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High-Resolution Seismic Study of Modern Fine-Grained Deposits: Inner Shelf off the Southeastern Coast of Korea

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Abstract

The geometry and internal structures of modern sediments on the inner shelf off the southeastern coast of Korea were investigated by means of analysing high-frequency (3.5 kHz) seismic records. The records reveal a wedge-shaped sediment body, tapering off toward the sea. On the basis of reflection patterns, the sediments can be classified into two units; "foreset" (prodelta) unit and "bottomset" unit, consisting of sandy muds and clays, respectively. The lateral transition from foreset to bottomset deposits suggests a prograding delta system of the Nakdong River since the late Holocene.

Introduction

Many seismic surveys have been carried out to understand the seismic framework of the continental shelf of the Korea Strait. Most seismic sources employed were low-frequency (air gun and/or sparker) systems, which provide relatively deep penetration, but poor resolution (Korea Institute of Energy and Resources 1983, 1987). However, on the inner shelf with its modern sedimentation, more accurate interpretation of high-frequency seismic records is needed to delineate the near-bottom sedimentary processes. This requires the use of high-frequency seismic sources (generally 2–12 kHz), which provide less penetration but enhance resolution.

Previous studies (Park and Choi 1986, Park and Yoo 1988) indicate that the inner shelf off the southeastern coast of Korea is an area with thick accumulations of modern sediments, mainly influenced by the Nakdong River, the largest fluvial system in Korea. This river annually contributes 10 million tons of sediment to the shelf, with its discharge concentrated during the rainy season from July to August (Kim and Lee 1980). Sediment is introduced onto the shelf through three distributary channels. Linear sand ridges are developed in the delta front along the shoreline.

This paper describes the internal structure of the modern sedimentary wedge on the basis of 3.5 kHz subbottom profiles (Fig. 1). The 3.5 kHz profiles were collected during the Busan 403 cruise in March and May, 1989, utilizing an O.R.E. subbottom profiling system (2–7 kHz transducer). Bottom sediment samples were also collected with a gravity corer. Positioning was maintained with a combination of Decca and Radar navigation systems.

Results and Discussion

Sedimentary Wedge

High-resolution seismic records (3.5 kHz) reveal a sedimentary wedge of modern deposits (sequence A) above a strong reflector (R) (Figs. 2, 3). This reflector was also identified in a previous study and was interpreted to be an erosional unconformity developed during the late glacial period (Park and Yoo 1988). This horizon (R) is relatively flat-lying compared to the seafloor, and is present over a wide area of the inner shelf. In the vicinity of the river mouth, however, this horizon is cut by some erosional channels and infilled with stratified modern sediments (Fig. 2b). A wide and deep erosional channel can be identified, which might be the extension of the Nakdong River during low sea level. The detailed isopach

