Petrography of the Cretaceous Sandstones of Hokkaido, Japan

Fujii, Koji
Faculty of Sciences, Kyushu University

https://doi.org/10.5109/1524310

出版情報：九州大學理學部紀要 : Series D, Geology. 6 (3), pp.129-152, 1958-03-10. Faculty of Science, Kyushu University
バージョン：
権利関係：

Mem. Fac. Sci., Kyushu Univ., Ser. D, Geology, Vol. VI, No. 3, pp. 129-152,
tables 1-7, text-fig. 1-7, pl. 23, March, 1958

Petrography of the Cretaceous Sandstones of Hokkaido, Japan*

By

Koji FUJII

Introduction

The celebrated Cretaceous deposits of Hokkaido have been studied by a number of stratigraphers and palaeontologists. MATSUMOTO (1954) has recently shown a summary of the stratigraphy of these deposits. On the other hand the "Hidaka Orogenesis" in the backbone of Hokkaido has been outlined by the investigation of a group of field geologists and petrologists (FUNAHASHI and HASHIMOTO 1951). Yet up-to-date petrographical study of sandstones is necessary for tracing their provenance and making clear the relationship between tectonics and sedimentation; nevertheless few precise descriptions of them have previously been published.

Having paid much attention to the constituting matters of these deposits since the beginning of his study, Professor MATSUMOTO has suggested me to examine them in detail and facilitated my study by placing at my disposal his large collection of sandstones. Furthermore, through his kind offices, I could visit some selected places in Hokkaido to take more specimens of sandstones, especially those from the standard fields of Ishikari Province. I have studied those specimens in the laboratory through both thin-section observation and heavy mineral separation.

In this paper I describe the petrographical characters of the sandstones in question and inquire further the origin of the deposits, thus attempting to clarify the Cretaceous geological history of Hokkaido. However, in view of the fact that the standard fields cover relatively small areas within the extensive Cretaceous deposits, it may be natural to say that the present study should be of only an exploratory character.

Acknowledgements

I wish to express my most sincere thanks to Professor T. MATSUMOTO of our Department, under whose helpful suggestion and sympathetic guidance I have undertaken this research. He has not only provided me with his own collection as well as stratigraphic records, but also cooperated with me in describing an

* Received July 22, 1957

article "Further discussion" as the appendix. I am much indebted to Professor T. TOMITA of our Department who has critically read the manuscript and has shared with me in many opportunities for fruitful discussions. I wish, further, to express my hearty thanks to many gentlemen who have given me kind help and encouragement in carrying out my field work: especially Emeritus Professor H. YABE of Tohoku University, Professor W. HASHIMOTO of Tokyo University of Education, Mr. S. NAGAO of the Hokkaido Geological Survey, Dr. S. TAKAO and Mr. H. SHIMOGAWARA, pre-and present Directors of the Geological Survey of the Hokkaido Ship and Coal Co., Messrs. N. KANBE and T. YOSHIDA of the Geological Survey of Japan and Mr. A. FUKADA of the FUKADA Geological Institute. I am indebted to Messrs M. KIMURA and F. HIROWATARI for taking the X-ray powder photographs, to Messrs M. MIYAHISA and K. MUTA for identifying the opaque minerals, to Messrs. K. KANMERA, Y. UEDA and I. OBATA for their help in taking microphotographs, Mr. H. TAKATA and Miss J. TAKAMIYA have assisted me in making a fair copy of the text figures and tables.*

General Straitgraphy

Fig. 1 shows the nomenclature of the stages and formations of the Cretaceous deposits in the standard fields of Hokkaido. It is reproduced principally from MATSUMOTO's (1954) and partly from HASHIMOTO's papers (1953, 1955). Fig. 2 (adapted from MATSUMOTO, 1954) schematically illustrates the change of sedimentary facies in space and time.

Generally speaking, in the Cretaceous rocks of Hokkaido, mudstones or siltstones are predominant, while sandstones are subordinate in amount, occurring at several horizons. Some of the latter rocks have been regarded as representing the marginal parts of the sedimentary basin which contrast to the deeper, muddy facies in the off shore. Some geologists interpret that the Cretaceous Yezo group, especially its lower half, has the character of what Alpine geologists call flysh. The deposits may have been accumulated in the period of tectonic mobility following the depositional period of the Sorachi group.

Material For Study

The following list shows the derivation of the material which I have dealt with. The major formational names and the areas of the derivation are indicated along with the contributors and the data of their sample collection. As to the details of the localities and stratigraphic records, the reader may refer to the descriptions by MATSUMOTO (1941–43, 1954) and by HASHIMOTO (1936, 1953, 1955).

(1) Sorachhi group: (a) Si-yubari valley (MATSUMOTO, 1939)

* This paper is a part of the results of "A Synthetic Study of the Late Mesozoic of Japan." We are indebted to the Ministry of Education whose aid has rendered it possible for us to undertake the study. (T. MATSUMOTO and K. FUJII.)

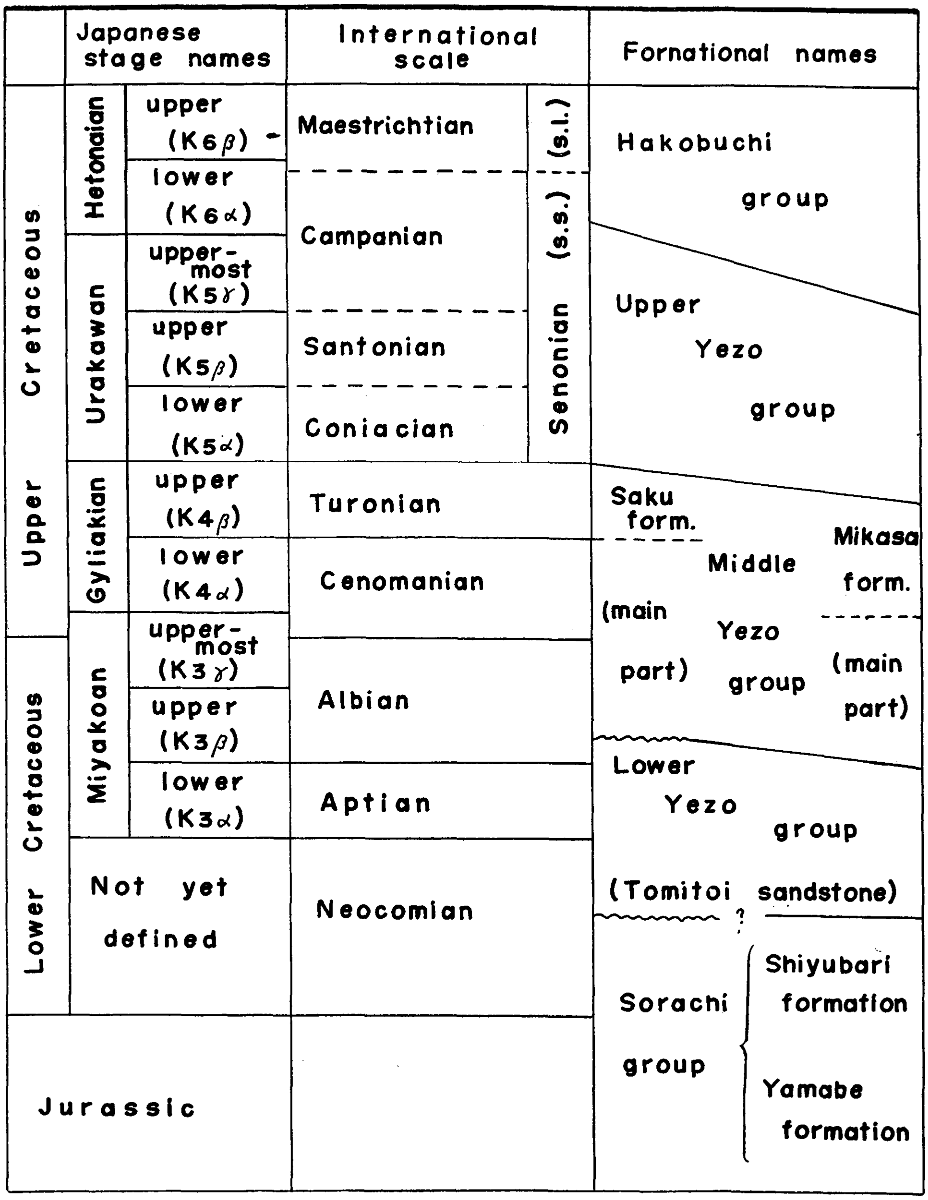


Fig. 1. The generalized stratigraphy of the Cretaceous deposits of Hokkaido (after T. MATSUMOTO, 1954).

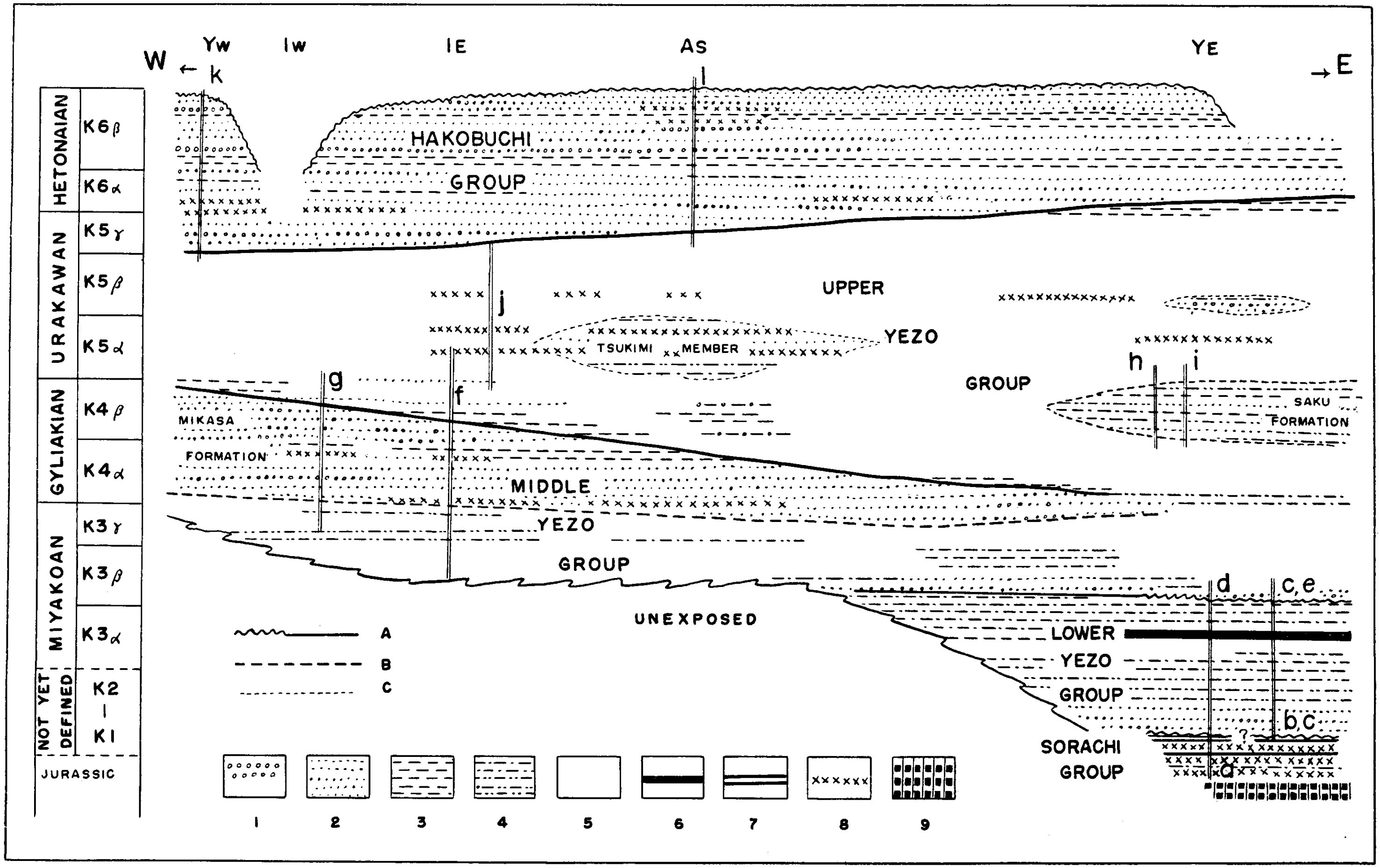


Fig. 2. Schematic illustration of the Cretaceous deposits of the standard areas in Hokkaido, showing both the rock-stratigraphic and time-stratigraphic classifications (adapted from T. MATSUMOTO, 1954). Boundaries of the rock-stratigraphic units.—A: groups, B: formations, C: members. Predominant lithology.—1: conglomerates, 2: sandstones, 3: fine sandy siltstones, 4: interbedded sandstone and shale, 5: massive mudstones and laminated shales, 6: limestone, 7: chert, 8: tuff, 9: basic lavas. Localities.—Yw: Ôyubari, Iw: Ikushunbetsu-Ponbetsu, IE: Ikushunbetsu valley (eastern wing), As: Ashibetsu valley (main part), YE: Western side of the Ashibetsu-Yubari mountain-range (the Shiyubari and the upper Ashibetsu); a, b, c, d, e, f, g, h, i, j, k and l indicate the approximate position of the localities in the text and in the geological map (fig. 3).

