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Kizekkyo Sandstone and Conglomerate of the Paleogene Muro Group in the Kii Peninsula, Japan

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Abstract

This paper deals with the source areas of the sediments of the Muro group with special reference to the composition of conglomerates and sandstones. The Muro group may have been supplied mainly from the north. The Ryoke Metamorphic Belt, the Sanbagawa Metamorphic Belt, the Paleozoic regions of the Chichibu Terrain, and the regions of the Sennan Acidic Rocks and the so-called Torinosu Series may be regarded as the provenances of the Muro group. However the materials derived from the Sanbagawa Metamorphic Belt are smaller in quantity and have been discovered only in the rock fragments of the sandstones.

Introduction

The Paleogene Muro group in the southern part of the Kii Peninsula occupies the upper part of the Shimanto Supergroup, which is composed of geosynclinal sediments and ranges from the Mesozoic to the early Cenozoic in age. In this paper the Muro group in the northwestern end is described (Figure 1).

The problem of the source area, which is very important in clarifying geologic developments, has long been ignored in the Shimanto Terrain. The writer will refer to the provenance of the Muro group with special reference to the composition of conglomerates and sandstones. However, the precise discussion will be left to further study.

General Remarks on the Muro Group and the Reported Area

The Muro group is composed of thick geosynclinal sediments, which are flysch-type alternations of sandstone and shale, frequently intercalated by conglomerates, and shows completely folded structures. The Muro group is thought to be upper Oligocene or lower Miocene from molluscan fossil evidences (HARATA et al, 1963;

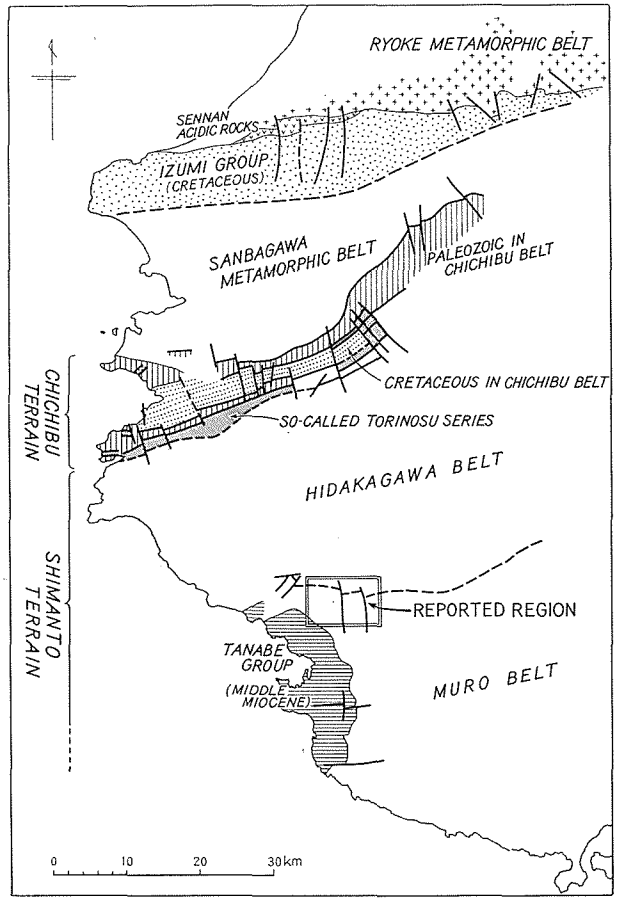

Fig. 1. Index map.

MATSUMOTO, in press). The folded structures have been clarified along the Hiki river where the Muro group attains more than 4000 m. in total thickness (TOKUOKA, 1966). The Muro group in the Kii Peninsula was generally reported by T. HARATA (1964).

The Muro group in this area had once been studied by K. HIROSE (1961, unpublished). It is composed of alternations of sandstone and shale in the lower part. In the upper part it is composed of massive sandstones intercalating conglomerates. The lower part, which is ill exposed and whose geologic structure cannot be well defined, may have isoclinally folded structures. On the contrary, the upper part dips at about 20-40 degrees to the north and overlies conformably on the lower part as shown in Figure 2.

Stratigraphy

The Muro group of this area can be divided into the following three formations, i.e. the Kamiakitsu alternation, the Kizekkyo sandstone and conglomerate, and the Fuzono alternation in ascending order.

