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Beach Deposits of the Eastern Coast of Hakodate City, Japan

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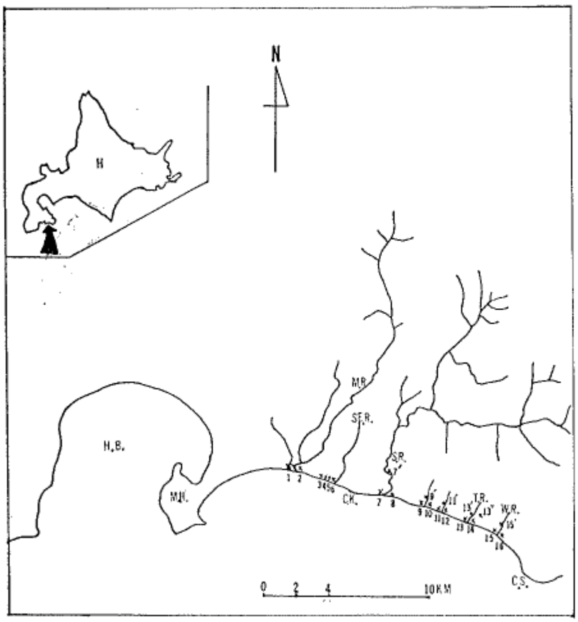
瀬 川 秀 良： 函館市東方の海岸堆積物

Introduction

The study of recent beach deposits is quite useful for the survey of marine terrace deposits. The mechanism of littoral transport and the direction of beach drift was described by the author in a former report (Segawa 1965). In the report, also, he estimated the direction of ancient littoral transportation and the sedimentary environments of terrace deposits.

This paper is concerned with the results of the study of beach sediment on the Eastern Coast of Hakodate City (Shimokaigan). (**Fig. 1.**)



1–16 : Sampling stations of the beach sediments
7′, 9′, 13′, 15′ : Sampling stations of the river bed sediments
13′′ : Sampling station of the marine terrace sediment
H : Hokkaido, C. K. : Cape Kuroiwa,
H. B. : Hakodate Bay
M. H. : Mount Hakodate
C. S. : Cape Shiokubi
M. R. : Matsukura River
SE. R. : Seto River, S. R. : Shiodomari River
T. R. : Takayashiki River, W. R. : Wen River

Fig. 1 Index map of the study area

The field work was done in August, 1964.

General Description of the Area

In this area, two series of marine terraces, the Akagawa Terrace and the Hiyoshi-cho

Terrace, are observed. Toward the east, the width of the lower terrace (Hiyoshi-cho Terrace) is narrower, the surface is more inclined to the recent sea shore, and the old strand line has become lower (Segawa 1964).

A part of the sea cliff on the rear side of Akagawa Terrace was formed by a great fault or displacement.

In this area, so-called palaeozoic and the cenozoic formations are observed but no mesozoic formations are observed. Some of the area, several igneous rocks, i. e., andesite, basalt, liparite and gabbro, etc., are observed (**Fig. 2**). (Hashimoto W., and others 1958)