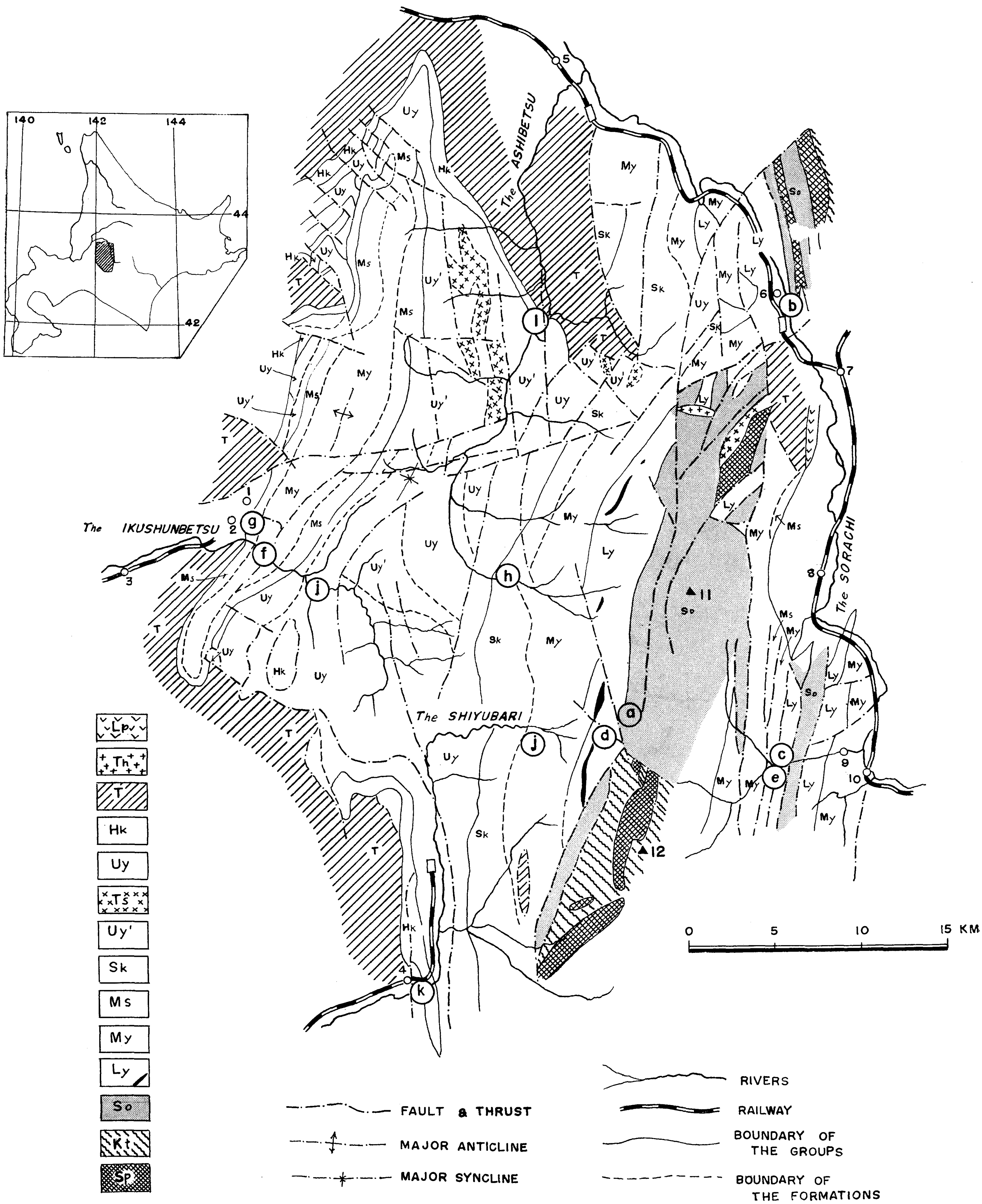


Fig. 3. A compiled geological map of the Cretaceous area in Ishikari Province, central Hokkaido (adapted from T. MATSUMOTO, 1954).

Geological legend.—Lp: Liparite (late Tertiary), Tr: Trondhjemite and other leucocrates (late- to post-Cretaceous), T: Tertiary, Hk: Hakobuchi group (Hetonaian), Uy: Upper Yezo group (main or upper part) (mainly Urakawan), Ts: Tsukimi member in the Upper Yezo group, Uy': Lower part of the Upper Yezo group (mainly Upper Gyliakian), Sk: Saku formation (Upper Gyliakian), Ms: Mikasa formation (mainly Gyliakian), My: Middle Yezo group (main or lower part) (Upper Miyakoan-Lower Gyliakian), Ly: Lower Yezo group (Lower Miyakoan+?), So: Sorachi group (Jurassic-Neocomian ?), Kt: Kamuikotan metamorphic rocks (uncertain age), Sp: Serpentinite (late- to post-Cretaceous).

Localities.—1: Ponbetsu, 2: Ikushunbetsu, 3: Mikasa-machi, 4: Ôyubari, 5: Ashibetsu, 6: Tomitoi, 7: Furano, 8: Yamabé, 9: Tonashibetsu, 10: Kanayama, 11: Mt. Ashibetsu-dake, 12: Mt. Yubari-dake. a-1 indicate the localities from which specimens have been collected (referred to fig. 2 and pp. 130, 133).

(2) Lower Yezo group: (b) Tomitoi and Ochiai, Ashibetsu-shi, Sorachi-gun (MATSUMOTO and FUJII, 1952)
(c) Tonashibetsu river and Sekkaizawa, Minamifurano-machi, Sorachi-gun (MATSUMOTO and FUJII, 1952)
(d) Shi-yubari valley (MATSUMOTO, 1939)

(3) Middle Yezo group: (e) Tonashibetsu river (MATSUMOTO and FUJII, 1952)
(f) Ikushunbetsu valley (MATSUMOTO, 1951, 1955-56; FUJII, 1952)
(g) Ponbetsu river, a tributary of the Ikushunbetsu (MATSUMOTO, 1955-1956)
(h) Ashibetsu valley (MATSUMOTO, KANBE, YOSHIDA and FUJII, 1952)
(i) Shi-yubari valley (MATSUMOTO, 1939)

(4) Upper Yezo group: (j) Ikushunbetsu valley (MATSUMOTO, 1951; FUJII, 1952)

(5) Hakobuchi group: (k) Hakobuchi gorge, Yobari-Shi (FUJII, 1952)
(l) Asibetsu valley (MATSUMOTO, 1951; MATSUMOTO and FUJII, 1952)

As is shown in the index geological map (Fig. 3), all the localities from (a) to (l) are situated in Ishikari Province, where the standard of the Cretaceous succession has been established.

Petrography

The characters of sandstones

Before entering into the description, I make some mention of the classification of sandstones. Although various schemes have been proposed and discussed by a number of authors (KRYNINE, 1948; PETTIJOHN, 1949, 1954; NIGGLI, 1952; DAPPLES, KRUMBEIN and SLOSS, 1953; FOLK, 1954; WILLIAMS, TURNER and GILBERT, 1954), they are not always adequate for describing the natural states of the rocks. My proposal made in Japanese papers (FUJII, 1955, 1956) for descriptive purpose is outlined here. At first, sandstones are divided into two main types based upon the proportion of their matrix. Thus, sandstones containing more than 25 per cent matrix are called *muddy sandstone*, while those containing less than 25 per cent matrix *sandstone*. Further subdivision is based on relative amount of the three components: quartz+chert, feldspar and rock fragments. Fig. 4 shows the subdivisions with their nomenclature.

1. *The Lower Yezo group.* At the base of the formation, a member of sandstones, 300-500 m thick, is developed on the eastern and western sides of the Yubari mountainrange. This is locally called the Tomitoi sandstone (HASHIMOTO, 1936, YOSHIDA and KANBE, 1955). The sandstone is rather massive, thick bedded and alternated with shale and mudstone. It is megascopically white or light grey and coarse-grained. The composition is as follows: matrix 15, quartz+chert 30, feldspar 40, rock fragments 10 per cent.* It belongs to a coarse sublithic sandstone in my classification.

The remaining part of the Lower Yezo group, superjacent to the Tomitoi

* The percentage in the text shows the average of the examined specimens. Therefore these values do not always make a sum total of 100. More precise data are given in Table 1.

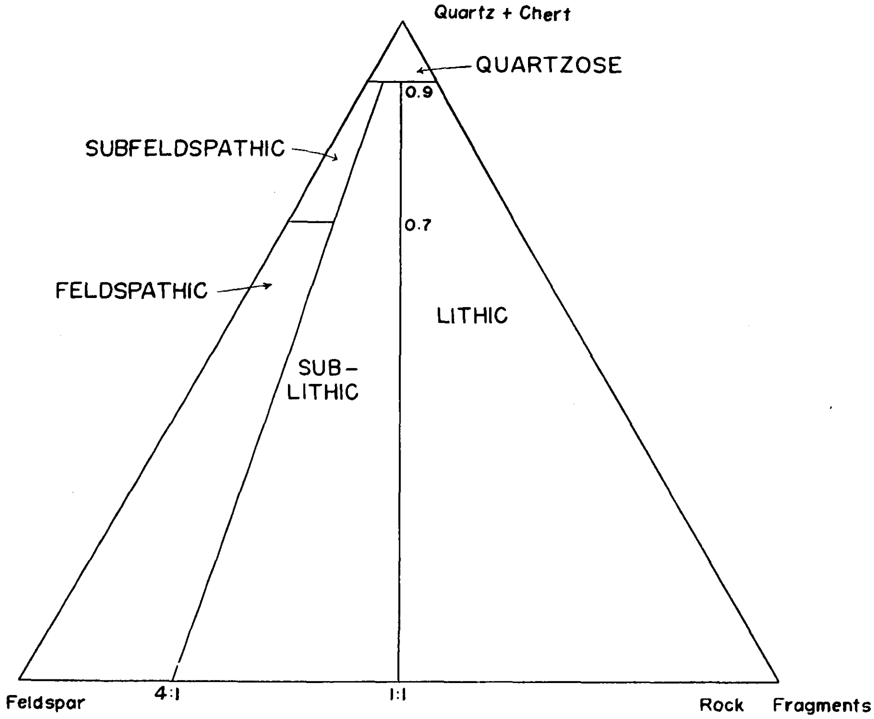


Fig. 4. The composition diagram of sandstones.

sandstone, is composed mostly of sandstone and shale in frequent alternation. The sandstone in this part is fine-grained and dark grey in colour.

