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The Natural Environment during the Last Glacial Maximum Age around Korea and Adjacent Area

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ABSTRACT

This study is conducted to examine the data of climate or environmental change in the northeastern Asia during the last glacial maximum. A remarkable feature of the 18,000 BP biome reconstructions for China is the mid-latitude extention of steppe and desert biomes to the modern eastern coast. Terrestrial deposits of glacial maximum age from the northern part of Yellow Sea suggest that this region of the continental shelf was occupied by desert and steppe vegetation. And the shift from temperate forest to steppe and desert implies conditions very much drier than present in eastern Asia. Dry conditions might be explained by a strong winter monsoon and/or a weak summer monsoon. A very strong depression of winter temperatures at LGM.has in the center of continent has influenced in northeast Asia similarly. The vegetation of Hokkaido at LGM was subarctic thin forest distributed on the northern area of middle Honshu and cool and temperate mixed forest at southern area of middle Honshu in Japan. The vegetation landscape of mountain- and East coast region of Korea was composed of herbaceous plants with sparse arctic or subarctic trees. The climate of yellow sea surface and west region of Korea was much drier and temperate steppe landscape was extended broadly. It is supposed that a temperate desert appeared on the west coast area of Pyeongan-Do and Cheolla-Do of Korea. The reconstruction of year-round conditions much colder than today right across China, Korea and Japan is consistent with biome reconstruction at the LGM.

Keywords: environmental change, biome reconstructions, steppe and desert biomes, LGM, winter monsoon

Introduction

The natural environment during the last glacial period, which was continued from 70,000 BP to 10,000 BP, was not kept in constant owing to the climatic fluctuation. The last glacial period is classified to three substages, such as early stadial-, interstadial- and late stadial substage based on the data of deep sea cores. The late stadial substage among them, called the last glacial maximum, was continued from 20,000 BP to 18,000 BP. The natural environment of Korea at that time was restored in this study with the special reference to the northeastern Asia.

The Environment of Northeast Asia during the Last Glacial Maximum

1. Monsoon

The most characteristic phenomenon in the climate

of the northeast Asia is 'monsoon'. It is very cold at the north of high mountains across the large continent of Asia in winter. A strong high air pressure occurs on the northeastern Asia. Its center is the lake Baikal in Siberia(Yim, 1993). And the airflow of N-S direction is troubled by high mountains of Cenozoic mountain ranges from Iran, Afghanistan and to the Himalaya.

The possibility of rainfall is very low at the center of cold and dry air. So the climatic disturbance occurs in northeast Asia along the cold front on the boundary between the cold air and a trade wind. The Mongolian high air pressure influenced the ancient monsoon in Asia during the last glacial age. This mongolian air mass was very cold and dry. This cold front was extended to the direction of NE-SW from Setonaikai - Is. Tsushima to the south sea of Is. Cheju during the last glacial period. Based on it, the front during the summer of the last glacial stage was probably arranged similar to that of January of the present in Asia.

It means that the maritime air mass couldn't influence on the northern part of Korea in summer. It is supposed that precipitation was conspicuously low because the continental shelf of the West Sea was emerged to inland. The precipitation at East Korea was probably much more than on West Korea due to the orogenic rainfall, which was occurring passing through over the Taebaek mountains higher than today from the East Sea similar size to today. The cold front might also often influence South Korea. But it wasn't always cold during the last glacial stage. The humidity could be produced during the interstadial substage among the glacial substages as the cold front moved to the north relatively on the warmer period. And it was possibly more humid in the southern area, when the cold front was pushed to the north strongly, while the tropic maritime air mass was powerful. There is limit discussing the definite climate environment during the last glacial stage only by the front migration. But it was surely colder and drier much more than today on the northeast Asia at that time. The continental shelf of East China Sea was almost emerged except Okinawa strait between China and Nansei Islands. The sea level was fallen down and Yellow Sea and the Gulf of Pohai emerged completely in the air. And Korea Peninsula with Cheju Island was connected to the Eurasian Continent and the lowland with gentle slope was distributed widely between China and Korea. It might be still cold and dry in the northern continental shelf of Chinese Sea, Yellow Sea and the Gulf of Pohai during the last glacial stage on the summer at that time, supposing on the fossils of animals preferring to the cold climate, such as Mammoth, Bos primigenius, Rhinoceros tichorhinus. And permafrost was found 1.8m under the surface at city Qiqihar of Neijiang river basin. It suggests that the permafrost was also made in the Gulf of Pohai and Yellow Sea during the last glacial period. It was clarified based on sedimentology, that the dry region composed of several small scale deserts, called the semicircular desert zone, was distributed from Sea Caspi to the present continental shelf of East China. It is reported that the distribution of loess in China is related to the desert of inland area, based on the data about ancient environment of continental shelf and loess. The submarine boring data under the Yellow Sea confirms the existence of the ancient desert recently. The East Sea of Korea was a large lake during the last glacial stage because Tsushima current didn't flow at that time. The temperature of the sea water was supposed to be $8\text{-}12^0$ lower than $7\text{-}8^0$ of today. The surface water of the East Sea was probably fresh one flowing into a lake from inland. The evaporation of the East Sea might be very low, and snowfall was also much lower than today.