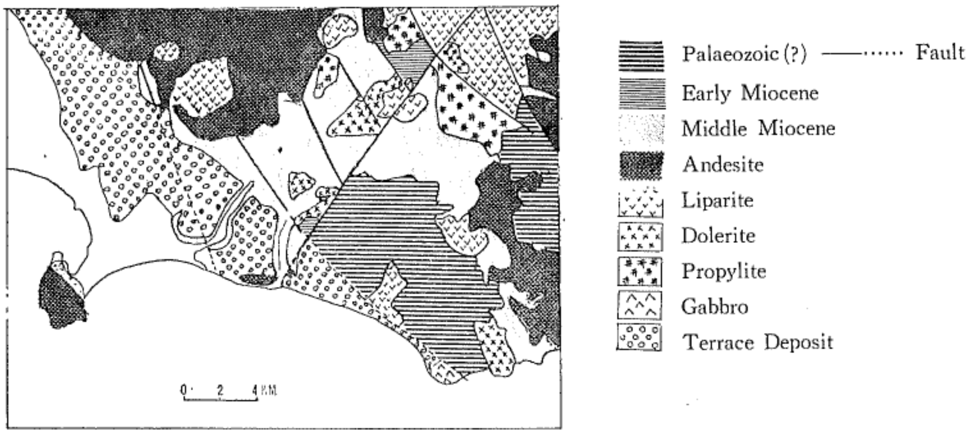


Fig. 2. After Geological map of Hokkido, 1 : 200,000

The rivers running through in this area, usually are quite short and narrow.

Analysing Items and the Results

1) Grain Sizes of Beach Deposits

The author selected every point at both sides of the river mouth along the beach coast of Shimo-kaigan, about 15 km from Matsukura River to Shiokubi Çape, in order to collect the sediments of about 20 kg at each. Then these sediments were sieved. Gravel and sand larger than 4 mm in diameter were sieved in the field, but those smaller than 4 mm in diameter were sieved in the laboratory. Fig. 1 shows the sampling points where the gravel was collected, and the results of the analyses of sieving are shown in Table 1. According to Wentworth's size grade (Wentworth 1922), which is equivalent to one phi grade (ϕ)*, the distribution of grain size on the beach deposits was shown graphically.

Fig. 3 shows the relation of grain size diameter in phi (ϕ), abscissa, to percentage of weight ordinate.

It can be recognized that at Stations 1 and 7, gravel is having a grain diameter phi of 2 is most abundant, at Stations 2, 3, 13, 15 and 16, -6 is most abundant, at Stations 4, 5 and 12, -5 is most abundant, at Station 9, -4 is most abundant.

The graph of the cumulative frequency and continuous frequency curves reflects the environment where these sampling materials were deposited.

*phi(ϕ): diameter (ϕ) $= -\log_2$ (diameter in mm)

Table 1. Results of Sieving of the beach deposits at each sampling station

	Sampling stations (%)											
Diameter (*mm*)	St. 1	St. 3	St. 4	St. 5	St. 6	St. 7	St. 9	St. 12	St. 13	St. 14	St. 15	St. 16
128–64	0.00	56.65	38.00	31.50	64.92	0.00	0.00	6.63	52.97	54.34	84.70	61.90
64–32	3.18	42.91	57.00	68.50	33.17	5.74	14.66	33.11	43.56	16.98	13.33	37.14
32–16	4.54	0.42	5.00		1.90	11.01	32.00	7.95	3.46	10.94	1.96	0.95
16–8	1.36					6,16	24.44	0.44		2.64		
8–4	0.09					3.52	14.22	0.08		0.75		
4–2	0.22					7.09	7.24	0.07		0.91		
2–1	1.86					19.05	3.04	0.23		0.97		
1–0.5	8.44					18.68	1.83	1.96		1.80		
0.5–0.25	51.81					22.14	1.55	13.08		4.05		
0.25–	28.47					6.58	0.99	36.36		6.59		
Total	99.97	99.98	100.00	100.00	99.99	99.97	99.97	99.91	99.99	99.97	99.99	99.99

