The Journal of the Oceanological Society of Korea
Vol. 21, No. 1, p. 34~45, March 1986.

Factor Analysis of the Continental Shelf Sediments off the Southeast Coast of Korea and Its Impplication to the Depositional Environments

Yong Ahn Park and Jin Yong Choi

Department of Oceanography, Seoul National University, Seoul 151.

한반도 동남해역 대륙붕 표층퇴적물의 요인분석과 그 퇴적역사

朴　龍　安·崔　鎭　勇
서울大學校 海洋學科

Abstract: A Q-mode factor analysis for 115 surficial bottom sediments on the continental shelf off the southeast coast of Korean Peninsula (the Korea Strait) has been carried out to determine the depositional environments. The first four factors are taken as the "principal" factors, and the results are considered to represent the depositional history and sedimentary processes in relation to the Holocene sea-level changes. The fact implies that the sediments are grouped as outer-shelf relict sand sediments, inner-shelf modern muddy sediments, and finally the palimpsest sediments that are mainly distributed within and around the Korea Trough.

요약 : 한반도 동남해역(한국해협) 대륙붕의 표층 퇴적물의 입도 분석 자료에 대한 Q-mode 요인 분석을 실시하였고, 그 결과는 해수면 변동에 따른 퇴적환경의 변화를 시사하는 것으로 해석된다. 즉 외대륙붕과 붕단의 퇴적물은 분급이 양호한 사질 퇴적물이며 연근해성 패각을 많이 포함하고 있으므로 해수면이 낮았을 때(약 −150m) 집적된 잔유 퇴적물로 생각된다.

최대 수심 230m에 달하는 한국해곡(Korean Trough)에 분포하는 퇴적물은 주로 원마도가 매우 양호한 역질 물질이며 이들은 해수면이 상승하면서 재동작용을 받은 Palimpsest 퇴적물로 해석된다. 수심 약 120m이내의 내 대륙붕에는 실트와 점토가 우세한 니질 퇴적물이 분포하며 이들은 해수면이 거의 현 수준으로 상승한 지난 7000 년 이후에 집적된 것으로서, 소위 내 대륙붕 니질대를 이루고 있다.

INTRODUCTION

During the last three decades, a great deal of sedimentologic studies have been made to interpret the clastic depositional environments using the textural parameters of the sediment grain size distribution (Folk and Ward, 1957; Folk, 1962, 1966; Friedman, 1961, 1962, 1967, 1979; Passega, 1957, 1964; Duane, 1964; Cronan, 1972; Moiola and Weiser, 1968). Certainly significant advances have been made to define and interpret the depositional environments by using the textural parameters. Multivariate analysis techniques, however, were proposed (Imbrie and Van Andel, 1964) and used to discriminate the environments. Klovan (1966) performed a Q-mode factor analysis using the entire grain-size

* The present study was supported by the Basic Science Research Institute Program, Ministry of Education, 1984.

spectrum as input data, and Solohub and Klovan (1970) concluded that Q-mode factor analysis might be useful to identify depositional environments.

In the present study, a Q-mode factor analysis have been carried out based on the grain-size data of the continental shelf sediment samples. The purposes of the present study are 1) to evaluate the merits of factor analysis, 2) to differentiate the regional depositional environments, and further 3) to interpret these results in relation to the history of Holocene sea-level changes.

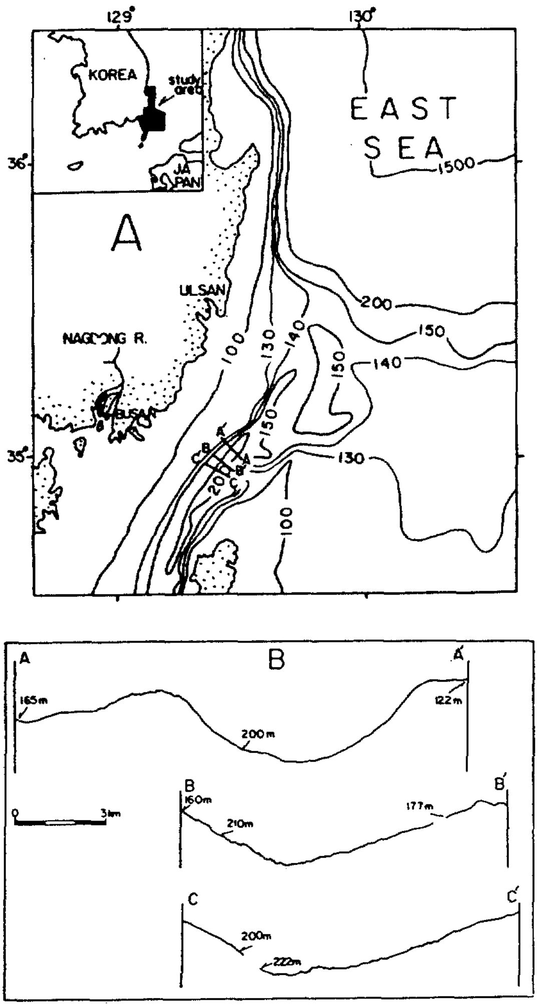


Fig. 1. Index map. A) Bathymetry. B) 3 lines of cross-section. Note water depth in meter.

The study area is the continental shelf off the southeastern part of the Korean Peninsula and covers approximately 10,000km^2, where most of the area is shallower than 200m water depth. The study area has a trough between Korean Peninsula and Tsushima Island, which is named as the Korean Trough (Fig. 1A). The Korean Trough has the maximum depth of deeper than 230m and its shape is rather symmetric in cross-section (Fig. 1B). The slope of the side walls changes abruptly at the depth between 120m and 130m forming an edge-like morphology. The northeastern part of the study area is bordered by shelf break and steep continental slope passing into the deep Ulleung Basin of more than 1,500m water depth.

