Nineteenth Indian Expedition to Antarctica, Scientific Report, 2004
Department of Ocean Development, Technical Publication No. 17, pp 33-40

Reconstruction of Palaeoclimate from Holocene Sequences of Lake Sediment Schirmacher Oasis, East Antarctica

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Abstract

Pollen analysis of twenty moss turfs and Antarctic soil samples collected in and around Schumacher Oasis, East Antarctica has been carried out in order to elucidate the interplay of pollen and spores deposited in the sediments. The occurrence of different pollen-spore types reflects their long distance transport ranging from tropical to temperate floristic regions around Antarctic mainland. The palynological study of a 60 cm sediment profile from Priyadarshini lake under 6 meter water column reflects three-fold climatic oscillations viz., arid, warm & humid and warm & more humid since last 8000 years BP. The maiden palynological data has provided an insight into the potential of the further palaeoclimatic work in the region.

Introduction

The study area, Schumacher Oasis, is one of the small ice-free polar rocky hill near the shore of East Antarctica with a maximum width of 2 km and a length of about 18 km in east-west direction. Its size is approximately 35 sq km. The lakes, ponds and pools cover a large area representing essentially part of the surface water. The elevation of the oasis ranges between 0-228 m with an average of about 100 m above the msl.. The gentle slopes and plains are covered with a thin blanket of morainal debris.

The continent's hostile climate precludes most terrestrial life: mosses and lichens are the most widespread vegetation where the ground is exposed and moisture is available. In the Schirmacher Oasis the Precambrian crystalline basement of East Antarctic platform is exposed over an area of about 30 sq km. The poly-metamorphic rock sequence consisting dominantly of biotite-garnet gneiss and pyroxene bearing granulites with minor intercalation of marbles and calc-silicate rocks, ultramafics, amphibolites and other metabasites is traversed by a number of distinctly

younger amphibolite/dolerite dykes. The rocks have undergone multiple episodes of metamorphism, migmatization and deformation.

Floristically Antarctica is almost barren and is restricted to only two existing known vascular plant spp. Deschampsia antarctica (Fam. Poaceae 50%) and Colobanthus quitensis (Fam. Caryophyllaceae 10%), apart from Mosses Polytrichum alpinum (20%), Drepanocladus uncinatus *(10*%), preponderance of aquatic algae and luxuriant growth of various lichens on exposed rocky stratum. The main objective of the present work is to understand the distribution of palynodebris through the study of various Antarctic surface sediment in the first phase and subsequently the transmitted proxy data could be used in deciphering Early Holocene climatic changes in lake sediments. Hitherto no palynological studies were reported from the region so far. Moreover, transport of exotic palynomorps into the Antarctic region has been investigated by Kappen and Straka (1988), Smith (1991), and Wynn Williams (1991). First pollen diagram was published from Antarctica (King George Island, South Shetland Island) by Van der Knaap *et al.* (1993).

Materials and Methods

To achieve the target many potential areas were explored to procure palynological samples including moss turfs, frozen soil samples etc. from different lake sites, valleys, in and around Schirmacher Oasis of East Antarctica (Fig.l). Two sediment profiles (50-60cm) were collected from "Priyadarshini Lake" (70°45'39.4"S : 11°44'48.6"E) during the 19th expedition forpalynostratigraphical studies. Sediment profile samples were collected in the interval of 5 cm in each case, using a HYDROBIOS gravity corer (Kiel, Germany) for palynological studies; and for the radiometric

