of the inferred active fault along the coast line, in accordance with the cumulative deformation of anticline/monocline in Plio-Quaternary sediments imaged by P-wave seismic reflection survey. The spatial extent of the fault trace along the coast line and deeper fault structure is necessary to be further explored for seismic source models and the following strong ground motion simulations.

Keywords: active fault, paleoseismology, Uemachi fault zone

Japan Geoscience Union Meeting 2012
(May 20-25 2012 at Makuhari, Chiba, Japan)


SSS35-P14 Room:Convention Hall Time:May 22 18:00-19:30

# Deep subsurface structure of the Uemachi fault zone inferred by 3-dimensional balancing geological structural analysis

KIMURA, Haruo[1*], HORIKAWA, Haruo[1], Masaaki Suehiro[2]

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We constructed a 3-dimensional fault model of the Uemachi fault zone based on 3-dimensional balancing geological structural analysis. The Uemachi fault zone is located in the center of the Osaka Plain in central Japan. We analyzed the deformation of the strata in the study area using the 3DMove in Move2011 (Midland Valley Exploration Ltd.).

Keywords: active fault, reverse fault, Uemachi fault zone, Osaka Group, fault-related fold, 3-dimensional balancing

**Japan Geoscience Union Meeting 2012**
(May 20-25 2012 at Makuhari, Chiba, Japan)


SSS35-P15 Room:Convention Hall Time:May 22 18:00-19:30

# Subsurface flexure of Uemachi Fault

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In Osaka, Uemachi Fault is one of the famous active faults. It across the center of Osaka and lies in N?S direction mainly and is more than 40 km in length. Pliocene to Quaternary sediment 'Osaka Group' and terrace sediment are found to be deposited in the Osaka Plain and Holocene marine clay layers (Ma13) are covered these plains in order to sea level change. These sediment are very thick layers over 1000m therefore, fault structure are appeared as flexure zone (only vending the strata) and hidden the fault displacement around the surface. The up side on the fault (east side) is modified by erosion and urban development however, many seismic reflection surveys information the fault trace line on a piecemeal basis.

GI database collects more than 40,000 boreholes and includes both geological information and soil properties around Osaka by the Geo-database Information Committee of Kansai Area. In this study, we try to show the flexure zone around central Osaka area and decided the site of borehole drilling site and carried out the survey in order to decide the displacement rate of Uemachi fault. About 2500 borehole data exist in the fault area and made many section using GI base.

In this study, we carried out the drilling the borehole and sampling the core samples in the Sakuragawa flexure zone. About 120m deep core sample were analyzed by tephrochronological method, and correlated around borehole data. Ma5, Ma6 and Ma8 marine clay layers are correlated. The result of compare with the neighbor area, the average displacement speed indicates more active the Sakuragawa flexure rather than Uemachi fault zone. And the results of this drilling indicate the good information to correlate other borehole data around this area.

Acknowledgment: This research is funded by the integrated research project for the Uemachi active fault system in FY2011 by MEXT.

Keywords: Osaka, Uemachi Fault, marine clay, flexture structure

Japan Geoscience Union Meeting 2012
(May 20-25 2012 at Makuhari, Chiba, Japan)


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# Deformation of a thick sedimentary layer caused by dip-slip motions of the faults reaching to an interior of the layer

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We employed the software Particle Flow Code in 2D (PFC 2D) based on discrete element modeling and attempted to simulate deformations of a thick sedimentary layer caused by dip-slip fault motions. In this study, we discussed (1) effects of which the dip-slip motions of the faults reaching from the basement to an interior of sedimentary layer deform an interior and surface of the layer, and (2) effects of frictional coefficient between the fault plane and the particles.

The 2D discrete element modeling represents an arbitrary medium by an aggregate of rigid disks and its elasticity is described by connecting each disk by elastic springs. Young's modulus and Poisson's ratio are decided by spring constants in a computer. In 2D analysis, magnitudes of spring constants and contact bonds are set by the biaxial compression test. In this study, because we evaluate behaviors of soft sedimentary layers, we assumed Young's modulus of 207 MPa, Poisson's ratio of 0.24 and the compressive strength of 13 MPa. In order to represent these elastic constants and strength, we set each spring constant (normal direction and shear direction) of 500 MN/m, frictional coefficient of 0.6, the contact bond of 1 MN.

In the simulations, the sedimentary layer modeled with depth of 900 m and width of 5000 m was assumed and the basement under the layer is the rigid body. We moved the basement to vertical direction till depth of 600m from the surface. We considered the cases that the fault will reach to the depth of 810m, 720m, 530m, 450m, 180m and 0m from the surface, in the simulations. And, we assumed 0.6 and 0.06 as the frictional coefficient between the fault plane and the particles in each case.

