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Decreasing trend of temperature in Princess Elizabeth Land, Antarctica in the past 150 years

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Abstract **A 50-m firn core drilled in Princess Elizabeth Land, Antarctica, during the 1996/1997 Chinese First Antarctic Inland Expedition, has been measured for $d^{18}O$ and major ions. Based on the high quality of the seasonal variations of major ions, the firn core was dated with errors within ±3 years. The features of the temperature change in the past 150 years in the investigated region have first been studied based on the oxygen isotope in the upper 32.93 m of the firn core. Results show that the temperature decreased nearly by 2℃ in Princess Elizabeth Land in the past 150 years. On the background of the global, especially the Southern Hemispheric warming in the past 150 years, a temperature decline of 2℃ in Princess Elizabeth Land likely reflects the impacts of the unique Southern Hemisphere atmospheric circulation, the Antarctic Circumpolar Wave (ACW) and the special terrain (such as the large drainage basins) on the coastal regions of Antarctica.**

Keywords: Antarctica, firn core, decline of temperature.

Both hemispheric and global annual surface air temperatures show an increasing trend in the past 150 years based on the studying of global meteorologic data[1]. However, because of a lack of meteorologic data in Antarctica, the temperature change in the past 150 years in Antarctica was not included in the studying. Due to its unique geographical setting, Antarctic ice sheet becomes an exceptional region in reflecting and contributing to the global climate change. Therefore, it is significant to recover the past temperature features of Antarctica to study the temperature changes of the Globe, especially the Southern Hemisphere.

As the oxygen and hydrogen isotope in the ice cores from Antarctica can indicate the change of temperature[2], it is important to study the global, especially the Southern Hemispheric air temperature change using the averages of the oxygen and hydrogen isotopes in the ice cores from Antarctica. There is no systematical investigation on glaciology and climatology in Princess Elizabeth Land, Antarctica, where is a virgin region for ice core study. A 50-m firn core drilled during 1996/1997 Chinese First Antarctic Inland Expedition provided us valuable data, and based on the oxygen isotope in the upper 32.93 m of the firn core, we will discuss the temperature change in the study region for the past 150 years, and compare it with the global, especially the Southern Hemispheric annual surface air temperatures in the past 150 years.

1 Sampling, analysis and dating

During the 1996/1997 Chinese First Antarctic Inland Expedition from Zhongshan Station to Dome A, two firn cores (one is 51.85 m in length, the other is 50.32 m deep) apart from 2 m were drilled at LGB65 on Princess Elizabeth Land[3] (fig. 1). The major ions and $d^{18}O$ of the 51.85 m firn core were analyzed at the Laboratory of Ice Core and Cold Regions Environment, Cold and Arid Regions Environmental and Engineering Research Institute, CAS. The ice core drilling, sampling and analysis are discussed elsewhere in detail[4, 5].

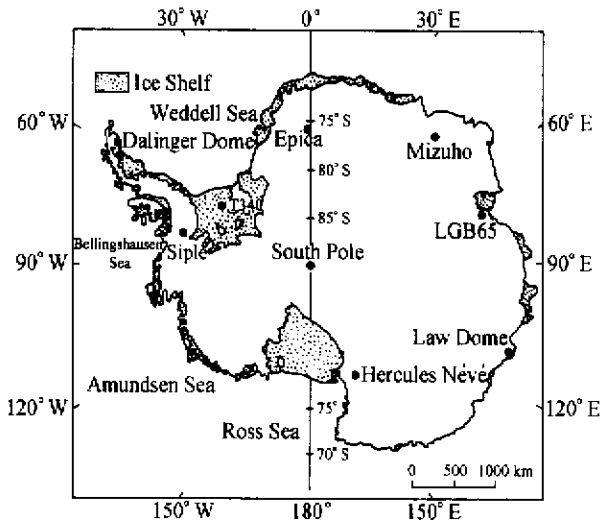

Fig. 1. The map illustrates location of LGB65 and other core sites discussed in the text. ●, Coring site.