Recently, continental shelf sediments around the Korea Strait area were studied by many workers. Park (1983a, 1985) found the so called relict sand materials along the shelf break off the southeast coasts of Korea. Park and Song (1971) also recognized a sort of relict sediments in the outer part of South Sea shelf of Korea. The modern fine-grained materials derived from the nearby landmasses are confined and deposited within the inner shelf region forming the typical "nearshore mud-belt" (Park, 1983b).

MATERIALS AND METHODS

A total of 115 superficial bottom sediment samples were obtained during the three cruises in 1981, 1982 and 1983 using a Van-Veen type grab sampler (Fig. 2). For the granulometric data, sediment samples were analyzed by the standard dry-sieving and pipetting methods proposed by Carver (1971). After removing the organic matters by treatment with 6% hydrogen peroxide, each samples were sieved into 13 size-fractions from $-1\ \phi$ to $> 10\ \phi$ with $1\ \phi$ interval. From weight percentages of each fractions, 115 by 13 data matrix was constructed and used for Q-mode factor analysis with a technique of

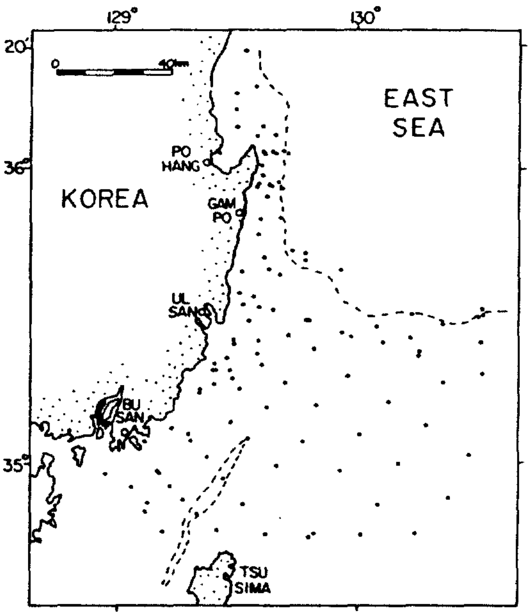


Fig. 2. Location of sample stations. Dashed line represents 200m water depth.

varimax rotation. Computer program for the Q-mode factor analysis was adopted from Davis (1973) and was run on a VAX-11 computer at the Seoul National University, Seoul, Korea.

RESULTS

Table 1 shows the eigenvalues, percent sums of squares and cumulative sums of squares for each factors. The first four factors were chosen as the "principal" factors. The selection of the principals were determined for two reasons: 1) cummulative sums of squares exceeding 86%, and 2) most of the samples within the range over 90% of totals depend significantly (communality larger than 0.7) on the "principals" (Table 2).

Table 3 shows the varimax factor scores which represent the effects of each variables to the selected factors. Factor 1 depends mainly on the fine sand class (variable 5) and very fine sand class (variable 6) materials with factor scores of 52.85 and 24.80, respectively. Factor 2 represents the clay-sized materials smaller than 8 μm (variable 10, 11, 12 and 13) with scores ranging from 16.86 to 26.42. Factor 3 depends on the medium sand (variable 4) and coarse sand fraction (variable 5), whereas Factor 4 depends primarily on the fine silt sized materials (variable 9).

Table 1. Eigenvalues, percent sums of squares, and cumulative percent sums of squares.

Factor	Eigenvalue	Percent sums of Squares	Cumulative sums of Squares
1	48.80	41.71	41.71
2	29.70	25.38	67.09
3	15.04	12.86	79.95
4	7.21	6.16	86.11
5	5.04	4.31	90.42
6	3.07	2.26	93.04
7	2.34	2.00	95.04
8	1.68	1.44	96.48
9	1.21	1.03	97.51
10	1.10	0.94	98.45
11	1.05	0.90	99.35
12	0.41	0.35	99.70
13	0.34	0.29	99.99

The contour maps of factor loadings are shown in Figure 3. The sediments of Factor 1 with high loading values (0.5-0.9 and 0.9-1.0) are distributed widely on the northeastern part of the study area, especially near the shelf break area (Fig. 3A). These fine-sand deposits are well sorted and characterized by iron stained quartz grains. Furthermore, the sediments contain abundant shells and other carbonate materials (maximum of more than 50% in weight). Most of the shell fragments are deeply weathered (Park, 1985), but some of them were identified to be

Table 2. Number of samples, cumulative percentages with communality to the selected factors.

Number of factors	Communality	Number of samples	Cumulative percent
3	> 0.90	43	37
	0.89-0.80	35	67
	0.79-0.70	10	76
	0.69-0.60	8	83
	< 0.59	21	100
4	> 0.90	63	54
	0.89-0.80	33	82
	0.79-0.70	9	**90**
	0.69-0.60	3	93
	< 0.59	9	100
5	> 0.90	82	70
	0.89-0.80	21	88
	0.79-0.70	9	96
	0.69-0.60	1	97
	< 0.59	4	100