Kamiakitsu Alternation: This is distributed along the downstream of the Aizu river in the neighbourhood of Sugihara, and is composed of alternations of sandstone and shale, 10 to 20 cm. bedded. The lower parts are rich in shale, while the upper parts are rich in sandstone. Several sole markings such as flute cast, load cast and biohieroglyph can be seen commonly on the bottom surface of sandstone beds.

Kizekkyo Sandstone and Conglomerate: (a) Kizekkyo Sandstone: This is distributed typically besides the gorge of Kizekkyo. It is composed mainly of massive, very coarse sandstones in which granules are contained in abundance and pebble or cobble gravels are also contained sporadically. It is rarely intercalated by thin alternations of sandstone and shale, 5 to 10 cm. bedded. The composition of massive sandstones, which will be described later in detail, is arkosic, and shale patches are contained in abundance. (b) Kizekkyo Conglomerate: The Kizekkyo sandstone is frequently intercalated by conglomerate beds in the upper part. They are collectively called the Kizekkyo Conglomerate. This is distributed typically in the neighbourhood of Shimomura along the Aizu river and its tributary. Along the Aizu river the conglomerate beds are of more than 12 horizons, while along the upper reaches of the Misu river they are of 3 horizons. This is shown in Figure 3. Their constitution will be discussed later on in detail. They are rounded or subrounded pebble, cobble and boulder gravels. The matrix is very coarse sandstones.

Fuzono Alternation: This is distributed along the road from Kengyo to Fuzono and along the Aizu river from Shimomura to Kagihara. It overlies conformably on the Kizekkyo sandstone. It is 5 to 10 cm. bedded alternations of sandstone and shale rich in the latter, and frequently is intercalated by sandstones of 20 to 100 cm. thick. Minor folded structures are found occasionally.

Kōyadani Formation: This is seen typically around Koyadani. It is mainly composed of shales and rarely intercalated by fine sandstones, 2 to 5 cm. thick, and frequently includes calcareous nodules. It may be correlated to the Inami series at the western coast of Inami-Town, Wakayama Prefecture (MATSUSHITA, 1953). Its geologic age has not been clarified, but it must be older than the Muro group. In this region the Koyadani formation is in contact with the Muro group by the Koyadani fault of E-W trend.

