Japan Geoscience Union Meeting 2015
(May 24th - 28th at Makuhari, Chiba, Japan)

SSS28-01 Room:103 Time:May 27 16:15-16:30

On the Ansei-type and the Hoei-type of great Nankai trough earthquakes

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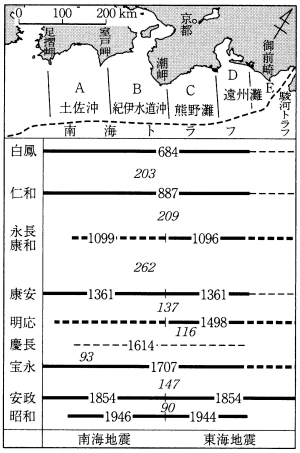
Seno (2012) proposed a new idea for the rupture mode and time series of great interplate earthquakes that have repeatedly occurred along the Nankai trough off southwest Japan. He characterized a fault plane of a great earthquake into a seismic-b.eq, a tsunami-b.eq, and a geodetic-b.eq, in which seismic waves, tsunamis, and crustal deformations are dominantly generated, respectively.

Among his various discussions, Seno compared seismic-b.eqs between the 1944 Showa-Tonankai, 1854 Ansei-Tokai, the 1707 Hoei and other earthquakes, using seismic intensity data and previous studies. As one of his main conclusions, Seno grouped historical great earthquakes into the Ansei-type or the Hoei-type, which has a seismic-b.eq similar to either of the Ansei (seismic-b.eq occupies E but not C in the Figure) or the Hoei (seismic-b.eq occupies C but not E jn the Figure) earthquakes. He interpreted that the Ansei-type earthquakes were the 684 Hakuho, 1096 Eicho, 1498 Meio, and 1854 Ansei earthquakes and recurred with about 400-year period, and that the Hoei-type earthquakes were the 887 Ninna, 1361 ko'an, 1707 Hoei, and 1944 Tonankai-1946 Nankai earthquakes and recurred with about 350-year period.

In this study, I examined Seno's (2012) idea on the Ansei-type and the Hoei-type carefully by means of historical seismology, and concluded that the grouping of historical Nankai trough earthquakes into the two types is difficult.

The figure shows a revised space-time recurrence pattern of the Nankai trough earthquakes after Ishibashi (2014).

Keywords: great Nankai trough earthquakes, historical earthquakes, recurrence pattern, Ansei-type, Hoei-type



Japan Geoscience Union Meeting 2015
(May 24th - 28th at Makuhari, Chiba, Japan)

SSS28-02 Room:103 Time:May 27 16:30-16:45

Pre-1703 Genroku earthquake estimated from coastal geology at the southwestern Boso Peninsula

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We conducted a drilling survey to detect the previous great Kanto earthquake to the 1703 Genroku earthquake at the Tateyama Plain, near the Sagami Trough. In this plain, coseismic uplift events to form the emerged marine terrace and bench were observed during the 1703 and 1923 Kanto earthquakes. Our drilling site was located on the beach ridge marking the coast line before the Genroku event. Considering the Holocene development of the Tateyama Plain (progradation of the strand plain closely relating to the coseismic uplift), emergence of this beach ridge would have a connection with the coastal uplift during the previous Kanto earthquake to the Genroku event.

The cores are composed of very fine-grained sand beds with marine shells (inner bay deposits) in their lower part and an alternation of sand and gravel beds (beach ridge deposits) in their upper part. Rapid sedimentary facies change from the lower to upper parts suggests the occurrence of uplift event. Alternating bed of gravelly sand with molluscan shells and clay is intercalated between the lower and upper parts of the cores. Possible source of this alternating bed is tsunami generated by the great earthquake that caused the coastal uplift. According to the ^{14}C age determination, the coastal uplift event is estimated to have occurred somewhere between the 13th and late of 14th century.

Keywords: Kanto earthquake, Coastal uplift, Tsunami deposit, Paleoearthquake

Japan Geoscience Union Meeting 2015
(May 24th - 28th at Makuhari, Chiba, Japan)

SSS28-03 Room:103 Time:May 27 16:45-17:00

Late Holocene uplifts of Shikine Island on the northern Zenisu Ridge off Central Japan

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Emerged marine sessile assemblages are observed on Shikine Island, located on the northern Zenisu Ridge in the northern Philippine Sea plate, Japan. A previous study obtained ^{14}C ages of 1400 years BP from these assemblages by the liquid scintillation counter method and concluded that approximately 3 m of uplift occurred suddenly at 1400 years BP (Ota et al., 1983). The present study examined emerged assemblages at four sites on the island, and dated the assemblages at all four sites, and well as the assemblages reported by Ota et al. (1983), by accelerator mass spectrometry (AMS) ^{14}C dating. The results show that all the specimens are younger than AD 950. The difference in ages between the previous work and this study reflects contamination by dead carbon of the specimens measured in the previous work. By combining the our ^{14}C age data of the emerged sessile assemblages and faunal analysis of present-day rocky intertidal sessile assemblages around the study area, we suggest that uplift events took place at AD 1120-1400, AD 1530-1890, and AD 1858-1950. The amount of uplifts were estimated to be 0.4-1.8 m. It is likely that the modern uplift was due to an earthquake which occurred along south Zenisu fault system at AD 1890. The two older uplift events were caused by either fault motion or igneous activity. Although the timing of the uplift event at AD 1530-1890 corresponds to AD 1605 Keicho earthquake, our fault model did not support relationship between the uplift event and the earthquake. In conclusion, this study do not support possibility that tsunami source areas of AD 1498 Meio and 1605 Keicho tsunamis were located at the northern Zenisu Ridge.

Keywords: Shikine Island, Emerged marine sessile assemblages, Late Holocene, uplifts, ^{14}C dating

Japan Geoscience Union Meeting 2015
(May 24th - 28th at Makuhari, Chiba, Japan)

SSS28-04 Room:103 Time:May 27 17:00-17:15

Seismicity of Kanto District for 400 years since 1615

MATSU'URA, Ritsuko S.[1*]

[1]ADEP

Kanto District shows the most active seismicity in Japan due to the subductions of PAC and PHS plates underneath, in addition to the collision of the Izu Peninsula in the western end of Sagami trough. There are 127 events of recorded destructive earthquakes in the area since 1615. Among them, 111 events are intermediate depth earthquakes related to the two oceanic plates, including inter-plate around M8 earthquakes: 1703 Genroku, 1923 Kanto, and 1923 off Katsuura, and intra-plate around M7 earthqukes: 1782 Tenmei Odawara, 1855 Ansei Edo, and 1924 Tanzawa. Only 20 earthquakes are shallow.

There are only 15 events of shallow depth. 6 of them are caused by the liquid motion due to some volcanic activities. 4 of them occurred after the 2011 off Tohoku earthquake in the northeastern part of Kanto. Among remaining 5, 1633 Kanei Odawara and 1853 Kaei Odawara occurred in some shallow part of spray faults around the collision area of the Izu Peninsula. 1683 Tenwa Shimotsuke, and 1931 Western Saitama are rare shallow events in the crust. The rupture zone of 1887 M6.2 shallow Hadano earthquake extended in the east-west direction.

1856 Ansei Musashi remains depth undetermined. If the intensity distributions of various depth events are carefully compared, we realize the difficulty of the depth determination of historical events in Kanto district with limited materials.

The research was done by the contract of MEXT in addition to the priority research project on Tachikawa Fault.

Keywords: Depth of histrical Earthquake in Kanto District, 1921 Ryugasaki Earthquake, 1855 Ansei Edo Earthquake, 1856 Ansei Musashi Earthquake, 1887 Hadano Eaerthquake, 1924 Tanzawa Earthquake

Japan Geoscience Union Meeting 2015
(May 24th - 28th at Makuhari, Chiba, Japan)

SSS28-05 Room:103 Time:May 27 17:15-17:30

Damage in the Chiba Prefecture from the 1855 Ansei Edo earthquake

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The Ansei Edo earthquake occurred on November 11 1855 and caused severe damage in and around Edo City (former Tokyo). Kitahara (2013, Social History of Earthquakes) discussed damage and rescue in Edo City after the Ansei Edo earthquake. Nakamura et al. (2011, Historical Earthquakes) estimated seismic intensity distribution in and around Edo City from damage description in historical literature. The main target for both studies was Edo City and the damage in Chiba Prefecture has not been fully revealed except for a part of Chiba Prefecture such as Sakura and Kisarazu. To reveal the damage in Chiba Prefecture, we conducted survey of historical literature at the Chiba Prefectural Archives, Funabashi Hometown Museum, and department of literature at the Keio University.

For damage in the northwest Chiba, there is a historical document *Watanabe-Toen-Zatsuroku* printed in *History of Narashino City volume 3*. Toen Watanabe, a doctor of Saginuma Village compiled the document which describes events in the vicinity of the village during the period of 1824 – 1859. The document recorded a ground fissure due to the earthquake in Saginuma Village. The casualties and damage of houses are not described and unknown, while the ground shaking was strong enough to cause fissures.

In Funabashi City, *Jishin-Hendo-Hikae* printed in *History in Funabashi City volume 10* described that “there was a large earthquakes in four (former) countries, Musashi, Shimousa, Kazusa, and Hitachi and many houses were collapsed” , while there were no descriptions on damage in Funabashi area. We found a description of earthquake in *Daifuku-cho* of *Muto-ke Monjo* from the survey at the Funabashi Hometown Museum. The house of Muto family was located in the present Miyamoto district, Funabashi City. This document suggests that there was not severe damage such as collapsed houses and injured persons in this area.

While the above one was an only document written in Funabashi City, there is a diary of Maejima Jisuke, a mayor of Daikata Village in Togane City. He left that village toward Edo City on 11th because he was called from a feudal lord. The diary recorded that he started to see collapsed houses around Gyotoku on the way to Edo City. Another document *Edo-Kaicho-Shoyo-Dome* printed in *Archives of Narita-San Shinsho-ji volume 5*, recorded that accommodation place was asked to change in Senju post station due to severe damage, while the accommodation place was not changed in Funabashi post station. This suggests that the damage in Funabashi area was minor compared to that in Edo City.

In the southern part of Chiba, we found a diary of *Hoju-in* temple from replicated documents at the Chiba Prefectural Archives. The diary recorded that the stone monuments, stone lanterns, and Hokyoin-to Pagoda fell over and that the gate *Nio-mon* moved toward west. The diary also recorded that there was damage in surrounding temples. The diary *Nikki-Oboe* in *Kato-Ke Monjo* in Moto-Ori Village next to the village of Hoju-in recorded the Ansei Edo earthquake as “an extremely large earthquake” . These descriptions suggest that the ground shaking was strong in not only Edo City but also the southern part of Chiba Prefecture.

Acknowledgements

This study was supported by the Special project for reducing vulnerability for urban mega earthquake disasters from the Ministry of Education, Culture, Sports, Science and Technology of Japan.

Keywords: 1855 Ansei Edo earthquake, Historical earthquake, Historical document

Japan Geoscience Union Meeting 2015
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SSS28-06 Room:A04 Time:May 28 09:15-09:30

Numerical simulation of long-term earthquake activity on an active-fault cluster in the Japanese island

CHO, Ikuo[1] ; KUWAHARA, Yasuto[1*]

[1]AIST, GSJ

We have conducted numerical simulations of earthquake activity on an active fault cluster in the Japanese island for 50,000 years. Sixty major active faults were embedded into a 3D realistic inhomogeneous rheological structure model of crust and mantle of the central part of Japanese island for FEM simulations. The rheological model has been constructed, considering geophysical and geological data (Cho & Kuwahara, 2013a, b). The model consists of two layers: an upper part is of the elastic layer which has non-uniform thickness and a lower part is of a Maxwell viscoelastic layer whose viscosity is spatially uniform with a value of 10E21Pas. Parameters of active fault geometries, such as strikes and dips, were given with reference to results of fault evaluations by the Headquarters for Earthquake Research Promotion of Japanese government. We incoorporate a 5-km width shear zone and viscous edge zones into the model as deep extension and both lateral edges of each active fault, respectively, with the same Maxwell viscoelastic properties as the lower layer of the structure model. Tectonic stresses assumed in the simulations are a superposition of an E-W compressional stress to an entire body of the model and stresses that are generated by a collision of the Izu Peninsula to the main land of Japan.

Earthquake ruptures on the active faults are triggered on the occasion that a shear stress reaches an assumed level on some monitoring points on the fault plane. Stresses on the monitoring points are a superposition of the tectonic stress above-mentioned and Green's functions beforehand calculated for the rheology structure model from the ruptured fault to the other faults. Thus, we can show the calculation results involving the effects of constant loading of the tectonic stress and the stress perturbations due to inland large earthquakes on an earthquake cycle of each active fault with the present simulation.

References

Cho, I. and Y. Kuwahara, 2013, Modeling of a three-dimensional thermal structure in the lower crust for numerical simulations of crustal deformation of the Japanese Islands, EPS, 65, 855-861.

Cho, I. and Y. Kuwahara, 2013, Numerical simulation of crustal deformation using a three-dimensional viscoelastic crustal structure model for the Japanese Islands under east-west compression , EPS, 65, 1041-1046.

(present affiliation of I. Cho: MEXT)

Keywords: active fault, long-term earthquake activity, numerical simulation, Japanese island, crustal stress, rheology structure

Japan Geoscience Union Meeting 2015
(May 24th - 28th at Makuhari, Chiba, Japan)

SSS28-07 Room:A04 Time:May 28 09:30-09:45

Predicted seismic moment based on the length of active fault

SHIMAZAKI, Kunihiko[1*]

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Seismic moment of future earthquake is possibly underestimated with the conventional use of active fault data. Often used empirical relationship is based on seismic fault data that is only available after the occurrence of the earthquake. Careful consideration on the choice of the relationship is desirable for avoiding damage beyond expectations.

