Chinese Journal of Polar Science, Vol. 8, No. 1, 27～32, June 1997

Climatic changes in the regions of Antarctic Great Wall Station, Southern Chile and South Georgia Island*

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Received April 17, 1997

Abstract In this paper a comparison is made between the curve of climatic changes in the Alerce region of the southern Chile during the past 4000 a and the temperature and precipitation curves in the region around the Great Wall Station of Antarctica, and an inference is also made about the trend of precipitation change for the past 16000 a in the region of King George Island of Antarctica and the trend of the pendulation of the Antarctic Convergence for the past 4000 a. By analysis of the response time or the amplitude of environmental changes, the response of the Antarctic region to the global environmental changes is more sensitive. The climatic research of the South Georgia Island (54°～55°S, 36°～38°W) in the South Ocean also confirms the above environmental changes. The uniformity of environmental changes in the region of Antarctic Great Wall Station, the South Georgia Island and the Alerce region of the southern part of Chile shows that they are controlled by one similar factor, and the pendulation of the Antarctic Convergence is just the reflection of such an impact.

Key words Antarctica, environment, global change.

1 Introduction

The King George Island, the largest one of the south Shetland archipelago at the northmost part of Antarctica, covers an area of 1430 km^2, 90% of which is covered with glacier. The ice and snow are melting only at the western and southern coast in summer. The Chinese Antarctic Great Wall Station is just situated at the iceless area —the southern part of the island, i.e., the eastern side of the Fildes Peninsula.

The climate of King George Island is of the sub-Antarctic oceanic type. The mean air pressure of the region is about 992.2 hPa. Its wind direction frequency is basically a doublepeak distribution with the northwesterly predominating primarily to be seconded by the southeasterly. Its maximum speed is 30 m/s. The annual average temperature is about −3℃, its maximum temperature can reach 13℃, its lowest temperature may be −30℃. The annual average precipitation is 400 mm and generally the precipitation is evenly distributed in a year, nevertheless, a little more in sum-

* The project was supported by Doctoral Programme Foundation of Institution of Higher Education.

mer. The main precipitation is mainly snow and rain, but the ice and snow in this area basically melt away in summer.

In the viewpoint of environmental evolution, geographically, King George Island is located on the edge of the Antarctic Convergence, whose north and south oscillation in position is chiefly governed by environmental changes of southern hemisphere (even of the whole globe). The effect of regional environmental changes is not enough to cause any conspicuous change in the position of the above convergence which, circumscribing the Antarctic continent, is the region of maximum frequency for air whirl activity in the southern hemisphere. The characteristics of the environmental changes for this region are reckoned to be both sensitive and representative. The pedulation of the Antarctic Convergence and the changes in floating ice would very sensitively reflect the climatic fluctuation there. Therefore, the research into its climatic change is of global significance.

2 Climatic research on the regions of Great Wall Station and Southern Chile

When a comparison is made between the curve of climatic changes of the Alerce region in the southern part of Chile in the past 4000 a (Heusser *et al* . 1980) and the temperature and precipitation curves in the region around Great Wall Station of

