SGL40-P01 Room:Convention Hall Time:May 27 18:15-19:30

Origin and tectonic evolution of the accretionary complex in north-central Mongolia

UEDA, Tetsuya[1*] ; OTOH, Shigeru[1] ; FUJIMOTO, Tatsuya[1] ; KOUCHI, Yoshikazu[1] ; YAMAMOTO, Koshi[2]

[1]Grad. School Sci. Eng., Univ. Toyama, [2]Grad. School Env., Stu. Nagoya Univ.

Introduction Mongolia occupies a part of the Central Asian Orogenic Belt and consists of complicated collage of terranes. Despite various previous geological studies, we do not share a common scenario on the origin and assemblage process of these terranes. This study aims to clarify the origin and tectonic evolution of an accretionary complex (AC) in north-central Mongolia from detrital zircon geochronology.

Geologic setting North-central Mongolia consists of the following three terranes: **Haraa** and **Bayangol terranes** consisting of shallow-marine formations and an AC with many pyroclastic-rock layers, and **Khangai-Khentei terrane** consisting of an AC overlain by shallow-marine formations. The AC of the Khangai-Khentei terrane trend northeast and dip north. The pelagic chert of the AC yields Late Silurian conodonts and Early-Late Devonian radiolarians (Kurihara et al., 2009), whereas the overlying mudstone yields Early Carboniferous brachiopods.

Method We extracted detrital zircons from 13 sandstone samples of the accretionary units in the Khangai-Khentei (6 samples), Haraa (5), and Bayangol (2) terranes and measured their U-Pb ages with the Laser Ablation Inductively Coupled Plasma Mass Spectrometer equipped in the Graduate School of Environmental Studies, Nagoya University. In addition, we compiled detrital-zircon-age data of 19 sandstone samples from previous studies (Kelty et al., 2008; Bussien et al., 2014).

Results We recognized two types of detrital-zircon-age spectra. One was a multimodal pattern with small peaks at 420-650 Ma, 700-1000 Ma, 1600-2200 Ma, and 2300-2700 Ma and had 75 % or more Precambrian zircons. Three samples from the upper part of the AC showed this pattern. The other was a unimodal pattern with a large single peak between the Devonian and Early Triassic and has virtually no Precambrian zircons, indicative of an oceanic-island-arc setting. Eleven samples from the lower part of the AC showed this pattern.

Discussion We assumed, from the volcaniclastic nature of most of the sandstone samples, that the youngest peak of the spectrum is the depositional age of each sample. The depositional ages of multimodal-type sandstone clustered at 526-426 Ma, whereas those of unimodal-type sandstone clustered at 409-374 Ma (Early Devonian), 358-339 Ma (Early Carboniferous), and 289-245 Ma (Early Permian-Early Triassic). Moreover the depositional age clearly showed a downward-younging age polarity. There is a rough coincidence between the older time-interval (404-348 Ma) and the hiatus of Paleozoic igneous activity in the Tuva-Mongol Massif to the northeast of the study area (385-350 Ma). These facts indicate that the studied AC intermittently grew downwards in front of the Tuva-Mongol Massif. The multimodal-type sandstone, on the other hand, settled in the Cambrian-Ordovician and contained Pan-African (550-750 Ma) zircons indicative of their derivation from Gondwana. Among Cambrian-Ordovician sandstone along the northern Gondwana margin, that of the Kufra Basin in the Saharan Metacraton has close similarity with that of north-central Mongolia. The detrital zircons from the Kufra Basin have age peaks at 450-750 Ma, 800-1000 Ma, 1600-2200 Ma, and 2300-2800 Ma. This study hence concludes that the unimodal-type AC of north-central Mongolia grew along the subduction zone in front of the oceanic island arc of the Tuva-Mongol Massif, rifted from the Saharan Metacraton in the northern margin of Gondwana.

Keywords: U-Pb age, detrital zircon, LA-ICP-MS, Mongolia, CAOB, province

SGL40-P02 Room:Convention Hall Time:May 27 18:15-19:30

Detrital zircon geochronology of Early Mesozoic evolution of a northeastern part of the Pangea Supercontinent

KOUCHI, Yoshikazu[1*] ; UEDA, Tetsuya[1] ; TAKUJI, Ikeda[1] ; HARADA, Takuya[1] ; ORIHASHI, Yuji[3] ; YAMAMOTO, Koshi[2] ; OTOH, Shigeru[1]

[1]Grad. School Sci. Eng., Univ. Toyama, [2]Grad. School Env., Stu. Nagoya Univ., [3]ERI, Univ. Tokyo

Introduction In the Paleo-Mesozoic succession of the South Kitakami Belt in NE Japan, the detrital-zircon-age-distribution pattern on a probability density plot changed from multimodal type II (see below for pattern names; Silurian-Carboniferous) through unimodal (Permian-Lower Jurassic) to bimodal (Middle Jurassic-Lower Cretaceous). Okawa *et al.* (2013 *Mem. FPDM*) explained these transition by the Middle Jurassic collision of Gondwana-derived (multimodal) oceanic island arc (unimodal) with Asia (bimodal). This study reviews similar temporal transition in geologic belts of Japan and Mongolia and discusses Early Mesozoic assembly of a northeastern part of the Pangea Supercontinent.

Method We measured the LA-ICP-MS U-Pb age of detrital zircons at the Earthquake Research Institute of the University of Tokyo and the Graduate School of Environmental Studies of Nagoya University.

Age-distribution patterns

The unimodal type consists of a single peak at the age of deposition, indicating an environment along the active margin of an **oceanic island arc**.

Multimodal type I consists of large peaks at the age of deposition, 500 Ma, and 900 Ma, indicating an environment along a margin of the **Khanka-Jiamusi Block**, which was likely a part of Gondwana and contains 500-Ma and 900-Ma igneous and metamorphic rocks.

Multimodal type II consists of a large peak at the age of deposition and small Neo- to Paleoproterozoic peaks, indicating an environment along a margin of Gondwana.

The bimodal type consists of large peaks at the age of deposition and Paleoproterozoic, indicating an environment along a margin of the **North China Block**.

Temporal and special change of age-distribution patterns

North-central Mongolia: The pattern in a downward-younging accretionary complex (AC) changes from multimodal type I (Cambrian-Silurian) to unimodal (Devonian-Early Triassic; Ueda *et al.*, 2015 *JpGU*). North-central Mongolia has widely been cut by Triassic-Jurassic granitoids.

Hida Gaien Belt: The pattern changes from unimodal (Middle Permian-Lower Triassic) to multimodal type I (Middle Triassic; Kawagoe *et al.*, 2013 *Mem. FPDM*).

Renge Belt: The pattern changes from multimodal type II (Devonian: depositional age) to bimodal (Lower Jurassic cover).

Akiyoshi Belt: The pattern changes from unimodal (Permian AC) to bimodal or multimodal type I (Upper Triassic cover).

