Late Pleistocene Fluvial Sequence in South Korea

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Abstract : In South Korea a Pedo-sedimentary Sequence(PS) indicating the Last Glacial Maximum(LGM) is typified by a brown to dark brown, relatively stiff paleosol layers formed by repetitive freezing and thawing processes which in turn left chracteristic glossic textures in soil solum, polygolnal structures with a flagipans, vertical soil wedges or freezing cracks, and horizontal foliations. As a pre-LGM sedimentary sequences (older than 25Ka), the Old Fluvial Sequence(OFS) overlain by the Slope Sedimentary Sequence(SS) are distributed commonly at the base level higher than 14-15m above present river-bed along the major river basin. After the LGM (ca. 18Ka), the Young Fluvial Sequence(YFS) appears at an altitude of about 7-8m above river-bed. They are composed of fluvial sand and gravels, organic muds and flooding muds in ascending order of sedimentary profiles. In this study fluvial organic muds of Jangheungri site(Jinju), Sorori site(Cheonwon), and Youngsan estuarine rivermouth(Mokpo) were exemplified in order to interpret their formation ages and environments. As result of ^{14}C datings, the formation ages of the organic muds are Boelling to Alleroed (MIS-1). These organic muds were formed in fluvial backswamp or local pond/bog in response to shifting fluvial system. On the basis of palynological production dominant with Abies/Picea-Betula and Ranunculaceae, Compositae, Cyperaceae, and Graminae, it was interpreted that more boreal to subboreal condition was prevailed rather than temperate like today during the formation of organic muds and soil moisture condition was a repetition of wet and dry condition.

Key Words : LGM, fluvial sequence, organic muds, palynological production, Boelling- Alleroed

I. Introduction

This research is aimed to revealing the last glacial environmental changes of fluvial sedimentary sequences of South Korea. The sedimentary stratigraphy of the latest Pleistocene sequences of several fluvial drainage basins were analyzed on the basis of fluvial deposits, especially during post-LGM period. Several fluvial organic mud layers, intercalated in fluvial deposits, were illustrated as a sedimentary sequence stratigraphy. They include Jangheung-ri of Nam river, Soro-ri of Miho river, Yeongsan river mouth near Mokpo county. The methodology of this study covers an analysis of sedimentary facies, carbon radiometric age and palynological data. The terrestrial post-LGM sequences is interpreted to be responded to several millenium-scale fluctuations of fluvial environmental changes. A general fluvial sequences show a cyclicity of fluvial sands and gravels derived from an older river-bed, organic muds and muds with paleosols.

II. post-LGM Fluvial Sedimentary Deposits

Fluvial sedimentary sequences are associated with backswamp organic muds. The formation age of lower organic mud layer is older than 36,000 yrB.P, and those of upperorganic mud layer ranges from 12,000 yrB.P, up to 17,000yr. B.P in Jangheung-ri site, Sorori site(Kim, *et al*, 2002a; Kim, *et al*, 2002b), and Youngsan Estuarine rivermouth(Nahm *et al*, 2002).

1. Jangheungri Area

The distribution of soil and sedimentary deposits and fluvial sedimentary stratigraphy, environmental change and chronology of the Jangheungri palaeolithic sites were investigated by sedimentary facies, pollen analysis, and carbon datings. The fluvial deposits of Jangheungri site is composed of (1) lower paleosols, (2) young fluvial sand and gravel with backwamp organic mud, and (3) young paleosol were all formed after ca 22Ka, based on radiometric datings of JHR-Profile(JHRF), S30-Profile, S36-Profile, R35-Profile, K17-Profile, and Step Trench-Profile(STF). For the pollen analytical research in Jangheungri site, it is interpreted thatduring the last 10Ka,Abies-Betula Zone(JH-I) was dominant at the level of 14.0-14.7m(msl), indicating mountain vegetation.Non-arboreal pollen Zone(JH-II) was conspicuously identified as the predominance of backswamp vegetation at the altitude of 14.7-15.2 m(msl). After 10Ka, however, Pinus-Quercus-Alnus Zone(JH-III) is representing mixed forest of broad-leaved deciduous and conifer trees at the levels of 15.2-15.9 m(msl). Pinus-QuercusZone(JH-IV) shows mixed forest of conifer and broad-leaved deciduous trees) at the levels of 15.9-17.1 m(msl), and Pinus Zone(JH-V) was prevailed as conifer forest at the level of 17.1-17.5 m(msl).

