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HOLOCENE DEPOSITIONAL ENVIRONMENT CHANGE FROM MICROFOSSIL DATA OF DT1 CORE, MEKONG RIVER DELTA

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Sumarry: *Holocene depositional environmental change in Dong Thap province, Mekong River Delta is reported on the base of microfossil data (diatom and foraminifera) from the boring core DT1. Totally 65 genera, 41 species of diatom, 27 benthic foraminifera genera (20 calcareous and 7 agglutinated genera) and 07 species are identified from the core samples. The stratigraphical changes of both diatom and foraminifera are useful to clarify Holocene sedimentary environments. 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 facies changes related to sea-level changes, specially in early-middle Holocene, are the first discovery in the upper delta plain of the MRD.*

I. INTRODUCTION

Diatom and foraminifera have been used as the significant indicators for paleo-ecology, sedimentary environment and stratigraphical correlation in Quaternary [2, 3, 4, 9]. Recently diatom and foraminifera are useful for studying sedimentary environment, relative sea- level changes in the Pleistocene, Holocene and environmental changes due to human impacts specially in the coastal zone. Together with lithological features, sedimentary structure and absolute ^{14}C dating, diatom, foraminifera and molluscs contribute considerably to identify sedimentary environments related to Late Pleistocene-Holocene sea-level change in the Mekong River Delta (MRD) [1, 5, 6, 7]. Diatom and foraminifera have many species ranging from fresh to saline and brackish to saline environments respectively, thus a compilation of both microfossils is necessary and significant for investigating the change of sedimentary environments. Based on a succession of transgressive incised-valley fill sediments found at the BT2 boring core in the lower delta plain, Ben Tre province [6, 7], a DT1 boring site was drilled to investigate upstream- forward sedimentary facies of an incised-valley in Dong Thap province (Fig. 1). This paper presents a detailed description of diatom and foraminifera assemblages, ^{14}C ages of the DT1 core, and discusses the change of sedimentary facies related to sea-levels, specially early- middle Holocene tidal sediments are the first discovery in the upper delta plain of the MRD.

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II. METHODS

The core samples were split out and described. Diatoms and foraminifera were identified and counted under optical microscope. Total 54 diatom and 51 foraminifera samples were analysed. Based on ecological spectra, these diatoms are grouped into five ecological groups, namely marine plankton, marine-brackish, brackish, fresh-brackish and fresh water. Foraminifera are grouped into calcareous and agglutinated foraminifera. Moreover, there are planktonic and benthonic foraminifera belonging to brackish species, inner and outer sublittoral and ocean sublittoral species.

III. RESULTS

1. Stratigraphical changes of diatom and foraminifera

Totally 65 genera, 41 species of diatom, 27 benthic foraminifera genera (20 calcareous and 7 agglutinated genera) and 07 species are identified from DT1 core samples. Stratigraphical changes of diatom and foraminifera are divided as follows:

Diatom division

The stratigraphical change of diatom flora in DT1 core is divided into four diatom divisions, namely D1, D2, D3 and D4 in ascending order (Fig. 2).

- D1 (-52.6 to -32.2 m) is characterized by fresh and marine-brackish water species. It is composed of 52.5% fresh water, 18.2% marine-brackish water and 13.5% marine planktonic groups. In particular, fresh water species become dominant in peat layers and reach to 95.9%. *Achnanthes brevipes*, *Aulacoseira granulata*, *Cyclotella caspia*, *C. styrolum*, *Cymbella* spp. and *Eunotia* spp. are common. This indicates a habitat under fresh-brackish water.

- D2 (-32.2 to -20.8 m) is characterized by the predominance of brackish water and marine planktonic species. It is composed of 32.8-48.9% brackish water, 15.5-

49.9% marine planktonic and 4.40-29.3% fresh water groups. *Cyclotella* caspia, C. *styrolum* and *Thalassiosira excentrica* are abundant. This indicates a habitat under marine-brackish water.