Ice core dating is the basis of ice core research. In order to date the firn core accurately, we paid special attention to seasonal variations in major ions from snow and firn recovered from Princess Elizabeth Land, Antarctica. Our results show that variations in sea-salt ions (Cl^- and Na^+) and NO_3^- reasonably represent seasonal variations[4]. Therefore, the firn core was dated on the basis of well-preserved $d^{18}O$ (smoothed below 3 m), NO_3^-, Cl^- and Na^+ seasonal cycles counted to establish the depth-age relationship with high accuracy. The accumulated errors, attributable to a few ambiguous seasonal cycles, are esti-

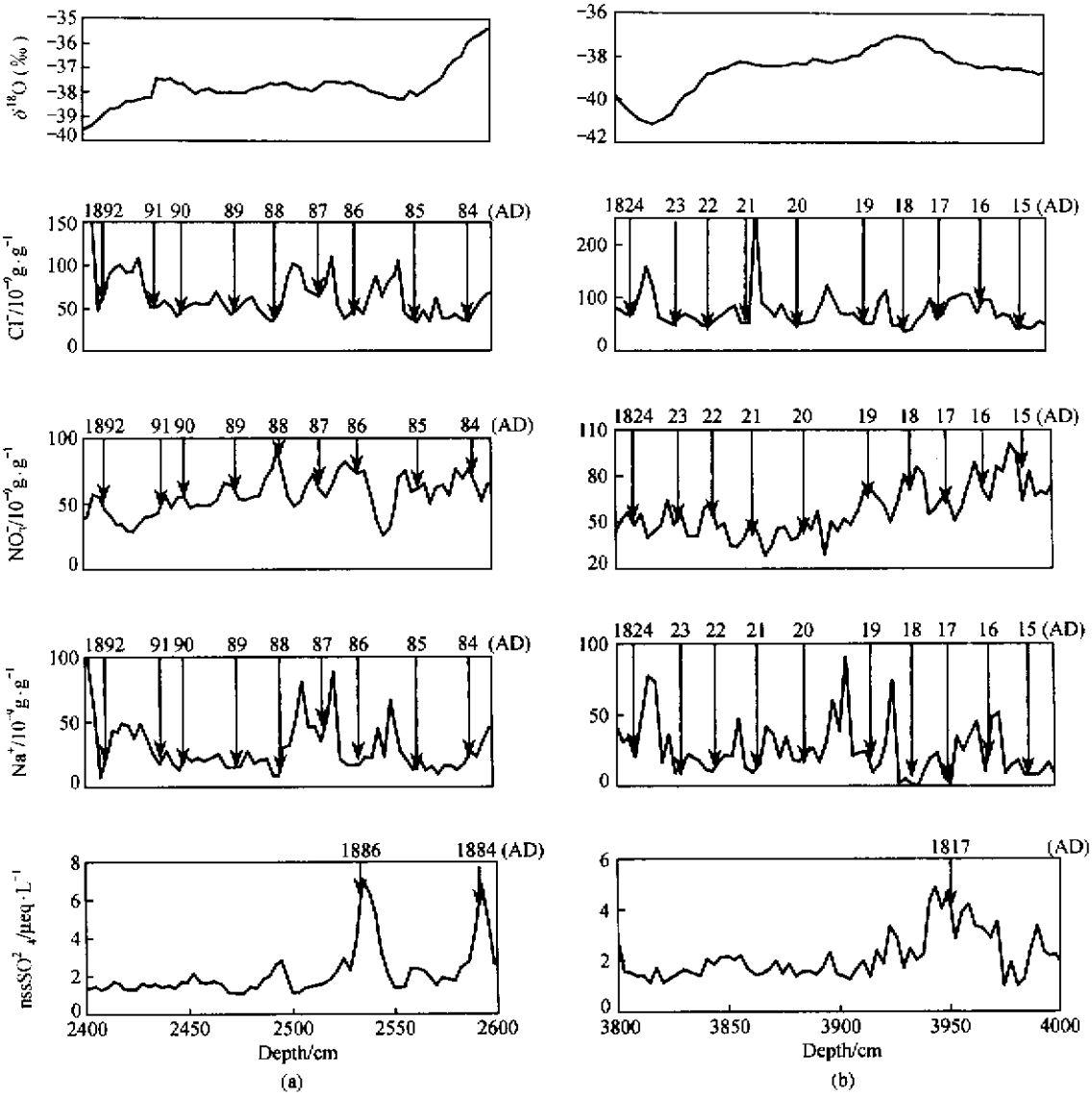

Fig. 2. $d^{18}O$, Cl^-, NO_3^-, Na^+, and $nssSO_4^{2-}$ profile from firn core at LGB65 covering depths: (a) 24—26 m; (b) 38—40 m.

mated to be only ±3 years at the end of the record. The 51.85-m firn core record extends for 251 years (AD 1745—1996). The accuracy of our dating is confirmed by two proofs: (1) the major volcanic eruptions such as Tambora (AD1815), Krakatoa (AD1883) and Tarawera (AD 1886) were dated in the firn core at 1817, 1886 and 1884, respectively, as expected (fig. 2). (2) The 50.32-m firn core carried to Chinese Institute of Polar Research was dated by the density and stratigraphic features and contains 243 years, which is consistent with our dating[6].

