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An Approach to Peat Formation Period on Both Coast of Fildes Strait, Antarctica

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SUMMARY: This paper carries out how to use radiocarbon (^{14}C) to study the peat age. The research area of the item is China Great Wall Station in Antarctica and nearby area(both coast of Fildes Strait). We study more than ten ^{14}C samples of Antarctica and contrast with the peat samples of other areas. The authors find out the difference of peat formation period between the pole and other areas.

1. PEAT FORMATION PERIOD ON BOTH COAST OF FILDES STRAIT

This study approaches the peat age on both coast of Fildes Strait, that is Fildes Peninsula at King George Island of South Shetland Islnads, the northern peninsula in Nelson Island and Ardley Island.

Ten wetland peat samples were analyzed. The determined results show that the age of peat at China Great Wall Station located in Fildes Peninsula was 2750symbol 177 \f "Symbol" \s 11±}110 a B.P., the profile was at subsurface 40-42 cm, consists of grey-mud and peat together with big stones. Below the subsurface 37 cm there were nearly peat sandwiched with mud and stone, reflecting that the peat depositing environment at that time was unstable. The sample taken from 26-27 cm in the very profile was peat of freezing layer, the ^{14}C age was 2360symbol 177 \f "Symbol" \s 11±}100 a B.P. It is inferred from peat homogeneity, that the depositing environment at that time was quite stable, The profile's surface plants are *Calliergidium austro-stramineum, Polytrichastrum alpinum*(Hedw.) G. Sm. and *Dreanocladus A.*

The first sample of Ardley Island was taken from 20-32 cm deep, the peat ^{14}C age was 1860symbol 177 \f "Symbol" \s 11±}100 a B.P.. It was a peat layer with small amount of debris, above the peat layer, 14-20 cm was freezing peat, 10-14 cm was yellow-brown peat, 0-10 cm was moss layer, consisting of *Calliergidium austro-stramineum* and *Drepanocladus*. The sampling site was at the highest plane near the east coast, the ground slope was 0-5symbol 176 \f "Symbol" \s 11°} , the profile of 0-7 cm sampled on February 17 had been freezing phase. The sampling site of the second sample in Ardley Island was a gentle slope. The sample taken on February 11 from subsurface 20-35 cm, was freezing peat, the peat ^{14}C was 1630symbol 177 \f "Symbol" \s 11±}130 a B.P., below 35 cm was mineral, 9-20 cm brown humid unfreezing peat, 0-9 cm living moss layer, consisting of *Chorisodontium aciphyllum*(Hook. f. et Wils.) Borth. etc. The wetland in whole Ardley Island is developed well. The proportion of wetland area in Ardley Island is larger than that in Fildes Peninsula and that in the northern peninsula to the north of Nelson ice cap.

The ^{14}C age of Xiangxi peat in Fildes Peninsula is 950symbol 177 \f "Symbol" \s 11±}100 a B.P.. The sampling site was on the upper part of south slope, the slope is 38-40symbol 176 \f "Symbol" \s 11°}, the peat was 13 cm thick, the buried depth was 5-18 cm. The vegetation is *Polytrichastrum alpinum*(Hedw.) G. Sm., *Bartramia patens* Brid, and small amount of *Drepanocladus*, as well as several kinds of lichen.

The sampling site of No.22 sample is comparatively particular, located in the cape of the southmost of Sancha coast along Fildes west coast, about 3000 m from the ice cap, 40 m above sea level, stagnant water 0 cm, the plant is dominated by *Drepanocladus*, 5 cm high, the cover degree is 60 %, the peat is 5 cm thick, under thepeat layer is yellow-brown sand filling between big stones. Although the peat is only 5 cm thick, the peat ^{14}C age is 260symbol 177 \f "Symbol" \s 11±}100 a B.P.

Among the determination of the peat samples, the deposition ages of 4 peat sites are comparatively new. They are 1) Nelson periglacial brook valley wetland 400 m from Nelson ice cap, 2) wetland on north slope of Nelson Island 1400 m away from Nelson ice cap, 3) seashore wetland of Biology cove 20 m from seashore, 4) Collins periglacial meltwater lakeshore wetland 450-500 m from Collins ice cap.

