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DEPOSITIONAL FACIES AND RADIOCARBON AGES FROM DT1 CORE IN THE MEKONG RIVER DELTA: EVIDENCE OF INCISED- VALLEY FILLING IN HOLOCENE TRANSGRESSION

NGUYEN VAN LAP, TA THI KIM OANH

Summary: *The DT1 boring site located in Dong Thap province, 51.5m in depth, gives a good opportunity to study Holocene depositional facies related to sea- level changes at an incised valley of the Mekong River. Based on lithological units and radiocarbon dating, six depositional facies are recognized in asending order as follows: marsh/tidal flat sandy silt, sub- to intertidal flat sandy silt, inner bay/prodelta mud, delta front sandy silt, sub- to intertidal flat sandy silt and flood plain silty clay facies. A 34.5m thick- succession from marsh/tidal flat sandy silt facies to inner bay/prodelta mud facies suggests sea- level rising. Moreover, this succession was dated 11,285 to 7,090 ca.y.BP, and its accumulation rates are high at 4.80- 16.20mmy ^{1}. These data suggest that a high sediment supply from the Mekong River accumulated at the incised valley throughout early to middle Holocene transgression.*

I. INTRODUCTION

Depositional facies and deltaic evolution of the Mekong River Delta (MRD) have been studied in the lower delta plain recently [1, 2, 6]. Detail studies by using borehole samples and high-resolution ^{14}C dating are important to speculate the changes of depositional facies related to sea-level changes [1, 3, 4]. A coarsening- upward succession of regressive deltaic facies including prodelta, delta front and subaqueous delta plain is about 15-20m and dated after 5.3 ca.ky.BP [5, 6, 7]. Due to a succession of transgressive incised-valley fill sediments that was found at the lower part of BT2 core in Ben Tre province [4, 5, 6], the DT1 boring site was drilled at the upper delta plain (Fig. 1) to investigate depositional facies related to sea- level changes in the incised valley of the Mekong River. This paper presents a detailed description of depositional facies and ^{14}C ages of the DT1 core, and discusses the changes of depositional facies related to sea-levels and accumulation rate at the incised valley of the Mekong River.

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II. METHODS

The 51.5m long core samples were split out and described. Slab samples (5 x 25 x 1 cm) were collected from the whole cores. These slab samples were photographed, X-radiographed, and described in detail in terms of lithology, granulometry, and sedimentary structures. Sand and mud contents were measured every 20cm throughout the core. Sand samples were 5 cm thick and mud samples were 2cm thick. After removing organic materials with 10% H_2O_2 sands were separated on a 63-μm sieve under pored water. The dry weight of sand portion was measured and sand- mud contents were calculated. Four radiocarbon samples were measured on plant fragments and molluscan shells by accelerator mass spectrometry (AMS) at Beta Analytic Inc. Calendar ages were calculated by the INCAL98 calibration curve.