2. Vegetation and climate in China

The biome map for 18,000 BP in China(Yu, G.

et al., 2000) shows a notable eastward expansion of both steppe and desert vegetation, reaching the present-day coastline in the latitude band between 32°N and 40°N. The temperate deciduous forests characteristic of this latitude band today are not present in the 18,000 BP map. A single site on the Jianghan Plain(31.10°N, 112.20°E), with an assemblage including *Abies, Betula, Cretaegus, Pinus and Quercus*(deciduous) is classified as temperate deciduous forest. It is possible that the temperate deciduous forest occurred further south than today, but we have no sites from eastern China 25°N and 30°N to test this hypothesis. To the south, tropical forests were apparently banished, and broadleaved evergreen/warm mixed forests were forced to retreat southward in the lowlands as far as 24°N, a shift of c. 1,000km relative to today. Cool mixed forest is occurred on the northern margin of the broadleaved evergreen/warm mixed forests zone. Cool mixed forest is found today at high elevations in the eastern Tibetan mountains, and its eastward expansion into the lowlands to c. 109°E implies a shift of 1,000km. To the north of steppe/desert zone there was southward expansion of taiga. One taiga site(Dalainuoer) occurs as far as south 43.2°N in a region where temperate deciduous forest occurs today.

3. Vegetation and climate in Japan

The vegetation today in Japan shows the transition of subtropical temperate evergreen broadleaved forest zone, middle temperate forest zone, cool temperate broadleaves forest zone, and the subarctic needle leaves forest zone, from south to the north. The representative vegetation of subtropical- and temperate evergreen broadleaves forest zone on the southeastern lowland of Kanto, is *Quercus subgenus Cyclobalanopsis, Castanopsis, Pasania* and Fagaceae, Lauraceae, Theaceae, Symplocaceae, Aquifoliaceae. WI= 85-180 and the boundary of CI = -10 controls this zone.

The middle temperate forest zone is located between subtropical-, temperate evergreen broadleaves forest zone and the cool temperate broadleaves forest zone. This forest zone is near WI = 85 and CI = -10.

The vegetation of this zone, on the Pacific seaside except Tohoku area of Honshu, is almost temperate neeedle leaves such as *Abies firma, Tsuga sieboldi* with *Cryptomeria japonica, Chamaecyparis obtusa, Sciadopitys, Psedotsuga japonica* including *Quercus acuta, Q.salicina, Fagus japonica, Castanea crenata, Carpinus spp., Acer spp.*

The vegetation of the last glacial stage was restored by Nasu(2002). Northern needle forest as a type of Hokkaido and Siberia was extented to the northern area of Honshu. But Tundra didn't exist at Hokkaido.

Subarctic thin forest and *Pinus pumila* were distributed on the most part of Hokkaido, subarctic needle forest with *Larix gmelini* were on the northern area of Honshu and southern area of Hokkaido. Subarctic needle forest without *Larix gmelini* were located on the southern mountain area of these.

Subarctic needle leaves forest as a type of Honshu advanced southwards and forested densely. Among the advanced cool and temperate deciduous broadleaves forest, the area of temperate needle leaved trees including *Fagus crenata* was limited and narrow. They were distributed widely on the coast region of heavy snowy East sea and heavy rainy Pacific ocean at south of middle Honshu. The cool and temperate mixed forest including *Fagus crenata* were distributed widely on the coast region of East sea and Pacific ocean south of middle Honshu. And those without *Fagus crenata* was located on the mountain area. The vegetation distribution of Japanese Isles is very different from that of Chinese continent. Subarctic needle forest as a type of Hokkaido and Siberia was extended to the northern Honshu. Subtropic evergreen leaved forest was almost disappeared inland of Japan.