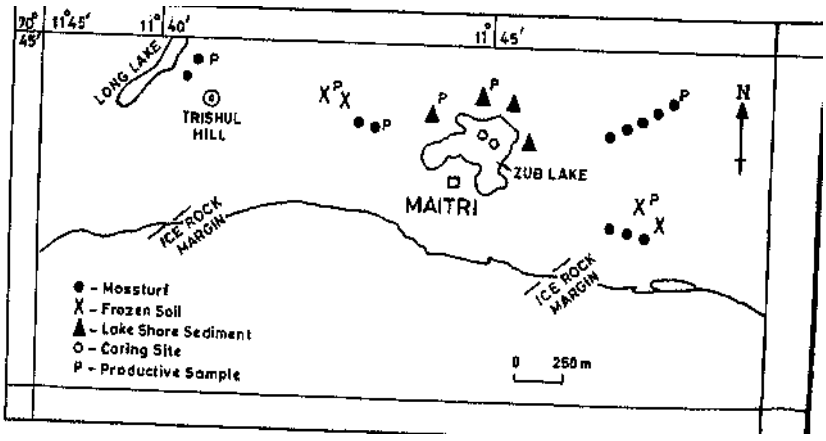

Fig- 1: Site of sampling in Schirmacher oasis East Antarctica

dates the same were collected in the interval of 10 cm. The corer with a 1 meter long core tube was dropped into the lake at specific sites with some additional weights attached to it and was allowed to sink to the lake bottom. After about 5 minutes, it was pulled back, sealed and brought back to the base camp and cut into pieces of 5 cm each and stored in double polythene bags and kept in frozen condition. After draining the excess water by siphoning through rubber tube from the top, to avoid contamination, the total core recovery become about 50-60 cm. The various other samples like moss turf, soil and moraines are stored properly in double polythene bags for palynological as well as other chemical analysis in the laboratory.

Daily air sampling was done by exposing glycerine smeared glass slides using Burkard personal air sampler (U.K) starting from 40^0-S of Cape Town to Antarctica mainland through Southern Ocean and on return voyage from Antarctica to Cape Town respectively. The air samples are processed immediately after collection, in proper mounting medium, for microscopic studies.

Aerospora Over Southern Ocean and Around Maitri

Burkard volumetric air sampler was employed for air sampling over a period from December 1999 to February 2000 during to and fro journey from Cape Town to Maitri, East Antarctica. The safranin stained slides were exposed daily for ten minutes and were studied microscopically. The pollen belonging to the families like Asteraceae, Rosaceae, Oleaceae, Chenopodiaceae-Amaranthaceae and Poaceae in low concentration. The fungal spores such as *Alternaria, Helminthosporium, Cladosporium, Cercospora* and *Memnoniella* along with small hyaline and coloured spores were recorded. Very rare occurrence of algae like *Cosmarium* was also noticed. The study indicates that even the air over polar region is charged with airborne palynodebris.

How far the wind has operated, and how far other means especially birds and men are responsible, for the world distribution of micro biota, is still to be investigated.

Pollen Rain In and Around Schirmacher Oasis

As the modern pollen-spore data are designated the proxy climate signal for the interpretation of past vegetation and environment, the detailed palynological studies on a large number of samples are required in order to make a pollen deposition model in the first phase. An extensive survey was done to procure maximum samples in and around Schirmacher Oasis. Out of whole lot, 20 surface sediments were pollen analyzed, in which 7 were found productive. The picture obtained from the pollen spectra

deduced an overall dominance of non tree taxa over tree taxa. Among trees, the taxa like *Larix,Pinus, Podocarpus, Betula, Ulmus* etc. are of subtropical to temperate in origin and others are of tropical in origin. The above taxa were drifted from far off to the sites of deposition in favourable climatic conditions. Nevertheless, the occurrence of the grass sp. *Deschampsia antarctica* and *Colobanthus quitensis,* only herb species in the sediments, is indicative of local deposition though they are not growing presently in the study area. *Cosmarium,* along with other algal remains including Diatoms, are also encountered in good amount. Fungal spores and other dispersed organic matter are also reported in low values. The air data also supplement the study of the pollen-spore distribution in surface sediment of polar region. Further detailed studies with more samples are in progress to understand the distribution of micro biota in polar region through which a pollen spore deposition model can be made (Fig. 2).

