On the Onuma Formation of the Kumano Group (A study of the Tertiary formations of the Kumano Coal-field in the Kii Peninsula, Southwest Japan, Part 3)

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On the Onuma Formation of the Kumano Group

(A study of the Tertiary formations of the Kumano Coal-field in the Kii Peninsula, Southwest Japan, Part 3)

Kazutoyo CHIJIWA and Suzuomi TOMITA

Abstract

The Onuma Formation, which is a basal one of the Kumano Group in the northern district of the Kumano basin, has a maximum thickness of 800–900 m, and is lithologically divided into the Komatsu, Kohno-ue and Kawabata members in ascending order. The Komatsu Member consists of basal conglomerate and sandstone, and is characterized by a considerable variation of thickness. The Kohno-ue Member is composed mainly of massive to thick-bedded dark grey siltstone, of which silicified and hardened rock is known as 'Nachi-guro' stone. The Kohno-ue Member is estimated to be of offshore sediments under the continental shelf or more deeper environments judging from fossil habitat. The Kawabata Member is made up largely of rhythmically alternating beds of sandstone and mudstone, and contains a channel-fill conglomerate lens in the lower part and pebbly mudstone closely associated with slump beds in the middle and upper parts. This member is interpreted as a turbidite clastic wedge which was deposited in a continental slope basin having some submarine canyons, which inclined toward the south or southwest. The clastic wedge thins away to the southward. A detailed field-research has confined that the Onuma Formation is correlative with the lower part of the Koguchi Formation in the southern district and that the Kawabata Member of the Onuma Formation and a part of the Shikiya Member of the Koguchi Formation in the southern district are heteropic.

Introduction

The Miocene Kumano Group is widely exposed in the southeast part of the Kii Peninsula and covers with remarkable unconformity the basement Shimantogawa Supergroup developed in the Shimanto terrain.

The Kumano Group is one of the post Shimanto Neogene strata which are intermittently distributed in the Outer Zone of Southwest Japan. Geological reports dealing with this group have been published by many authors, in which TANAI and MIZUNO (1954), MURAYAMA (1954), MIZUNO (1957), MIZUNO and IMAI (1964), HIROKAWA and MIZUNO (1965), SAEKI and KOTO (1972), MITI (1979), CHIJIWA and TOMITA (1981 a and b), HISATOMI (1981), and HISATOMI and MIYAKE (1981) must be counted, but generalized stratigraphy of this group being applicable to whole sedimentary basin has not been established because of its characteristic lateral change of lithofacies. Particularly, of the Kumano

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Group, the Onuma Formation, a basal one in the northern district of Kumano basin, has still many unsolved problems concerned with its formation and distribution. To make clear such problems is the most important for study on the sedimentary basin and drawing of paleogeography of the Kumano Coal-field.

We have been engaged in a sedimentological study of the Kumano Group in and around the Kumano Coal-field and have briefly reported on the one of a part of the Onuma Formation (CHIJIWA and TOMITA, 1981 a). More detailed stratigraphy and distribution of the Onuma Formation with some analytical report from sedimentological point of view are given in this paper, and its sedimentary feature is also discussed.

I. Geological setting

The Kumano Group is the latest Early to eariest Medial Miocene in age and is distributed in the large area of the southeast part of the Kii Peninsula. This group overlies unconformably the Shimantogawa Supergroup and is overlain by the Kumano acidic rocks which forms a rugged mountainous area and separates the distribution area of the Kumano Group into several districts. From the lithological facies, the Kumano Group in the northern district* is divided into three formations, the Onuma, Koguchi and Mitsuno formations in ascending order. The lowermost Onuma Formation is restricted in its distribution to the northern two districts. The Koguchi Formation is lithologically distinguished into two members, thick siltstone of the Shikiya Member and alternating sandstone and siltstone of the Koguchi Member. The uppermost Mitsuno Formation consists of sandstone, siltstone and alternating sandstone and mudstone with some intercalations of conglomerate and coal. The Mitsuno Formation is divided into four members by lithofacies, but which change from place to place to a great extent. In the southern district, on the other hand, the Kumano Group is composed of two formations, the lower, Koguchi and the upper, Mitsuno. The Koguchi Formation in this district lies directly on the basement rocks with an unconformity and is divided into three members, the Ohara, Shikiya and Koguchi members in ascending order. Of these members, the lowermost Ohara Member consists of conglomerate and sandstone and is considered to be equivalent to a part of the Onuma Formation in the northern district as discussed in Chapter IV. The Mitsuno Formation in the southern district falls into seven members from lithofacies. The Kumano Group in the southernmost district including the coastal parts of the Kii Peninsula is divided into three formations, the Shimosato, Shikiya and Mitsuno formations in ascending order (HISATOMI, 1981). The lowermost Shimosato Formation is composed of flysh-type muddy thick sediments and is heteropic to the Onuma Formation.

The members of the Kumano Group in the northern and southern districts show semi-trough structure stretching NNE-SSW with gentle inclination to the

* Division of the distribution area of the Kumano Group was explained in the footnote of the first report (CHIJIWA and TOMITA, 1981a, p. 158).

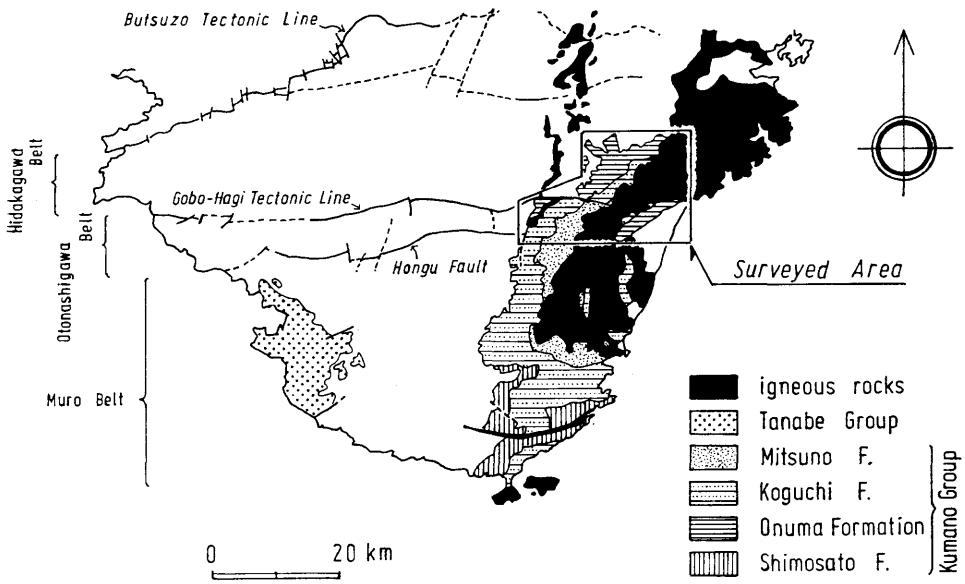

Fig. 1. Generalized geological map of the southern Kii Peninsula.

