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<Review>

The Post-glacial Vegetation History of the Lowland in Korean Peninsula

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韓半島 後氷期의 低地帶 植生史

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ABSTRACT

This is the review of vegetational history of the post-glacial period in Korea. Most of studies for vegetational changes are located in the lowland alluvial plain, especially below the hilly zone of western and eastern coastal regions of Korea. A couple of methods, pollen analysis and radiocarbon dating, have been employed in these studies. These results lead us to establish the pollen zonation in Korea as the followings. Yasuda *et al.*(1980) classified six period in Yongrang lake of Sokcho. These are as follow; Ⅰ.17,000~15,000yr B.P.: *Picea, Abies, Pinus(Haploxylon), Larix* stage, Ⅱ.15,000~10,000yr B.P.:Herb, Pteridophyta stage, Ⅲ.10,000~6,700yr B.P.:*Quercus* stage, Ⅳ.6,700~4,500yr B.P.:*Pinus, Quercus, Carpinus* stage, Ⅴ.4,500~1,400yr B.P.: *Quercus, Pinus* stage, Ⅵ.1,400yr B.P.-present: Pinus, Herbs stage. Jo (1979) also divided the period into two stages from the outcomes of analysis done in Jumoonjin and other sites; I.10,00~6,000yr B.P.:*Quercus* stage, II.6,000-present: *Pinus-Quercus* stage, and three substages: IIa.6,000~3,400 yr B.P.:lower *Pinus* stage, IIb.3,400~2,000yr B.P.:*Pinus-Quercus* stage, IIc.2,000-present: *Pinus* stage. Choi(1993, 1996) divided the period into three stages: Ⅰ.6,000~5,000yr B.P.:*Alnus, Quercus* stage, Ⅱ.5,000~4,500yr B.P.: *Alnus, Quercus, Pinus* stage, Ⅲ.4,500~2,600yr B.P.: *Alnus, Pinus* stage. In the period around 6,000yr B.P. distinct dominant species clearly occupied the lowland of the eastern and western coasts. Thus, this strongly supports the fact that even if Korea experienced its warm and wet climate after the lateglacial, it underwent a different environmental change, dry climate, compared to the regions of Japan.

Key words: vegetation history, lowland, post glacial period, pollen analysis

INTRODUCTION

In Korea, there are a few studies in which the vegetational and natural environmental changes in the post maximum glacial period have been examined. These previous reports, however, are not enough neither to locate the time and the space of local and regional ecosystem or to interpreted the differentiated change of the forest in Korean peninsula. In this respect, this reviewed study mainly concerns the vegetational history during the post glacial period of Korea on the basis of the analyses measured by radiocarbon dating in representative sites of the low-

land. The post glacial period used here refers to the period from the last European glacier started with warm temperature, i.e. 14,000~15,000yr B.P. to the present.

Short history of pollen analysis in Korea

In 1940, Yamazaki attempted to study pollen analysis for the first time in Korea. After Yamazaki (1940), Matsushima(1941) and other scientists conducted the pollen analysis in Korean peninsula but a silent period of pollen analysis was lasted for about 30 years in Korea.

Even though Oh(1971) reported some data on pollen analysis, it is quite insufficient and irrational to discuss the vegetational history of Korea in terms of its ecosystem changes.

About 16 papers or reports were published by the present and the research sites were approximately 31 sites in Korean peninsula. Most of these studies were carried out in the lowland alluvial plains, especially below hilly zones of western and eastern coastal regions. Only Yasuda *et al.* (1980), Jo(1979) and Choi(1993, 1996) attempted to arrange the chronology with radiocarbon dating.

This review is confined to most of the above three data with exception of the unspecified and overlapping sites by other researchers. With the limited to obtain the results on pollen analysis in North Korea, it needs to collect a great amount of data for interpreting the vegetational history in Korea peninsula.

However, the recent studies on Moojechi bog and other moors suggest that the montane or cool temperature zone of Korea will shed light on the vegetational history of Korean peninsula.

Vegetational history of Korea

Most of the sites for pollen analysis are located in the lowland alluvial plains of the western and eastern coasts. Therefore, many study is needed for us to discuss the vegetational history of the Korean peninsula. The vegetational history made by the results of the pollen analysis and radiocarbon dating of the lowland and below hilly zones in Korea is shown in Fig. 1 and Table 1.

