Ocean Sci. J. (2016) 51(2):251–261
http://dx.doi.org/10.1007/s12601-016-0021-0

Article

Available online at http://link.springer.com
SpringerLink

Ocean Science Journal

pISSN 1738-5261
eISSN 2005-7172

Holocene Depositional Patterns of the Subaqueous Nakdong Delta on the Korea Strait with Respect to Sequence Stratigraphy

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Received 27 May 2015; Revised 9 November 2015; Accepted 22 February 2016

Abstract – A sequence stratigraphic analysis was conducted using high-resolution 'Chirp' seismic profiles and a long core data off the Nakdong River where Holocene deltaic deposition prevails in the Korea Strait. The depositional sequence comprises a group of transgressive and highstand systems tracts, intercalated with their bounding surfaces of maximum flooding surfaces, above a sequence boundary. It is formed by an erosional process within an incised valley, indicating the Nakdong River at the lowstand of sea level. The transgressive systems tract consists of the lower and upper depositional units, bounded by a ravinement surface, formed during the early Holocene when sea-level rose between 12.0 and 6.0 ka BP. The lower depositional unit mostly occurs in the incised valley area, comprising fluvio-estuarine sediments, whereas the upper one nearshore environments consist of sand sheet and ridges. The overall stacking pattern of these sequences demonstrates retrogradation. During the late Holocene sea-level highstand of around 6.0 ka BP, the highstand systems tract overlying the maximum flooding surface consists of the deltaic sequence, formed as a seaward sigmoid progradational pattern. The subaqueous Nakdong delta system has evolved to depositional units of the retrogradational transgressive and then the progradational highstand systems tract over a sequence boundary during the Holocene transgression.

Key words – Nakdong delta, sequence stratigraphy, Holocene transgression, Korea Strait

1. Introduction

The Nakdong subaqueous delta in the inner shelf off the southeastern corner of the Korean Peninsula is an active depositional system where river-supplied sediment has been deposited since the Last Glacial Maximum (LGM) (Fig. 1). Several studies concerning the depositional system of the Korea Strait shelf region that is influenced by high sediment input from the Nakdong and Seomjin rivers have examined the formation of the post-glacial depositional sequences (Park et al. 1990, 1999; Lee and Chung 2000; Lee et al. 2005).

The late Quaternary depositional systems established on modern shelves have successfully been analyzed by application of sequence stratigraphic techniques to high-resolution seismic data (Tesson et al. 1993; Bellotti et al. 1994; Trincardi et al. 1994; Somoza et al. 1998; Amorosi and Milli 2001; Lobo et al. 2004). The sequence stratigraphic concept has also been applied to the late Quaternary sediments on the Korea Strait by means of high-resolution seismic profiles and sediment data (Yoo and Park 2000; Yoo et al. 2014).

However, the details of the Nakdong delta architecture in response to the Holocene sea-level rise remain poorly understood. In association with stratal geometry and sedimentation pattern, the overall development features of the Nakdong delta have been identified in detail through high-resolution 'Chirp' seismic profiles that range from the mouth of the river to offshore, and by using a long core data presented by the studies (Kim et al.1999; Nam et al. 2000). The data provide us with useful information and reveal the formation of the Nakdong delta sequences which consisted of successively underlying transgressive estuarine valley-filled sediments and nearshore sand deposits, and overlying highstand deltaic wedges. The purposes of this study are to identify the sequence stratigraphic framework and to propose a generalized depositional model of the subaqueous Nakdong Delta related to the Holocene transgression.

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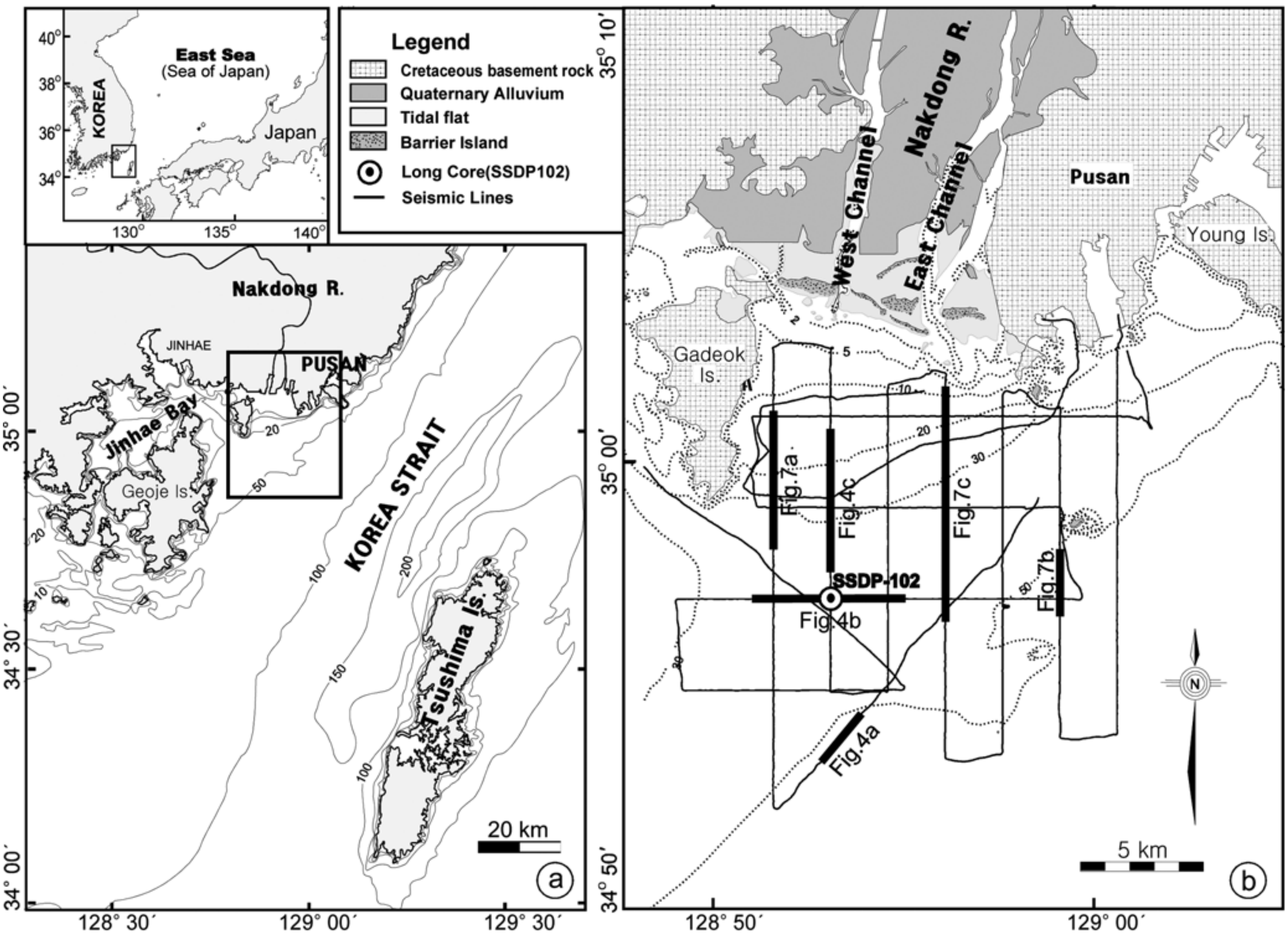