Kumano acidic rocks as if the former surrounds the latter (Fig. 1).

The stratigraphy and sedimentary environments of the upper two formations of this group in the northern and southern districts have been described and discussed in the previous reports.

II. Stratigraphy of the Onuma Formation

A. General remarks

Because the northern district of the Kumano basin is situated in a mined area of ore deposits, various informations on the geology and ore deposits were published by many workers including the research group of the old Kishu Mine (i.e. WATANABE, *et al.*, 1951; SAEKI, 1955・1959 and 1961; SATO, 1958; ONO, 1961・1969 and 1971; ABE and ONO, 1967; SAEKI and KOTO, 1972; and MITI, 1979). WATANABE *et al.* divided the Kumano Group in the vicinity of the Kishu Mine lithologically into three formations, the Kawabata, Taketo and Itaya in ascending order. Four formations, the Onuma, Taketo, Itaya and Ohkochi, were distinguished by SAEKI (1955). The authors show new classification of this group such as the Onuma, the Koguchi and the Mitsuno Formation in ascending order from the lithofacies being distinguishable throughout the northern to southern districts (CHIJIWA and TOMITA, 1981 a). The Koguchi Formation corresponds to the Taketo Formation of WATANABE and SAEKI, and both of the Itaya and Ohkochi formations of the latter belongs to the Mitsuno Formation. The typical lithofacies of Kumano Group in the northern district is illustrated in Fig. 2.

By the mountain mass composed of Kumano acidic rocks, the Onuma Formation is separated into two distribution districts, the Onuma district along

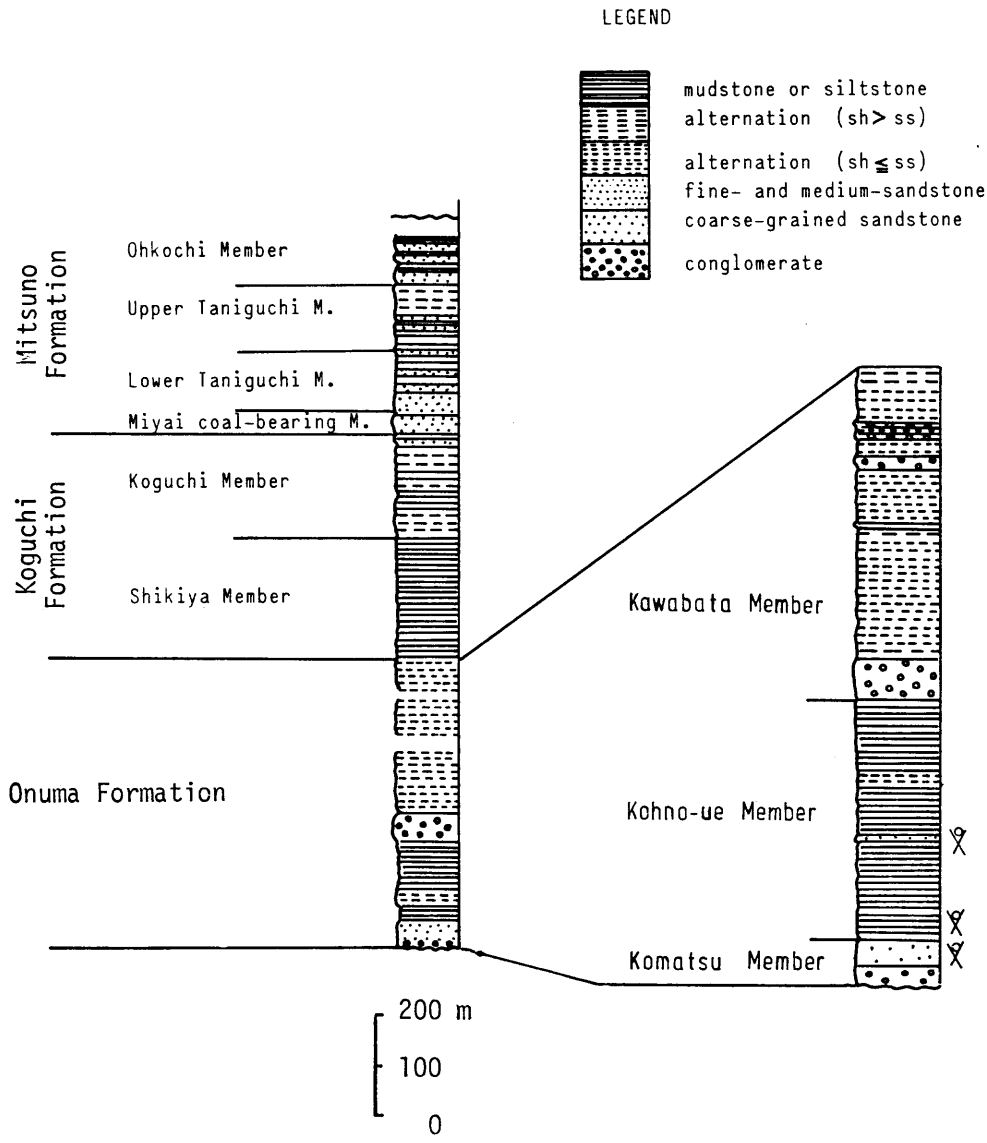

Fig. 2. Type section of the Kumano Group in the northern district.

the mid-stream of Kitayama, a branch of the Kumano River, to the west of mountain mass and the Oroshi district giving a distant view of the Pacific Ocean to the east. The strata of the Onuma Formation trend north-northeasterly or northeasterly with dip of 10° to 25° to the southeast in the Onuma district, and strike northeast to southwest with northwesterly dip of 10° to 20° in the Oroshi district. The lower part of the Onuma Formation in the former district is subjected to mineralization, which is called as the Kinan type mineralization and appear to have genetically close relation to the igneous activity of the Kumano acidic rocks (SAEKI and KOTO, 1972), and is hardened by

silicification as far traceable to the township-boundary of Kumanogawa-cho (town), Wakayama Prefecture. But degree of silicification varies locally. In the Oroshi district, on the other hand, both mineralization and silicification have limitedly occurred.

The Onuma Formation has a maximum thickness of 800 to 900 m, and is lithologically divided into three members, tentatively named Komatsu, Kohno-ue and Kawabata in ascending order. They seem to correspond with the Komatsu fine-grained sandstone Member, the Nachiguro black shale Member and the Kawabata alternating beds Member defined by SAEKI and KOTO respectively. The distribution and lithological facies are described as follows and are shown as Figs. 9 and 10.

B. Descriptive notes on the Onuma Formation

1. Komatsu Member*

The lowermost division of the Onuma Formation, the Komatsu Member, is the basal sequence of Kumano Group in the northern district. It is composed of conglomerate and sandstone and is characterized noticeable variations of thickness and lithofacies as shown Fig. 9.