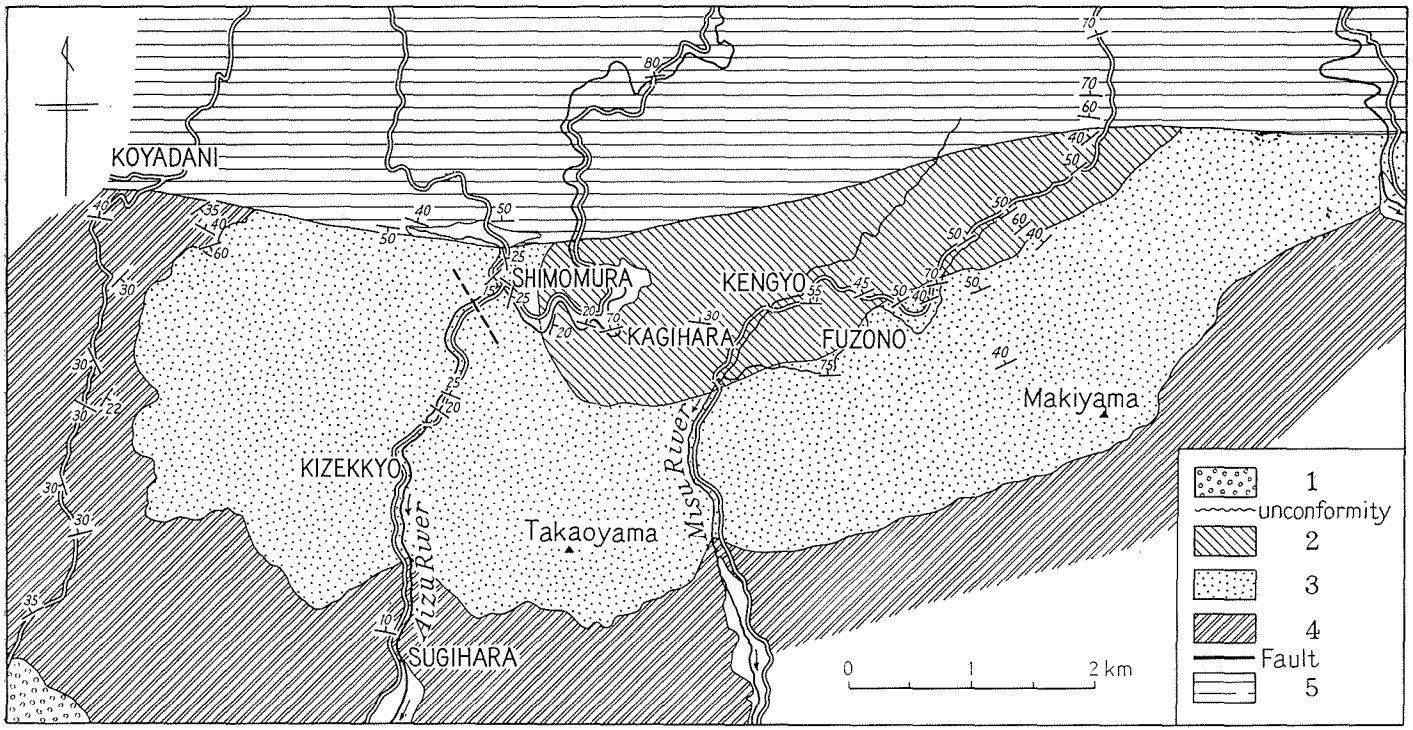

Fig. 2. Geologic map of the northern part of the Tanabe City, Wakayama Prefecture.
(1. Tanabe group, 2. Fuzono alternation, 3. Kizekkyo sandstone and conglomerate, 4. Kamiakitsu alternation, 5. Koyadani formation)