1. Vegetation of the lateglacial period

When we assume that the post-glacial period starts about 10,000 years ago, the period before that was entirely investigated by Yasuda *et al.*(1980), based on Yongrang lake(St. 6 in Fig. 1.). They show that during the period of 17,000-15,000yr B.P., the late cold period after the last glacial period, the surroundings of Yongrang lake were dominated by subartic

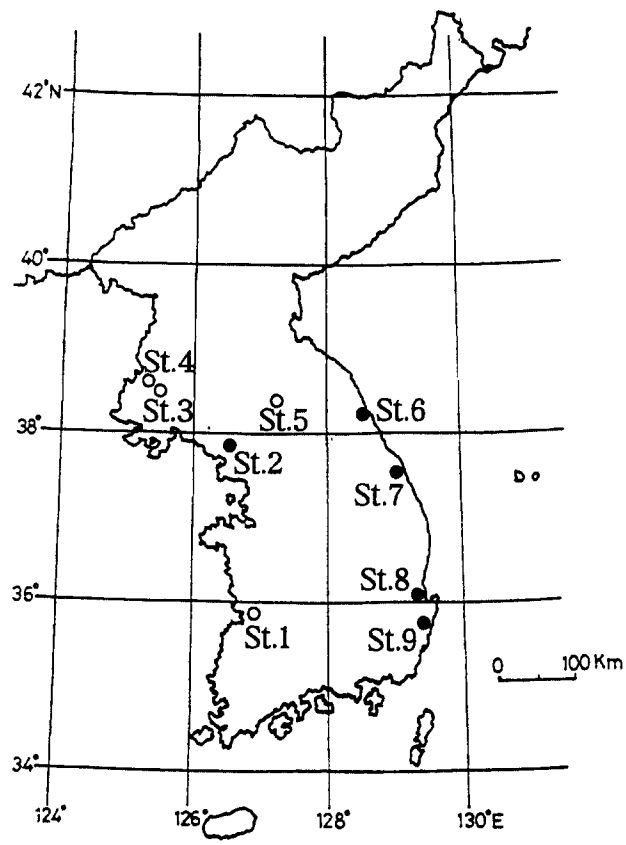
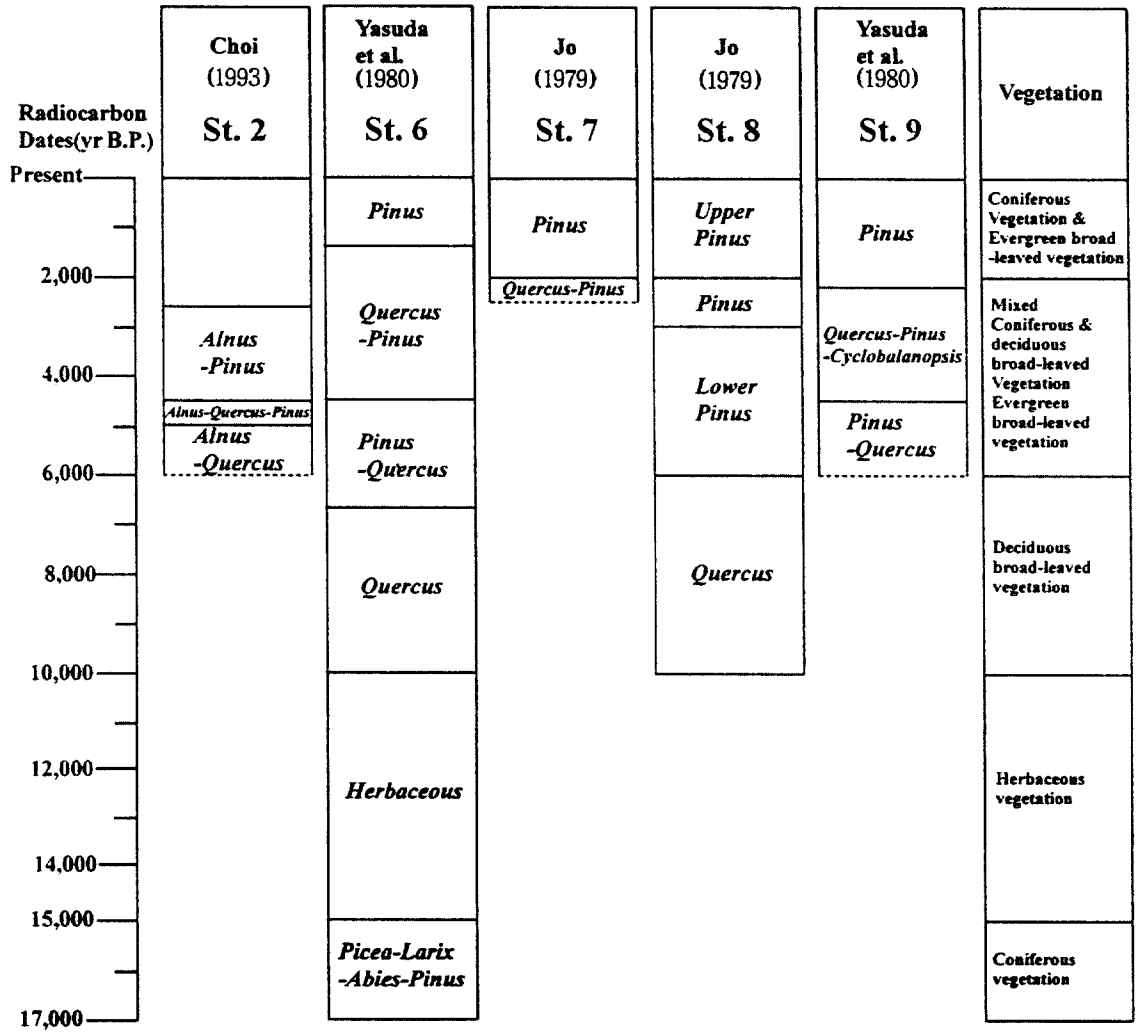