In general, conglomerate and conglomeratic sandstone of the basal part rests unconformably upon the basement rocks and is overlain by sandstone. Sandstone in the main part of this member shows an upward-fining lithofacies and gradually changes into massive dark siltstone of the overlying Kohno-ue Member. Conglomerates are also sometimes intercalated in the upper part. The very fine-grained sandstone in the upper part of this membr yields such molluscan fossils as *Cyclocardia* sp. and *Turritella* sp. at two localities.

The Komatsu Member attains to maximum thickness of 170 m at Kanahori in the Oroshi district, but only 2 m near Kohno-ue in the Onuma district.

2. Kohno-ue Member**

The Kohno-ue Member is made up largely of massive to thick-bedded, fairly homogeneous, medium- to caorse-grained dark grey siltstone with thinly alternating beds of sandstone and mudstone. Conglomerate lens, conglomeratic sandstone, pebbly mudstone, structureless fine-grained sandstone of 1–2 m in thickness and bedded muddy sandstone are also occasionally inserted. Many of the occasional intercalations said above are discontinuous, but bedded muddy sandstone, which is intercalated in the middle part of this member in the Oroshi district with a thickness of 40–80 m, is well traceable over 7 km. The siltstone of this member in the Onuma district, as mentioned previously, is remarkably silicified and has been metamorphosed to slate. This hardened and fine-textured black slate is called as 'Nachi-guro' stone and is quarried in the vicinity of Kohno-ue.

The Kohno-ue Member has a maximum thickness of 500 m in the Onuma district and thins rapidly toward the southwest. The thickness of this member

* 小松層（模式地：和歌山県東牟婁郡北山村小松）
** 神ノ上層（模式地：三重県熊野市神ノ上）

cannot be estimated near Isato, northernmost of the distribution area of the Kumano Group, because the boundary between this member and the overlying Kawabata Member becomes indistinct northeastward. In the Oroshi district, the Kohno-ue Member attains 440 m as the maximum thickness near the southwesternmost part, and has a tendency of northeastward thinning.

Various fossils are obtained from the lower and middle part of this member. They are molluscs, echinoids, elasmobranchs, corals and foraminifers as shown in Table 1, and have occurred in the massive siltstone and muddy sandstone.

3. Kawabata Member*

Both the lower and the upper boundaries of the Kawabata Member between the overlying and underlying ones are conformable. In the west of Kohno-ue in the Onuma district, conglomerate sequence lies upon massive siltstone of the underlying Kohno-ue Member with a sharp contact. On the other hand, the conglomerate of basal part of this member in the Oroshi district is locally observed near Kanayama, northeasternmost of this district, but pebbly mudstone of several meters in thickness covers the top of Kohno-ue Member at Konogi. These conglomeratic sequences are overlain by alternating beds of sandstone and mudstone. Thin alternation of sandstone and mudstone occupies most of the Kawabata Member. Some intercalations such as massive or bedded conglomerate, conglomeratic sandstone, bedded sandstone, pebbly mudstone, slump beds and structureless thick sandstone beds are also found. Intercalating pebbly mudstone or conglomeratic sandstone shows thickness ranging from several tens centimeters to several meters, but exceptionally attains upward of 10 m in thickness.

While a thickness of the Kawabata Member in the Onuma district is great and invariable, and reaches to 390 m as the maximum, it decreases to 280 m in the Oroshi district, and tends rapidly to be thin and fine southwestward. Then it is less than 10 m thick near Oroshi, and thins away to the southwest. Near Oroshi in the Oroshi district, this member consists of thinly bedded sandy siltstone, sandstone and mudstone.

III. Sedimentary features of the Onuma Formation

A. Lithological description

1. Conglomerate

Of the lowermost Komatsu Member, conglomerates are composed of rounded to well-rounded gravels ranging granule to bouler in size and ill-sorted fine- to medium-grained sandy matrix. The dominant gravels are pebble-sized, but rarely boulder with a length of 1 m or more are observed. Granule and pebble conglomerates exhibit clast-support texture. Conglomerates are polymictic and contain such gravels as sandstone, chert, hornfels, vein-quartz, felsite, slate, acidic tuff, siltstone, granite, quartz porphyry, quartzose schist and

* 川畑層（模式地：三重県南牟婁郡紀和町川畑）

metaquartzite, but both sandstone and chert exceed 90% of gravels in each locality. Nearby the same gravel compositions are also recognized in conglomerates of other two members of the Onuma Formation.

The conglomerate sequence at the lowermost part of the Kawabata Member consists mainly of medium- to very thick-bedded pebble conglomerate beds, and shows remarkably changeable thickness ranging from 0 to 70 m as shown in Fig. 3. This sequence is interpreted as a kind of channel-fill deposits judging from its local distribution and rapid lateral change of the thickness, although it rests on the underlying massive siltstone with sharp contact and scouring cannot be observed. And in a thicker sequence (regarded as an axial part of the channel), it exhibits a thinning and fining upward sequence starting from pebble conglomerate in the basal part and ending to sandstone in the uppermost as shown in Fig. 4. Until now, the sedimentary structures of channel-fill conglomerates have been discussed in relation to the ones in a submarine fan facies model, and some internal structural models of conglomerate have been established on the basis of existense of reverse grading, normal grading and stratification (DAVIS and WALKER, 1974; WALKER, 1975・1978 and 1979; and TATEISHI, 1977). The conglomerate sequence, which is closely associated with turbidite as mentioned later, in the Kawabata Member are evidently regarded as channel-fill conglomerate, in which various internal sedimentary structures besides ones

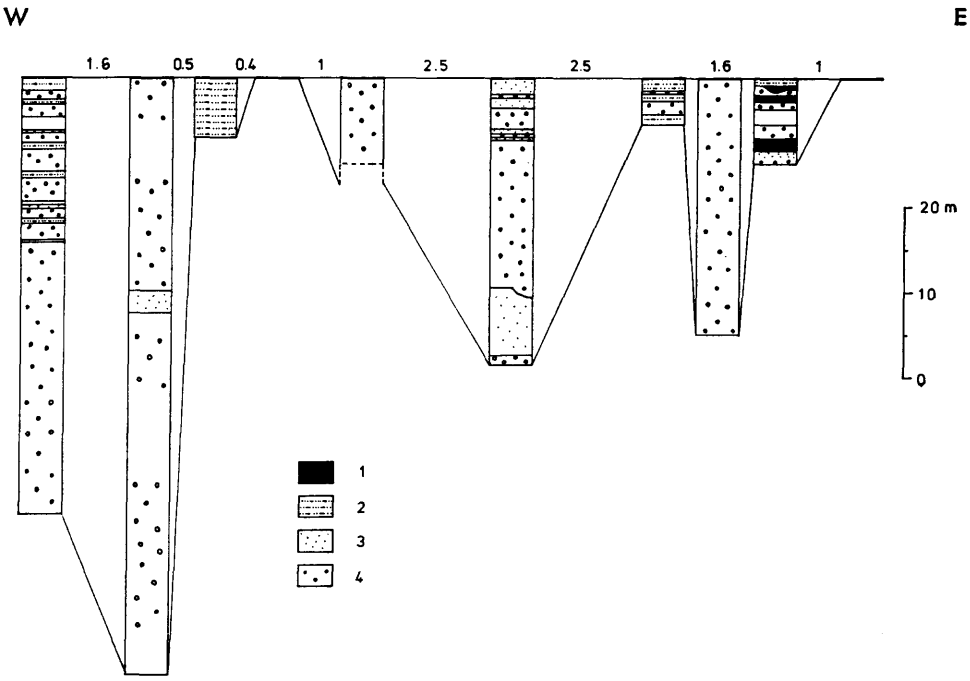

Fig. 3. Comparative columnar sections of the conglomerate sequence at the lowermost part of the Kawabata Member in the Onuma district. Numerals above the upper line indicate the distance(km) between each section. (1: siltstone, 2: alternative sandstone and siltstone, 3: sandstone, 4: conglomerate)