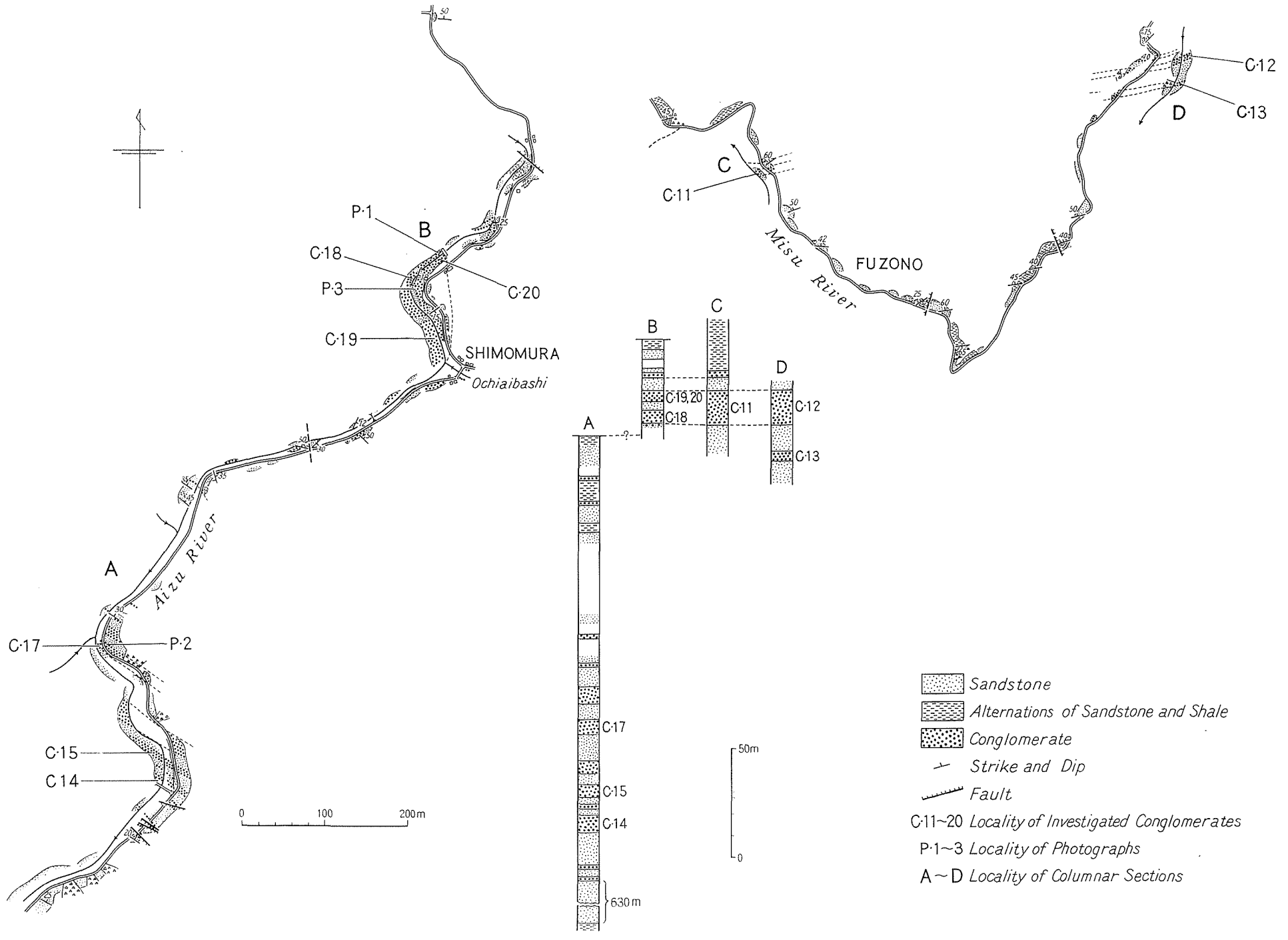

Fig. 3. Route maps and columnar sections of the Muro group.

Geologic Structures

Although the Muro group in general has completely folded structures, it has somewhat gently folded or in other words somewhat basin-like structure in this area. As shown in Figure 2 the Kizekkyo sandstone has NW-SE strike in the west, E-W strike in the central part and NE-SW strike in the east, and as a whole takes basin-like structure, which is cut off by the Koyadani fault. In alternations of sandstone and shale of the Kamiakitsu and Fuzono formations, minor folded structures can be observed frequently.

The Koyadani fault which is seen 500 m. northwest of Shimomura is the boundary between the Koyadani formation and the Muro group. It can be traced continuously to the east in Wakayama Prefecture (HARATA, 1964). The Koyadani formation, the structure of which has not been determined yet, has E-W trend generally and may have isoclinally folded structures which are in accordance with the general trend of the Outer Zone of the Southwest Japan.

The Composition of the Kizekkyo Conglomerate

The study of the composition of the Kizekkyo conglomerate is significant for clarifying the provenance of the Muro group. There are more than 12 layers of conglomerate beds in this area. The writer studied their compositions at 9 localities. In each locality he counted 300 gravels at random at three points in one exposure (at one point 100 gravels were counted). These gravels were limited to the ones larger than 1 cm. in diameter. They were classified in the field into 6 elements by unaided eye, that is, sandstone, shale, chert*, limestone, granitic and gneissose rocks, and acidic volcanic and dyke rocks. These are shown in Figure 4. The quantity of the gravels larger than 10 cm. in diameter is also shown by the inner circles, whose sizes are propotional to their total volume (for instance the quantity of the gravels larger than 10 cm. in C-12 is 16%, and in C-13 it is 1%). Their properties were examined microscopically with gravels of random sampling (Table 1).

Figure 4 suggests the following facts.

1. The gravels are classified into the above mentioned 6 elements, in which sandstone, chert, and granitic and gneissose rocks are dominant.

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* Metamorphic rocks such as schistose hornfels, sandstone hornfels were included in chert. These are very similar with chert and cannot be discriminated from chert by unaided eye. Their quantity may attain to 20% or so of chert mentioned here.

