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Peat record of climate change for the last 3000 years in Yangmu, Mishan region of Sanjiang Plain

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Abstract: Five pollen zones are identified in Yangmu peatland of Mishan region located at 45o34′N, 132o23′E through spo ro-pollen analysis. The changing process of paleovegetation and paleoclimate was obtained. Warm-inclined broad-leaved forest predominated in the environment of warm climate with a little dry 3400 yr BP. Deciduous broad-leaved and coniferous mixed forests predominated, in which Pinus, Picea and Abies were main species, together with wet meadow in the environment of cool and humid climate during 3400-1940 yr BP. Deciduous broad-leaved and coniferous mixed forests predominated in the dry and warm climate environment 1940-1090 yr BP. Broad-leaved forest was predominant, and the climate was warm and humid 1090-545 yr BP. Marsh meadow predominated when the climate changed to cool and dry 545 yr BP. The composition of the upper part of the 143-125 cm of the peat profile presented the cold period in the early Christian era through mutual identification between the records of historical material such as spores and pollens, susceptibility, organic matter and archaeological studies. The composition of the parts of 125-85 cm and 85-38 cm presented the warm climate in the Northern and Southern Dynasty and Sui and Tang dynasties. Since 3400 yr BP because of the frequent human activities in Mishan region, the amount of cultural relics in the Sui and Tang dynasties increased, which indicated that the ancients took much more woods from the forests in the warm climate environment.

Peat record of climate change for the last 3000 years in Yangmu, Mishan region of Sanjiang Plain XIA Yu-mei, WANG Pei-fang (Changchun Institute of Geography, CAS, Changchun 130021, China) The study of global climate change for the last 2000 years is very important for predicting climate evolution in the future. In order to explore the evidence of climate change for that period, the Chinese scientists made convincing statements using high-resolution substitution data such as tree-ring, coral and ice core. Continuous accumulated peat sediment is the better substitution data to provide climate information. Selecting the peatlands with a certain area and less human interference, through comprehensive analysis of sporo-pollens, 14C dating and physio-chemical indexes, the regional climate and vegetation change process for the last 3000 years can be reconstructed, so as to find the mutual identification degree of human activities (archaeological and historical record) and natural environment change. The Sanjiang Plain is one of the relative larger peat bog regions in China. In recent years a lot of spore pollen analyses and 14C dating have been done for the Holocene peat strata to the north of the Sanjiang Plain[1-6] , but little work has been done for the Muling-Xingkai Plain to the south of the Wanda Mountain. This paper selected Yangmu peat profile of Mishan to the north of Xingkai Lake to extract the environmental change information for the last 3000 years. Yangmu peatland of Mishan is located at 45o34′N, 132o23′E to the south of the Wanda Mountain, 20 km away from Dangbi Town of Greater Xingkai Lake. The peatland covers 50 ha with an altitude of 100 m above sea level and peat reserves of 118?104m3, belonging to valley peat bog. 1 Sampling and detecting method 1.1 Sampling The peat profile studied is an artificial dug outcrop. The total thickness of the profile is 150 cm, the lithologic change is that 0-20 cm is cultivated layer, 20-145 cm is peat layer, mostly composed of plant residues of Carex, Equisetum and Phragmites, and organic humus soil, 106-110 cm is peat soil with charcoal, and 145-150 cm is gray clayey soil with sand. Samples are collected at a 5-cm interval for 10-45 cm, at a 2-cm interval for 45-130 cm, and at a 3-cm interval for 130-150cm. Figure 1 Age versus depth of Yangmu sediment 14C dating, sporo-pollen, susceptibility and organic matter analyses are made for this profile. 1.2 Sedimentary age determination and sedimentary rate From this profile four 14C dating data were obtained from the lower part to the upper part: 145-139 cm is 3400±342 yr BP; 130-126 cm is 1900±205 yr BP; 104-100 cm is 1048±247 yr BP; 80-76 cm is 860