2. *The Middle Yezo group.* In the Tonashibetsu river, the basal part of the group is represented by rather thick bedded, coarse to medium-grained sandstones of light grey colour. The composition is as follows: matrix 19, quartz+chert 35 +10,* feldspar 35, rock fragments 5 par cent. That is a feldspathic sandstone.

In the Ikushunbetsn area shales predominate in the lower part of this group (i. e. the Lower Ammonite group of YABE, 1926), but in the middle part there is a member that consists of rather thick bedded sandstones with intervening shales. This is the Yunosawa sandstone of FUKADA *et al.*, 1953. The sandstone is partly massive and even conglomeratic. In this member ripple marks are found on the bedding planes. The sandstone is muddy and light green owing to its chloritic matrix. The composition is as follows: matrix 30, quartz+chert 30+5, feldspar 25, rock fragments 10 par cent. This is a muddy feldspathic sandstone. The Yunosawa sandstone is overlain in turn by a member of predominant shale and sandy shale with a laminated structure occasionally associated with thin-bedded sandstone. Further upwards but still about a hundred meters below the unmistakable Mikasa formation there is another member of alternating sandstone and shale. The composition of this sandstone is as follows: matrix 40, quartz+chert

* This means 35 per cent of quartz *plus* 10 per cent of chert.

Table 1. Percentage composition of the selected Cretaceous sandstones of Hokkaido

		Quartz	Matrix	Feldspar	Chert	Other rock fragments	Accessary minerals
Tomitoi	1	24.2	17.3	44.4	4.3	9.5	0.1
”	9	33.0	14.0	37.4	1.0	13.4	0.5
”	15a	36.7	17.5	20.6	9.4	15.7	0.2
Ky	80	31.4	17.0	33.6	1.3	17.2	
”	81	25.7	28.1	40.6	2.2	2.7	0.4
”	104	35.1	18.5	33.0	8.7	3.3	0.5
Yonosawa ss.		30.7	30.0	35.2	1.4	2.5	0.1
Ik	3a	27.0	32.0	15.0	7.0	17.0	
”	11′	17.0	48.0	18.0	14.0	1.0	
”	1061	34.0	33.0	15.0	11.0	4.1	
Torigonia ss.		15.0	48.0	20.0	1.0	15.0	0.4
Ik	3d	20.2	42.4	33.8	0.8	1.2	1.4
”	980	31.6	42.0	22.0	3.8	3.0	
”	985a	23.0	45.0	23.0	6.3	0.7	
“Suiro 1”		28.7	34.7	35.7	0.2		0.4
Ia	12	26.4	20.3	32.3	13.8	6.8	0.1
Yu	18	10.8	50.0	17.8	2.0	15.0	3.0
”	21	21.0	45.0	21.0	1.1	11.0	0.4
”	30a	23.0	33.0	5.0	3.0	33.0	2.8

25+12, feldspar 17, rock fragments 3 per cent. This is a muddy feldspathic sandstone. The alternating sandstone and shale just mentioned is followed by a member of fine-sandy siltstone containing fossiliferous nodules. There is a bed of tufaceous sandstone in the lower part of the member.

Above this member comes the Mikasa formation (MATSUMOTO, 1951; “*Trigonia* sandstone” of YABE, 1926). In the eastern wing of the Ikushunbetsu anticline it consists of three members (Fig. 5). The lower member consists principally of massive and partly of stratified sandstone and sandy siltstone containing fossiliferous nodules along with scattered fossils. The sandstone is muddy and fine to medium-grained. Its essential composition is: matrix 48, quartz+chert 15+1, feldspar 20 and rock fragments 15 per cent. This is a muddy sublithic sandstone. The matrix is composed chiefly of chloritic clay minerals, to which is perhaps due the greenish tint of the rock.

The middle member of the Mikasa formation on the eastern wing of the anticline is occupied mostly by mudstones or siltstones rich in calcareous nodules. The upper member is again composed of sandstones of various coarseness; pebbly layers or conglomerates and shell beds (“*Glycymeris* beds”) are found at several horizons. The composition of this sandstone is: matrix 44, quartz 25, feldspar 22, rock fragments 4 per cent. This rock is a muddy feldspathic sandstone.

Further east in the Ashibetsu-Yubari mountain-range the main part of the Middle Yezo group is composed mostly of predominant shale with occasional sandy

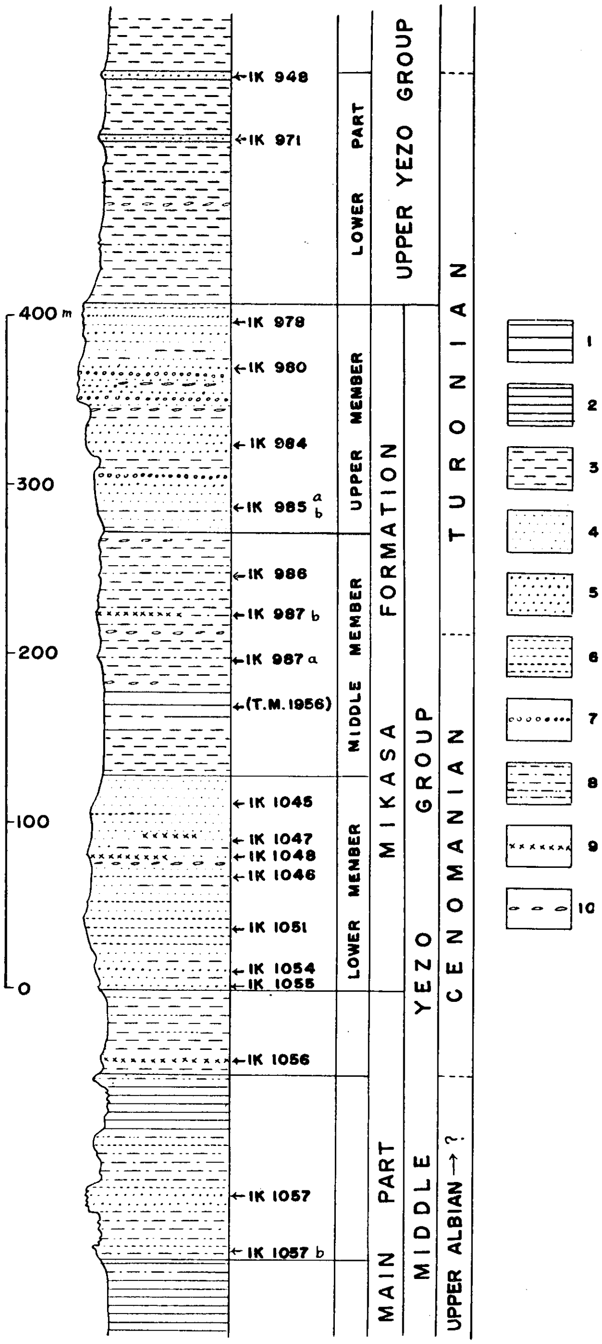


Fig. 5. Stratigraphic section of the Mikasa formation and sub- and superjacent parts in the Ikushunbetsu valley (on the eastern wing of the anticline) (after T. MATSUMOTO, 1955-56 MS.).
←: horizon of rock samples. 1-10: predominant lithology.—1: mudstone, 2: shale with interlaminated sandy siltstone and fine-sandstone, 3: fine-sandy siltstone, 4: muddy fine-grained sandstone (rather massive), 5: muddy medium-grained sandstone (rather massive). 6: stratified sandstones (fine- to medium-grained), 7: conglomerate and coarse-grained sandstone, 8: shale and sandstone in alternation, 9: tuff, 10: train of huge nodules. Smaller nodules are omitted from the figure.

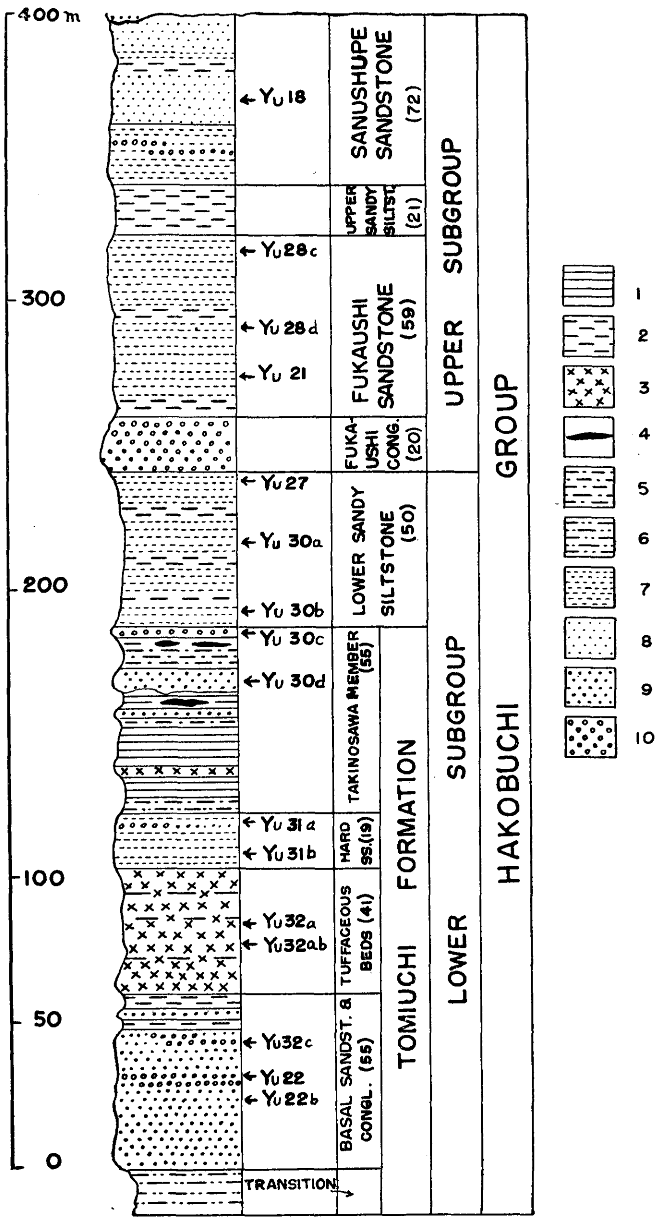


Fig. 6. Stratigraphic section of the Hakobuchi group at Hakobuchi gorge (type locality). Predominant lithology.—1: mudstone, 2: fine-sandy siltstone, 3: tuff, 4: coal, 5: shale and sandstone in alternation (shale being predominant), 6: shale and sandstone in alternation (both being approximately in equal amount), 7: fine-grained sandstone, 8: medium-grained sandstone, 9: coarse-grained sandstone, 10: conglomerate. ←: horizon of rock specimens.

laminae and thin layers. Only in its upper part (of Turonian age) sandstones become predominant, though they are still frequently intercalated with shale. This part is considered as a continuation of the Saku formation, the type locality of which is in the Saku area of Teshio Province. An example of the sandstone of the Saku formation has the following composition: matrix 20, quartz+chert 26+13, feldspar 32, rock fragments 5 per cent. This is a feldspathic sandstone. The examined sandstone is medium-grained and light grey in colour.

3. *The Upper Yezo group.* The Upper Yezo group consists mainly of mudstones containing fossiliferous nodules. Only a few sandstone-beds of about 10 m or less thickness are intercalated. Several specimens of them are similar in the assemblage of heavy minerals to those from the lower part of the Mikasa formation.