In addition, In the JHR-Profile(JHRF), lower paleosols were yellowish brown silty sandy loamy soil with vertical cracks were found at the level of 16m(asl) and this layer was overlain by yellow sandy loamy soil, dark brown sandy loamy soil and dense brown sandy loamy soil. The radiocarbon ages of the paleosol layers are, from bottom to top, 20,480±800yrsB.P(5B:SNU02-336), 19,480±540yrsB.P(4B:SNU02-335), 13,160±280yrsB.P (3B:SNU02-334), 6,980±100yrsB.P(2B: SNU02-333), 5,480±30yrsB.P(1B: SNU02-332). The radiocarbon ages of charcoals in the excavation pit of Jangheungri site are as follows: (1) 20,150±100yrsB.P(Beta-171404) in Pit-S30, (2) 19,640±100yrsB.P(Beta-171405), 19,490±90yrsB.P (Beta-171406), 19,230±90yrs B.P(Beta-171409) in Pit-R35, (3) 22,170±120yrsB.P(Beta-171407) in Pit-R35, and (4) 18,730±80yrsB.P(Beta-171408) in Pit-K17.

Based on the topographic levels of excavation pits and chronology, it is inferred that the level of the paleosol profiles are higher in S30, S36 and R35 than those in K15 and STF during 20Ka-18 Ka(Fig. 1). This imply that the direction of valley erosion were assumed toward northward during LGM. The initiation of valley degradation was ca 19Ka, if the 18.7 Ka of radiocarbon ages dated for charcoals taken at the level of 17.3m in K17-Pit was taken into consideration. The erosion of LGM was subsequently replaced by the deposition of younger fluvial deposits which are composed of gravels, sands and backwamp organic muds. The radiometric datings of the young fluvial deposits carried on the STF are 15,070±20yrsB.P(GX-28664) for wood fragments between sand and gravel boundary, 14,600±190yrsB.P(GX-28663) for lowermost organic mud layers, and 10,780±100yrsB.P(GX-28662) for the upper organic mud

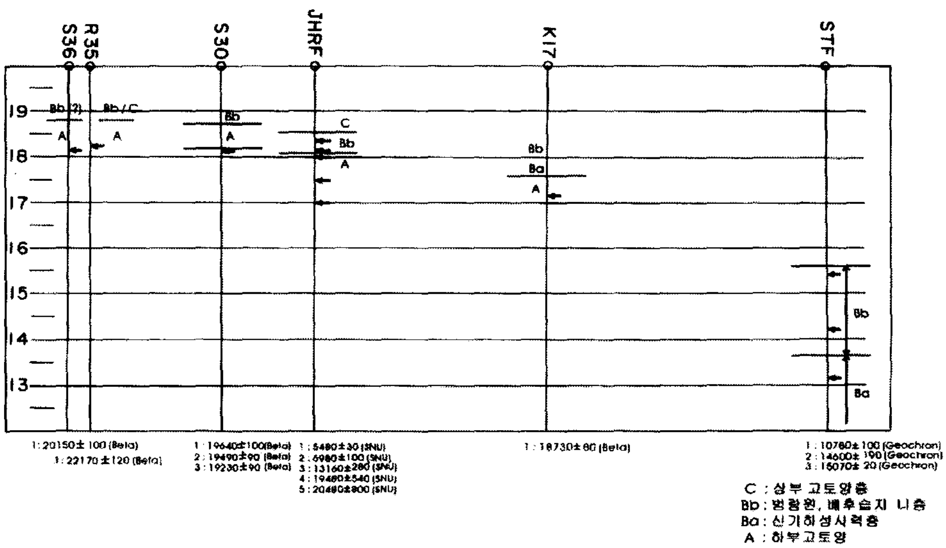

Fig. 1. Sedimentary sequences of Jangheungri area.(A) old fluvial sequences(pre-LGM) with lower paleosol, (B) the latest Pleistocene young fluvial sequences(post-LGM), and (C) paleosol sequences of the Holocene.

later. This radiometric data supports that the erosion took place at maximum until ca 17Ka-16Ka. The frequent inundation were prevailed between 14-13Ka and continued until ca 11Ka

Lastly palesols were mottled by yellow and dark gray nodules and the cracking of soil structure found at the 16-17m of STF site. The soil structure shows typical braided-typed cracks in the root part of crackings, and more diversified pattern of crackings downward. This is named as "dessication cracks" which are different from frost cracks(or soil wedges). This type of dry cracks were interpreted to be formed when the flooding muds, during the Holocene, were subaerially revealed for a long time under dry warm climatic condition. On this layer accumulated a lenticular organic muds filled in the local eroded gullies, formed by frequent runoff on the dry flooding surface.