Although Nelson periglacial valley wetland is 400 m away from Nelson ice cap, there is peat layer in wetland, the buried depth is 5-8 cm, 8-12 cm is weathering matter and debris layer, the peat ^{14}C age is 1.040symbol 177 \f "Symbol" \s 11±}0.11 a B.P., the peat-forming plant is *Calliergon stramineum*(Brid.)Kindb. As to the wetland on north slope of Nelson Island, the slope is 10-20symbol 176 \f "Symbol" \s 11°}, the determined peat depth is 8-10 cm, the ^{14}C age is 1.294symbol 177 \f "Symbol" \s 11±}0.012 a B.P., 10-18 cm is sand and stone, below 18 cm is weathering stone, the maximum section area of the stone is 10cmsymbol 180 \f "Symbol" \s 11×}17 cm and 5 cmsymbol 180 \f "Symbol" \s 11×}6 cm, the peat-forming plant of the wetland is *Drepanocladus* and *Brachythecium subplosum*(Hook. f.et Wils) Jaeg. In seashore wetland of Bilogy cove, the peat develops on black fine sand, the buried depth is 10-12 cm, the ^{14}C age is 1.126symbol 177 \f "Symbol" \s 11±}0.011 a B.P., the peat-forming plant is *Drepanocladus uncinatus*(Hedw.)Warnst. In Collins ice-meltwater lakeshore wetland, the buried depth of the peat is 5-12 cm, below 12 cm is stone, the peat ^{14}C age is 1.049symbol 177 \f "Symbol" \s 11±}0.011 a B.P.. the peat-forming plant is *Calliergon sarmentosum*(Wahlenb.) Kindb. and *Drepanocladus*.

2. ICE AREA DISTRIBUTION OF EARTH SURFACE AND TREND OF PEAT ACCUMULATION AFTER I

2.1 Ice area distribution in polar and sub-polar regions

The wetland distribution in polar and sub-polar regions is closely related to ice melting environment. The present ice cap area in all continents in the Northern Hemisphere corresponds to 7.175% of the maximum ice cap area in glacial epoch, that in the Southern Hemisphere corresponds to 89.182%(1). The first flash deterioration of climate in Antarctica occurred in the end of Eocene epoch (38Ma B.P.)when shallow-water environment appeared between Australia and Antarctica. Antarctic climate began vicious circle, the present climate pattern was formed in the end of the Oligocene Epoch when Deleic Strait formed between South America and Antarctica(23.5 Ma B.P.)(2) and deep-water current of rim-Antarctica formed. From the model of growth and decline of Antarctic ice cap (Payne A J, Sugden D.E et al., 1989), it can be found that the present stable ice cap formed in 6500 a B.P.(3)

2.2 Peat accumulation in the polar and sub-polar regions after ice melting

Global climatic fluctuation is the decisive factor to form concentrative peat-forming period. With the climatic cold-warm fluctuation caused by ice age and interglacial period there appeared a trend that climatic zone on the earth moved towards low latitude and low elevation or towards high latitude and high elevation. At the same time, tectonic change of the earth itself, and continentality had certain interference and change to this trend. Global peat-forming period is basically consistent with sub-interglacial epoch and post-glacial period, corresponding to 1-2(symbol 180 \f "Symbol" \s 11×}10^4) years, while peat-forming sub-period controlled by zonality and regionality only had a year scale of 2-4(symbol 180 \f "Symbol" \s 11×}10^3) years. the analysis of stratum data show that the peat concentrative zone in the Northern Hemisphere is located at the edge of continental ice cap alternation of glacial and interglacial epoch directly controlled peat mire development. This paper only contrast the peat formation ages and rates after ice melting in last glacial period.

From the Late Pleistocene to paleo-holocene(4), with glacier retreaing, peat mire began to develop. From about 11000-12000 a B.P., Minnesota in north America, European part and north of west Siberia of Russia etc. began to lie in ice lake after cap melting, and began organic matter accumulation. In the first turn of the Yellow River on the east edge of the Qinghai-Xizang Planteau, China, there was peat of 12330symbol 177 \f "Symbol" \s 11±}215 a B.P.. At the same time, Harberton bog (lat. 54symbol 176 \f "Symbol" \s 11°} 52symbol 162 \f "Symbol" \s 11′} S, ,long 67symbol 176 \f "Symbol" \s 11°} 53symbol 162 \f "Symbol" \s 11′} W) at the south end of south America began to accumulate organic snady silt from 13000 a B.P.(buried depth was 9.5m). According to the study of Rabassa et al.(5) in the south end of south America in 14670 and 13000 a B.P. warmer climate made *Nothofagus* forest quickly develop. This kind of forest expasion was from the maximum edge in last glacial epoch to ice retreating zone, in 11500 a B.P. and 11200 a B.P. the climate got colder, the forest retreated, tundra expanded (nearly in 11000-10500 a B.P.).