Suo Belt: The pattern of downward-younging metamorphic rocks changes from unimodal (Permian) to bimodal (Triassic-Jurassic; Obara *et al.*, 2012 *JpGU*).

Ultra Tamba and Tamba belts: The pattern of a downward-younging AC changes from mostly unimodal (Permian) to bimodal or multimodal type I (Triassic-Jurassic).

Northern Chichibu Belt: The pattern of a downward-younging AC changes from unimodal or multimodal type I (Permian) to bimodal (Jurassic; Morita *et al.*, 2012 *JpGU*; Yokogawa *et al.*, 2013 *JpGU*).

Discussion The above data set suggests that the Middle Paleozoic of Japan and Mongolia (Central Asian Orogenic Belt: CAOB) was mostly formed along a margin of Gondwana. The paleobiogeographic analysis of Williams et al. (2014 *Isl. Arc*) indicates close affinities between Ordovician-Devonian strata of Japan and CAOB. Because Late Paleozoic igneous activity in East Asia is only recorded in CAOB and Hainan Island-Malay Peninsula region (Ikeda *et al.*, 2015 *JpGU*), we suggest that the Late Paleozoic AC's of Japan and Mongolia formed oceanic island arc-trench systems together with some “island-arc terranes” in the CAOB. Triassic-Jurassic times are characterized by (1) introduction of Precambrian zircons to the sandstones in Japan and (2) wide occurrence of igneous rocks in the North and South China blocks (Ikeda *et al.*, 2015 *JpGU*). These facts suggest the successive collision of the above oceanic island arcs with supercontinent Pangea, including the North and South China blocks. Further study will clarify the timing of introduction of Precambrian zircons to each geologic belt and collision of each oceanic island arc.

Keywords: U-Pb age, detrital zircon, LA-ICP-MS, accretionary complex, Japan, CAOB

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

SGL40-P03 Room:Convention Hall Time:May 27 18:15-19:30

Provenance analysis of Jurassic-Cretaceous formations in Japan using etrital-zircon-age spectra

OTOH, Shigeru[1*] ; KOUCHI, Yoshikazu[1] ; HARADA, Takuya[1] ; TAKUJI, Ikeda[1] ; ORIHASHI, Yuji[2] ; YAMAMOTO, Koshi[3]

[1]University of Toyama, [2]ERI, University of Tokyo, [3]Nagoya University

Several patterns of detrital-zircon-age distribution are discriminated of pre-Jurassic clastic rocks of Japan and Mongolia, and transition of the tectonic setting of each geologic body or stratigraphic succession can be traced from the temporal change of these patterns. In the following geologic belts, the pattern changed from (1) a multimodal pattern with Meso- and Neoproterozoic small peaks through (2) a unimodal pattern to (3) a bimodal pattern without Meso- and Neoproterozoic zircons: the Hida Gaien, Renge, Akiyoshi, Suo, Ultra Tamba-Tamba, and Northern Chichibu belts of Japan and north-central Mongolia. Okawa *et al.* (2013 *Mem. FPDM*), Kouchi *et al.* (2015 *JpGU*), and Ueda *et al.* (2015 *JpGU*) interpreted that the transition indicates the following tectonic evolution: (1) Gondwana margin ->rifting ->(2) oceanic island arc ->collision ->(3) northeastern margin of Pangea.

From the Triassic, the northeastern margin of Pangea or Laurasia changed to a large igneous province and the provenance analysis with detrital-zircon-age distribution become more difficult. However, compilation of the zircon U-Pb ages of igneous rocks in (present-day) East Asia has revealed certain provinciality at the age of igneous rock bodies. On the other hand, we made classification of Jurassic-Cretaceous geologic units in Japan from a simple verification of the similarity in detrital-zircon-age distribution. By comparison of a certain detrital-zircon-age spectrum with the age-distribution of igneous rock bodies in East Asia, we induced the provenance that could make the age spectrum. Moreover, we induced relative displacements of geologic bodies from the analysis of provenance transition of each geologic belt or stratigraphic succession.

Ikeda *et al.* (2015 *JpGU*) presented preliminary results of our study. In the postr presentation, we will introduce and discuss the detailed results.

Keywords: detrital zircon, U-Pb age, East Asia, Jurassic, Cretaceous, tectonics

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

SGL40-P04 Room:Convention Hall Time:May 27 18:15-19:30

U-Pb geochronology of detrital zircons from the Lower Cretaceous formations of the Chichibu-Shimanto belts, SW Japan

TAKUJI, Ikeda[1*] ; HARADA, Takuya[1] ; KOUCHI, Yoshikazu[1] ; YAMAMOTO, Koshi[2] ; OTOH, Shigeru[1]

[1]Grad. School Sci. Eng., Univ. Toyama, [2]Grad. School Env., Stu. Nagoya Univ.

Introduction The Japanese Islands record signs of Cretaceous igneous activity and crustal movements. To decode the Cretaceous tectonic evolution, we have started the provenance analysis of the Lower Cretaceous formations in the Chichibu-Shimanto belts from detrital-zircon-age spectra.

Samples

Northern Chichibu Belt:

Sebayashi Formation (Fm.) (**01**) and Sanyama Fm. (**02**) of the Sanchu Cretaceous; Idaira Fm. (**03**); Ryoseki Fm. (**04**), Monobe Fm. (**05**), Yunoki Fm. (**06**), and Hibihara Fm. (**07**) of the Monobegawa Group; Haidateyama Fm. (**08**)

Kurosegawa Tectonic Belt:

Birafu Fm. (**09**), Funadani Fm. (**10**), and Hagino Fm. (**11**) of the Nankai Group; Yamabu Fm. (**12**)

Southern Chichibu Belt: Torinosu Group (**13**)

Shimanto Belt: Doganaro Fm. (**14**)

Results We measured the U-Pb age of zircons with the LA-ICPMS equipped in the Graduate School of Environmental Studies, Nagoya University. We discriminated three patterns of detrital-zircon-age spectra.

Pattern I contains some 70% of Early Cretaceous zircons (**02** and **07**).

Pattern II contains more than 40% of Jurassic zircons and minor (15%) Early Cretaceous zircons (**01**, **05**, **06**, **09**, and **11**).

Pattern III contains some 70 % of Permo-Triassic zircons (**03**, **04**, and **08**).

Pattern IV contains all the remaining spectra (**10**, **12**, and **14**). See the attached figure for details.

Age distribution of igneous rocks in East Asia

Paleoproterozoic: Widely in the North China Block and Korean Peninsula; sporadically in the South China Block.

Permian: Hainan Province in SE China to the Malay Peninsula and the Maizuru and Akiyoshi Belts in SW Japan.

Triassic: Western Guangdong and Hunan provinces in SE China, Northeast China, the Korean Peninsula, and Hida-Hida Gaien Belts in SE Japan.

Jurassic: Northeastern to eastern Guangdong Province, Northeast China, and the Korean Peninsula.