4. *The Hakobuchi group.* Showing a distinct contrast to the muddy facies of the Upper Yezo group, various sandstones are developed abundantly in the Hakobuchi group. Even a conglomerate, though in a subordinate amount, is met with. In the type section at Hakobuchi gorge (Fig. 6), the group is divided into two parts, each of which represents a sedimentary cycle. The sandstones are classified into six types based upon the constituents of their matrix: (1) The sandstone with a matrix of illitic clay minerals and certain green mineral (e. g. Yu 18). This is muddy and has dark green spots composed of glauconite. (The details of this mineral will be given on p. 140.) The composition is as follows: matrix 50, quartz+chert 11, feldspar 17, rock fragments 15 per cent. It falls into a muddy sublithic sandstone; (2) The sandstone with a matrix of chloritic clay mineral is fine-grained and dark greenish grey. The examples are Yu28c, Yu28d and Yu21. The percentage composition is: matrix 45, quarzt+chert 20, feldspar 21 and rock fragments 15. This indicates a muddy sublithic sandstone; (3) The sandstone with a matrix of clay mineral and calcite is fine-grained and white grey (e. g., Yu30a, Yu30b). The composition is matrix 33, quartz+chert 26, feldspar 5 and rock fragments 33 per cent. The rock is a muddy lithic sondstone; (4) The sandstone with a matrix of illitic clay mineral (e. g., Yu31a, Yu31b). It is muddy and contains the fragments of drift wood; (5) The sandstone with a matrix of green (chloritic) mineral and calcite (e. g., Yu32c, Yu22a, Yu22b). It is dark green and medium to coarse-grained. The film of chlorite coats the grains and calcite fills the interspaces between the coated grains—this may suggest the special physico-chemical processes for the deposition of this sandstone. The sand grains consist of angular zoned sodic plagioclase and euhedral quartz, though extremely rounded and corroded quartz are also met with. (6) The sandstone with a tufaceous matrix (e. g., Yu32b). It is white and medium-grained.

Mineral Composition

The mineral composition, i. e., major constituents and heavy minerals (S. G.> 2.9, separated with Thoulet's solution), of the examined sandstones are shown in Tables 2–5, Table 6 being a general summary. Some explanatory notes on these tables are given below.

Table 2. Mineral composition of the sandstones in the Sorachi and Lower Yezo groups.

	Sp. No.	Quartz			Feldspar				R. F.			Tm	Zr		Gt		Ru	Ep	Am	Px	An	Bi	Ms	Ch
		(1)	(3)	(4)	(K)	(P)	(Mi)	(My)	(I)	(M)	(S)		(a)	(b)	(a)	(b)								
Sorachi group	Y 317(OT)	×		×	×	×	×	×				×	●	△	△					△	△		△	
	Y 303(OY)																			●				
	Y 304(OX)																			△				
	Y 306(OY)																			●				
Tomitoi sandstone and its equivalent	Tomitoi 1	×		×	×	×	×	×	×	×	×	×	●	△	▲	△	△					△		×
	Tomitoi 9	×	×	×	×	×			×	×	×	×	○	△	△							△	▲	
	81504	×	×			×	×	×	×				●	△				△						
	Ky 66											△	○		○		×				×	△	△	
	Ky 80	×	×	×									●											
	Ky 81	×											●											
Lower Yezo group of the Tonashibetsu	Ky 97	×		×		×	×		×		×	×	●	△	△				×		△	△		
	Ky 97b	×		×	×	×			×		×		▲	▲	○					○		△		
	Ky 97c	×		×	×	×						×	●	×	△				×			△		
	Ky 98	×		×		×						×	▲		○				△					
Lower Yezo group of the Sekkaizawa	Ky 219	×		×	×	×	×				×	×	○	△	○		×					△		
	Ky 220	×		×		×	×						○	▲	○							△		
	Ky 221	×		×	×		×	×					○	▲	▲		×				△	△		
Lower Yezo group of the Shi-yubari	Y 273(Ie)	×		×	×	×			×		×		●											
	Y 274(Ie)	×		×		×	×		×		×		●	△	▲	△	×			×	×			

Table 3. Mineral composition of the sandstones in the Middle Yezo group

	Sp. No.	Quartz			Feldspar			R. F.			Tm	Zr		Gt		Ru	Tn	Ep	Zs	Am	Px	Hy	An	Bi	Ch
		(1)	(2)	(4)	(K)	(P)	(Mi)	(I)	(M)	(S)		(a)	(b)	(a)	(b)										
The lower part of the Middle Yezo group	Ik 21a	×		×		×		×		×		○	△	○	△	×								△	
	Ik 21c										△	○	▲	○	▲		△							△	
	Ik 19	×	×	×		×		×		×	×	○		○		×				×					▲
	Ik 1061					×		×		×															
	Ik 11										△	○		○				△		△					
	Ik 11′	×	×	×		×		×		×	△	○	△	○			△				×				
	Yunosowa											○	△	○		×									
	Ik 1060	×	×	×		×		×	×	×	△	○	△	○		×								△	
Mikasa formation	Ik 1057	×		×		×	×	×		×	△	○													
	Ik 1056	×				×						△				×		iron ores							
	Ik 1056E											△						iron ores							
	Ik 1054	×	×	×		×				×	×	▲	△	▲		×		○	▲		×				
	Ik 1052	×	×	×		×					×	▲	×	△				○	△					△	
	Ik 1051										△	○						○						△	
	Ik 1048	×			×	×											green mineral								
	Suiro No. 1											○	△												
	Ik 987	×		×		×	×				△	○				△		green mineral							
	Ik 985a	×	×		×	×	×	×		×	△	○	▲	○							▲				×
	Trigonia ss.										×	▲		△				●	△			△		△	▲
	Ik 13	×	×	×		×						●		△											
	Ik 3a										△	○		△											
	Ik 3d	×	×	×		×					△	○		△				△		△	△				
	Ik 980	×	×	×		×						○	×	○				▲			×				
	Ik 16											○		○				▲	×				×		
Saku formation of the Ashibetsu	IA 7	×		×	×	×		×		×		○	△	△				○	△					△	
	IA 8	×		×		×				×		○		△				○						△	
	IA 12	×		×		×		×		×		○		△				○	△						
Shi-yubari district	Y 270											●	△	▲		×								△	
	Y 134											○	▲	○		×								△	
	Y 574b											●								△					

Table 4. Mineral composition of the sandstones in the Upper Yezo group of the Ikushunbetsu valley

	Sp. No.	Quartz		Feldspar			R. F.	Tm	Zr		Gt		Ep	Am	Hy	Bi
		(1)	(4)	(P)	(Mi)	(My)	(S)		(a)	(b)	(a)	(b)				
Upper Yezo group	Ik 17	×	×	×			×	△	○	△	○		△			△
	Ik 971	×	×	×	×	×		△	○	△	○		△			△
	Ik 948	×	×	×		×					green mineral					
	Ik 930							△	●					△		△
	Ik 980										green mineral					
	Ik 902	×						△	●	▲					△	▲

Table 5. Mineral composition of the sandstones in the Hakobuchi group

	Sp. No.	Quartz				Feldspar		R. F.			Tm	Zr		Gt		Ru	Tn	Ep	Zs	Am	Px	Hy	An	Bi
		(1)	(2)	(3)	(4)	(K)	(P)	(I)	(M)	(S)		(a)	(b)	(a)	(b)									
Hakobuchi group of Hakobuchi gorge	Yu 18	×			×		×	×	×	×		○	×	○		△		△						
	Yu 28d	×	×				×	×		×		○		○				△		△				
	Yu 21	×					×	×		×		▲						▲	×		▲			▲
	Yu 27	×					×	×		×		○		○			△							△
	Yu 30a	×					×	×		×	×	●	△	△	△					△	△			
	Yu 30b	×				×		×		×	×	●	×	▲				△				△		
	Yu 30c	×					×					●		○	▲									
	Yu 30d	×					×					○		△	○					×	×			
	Yu 31a	×					×	×				●			▲									△
	Yu 31b	×					×		iron ore+biotite like clay minerals															
	Yu 32a											●									△	△	△	△
	Yu 32a b														rare									
	Yu 32c	×		×	×	×	×	×	×	×		●						green minerals						
	Yu 32b	×				×	×					●												
	Yu 23a	×			×		×	×		×				iron ore										
	Yu 22	×			×		×	×		×				iron ore									△	
	Yu 22b	×			×		×	×	×	×		●	×	△										
Hakobuchi group of the mid-valley of the Ashibetsu	Ka 2a	×		×			×				×	○	△	○						×				
	Ka 2b	×		×			×					○		○	×									△
	Ka 3b	×		×			×					●	×				△			×				△
	Ka 4a	×					×					●		△										△
	Ka 4b	×									△	●												
	Ka 4c	×					×	×				●												×
	Ka 5d	×					×	×				●								△				
	Ka 5a	×					×					●				×								△
	Ka 8	×		×	×		×	×				▲				△	iron ore						●	
	Ka 8c	×		×			×					●		△									△	
	Ka 6	×		×	×			×		×	×	●		△									△	
	Ka 12	×		×	×		×	×				○											○	

Explanatory notes for the tables 2–6.

Quartz
- (1) plutonic
- (2) metamorphic
- (3) volcanic
- (4) aggregates of cryptocrystalline quartz

Feldspar
- (K) K-feldspar
- (P) plagioclase
- (Mi) microcline
- (My) myrmekite

R. F. (Rock Fragments)
- (I) igneous rocks
- (M) metamorphic rocks
- (S) sedimentary rocks

Heavy Minerals
- Tm: tourmaline
- Zr: zircon
- Gt: garnet
- Ru: rutile
- Tn: titanite
- Ep: epidote
- Zs: zoisite
- Am: amphibole
- Px: pyroxene
- Hy: hypersthene
- An: anatase
- Bi: biotite
- Ms: muscovite
- Ch: chlorite

- (a) colourless
- (b) coloured

- ● predominant
- ○ abundant
- △ fairly abundant
- ▲ common
- × rare

1. *The amount of non-opaque minerals.* The amount of heavy minerals excluding opaque minerals (mainly iron ores and their altered products) falls into three classes: small, moderate and large. Generally, the muddy sandstone tends to contain larger amount of heavy minerals than the less muddy one. Thus the Mikasa formation contains the largest amount of heavy minerals. In the Hakobuchi group the non-opaque heavy minerals are scanty, while opaque minerals (ilmenite and magnetite) are abundant.

2. *The roundness of mineral grains.* The degrees of roundness are divided into four classes: angular (A), subangular (SA), subrounded (SR) and rounded (R). The roundness of mineral grains less than 0.06 mm is noted, for it has been known as the reliable criterion for judging whether or not the grains have passed through more than one sedimentary cycle. In this paper the roundness of predominant types of zircon grains in various sandstones has been compared with one another.

3. *Heavy mineral suite.* The heavy mineral assemblage in sandstones may be more or less variable even in one definite formation. Nevertheless, the variation within one formation is so small that almost all the sandstones belonging to one formation has a characteristic mineral assemblage in common which is easily distinguished from that of the sandstones of other formations. The term "mineral assemblage" in this paper refers not only to the kinds of associated minerals but also to their physical properties as mineral species, such as colour, crystal habit, etching figure and pleochroism. The heavy mineral suite in Table 6 has been led from the actual observation of all the specimens listed in Tables 2-5.

4. *Index mineral.* Index mineral in this paper means a particular mineral that is characteristic to a certain formation and is not found in other formations. The heavy mineral suite consists of common mineral which appear rather in abundance, while the index mineral is of relatively rare or sporadic occurrence.