As a result, it was found that the depth of tip of the fault affected the geometry of sedimentary layer and the deformation zone at the surface. If the fault tip reaches to thickness (450 m) of 50 % of the sedimentary layer from the basement rock, the fault motion made the interior deformation field that is different from the field caused by the motion of the fault without its extension to the layer. If the fault tip reaches to thickness more than 80 % of the sedimentary layer from the basement rock, the fault motion made the interior and surface deformation field that are different from the field caused by the motion of the fault without its extension to the layer. And, the difference of the frictional coefficient between the fault plane and the particles also affected the geometry of sedimentary layer and the deformation zone at the surface. If the fractional coefficient is large, it was found the structures of which the sedimentary layers around the fault were dragged toward the directions of the fault motions. If the fractional coefficient is small, it was not found the structures mentioned above. These characteristic structure described here appeared only under the condition of which the fault tip reaches to thickness more than 50 % of the sedimentary layer from the basement rock. If the fault tip reaches to thickness less than 50 % of the sedimentary layer from the basement rock, these structures did not appear in the sedimentary layer simulated.

Acknowledgement: This research is funded by the integrated research project for the Uemachi active fault system in FY2011 by MEXT.

Keywords: Numerical simulation, Discrete element method, PFC 2D, Fault reaching to an interior of sedimentary layer, Fault motion

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# Stratigraphy about UHM22-1 core and activity of Uemachi Fault

KITADA, Naoko[1*], TAKEMURA, Keiji[2], ITO, Hiroko[1], INOUE, Naoto[1], MITAMURA, Muneki[3], ECHIGO, Tomoo[1]

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In Osaka, Uemachi Fault is one of the famous active faults. It across the center of Osaka and lies in N?S direction mainly and is more than 40 km in length. Pliocene to Quaternary sediment 'Osaka Group' and terrace sediment are found to be deposited in the Osaka Plain and Holocene marine clay layers (Ma13) are covered these plains in order to sea level change. These sediment are very thick layers over 1000m therefore, fault structure are appeared as flexure zone (only vending the strata) and hidden the fault displacement around the surface. The up side on the fault (east side) is modified by erosion and urban development however, many seismic reflection surveys information the fault trace line on a piecemeal basis. One of the subway construction project across the fault, are carried out the many borehole drilling survey around the fault. It is the good case to understand the subsurface structure around fault.

KG-Net borehole database has more than 20,000 borehole data around Osaka. At first, we examined the borehole data along the seismic reflection line. And then consider the surrounded area. As a result, folding zone is distributed in the west side of Osaka area. We carried out the drilling the borehole and sampling the core samples in the Sakuragawa flexure zone near JR Nanba station (UMH22-1). About 120m deep core sample were analyzed by tephrochronological method, and correlated around borehole data. Ma5, Ma6 and Ma8 marine clay layers are correlated. The result of compare with the neighbor area, the average displacement speed indicates more active the Sakuragawa flexure rather than Uemachi fault zone

Acknowledgment: This research is funded by the integrated research project for the Uemachi active fault system in FY2011 by MEXT.

Keywords: Osaka, Uemachi Fault, marine clay, Osaka Group, tephra

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# Relationship between displacement and gravity change of Uemachi Faults and surrounding faults of Osaka basin, Southwest

INOUE, Naoto[1*], KITADA, Naoko[1], TAKEMURA, Keiji[2]

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The Osaka basin surrounded by the Rokko and Ikoma Ranges is one of the typical Quaternary sedimentary basins in Japan. The Osaka basin has been filled by the Pleistocene Osaka group and the later sediments. Several large cities and metropolitan areas, such as Osaka and Kobe are located in the Osaka basin. The basin is surrounded by E-W trending strike slip faults and N-S trending reverse faults. The N-S trending 42-km-long Uemachi faults traverse in the central part of the Osaka city. The Uemachi faults have been investigated for countermeasures against earthquake disaster. It is important to reveal the detailed fault parameters, such as length, dip and recurrence interval, so on for strong ground motion simulation and disaster prevention. For strong ground motion simulation, the fault model of the Uemachi faults consist of the two parts, the north and south parts, because of the no basement displacement in the central part of the faults.

The Ministry of Education, Culture, Sports, Science and Technology started the project to survey of the Uemachi faults. The Disaster Prevention Institute of Kyoto University is carried out various surveys from 2009 to 2012 for 3 years. The result of the last year revealed the higher fault activity of the branch fault than main faults in the central part. Kusumoto et al. (2001) reported that surrounding faults enable to form the similar basement relief without the Uemachi faults model based on a dislocation model.