Early Cretaceous: (140-120 Ma) Part of Guangdong Province and Anhui-Zhejiang provinces in China, and Kitakami Mountains in NE Japan; (120-110 Ma) Zhejiang Province and Kitakami Mountains; (110-90 Ma) Zhejiang-Fujian-Guangdong coast and the Abukuma and a part of the Higo-Ryoke belts in Japan.

Provenance analysis The 158-110 Ma magmatic hiatus in Korea (Sagong *et a*l., 2005 *Tectonics*) precludes the Korean Peninsula from the provenance of the sandstone with Early Cretaceous zircons. The pattern I spectrum indicates the deposition **near the Zhejiang Province** with abundant Early Cretaceous (120-110 Ma) igneous rocks.

The pattern II spectrum indicates the deposition **near the Guangdong-Fujian provinces** with abundant Jurassic and minor Early Cretaceous (130-120 Ma) plutons.

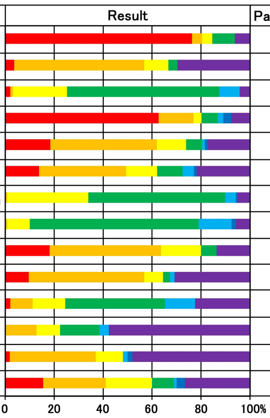
Among the pattern IV samples, the provenance of **10** and **12** was likely the Guangdong-Hainan coast, because the two samples contained Permian to Jurassic zircons. For sample **13**, the inclusion of 48% Paleoproterozoic zircons likely indicates its deposition near the **Korean Peninsula**, although the derivation of Jurassic zircons (34%) from the **Guangdong Province** cannot be ruled out.

In the pattern III spectrum, on the other hand, only Permian (270-240 Ma) peak predominated. However, there is no place in and around China where Permian igneous rocks predominate. We propose that the Permian zircons in pattern III were originated from the Permian sandstones in the accretionary complex (AC) of the Northern Chichibu Belt, because 1) the Ryoseki Fm. unconformably covers the Permian AC (Yamakita, 1998 *JGSJ*) and the clasts in the Monobegawa Group were likely supplied from the AC (Matsukawa and Tsuneoka, 1993 *Mem. GSJ*), and 2) the sandstone in the Permian AC contains abundant Permian zircons (Morita, 2012 *JpGU*). Moreover, the Idaira Fm. (**03**) of pattern III contains small amounts of 120 Ma zircons, suggesting that the Permian AC was in front of the Early Cretaceous igneous rocks of the **Zhejiang Province**.

Keywords: U-Pb age, detrital zircon, LA-ICP-MS, SW Japan, Lower Cretaceous

SGL40-P04 Room:Convention Hall Time:May 27 18:15-19:30

Zone	Region	Formation	Age	Result	Pattern	Place of deposition
Northern Chichibu Belt	Ka	1. Sanyama	Albian		I	Zhejiang
		2. Sebayashi	Aptian		II	Guangdong-Fujian
	Ch	3. Idaira	Barremian		III	Zhejiang
	Sh	4. Hibihara	Aptian–Albian		I	Zhejiang
		5. Yunoki	Barremian		II	Guangdong-Fujian
		6. Monobe	Barremian		II	Guangdong-Fujian
		7. Ryoseki	Berriasian–Hauterivian		III	Zhejiang
	Ky	8. Haidateyama	Barremian		III	Zhejiang
Kurosegawa Belt	Sh	9. Hagino	Aptian		II	Guangdong-Fujian
		10. Birafu	Berriasian–Valanginian		II	Guangdong-Fujian
		11. Funadani	Unknown		IV	Guangdong-Hainan
	Ky	12. Yamabu	Valanginian		IV	Guangdong-Hainan
SCB	Sh	13. Torinosu G.	Berriasian		IV	Guangdong (Korea?)
SB		14. Doganaro	Aptian–Albian		IV	Zhejiang



SCB: Southern Chichibu Belt , SB: Shimanto Belt , Ka: Kanto region , Ch: Chubu region , Sh: Shikoku region , Ky: Kyushu region
Cretaceous, Jurassic, Triassic, Permian, 540-300 Ma, 1600-540 Ma, -1600 Ma

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

SGL40-P05 Room:Convention Hall Time:May 27 18:15-19:30

Zircon U-Pb geochronology of Nagasaki Metamorphic Rocks and related geological units in Kyushu, SE Japan

NAGATA, Mitsuhiro[1*] ; KOUCHI, Yoshikazu[1] ; YOKOGAWA, Miwa[1] ; YAMAMOTO, Koshi[2] ; OTOH, Shigeru[1]

[1]Grad. Sch. Sci. Eng., Univ. Toyama, [2]Grad. Sch. Env. Studies, Nagoya Univ.

Introduction Nagasaki Metamorphic Rocks (NMR) occupy the Nishisonogi (NsP) and Nomo (NmP) peninsulas of Nagasaki Prefecture and the western part of the Amakusa Shimoshima Island (ASI) of Kumamoto Prefecture, SW Japan. Nishimura et al. (2004), Takeda et al, (2002), and other researchers proposed that NMR consist of Late Cretaceous Sambagawa Metamorphic Rocks (SMR), Early Cretaceous Higo Plutonic Rocks, Triassic Suo Metamorphic Rocks, and Late Cambrian Metagabbro Complex. In addition, Late Cretaceous-Paleogene sedimentary rocks cover NMR. In this study we measured the zircon U-Pb ages of NMR and related rocks and to propose a model of tectonic evolution of NMR.

Geologic Setting Geologic setting of each distribution area of NMR is as follows.

The NsP consists of SMR and Late Cretaceous Oseto granite, in apparent ascending order, and the Paleogene cover of the Akasaki, Terashima, Matsushima, and Nishisonogi groups.

The NmP consists of SMR, Higo Plutonic Rocks, Suo Metamorphic Rocks, and Nomo Metagabbro Complex, in apparent ascending order, and the overlying Upper Cretaceous Mitsuze and Paleogene Koyagi formations and Paleogene Takashima and Iojima groups.

The ASI consists of SMR, Higo Plutonic Rocks, Upper Cretaceous Himenoura Group, and Paleogene sedimentary rocks, in apparent ascending order.

Materials and method The samples we studied were as follows.

ASI: SMR

NmP: Metagabbro Complex from the eastern and western coasts, and a metamorphic-rock cobble from the Lower Eocene Koyagi Formation

The U-Pb age was measured with the LA-ICP-MS equipped in the Graduate School of Environmental Studies, Nagoya University.

Age dating results

SMR from the ASI: The age composition of zircons (%) was as follows: Early Cretaceous (7.1), Jurassic (30.3), Triassic (19.6), Permian (7.1), Paleoproterozoic (33.9), and Archean (1.8). The youngest zircon age (YZ) was 117.4 +/- 3.7 Ma.