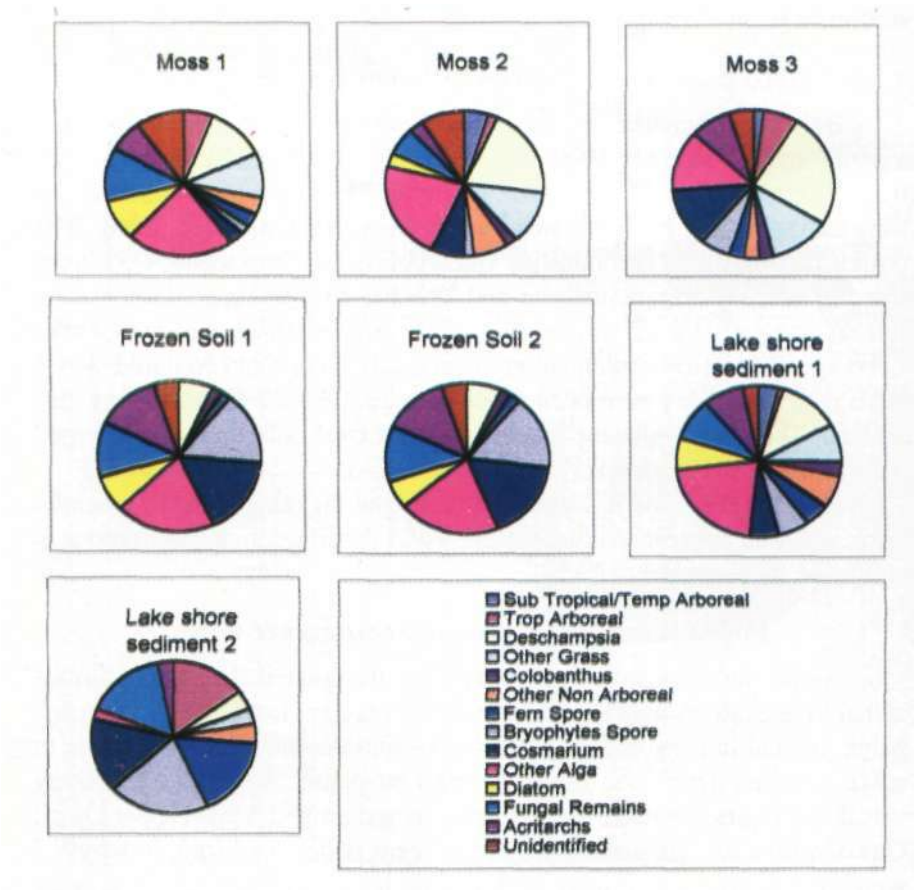

Fig. 2: Pollen Spectra from Schirmacher Oasis, East Antractica

Palynological studies of lake sediments

One sediment core from Priyadarshini lake is radiometrically dated i.e, 7130± 140 & 5110+ 140 years BP at 55-60 & 30-40 cm depths, respectively. The core comprises the alternate layers of silty clay with organic matter and algal growth. The palynological studies reflect three distinct palaeoclimatic phases on the basis of fluctuation in the value of different micro biota during last 8000 years BP (Fig. 3). In the first phase, the palyno-assemblage indicate arid climate in which the lake was shallow and small in spread during 8000 years BP. The occurrence of moderate values of *Cosmarium* (4-11%) along with preponderance of Acritarchs (32-39%) show freshwater/marine environment. Tree taxa like *Larix, Betula,* Moraceae and a few non tree taxa such as Chenopodiaceae and Caryophyllaceae have drifted from distant islands/continents by winds. The grass pollen recorded in the assemblage are grouped in three categories because of its different sizes and characters: *i.e. Deschampsia;* 5-8% (Antarctic grass), Poaceae ; 2-4% (20-40 m) & Poaceae ; < 1% (40-80 im) respectively. Moss spores (10.5-12%) are represented in moderate value. Fungal spores and fruiting body encountered in low values are indicative of saprophytic in nature (Fig. 4).

In the second phase, around 5000 years BP, the improvement in overall palyno-assemblage indicates warm and humid climatic conditions, wherein the increased value of *Cosmarium* (13-22%) along with dinoflagellates and diatoms and simultaneous decrease in Acritarchs (1.5-6%) have been observed, due to which the lake became wider than before. During this phase, the frequent occurrence of grasses among which *Deschampsia* ; 8-16%, Poaceae ; 15-27% (20-40 im) and Poaceae ; 2-12% (40-80 im) indicate luxuriant growth in the region; whereas, the tree pollen taxa like *Larix* (4-15%) shows good values and *Betula, Podocarpus* and Moraceae etc are encountered in low values. Other nonarboreal taxa like Chenopodiaceae, Caryophyllaceae, Asteraceae (tubuliflorae) and *Artemisia* are recorded in low to sporadic values . Monolete fern spores are scanty . Moss spores are continuously showing high values (18-24%). Fungal fruiting body and spores are encountered in almost same values as before. The occurrence of most of the plant taxa, excepting moss spores and other cryptogams already growing, supposed to have been drifted away from surrounding islands/continents which still needs to be investigated.