depicted by DAVIS and WALKER (1974) are observed as shown in Fig. 5. In general, disorganized-bed typed conglomerates (WALKER, 1975 and 1978) are rich in the lower part of the conglomerate sequence; inverse to normal graded and graded-bed typed conglomerates in the middle part; graded-stratified conglomerates in the upper part.

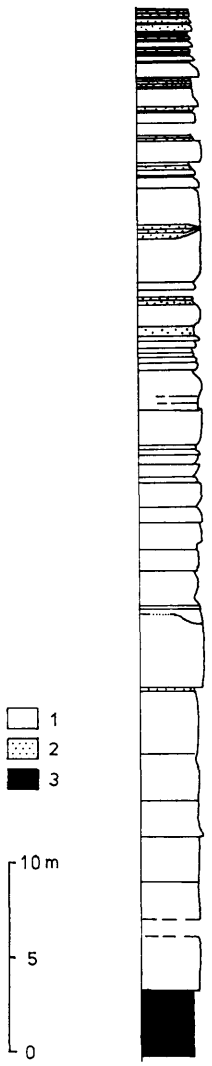

Fig. 4. Upward-thinning sequence of the conglomerate at the lowermost part of the Kawabata Member.
(1: conglomerate, 2: sandstone and conglomeratic sandstone, 3: siltstone)

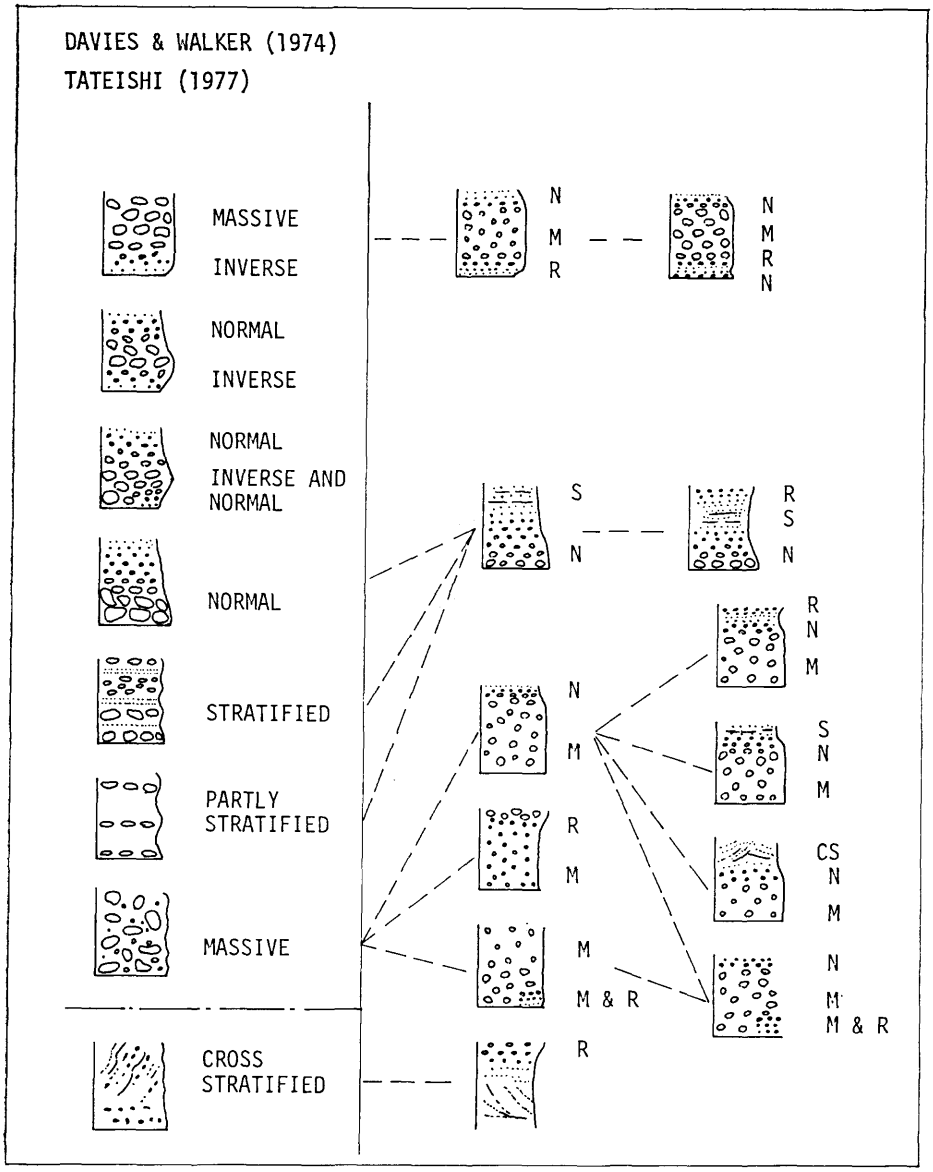

Fig. 5. Internal sedimentary structures of conglomerate beds in the Kawabata Member. (M: massive or structureless, R: reverse grading, N: normal grading, S: parallel to sub-parallel stratification, CS: cross-stratification)

2. Sandy and muddy sediments

Sandstones of the Komatsu Member are in general of massive to thick-bedded very fine- to medium-grained, ill-sorted wacke type. They contain scattered pebbles in places and very rarely exhibit low-angle cross-stratification.

Of the Kohno-ue Member, bedded thick muddy sandstone of about 4 to 80 m thick is remarkable and traceable on many outcrops in the Oroshi district,

but other intercalations are discontinuous. Thinly bedded sandstones alternating with siltstone of the same member are of ill-sorted wacke type.

Pebbly mudstones of the Kohno-ue Member having a thickness of several meters crop out at Utsukio* in the Onuma district and also at Kanayama in the Oroshi district, and have rounded to subrounded pebble- to cobble-sized sandstone gravels. They show a matrix-support texture.