2 Results and discussion

From fig. 3 we can see that the oxygen isotope temperature in Princess Elizabeth Land shows prominently decreasing trend which conflicts with the Northern Hemispheric and the global, especially the Southern Hemispheric surface air temperature change trends over the past 150 years. The preliminary results of the oxygen isotope temperature in the firn core collected from Princess Elizabeth Land, East Antarctica, during 1997—1998 Chinese Second Antarctic Inland Expedition show a similar decreasing trend during the period of 1860—1996 (with Dr. Xiao communication). There are more ice cores from Antarctica showing increasing isotope temperature trends in the past 150 years[7—10]. For example, the isotope temperature increase of about 0.8℃ in Dronning Maud Land since AD1865 was reported by Isaksson et al.[7]. However, some other ice core records show decreasing isotope temperature[10, 11] such as Aristarain and others

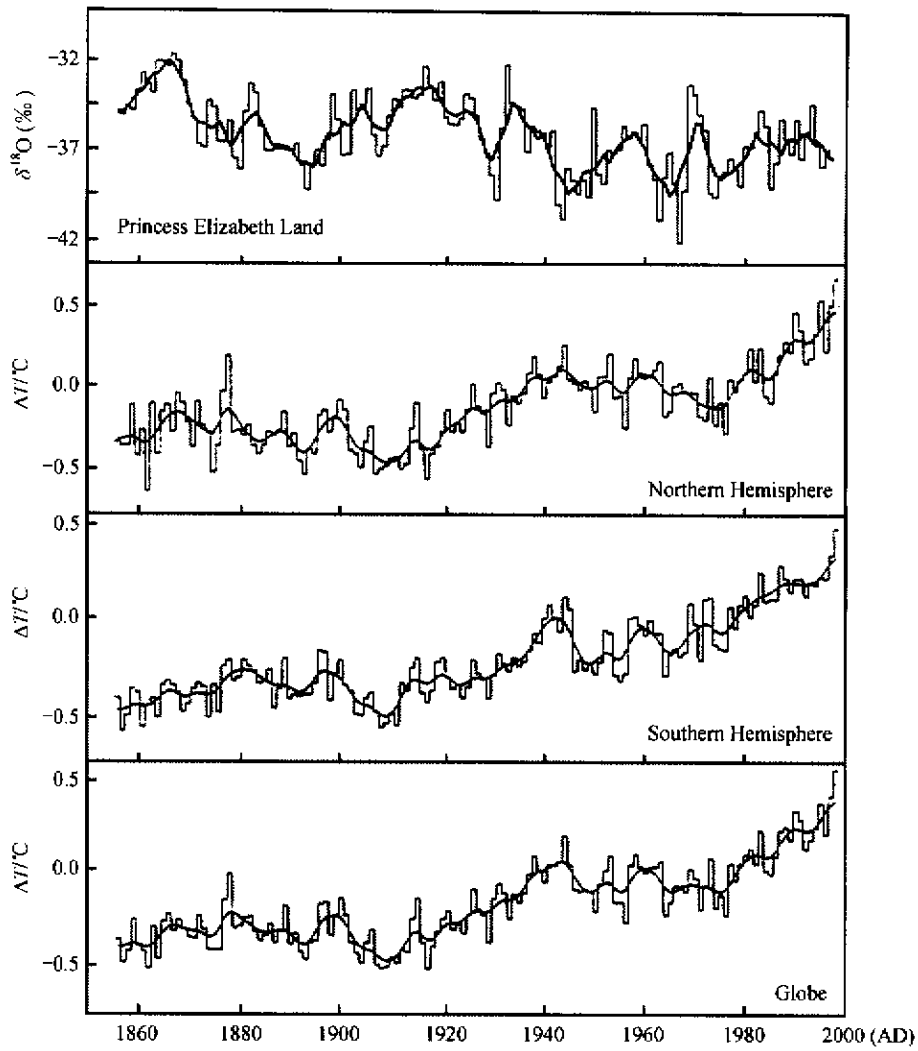

Fig. 3. Comparison oxygen isotope in the past 150 years recorded by LGB65 firn core in Princess Elizabeth Land with hemispheric and global temperature average on the annual timescale (1856—1998), relative to 1961—1990 (denoted by $\triangle T$)[1].

reported a temperature decline of −2℃ from 1850 to the present in the Antarctic Peninsula[11].