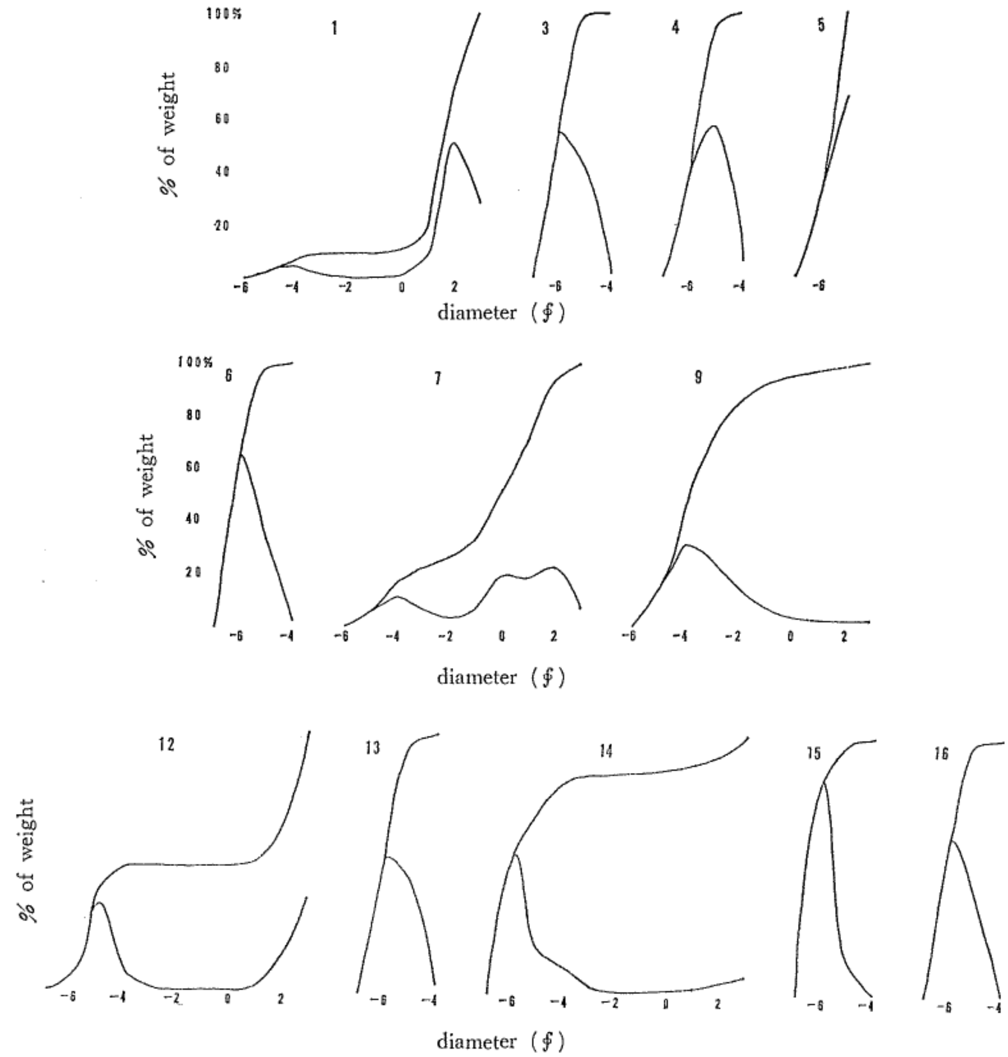


Fig. 3. Cumulative frequency and continuous frequency curves of the grain sizes of beach deposits. The number in the diagrams corresponds to that of sampling stations.

Table 2. Md∮, QD∮, Md and So of beach deposits

Sampling stations	Md∮	QD∮	Md (mm)	So
St. 1	1.6	0.45	0.33	1.4
St. 3	−6.1	0.4	68.59	1.3
St. 4	−5.8	0.4	55.72	1.3
St. 5	−5.7	0.3	51.98	1.2
St. 6	−6.2	0.4	73.52	1.3
St. 7	−0.1	1.75	1.07	3.0
St. 9	−3.8	0.9	13.93	1.5
St. 12	1.0	3.0	0.5	14.9
St. 13	−6.1	0.45	68.60	1.3
St. 14	−6.2	0.95	73.52	1.9
St. 15	−6.6	0.25	97.01	1.1
St. 16	−6.2	0.35	73.52	1.2

Table 2 shows that median diameter in ∮ (md∮ = median ∮) which corresponds to 50 % for each of the cumulative curves in Fig. 3. Then the author examined QD ∮ ($\frac{1}{2}Q_3 - Q_1$) and So ($\sqrt{Q_3/Q_1}$, where $Q_3 > Q_1$. The quartile is the size value associated with the intersection of the 25 % and 75 % values with the cumulative curve.) as indices for sorting in the natural condition as shown in Table 2.

