Tectonic landform in the area around the southern segment of the Itoigawa-Shizuoka Tectonic Line, central Japan

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Tectonic landform around inland active fault is formed by fault accumulation displacement due to big earthquakes occurred repeatedly. Detail distribution of active fault and information on tectonic landform are necessarily to reveal structure progression developed by repeated active faulting. In this study, we focus on the area around Hakusyu fault, Shimotsuburai fault and Ichinose fault which compose the southern segment of the Itoigawa-Shizuoka Tectonic Line (ISTL) in central Japan where has highly activated recently.
In this study, to understand the relationship between tectonic landform and the active fault structure. we identify the active fault traces and tectonic landform using perspective maps made from the 5m-mesh digital elevation mode (DEM) data, stereo-examination of aerial photography, and conducted field investigations. Interpretations of perspective topographic maps, field investigations, and structural analysis of fault zones reveal that i) the active fault traces show more irregular, curved shape than previously studies; ii) trace of which dip-angle of thrust fault is low curves close to a contour line.
We classify the tectonic landform into 3 groups according to its shape. The first is the flexure scarp seen in the northern part of Hakusyu fault which have the highly relative elevation and which can't see the inclination of the inclination on the hanging wall side. The second is flexure scarp which has greatly monoclinal flexure near the fault, and seen geomorphic surface of reverse inclination on the hanging wall side (the west side) seen by the southern part of Hakusyu fault and an alluvial fan plateau leading edge department of eastern inclination in an area around the Ichinose gap. The third is flexure scarp with a fold scarp of low relative elevation and monoclinal flexure with the long wave length in the hanging wall side seen along Shimotsuburai fault.
To characterize these three types of tectonic landform, we establish fault scarp index (Fsi), which is defined by the length of the wing (L) of each flexure scarp divided by relative elevation (H). As a result, Fsi in Hakusyu fault plateau have relatively low values, Shimotsuburai fault has highest, and Ichinose fault has an intermediate. According to these results, fault dip is steep in Hakusyu fault which have low Fsi values. On the other hand, fault dip is almost horizontal in Shimotsuburai fault which have high Fsi values. This study indicates it is possible to presume the characteristics of the active fault from the feature of the tectonic landform and the fault scarp index (Fsi) is valid for assessing the property of active fault scarps.

Keywords: Itoigawa-Shizuoka Tectonic Line active fault system, active fault, Tectonic landform

Paleoseismological study on subsidiary surface fault ruptures produced by the 2014 Mw 6.2 Northern Nagano earthquake, central Japan: Preliminary report

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The 2014 Mw 6.2 Northern Nagano earthquake (central Japan) produced a 10 km long surface rupture zone that consists of main rupture and subsidiary ruptures. We carried out trench excavation surveys on the subsidiary ruptures to reveal paleoseismic activities. Reverse faults cutting bedrock and terrace deposits were exposed on the trench walls. Judging from upward fault termination and other deformation structures, we identified three paleoearthquake events. The timing of these events is still under way.

Seismic reflection survey across the coseismic surface ruptures of the 2014 nagano-ken-hokubu earthquake of Mw 6.2, central Japan

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The Nagano-ken-hokubu earthquake (Mw 6.2) struck Hakuba village, Nagano Prefecture, on 22 November 2014. A 9.2-km-long surface rupture appeared along the Kamishiro fault of the Itoigawa-Shizuoka tectonic line active fault system in association with the earthquake from Shiojima to Higasisano in Hakuba village. In this stady, to reveal the subsurface structure of the focal area, we executed seismic reflection survey across the Kamishiro fault on 19-28 October 2015. The seismic line has a length of 4.2 km and started from the center of Kamishiro basin to Route 406 via Mikka-ichiba and Horinouchi. The roads along the seismic line were under repair due to the earthquake. We needed a lot of adjustments to the progress of road repairing.
The source used in this survey was Enviro Vib (IVI Inc.). Sweep length was 16 sec and sweep frequency range beginning at 10 Hz up to 100 Hz. The receiver was GS-20DX (natural frequency, 10 Hz; Geospace Inc.). The source interval was 20 m and the receiver spacing was 10 m, with 192 ch geophones used for each recording. We selected the Geode recording system (Geometrics) and its sampling rate is 1 msec.
We thank Hakuba village office, Himekawa construction company, and Hakuba-mitsuno construction company for their assistance with our seismic survey.

Keywords: seismic reflection survey, 2014 Nagano-ken-hokubu earthquake, Kamishiro fault, Itoigawa-Shizuoka tectonic line active fault system

Outcrop data of geological structure associated with active thrust zone along western margin of Yamagata basin around Murayama city, NE Japan

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We describe deformation of Plio-Pleistocene strata and late Pleistocene terrace deposits associated with the active thrust zone along western margin of the Yamagata basin, which is composed of a complex faults and folds, based on observation of new outcrops. Outcrops along the foot of the mountain show monocline fold of steeply dipping Plio-Pleistocene strata, and growth strata on an angular unconformity. This structure is continuous along the foot of the mountain, and most large scale in the active thrust zone. Outcrop around Takamoriyama hill shows the steeply dipping middle Pleistocene Hayama mudflow and late Pleistocene fluvial terrace deposits over the back limb of the asymmetric fold, and decreasing dips upward in the terrace deposit (growth strata). Outcrops around Kawashimayama hill, where frontal deformation of the active thrust zone, show flexure, faults and folds of Hayama mudflow and terrace deposits. These deformations of the terraces around Kawashimayama hill suggest cumulative thrust fault slip. These results propose an active structure key to understanding profile across the complex active thrust zone.

