HIGH-RESOLUTION SEQUENCE STRATIGRAPHY: LATEST PLEISTOCENE-HOLOCENE EXAMPLE FROM THE KOREA STRAIT SHELF

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Abstract

The latest Pleistocene-Holocene deposits on the Korea Strait shelf form a high-frequency sequence which consists of three systems tracts: the lowstand, transgressive and highstand systems tract. The lowstand systems tract is distributed on the shelf margin and trough region, whereas the highstand systems tract is confined only to the inner shelf. Although the transgressive systems tract between the lowstand systems tract and the highstand systems tract was identified over a wide area of the shelf, it is either very thin (a few meters thick) or absent.

Introduction

The concept of sequence stratigraphy, as defined by the Exxon Production Research Group, was systematized as a general methodology for the reconstruction of stratigraphic framework in late 1980's (e.g. Vail, 1987; Posamentier et al., 1988; Van Wagoner et al., 1988). This conceptual model is a popular method for the description of the sedimentary succession on the continental shelf and slope, and offers powerful informations for the interpretation of geologic record in terms of sea-level changes. In particular, new senses for systems tracts, consisting of a depositional system and characteristic bounding surface, have been applied to sequence stratigraphic architecture (Posamentier et al., 1988; Van Wagoner et al., 1988; Haq, 1991).

Although the sequence-stratigraphic model was mainly developed to account for sea-level cycles of 1.0-5.0 Ma (third-order cycle), it has shown

recently to be a useful tool for the interpretation of high-frequency cyclothemic sequence influenced by glacio-eustatic sea-level cycles, corresponding to about 40 Ka and 100 Ka frequency (5th or 6th-order cyclicity (Mitchum and Van Wagoner, 1991; Vail et al., 1991). The application of this concept to study the Quaternary depositional sequences, using high-resolution seismic profiles and sediment samples, has been a common practice in recent years (Suter et al., 1987; Boyd et al., 1989; Tesson et al., 1993; Hernandez-Molina et al., 1994; Saito, 1994). In spite of some differences from the classic sequence-stratigraphic model, they suggest that it is an efficient tool to analyze the Quaternary depositional history of areas under the influence of relative sea-level changes coupled with high sediment discharges.

In this study, we have applied sequence-stratigraphic concept to study the latest Pleistocene-Holocene sequence on the Korea Strait shelf(Fig. 1). Purpose of this paper is to describe the geometry and high-resolution seismic stratigraphy of latest Pleistocene-Holocene sequence on the Korea Strait shelf, and reconstruct the sequence stratigraphy in this area and its depositional processes related to the relative changes of sea level.

Sequence Stratigraphy Analysis

Systems Tracts

The latest Pleistocene-Holocene sedimentary deposits on the Korea Strait shelf comprise the lowstand (LST), transgressive (TST) and highstand systems tract (HST).

Lowstand systems tract (LST): Stratigraphically, the LST above the sequence boundary is the lowest part of the latest Pleistocene-Holocene deposits on the Korea Strait shelf. This systems tract comprises the LDW, showing progradational parasequence stacking patterns. It is found only on the shelf margin and the trough region (Fig. 2). It is acoustically defined by well-stratified and seaward dipping clinoforms with high amplitudes. The external form of this system shows a mound or wedge shape that thickens seaward.

Transgressive systems tract (TST): The TST is the middle part of the depositional sequence. Based on seismic profiles, this systems tract deposits show a small-scale retrogradation or coastal onlap, suggesting landward-migrating