It is considered that the gravel of every station is well sorted by the QD∮ and So values.

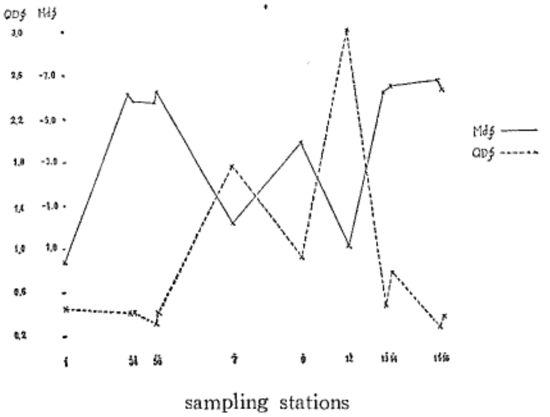


Fig. 4. Md∮ and QD∮ of the beach deposits

Fig. 4 shows the variation of Md∮ and QD∮ data of the stations 2, 8, 10 and 11 are missing, since there is no gravel at these stations.

It is concluded that the relation between Md∮ and QD∮, has the negative linear correlation.

2) Five Largest Gravel

Of the different kinds of rocks, five largest

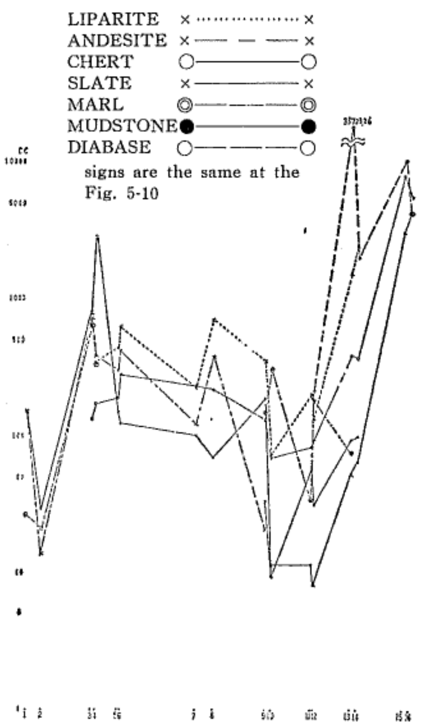


Fig. 5. Five largest gravels

kinds gravel of each were picked up respectively. From length, breadth and thickness of each gravel, the individual volume and the average volume were calculated (Fig. 5).

Variation in the average volume of the five kinds of gravel at each stations were closely correlated to the Md ϕ values. The average of those at both sides of the river mouth is different since the mouth is under the influence of the littoral drift.

When the river has a steep gradient and a short course, the average volume of gravel is larger. When the river has a gentle slope and a long course, the average volume of gravel becomes smaller. From station 3 to 9, the average volume is increased. It will be under the influence of the longshore current.

3) Rock Types in the Beach Deposits at Shimokaigan

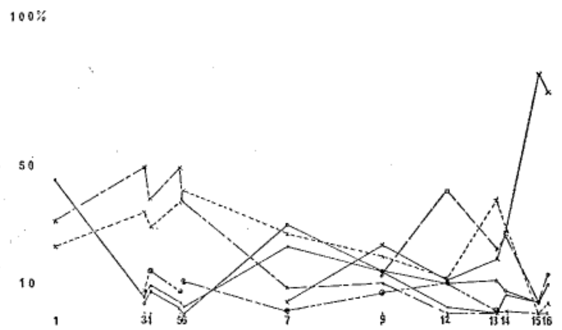


Fig. 6. Rock types in the beach deposits at Shimokaigan

The author sampled 100 particles with a diameter between 32–16 mm at random from each sampling station. Fig. 6 shows the percentage of rock types in the sample. According to Fig. 6, rock types of the field reflect the distribution of rocks (Fig. 2).