Fig. 1. The investigated locations of pollen analysis in Korea(Source: Matsushima, 1941; Jo, 1979; Yasuda *et al.*, 1980; Choi, 1993).
Open circles : Sites by M. Matsushima(1941)
Closed circles : Sites by other scholars
St.1: Igsan St.2: Ilsan St.3,4: Onjeong
St.5: Pyeonggang St.6: Lake Younglang
St.7: Jumoonjin St.8: Pohan St.9: Bangeojin

Table 1. Diagram of pollen zonation during the post-glacial period in Korea



conifers, such as *Picea, Larix, Abies,* and *Pinus* (Haploxylon). This is highly correlative to the pattern of the forests in various places in Japan which are located nearly at the same latitude and which were not directly affected by the glacier as shown by Nakamura(1967), Tsukada (1974), and Yasuda (1982). These highly correlative patterns of forest change indicate that the Korean peninsula surely underwent the process of global climate change rather than being affected by mere accidental environmental change depending on the regional climatic conditions. However, it is difficult to generalize this pattern over Korean peninsula, considering the lowland of the eastern coast extended across Taebaek mountains as the barriers of the plant migration paths, no appearance of *Tsuga,* and different appearance rates of a few pollens that are the indicators of the natural environment in pollen analysis. The climatic characteristics of the period were cold and dry and etc.

There are no enough data to explain the period between 15,000yr B.P. and 10,000yr B.P. when the lateglacial period ended. It should be noted that after 15,000yr B.P., around Yongrang lake, subarctic conifers was rapidly replaced by a few deciduous-broad leaved trees such as *Tilia* and *Quercus* as well as the ferns appearing much in number. This period also were kept on unfavorable conditions for the development of forest vegetation and cold and dry climate after the maximum glacial period in the last glacial era. However, climate might have started to

change warm and wet when it came close to 10,000yr B.P.

2. Vegetation of the post-glacial period

The begining of the post-glacial period in Korea still remained some doubt but here it is dated from 10,000yr B.P. The period between about 10,000yr B. P. and 6,000yr B.P. is characterized as the era of the predominance of the deciduous broad-leaved forests with the subarctic conifers decreasing rapidly across the Korean peninsula. Since about 10,000yr B.P. the lowland of the eastern coast(St. 6 & 8 in Fig. 1.) underwent a rapid increase of *Quercus,* following the period of a rapid growing of *Pinus* from 6,700yr B. P., according to Yasuda *et al.*(1980), and from 6, 000yr B.P. according to Jo(1979). The slight difference of the eastern coast in line with the research sites and the period prior to the same period can be attributed to the difference of the latitude of the sites and of geography. The uncertainty should be clarified in further works. On the other hand, though there still is no results of the analysis for the western coast, which will be compared to the eastern coast, we could say that *Alnus* was dominated before 6, 000yr B.P., with reference to the pollen analysis of the Ilsan area of Kyongki province(St. 2 in Fig. 1.; Fig. 2). Also it was increased the deciduous broad-leaved trees such as *Salix, Juglans, Carpinus, Fraxinus, Alnus* and etc., over Korean peninsula.