- D3 (-20.8 to -10.8 m) is characterized by brackish water species. It is composed of 45.7-75.0% brackish water, 5.6-33.2% marine planktonic and 6.3-17.2% marine-brackish water groups. *Cyclotella caspia* and *C. styrolum* are abundant. *Aulacoseira granulata*, *Coscinodiscus nodulifer*, *C. radiatus*, *Grammatophora oceanica*, *Paralia sulcata* and *Thalassiosira excentrica* occur with low frequency. This indicates a habitat under brackish water.

- D4 (-10.8 to -0.2 m) is characterized by the intermixture of marine planktonic, brackish water and fresh water groups. It is composed of 21.3-43.3% marine planktonic, 20.6-42.4% brackish water and 8.5-28.3% fresh water groups. *Cyclotella caspia* and *C. styrolum* are common. *Aulacoseira granulata*, *Coscinodiscus nodulifer*, *C. radiatus*, *Paralia sulcata* and *Thalassiosira excentrica* occur with low frequency. This indicates a habitat under marine-brackish water.

Foraminifera division

Foraminifera in DT1 core has a poor species diversity and planktonic species is not found. Benthic foraminifera are grouped into calcareous and agglutinated foraminifera consisting of brackish and inner sublittoral species. The stratigraphical change of foraminifera flora in DT1 core is divided into three foraminifera divisions, namely F1, F2 and F3 in ascending order (Fig. 3).

- F1 (-40.64 to -22.64m) is of rare species consisting of a few agglutinated species such as *Trochammina* and *Haplophragmoides* assemblage. Some inner sublittoral calcareous foraminifera are accompanied as *Ammonia beccarii, Elphidium* spp, *Quinqueloculina* spp. It is characterized by *Ammonia beccarii*, *Arenoparella* sp., *Haplophragmoides* sp., *Jadammina macrescens* and *Trochammina* sp.. It indicates a brackish environment sometimes with mangrove marsh.

- F2 (-21.64 to -10.64 m) consists of a higher frequency of foraminifera species. It is characterized by *Ammonia* spp., *Asterorotalia* spp., *Quinqueloculina* spp., and *Elphidium* spp. indicating brackish to inner sublittoral habitat. It suggests inner sublittoral environment.

- F3 (-9.64 to -5.64 m) is presented by rare foraminifera species with *Ammonia* spp., *Arenoparrella* sp., *Elphidium* spp. and *Quinqueloculina* spp. It indicates a brackish environment.

2. Depositional environments

Based on lithological, sedimentological characteristics, diatom and

foraminifera divisions depositional environments of the DT1 core (Fig. 3) are discussed as follows:

Sandy silt marsh / tidal flat facies

This facies is 15.5m thick and mainly composed of sandy silt and silty clay. Rhythmic sandy silt layers and mud drapes are common. Mud content is over 90% in which alternated sandy silt layer shows 80-86% mud. 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 peaty layers are common. Sandy silt with mud drapes are common. The lower part is silt and silty clay and consists of lenticular beds of sandy silt. It contains very fine silty laminae and carbonaceous laminae made of plant fragments. Carbonaceous laminae are abundant frequency, several to 10mm in thickness. These sediments coincide with diatom assemblage D1. It is characterized by fresh and brackish water diatoms. *Achnanthes brevipes*, *Aulacoseira granulata*, *Cyclotella caspia, C. styrolum, Cymbella* spp., and *Eunotia* spp. are common. Arenaceous *Arenoparella* sp., *Haplophragmoides* sp. and *Jadammina* sp. are characteristic in nearly depth in core 40 m. They indicate the existence of mangrove marsh. Moreover, fresh diatoms are very abundant in the upper part of this facies. This facies is interpreted as marsh / tidal flat deposit affected more fluvial influence and is dated from 11,285 to 10,557 ca. y. BP.