We performed various parameter studies for dislocation model and gravity changes based on simplified faults model, which were designed based on the distribution of the real faults. The model was consisted 7 faults including the Uemachi faults. The dislocation and gravity change were calculated based on the Okada et al. (1985) and Okubo et al. (1993) respectively. The results show the similar basement displacement pattern to the Kusumoto et al. (2001) and no characteristic gravity change pattern. The Quantitative estimation is further problem.

This research is funded by the Comprehensive Research on the Uemachi Fault Zone (in FY2011) by MEXT.

Keywords: Uemachi fault, gravity anomaly, dislocation model

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# Paleoseismicity on the Sami and Shirakawa faults in the Atera fault system, eastern Gifu prefecture, central Japan

YOSHIOKA, Toshikazu[1*], HIROUCHI, Daisuke[2], SUGITO, Nobuhiko[3], HOSOYA, Takashi[4], MAGARA, Koji[4]

[1]Active Fault and Eq. Res. Ctr, AIST/GSJ, [2]Shinshu University, [3]Nagoya University, [4]Chuo Kaihatsu

The Atera fault zone in the eastern Gifu prefecture consists of the Hagiwara, Gero, Yugamine and Atere faults extending in the NW-SE direction with left-lateral stike slip, and the Sami and Shirakawa faults extending in the NE-SW direction with right-lateral strike slip. The Earthquake Research Committee evaluated that the probability of the earthquake occurrence in the future on the Sami and Shirakawa fault zones is unknown because of the luck of paleoseismological data. We carried out paleoseismological studies on the Sami and Shirakawa faults to evaluate the rupture probability in the future of these faults, using the fund of the Ministry of Education, Culture, Sports, Science and Technology. Three trenches were excavated at the Kono site on the Sami fault, and one trench on at the Nishibora site on the Shirakawa fault. V-shaped small faults and cracks were obserbed on the east wall of Kono C trench on the Sami fault. Radiocarbon dates of samples from inside of the cracks are about 1,100 years ago, and this indicate that the last faulting event occurred in these 1,100 years. At the Nishibora site, a clear vertical boundary between bedrock and soft sediment including many wood fragments and plant remains. However, Radiocarbon dates of samples from this sediment are almost modern, and this means this sediment are an artificial buried soil.

Keywords: Atera fault, Sami fault, Shirakawa fault, Gifu prefecture, trench excavation, paleoseismology

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(May 20-25 2012 at Makuhari, Chiba, Japan)


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# High resolution geostratigraphic survey of the Urazoko Fault in Turuga Bay on the Sea of Japan

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High-resolution geostratigaraphic survey was carried out for Urazoko Yanagase-yama fault group around the Turuga bay in 2011. We have planed a NE-SW survey line (total 123.5Km) with 2-5km lengths and 500m intervals, also planed short survey line (total 57km) with 1km length and 20m intervals for detail exploration. Some clear reflector that estimated formed after the alluvium plain observed at the Turuga-bay. Theses reflector have fitted together with the result of sediment corer survey, which carried out around the central part of Turuga-bay. Five reflectors ranges in age from 7300 to 9600yBP were confirmed. We have described the height of fault step using the reflectors. The main fault (F-39-40) of Urazoko group with 1.7 to 2m in heights has observed over a range of 1km around the detailed exploration area. There is no accumulating formation for displacement component from the basement of Alluvium plain to K-Ah layer. At the edge of this fault, the step decreases toward the southern part. And this fault diverged in another fault, which presented the same structure in the southern part of Turuga-Bay.

Keywords: active fault, Urazoko fault, High resolution geostratigraphic surveyc

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# Coring survey of the Urazoko Fault in Tsuruga Bay on the Sea of Japan

SUGIYAMA, Yuichi[1*], SAKAMOTO, Izumi[2], yoshiyuki Takino[2], Takuya Usami[3], Masanori Shimazaki[3], Nobukatsu Takeda[4], Takahiro Nagata[4], Kota Shimogama[4], Kazuma Matsuyama[4]

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We have conducted coring survey of F-39/40 fault, one of the two branch faults of the Urazoko fault system in the central part of Tsuruga Bay on the Sea of Japan, in order to reveal the Holocene faulting history of the fault system. In our presentation, main results of core observation, 14C dating and volcanic ash analyses are reported. We finally estimate about 2-meter vertical displacement of the Kikai-Akahoya volcanic ash horizon of 7300 years BP by the F-39/40 fault. The faulting history of the fault system is discussed in our oral presentation, integrating our high-resolution sonic survey and coring results with reexamination results of the existing survey data.