At the western coast of the Seto River, the andesite gravel were distinguished. Clearly, these andesite were derived from Cape Kuroiwa. No andesite gravel was almost found on the Eastern Coast at station 9. Considerable liparite gravel was found almost at every station.

This liparite gravel runs down the Takayashiki and Shiodomari Rivers to the sea shore, and then is transported to the area by longshore currents.

Mudstone gravel was distinguished at stations 1 and 7. It was transported by Matsukura and Shiodomari Rivers from the Kunnui formation, dated in the middle Miocene and is distributed in the upper courses of them.

Slate gravel is extremely rich on the Eastern Coast of station 13 since so-called palaeozoic formation is widely found close to this coast. At Stations 15 and 16, slate gravel occupies 81 % and 74 % respectively of all the gravel.

A considerable amount of diabase gravel is found at Stations 12 and 14. Little chert gravel is found in any of the areas.

4) Roundness

The author determined roundness by Krumbein's chert (Krumbein, 1941), used by 100 kinds of already mentioned (Fig. 7).

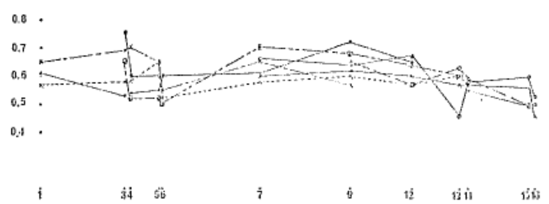


Fig. 7. Roundness

The roundness of gravel gradually increases from Station 7 to 16 except that of chert gravel. At stations 3, 4, 5 and 6, many varieties of roundness are observed.

It will not be the result of the kind of rocks but caused by sedimentary environment.

In the former report, the variations of roundness were mentioned at the Western Coast of Hakodate Bay (Segawa 1965). Otherwise, no variation of roundness of gravel was observed at either side of the river mouth in this area. It may be considered that the cause is the longshore current which has stronger power than the transportation power of the river.

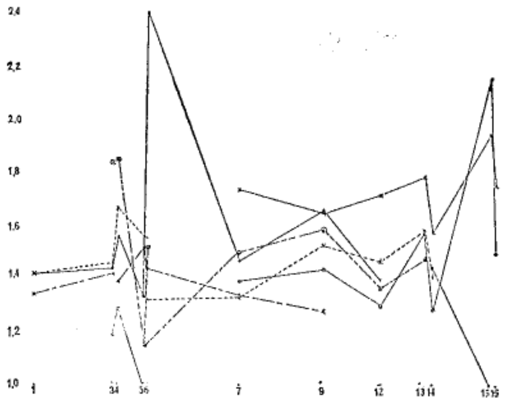


Fig. 8 Squareness

5) Squareness

The squareness was decided from the length/breadth (a/b) value used by the same 100 samples (Fig. 8). Of the mudstone and chert gravel, there was a large variation in the squareness. Toward the east, the squareness of the slate gravel increased.

At Stations 5, 6, 13 and 14, there was a big variation in the squareness of all rocks the same as in the variation of roundness.

6) Slenderness

The slenderness was decided by the length/thickness (a/c) of the same samples (Fig. 9).

The values of slenderness have almost the reverse correlation against those of the squareness. At Stations 3, 4, 5, 13 and 14, a big variation was found.

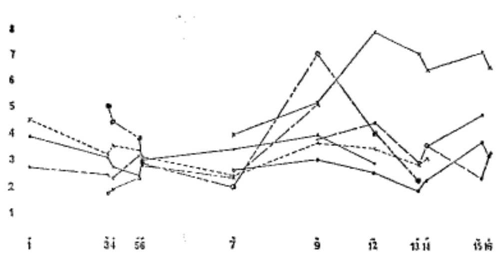


Fig. 9. Slenderness

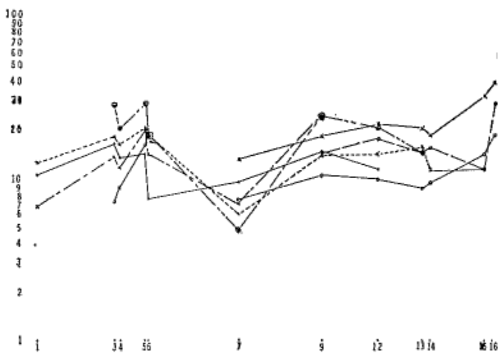


Fig. 10 Flatness

7) Flatness

The flatness was determined by the ab/c of the same samples (Fig. 10). The variation of flatness resembles the variation of squareness but has the reverse correlation of slenderness. In short, value *a* is quite different from the value *c*.