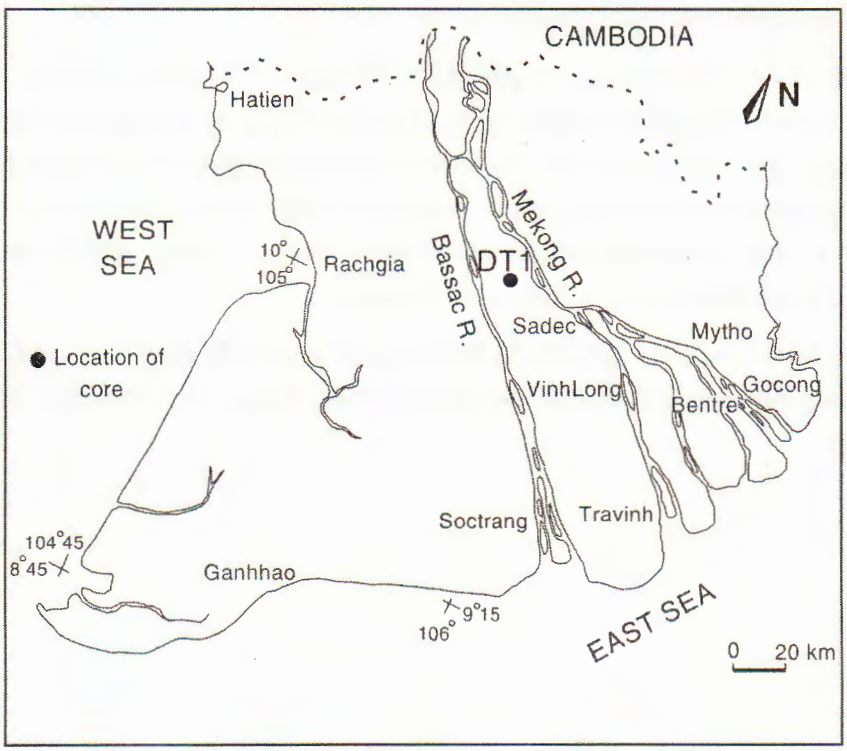

Fig 1. Location of DT1 core

III. RESEARCH RESULTS

1. Lithological units

On the basis of sedimentary characteristics, granulometry and sedimentary structure, the DT1 core can be divided into five lithological units (Fig.2) in ascending order as follows:

Unit 1 (-49.5 to -23.0m) shows three parts. The lower part (-49.5 to -44.0 m) mainly consists of brownish grey- stiff silty clay. The silty clay seems to be massive, structureless containing a few scattered clay pebbles around 40-45mm in diameter. Some fine sandy layers are also found. Mud content is 80-90%, plant fragments are found in -45.87m. The middle part (-44 to -34m) is mainly composed of sandy silt. Very thin parallel laminae are characteristic. Clay pebbles are common. Mud content is 75-87%. The upper part (-34.0 to -23.0m) is generally made of dark brown- grey silty clay and rich in organic materials. It is characterized by paralell laminae and peaty layers. Rhythmic sandy silt layers and mud drapes are common. Mud content is over 90% in which alternated sandy silt layer shows 80-86% mud. It contains very fine silty laminae and carbonaceous laminae made of plant fragments. Carbonaceous laminae are abundant frequency, several to 10mm in thickness. Clay pebbles are common throughout the unit.

Unit 2 (-23.0 to -15.0m) is composed of dark grey laminated silty clay, sandy silt in a coarsening-upward succession. Discontinuous parallel laminae commonly exist and very fine sandy layers are occationally found at the middle to upper parts. Parallel laminae and wavy beddings are common at the upper part of this unit. Mud content ranges from 80-85 and 65-75% at the lower and upper parts respectively. A few shell fragments, plant fragments and bioturbations are scattered in this unit.

Unit 3 (-15.0 to -7.0m) consists of interlayered greenish- grey silt, sandy silt and fine sand in a fining-upward succession. Sand-mud couplets, parallel laminae, lenticular and wavy bedding

