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SEDIMENTS OF THE CONTINENTAL SHELF OFF THE SOUTHERN COASTS OF KOREA

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ABSTRACT

Over 40 bottom sediment samples were collected from the southern sea of Korea. The detailed textural characteristics of the sediments, percent calcium carbonate and heavy and light mineralogy were determined.

Seaward of these sediments is a nearly broad belt of sandy sediments. In a broad outline it is considered to constitute a near-shore deposits left from a Pleistocene time of eustatically lowered level of sea water, because the sediments on the outer half of the continental shelf are much coarser than that nearer shore.

The carbonate content increases strongly to the southeast and northwest of Cheju Island. It is believed that the high calcium carbonate content can be largely attributed to the availabilty of carbonate materials.

INTRODUCTION

Up to now little information on th sediments of the southern sea of Korea exists in the literature. This paper describes the sedimentological features of the area in a broad outline. And the results of detailed textural and mineralogical studies are presented in the present report. Information presented here is based on the study of 42 dredge samples from stations spaced at some irregular intervals over the area studied. Certain mineralogical aspects of this area, however, became evident and have been reported by Emery and Niino in 1961.

PHYSICAL SETTING AND OCEANOGRAPHY

The southern sea of Korea is bounded on the east by the eastern sea (Sea of Japan) and on the west by the Yellow Sea. Cheju Strait joins the sea at its west end to the Yellow Sea and Korea Strait joins at its east end to the eastern sea.

The sea floor is the shallow region at depth of about 50m to 150m as a part of the continental shelf. The floor of Korea Strait between Korea and Tsushima Island has a width of about 75 km and the one between Cheju Island and the south-west coasts of Korea a width of about

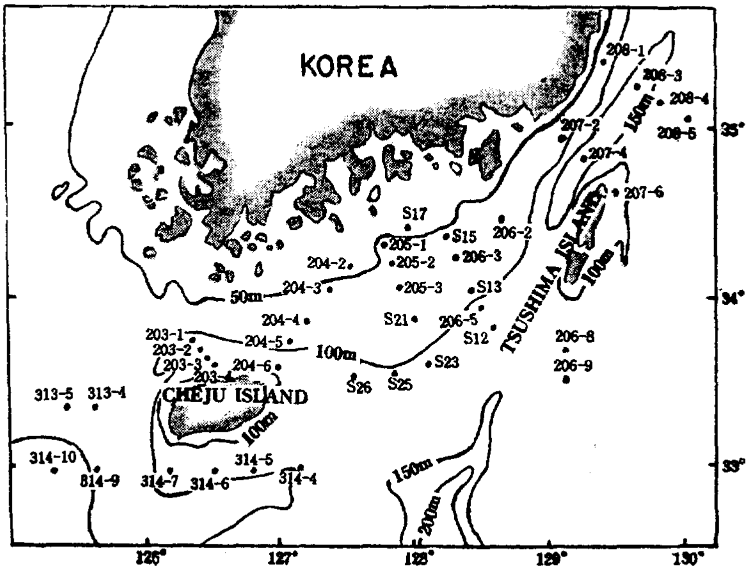

Fig. 1. Bathymetric map showing sample locations.

80km. Existing soundings show that the floor of the southern sea slopes seaward more or less continuously to the shelf-break (Fig. 1).

The surface currents of the region are dominated by the warm high-salinity Kuroshio. Most of the Kuroshio water moves eastward out of the region just south of Japan. The Tsushima Current, branching from the Kuroshio on the southwest of Kyushu, moves north-eastward through the Korea Strait into the eastern sea with a velocity of about 0.5-1.0 knot. In general the velocity of the ocean current in the strait, being influenced by the tidal current, fluctuates twice a day, and the ocean current strength become weak from the surface downward (Yi, 1970).