Keywords: seismic moment, active fault, seismic fault, prediction, hazard, tsunami

Japan Geoscience Union Meeting 2015
(May 24th - 28th at Makuhari, Chiba, Japan)

SSS28-08 Room:A04 Time:May 28 09:45-10:00

Geologic structure across the central part of the western marginal faults of the Kitakami Lowland

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[1]Fac. Eng., Iwate Univ., [2]ERI, Univ. Tokyo, [3]JGI

The western marginal faults of the Kitakami Lowland are active thrust faults, which develop along the eastern margin of the Ou Back-bone range. They have been believed to originate from normal faults caused by E-W extensional stress field during middle Miocene, and to activate as reverse faults under E-W compressional stress field since Pliocene. Though Kato et al. (2006) has shown normal inversion structures in the southern part of the faults, these structures have not been found in the central part. In this study, we modeled two dimensional shallow geological structure across the faults mainly based on gravity survey. And we discussed the structural relationship between the faults and the Tsunatori fault, which trends parallel to the faults, and lies to the west.

The gravity survey was conducted across the faults with a Sintrex gravity meter CG-5 along an E-W survey line, 12 km long. The typical interval of observation sites is 200 m. The elevation of the sites was surveyed with RTK-GPS. Acquired gravity data was processed to obtain Bouguer anomaly mostly according to the methodology of Geological Survey of Japan, AIST (2004). We assumed that the density for Bouguer and terrain corrections were 2.2 g/cm^3.

Obtained Bouguer anomaly after trend correction shows lower value around the western marginal faults, and higher value in the eastern and western areas. The difference between these values is about 20 mgal. We assume three layers in our model, which have densities of 2.1 g/cm^3 (layer 1), 2.5 g/cm^3 (layer 2) and 2.7 g/cm^3 (layer 3), respectively. The interpretation of the model is as follows. Layer 1 is correlated to the surface covers, Pliocene and upper Miocene sedimentary rocks, layer 2 middle Miocene sedimentary rocks, and layer 3 basement rocks.

In the model, two half-grabens, filled with middle Miocene, develop below the western sides of the western marginal faults and the Tsunatori fault, both of which constitute listric boundary faults of the half-grabens. And they show thrusting displacement. We will discuss the development of this inversion structure in detail.

References

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Kato et al., 2006, Journal of Structural Geology, 28, 2011-2022.

Keywords: the western marginal faults of the Kitakami Lowland, gravity anomaly, active fault

Japan Geoscience Union Meeting 2015
(May 24th - 28th at Makuhari, Chiba, Japan)

SSS28-09 Room:A04 Time:May 28 10:00-10:15

Seismic Reflection Survey at Eastern and Western Edge of Aizu Basin

ITO, Shinobu[1*] ; YAMAGUCHI, Kazuo[1] ; UCHIDA, Youhei[1] ; ISHIHARA, Takeshi[1]

[1]GSJ, AIST

We conducted seismic reflection survey at eastern and western edge of Aizu Basin in Kitakata City. The Aizu Basin is located between the Western and Eastern Aizu Basin Fault Zones. It is helpful to reveal detailed structure of the fault zones that segment the edge of the Aizu Basin, in order to understand the whole Aizu Basin. Our purpose of the study is to obtain control data to understand the whole Aizu Basin.

It is deduced that the Western Aizu Basin Active Fault Zone is the source fault of the Keicho Aizu Earthquake, and there are some signs of the earthquake at surface. Regional flexure can be revealed by seismic reflection survey. On the other hand, no clear sign of the Eastern Aizu Basin Active Fault Zone can be seen and the activity history is not clear although it is deduced by surface topography.

The survey for the Western Fault Zone was executed at Keitokucho-Yamashina, Kitakata City (KKY), where a ponded lake appeared by the Keicho Aizu Earthquake. Both source and receivers are set at a dry riverbed of Aga River. The length of the survey line is about 500m. The survey for the Eastern Fault Zone was carried out at Kumakuracho-Oguni, Kitakata City (KKO). In this region, volcanic fan deposits cover the products of Nekoma Volcano. The length of the survey line is about 800m. We used a portable vibrator ElViS III by GEOSYM with S-wave for both survey lines. Spatial intervals of shot points are 2m, sweep frequency is 20 to 160Hz, and sweep duration is 7s. We used single horizontal component geophones with GS32CT(f_O =10Hz) by Geospace, and the intervals are also 2m. We deployed 96 geophones simultaneously, and moved 48 geophones at a time.

We cannot obtain clear profile for the KKY in spite of our hope because of the knowledge of the fault zone. It is possible that the ground at a dry riverbed is not firm, and that seismic wave cannot propagate to the geophone effectively. Unpavement surface may not appropriate to this seismic source. We can see the significant structure regarded as flexure for the KKO although the surface of the survey line is over products of volcano. We are going to continue more detailed processing and analyses.

Keywords: Aizu Basin, active fault, seismic reflection survey

Japan Geoscience Union Meeting 2015
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SSS28-10 Room:A04 Time:May 28 10:15-10:30

Structural characters of active faults in the Toyama sedimentary basin revealed by shallow to deep seismic profiling

ISHIYAMA, Tatsuya[1*] ; SATO, Hiroshi[1] ; KATO, Naoko[1]

[1]Earthquake Research Institute, University of Tokyo

We discuss about structural characters of crustal architectures around the Toyama trough and Toyama sedimentary basin to the south revealed by new seismic reflection and refraction profiles and seismic tomography, and active structures based on Neogene geology and tectonic geomorphology. As revealed by onshore offshore deep seismic reflection profiling across the Toyama trough and Toyama sedimentary basin, crustal architectures are characterized by three domains: (1) crustal thrust wedge comprising the northwestern flanks of the Hida Mountains, (2) Neogene sedimentary basin near the axis of the Toyama trough, and (3) reactivated normal faults as thrust (or obliquely slipping) faults along structural higher domain boundaries between Noto Peninsula and Toyama trough. These structural patterns, permanent, late Quaternary crustal deformation recorded by tectonic geomorphology, and their tectonic origins are quite similar to adjacent Neogene sedimentary basins in the backarc failed rifts in the Sea of Japan, including northern Fossa Magna, Niigata, and Akita sedimentary basins.

Japan Geoscience Union Meeting 2015
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SSS28-11 Room:A04 Time:May 28 10:30-10:45

Blind active fault beneath Shonai plain, NE Japan

SATO, Hiroshi[1*] ; INABA, Mitsuru[2] ; ISHIYAMA, Tatsuya[1] ; KATO, Naoko[1] ; HAKEHANA, Yasuo[2]

[1]ERI, Univ. Tokyo, [2]JAPEX Co., Ltd.

The sedimentary basins along the Sea of Japan coast of northern Honshu, such as Akita-Yamagata, Niigata basins, suggest large amount of subsidence since late Pliocene. Such basin scale subsidence makes it difficult to identify active tectonic movements by tectonic geomorphological method. The Shonai basin has thick Quaternary sediments and the active tectonic feature beneath the plain is poorly understood,including the source fault of the 1894 Shonai earthquake (M7.0). We present the geologic interpretation of seismic sections and suggest an active blind thrust beneath the Shonai plain.

We interpreted the 15-km-long seismic section perpendicular to the Aosawa fault and the eastern boundary fault of the Shonai plain along the River Arase-gawa. CMP seismic reflection data were collected using four vibroseis trucks at 25-m shot and recorder interval. The seismic section was interpreted based on surface geology and drill hole data. The interpreted seismic section was examined using balanced cross sectional method.

The seismic section portrays the fault-related fold system developed by sequential thrust frontal migration from the Aosawa fault, which bounds the western margin of the Dewa Hills, The detachment is developed at the horizon of the Kusanagi and Kitamata formation, which consist of mudstone. The thrust front is located at the eastern flank of the Shonai ridge. The sediments on the western flank of the Shonai ridge suggest growth strata including Quaternary sediments. The structure was produced by thrusting at the western flank of the Shonai ridge. The source fault of the Shonai earthquake is estimated to be the eastern boundary fault of the Shonai plain. However, strongly damaged houses were located just the center of the basin, suggesting that 1894 Shonai earthquake probably produced by the blind active fault beneath the Shonai plain.

Keywords: Blind active fault, Seismic refection profiling, Shonai earthquake, Reverse fault

Japan Geoscience Union Meeting 2015
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SSS28-12 Room:A04 Time:May 28 11:00-11:15

High-resolution sonic survey of the shallow structure of the southern extension of the Kochien fault, Hokkaido

UCHIDA, Yasuhito[1*] ; NISHINA, Kenji[1] ; TAKAMI, Masazo[1]

[1]Geological Survey of Hokkaido, Hokkaido Research Organization

The Kochien fault, located at the southwestern edge of the Tokachi Plains, is a reverse fault characterized by an east-side upheaval. From two trench surveys, Hokkaido (2004) showed an apparent topography displacement on the lower terrace surface, and confirmed this fault to be a high-angle (about 30-60 degrees) reverse fault. A precise interpretation of the trench logs, together with carbon-14 dating results, showed that this reverse fault ruptured at least twice after the Late Pleistocene. An older event occurred at about 17,700±70yBP-12 ka, and a younger event occurred after about 2,160±60yBP. In contrast, the National Institute of Advanced Industrial Science and Technology (AIST) conducted a trench and drilling survey at two sites on this fault to supplement a former result. Based on the AIST surveys results, it was determined that the Kochien fault ruptured only once between 40 ka and 12 ka.

To clarify the distribution of the Kochien fault, we performed preliminary high-resolution sonic surveys using a parametric sub-bottom profiler across the possible active fault on an offshore area of the Tokachi Plains. We located our survey lines in the WSW-ENE direction at 500 m intervals, over a total survey track length of about 75 km.

Results from the high-resolution reflection profiles revealed flexural deformation of the shallow marine sediments. We will give a presentation on the results of this survey.

Keywords: Kochien fault, offshore, active structure, high-resolution sonic survey, Hokkaido

Japan Geoscience Union Meeting 2015
(May 24th - 28th at Makuhari, Chiba, Japan)

SSS28-13 Room:A04 Time:May 28 11:15-11:30

Submarine active fault and uplift of the northen part of Sanriku coast

WATANABE, Mitsuhisa[1*]

[1]Toyo Univ.

The coastal area around Kuji city, northern part of Sanriku coast, has been subsided for several decades and a characteristic co-seismic subsidence is observed there in 2011. However, marine terraces are well developed along the coast, which imply that the coastal area has been uplifted since middle Quaternary. The marine terrace surfaces around Kuji city, are classified into H1˜H5 surfaces and M surface. The M surface is correlated with that formed in MIS 5e. The heights of the former shorelines of H2˜H5 and M surfaces are , respectively. A wide flexural scarp tilting toward east is found on H2˜H5 and M surfaces. It is reasonable to assume that west-dipping submarine active fault may dislocate these marine terrace surfaces and play important role in the coastal uplift.

Keywords: submarine active fault, marine terrace surface, flexure, Sanriku coast

Japan Geoscience Union Meeting 2015
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SSS28-14 Room:A04 Time:May 28 11:30-11:45

Active fault investigations in the offshore extension of the Miura Peninsula Faults and the Kamogawa-teichi Fault Zone

ABE, Shintaro[1*] ; SAKAMOTO, Izumi[2] ; MORI, Hiroshi[1] ; ARAI, Ryoyu[3]

[1]AIST, [2]Tokai University, [3]KGE Co.,Ltd.

We conducted marine active fault investigations in the offshore extension of the Miura Peninsula Faults and the Kamogawa-teichi Fault Zone as parts of the offshore active fault survey project promoted by MEXT (Ministry of Education, Culture, Sports, Science and Technology).

In this study, we conducted high-resolution multichannel seismic reflection surveys off the Kamogawa (in the Sotobo side) and off the Hota (in the Tokyo Bay side) in the offshore extension of the Kamogawa-teichi Fault Zone, and off the Kaneda (in the Tokyo Bay side) and off the Hayama (in the Sagami Bay side) in the offshore extension of the Miura Peninsula Faults for the purpose to understand distributions and geometries of active structures in these areas. We also conducted columnar core sampling of mud off the Hota and off the Hayama.

The boundary between the Hota group and Miura group off the Kamogawa are recognized as a fault with displacements on the seafloor. However, the fault is not directly connected to the trace of the Kamogawa-teichi Fault Zone in land area. In addition, the remarkable displacements on the seafloor change to flexural structures with echelon arrangements towards the land area. In contrast, although development of a large-scale submarine canyon is observed off the Hota, no remarkable active structure is recognized in this area.

The extended parts of the uplift zone traversing the Miura Peninsula are recognized off the Kaneda and Hayama as remarkable geological structures. The southern margin of the geological structures is correlated to the offshore extension of the fault zone. Deformed geological layers are also recognized at the deeper parts. In addition, multiple faults are also recognized within the uplift zone.

Keywords: Miura Peninsula Faults, Kamogawa-teichi Fault Zone, marine active fault investigation, high-resolution multichannel seismic reflection survey, offshore extension, active structure

Japan Geoscience Union Meeting 2015
(May 24th - 28th at Makuhari, Chiba, Japan)

SSS28-15 Room:A04 Time:May 28 11:45-12:00

Examination of submarine active fault off southeast Izu Peninsular, central Japan

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Faunal compositions and ^{14}C ages of emerged sessile assemblages at four sites in the southern part of Izu Peninsula, central Japan, indicate that co-seismic uplift occurred at 1256-950 BC, AD 1000-1270, AD 1430-1660, and AD 1506-1815 (Kitamura et al., submitted). This study found emerged sessile assemblages at two sites (Kujyuhama and Tarai Cape) which are located at outside of the previous studied area, and examined their faunal compositions and ^{14}C ages. Moreover, we estimated average co-seismic vertical displacement based on combination of previous works and new data obtained in this study. Using these values and source fault model, we examined submarine active fault that caused four uplift events. The results showed that a reversal fault has 12 km length and 15 km width (strike = 70, dip = 25N, slip = 3 m, Mw = 6.7), and is located about 5 km off Shimoda.