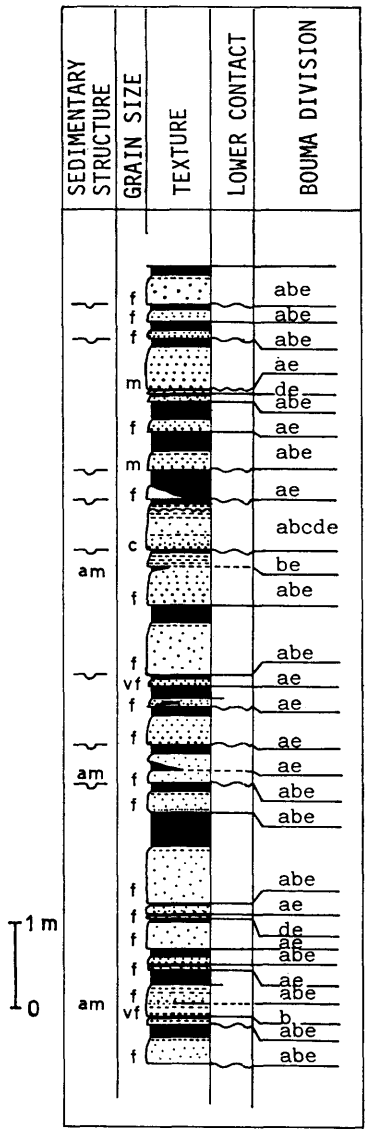

Fig. 6. Detailed columnar section of rhythmically alternating beds of sandstone and mudstone. Sandstones exhibit Bouma sequence and rarely amalgamated bedding (am).

* At present, uninhabited hamlet.

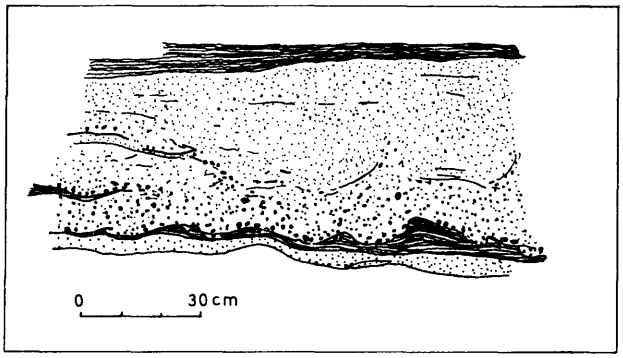

Fig. 7. Amalgamation in pebbly medium- to coarse-grained sandstone.

The alternating beds of sandstone and mudstone are representative of the Kawabata Member. The sand-mud ratio changes regionally and horizontally. Thickness of sandstone beds in the alternation ranges 5 to 75 cm, but in most of it is less than 15 cm. Almost all sandstones are ill-sorted lithic wacke, and exhibit normal graded bedding and regular change of internal sedimentary structure, which is observed in Bouma sequence (BOUMA, 1962) as shown in Fig. 6. Of them, medium- to coarse-grained sandstones are liable to show BOUMA's complete sequence, but many fine-grained one show Tabe, Tae, Tabcde, Tcde and Tde of Bouma sequence. Composite grading, amalgamated bedding (Fig. 7) and current marks are rarely recognized. Therefore, thin sandstone beds in the Kawabata Member are decided as turbidite derived from turbidity current.

In the Kawabata Member, intercalated pebbly mudstone has rounded to subangular granule to boulder gravels and irregular sandstone lens. This mudstone shows a matrix-support texture and scours the underlying bed. Slump beds are also found closely with pebbly mudstones. In the slump beds, contorted bedding of sandstone are recognized.

B. Discussions

This time the fossils such as molluscs, echinoids, corals and elamoblanchs were collected from the Komatsu and Kohno-ue members of the Onuma Formation exposed at 10 localities (Fig. 10), and particularly the Kohno-ue Member in the Oroshi district yields abundant fossils. Horizons and lithofacies of the fossil-bearing beds of each locality are as follows:

Loc. 1 and 2 Komatsu Member, massive very fine ss.
Loc. 3–7 and 9 Kohno-ue Member, massive dark grey siltstone.
Loc. 8 Kohno-ue Member, muddy sandstone.
Loc. 10 Kohno-ue Member, conglomeratic muddy ss.

The mode of occurrence of bivalves and gastropods at each locality is as follows, except for Loc. 10 where only corals were obtained: At Loc. 1,

Turritella sp. is scattered and arranged subparallel to the bedding plane. The abrasion and preferred orientation of shell is hardly observed. Loc. 2–6 and 9 show sporadically scattered occurrence of shells, but Loc. 7 exhibits fairly crowded occurrence. Shells at these localities are arranged parallel or oblique to the bedding plane is general. The abrasion and fragmentation of shells are slight. Many bivalves are disarticulated. However, some individuals of *Cyclocardia* sp. and *Saccella* sp. are preserved with the conjoined valves. All of *Cultellus izumoensis* are articulated and well preserved. At Loc. 8, Pectinidae associated with corals are yielded abundantly. The abraded and fragmentary shells including pectinids are as many as non-abraded and non-fragmentary ones. The mode of preservation is not good. All of shells are disarticulated and are arranged parallel to the bedding plane.

Judging from the above-mentioned observations, it might be supported that the bivalves and gastropods at Loc. 1–7 and 9 show an autochthonous occurrence, and they would not have been carried from a distance even if they had been reworked after their death. On the other hand, in a strict sense, the fossils occurrence at Loc. 8 might not be of autochthonous since the abraded and fragmented shells could be seen. However, the fact of the association with the non-abraded shells of the same species suggests that the fossils at Loc. 8 didn't undergo further transport after death from their habitat. This is also supported by the coincidence of the lithology of the Loc. 8 and of the modern habitat of the same genus yielded at Loc. 8. Taking above things into consideration, it might safely to said that the bivalves and gastropods at each locality were deposited in and/or near their habitat.

From the fossils assemblage as shown in Table 1 and the fossil-occurrence, it could be said that the sediments bearing such fossils may be accumulated in the inner sublittoral zone (HIGO, 1973; and HABE, 1977). From barren of current- or wave-generated sedimentary structure and from fossil habitat, it is estimated that the thick massive siltstone occupying most of the Kohno-ue Member is of offshore sediments deposited from suspension under the continental shelf or more deeper environment.

Explanation of Plate 41

Fig. 1. *Cultellus izumoensis* YOKOYAMA Loc. 7.
Fig. 2. *Chlamys* cf. *nisataiensis* OTUKA Loc. 8.
Fig. 3. *Chlamys* cf. *iwamurensis* ITOIGAWA Loc. 8.
Figs. 4 and 5. *Cyclocardia siogamensis* (NOMURA) Loc. 7.
Fig. 6. *Placopecten* ? *protomollitus* (NOMURA) Loc. 8.
Fig. 7. *Cryptopecten yanagawaensis* (NOMURA & ZINBO) Loc. 8.
Figs. 8 and 9. *Macoma izurensis* (YOKOYAMA) Loc. 7.
Fig. 10. *Macoma optiva* (YOKOYAMA) Loc. 7.
Figs. 11 and 12. *Periploma* sp. Loc. 7.
Figs. 13 and 14. *Saccella miensis* ARAKI ×1.2. Loc. 7.
Fig. 15. *Portlandia* (*Portlandella*) *watasei* (KANEHARA) Loc. 9.
Fig. 16. *Crassatella* sp. ×1.2. Loc. 8.
Fig. 17. *Acila* (*Trancacila*) sp. Loc. 9.
Fig. 18. *Nuculana* sp. ×2. Loc. 9.