Fig. 1. Map of (a) bathymetry of the study area and its surroundings (depth in meter) and (b) locations of high-resolution 'Chirp' seismic tracklines and a long core (SSDP-102). Heavy lines with numbers denote the locations of seismic profiles shown in corresponding figures

Geologic and oceanographic setting

The Nakdong delta just offshore of the Nakdong River extends from Gadeok Island on the west to Young Island on the east, and from the coastal area (about 5 m isobath) to water depths of 60 m, approximately 20 km offshore. The seafloor feature shows a gradually deepening trend toward the open sea, with a relatively coastal-parallel bathymetric contour line trending NE-SW. The study area is connected to Jinhae Bay to the west and extends to the East Sea (Sea of Japan) in the northeast (Fig. 1a). The geology of the hinterland is characterized by the Cretaceous igneous and sedimentary rocks (KIER 1983), which constitute the basement of the Nakdong delta system (Fig. 1b).

The Nakdong estuary has dominantly semidiurnal tides, with mean tidal range varying from 1.2 m during neap tides to 1.7 m during spring tides (Yoon and Lee 2008). Tidal currents in the coastal area move in a west-to-southwestward direction during flood tide and in an east-to-northeastward direction during ebb tide parallel to the coastal line (Kim et al. 1986; KHO 1982). The northeasterly littoral drift prevails along the southeastern Korea coast. Hydrological circulation analyses indicate that the Korea Strait including the study area is significantly affected by the northeastward-flowing Tsushima Current, a part of the Kuroshio Warm Current. An early study showed that about ten million tons of fluvial sand and mud from the Nakdong River are annually supplied into the shelf (KMC 1974). Approximately 14% of the annual fluvial-source discharge of suspended sediments from the Nakdong River is deposited the inner shelf off the southeastern coast of Korea; the rest is dumped onto the shelf (Park and Chu 1991).

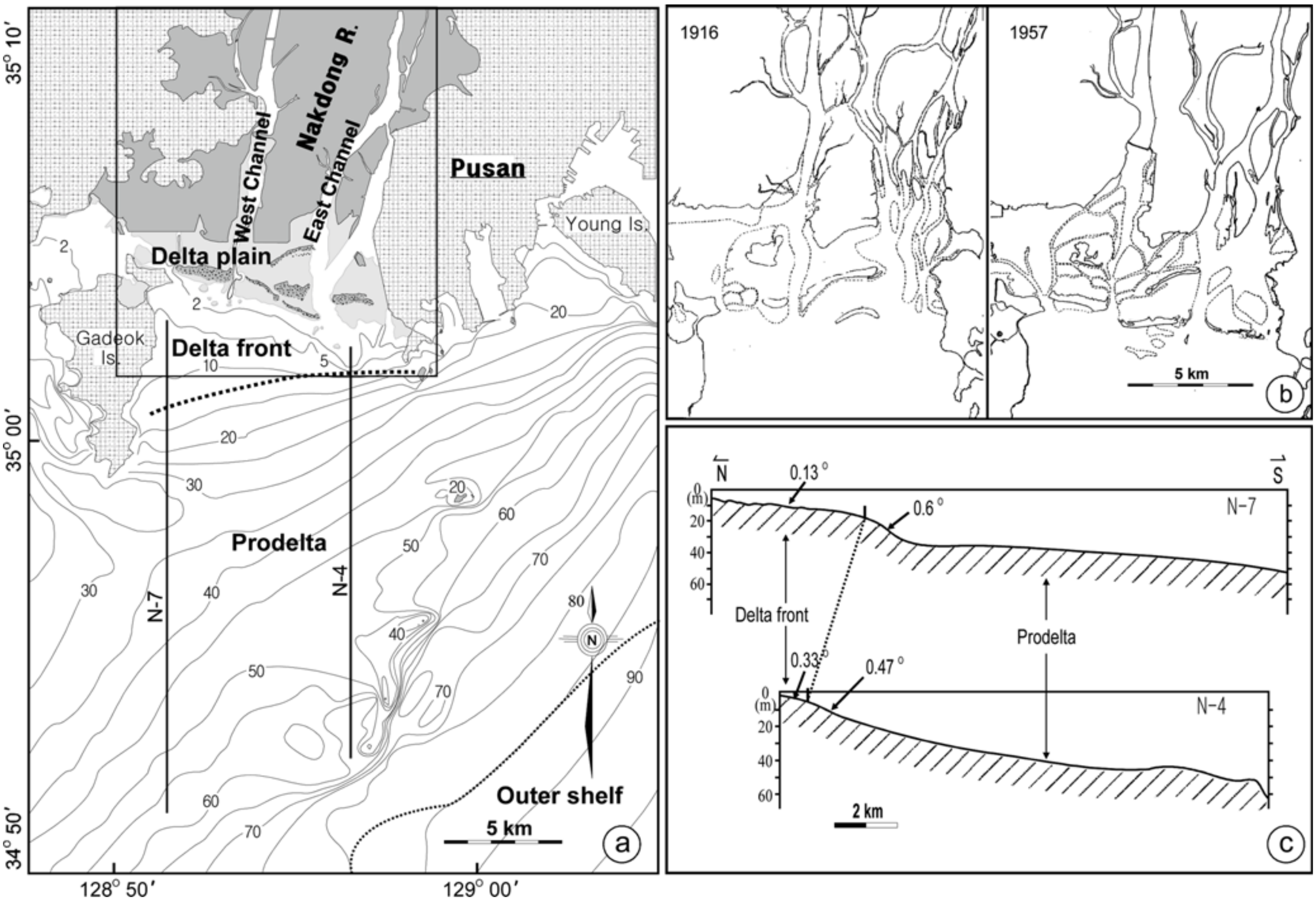

Fig. 2. Morphologic map of the Nakdong delta system. (a) Present morphology of the Nakdong delta (depth in meters) (Bathymetric data is from KHO chart 202 and 224A). Boxed outline denotes approximate area covered on Fig. 2b. (b) The Nakdong delta plain morphology in 1916 and 1957 (KORDI 1978). (c) Bottom profiles of the submerged Nakdong delta. Locations of profiles are indicated on Fig. 2a

Seafloor morphology

The Nakdong delta system can be divided into three subsections according to morphologic features, delta plain, delta front, and prodelta (Fig. 2a). The upper delta plain consists mainly of distributary channels (east and west channel), which has been highly modified by reclamation, man-made structures (dams, bridges, etc.) and dredging activities (Fig. 2b). The east channel has become the major source of the sediment for the shelf, whereas the west channel has rapidly reduced the sediment discharges since a dam was constructed in 1934 (Kim and Park 1980). The lower delta plain is characterized by tidal flats enclosed by shoreline-parallel barrier sand ridges. These ridges are dissected by active and abandoned distributary channels. Given the development pattern of the shoreline-parallel barrier islands in front of the delta, the Nakdong delta system could be categorized as a microtidal wave-dominated delta (Reading and Collinson 1996).