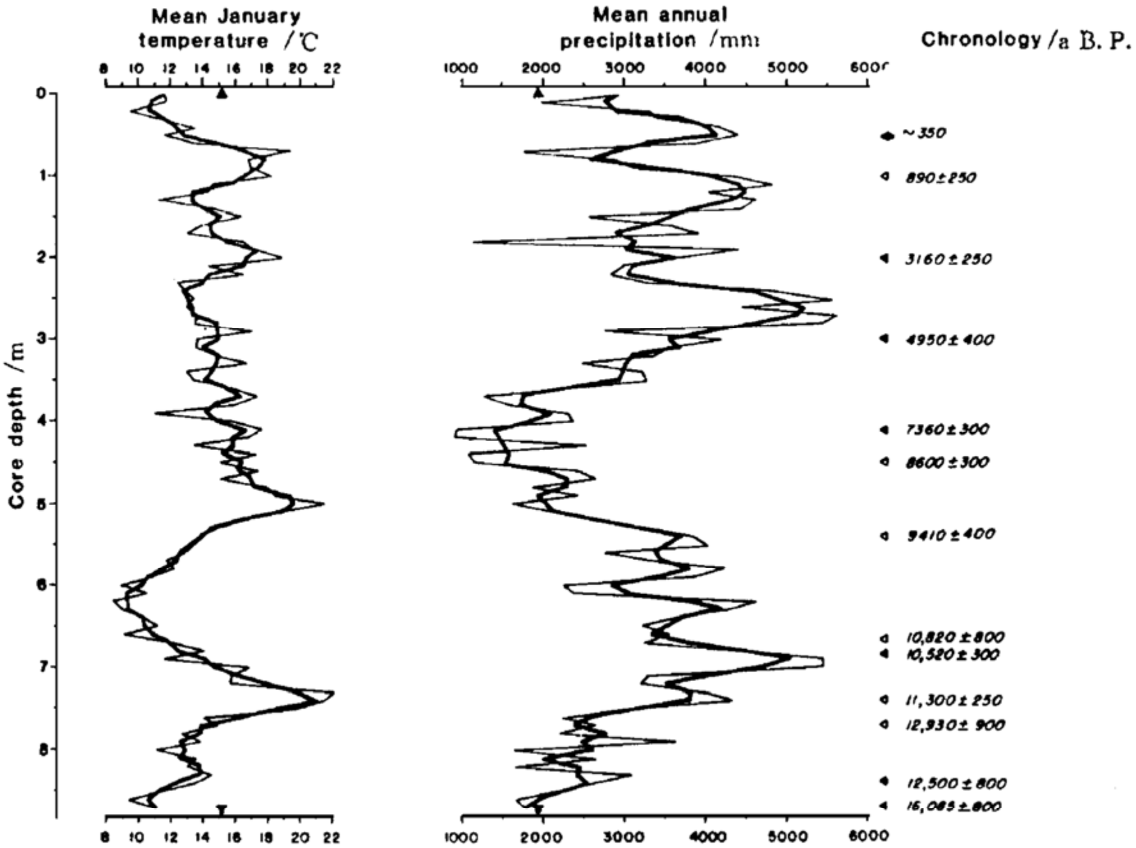

Fig. 1. Mean January temperature and mean annual precipitation for the past 16000 a in Alerce (after Heusser *et al*. 1980).

Antarctica (Zhao 1990) as shown in Fig. 1. and Fig. 2, it can be seen that the changes in the temperature are almost identical, and that the changes in precipitation are inverse in the two regions. This kind of precipitation correlation is so marked that it is possible to find the corresponding points for the peak and the valley values on each other's curves. Such a fine inverse correlation is not at all accidental but is related directly to the geographical position in which King George Island and the Alerce region are located.