2. Sorori Area

The Sorori site is characterized by three typical deposits in the late Quaternary profiles. The lowermost deposits are typified by old river bed deposits which are composed of the gravels, sands and peaty muds. The peaty muds were formed under the backswamp environment of the old Miho stream channel. The ^{14}C age of the peaty muds are older than 36Ka. The second deposits are characterized with a matrix of the soil-sedimentary layers derived from both slope process and pedological process. They show mottled soils and pseudo-gleization by groundwater fluctuations with nodular Fe-Mn hydroxides, soil wedges(frost cracks), foliation, polygonal textures and fragipans. Third deposits are equivalent to the young fluvial deposits in which several horizons of peaty muds and flooding sandy muds are intercalated. During the last glacial episode the base level of old Miho

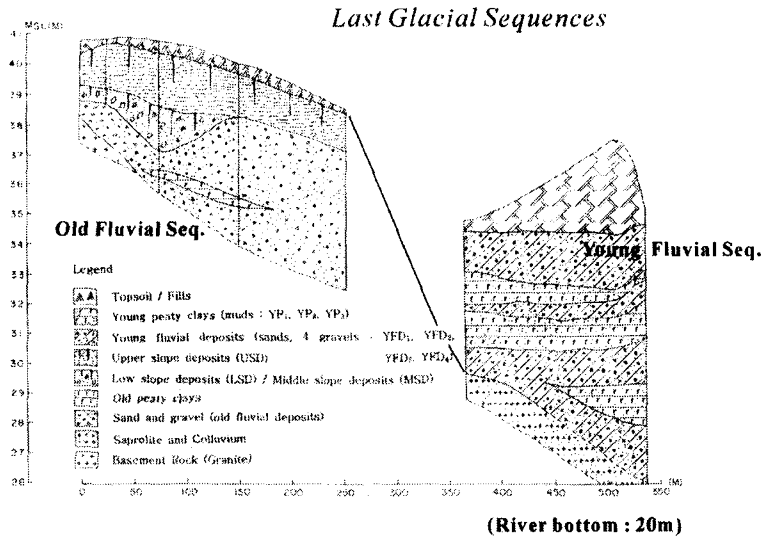

Fig. 2. Last Glacial Sorori Fluvial Sequences Distribution.

stream channel is supposed to have been dropped to the level of the boundary of the basement rock(at least about 8m) along the present Miho alluvial plain(Fig. 2). During post-LGM nad subsequent post -glacial rising episodes of stream base level, the stream channel and flooding deposits were ubiquitously formed along by the river.

The younger fluvial sequences are associated with several horizons of peaty clays and intercalation of flooding muds which had been formed since ca 17ka(Fig. 3). Sorori site in Miho river contains a post-LGM fluvial sequence composed of flooding sandy muds, peaty muds and fluvial sand and gravels. The formation age of them ranges between 17-10ka. Pollen zones are divided into three from bottom to top. Carbon Radiometric dating of Sorori organic muds ranges from 17,310±310 yrBP(GX-25495), 16,680±50 yrBP(GX-28504) and 17,300±150 yrBP(SNU01-297), through 14,820±250 yrBP(GX-25494), 14,800

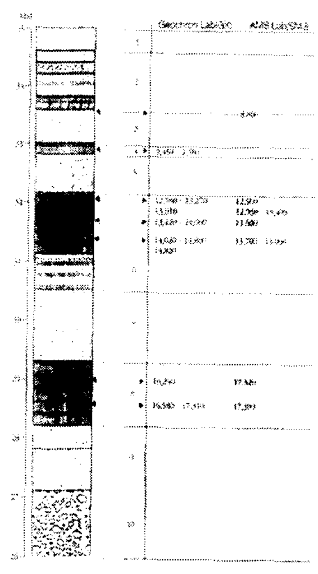

Fig. 3. Young Fluvial sequence in Sorori Site. Lithology noted as follows: 1;fills, 2;upper paleosols, 3;flooding sandy muds, 4;upper peaty muds, 5;flooding sandy muds, 6;middle peaty muds(domesticated rice seeds found in the uppermost layer-12,500ysB.P), 7;fluvial sands, 8;lower peaty muds, 9;fluvial sands, and 10;fluvial sands and gravels.