Keywords: active thrust zone, active structure, growth strata

The origin of the anticline founded on fluvial terraces at the eastern part of the Tokamachi Basin, Niigata Prefecture

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Many fluvial terraces formed by Shinano River can be seen in the Tokamachi Basin, which is located between the Uonuma and Higashikubiki Hills. Previous researchers reported that some thrusts along the eastern and western margin of the basin cut and deformed those fluvial terraces, and have surveyed their distribution, activities and structures. The Headquarters for Earthquake Research Promotion (HERP) named these faults western and eastern segment of Tokamachi Fault Zone (TFZ) and revealed each last event based on the results of previous and contract researches. However, relationships with other faults around of the TFZ and their recurrence interval have still been highly debatable.
We found a plunging anticline on the terrace surface by detail geomorphological analyses around the eastern TFZ. The anticline, which is likely to be symmetric fold, has about 1.5 km-wavelength and uplifted the top terrace classified as Mibara group (formed in 140-300 ka) about 20 m high. Near Nakazaike village, one and two steps lower of the top terrace classified as Hoonokizaka (140-170 ka) and Kaisaka (50 ka) groups, respectively, have been uplifted progressively. In addition, geological survey about the Uonuma Formation, basement rock of the terraces revealed that the upper layer has deformed in keeping with the deformation pattern of the surface anticline. These results suggest that the anticline had deformed in the period at least from the time when the upper Uonuma Formation deposited until about 50 ka. The surface deformation which we judged as the anticline is looked as the deformation related to Hosoo-Nyoraiji Fault, striking NNE-SSW, reported by Active Fault Map in Urban Area (Tokamachi) and Active Faults in Japan (Active fault research group, 1991). Our geological and geomorphological study, however, revealed that there is no surface rupture along the fault and the anticline have NE-SW strike. Wavelength of the anticline yields thickness of deformed layer is about 1-1.5 km, suggesting that the anticline formed by the slip on the detachment fault inside of the Uonuma Formation. The depth of the detachment fault is consisted with that reported by Yokokura et al. (Chishitsu News, 2008). It implies that the detachment fault is connected to the eastern TFZ.
The contents of this presentation is a part of the result of the Complementary Survey Project of Active Fault by HERP in 2015 FY.

Keywords: Tokamachi Fault Zone , tectonic landforms, fluvial terraces, Uonuma Formation

Trench Excavation Study and Drilling Survey on the Eastern Segment of Tokamachi Fault Zone, Central Japan

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The eastern segment of Tokamachi fault zone is an active fault with 19 km length, located in the southern part of Niigata prefecture, in central Japan. It extends in NNE-SSW direction along the eastern margin of Tokamachi basin with east-side-up vertical displacement.
The Earthquake Research Committee evaluated that the probability of the earthquake occurrence in the future of this segment was uncertain because of luck of paleoseismological data, although Ota et al. (2010) had reported the timing of the last fault events of this segment as 3,800-3,200 yrs.BP based on results of several trench surveys.
We carried out trench excavation study and drilling surveys at Otajima, Tokamachi city, for estimating activity of the eastern segment of Tokamachi fault zone. The trench was excavated at the foot of a fault scarp with 4 m high on the Holocene fluvial terrace along the Shinano river.
Details of our results will be reported in the presentation.
This project is supported by the Ministry of Education, Culture, Sports, Science and Technology of Japan.

Keywords: active fault, trench excavation study, drilling survey, Tokamachi Basin, Tokamachi fault zone

Tectonic map for the late Quaternary in and around the Kanto Plain; Based on Interpretation of Topographic Anaglyphs Derived Using a Detailed Digital Elevation Model

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Topographic anaglyph images were viewed with red-cyan glasses, making it possible to recognize topographic relief features easily. Anaglyphs produced from digital elevation model (DEM) data are a very effective way of identifying tectonic geomorphology. The aim of this paper was to introduce an extensive area of topographic anaglyph images produced from the 5-m-mesh and 10-m-mesh inland DEM of Geospatial Information Authority of Japan, as well as the 1-second-mesh DEM on the seafloor. This paper also aims to re-examine tectonic geomorphology and to present a new tectonic map for the late Quaternary in and around the Kanto Plain, which is sedimentary basin and the largest plain in Japan, by means of interpretation of the extensive topographical anaglyph image.

Keywords: digital elevation model (DEM), anaglyph, tectonic geomorphology, Kanto Plain

Fault Zone Off the coast of Shimoda and Irozaki Fault Inferred from Geomorphic Analysis for Digital Water Depth Model of 50 m mesh and 150 m mesh