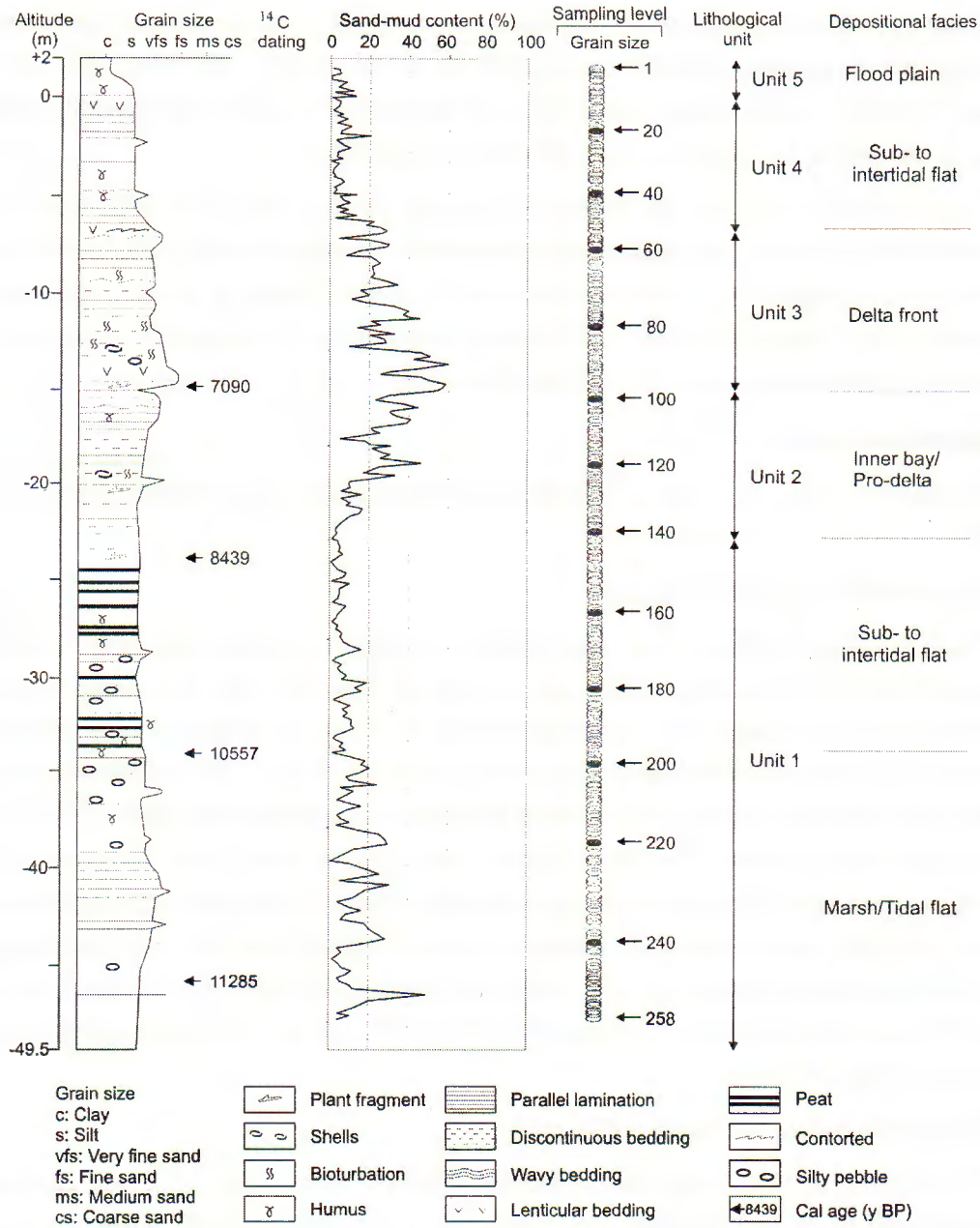

Fig 2. Depositional facies of DT1 core

are characterized at the upper part. Discontinuous parallel laminae and lenticular bedding are common at the lower part. Mud content is 60-65% at the lower part and gradually increases to 80-85% at the upper part of the unit. Shell fragments, mica flakes and bioturbations are scattered throughout the unit.

Unit 4 (-7.0 to 0.0m) consists of laminated dark- grey sandy silt and fine sand in a fining-upward succesion. Parallel lamination is characteristic structure, and lenticular bedding is common at the upper part of the unit. Bioturbations decrease upwards and shell fragments are sparce but organic materials become abundant.

Unit 5 (0.0 to +2.0m) composed of grayish- brown silty clay with rich organic matters and mica flakes. This unit is characterized by parallel laminations. Color laminae are common and made by yellowish-grey clay with 10-20mm in thickness. Moreover, laminae are also composed of silty sand to very fine sand with the sand content over 10%. Jarosite is crystallized on the surface of dried samples.

2. Depositional facies

In the DT1 core, six depositional facies are interpreted (Fig.2) in ascending order as follows:

Marsh/tidal flat sandy silt facies

This facies is 15.5m thick and coincides with the lower and middle parts of lithological unit 1. It is mainly composed of sandy silt and silty clay. Laminae of very fine sand to silty sand are found. The upper part of this facies is composed of very thin parallel laminae and lenticular bedding with flat lenses can be observed. Clay pebbles and organic materials are common. Sandy silt with mud drapes are common at the intervals of -33.0 to -34.5m and -40 to -41m. The mud drapes are thinner than 5mm in general occur rhythmically, but some of them to be approximately 10mm. The lower part of this facies is silt and silty clay and consists of lenticular beds of sandy silt with 1-3mm thick sand layers. It is interpreted as sandy silt marsh/tidal flat facies under fluvial influence. Two radiocarbon ages were dated 11,285 and 10,557 ca.y.BP., at the lower and uppermost parts of this facies respectively.