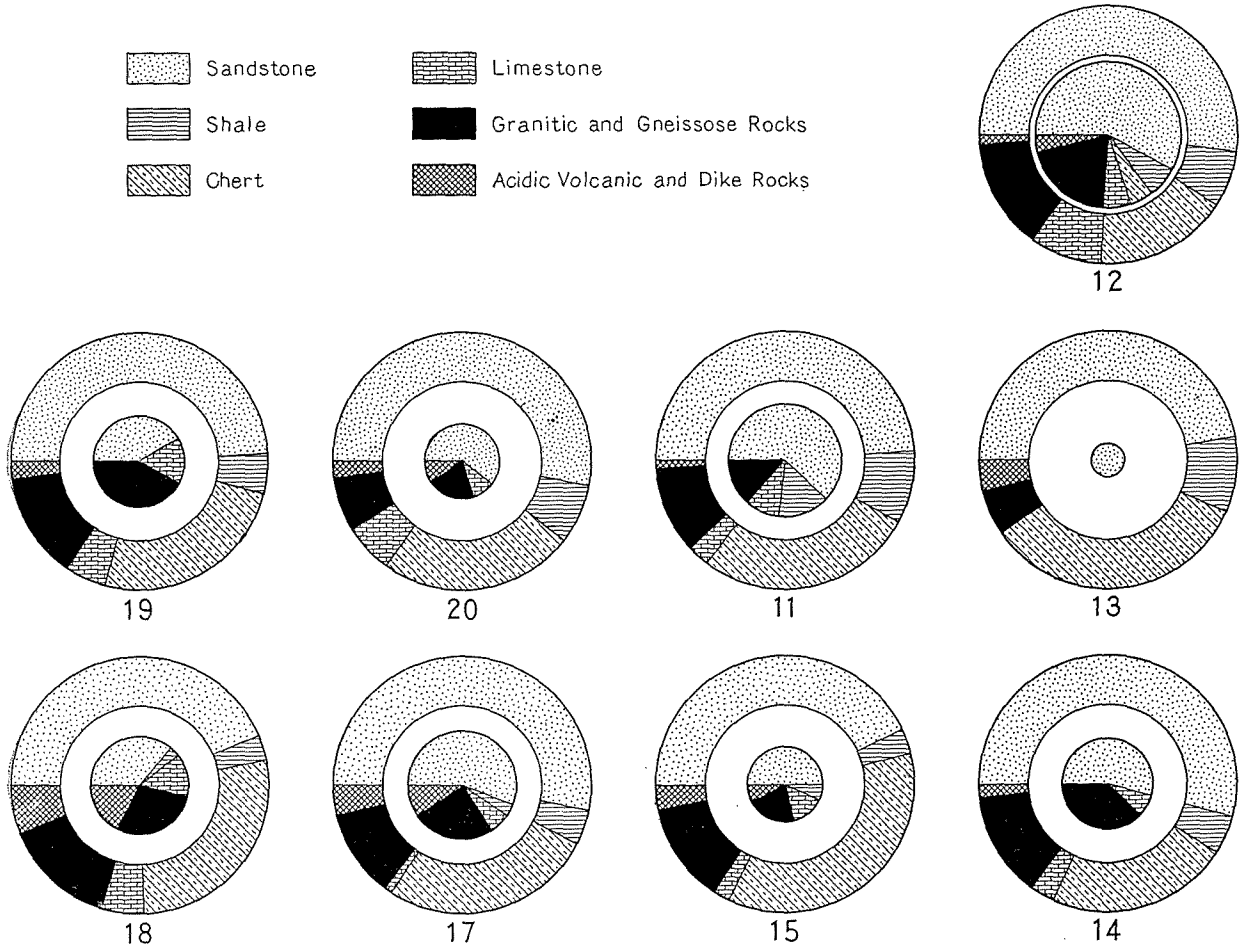

Fig. 4. The composition of the Kizekkyo Conglomerate at 9 localities.

	Locality	C-11	C-12	C-13	C-14	C-15	C-17	C-18	C-19	C-20	Total	
	Number of Sections	38	28	7	40	19	59	12	29	1	233	
GRANITIC AND GNEISSOSE ROCKS	Biotite Granite		9				5	1	9		24	47
	Muscovite Granite								1		1	
	Two Mica Granite		4				3				7	
	Gneissose Granite～Gneiss	1	2				6	1	3	1	14	
	Granodiorite		1								1	
ACIDIC VOLCANIC AND DYKE ROCKS	Graphic granite, Granite Porphyry Microgranite, Aplite	1		1	4	3	3		6		18	55
	Granophyre	1	1	2	2	3	2	1	1		13	
	Quartz Porphyry		1	2	3		3		3		12	
	Dacite								1		1	
	Porphyrite		1					2			3	
	Rhyolite Tuff	1	2	2	1			1	1		8	
LIMESTONE	Muddy Limestone including Foraminifers	5	4		1		3	1	1		15	76
	Muddy Limestone including no Foraminifer	3			1		3	2	1		10	
	Oolitic Limestone	5	2		6		19				32	
	Pure Limestone	16	1						2		19	
CHERT	Chert	1			5	2					8	8
SAND-STONE	Calcareous Sandstone				9	6	4	1			20	36
	Non-Calcareous Sandstone				2	5	8	1			16	
METAMOR-PHIC ROCKS	Schistose Hornfels	2			4			1			7	11
	Sandstone Hornfels	2			2						4	

Table 1. The properties of the Kizekkyo Conglomerate examined by gravels of random sampling (one section shows one gravel, excluding the cases of oolitic limestone and pure limestone).

