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# $^{210}$Pb distribution characteristics in the lake sediment core at Great Wall Station, Antarctica*

Zhao Ye (赵 烨)

*Institute of Resources and Environmental Sciences, Beijing Normal University, Beijing 100875, China*

Xu Cuihua (徐翠华)

*Laboratory of Industrial Hygiene, Ministry of Public Health, Beijing 100088, China*

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**Abstract** The results of $^{210}$Pb measurements in the lake sediment core from Antarctica are reported: the relative specific activities of $^{210}$Pb in the lake sediment were found to decrease exponentially with the depth in the study area; the sedimentation rate of the lake is about 0.072 cm/a. This paper shows that $^{210}$Pb method is applicable to Antarctic lake sediment, and during the 1960's the atmospheric nuclear tests have an effect on the rate of $^{210}$Pb deposition in Antarctica.

**Key words** Antarctica, Great Wall Station, lake sediment core, $^{210}$Pb method.

## 1 Introduction

The lake sediment core is one of the most effective indicators of the environmental change (Zhang 1992). In the coastal ice-free areas around Antarctica, the immense number of small lakes have been formed, for example, there are about 54 lakes in the Fildes Peninsula (only 36 km$^2$) of King George Island (Xie 1993). In the recent years an increasing number of scientists have reported the characteristics of Antarctic lakes, and the environment change-sequences during Holocene have been set up using $^{14}$C method (Xie 1993; Gillieson and Burgess 1990). Southern Ocean waters are known to be depleted in $^{14}$C (Stuiver and Ostlund 1980; Yue 1989; Herron and Anderson 1990). But $^{14}$C depletion is not existing in the mosses which grow in Antarctic oasis. In most lakes of Antarctic coastal areas, there is the mixture of the organic carbon of terrestrial origin with the organic carbon of marine origin (Bonner and Walton 1985), which makes $^{14}$C method difficult in dating the Antarctic lake sediment. $^{210}$Pb method is used by the $^{210}$Pb distribution in lake sediment core to determine the sedimentation rate and the age. It was shown that $^{210}$Pb method is ideal for dating lake sediments as far back as a century or so (Robbins and Edgington 1975).

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In this paper we report the measurement of $^{210}Pb$ in the sediment core and its utility for the determination of sedimentation rate in Antarctic lakes.

## 2 Lake survey

The study lake(62°12′45″S,58°56′20″W) is located in the northwest part of the Ardley Island nearby the Great Wall Station of China. The climate belongs to the subantarctic oceanic type, and the annual average temperature is about −2.1℃, the annual average precipitation is about 630 mm, the annual average relative humidity is about 90% (Zhao *et al.* 1993). In these areas, there are 6 stages of sea terraces which are mostly covered with gravel and sands, as shown in Fig. 1.

The sampling lake is a coastal seasonal lake, the east bank is rocky platform, while the west bank, southern bank and northern bank are marine deposit terraces which are gravel and sandy. The bryophyta and lichens occur extensively in the lake basin areas, the cover degree may reach 85%～90% on the rocky platform, the cover degree of the bryophyta and fruticose lichens on the marine deposit terraces may reach 50%～70%. From November to middle January, the meltwater of the snow-mantle in the lake basin runs into the lake, and there are little runoff into the lake, the water depth of the lake is maximum (about 2 m) in December, and then the water of the lake goes down as the summer-thawing layer deepens, in February and March the lake is dried up.

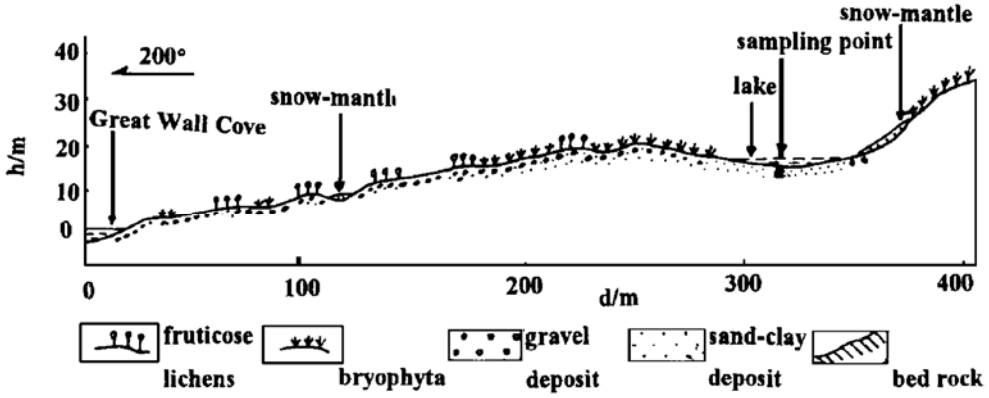


Fig. 1. Map showing the geographical section in the northern part of the Ardley Island.