Major constituents

1. *Quartz.* As usual, detrital quartz is the chief component of the investigated sandstones. The following kinds of different origin have been distinguished:

(1) Plutonic quartz (Mackie, 1896; Gilligan, 1920; Tyler, 1936; Krynine, 1940; Weaver, 1955) (a) free of inclusions, (b) with inclusions of small disected bubbles, (c) with inclusions of bubble trains, (d) with inclusions of dendritic bacuolas, (e) with inclusions of microlithic rutile. The grain may show either no or moderate strain shadows.

(2) Metamorphic quartz (Krynine, 1940)

(3) Volcanic quartz (Weaver, 1955)

(4) Aggregates of cryptocrystalline quartz.

The plutonic quartz is most abundant in the examined sandstones. The metamorphic quartz is often met with, especially in the Mikasa and Saku formations. The volcanic quartz is common in the sandstones of the Hakobuchi group—in fact, euhedral prismatic quartz with pyramidal faces is characteristic to this group, though corroded and distinctly rounded grains are often present as well.

They may have been derived from some porphyritic acid rock.

2. *Feldspars.* Feldspars are common constituents in the Cretaceous sandstones of Hokkaido.

(1) K-feldspar is common in the Lower Yezo group and fairly common in the Hakobuchi group, while rare in the Middle Yezo group.

(2) Microcline is common in the Lower Yezo group, while rare in the Middle Yezo group.

(3) Plagioclase occurs commonly in all the groups. Zoned plagioclase is found in the tufaceous sandstones of the Middle Yezo, Upper Yezo and Hakobuchi groups.

(4) Myrmekite is found, though rarely, in the Lower and Middle Yezo groups.

3. *Rock fragments.* Common rock fragments are of chert, sandstone and volcanic rocks. Schist and granite fragments are occasionally met with.

(1) Chert occurs in almost all the samples. Sometimes radioralian remains are detected in the chert fragments.

(2) Volcanic rocks, including such rocks as showing hypabyssal rock texture, are found in almost all the specimens. They are especially abundant in the Hakobuchi group.

(3) Schists: Fragments of sericite-quartz schist are occasionally found in the Tomitoi sandstone and rarely in the Hakobuchi group.

(4) Granite: Grains composed of quartz and microcline with hypidiomorphic granular texture occur in the Lower Yezo group.

4. *Clay minerals.* Some matrixes of sandstones have been examined by D. T. A. and the X-ray powder method. Nevertheless, since no precise identification has been done owing to impurities of the samples, they have been roughly identified under the microscope.

5. *Green minerals.* So-called "Glauconite Sandstone" has repeatedly been reported from the Tertiary and Upper Cretaceous deposits of Hokkaido, but few reliable data on the green minerals have been added since YAGI and TAKAHASHI's work (1932, 1939). I have studied some green minerals of the Cretaceous sandstones by D. T. A. and the X-ray powder method. The mineral samples have been prepared through the following procedure: (i) crushed in an iron mortar, (ii) passed through a 80-mesh standard screen, (iii) separated with Thoulet's solution and (iv) picked up with a needle under the microscope.

The green minerals are classified according to their mode of ocurrence as follows: (1) granular grains consisting of dark green microcrystalline minerals, (2) coats and cement with radial structure of and around the grains. It is noted that the latter is always intimately associated with calcite.

X-ray powder photographs (Fig. 7) indicate that (1) is glauconite, while (2) is a species of chlorite group.* The result is in exact accordance with that of

* YOSHIMURA (1938) has already pointed out after his microscopic examination that a certain green sandstone of the Hakobuchi group in the Hetonai area of Iburi Province is characterized by a cementing matter which is made up of the delessite-like chlorite.

Table 6. General summary of the heavy mineral composition

Formation name and locality		Amount of non-opaque minerals	Roundness of grains	Heavy mineral suite	Index mineral	Rock fragments as sand grains
Sorachi group	(a) OX	large	A	Zr (colourless, pink), Gt, Am, Px	Px	andesite
	OY	large	A	Zr (colourless, pink), Gt, Px		
	OZ	large	A	Px		
Lower Yezo group	(b) Tomitoi sandstone	moderate	SR	Zr (type A), Tm, Bi, Gt, Zr (type E), Gt, Ms		andesite, schist, chert
	(c) Tonashibetsu-river and Sekkaizawa	moderate	SR	Zr (type A), Am, Px		
	(d) Shi-yubari district	moderate	SR	Zr, Px		
Middle Yezo group	(e) Tonashibetsu-river	small	SA	Zr, Gt, Px, Hy	Ep	andesite, chert, shale, sandstone, granite, diabase, porphyrite (granite, diabase, porphyrite → pebbles in conglomerate.)
	(f 1) Lower part of the Ikushunbetsu valley	large	A	Zr (type A), Tm, Bi, Zr (type E), Gt, Am, Ep, Px		
	(f 2) Mikasa formation	large	A	Zr (type A), Tm, Bi, Ep, Zs, Gt, Zr (type E), Px, Hy		
	(g) Ponbetsu valley	large	A	Zr (type A), Tm, Bi, Ep, Zs, Gt, Zr (type E)		
	(h) Saku formation of the Ashibetsu valley	large	A	Zr (type A), Tm, Bi, Ep, Zs, Gt, Zr (type E)		
Upper Yezo group	(j) Ikushunbetsu valley	moderate	A	Zr (type A), Tm, Bi, Ep, Zr (type E), Gt	Ep	
Hakobuchi group	(k) Hakobuchi gorge	small moderate	A A	Iron ore, Zr, Zr, Gt, Ep	very scarce of E type Zr.	andesite, chert, shale, schist or phyllite
	(l) Ashibetsu valley	small moderate	A A	Iron ore, Zr, An, Zr, Gt, Ep		

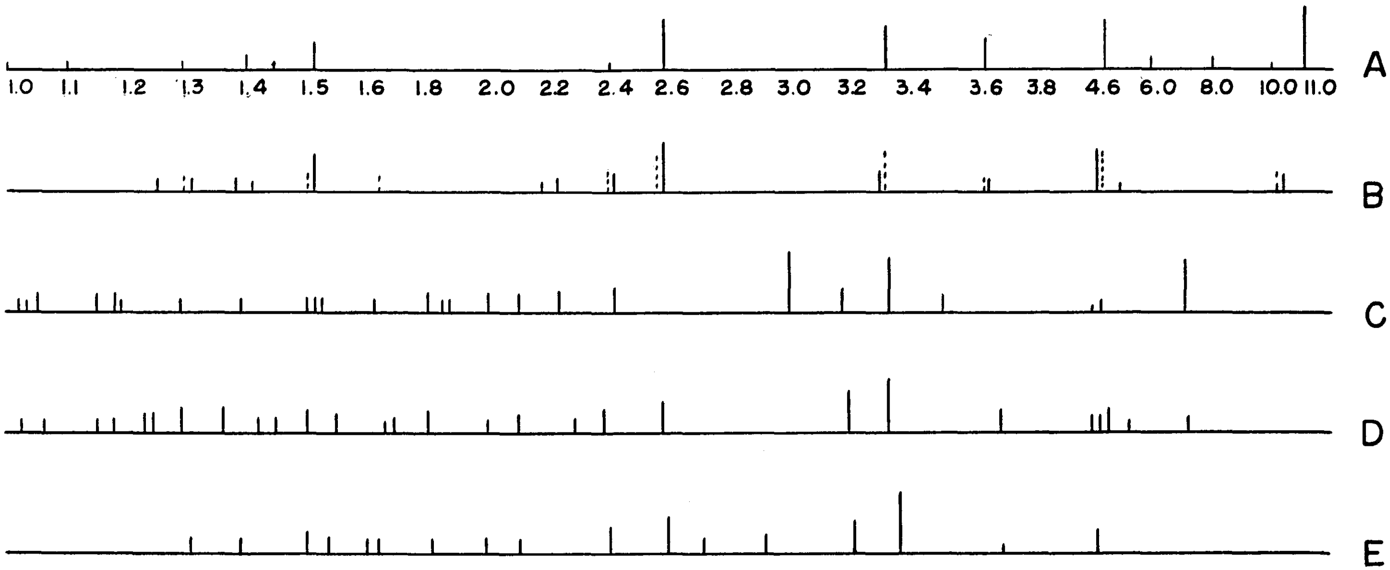


Fig. 7. The date of X-ray powder diffraction photograph. The length of the vertical line show intensity.

A: Ik 948 (Lower part of the Upper Yezo group)
B: Glauconite (H. SHIROZU, 1956) ——— No. 2, ---------- No. 3.
C: Yu 32 c (Hakobuchi group)
D: Yu 18 (Hakobuchi group)
E: Ik 1048 (Mikasa formation)

SHIROZU's study (1956) of the minerals in the Lower Tertiary sandstones of Kyushu.

Heavy minerals

In the following pages I describe the heavy mineral in order of abundance.

1. *Zircon.* Zircons occur in all the samples examined without a single exception, but they are varirble in their kinds. They are classified according to their colour by transmitted light, crystal habit and roundness for mere descriptive purpose. Following are typical varieties:

colourless { euhedral .... A
rounded .... B

light purple { euhedral C
rounded .... D

purple: rounded .... E

broken crystals of the above varieties .... br.

The distribution of these types in the examined specimens is shown in Table 7.

The type E which is characterized by dark purple colour, dark spot-like inclusions and nearly perfect roundness probably belongs to TOMITA's Archean granite zircon (TOMITA, 1954). Though it may have been derived, at last partly, from reworked sediments and metasediments, its ultimate source rock may be in some Pre-Cambrian area. The Hakobuchi group is distingushed by the exceedingly rare occurrence of the type E. It contains also corroded as well as long prismatic zircons, the latter being liable to be broken during sample preparation. According to MATSUMOTO and TOMITA's view (1953) that long prismatic zircon

Table 7.

	A	B	C	D	E	br.
b	21	37		8	12	21
c	43	10	3	4	18	17
f 1	24	34	1	4	29	8
f 2	42	36		6	13	8
k	45	23			2	30

b: Lower Yezo group, at Tomitoi and Ochiai;
c: Lower Yezo group, in the Tonashibetsu river and Sekkaizawa;
f 1: Middle Yezo group (Lower Ammonite group) in the Ikushunbetsu valley;
f 2: Mikasa formation (*Torigonia* Sandstone) in the Ikushunbetsu valley;
k: Hakobuchi group. Numerals show the percentage of the subdivided types.

(elongation ratio of which is about 4) is characteristic to volcanic rocks, the long prismatic zircon of the Hakobuchi group may have been derived from some volcanic rocks.

2. *Garnet.* Garnets are common in many specimens.* The are mostly colour-

* Required further study to discriminate the species of garnets is postponed to the future.

less to pink and rarely dark brown, and show angular shape characterized by marked concoidal fracture, euhedral crystal (dodecahedron) being rare. The grain surface is often peculiarly patterned by the mosaic development of rectangular facets on it.

In some grains the pattern is less geometrical in appearance, in which case the grain surface seems to be covered with closely spaced hillocks. Many authors have attributed this patterning to the impact between mineral grains which occurs during transportation. Recently KOEN (1955) has postulated that the patterns on detrital garnets were formed after their deposition. Anyhow the patterned garnet is abundant in the sandstones of the lower part of the Middle Yezo group and the Mikasa formation in the Ikushunbetsu valley, but rare in the Hakobuchi group.

3. *Tourmaline*. This mineral is sporadically found in the specimens hitherto examined. KRYNINE (1946) attempted to trace the varieties of tourmaline up to their original rocks. He classified (a) granite tourmaline, (b) pegmatitic tourmaline, (c) pegmatitized, injected metamorphic terrane tourmaline, (d) authigenic tourmaline and (e) reworked sediment tourmaline.

