The Korean Journal of Quaternary Research
Vol. 17, No. 2, pp. 17~23 (2003)

Post LGM Fluvial Environment and Palynological Changes of South Korea*

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ABSTRACT

In Korea terrestrial fluvial sequences can be used as pedological and sedimentological markers indicating a millenium-scale environmental and climatic changes imprinted in fluvial sub-environments, which in turn are represented by the cyclicity of fluvial sands, backswamp organic muds, and flooding muds intercalations of frostcracked or dessicated brown paleosols. Post LGM and Holocene fluvial and alluvial sedimentary sequences of Korea are formed in such landscapes of coastal, floodplain, backswamp and hillslope areas. Among them, the most outstanding depositional sequences are fluvial gravels, sands and organic mud deposits in coastal, fluvial, or alluvial wetlands.

The aim of this study is to explain the sedimentary sequences and palynofloral zones since the last 15,000years, on the basis of organic muds layers intercalated in fluvial sand deposits. Jangheung-ri site of Nam river, Soro-ri site of Miho river, Youngsan rivermouth site in Muan, Oksan-ri site of Hampyeong and Sanggap-ri site of Gochang are illustrated to interpret their sedimentary facies, radiocarbon datings, and palynofloral zonation. Up to the Middle to Late Last Glacial(up to 30-35Ka), old river-bed, flooding, and backswamp sequences contain such arboreal pollens as Pinus, Abies, and Picea, and rich in non-arboreal pollens like Cyperaceae, Gramineae, Ranunculaceae, and Compositae.

During the LGM and post-LGM periods until Younger Dryas, vegetation has changes from the sub-alpine conifer forest(up to about 17-11Ka), through the conifer and broad-leaved deciduous forest, or mixed forest (formed during 16,680-13,010yrB.P), to the deciduous and broad-leaved forest (older than 9,500yrB.P). In the Earliest Holocene flooding deposits, fragments of plant roots are abundant and subjected to intensive pedogenic processes. During Holocene, three arboreal pollen zones are identified in the ascending order of strata; Pinus-Colyus zone(mixed conifer and deciduous broad-leaved forest, about up to 10Ka), Alnus-Quercus forest (the cool temperate deciduous broad-leaved forest, about 10Ka-2Ka), and Pinus forest (the conifer forest, about after 2Ka), as examplified in Soro-ri site of Cheonwon county. The palynological zonations of Soro-ri, Oksan-ri, Sanggap-ri, Youngsan estuary, and Gimhae fluvial plain have been recognized as a provisional correlation tool, and zonations based on fluvial backswamp and flooding deposits shows a similar result with those of previous researchers.

Keywords : Last Glacial, LGM, fluvial, floodplain, backswamp, palynofloral)

* The paper was prepared with the help of financial supports from both the Ministry of Science and Technology-KIGAM and the Korea Research Foundation.

Introduction

In Korean peninsula, Holocene sedimentary deposits occupies quite a large surface areas, while the upper Pleistocene fluvial deposits are less developed apparently, except coastal, old fluvial and hillslope areas. As to the latter deposits, terrace sequences, composed of both marine terraces in coastal areas and fluvial terraces along main river cources, are prevailed mostly at the level of about 10-20meter above base level (asl) or river bottom).

During the Last Glacial period, however, slope processes were developed along the foothill of mountain slopes. But the most outstanding depositional sequences are post LGM and Holocene alluvial and/or fluvial deposits, filled in the current or old river-bed, drowned river valleys along the coastal area, or associated with alluvial to proluvial environments. During the Last Glacial Maximum (LGM) period, the major rivers prograded toward Sea.

The Yellow Sea was almost disappeared at the LGM, ca.18Ka, when sea level was almost dropped at the level of about 120 m below the present (Lee, 1987; Lee and Kim, 1992). After LGM, the sea levels were abruptly rose up due to the rapid melting ofcontinental ice in polar region. Three major geomorphic responses during the last Glacial time period were marked by firstly, the formation of sedimentary sequences derived mostly from mass movement, which were prevailed along the previous hillslopes or at the foot of mountains, secondly, the formation of fluvial/backswamp deposits during interstadial, and thirdly, several conspicuous horizons of soil wedges (or frost crackings), developed in various depositional sequences of the last glacial maxium.