Keywords: submarine active fault, southeast Izu Peninsular, coseismic uplift events, fault model

Japan Geoscience Union Meeting 2015
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SSS28-16 Room:A04 Time:May 28 12:00-12:15

The latest event and its fault model of active faults off the northern coast of the Noto Peninsula, central Japan

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The active faults zone on the seafloor off the northern coast of Noto Peninsula are divided into four segments, Monzen-oki, Saruyama-oki, Wajima-oki, and Suzu-oki, from west to east. The eastern half of the Monzen-oki segment corresponds to the active fault that caused the 2007 Noto Hanto earthquake (M_{JMA} 6.9). The average recurrence interval of the Monzen-oki segment was inferred from the relationship between the amount of coseismic vertical displacement and the height of the former shoreline of middle marine terraces. However, there is no data on the latest event for the other segments.

To reveal the coseismic crustal movement of the Saruyama-oki segment to the Suzu-oki segment, we investigated the vertical displacement along northern coast of the Noto peninsula. We chose *Pomatoleios kraussii*, which is one of intertidal sessile organisms for a marker of movement. We obtained 13 fossilized *P. kraussii* in rocky coast, measured the height of them by GPS surveying and dated them using the AMS ^{14}C method.

Since the altitude of the sampled fossilized assemblages includes the effect of a sea level change, it is necessary to remove it. Therefore, we apply an altitude correction based on the millennium sea level change for the northern hemisphere from data on climate changes reported by Grinsted *et al.* (2009). The vertical displacements and the dates at the sites implied that the coastal uplift occurred most likely between 1600 and 1800 AD. The uplift is recognized in a distance range of 20 km along the coast south of the Wajima-oki segment. Historical documents record seismic damages in this area in 1729 AD, although the hypocenter of this event has not been specified.

To confirm that the uplift is caused by the fault movement of the Wajima-oki segment, we constructed a fault model of the segment. In the calculation of displacements, we set rectangular faults in a homogenous elastic half-space. Based on the facts of the 2007 earthquake, the dip is set to be 60 degrees, the depth of the upper fault end is set to be 2 km and the depth of the lower fault end is set to be 15 km. We set the location of the fault based on the fault trace of the Wajima-oki segment. In the western part of the Wajima-oki segment, two faults extend parallel to each other and we selected the southern trace as the location of the rectangular faults. We used rakes of 90 degrees, 105 degrees, 120 degrees and 135 degrees. The rectangular faults consist of three sections. We used the non-linear inversion method to estimate the optimum net slip.

Our inversion result shows that a rake of 90 degrees, a net slip of the western fault plane of 1.8 m and a net slip of the center and the eastern fault planes of 0.6 m provide the best fit to the estimated vertical displacements. The zones damaged by the 1729 earthquake are included in the area above the fault model. The moment magnitude (Mw) calculated from these parameters with a rigidity of 30 GPa is 6.6 (M_{JMA} 6.7). This is coincident with the magnitude of 6.6 — 7.0 estimated empirically from the area of the damaged zones of the 1729 earthquake.

We, thus, conclude that the latest event of the Wajima-oki segment is the 1729 earthquake.

Keywords: coseismic crustal movement, active fault, intertidal sessile organisms, carbon dating, fault model, the Noto Peninsula

Japan Geoscience Union Meeting 2015
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SSS28-17 Room:A04 Time:May 28 12:15-12:30

Integrated Research for Beppu Haneyama Fault Zone (East part of Oita Plain to Yufuin Fault)

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<Introduction>

Integrated Research for Beppu Haneyama Fault Zone (East part of Oita Plain to 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.

<Purpose of project>

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 groups and contents of observation and survey>

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. Subtheme group 1: Research on precise location and shape of active fault, and average slip rate and event age. Subtheme group 2: Research on three dimensional structure and subsurface structure of fault zone and the area. Subtheme group 3: Research on establishment of subsurface structure model and evaluation of ground motion.

The result during 2014 fiscal year will be presented in the session.

Keywords: Beppu Haneyama Fault Zone, Integrated Research Project, Active fault, Fault model, strong ground motion

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SSS28-18 Room:A04 Time:May 28 12:30-12:45

Results of the High-resolution seismic survey for the offshore extension of the Futagawa-Hinagu fault zone

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Futagawa-Hinagu fault zone (mainly right -lateral strike-slip faults) extends from Aso volcano to the Yatsushiro-sea (The Headquarters for Earthquake Research Promotion, 2002). A number of faults exist in the Yatsushiro-sea bottom.

In acroteric part of strike-slip fault annihilation mechanism, develop complex structures (e.g. Kakimi and Kato, 1994). To comprehend these structures, it is necessary construct the research technique with three-dimensionally and high precision (Abe and Aoyanagi, 2004).

We have carried out the high-resolution seismic survey to comprehend the deformation structures of fault at Yatsushiro-sea. Furthermore, we plan to submarine topography survey and piston coring in the future

Keywords: Futagawa-Hinagu fault zone, right-lateral strike-slip fault, High-resolution seismic survey

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SSS28-19 Room:A04 Time:May 28 14:15-14:30

A newly-found active fault in the Izu peninsula: the Kanogawa fault and its seismotectonic implication

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During the past 20 years since the 1995 Mw6.9 Kobe earthquake, many studies have investigated the presence and recent activity of active faults and assessed the seismic hazard associated with the active faults in Japan, but many unknown active faults that triggered the damage earthquakes, such as the 2013 Awajishima Mw5.8 earthquake (Lin et al., 2015). Therefore, it is necessary to do more work for identifying active faults and assessing their recent activity including the slip rate and paleoseismicity and to reassess the seismic hazard associated with active faults in Japan.

It is well known that many active faults developed in the Izu peninsula, central Japan, that triggered large earthquakes caused great damages, e.g., the Tanna fault that triggered the 1930 M 7.3 earthquake, the Ishirozaki fault that triggered the 1974 M 6.9 Izuhandtou-oki earthquake. Besides the 1930 and 1974 earthquakes that triggered by the well-known active faults, there are many other damage earthquakes that caused by unknown active faults in the Izu peninsula during the past half century, e.g.,the 1934 M5.5 Amagijoyama earthquake, 1976 M5.4 Kawatsu earthquake, 1978 M7.0 Izu-Oshima Kinkai earthquake, and 1980 M6.7 Izu-Touhou-oki earthquake. In this presentation, we report the tectonic topography that characterizes recent faulting along a newly-found fault, called the Kanogawa Fault, developed in the central Izu peninsula, parallel to the Tanna fault in the east side. This fault strikes north-south, extends from Mishima City in the north through the Amagi-Touge (Amagi pass) in the south for $>$30 km. The analysis on the tectonic topography and identification of active faults were mainly based on interpretations of aerial photographs, topographical maps of 1:25,000, and 3D perspective images made with Digital Elevation Model (DEM) data with 10-m-contours and field investigations. The analytical results and fieldworks reveal that the distinct fault scarps developed on the low-high terrace risers and alluvial fans, along which the vertical offsets measured in-site range from a few centimeters to $>$10 m. This finding indicates that the offset has been accumulated on the fault in the recent geological time since the formation of the terrace risers and alluvial fans.

Reference:

Lin, A., Katayama, S., and Kubota, Y., 2015. Structural analysis of seismogenic fault of the 2013 Mw5.8 Awaji Island earthquake, NW Japan. Bulletin of Seismological Society of America, in press.

Keywords: Izu peninsula, active fault, Kanogawa fault, tectonic topography, DEM image, Aerial photography

Japan Geoscience Union Meeting 2015
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SSS28-20 Room:A04 Time:May 28 14:30-14:45

Epicenter of the Ansei Hietsu Earthquake in 1858 inferred from ratio of dead persons in each village

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1. Introduction

Historical documents are key data for reconstruct the features of paleo-earthquakes. However, it is still rare to restore the source mechanism and/or location of epicenter of paleo-earthquakes from human damage data. The presenter tries to estimate the epicenter of the first shock during the Ansei Hietsu Earthquake in 1858 (M=7.0˜7.1:Usami et al., 1979) which are considered to be double earthquakes from ratio of dead persons in each village.

2. Features of the 1858 Ansei Hietsu Earthquake

The Ansei Hietsu Earthquake occurred on mid-night on 9 April 1858. Historical documents described that this earthquake is composed of two large shocks on 12PM and on 01AM (Cabinet office, 2008). Damages of human and houses by this earthquake are described by Takayama Gundai (local governor) in detail. We can analyze the damages quantitatively by these documents. They denote that damage of houses were bitter along the Atotsugawa fault, where 50˜100% houses collapsed, damage of houses occurred along the Miboro fault, where 20˜60% houses collapsed, and much less damages occurred in other areas (Usami et al, 2013). Trenching survey (Tsukuda et al., 1986) and detailed dating of active fault outcrops (Doke and Takeuchi, 2009) revealed that the Atostugawa fault is the source of this earthquake.

3. Estimated epicenter of the first shock of the Ansei Hietsu Earthquake inferred from the human damages described in Ansei Go Uma-no-toshi Hishu Muramura Jishin Ikken (A report on the aspects of damages by the Ansei Hietsu Earthquake)

This earthquake occurred in mid-night, the almost all peoples would be in the houses at the first shock. So peoples near the epicenter of the first shock were thought to be hard to escape from collapsing houses, on the other hand, peoples near the epicenter of the second shock would be able to escape from the damages by largest shock.

The ratio of dead persons is high (4˜54%) along the central part of the Atotsugawa fault (from Amou village to Suganuma village), and it is low (less than 4%) along the eastern part of the Atotsugawa fault. All villages along the Miboro fault is 0% in the ratio of dead persons.

This fact indicates the first shock occurred on the central part of the Atotsugawa fault, and epicenter of the second (or later) shock was near the Miboro fault.

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Doke and Takeuchi (2009) The Quaternary Research, 48, 11-17.
Tsukuda et al.(1986)Active Fault Research, 3, 59-64.
Usami et al.,(1979) Report of the coordinating committee for earthquake prediction, 21, 115-119.
Usami et al.,(2013) Materials for Comprehensive List of Destructive Earthquakes inJapan,599-2012, Univ. of Tokyo Press.

Keywords: Ansei Hietsu Earthquake, historical earthquake, human damage, Atotsugawa fault, epicenter

Japan Geoscience Union Meeting 2015
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SSS28-21 Room:A04 Time:May 28 14:45-15:00

Reevaluated age of the latest activity of Ushikubi fault with ESR method using calcite proportion in calcareous gouge

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The Ushikubi fault with a recurrence interval of 4-5 ka (Miyashita et al., 2004b) is a 52 km long, NE-SW dextral trending fault and composes of a complex network of active faults in central Japan. Because active faults in Japan have become a major threat to the location and re-running of the nuclear power plants in the country, various methods have been employed to unravel their fault histories and to determine ages of their recent activities. According to previous radiocarbon dating of overlying contact, the latest activity of this fault is about 1 ka while a close age of 1.9 Ka has been obtained directly from calcareous fault gouge using the ESR method (Fantong et al., 2013).

Although ESR ages obtain from defect centers in quartz grains are always greater than 10,000 yrs, age determination of the recent movement of the Ushikubi fault using calcite proportion in the mixture could give a relatively younger and more precise age. This is because defects from calcites have a younger dating range and therefore may be appropriate for determining the age of the most recent fault activities. Accordingly, the main aim of this investigation is to reevaluate the age of the Ushikubi fault based on the proportion of calcite in the samples and also to verify additive dose rate dependency on the ESR signal intensities.

The calcite proportion from the mixture was estimated using calibration curves constructed from known concentrations of pure quartz and calcite obtained from XRD diffractograms. The equivalent doses were estimated using the additive dose method and the annual dose rates (adopted from Fukuchi et al., 2002) were calculated from the concentrations of radioactive elements. Calibration curves revealed that the proportion of calcite in the samples range from 26-37% and 9-17% in the central and eastern part of the Ushikubi fault respectively. Although no great discrepancy was observed in the equivalent dose and the signal intensity upon addition of artificial irradiation (50 Gy/hr and 20 Gy/hr), the equivalent dose determined from some of the samples irradiated at 20 Gy/hr was slightly larger. The average age obtained from these proportion range from 0.75 - 1.15 ka (50 Gy/hr) and 0.88 - 1.2 ka (20 Gy/hr). These ages are in good agreement with that determined by radiocarbon dating (1 ka) (Miyashita et al., 2004b).

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Miyashita, Y., Yoshioka, T., Nikaido, M., Takase, N. and Tachibana, T., (2004b): Paleoseimological surveys of the Northeastern part of Ushikubi fault on Toyama/Gifu prefectural border-A trench excavation survey at kamishirakimine site. Annual Report on Active Fault and Paleoearthquake Research, 4: 131-142 (In Japanese with English abstract).

Keywords: ESR, Calcareous fault gouge, Calcite proportion, Ushikubi fault, Active fault

Japan Geoscience Union Meeting 2015
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SSS28-22 Room:A04 Time:May 28 15:00-15:15

Surface trace and latest activities of the Kurehayama Fault through the urban area of Toyama City, north-central Ja

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The Krehayama fault zone is an active, high-angle reverse fault running through the central part of urban area in Toyama City. The surface-fault trace and the fault history are still unclear because of much limitation for geological surveys in such an urban area. Recently, however, boring investigation has been carried out along the National highway No. 8 for the construction of bridge in the segment from Awashima-machi to Toyoda-honmachi, Toyama City. Descriptive reports on stratigraphy of boring investigation and core-samples were available and quite useful for the five sites of boring investigation (T7, T8, T2, T3 and T9 from west to east) were offered by the Toyama Office of River and National Highway, Hokuriku Regional Development Bureau, MLIT, Japan.