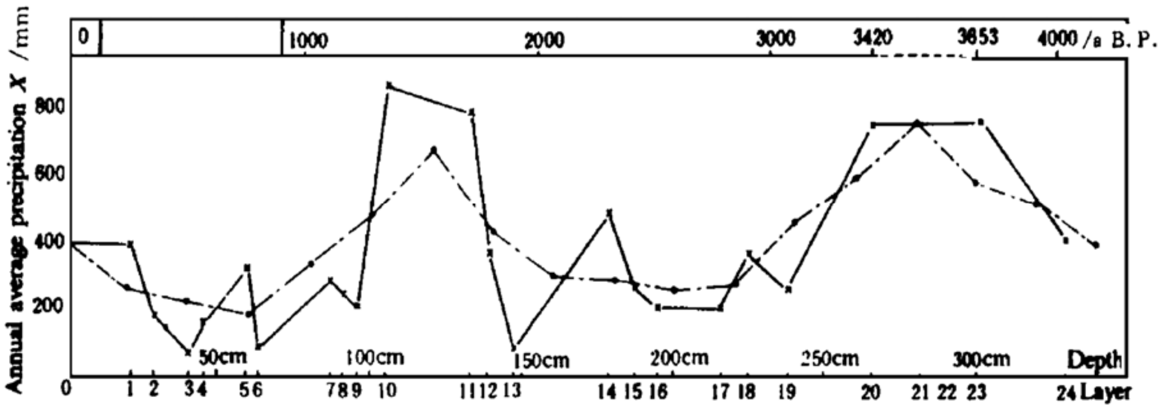

Fig. 2. Average precipitation for the past 4000 a in the region of Antarctic Great Wall Station.

The longitude of King George Island (61°53′～62°16′S, 57°34′～59°3′W) and that of the Alerce region (41°25′S, 72°54′W) are close to each other; but the former lies on the south side of the Antarctic Convergence while the latter on its northern side and close to the subtropic Convergence. The Antarctic Convergence lies between latitudes 50°～60°S. The Antarctic superficial water, leaving the Antarctic region and flowing towards the north, meets the relatively warm ocean water, which flows southwards there to constitute one of the most important boundary lines for all the oceans of the world — the Antarctic Convergence, or so-called the Polar Front. The difference in temperature on both sides of it is extremely marked during the summer, reaching as far as 4～8℃, while 1～3℃ in winter. Moreover, it is the belt that goes entirely round Antarctica where the westerly drift prevails. No doubt, both the Antarctic and the subtropic convergences are of great significance to the atmospheric circulation of the southern hemisphere. The common action of the two produces an intense temperature gradient of sea water on the waters between the latitudes 40°～50°S.

Precipitation of the region in the vicinity of the Antarctic Convergence is chiefly cyclonic precipitation. Under the condition of slight changes in global atmospheric circulation for the past 10000 a, Antarctic Convergence moved southward when global temperature rose, thus enabling cyclonic precipitation to increase on the south of the region (like the Great Wall Station region), whereas on the north of the region, cyclonic precipitation correspondingly decreased (like the Alerce region); reversely, when global temperature fell, the convergence moved northward so that the equatorial rain belt was "compressed". Thus , the cyclonic precipitation in the south of the region decreased (like the Great Wall Station region), whereas that in the north correspondingly increased(like the Alerce region). It is just because of this reason that the marked inverse correlation of precipitation changes between the King George Island region in Antarctica and the Alerce region in southern Chile has resulted although temperature changes might tend to be identical. On such a reason ,we may infer the trend of precipitation changes in the region of King George Island of Antarctica for the past 16000 a from the precipitation of the Alerce region in the southern part of Chile; and as the precipitation changes of the King George Island region have already been known quantitatively since the last 4000 a, so Fig. 3. merely shows the trend of changes in precipitation for the period 4000～16000 a B. P.. For the same reason , it is possible to figure out the trend of the pendulation of the Antarctic Convergence for the last 4000 a (or even longer) (Fig. 4).