There is no doubt in saying that *Quercus* took the lead in rapid growth when the climate changed warm and wet in gradual and soil became favorable to vegetation from the conditions which were cold, dry and unfavorable in 10,000yr B.P. After the period of *Quercus* predominance, the plants such as *Fagus* and *Cryptomeria* appeared the upper land in the region of the same latitude in Japan, but never detected in Korea. The period of deciduous broad-leaved forests were dominated not by *Fagus* but *Quercus* in the montane zone in central Japan which had less than 1,200mm of annual rainfall(Choi, 1987). This supports the fact that even if Korea experienced its warm and wet climate after the lateglacial period, it underwent a different environmental change in dry climate compared to the regions of Japan. There, it should be emphasized that distinct dominant species clearly occupied the lowland of the eastern and western coasts in the period around 6,000yr B.P. According to the pollen analysis, the western region changed from *Quercus* to *Alnus* following Pinus, while the eastern region was changed from *Quercus* to *Pinus.* Most of the region seem to be wet, because the lowland is directly under the influence of the changing

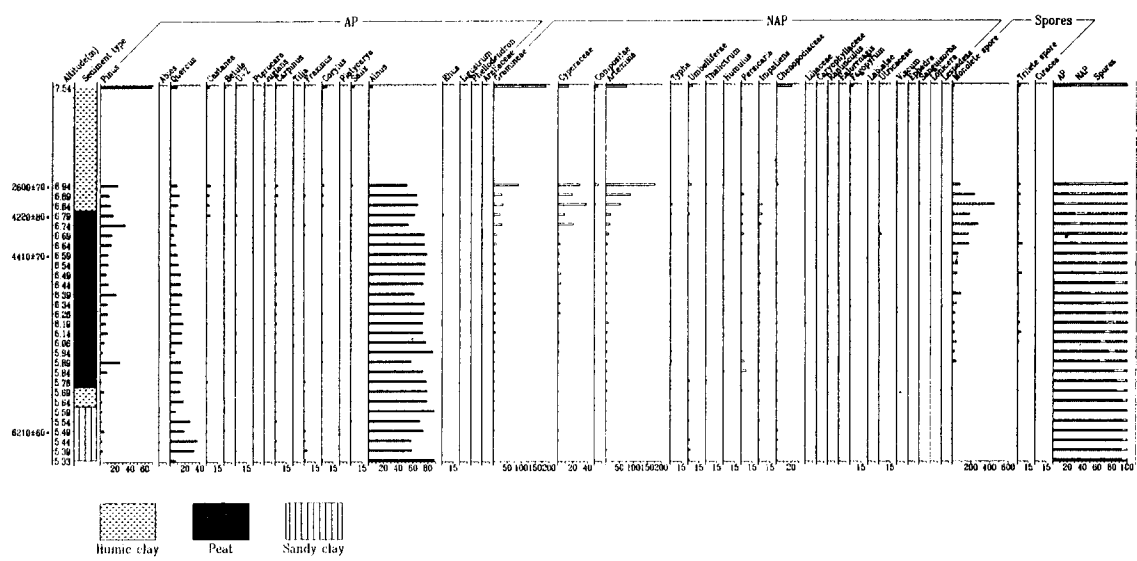


Fig. 2. The pollen diagram of the lowland alluvial plain in Ilsan, the western coast of Korea (by Choi, 1993).

sea level. *Alnus* is the species which indicates the wet climate of the period. The parent tree of *Alnus* might be *Alnus japonica*, according to Kim and Jung(1995), which dominated the western coastal lowland of Korea between 10,000yr B.P. and 2,000yr B.P.

Over the eastern coast there were the coniferous and the broad-leaved forests dominated with *Pinus* and *Quercus* in the period between 6,000 and 2,000 yr B.P. In the early of the period(6,700~6,000yr B. P.), *Pinus*(Diploxilon) increased. *Cyclobalanopsis* was on the increase in the southern coast around 4,500yr B.P. and the increase was until about 2,000yr B.P.(St. 9 in Fig. 1.). The fact that the over-wettness of the soil lasted much longer in the west than in the east is give rise to the low rate of appearance of herbs and the dominance of the *Alnus*, over the period in the lowland of the west after 6,000yr B.P. before the *Pinus* dominant period.