Metamorphic-rock cobble: The age composition of zircons was as follows: Late Cretaceous (18.4), Early Cretaceous (47.4), Jurassic (7.9), Triassic (10.5), Permian (5.3), Carboniferous-Cambrian (2.6), and Paleoproterozoic (7.9). The youngest zircon age was 87.4 +/- 2.0 Ma.

Metagabbro Complex: U-Pb data from three spots out of five gave the concordia age of 526 +/- 19 Ma.

Discussion

NsP: SMR with the YZ of 74 Ma (Late Cretaceous) lacked zircons of 130-160 Ma (including the magmatic hiatus in Korea: 110-158 Ma; Sagong et al., 2010), suggesting that the protolith was deposited in the trench near the Korean Peninsula in the Late Cretaceous (Kouchi et al., 2011). The Oligocene Matsushima Group contains pebbles of metamorphic rocks (Nagahama, 1962).

NmP: The metamorphic-rock cobble differed from the SMR of ASI and NsP, because it contained many Late Cretaceous zircons. The cobble bearing bed has paleocurrent indicators showing that the cobble was derived from SMR in the NmP (Nagahama, 1965). The SMR in the NmP were hence exhumed by the Early Eocene.

ASI: SMR in the ASI contained zircons formed during the magmatic hiatus in Korea and may have had different hinterland from the SMR in the NsP. 110-158 Ma igneous rocks widely occur in Zhejiang-Guangdong provinces Southeast China, suggesting that the protolith of the SMR in the ASI was deposited in the trench off Southeast China in the Early Cretaceous (around 117 Ma). In the ASI, the Late Cretaceous Himenoura Group contains pebbles of metamorphic rocks (Yamaguchi et al., 2008).

Tectonic evolution of the SMR in NMR: The protolith of the SMR in NMR was deposited after 121 Ma in different parts of the trench along the eastern margin of Asia, metamorphosed, and was successively exhumed in latest Cretaceous-Oligocene times in the ASI ->NmP ->NsP.

Metagabbro Complex: The complex (ca. 500 Ma) in the eastern part of the NmP occurs along the axis of a small syncline, suggesting that the complex as a whole occupies the uppermost part of NMR as a low-angle sheet-like body.

Keywords: U-Pb age, zircon, LA-ICPMS, Nagasaki metamorphic rocks, Sanbagawa metamorphic rocks

SGL40-P06 Room:Convention Hall Time:May 27 18:15-19:30

Sr-Nd-Pb isotopic ratios of the Miocene accretionary complex on southern Boso Peninsula, Japan

SAITOH, Yu[1*] ; YAMAMOTO, Yuzuru[2] ; ISHIKAWA, Tsuyoshi[3] ; TANIMIZU, Masaharu[3]

[1]Center for Advanced Marin Core Research, Kochi University, [2]JAMSTEC, [3]Kochi Institute for Core Sample Research, JAMSTEC

In the southern regions of the Boso peninsula, shallow levels of the accretionary prisms and their cover sediments, which were formed in the late Miocene age, are exposed (Yamamoto and Kawakami, 2005; Yamamoto et al., 2005). These strata are valuable in that they preserve much of the original physical information (Yamamoto 2003). This means that they can provide information about the ongoing accretionary process under the floor of deep sea as an analogue. We conducted Sr-Nd-Pb isotope analysis of mudstones from the accretionary prisms and their cover sediments on the Boso peninsula with the aim of reinforcing the existing lithologic classification (e.g., Mitsunashi, 1989; Saito, 1992). Isotope ratios of Sr, Nd, Pb in detrital fine particles preserve their original source-area signatures. Mudstones were taken from the Aokiyama Formation of the Hota Group, the Nishizaki Formation, the Kinone Formation and the Amatsu Formation of the Miura Group. The former two formations are supposed to be the accretionary prism sediments, and the latter two are their cover sediments. The Nishizaki Formation, the Amatsu Formation, and the Kinone Formation can be differentiated each other by considering comprehensively the Sr-Nd-Pb isotope ratios. The mudstones of the Nishizaki Formation show higher Sr and Pb isotope ratios than the Amatsu Formation. Mudstones of the Kinone Formation is characterized by lower isotope ratios of Pb than those of the Nishizaki and Kinone Formations of similar isotope ratios of Sr and Nd. In the Kinone Formation, Sr isotope ratio of mudstones increases, while Nd isotope ratio of them decreases westward. This suggests that the sediment feeding system of the Kinone Formation was different between east and west. Unlike the others, the Aokiyama Formation shows large isotopic variation. This makes differentiation of the Aokiyama Group from the others difficult. The isotopic ratios of the Aokiyama Formation may be influenced by diagenesis due to deep burial.

Keywords: accretionary prism, Sr-Nd-Pb isotope ratios, The Miura Group, The Hota Group

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

SGL40-P07 Room:Convention Hall Time:May 27 18:15-19:30

Paleostress study with the muitiple inverse method using fault-slip data from southern end of Miura peninsula

KUSUHARA, Fumitake[1*] ; TANAKA, Hidemi[1]

[1]The University of Tokyo

Kenzaki anticline, which is ~8km along with a E-W trend, is located at the south end of Miura peninsula, Kanagawa prefecture. Around Kenzaki anticline, some researches on paleostress have been done using the conjugate fault method (Kodama, 1968; Kuniyasu, 1980). However, new methods which solved the theoretical problems of the conjugate fault method have not been applied to Kenzaki anticline area. In this study, the multiple inverse method(Yamaji, 1999) is applied to the fault-slip data from limbs of Kenzaki anticline and some paleostresses are detected. The order of these paleostresses and its relation to the formation of Kenzaki anticline are considered from the result of this method and cross cutting relation among observed faults.

SGL40-P08 Room:Convention Hall Time:May 27 18:15-19:30

Chronology of Early Cretaceous tectonic evolution of the North Kitakami Belt, Northeast Japan

HARADA, Takuya[1*] ; KOUCHI, Yoshikazu[1] ; YAMAMOTO, Koshi[2] ; OTOH, Shigeru[1]

[1]Grad. School Sci. Eng., Univ. Toyama, [2]Grad. School Env., Stu. Nagoya Univ

Introduction We measured the U-Pb zircon age of Lower Cretaceous rocks (part of which is age unconstrained) in the Taro-Tanohata area of the North Kitakami Belt, Northeast Japan, to constrain the age of tectonic evolution. The rock units we studied are the Omoto (sandstone) and Harachiyama (sandstone and dacitic lapilli tuff) formations, the Taro pluton (diorite), and the Raga Formation of the Miyako Group (sandstone).