The delta front, stretching out up to 15 m deep, shows an even seafloor with a slope gradient ranging from 0.13° in the west to 0.33° in the east (Fig. 2c). Off the eastern channel mouth, a lobe-like morphology develops, reflecting relatively high sedimentation rates. The prodelta is subdivided into upper (15–30 m deep) and lower part (deeper than 30 m) based on the seafloor gradient. The upper prodelta is characterized by a rather steep profile with a dip ranging between 0.6° and 0.3°; the lower one forming a very flat seafloor with a dip less than 0.18° extends out toward the outer shelf.

2. Materials and Methods

The data base for this study includes ‘Chirp’ seismic profiles and long core data (Fig. 1). A seismic survey (Model CAP-6000A, Datasonics) was conducted aboard R/V Olympic V at about the 7 knots of average ship speed in June 2000.

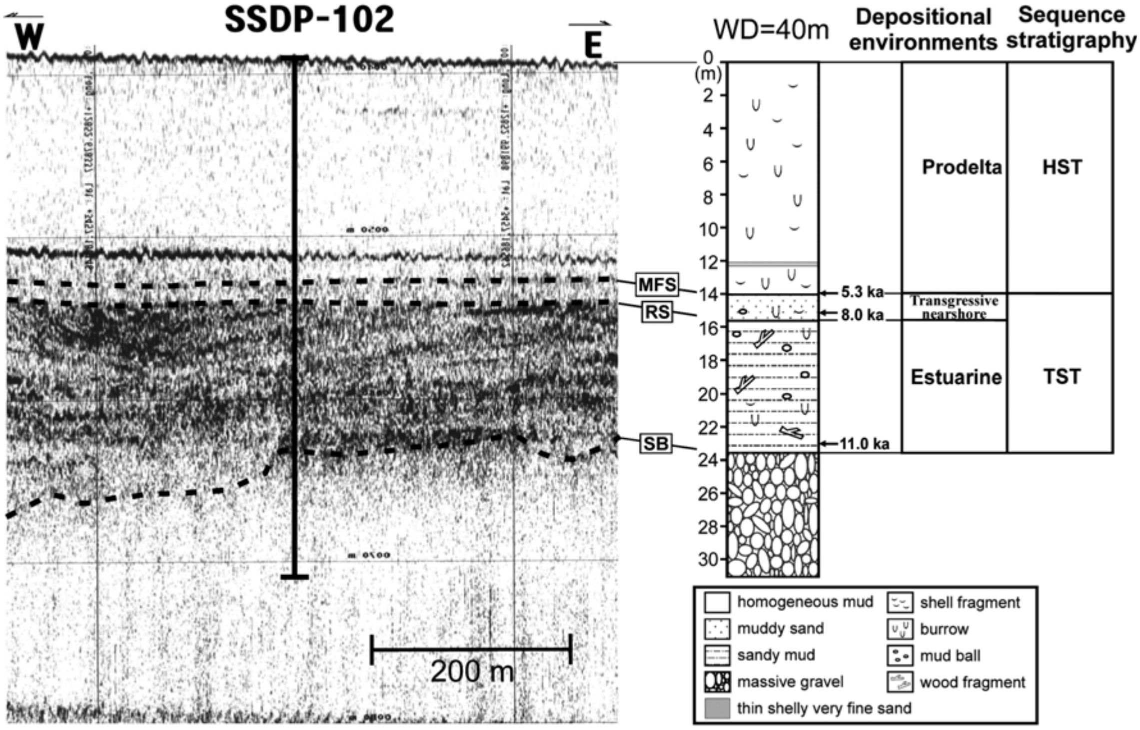

Fig. 3. Correlation between the seismic profile and the stratigraphic section of core SSDP-102. Lithology and age data are from Kim et al. (1999) and Nam et al. (2000). Refer to Fig. 4b for the location of profile

During the survey, triggering was made at an interval of 250 msec with pulse length of 10 msec, and the frequency range was between 1 and 10 kHz. The seismic profiles were printed in an EPC 1086 graphic recorder. The seismic survey grid consists mainly of seven N-S lines at an interval of about 2.3 km apart and four E-W lines at an interval of 3.7 km apart. A few supplementary lines are included. In total, about 240 km of seismic data were collected over an area of 320 km^2. DGPS (differential Global Positioning System) was used for navigation. A sound velocity of 1500 m/s was assumed for depth conversion. Sedimentary information was also obtained from SSDP 102 core (about 31 m long) analyses (Kim et al. 1999; Nam et al. 2000). The correlation of seismic profiles and long core data were correlated to infer the lithologic nature of bounding surfaces and systems tracts and to constrain their ages (Figs. 1 and 3). The seismic data analysis was conducted based on the interpretation of seismic reflection patterns that include seismic reflection terminations, reflection configurations, and external form (Mitchum et al. 1977).

3. Results

The Nakdong delta sequence (NDS) lies on a Type I sequence boundary of a highly reflective erosional surface that represents the basal unconformity of a post-glacial depositional sequence. The NDS consists of the transgressive (TST) and highstand systems tracts (HST), resting on the sequence boundary (SB). They are separated by bounding surfaces: the ravinement surface (RS) and the maximum flooding surface (MFS). The lowstand systems tract (LST) is not discernible in the seismic profiles from the study area.