Sub- to intertidal flat sandy silt facies

This facies is 11m thick mainly consisting of dark brown- grey silty clay. It is characterized by paralell laminae and commonly peaty layers. Rhythmic sandy silt layers and mud drapes are common then overlain by a succession of discontinuous sandy layers and peaty layers. Clay pebbles are common throughout the facies. Mud content is over 90%. This facies is characterized by the predominance of brackish water and marine planktonic diatoms of assemblage D2 . *Cyclotella caspia, C. styrolum* and *Thalassiosira excentrica,* are abundant. This facies is characterized by the presence of inner sublittoral species of *Ammonia* sp., *Elphidium* sp. and *Quinqueloculina* sp in F1 foraminiferal assemblage. This facies can be interpreted a sub- to intertidal flat under marine-brackish, sea level is rising with water level deeper than those of the marsh/tidal flat environment. A radiocarbon age was dated 8,439 y. PB. at the uppermost part of this facies.

Inner bay/prodelta mud facies

This facies is 8m thick mainly consisting of dark- grey sandy silt in a coarsening-upward succession. Discontinuous parallel laminae commonly exist 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 65-85%. Very fine to fine sandy layers are common in the upper part. A few shell fragments, plant fragments and bioturbation scattered throughout the facies. This facies

corresponds to the lower part of D2 and D3 divisions and characterized by dominance of marine plantonic and brackish- water diatoms. *Thalasiosira excentrica, Cyclotela caspia* and *C. styrolum* are dominant at the low part and then *Cyclotela caspia* and *C. styrolum* become abundance at the upper part of the facies. Moreover *Aulacoseira granulata, Coscinodiscus nodulifer, C. radiatus, Grammatophora oceanica* and *Paralia sulcata* occur with low frequency (Fig. 2). This suggests that the affects of fluvial processes gradualy increase at the upper part, meanwhile, marine processes are mainly at the lower part of this facies. This facies coincides with foraminiferal F2 of an inner sublittoral assemblage with the presence of *Ammonia* spp., *Asterorotalia* sp., *Elphidium* sp. and *Quinqueloculina* spp. 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.

Sandy silt delta front facies

This facies is 8m thick and composed of interlayered greenish grey silt, sandy silt and fine sand in a fining-upward succession. Sedimentary structures are characterized by sand-mud couplets, flaser, lenticular, wavy beddings and discontinuous parallel laminae. Mud content changes from 55 to 85% at the lower and upper parts respectiverly. Bioturbation is recorded thoughout the unit, while shell fragments and mica flakes are scattered. This facies is corresponded to the upper part of D3 and the lower part of D4 characterized by brackish water diatoms. *Cyclotella caspia* and *C. styrolum* are abundant. *Aulacoseira granulata, Coscinodiscus nodulifer, C. radiatus, Paralia sulcata, Grammatophora oceanica* and *Thalassiosira excentrica* occur with low frequency. This facies corresponds with the uppermost part of F2 and division F3 in which foraminifera species are rare upward. A few representative species such as *Ammonia* spp., *Asterorotalia* sp., *Elphidium* sp., and *Quinqueloculina* spp. indicate inner sublittoral zone. This facies is interpreted as delta front sandy silt facies. A radiocarbon age was dated 7,090 y. BP., at the lowermost part of this facies.

Sandy silt sub- to inter- tidal flat facies

This facies is about 7 m thick and consisting of laminated dark gray sandy silt and fine sand in the fining-upward succession. Parallel laminae and lenticular beddings are characteristic. Bioturbation decreases upwards and shell fragment is sparse, but organic materials become abundant. It is corresponded to the upper part of D4 assemblage characterized by the intermixture of marine planktonic, brackish water and fresh water diatoms. *Cyclotella caspia* and *C. styrolum* are common. *Aulacoseira granulata, Coscinodiscus nodulifer, C. radiatus, Paralia sulcata* and *Thalassiosira excentrica* occur with low frequency. This diatom assemblage indicates a marine-brackish water habitat. Foraminiferal species is sparse and not found in the upper part. It is considered as a sub- to inter- tidal flat environment.

Silty clay marsh/flood plain facies (subaerial delta plain)

This facies is 2 m thick and composed of grayish brown clayey silt to clay with

rich organic matters and mica flakes. It is characterized by parallel laminae, especially color laminae. Jarosite is crystallized on the surface of dried samples. Diatom and foraminifera are absent in this facies suggesting a marsh/flood plain of subaerial delta plain environment.