±210 yrBP(GX-28421) and 13,920±200 yrBP (SNU01-291), to 12,780±170 yrBP(GX-28416), 12,500± 200 yrBP(SNU01-293, seed of old rice)(Lee, *et al*, 2002a) to 12,930±400 yrBP(SNU01-286)(Lee, *et al*, 2002b). The vegetation changes of Sorori shows from (1) conifer and broad-leaved deciduous forest, or mixed forest(formed warm and wet backswamp condition during 16,680-13,010 yrBP), through (2) deciduous and broad-leaved forest(typified by warm and swamp condition older than 9,500 yrBP), to (3) conifer forest and abundant fresh water diatom (indicating relatively cool condition)and later changed into backswamp environment predominant with Gramineae(Kim, *et al*, 2002b). In particular the middle to upper organic mud layers was derived from local backswamp, such arboreal pollens as Abies / Picea-Betula with Ranunculaceae, Compositae, Cyperaceae are prevalent until ca. 10ka. The upper flooding deposits of earliest Holocene contain a number of fragments of plant roots, and this deposits are subjected to an intensive pedogenic processes.

3. Youngsan Estuarine Rivermouth

The Youngsan Estuarine fill deposits, according

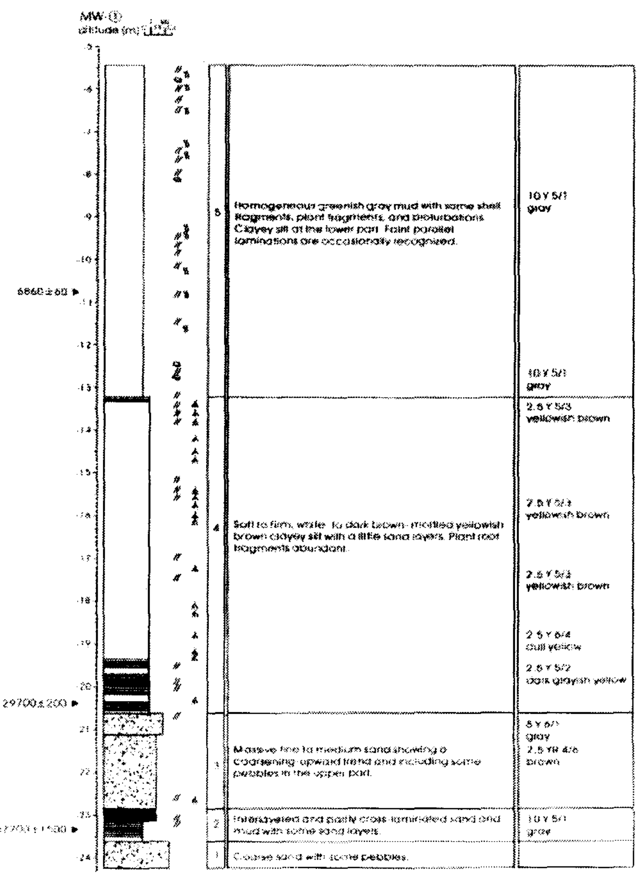

Fig. 4. Lithologic profile of MW-1 borehole in Youngsan estuarine river(Nahm, 2005).