If the experiential d-T formula in Princess Elizabeth Land[12], $d\,^{18}O = 0.70T - 11.36$, was used to calculate the temperature change, a decrease of about −1.8℃ in Princess Elizabeth Land would appear. The range of the decreasing temperature in Princess Elizabeth Land is comparable to that in the Antarctic Peninsula.

Making a comprehensive view of the isotope records of the ice cores from the coastal regions of Antarctica (fig. 4), we can see that most of isotope temperature records of the ice core show a warming trend in the past 150 years, however, the records from Antarctic Peninsula and Princess Elizabeth Land show a decline trend of temperature.

Thus, it can be seen that the surface air temperatures of the Northern Hemisphere, the Southern Hemisphere and the Globe show obviously increasing trend over the past 150 years, but the isotope temperatures in Antarctica over the same period show obviously regional differences. The reason may be as follows: there is a lack of high latitude/low latitude link particularly due to the nature of the Southern Hemisphere atmospheric circulation. It does not favor strong north-south energy exchange, due to the relatively small meridional amplitude of the long waves and to the strong circumpolar circulation around the Antarctic continent.

Studies show that climate change over the coastal regions of the east Antarctic ice sheet may has a tight connection with the climatic variation over the Southern Ocean[13, 14]. In the past several years, a phenomenon called Antarctic Circumpolar Wave (ACW) was found by oceangraphers[15]. ACW is a phenomenon transmitting climate anomalies around the globe which is induced by the circumpolar circulation, the climate anomalies in-

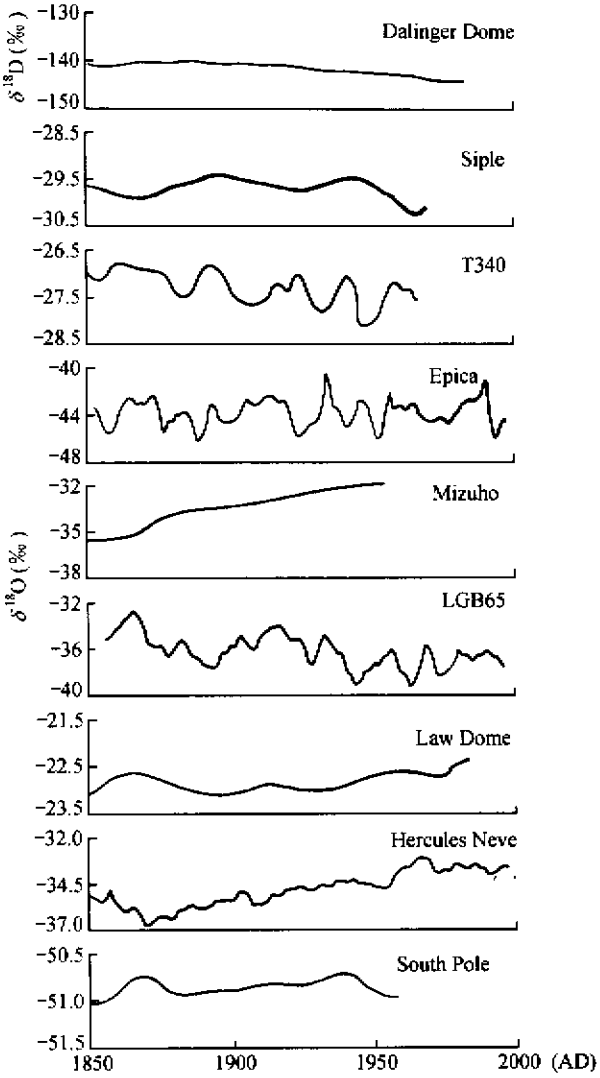

Fig. 4. The Antarctic isotope records in the past 150 years: Dalinger Dome, Siple, T340, Epica, Mizuho, LGB65, Law Dome, Hercules Névé and South Pole[7, 9—11].

clude sea surface temperature (SST), sea level pressure (SLP), meridional wind stress (MWS), sea ice extent (SIE), etc. Studies show the anomalies of sea and air of the Southern Hemisphere such as ENSO can be carried to the circumpolar circulation, which caused the anomalies of the temperature and pressure alternately distributing around the Southern Ocean (fig. 5). This distributing pattern may affect the coastal regions of Antarctica and cause the climate in the coastal regions showing obviously regional differences. Figs. 1 and 4 show that the isotope temperatures in the coastal regions of Antarctica in the past 150 years also show an alternant distributing pattern. Princess Elizabeth Land is located in the eastern side of Lambert Glacier Basin, the biggest basin in east Antarctica, where the local atmospheric circulation and wind