Geologic Setting Jurassic to earliest Cretaceous accretionary complex (AC) and Early Cretaceous plutonic and shallow-marine sedimentary rocks occur in the Taro-Tanohata area. The Omoto Formation consists of sandstone, mudstone, and minor felsic pyroclastic rocks. The formation was correlated with the Berriasian-Valanginian because of its stratigraphic position and the common occurrence of the Ryoseki-type flora with the Berriasian-Valanginian Ayukawa Formation of the South Kitakami Belt (Sugimoto, 1974). The overlying Harachiyama Formation consists mainly of andesitic to dacitic lava and pyroclastic rocks with the K-Ar hornblende age of 122 $\pm$ 5 Ma although the age has been interpreted to be of contact metamorphism by later granitic plutons. (Shibata et al., 1978). The Taro diorite cutting the two formations has K-Ar hornblende ages of 120-110 Ma (e.g., Kawano and Ueda, 1965). The Miyako Group, covering the Taro diorite, yields ammonoids such as *Hypacanthopltes subcornuerianus* and *Valdedorsella akuschaensis* and has been correlated with the Upper Aptian-Albian (Hanai et al., 1968). In summary, the magmatic or depositional age of the Early Cretaceous rocks except for that of the Miyako Group has not well been constrained.

Age determination The U-Pb age of igneous detrital zircons extracted from the studied rock units was measured with the LA-ICP-MS equipped in the Graduate School of Environmental Studies of Nagoya University. The results were as follows. The age of the youngest zircon from the sandstone sample of the Omoto and Harachiyama Formations was 132.3 $\pm$ 3.5 Ma and 119.0 $\pm$ 4.7 Ma, respectively. The zircon ages from the lapilli tuff sample of the Harachiyama Formation clustered around 126 Ma and 133 Ma, with the concordia age of the former cluster (5 grains) of 126.3 $\pm$ 2.0 Ma. The zircon ages from the Taro diorite clustered around 120 Ma and 128 Ma, with the concordia age of the former cluster (5 grains) of 121.0 $\pm$ 2.2 Ma. The age of the youngest zircon from the sandstone sample of the Raga Formation of the Miyako Group was 117.5 $\pm$ 3.1 Ma.

Discussion Previous studies have proposed that the Omoto and Harachiyama formations, together with the underlying AC, were involved in NS-trending folding and sinistral strike-slip shearing. Granitic plutons cut these geologic units and structures coevally with NS-trending dip-slip shearing (e.g., Minoura and Tsushima, 1984). Our new U-Pb data constrain the age of tectonic evolution as follows. The Omoto Formation was deposited at 136 Ma (Valanginian) or later and was covered with the Harachiyama Formation with the dacitic lapilli tuff of 128.2-124.2 Ma (Barremian-Early Aptian) and sandstone of 123.7 Ma (Early Aptian) or younger. NS-trending folding and sinistral shearing followed and were cut by Taro diorite at 121.2 $\pm$ 2.2 Ma (Aptian) coevally with NS-trending dip-slip shearing. Finally the Miyako Group covered all of the above elements at 120.6 Ma (Late Aptian) or later.

Keywords: U-Pb age, zircon, LA-ICP-MS, Northeast Japan, North Kitakami Belt

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

SGL40-P09 Room:Convention Hall Time:May 27 18:15-19:30

Stratigraphy of the Tetori Group in the Nagano area, Ono City, Fukui Prefecture, Central Japan

SHIKAZAWA, Yusuke[1*] ; MATSUOKA, Atsushi[2]

[1]Graduate School of Science and Technology, Niigata University, [2]Department of Geology, Faculty of Science, Niigata University

The Middle Jurassic to Lower Cretaceous Tetori Group is distributed in the Jinzu and Hakusan regions. The Group is divided into the Kuzuryu, Itoshiro, and Akaiwa Subgroups in ascending order (Maeda, 1961).

The Nagano area is located in the upper reaches of the Kuzuryu River. It is known the Kuzuryu, Itoshiro and Akaiwa Subgroups are distributed in the Nagano area in ascending order (e.g. Yamada et al., 1989 ; Fujita, 2002 ; Matsukawa et al., 2006). It is also known the formation in the area contains ammonite fossils. The formation containing Bathonian-Callovian ammonite fossils is regarded the Kaizara Formation or Middle Formation of the Kuzuryu Subgroup. However, the ammonite in the formation shows the geological age of Oxfordian (Sato and Westermann, 1991). Therefore, the formation is younger than the Kaizara Formation.

The Itoshiro area is type locality of the Kuzuryu and Itoshiro Subgroups. There are problem of stratigraphycal correlation.

The Tetori Group in the Nagano area is divided into the A , B and C Formations in ascending order. The A Formation consists of mudstone. The B Formation consists of alternation of sandstone and mudstone. The C Formation consists of alternation of conglomerate, sandstone and siltstone. The A Formation contains molluskan fossils and trace fossils. Thickness of the A Formation is over 360m. The B Formation contains trace fossils in the lower part, leaf fossils in the middle to upper part. The B Formation also contains roots in the upper part. Thickness of the B Formation is 280 to 380m. The C Formation scraped the B Formation. The lowest part of the C Formation contains cobbles. Siltstone of the C Formation contains leaf fossils. Thickness of the C Formation is over 190m. The A, B and C Formations are limited by monoclinal structure. The structure has E-W strike and N dip.

The result of lithostratigraphical correlation, the A Formation to the C Formation in the Nagano area is similar to the Kaizara Formation to the Yambara Formation in Itoshiro area. However, there are some difference including lithostratigraphy, conglomerates and fossils. We found the change of marine sediments to continental sediments, because B Formation contains trace fossils and roots. We reviewed lithostratigraphical correlation between formations in Nagano and Itoshiro areas. Result of conglomerates correlation in the B and C Formations, they are granite-dominant type. However, the amount of chert becomes larger to the C Formation. This changing pattern is similar to Fujita (2002). On the other hand, the changing pattern is upperpart of the Ashidani Formation to the Obuchi Formation in Fujita (2002). It is not harmonic in lithostratigraphy.

There is a little gap in the two areas such a lithofacis and geological age. Therefore, we think the setting of basin is similar between the Itoshiro and Nagano areas. We need to survey in the Kamihambara area.

Keywords: Tetori Group, Kuzuryu Subgroup, Itoshiro Subgroup, Stratigraphy, Conglomerates, Nagano area

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

SGL40-P10 Room:Convention Hall Time:May 27 18:15-19:30

Geologic age of the Nishino-omote Formation in the Tanegashima Island based on radiolarians and calcareous nannofossils

KIKUKAWA, Akihide[1*] ; AITA, Yoshiaki[2] ; KAMEO, Koji[1] ; KOTAKE, Nobuhiro[1]

[1]Chiba University, [2]Utsunomiya University

<Introduction>

The Paleogene Kumage Group (Hannzawa, 1934) is widely distributed in the Tanegashima Island, Kagoshima Prefecture, southwest Japan. The Kumage Group is divided into the Kadokurazaki, Tateishi, and Nishino-omote Formations in ascending order (Okada, 1982). Because of the lack of detailed lithological distribution map and reliable chronological data of the formations, geological structures and ages of them are still unclear. In this study, detailed field observation of the northern part of the Tanegashima Island was carried out and we also examined radiolarians and calcareous nannofossils from the Nishino-omote Formation in order to clarify its geological age.