Sub- to intertidal flat sandy silt facies

This facies is 11m thick and coincides with the upper part of lithological unit 1 consisting mainly of dark brown- grey silty clay. It is characterized by paralell laminae and commonly peaty layers (Fig. 3A). The peaty layers are proximately 10-25mm in thickness with gradual contact borders (Fig. 3E). Rhythmic sandy silt layers and mud drapes are common suggesting a high energy period (Fig. 3B), then overlain by a succession of discontinuous sandy layers and peaty layers indicate a lower energy period (Fig. 3A, B). Mud content is over 90% of which alternated sandy silt layer is 80-86%. Carbonaceous laminae are abundant frequency, several to 10mm in thickness. Clay pebbles are common throughout the facies. This facies overlies sandy silt marsh/tidal flat facies and characterized by well developed peaty layers and mud drapes suggests sub- to

intertidal flat. Moreover, the rhythmic alternation of sandy silt layers and mud drapes imply transportation and deposition under flood and ebb tidal currents, followed by the settling of suspended mud or organic materials during the slack- water periods. This facies is interpreted as having formed in a sub- to intertidal flat, sea level is rising with water level deeper than those of the marsh/tidal flat deposits. A radiocarbon age was dated 8,439 ca.y.BP., at the uppermost part of this facies.

Inner bay/prodelta mud facies

This facies is 8m thick and coincides with the lithological unit 2 mainly consisting of dark- grey sandy silt in a coarsening-upward succession. Discontinuous parallel laminae commonly exist (Fig. 3C) and very fine sandy layers are occationally found at the lower to middle parts of the facies. Parallel laminae, wavy beddings are common at the upper part of this facies. Mud content ranges from 80-85 and 65-75% at the lower and upper parts respectively. A few shell fragments, plant fragments and bioturbation scattered throughout the facies (Fig. 3D). Very fine to fine sandy layers are common in the upper part with mud content about 65-75%. It suggest that environment changes from lower energy at the lower part to higher energy at the upper parts of this facies. This facies is interpreted as inner bay/pro-delta mud facies, sea level is rising with water level deeper than those of the underlying sub- to tidal flat sediments.

Delta front sandy silt facies

This facies is 8m thick and coincides to lithological unit 3. It is composed of interlayered