In the last phase, during 3000 years BP, the climatic condition seems to have once again deteriorated as inferred by the decline in grasses *(Deschampsia* 1-3% & others upto 18%) as compared to the preceding phase; and the disappearance of most of the herbs from the scenario. The low frequency of *Cosmarium* (4 - 6%) along with diatom & dinoflagellates

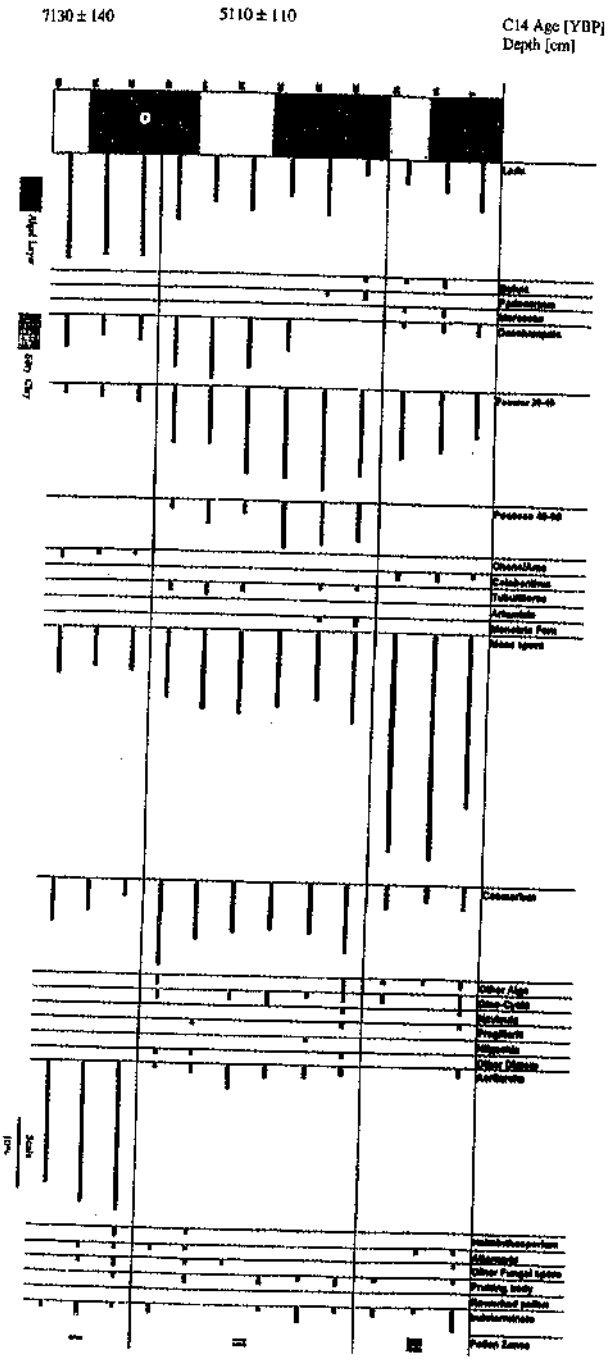

Fig. 3: Pollen diagram from Zub Lake, East Antractica

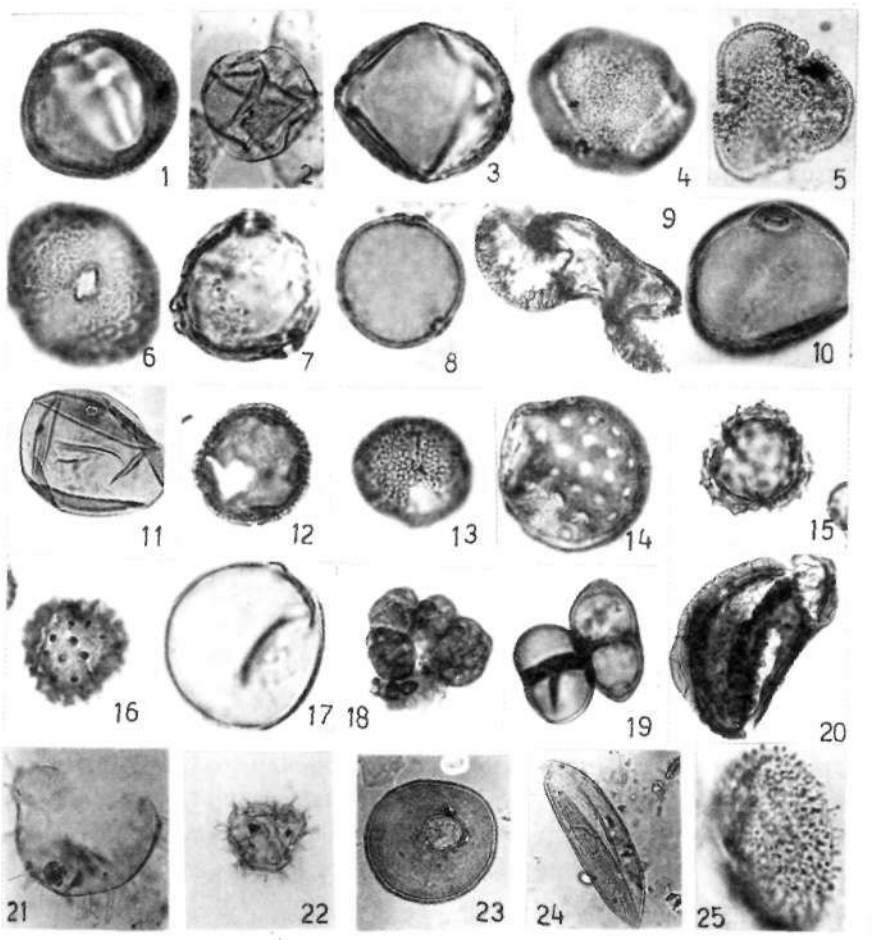

Fig. 4: Palynomorphs recovered from various sediments, East Antarctica
Explanation of plate (X 1000): 1. Euphorbiaceae; 2. Larix; 3-4. Fabaceae; 5. Salmalia; 6. unknown; 7. Betula; 8. Moraceae-Urticaceae; 9. Podocarpus; 10. Deschampsia; 11. Poaceae; 12-13. Rubiaceae; 14. Cheno-Ams.; 15-16. Asteraceae (tubuliflorae); 17-19 & 24. Unknown; 20. Reworked pollen; 21-22. Dinoflagellate cyst; 23. Algal cyst; 25. Acritarch

which is indicative of shallowness of the lake under warm and more humid climatic regime. There is no change in the value of fungal spores as compared to the preceding phase. The higher representation of moss spores (46-60%), for the first time in the assemblage during this phase, are supportive of extremely harsh climatic conditions and lasts till present. There is no such marked change in the value of fungal spores.

Conclusion

The poverty of Antarctic vascular plant flora, containing only two species, may have discouraged pollen analytical work but the pollen diagrams can be made through the study of lake sediments from Antarctica. The palynomorphs encountered can be divided into a strictly local and transported components. Explanation of changes in past local vegetation should first be attempted in terms of changes in past local factors such as hydrology, slope processes, snow cover and nutrient status, since past climatic change often plays an indirect role by influencing these factors. Moreover, a detailed study on deeper sediment profiles, moss, peat and glacial clay varves is required, which are existing in the region, for understanding local peat development for reconstruction of past climate, as well as the palaeowind current around the polar region. For this, a beginning has been made through the present study.

Acknowledgements

The author thanks Prof. A.K.Sinha, Director, BSIP for initiating the Antarctic research and constant support right from the inception of the project till date in all the activities of the project. The author is also grateful to the DOD, New Delhi for all sorts of cooperation needed for participation in the 19th expedition. Finally the author wishes to record his gratefulness to Shri Arun Chaturvedi, Leader of the expedition, for extending all possible cooperation especially for coring operations.

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