From the Early Holocene to the Middle Holocene was the flourishing period of peat mire development. In the Early to Middle Holocene(10000-3000 a B.P.) temperature was higher, especially in Atlantic period(7500-5000 aB.P.) with high temperature and humid climate, peat mire widely developed, for example, paludification occurred commonly near 70symbol 176 \f "Symbol" \s 11°} N. In England low-land peat accumulation began from 7000 a B.P., high-land peat began to accumulate from 5000 a B.P. After glacier retreat of northwest Europe in Province of North Karelia (61symbol 176 \f "Symbol" \s 11°} 45symbol 162 \f "Symbol" \s 11′} -63symbol 176 \f "Symbol" \s 11°} 55symbol 162 \f "Symbol" \s 11′} N, 28symbol 176 \f "Symbol" \s 11°} 15symbol 162 \f "Symbol" \s 11′}-31symbol 176 \f "Symbol" \s 11°} 35symbol 162 \f "Symbol" \s 11′} E) large-scale paludification occurred on vast low-land. In pre-boreal period(about 10000-8000 a B.P.) peat accumulated quickly and eutrophic fen prevailed. In sub-boreal period (5000-2500 a B.P.), paludification increased again and developed towards high bog. Patvinsuo peat in east Finland began to form in *Betula-Pinus* period(9000-8000 a B.P.), the mire vegetation grew on the earth after ice cap melting. In 5500 a B.P. spruce invaded Piipsanneva(64symbol 176 \f "Symbol" \s 11°} 20symbol 162 \f "Symbol" \s 11'} N) peatland in west Finland formed about 7000 a B.P. the deepest peat was 4.9 m, main types were *Carex* peat and *Sphagnum* peat, ash content was only 2%-6%. The northern part of European section and west Siberia area in Russia, moss peat, herb-moss peat and wood-herb peat developed in pre-boreal period and boreal period(9800-7700a B.P.). In Atlantic period and subboreal period(7700-2500 a B.P.) in the Middle Holocene, weak decomposed *Sphagnum fuseum* peat developed, the accumulation thickness was 1.8 m (0.2 limiting layer and 1.6 m weak decomposed layer) in northwestern part of European section in Russia, the accumulation rate was 0.346 mm/a, in west Seberia, there was 2-4.5-m weak decomposed *Sphagnum fuseum* peat, the accumulation rate was 0.625 mm/a.

Over the past 5000 years, North America peatlands have rapidly developed under the influence of a variety of climatic, biotic and geologic factors. They are commonly found in a wide range of environments including the polar tundra regions of the upper latitudes; boreal forest and humid temperate prairie regions of the mid-and upper mid-latitudes; coastal areas of the Atlantic and North Pacific Oceans; sub-tropical savanna areas of the Southeast United States; and Alpine settings throughout mountainous Canada and the United States. Rates of peat accumulation vary according to environmental conditions during peat formation. It is estimated that the average rate of peat accumualtion is 0.6-0.7 mm/a for Canadian peatlands and 0.3-0.4 mm/a for the United States's peatlands(6).

During the period of the Early Holocene, South America climate got drier and warmer than the present, peat developed in alternative zone of forest and steppe , detritus peat, except volcanic and sandwich, nearly successively accumulated, the accumulation rate was 0.865 mm/a.

Over sub-Atlantic period (2500-) of the Late Holocene, in Province of North Karelia, fen developed towards high bog. Patvinsuo wetland *Sphagnum* mostly began to grow about 2500 a B.P.. At the same time, in western part of European section and west Seberia in Russia, *Sphagnum fuseum* developed well, the accumulation thickness was 1.25-1.5 m and 3-3.5m, the accumulation rate was 0.55 mm/a and 1.3mm/a, respectively.(4)

Towards the Late Holocene, the climate moved to cooler and wetter conditions, permiting the development of closed forest environments and the accumulation of *Sphagnum* peat in shallow depressions and small pond and lakes. A comparison between palynological sections of forest bogs and steppe bogs indicates that the more arid environments, located farther from the maritime influence , resulted in a slower more recent climatic response to environmental variations, with a time delay of the order of 2000 to 3000 years(4,5).