Table 3. Varimax factor scores for each variable

VAR.	Size (μm)	Factor 1	Factor 2	Factor 3	Factor 4
1	> 2,000	1.8449	−1.2814	5.7072	0.5539
2	1,000-2,000	1.8587	−1.0470	6.0887	0.7602
3	500-1,000	2.0059	−1.2917	**14.5282**	0.5820
4	250-500	3.3950	−4.9961	**49.6949**	−0.3745
5	125-250	**52.8466**	−7.2307	−2.7477	3.3525
6	64-125	**24.8011**	8.5732	−3.9397	−3.9253
7	32-64	2.5824	4.5256	0.8723	0.9289
8	16-32	1.6599	3.7887	0.7257	8.0589
9	8-16	0.5180	−3.6757	0.2863	**53.6782**
10	4-8	−1.0172	**20.0399**	0.8883	**18.1506**
11	2-4	−0.7169	**17.8430**	1.3126	−0.5159
12	1-2	−0.8206	**16.8631**	1.2184	−0.6730
13	< 1	0.2055	**26.4197**	2.2271	−10.7509

the cold water species such as *Patinopecten yessoensis, Swiftpecten swifti, Mercenaria stimpsoni* (Chiji, et al., 1981) and *Amussiopecten praesignis* (Honza, 1978). The age of these carbonates is considered to be up to 16,000 yrs B.P. representing the Wuerm Glacial time (Chiji, et al., 1981). On the basis of lithology and biology, Park (1985) and Chiji, et al. (1981) considered the sediments on the Korea Strait shelf area to be the relict sediments that were deposited in the shallow water environments such as beach, when the sea level was lower than the present level. In

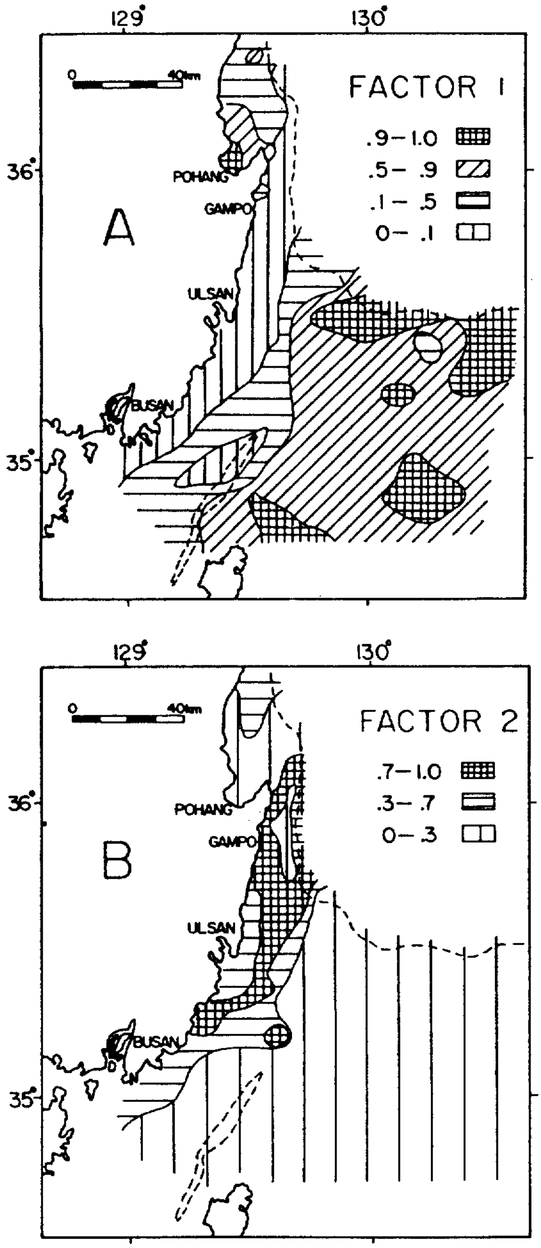
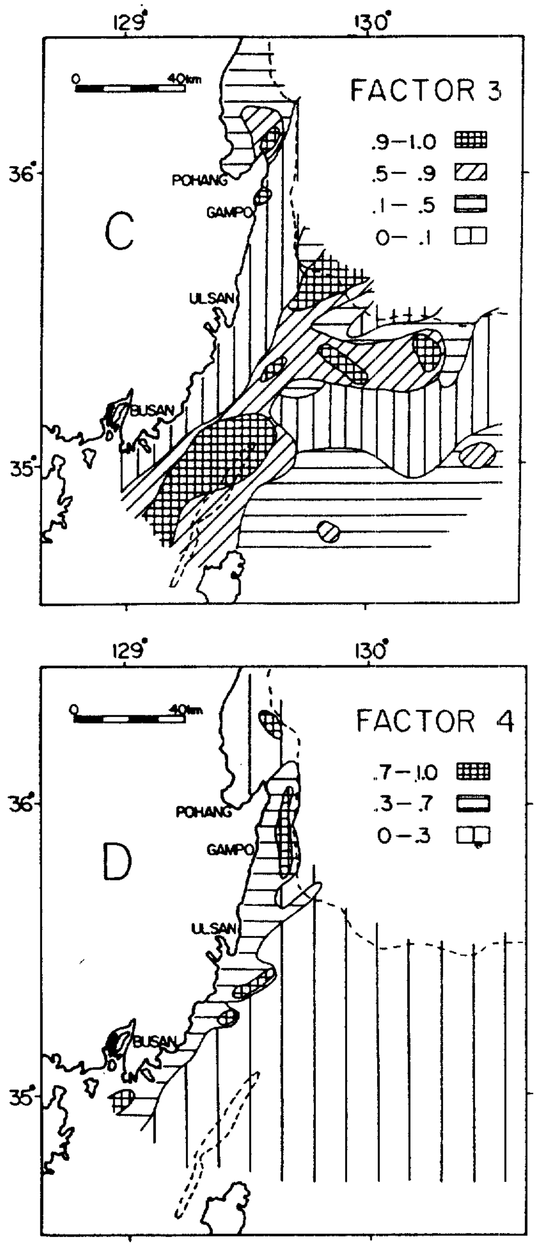


Fig. 3. Distribution of loading values. A) Factor 1. B) Factor 2. C) Factor 3. D) Factor 4. Note dashed line showing 200m water depth.



fact, the authors agree that the Factor 1 sediments in the present study area might be the relict sediments.