Out of this vegetation characteristics, it is supposed

that the yearly mean temperature at that time was 10^0 lower than today, it was cold remarkably. The powerful cold front over the continent was advanced southwards during summer and located along the line of Isle Penn.-central Sikoku Is.-central Kyushu. And it was drier than before on the whole Japanese Islands, so rainy region was limited on the southern area of the cold front. Winter seasonal wind was very strong and it became much drier on the coast of Pacific ocean. Especially it snowed sparsely and hit a wave on winter.

4. Vegetation and climate in Korea

There are very little data, only pollen data at Youngyang area of Gyeongbuk Province and at Younglang lake of Gangwon Province during the last glacial period in Korea. The percentage of tree pollen 20,000 BP of the last glacial stage was only 20-40% of sum and *Picea* and *Betula* were dominant (Hwang (Yoon), 1995; Yoon & Jo, 1996). *Betula spp.* as subarctic tree demands 1,500mm per year in precipitation and 15^0 in July mean temperature. And *Picea* demands 800-1200mm/y., and shouldn't be over 1500mm and $12\text{-}15^0$ in July. In particular *Picea* is contrasted to *Quercus* on the temperature and precipitation. 4^0/y is the boundary temperature between *Quercus*-dominance and *Picea*-dominance. It means that the mean temperature during the last glacial stage was 10^0 lower than today at Youngyang area in July. It was supposed that subarctic trees were growing sparsely among the dominance of plants.

Yasuda (1980) has indicated it from pollen data at the lowest horizon from the material of Younglang lake that subarctic trees such as *Abies, Pinus(Haploxylon), Picea, Larix* were dominant during 17,000-15,000 BP with a similar rate separately. It shows almost the vegetation characteristic during the coldest stage slightly over the glacial maximum in East coast of middle Korea.

Conclusion

A remarkable feature of the 18,000 BP biome reconstructions for China is the mid-latitude (30-40°N) extention of steppe and desert biomes to the modern eastern coast. Terrestrial deposits of glacial maximum age from the northern part of Yellow Sea between 33°N and 40°N suggest that this region of the continental shelf was occupied by desert and steppe vegetation. The presence of single site with temperate deciduous forest at 31°N suggest that temperate forests could have been displaced southwards. The shift from temperate forest to steppe and desert implies conditions very much drier than present in eastern China. This conclusion is fully consistent with other paleodata, including the huge thickness of last glacial loess deposits drying up of numerous lakes in eastern China. Dry conditions might be explained by a strong winter monsoon and/or a weak summer monsoon, both of which are plausible for the glacial maximum. In addition, relative sea level along the East China Sea coast was as low as -140m and the coastline was located at the far edge of the continental shelf at 125-127°E. The northern boundary of broad leaved evergreen/warm mixed forest at 18,000BP has previously been reconstructed at 23°N or 21-22°N, in broad agreement with the results. This boundary was displaced southwards by c. 1,000km. Together with the extension of cool mixed forests c. 1000km eastwards into the lowlands, this displacement indicates a very strong depression of winter temperatures in southern China at LGM and contrasts with the rather slight change since Mid-Holocene. The equatorward shifts of the northern forest biomes also imply large reductions in winter and/or growing season temperature over the whole of northeastern China. One site from the Tibetan Plateau showed tundra at 18,000BP in the

far western region where today there is steppe or desert. This finding could be taken to imply conditions that were wetter than present, consistent with high LGM water levels reconstructed from inland lake on Tibetan Plateau. However, there is no evidence for wetter conditions at lower elevations (extensive deserts were still present in western China). The reconstruction of year-round conditions much colder than today right across China is consistent with biome reconstruction from adjacent regions including Japan and western Beringia at the LGM, and testifies to the global scale of the climatic impacts of glacial boundary conditions on climate and vegetation.

The vegetation of Hokkaido was subarctic thin forest with a group of *Pinus pumila*, subarctic needle leaves forest distributed on the northern area of middle Honshu and cool and temperate mixed forest at southern area of middle Honshu. The vegetational landscape of mountain- and East coast areas of Korea was that nonarboreal plants were dominant with sparse arctic or subarctic trees. The climate of yellow sea surface and west region of Korea was dry and temperate steppe landscape was extended broadly. It is supposed that a temperate desert appeared on the west coast area of Pyeongan-Do and Cheolla-Do of Korea.

References

Barber, K. E., 1981, Peat Stratigraphy and Climate Change.- Rotterdam, A. A. Balkema.

Bartlein, P. J., I. C. Prentice & T. Webb III, 1986, Climate response surfaces from pollen data for some eastern North American taxa.- Jour. Biogeogr., 13: 35-57.