Around 2,000yr B.P. the distribution range of the deciduous broad-leaved forests dominated with *Quercus* and *Alnus* and of the evergreen broad-leaved forests dominated *Cyclobalanopsis* became narrower, while the distribution range of the coniferous forest dominated by *Pinus*(Diploxilon) became wider. In general, this period was seen as the time of increase of pine forests due to human impact, but the author takes a different view. It seems more reasonable to say that the development of the *Pine* forest in the infertile soil and dry climate was due to both the exposure of the barren bare-soil caused by the alternation of the sea level and the extension of dryness around 2,000 yr B.P. This point seems strongly if we observe the fact that the rate of appearance of *Alnus japonica* showed no change at the time when herbs grew extensively and increasingly in the Ilsan region. However, we need more evidence to prove this point. The period when the secondary forest was established extensively by human impact as the present, and with little appearance of plants, such as *Quercus, Alnus, Carpinus, Fraxinus,* and *Cyclobalanopsis* with a rapid increase of *Pinus,* could be located further after 2, 000yr B.P. depending on the region.

CONCLUSION

The information about the vegetation history of Korea during the post-glacial period could be obtained from the results of the pollen analyses in the lowland of the eastern and western coasts of Korea.

At the period of 10,000yr B.P., it is obvious that *Quercus* took the lead in a rapid growth when the climate of Korea turned gradually to warm and wet from cold and dry and the soil became favorable to the vegetation. After the period of *Quercus* predominance, the plants such as *Fagus* and *Cryptomeria* had never been detected in Korea whereas the plants had appeared in the upper land in the region of the same latitude in Japan.

Around the period of 6,000yr B.P., several distinct species occupied dominantly in the lowland of the eastern and western coasts in Korea. The year 6, 000yr B.P seems to be the time of the regional differentiation in Korea. Therefore, these analyses strongly supports the fact that even if Korea experienced its warm and wet climate after the lateglacial period it underwent a different environmental change, dry climate, compared to the regions of Japan.

Even though it is expected that Korea has a simple vegetaion and climate because of its small land, the analyses in this review reveal that the vegetation and climate of Korea was various. In addition, the vegetaion existing in the forest of Korea to date suggests that Korea has its own natural environmental history compared to that of Japan and China. However, many analyses are needed to reconstruct the vegetaion and climate of Korea including North Korea more completely.

적 요

한반도를 대상으로한 화분분석 연구를 중심으로 저지대의 식생변천사와 식생의 지역적 분화 시기를 밝히고자 하였다. 그 결과, 약 10,000yr B.P.이후 한냉·건조한 기후와 식물의 생육에 불리한 토지가 온난·습윤한 기후로 이행되기 시작하였으며 토지조건의 변화와 함께

선구적으로 *Quercus*를 우점으로하는 낙엽활엽수림이 급격히 증가하였음을 알 수 있었다. *Quercus*를 우점으로 하는 낙엽활엽수림시대 이후 약 6,000yr B.P.를 전후하여 동해안 저지대에서는 *Quercus→Pinus*, 서해안 저지대에서는 *Quercus→Alnus→Pinus*의 삼림변천이 있었다. 이는 만빙기 이후 한반도 지역이 온난·습윤한 시대로 이행되나 동위도상의 일본지역과는 또 다른 보다 건조한 기후하에서의 환경변천과정을 거쳤음을 뒷받침하여 준다. 또한 약 6,000yr B.P.를 전후하여 동해안과 서해안 저지대의 삼림식생의 지역적 분화가 일어났을 것으로 추정된다. 한편 4,500yr B.P.를 전후하여 남해안 저지대에서는 *Cyclobalanopsis*가 급증하였으며 이는 약 2,000yr B.P.까지 계속 된다. 약 2,000yr B.P.이후 *Quercus, Alnus*를 우점으로하는 낙엽활엽수림과 *Cyclobalanopsis*를 우점으로하는 상록활엽수림의 분포역이 좁아지며 *Pinus*를 우점으로하는 침엽수림의 분포역이 확대되었다. 일반적으로 이 시대를 인류에 의한 삼림파괴로 소나무림이 증가하는 시기로 해석하고 있다. 그러나 약 2,000yr B.P. 전후의 해수준변동에 의한 척박한 나대지의 노출과 건조한 기후대의 확대로 소나무림이 그 분포역을 보다 확대하였을 가능성도 배제할 수 없다.

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