Granitic tourmaline (a) is common in all the Cretaceous group of Hokkaido; the type (c) occasionally occurs in the Lower and Middle Yezo groups; the type (b) is rare.

4. *Amphibole*. Sparse as its distribution is, amphibole falls into three types. (a) Thick prismatic flake with dark yellowish green colour and indistinct dichroism (Z′: dark yellowish green; X′: with increased yellowish tint); $\hat{CZ'}$: 20°. This amphibole may be common hornblende. (b) Green, prismatic, fibrous, actinolitic amphibole with distinct dichroism (Z′: dark green; X′: light yellowish green); $\hat{CZ'}$: 10°. (c) Tiny green flake.

There is a tendency that the type (a) is rather predominant in the Lower Yezo group and the type (b) is common in the Middle Yezo group.

5. *Hypersthene*. It occurs as fresh, large prismatic grains with rather rounded, dome-like termination. Pleochroism is distinct with X′: light brown and Z′: green. Inclusions are classified into two types; (a) abundant rectangular inclusions arranged in a plane and (b) those in an irregular arrangement.

6. *Pyroxene*. Of the heavy mineral concentrates of the Cretaceous sandstones, pyroxene is not uncommon in the Middle Yezo and Hakobuchi groups. Pyroxene grains have brilliant light green colour and vitreous luster; $\hat{CZ'}$: 35°-40°. Prismatic grains are rarely met with. The pyroxene grains may have been derived from the Sorachi and related volcanic groups, because a similar pyroxene is characteristic to the volcanic and tufaceous sandstones of the Sorachi group.

7. *Epidote*. Tabular and prismatic epidote occurs as angular or subangular grains. It is mostly yellowish green and faintly pleochroic. This mineral is the index mineral of the Middle and Upper Yezo groups.

8. *Biotite*. Biotite is common. Brown flakes without distinct dichroism are abundant. The tufaceous sandstones of the Middle and Upper Yezo groups contain

prismatic biotites with distinct dichroism.

9. *Anatase.* This is generally rare, but is abundant in certain sandstones of the Hakobuchi group. It is euhedral (pyramidal or tabular) or anhedral and light blue or colourless.

10. *Rutile.* It is occasionally found in the Lower and Middle Yezo groups and rarely in the Hakobuchi group. It is prismatic and blood-red, orange-red or yellow in colour.

11. *Opaque minerals.* Opaque minerals cemented by polyester resin are examined under the reflecting microscope. Ilmenite is abundant in the sandstones of the Hakobuchi group.

Heavy mineral suites

When we consider the origin of heavy mineral assemblages in sediments, we should take into consideration the horizontal distribution of component minerals. There are various factors that have combined to produce the distribution of heavy minerals in sediments, say in sandstones, so that their separate effect in the result may sometimes be untangled with difficulty and sometimes be undissolved. Eactors such as difference in density and in resistance to weathering and attrition of the different component minerals, the amount of abrasion that all mineral grains have undergone during transportation, the different settling velocities of the different grains at the site of their deposition, and the degree of sorting to which all grains have been subjected there—all these factors seem to be competent to cause large variation in the relative abundance of various minerals not only in different samples of the deposits that have been derived from a single source rock, but also in different size-fractions of each sample; thus for example, zircon is more abundant in finer-grained sediments than in coarser ones. To grasp any major geologic events, if present, during the deposition of the Cretaceous of Hokkaido, I, taking one formation as an unit, have summarized the mineral assemblage of each formation in Table 6. Predominant minerals and the index mineral shown in the Table are of great importance to this broader problem of sedimentation.

As has already been pointed out in my previous paper (FUJII, 1956), the sandstones of similar rock types in a given geological province tend to exhibit certain similarities of heavy mineral assemblages. Thus in the Cretaceous basin of Hokkaido, for example, the less-muddy sandstones are apt to contain the assemblage of *zircon, garnet, tourmaline, biotite, amphibole* (rare) and *pyroxene* (rare), while the muddy sandstones of the same age apt to cantain the mineral assemblage of *epidote, zoisite, zircon, pyroxene, amphibole, garnet* and *tourmaline*, both in order of abundance. Therefore, comparision of given sandstones taken from different formations should be made on the basis of both sandstone type and heavy mineral assemblage.

The heavy mineral suites and the predominant rock types of the formations (or groups) under consideration are summarized below.

1. *Lower Yezo group.* The heavy mineral grains are sub-rounded and ill-sorted.

Suite A: zircon (type A), biotite, tourmaline (granitic), garnet......predominat

Suite B: zircon (types B, D, E), tourmaline (type C), muscovite, Garnet

....subordinate

Suite C: pyroxene ....rare

The predominant type of sandstone in the Lower Yezo group is sublithic sandstone.

2. *Middle Yezo group.*

(a) In the Mikasa formation and other members of the Middle Yezo group in the Ikushunbetsu valley the heavy mineral grains are abundant and well-sorted.

Suite A: zircon (type A), tourmaline (granitic), biotite, garnet ...subordinate

Suite B: zircon (type E, doubtfully types B, D), epidote, zoisite
.... fairly predominant

Suite C: hypersthene, pyroxene ....subordinate

Suite D: zircon (types B, D, E)..fairly predominant

(b) The heavy mineral assemblage of the Saku formation in the Ashibetsu valley is similar to that of the Mikasa formation of the Ikushunbetsu valley. The index mineral is epidote.

(c) The heavy mineral assemblage of the Mikasa formation in the Ponbetsu canyon is similar to that of the Mikasa formation in the Ikushunbetsu valley. In the Ponbetsu valley and in the western wing of the Ikushunbetsu anticline, conglomerate beds are frequent. The pebbles are mostly of chert. In addition there is a conglomerate bed of about 10 m thickness in the middle part of the Mikasa formation at Ponbetsu. The pebbles in this conglomerate are, according to T. MATSUMOTO's observation, cherts, chloritized granite (granodiorite), aplite, diabase, porphyrite, andesite, liparite and hornfels. As sand grains chert (including aggregates of cryptocrystalline quartz) is very common.

(d) The heavy residues of the Middle Yezo group in the Shi-yubari district consist of zircon, garnet, tourmaline, amphibole, pyroxene, biotite, muscovite and rather scanty epidote. This assemblage is rather similar to that of the lower part of Middle Yezo group of the Ikushunbetsu valley. The sandstones of this group are muddy feldspathic-sublithic.

3. *Upper Yezo group.* So far as the sandstones are concerned, the heavy mineral assemblage is similar to that of the Mikasa formation.

4. *Hakobuchi group.* Non-opaque minerals are rather scanty, while iron ores are abundant. The genetical assemblage of heavy minerals are not precisely determined, but the following two types of assemblages may be distinguished:

Suite C′: pyroxene, zircon (volcanic type), amphibole, garnet,
biotite...generally predominant

Special suite: iron ores, anatase, zircon..........................locally predominant*

The absence or rarity of the type E zircon may be a characteristic feature. The predominant rock type for suite C′ is muddy sublithic sandstone.

---

* According to YOSHIMURA (1938) an iron ore bed that occurs at the base of the Hakobuchi group in Iburi Province is a sandstone consisting mainly of ilmenite cemented with greenalite-like chlorite, the associated heavy minerals being commonly pyroxene and amphibole and rarely olivine and allanite.

Source Rocks

Generally speaking, source rocks for materials of a given sandstone can be inferred from its heavy minerals as well as its major constituents. In this paper, the source rocks have been determined as follows for respective heavy mineral suites already referred to:

Suite A: granitic rocks
Suite B: metamorphic rocks
Suite C: volcanic rocks
Suite D: reworked sediments

This determination has been supported by the major constituents of the sandstones in question. The Tomitoi sandstone, for example, that is characterized by the heavy mineral suite of granitic origin (Suite A), consists mainly of quartz, K-feldspar, microcline and fragments of granite, aside from other admixtures.

In conclusion, the source rocks of the Cretaceous sandstones in Hokkaido are as follows (* determined by rock fragments):

Lower Yezo group:
- granitic rocks ....predominant
- reworked sediments* ....subordinate
- schist..subordinate
- volcanic rocks ....rare

Middle and Upper Yezo groups:
- reworked sediments ....predominant
- metamorphic rocks (schist or phyllite) ....fairly predominant
- granitic rocks ....subordinate
- volcanic rocks ....subordinate

Hakobuchi group:
- volcanic rocks ....predominant
- reworked sediments*..fairly predominant
- metamorphic rocks (phyllite)* ....rare

The index mineral epidote of the Middle Yezo group is of questionable origin. Thus, judging from its crystal habits and its separate occurrence as single grains without intermingling with mafic minerals or feldspar, this mineral cannot be regarded as of authigenic origin, but in view of the fact that garnet, zoisite and metamorphic quartz also occur in abundance in the sandstones of this group, much supply of this mineral from a certain metamorphic terrane may be inferred.

Concluding Remarks

As concluding remarks palaeogeographic and palaeotectonic aspects of the results are summarized. Further discussion of the subject is given below as an appendix in cooperation with Professor Matsumoto.

Summary of results

1. *The Lower Yezo group.* The Tomitoi sandstone in the lower part of the group is characterized by sublithic sandstones which differ entirely from the lithological characters of the subjacent Sorachi group. The difference between the two groups has already been pointed out by previous authors on the constituting rocks other than sandstones. However the stratigraphic relation between the two groups is still uncertain.

As has already been pointed out by me (FUJII, 1956), the presence of non- or less-muddy feldspathic-sublithic sandstone may generally indicate the change of depositional environment at that horizon from subjacent to superjacent formation. In many, if not all, cases it is possible to expect a disconformity or unconformity below the sandstone of this type. Therefore, further field work is required to confirm the possible unconformity at the base of the Lower Yezo group.

The sandstones of the Lower Yezo group contain fragments of radiolarian chert and grains of pyroxene which resemble the radiolarian chert and pyroxene of the Sorachi group respectively. This fact may suggest that the Sorachi group, at least a part of it, may have been warped up by an embryonic folding and have supplied its material to the Lower Yezo group.

The site of the granitic and schistose rocks that supplied the material to the Lower Yezo group is uncertain. Geologist in Hokkaido have not arrived at an agreement as to the exact age of the granitic, gneissic and schistose rocks in the backbone of Hokkaido (Kamuikotan and Hidaka metamorphic zones). There are two schools of thought: one school insists that these rocks are of the latest Cretaceous or the early Tertiary intrusion and metamorphism, and the other school still holds the view that some of the gneiss and schists are much older. In addition, in southwest Hokkaido, there are granites as an geological extension of the Norteast Honshu ones, some of which are of Miocene and some of Mesozoic age (Professor T. TOMITA's oral communication).

2. *The Middle Yezo group.* The sandstone near the basal part of the Middle Yezo group is less-muddy feldspathic; this suggests an existence of unconformity at the base. The actual unconformity between the Lower and Middle Yezo groups has been proved by W. HASHIMOTO and T. MATSUMOTO in the Ashibetsu-Yubari mountain-range. The geanticlinal belt, which had been embryonic in the age of the Tomitoi sandstone, may have continued it elevation towards this stage.

In the upper part of the Middle Yezo group sandy sediments are better concentrated than in other parts of this group. To these sandy parts T. MATSUMOTO has given the names of the Mikasa and Saku formations. The Mikasa formation contains shallow-sea fossils and locally those of the littoral type. This fact is in harmony with the abundance of well-sorted heavy minerals in the sandstones of this formation. As has been pointed out in the foregoing chapter, the source rocks may be mainly schists and reworked sediments. Where was the mountain-land from which the materials were supplied? Part of them may have been supplied from the above-mentioned geanticlinal area. However the well-recognized fact that the Mikasa sediments are coarser in the west than in the east suggests another possible source area on the west side of the depositional basin. In this connection it is interesting to note that volcanic and granitic rocks, though subordinate in amount, may have existed in the source areas, where the volcanic activity as indicated by the occasional intercalation of tuffs in the Middle Yezo group was rather episodic, though not violent.