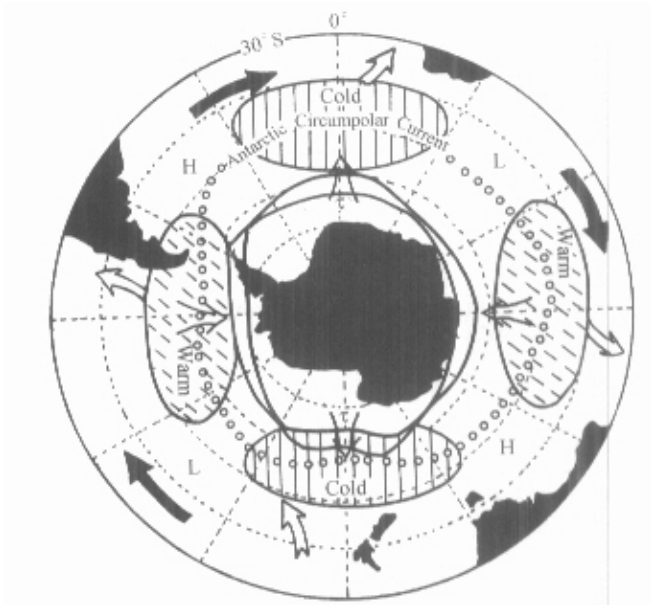

Fig. 5. Simplified schematic summary of Antarctic Circumpolar Wave[15]. H indicates high atmospheric sea-level pressure, L low high atmospheric sea-level pressure, *t* meridional wind stress. Black arrows depict the general eastward motion of anomalies and white arrows communications between the circumpolar current and the more northerly subtropical gyres.

field is complicated. Therefore, a temperature decline of 2℃ in Princess Elizabeth Land likely reflects the impacts of the unique Southern Hemisphere atmospheric circulation, the ACW and the special terrain (such as the large drainage basins) on the coastal regions of Antarctica.

3 Conclusion

It is a virgin region for ice core study in Princess Elizabeth Land, East Antarctica. Studies show the Lambert Glacier Basin is a dividing region for the different climatic regimes over the coastal regions of the eastern Antarctic ice sheet. The climate change trend in the past 50 years in both sides of the Lambert Glacier Basin is completely opposite[14]. On the background of the global, especially the Southern Hemispheric warming in the past 150 years, the temperatures in Princess Elizabeth Land which is located in the eastern side of Lambert Glacier Basin over the same period show a decreasing trend, which may reflect regional differences of climate change in this region. Therefore, it needs further study on many shallow firn cores to reveal the overall features of the climate change in this region in the past 100 years. Fortunately, during 1997—1998 and 1998—1999 Chinese National Antarctic Research Expedition, three firn cores were drilled in Princess Elizabeth Land[12]. Most of the laboratory analyses of the cores are in progress, and the expected results may be helpful to revealing the overall features of the climate change in this region.

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Radiolarian record to paleoecological environment change events over the past 1.2 MaBP in the southern South China Sea

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Abstract **This note studies the Radiolarian fossil groups since 1.2 MaBP in ODP leg 184 site 1143, the southern South China Sea (SCS). The result shows that radiolarian abundance experienced a significant variation: before 0.9 MaBP it remained at the extremely low level, but increased with low extent between 0.9—0.65 Ma, which corresponded to the Mid-Pleistocene Transition stage, and it increased rapidly after 0.65 MaBP. During the whole process, the average abundance became higher and higher in each stage, and showed regularly periodic fluctuations. The obvious increase after 0.65 MaBP is inferred to result from the enhanced upwelling in this region, which was induced by the intensified monsoon circulation after the "Mid-Pleistocene Transition". An outstanding result of the spectral analyses is that a long oscillation of ~ 0.2 Ma cycle was found in the records of radiolarian abundance and complex diversity, which corresponds well to the result of other paleoceanographic indexes. This probably indicated a special cycle characteristic of paleoecological environment evolution in this area. In addition, all of the radiolarian indexes show an obvious boundary in about 0.47 MaBP, indicating the abrupt variation of the community structure and radiolarian abundance level before and after 0.47 MaBP. So we suppose that there existed a distinct change event of oceanic ecology environment during that period.**

Keywords: radiolarian, southern South China Sea, distribution, environmental change, site 1143.

The high-resolution quantitative oxygen isotope records at ODP Site 1143 showed the response of Mid-Pleistocene Transition in the southern South China Sea and suggested the important influence of the low latitude region to global climate changes[1]. The studies on planktonic foraminifers and calcareous nannofossils have revealed the evolution of upper water-column structure and productivity, and responded the global climate events[2,3], which provided important evidence for the study on the