The sediments of Factor 2 with significant loading values (0.7-1.0) are distributed mainly in the inner shelf area forming a so called inner shelf mud belt paralleling the coast, especially on the inner shelf area off the coast between Ulsan and Gampo (Fib. 3B).

The sediments of Factor 3 with significant values (0.5-0.9 and 0.9-1.0) are mainly distributed on the floor of the Korean Trough deeper than 140m and on the northeastern part of the study area (Fig. 3C). The distribution pattern of Factor 3 sediments is similar to that of the gravel, which is abundant near the Korean Trough area and on the northeastern part of the study area (Fig. 4). These gravels are well rounded (Park, 1985) and some of them have traces of attaching mark of oysters and other kind of mollusks. These gravelly coarse sediments are considered to be a sort of relict sediments deposited during the earlier glacial time (Inoue, 1975; Honza, 1978; Park, 1985).

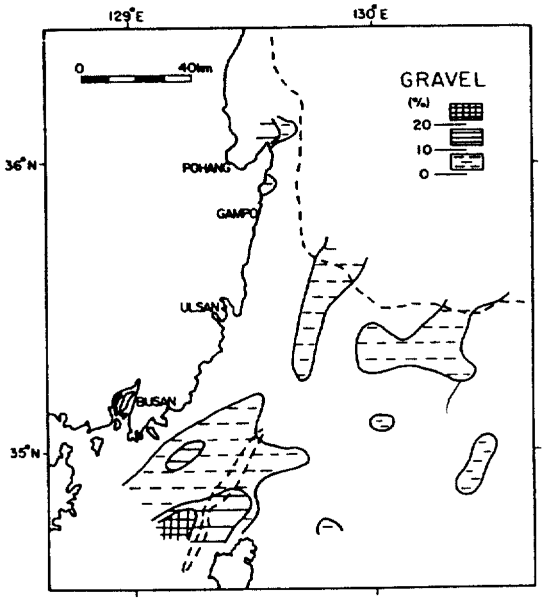


Fig. 4. Distribution of gravel content.

The sediments of Factor 4 are also distributed dominantly in the inner shelf area as the distribution of the Factor 2 sediments (Fig. 3D). Especially the inner shelf area off Gampo, Ulsan, and the Nagdong River estuary have high loading values (0.7-1.0) to Factor 4 forming local patch distributions.

Figure 5A, 5B and 5C show the results of plotting the rotated varimax factor loadings for Factor 1 and 3, Factor 2 and 4, and Factor 1 and 2, respectively. As shown in Figure 5A and 5B, there are trends in loading values between Factor 1 and 3, and between Factor 2 and 4. In Figure 5C, however, data points are scattered widely and do not show any continuous trend between Factor 1 and 2. These results indicate that most of the samples are grouped and distinguished into the sandy sediments of Factor 1 and Factor 3 and muddy sediments of Factor 2 and Factor 4.

For a better interpretation of the distribution of sediments, the principal factors are taken as end-members, and the normalized factor components are plotted on the modified ternary diagram (Fig. 6). From the scattered data points shown in Figure 6, the samples are further divided into 7 sub-groups, and the distribution pattern of these sub-grouped sediments is shown in Figure 7.

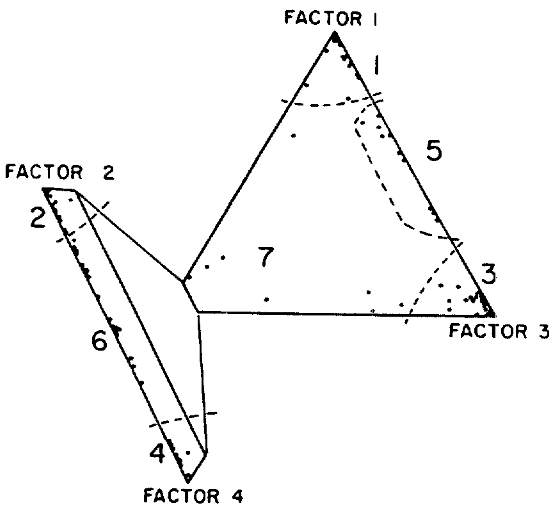
In general, the sub-group 3 sediments occur mainly on the central part (deeper than 140m) of the Korean Trough. To the east, they are bounded by the sub-group 1 and 5 sediments. Subgroup 5, however, is the mixed sediments between sub-group 1 and 3 (Fig. 6). These three sub-grouped (sub-group 1, 3 and 5) sediments are dominated by the sandy materials and are considered probably to be the relict sediments as mentioned above.

Sub-group 2, 4 and 6 sediments are distributed in the inner shelf region between Busan and Gampo. These sediments are considered to be the modern sediments that have been deposited during the last 7,000 years since the sea level approached to the present level.

Sub-group 7 sediments are characterized as the mixed facies between modern muddy sediments and relict sandy deposits. They occur only on the western part (between 100m and 130m water depth) of the Korean Trough.