Sequence boundary

The SB is marked by erosional truncation of underlying strata within an incised valley, and may indicate a possible former location of the Nakdong River (Fig. 4a). The sea-level of the Korea Strait shelf was as low as -130 m during the LGM (Last Glacial Maximum) (Park and Yoo 1988). A contour map of the SB shows an incised-valley type of erosional unconformity formed during the LGM period (Fig. 5a). Because the maximum depth of the SB is about 70 m below the present sea-level, the SB is thought to have resulted from subaerial exposure during the LGM. The axis of the incised-valley area is oriented NNE to SSW in the western part of the study area. A basement high with trending N to S exists in the eastern part. The basement high seems to have played an important

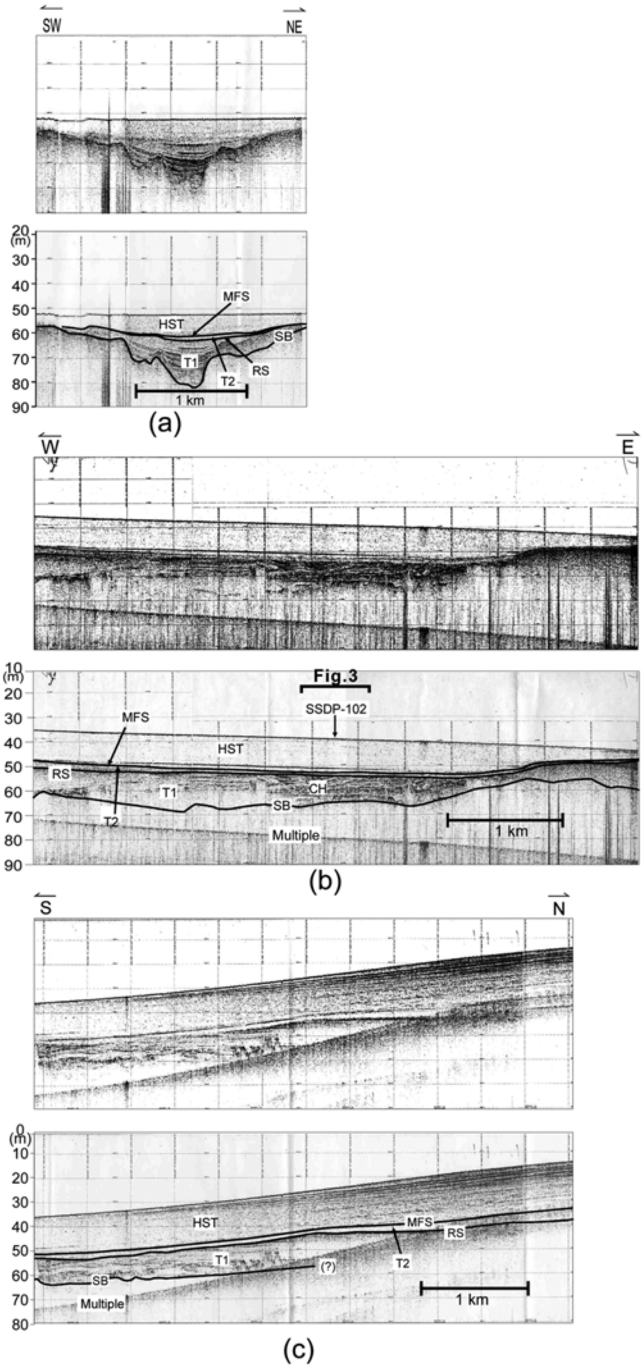

Fig. 4. Uninterpreted and interpreted high-resolution 'Chirp' seismic profiles. (a) Incised-valley and associated sediments of unit T1 in the transgressive system tract (TST). (b) Area of T1 unit around the core penetration highlights channel-fill facies (CH). Bold bracket above core SSDP-102 indicates location of the seismic profile shown in Fig. 3. (c) Transgressive sand sheet (T2) bounded by the ravinement surface (RS) below and the maximum flooding surface (MFS) above. The unit has transparent reflections and pinches out seaward. The RS erodes underlying T2 unit. The highstand systems tract (HST) lies on the MFS

role in blocking the overflow of sediment eastward across the eastern bank of the incised valley. The total sediment thickness of the delta above the SB exceeds 35 m offshore of Gadeok Island (Fig. 5b).

Transgressive systems tract

The TST consists of two major units (T1 and T2 in ascending order) with an intervening boundary of the RS. The top of the TST is bounded by the MFS. Unit T1 rests directly on the SB and its upper boundary is truncated by the overlying RS (Fig. 4b). Unit T1 is as thick as 15 m with a downlapping pattern on the SB in an elongated SW-NE trending incised-valley. However, the unit decreases in thickness eastward to the basement high and landward (Fig. 6a). The seismic facies is characterized by complex channel-fill reflection patterns showing mostly NNE-SSW trending reflectors and many paleo-channels (Fig. 6a). The core data show that unit T1 is composed of sandy mud with occasional laminations, peats and shells (KORDI 2002).

As the RS is the key surface produced by the gradual landward migration of an erosional shoreface during transgression (Suter et al. 1987; Demarest and Kraft 1987), it separates the TST into two units, T1 in the lower part and T2 in the upper part (Fig. 4). To the east, the RS merges with SB near the basement high. Locally, the RS occurs as deep as about 50 m below the present sea-level. Core data indicate an upward lithologic change from lower sandy mud to upper muddy sand is characteristic at the RS (Fig. 3).

Unit T2 onlaps onto the RS and its upper boundary is marked by the MFS. The unit is acoustically transparent and has a wedge form, which attains a maximum thickness of 4 m at the river mouth and thins in a seaward direction (Fig. 6a). The sand ridges remain aligned sub-parallel to the shore and have a maximum thickness in the range of 2–12 m (Figs. 6a, 7a and b). A wedge-like morphology and sand-rich texture of T2 indicate that T2 originated from the sand ridges that overlie erosional steps or step-like terraces (Fig. 7a). Similar features are documented on the Adriatic shelf (Trincardi et al. 1994). The sediments of unit T2 consist of massive muddy sand with abundant shell fragments (Kim et al. 1999).

Maximum flooding surface

The MFS refers to the surface of deposition at the time the shoreline was at its maximum landward position (Posamentier and Allen 1999). It is the key surface that divided the NDS into the lower TST and upper HST. The MFS is an extensive