2. No difference in composition is observed at each locality generally*.
3. The difference of composition according to size is not so much.
4. Granitic and gneissose rocks attain to 15-25% of the total numbers, besides those larger than 10 cm. in diameter attain to 40-60%.
5. Limestones, in which muddy limestones are very much, are commonly contained at each locality.

The properties of the constituent rocks are described in the following.

Sandstone (a) Calcareous sandstone: coarse-medium, subangular-subrounded with calcite matrix. It is noteworthy that this rock contains fragments of schistose hornfels and some schists as grains. (b) Non-calcareous sandstone: medium-fine, angular-subangular graywackes. Schistose hornfels are sometimes included as in the case of calcareous ones.

Limestone (a) Muddy limestone: In fine muddy limestones, sand grains are frequently contained. There are also some schistose hornfels and quartz-schists as sand grains. Undetermined small foraminifers are frequently found. (b) Oolitic limestone: Smaller in quantity, but these are cobbles or boulders in general and sometimes attain to more than 50 cm. in diameter. It is significant that they include abundant fossils such as corals, various small foraminifers, molluscs, stromatoporoids and "*Cidaris*" spines. (c) Pure limestone: The maximum diameter attains to 60 cm. These also include many fossils such as corals, stromatoporoids, molluscs and small foraminifers.

Limestones mentioned above, in particular b and c, are somewhat similar to the so-called Torinosu Limestone of the upper Jurassic and the lower Cretaceous. Corals such as *Thamnastreria* spp., *Aplosmilia* cf. *somaensis* EGUCHI, *Diplaraea?* sp. were found in them**.

Granitic and Gneissose Rocks (a) Granite: This includes biotite granite, muscovite granite and two mica granite, and among them biotite granite is most abundant. They often bear garnet. (b) Gneissose granite and gneiss: Gneissose granites form the majority. It is frequently garnet-bearing. Mosaic structure and undulose extinction are clearly observed in quartz. Secondary twin lamellation in plagioclase felspar can commonly be seen.

Acidic Volcanic and Dyke Rocks: (a) Rhyolite tuff: Flow structure and welded

* In comparison with the composition of conglomerates in the Hiki river area, there are many granites and gneissose granites, and less acidic volcanic and dyke rocks in this area. In acidic volcanic and dyke rocks, there are abundant rhyolite tuffs, in which about a half are welded ones, and few dyke rocks in the Hiki river area (TOKUOKA, 1966). On the contrary there are few rhyolite tuffs and comparatively many dyke rocks in this area.

** Corals were identified by N. YAMAGIWA.

structure are scarcely observed, and crystals of quartz are commonly corroded. (b) Dyke rocks: Granophyre, quartz porphyry, dacite and porphyrite are included. Although their quantity is not so large, they are commonly contained in all layers.

The above-mentioned facts lead to the following considerations.

1. The granitic and gneissose rocks and schistose hornfels may have been supplied from the Ryoke Metamorphic Belt which is situated to the north of the Shimanto Terrain.
2. The limestones must have been transported from the areas where the so-called Torinosu limestones are distributed or have once been distributed.
3. The acidic volcanic and dyke rocks may have been supplied from the Sennan Acidic Rocks along the southern margin of the Ryoke Metamorphic Belt.
4. The calcareous sandstones, whose quantity is about half of the sandstone gravels, may have been derived from the so-called Torinosu series, although it is not so clear.
5. The cherts may have been supplied from the Paleozoic rocks of the Chichibu Terrain.

The Composition of the Kizekkyo Sandstone

Massive, very coarse Kizekkyo sandstones were investigated. They were studied in thin slices and their compositions were plotted to a triangle diagram based on the three end members, quartz, felspars, and rock fragments and matrix (Figure 5).

The following facts were clarified.

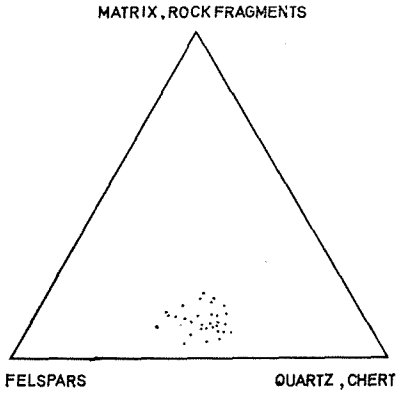

Fig. 5. The composition of the Kizekkyo Sandstone.