<Materials and Methods>

A total of 110 mudstone were collected from mudstone dominant intervals of the Nishino-omote Formation and we examined radiolarians and calcareous nannofossils. To avoid collecting turbidite mudstone, monotonous, intensely bioturbated mudstones were selected. Fifty and 60 samples were used for analyses of radiolarians and calcareous nannofossils, respectively.

<Results and discussion>

Detailed geological survey revealed that a lot of NNE-SSW trending fold structures and thrust faults were developed in the northern part of the Tanegashima Island and an interval of "trace fossils concentration beds" is repeatedly recognized as a key horizon in the studied area. Thus, total thickness of the Nishino-omote Formation by previous study is overestimated. Within the examined samples, 11 samples contain radiolarians fossils. Occurreences of *Artophrmis gracilis*, *Eucyritidium plesiodiaphanes*, *Theocyrtis setanios*, *Theocorys perforalvus* and *Lithocyclia angusta* are recognized in a single sample from the upper part of Nishino-omote Formation and the preservation of the radiolarian fauna in this sample is moderately. Co-occurrence of *E. plesiodiaphanes* and *T. setanios* coincides with the radiolarian zone RP20c to RP21a (Kamikuri et al., 2012) and its age is considered to be 31.1 to 28.5 Ma. Calcareous nannofossils are observed only in 3 samples in the lower part of Nishino-omote Formation. Paleogene species consistently occur even though preservation of specimens is not good. *Sphenolithus distentus* and *S. predistentus* are stratigraphically important and geologic age of samples are 30.00-26.8 Ma based on total range of *S. distentus*.

Our field observation and microfossil investigation indicate that the Nishino-omote Formation seems to be deposited during a short period between 31.1 and 26.8 Ma and the Nishino-omote Formation is characterized by repetition of simultaneous intervals associated with holds and thrusts.

Keywords: Nishino-omote Formation, Kumage Group, Tanegashima Island, radiolarian, calcareous nannofossil

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

SGL40-P11 Room:Convention Hall Time:May 27 18:15-19:30

A Cretaceous cauldron in the Yanahara area,

ISHIKAWA, Nobuyo[1*] ; KOMURO, Hiroaki[1]

[1]Shimane University

Cretaceous volcanic rocks (volcanic, pyroclastic and lesser sedimentary rocks) unconformable overlying the basement rocks composed of the Maizuru Group and the Yakuno complex are widely distributed in the region from Okayama to Hyogo Prefectures, central Chugoku, SW Japan.

Low gravity anomalies concordant with the thick Cretaceous volcanic rocks and the surrounding high gravity anomalies concordant with the basement rocks are observed in the Yanahara area, Okayama Prefecture (Ishikawa et al. 2014). These low gravity anomalies suggest concealed calderas (cauldrons) filled-up with ignimbrite. Its age was estimated as ca. 80Ma by the K-Ar dating of quartz diorite intruded into this ignimbrite. 3-D inversion analysis for gravity anomaly reveals that the cauldron floor lies 1 to 3km deep (Ishikawa et al. 2014b).

The lithofacies and geologic structure of the Cretaceous volcanic rocks in the Yanahara area are as follows. The volcanic rocks in this area consist of welded tuff, crystal tuff, andesite lava, rhyolite lava, tuffaceous sandstone, lapilli stone and lapilli tuff, in ascending order. The felsic rocks are dominant in these seccessions, whereas the andesite lava is not so thick as the previous study described (Okayama Geologic map project, 2009). The rhyolite lavas laterally attenuate and change to well-bedded rhyolitic lapilli stones and tuffaceous sandstones.

These volcanic, pyroclastic and epiclastic sedimentary rocks, which gently incline northward in the main part, shows nearly vertical attitude along the basement rocks. Some ring dikes of quartz porphyry and andesitic porphyry are also found along these boundary faults, and some fracture zones intercalating fault breccias are observed in the peripheral basement rocks. These structures suggest the syn-eruptional subsidence along the boundary faults. No unconformable relationship is observed. The fault displacement is estimated more than 1km by the borehole evidence (MMAJ 1980).

Keywords: cauldron, Yanahara, Cretaceous volcanic rocks

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

SGL40-P12 Room:Convention Hall Time:May 27 18:15-19:30

Greenstone melange of the Atogura Nappe in the Iyou district, Saitama Prefecture, central Japan

ONO, Akira[1]*

[1]None

The Atogura Nappe in the northeastern margin of the Kanto Mountains consists of various kinds of geological units. The Kiroko greenstone melange is a geological unit distributed in the southern part of the Atogura Nappe. It is composed of the Kiroko metamorphic rocks, serpentinites and various kinds of tectonic blocks. The Kiroko metamorphic rocks mainly consist of weakly metamorphosed slate, sandstone, mixed rock, chert, greenstone and actinolite rocks. These rocks are usually exposed separately. However, slate, psammitic rock, mixed rocks, chert, greenstone and conglomerate of serpentinites are conformably piled up at locations *a* and *f* of Figure-Kiroko. Hornblendite, amphibolite, epidote amphibolite, psammitic metamorphic rocks, meta-tonalite and acidic tuff are representative tectonic blocks. The Kiroko metamorphic rocks and tectonic blocks were intruded by serpentinites.

The important geological data obtained to date for the Kiroko greenstone melange are as follows. 1) The K-Ar whole rock age of a greenstone at loc.*a* is 57.4Ma. Thin pelitic lenses mainly consisting of fine-grained actinolite, chlorite, white mica, carbonaceous material and quartz exist in the studied greenstone. The dating result suggests that the Kiroko metamorphic rock is a member of the Sanbagawa metamorphic rock. 2) The K-Ar hornblende age of a small amphibolite block included in an actinolite rock is 402Ma. 3) A thin layer of muscovite-biotite-garnet schist was found in a psammitic metamorphic rock exposed in the Iyou area, Higashi-chichibu village. The K-Ar age of white mica from the muscovite-garnet schist is 109Ma (Figure-Iyo). The metamorphic rocks are considered to be members of the Higo- Abukuma metamorphic belt [1,2].

The following facts are revealed by a recent geological study of the Iyou area (Figure- Iyo). (a) Psammitic metamorphic rocks and thin aplitic granites are distributed in the northern part of the Kiroko greenstone melange. The metamorphic and granitic rocks show no evidence for suffering from the Kiroko metamorphism. (b) Similar metamorphic and granitic rocks occur as a small block of approximately 30m long and 12m wide to the south of the above mentioned psammitic metamorphic rocks. (c) A tectonic block of meta-tonalites was found to the southwest of the small psammitic metamorphic block. Plagioclases of the meta-tonalites are replaced by fine zoisite grains. Some meta-tonalites show mylonitic textures, but others show weak schistosity. In the latter case, most of plagioclase grains have many tension cracks which are filled with quartz and plagioclase. Chlorite-rich veins and pools are not rare. Edges of large amphibole crystals are replaced by colorless amphiboles. The K content of a whole rock sample is less than 0.05% by weight. (d) Floatstones of psammitic metamorphic rocks are found near the western part of the meta-tonalite.