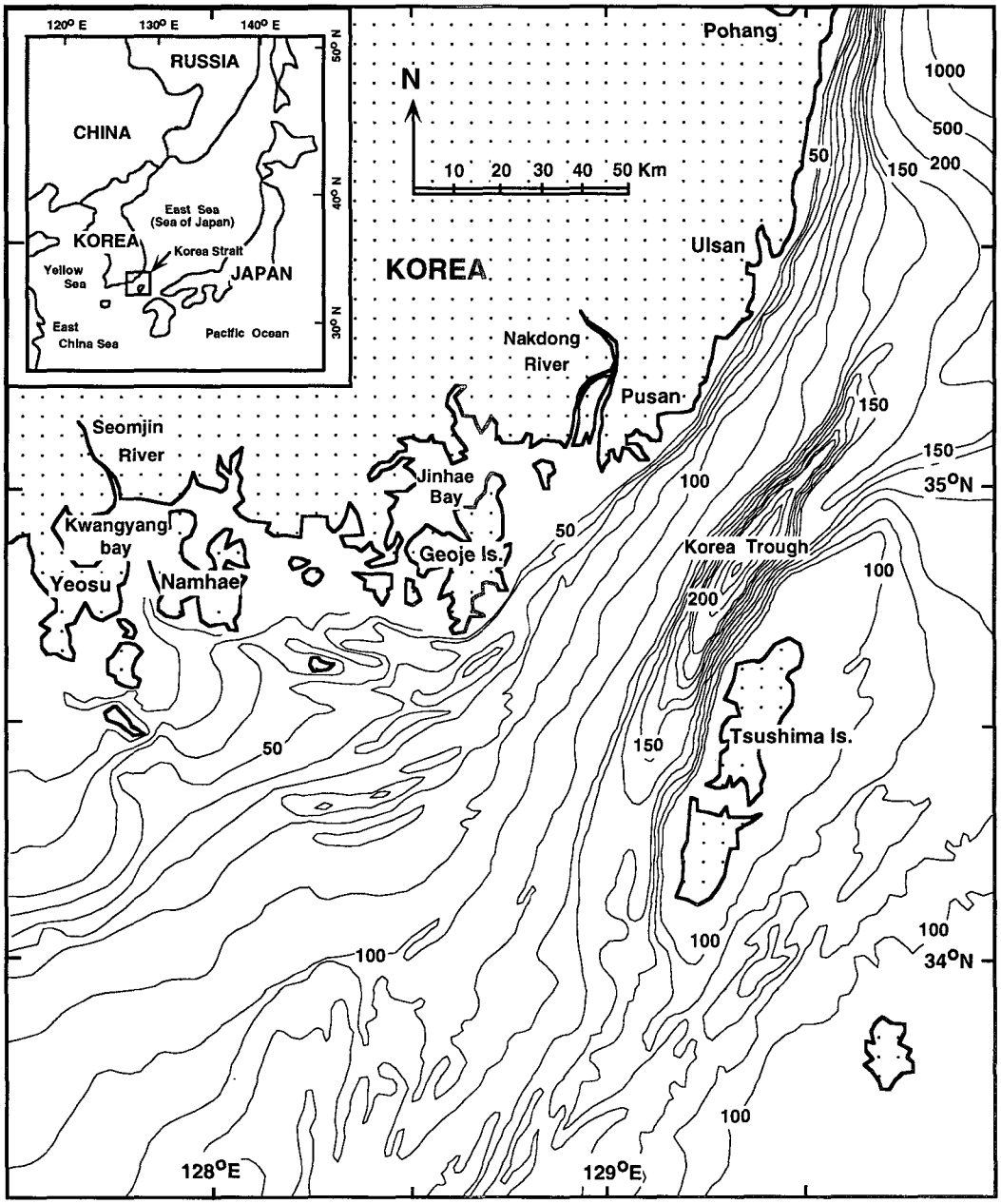

Fig. 1. Detailed bathymetry on the Korea Strait shelf (contour interval 10 m).