This study utilized those samples and records to clarify the location of fault trace and to determine the age of latest activities of Kurehayama Fault by visual observation and age determination using carbon isotope analysis of core samples. Seven radiometric carbon ages were also obtained from T7, T8, and T9 for time-stratigraphy.

Analytical results of this study suggest that the surface trace of Kurehayama Fault across the survey line between T3 and T9 and displaced at least twice after 9680calBC with approximately 4.7 m in accumulated displacement. The latest activity occurred within the interval after 4960calBC and before 1360calBC with approximately 2.5 m vertical displacement. Regarding the estimated range in the neighbor segments of Kurehayama Fault, this study limited the evaluated span of fault activity into a narrow range ca.2285BC- ca.1360BC.

The second latest activity occurred within the span from ca.9500calBC to ca.8380calBC, and its vertical displacement was evaluated 2.54m, suggesting a moment magnitude 7.2 if the whole fault were activated to generate earthquake. The time interval between the first and second latest events was calculated as about 7100 years.

Since the net-slip rate becomes 0.5m kyr-1 and the activity of Kurehayama Fault is classified into B class.

It is necessary to explain the geomorphological development of target area is necessary in the future.

Keywords: active fault, reverse fault, Kurehayama Fault, Toyama Plain, latest activity, fault trace

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SSS28-23 Room:A04 Time:May 28 15:15-15:30

Offset clusters on the Haiyuan Fault and its implications to earthquake rupture pattern

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Abstract We use airborne LiDAR data to re-evaluate the single-event offsets of the 1920 Haiyuan Ms 8.5 earthquake and the cumulative offsets along the western and middle segments of the co-seismic surface rupture zone. Our LiDAR data indicate the offset observations along both the western and middle segments fall into groups. The group with minimum slip amount is associated with the 1920 Haiyuan Ms 8.5 earthquake, which ruptured both the western and middle segments. Our research highlights two new interpretations: firstly, the previously reported maximum displacement of the 1920 Earthquake is likely to due to at least two earthquakes; secondly, Our results reveal that the Cumulative Offset Probability Density (COPD) peaks of same offset amount on western segment and middles segment did not corresponding to each other one by one. We suggest that any discussion of the rupture pattern of a certain fault based on the offset data should also consider fault segmentation and paleoseismological data; Therefore, using the COPD peaks for studying the number of palaeo-events and their rupture patterns, the COPD peaks should be computed and analyzed on fault sub-sections and not entire fault zones.

Japan Geoscience Union Meeting 2015
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SSS28-24 Room:A04 Time:May 28 15:30-15:45

Active thrust faulting and paleoseismic records of the Longquanshan Fault in the interior of the Sichuan Basin, China

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The Longquanshan Fault (LQSF), located in the interior of the Sichuan basin, China, defines the east boundary of the Longmen Shan fold-and-thrust belt. Previous studies have shown the geometry and kinematic of the LQSF that formed above the shallow (3-5 km) detachment within the Triassic evaporite sequences within the basin. Despite its location near the metropolitan of Chengdu, and total length of about 230 km, evidences for active faulting and paleoseisimic records of the LQSF are quite unknown. Here we define the fault activity of the LQSF by integrating seismic reflection profiles, geomorphic observations, and trench survey. Analysis of seismic refection data and focal mechanism solution show that the 1967 Ms 5.5 Renshou earthquake ruptured the back-thrust of the structural wedge system in the LQSF, causing 7 deaths and 57 injuries. By using high-resolution satellite images combined with the field observations, we mapped the active fault traces of the back-thrust of the LQSF. We excavated the trench across the ˜5 m high fault scarp that formed on the alluvial fan. Based on the indentification of the colluvial wedges and the uplift and folding of the paleosoil, we infer that there are at least two paleoearthquake events are recorded in the trench wall. These findings confirm the cumulative of uplift of river terraces are produced by the LQSF through repeated paleoearthquake events. Our study shows that the LQSF represents a significant seismic hazard in the center of the high densely inhabited area in the Sichuan basin.

Keywords: Active tectonics, thrust fault, paleoseismic, seismic reflection profile, trench survey, Sichuan basin

Japan Geoscience Union Meeting 2015
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SSS28-25 Room:A04 Time:May 28 16:15-16:30

The surface rupture of the 22 November 2014 Nagano-ken-hokubu earthquake (Mw 6.2), Nagano prefecture, central Japan

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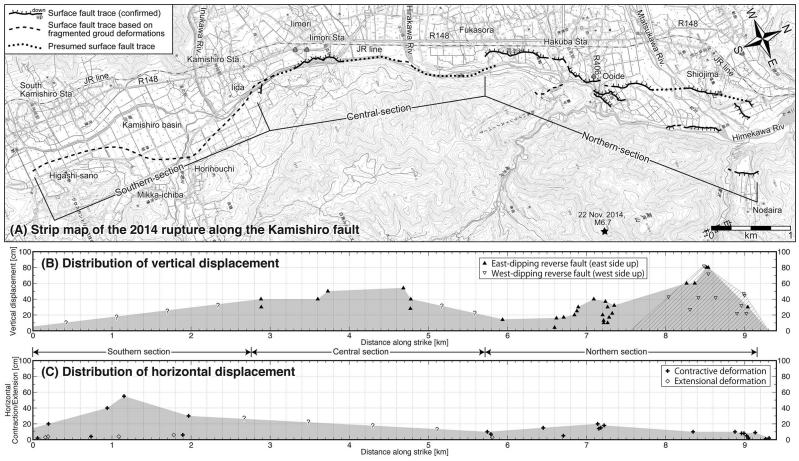
The Nagano-ken-hokubu earthquake (Mw = 6.2) occurred on 22 November 2014 and the surface rupture due to the earthquake appeared along the Kamishiro fault (Sawa et al., 1999; Togo et al., 1999). To reveal features of the surface ruptures, we carried out surface exploration from 23 November to 26, and from 29 November to 3 December. In this survey, we observed ground deformations, recorded location data of fault traces with handy GPS, and carried out simple measurement of vertical displacement and horizontal shortening. As a result, we confirmed 9.2-km-long surface ruptures and ground deformations along the Kamishiro fault. These surface ruptures and their distributions indicate that NW-SE compressive east-dipping reverse fault (east side up) slipped at depth, which is consistent with fault-plane solution of main shock (JMA, 2014) and deformation pattern using SAR interferograms (GSI, 2014). In our surface exploration, we confirm flexural deformation that has contractive deformation near the fault tip and extensional deformation in the hanging wall side. These deformations show that the reverse fault change to low-angle at shallow depth and deform unconsolidated sediments in the basin.

Keywords: surface rupture, the 22 November 2014 Nagano-ken-hokubu earthquake, Itoigawa-Shizuoka Tectonic Line, Kamishiro fault



Japan Geoscience Union Meeting 2015
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SSS28-26 Room:A04 Time:May 28 16:30-16:45

Ground penetrating radar survey across the surface rupture generated by the 2014 Northern Nagano Earthquake

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[1]GSI of Japan

Surface ruptures emerged over 9 kilometers or more length intermittently along Kamishiro fault caused by the Northern Nagano Earthquake on November 22, 2014 (hereafter is "the 2014 Northern Nagano Earthquake") (Hirouchi et al., 2014; Kondo et al., 2014; Okada et al., 2014 etc.). The surface ruptures have about 90 and 40 centimeters vertical displacements in Hokujo Shiojima and Hokujo Ooide section, northern Hakuba Village respectively (Hirouchi et al., 2014), and these ruptures emerged linearly. On the other hand, crooked surface ruptures with horizontal shortening displacement emerged along topography around Kamishiro Iida and Kamishiro Horinouchi section in the southern Hakuba Village. The cause is presumed that dip angles of subsurface ruptures are high around the northern area and low around the southern area. At the Kamishiro Horinouchi section, Okumura et al. (1998) indicated almost horizontal active fault (subsurface rupture) by the past trench survey. In order to confirm these conditions, we tried to detect shallow underground structure of the surface ruptures by ground penetrating radar (GPR) survey at the Hokujo Ooide and Kamishiro Iida section.

The survey was conducted on December 2, 2014. At the Hokujo Ooide section, the GPR survey was performed along the Route 406 (Line Oi-1) and on the cultivated land 10 meters south from the Route 406 (Line Oi-2). At the Kamishiro Iida section, the GPR survey was performed on the path between the paddy fields (Line Id-1). The GPR device used, was "Noggin plus" with 250 MHz antenna manufactured by Sensors & Software Inc.

The GPR survey profile of Line Oi-1 showed the characteristics as follows. 1) A clear horizontal reflection patterns displaced near the position of surface rupture were approximately at the depth of 0.5-1.0 meter. These displacements had 20-30 centimeters uplift on the east side. The displacement tendency shown here roughly correspond to the vertical displacement of ground surface. 2) A vertical linear gap of reflection with displacement appeared at the position of 1-2 meters west from surface rupture and at the depth from 0.5 to 2 meters. It conforms to the reflection pattern at the active fault reported by Nakano and Sakai (2007). 3) A whole reflection intensity at the west side of surface rupture was strong, while reflection intensity at the east side of surface rupture was weak. It depends on a difference of the dielectric properties on both sides of the surface rupture.

The dip angle of subsurface rupture estimated from GPR survey profile is high at the Line Oi-1. However, similar pattern cannot be identified clearly on the GPR survey profile of Line Oi-2.

The pattern of subsurface rupture like the GPR survey profile of Line Oi-1 is not clear on the GPR survey profile of Line Id-1, although Okumura et al. (1998) reported almost horizontal active fault (subsurface rupture) about 4 meters deep by the past trench survey nearby Line Id-1. This is because the detectable depth (skin depth) of GPR survey at the Line Oi-1 was about 2 meters deep.

Consequently, the GPR survey could detect the subsurface rupture of high dip angle at the Hokujo Ooide section. However, the subsurface rupture of low dip angle could not be detected at the Kamishiro Iida section. In the future, it is preferable to perform the GPR survey by more survey lines and different antenna frequencies with simple boring.

Acknowledgement
We borrowed the GPR device from Prof. Yasuhiro Suzuki, Nagoya University. We appreciate his assistance very much.

Keywords: the 2014 Northern Nagano Earthquake, Kamishiro fault, surface rupture, Ground penetrating radar (GPR), shallow underground structure

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SSS28-27 Room:A04 Time:May 28 16:45-17:00

Outcrops around the Kamishiro fault, Nagano Prefecture, Central Japan

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We observed active fault outcrops considered to be related to the 2014 Nagano-Ken Kamishiro fault earthquake (M6.7). Altered tuff breccia (Miocene Iwato-Yama Formation) overlies Middle terrace deposits. Bounding thrust plane is dipping SE. Based on the observed Y-P-R1 fabric and slickenlines, reverse sense with a minor sinistral slip are determined.

Keywords: Nagano Prefecture, Hakuba Village, Kamishiro fault, active fault, outcrop, fault gouge

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SSS28-28 Room:A04 Time:May 28 17:00-17:15

Paleoseismic study on the Kamishiro Fault that triggered the 2014 Mw 6.2 Nagano earthquake, Japan

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The Mj 6.8 (Mw 6.2) Nagano (Japan) earthquake of 22 November 2014 ruptured the preexisting Kamishiro Fault along the Itoigawa-Shizuoka Tectonic Line, in the northern Nagano Prefecture, central Japan. Field investigations reveal that the earthquake produced a 9.3-km-long surface rupture zone with a thrust-dominated displacement that is characterized by distinct fault scarps with vertical offsets of up to 1.5 m, that are duplicated on the preexisting fault scarps (Lin et al., 2015).

Historical and instrumentally-records show that five large earthquakes of M >6.0 occurred in the study area around the Matsumoto Basin during the past 1200 years, which were almost located upon the active Kamishiro Fault (841 M 6.5, 1714 M 6.3, 1791 M 6.8, 1918 M 6.5 and M 6.1 (Headquarters for Earthquake Research Promotion, 2000), in which the 1918 M 6.5 earthquake caused the ground deformation along the active fault with a high dip angle, the northern part of the ISTL (Tada and Hashimoto, 1988). Based on geologic and seismic data, it is inferred that the active faults developed in the eastern margin of the Matsumoto and Kamishiro basins have a potential to trigger a large earthquake of M >8.0 (Headquarters for Earthquake Research Promotion, 2000).

To better understand the nature of the Kamishiro Fault, we carried out paleoseismic study immediately on the seismogenic fault by fieldworks including fault outcrop investigations within one week after the earthquake. Field investigations and analyses of excavated outcrops reveal that at least two morphogenic earthquakes have occurred on the Kamishiro Fault in the past millennium. Paleoseismic evidence, historical records, and radiocarbon age data show that (1) the penultimate large-magnitude earthquake (i.e., prior to the 2014 Nagano earthquake) occurred within the past 400 yr, probably corresponding to the 1918 M 6.5 or 1791 M 6.8 earthquake; and (2) the third most recent event occurred between A.D. 550 and A.D. 1000, probably corresponding to the 841 M 6.5 earthquake, suggesting at least three large earthquakes associated with surface rupture of the Kamishiro Fault in the past ˜1500 years with an average recurrence interval of ˜300-500 years. Our results reveal that the style and magnitude of thrust displacements indicate that the present-day shortening strain on the Itoigawa-Shizuoka Tectonic Line, the Eurasian-North American plate boundary in the study area, is released mainly by seismic thrust displacements along the active Kamishiro Fault.