On the Western Coast from Station 6 and the Eastern Coast from Station 7, there is a great difference in the flatness. This fact is caused by the longshore current and the location of Kuroiwa Cape which has an influence on the longshore current.

The same influence is observed on the slenderness of the area, too.

Estimated Longshore Current by the Analyses of Beach Deposits

The longshore current was estimated by the above mentioned studies. Namely, the large gravel became gradually smaller along the direction of the longshore current. So the following result was estimated.

The beach deposits consisting of the larger gravel rather than the smaller may be located on an upper stream position.

From the comparison of gravel on the river bed and the gravel on both sides of the river mouth, the direction of longshore current may be considered.

The changing value of the roundness is correlated with this same fact too. The roundness of the gravel in the upper stream is smaller than the roundness of the gravel in the down stream.

It may be clear that Mdϕ, sorting, rock types, squareness, slenderness and flatness are correlated with the direction of the longshore current, also.

In this area, the longshore currents flow down from east to west.

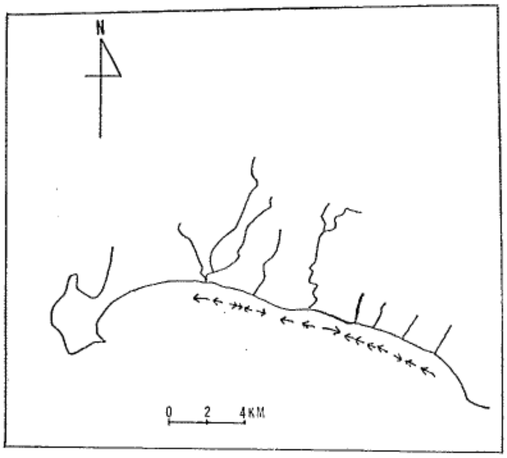


Fig. 11. Estimated longshore current by the analyses of beach deposits

But, the currents at Stations 3 to 4, 6 to 7, 8 to 9 and 13 to 14 have a reverse direction from the usual current, since in these area all data on gravel are unusual (Fig. 11).

According to a report by the Hakodate Branch of the Meteorological Society, Hokkaido (Oshite and others 1957), the main axis of the offshore currents in this area have two directions. They are NE-SW and SE-NW. But there is no description of the longshore current in the report.

The sand spits of the Matsukura, Shiodomari and Wen River are stretched to the west by the longshore current. Slate and diabase gravel which originated in Cape Shiokubi is distributed from the cape to the western part only. Clearly, this distribution form of this gravel is caused by the longshore currents.

Interesting enough, gravel from the bottom of sea in the area, is transported from the east to the west, in the report (Oshite and others 1957).

Relation Between Beach Deposits and Terrace Deposits

Deposits of the Hiyoshi-cho Terrace, mainly consisted of pumice flow. But at the Takayashiki River, sand and gravel are distinguished.

Table 3 shows the results of the analyses of beach, river bed, and marine terrace deposits around the Takayashiki River.