Bell, M. & M. J. C. Walker, 1992, Late Quaternary Environmental Change.- New York, Longman Scientific & Technical.

Birks, H. J. B. & H. H. Birks, 1980, Quaternary Paleoecology.- London, Edward Arnold.

Bloom, A. L. & Y. A. Park, 1985, Holocene sea-level history and tectonic movement, Republic of Korea.- The Quaternary Research, 24(2), 77-84.

Bludau, W., 1985, Zur Palaeologie des Ammergebirges, Rheinfelden, Schaeuble Verlag.

Chang, C. H. & C. M. Kim(1982): Late-Quaternary Vegetation in the lake Korea. -Korean Jour. Botany. vol. 25(1), 37-53.

Delcourt, H. R. & P. A. Delcourt, 1987, Long-Term Forest dynamics of the Temperate Zone.- Heidelberg, Springer Verlag.

Faegri & Iversen, 1989, Textbook of Pollen Analysis, 4th ed.- New York, John Wiley & Sons Ltd.

Firbas, F., 1949, Spaet- und Nacheiszeitliche Waldgeschichte Mitteleuropas noerdlich der Alpen. Bd. I-Jena, Gustav Fischer Verlag.

Frenzel, B., 1968, Grundzuege der pleistozaen Vegetationsgeschichte Nord-Eurasians, -Erdwiss. Forschg., 1, Wiesbaden, Franz-Steiner-Verlag.

Institute of Kansai Natural History, 1980, The Biogeography since Wuerm Glacial Period, 81 p.

Klink, H. J. and E. Mayer, 1983, Vegetationsgeographie.- Braunschweig, Westermann.

Kim, Y.-O., 2001, The Quaternary climatic change(The Quaternary environment in Korea, Ed. Park, Y. A. & Kong, W. S.), Seoul National University Press, 323 p.

Matusima, M., 1941, Betrachtung zur Waldentwicklung in Korea auf Grund von Pollenstatistik, -Jap. Jour. Forst., vol.23, 441-450.

Nakamura, J, 1975, Pollen Analysis-Global Series-, Tokyo, Koin-Shoin Press, 42p.

Nasu,T.,2002, The agricultural comparison between Korea and Japan, Joint Symposium of Korea and Japan, 245p.

Patrick, J., Bartlein, I., Prentice, C. & Webb III,T., 1986, Climatic response surfaces from pollen data for some eastern North American Taxa, -Jour. Biogeogr., 13, 35-57.

Qin, Yunshan and Zhao Sangling, 1991, Quaternary coastline changes in China, China Ocean Press, Beijing, 192p.

Straka, H., 1975, Pollen und Sporenkunde, -Stuttgart, Gustav Fisher Verlag.

Walter, H & Straka, H., 1970, Arealkunde. floristische-, historische Geobotanik, Einfuerung in die Phytologie III/2,2 Aufl., Stuttgart, Eugen Ulmer Verlag.

Woldstedt, P., 1962, Ueber die Gliederung des Quartaers und Pleistozaens.-Eiszeitalter u. Gegenwart, Bd. 23/24, 115-124.

Yasuda, Y.Tsukada, M.Kim, J. M.Lee, S. T., 1980, Environmental Changes and Agricultural Origin in Korea, Jap. Min. Educ. Overseas Res. Rep., pp. 1-19.

Yim, K. T., 1993, Meteorology and Air Pollution, KERI, Seoul, 384p.

Yu, G.. *et al*, 2000, Paleovegetation of China: a pollen data-based synthesis for the mid-Holocene and last glacial maximum, Journ.of Biogeogr., 27, 635-664.

Yoon, S. O.(1994): Untersuchungen zur jungquart?en Vegetationsentwicklung in den Flussgebieten des Gawaji-, Dodaecheon-, Youngyang-, Unsan- und Jumunjin-Gebietes Suedkoreas.- Dissertation. Freiburg Univ.

Yoon, S. O.Jo, W., 1996, The late Quaternary Environmental Change in Youngyang Basin, Southeastern Part of Korea Peninsula, Jour. of the Korean Geographical Society, 31(3), 447-468.

Yoon, S. O., 1996, The application of the pollen analysis in the Quaternary Research and its historical review in Korean Peninsula, Kyunghee Geographical Review, 24, 19-47.

Yoon, S. O., 1997, The Holocene Environmental Change and Reconstruction of the Paleogeography at Ilsan Area with the Special Reference to Pollen Analysis, Jour. of the Korean Geographical Society, 32(1), 15-30.