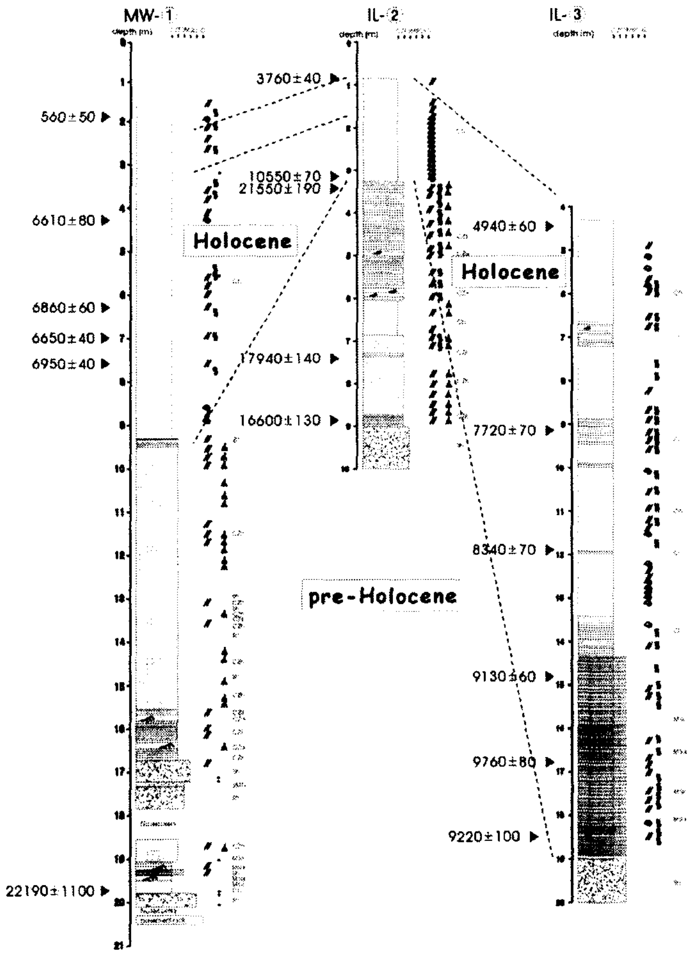

Fig. 5. Correlation of lithologic profiles of MW-1, IL-2 and IL-3 boreholes in Youngsan estuarine river(Nahm, 2005).

to MW-1 borehole, 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 white to dark brown mottled clayey silt with a little sand layers(flooding paleosols, after ca 29~27ka) and with freshwater algae, *Pinus* and herbaceous plants(Fig. 4). This flooding unit has a sharp upper contact with Holocene flat to estuarine deposits which are composed of homogeneous greenish gray mud with some shell fragments, plant fragments and bioturbation clayey silt at lower part. In general faint parallel lamination are occasionally recognized. The boundary between estarine and fluvial deposits has a relatively long time of non-deposition or erosion episode in the Youngsan estuarine river mouth(refer to Unit 1, 2, 3 and 4 in Fig. 4). As to the Pleistocene and Holocene Transition, the borehole data of MW-1, IL-2, and IL-3 can be taken into consideration(Fig. 5). Particularly the upper Pleistocene deposits are characterized with paleosol layers of the Last Glacial Maximum(LGM), the radiometric carbon ages of which are converged into the 27000~21000yr B.P(ca MIS 2) based on AMS ^{14}C of the SOM(soil organic matter) in paleosols. The altitude of this transition is about -11.3 m(asl) in MW-1, -8.0 m in IL-2 and -21.5 m in IL-3, respectively. The depth to the boundary is changed in accordance to the depositional process during the Holocene. and not becomes simply deeper or shallower landward direction. In the flooding deposits a freshwater algae like *Pseudoschizaea* is abundant and this species are known to be associated with local bog of fluvial terrace environment(Christopher, 1976). Palynological viewpoint broad-leaved pollen is little produced, but Betlua, Pinus, Cyperaceae and Gramineae are relatively abundant. In common dark brown and mottled yellowish brown clay silts with parallel lamination and partial cross-lamination and plant fragments and bioturbation observed in IL-2 cores are also indicative to pedo-sediment or syn-genetical soil(Nahm, 2005), under the fluvial environment where flooding/ overbank process and pedogenetic process are duplicated under subaerial condition. In Yeoungsan estuarine mouth the paleosols have no cliche, calcrete, or calcareous horizons, which in turn implicate the climate of LGM was not as dry as desert or semi-desert. If such paleosols are also developed in Yangtz River Delta formed during LGM(MIS 2), and the annual precipitation was assumed to be about 750 mm(Li *et al.* 2000). Therefore it is interpreted that this kind of paleosols are resulted from a repetition of dry and wet soil moisture condition under boreal and sub-boreal climate during the LGM.

III. Summary and Conclusions

In South Korea Last Glacial sedimentary and pedological sequences are composed of Old Fluvial Sequences(pre-LGM),Slope Deposits of pre-LGM, brown to dark brown Paleosols of LGM period, and Young Fluvial Deposits(post-LGM). As a pre-LGM sedimentary sequences(older than 20Ka), the Old Fluvial Sequence(OFS) overlain by the Slope Sedimentary Sequence(SS) are developed commonly at the base level higher than 14-15m above present river bed along the major river basin Fig. 6). A Pedo-sedimentary Sequence(PS) indicating the Last Glacial Maximum(LGM) is particularly typified by a brown to dark brown relatively stiff paleosol layers formed by repetitive freezing and thawing processes which in turn left chracteristic glossy textures in soil solum, polygolnal structures with a flagipans, vertical soil wedges or freezing cracks, and horizontal foliations.