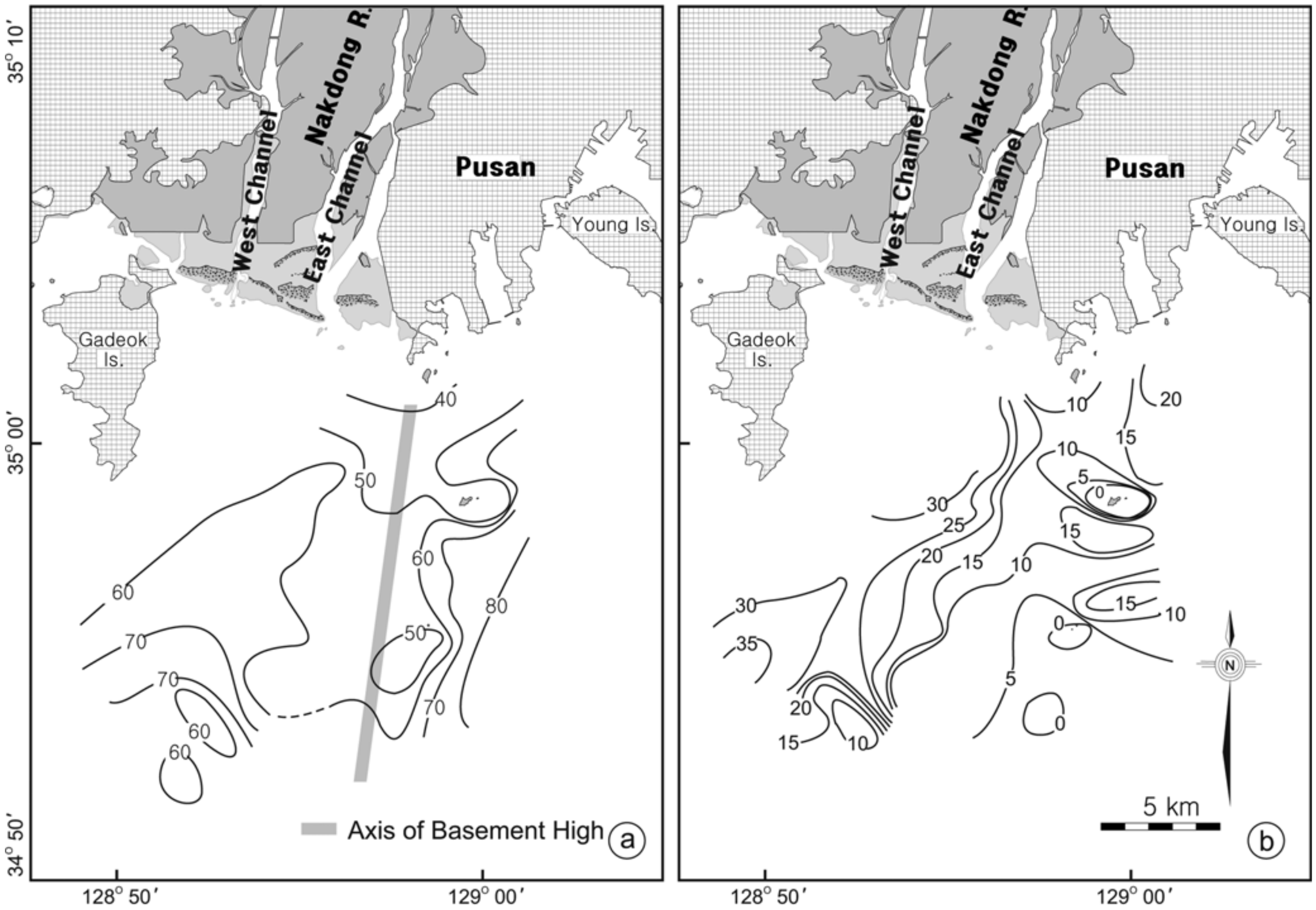

Fig. 5. Maps showing (a) the depth to sequence boundary (SB) interpreted from seismic data and (b) total isopach over the SB. Contours are in meters

and smooth surface with high amplitude, continuous reflections (Fig. 4c). It occurs as deep as -80 m in the southeastern-most part of the study area and as shallow as -35 m at the river mouth (Fig. 6b). The sediment core shows that the MFS marks an abrupt lithologic change between massive muddy sand and overlying homogeneous mud (Kim et al. 1999).

Highstand systems tract

The HST is widely recognized over the study area, which rests on the MFS. The basal depth of the HST varies from -35 m in the river mouth to -80 m in the southeastern end of the study area (Fig. 6b). The NE-SW trending trough, deeper than 50 m at the deepest location, is found in the central part of the study area. The HST has a wedge-shaped external form that is about 23 m thick in the river mouth, and thins gradually out seaward (Fig. 6b).

The HST shows spatially different seismic facies: a very prolonged bottom echo with continuous or intermittent subbottom reflections in the delta front near the river mouth, and continuous, parallel to subparallel reflections in the delta front through the upper prodelta (Figs. 7a and c). This reflection pattern indicates that the HST consists mainly of alternating sand and mud. Two different seismic reflection configurations are identified: the sigmoid progradational stacking pattern that outbuilds seaward at the west channel mouth of the Nakdong River (Fig. 7a), and the wedge-shape external form at the east channel mouth (Fig. 7c). The lower prodelta exhibits a transparent reflection, indicating the occurrence of homogeneous mud (Fig. 7c). The acoustically turbid reflections probably associated with gas-charged sediments are locally distributed in front of the west channel and the south of Gadeok Island (Fig. 7c).