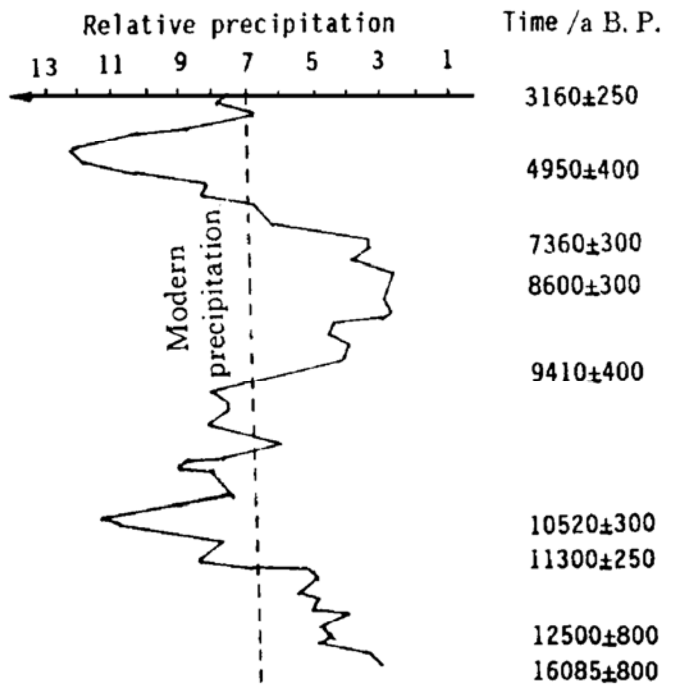

Fig. 3. Relative precipitation for the period of 16000～4000 a B. P. in the region of King George Island.

On making a further study of the relationship between the precipitation and temperature of the King George Island region and those of the Alerce region in southern Chile, it is found that the change in temperature leads the change in precipitation somewhat in the former region , whereas in the latter, such a condition is reversed . The changes in precipitation in these two regions are "inversely synchronous"in time, thereby the conclusion is drown that the change in temperature of the King George Island region leads that of the Alerce region. Since the last 4000 a, the amount of precipitation might have increased ten-fold on the King George Island, whereas in the Alerce region less than three-fold. The above analysis indicates that in view of the response time of climatic changes or the amplitude of the changes , the response of the Antarctic region to climatic changes is more sensitive.

3 Climatic research on the regions of Great Wall Station and South Georgia Island

The climatic research of the South Georgia Island (54°～55°S, 36°～38°W) in the South Ocean also confirms the above climatic changes. The climatic changes of this island are not only representative of the south westerly belt region but also provide the connection between the Antarctic and the temperate zone on the southern part of

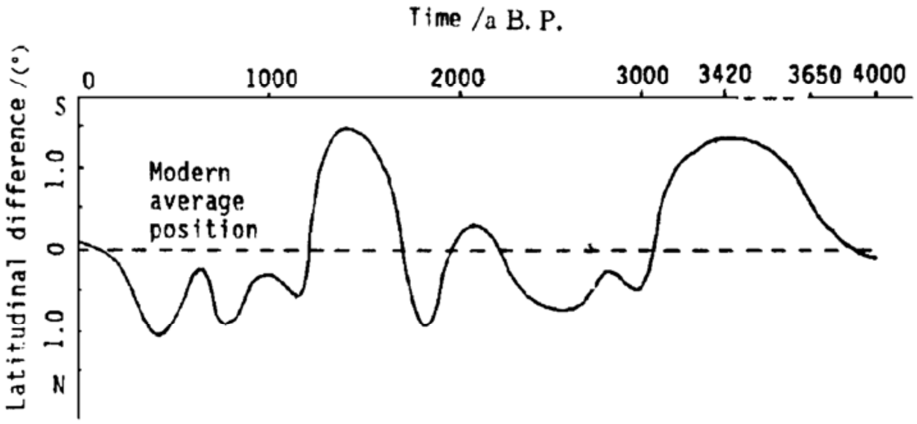

Fig. 4. The trend of the pendulation of the Antarctic Convergence for the last 4000 a.