Keywords: 2014 Mw 6.2 Nagano earthquake, paleoearthquake, Kamishiro fault, Itoigawa?Shizuoka Tectonic Line, plate boundary, thrust

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(May 24th - 28th at Makuhari, Chiba, Japan)

SSS28-29 Room:A04 Time:May 28 17:15-17:30

Surface rupture and slip distribution of the 22 Nov. 2014 Mw 6.2 earthquake at Nagano Prefecture, central Japan

KATSUBE, Aya[1*] ; KONDO, Hisao[1] ; TANIGUCHI, Kaoru[2] ; KASE, Yuko[1]

[1]Geological Survey of Japan/AIST, [2]Geological Survey of Japan/AIST: now at Crearia Inc

The 22 November 2014 Mw 6.2 Nagano-ken Hokubu earthquake occurred on the Kamishiro fault, consisting of the northern most segment of the Itoigawa-Shizuoka Tectonic Line active fault system (ISTL). The moderate-sized earthquake is associated with a 9-km-long surface rupture, which extends from the northern margin of Hokujyo Basin to the middle of Kamishiro Basin from north to south.

We mapped surface rupture and other related deformation produced by the earthquake, and measured coseismic displacement at 42 localities. The results of detailed mapping show that the surface rupture extends mostly along the previously-mapped Kamishiro fault (e.g. Active Fault Research Group, 1990; Shimokawa et al., 1995; Sawa et al., 1999; Togo et al., 1999; Nakata and Imaizumi eds., 2002). All the data at measurement localities exhibit pure reverse fault or thrust component with relative uplift at the eastern side, except for a back thrust and a pop-up structure. The surface rupture consists of main and additional fault sections. The main section of the surface rupture extends from Shiojima to Iida for ca. 6 km long. The general strike of the fault section is N25E. The amount of displacement generally increases to the north on the main section, and the maximum vertical displacement is 90cm at Shiojima. The northern termination of the main section is accompanied by the back thrust and the pop-up structure. Meanwhile, the additional section of surface rupture shows the general strike from N20E to N20W, extending from Iida to Mikkaichiba for ca. 2 km long. The amount of displacement and shortening along this section is less than ˜30 cm.

The main shock epicenter is located near the northern most termination of the surface rupture. However, the aftershock distribution exhibits that the seismogenic fault plane extends to the north from the epicenter for >5km long (e.g. The Headquarters for Earthquake Research Promotion, 2014), though significant surface rupture has been reported yet along this fault section. Tectonic landforms associated with the Kamishiro fault are clearly observed at the northern and southern extensions of the surface rupture. Therefore, the earthquake was caused by a part of the Kamishiro fault. Moreover, four paleoseismic events were identified by a pre-existing trench study, and the recurrence interval was estimated to be about 1100 to 2400 years (Okumura et al., 1998). Based on the maximum coseismic displacement of the 2014 earthquake and the average recurrence interval, the vertical slip rate of the Kamishiro fault is presumably at 0.4-0.8 m/kyr. However, it is much smaller than geologic vertical slip rate of 1.5-2.7m/kyr during the late Pleistocene (Shimokawa and Yamazaki, 1987; Imaizumi et al., 1997; Matsuta et al., 2001). To understand the recurrence of the irregular earthquakes on the Kamishiro fault, the reconstruction of displacements during paleoseismic events are necessary.

Keywords: active fault, inland earthquake, ISTL active fault system, Kamishiro Fault, coseismic slip

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SSS28-30 Room:A04 Time:May 28 17:30-17:45

Issues posed by the 2014 Kamishiro Fault Earthquake, central Japan

SUZUKI, Yasuhiro[1*] ; TECTONIC GEOMORPHOLOGICAL RESEARCH GROUP, For 2014 kamishiro fault earthquake[1]

[1]Nagoya University

The 2014 Kamishiro Fault Earthquake was generated by reactivation of the northern part of the Itoigawa-Shizuoka Tectonic Line, one of the ”110 major active faults” chosen by the Headquarters for Earthquake Research Promotion. Surface rupture has emerged just on the active fault lines shown on the pre-existing active fault maps. As the source fault was located shallower, strong ground motion occurred along the fault lines. However, it is clearly ”one scale smaller earthquake” than the earthquake that was predicted by the Headquarters for Earthquake Research Promotion.

Keywords: active fault, earthquake fault, Kamishiro Fault Earthquake

Japan Geoscience Union Meeting 2015
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SSS28-P01 Room:Convention Hall Time:May 27 18:15-19:30

DEM-derived stereo contour maps for visual analysis of tectonic geomorphology

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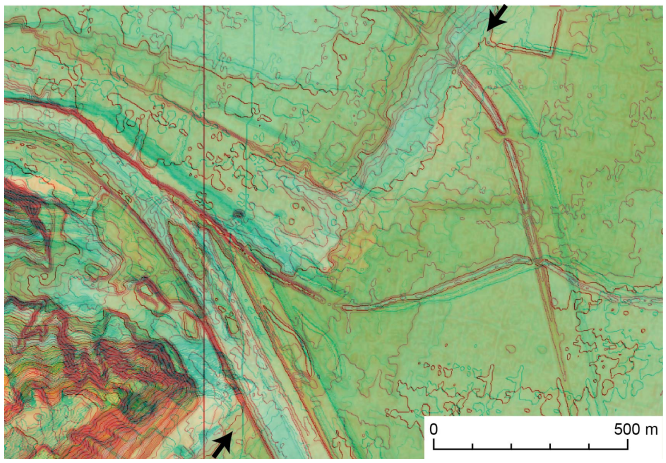
I developed a set of stereo contour maps generated from high quality DEMs to visually analyze geomorphological features in detail. The stereo contour maps together with a stereo slope map are more intuitive and efficient for interpretation of tectonic geomrphology than any existing thematic maps.

A DEM visualization feeware, SimpleDEMViewer is used to generate 2D thematic map and 3D anaglyph map. The 2D contour map is superposed by elevation tints, slope gradation and hillshading to emphasize pseude-3D effect and micro topography. The image size of raster contour map must be adjusted according the mesh size of DEMs, contour interval and slope, and therefore multiple 2D maps are recommended to depict the variety of topography. 3D stereoscopic image in anaglyph makes a substantial visual effect to interpretation of contour maps.

Stereo contour maps are superior to depict geomorphic surface features, such as alluvial plain, fan, terrace surface, and mountain and volcano slopes. Stereo slop map is superior to highlight geomorphic line features, such as lines of ridge, valley and small scarp, and micro topography smaller than a contour interval.

Figure A stereo contour map showing the tectonic geomorphology of the Nagamachi-Rifu fault zone, Sendai, Japan, generated from 5-m-DEM. Arrows indicate the base line of the flexure scarp on terrace surfaces. Contour interval is 1 m.

Keywords: stereo contour map, stereo slope map, DEM, geomorphological analysis, tectonic geomorphology



Japan Geoscience Union Meeting 2015
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SSS28-P02 Room:Convention Hall Time:May 27 18:15-19:30

Characteristics of the fault zones of their activities terminated until the Early Pleistocene

TSUBAKI, Junichi[1*] ; OHTANI, Tomoyuki[1] ; KONO, Masahiro[1] ; KOJIMA, Satoru[1]

[1]Gifu Univ.

In the active fault surveys without younger sedimentary layers, it is desired that the new method is developed to assess the fault activity using the fault rocks in the basement rocks. To achieve this, it is important to understand the characteristic features of the fault zones not only active faults, but also the faults terminated their activities recently. We studied the fault zone of the Median Tectonic Line (MTL) in Yoshino, Nara, and compare its results with those of the active faults.

The MTL is the active fault in the west of the central part of the Kii peninsula, in which the fault activity is terminated recently in the east. In this eastern area, Okada and Togo (2000) show the fault which terminated its activity until 300 ka in the active fault maps. Sangawa and Okada (1977) reported an exposure of fault zone that makes a border of the Early Pleistocene Lower Shobudani Formation and the Cretaceous Izumi Group, and that is covered by the Middle Pleistocene Upper Shobudani Formation unconformably. Based on the sedimentary ages of their formations (Mizuno and Momohara, 1993), the MTL in this area is terminated until 1 to 1.2 Ma. The fault exposure reported by Sangawa and Okada (1977) is covered by concrete presently, we studied the fault exposures 13 km east and 1 km west away from the previous exposure.

In the former exposure, the fault gouge zone with ca. 1 m thickness strikes E-W. The Izumi formation is in the northern side of the fault zone, in which no exposure in the southern side. The Izumi Formation in this exposure is mainly mudstone. Bedding plane is subholizontal in the host rock, in which foliation is subvertical in cataclasite near the fault gouge. Composite planar fabric in foliated cataclasite indicates the uplift of the southern side. In the latter exposure, the fault gouge zone with ca. 10 cm thickness strikes E-W and distributes between the Izumi formation in the northen side and the Shobudani Formation in the southern side. Matsumoto (2001) reported that the MTL displaces the Upper Shobudani Formation and the activity of the MTL was continue had continued after the deposition of the Upper Shobudani Formation in this exposure.

The powder X-ray diffraction and X-ray fluorescence analyses were performed using the samples from these fault exposures. In the former exposure, the results of the powder X-ray diffraction analysis shows disappearance of mica and formation of chlorite in the foliated cataclasite close to the fault gouge, and decomposition of plagioclase in foliated cataclasite and fault gouge. The altered minerals indicate a remarkable alteration in foliated cataclasite rather than fault gouge. Smectite is not detected in fault gouge and cataclasite. The results of the X-ray fluorescence analysis show the increase of MgO, CaO, Fe2O3 and TiO2 and the decrease of SiO2 toward the cataclasite from the host rocks. From the cataclasite to the fault gouge, MgO, CaO, Fe2O3 and TiO2 decrease and SiO2 increases. The decrease of K2O is especially in foliated cataclasite rather than fault gouge. In the latter exposure, the results of the powder X-ray diffraction show the occurrence of smectite in the fault gouge. The results of the X-ray fluorescence show the increase of MgO, CaO, Fe2O3 and Al2O3 and the decrease of SiO2 toward the fault gouge.

The studied feature is compared by that of the active faults. In the active fault zone, the latest fault gouge is characterized by the formation of smectite and concentration of Mn. Smectite is the mineral formed under lower temperature. Mn deposits under the oxidized condition. These are consistent with recent near-surface condition of the active fault zone. The studied fault zones would be displaced in the deeper part because their activities have been terminated and present surface exposure should be exhumed from 1 to 1.2 Ma to present. Mn is difficult to concentrate in the deeper reduction condition.

Keywords: fault zone

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Fault exposure in the Yokote basin accompanied with the 1896 Rikuu earthquake Akita prefecture, Northeast Japan

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Surface ruptures occurred with the 1896 Rikuu earthquake in the northern part of the eastern margin of the Yokote Basin fault zone in Akita Prefecture (the Shiraiwa, Ota, and Senya faults). However, the accurate traces of surface ruptures were not settled especially around the Takayashiki area, Shiraiwa fault.

In this study, we found a new outcrop of the Shiraiwa fault which moved associated with the Rikuu Earthquake and revealed that the surface traces of 1896 faulting was convexly curved to the upstream ward in the valley floor.

Keywords: Rikuu earthquake, surface trace, fault scarp, fault outcrop

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SSS28-P04 Room:Convention Hall Time:May 27 18:15-19:30

Fault distribution in the Japan Sea

ARAI, Rei[1*] ; KATSUYAMA, Minako[1] ; OIKAWA, Nobutaka[1] ; SHIMIZU, Shoshiro[1] ; ANDO, Goro[1] ; TAKAHASHI, Narumi[1] ; KANEDA, Yoshiyuki[2]

[1]JAMSTEC, [2]Disaster mitigation research center

This study is a part of ”the Comprehensive evaluation of offshore fault information project” by the Ministry of Education, Culture, Sports, Science and Technology (MEXT). The project composes three themes, 1) Collecting seismic survey data and building a database, 2) Data processing and analysis using unified methods, and interpreting faults utilizing the processed seismic sections, 3) Building fault models from the interpreting results and simulating strong motion and tsunami utilizing these models. Here, we present the interpretation of the fault distribution in the Japan Sea and re-processing to trace faults. Various research institutes have conducted seismic surveys over the decades in the Japan Sea. The dense seismic survey data has been collected and provided us an opportunity to observe seismic data from multiple surveys at the same time. This gave us a great advance to investigate and evaluate submarine active faults.

The past seismic survey data was re-processed using state-of-the-art data processing methods for obtaining high resolution seismic profiles. In particular, it is important to remove multiple reflections and we specially paid attention to apply the algorithm for demultiples. The revised seismic profiles defined clearly the geometry of subsurface structure, and provided us better understanding to determine fault system and shape. Since the fault models for simulation require parameters of length, strike and dip angles and depth, a velocity model for entire seismic data must be constructed to convert seismic section in depth unit. With the depth section we carry quality control of the interpretation results and evaluate their spatial distribution. Discussion includes demonstration of the fault interpretation on representative seismic sections from Tsushima-Kita Kyushu area to off northern tip of Hokkaido.

Normal faults which have developed during the opening of the Japan Sea in the Miocene and reverse faults which have developed after from the normal faults under inversion tectonic settings at compressive stress exist along Japan Sea coast. Those faults in the north eastern area especially reverse faults in the earthquake zone of the Nihonkai-Chubu earthquake extend at depth near the Moho. On the other, those reverse faults in landward are in large scale but extend at depth near Upper-Lower crust boundary. Lateral strike-slip faults are developed in the Sanin coast area, and fault-related-fold structures are observed. Those structures were developed under compressive stress field after the opening of the Japan Sea and following lateral stress field was much dominated to form lateral slip. In Kita Kyushu coast area, fault belts, which composes small strike-slip faults, develop forming echelon structure. As studies on 2005 Fukuoka earthquake suggest that those small individual faults could cause interrelated earthquakes, it is very essential to argue the possible occurrence pattern of interrelated earthquakes to build fault model.