## 3 Sample collection and analytical methods

During the last ten-day period of February 1993, the lake was dried up, the sediment cores were sampled using a plexiglass tube, the internal diameter and external diameter of the tube is 5 cm and 6 cm separately, and a core 46 cm in length was taken and covered with polyethylene film carefully. At the laboratory the core was cut into 1 cm layers using plastic knife, the wet weights of the layers were measured separately, and then the layers were dried in the oven, the dry weights were measured separately, the samples were sieved with nylon sieve. These results show that the

moisture contents of samples are 24%～30%, and the texture of the sediment is sandy loam.

The samples were kept in the sampling boxes and were condensed for 3 weeks with plexiglass plates, then the $^{210}$Pb activities of different-layer samples were measured using GEM series HPGe (high-purity Germanium) coaxial detector system made by EG & G Ortec company in USA. The $^{210}$Pb activities of the samples were measured with the germanium plane detector, the effective area of the detector is 100 mm$^2$, and the thickness of the detector is 7 mm, the resolution (FWHM) at 5.9 keV for $^{55}$Fe is 0.183 keV, the count rate of the peak at 46.5 keV for $^{210}$Pb is $0.80\times10^{-2}$/min. During the measuring, the detector was put in the shielded lead-room, the internal volume of the room is 60 cm×60 cm×60 cm, the measuring time for every sample was $3.5\times10^5$ s. The organic carbon content of the sample was determined by the $K_2Cr_2O_7$-$H_2SO_4$ digestion method, and the size composition was determined by the sedimentation-pipette method. The results are shown in Table 1.

Table 1. The $^{210}$Pb activities($a$), the organic carbon content ($W_{(C)}$) and the size composition of the lake sediment in Great Wall Station area, Antarctica

| Depth /cm | $a_{tot}$/ min$^{-1}$·kg$^{-1}$ | $a_{ex}$/ min$^{-1}$·kg$^{-1}$ | $W_{(C)}$/ % | Size composition*/% | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | | 2～0.25 mm | 0.25～0.10 mm | 0.10～0.05 mm | 0.05～0.002 mm | <0.002 mm |
| 0～1 | 1.68±0.34 | 1.50±0.30 | 5.195 | 3.30 | 10.63 | 20.74 | 52.78 | 12.55 |
| 1～2 | 0.87±0.18 | 0.69±0.14 | 4.549 | 7.13 | 22.93 | 24.05 | 35.13 | 10.76 |
| 2～3 | 0.99±0.20 | 0.81±0.17 | 4.281 | 9.98 | 27.38 | 23.15 | 28.14 | 11.35 |
| 3～4 | 0.46±0.10 | 0.28±0.06 | 4.093 | 6.80 | 22.11 | 32.37 | 28.22 | 10.50 |
| 4～5 | 0.46±0.12 | 0.28±0.07 | 4.487 | 6.87 | 20.60 | 32.19 | 30.29 | 10.05 |
| 5～6 | 0.19±0.06 | | 4.088 | 6.96 | 20.80 | 25.53 | 35.28 | 11.43 |
| 6～7 | 0.17±0.07 | | 4.243 | 6.85 | 20.68 | 27.56 | 34.78 | 10.13 |

*:Based on the USDA scale (Soil survey manual. US Dept. Agr. 1952).