3. *The Upper Yezo group.* In the Upper Yezo group, fine-grained sediments are predominant. As far as the mineral components are concerned, the sandstones of this group are similar to those of the Middle Yezo group. Members and lentils of acid tuff are occasionally intercalated.

4. *The Hakobuchi group.* The lithological change from the Upper Yezo group to the Hakobuchi group is very rapid and distinct. As has been described by many authors, the latter group shows marked increase of coarse-grained sediments, among which sandy rocks are predominant. It is notworthy that the materials of the sandstones of this group are largely of volcanic origin and that there are beds of tuff or tufaceous rock which contains zircon and hypersthene, showing an interesting contrast to those of the Middle and Upper Yezo groups which contain zircon and biotite.

Appendix

Further discussion

By

Koji FUJII and Tatsuo MATSUMOTO

As has been described by T. M. [MATSUMOTO (Editor) 1954], the Cretaceous basin of sedimentation in the meridional zone of Hokkaido (and Saghalien) is probably of geosynclinal nature in its long extension, thick clastic deposition within it and the intense folding after deposition. Moreover, the approximate proportion of the contrasting components estimated by the same author for the common sediments in the Cretaceous basin of Hokkaido, in which shales are predominant over sandstones, indicates that it is of just what PETTIJOHN (1949) calls the geosynclinal suite. Therefore the basin has been called the Yezo geosyncline.

Now from the result of the present study the principal types of the Cretaceous sandstones of Hokkaido are defined as follows: [In brackets the terms of DAPPLES *et al.* (1953) are given.]

Tomitoi sandstone	sublithic s. s.	[arkose]
Sandtone in the Tonashibetsu (Middle Yezo group)	feldspathic s. s.	[arkose]
Lower part of the Middle Yezo group in the Ikushunbetsu valley	muddy sublithic s. s.	[greywacke]
Mikasa formation	muddy sublithic s. s.	[greywacke]

Saku formation	feldspathic s. s.	[greywacke]
Hakobuchi group Type 1	muddy sublithic s. s.	[greywacke]
Type 2	muddy sublithic s. s.	[greywacke]
Type 3	muddy lithic s. s.	[greywacke]

The above list clearly shows that the term greywacke and arkose are so insufficient and unsuitable for describing the natural features of sandstones that the extravagant use of these terms should be rejected. The sandstones of the Yezo geosyncline are mostly muddy and partly less or non-muddy. The muddy sublithic and feldspathic ones are common throughout the main part, whereas less-muddy, sublithic and feldspathic ones characterize the lower and certain particular parts. The quartzose sandstone in FUJII's classification is absent.

Further research is necessary before the Cretaceous palaeogeography of Hokkaido can be elucidated. Again, the provenance of materials of the sediments concerned is still questionable, though the source rocks of the sandstones revealed by the present study are in harmony with the results of the studies of facies-changes and the preliminary observations on the constituents of sandstones and conglomerates by MATSUMOTO (1939, 1942-43, 1954) and HASHIMOTO (1936, 1953, 1954, 1955). The reworked sediments and lower grade metamorphic rocks may have been derived partly from the geanticlinal islands in the depositonal area and partly from the main mountainland. Although the exact position of the main mountainland has not been known yet, it may not be imporbable that at least a part of it was situated on the west side of the depositional area. Certainly, in the mountainland there were certain volcanos, which may have become more active towards the late Senonian (i. e. Hetonaian). On the other hand, another volcanic activity took place on the geanticlinal islands, where parts of the Sorachi group may have been cropped out.

The origin of the granitic material will provoke an interesting debate. First of all the well-known granitic rocks in the backbone of Hokkaido might be regarded as the original rocks. However they are, according to the recent work by FUNAHASHI *et al.* (1951), mostly of Early and Middle Tertiary age. So long as their view is correct, the Tertiary granitic rocks could not have been the source of the granitic materials in the Cretaceous sediments. Secondly certain granitic intrusions which may have provided the granitic materials of the molasse facies to the Cretaceous sediments can not be considered to have occurred contemporaneously with the sedimentation, because the sediments of the typical molasse facies are not actually found in the Cretaceous of Hokkaido and because the granitic materials in the sediments are too large in amount to be neglected as an accidental admixture. Our conclusion most commonly reached is that they were derived from the older granitic bodies that were exposed in the above-mentioned mountainland. Now it is very interesting problem to decide the geologic age of the older granitic bodies just mentioned, but the subject demands close investigation, more data being needed on this point.

From underneath the extensive cover of the Cenozoic sediments and volcanic ejecta crop out the presumed Palaeozoic rocks* and granites of uncertain age in the southwest and northeast parts of Hokkaido. They are the remnants of the old mountainlands, though they are separated in distribution by the post-Cretaceous crustal deformation. However, the northern extension of the Palaeozoic and older Mesozoic rocks that are better exposed in the Kitakami and Abukuma massifs and adjacent areas in Northeast Honshu might be concealed somewhere in the subground of the Cenozoic area on the western side of the Cretaceous belt of Hokkaido; the Kabato massif, for example, might be its small fragmentary remnant. If we compare the sedimentary materials of the Urakawan and Miyakoan sediments along the eastern fringe of the two massifs just mentioned with those of Hokkaido, we shall be able to obtain much reliable data on the above postulated mountainland.

Another old landmass has been postulated by Hashimoto (1954) on the northeast of Hokkaido, covering mainly the area of the present Okhotsk Sea. This assumption, though based on less sufficient evidence, may not be deniable, since the overturned folds and thrusts in central Hokkaido are from east (or northeast) to west (or southwest).

In addition to the older (probably Permo-Triassic) granitic bodies Lower and Upper Cretaceous granites are known in the Kitakami and Abukuma massifs as well as other areas in the Japanese Islands. Of these granites the Lower Cretaceous one might have already been partly eroded out during the depositional period of the Yezo group to come into the corresponding sediments. In conclusion, it is of the utmost importance to make clear the origin of the granitic materials in the Cretaceous sediments of Japan, as has been pointed out by several suthors with regard to the coarser sediments of the Lower Cretaceous in Southwest Japan. Therefore the subject is to be discussed from various points of view. The outstanding questions in the Cretaceous sediments of Hokkaido should be considered in relation to the facts in various other parts of the Japanese Islands and adjacent areas.

* Endo and Hashimoto (1955) discovered Permian fossils in the limestone that occurs as pebbles in Kitami Province, northeast Hokkaido.

References Cited

Dapples, E. C., W. C. Krumbein and L. L. Sloss (1953): Petrographic and lithologic attributes of sandstones. *Jour. Geol.*, **61**, 291-317.

Endo, R. and W. Hashimoto (1955): Unquestionable Paleozoic (Permian) Fossils found in Hokkaido, Japan. *Proc. Japan Academy*, **31**, 704-708.

Folk, R. L. (1954): The distinction between grain size and mineral composition in sedimentary-rock nomenclature. *Jour. Geol.*, **62**, (4) 344-359.

Fujii, K. (1955): 砂岩研究の 2, 3 のもんだい. 地球科学 20号, 9-18. [Some problems on the studies of sandstone (in Japanese with English résumé). *Chikyukagaku* **20**, 9-18.]

——— (1956): 九州八代地方中生界の砂岩. 地質学雑誌 62巻, 193-211. [Sandstones of the Mesozoic Formations in the Yatsushiro district, Kumamoto Prefecture, Kyushu, Japan (in Japanese with English résumé). *Jour. Geol. Soc. Japan*, **62**, 193-211.]

FUKADA, A, J. ISHII, T. ICHIKAWA and M. SARAKI (1953): 幾春別流域の白堊系。 北海道地質要報 22号, 1-19. [Cretaceous deposits of the Ikushunbetsu valley (in Japanese). *Geol. Bull. Hokkaido*, no. 22, 1-19.]

FUNAHASHI, M. and S. HASHIMOTO (1951): 日高帯の地質. 地質団体研究会専報, 6, 1-38. [Geology of the Hidaka zone, Hokkaido (in Japanese). *Mono. Asso. Geol. Coll.* no. 6, 1-38, 1 map.]

GILLIGAN, A. (1920): The petrography of the Millstone Grit of Yorkshire. *Quart. Jour. Geol. Soc.*, 75, 251-294.

HASHIMOTO, W. (1936): 石狩国空知郡富良野盆地西部山地の地質. 地質学雑誌 43巻, 493-530, 図版 22-24. [Geology of the Western Mountainous Land in the Hurano Basin, Province Ishikari (in Japanese). *Jour. Geol. Soc. Japan*, 43, 493-530, pls. 22-24.]

——— (1952): 北海道侏羅系の地質. 地質調査所報告特別号 (B), 1954. [Jurassic stratigraphy of Hokkaido (in Japanese with English résumé). *Report Special* No. (B), *Geol. Surv. Japan.*]

——— (1953): 山部. 5万分の1地質図幅. 説明書 82頁, 9図版, 北海道開発庁. [YAMABE (in Japanese with English résumé). *Explanatory Text of the Geol. Map of Japan, Scale* 1:50,000, 82 pp., 9 pls. *Hokkaido Geol. Surv., Hokkaido Dev. Ag.*]

——— (1954): 北海道中生界の堆積と変形, 315頁。 [Sedimentation and Deformation of the Mesozoic System in Hokkaido. *Thesis in mineograph* (in Japan), 315 pp.]

——— (1955): 下富良野. 5万分の1地質図幅, 説明書, 71頁, 8図版, 北海道開発庁. [SHIMOFURANO (in Japanese with English résumé). *Explanatory Text of the Geol. Map of Japan, Scale* 1:50,000, 71 pp., 8 pls., *Hokkaido Geol. Surv., Hokkaido Dev. Ag.*]

KOEN, G. M. (1955): Heavy minerals as an aid to the correlation of sediments of the Karoo System in the Northern part of the Union of South Africa. *Trans. Proc. Geol. Soc. South Africa*, 58, 281-367.

KRUMBEIN, W. C. and L. L. SLOSS (1951): Stratigraphy and Sedimentation. W. H. Freeman and Co.

KRYNINE, P. D. (1946): The tourmaline group in sediments. *Jour. Geol.*, 54, 65-87.

——— (1948): The megascopic study and field classification of sedimentary rocks. *Jour. Geol.* 56, 130-165.

MACKIE, W. (1896): The sands and sandstones of Eastern moray. *Trans. Edinburgh Geol. Soc.* 7, 389.

MATSUMOTO, T. (1939): 樺太最上部白堊系龍が瀬層群の構造物質について. 地質学雑誌 47巻, 383-385. [On the Constituent Materials of the Ryugase Group, the Uppermost Cretaceous in Saghalien (in Japanese). *Jour. Geol. Soc. Japan*, 47, 383-385.]

——— (1942-43): Fundamentals in the Cretaceous Stratigraphy of Japan. Part I. *Mem. Fac. Sci., Kyushu Imp. Univ.*, [D] 1, 129-280, pls. V-XX (1942); Parts II & III, *Ibid.*, 2, 97-237 (1943).

——— (1951): 蝦夷層群と関門層群, 地質学雑誌 57巻, 95-98. [The Yezo Group and the Kwanmon Group (in Japanese with English résumé). *Jour. Geol. Soc. Japan*, 47, 95-98.

——— [Editor] (1954): The Cretaceous System in the Japanese Islands. i-xiv, 324 pp., 36 pls., Tokyo.