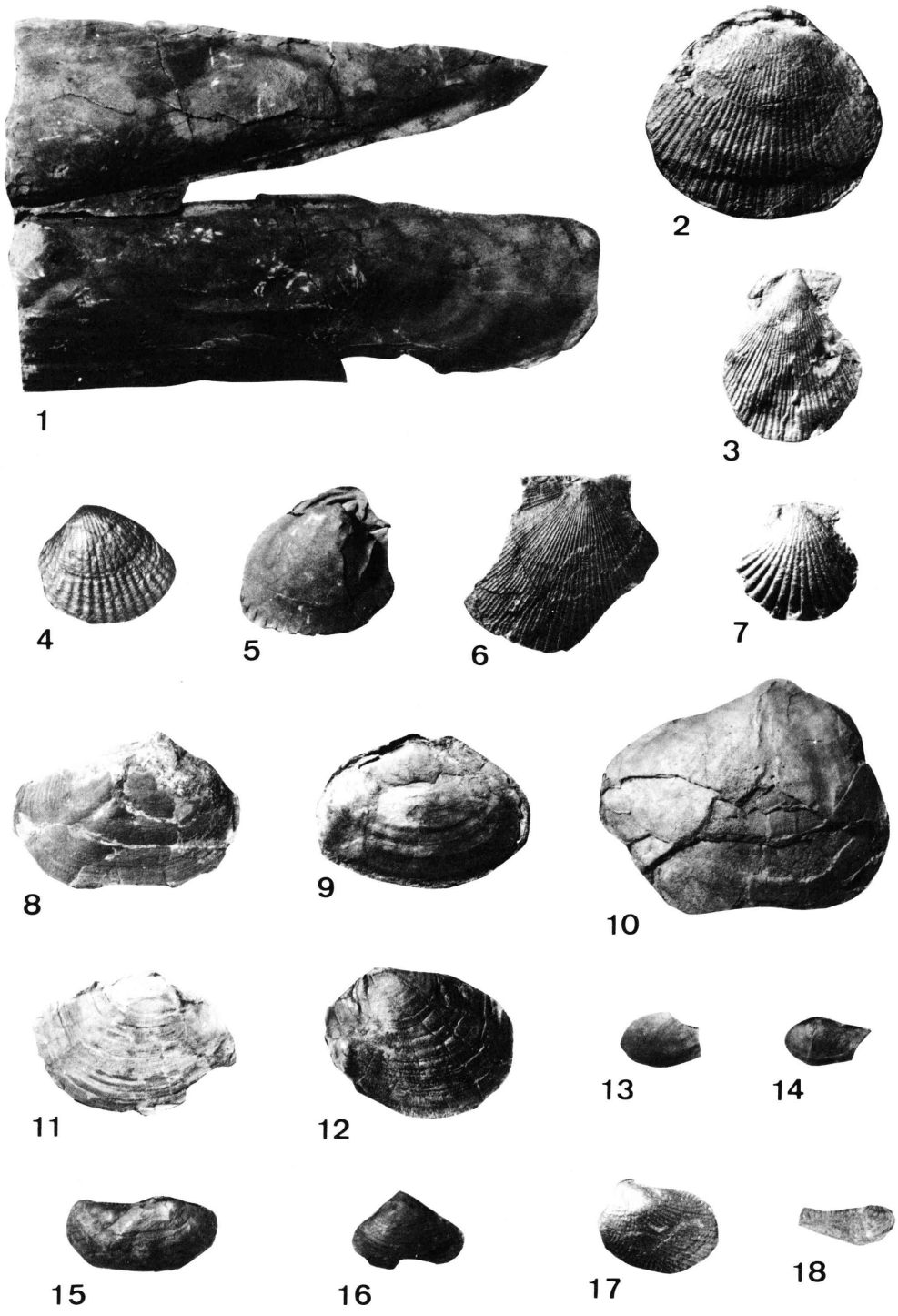

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Table 1. List of fossils from the Onuma Formation
(C: more than 5 individuals, R: less than 5 individuals)

	Species	Locality									
		1	2	3	4	5	6	7	8	9	10
Molluscs	*Cultellus izumoensis* YOKAYAMA							C			
	Cyclocardia siogamensis (NOMURA)						R	C			
	Cyclocardia sp. A		R					C		R	
	Cyclocardia sp. B							R			
	Macoma optiva (YOKOYAMA)						R	C			
	Macoma izurensis (YOKOYAMA)							C		R	
	Macoma sp.			R		R	C				
	Periploma cf. *mitsuganoense* ARAKI					R					
	Periploma sp.				R		R	C			
	Portlandia (Portlandella) watasei (KANEHARA)						R	C		C	
	Nucula sp.							R		R	
	Saccella miensis ARAKI							R			
	Saccella sp.					R		R			
	Acila sp.							R		C	
	Acila (*Truncacila*) sp.									R	
	Chlamys sp.							R			
	Sarepta ? sp.							R			
	Nuculana sp.							R		R	
	Natica sp.							R		R	
	"*Tellina*" sp.							R	R		
	Panopea sp.							R			
	Cerullia sp.							R			
	Circe sp.							R			
	Plicatula sp.							R			
	Mysella sp.							R			
	Cryptopecten yanagawaensis (NOMURA & ZINBO)								R		
	Placopecten ? *protomollitus* (NOMURA)								C		
	Chlamys cf. *nisataiensis* OTUKA								R		
	Chlamys cf. *iwamurensis* ITOIGAWA								C		
	Crassatella sp.								R		
	Conus sp.								R		
	Pitar sp.								R		
	Spondylus sp.								R		
	Dosinia sp.								R		
	Nemocardium sp.								R		
	Mytilus ? sp.								R		
	Cerithidea ? sp.								R		
	Laternula sp.						R				
	Turricula sp.						R				
	Cylichna sp.						R				
	Turritella cf. *nipponica* YOKOYAMA						R				
	Turritella sp.	C									
	Cycladicama sp.						R				
	Gari sp.									R	
	Bittium sp.					R					
Echinoid	*Echinocyamus* cf. *crispus* MAZZETTI						C	C			
Coral									C		C
Elasmobranchs	*Carcharodon* sp.								R		
	Carcharhinus sp.								R		

Alternating beds of sandstone and mudstone of the Kawabata Member are so-called the flysh-typed rhythmic alternation. Sandstone of the alternation shows a typical feature of turbidite and generally has load cast. From the lithological features of conglomerate and sandstone as described in the precednig paragraph, the Kawabata Member exhibits almost all facies of turbidite and turbidite facies association preferred by WALKER and MUTTI (1973).