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Izu Peninsula is located between Suruga Trough and Sagami Trough, and lies near and at the northern tip of the Izu-Bonin Arc. This Arc is currently colliding with the Central Japan Arc. And the great interplate earthquakes were frequently repeated at those subduction zones along Troughs, respectively. Instead, the inland large earthquakes were frequently occurred in Izu area due to the plate collision. To understand the collision tectonics, we made an anaglyph image and a figure of contour line from seafloor topography data of 150m mesh and the 50m mesh, and this study investigated a trace of the surface dislocation associated with faulting.
Irozaki Fault: An earthquake (Mw6.9) was occurred in 1974 from an inland active fault called Irozaki Fault, which was ruptured striking WNW-ESE at the southern tip of Izu Peninsula. However, the dislocation of the sea bottom is not clarified until now. Reefs, sea ridges and submarine valleys formed in the continental shelf are systematically offset right laterally in the sea part of east from the Irozaki fault when based on a contours map made of the 150m mesh. It is a dextral fault, coincident with the condition of fault offset in the inland. The sea gorge is blocked up associated with a drag of direction, and the gorge low land is expanded laterally along the fault trace. Irozaki fault, thus, extends to offing approximately 7-8km of Irozaki.
Fault Zone Off coast of the Shimoda (ITTL F2): We recognized three active faults lifting west, Faults a, b and c in order from west to east, cut the sea bottom of the Shimoda offing.
Fault a: Based on the DEM50 m mesh around Shimoda Port, we made a figure of contour line of the 2 m interval. There are Susaki Peninsula and the other submarine peninsula, jutting out into southeast in the north side and the south side of a submarine valley extending from the inlet of the Shimoda Port, respectively. In the neighborhood of tip of these peninsulas, the depth of the water is suddenly deepened. At Susaki Peninsula, the abrasion platform juts into the southeastern side from the shoreline. The submarine cliff of a drop of up to approximately 18m is observed on this abrasion platform. And it is divided into two steps of submarine terrace with depth of the water approximately 2-4m and 20-26m by the cliff. Also in the neighborhood of tip of the submarine peninsula of the south side, a submarine cliff of a fall up to approximately 16m is recognized at about 2 km point off a shoreline, and a submarine reef ridge is divided two steps. A small valley is formed in this cliff in our interpretation of the anaglyph image. And a low scarp of a 2m drop crosses the small submarine alluvial fan formed around and at the valley mouth. The resolution of topography data is not good, but may be caused by an active fault so as to be able to judge displacement, transformation because this low cliff develops in the direction at right angles to the valley. Fault to estimate in this study is more likely to be concordant with this dislocation model by Kitamura et al. (2015).
Faults B and C: We made a figure of contour line of the 10m interval from DEM150m mesh. A sea plateau is formed in and around the bent of the continental shelf slope of Shimoda offing approximately 10km. A water depth of the sea plateau is approximately 200-540m. On this sea plateau, the two flexure scarps, uplifting west, strike NNE-SSW in a parallel row. Fault length is approximately 26km each. Kim et al. (2012) assumed these two fault b and c in Shimoda offing (F2 of the ITTL), but we do make a redefinition for Fault Zone Off Coast of Shimoda involving Fault a. In addition, we judge that Irozaki Fault (WNW-ESE strike, High-angle dextral slip fault) has been formed in a conjugate relation with Fault Zone Off Coast of Shimoda (NNE-SSW strike, West dipping

reverse fault).
An address of gratitude: Tsunami mesh data of the Coast Guard Hydrographic & Oceanographic Department is used.

Keywords: Submarine Geomorophology, Izu Collision Zone, Irozaki Fault, Submarine Fault Zone Off Shimoda, Submarine Fault, ITTL

1:500,000 Compiled geological map of the Fujigawa-kako Fault Zone and its surroundings

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This geological map was created for seamless integration of land and sea geoinformation, based on the existing geology and active fault research results, in addition to the research results of Iriyamase fault that was carried out in “Geology and Active Fault Study of the Coastal Area” as the project of Geological Survey of Japan, AIST. The map is intended to be basic information diagram to be utilized for future research and disaster prevention. Therefore, it will be revised based on the research achievements of the future.

The older Fuji mudflows and lava flows of the Fuji Volcano (e.g., Tsuya, 1978) have been good reference surfaces to study the activities of the fault zone. However, based on the latest research results of new stratigraphy of the products of Fuji Volcano at the southwestern foot (e.g., Yamamoto, 2014), the older Fuji mudflows is divided into the volcanic fan Ⅳ deposits and Ⅲ volcanic fan deposits, whose abandonments occurred at MIS 4 and MIS 2, respectively. Furthermore, stratigraphy and ages of some lava flows deformed by active faults, has been corrected. Below, it shows the outline. As a result of review of existing studies based on these, some of the setting of the reference plane and the average displacement velocity were found to be necessary to be reconsidered.

(1) It became clear that continuity and configuration of the Iriyamase Fault in coastal area, based on results of onshore shallow seismic reflection survey (Ito and Yamaguchi, 2016), boring surveys (Ishihara and Mizuno, 2016) and offshore seismic reflection survey (Sato and Arai, 2016) of the GSJ project. In addition, there is a large possibility that two parallel or en echelon faults has been developed on both sides of the Kanbara Jishinyama (earthquake mound) (Omori, 1920).

(2) The average activity rate of the Iriyamase Fault estimated to be 7 m/1000 years is based on the altitude difference between the Suijin Lava Flow on the hanging wall side and the Obuchi Lava Flow distributed under the Fujikawa-kako Alluvial Fan on the footwall side (Yamazaki, 1979). However, the former has an age of 17 ka and was flowed from along the Fuji River to the southeast, the latter have an age of 10 ka and was flowed from the south-southwestern foot of the Fuji Volcano to the southwest (Yamamoto, 2014). In addition, Yamazaki (1979) was estimated the displacement of the Iriyamase Fault from elevation distribution map of lava flows under the alluvial fan by Murashita (1977), which shows the shape of the foot of Mt. Fuji to be reduced to the southwest direction at about 10 ka. However, there is almost no data on footwall side zone of width 2 km (from Matsuoka to Gokanjima districts) along the Iriyamase Fault in order to lacking lava flows are in boring core data, it is not possible to accurately estimate about depth of the lava flows in footwall side from the map. The lava flow as a reference is considered to be hardly deposited in the zone due to the downward erosion at the last glacial period and valley-filling sedimentation at the post-glacial period by the Paleo-Fuji River stream in addition to the subsidence by the Iriyamase Fault. And furthermore, effect of sea level between 10 ka and 17 ka to reach 60 to 70 meters (e.g., Siddall et al., 2003) must be also taken into account. In the present situation, by combining the various conditions of the above, the amount of displacement of the Iriyamase fault, can be large, or small than the existing estimates. Therefore, in order to estimate the exact average displacement rate of the Iriyamase Fault, it is necessary to carry out a new investigation.

(3) The Shibakawa and Iriyama Faults are distributed continuously as a geological fault, but unlikely as an active fault. Several N-S trending faults in length from 0.5 to 1.5 km are well

developed in the areas where both of faults are connected while bending. Among these, the Gendai Fault (Otsuka,1938) is considered to be an active fault.