± 180 yr BP. Tree-ring corrected age is T1/2 = 5568 a. The age versus depth from determined data are shown in Figur e 1. 14C dating ages and calculated rate of sedimentation are shown in Table 1. Table 1 Sedimentation rate of peat 1.3 Sporo-pollen analysis Fifty-six samples from the profile were analyzed. The samples include more than 300 grains except 3 samples which include 250 grains. Using conversion percentage and Lycopodium spores, the percentage and conc entration are shown in Figures 2 and 3. The concentration is calculated based on grains per gram. After analyzing 35 samples, low-frequency susceptibility data were obtained. Besides, 17 samples were analyzed for organic matter (TO C). 2 Results of sporo-pollen analysis Through drawing sporo-pollen percentage diagram (Figure 2) and sporo-pollen co ncentration diagram (Figure 3), we can find that the sporo-pollen type of this profile belongs to temperate plant typ e. From Figure 2 it can be seen that the total woody pollen content curve from the lower to the upper accounts for 4 0-60%, the curve of herb pollen is 18-55%, and fern spore curve is 5-40%. As to the total sporo-pollen concentration of the profile, at the upper part of 10-25 cm the concentration is the lowest, 305-5866 grains/g, the total concentra tion of 72-85 cm is the highest, 20,397-45,104 grains/g. According to the obvious changes of the percentage diagram a nd the concentration diagram, 5 sporo-pollen zones can be divided from the lower to the upper part, numbering Ms-5, M s-4, Ms-3, Ms-2, Ms-1. Figure 2 Pollen percentage diagram of Yangmu peat profile in Mishan Figure 3 Pollen concentrat ion diagram of Tangmu peat profile in Mishan Ms-5 zone (150-143 cm, 3400 yr BP; 145-139 cm, 3400 ± 342 yr BP): This zo ne is predominated by Quercus, Corylus, Tilia, Acer and Juglans. From the percentage diagram it can be seen that wood y plant prevails, fern comes the next and herb is the lowest. This change can be seen obviously from the concentratio n diagram. The lowest Betula concentration is 1040 grains/g, the highest is 1496 grains/g, spores of the broad-leave d trees are 1203-1944 grains/g. Among herb pollens, Artemisia concentration is 324-897 grains/g, the concentrations o f Sanguisorba, Clematis and Thalictrum are lower than Artemisia, 122-224 grams/g, Cyperaceae and Gramineae contents a re the lowest of the curve. Ms-4 zone (143-125 cm, 3400-1940 yr BP; 130-126 cm, 1900 ± 205 yr BP): This zone is charac terized by increase of Picea and Abies and decrease of broad-leaved trees. In the concentration diagram, the highest content of Pinus is 6579 grains/g, Picea content is 1468 grains/g, and Abies content is 1346 grains/g. The number of pollens in broad-leaved trees is 1234 grains/g, Gramineae pollen content increases obviously, the highest is 703 grai ns/g, Sanguisorba and Clematis pollen contents increase gradually. Ms-3 zone (125-85 cm, 1940-1090 yr BP; 104-100 c m, 1048 ± 247 yr BP): In this zone pollens of broad-leaved trees increase obviously, but Picea and Abies concentratio n curves present a declining trend. At 115-110 cm, the highest concentration of broad-leaved tree pollens dominated b y Quercur reaches 5105 grains/g, becoming the highest peak. In peat layer of 106-110 cm there is a lot of charcoal, t he highest content of charcoal osculates with the high peak of broad-leaved trees. The concentration of Pinus, Picea and Abies present a declining trend compared with Ms-4 zone. The highest concentration of Pinus is 3156 grains/g, tho se of Picea and Abies are 1234 grains/g and 936 grains/g respectively. Among herb pollens, Syperaceae and Gramineae c ontents increase continuously. Ms-2 zone (85-35 cm, 1090-545 yr BP; 80-76 cm, 860-180 yr BP): This zone is composed o f Pinus, Picea and Abies, pollens of Betula and broad-leaved trees present serrate increase. The total pollen concent ration curve shows that the concentration at 82 cm is 41065 grains/g, that at 72 cm is 45104 grains/g, the concentrat ion of Betula pollen curve at 56-54 cm is 1009-1418 grains/g. The pollen concentration curve of aquatic plants presen ts two peaks in this zone, one is 1615 grains/g at 72 cm, and the other is 1234 grains/g at 76 cm. The amount of aqua tic algae of Mougeotia and Spirogya spores is much more in this zone. Fern spore Osmunda increases intermittently. M s-1 zone (35-10 cm, since 545 yr BP): The general character of this zone is that the total concentration decreases ob viously, and presents Helianthus sp. and Osmunda