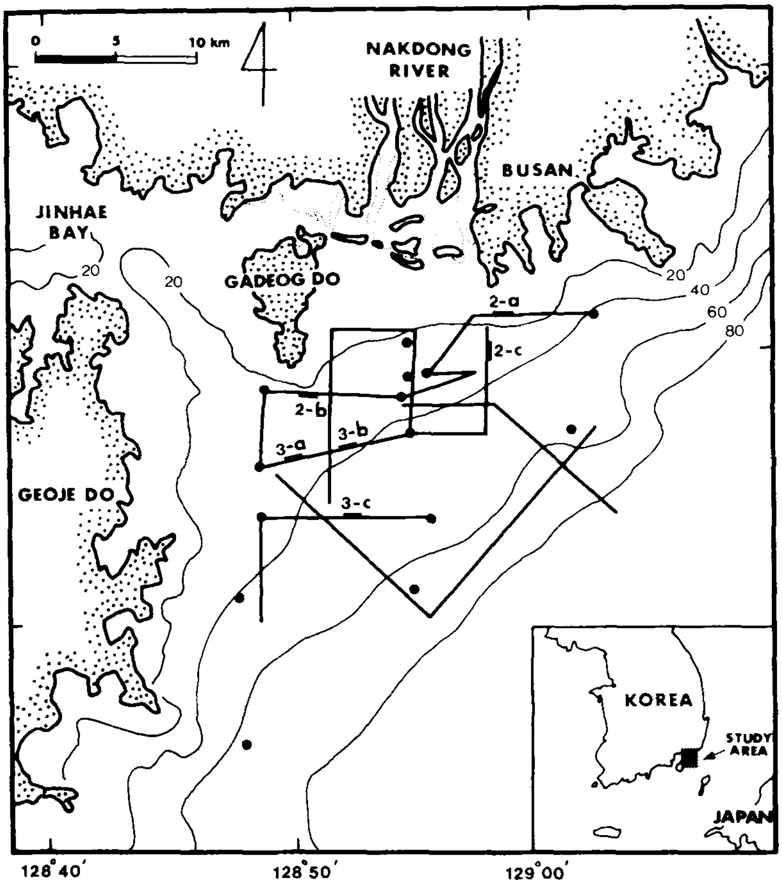

Figure 1. Study area showing track lines of 3.5 kHz subbottom profiles and sediment sampling stations. Contours in meters. The numbers 2a–5c indicate the locations of profiles shown in Figs. 2 and 3.

map of modern sediments (Fig. 4) reveals thick accumulations of sediment near the mouth of the Nakdong River and east of Geoje-Do, and a thinning trend toward the sea in a SE direction. The average gradient between water depths of 20 to 60 m is approximately 0.25°.

Depositional Units

Modern sediments (sequence A) on the inner shelf can be classified into two different units based on the reflection patterns of 3.5 kHz profiles. The first unit (unit 1) in the landward portion of the sedimentary wedge, is characterized by distinct and laterally persistent internal reflectors (Fig. 2). The internal layering is concordant with the surface, showing parallel to subparallel reflection patterns. Reflectors are postulated to be interbeds of coarse-grained material in the subsurface. However, direct correlation of sedimentological and acoustical properties was not possible because of short core length. In some places, the acoustically opaque layer masks the underlying sediment layers (Fig. 2a). In the seaward region of the delta front, unit 1 directly overlies the erosional pre-Holocene surface and reaches up to 20 m in thickness. The thickness of the unit decreases seaward (Fig. 4). It is underlain by unit 2 at water depths of about 20 to 40 m, showing a gradational transition between the two (Fig. 5).

The second unit (unit 2), overlying the pre-Holocene surface, is laterally variable in thickness. The maximum thickness reaches up to 20 m in water depths of 30 to 40 m east of Geoje-Do (Fig. 4). This unit is overlain by unit 1; locally unit 1 grades into unit 2 (Fig. 5). The unit 2 is acoustically characterized by a semi-transparent subbottom usually with no reflectors (Fig. 3). In some areas, poorly developed reflectors can be seen in this unit (Fig. 3a). This type of reflection pattern indicates one predominant lithologic type. In some places, unit 2 overlies the basal transgressive facies, which is only a few meters thick. This facies is identified by a rather strong reflector at water depths of 40 and 60 m, and it is traced over the mid-shelf beyond the seaward limit of unit 2.

Delta Progradation

Sea level curves from the Korean continental shelf show that sea level rose to the present level until