Keywords: Fujikawa-kako Fault Zone, Iriyamase Fault, geological map, 1:500000

Topography of late Quaternary in the Tonami plain and activity of the Tonami-heiya fault zone, Toyama Prefecture

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The purpose of this research is to restudy the late Quaternary topography and activity of the Tonami-heiya fault zone, and to discuss the geomorphological development of the Tonami plain in the western part of Toyama Prefecture, central Japan.
The Holocene alluvial fans and flood plains formed by the Sho and Oyabe Rivers spread out in the Tonami plain from the central through the northern parts. Along the foot of the surrounding mountains and hills, higher, middle and lower terraces of late Pleistocene-Holocene in age are distributed. These terraces have been displaced, even during the Holocene time, by the reverse dip-slip activities of Tonami-heiya fault zone in a sense of upheaval in the mountains side.
We examined stratigraphic cross section utilizing borehole data and morphologically analyzed 5m-DEM in order to elucidate the fault trace of the Isurugi fault which belongs to the Western Tonami-heiya fault zone. As the results, the northern segment of Isurugi fault seems to run along the northeastern foot of Hodatsu hill and extends underground through the lower-most Oyabe River into the Toyama Bay. Consequently its total length reaches about 30 km. In the southern segment, a continuous fault scarplet was recognized to cut across the lower dissected fans. The slip-rate of Isurugi fault is estimated to be 0.31-0.64m/kyr. As for the Eastern Tonami-heiya fault zone, the mid-Holocene and later activities along Horinji and Takashozu faults were also identified from previous studies by trench excavation surveys (AIST, 2012, Toyama Pref., 2000).
In the Hokuriku region, reverse faulting and related folding with strike in a NE-SW direction have occurred during the late Quaternary. In this process, the upheaval of mountains and hills as well as the subsidence of plain were reactivated and have continued. Then, the hinge line of block movement due to the activities of the Tonami-heiya fault zone is revealed to have shifted from the mountain side into the plain side within the Holocene time. In conclusion, the Quaternary folding and faulting associated with the crustal warping at a wavelength of about 20 km is currently in progress, causing both the subsidence of Tonami plain and the upheaval of surrounding mountains and hills.

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Characteristics of the fault zones terminated by the Late Quaternary - an example of the Median Tectonic Line in Nara Prefecture -

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The activity assessment of the active faults basically needs younger sediments. To understand the fault activity in the area with no youner sediments, it is desired that the new method is developed to study the fault activity from the fault rocks in the basement rocks. A comparison of the fault zone characteristics between active faults and inactive faults. To understand the characteristics of inactive fault zone, we have studied the Median Tctonic Line (MTL) in Ohyodo, Nara Prefecture. The MTL is the active fault in the western part of the Kii peninsula to Shikoku Island. , which it is not active fault in the central to eastern part of the Kii peninsula. Okada and Togo (2000) showed that the fault activity of the MTL has terminated by the Late Quaternary in Ohyodo Nara Prefecture. Matsumoto (2001) studied the fault exposure in this area and reported that the MTL cut the upper Shobudani Formation. The MTL had been active in the Middle Quaternary, but it is not active in the Late Quaternary. In this exposure, the fault gouge with a thickness of 10cm extends to east-west and distributes between the Izumi Group in the northern side and the Shobudani Formation in the southern side. The Shobudani Formation is divided into the lower Shobudani Formation and the upper Shobudani Formation.
We collected the samples from this exposure , and performed the powder X-ray diffraction (XRD) and X-ray fluorescence (XRF) analyses. The samples collected 0.5 m, 1.5 m, 6 m below the uppermost of the exposure. The results of XRD show the formation of smectite in the fault gouge in 6 m below the uppermsot of the exposure. Albite is detected from the and the upper Shobudani Formation near the fault gouge and the intact rock of the Izumi Group in 0.5m below the uppermost. The results of XRF exhibit that the increases of Al_2O_3, Fe_2O_3, LOI, MgO, CaO and the decrease of SiO_2 in the fault gouge in 6m below the uppermost. In 1.5m below, the increases of LOI, MgO is recognized. In 0.5m below, no clear change of the chemical composition is detected in the fault gouge.
Compared among the same lithofacies in the intact rocks, the Izumi Group in 0.5m below shows the decreases of Na_2O and CaO, which no significant change is detected in 1.5m and 6m below. The Shobudani Formation and the fault gouge do not show clear change of the chemical composition.
This exposure had been in the underground before this site has been developed as a quarry. Near the uppermost of the exposure, the leaching of the elements in the fault gouge would be occurred due to the weathering.
Compared the fault zone characteristics studied in this study with that of active faults, the active fault zones are characterized by the formation of smectite and increase of manganese. To understand the differences of the fault zones between active and inactive faults, the characteristics of active fault zones would be detected.

Keywords: fault zone

Topographical and geological explorations along the Gomura and the Yamada fault zone: Part 2 observation and ESR analysis

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As a part of a research project commissioned by Secretariat of Nuclear Regulation Authority (S/NRA/R), to organize information about evaluation techniques of active faults, we executed topographical and geological explorations along the Gomura and the Yamada fault zone. Here, we show the fault rocks observed in outcrops and core samples, and results of Electron Spin Resonance (ESR) analyses in them.

Keywords: ESR analysis, Gomura fault zone, Yamada fault zone

Geophysical explorations along the Gomura and the Yamada fault zone, and its applicability: Part 2 P-wave seismic reflection survey, seismic refraction survey, CSAMT survey, and gravity survey

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As a part of a research project commissioned by Secretariat of Nuclear Regulation Authority (S/NRA/R), to reveal the subsurface geometry of active fault and geological structure around the Gomura fault zone and the Yamada fault zone, we execute a seismic reflection and refraction survey, S-wave shallow seismic reflection survey, CSAMT survey, high-density electrical resistivity survey, and gravity survey. In this presentation, we demonstrate detail results of P-wave seismic reflection survey, seismic refraction survey, CSAMT survey, and gravity survey. Finally, we summarize applicability and efficiency of these geophysical explorations for the strike-slip active fault.