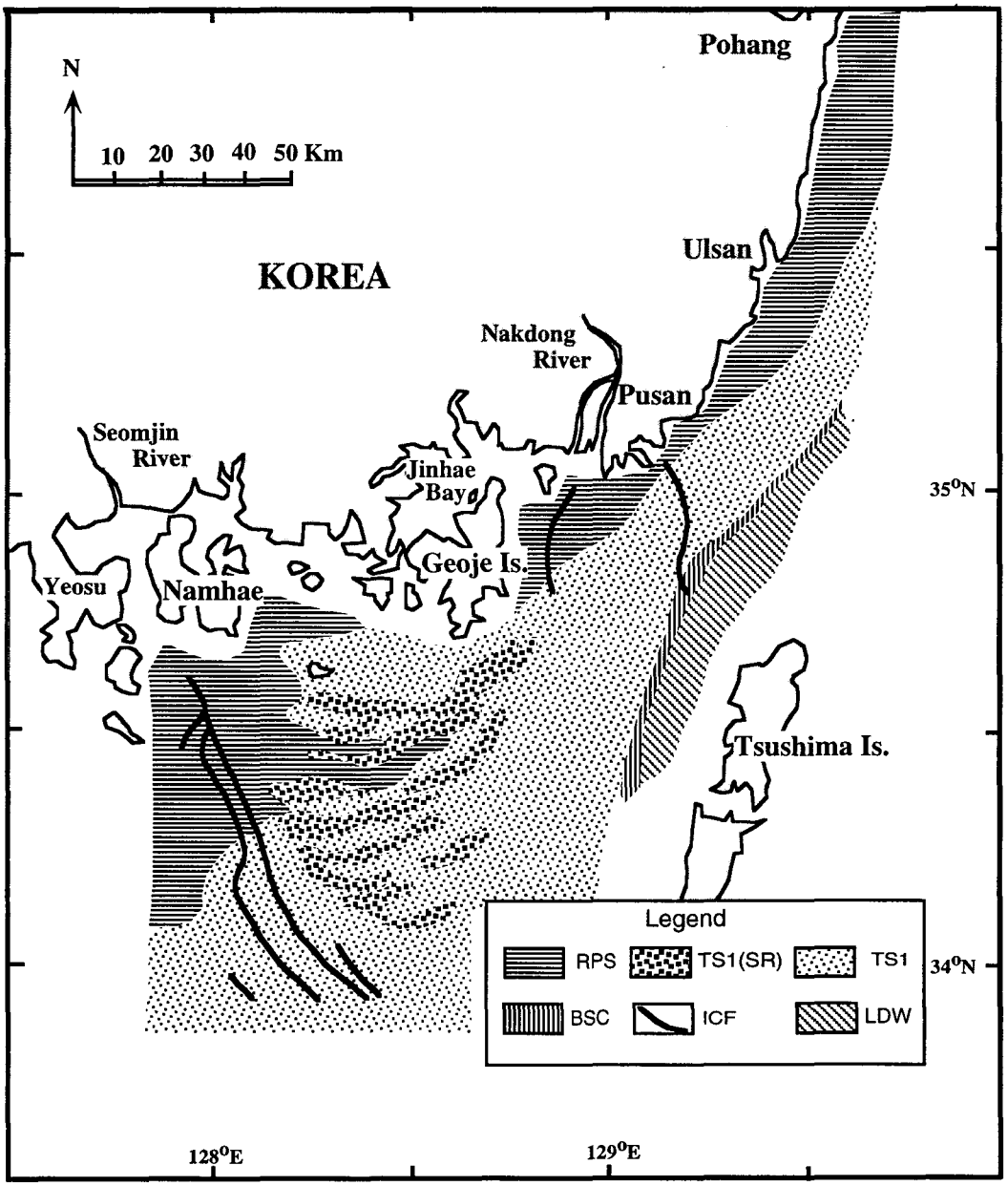

Fig. 2. Areal distribution pattern of depositional systems in the Korea Strait. Five depositional systems (RPS, TS1, BSC, ICF, and LDW) are exposed on the sea floor, whereas the other two depositional systems (TED and TS2) are completely covered by RPS depositional system. RPS = recent prodelta/shelf depositional system; TS1 (SR) = transgressive sand (sand ridge) depositional system; TS1 = transgressive depositional system; BSC = beach-shoreface complex depositional system; ICF = incised channel fill depositional system; LDW = lowstand deltaic wedge depositional system.

coastal environments, and comprise five depositional systems including beach-shoreface complex (BSC), incised channel fill (ICF), transgressive sand (TS1 and 2) and transgressive estuarine/delta (TED).

The BSC is defined by hummocky or chaotic reflection patterns and forms a narrow fringing belt oriented parallel to the present bathymetry (Fig. 2). Externally, it is shaped in a lobe or bank type with a steep side oriented seaward. The ICF forms channel fills and is acoustically defined by well-stratified reflection patterns with divergent, prograded fill patterns. The TS1 is present over a wide area of the mid-shelf (Fig. 2). Internally, it shows hummocky or chaotic reflection patterns. In most cases, it is thinner than a few meters. The TED is acoustically defined by a transparent subbottom without any internal reflectors. The external form of this system shows a small-scale ponded shape associated with a deep, depressional part. The TS2 on the inner shelf between the Geoje Island and present river mouth is acoustically characterized by hummocky or chaotic reflection patterns, similar to the transgressive sand layer (TS1) on the mid-shelf. Externally, it is shaped in a sheet type.

Highstand systems tract (HST): The HST is the upper systems tract in the Korea Strait. The base of this systems tract is associated with the maximum flooding surface. It contains the recent prodelta/shelf (RPS) system. It is found only on the inner shelf along the coast (Fig. 2). It is acoustically defined by a semi-transparent or weakly stratified subbottom reflectors. Externally, this is shaped in a wedge type decreasing in thickness seaward.

Definition of key surfaces

Characteristic key surfaces within the sedimentary deposits comprise the sequence boundary (SB), transgressive surface (TS), ravinement surface (RS), and maximum flooding surface (MFS).

Sequence boundary (SB): The type 1 sequence boundary at the basal surface of the latest Pleistocene-Holocene sequence was created in response to falling sea level. It represents an irregular, erosional surface that truncates the underlying Pleistocene sequence and has a high acoustic impedance contrast on seismic profiles.