Table 3. Results of the analyses of beach, river bed and marine terrace deposits around the Takayashiki River

St. No.	Md ϕ	QD ϕ	Md (mm)	So
13	−6.1	0.45	68.60	1.3
13′	−6.4	0.5	84.45	1.4
13″	−6.5	0.35	90.51	1.2

Roundness

	Li	An	Ch	SL	Mr	Mds	S.S.	Di	C.G.
13	0.6		0.46	0.57	0.6		0.6	0.63	
13′	0.57	0.55	0.45	0.52			0.45	0.42	0.7
13″	0.48			0.54				0.5	

Squareness

	Li	An	Ch	SL	Mr	Mds	S.S.	Di	C.G.
13	1.59		1.58	1.79	1.38		1.69	1.54	
13′	1.47	1.81	1.33	1.61			1.40	1.39	1.17
13″	1.35			1.34				1.44	

Slenderness

	Li	An	Ch	SL	Mr	Mds	S.S.	Di	C.G.
13	2.89		1.89	7.02	2.25		2.22	2.93	
13′	2.29	2.60	1.89	5.81			8.70	3.06	2.0
13″	2.44			4.81				3.30	

Flatness

	Li	An	Ch	SL	Mr	Mds	S.S.	Di	C.G.
13	15.93		8.87	20.34	14.63		11.38	14.59	
13′	10.25	9.59	11.97	22.52			44.50	18.53	12.0
13″	14.11			25.35				17.63	

Largest Gravels (c.c.)

	Li	An	Ch	SL	Mr	Mds	S.S.	Di	C.G.
13	1617.21		403.73	54.13	79.64	99.20		35723.26	24.22
13′	2828.93	16.10	145.78	28.89				525.77	70.75
13″	2606.83		858.46	307.35				2261.95	

Rock Types (%)

	Li	An	Ch	SL	Mr	Mds	S.S.	Di	C.G.
13	38.18		10.90	18.18	1.81		3.63	21.81	5.45
13′	28.33	3.33	6.66	38.33			3.33	18.33	1.66
13″	48.38			35.48				16.13	

Li : Liparite An : Andesite Ch : Chert SL : Slate Mr : Marl
Mds : Mudstone S.S. : Sandstone Di : Diabase C.G. : Conglomerate

In the Hiyoshi-cho Terrace deposits, the value of Md ϕ is larger than the value of Md ϕ in the beach deposits of the Takayashiki River area.

Concerning the sorting of the gravel, the former area is better than the latter. Mdϕ QDϕ and So values of the Hiyoshi-cho terrace are close to those of the Takayashiki River bed.

In the deposit of the Hiyoshi-cho Terrace a high percentage of slate and liparite gravel is found, as in the recent river bed of Takayashiki River.

The percentage of slate and liparite gravel in the deposit of a recent beach is lower than the above mentioned deposits.

It may be concluded that the Hiyoshi-cho Terrace deposit was transported by ancient Takayashiki River.

The roundness of gravel in beach deposits is the greatest in the area and in the Takayashiki River bed, the least.

In the marine terrace deposits, values of squareness, slenderness and flatness are close to those of the Takayashiki River bed.

It may be concluded that the marine terrace deposits were under the more direct influence of the rock distribution than now. And the longshore current was weaker than now.

Conclusion

The above-mentioned observations can be summarized as follows :

1) The rock types of beach deposits have a close relation to the geological background and if the mountain and plateau are close to the beach, its relation is greater.

2) The Mdϕ value of river bed is larger than those of recent beach deposits. And grain size of the beach deposits is similar to those of sediments of the stream in which they are running.

3) The Mdϕ and QDϕ of beach deposits show a reversed relation.

4) Squareness and flatness of beach deposits have a similar variation. But the slenderness of beach deposits has the reversed variation.

5) There are close correlations between beach deposits, shape of sand spits and longshore currents.

6) Longshore currents meet at neary the tip of the cape.

7) Hiyoshi-cho Terrace deposits were more closely related to the background than at present.

The longshore current correlated with Hiyoshi-cho Terrace deposits were weaker than now.

8) The direction of transportation of the gravel in the bottom of the sea are closely correlated to recent beach sediments.

9) The bottom of the sea at the Shimokaigan area consists of a wide erosion surface and a narrow accumulation surface. Also, similar kinds of topographical surfaces are observed in the deposits of the Hiyoshi-cho Terrace.

Acknowledgement

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