1. Sandstones are very coarse and contain abundant granule gravels and shale patches.
2. The grains are subangular and generally ill sorted.

3. They are arkosic and have very smaller amount of matrix.
4. Many quartz grains show undulose extinction, which suggests gneissose source areas.
5. K-felspars are abundant and angular in shape, suggesting their granitic origin.
6. Rock fragments are granitic rocks, acidic rocks, shales, sandstones, schistose hornfels, schists and andesitic rocks. Among them fragments of schist are noteworthy, although they are very rare. They are mostly quartz-schists, and rarely graphite-schist.* They may have been derived from the Sanbagawa Metamorphic Belt.

Summary

1. The Paleogene Muro group in the northern part of the Tanabe City was investigated with special reference to the composition of conglomerates and sandstones.
2. The Muro group of this area is divided into the following formation, i.e. the Kamiakitsu alternation, the Kizekkyo sandstone and conglomerate, and the Fuzono alternation in ascending order.
3. The composition of the Kizekkyo conglomerate was studied. There are sandstone, shale, chert, limestone, granitic and gneissose rocks, acidic volcanic and dyke rocks, schistose hornfels and others in the gravels of the Kizekkyo conglomerate. They may have been supplied from the Ryoke Metamorphic Belt, the region of the Sennan Acidic Rocks, the Paleozoics of the Chichibu Terrain and the regions of the so-called Torinosu series.
4. The composition of the Kizekkyo sandstone was also studied. It is arkosic. In the rock fragments of sandstones there are small quantities of schist in addition to all rocks found as the gravels of the Kizekkyo conglomerate. The fragments of schist may have been derived from the Sanbagawa Metamorphic Belt.

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* Schists were determined by I. NAKAYAMA, to whom the writer expresses his thanks.

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Explanation of Plate 7

Fig. 1. Maximum granite boulder in the Kizekkyo Conglomerate (Locality C-20, Gneissose granite)
Fig. 2. Limestone boulder in the Kizekkyo Conglomerate (Locality C-17, Oolitic limestone)

Fig. 1.

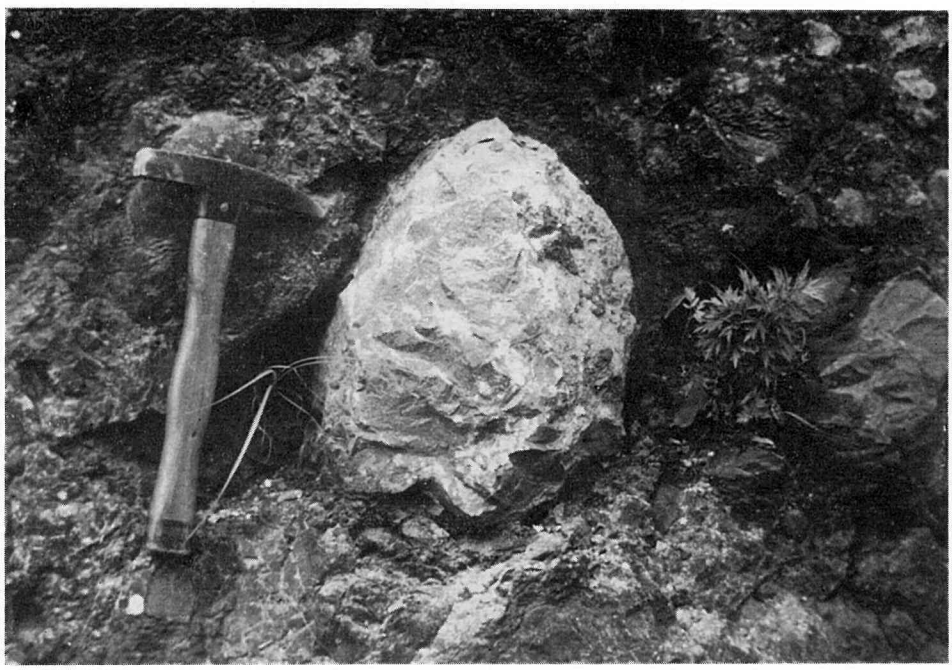

Fig. 2.