The older soil wedge structures were interpreted to be developed in the period equivalent to the marine isotope stage 4(MIS-4), i.e., ca.65-55Ka, while the younger ones to the marine isotope stage 2(MIS-2), i.e., ca 18-22Ka[3], as illustrated in Soro-ri fluvial sequence of Cheonwon county, Jeonjangri fluvial squence of Goechang county. Estuarine fill sequence of Youngsan River mouth is another example, based on 20 m(20.50~1.60m depth) of core (MW-1). They are composed of 1) lower river-bed coarse sands and pebbles, with levee/backswamp homogeneous mud, partly cross-laminated muds (38-29Ka), and 2) upper floodplain brown-mottled clayey silt with a little sand layers (flooding paleosols, 29-27Ka.). In Youngsan estuarine fill sequence older than the LGM, lower fluvial/backswamp sequence contain much of such arboreal pollens as Pinus, Abies, and Picea, and rich in non-arboreal pollens such as Cyperaceae and Gramineae. In the upper flooding deposits fragments of plant roots are abundant and subjected to intensive pedogenic processes.

Post-LGM Sequences

1. Young Fluvial Sequence of post-LGM

The latest Pleistocene fluvial sequence after LGM is examplified in Jangheung-ri site and Soro-ri site (Kim, Lee, and others, 2002). In the former site it is subdivided into 2 typical sequences, based on the lithofacies and radiocarbon ages. They are 1) young fluvial sands and gravels, and 2) backswamp organic muds. The lower part of post-LGM sequence is typified by young fluvial sand and gravel which were formed by rather perennial streams. But the middle part of post-LGM sequence is characterized by organic muds, particularly formed after 12-14Ka. Local backswamp were flourished with organic muds and graded suspension materials in the flooding muds were intermittently accumulated in the organic muds until ca. 11Ka. This episode was associated with migration of Nam River toward present course. Organic muds were formed in backswamp or local pond. Such

pollen as Abies/Picea-Betula with Ranunculaceae, Compositae, Cyperaceae are prevalent. This period is characterized with Bolling, Older Dryas, Allerod, and Younger Dryas (Kim, Park, and others, 2002).

As for latter site, Soro-ri site of Miho River valley shows also post-LGM Soro-ri organic muds and the formation age of them are 15-12Ka. Pollen zones are divided into three from bottom to top. The younger fluvial sequences with several horizons of peaty clays and intercalation of flooding muds, have been formed since 17Ka. Carbon Radiometric dating of Soro-ri organic muds ranges from 17,310± 310yrs BP (GX-25495), 16,680±50yrs BP (GX-28504) and 17,300±150yrs BP (SNU01-297), through 14,820 ± 250yrs BP (GX-25494), 14,800±210yrs BP (GX-28421) and 13,920±200yrs BP (SNU01-291), to 12,780±170yrs BP (GX-28416), 12,500±200yrs BP (SNU01-293m, seed of old rice; Lee and Woo, 2002b). 6]) to 12,930±400yrs BP (SNU01-286)(Lee and Woo, 2002a). The pollen analysis of the younger fluvial sequences shows Pinus-Abies-Picea forest(OS-1 zone, sub-alpine conifer forest), indicating the Latest Pleistocene (about 17-11Ka). The vegetation changes of Soro-ri shows from 1) conifer and broad-leaved deciduous forest, or mixed forest (formed warm and wet backswamp condition during 16,680- 13,010yrsB.P), through 2) deciduous and broad-leaved forest(typified by warm and swamp condition older than 9,500yrB.P), to 3) conifer forest (indicating relatively cool condition and abundant fresh water diatom, and later changed into backswamp environment predominant with Gramineae) (Kim, Lee, and others, 2002).

2. Paleosol Sequences of the post-Glacial

The uppermost part of post-LGM sequence shows dessicated paleosol layers which were formed under rather dry climatic condition between each flooding period in the early Holocene. Dessication cracks were prevalent in the soil solum which was filled with secondarily minuted fragments due to pedogenetic process. The soil structure shows typical braided-typed cracks in the root part of crackings, and more diversified pattern of crackings downward. The ages of Holocene paleosols of Jangheung-ri shows 5Ka or 6Ka, while those of Soro-ri dated as 9,580± 40yrs BP (GX-28505, S. wall), 9,450±40yrs BP (GX-28506, N. wall), and 8,800yrs B.P(50cm up from GX-26506)(Kim, Lee, and others, 2002).