Keywords: submarine fault, Japan Sea, seismic survey

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Characteristics of the Eastern Boundary Fault Zone of the Niigata Plain as inferred from gravity anomalies

WADA, Shigeki[1*] ; SAWADA, Akihiro[2] ; HIRAMATSU, Yoshihiro[2] ; OKADA, Shinsuke[3] ; TANAKA, Toshiyuki[4] ; HONDA, Ryo[4]

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Along the boundary range of the Niigata plain and the Echigo Mts., the Kushigata Mts. fault zone and the Tsukioka fault zone are distributed in the NNE-SSW direction, and Ikeda *et al.* [2002] call them for the Eastern Boundary Fault Zone of the Niigata Plain (EBFZNP). The EBFZNP is a part of the eastern margin of the northern Fossa Magna, and is distributed along the Shibata-Koide tectonic line proposed by Yamashita [1970]. The Niigata plain is a very thick sedimentary basin of which the thickness is over 6000 m. On the other hand, the basement rocks are exposed at the Echigo Mts. and the Niitsu hill (anticline) has been developed in the west of the Tsukioka fault zone. A high-resolution seismic reflection survey across the Tsukioka fault [Kato *et al.*, 2013] revealed that this fault is a bedding-slip fault which develops along the unconformity between the Miocene base and the basement rocks. Because the geological structure around this region has encountered heavily tectonic deformation, it has been uncertain that how active structures on the surface is related in the subsurface each other.

The purpose of this study is to reveal the characteristics of the EBFZNP through gravity anomalies. We report here the results of a dense gravity survey in and around the EBFZNP and the characteristics of the EBFZNP obtained from gravity analysis.

We conducted a gravity survey from 1st to 9th, September, 2014 in and around the EBFZNP. A Scintrex CG-3M gravimeter was used for the survey. We set the four gravity survey lines across the Tsukioka fault zone and/or the Niitsu hill. The total number of the measurement points was 181 points. The gravity data published by GSI [2006], Yamamoto *et al.* [2011] and Geological Survey of Japan (AIST) [2013] were also compiled in this study.

We applied a terrain correction [Honda and Kono, 2005] and a slab correction [Furuse and Kono, 2003] to the gravity data in addition to a normal correction procedure (the assuming density for Bouguer correction is 2,670 kg/m^3), then obtained a Bouguer anomaly map. The density structural analysis along the four survey lines was carried out by applying the 2-D Talwani method [Talwani *et al.*, 1959]. In order to illustrate discontinuous lines of the geological structures, the filtering processes of the horizontal and vertical first-order differential operation was applied to the Bouguer anomalies.

Bouguer anomalies show low anomalies in the plain side and 40 mGal more high ones than the plain side in the Echigo Mts. side. Both of the steep Bouguer gravity gradients and the zero isolines of vertical differentiation, which represent the tectonic discontinuities in the subsurface, are continuous and clearly extend along the EBFZNP. These features suggest that the subsurface structures of the EBFZNP form a single fault structure. Somewhat high Bouguer anomalies (30 to 40 mGal higher than the plain side) and both of the steep Bouguer gravity gradients and the zero isolines of vertical differentiation exist in the western part of the Niitsu hill.

The dense gravity survey on the seismic line suggests that the EBFZNP is estimated to be a highly west-dipping fault structure because the Bouguer anomalies continuously increase from the west to the east of the line and both the steep Bouguer gravity gradients and the zero isolines are located in the vicinity of the fault traces. This is coincident with the results of the seismic survey. From the density structural analysis, we also reveal that there are the west-dipping blind fault structure and the east-dipping half-graben between the Kushigata Mts. fault zone and the Tsukioka fault zone, and that the Niitsu anticline is an asymmetric structure with gentle western flank.

This study was supported by JSPS KAKENHI Grant Number 26400450.

Keywords: Kushigata Mts. fault zone, Tsukioka fault zone, gravity survey, density structural analysis

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SSS28-P06 Room:Convention Hall Time:May 27 18:15-19:30

Active tectonics and landform development in Takada and Echigo plain estimated from fluvial terrace data

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This study area belongs to the Northern Fossa Magna region. In this area, folding deformation due to the fault activity at the time of the earthquake has been reported[Okamura,Y., Ishiyama ,T.,2002]. Long wavelength deformation of the geomorphic surface, such as folds and flexures, the paradoxically is the constraints of underground shape of fault.Therefore, by revealing the details of long-wavelength topography deformation, it is considered to contribute to the understanding of the fault underground shape and evolution. Standing of the above perspective, We have conducted tectonic geomorphological studies on the eastern part of Takada Plain and Echigo Plain, in order to reveal Late Quaternary crustal movement estimated from the formation process of fluvial terraces.

In the poster presentation, We shall report on these results.

Keywords: fluvial terrace, eastern boundary fault zone of the Tkada plain, eastern boundary fault zone of the Tkada plain, crustal movement, tephrochronology

Japan Geoscience Union Meeting 2015
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SSS28-P07 Room:Convention Hall Time:May 27 18:15-19:30

Offshore active survey ”Kamogawa lowland fault zone” -Result of high-resolution stratigraphic survey-

SAKAMOTO, Izumi[1*] ; YAGI, Masatoshi[1] ; TAKINO, Yoshiyuki[1] ; MATSUSHITA, Kaharu[1] ; ARAKAWA, Takuya[1] ; FUJIMAKI, Mikio[2] ; ABE, Shintarou[3]

[1]School of Marine Science and Technology, Tokai Univ., [2]COR, [3]AIST

Kamogawa lowland fault zone is EW-trending, it is located the south part of Boso peninsula. This fault zone consists of North Kamogawa graben fault and South Kamogawa graben fault. The recurrence period and slip-rate of Kamogawa lowland fault zone has not been clarified until now.

We performed high-resolution stratigraphic survey to confirm a formation, distribution, and displacement of coastal area of the Kamogawa lowland fault zone. Survey area divided into two sub-area 1) Hota area (North-West side extension of the fault zone). 2) Kamogawa area (South-East side extension of the fault zone). We describe results for each sub-area as follow:

<Hota area >

We have carried out the seismic survey with NS direction survey line. Acoustic transparent layer with poor internal reflection was covered in this survey area. And acoustic basement exposed to the seafloor in spots.

<Kamogawa area >

We have carried out the seismic survey with NE-SW or NS direction survey line. Acoustic basement exposed to the seafloor in North part and South part of this area. We recognized the steep escarpment of trending EW and continuing about 3km long. And also tilting structure with NE direction in dip is observed around the coastal side. These two structures distribute to the echelon arrangement.

As described above, we have captured distribute of fault by tectonic relief. But we have not able to gain the proof of recent activity.

Keywords: active fault, Kamogawa lowland fault zone

Japan Geoscience Union Meeting 2015
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SSS28-P08 Room:Convention Hall Time:May 27 18:15-19:30

Offshore active survey ”Miura peninsula fault groups” - Result of high-resolution stratigraphic survey-

MATSUSHITA, Kaharu[1*] ; SAKAMOTO, Izumi[1] ; YAGI, Masatoshi[1] ; ARAKAWA, Takuya[1] ; FUJIMAKI, Mikio[2] ; ABE, Shintaro[3]

[1]Tokai University, [2]Coastal Ocean Research, [3]AIST

The Miura peninsula fault groups where is lacated in Miura peninsula is subdivided into 5 fault zones in geologically, such as Kinugasa, Kitatake, Takeyama, Minamishimoura and Hikihashi. But section on the offshore area of Miura peninsula fault groups has yet to be fully realized. Therefore, Tokai University preformed high-resolution stratigraphic survey to confirm a formation, distribution, and displacement of crust around the coastal area of the Miura peninsula fault groups at Sagami Bay and Tokyo Bay (Kaneda Bay) in 2014.

Sagami Bays result has not seen surficial deposit, because of there exposed basement rock. The basement rocks were confirmed that are extension of the peninsula fault groups. But we can not get geological information of theres active histories.

In Kaneda Bay, it was confirmed that shows the structure of strike slip. There were confirmed that are about 1.5 km width to NE-SW direction where there are 3 km offshore of Kaneda Bay. There was no reflector in the surface sediment above the Kaneda bay fault. So, we could not estimate the active histories of these fault.

Keywords: Miura peninsula fault groups, Sagami Bay, Kaneda Bay

Japan Geoscience Union Meeting 2015
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Recurrence History and Crustal Movement for Recent Four Times of Kanto Earthquakes at Southern Miura Peninsula

KIM, Haeng yoong[1*] ; MANNEN, Kazutaka[1] ; KUMAKI, Yohta[2] ; MATSUSHIMA, Yoshiaki[3]

[1]Hot Springs Research Institute of Kanagawa Prefecture, [2]Senshu University, [3]Kanagawa Prefecture Museum of Natural History

The purpose is geologically to resolve the occurrence timing and the accumulation process of the crustal movement associated with the Kanto Earthquake repeated at the plate boundary along the Sagami Trough. Study site is the coastal lower land along Bishamon Bay which an estuary is formed in south Miura Peninsula. An evidence of four times of Kanto earthquake during approximately 1000 years was identified, and the crustal movement cycle caused by these earthquakes was estimated. (Figure 1).

In the low land, the Holocene flights of marine terrace with the low cliff of 1-2m in height were authorized (National Geography Survey, 1981) . In this study, moreover, the lowest terrace was classified in five terraces from the interpretation of the aerial photographs. We named these lower terraces L1, L2, L3, L4 and L5 in the old order.

The low land is raised for development now. From boring survey, the sediment mixed for abundant shell fragments and gravels in motley was founded below +2m above sea level. These deposits are estimated the tidal-flat deposits from such facies, those are uplifted clearly. The elevation of these tidal-flat deposits varies according to terraces; L2:0.6 - 2.0 m, L3:1.2 m, L4: 1.6 m, L5: 0.9 - 1.6 m. Moreover, the timing that these tidal-flat deposits were uplifted varies according to terraces from the radio carbon analysis of woods and shells and from the Cs137 and Pb210 analysis of the sediments; L2: between 1000 and 1210 cal. AD, L3: after 1260 cal.AD, L4: 1703AD, L5: 1923AD. These show that the terraces is a marine terraces formed with an uplifting of the tidal flat deposits.

It is inferred that the marine terraces are formed by a sudden upheaval caused by the Kanto earthquake, and it is recognized that the terrace formation of the L3, L4 and L5 are associated with 1293 Earthquake, 1703 Earthquake and 1923 Earthquake in historical documents. In addition, the generation of L2 is before 1210 cal. AD, but the earthquake during 1180 AD through 1210 AD is unknown in the AZUMAKAGAMI which is a history editing book of the Kamakura Shogunate Therefore, the earthquake corresponding to L2 is estimated after 1000 from the radiocarbon dating before 1180 from the AZUMAKAGAMI.

The recurrence interval of the Kanto earthquake varies; 113 to 293 years for before 1293 Earthquake during 1180 AD through 1210 AD, 410 years for between 1293 Earthquake and 1703 Eathquake, and 220 years for between 1703 Earthquake and 1923 Earthquake.

The elevation of lower terraces L2, L3, L4 and L5 is almost similar. Miura Peninsula greatly is uplifted during the earthquake occurred at the plate boundary along the Sagami Trough, but slowly is subsided between earthquakes. Through historical age, the uplift in associated with earthquake is returned in the period between a former earthquake and a next earthquake.

Keywords: Kanto Earthquake, Recurrence Interval, Residual Displacement, Paleo Seismology

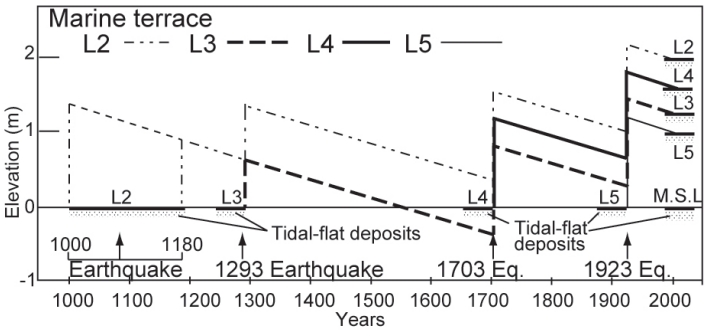

Figure1 Estimation of the Accumulation Process of Vertical Displacement associated with Recently Four times of Kanto Earthquake

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Structural features of co-seismic surface ruptures produced by the 2014 Mw 6.2 Nagano earthquake, central Japan

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The 2014 Mw 6.2 (Mj 6.8) Nagano earthquake occurred at 22:08 (Japan Standard Time) on 22 November, 2014 and resulted in extensive damage in the intermontane area of northern Nagano Prefecture, central Japan (Japan Meteorological Agency, 2014). A maximum seismic intensity of 6.0 (on the Japanese seven-point seismic intensity scale) was observed in the area around the epicenter of the earthquake. Our survey group traveled to the epicentral area one day after the earthquake to investigate the mechanism, earthquake surface deformation features, and nature of the seismogenic fault. We undertook one week of fieldwork, during which time we collected primary field data related to the geometry, morphology, and spatial distribution of co-seismic surface displacements. Here, we report the main results of our field investigations. We also discuss the co-seismic rupturing mechanism and the implications of our findings for the seismo-tectonics of the Itoigawa-Shizuoka Tectonic Line (ISTL).

Field investigations reveal that the Mj 6.8 (Mw 6.2) Nagano (Japan) earthquake of 22 November 2014 produced a 9.3-km-long co-seismic surface rupture zone. Slip occurred on the pre-existing active Kamishiro Fault, which is developed along the Itoigawa-Shizuoka Tectonic Line, which defines the boundary between the Eurasian and North American plates. The surface-rupturing earthquake produced dominant thrusting and subordinate strike-slip displacement. Structures that developed during the co-seismic surface rupture include thrust faults, fault scarps, en-echelon tension cracks, folding structures such as mole tracks and flexural folds, and sand-boils. The surface displacements measured in the field range from ˜5 cm to 1.5 m in the vertical (typically 0.5-1 m), accompanied by a strike-slip component that reached 0.7 m along NE-trending ruptures. These observations indicate a thrust-dominated displacement along the seismogenic fault. Our results show that (i) the pre-existing Kamishiro Fault, which strikes NNE-SSW, controlled the spatial distribution of co-seismic surface ruptures and displacements; and (ii) the style and magnitude of thrust displacements indicate that the present-day shortening strain on the Eurasian?North American plate boundary in the study area is released mainly by seismic thrust displacements along the active Kamishiro Fault.