Keywords: P-wave seismic reflection survey, seismic refraction survey, CSAMT survey, gravity survey, Gomura fault zone, Yamada fault zone

Geophysical explorations along the Gomura and the Yamada fault zone, and its applicability: Part 1 S-wave shallow seismic reflection survey and high-density electrical resistivity survey

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As a part of a research project commissioned by Secretariat of Nuclear Regulation Authority (S/NRA/R), to reveal the subsurface geometry of active fault and geological structure around the Gomura fault zone and the Yamada fault zone, we execute a seismic reflection and refraction survey, S-wave shallow seismic reflection survey, CSAMT survey, high-density electrical resistivity survey, and gravity survey. In this presentation, we demonstrate detail results of S-wave shallow seismic reflection survey and high-density electrical resistivity survey. Finally, we summarize applicability and efficiency of these geophysical explorations for the strike-slip active fault.

Keywords: S-wave shallow seismic reflection survey, high-density electrical resistivity survey, strike-slip fault, Gomura fault zone, Yamada fault zone

Topographical and geological explorations along the Gomura and the Yamada fault zone: Part 1 aerial photointerpretation and geological survey

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As a part of a research project commissioned by Secretariat of Nuclear Regulation Authority (S/NRA/R), to organize information about evaluation techniques of active faults, we executed topographical and geological explorations along the Gomura and the Yamada fault zone. Here, we show the results of aerial photointerpretation and geological survey.

Keywords: aerial photointerpretation, geological survey, Gomura fault zone, Yamada fault zone

Active faults around the Shimane Peninsula and their tectonic implications, northern Chugoku region, Japan

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The Shimane Peninsula is located along northern coast of the Chugoku district, and consists of the three mountains, the Seiretsu Mountains, the Churetsu Mountains, and the Toretsu Mountains. The Kashima Fault (Shinji Fault) develops along the southern margin of the western part of the Toretsu Mountains, but existence of certain active faults has not been known in the other area. Based on detailed investigation of aerial photograph and stereoscopic images delivered from 5 m –10 m DEM, we found active faults in the east and west extension of the previous reported active faults. In this presentation, we reported the distribution and characteristics of these active faults, and discuss tectonic implications of these active faults.
Based on the characteristics of the morphology of the Toretsu Mountains, we estimated the existence of northern-side-up concealed active faults with right-lateral slip along the southern margin of the Toretsu Mountains. We mapped three en echelon active faults in the Churetsu Mountains. We estimated that these active faults have right-lateral strike-slip components, based on right-lateral flection of stream valleys. We estimated that these active faults are secondary faults delivered from submarine active fault along the northern margin of the Churetsu Mountains.
Along the southern margin of the Seiretsu Mountains, we estimated existence of northern-side-up concealed active faults, based on the characteristics of the morphology of the Seiretsu Mountain, as in the Toretsu Mountains.
East and west of the Shimane Peninsula, long submarine active faults with east-west strike are known. These active faults develops along the coastal area of the Shimane and Tottori Prefecture, and form large tectonic deformation belt over several 100 km. we estimated that active faults in the Shimane Peninsula are extension of these submarine active faults, and are constitute a part of the large tectonic deformation belt.

Keywords: Kashima fault, active fault, Chugoku, inland earthquake, submarine fault, aerial photograph