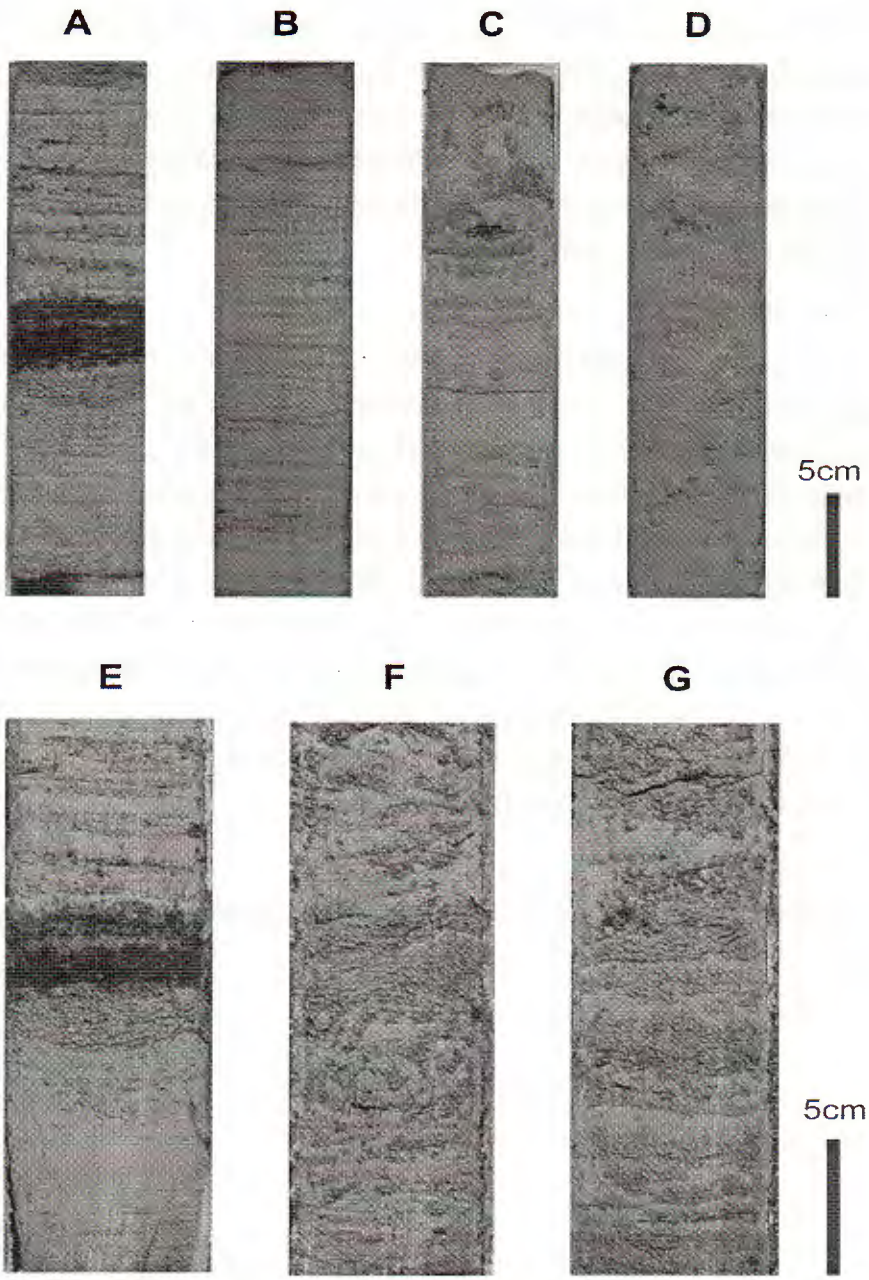

Fig 3. Selected photographs of the DT1 core samples. A (-25.75 -26.0m): parallel laminae of dark brown silty clay at the upper, peaty layer at the middle and discontinuous parallel laminae at the lower part (sub- to intertidal flat). B (-26.0 -26.25m): rhythmic sandy silt layer and mud drapes (sub- to intertidal flat). C (-21.0 -21.25m): discontinuous laminae of dark grey silt (prodelta). D (-21.50 -21.75m): dark grey silt with bioturbation (prodelta). E (-25.30 -25.50m): mud drapes at upper, gradual contact borders of peaty layers (sub- to intertidal flat). F (-13.80 -14.0m): discontinuous sandy silt and bioturbation (delta front). G (-14.73 -14.93) sandy silt with lenticular and wave beddings (delta front)

greenish grey silt, sandy silt and fine sand in a fining-upward succession. Sedimentary structures are characterized by sand-mud couplets, flaser, lenticular, wavy bedding and discontinuous parallel laminae. Parallel laminae, lenticular and wavy bedding are characterized at the upper part, discontinuous parallel laminae and lenticular bedding are common at the lower part of this facies (Fig. 3G). Bioturbations are also observed thoughout the unit (Fig. 3F). Mud content changes from 55 to 85% at the lower and upper parts respectiverly. Shell fragments and mica flakes are scattered throughout the facies. This facies is interpreted as delta front sandy silt facies. A radiocarbon age was dated 7,090 ca.y.BP., at the lowermost part of this facies.

Sub- to intertidal flat sandy silt facies

This facies is 7 m thick and coincides with lithological unit 4. It consists of laminated dark- grey sandy silt and fine sand in a fining-upward succession. Parallel laminae, lenticular bedding are characteristics. Bioturbations decrease upwards and shell fragments are sparce but organic materials become abundant. It is suggested a sub- to intertidal flat sandy silt facies.

Subaerial delta plain silty clay facies (marsh/flood plain)

This facies is 2 m thick and coincides with the lithological unit 4. It composed of greyish- brown silty clay and clay with rich organic matter and mica flakes. It is characterized by parallel laminae, especially color laminae. Jarosite is crystallized on the surface of dried samples.

3. Sea level change and accumulation rate

The change of depositional facies at DT1 core is clearly controlled by Holocene sea-level change. A succession from marsh/tidal flat sandy silt facies, sub- to intertidal flat to inner bay/prodelta mud facies suggests sea- level rising and dated from 11,285 to 7,090 ca.y.BP. These data show that there is a succession of tidal sediments formed from early to middle Holocene transgression in the upper delta plain of the MRD. This could correspond to depositional succession at the lower part of BT2 core of which Holocene trangressive incised-valley filling sediments dated 13.0 to 5.3 ca.ky.BP [4, 5, 6, 7]. Both BT2 and DT1 boring sites are located at the incised valleys of the Mekong River system, but the DT1 site is at upstream-ward in comparison with the BT2 site. The seaward shifting of depositional facies from marsh/tidat flat to sub-to intertidal and inner bay/prodelta facies, is related to the transgression associated with the rapid rise of relative sea- level in the early to middle Holocene. On the other hand, the formation of inner bay/prodelta mud facies and delta front sandy silt facies suggest an upward shallowing of water depth caused by a considerable sediment supply and restricted accommodation

space at the incised valley, although the relative sea- level was still rising. Thus the maximum flooding surface is considered to be somewhere within the deltaic facies interval. These data could correspond to Holocene maximum transgression occurred at 5.0-5.5 ca.ky.BP, and coastline was arround the border Vietnam- Cambodia in the north part of MRD [1, 2, 6, 7].