Keywords: 2014 Mw 6.2 Nagano earthquake, co-seismic surface rupture, Kamishiro Fault, Itoigawa?Shizuoka Tectonic Line, plate boundary, thrust

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Surface rupture of the 2014 Kamishiro fault earthquake

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The Kamishiro fault is located in the northernmost part of the 150-km-long Itoigawa-Shizuoka Tectonic Line (ISTL) active fault zone, central Japan. Immediately after the destructive Mj 6.7 earthquake of November 22, 2014, which occurred in the northern part of the Nagano Prefecture, we conducted field reconnaissance surveys, and found coseismic surface ruptures exactly along the northern part of the reverse-faulting Kamishiro fault. Based on our surveys, in addition to the reports of other universities or research institutes, primary coseismic surface ruptures extend for ca. 9 km, most of which runs along the previously-identified active fault traces (Research Group for ISTL Tectonic Landforms, 2007; Suzuki et al., 2009, 2010). Various methodologies to record the surface ruptures have been applied until now, including aerial photographs, UAV and high-pole SfM, TLS (Terrestrial Laser Scanner), AL (Auto Level), and TS (Total Station), as reported in other presentations.

Keywords: The 2014 Kamishiro fault earthquake, surface rupture, ISTL active fault zone

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Active fault along the Kamishiro fault, Central Japan, Especially its close coincidence with the location of the surface

SAWA, Hiroshi[1*] ; MATSUTA, Nobuhisa[2] ; WATANABE, Mitsuhisa[3] ; SUZUKI, Yasuhiro[4] ; NAKATA, Takashi[5] ; GEOMORPHOLOGICAL RESEARCH GROUP FOR, The 2014 kamishiro fault earthquake[4]

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Introduction

On November 22, 2014 at 10:08 PM local time, a JMA magnitude-6.7 earthquake (the 2014 Kamishiro fault earthquake) occurred in northern Nagano Prefecture, central Japan. The spatial distribution of aftershocks and the focal mechanism indicates that this earthquake was generated by movement along a reverse fault known as the Kamishiro fault - the northern part of the Itoigawa - Shizuoka Tectonic Line (ISTL) active fault system. Remarkable surface ruptures, over 9 km long, appeared along the Kamishiro fault. We have made public details about the nature and location of the Kamishiro fault before the earthquake on an active fault map (Matsuta et al, 2006; Research Group for ISTL Tectonic Landforms, 2007; http://danso.env.nagoya-u.ac.jp/istl-gis/). We wish to establish a location relationship between this surface rupture and the pre-existing active fault trace.

Re-examination of active fault maps of ISTL

Most of the 2014 surface ruptures appeared along pre-existing active fault traces. However, a very few surface ruptures appeared where there was no pre-existing active fault trace, prompting us to re-examine our former active fault maps. We looked again at a series of 1:10,000 aerial photographs archived in the 1940s and 1950s. The aerial photo analysis was supplemented and reinforced by field observations. Although the detailed re-interpretation of aerial photographs caused a few modifications of the locations of active fault traces, we concluded that the location of some active fault traces had not been added on former maps.

Implications for long-term earthquake prediction

The surface ruptures associated with the 2014 Kamishiro fault earthquake appeared in the area covered by a detailed active fault map (Matsuta et al, 2006; Research Group for ISTL Tectonic Landforms, 2007). Most of the 2014 surface ruptures appeared along pre-existing active fault traces shown on the maps. The proper maintenance of an active fault map contributes greatly to earthquake damage reduction. In this area, there have been three active fault maps apart from our map (Ikeda et al., 2002; Sawa et al., 1999; Togo et al., 1999). However, almost no back-thrust faulting associated with the main Kamishiro fault has been mapped on these three maps. The 2014 surface ruptures appeared along some back-thrust traces. It is important that we study small - less than 1 m - tectonic landforms, i.e., reverse tilting of the surface, flexural scarp, scarplet and back-thrust scarp. In the northern part of the ISTL active fault system (Hakuba Village to Matsumoto City, with a length of 55 km), the maximum vertical offset and a JMA magnitude during the last earthquake were estimated to be 5 - 6 m and MJMA 8.2 - 8.3, respectively (Suzuki et al., 2010). However, the maximum vertical offset during the 2014 Kamishiro fault earthquake is approximately one fifth as large as the above estimation. It could indicate that one-scale-smaller earthquake with MJMA -7 has been probably occurring with a shorter interval in the northern part of ISTL active fault system. Considering such a supposition, we need to re-evaluate a long-term earthquake prediction properly.

Keywords: the 2014 Kamishiro fault earthquake, Surface rupture, Active fault, Tectonic landform, Detailed active fault map

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About the amount of fault displacement presumed from oblique aerial photograph.

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When an inland inland earthquake occurred, I clarify the relations with the authorization of the seismic dislocation and the known active fault, and it is important to get a clue to estimate earthquake mechanism in detail. I can grasp the section of the active fault of a prediction of the future aftershock activity and non-activity if I can grasp mechanism in detail.It is necessary to investigate distribution of the surface of the earth displacement around the focal region regionally to estimate earthquake mechanism in detail, but it is difficult to raise investigation efficiency in the Yamaji region because it is a survey-based investigation. By the method using the aerial photo reading of the one wide area, cyclopedic for existence of ground surface displacement; can make it out effectively, but it is difficult to estimate the quantity of displacement particularly perpendicular displacement quantity.In an earthquake to assume Kamishiro dislocation of North Nagano that occurred this time on November 22, 2014 cause, I confirmed secondary dislocation parallel east of the Kamishiro dislocation from the slant aerial photo group photographed in a news purpose and succeeded in making the simple three dimensions topography model. As a result, I was able to estimate perpendicular displacement in the dislocation concerned at approximately 0.3m.This area was snow area in the winter season, and a quick investigation was necessary for the surface of the earth survey when I did the snow not to be able to do it. This dislocation was investigated just before the snow afterwards By the surface of the earth survey of a different researcher, but there is value in the simple three dimensions topography model enough if I cannot investigate it.It will be important in future to examine a method of precision confirmation of this technique and the establishment of an effective photography method and the cyclopedic photography of the wide area.

Keywords: fault associated with earthquake, ground surface displacement, Investigation for wide-area, oblique aerial photograph, three-dimensional terrain model

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Reconstruction of paleo-slips based on DEMs and geologic sections across the East Matsumoto Basin faults of ISTL

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The ISTL active fault system extending for about 150-160km long is one of the most active fault systems in Japan. The earthquake probability of the Gofukuji fault, composed of the central section of the fault system, is well known to be 14 % in the next 30 years. This estimation is based on paleoseismological researches and long term forecast on the fault, and the maximum size of the next earthquake is expected to be M8 class. However, the size of the next earthquake on the Gofukuji fault is still under the discussion, especially, whether the rupture would propagate with the adjacent faults to the north and south. Since the East Matsumoto Basin fault is located to the north of the Gofukuji fault, the recurrence behavior and slip per event are significant to estimate the past multi-segment earthquakes on the fault system. To address these issues, we conducted detailed mapping of the faults based on the 2-m-DEMs interpretation, trench, borehole and shallow seismic reflection surveys. As a result, we reconstructed possible three slips per event during the last 9000 years at the Aizome site on the northern section of the East Matsumoto Basin faults. The reconstructed vertical slip is 1.8 m as the average value for the last three events. The 1.8-m-slip is converted to be 3.6-4.3 m as dip slip component, because the dip of the fault across the geologic section is measured at 25-30 degreee to the east. Judging from the amount of slip per event, the size of the earthquake is empirically estimated at M7.6. Meanwhile, based on the relationship between length of the East Matsumoto Basin faults and the size of the earthquake, the magnitude of earthquake is estimated at M7.0. This discrepancy of the estimated magnitude means that the most recent three earthquakes did not rupture only the East Matsumoto Basin faults as single segment earthquakes but ruptured in tandem with adjacent faults. Thus, the reconstruction of slip per event during individual paleoseismic events is essential to reveal the spatial extent of past earthquakes, hence, paleoearthquake scenario can be reconstructed based on densely populated actual slip per event data.

Keywords: active fault, paleoseismology, ISTL active fault system, East Matsumoto Basin faults, coseismic slip

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Drilling Survey and GPR Profiling on the Chino Fault in the Middle ISTL Active Fault System, Central Japan

TANIGUCHI, Kaoru[1*] ; KONDO, Hisao[1] ; KIMURA, Haruo[2] ; SUGITO, Nobuhiko[3] ; ICHIKAWA, Kiyoshi[4]

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The 150-km-long Itoigawa-Shizuoka Tectonic Line active fault system (ISTL) in central Japan is one of the most active fault systems in Japan. The Chino fault is located in the middle part of the ISTL. The fault is characterized by a left-lateral high-average slip rate reaching 10 mm/yr, which is one of the most highest slip rates reported on active faults onshore in Japan. Along the linear fault traces of the Chino fault, terrace risers and river channels are systematically deflected by left-lateral slip, and fault scarps caused by vertical component of slip are identified in late Quaternary terrace surfaces. We carried out drilling surveys and ground penetrating radar profiling at Sakamuro, Chino City, for estimating activity of the Chino fault. Details of our results will be reported in the presentation.

Keywords: active fault, drilling survey, ground penetrating radar profiling, ISTL

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S-wave seismic refletion profiling across the Horikawa fault, Nagoya central Japan

NAKAMURA, Yuki[1] ; IMAIZUMI, Mitsutaka[1] ; TODA, Saya[1] ; NAGAYA, Junko[1] ; NOMURA, Takaya[1] ; TODA, Shigeru[1*]

[1]Aichi University of Education

A seismic reflection survey was made in Nagoya city, the Nobi Plain Chubu region. According to Sugito and Goto (2012), the Horikawa fault is an N-S striking, 10 km long, reverse fault located on the central Nagoya.

The survey line was carried out across the Horikawa fault. A S-wave handy vibrator seismic source (Geomatrix Earth Science Ltd, Elvis) and, a 24 channel seismic recording system (Seismic Source, DAQlink 3) was used for these surveys. The spread of the source and receivers was usually the split-spread type with the shot and receiver intervals being 1 meter. Maximum receiver-group offset was 48 meter. Single geophones of 30 Hz natural frequency were used. The sampling rate for all data was 1.0 msec. Sweep length and frequency selected 10 sec. and 20 - 80 Hz, respectively.

Field data were analyzed by using a general CMP Stack Method. Static correction was made by using the first arrival times based on the seismic refraction method, and predictive deconvolution was applied. Velocity analysis was carried out by constant velocity stack and velocity-spectrum method. The RMS velocity was picked up, and the interval velocities were calculated from the resultant RMS velocities. F-K migration was applied to the time sections.

The results of this study are summarized as follows:

The subsurface structure of the Horikawa fault was discerned in a buried fault zone and they form reverse fault.

Growing seismic strata was recognized in Holocene sediments.

Keywords: Horikawa fault, S-wave seismic reflecton profiling, Nagoya city, Active fault

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Paleoseismological survey on the Median Tectonic Line active fault zone in Kinki district

TSUTSUMI, Hiroyuki[1*] ; SUGITO, Nobuhiko[2] ; OKADA, Atsumasa[3] ; GOTO, Hideaki[4] ; KORIYA, Yorihide[5] ; TANIGUCHI, Kaoru[5] ; OMATA, Masashi[5]

[1]Kyoto Univ., [2]Hosei Univ., [3]Ritsumeikan Univ., [4]Hiroshima Univ., [5]Crearia Co. Ltd.

Under the comprehensive study program on the Median Tectonic Line active fault zone in Kinki district supported by MEXT, we have conducted paleoseismic trenching and arrayed borehole drilling of the fault zone in the past two years. We present the preliminary observations and interpretations on the late Quaternary faulting history of the different segments of the fault zone.

Keywords: Median Tectonic Line active fault zone, Kinki district, Paleoseismology, Trenching, Arrayed borehole survey

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Distribution and tectonic landforms around the Tsutsuga fault zone, western Chugoku region, Japan

TAJIKARA, Masayoshi[1*] ; NAKATA, Takashi[2] ; TSUTSUMI, Hiroyuki[3] ; GOTO, Hideaki[2] ; MIZUMOTO, Tadaki[1] ; MATSUDA, Tokihiko[1]

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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 interpretation during the last several 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 Tsutsuga Fault Zone and its adjacent areas 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. Along the previously mapped active faults traces, many tectonic landforms (lateral offset streams, offset hills, beheaded stream, dammed stream) are newly mapped. As a result, we clarified that the Tsutsuga fault zone is an active fault system with 100 km in length. However, based on distribution of fault traces, we consider that a segment boundary exists at the central part of the Tsutsuga fault zone, and that the length of the northern part and the southern part of the fault zone are 60 km and 44 km, respectively. Therefore, the northern and southern part of the fault zone have a capability of causing M7.8 and M7.6 earthquake, respectively.

Keywords: Tsutsuga fault, active fault, Chugoku, inland earthquake, air photo

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Damage and seismic intensity distributions of the 1946 Nankai earthquake by the reanalysis of questionnaire survey

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A questionnaire survey to investigate the strength of felt ground motion and earthquake induced damage of the 1946 Nankai earthquake was performed immediately after the earthquake for elementary schools in western Japan by the Earthquake Research Institute and the Department of Science of Tokyo Imperial University, but the results has not been published. We analyzed the questionnaire and summary sheets of the survey, and estimated the distributions of seismic intensity, various kinds of damage, and human behaviors. Total number of responses is 1,034 and we obtained 1, 014 seismic intensities on modified Mercalli (MM) scale.