MATSUMOTO, Y. and T. TOMITA (1953): ジルコンの晶癖に現れた火成岩生成条件の異同(要旨)。地質学雑誌 59巻, 361-362. [Difference in crystal habits between plutonic and volcanic zircons (abstract in Japanese). *Jour. Geol. Soc. Japan*, 59, 361-362.]

MILNER, H. R. (1940): Sedimentary petrography. Thomas Murby and Co., London.

NAGAO, S., H. OSANAI and S. SAKAO (1954): 大夕張. 5万分の1地質図幅. 説明書, 121頁, 9図版. [O-YUBARI (in Japanese with English résumé). *Explanatory Text of the Geol. Map of Japan, Scale* 1:50,000, 121 pp., 9 pls., *Hokkaido Geol. Surv.; Hokkaido Dev. Ag.*]

NIGGLI, P. (1952): Gestein und Minerallagerstäten. II Exogene Gestein und Minerallagerstätten. Verlag Birkhauser basel.

PETTIJOHN, F. J. (1949): Sedimentary rocks. Harper and Brothers, New York.

——— (1954): Classification of sandstones. *Jour. Geol.* 62, (4) 360-365.

SCHIMIZU, I., K. TANAKA and I. IMAI (1953): 上芦別. 5万分の1地質図幅. 説明書, 78+21頁, 2

表, 6図幅, 8踏査図, 北海道開発庁. [KAMI-ASHIBETSU (in Japanese with English résumé). *Explanatory Text of the Geol. Map. of Japan, Scale* 1:50,000, 78+21 pp., 2 tables, 6 pls, 8 maps, *Geol. Surv. Japan; Hokkaido Dev. Ag.*]

SHIROZU, H. (1956): 杵島層群砂岩中の緑色鉱物. 地質学雑誌, 62巻, 280-281. [Green Minerals in Sandstones of the Kishima formation (in Japanese). *Jour. Geol. Soc. Japan,* **62**, 280-281.]

TAKAHASHI, J. (1939): Synopsis of Glauconitization *in* P. D. TRASK [Editor]: Recent Marine Sediments, A Symposium, 503-512.

TOMITA, T. (1954): Geologic significance of the colour of granite zircon, and the discovery of the Pre-Cambrian in Japan. *Mem. Fac. Sci., Kyushu Univ.,* [D], **4**, 134-161.

TYLER, S. A. (1936): Heavy minerals of the St. Peter sandstone in Wisconsin. *Jour. Sed. Petr.* **6**, 55-84.

UWATOKO, K. and K. OTATSUME (1932): The Upper Cretaceous Oil-bearing Sedimentary Rocks of Hokkaido, Japan. *Jour. Fac. Sci., Hokkaido Imp. Univ.,* [IV], **2**, 133-161.

WEAVER, C. E. (1955): Mineralogy and petrology of the rocks near the Quadrant-Phosphoria boundary in southwest Montana. *Jour. Sed. Petr.,* **25**, 163-193.

WILLIAMS, E., F. T. TURNER and C. M. GILBERT (1954): Petrography. W. H. Freeman and Co.

YABE, H. (1926): A New Scheme of the Stratigraphical subdivision of the Cretaceous Deposits of Hokkaido. *Proc. Imp. Acad. Japan,* **2**, 214-218.

YAGI, T. (1932): 海緑石, 岩波講座. [Glauconite (in Japanese). Iwanami Koza.]

YOSHIDA, T. and N. KANBE (1955): 幾春別岳. 5万分の1地質図幅, 説明書, 31+7頁, 北海道開発庁. [IKUSHUNBETSR-DAKE. (in Japanese with English résumé). *Explanatory Text of the Geol. Map of Japan, Scele* 1:50,000, 31+7 pp., *Geol. Surv. Japan; Hokkaido Dev. Ag.*]

YOSHIMURA, T. (1938): 膽振国穂別鉱山の鉄鉱床, 岩礦, 19 巻, 266-277. [The iron ore of Hobetsu Mine, Iburi Province (in Japanese). *Japan Assoc. Petr. Min. & Econ. Geol.,* **19**, 266-277.]

K. FUJII

Petrography of the Cretaceous Sandstones of Hokkaido, Japan

Plate

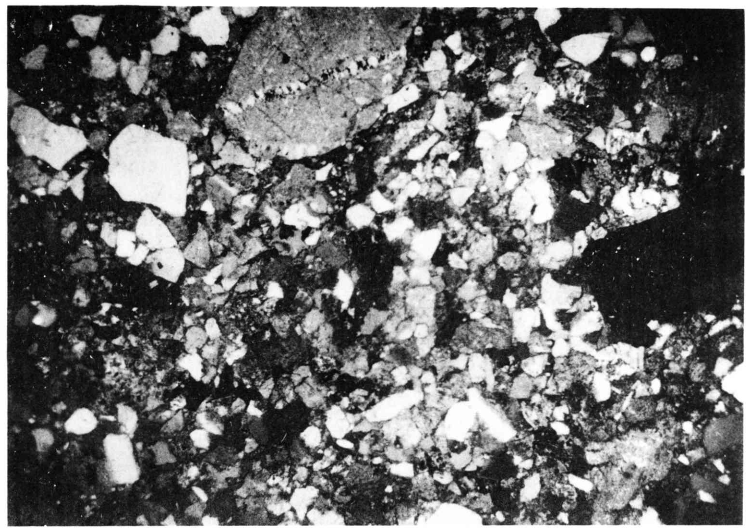
Plate 23

Figs. 1–6. Examples of the Cretaceous sandstones of Hokkaido in thin section (microscopic photographs).

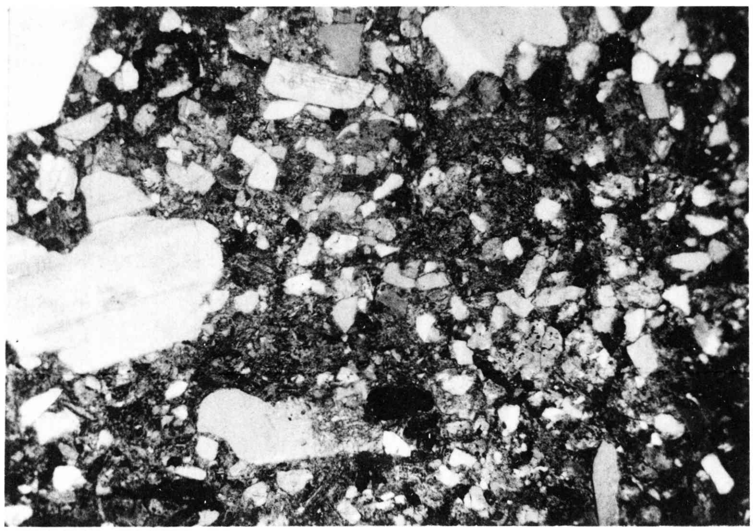
1. Tomitoi 9, Tomitoi Sandstone, Lower Yezo group, near Tomitoi, ×25, crosed nicols (T. MATSUMOTO and K. FUJII Coll.).
2. Ik 1061, Yunosawa Sandstone, Middle Yezo group, the Ikushunbetsu valley, ×30, crossed nicols (T. MATSUMOTO Coll.).
3. Ik 1055, Lower member of the Mikasa formation, Middle Yezo group, the Ikushunbetsu valley, ×25, crossed nicols (T. MATSUMOTO Coll.).
4. Ik 1048, Green, tufaceous sandstone in the Mikasa formation, Middle Yezo group, the Ikushunbetsu valley, ×25, parallel nicols (T. MATSUMOTO and K. FUJII Coll.).
5. Yu 18, Type (1) sandstone of the Hakobuchi group at Hakobuchi gorge, ×62, crossed nicols (K. FUJII Coll.).
6. Yu 32c, Type (5) sandstone of the Hakobuchi group at Hakobuchi gorge, ×25, crossed nicols (K. FUJII Coll.).

Photos by Y. UEDA and I. OBATA.

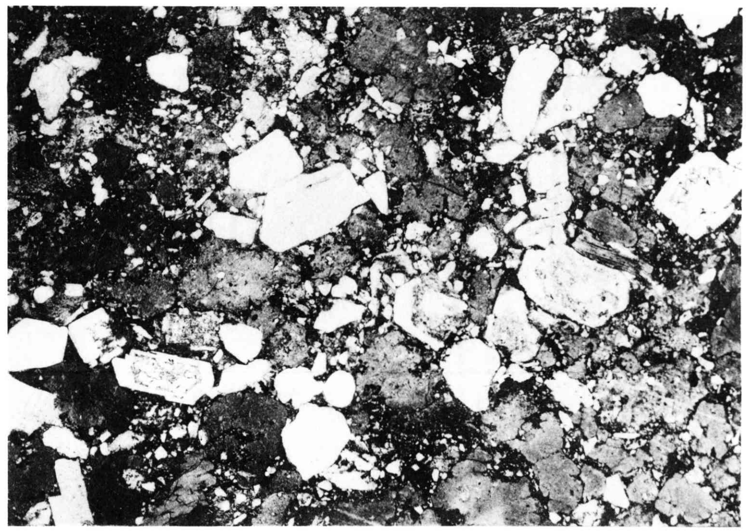
1



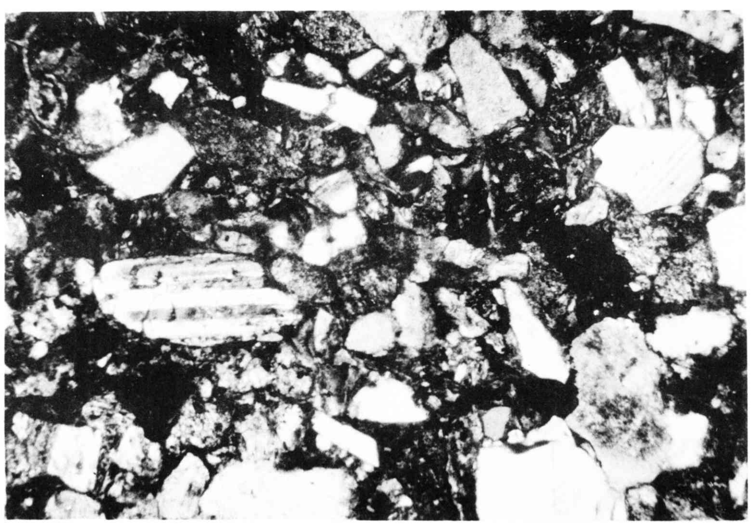
2



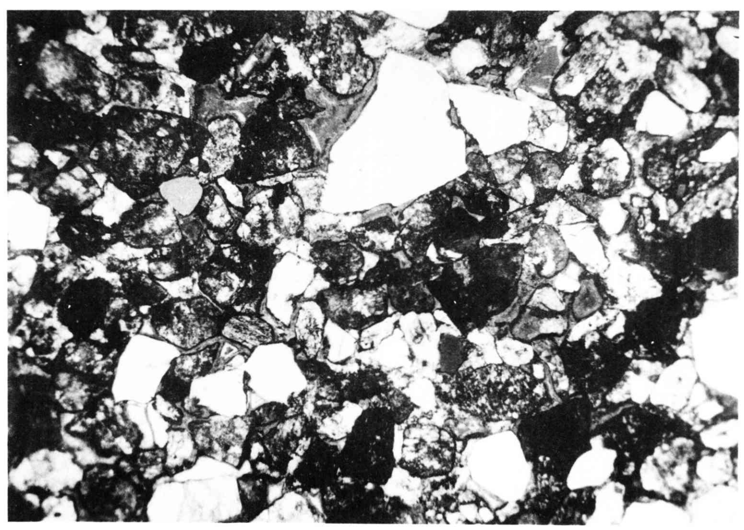
3



4



5



6

K. Fujii: Cretaceous Sandstones