Middle and Late Holocene Sequences

1. Flooding Mud/Backswamp Organic Mud Sequences

Holocene coastal deposits of the western part of the Korean peninsula are composed of coastal alluvial plain deposits, widely developed in shallow but broad drowned valleys(Kim, Lee and Choi, 1998). The alluvial plain deposits are composed of gravelly sands in the upper valley and silty clay in the down valley. Toward the coastal area, alluvial deposits gradually change into bluish silty clay in the lower part, overlying directly Pre-cambrian bedrock, and brownish grey silty clay in the upper part. Coastal peaty clays are found at the level of about 7-8m above mean sea level between these two clay deposits, as shown in Pyeongtak and Ilsan areas. The top of flooding mud deposits, ranging to 6-8 Ka, are now almost equal to the present alluvial surface(Kim, 2001).

Holocene alluvial plain deposits are variously depending on the geomorphology and distance from the main river. At Nakdong river, for instance, the coastal and fluvial sediments reach up to the depth of about 50m below mean sea level. At the river mouth, fluvial deposits are composed of marine sediments at the lower part, and overlain by fluvial sandy silt deposits near the surface. Among the fluvial deposits,

organic muds (or peaty clays) are interlayered at the depths of 0m, 3m, 5m and 8m above mean sea level in the western coast. Between each of these layers, four peaty clay layers are intercalated by dark gray muds or fluvial silty muds. The carbon radiometric dating of peaty clay layers are 6,440yrs BP. 5,500~5,000yrs BP. 3,000~2,500yrs BP,and about 1,500yrs BP, in the ascending order of stratigraphic colume(Lee, Kim, an d Yang, 1992; Shin, Kim, and others, 1993; Choi, and Kim, 1995). The geo-environment of these peaty formations is interpreted as a presence of local marsh at the beginning of regression during slightly warmer period than the present time based on the profiles of Ilsan coastal plain area (Lee and Kim, 1992; Choi, 1992; Hwang, 1992).

Accordingly, these peaty layers represent higher stand of sea level than the present time along the western coast of the Korean peninsula, even though there might be a tectonic influence. These peaty formation became interested to prehistory archaeologists because they may contain relics of ancient agricultural practices. It is already known that the rice cultivation began at the time of the second peat formation about 5,400yrs BP.

Since the Middle Holocene, ca 5Ka, the frequent flooding episodes, reached on the top of the previous flooding deposits, made prehistory people move onto secure level, and settle there. They had lived on that level until another devastating inundation. In such a way, continuous records of human occupations are prevalent in the Middle to Late Holocene deposits. A few of Holocene palynological researches supports that the predominnce of Quercus since 10Ka. The drastic climatic change and sea level rise are distinctly associated with the period up to 10Ka-6Ka, based on the pollen diagram. Holocene vegetations are also examplified by the pollen zonations of several different sites;

1) Soro-ri zonation in Cheongwon county ; OS-2 : Pinus-Colyus zone(mixed conifer and deciduous broad-leaved forest, about up to 10Ka), OS-3 : Alnus-Quercus forest(the cool temperate deciduous broad-leaved forest, about 10Ka-2Ka), and OS-4 : Pinus forest (the conifer forest, about after 2Ka) (Kim, Lee, Yang and others, 2002; Kim, Park and others, 2001; Kim, Yang and others, 2002).
2) Oksan-ri zonation in Hampyeong county ; HP-I: Alnus-Quercus zone(bottommost, 2.5Ka), HP-II: Pinus-Quercus zone(-90- 156cm), HP-III: Pinus zone (bottom) (Kim, Yang and Bong, 2002).
3) Sanggap-ri zonation in Gochang county ; GC-I: the Alnus zone, thedeciduous broad-leaved forest, before about 5Ka, GC-II: the Alnus-Quercus zone, the cool temperate deciduous broad-leaved forest about 5-2Ka, GC-III: the Laevigatosporites zone, and GC-IY: the Pinuszone, the temperate conifer forest, after about 2Ka.(Kim, Yang, Bong, Nahm and Park, 2002)
4) Youngsan estuarine mouth; late Holocene pollen zonation characterized by Quercus zone(since ca. 10Ka) and Quercus-Pinus zone(since ca. 5-6Ka) (Nahm, Kim and others, 2002)
5) Gimhae fluvial plain late Holocene pollen zonation typified by Quercus-Pinus zone (since ca. 2-3Ka) (Yi, Kim, and others, 2001).

As a result, the palynological zonations of Soro-ri, Oksan-ri, Sanggap-ri, Youngsan estuary, and Gimhae fluvial plain, as illustrated in this research, show a similar zonation with those of previous researchers (Choi, 1997; Yi, Kim and others, 1996; Park, 1990; Chun, Kim and others, 1998).