According to the study of the seasonal variation of surface water temperature in the strait by Yi (1966), the range of the annual component of surface water temperature in the strait extends from 5° to 7°C. Large values occur along the

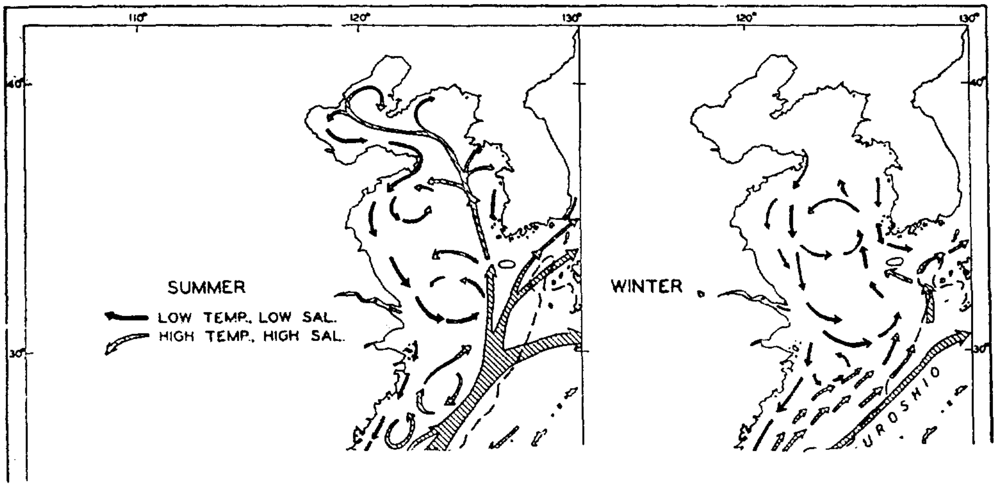

Fig. 2. Surface currents, summer and winter.

south coast of Korea. The maximum temperature of the surface water occurs at the end of August along the south coast (Fig. 3).

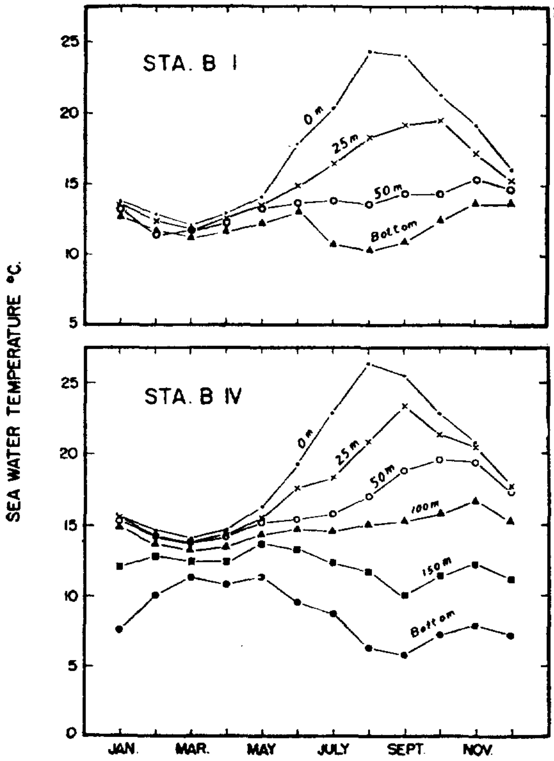

Fig. 3. Average seasonal changes of sea water temperature for different depths at station B I and B IV between Pusan and Tsushima Island (Yi, 1970).

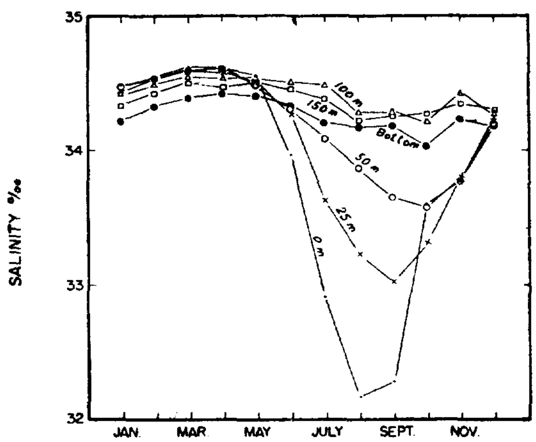

Fig. 4. Average changes of salinity for different depths at station B IV between Pusan and Tsushima Island.

The water below the surface layer of the Tsushima Current has salinities of 33.60‰ to 34.60‰; its annual range is about 1.00‰ or so. But the surface water has relatively large fluctuation in a year; the range amounts to 2.45 ‰ or more (Yi, 1970).