Keywords: Urazoko fault, Tsuruga Bay, Coring, Active fault

Table 1. Correlative horizons, their estimated ages and depth differences between the both sides of F-39/40 fault.

| **Correlative horizon** | Stratigraphic unit | **Estimated age in core DA-7 (cal yBP)** | Depth (bsl, m) in core DA-7 (downthrown side) | Depth (bsl, m) in core UA-5 (upthrown side) | **Depth difference between the both sides** |
|---|---|---|---|---|---|
| | a | | | | |
| 1 | | 7300 | 38.6 | 36.7(erosion surface) | 1.9 |
| **K-Ah tephra** | | **7300** | **38.6** | **36.5 (estimated)** | **2.1 (estimated)** |
| Z | b | 8900 | 39.5 | 37.2 | 2.3 |
| A | | 9100 | 40.1 | 37.7 | 2.4 |
| 2 | | 9300 | 40.8 | 38.2 | 2.6 |
| 3 | | 9400 | 41.3 | 38.6 | 2.7 |
| B | c | 9600 | 42.0 | 39.4 | 2.6 |
| 4 | d | 10200 | ≧42.9 | 39.5 | ≧3.4 |

**Japan Geoscience Union Meeting 2012**
(May 20-25 2012 at Makuhari, Chiba, Japan)


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# Seismic reflection profiling across the Mikata 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, Mikata Fault

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(May 20-25 2012 at Makuhari, Chiba, Japan)


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# Crustal movement during the late Quaternary in the Ise Bay and Ohmi Basin, based on terraces and subsurface geology

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This study aims to reveal distribution of crustal movement during the late Quaternary. Yoro-Kuwana-Yokkaishi fault zone and Biwako-seigan fault zone consisting of west dipping reverse faults is one of the largest active fault zones in southwest Japan. However, the pattern and distribution of vertical deformation around the fault trace are not revealed quantitatively. Thus, amounts of uplift and subsidence were estimated based on terrace surfaces and subsurface geology.

Keywords: Crustal movement, Ohmi Basin, Ise Bay, Active fault, Terrace

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# Tectonic geomorphology and late Pleistocene activity of western marginal faults of the Suzuka Mountains, central Japan

MIZUMOTO, Tadaki[1*], AZUMA, Takashi[2], NAKATA, Takashi[3], TSUTSUMI, Hiroyuki[4], GOTO, Hideaki[5], TAJIKARA, Masayoshi[1], MATSUDA, Tokihiko[1], MATSU'URA, Ritsuko S.[1]

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This study focuses on the tectonic geomorphology in small scales derived from precise aerial photograph interpretation of tectonic landforms. Marginal fault zone at the western foot of the Suzuka mountain range is one of major active faults in Japan. This fault zone, composed of east-dipping thrust faults trending N to S, is about 44km long containing many presumed active faults. One of a recent previous work have carried out a seismic reflection profiling and boring survey across the presumed zone of faults to be along the Uso River, but have not clear the late Pleistocene to Holocene activity of faults because of no detailed data on the recent deposits.

This work shows that surface fault traces are recognized in the northern half of the fault zone. It extends at least 9km in length. At the site of the Uso River, small tectonic scarp recognized on young terraces developed along the river are well accord with the assumed sites of the fault by the seismic reflection records. Based on reported data on geomorphological history in central Japan, it is reasonable to assume that the latest faulted terraces formed after the late Pleistocene by geomorphological evidences. A possible interpretation of tectonic geomorphology can be such that the small fault scarp identified on such terraces adjoining a flood plain is the movement of the fault associated with the most recent event of surface rupture during the Holocene time.

Though Seismic reflection profiling also plays an important role in the understanding of the relationship between underground seismogenic and surface faults in order to clarify the regional characteristics of the faults, it is needed to attach the highest importance on the tectonic landforms on everything from large to small scales for them. In particular, recent fault activity can be seen such as the small displacement of landforms and can be clearly differentiated as compared to those from earlier times. To identify the recent fault activity on the surface is highly effective subjects for mitigation of seismic hazards, simulation of earthquakes associated with active faults.

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

Keywords: active fault, tectonic geomorphology, suzuka mountain range, aerial photograph

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# Active tilting along the eastern margin of the southern part of Kyoto Basin, central Japan

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1. Introduction

The presenter describes the newly discovered late Quaternary flexure that divides the Kyoto Basin and its surrounding hills. The Kyoto Basin is bounded by active faults, however there is only a little knowledge on the geologic structure of the eastern margin of its southern part.

2. Features of higher terraces and their deposits

There are higher river terraces along the Uji River that run from east-ward hills to the Kyoto Basin. These terraces are useful to horizons of late Quaternary crustal movement. The higher terraces are subdivided into two surfaces.