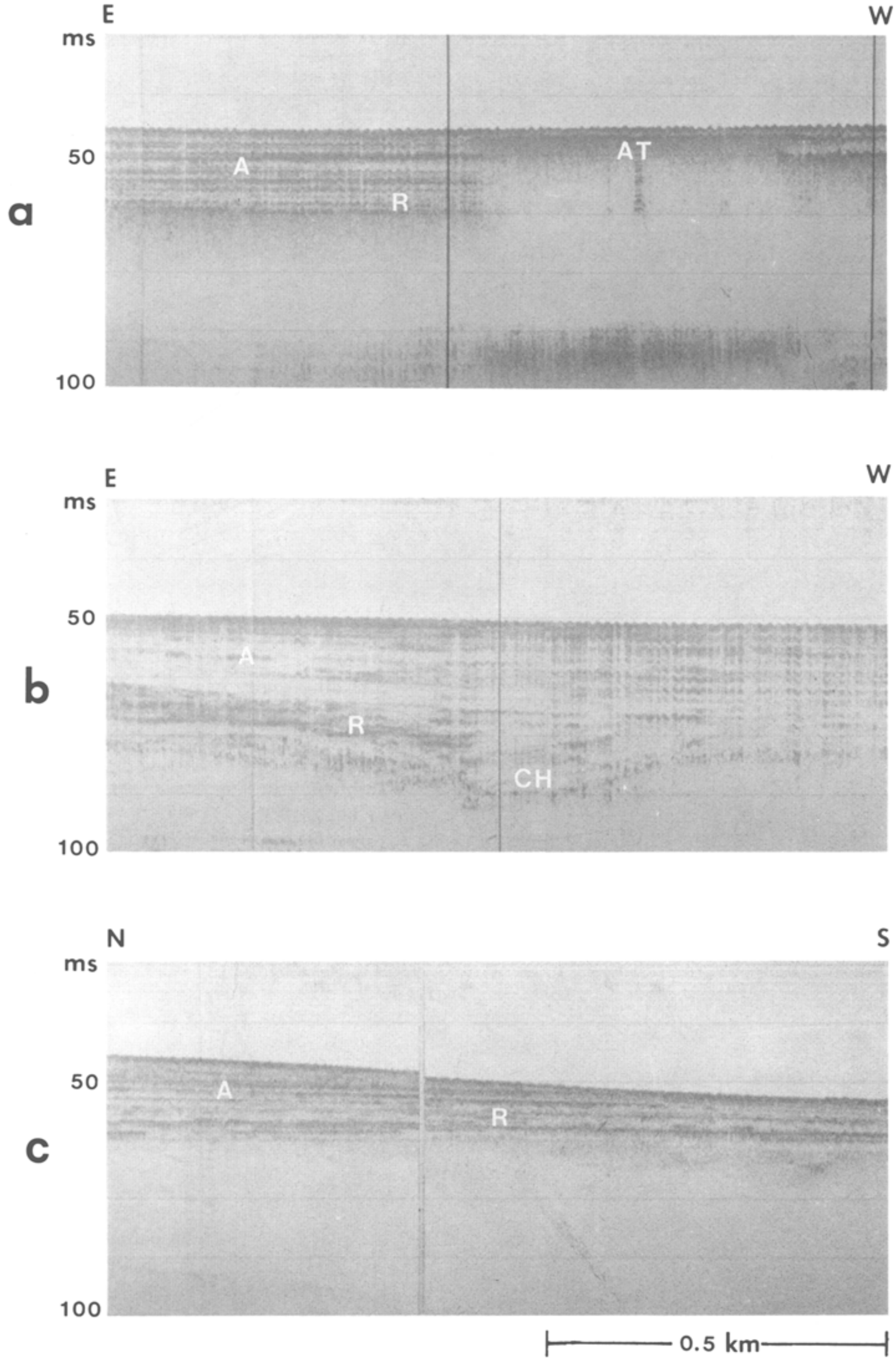

Figure 2. High-frequency (3.5 kHz) subbottom profiles (unit 1) showing distinct and laterally persistent internal reflectors above the pre-Holocene surface (reflector R). Note the uniform thickness and a channel structure in sections parallel to the coast in profiles a and b, and a sedimentary wedge of modern deposits (sequence A) above a strong reflector in a section perpendicular to the coast in profile c. AT—acoustically turbid layer. Vertical scale is two-way travel time (TWT) in ms. (10 ms is about 7.5 m of sediment). For location see Fig. 1.

approximately 5,000 years BP (Park 1983). Deposition of modern sediments probably started after that time. Most of coarse-grained sediment supplied from the river has been deposited in the delta front, forming tidal sand ridges and sandy shoals in water depths less than about 20 m (Kim and Lee 1980). The remaining fine-grained sediment has been transported further offshore in a suspended mode. The sediment texture of unit 1 is a sandy mud, while that of unit 2 is clay (Table 1). The mean grain sizes are 7.57ϕ and 9.75ϕ, respectively. There is a clear decrease in both sand and silt content with distance from the river mouth.

Unit 1 is interpreted to be deposited in the prodelta environment (foreset deposits) from the river plume that carries suspended load. The distribution map of unit 1 (Fig. 5) shows that most of the sediments have been deposited within 10 km from the river mouth.