The shores of the southern sea of Korea are composed predominantly of Mesozoic formation and volcanics, with minor occurrences of acid crystalline rocks. Cheju Island is chiefly composed of Tertiary volcanic rock and small areas of outcrop of Tertiary sedimatary rocks are located along the south coasts of the island. And Tsushima Island is principally composed of Mesozoic and Tertiary sedimentary rocks with small occurrence of volcanic rocks.

According to the recent investigation by Wageman, Hilde and Emery (1970), three general lithologic units were considered mappable facies in the Yellow Sea and the continental shelf. The lowest and oldest facies are believed to be igneous rock rather than sediment, while generally would not show large magnetic contrasts even if it were accoustically opaque. The second and third facies are believed to be well-stratified sedimentary units. The second facies, however, is considered to be subjected to structural deformation followed by erosion and the third facies is believed to be horizontal layers separated from the underlying facies by an angular unconformity.

TEXTURE OF SEDIMENT

In order to study fine-grained unconsolidated marine sediments it has been found convenient elsewhere (Marlowe, 1965) to divide the silt-clay end member series into classes at 80, 55, and 33 percent clay. The resulting textural classes are named clay, clay mud, mud, and silt. In this investigation, however, mud required that 80 per cent of the bulk must consist of grains of silt or clay size, and silty sand that more than 30 per cent of the bulk consist of grains of silt or clay size. Gravelly sand also required that 30 per cent of the total sediments consist of grains of gravel size (coarser than 2mm). Textural analyses of the total sediments were carried out by the pipette and settling tube method.

The distribution of textural types in bottom sediments is shown in figure 5. Based on the information from this study, it appears that clay silt covers most of the near-shore shallow area, that is, near or above the 70-meter contour line off the southern coast of Korea. Sand bottom occupies the outer half of the continental shelf from the east coast of Cheju Island to the southwest coast of Tsushima Island. That is, area of sand bottom occurs from about 100-meter contour line down to about 130-meter contour or more so. The silty sand occupies an intermediate position between sand and mud except the bottom off the coast of Cheju and Tsushima Island. A small patch of sand is present in this silty sand bottom area. In particular, a small patch of gravelly sand is also present in the area of silty sand and bottom near the northeast coast of Cheju Island.

Mud encircling coasts of the southern sea would

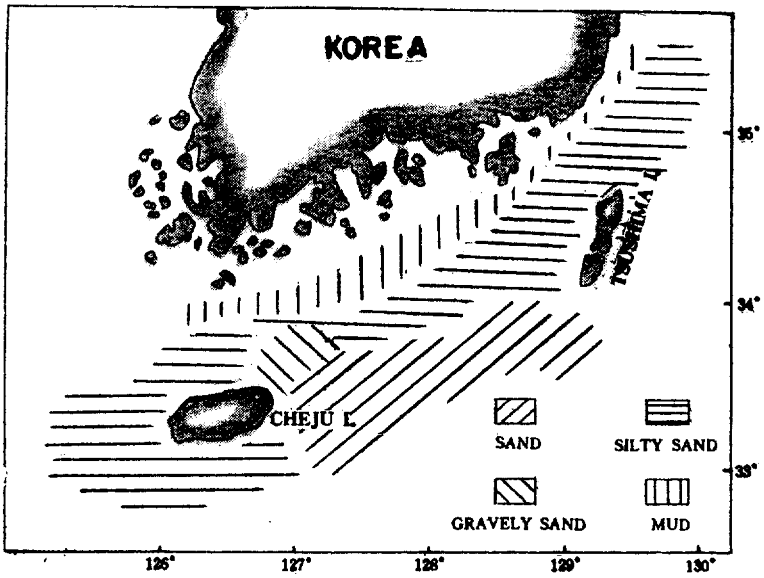

Fig. 5. Distribution of textural types of the southern sea sediments.

be interpreted by a possible reason that mud was more rapidly supplied by rivers and streams than removal by currents and sand bottom probably largely in response to the winnowing of finer grains by the Kuroshio (Emery and Niino, 1967). By considering the various informations so far about a relative rise in sea level after post-glacial events, it is suggested that the increase in coarseness of the sediments from near-shore areas to deep water is due to this deepening. But to some extent, the Kurosnio Current will be responsible for the textural types in bottom sediments of the southern sea area studied.