The highest terrace called the higher 1 terrace consist of thin (less than several meter) hard-weathered gravel and sand, and it is covered with reddish soil that accompanied with reticular texture. These reticular texture in surface soil are major index to identify the higher 1 terrace. The higher 1 terrace forms hill-top flat land, and is continuously distributed in the southern side of the Uji River.

The higher 2 terrace deposits comprise thick (over 50 m at the thickest point) weathered gravel, sand and mud, and its surface is covered with reddish soil. This thick fill deposits and reddish soil that not accompanied with reticular fabric are index to identify the higher 2 terraces. The higher 2 terrace is discontinuously distributed along the Uji river.

No geo-chronological samples are gotten in this study area, however color of the surface soil and weathering degree of sediments indicates these two terraces are late middle Pleistocene in age.

3. Deformation of horizons and description of the late Quaternary tectonic movement

These two wide-spreading river terraces have west-ward gradient. The inclination of higher 1 terrace and the higher 2 terrace are 35/1000 and 17/1000 respectively on the projection to N70W direction in 2 km section. The inclination of the higher 2 terrace is 28/1000 in 5 km section, and relative height of this section is 140m. On the other hand, inclination of the recent river bed of the Uji river is about 1/1000.

These facts indicate the cumulative west-ward tilting have occurred during the late Quaternary, and mean vertical displacement rate of this tilting movement would be ranked to B class (0.1 to 1 mm/yr) in activity. This activity would be comparable to the other given active faults surrounding the Kyoto Basin. The length of this geologic structure is thought to be longer than 3km according to the width of the higher terrace. This late Quaternary geologic structure is called the Uji flexure.

The deepest subsidence has occurred near the Oguraike marsh in the Kyoto basin during Quaternary (e.g. Kansai Geo-information Application Committee, 2002).About 800m Quaternary Basin-fill deposits have piled in this area. This distinct subsidence area locates just west of the Uji flexure. This fact also supports that the Uji flexure is active structure during late Quaternary.

4. Re-examination of the continuity of active fault zone

The former studies had not recognized active fault in the southern end of the Kyoto Basin. And there is about 7km-long gap of active fault between the Kyoto Basin and the Nara Basin. The Headquarters for Earthquake Research Promotion (HERP;2005) summed up that the Kyoto bonchi toen fault zone (eastern marginal fault of the Kyoto Basin) has to be evaluate different segment from the Nara bonchi toen fault zone. The presenter thinks that at least northern 3km of this active fault gap is not exist. And activity of newly discovered active flexure would be comparable to the other active fault. This suggests necessity of re-examine the long-term fault evaluation.

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Keywords: active tilting, active fault, Kyoto Basin, higher terrace, Uji Flexure

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(May 20-25 2012 at Makuhari, Chiba, Japan)


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# The outcrops of the fracture zone along the Gomura Fault in Kyoto, Japan

SATO, Fumi[1*], Masahiro Fujii[1], MARUYAMA, Michiko[1], Junichi Uchida[2], Yoko Michiguchi[2], Hideaki Tsutsumi[2]

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The Gomura fault is 13km-long northeast-trending left lateral active fault in Kyoto, Japan. Kita-Tango earthquake was occurred on March 7th 1927 and formed surface ruptures along the Gomura fault. The part of this ruptures is received certification of the natural monument on 1929. This preservation of historic spots selected one of the Geosite of Saninkaigan Geopark plays an important role especially for the tourist attractions and educational resources.

The purposes of this study were to find the way to estimate the fault activities using the characteristic of the fault fracture zones. We performed a geomorphological and geological survey of this fault.

As a result, We found 11 outcrops along the Gomura fault, Amino-cho Go, Ikunouchi, Mineyama-cho Yasu. These outcrops located on the main trace of Gomura fault zone drawn by Okada and Matsuda ( 1997 ) . We found the fracture zones in basement rock (Granite) distributed in this area. We will present here the details of the fracture zones.

Keywords: Gomura Fault, Surface ruputure, Fault fracture zone, Geo-park

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# Relationship of fracture zone and tectonic landform in the Yasutomi falut of the Yamasaki falut zone, in southwest Japan

KUROSAWA, Hideki[1*], Shotaro Sezaki[2], KOSAKA, Hideki[2], Jun-ichi Uchida[3], Yoko Michiguchi[3], Hideaki Tsutsumi[3]

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We studied the fault zone in the area around the Yamasaki fault zone, one of the active faults in southwestern Japan. The Yamasaki fault zone is a left-lateral strike slip fault. The investigation of outcrops, pits and trench indicated palaeoseismic evnt and fracture zone associated with the Yamasaki falut zone.