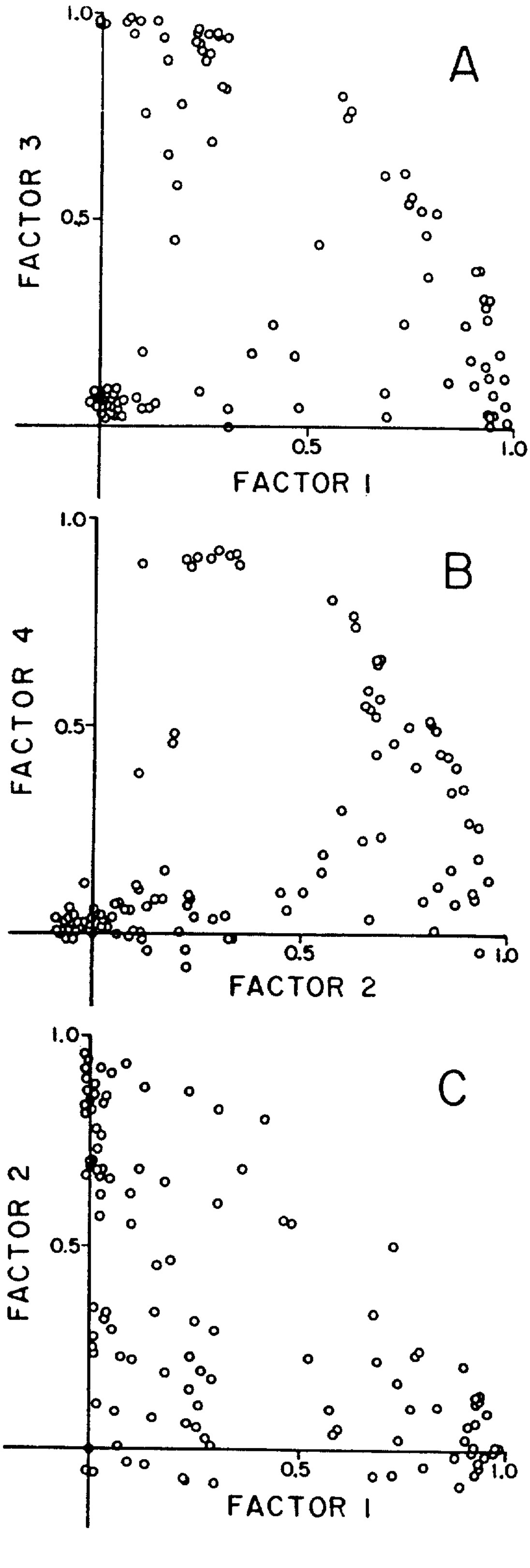
DISCUSSION

In general it has been understood that most of the continental shelf sediments have experienced several significant dynamic transgressive-regressive effects due to the sea level fluctuations during the Quaternary. Niino and Emery (1961), Park and Song (1971), Inoue (1975), Honza (1978), Kim, S.W. et al. (1980, 1981, 1984, 1985), Kim, C.S. et al. (1982, 1983, 1985), Oshima, et al. (1982), and Chough (1983) studied the continental shelf sediments around the Korean Peninsula, and stated that the sandy materials distributed on the outer shelf and near the shelf break area



▲

Fig. 6. Plots of normalized factor components.



◀

Fig. 5. Plots of factor loadings. A) Factor 1 and 3. B) Factor 2 and 4. C) Factor 1 and 2.

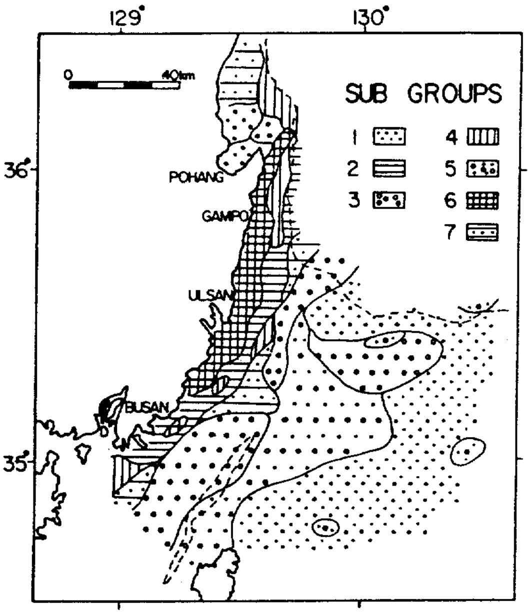


Fig. 7. Distribution of sub-grouped sediments.

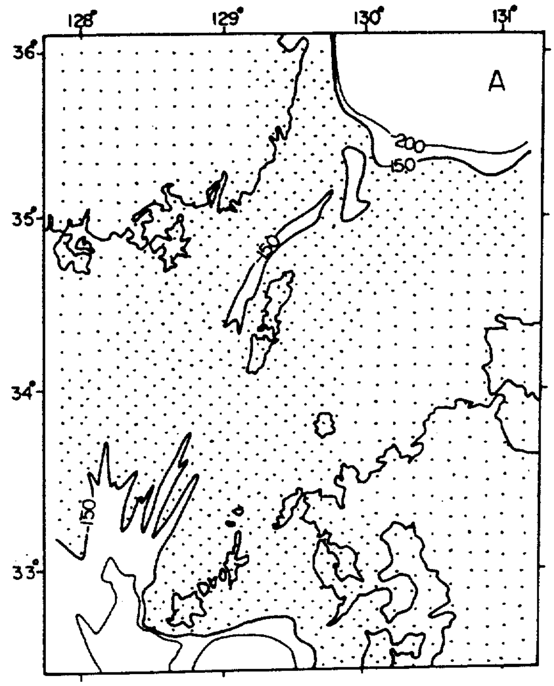
might be the relict sediments deposited during the last glacial time when the sea level was low. More recently, Park (1983a, 1985) focused on the sedimentary processes of continental shelf off the southeastern coasts of Korea to find out the probable boundary between modern and relict sediments. The former group of sediments, i.e. modern muddy sediments are deposited in the nearshore and inner shelf area and the latter are distributed widely on the outer shelf and shelf break area.