Holocene activity of the Northern Marginal Faults of the Saga Plain

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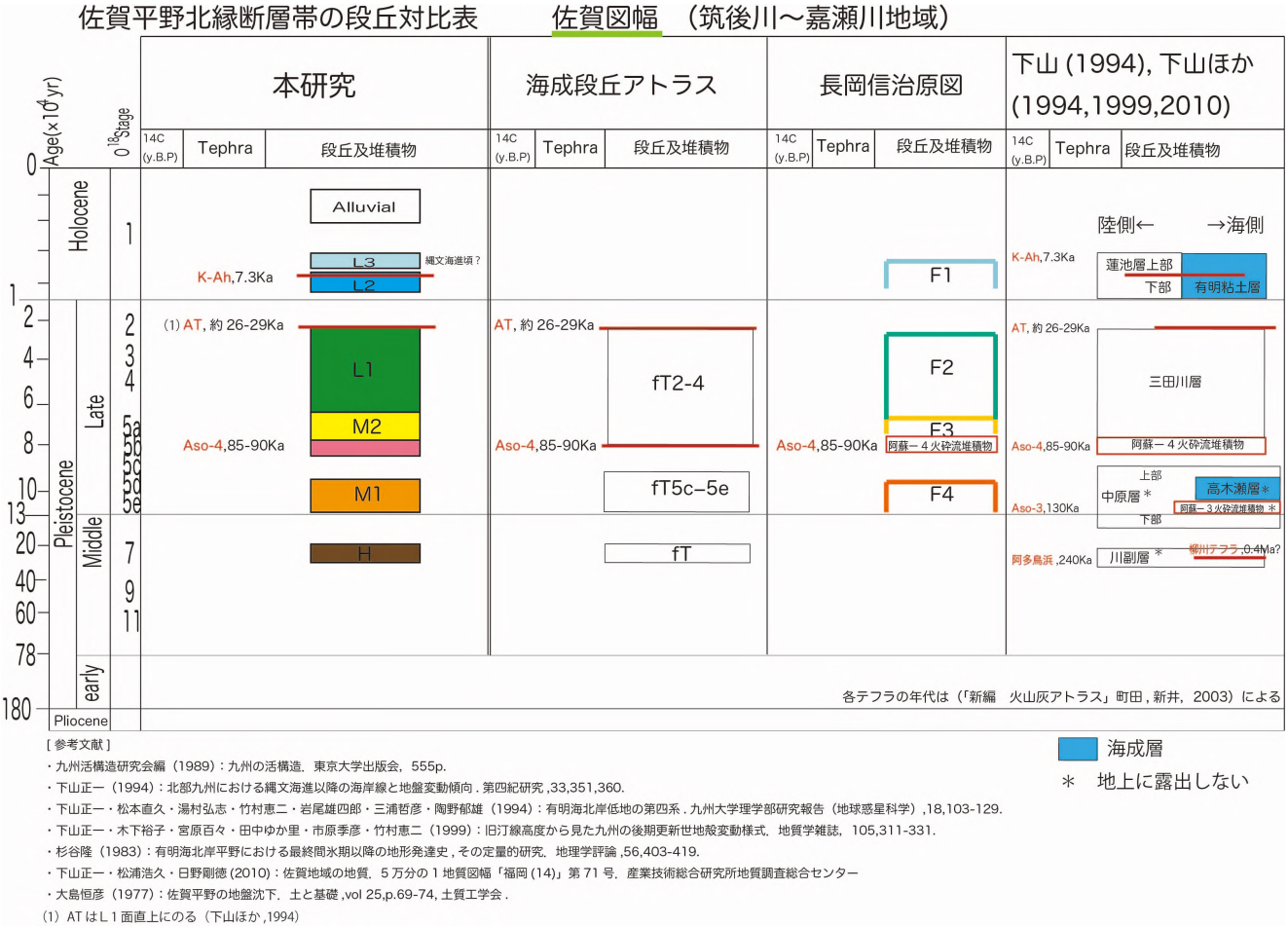
Kyushu of active faults is divided into three zones. Active faults of the central Kyushu, mainly extends to east-west direction. A study area the Northern Marginal Faults of the Saga Plain is located in the central Kyushu. Most of these active faults are normal faults by the force extended to north-south direction (Headquarters for Earthquake Research Promotion, 2012). The faults are normal faults, it is estimated that the south side is down (Headquarters for Earthquake Research Promotion, 2013). The distribution forms of these active faults are linear trace that extends east to west. Regarding the Northern Marginal Faults of the Saga Plain, Research Group for Active Tectonic Structures in Kyushu ed. (1989) and Nakata-Imaizumi ed. (2002) has certified the active faults along the boundary of the plains and mountains on the North side of the Ariake Sea. AIST (2014) reported that fault scarp of about 0.7~2.5m were observed intermittently along the south portion of the Saga plain. However, such as average vertical slip rate and the age of the latest activity of the Northern Marginal Faults of the Saga Plain are unknown because information of the trench survey poor. We have already done reports by the present study, Kagohara et al. (2014, 2015) and Imaizumi et al. (2014), Yoshida et al. (2015). In this report, F3~F7 fault be discussed on the basis of the average vertical slip rate of the faults for the activity in the Quaternary the Northern marginal faults of the Saga plain. H surfaces were MIS7 equivalent, M1 surface were located in the lower Aso-4 pyroclastic flow deposition surfaces, it were MIS5e equivalent of last interglacial period, Aso-4 pyroclastic flow deposits surfaces were 8.9ka and M2 surfaces were MIS 5a equivalent the formation age from such were covered discordance Aso-4.And we estimated to that L1 surfaces were MIS2-4 because AT (26-29ka) were included in the upper part of L1 sediments. L2 surfaces were estimated to MIS1 because K-Ah (7.3ka) was included in the upper part of L2 sediments.

F3 faults correspond to the active fault that has been pointed out in Research Group for Active Tectonic Structures in Kyushu ed. (1989) and Nakata-Imaizumi ed. (2002). The F3 faults were recognized as distinct scarps of about 1.8m on alluvial fan surface (L1 planes). These faults were intermittently until Jobaru-river from Saga City Yamato-cho, but could be clearly tracked. The average vertical slip rate of F3 faults in L1 planes were estimated to 0.07mm/yr. F6 faults could be tracked continuously lineament from the Kase-river to the Jobaru-river on L2 surfaces. F6 faults has tectonic bulge that may be low fault scarps or about 50cm low fault scarps on the L2 planes. These were observed the slopes of the terrace surfaces by field observations and topographic profile. The average vertical slip rate of F6 fault in L2 planes were estimated to 0.07mm/yr. F7 faults were located on the south side of the F6 faults. F7 faults could be tracked continuously from the Kase-river to the Jobaru-river on L2 planes. In Saga-city Kuboizumi-cho Shimoizumi, we made simple boring survey in the hanging wall and footwall side of the border the F7 faults. As a result, AT was confirmed in the deposits of L1 planes that were buried terraces. F7 faults of average vertical slip rate were estimated to be at least 185cm or more. Thus, average vertical slip rate of F7 faults were estimated to 0.07mm/yr.

Tectonic geomorphology that were estimated to scarps that were observed continuously on the L2 planes of the North portion of the Saga plain. Because of texture on the L2 surfaces were observed, Holocene activity of this fault zone was active at least once after L2 planes formation (7.3ka). L3 planes were observed scarps about 50cm, but it's issues there were also the possibility of

artificial modification.

Keywords: Northern Marginal Faults of the Saga Plain, normal fault, large-scale geographical map, tectonic bulge, average vertical slip rate



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Integrated Research for Beppu -Haneyama Fault Zone (East part of Oita Plain -Yufuin Fault) -Research in 2015 -

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Integrated Research for Beppu -Haneyama Fault Zone (East part of Oita Plain -Yufuin Fault) in central Kyushu started on 2014 as one of Integrated Research Project for Active Fault Systems of MEXT. We need more precise study on fault distribution, latest event in and around Beppu Bay region and relationship with western end of Median Tectonic Line for understanding of Beppu -Haneyama Fault Zone. We carry out geomorphological, geological and geophysical researches on the basis of existing research findings. Obtained new data on geomorphology and geology will let us know new findings on precise location and activity of fault in and around Beppu Bay area. Moreover, new geophysical data on subsurface structure indicate size and motion of earthquake fault reached to the earthquake occurrence layer, and we also calculate precisely ground motion on the basis of precise subsurface structure and earthquake fault model.Research group consists of about 40 researchers of Kyoto University, Kyushu University, Advanced Industrial Science and Technology and related Institutions, and also three sub-groups on the basis of methodology and science target. Sub-theme group 1: Research on precise location and shape of active fault, and average slip rate and event age. Sub-theme group 2: Research on three dimensional structure and subsurface structure of fault zone and the area. Sub-theme group 3: Research on establishment of subsurface structure model and evaluation of ground motion.The result during 2015 fiscal year will be presented in the session.