Keywords: Yamasaki fault, Yasutomi fault, fault zone

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(May 20-25 2012 at Makuhari, Chiba, Japan)


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# Distribution and occurrence of the fault rocks associated with the Nojima fault, Central Japan

NAKAMURA, Masaru[1*], Kanae KAIDA[2], Takashi KUSANO-HONGO[3], Masaki MURAKAMI[1], Junichi UCHIDA[4]

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Investigation of the trenching and fault outcrop observation of active fault at the Nojima fault the surface fault ruptures associated with the 1995 Hyogo-Ken Nanbu earthquake , Central Japan around the Nojima fault, interpreted paleoseismic event and fault feature.

Multitle fault is exposed in the trench. We identified at last 2 , and possibly more ,late Pleistocene- Holocene paleoseismic event , based on the upword termination of fault

Keywords: Nojima fault, the 1995 Hyogo-Ken Nanbu earthquake, Central Japan, paleoseismic event, active fault, fracture zone

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# Gravity Measurement around source region of 2000 Tottoriken-seibu earthquake

INOUE, Naoto[1*], ECHIGO, Tomoo[1], MIYAKOSHI, Ken[1], NOGUCHI, Tatsuya[2], KAGAWA, Takao[2]

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The 2000 Tottoriken-seibu earthquake was occurred in the area where no active faults were mapped before the earthquake (Active Faults Research Group, 1991). The detailed analysis of aerial photograph revealed several new active faults and lineaments (Tsutsumi et al., 2000; Inoue et al., 2002; Takada et al., 2003). In the southwestern part of the seismogenic source fault of the 2000 Tottoriken-seibu earthquake, several short lineaments were revealed. The Bouguer anomaly, which indicated the subsurface density structure, indicated relatively steep gradient zone around the newly recognized lineaments. The Bouguer anomaly of 1-km gridded data of the Gravity CD-ROM published from the Advanced Industrial Science and Technology was the high gravity anomaly region around the seismogenic source faults. The similar relation was recognized in the 2002 Kagoshimaken-hokuseibu earthquake (Miyamachi et al., 2004). The detailed gravity map derived from data which published by Gravity Database of Southwest Japan (CD-ROM)(Gravity Research Group in Southwest Japan, 2001) indicated the narrow gravity low zone around the lineaments. We carried out gravity measurement cross surface rupture with station interval of 50 - 250m. The measured detailed gravity anomaly indicated the relative low anomaly around area where the small lineaments and ruptures were recognized.

This research was commissioned by the Japan Nuclear Energy Safety Organization (JNES).

Keywords: 2000 Tottoriken-seibu earthquake, Gravtiy measurement, lineament

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# Tectonic geomorphology along the Yasaka Fault Zone: a long active fault in the area of dense population of active faults

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In the western Chugoku district (Yamaguchi prefecture, western Hiroshima Prefecture, western Shimane Prefecture), it has been thought that distribution of active faults is very sparse. However, several active faults were newly mapped by several researchers in recent years. We have been mapped active faults in the whole area of the Chugoku District by detailed air photograph analysis during the last two years. As a result, we revealed that many active faults are densely distributed in this area. In this presentation, we report tectonic geomorphology along the Yasaka Fault Zone as an example of such active faults, and discuss the characteristics of distribution pattern of this Fault Zone.

Although distribution of active fault traces in our result is similar to those of the published data in large scale view, some active fault traces are mapped in different location and some active faults traces are newly mapped. Active fault traces in our map have a tendency that shorter traces are distributed in en echelon pattern. Along the previously mapped active faults traces, many tectonic landforms (lateral offset streams, offset hills, uphill-facing fault scarplet, beheaded stream, dammed stream) are newly mapped. As a result, we clarified that the Yasaka Fault Zone is an active fault system with 55 km in length, and that the Yasaka Fault Zone have a capability of causing M7.5 earthquake.

Keywords: Yasaka Fault Zone, active fault, aerial photograph, inland earthquake, Chigoku region

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# Arrayed boring survey across the eastern extension of the Kawakami fault of the Median Tectonic Line active fault zone i

IKEDA, Michiharu[1*], TSUJI, Tomohiro[1], GOTO, Hideaki[2], TSUTSUMI, Hiroyuki[3], Masahiro Okitsu[4], NISHIZAKA, Naoki[5]

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We drilled four cores across the estimated fault line of the Kawakami fault at Yokoguro in Saijyo-city to obtain geological evidence for the eastern extension of the Kawakami fault. The drilled length of each core is core A: 27 m, B: 25 m, C: 30 m and core D: 28 m in the direction of N to S. Then we conducted geological observation, recognition of volcanic ash, color measurement, pollen analysis, measurement of magnetic susceptibility value, and microfossil analysis.

The observation and analyses results are as follows.