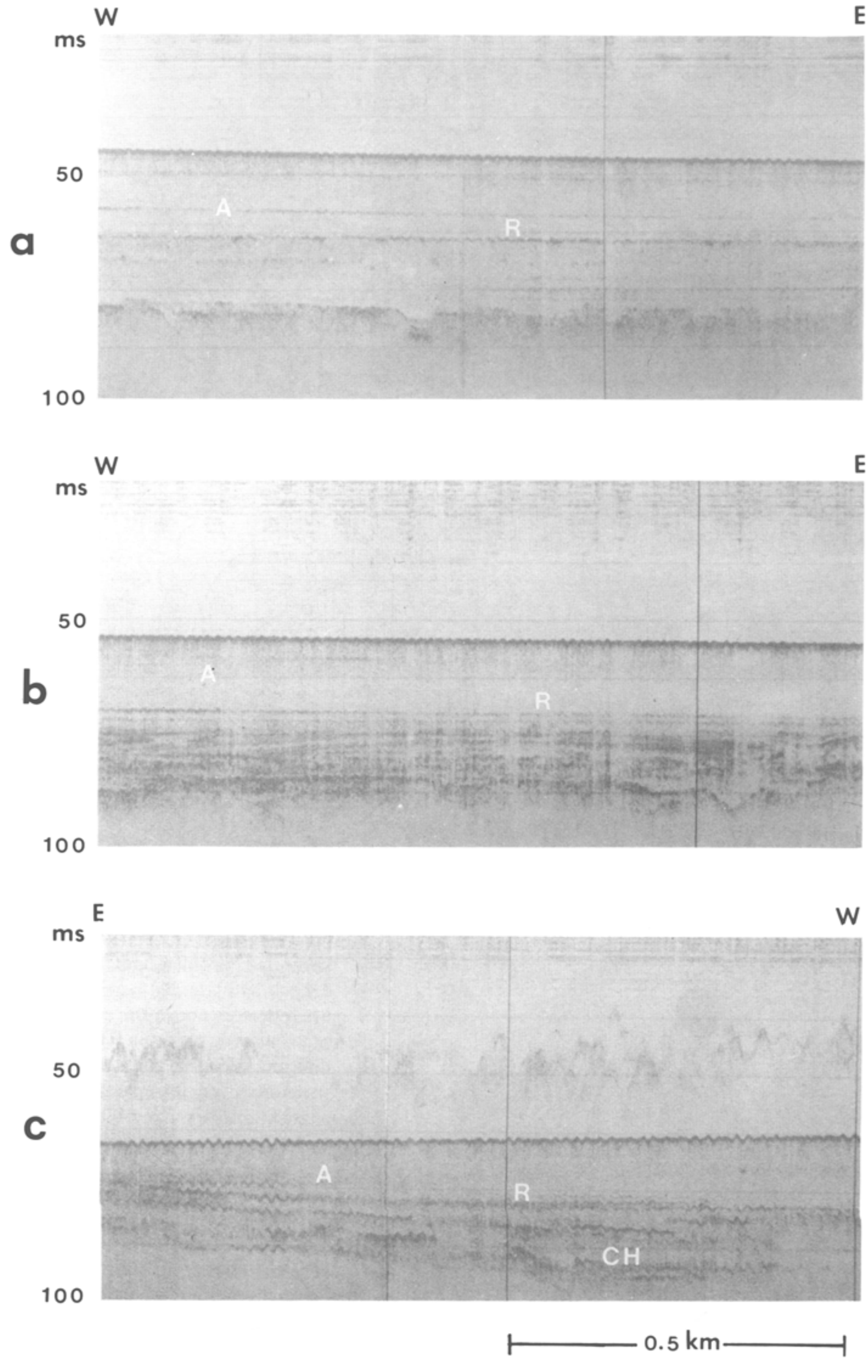

Figure 3. High-frequency (3.5 kHz) subbottom profiles (unit 2) showing semi-transparent subbottom characteristics usually with no reflectors above the pre-Holocene surface (R). For explanation of abbreviations and vertical scale, see Fig. 2.

In contrast, unit 2 is interpreted to be deposited in the bottomset environment. The acoustically transparent aspect of unit 2 in most areas is postulated to be due to a lack of coarse-grained material. The alignment of contour lines in the isopach map (Fig. 5) suggests that most of bottomset sediments have been influenced by tidal currents which flow predominantly in SW-NE direction in this area (Korea Hydrographic Office 1982). The laterally transitional pattern from foreset to bottomset sediments suggests a prograding delta system over a basal transgressive facies.