In order to describe the textural character and parameter of the total bottom sediments, textural types of the sediments have been established based on the results of textural analyses (Fig. 5).

Namely, they are mud, silty sand, sand and gravely sand bottom.

Based on the textural parameters calculated (Table 1), the mean value of standard deviation of the total sediments in the silty sand bottom is 2.51, the mean value of median diameter, 2.6ϕ the mean value of skewness, 0.19 and the value

Table 1. Textural parameters of sediment.

Sample number	Median diameter (ϕ)	Standard deviation	Skewness	Kurtosis	
203-1	2.1	2.80	0.15	0.92	Silty sand zone
203-2	3.8	2.86	0.15	0.60	
203-3	1.6	2.43	0.45	0.61	
203-4	3.6	2.52	−0.21	0.69	
204-4	1.4	2.78	0.28	1.10	
205-3	4.7	2.34	−0.40	0.69	
206-2	1.1	2.99	0.29	0.89	
207-2	1.1	2.79	0.34	1.00	
207-4	1.6	2.30	0.21	1.11	
207-6	3.1	2.29	−0.03	1.18	
208-3	2.3	2.50	0.10	0.91	
208-4	4.6	2.14	0.32	0.94	
208-5	3.3	2.56	0.14	0.98	
313-1	2.7	1.57	0.75	0.59	
313-4	2.9	2.09	0.43	0.59	
313-5	3.5	1.93	0.41	0.79	
314-4	2.7	2.70	0.07	0.78	
314-5	3.1	2.40	0.37	0.75	
314-6	2.7	2.74	0.09	0.67	
314-7	1.8	2.84	0.35	0.67	
314-9	1.9	2.73	0.38	1.14	
314-10	3.0	2.30	0.22	0.78	
206-3	1.6	2.10	0.55	2.28	
St-13	1.7	1.83	0.09	1.68	
St-15	2.4	2.02	0.20	1.80	
St-21	2.6	3.22	0.14	0.71	
206-3	1.7	0.75	0.12	0.96	Sand zone
206-8	2.1	1.16	−0.53	1.00	
206-9	2.1	1.18	−0.23	1.41	
St-12	2.3	0.94	−0.14	1.24	
St-23	2.5	1.48	0.26	2.15	
St-24	3.1	1.10	−0.22	1.25	
St-25	2.5	0.55	0.67	1.35	
St-26	2.4	0.44	−0.34	0.95	

of kurtosis, 0.98. On the other hand, the parameters of the sediments in sand bottom are the following. The mean value of standard deviation is 1.08, median diameter, 2.25ϕ, skewness, −0.52, kurtosis, 1.40.

In general, sediments are better sorted in the sand zone toward outer shelf and tend to become more poorly sorted in the silty sand zone toward the coast. Skewness values for the shelf sand sediments appear randomly distributed and has negative value.

Table 2. Relative abundance of light minerals in three types of sediment.

Sample number	quartz	calcium carbonate	feldspar	others	
203-3	65	17	8	10	Quartz rich sediment
204-5	53	31	11	4	
204-6	71	12	6	11	
206-2	66	14	11	9	
206-3	66	27	3	4	
207-4	53	35	9	3	
208-3	57	19	14	10	
208-4	66	22	5	7	
313-4	55	31	9	5	
313-5	59	15	9	17	
314-10	54	21	11	14	
St-24	50	36	7	7	
St-25	68	18	9	5	
St-26	61	13	16	10	
203-2	27	65	5	3	Calcium carbonate rich sediment
204-4	18	61	14	7	
207-6	14	71	8	7	
313-1	19	38	13	10	
314-4	30	54	4	12	
314-5	29	64	2	5	
314-6	30	56	6	8	
St-12	41	50	8	1	
203-1	40	44	7	9	Less than 50% of quatz and carbonate
205-3	34	43	13	10	
207-2	34	39	18	9	
314-7	39	37	9	15	
St-21	39	40	14	7	

MINERALOGY OF SEDIMENTS

Light minerals

A separation of the sand-size insoluble residue into heavy and light minerals was made by sinking or floating with the heavy liquid, bromoform.