IV. DISCUSSIONS

Based on lithological characteristic, sedimetary structure, diatom and foraminiferal assemblage sedimentary environments from DT1 core is reconstructed. 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 indicate an occurrence of early to middle Holocene transgression and evidenced by the 43m thickness of the aforementioned succession in the upper delta plain. This could correspond to depositional succession at the lower part of BT2 core drilled in the lower delta plain in which Holocene trangressive incised-valley filling sediments dated 13.0 to 5.3 ca.ky.BP [7, 8]. Both BT2 and DT1 sites are located at the incised valleys of the Mekong River system, but the DT1 site is located at upstream-ward in comparison with the BT2 site. These incised valleys were formed during the last glacial stage when sea level lowered down about -120 m below present sea level. In the incised valley, where sediment supply is always very high and high tidal energy generated by sea-level rose rapidly after the last glacial maximum. The facies change from marsh/tidat flat to sub-to intertidal and inner bay/prodelta facies, is related to rapid rise of sea- level in the early to middle Holocene at the DT1 site. The sedimentation is continued under aggradational process and also evidenced by predominance of marine plankton and brackish water diatom species such as *Thalassiosira excentrica, Cyclotella caspia* and *C. styrolum* [7, 8]; and sublittoral foraminifera as *Ammonia* spp., *Asterorotalia* spp., *Elphidium* spp. and *Quinqueloculina* spp. Moreover, the formation of inner bay/prodelta mud facies and delta front sandy silt facies suggest an upward shallowing of water level caused by a considerable sediment supply and restricted accommodation space at the incised valley, although the relative sea- level was still rising. The sub- to intertidal flats under inner sublittoral and tidal zones were influenced with moderate river inflow. The tidal environment inland-side at DT1 probably started at about 5 ky.BP., subsequently, delta progradation to the east and fluvial process becomes predominant and characterized by flood plain and back marsh deposits.

V. CONCLUSION

Totally 65 genera, 41 species of diatom, 27 benthic foraminifera genera (20 calcareous and 7 agglutinated genera) and 07 species are identified in this study. The stratigraphical changes of both diatom and foraminifera are useful to clarify Holocene sedimentary environments. Inner bay/prodelta mud facies is represented by dominance of *Thalasiosira excentrica, Cyclotela caspia* and *C. styrolum.* Six sedimentary 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 flood plain silty clay facies. A succession, 34.5m thickness, changed from marsh/tidal flat to inner bay/prodelta mud facies suggests sea- level rising and dated at 11,285 to 7,090 ca.y.BP. These facies changes related to sea-level changes, specially in early to middle Holocene, are the first discovery in the upper delta plain of the MRD.

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THAY ĐỔI MÔI TRƯỜNG TRẦM TÍCH HOLOCEN TỪ TÀI LIỆU VI CỔ SINH LỖ KHOAN DT1, ĐỒNG BẰNG SÔNG CỬU LONG

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Tóm tắt: *Thay đổi môi trường trầm tích Holocen tỉnh Đồng Tháp, Đồng bằng sông Cửu Long được ghi nhận trên cơ sở tài liệu vi cổ sinh tảo silic và trùng lỗ từ lỗ khoan DT1. Tổng cộng 65 giống, 41 loài tảo silic, 27 giống lòai trùng lỗ bám đáy (20 giống vỏ vôi và 7 giống vỏ gắn kết) đã được xác định. Thay đổi theo địa tầng của tảo silic và trùng lỗ rất có ích để xác định các môi trường trầm tích. Loạt trầm tích từ tướng bột cát đầm lầy/bãi triều, tướng bột cát bãi dưới- gian triều đến tướng bùn vịnh biển kín/prodelta minh chứng mực nước biển đang dâng từ khoảng11.285 đến 7.090 năm trước hiện tại. Các thay đổi tướng trầm tích này liên quan đến thay đổi mực nước biển, đặc biệt vào giai đọan Holocen sớm- giữa, lần đầu tiên được phát hiện ở đồng bằng tam giác châu trên của ĐBSCL.*

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