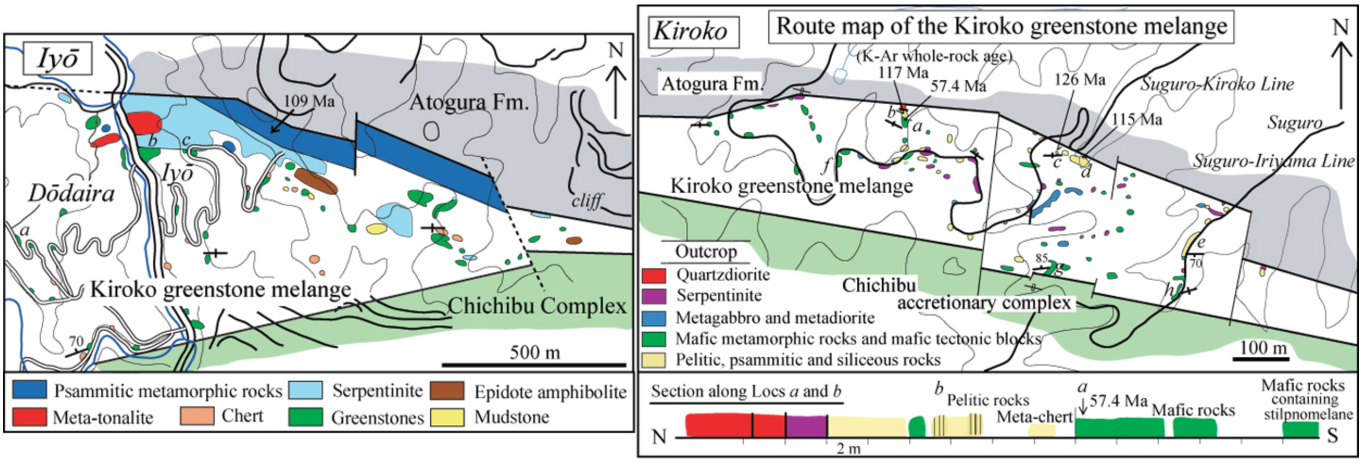
The present study has revealed the existence of melange structures in the Iyou area. Allochthonous blocks were captured during the exhumation of the Kiroko metamorphic rock before the intrusion of serpentinite. The finding of tectonic blocks of mid-Cretaceous metamorphic and granitic rocks suggests that the intrusion of serpentinite and the exhumation of the Kiroko metamorphic rocks took place in the eastern marginal portion of the early Paleogene forearc region where Higo-Abukuma metamorphic and granitic rocks are distributed in the upper crust [1,2]. The shift of the Higo-Abukuma belt toward the late Cretaceous trench was caused by nappe tectonics.

[1] A. Ono, 2011, Abs. Geol. Soc. Japan, Meeting, R9-P-9, p. 196.
[2] A. Ono, 2013, Abs. Japan Geosci. Union Meeting, SMP43-P16.

Keywords: Atogura Nappe, Greenstone melange, Tectonic blocks, Higo-Abukuma Belt, Serpentinite

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

SGL40-P12 Room:Convention Hall Time:May 27 18:15-19:30



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

SGL40-P13 Room:Convention Hall Time:May 27 18:15-19:30

Active and subsurface structure in the middle Ryukyu Islands around Yoron Island

KITAMURA, Yujin[1*]

[1]Dept. Earth and Environmental Sciences, Grad. Sch. Science and Engineering, Kagoshima University

The Ryukyu arc lies along the Ryukyu trench in the south of Kyushu island. Geology in the middle Ryukyu arc consists of Chichibu belt, Shimanto belt and overlying limestones with sporadic igneous intrusions. Yoron island which locates in the questioned area have two active faults whose strikes are highly oblique each other and they are probable normal faults. To evaluate these active faults in terms of documenting present tectonic framework, we carefully reviewed topography, degree and direction of surface slope and gravity anomaly. As a result, accurate trace of the active faults is drawn. Positive free air gravity anomaly suggests plutonic body beneath the Yoron island although there is no outcrop on the island surface. This upwelling pluton can be a reason for the unexpected normal faults in this island.

Keywords: Shimanto Belt, Chichibu Belt, Active fault

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

SGL40-P14 Room:Convention Hall Time:May 27 18:15-19:30

Geology of the area of 1:200,000 quadrangle geological map of the Matsuyama district

MIYAZAKI, Kazuhiro[1*] ; WAKITA, Koji[2] ; MIYASHITA, Yukari[1] ; MIZUNO, Kiyohide[1] ; TAKAHASHI, Masaki[1] ; NODA, Atsushi[1] ; TOSHIMITSU, Seiichi[1] ; SUMII, Tomoaki[1] ; OHNO, Tetsuji[1] ; NAWA, Kazunari[1] ; MIYAKAWA, Ayumu[1]

[1]GSJ AIST, [2]Yamaguchi Univ.

The Matsuya district, located in the northwestern part of Shikoku Island and western part of the Seto Inland Sea, geologically comprise various rock types from Paleozoic to Quaternary in age.

The following Paleozoic units are distributed in the district, 1) Late Cambrian ultramafic rocks, 2) Late Devonian to Early Silurian plutono-metamorphic complex, 3) Silurian to Devonian Okanaro Formation, 4) Early Permian high-pressure metamorphic complex, 3) Permian accretionary complexes.

Mesozoic units on the north side of the Median Tectonic Line (MTL) are 1) Cretaceous Ryoke Pluton-metamorphic Complex, and 2) Upper Cretaceous Izumi Group. Mesozoic units on the south side of the MTL are 1) Late Triassic to Early Jurassic high-pressure metamorphic complex, 2) Early to Middle Jurassic accretionary complex in the north Chichibu belt (Yusugawa, Sumiizuku, and Kamiyoshida units), 3) Middle Jurassic to Early Cretaceous accretionary complex in the south Chichibu belt (Ohirayama, Togano, Shirahigeyama, and Sanbosan units), 4) Early Cretaceous accretionary complex in the Shimanto belt, 5) Early Cretaceous high-temperature metamorphic complex, 6) Cretaceous Sanbagawa Metamorphic Complex (Iyo, Uchiko, Ozu, Hijikawa, and Mikabu units and Karasaki Mylonite), 7) Triassic shallow marine sediments, and 8) Jurassic shallow marine sediments, 9) Cretaceous shallow marine sediments (Nankai, Monobegawa, and Sotoizumi Groups).

The Jurassic to Early Cretaceous accretionary complexes tectonically underlie the mentioned-above Paleozoic units and early Mesozoic high-pressure metamorphic complex. The age of each Mesozoic accretionary complex becomes younger towards the apparent lower structural levels.