Transgressive surface (TS): The TS is an isochronous boundary created

when the shoreline had started to move landward from its maximum seaward excursion, and marks the change from the lowstand progradation to the transgressive retrogradation. On the Korea Strait shelf, it is typically observed at the top surface of the LDW. Toward the land, this surface is merged into the sequence boundary.

Ravinement surface (RS): The RS within the transgressive systems tract is a time-transgressive, erosional surface formed by shoreface erosion that shifted landward during the postglacial transgression (Nummedal and Swift, 1987). This surface is well preserved on the inner and mid-shelf and represents an erosional surface with a strong, continuous reflectivity, possibly developed by high energy condition such as coastal environment .

Maximum flooding surface (MFS): This surface is the uppermost surface within the latest Pleistocene-Holocene sedimentary sequence, which is defined by an isochronous surface that originates when the shoreline reached its maximum landward excursion. Acoustically, it shows a non-erosional surface with a strong, continuous reflectivity.

Evolution of depositional systems

The generation of depositional sequence and systems tracts on the shelf is the results of the interplay between the available accommodation, sedimentation, and erosion rates closely related to the relative sea-level change (Posamentier et al., 1988). The lowstand systems tract and sequence boundary were created in response to relative sea-level falls, whereas transgressive and highstand systems tract were developed when the rates of increase in accommodation were more continuous. Relative sea-level fall, possibly about -130 m in this area, reduces the space available on the Korea Strait shelf, and a type 1 sequence boundary accompanying incised paleochannels was formed on the top surface of the old Pleistocene strata. The lowstand systems tract was constructed by the clastic sediment derived from the paleo-Nakdong and paleo-Seomjin River during that time. Evidence of sediment deposition related with the sea-level lowstand, when the Nakdong and Seomjin river mouths were located at the shelf margin, is also described by Yoo et al. (1996) and Yoo and Park (1996).

As the shoreline migrated landward during the postglacial transgression, sedimentation rate may have decreased drastically on the slope and trough

region. As the eustatic sea level rise outpaced the regional subsidence, successive flooding events were marked by individual marine flooding surface, forming a different transgressive parasequence and depositional system, that shifted landward. Because the amplitude and rate of sea-level rise were not continuous, distinct and various depositional systems composed of different seismic and lithofacies associations were formed and left on a wide area of the shelf from the shelf margin to the inner shelf.

The highstand systems tract was created during the eustatic highstand, defined as the interval starting sometime after the R inflection point and ending before or at late F inflection point (Posamentier et al., 1988; Vail et al., 1991). In the Korea Strait, the sea-level highstand commenced at approximately 5000 yrs B.P. During this time, the rate of eustatic change was almost negligible and sediment supply from the inland fluvial system became dominant. Thick accumulations of the highstand systems tract deposits occurred on the inner shelf as the product of present-day shelf sedimentation.

Sequence model for the Korea Strait shelf

In the present study, we have applied the high-frequency sequence-stratigraphic concept to study the latest Pleistocene-Holocene sequence on the Korea Strait shelf. Our study in this region has shown that the latest Pleistocene-Holocene sequence is mainly composed of both the lowstand systems tract on the shelf margin and trough region, and highstand systems tract confined only to the inner shelf along the coast (Fig. 3). During the lowstand phase, much of the Korea Strait shelf is subaerially exposed and river-derived sediment by-passed the shelf to form a deltaic wedge with a thickness up to 45 m, on the shelf margin and the trough region (Park and Yoo, 1992). Although the transgressive systems tract was identified over a wide area of the shelf, it is either very thin (a few meters thick) or absent (Fig. 3). Stratigraphically, the transgressive systems tract shows a retrogradational backstepping arrangement of strata on the study area. During the relative highstand phase of sea level, the highstand systems tract progrades and forms a thick, inner shelf mud deposits.

Consequently, this study show a good example of a shelf sequence controlled by the different stages of high-frequency sea-level change coupled with a high sediment discharge from the inland fluvial system. In spite of some