Explanation of Plate 8

Fig. 3. Exposure of the Kizekkyo Conglomerate at Locality C-18
Fig. 4. Massive, very coarse Kizekkyo Sandstone including abundant shale patches (large block of shale also included at the right)

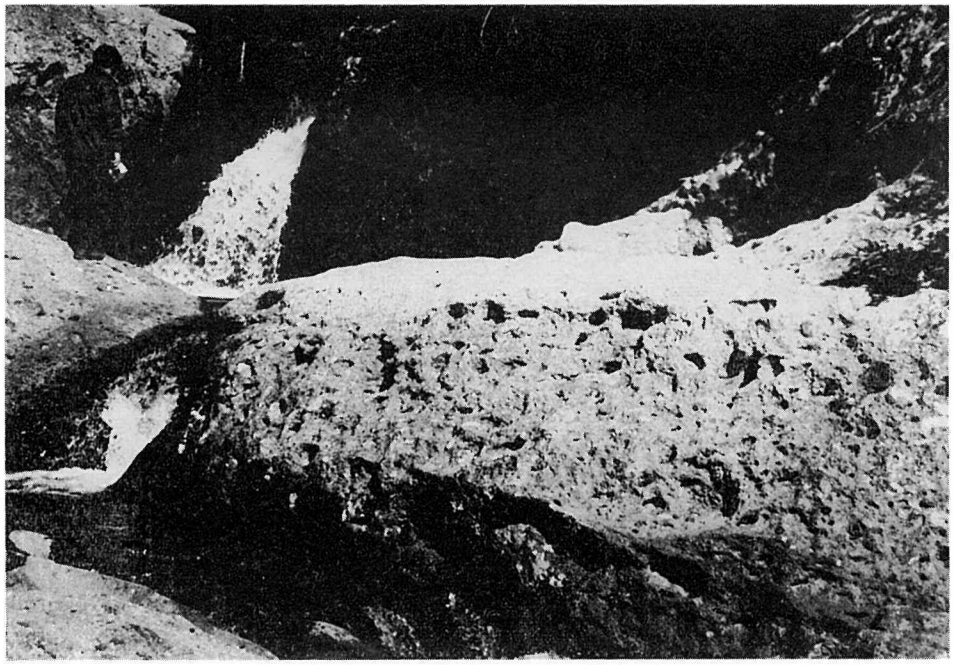

Fig. 3.

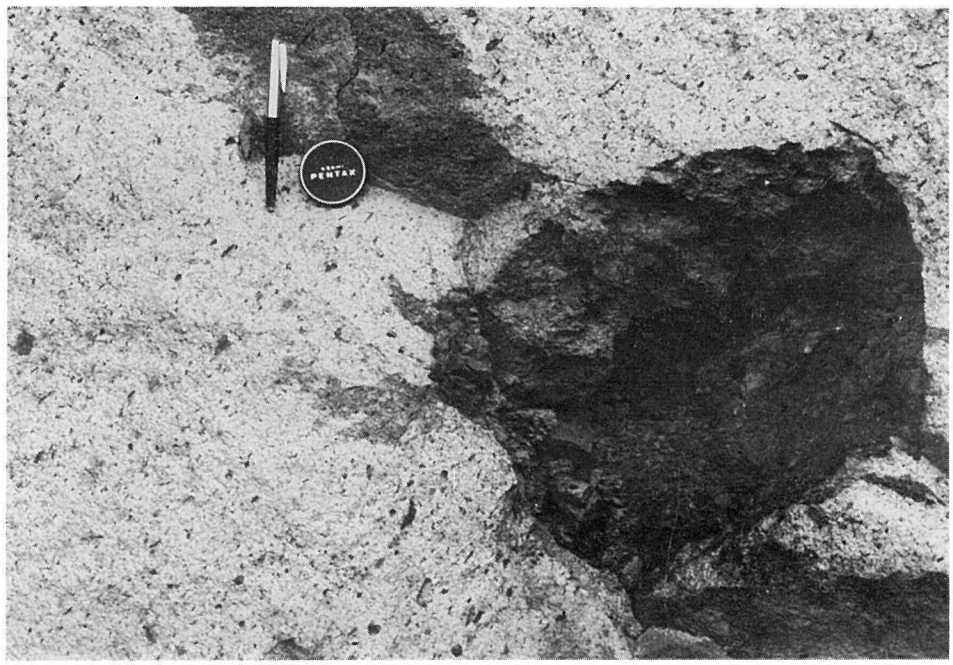

Fig. 4.