Neogene System in this area is divided into the Kuma and Ishizuchi Groups. The Kuma Group consists of three stratigraphic units of the Hiwadatoge (shallow marine calcareous sandstone), Furuiwaya (talus breccia) and Myojin Formations (conglomerate and lacustrine sediments) in ascending order. The Ishizuchi Group, horizontally overlies the Kuma Group unconformably, is composed of the Takano (tuff) and Kuromoritoge (welded tuff and andesite lava) Formations. These clastic and volcaniclastic sediments are intruded by a large number of andesitic to rhyolitic dykes and stocks.

The Setouchi-volcanic rocks in this area are olivine andesite, pyroxene hornblende andesite and biotite dacite. The reported radiometoric ages of these rocks range from 16 Ma to 12 Ma, and most of them concentrate between 15.5 Ma and 14 Ma. The Gogoshima formation and the Takahama formation are composed of volcano-clastic rocks and volcanic rocks, which is similar to the Setouchi-volcanic rocks.

The early to middle Pleistocene fluvial sediments such as the Gunchu, Tomisuyama, Yakura, Torinoko and Iyoki Formations are exposed in the Matsuyama plain and in the middle to upper area of the Hiji River. The terrace deposits and Holocene sediments are distributed in and around the Matsuyama plain and sporadically along many rivers.

In the Matsuyama Plain, many E-W trending active faults are developed. These are called the Median Tectonic Line fault. This fault system extends to the Iyonada of the Set Inland Sea.

In this area, two of mineralization belt is running to east and west. One is a Bedded Deposits of Cupriferous Pyrite in the Sanbagawa metamorphic complex, and another is bedded manganese ore deposit in the Jurassic accretionary complex in the southern Chichibu belt.

Large horizontal gradient zone of the Bouguer anomalies (assumed density 2.59 g/cm) shown in central region corresponds to northern edge of the MTL. Northwestern part of the MTL shows negative anomalies and minimum value is approximately – 50 mgal near Iyo-nada in the Seto Inland Sea. Southeastern part of the MTL shows a mix of negative and positive anomalies in the middle and the other region, respectively. It is noted that small high anomalies correspond to areas of the Mikabu unit.

Keywords: Matsuyama, Geological map, gravity, active fault, mineral resource

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

SGL40-P15 Room:Convention Hall Time:May 27 18:15-19:30

Geological Map of Japan 1:200:000, Oita

HOSHIZUMI, Hideo[1*] ; SAITO, Makoto[1] ; MIZUNO, Kiyohide[1] ; MIYAZAKI, Kazuhiro[1] ; TOSHIMITSU, Seiichi[1] ; MATSUMOTO, Akikazu[1] ; OHNO, Tetsuji[1] ; MIYAKAWA, Ayumu[1]

[1]Geological Survey of Japan, AIST

The Oita district, located in the northeastern part of Kyushu Island, geologically comprises various rock types of Paleozoic to Quaternary in age.

The following Paleozoic units are distributed: 1) Late Cambrian ultramafic rocks consisting of serpentinite and pyroxenite with small amounts of gabbro and amphibolite, 2) Late Devonian to Early Silurian Mikuni Cataclastic Granitic Rocks and Honjo Metamorphic Rocks, 3) Silurian to Devonian formations, 4) Permian accretionary complexes, and 5) Early Permian Usukigawa Quartz Diorite.

Mesozoic units on the north side of the UYTL (Usuki-Yatsushiro Tectonic Line) are 1) Cretaceous high-temperature, low-pressure Asaji Metamorphic Rocks and plutonic rocks and Cretaceous low-temperature and high-pressure Sanbagawa Metamorphic Rocks, and 2) a small body of an Early Jurassic accretionary complex of the Nishikawauchi Formation and cataclasite of Cretaceous quartz diorite mylonite.

Mesozoic units on the south of the UYTL are 1) Early Cretaceous high-temperature metamorphic rocks, 2) Late Triassic to Early Jurassic low-temperature and high-pressure metamorphic rocks, 3) Jurassic to Early Cretaceous and Cretaceous accretionary complexes, 4) Late Triassic, Late Jurassic and Cretaceous formations, and 5) Eocene formations. The Mesozoic accretionary complexes are younger approaching apparent lower structural levels, and the thrusts between the each accretionary complex originally dip gently northwest.

The Jurassic to Early Cretaceous accretionary complexes tectonically underlie the serpentinite complex composed of Paleozoic plutonic and metamorphic rocks, low-temperature and high-pressure metamorphic rocks, Permian accretionary complex and Paleozoic and Mesozoic formations.

The Miocene Okueyama Volcano?intrusion Complex is composed of effusive rocks, granitic rocks, and ring dikes. The Ono Volcanic Rocks comprise pyroclastic flow deposits, lava, and tuffaceous sediments.

The Late Pliocene and Early Pleistocene volcanic rocks are composed of Yoshinomoto Andesite, Kantodake Andesite, Hitomidake Andesite, the Shonai, Komatsudai, Tsuetate, Kusu, and Karutoyama volcano groups (VGs), and the Shishimuta Caldera. The Middle Pleistocene to Holocene volcanic rocks are the Tokisan, Kanagoe, Pre-Aso, Haneyama, Ogidake, and Waitasan VGs, the Amagoidake, Takasakiyama Volcano, the Noinedake, Tateishiyama, and Takahirayama VGs, the Ayukawa, Kamiyashiki, Nakatoge, and Yufugawa pyroclastic flow deposits (PFDs), and the Nekodake, Aso, Kuju, Yufu, and Tsurumi Volcanoes.

Pliocene to early Middle Pleistocene fluvial sediments, such as the Sekinan and Oita Groups, the Otagawa Formation, and Tanaka and Hiraishi Gravel members are exposed in the downstream basin of the Oita and Ono Rivers where marine sediments are included in and around the Kusu Basin and in the middle area of the Ono River.

In the northern part of the district, many E?W tending active normal faults are developed. This is called the Beppu?Haneyama Fault Zone.

This area is famous as a dense deposit zone. Especially, Tin deposits in the vicinity Furusobo San (Obira, Mitate and Toroku mine) and limestone of Tsukumi City (Todaka and Shintukumi mine) are well-known. In addition, oldest sulfur mine of Japan was present in the Kuju Volcano.

A high-gravity anomaly trending ENE-WSW is located in the northeastern part of this region. This high-gravity anomaly is consistent with the distribution of high-density metamorphic rocks. Four segments of low-gravity anomalies are observed in the northern part of the region. The northwest low-gravity anomaly segment may be a volcanic basin, namely the Shishimuta Caldera. The other three low-gravity anomalies correspond to tectonically formed basins. The low-gravity anomaly at the west edge of this region originated in the Aso caldera. A wide low-gravity anomaly is observed at Okue Yama in the southern part of this region. This low-gravity anomaly might reflect the physical property of batholithic mass beneath Okue Yama.

Keywords: regional geology, Sanbagawa Metamorphic Rocks, Onogawa Group, Cretaceous accretionary complex, Oita Group, Aso Caldera