The questionnaire consists of 28 questions and descriptions for seismic intensities on the MM intensity scale. The maximum seismic intensity estimated from the damage of Japanese-style wooden houses reaches X-XI near the source-rupture area such as in Shikoku Island and Wakayama and Okayama Prefectures. The damage rate of wooden houses was more serious in the populated cities in the plains and basins than that in the mountainous regions. The expected seismic intensities from other damage (bridges, stone walls, underground pipes, etc.) also exceed X. The X or higher seismic intensities on MM-scale corresponds to VII on the Japan Meteorological Agency's intensity scale (JMA-scale), which was introduced only after the 1948 Fukui earthquake (M7.1). Therefore, the previously-estimated seismic intensity distribution of the 1946 earthquake on the JMA-scale may be underestimated. The questionnaire survey also shows that sand boils by liquefactions were generated in Mie Prefecture even though it is located relatively far from the 1946 source region.

Acknowledgement: This study was supported by the MEXT's "New disaster mitigation research project on Mega thrust earthquakes around Nankai/Ryukyu subduction zones".

Keywords: 1946 Nankai earthquake, questionnaire survey, Modified Mercalli (MM) seismic intensity scale, seismic intensity distribution, earthquake damage distribution

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Submarine rock forming structures at shore of Kochi Prefecture and their correlation with historical Nankai earthquakes

TANIKAWA, Wataru[1*] ; YAMAMOTO, Yuhji[2] ; MURAYAMA, Masafumi[2] ; TOKUYAMA, Eiichi[2] ; WAKAKI, Shigeyuki[1] ; HIROSE, Takehiro[1] ; IJIRI, Akira[1] ; HOSHINO, Tatsuhiko[1]

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Ancient documents and folklores about Kochi area tell the story about 'Kuroda-gori' which is the small village that was thought to be submerged by the historical Nankai earthquakes. An interesting fact is that ancient artificial buildings and artifacts had been found in seafloor at the shores of Kochi Prefecture. Historical tsunami disasters might have formed these artificial artifacts, though, the relationship between the ancient foundation and the historical Nankai earthquake is not well understood.

A rock forming structure which looks like ocean bank was formed under sea along the coast near the Kashiwa-jima, a western end of Kochi Prefecture. This ocean bank with 2 m height is made by stacking conglomerates, and spaces between conglomerates were filled by solid fine grained matrix, which bond to conglomerates strongly. This 'ocean bank' is elongated along the coast and parallel to the historical onshore bank made in the Edo period. These features indicates the structure could be an artifact. However, conglomerates were randomly piled up, and the similar structures, called as beach rock, can be formed in natural sediment process. 'Artificial' concrete was began to use as building materials in the Meiji period. Therefore, three assumptions listed below are possible to explain the bank like structures in Kashiwa-jima.

1. Real ocean bank made by artificial cement material, which was used as bank and local harbor
2. Beach rock (natural structure)
3. A man-made stone wall, only matrix cement was formed by natural phenomena

Revealing the origin of the seafloor structures are interesting itself, though to evaluate the coseismic uplift and subsidence process and the scale of earthquake-induced disasters, it is important to investigate the age and the environment in which the structure was built.

In this study, we carried out radiocarbon dating, Sr isotope analysis, and chemical analyses (XRF, SIMS) to determine the age and environment when and where the structure was built. These data are compared to those from the river banks near Kochi city and the onshore banks near the ocean bank.

Acknowledgement
We appreciate the technical support by Nippon Kaiyo ltd.

Keywords: Nankai earthquake, beach rock, cementation, coseismic uplift and subsidence

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High-resolution Multi-Channel Sonic survey on the seaward extension of the Kokura-Higashi Faults

KAGOHARA, Kyoko[1*] ; YOSHIOKA, Toshikazu[2] ; KATO, Isamu[3] ; HAMBA, Yasuhiro[3]

[1]Yamaguchi Univ., [2]IEVG, AIST, [3]Kawasaki Geological Engineering Co. Ltd.

The Kokura-Higashi Faults are NNE-SSW trending left lateral strike-slip fault. It is recognized obviously the Kokura-Higashi Faults are distributing from Kokura-Kita to Kokura-Minami ward, Fukuoka Prefecture. However, the Headquarters for Earthquake Research Promotion (2013) pointed that the northern extent of the faults could reach to off Hikoshima, Hibiki-nada, based on the distribution of steep gravity gradient zone in the northern Kyushu. We have conducted a high-resolution multi-channel sonic survey using Boomer source and 12-channel, 2.5-m-channel-interval streamer to clarify the precise fault distribution and structure in Hibiki-nada. The acoustic profiles imaged several faults that deform shallow strata.

Keywords: Kokura-Higashi Faults, multi-channel sonic survey, strike-slip fault, Hibiki-nada

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Paleoseimological study of the Kokura-higashi fault and the Fukuchiyama fault zone in northern Kyushu Island, Japan

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The Kokura-higashi fault is an active fault extending in NNE-SSW direction with west-side-up vertical displacement. The Fukuchiyama fault is extending in NNW-SSE direction with also west-side-up vertical displacement. Both are located in the northern Kyushu Island. The Earthquake Research Committee evaluated that the probability of the earthquake occurrence in the future on the Kokura-higashi fault and the Fukuchiyama fault zone are unknown or ambiguous because of the luck of paleoseismological data. We carried out a trench excavation study and boring surveys on both faults.

A trench is excavated on the fault trace of the Kokura-higashi fault, and three trenches are excavated on the Fukuchiyama fault. On the trench wall of the Kokura-higashi fault, a steeply dipping fault cutting bedrocks and overlying sediments was cropped out. The lower part of the sediments includes some humic soil layers with many wood fragments. The fault displaces these layers vertically in more than 1 meter, and cuts until the top of the sediments just below artificial soil. Two faulting events and former two liquefied events are revealed on the trench wall. The penultimate faulting event is recognized because younger sediments cover a subordinary fault cut lower humic soil layers at the downthrown side of the main fault. This event may have occurred in 19-20 ka.

As the result of the trenching survey on the Fukuchiyama fault, the boundary fault between the Paleogene sedimentary rocks and the Paleozoic green rocks was recongnized. This fault cuts overlying gravel and sandy silt layer in one of the trenches.

Keywords: Kokura-higashi fault, Fukuchiyama fault, Fukuoka prefecture, Kyushu, active fault, paleoseismology

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Borehole drillings and reanalysis of the S-wave reflection data across the Kamatoge segment of the Nishiyama fault

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The Nishiyama fault, northern Kyushu, run along the sea of Genkai to Toho village and Asakura city. This fault is divided to three segments, such as Oshima segment, Nishiyama sement and Kamatoge segment. In the Kamatoge segment, there are two faults: the Kamatoge-Koishihara fault, trending NW-SE and the Haki fault, trending NE-SE. The former fault is a sinistral strike-slip fault and the later fault is dextral strike-slip fault. To clarify the subsurface geometry, geological structure and the fault activity, we carried out borehole drillings and reanalysis of the high resolution S-wave seismic reflection data based on the borehole data across the Haki fault in a Haki area.

According to the stratigraphic correlation, two beds of Quaternary strata, consisted of eight beds, are existed only lowland area. We estimated that the Haki fault is run near the low cliff.

In the result of the reanalysis seismic reflection data, the geological structure around the middle of the seismic line is characterized by north-dip (to lowland area) reflection layer in more than 10m depth.

Keywords: Nishiyama fault, borehole drillings, S-wave seismic reflection

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Activity of the Northern Marginal Faults of the Saga Plain

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The Northern Marginal Faults of the Saga Plain are normal fault zones of up thrown to the north stretching east and west about 19 km. It starts from the vicinity of the Yoshinogari Tateno, Saga Prefecture and continues toward Matsuo Ogi-cho, Ogi. The distribution form of this active fault is a 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. 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. Therefore, in this study, we had a survey of interpretation of microtopography, field survey and ultra-shallow seismic reflection profiling, to purpose average vertical slip rate, the paleoseismic history as well as the latest activity in the Northern Marginal Faults of the Saga Plain. We have already done a report by the present study, Kagohara et al. (2014) and Imaizumi et al. (2014). In addition, we reaffirmed the distribution of the active fault with a focus on the distribution and shape of microtopography, further, to discuss the activities of these faults band on the basis of the presence or absence of contrast and fault displacement of microtopography. The investigation was conducted from eastern Yoshinogari going west through Kanzaki as far as the Kase River of Saga.

In interpretation of microtopography, we created contour maps of 1m intervals from city planning 1:2500 maps. And we used aerial photographs of scale of 1 per million taken that GSI was taken in the 1960s. Also, we conducted a field survey, including simple boring survey and ultra-shallow seismic reflection profiling.

Resulting in, terraces surface classification of the north portion of the Saga plain has been divided into 7 side of as follows:[the higher than] H, M1, Aso-4pyroclastic flow depositional surface, M2, L1, L2 andL3. Also, light of the comparison with the terraces classification diagram studied (the late Nagaoka originals; Shimoyama, 1999; Shimoyama et al., 1999, 2010, etc.) so far, each of the formation age is as follows. H surface MIS7 equivalent, M1 surface is located in the lower Aso-4 pyroclastic flow deposition surface, it is MIS5e equivalent of last interglacial period, Aso-4 pyroclastic flow deposit surface is 8.9ka and M2 surface is MIS 5a equivalent the formation age from such be covered discordance Aso-4.

Further, L1 surface in terms of the most widely distributed in this study area, it is the Last glacial epoch (MIS 2-4 equivalent) because AT(26-29ka) was sandwiched directly above emerged surface, L2 surface is MIS 1 equivalent for just above the K-Ah (7.3ka) on emerged surface, L3 surface is MIS 1 equivalent lower than L2 surface.

In these L2 surface was observed tectonic bulges lie on the southern side of the known fault trace that continues in the east-west direction. These tectonic bulges are anticline-like, decrease flexure to the south and these states can be read also from the detailed contour map. According to surface exploration, these tectonic bulges have slightly tilted to be confirmed visually. In addition, a simple boring survey around the L2 side with these tectonic bulges, was carried out plurality of places in the hanging wall side footwall side of the fault trace. As a result, relative uplift side of the fault trace on L2 surface in Kawakubo Saga city (altitude about 5m), K-Ah was found in depth 102˜105cm, and AT was found in depth 120 ˜126 cm. For this presentation, we got some results by drilling survey, surface exploration and Ultra-shallow seismic reflection profiling. So we described the discussion on the activities of the active faults in the Northern Marginal of the Saga Plain.

Keywords: Northern Marginal Faults of the Saga Plain, normal fault, large-scale geographical map, tectonic bulge, interpretation of microtopography

Japan Geoscience Union Meeting 2015
(May 24th - 28th at Makuhari, Chiba, Japan)

SSS28-P25 Room:Convention Hall Time:May 27 18:15-19:30

Morphological features of offshore extension of the Futagawa-Hinagu fault zone

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Futagawa-Hinagu fault zone (mainly right -lateral strike-slip faults) extends from Aso volcano to the Yatsushiro-sea (The Headquarters for Earthquake Research Promotion, 2002). A number of sub-aerial faults exist in the Yatsushiro-sea.

In acroteric part of strike-slip fault annihilation mechanism, develop complex structures (e.g. Kakimi and Kato, 1994). To comprehend these structures, it is necessary construct the research technique with three-dimensionally and high precision (Abe and Aoyanagi, 2004).

We have carried out the high-resolution seismic surveys with a series of cross sectional observations at the Yatsushiro-sea. Survey area divided into two sub-areas 1) North eastern area, and 2) South western area. We describe results for each sub-area as follow:

Sub-area 1

Main fault (MA fault) with NE-SW trending is distributed in this area. In-cross-sections, sub-vertical fault deformed the seafloor and sediments. Also, observed the flower structure. And displacement of faults becomes smaller to the south.

Sub-area 2

MA fault splayed off here. Almost these faults had normal components and forming a graben structure.

As described above, we have captured the features of the deformation structures, three-dimensionally.

Keywords: Futagawa-Hinagu fault zone, right-lateral strike-slip fault, flower structure

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Recurrence interval analysis along the strike-slip Xianshuihe-Xiaojiang Fault System: by Coulomb stress change history

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Stress-triggering theory of earthquakes has been generally concerning to evaluate earthquake interactions in the past two decades. Evolution of stress change deduced from the sequences of great earthquakes along fault offers crucial quantitative restriction to the understanding of earthquake cycles.

The Xianshuihe-Xiaojiang Fault System (XXFS) is a typical left-lateral strike-slip fault that has triggered many large historical earthquakes, including the 2010 Mw 6.9 Yushu earthquake in the central Tibetan Plateau. Thirty-five M ? 6.5 earthquakes have been recorded along the ca. 1500-km-long XXFS since 1327, which provides an unsurpassed opportunity to study the stress change history. To assess the recurrence interval and seismic hazard of the XXFS, we analyzed the Coulomb stress change history along this fault system using elements including the rupture lengths caused by the 35 events, GPS slip rate and simplified fault geometry. The results of previous paleoearthquake investigations along the XXFS are introduced into the Coulomb stress change history to examine the earthquake recurrence characteristics. The southeastern segment of the Xianshuihe Fault Zone expresses recurrence interval of characteristic earthquake model, which is consistent with the historical earthquake records and result of paleoseismic investigations. Comparatively, the northwestern segment of Xianshuihe Fault Zone displays a characteristic of clustered earthquake model. Modeling of Coulomb stress change revealed that the earthquake recurrence model along the strike-slip XXFS is of multiplicity.

Keywords: Xianshuihe-Xiaojiang Fault System, seismic modeling, Coulomb stress change, recurrence interval, seismic hazard