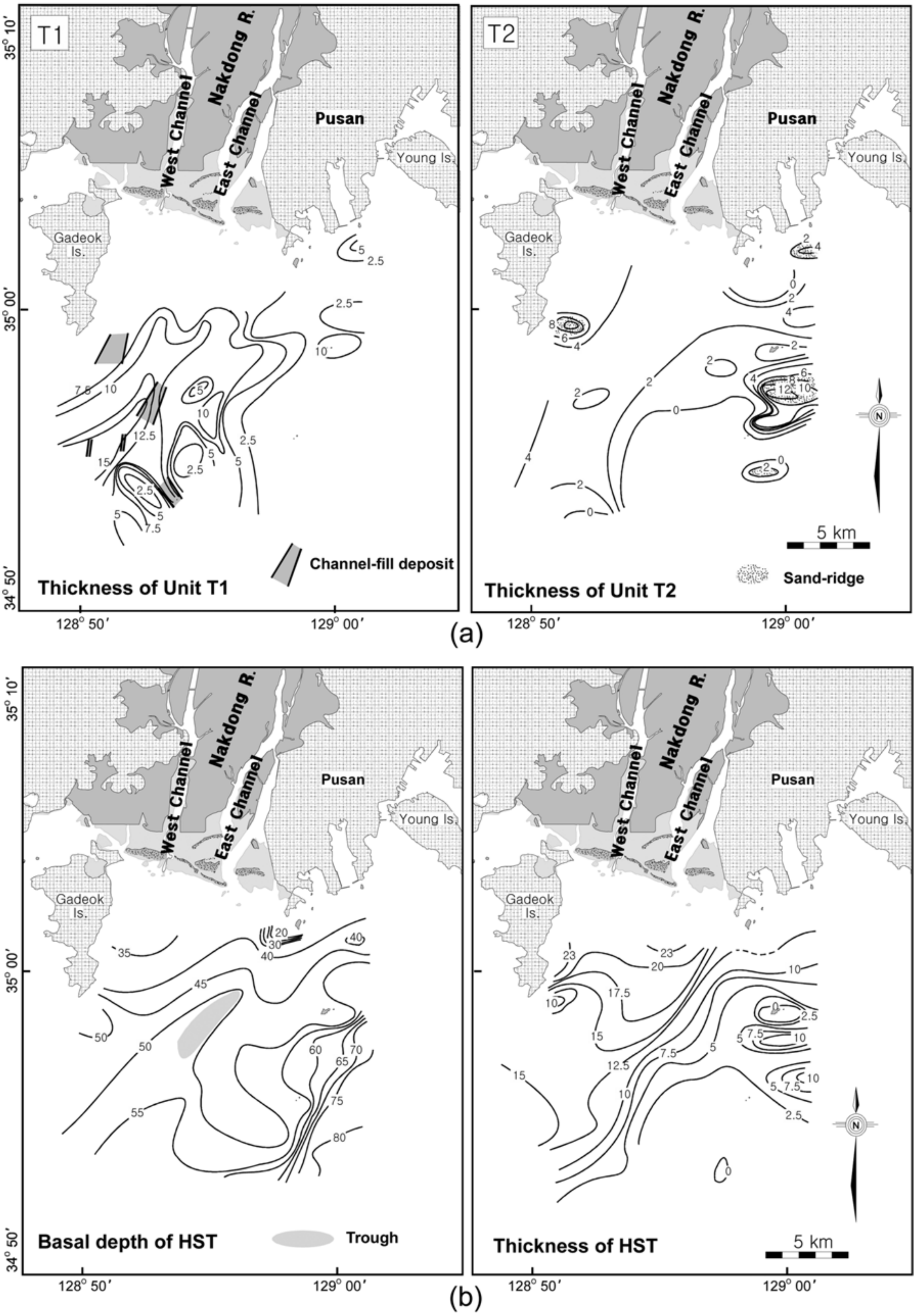

Fig. 6. Maps showing (a) isopach of units T1 and T2 (in ascending order) of the transgressive systems tract (TST) and (b) isobath and isopach of the highstand systems tract (HST). Contours are in meters

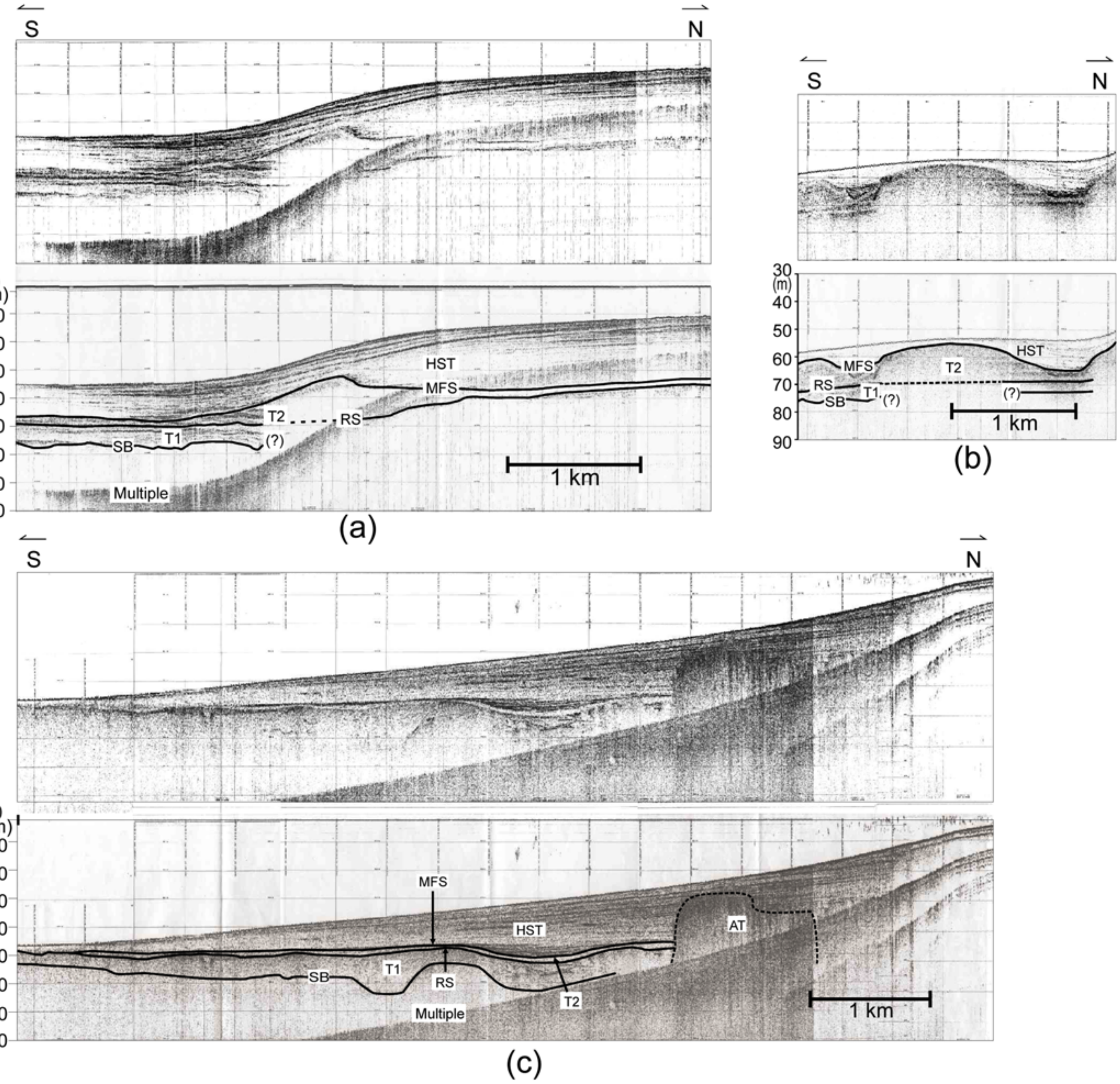

Fig. 7. Uninterpreted and interpreted high-resolution 'Chirp' seismic profiles. (a) Submerged deltaic wedge in front of the west Nakdong channel. This profile illustrates seaward sigmoid progradational pattern of the highstand systems tract (HST). The ravinement surface (RS) covered with the transgressive sand-ridge forms step-like erosional terraces landward. (b) Transgressive sand-ridge bounded by the RS below and the maximum flooding surface (MFS) above. (c) Submerged deltaic wedge in front of the east Nakdong channel. The HST shows a wedge-shaped form and includes the AT (acoustic turbid zone). The base of the HST is defined by the MFS

4. Discussion

Sedimentary environments

Three sedimentary units are identified in the Nakdong depositional sequence; the transgressive estuarine deposits, the transgressive nearshore sand sheet, and the highstand Nakdong delta. The transgressive deposits overlying the SB are confined to the western part of the study area where the incised valley occurred. In general, the incised valley is filled with fluvial and estuarine deposits during sea-level rise (Zaitlin et al. 1994). Sediments in the incised valley of this study consist predominantly of sandy mud with shell fragments, indicated by depositions in the coastal environment (Kim et al. 1999). It is also suggested that these fine grained sediments originated from the paleo-Nakdong River (Nam et al. 2000). The transgressive estuarine-deltaic complex in the inner shelf near the eastern part of Geoje Island was identified in a previous study (Yoo and Park 2000). It is suggested that incised valley was transformed into a drowned river mouth estuary during transgression and then filled with the estuarine sand and mud (Allen and Posamentier 1994). ^{14}C dates on shells reveal that the basal transgressive deposits were deposited about 11 ka BP (Fig. 3).