peaks. The highest Helianthus sp. pollen is 194 grains/g, that of Os munda is 257 grains/g. Among conifer pollen, Pinus, Picea and Abies pollen contents drop to the lowest, Picea conten t is 169 grains/g, Abies pollen is 173 grains/g, the lowest Betula pollen is 15 grains/g, broad-leaved trees pollen i s 42 grains/g. 3 Analytical results of other environment substitution indexes Susceptibility character: susceptibilit y determination mainly reflects the magnetic mineral concentration and magnetic behavior character of sediments. Fro m this profile low-frequency susceptibility data are obtained (Figure 4). At 142-148 cm the low-frequency susceptibil ity is about 10?10-8 m3/kg. Towards 142-55 cm the mean susceptibility is lower than 10?10-8 m3/kg, and only at 50 c m, the high peak appears, being 18?10-8 m3/kg. Peat sediment susceptibility shows a curve change generally. Because p eat soil is composed of fine particle substance, the profile lithologic change is little, compared with lake facies s ediment, the susceptibility is much lower[7]. Organic matter character (TOC): The content of organic matter of the wh ole profile varies from 12.7% to 38.4%, and the mean is 25.4 %. Because the profile´s peat belongs to herb peat, lith ologic change is little, at 124 cm, the organic matter content is up to 31.5%, which is within Ms-3 zone. The surfac e content is the highest, within Ms-1 zone. Figure 4 Curves of susceptibility and organic matter in Yangmu sediment o f Mishan region 4 Evidences of paleoclimate and paleovegetation change and impact of human activities 4.1 Paleoclimat

e and paleovegetation evolution process Since 3000 yr BP, according to the traditional division of Holocene, it entered the Late Holocene from the end of the Middle Holocene. According to sporo-pollen analytical results and other environment substitution indexes, the above-mentioned 5 sporo-pollen zones are discussed based on the corresponding Chinese historical ages. Before 3400 yr BP (corresponding to 1450BC, Shang Dynasty): Ms-5 zone sporo-pollen analysis clearly shows that woody pollens dominated. Because Betula and other broad-leaved trees were predominant, there were large-scale conifer and broad-leaved forests around there then. Among herb pollens, the content of aquatic plants, Cyperaceae and Gramineae pollen contents are the lowest, and that of Artemisia is higher. And low-frequency susceptibility is high, showing a warm and dry-inclined climate. 3400-1940 yr BP (corresponding to 1450BC-10AD, the end of the Shang Dynasty to Western Han Dynasty): In Ms-4 zone Pinus, Picea and Abies increased but broad-leaved trees obviously decreased, Gramineae, Clematis increased, showing that the climate changed from warm and dry-inclined to cool and humid-inclined, conifer and broad-leaved forests decreased, wet meadow vegetation enlarged. 1940-1090 yr BP (corresponding to 10-860AD, the end of Western Han Dynasty, Northern and Southern Dynasties to Sui and Tang dynasties): Sporo-pollen characters of Ms-3 zone reflect that broad-leaved trees dominated by Betula increased rapidly, and the pollen contents of Pinus, Picea and Abies decreased, showing that with temperature rising, conifer advanced towards mountains, and broad-leaved trees increased greatly, presenting warm and dry-inclined climate. Peat accumulation rate reached to 1.2 mm/a. 1090-545 yr BP (corresponding to post Sui and Tang dynasties, Song to Yuan dynasties): Based on the sporo-pollen analysis of Ms-2 zone, it can be seen that the general change of pollens of Pinus, Picea and Abies as well as those of broad-leaved trees showed an increasing trend, but the curve change is serration-like fluctuation, Betula pollen curve change and Pinus pollen curve change are in complementary form, when Pinus increased, Betula decreased, and vice versa. The total contents of broad-leaved trees are higher than that of Ms-3 zone. While aquatic plants and algae spores increased, Cyperaceae and Gramineae pollen increased obviously, showing a continuous warm and humid declining trend of climate then. Not only conifer and broad-leaved forests grew luxuriantly, but also the area of mires and waters enlarged. Peat accumulation rate is 0.93mm/a. After 545 yr BP (after Qing Dynasty): From Ms-1 zone it can be seen evidently that contents of Pinus, Picea and Abies decreased sharply, Betula and broad-leaved trees dropped to the lowest, and those of Cyperaceae, Gramineae and Sanguisorba, Clematis and Thalictrum also dropped to the lowest. The above characters reflect that the vegetation cover degree declined, mire growth entered shrinkage period, especially woody plants above 25 cm of the profile suddenly shrank mainly due to human activities. Besides, the high TOC content from 30 cm in depth to the surface is also caused by human interference. Generally, climate turning cold and dry, together with human activities and excessive exploitation, led to gradual deterioration of local forest vegetation, and paludified wet meadow became the main vegetation landscape of the region. 