Conclusions

Modern deposits on the inner shelf acoustically show a wedge-shaped deltaic form. The maximum thick-

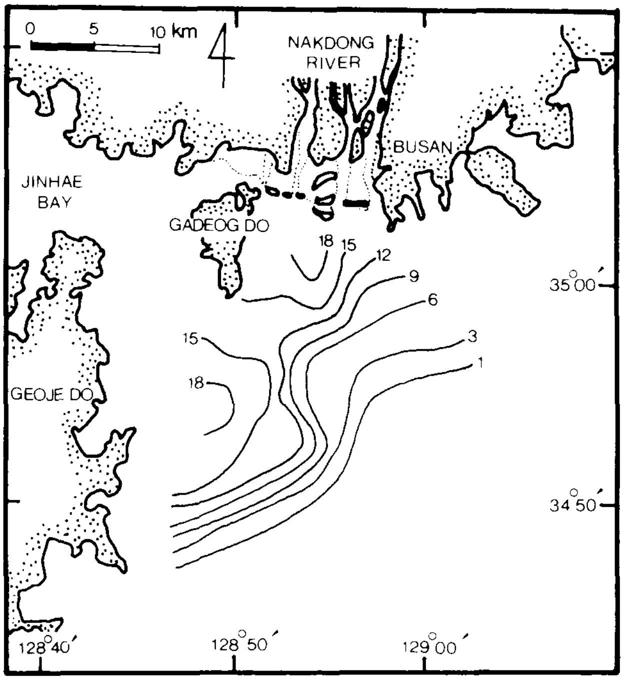

Figure 4. Isopach map showing thickness of modern sediments (sequence A). Contours in meters. Thickness values are calculated assuming a seismic velocity of 1,450 m/s (Kim and Suk 1985).

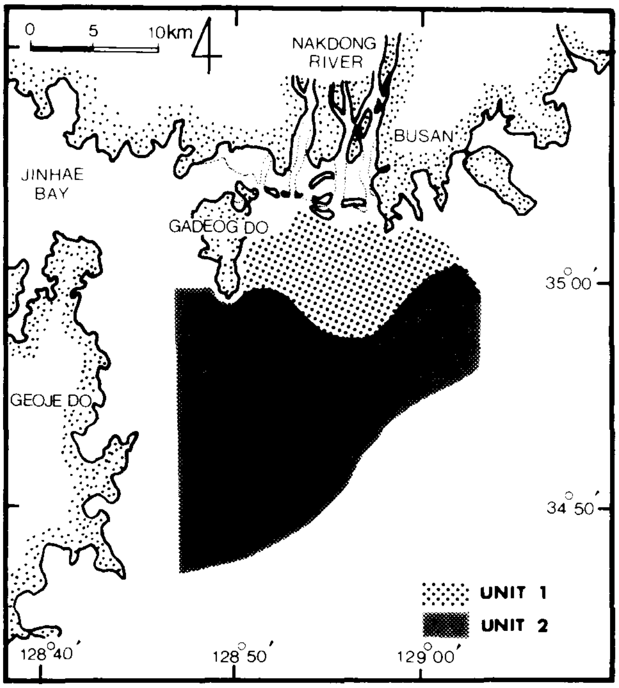

Figure 5. Areal distribution pattern of unit 1 (prodelta sediments) and unit 2 (bottomset sediments). The boundary between the two units is gradational.

ness of the delta wedge is about 20 m, decreasing in thickness from the sediment source seaward.

Modern deposits can be classified into two facies based on acoustic characters: foreset (prodelta) deposits and bottomset deposits. The transition from foreset to bottomset deposits suggests a prograding delta system.

The texture of sediments accumulating in the prodelta is a sandy mud, while offshore clays predominate the bottomset sediments.

Table 1. Sediment textures of unit 1 (prodelta sediments) and unit 2 (bottomset sediments). Mz is an average mean grain size in phi scale. The sediment type is based on the nomenclature suggested by Folk (1954)

	Average grain size (wt.%)				
	Sand	Silt	Clay	Mz(ϕ)	Sediment type
Unit 1	10.77	46.33	43.81	7.57	Sandy mud
Unit 2	2.05	25.46	72.49	9.75	Clay

Acknowledgments

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