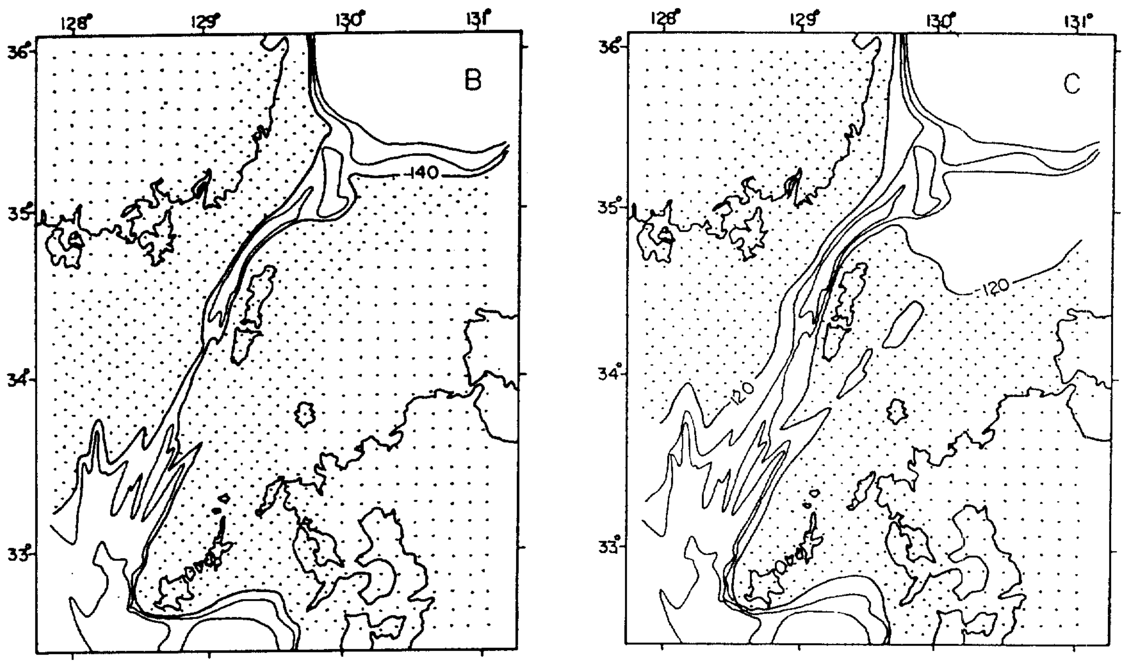
As described above, the results of the present study do indicate that the continental shelf sediments around the Korea Strait area can be differentiated into three-main groups, that is, modern inner shelf muddy deposits, outer shelf fine-sand deposits, and the gravelly sand deposits on the floor of the Korean Trough.

During the last glacial time at about 18,000 yrs. B.P., the sea level was the lowest (about 150m lower than present). At that time, the Korea Strait shelf area was exposed to air and Korean Peninsula was connected with Japanese Islands (Fig. 8A, Katsura and Nagano, 1982), but the Korean Trough remained as an isolated basin. When the sea level rose to about 140m below the present level, the Korean Trough became no more isolated and was connected with the East Sea (Japan Sea) and East China Sea (Fig. 8B). During that dynamic circumstances, the current velocity in this trough might be so high that the finer materials were winnowed out of the bottom sediments leaving only the gravelly coarse materials as lag facies. Yuasa, M. and Ishibashi, K. (1978) stated that the pebbles in the Korean Trough area might have been supplied from the Korean Peninsula. At the present environmental condition, the current velocity in the Korean Trough are measured up to 0.8m/sec at 195m depth (Shim, et al., 1984). Such a current velocity can not only prevent the deposition of fine materials but also erode and rework the bottom sediments. In the Goto shelf area, in fact, most of pebbly coarse sediments are considered to be the palimpsests that are reworked by strong tidal currents (Inoue, 1975; Ohshima, et al., 1982). From the present study results, sub-group 3 sediments on the Korean Trough area are thought to be the palimpsest sediments.

When the sea level rose to about 100m-120m below the present level, most of the shelf area was submerged as shown in Figure 8C. In this period of transgression (from −150m to −100m) the retreat of coastline was so fast that the transgression did little to alter the distribution of the sand or gravelly coarse sediments, and a typical transgressive sand sheet deposit was formed. Unimodal fine sand deposits of sub-group 1 distributed on the outer shelf area, are considered to be the relict sediments that were deposited earlier glacial times and remained unaffected by modern environmental sedimentary processes.