Light sands are dominated by quartz, carbonate and feldspar. These light sediments are grouped

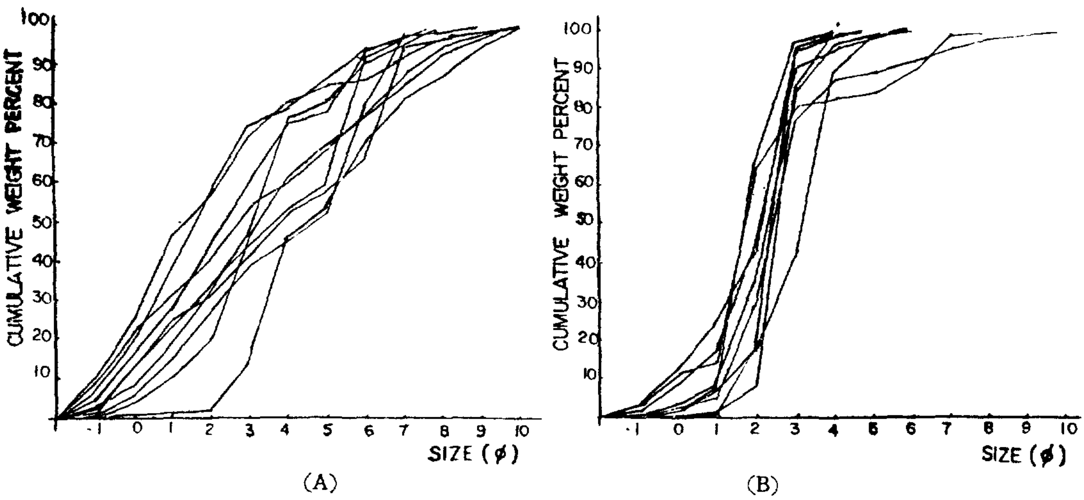

Fig. 6. Grain size distribution of silty sand and sand sediments.

into three types of sediment populations based on the relative percentage of quartz and carbonate. The one group contains more than 50 percent of quartz component, the other group more than 50 percent of carbonate and the last one, less than 50 percent of quartz and carbonate as it is shown in Table 2. And the areal distribution of these three types of sediment is presented in Fig. 7.

It appears that the predominant distribution of quartz is related to the path of the Kuroshio Current and major amounts of calcium carbonate off south and north east coasts of Cheju Island indicate the relatively large contribution of calcium carbonate grains along these coasts. In fact, along the coasts of Hanlim and Keumneung District, Cheju Island there are exposed abundant shell sand formation.

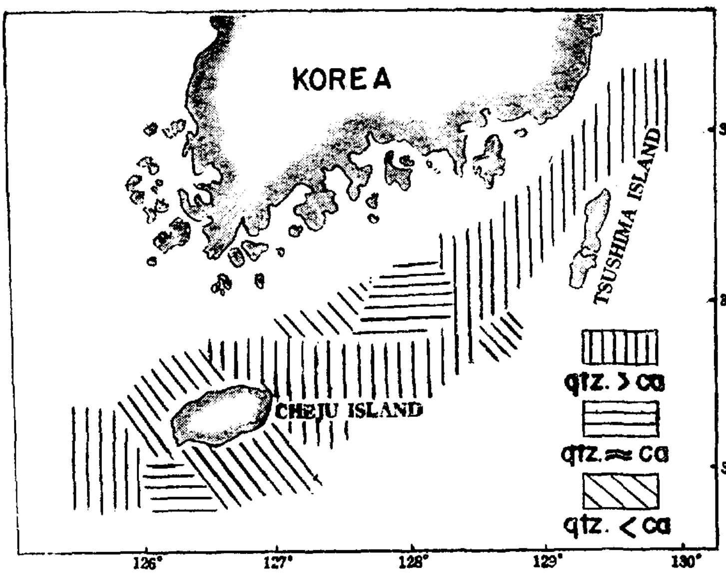

Fig. 7. Areal distribution of three types of sediment in the studied area.

Table 3. Total heavy mineral content in each sample and relative abundance of common heavy component (weight per cent).