(1) Core samples are divided four units (Unit 1 to 4 in descending order) based on geological characteristics. Unit 4 and 3 are channel deposits composed of pebbles in late Pleistocene. Unit 2 is brackish water environment to marine deposits in late Pleistocene to Holocene. Unit 1 is channel deposits composed of pebbles in Holocene.

(2) The all four units are recognized on the cores A, B and C, but the core D does not reach the Unit 4.

(3) The upper horizon of the K-Ah volcanic ash on cores A, B and C is 2 m shallower than core D. The boundary between the Unit 3 and Unit 4, which are beneath the K-Ah volcanic ash layer, on the core C is 9 m or over shallower than core D. Therefore, the depth differences of each correlation layer between the core C and D increase towered to the deeper part.

(4) The thicknesses of each unit on the core C are thinner than core D. For instance, the thickness of the Unit 2 is 2.8 m on the core C and 4.5 m on the core D. The thickness of the Unit 3 is 10.15 m on the core C and 16.5 m or over on the core D.

These results indicate that there is probably the Kawakami fault between the core C and D, and the Kawakami fault has caused repeatedly fault displacements downthrown to the south. The average slip-rate in vertical sense of the Kawakami fault is calculated as about 0.27 mm/yr at the research point based on the amounts of fault displacements (2 m) after the eruption age (ca. 7300yBP) of the K-Ah volcanic ash.

Keywords: Median Tectonic Line active fault zone, Kawakami fault, fault distribution

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SSS35-P32 Room:Convention Hall Time:May 22 18:00-19:30

# Trench excavation surveys on the Otake fault and the Hatakitoge fault, Iwakuni fault zone, Yamaguchi Prefecture, Japan

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The NE-SW trending Iwakuni fault zone in southwest Japan consists of many right-lateral strike-slip faults, which are considered to be low activity ones. We conducted two trench excavation surveys on the Otake fault and the Hatakitoge fault in the Iwakuni City in order to obtain the paleoseismological parameters and related fault gouges for evaluating earthquake potential. Based on the trench wall observation and radiocarbon dating, the latest faulting event of the Otake fault is after 2,800 cal yBP. This work was supported by Japan Nuclear Energy Safety Organization.

Keywords: Iwakuni fault zone, trench excavation survey, active faults, paleoseismology, Yamaguchi Prefecture

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# Recent surface faulting events of the Nishiyama fault zone, Fukuoka Pref.: a preliminary report of trenching surveys

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The Nishiyama fault zone is NW-SE trending left-lateral strike-slip fault located on North Kyushu. We performed geomorphological and geological surveys along the whole of the fault zone and its extending area to obtain the paleoseismological parameters for evaluating earthquake potential cased by the fault zone. The most valuable information was come from the Uruno trench site in Iizuka City. It revealed that the surface rupturing events of the fault occurred more than five or six times in recent several ten thousands years on the basis of the trench wall observation and preliminary radiocarbon dating.

Keywords: Nishiyama fault zone, trench excavation survey, active faults, paleoseismology, Fukuoka Prefecture

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# Development of the measuring method for the deformation by photogrammetry, A case study of the Chelungpu fault, Taiwan

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We have tried to estimate the amount of coseismic displacements on a fault, analyzing the tectonic geomorphology along an active fault. We tried to measure topography profiles on photogrammetry method in order to compare the deformation pattern and amount of the surface rupture and long term geomorphology, and then calculate the coseismic deformation. However, coordinates of GCP positions before the earthquake which are very important for accurate measurement are unknown. We tried to orient the GCP on aerial photograph before the earthquake by following three methods.

The 1999 Chichi earthquake was selected as a case study. We used aerial photograph taken in 1987 and stereoscopic SPOT satellite imagery taken in 2004.

Method 1: Reading coordinates on large scale photographic map.

We measure GCPs positions on the 1/5,000 photographic map by hand. Because the photographic map is based on 1987 aerial photograph, it has good resolution for vertical. But it has poor accuracy for horizontal coordinates, because it is difficult to indicate the exact location of GCP on the map.

Method 2: Reading coordinates on SPOT satellite imagery.

Since there is little distortion in each SPOT satellite image as compared with an aerial photograph, we can read coordinates on Spot image relatively accurate. However these data are coordinates of after the earthquake and it include coseismic deformation. In order to decrease the error of measurement near by the active fault, we set the GCP far away from the active fault.

3: Reading coordinates on SPOT satellite imagery and then correct it with observed deformation data.

As for this method, GCPs in the method 2 are added offset by observation data, which are measured across the surface rupture or crustal movement by GPS observation.

The aerial photograph was oriented by each method, and the surface profile on the same line was measured on each oriented aerial photograph and compared. There is not much difference between the three. Next, the same profile was measured on the SPOT image and calculated difference between aerial photograph and SPOT profiles. The displacement values are largely similar to observed displacement in the field.