Inner shelf sediments of sub-group 2,4, and 6 are dominated by silty and clayey sized materials, and are thought to be the modern sediments. Park (1983a, 1985) found the very turbid water mass in the inner shelf area with maximum TSM concentrations of more than 1.0mg/l and 7.0 mg/l in surface and near-bottom waters, respectively, and suggested that the source for these suspensates might be from the Nagdong River. Kim and Lee (1980) also referred to the Nagdong River as a source for the finer materials. Park and Han (1985), however, presented that the clay minerals in the Korea Strait area were influenced by the Tsushima Warm Current from the East China Sea. Huh (1982) and Wells et al. (1983, 1984) suggested a possible transport of fine-grained materials from the Yellow sea and coastal zones of the western coast of Korea Peninsula through so called Korean Coastal Current to the Korea Strait and East Sea, especially in winter time. Kim and Han (1971) found the cold water type foraminifera from the surficial sediments of Yeongil Bay near Gampo area, and Yoo





◀

Fig. 8. A) Paleogeography during pre-Holocene when sea level was lower (−150m) than the present. B) Early Holocene sea level lower (−140m) than the present. C) Early middle Holocene sea level lower (−120m) than the present. Note −200m, −150m, −140m and −120m bathymetry. Modified after Katsura and Nagano (1982).

(1970) pointed out the possibility that the cold currents from Okhotsk Sea might flow southerly to the Korea Strait shelf area. In fact, the authors also suggest the possibility that a great amount of fine grained sediments on the inner shelf area might be transported from the north by the southerly flowing North Korean Cold Water mass which was described by Lim, D.B. (1973), Kim and Chung (1982), Kim and Min (1983), Kim and Kim (1983) and Lim, K.S. (1973).

ACKNOWLEDGMENTS

The authors would like to thank captain S.K. Park of T/V Hanbada and his crew for their kind cooperation for sampling during the cruise period. Many able and diligent graduate students of the Department of Oceanography, Seoul National University are thanked for their assistance during the cruise and laboratory work. Dr. John D. Milliman of the Woods Hole Oceanographic Institution and Dr. S.C. Park of the Department of Oceanography, Chungnam National University are also thanked for helpful suggestions and constructive criticism.

REFERENCES

Carver, R.E., 1971. Procedures in sedimentary petrology. New York, Interscience Pub., 635pp.

Chiji, M., Okamoto, K., Yamauchi, S., Konda, I., Ishii, H., Inokuchi, H., Hayashida, A. and Ishigaki, I., 1981. Preliminary report of the Tansei-Maru Cruise KT-79-8 (the southwestern Japan Sea). Bull. Japan Sea Research Institute Kanazawa Univ., 13: 167-169. (in Japanese).

Chough, S.K., 1983. Marine geology of Korean Seas. IHRDC Pub., Boston, 157pp.

Cronan, D.S., 1972. Skewness and kurtosis in polymodal sediments from the Irish Sea. J. Sediment. Petrol., 42:102-106.

Davis, J.C., 1973. Statistics and data analysis in geology. John Wiley and Sons Inc., 550pp.

Duane, D.B., 1964. Significance of skewness in recent sediments, western Pamlico Sound, North Carolina. J. Sediment. Petrol., 34: 864-874.

Folk, R.L., 1962. Of skewness and sands. J. Sediment. Petrol., 32: 145-146.

Folk, R.L., 1966. A review of grain-size parameters. Sedimentology, 6:73-93.

Folk, R.L. and Ward, W.C., 1957. Brazos River bars, a study in the significance of grain-size parameters. J. Sediment. Petrol., 27: 3-27.

Friedman, G.M., 1961. Distinction between dune, beach, and river sands from their textual characteristics. J. Sediment. Petrol., 31: 514-529.

Friedman, G.M., 1962. On sorting, sorting coefficients, and the lognomality of the grain-size distribution of sandstones. J. Geol., 70: 737-756.

Friedman, G.M., 1967. Dynamic processes and statistical parameters compared for size frequency distribution of beach and river sands. J. Sediment. Petrol., 37: 327-354. 4.

Friedman, G.M., 1979. Differences in size distributions of populations of particles among sands of various origins. Sedimentology, 26: 3-32.

Honza, E., 1978. Geological investigations in the northern margin of the Okinawa Trough and the western margin of the Japan Sea, April-March 1977 (GH 77-2 Cruise). Cruise Rept., NO. 10, Geol. Surv. Japan, 79pp.

Huh, O.K., 1982. Satellite observation and the annual cycle of surface circulation in the Yellow Sea, East China Sea and Korea Strait. La mer, 20: 210-220.

Imbrie, J. and Van Andel, T.H., 1964. Vector analysis of heavy mineral data. Geol. Soc. Am. Bull., 75: 1131-1156.

Inoue, E., 1975. Goto-nada Sea and Tsushima Strait investigations, northwestern Kyushu, 1972-1973. Cruise Rept., No. 2, Geol. Surv. Japan, 68pp.

Katsura, T. and Nagano, M., 1982. Geomorphology of Goto shelf channels off northern Kyushu, Japan. Rept. Hydrogr. Res., 17: 71-92 (in Japanese with English abstract).

Kim, B.K. and Han, J.H., 1971. Foraminifera in the bottom sediments off the southeastern coast of Korea. J. Geol. Soc. Korea, 7: 11-36.

Kim, C.H. and Kim, K., 1983. Characteristics and origin of the cold water mass along the east coast of Korea. J. Oceanol. Soc. Korea, 18: 73-83.

Kim, C.S., Kim, S.W., Chang, J.H., Lee C.W., Min, G.H., Kim, C.M., Kim, W.S. and Shin, W.C., 1982. Geological and geophysical survey on the continental shelf off southwestern Korea. KIER Bull., No. 31, 48pp.

Kim, C.S., Kim, S.W., Chang, J.H., Lee C.W., Min, G.H., Shin, W.C., Cho, K.J. and Kim, W.S., 1983. Geological study on the shallow water (Geomun-do area). KIER, 82-Marine Resources-1-17, p.7-48.