South America. Comprehensive evidence has been obtained from the result of analysis of environmental indicators for glacial geomorphology, and the peat and lake cores. A curve for temperature changes for the last 11000 a has thereby been drawn (Clapperton and Streeter 1989). The climate prior to 6400 a B. P. was very harsh. Later on, the periods of cold climate occurred in 4800～3800 a B. P. and 3400～1800 a B. P. as well as within the last 1400 a. The maximum scale of Holocene ice advance on South Georgia Island reached its climax 2200 a ago. The most adverse climatic period occurred in about 3000～2000 a B. P.. The curve for climatic changes for the last 1000 a indicates that the glacier started to advance again after the 13th century, and the advances of glacier for the three small ice epochs occurred in the 18th ,19th and 20th centuries. When the above analysis is compared with the known Holocene (especially in the latter period) glacial fluctuations in the southern part of South America, some important similarities are revealed . The advance of the Patagonian glacier occurred in the periods 4600～4200 a B. P. and 2700～2000 a B. P.. Since the 14th century , a few minor fluctuations have also taken place. These research results almost fully coincide with the conclusions for King George Island. The three cold periods ,namely 4800～3800 a B. P. , 3400～1800 a B. P. as well as the last 1400 a of the South Georgia Island, are the epochs when the precipitation on King George Island was relatively low and its temperature was correspondingly low, too. In the Holocene the maximum glacier advance occurring on South Georgia Island some 2200 a ago manifested itself by the minimum of precipitation in the changes of precipitation on King George Island in 1800～2000 a B. P. . Between the first two cold period, i. e. , 4800～3800 a B. P. and 3400～1800 a B. P. , on South Georgia Island, there must be a warm period during 3800～3400 a B. P.. The last ice cap of the region around the Great Wall Station melted and regressed from this region during this period . In addition, in subsequent periods this region no longer came across any obvious glacial activities due to the collocation of warm-moist and cold-dry climates. The warm period, 1800～1400 a B. P. , between the other two periods (3400～1800 a B. P. and in the last 1400 a) of South Georgia Island also manifests itself in a warm period accompanied by heavy precipitation in the region of Great Wall Station. As to the few small ice epochs in the last 1000 a , all the records of their climatic fluctuations also correspond each other in these two places. Through the above analysis, a deduction may be made ,i. e. ,the changes in temperature for the King George Island region and the South Georgia Island for the last 11000 a are basically identical.

The uniformity of climatic changes in the regions of the Antarctic Great Wall Station, the South Georgia Island and the Alerce region of the southern part of Chile shows that they are controlled by one similar factor that is common to them, and the pendulation of the Antarctic Convergence is just the reflection of such an impact.

In their research on the glacial fluctuation and climatic changes of South Georgia Island ,Clapperton and Streeter (1989) considered that the Holocene temperature changes (between 0.5～1.0℃), on scale or in time, may be comparable to the recent results of analysis of the ice cores obtained from the Soviet Vostok Station. The climatic interpretation given by the oxygen isotope curve shows that the climatic trend towards the warm direction was interrupted by the temporary cold period that persisted for almost 1000 a between 12000～11000 a B. P. ,and the warmest period in the Holocene was about 9900 a ago. However , the warmest period on South Georgia Island seems to lag behind some 3000 odd years. The reason for this marked difference is not clear and so some further study is necessary . The results of Vostok's analysis reveal that starting from the warmest period in 9900 a B. P. , the temperature of the whole Holocene kept dropping irregularly all along. Vostok's curve indicates that relatively small but very obvious cold valleys appeared severally in 3500 a B. P. and 1400 a B. P. in the trend of temperature fall in the latter half of this period. These fluctuations coincide roughly with the glacial fluctuations on South Georgia Island . For instance, the marked temperature drop in 2500 a B. P. given by Vostok agrees very nicely with the largest glacier advance in the neo-ice age on South Georgia Island.

4 Conclusion

The region of Great Wall Station situated near the Antarctic Convergence is not only a sensitive region to global environmental changes but also a representative one, whose regularities are closely connected with that of other regions.

References

Clapperton C M, Streeter S S (1989): Late-glacial and holocene fluctuations and environmental changes on South Georgia, Southern Ocean. Quat. Res. , 31: 210～228.

Heusser C J, Sugden D E, Birnie J, Wilson M J (1980): A temperature and precipitation record of the past 16000 years in Southern Chile. Science, 210(19): 1345～1347.

Zhao Junlin(1990): The features of environmental evolution in the area of Fildes Peninsula, King George Island, Antarctic. Chinese Science Bulletin, 35(8): 661～666.