The mean annual peat accumulation rate has been estimated by Rabassa et al.(5) at 0.5 mm/a, based on the correlation between depth and the radiametric dating of specific layers. Some values show a significant increase in the relationship of accumulation rate with time during the Late Glacial and the Late Holocene. Towards 10000 a B.P., the accumulation rate reached up to 2.0 mm/a, whereas around 3000 a B.P. it varied between 2.0 and 3.0 mm/a.

3. CHARACTERISTICS OF PEAT FORMATION PERIOD ON BOTH COAST OF FILDES STRAIT

Peat is the accumulation of plant residues, the age is its experienced time after it basically stop the exchange with atmosphere, hydrosphere, lithosphere and bioshpere. Because peat mainly consists of organic matter and it is in a relatively closed system nearly without exchange with outside environment, both credibility and comparbility of the peat ^{14} C age are comparatively high. Comparing peat formation period on both coast of Fildes Strait with other areas, the characteristics of the Antarctic peat formation period are summarized as follows:

Antarctic peat began to form in the middle and late periods of the Late Holocene, especially late period, the lag section of peak period of peat formation of warm temperate zone, that is the stage that peat accumulation in the frigid zone was still in peak period. Since the Late Holocene with climate getting cold and wet, in peat accumulation regions in middle latitude after peat accumulation peak period in sub-boreal period(Q_4^2)(5000-2500 a B.P.), peat accumulation peak period began to reduce in sub-Atlantic period (Q_4^3)(2500 aB.P.: According to 121 peat ^{14}C dating of 10 provinces in cold-temperate zone in China, 42.15% of peatland began to accumulate in sub-boreal period, 22.31% in sub-Atlantic period(7). But sub-Atlantic period of the Late Holocene, was an important peat-forming period for sub-frigid and cold-temperate zones, which is proved from the peat accumulation rate of Arctica and Anrarctica mentioned above. ^{14}C ages of 2750 a B.P., 2360 a B.P., 1860 a B.P. and 1630 a B.P. basically occurred between glacial advanced events in 3500 a B.P., 3000 a B.P., 2500 a B.P., 2000 a B.P. in the Northern hemisphere. Comparison of lasting section of little ice age of East Asia, European section of Russia, North America, Arctica and the Southern Hemisphere, which is from Wang Shaowu (1995) can also confirm the basic consistence of the earth ice age. And comparing with research results of Man Zhimin, Zhang Xiugui(11) it can be confirmed that there was a law that peat formation age since 1000 a B.P. in Antarctic region (950 a B.P., 260 a B.P. and some modern carbon) appeared in the period that lasting stage of the Little ice age just ended.

Frontal surface Precipitation formed by meeting of oceanic air-mass of Antarctic nearshore zone and polar air-mass and topographic precipitation formed by moist air-mass carrying from coastline to inland 100 m (1000 a s.l.) due to topography enforcing lift, can make water within air-mass lose 2/3, even to 97%(12). Wetlands can only develop in the regions with allowable heat and water. Therefore, Antarctic peat only limited in nearshore icefree zones with good water supply, temperature enough to plants growth and accumulating residues.

In general, peat accumulation period in Antarctic region is from late period of the Holocene (3000 a B.P.). Peat(modern carbon) accumulation rate of 1.973-3.659 mm/a has certain error influenced by living moss layer, so only for reference. Peat accumulation rate of non-modern carbon is 0.114-0.323 mm/a, the accumulation rayeis lower, the lowest one is smaller than that of 67symbol 176 \f "Symbol" \s 11°} 33symbol 162 \f "Symbol" \s 11′} N. According to Ren Zhenqiu's (1993) prediction of climate on peat development, from present to the end of this century, air temperature will continue to rise, by the year 2020, the winter solstice revolution radius will prolong(960000 km), there will be a trend of climate getting cold in the early 22 century, the climate will get warmer, in the middle 22 century, air temperature will sharply drop. If these temlperature changes do not have an impact on the Antarctic wetland development essentially peat will continuously accumulate.

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