Kim, C.S., Kim, S.W., Cho, K.J., Chang, J.H., Kim, W.S. and Choi, W.S., 1985. Acoustostratigraphy and facies development of Quaternary sediments in the southeastern Yellow Sea. KIER Bull. 85-28, 32pp.

Kim, K. and Chung, J.Y., 1982. Branching of warm current and the origin of Korea Strait Bottom Water; in Shim, et al., 1982. Oceangraphic studies on the south eastern sea of Korea. Rept. Res. Inst. Basic Sci., S.N.U.

Kim, K. and Min, B.E., 1983. Hydrography and currents in the southeastern sea of Korea, October, 1982. RIBS-ED-82-507, p.59-100.

Ki, S.W., Min, G.H., Cho, K.J., Kim, C.M., Park, K.S., Kim, W.S. and Shin, W.C., 1980. Geophysical and geological study for base map of marine geology of Korean continental shelf between Cheju Island and Cheongsan Island, southern coast, Korea. Rept. on Geosci. and Min. Resour., KIGAM, v.9, p.15-33.

Kim, S.W., Min, G.H., 1981. Geological study of the Korean continental shelf between Chin-Do and Cheju-Do, southern coast, Korea. Rept. on Geosci. and Min. Resour., KIGAM, v.11, p.75-92.

Kim, S.W., Chang, J.H., Lee, C.W. and Min, G.H., 1984. Marine geological survey between Yeosu and Baek-Do, southern Korea. KIER, 83-Marine Resources-2-15, p.1-50.

Kim, S.W., Jang, J.H., Lee, C.W. and Min, G.H.. 1985. Marine geological study of the continental shelf around Cheju Island, southern coast, Korea, KIER, 85-18, p.7-45.

Kim, W.H. and Lee, H.H., 1980. Sediment transport and deposition in the Nagdong Estuary, Korea. J. Geol. Soc. Korea, v.16, p.180-188.

Klovan, J.E., 1966. The use of factor analysis in determining depositional environments from grain-size distributions. J. Sediment. Petrol., v.36, p.115-125.

Lim, D.B., 1973. The movement of the cold water mass in the Korea Strait. J. Oceanol. Soc. Korea, v.8, p.46-52.

Lim, K.S., 1983. The characteristics and the origin of the cold water mass in the southeastern sea off Korea. (unpublished) M.S. Thesis, Dept. Oceanography, S.N.U.

Moiola, R.J. and Weiser, D., 1968. Textural parameters: an evaluation. J. Sediment. Petrol., v.38, p.45-53.

Niino, H. and Emery, K.O., 1961. Sediments of shallow portions of East China Sea and South China Sea. Geol. Soc. Am. Bull., v.72, p.731-762.

Ohshima, K., Inoue, E., Koji, O., Makota, Y. and Kei, K., 1982. Sediments of the Tsushima Strait and Goto-nada Sea, northwestern Kyushu. Bull. Geol. Surv. Japan, v.33, p.321-350.

Park, B.K. and Han, S.J., 1985. The distribution of clay minerals in Recent sediments of the Korea Strait. Sediment. Geol., v.41, p.173-184.

Park, Y.A., 1983a. Late Quaternary sedimentation on the continental shelf off the southeast coasts of Korea. RIBS-ED-82-507, p.163-186.

Park, Y.A., 1983b. The nature of Holocene sedimentation and sedimentary facies of the continental shelves of Korea. Proceeding, 1983 Summer conference for domestic and foreign scholars of science and technology: KOFST, p.72-80.

Park, Y.A., 1985. Late Quaternary sedimentation on the continental shelf off the south-east coast of Korea – A further evidence of relict sediments. J. Oceanol. Soc. Korea, v.20, p.55-61.

Park, Y.A. and Song, M.Y., 1971. Sediments of the continental shelf off the southern coasts of Korea. J. Oceanol. Soc. Korea, v.6, p.16-24.

Passega, R., 1957. Texture as characteristics of clastic deposition. Bull. Am. Assoc. Petrol. Geol., v.41, p.1952-1984.

Passega, R., 1964. Grain size representation by CM patterns as a geologic tool. J. Sediment. Petrol., v.34, p.83-847.

Shim, T., Wiseman, W.J. Jr., Huh, O.K. and Chung, W.S., 1984. A test of the geostrophic approximation in the Western Channel of the Korea Strait, in Ichiye, T. (ed.), Ocean Hydrodynamics of the Japan and East China Seas, p.263-272.

Solohub, J.T. and Klovan, J.E., 1970. Evaluation of grain-size parameters in lacustrine environments. J. Sediment. Petrol., v.40, p.81-101.

Wells, J.T., Huh, O.K. and Park, Y.A., 1983. Dispersal of silt and clay by winter monsoon surges in the southeastern Huanghai Sea. International Symposium on sedimentation on the continental shelf, Hangzhou, China, v.1, p.462-472.

Wells, J.T., Park, Y.A. and Choi, J.H., 1984. Storm-induced fine sediment transport, west coast of South Korea. Proceedings in Korea-US seminar and workshop on marine geology and physical processes of the Yellow Sea, p.309-313.

Yoo, E.K., 1970. Recent distribution of Globigerina Pachyderma (Ehrenberg) and interpretation of Upper Cenozoic climatologic changes. J. Geol. Soc. Korea, v.6, p.119-127.

Yuasa, M. and Ishibashi, K., 1978. Description of rocks and sediments. in Honza, E. (ed.), Geological investigation in the northern margin of the Okinawa Trough and the western margin of the Japan Sea, April-May 1977 (GH 77-2 Cruise), p. 47-49.

Received February 15, 1986
Accepted February 28, 1986