The transgressive estuarine deposits are covered by the transgressive nearshore sand sheet. The bounding surface between them is the RS, illustrating erosional truncation with a flat surface. With the landward migration of shoreline, eroded materials transported by wave or current action were blanketed over the RS (Thorne and Swift 1991; Nummedal et al. 1993), thus forming a transgressive sand sheet over a wide area. The overall external form of the sand sheet shows a thinly wedge-shaped body which thickens landward near the river mouth and tapers out seaward, away from the river mouth area. The core data indicates that the sediments consist of muddy very fine sand, which has been interpreted as nearshore deposits (Kim et al. 1999). These sediments also constitute sand ridges. Similar sand ridges have been reported in studies on the shelf of Korea Strait studies (Min 1994; Yoo and Park 2000) as well as on the shelf of other epicontinental seas (Saito 1994; Trincard et al. 1994; Berne et al. 2002). A radiocarbon date of sand-ridge forming deposits is estimated at 8.0 ka BP (Fig. 3).

The Nakdong delta sequence represents the highstand systems tract, which consists of sand and mud with occasional shell fragments. According to the ^{14}C dating (Fig. 3), the highstand sediments appear to have accumulated on the shelf since about 5.3 ka BP, downlapping onto the maximum flooding surface. Sandy sediments are dominant in the delta front, whereas fine-grained sediments are deposited in the prodelta including the Jinhae Bay in the west and inner shelf along the southeastern coastline of Korea (Park et al. 1995, 1999; Lee et al. 2006).

Evolution of the Nakdong delta sequence

During the LGM period, the continental shelf would have been subaerially exposed, and an incised valley was formed by the paleo-Nakdong River inflow passages which may have extended to the shelf. As sea-level began to rise, the incised valley was initially flooded and then filled with estuarine deposits. The onset of flooding in the incised valley is inferred to be 12.0 ka BP. A rapid marine transgression occurred after sedimentation had slowed down within the incised valley during around 8.0 ka BP. While the shoreline retreated landward, the shoreface erosion of underlying sediments contributed to the formation of the transgressive sands over the RS. The TST shows a landward retrogradational stacking pattern as a whole, which is consistent with the scheme of Thorne and Swift (1991). The highstand Nakdong subaqueous delta deposits with a sigmoidal progradation pattern have been accumulating in front of the Nakdong River since the last 6.0 ka BP. A summary diagram to illustrate the evolution of the sequence architecture of the Nakdong delta deposits is shown in Fig. 8.

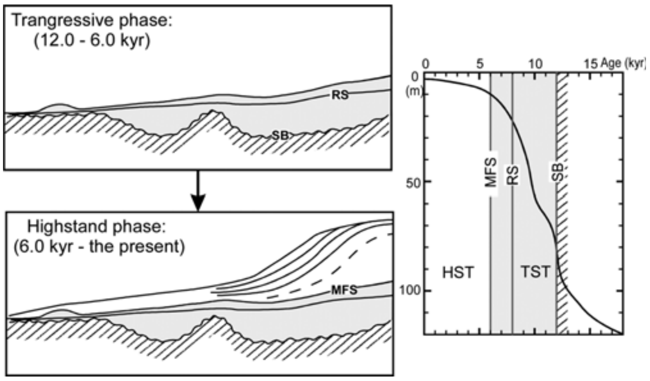

Fig. 8. Schematic diagram for the evolution of the Nakdong delta sequence during the Holocene transgression since 12.0 ka BP. The Holocene sea-level rise curve is adopted from Fairbanks's (1987) curve. SB: sequence boundary; TST: transgressive systems tract; RS: ravinement surface; MFS: maximum flooding surface; HST: highstand systems tract

5. Conclusions

The NDS consists of the TST and HST, resting on the SB during the Holocene transgression. The TST formed in an incised valley over the inner-shelf during the early Holocene transgression between 12.0 and 6.0 ka BP. The TST includes two depositional units separated by the RS. The lower depositional unit is composed of fluvial and estuarine sediments, whereas the upper one consists of transgressive fine sands. These depositional units show a landward retrogradational stacking pattern. The MFS separates the TST and the overlying HST that comprises a deltaic system during the late Holocene highstand. The architectural stacking patterns of the deltaic wedges show a seaward sigmoid progradation off the Nakdong River.

Acknowledgements

This research was supported by the Korea Institute of Ocean Science and Technology (KIOST)-sponsored project (PE99433). We thank the editor and two anonymous reviewers for their valuable and constructive comments on the manuscript.

References

Allen GP, Posamentier HW (1993) Sequence stratigraphy and facies model of an incised valley fill: the Gironde estuary, France. J Sediment Pet **63**:378–391

Amorosi A, Milli S (2001) Late Quaternary depositional architecture of Po and Tevere river deltas (Italy) and worldwide comparison with coeval deltaic successions. Sediment Geol **144**:357–375

Bellotti P, Chiocci FL, Milli S, Tortora P, Valeri P (1994) Sequence stratigraphy and depositional setting of the Tiber delta: Integration of high-resolution seismics, well logs, and archeological data. J Sediment Res **B64**:416–432

Berne S, Vagner P, Guichard F, Lericolais G, Liu Z, Trentesaux A, Yin P, Yi HI (2002) Pleistocene forced regression and tidal sand ridges in the East China Sea. Mar Geol **188**:293–315

Demarest JM, Kraft JC (1987) Stratigraphic record of Quaternary sea levels: Implications for more ancient strata. In: Nummedal D, Pilkey OH, Howard JD (eds) Sea-level fluctuation and coastal evolution. SEPM Special Publication 41, pp 223–239

Fairbanks RG (1989) A 17,000-year glacio-eustatic sea level record: influence of glacial melting rates on the Young Dryas event and deep-ocean circulation. Nature **342**:637–642

KHO (1982) Marine environmental atlas of Korean waters. Korea Hydrographic Office, 38 p (in Korean)

KIER (1983) Geological map of Busan-Gadeok sheet (1: 50,000). Korea Institute of Energy and Resources

Kim MS, Chu KS, Kim OS (1986) Investigation of some influence of the nakdong river water on marine environment in the estuarine area using landsat imagery. Technical Report of Korea Ministry Science and Technology, pp 93–147

Kim SP, Na KT, Kong KS, Bong PY, Lee HY, Jin JH, Yoo DG, Nam SI, Jang JH (1999) Sedimentary environments and paleoceanography in the eastern South Sea since the Last Glacial Maximum. In: Proceedings of the Autumn meeting, 1999 of the Korean Society of Oceanography, Mokpo, 22–23 Oct, pp 141–142

