Last Glacial Fluctuation of Fluvial Wetland Environment of Korea -with an Special Reference of Fluvial Organic Mud Formations

Proceedings: International Symposium of the Kanazawa University 21st-Century COE Program Vol. 1 (2003)
Edited by Naoto KAMATA

Last Glacial Fluctuation of Fluvial Wetland Environment of Korea - with a Special Reference of Fluvial Organic Mud Formations

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Abstract - The research is aimed to revealing last glacial environmental change of fluvial wetland in South Korea. The environmental fluctuation of the latest Pleistocene sequences were analyzed on the basis of organic muds intercalated in fluvial deposits of Post-LGM. Several fluvial sites, including Jangheung-ri of Nam rIver, Soro-ri of Miho river, Youngsan rivermouth in Muan, Oksan-ri of Hampyeong and Sanggap-ri of Gochang were selected to examine sedimentary facies, carbon radiometric age, and pollen analytical data. The terrestrial post-LGM sequences show millenium-scale fluctuation of fluvial environmental changes and respond to the cyclic sequences of fluvial sands, backswamp organic muds, and flooding muds with paleosols. (key word : fluvial wetland, organic muds, post-LGM, pollen, environmental change)

I. Introduction

In Korean peninsula, Holocene alluvial and/or fuvial deposits occupies quite a large surface areas, while upper Pleistocene fluvial deposits are less developed apparently, except coastal, old fluvial and hillslope areas. As to the latter deposits, terrace sequences were formed during the upper Pleistocene (since ca. 125Ka). Marine terraces in coastal areas and/or fluvial terraces along main river courses are prevailed mostly at the level of about 10-20meter above base level (asl, or river bottom)[1]. During the last glacial period, however, slope process was developed along the foothill of mountain slopes. But the most outstanding depositional sequences are latest Pleistocene and Holocene alluvial to fluvial deposits, filled in the drowned valleys along the coastal area or at inland alluvial plain.

II. Last Glacial Sequences

A. Pre-LGM Old Fluvial Sequence

During the early last glacial period, the major riversprograded towards the Yellow Sea, and this 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 [1, 2]. After LGM, the sea levels were abruptly rose up due to the rapid melting of ice in the 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 hill slopes or at the foot of mountain, secondly, the formation of fluvial/backswamp deposits during interstadial, and thirdly, several conspicuous horizons of soil wedge formations developed in various depositional sequences formed during the last glacial maxium.. The older soil wedge structures were interpreted to be developed in the period equivalent to the marine isotope age 4, i.e., ca.65Ka, while the younger ones to the marine isotope age 2, i.e., ca 18Ka [3].

Soro-ri fluvial sequences are illustrated as an example of pre-LGM fluvial sequence. They are composed of fluvial gravel, sand and organic muds. The fluvial deposits are interpreted to be associated with backswamp organic muds. The formation age of Middle fluvial sequence is older than 36,000yrsB.P, based on 14C age of organic muds above sand and gravel layer in P38 pit and U24 pit of Soro-ri site in Cheonwon County. Estuarine fill sequence in the Youngsan River mouth are another example. based on 20 m (20.50-1.60m depth) of core (MW-1). They are composed of 1) lower fluvial coarse sands and pebbles, with levee/backswamp homogeneous mud, partly cross-laminated mud, and massive sand (38-29Ka), and 2) upper floodplain brown-mottled clayey silt with a little sand layers (flooding paleosols, 29-27Ka.). In lower fluvial/backswamp sequences, such arboreal pollens as *Pinus, Abies*, and *Picea* are rich and non-arboreal pollens as *Cyperaceae* and *Gramineae* are common, while in the upper flooding deposits fragments of plant roots are abundant and subjected to intensive pedogenic processes.

B. Latest Pleistocene Young Fluvial Sequence of (post-LGM)

The latest Pleistocene fluvial sequence after LGM is examplified in Jangheung-ri site and Soro-ri site [4]. 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 Bφlling, Older Dryas, Alleröd, and Younger Dryas (MIS-1) [5].

As for latter site, Soro-ri area 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[6]) to 12,930±400yrs BP (SNU01-286)[7]. 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 16,680-13,010yrB.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) [4].

C. Paleosol (Young) Sequences of Holocene

The upper part of post-LGM sequence shows paleosol layers which were formed under rather dry climatic condition between each flooding period during 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 young paleosols of Jangheung-ri shows 50Ka or 60Ka, 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) [4].