Sample number	Total heavy fraction(%)	Hornblende	Magnetite
203-1	3.2	○*	△*
203-2	〈 0.1	○	△
203-3	0.7	○	△
203-4	〈 0.1	○	△
204-4	0.5	○	
204-5	0.5	△	△
204-6	0.2	○	△
205-3	1.0	○	△
206-2	0.8	○	△
206-3	5.5	○	
206-5	1.0	○	△
207-2	0.5	○	
207-4	2.0	△	△
207-6	trace	○	
208-3	1.0	△	○
208-4	0.8	○	
208-5	0.5	○	△
313-1	1.0	△	○
313-4	1.5	○	△
313-5	0.5	○	
314-4	0.3	○	△
314-5	2.8	○	△
314-6	0.5	○	△
314-7	1.0	○	△
314-9	4.8	○	
314-10	0.8	○	△
St-12	0.2	△	△
St-13	1.0	○	△
St-15	1.5	○	△
St-21	0.8	△	○
St-23	0.8	○	△
St-24	0.3	○	△
St-25	0.8	○	
St-26	2.2	○	△

* ○ abundant △ little

Heavy minerals

The percentage of heavy mineral in each samples ranges from 0.1% to 5.5% and in average the percentage is about 1% or so. Hornblende and magnetite are the dominant minor constituents. Monazite and apatite are found in lesser amounts of the heavy fraction of some stations. The weight percent of total heavy minerals in each station and the relative abundance of common heavy fractions are presented in Table 3. The areal distribution of total heavy minerals based on their precentage, namely, more Than 1%, 0.1%-1%, and less than 0.1%, is shown in Fig. 8.

As it is shown in Fig. 8, the heavy fractions are dominantly present in the area off the coast of Cheju Island and the north west coast of Tsushima Island.

X-ray diffractograms of the (−)2 micron fraction of seven representative samples from the silty sand bottom shows that kaolinite is the dominant clay mineral. Other minerals present in the (−)2 micron fractions include feldspar, quartz, chlorite, montmorillonite and muscovite.

SUMMARY AND CONCLUSIONS

Coarse sediments are present on the outer half of the shelf, and these grade into finer sediment toward both directions the nearshore and the shelf-break. The coarsening on the outer half in the area studied has its counter part elsewhere in the world. It seems that it probably was a zone of sand shore and littoral sediment deposited during a Pleistocene time of lowered sea level.

An abandance of calcium carbonate in the bottom sediments off the northeast and southern coasts of Cheju Island is attributed to the availability of the calcareous sand deposits along the coasts of Cheju Island.

The total amount of heavy minerals varies within the range of 0.1 per cent. And the area showing more than 1 per cent of heavy mineral is situated off Cheju Island and Strait of Korea.

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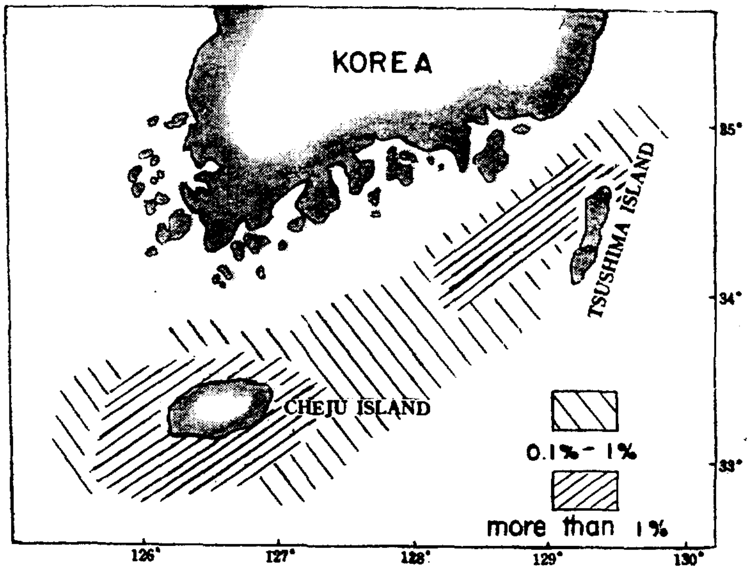

Fig. 8. Distribution of heavy minerals in the area studied.

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