Along the coastal areas, Youngsan estuarine rivermouth was prograded towards the Yellow Sea, when sea level was dropped at the level of about 120 m below the present sea level.

After the LGM(ca. 18Ka), Young Fluvial Sequence(post-LGM, YFS) was distributed at an altitude of about 7-8m above river bed(Fig. 2). They are composed of fluvial sand and gravels, organic muds and flooding muds in ascending order of sedimentary profiles. Fluvial organic muds of Jangheungri site(Jinju), Sorori site(Cheonwon), and Youngsan estuarine rivermouth(Mokpo) were interpreted their formation ages and environments.

Based on ^{14}C datings, the formation ages of the organic muds are Boelling to Alleroed(MIS-1).

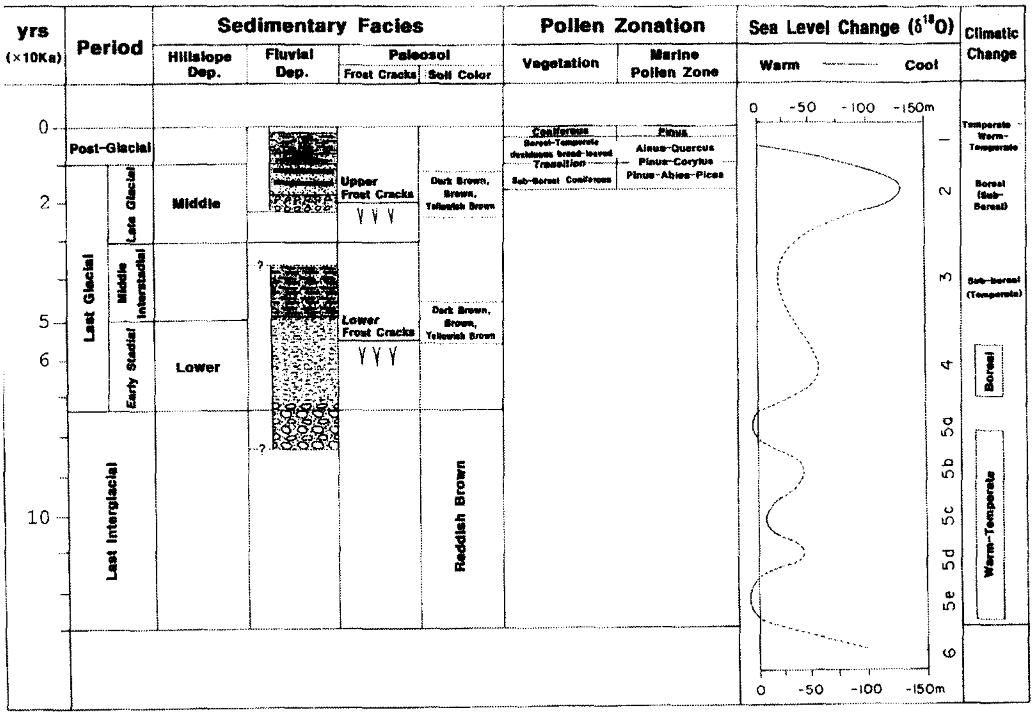

Fig. 6. Late Pleistocene Sedimentary Sequences in the fluvial environment of S. Korea.

These organic muds were formed in fluvial backswamp or local pond in response to shifting of fluvial system. On the basis of palynological production dominant with Abies/Picea-Betula and Ranunculaceae, Compositae, Cyperaceae, and Graminae, it was interpreted that more boreal to sub-boreal condition was prevailed rather than temperate like today during the formation of organic muds. On the basis of LGM paleosols of the Youngsan estuary river mouth, it is interpreted that the soil moisture condition was a periodic wet and dry like Yangtz River Delta, annual precipitation as low as 750 mm(Li *et al.* 2000).

In short landscape erosion process had become more pronounced until the end of LGM(ca 18ka). At beginning of post-LGM period from about 17-15ka, Young Fluvial Sequence was formed by fluvial depositional process and base level increase which was prevailed up to the end of the Last Glacial Period. The formation age of Young Fluvial Sequence is latest Pleistocene, which is intercalated with several horizons of organic mud layers and is associated with the Boelling-Alleroed stage indicating MIS-1 in Korea.

Acknowledgements

The paper was prepared with the help of financial supports from the Ministry of Science and Technology and the Korea Research Foundation(KRF-2002-072- AM1013).

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