4.2 Impact of human activities The evidences of climate and environmental changes from archaeological and historical records have not only filled the gaps in the research without determination method, but also confirmed mutually with determination analytical results. Archaeologists found the relics of production tools taking stonewares as the main about 4,000-6,000 years ago at Xinkailiu on Xingkai Lake of Mishan County of Heilongjiang Province, which is called Xinkailiu Culture of the Neolithic Age [8]. The Xiaonanshan relics in the south of Raohe County on the left bank of the Wusuli River are later than the Xinkailiu culture relics of the Neolithic Age. The existence of these relics marks that the ancients had lived in the Muling-Xingkai Plain before the Shang Dynasty. From the oxygen and carbon isotope determination of Jilin´s Jinchuan peat fiber[9], it can be seen that before Shang Dynasty of 1400 BC,δ13C value of peat carbon isotope record is the largest, at that time the climate of this region was slightly dry, which fits the warm and dry-inclined climate presenting in Ms-5 of Mishan profile. The relics of the Iron Age (Eastern and Western Dynasties) were found in Shuangyashan of Heilongjiang Province, which was called Guntuling culture, the 14C dating of carbonized seed--Cannabis is 2140 ± 70 yr BP after tree-ring correction, it is 175 ± 85 BC, this period is just the cool and humid stage of Ms-4, the ancients had begun to plant crops such as Cannabis. Tongren relics (Sui and Tang dynasties) was found in Suibin County, through 14C dating determination and tree-ring correction, charcoal age is 595 ± 85 yr. Besides, the cultural relics of the same period were found in Tuanjie of Luobei, China and, Russia. The cultural relics appearing on a large scale may show that warm climate in the Sui and Tang dynasties provided a good living environment for the ancients. The deduced age at the depth of 106-110 cm of the profile is 490-650 AD (Northern and Southern Dynasties). In this period a lot of charcoal appeared, which is identical to the peak for broad-leaved trees. Natural and artificial fire caused trees burning. Betula pollen curve of Ms-2 zone presents serration-like peak. And when Pinus pollen decreased and Betula increased, while Pinus pollen increased and Betula decreased. These changes are mainly caused by climatic factors, at the same time, the ancients had to cut and destroy Pinus for a living, instead, a lot of Betula forest appeared so as to cause a sudden increase of Betula pollen of Ms-2 zone. 5 Conclusions 1) Through the sporo-pollen analysis of

the peat profile, 5 sporo-pollen zones are divided, the change process of paleovegetation and paleoclimate of Yangmu of Mishan region for the last 3000 years is: before 3400 yr BP, broad-leaved forest predominated, the climate was warm and dry-inclined; 3400-1940 yr BP conifer and broad-leaved mixed forest was dominated by Pinus, Picea and Abies together with wet meadow, the climate was warm and dry; 1090-545 yr BP, conifer and broad-leaved mixed forest was dominated by broad-leaved trees, the climate was warm and humid; 545 yr BP to recent years paludified meadow was predominant. 2) Through comprehensive analysis, it can be confirmed that the cold period in the early of Christian era is located at the upper part of 143-125 cm, the warm climate in Northern and Southern dynasties to Sui and Tang dynasties is at 125-85 cm and 85-38 cm respectively. 3) Based on sporo-pollen analysis as well as archaeological and historical records, since 3400 yr BP, frequent human activities around Mishan region, especially the increase of cultural relics of the Sui and Tang dynasties indicate that in a warm climate environment, the ancients cut forest increasingly. References

关键词： peat record; sporo-pollen analysis; climate analysis; Mishan region