Then, distribution of the amount of displacement along a Chelungpu fault was measured by this method, and the amount of average slip rate was estimated.

Keywords: active fault, surface rupture, Chelungpu fault, photogrammetry, SPOT image, Taiwan

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# Paleoearthquake Investigations of the Mae Hong Son Fault in Mae Hong Son, northern Thailand

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The collision between Indian and Eurasian plates since the late Paleogene causes the NW-SE and NE-SW strike-slip faults and the N-S dip-slip faults in the Indochina region. In Mae Hong Son, northern Thailand, several fault lines trend in the NE-SW, NW-SE and N-S directions, and are temporally and spatially associated with Cenozoic basin. Previous remote sensing investigation reveals many lines of morphotectonic evidence along the Mae Hong Son Fault which suggest an active tectonic zone. In order to clarify tectonic activity of this region, we selected the Mae Hong Son Fault as a target (fault) for paleoearthquake investigation.

We applied remote sensing techniques and aerial photograph interpretation to a study of the Mae Hong Son Fault. The quarry with the Cenozoic strata was used for fault geometry analysis. The Mae Hong Son Fault mainly strikes N-S, with the NW-SE conjugate faults and some minor NE-SW faults. The N-S faults show a normal dip-slip, and bound the margins of the N-S elongate basins which might result from the movement of large-scale strike-slip fault in this region. The NW-SE faults show right-lateral strike-slip movement. Nevertheless, the NE-SW faults show left-lateral strike-slip movement. Essential morphotectonic landforms associated with the Mae Hong Son Fault are fault scarps, offset streams, linear valleys, shutter ridges, triangular facets, hot springs, and linear mountain fronts.

We observed the significant morphotectonic landforms along the NE-SW Mae La Noi segment of the Mae Hong Son Fault, suggesting oblique movement. We recognized two paleoearthquake events of this fault segment in the quarry using results on OSL age dating data; the older event occurred before 20,000 years ago, and the younger event occurred between 8,300 and 7,800 years ago. An average rate of the last fault movement was 0.14 mm/yr. Therefore, it is concluded that the Mae Hong Son Fault is still active till present, and the Mae La Noi segment is regarded as the active segment with the oblique movement.

Keywords: Mae Hong Son Fault, Northern Thailand, Mae La Noi, Paleoearthquake

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# Systematical deflections and offsets of the Yangtze River drainages along the Xianshuihe Fault, Tibetan Plateau

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During the past two decades, the integration of geologic, geomorphic, seismic, and geophysical information has led to increased recognition and understanding of the tectonic significance of geomorphic features caused by strike-slip along active strike-slip faults. Tectonic landforms developed along active strike-slip faults are mainly characterized by systematic deflections and offsets of streams and terraces, and fault sags which are regarded as reliable displacement markers useful for reconstructing the long-term activity of active faults. It has been demonstrated that stream offsets and fault-bounded geologic structures such as pull-apart basins have resulted from repeated large strike-slip earthquakes. The study of tectonic geomorphology will provide a new insight into the seismic activity, longevity and structural evolution of active strike-slip faults.

The Ganzi-Yushu-Xianshuihe Fault Zone is a typical strike-slip active fault, which triggered the 2010 Mw 6.9 Yushu earthquake in the central Tibetan Plateau. This fault zone extends for >800 km from the central to the southeastern margin of the Tibetan Plateau, which changes its strike from WNW-ESE to NNW-SSE. In this study, we investigated the systematical deflections and offsets of the Yangtze River and its main branches as well as small stream channel systems along the fault traces of the Ganzi-Yushu-Xianshuihe Fault Zone. The analysis of deflected small stream channels is carried out using Google earth images, 15m-resolution ETM+ L8 images, 30m-resolution ETM+ Mosaics images, and 0.5-1m high resolution World View images. The analytical results show that i) the drainage system of the Yangtze River and its branches have been systematically sinistrally-deflected; ii) the main river channels of the Yangtze River have been sinistrally offset 60-85 km; iii) the offset amount are cumulated on the offset river channels along the fault zone. Geomorphic and geologic evidence confirms that the systematical offsets of streams and gullies are the results of repeated large earthquakes and these topographic features are reliable indicators of seismic displacements accumulated on active strike-slip faults. Our findings support the idea that the strike-slip faults developed in the Tibetan Plateau have played an important role in the eastward extrusion of the Tibetan Plateau and accommodate the ongoing northward penetration of the Indian plate into the Eurasian plate.

Keywords: Tibetan Plateau, Ganzi-Yushu-Xianshuihe Fault Zone, Yangtze River system, systematical deflections and offsets, sinistral strike-slip fault