Current marks rarely found in the turbidite sandstone of this member show the trend of northeast to southwest, which is roughly in parallel with the elongate trend of sedimentary basin of the Onuma Formation. And they also show a southeastward direction. It is inferred that the paleoslope inclined toward the southeast in the Onuma district and toward the west or northwest near Konogi in the Oroshi district from the directional analysis of slump folding and basal planes of pebbly mudstone which scoured the underlying beds, although the utilized data are scanty. This member in the Oroshi district has a tendency of southwestward fining and thinning, and is less than that of the Onuma district in thickness.

From the fact mentioned above, the conglomerate sequence at the lowermost part of the Kawabata Member may be a channel-fill deposited in several feeder channels trending from north or northwest to south or southeast and belongs to the upper fan deposits of submarine-fan facies model (WALKER, 1978). And the turbidite sequence developing in the middle and upper parts of the same member may be correspond to mid-lower fan deposits from the lithofacies features, although it has no evidence of systematic sequence such as upward-thickening and thinning. Judging from the prevalence of turbidite, channel-fill conglomerate and slump beds, and from direction of paleocurrent and paleoslope, it is concluded that the Kawabata Member forms a turbidite clastic wedge thinning away toward the south and that this member were deposited in a continental slope basin with some submarine canyons, which stretched south- or southeastward.

IV. On the relationship between the Onuma and Koguchi formations

In the areas near the boundary between northern and southern districts, vicinity of old coal-mining area, the Kumano Group is divided into two formations, namely the lower, Koguchi and the upper, Mitsuno as described in previous report (CHIJIWA and TOMITA, 1981 a). There are some problems on the basal sequence of the Kumano Group remaining unsolved, because the southward successions of the Onuma Formation in the northern district is disappeared by intervention of quartz porphyry dykes and of the Otsuka Fault (Fig. 10).

As described before, the Kawabata Member of the Onuma Formation is thinning away toward the southwest in the Oroshi district, and a massive dark grey siltstone of the Kohno-ue Member is overlain by the massive dark grey siltstone of the Shikiya Member of the Koguchi Formation near Katagawa, southwesternmost part of this district. Both the massive dark grey siltstone are homogeneous and are hard to distinguish from appearances. This fact suggests

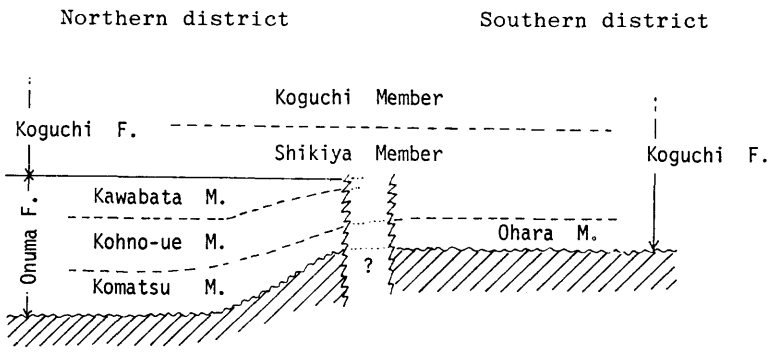

Fig. 8. Relationship of each member.

that the Kohno-ue Member of the Onuma Formation may belongs to a lower part of the Shikiya Member of the Koguchi Formation in the southern district, south of the Otsuka Fault, if the Kawabata Member is a clastic wedge mainly composed of turbidite and is restricted in its distribution only to the northern district.

That is to say, it is concluded that the Onuma Formation is correlative with the lower part of the Koguchi Formation in the southern district of Kumano basin and that the Kawabata Member of the Onuma Formation and a part of the Shikiya Member of the Koguchi Formation in the southern district are heteropic as shown in Fig. 8.

Concluding remarks

The third report on the Tertiary formations of Kumano Coal-field deals with the Onuma Formation, the lowermost sequence of Kumano Group in the northern district. Results obtained are as follows:

1. The Onuma Formation has a maximum thickness of 800 to 900 m, and is lithologically divided into three members, namely the Komatsu, Kohno-ue and Kawabata members in ascending order.

2. The Komatsu Member contains a basal conglomerate and sandstone beds and is characterized by a marked thickness variation. The Kohno-ue Member consists mainly of massive to thick-bedded dark grey siltstone. The Kawabata Member is largely composed of rhythmically alternating beds of turbidity sandstone and mudstone with a conglomerate at lowermost part and a pebbly mudstone in the upper one.

3. The thick massive siltstone occupying most of the Kohno-ue Member is interpreted to be of offshore sediments deposited from suspension under the continental shelf or more deeper environments judging from a fossil habitat.

4. The Kawabata Member is estimated as a turbidite clastic wedge thinning away toward the south, and deposited in a continental slope basin with some submarine canyons, which stretched south- or southeastward.

5. It is regarded that the Onuma Formation is correlative with the lower

part of the Koguchi Formation in the southern district of Kumano basin as shown in Fig. 8, and that the Kawabata Member of the Onuma Formation and a part of the Shikiya Member of the Koguchi Formation in the southern district are heteropic.