## 4 Results and discussion

It is shown in Table 1 that the supported $^{210}$Pb activities($a_{ex}$) at different depths in the sediment core are decreasing exponentially in distribution, the distribution equation is given by: $a_{ex,x}=a_{ex,0}\cdot e^{-\lambda t}$, where $a_{ex,0}$ is the supported $^{210}$Pb activity (min$^{-1}$·kg$^{-1}$) in a freshly deposited sediment at time $t=0$; $\lambda$ is the radioactive decay constant of $^{210}$Pb ($\lambda=0.03108$ a$^{-1}$); $t$ is the age (in a) of sediments at depth ($x$). Commonly, it is agreed that $^{210}$Pb does not migrate in the lake sediment column, and it is also assumed that the flux of $^{210}$Pb to the lake sediments is constant (Hakanson and Jansson 1983). And so it is applicable to use $^{210}$Pb method in determining the sedimentation rate and the ages of sediments in Antarctica, which is coincided with the results of measurements for $^{210}$Pb in Antarctic snow-cover (Crozaz *et al.* 1964). In comparison with the $^{210}$Pb activities of the sediments of Michigan Lake (Robbins and Edgington 1975), the supported $^{210}$Pb activities($a_{ex}$) of the lake sediments in Great Wall Station area are relatively low, the former are more than 3.76 pC$_i$·g$^{-1}$ and the latter are (1.50±0.30)/(min·kg), the adaptabilitive range of $^{210}$Pb method is less than 200 a.

The sampling lake is a paleolagoon (seasonal lake) in the subantarctic oceanic area, and there are scarce hydrophytes growing in the lake, but there are some pro-

to-malacology living in the lake. The sediment is of fine silt, which has been carried into the lake by the surface runoff. The main particles are silt (0.05～0.002 mm) and very fine sand (0.10～0.05 mm), and the texture has no difference in the 0～7 cm layer; the organic carbon content of the sediment is more than 4.0%. As a result, it is very possible that the sedimentation rate is relatively stable, based on the distribution equation of $^{210}$Pb in the sediment and the data in the Table 1, it is calculated that the average sedimentation rate is (0.072±0.018) cm/a.

From these results, the sample of 2～3 cm layer is the product of the sedimentation during 1953～1966, the supported $^{210}$Pb activities ($a_{ex}$) is particularly high, which is related to the global rich settlement of artificial $^{210}$Pb resulting from the frequent atmospheric nuclear weapons testing in 1950's and 1960's. Pereira and Kirchhoff (1988) measured the activities of $^{90}$Sr, $^{137}$Cs and $^{210}$Pb in the mosses, lichens, ice, snow, sea-water and marine sediment of King George Island, they concluded that the measurements confirmed the clearly artificial radioactive settlement in King George Island during 1960's. Therefore, it is necessary to consider the effect of the atmospheric nuclear testing on the antarctic environment, and the studies should be further made in the future.

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## References

Bonner W N, Walton D W H (1985): Key environments Antarctica. Pergamon Press, New York, 329～349.

Crozaz G, Picciotto E, Breuck W D (1964): Antarctic snow chronology with $^{210}$Pb. Journal of Geophysical Research, 69(12):2597～2604.

Gillieson D, Burgess J, Spate A, Cochrane A (1990): Australian National Antarctic Research Expeditions.

Hakanson L, Jansson M (1983): Principles of Lake Sedimentology. Springer-Verlag, Berlin, Germany, 237～243.

Herron M J, Anderson J B (1990): Late quaternary glacial history of the South Orkney Plateau, Antarctica. Quaternary Research, 33:265～275.

Pereira B E, Kirchhoff W J H V (1988): Ciencas Atmosfericas e Espaciais na Antarctica. Brazil, Sao Jose dos Campos: Instituto de Pesquisas Espaciais, Brasileira de Geofisica, 130～137.

Robbins J A, Edgington D N (1975): Determination of recent sedimentation rates in Lake Michigan using $^{210}$Pb and $^{137}$Cs. Geochimica et Cosmochimica Acta, 39:285～304.

Stuiver M, Ostlund H G (1980): GEOSECS Atlantic Radiocarbon. Radiocarbon, 22: 1～24.

Xie Youyu (1993): Geomorphology and sedimentation in Chinese Great Wall Station areas (Fildes Peninsula). China Ocean Press, Beijing, 116～136 (in Chinese).

Yue Yunzhang (1989): $^{14}$C dating of the surface sediments from sea area northwest of the Antarctic Peninsula and its errors. Antarctic Research (Chinese Edition), 1(4):52～56.

Zhang Lansheng (1992): Research on environmental change. Science Press, Beijing, 1～15 (in Chinese).

Zhao Ye, Yan Junfang, Li Tianjie (1993): An analysis on the spectral characteristics of the ground in the Great Wall Station area, Antarctica. Remote sensing information, 4:9.