Keywords: Beppu -Haneyama Fault Zone, Integrated Research Project, Active fault and subsurface structure

Take advantage of high-resolution seismic survey in the submarine active fault

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[Background]
Trenching, bowling and geo-slicer has used to clarify the latest activity timing and interval of the active fault. In the sea area, there is a limit of survey methods unlike the land. So, we usually use seismic survey. On the other hand, sea area is sediment accumulated place, possibility that the history of the fault movement is preserved successively. Therefore, we can higher accuracy estimate of active faults with high-resolution seismic survey densely.
[Target area and study methods]
Hinagu Fault Zone extends from the Aso volcano to the Yatsuhiro-sea. In the Yatsushiro-sea, some seismic surveys were carried out so far, and clarified distribution of a number of submarine fault group.
In this study, we aim to reveal the subsurface deformation of fault using high-resolution seismic survey with 20-50 meters interval survey lines. Furthermore, we carried out core sampling to obtain the geological information.
[Analysis]
Results of high-resolution seismic survey, we obtained a good reflection profile of up to about depth 60m. We recognized some reflectors (R1~8 from the bottom) and some deposition sequences (A1,A2,A3,B1,B2,C,D layers from the top) based on their reflection patterns. We pick up the three-dimensional coordinate point data from each reflector and make surface models.
[Results]
1) Surface of R2
a) Vertical fault scarp was developed with NE-SW direction along master fault (A-FA1). b) In west side of A-FA1, we observed some faults which is extends to NE-SW direction and curves clockwise. This feature is similar to Negative flower structure. c) Bulge is developed along A-FA1. Three faults cut the bulge and oblique to A-FA1 with high angle. These features which are similar to R2 has recognized in surface of R3 and R4.
2) Surface of R5
Depressed formation like a funnel-shaped has developed along A-FA1 at central part of survey area. This feature is observed on seafloor also.
A number of studies for the model test of strike-slip faulting are conducted so far. And it is argued about growing process of fault. Therefore, it is a possibility to clarify the growing fault process and activity history of active faults in the sea area.

Keywords: Hinagu Fault Zone, High-resolution seismic survey, Seismic stratigraphy

Recognition of the sea-floor event deposits by continuous radiocarbon measurements of total organic carbon

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The depositional age of hemipelagic mud are generally determined by radiocarbon dating of planktonic foraminifera. Radiocarbon dating using total organic carbon of sediments is not common for age determination, because total organic carbon include organic carbon of various origins, such as marine, terrestrial, and reworked old fragments. In the forearc basins along the Nankai Trough, the amount of planktonic foraminifera in the sea-floor sediments is not enough for radiocarbon age determinations. Therefore, we try to determine the depositional age of hemipelagic mud by using radiocarbon dating of total organic carbon. Radiocarbon ages of total organic carbon were measured in 0.5 to one centi-meter intervals of sediment core, and compensated with small-scale radiocarbon sample measurement of planktonic foraminifera.
Radiocarbon ages were measured with accelerator mass spectrometer of Atmosphere and Ocean Research Institute, the University of Tokyo. Total organic carbon contents and stable isotope ratio of organic carbon were measured using an elemental analyzer and a mass spectrometer of the National Museum of Nature and Science, Tokyo.
Sediment core was acquired from the western part of Kumano Trough at 2000 m water depth by using multiple corer. The sediment is composed of olive black clayey silt in 40 cm long core. Two light colored layers, which include coarse silt, were observed in X-ray CT images of the hole core. Several ^{14}C ages determined from total organic carbon were older than those of lower horizons. These may be because the organic carbon samples include some older carbon fragments remobilized from submarine slope. We excluded these ages from our estimation of depositional ages. ^{14}C ages of total organic carbon were found to be about 900 to 1200 years older than those from planktonic foraminifera from the same horizons. We converted the ^{14}C ages of total organic carbon to calibrated ^{14}C ages by using the age difference between total organic carbon and foraminifera. Our results show that the 40cm long sediments were deposited during about past 600 years.
The organic carbon of the event layers, which excluded from estimation of depositional ages, is mostly marine origin. Therefore, we considered that these event layers were deposited as a consequence of submarine slope failure. The event layer in upper part of the core was considered to be deposited by shallow submarine slope failure or flood, because this layer includes terrestrial organic carbon. On the basis of our radiocarbon dating of total organic carbon and planktonic foraminifera, these event layers might be deposited as consequences of submarine slope failure associated with historical earthquakes and flood after fifteen century.
Radiocarbon dating with total organic carbon is possible tool for not only determination of depositional age but also recognition of event deposits in homogenous hemipelagic mud.