There is a close relation of accumulation rate, depositional facies and sea- level changes. The thickness of tidal sediments are approximately 22m, which is much more than the presumed water depth of sub- to intertidal environment because even the maximum tidal range in the present MRD is around 3.2-3.8m [2, 7]. This implies that the rate of relative sea- level rise was approximately equal to the accumulation rate. Detailed radiocarbon ages and depositional facies of the DT1 core shows that accumulation rates are high at 16.20 and 4.80 mm y^{-1} in the marsh/tidal flat and sub- to intertidal flat sediments respectively. The first rate is extremly high due to a restricted accommodation space of an incised valley during marsh/tidalsediments were formed in the early Holocene. The following lower rate of sub- to intertidal sediments formed from 10,438 to 8,439 ca.y.BP., could be related to the formation of organic layers, however, more data would be collected to understand existence of considerably organic layers in this period. Accumulation rate of inner bay/prodelta sediments is 6.76mm y^{-1}, a slightly higher than those of the underlying sediments. These data suggest that high sediment supply from the Mekong River has occurred throughout early to middle Holocene transgression.

IV. CONCLUSION

This paper provides a detailed study of Holocene depositional facies related to sea-level change obtained from the DT1 core in the upper delta plain of the MRD. Six depositional facies are recognized in asending order as follows: marsh/tidal flat sandy silt, sub- to intertidal flat sandy silt, inner bay/prodelta mud, delta front sandy silt, sub- to intertidal flat sandy silt and subearial floodplain silty clay facies. A succession, 34.5m thickness, changed from marsh/tidal flat sandy silt facies, sub-to intertidal flat to inner bay/prodelta mud facies suggests sea- level rising and dated at 11,285 to 7,090 ca.y.BP. This identifies a discovered succession formed at the incised valley of Mekong River with a high accumulation rate in early to middle Holocene transgression. These data suggest that high sediment supply from the Mekong River has occurred throughout early to middle Holocene transgression.

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TƯỚNG TRẦM TÍCH VÀ TUỔI TUYỆT ĐỐI 14C LỖ KHOAN DT1 Ở ĐỒNG BẰNG SÔNG CỬU LONG: CHỨNG CỨ LẤP ĐẦY THUNG LŨNG BÀO MÒN GIAI ĐOẠN BIỂN TRÀN HOLOCEN

NGUYỄN VĂN LẬP, TẠ THỊ KIM OANH

Tóm tắt: *Lỗ khoan DT1 ở tỉnh Đồng Tháp sâu 51,5m được sử dụng để nghiên cứu tướng trầm tích Holocen tương ứng với thay đổi mực nước biển trong thung lũng bào mòn sông Cửu Long. Trên cơ sở các đơn vị thạch học và tuổi tuyệt đối, sáu tướng trầm tích được phân chia theo thứ tự từ dưới lên trên: tướng bột cát đầm lầy/bãi triều, tướng bột cát bãi dưới- gian triều, tướng bùn vịnh biển kín/prodelta, tướng bột cát delta front, tướng bột cát bãi dưới- gian triều và tướng sét bột đồng lụt. Loạt trầm tích dầy 34,5m từ tướng bột cát đầm lầy/bãi triều đến tướng bùn vịnh biển kín/prodelta minh chứng mực nước biển đang dâng. Ngòai ra, loạt trầm tích này có tuổi từ khoảng11.285 đến 7.090 năm trước hiện tại, và có tốc độ tích tụ cao từ 4,80- 16,20 mm/năm. Các tài liệu này cho thấy một lượng trầm tích dồi dào cung cấp từ sông Cửu Long được tích tụ trong thung lũng bào mòn vào giai đọan biển tiến Holocen sớm- giữa.*

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