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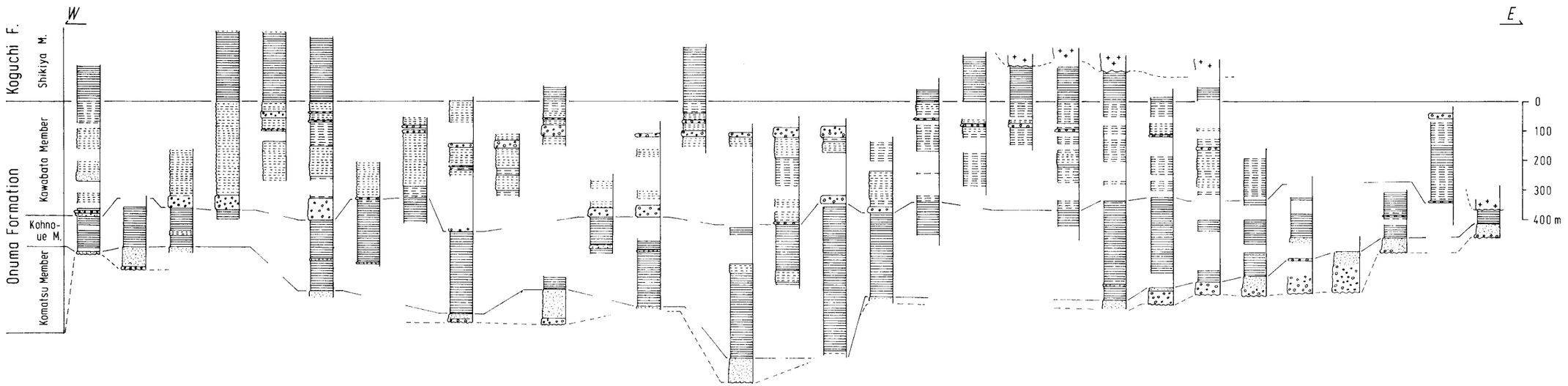
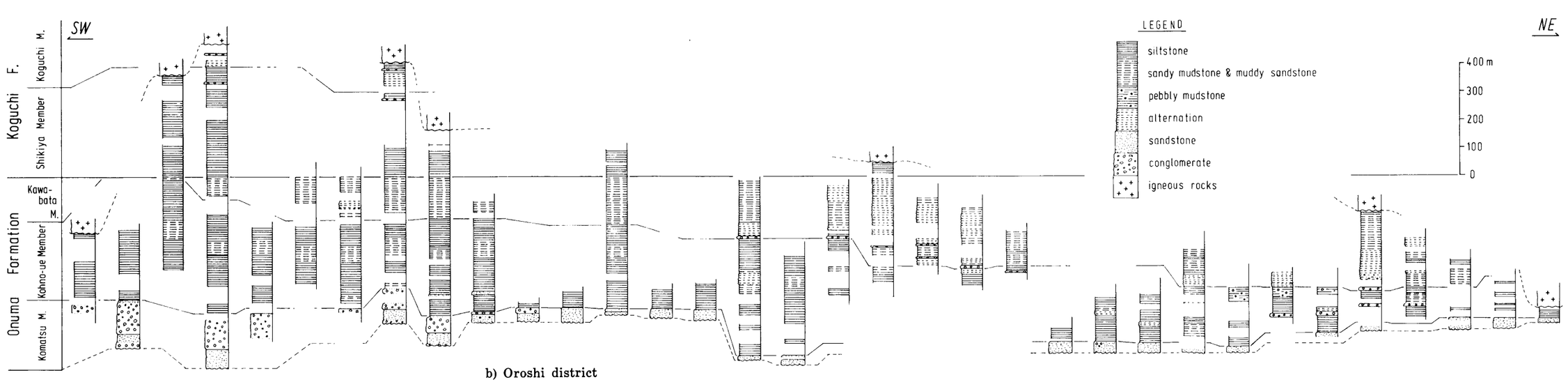
Appendix

Alphabetical index of place names with Japanese writing

Isato	五　郷	Kumanogawa	熊野川
Itaya	板　屋	Mihama	御　浜
Kanahori	金　堀	Mitsuno	三津野
Kanayama	金　山	Mukuro	椋　呂
Katagawa	片　川	Ohara	大　原
Kawabata	川　畑	Ohkochi	大河内
Kofune	小　船	Onuma	大　沼
Koguchi	小　口	Oroshi	尾呂志
Komatsu	小　松	Otsuka	大津荷
Konogi	神ノ木	Shikiya	敷　屋
Kohno-ue	神ノ上	Shimosato	下　里
Kumano	熊　野	Taketo	竹　筒



a) Onuma district.



b) Oroshi district

Fig. 9. Comparative sections of the lower part of the Kumano Group in the northern district.

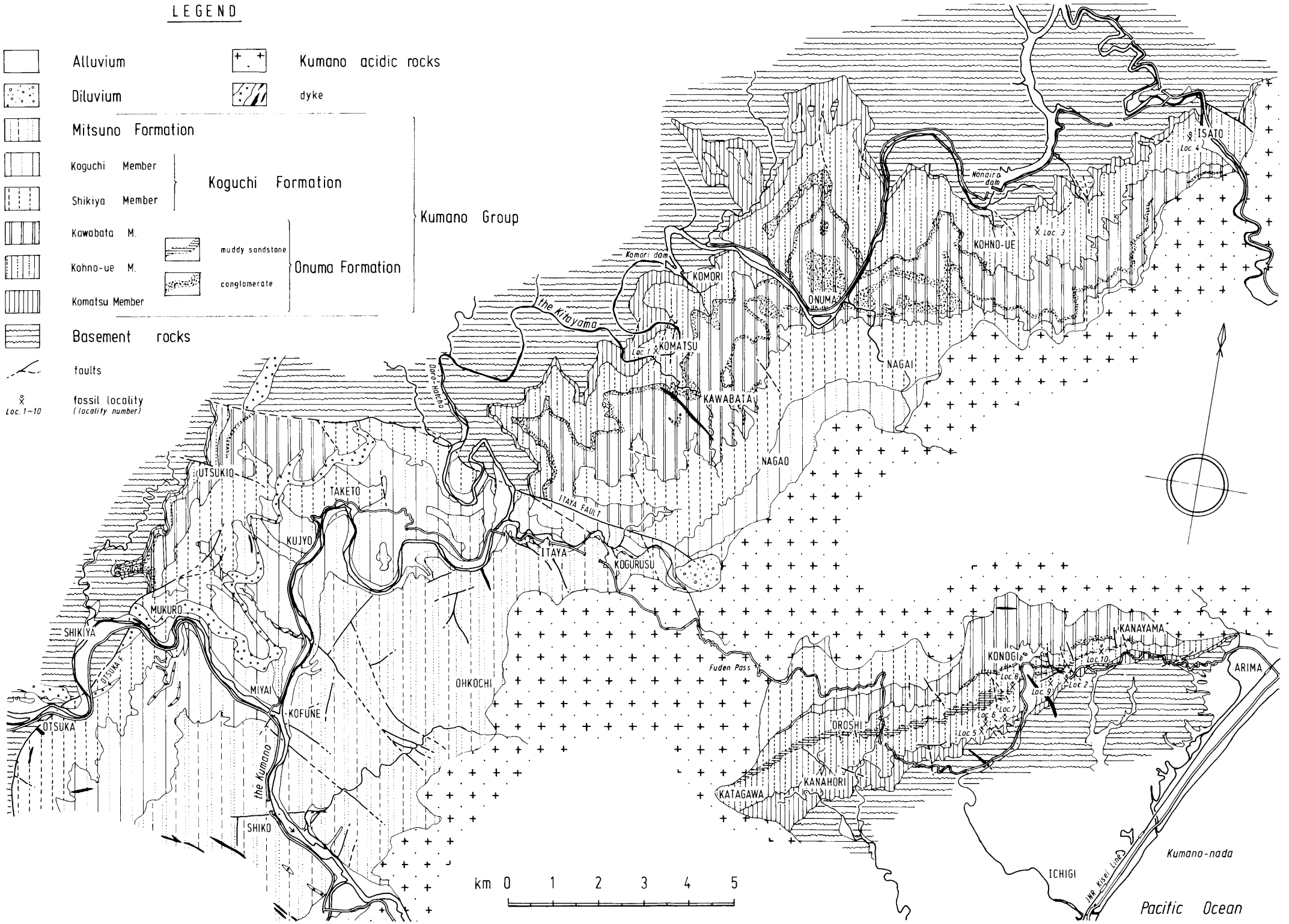


Fig. 10. Geological map of the northern district of Kumano basin.