2. Marginal Hillslope Organic Mud and Sand Sequence

Along the margins of hillslope in western coastal areas, there are several layers compsed of organic sand and mud deposits. They are fundamentally origi-

nated from local wet land formed due to rising groundwater table in response to sea level rise.

1) Naeheung-dong zonation in Gunsan city ; Middle to Late Holocene palynofloral zones are identified at the trench 2 profile of section 3-1 in Naeheungdong archaeological site of Kusan city. Two Palynological zones are identified; the lower zone(temperate mixed forest) is characterized by Alnus Quercus -Pinus zone (300-500cm, asl ca 5.3Ka - 6.5Ka), and the upper zone(temperate conifer forest) is designated by Pinus zone(500-58cm, ca.2Ka) with the predominance of Graminae, Cyperaceae, Compositae, and Polygonaceae(unpublished data of authors, 2003)
2) Gatap-ri zonation in Puyeo city, found in GT-2 pit as the Late Holocene palynofloral assemblages ; Poor palynofloral Zone(680-750cm, Zone 1) with rare Pinus(1,510yrs B.P 2,070 yre B.P), Rare palynofloral Zone(750-800cm, Zone 2), Pseudoschizaea Zone(800-825cm, Zone 3) wih Pseudoschizaea,Laevigatosporites, and Laevigatosporites Zone(825-860cm, Zone 4), and finally Poor palynofloral Zone(860-900cm, Zone 5) (unpublished data of authors, 2003).

Summary and Conclusions

In Korea, the uppermost Pleistocene sedimentary sequences are composed of the old(lower) fluvial sand and gravel sequence with organic muds, as well as the slope deposits with frost-cracked paleosol layers before LGM(inferred to be at least as old as 18Ka). On the other hand the young (upper) fluvial deposits were prevailed along the reaches of main river since ca. 18 Ka. In this sequences are several horizons of the fluvial sands and gravels intercalated with organic muds. The organic muds were found in two typical horizons of the last glacial sequences. The lower one is intercalated in or subjacent to the old fluvial sequences, while the upper one is found just below the younger fluvial sequences of the post-LGM. Since 18Ka, erosional process had become more pronounced at the beginning of post-LGM period. From about 17-15Ka, fluvial depositional process were prevailed up to the end of the Last Glacial period. The young fluvial sequences were characterized by the intercalations of organic muds, particularly formed after 13-14Ka. They were formed under local backswamp environment and they were intermittently interrupted by flooding muds until ca. 11Ka. Pollen as Abies/Picea-Betula with Ranunculaceae, Compositae, Cyperaceae are prevalent untill ca. 10Ka. Young fulvial sequences intercalated with organic muds are associated with Blling, Older Dryas, Aller?d, and Younger Dryas.

As of the Early Holocene, Early Holocene paleosols with abundant dessication cracks were interpreted to be formed under dry condition between flooding episodes of Earliest Holocene. Holocene fluvial sands and gravels are distributed above the uppermost Pleistocene young fluvial sequences or Early Holocene paleosols along 5 major river valleys in Korea.

In coastal areas, however, due to rapid sea level rise in accordance with the rapid melting of continental ice in the polar region, coastal areas move towards landward, and the major parts of the lower reaches of the old river mouth in the western coastal plain were submerged into the Yellow Sea. The sea level was almost arrived to that of the present at the Climatic Maximum of the Holocene, ranging from 7,000 to 6,000 years B.P. Frequent inundation of the coastal areas were subsequently followed after the Middle Holocene in Korean Peninsula. In the coastal and river mouth areas, dominant litho-sequences are associated with lowermost bluish gray flat muds, gray organic muds in the old wet landdue to migration or shifting of old mudflts and tidal channel in response of the fluctuation of mean sea level.

Sedimentary profiles of the alluvial archaeological

sites along the major rivers show the general flooding episodes after Holocene Climatic Maximum. Repetition of floodplain deposits with pedogenetic horizons indicates that particularly since 3,000 yearsB.P. up to 2,200 years B.P., the major rivers have been flooded several times. Many cultural evidences, including potteries and early human settlements, cultivations, and remnants of old land management were found in several alluvial archaeological sites of Bronze to Iron ages. Even during the historical ages after 2Ka, the coastal plains of Korea were inundated several times. Pottery fragments and other artefacts, belonging to the Koryeo and Chosun Kingdoms of the Middle Age, were frequently found in the archaeological sites, as evidences for historical human occupations especially on the reaches of major rivers on the coastal plains.

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