Keywords: hemipelagic mud, organic carbon, radiocarbon dating, earthquake

The Analysis of the Active Reverse Fault Zones in Japan through Gravity Anomalies

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The Japanese islands are located in a subduction zone and they have undergone complex deformations as a consequence of regional stress changes. Therefore the active structures are diverse. The object of our study is to reveal distinctive features of active faults and to examine their spatial continuity through gravity anomalies. Seismic reflection survey is a major method to detect subsurface structure of faults, but seismic velocity structure is obtained only on linear profiles. Over 20,000 points of gravity data has been measured in Japan. Recently released high resolution data set enable us to detect detailed density differences in a wide area around faults. We analyzed 43 reverse fault zones in northeast Japan and northern part of southwest Japan among major active fault zones selected by Headquarters for Earthquake Research Promotion.
The gravity data published by GSI [2006], Yamamoto *et al.* [2011], and Geological Survey of Japan (AIST) [2013] and Kanazawa University data were compiled in this study. We applied terrain corrections using 10 m DEM and filtered data with a band pass filter in addition to normal correction procedures, then obtained the Bouguer anomalies.
Steep Bouguer gravity gradients are clearly observed along the faults at 21 faults zones, a weak correlation is recognized at 13 faults, and no correlation at 9 faults. We evaluate the continuity of the faults based on the continuity of maximum points of the horizontal first derivation and inflection points of vertical first derivation together with geological and topographical observations. We infer a faulting type and a direction of dipping from fault traces and the maximum isoline or the inflection isoline of the derivations.
For example, we recognize following features for the Itoigawa Shizuoka tectonic line. The fault end seems to extend at the northern end. A left stepping of the faults in the subsurface is revealed around Hakuba. The maximum isoline and the inflection isoline are distributed on the east of the fault rupture in the north and on the west in the south, indicating that the dip direction changes the east dipping to the west dipping from north to south.

Keywords: gravity anomaly, active fault zone, spatial continuity of the fault

Co-seismic conjugate Riedel faulting associated with the 2014 M_w 6.9 Yutian earthquake on the Altyn Tagh Fault, Tibetan Plateau

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The Altyn Tagh Fault is located at the northwestern edge of the Tibetan Plateau, and is the largest active strike-slip fault in Asia with a total length of ~2000 km. The fault accommodates sinistral motion between the Tibetan Plateau and the Tarim Basin within the India–Eurasia collision zone. Although the Altyn Tagh Fault plays a key role in accommodating India–Eurasia convergence, little is known about its nature as a seismogenic strike-slip fault due to a lack of instrumentally recorded large earthquakes on the fault. The 12 February 2014 M_w 6.9 Yutian earthquake, which occurred in the Yutian region of the Tibetan Plateau, provides an opportunity to study the seismotectonic nature of the Altyn Tagh strike-slip fault system.

Field investigations reveal that the 2014 M_w 6.9 Yutian earthquake on the left-lateral strike-slip Altyn Tagh fault system, Tibetan Plateau, produced a ~25-km-long surface rupture zone that contains conjugate Riedel shear faults (Li et al., 2016). The co-seismic surface ruptures occurred mainly along two parallel ENE-trending active left-lateral strike-slip faults. Rupture also occurred in a conjugate, WNW-trending zone along an active right-lateral strike-slip fault. The ENE-trending ruptures are concentrated in a zone of <500 m wide and ~25 km long, and are characterized by Riedel shear structures including distinct shear faults (Y) with a maximum sinistral displacement of ~1 m, right-stepping en echelon cracks, and mole tracks. In contrast, the WNW-trending ruptures occur within a zone of up to 1.5 km wide and ~4 km long in the jog area between the two parallel ENE-trending faults, and this zone is characterized by discontinuous shear faults with dextral displacements of <0.5 m, left-stepping en echelon cracks, and mole tracks, all oriented oblique to the ENE-trending rupture zones at an angle of 30°–40°. The lengths and displacements of the co-seismic surface ruptures measured in the field are comparable with those obtained from the empirical relationships between magnitude and co-seismic surface rupture length and displacement. Our findings demonstrate that the co-seismic conjugate Riedel faulting was controlled mainly by pre-existing active faults of the Altyn Tagh fault system, reflecting the present-day tectonic stress field associated with the ongoing penetration of the Indian Plate into the Eurasian Plate.

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Keywords: Altyn Tagh fault, 2014 Mw 6.9 Yutian earthquake, Co-seismic conjugate faulting, Tibet Plateau

Role of the Longquan fault in the active deformation of the Longmen Shan fold-and-thrust belt, eastern Tibetan Plateau

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Present-day convergence within the Longmen Shan fold-and-thrust belt (LSFTB) was manifested by the 2008 Mw 7.9 Wenchuan and 2013 Mw 6.6 Lushan earthquakes, which ruptured multiple thrust ramps beneath the range front structures. However, it is still unclear whether fault slip has been propagated eastward into the foreland, closer to the Chengdu population center. In this study, we provide constraints on the 3D subsurface structure, fault activity and seismic hazards of the Longquan fault that is located in the central Sichuan basin, ~100 km east of the range front structures of the LSFTB. Our detailed 3D model of the Longquan fault reveals a segmented fault array involving an east-dipping back-thrust at the edge of the Quaternary basin between west-dipping fore-thrusts to the north and south. We evaluate the activity of the Longquan fault by interpretations of high-resolution satellite images, field mapping, paleoseismic logging of trench exposure walls and radiocarbon geochronology. Our results reveal that at least two surface rupturing events occurred on the Longquan fault in the Holocene, with the minimum of 3.2 m and 2.5-3.7 m slip for the most recent and penultimate events, respectively. The most recent event is inferred to be occurred in the period between 2060±30 yr BP and 580±30 yr BP, while the penultimate event occurred in the period before but around 3050±30 yr BP. These findings indicate a Holocene slip rate ranging from 0.95 to 1.65 mm/yr for the Longquan fault. The 3D structural model and the late Holocene faulting events occurred along the Longquan fault reveals that upper crustal shortening in the Sichuan basin is accommodated on a frontal thrust system that is linked to the recently active range front blind structures by a shallow detachment. We suggest that a dynamic weakening mechanism following fault activity closer to the Longmen Shan range front could help unlock the up-dip portion of this shallow detachment, sending slip eastward to the foreland and to the surface along the Longquan thrust ramps. These findings have important implications for seismic hazards of active frontal thrusts linked by upper crustal detachments in the Sichuan basin, as well as other active fold-and-thrust belts around the world.

Keywords: Active thrusting, paleoseismology, 3D structural modeling