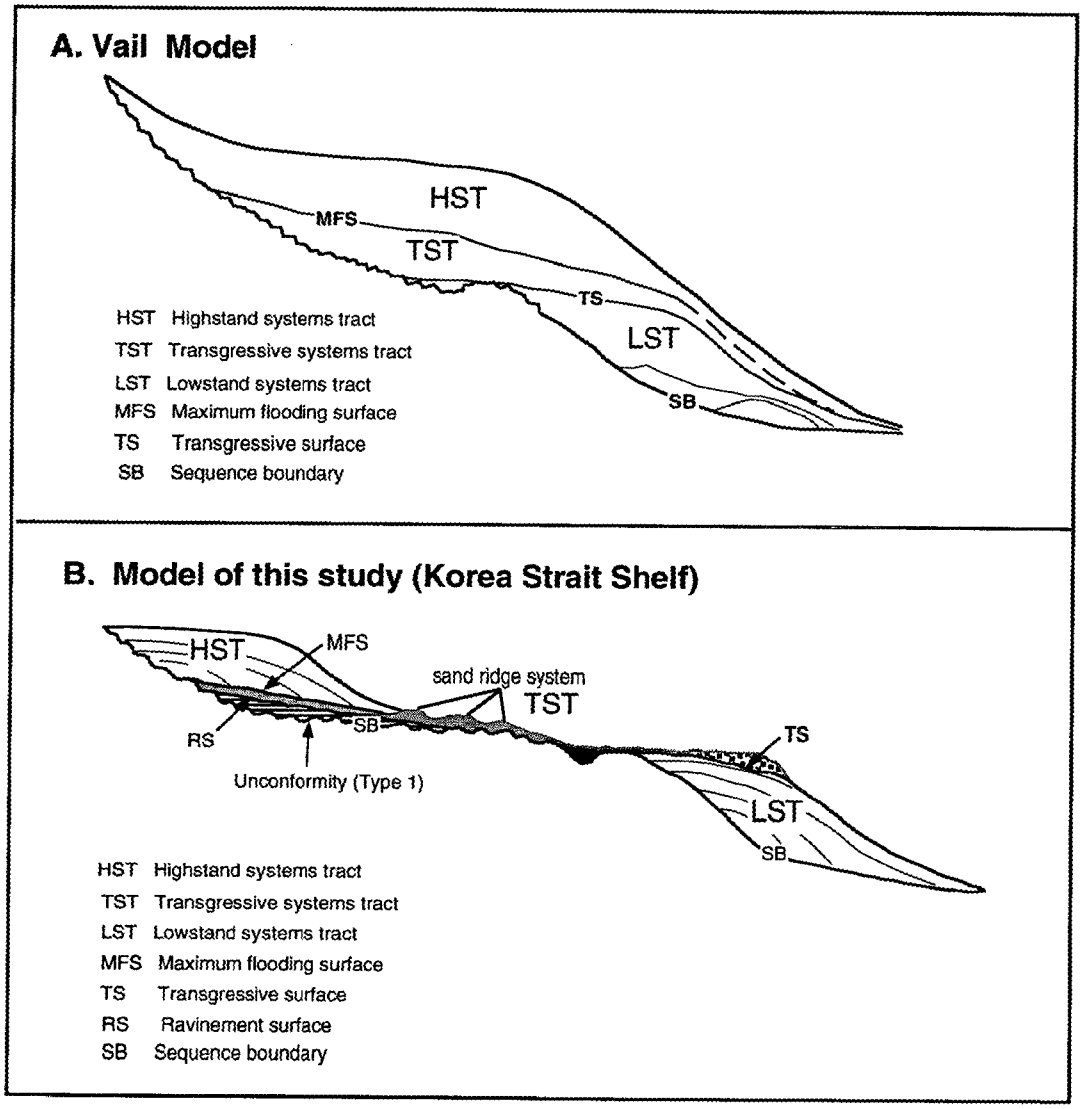

Fig. 3. Conceptual sequence-stratigraphic models for the continental margins in general (A) and the Korea Strait shelf (B). (A) Generalized model shows three systems tract (HST, TST, and LST) within an unconformity-bounded depositional sequence created on a complete cycle of sea level (Vail, 1987). (B) Conceptual model for the Korea Strait shelf shows that the latest Pleistocene-Holocene sequence comprises both the LST on the shelf margin and the HST on the inner shelf. The TST between the HST and the LST is either very thin (less than a few meters) or absent and stratigraphically forms diachronously as a backstepping arrangement of strata on a wide area of the shelf.

different geometries from the basic model, the present study leds us to consider that the basic model applied in the Korea Strait is a useful tool reconstructing the sequence stratigraphy and its depositional history of the shelf sequence, created under the high-frequency sea-level fluctuations during the late Quaternary period.

Conclusions

The latest Pleistocene-Holocene deposits in the Korea Strait comprise the lowstand (LST), transgressive (TST), and highstand systems tract (HST). These systems tracts constitute seven depositional systems, each with a different seismic facies and lithofacies associations. Key surfaces within the sedimentary deposits comprise the type 1 sequence boundary (SB), transgressive surface (TS), ravinement surface (RS), and maximum flooding surface (MFS).

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