Kim WH, Park YA (1980) Microbiogenic sediments in the Nakdong estuary, Korea. J Oceanol Soc Korea **15**:34–48

KMC (1974) Report on the Nakdong estuary: industrial site investigation. Korea Ministry of Construction, Unpublication Report, 56 p (in Korean)

KORDI (1978) A study on recent sedimentation in the Nakdong River estuary. Korea Ocean Research and Development Institute, Ansan, 54 p (in Korean)

KORDI (2002) Land-ocean interactions in the coastal zone. Korea Ocean Research and Development Institute, Ansan, Report No. BSPE 819-00-1392-4, 546 p (in Korean)

Lee CS, Chung YH (2000) Late Quaternary sedimentation in the Kadeok region, Korea. Geo-Mar Lett **20**:72–79

Lee HJ, Wang YP, Chu YS, Jo HR (2006) Suspended sediment transport in the coastal area of Jinhae Bay-Nakdong Estuary, Korea Strait. J Coastal Res **22**(5):1062–1069

Lee SH, Lee HJ, Jo HR, Bahk JJ, Chu YS (2005) Complex sedimentation of the Holocene mud deposits in aria-type coastal area, eastern Korea Strait. Mar Geol **214**:389–409

Lobo FJ, Tesson M, Gensous B (2004) Stratal architectures of late Quaternary regressive-transgressive cycles in the Roussillon Shelf (SW Gulf of Lion, France). Mar Petrol Geol **21**:1181–1203

Min GH (1994) Seismic stratigraphy and depositional history of Pliocene-Holocene deposits in the southeastern shelf, Korean Peninsular. Ph.D. Thesis, Seoul National University, 196 p (in Korean)

Mitchum RM, Jr (1977) Seismic stratigraphy and global changes of sea level, part 6: stratigraphic interpretation of seismic reflection patterns in depositional sequences. In: Payton CE (ed) Seismic stratigraphy-applications to hydrocarbon exploration. AAPG Memoir 26, pp 117–133

Nam SI, Kong KS, Kim SP, Na KT, Yoo DG, Jang JH, Jin JH, Mackensen A, Wand U (2000) Late Quaternary paleoenvironmental changes in the Korea Strait: estimates of marine vs terrigenous organic matter (SSDP-102). In: Proceedings of the Autumn meeting, 2000 of the Korean Society of Oceanography, pp 95

Nummedal D, Riley GW, Templet PL (1993) High-resolution sequence architecture: a chronostratigraphic model based on equilibrium profile studies. In: Posamentier HW, Summerhayes CP, Haq BU, Allen GP (eds) Sequence Stratigraphy and Facies Associations. IAS Special Publication 18, pp 55–68

Park SC, Yoo DG (1988) Depositional history of Quaternary deposits sediments on the continental shelf off the Southeastern coast of Korea (Korea Strait). Mar Geol **79**:65–75

Park SC, Chu KS (1991) Dispersal pattern of river-derived fine-grained sediment on the inner shelf of the Korea Strait. In: Takano K (ed) Oceanography of Asian marginal seas. Elservier, Amsterdam, Oceanography series 54, pp 231–240

Park SC, Jang KM, Lee SD (1990) High-resolution seismic study of modern fine-grained deposits: inner shelf off the southeastern coast of Korea. Geo-Mar Lett **10**:145–149

Park SC, Lee KW, Song YI (1995) Acoustic characters and distribution pattern of the mordern fine-grained deposits in a tide-dominated coastal bay: Jinhae Bay, Southeast Korea. Geo-Mar Lett **15**:77–

84

Park SC, Yoo DG, Lee KW, Lee HH (1999) Accumulation of recent muds associated with coastal circulations, southeastern Korea Sea (Korea Strait). Cont Shelf Res **19**:589–608

Posamentier HW, Allen GP (1999) Siliciclastic sequence stratigraphy-concepts and applications. SEPM concepts in Sedimentology and Paleontology 7, 210 p

Reading HG, Collinson JD (1996) Clastic coasts. In: Reading HG (ed) Sedimentary environments: processes, facies and stratigraphy. Blackwell Science, London, pp 154–231

Saito Y (1994) Shelf sequence and characteristic bounding surfaces in a wave-dominated setting: latest Pleistocene-Holocene examples from Northeast Japan. Mar Geol **120**:105–127

Somoza L, Barnolas A, Arasa A, Maestro A, Rees JG, Hernandez-Molina FJ (1998) Architectural stacking patterns of the Ebro delta conrolled by Holocene high-frequency eustatic fluctuations, delta-lobe switching and subsidence process. Sediment Geol **117**:11–32

Suter JR, Berryhill HI, Penland S (1987) Late Quaternary sea-level fluctuations and depositional sequences, Southwest Lousiana continental shelf. In: Nummedal D, Pilkey OH, Howard JD (eds) Sea-Level fluctuation and coastal evolution. SEPM Special Publication 41, pp 199–222

Tesson MR, Allen GP, Ravenne C (1993) Late Pleistocene shelf-perched lowstand wedges on the Rhone continental shelf. In: Posamentier HW, Summerhayes CP, Haq BU, Allen GP (eds) Sequence stratigraphy and facies associations. IAS Special Publication 18, pp 183–196

Thorne JA, Swift DJP (1991) Sedimentation on continental margins, part VI. a regime model for depositional sequences, their component systems tracts, and bounding surfaces. In: Swift DJP, Oertel GF, Tillman RW, Thorne JA (eds) Shelf sand and sandstone bodies: geometry, facies and sequence stratigraphy. IAS Special Publication 14, pp 189–255

Trincardi T, Correggiari A, Roveri M (1994) Late Quaternary transgressive erosion and deposition in a modern epicontinental shelf: the Adriatic semienclosed basin. Geo-Mar Lett **14**:41–51

Yoo DG, Park SC (2000) High-resolution seismic study as a tool for sequence stratigraphic evidence of high-frequency sea-level changes: latest Pleistocene-Holocene example from the Korea Strait. J Sediment Res **70**:296–309

Yoo DG, Kim SP, Lee CW, Chang TS, Kang NK, Lee GS (2014) Late Quaternary transgressive deposits in a low-gradient environmental setting: Korea Strait shelf, SE Korea. Quartern Int **344**:143–156

Yoon EC, Lee JS (2008) Characteristics of seasonal variation to sedimentary environment at the estuary area of the Nakdong. J Korean Soc Coast Ocean Eng **20**:372–389 (in Korean)

Zaitlin BA, Dalrymple RW, Boyd R (1994) The stratigraphic organization of incised-valley systems associated with relative sea-level change. In: Dalrymple RW, Boyd R, Zaitlin BA (eds) Incised-valley systems: origin and sedimentary sequences. SEPM Special Publication 51, pp 45–60