D. Fluvial/Backswamp Sequences of Holocene

As to Holocene deposits in the western part of the korean peninsula, coastal alluvial plain deposits are widely developed in shallow but broad drowned valleys [3]. 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. Peaty clays are found at the level of about 7-8m above mean sea level between these two clay deposits.

Fluvial/flooding deposits

From 10Ka up to 6-7 Ka, Holocene sea-level rise brought up the base level to the present, now almost equal to the alluvial surface [8]. Since the mid. Holocene, the fluvial flooding level reached top of the old fluvial deposits, leaving there flood deposits. The prehistory people began to settle on this newly-made flooding surface. They had lived there until another devastating flooding episode. In such a way, there are relatively continuous records of human occupations in the Holocene deposits.

Backswamp Organic Muds

Holocene alluvial plain deposits are variously depending on the geomorpholgy and distance from the main river. At the river channel, the sediments reach 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 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 blackish muds or fluvial silty muds. The carbon radiometric dating of peaty clay layers are 6,440yr BP. ± 245, 5,500~5,000yr BP. 3,000~2,500yr BP,and about 1,500yr BP, in the ascending order of stratigraphic colume [9, 10, 11]. 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 [12, 13, 14]. 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 formations 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 5,400yr BP.

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. In Soro-ri site, pollen analysis shows *Pinus-Colyus* forest(OS-2 zone, the mixed conifer and deciduous broad-leaved forest, about up to 10Ka), *Alnus-Quercus*

forest (OS-3 zone, the cool temperate deciduous broad-leaved forest, about 10Ka-2Ka), and *Pinus* forest (OS-4, the conifer forest, about after 2Ka [4, 15, 16]. Holocene vegetations are also examplified by the pollen zonations of four different sites; Oksan-ri zonation in Hampyeong county [17]; HP-I: *Alnus-Quercus* zone (bottommost, 2.5Ka), HP-II: *Pinus-Quercus* zone (-90~-156cm), HP-III: *Pinus* zone (bottom)), and 2) Sanggap-ri zonation in Gochang county [18]; GC-I: the *Alnus* zone, the deciduous 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-IV: the *Pinus* zone, the temperate conifer forest, after about 2Ka; in Youngsan estuarine mouth [19], late Holocene pollen zonation characterized by *Quercus* zone (since ca. 10Ka) *and Quercus-Pinus* zone (since ca. 5-6Ka); lastly in Gimhae fluvial plain [20], late Holocene pollen zonation typified by *Quercus-Pinus* zone (since ca. 2-3Ka). In conclusion the palynological zonations of Soro-ri, Oksan-ri, Sanggap-ri, Youngsan estuary and Gimhae fluvial plain, as illustrated in this research, are similar to those of other previous researches [21, 22].

III. Summary and Conclusions

For the Upper Pleistocene depositional sequences, the interglacial sands/gravels and the last glacial slope deposits with paleosols are main depositional sequences before LGM, inferred to be as of 18Ka. Several horizons of the fluvial sands and gravels are intercalated with organic muds. The organic muds were found in two typical horizons of the last glacial sequences. The lower one is intercalated in the old fluvial sequences, while the upper one is found in the younger fluvial sequences as the post-LGM sequences. 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 Bφlling, Older Dryas, Alleröd, and Younger Dryas (indicating MIS-1).

As Holocene sequences, Holocene paleosols with abundant Dessication cracks were interpreted to be formed under dry condition between flooding episodes until Holocene. Holocene fluvial sands and gravels are distributed above the young fluvial sequences or Holocene (young) paleosols along 5 major river valleys in Korea, including Han River. In coastal areas 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 land due 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.

Finally as an example of ancient human practices and management of wetland in Korea, it is inferred that ancient human intervention was accompanied in the process of old wetland management for the purpose of reclaming wetland into cultivating land at maximum extent. But episodical floodings inundated farm land so that ancient people might have moved towards hill side at least above 6.5 m to 7.0 m above base level in order to avoid next flooding hazard. Lastly modern artificial constructions in the fluvial areas, since the 20th century, including heavy construction of banks, dams and excessive aggregate extraction, have diminished flooding damage drastically. Yet it has not yet been fully prevented from occasionally high peaks of flooding attacks. Over-managements or artificial rising or decreasing of the equilibrium height of river-bed might be one of causes of flooding damages.

Acknowledgements

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

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