Antarctic Geoscience
Ocean-Atmosphere Interaction and Paleoclimatology

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Introduction

Antarctic Geoscience Ocean atmosphere interaction and Paleoclimatology is a collection of papers arising from a Seminar held at the National Centre for Antarctic and Ocean Research (NCAOR) Goa in November 2003 concurrently with the Annual Meeting of the Geological Society of India.

'Why study Antarctica?

Any answer to this question must first and foremost contend with the two seemingly diffeient but strangely inter related aspects of this icy continent the cold desolate geographically isolated and inhospitable piece of land which challenges the human psyche to reach out understand and conquer on the one hand the very pristine and geographic isolation that offer unique opportunities for research in a variety of disciplines which contribute to understanding problems outside the Antarctic on the other. The transformation of this region from a hostile land beyond the Southern Oceans for the adventurers whalers and the seal hunters into a continent primarily for science as enunciated in the spirit of the 1959. Antarctic Treaty is perhaps one of the most significant fallouts of The International Geophysical Year (IGY) of 1957- 58. This emphasis was soon to metamorphose into a newer concept natural reserve harmonising the interests of science environmental protection and conservation as highlighted by the Environmental Protocol.

At present science is the *force- rigueur* for the several scientists and support staff from over 30 nations working in Antarctica on both national and international projects in a range of disciplines .Tourism comes next And adventure is the common bond between both the scientists and the tourists.

What precisely is the Science of Antarctica?

Throughout the history of its existence, Antarctica has occupied a key position in the growth and lateral motion of the global plates .During the Paleozoic and early Mesozoic eras it formed part of a super continent Gondwana before separating from other continents 140 -160 million years ago. Alfred Wegener s hypothesis of continental drift was partially substantiated by Antarctic research which provided the basis for the theory of global plate tectonics Fossil remains of land based mammals and vegetation in an icy continent currently lacking such creatures and flora matched discovenes in other continents and ensured Antarctica 's importance in contemporary geological studies . In turn,

this linkage, suggesting continuities with geological structures on other continents, has influenced assessments of Antarctica's mineral resource potential.

Antarctica, its associated ecosystem and the Southern Ocean also play a critical role in the Earth's climate system. Regional processes on the icy continent and its surrounding oceans have important global consequences, from atmospheric composition to ocean circulation.. The region is also vulnerable to change in our global environment, potentially giving rise to strong feedbacks, which could accelerate climate change .When meteorological observations began during IGY, the main preoccupation was to establish the climatology of the gas. It was however, not until the mid-1980s that Antarctica was thrust to the centre stage in climatological studies with the observation that contemporary environmental problems (eg. the globally-dispersed air pollution, the ozone hole) arise primarily from global phenomena expressed in, rather than arising out of Antarctica.

The thick Antarctic ice cap is also an invaluable archive of global atmospheric environmental and climatic conditions. Proxy records of the climate system from the ice cores of Antarctica as well as the sediments from the Southern Ocean provide a detailed recoid oi past global climatic conditions dating back to the Holocene and the last glaciation .Comparison of these records with information from the high latitudes of the northern hemisphere also highlight the highly textured spatial distribution of centennial to millennial-scale high amplitude high frequency global climatic perturbations. An understanding of the forcing functions behind such naturally occurring abrupt climate changes and the inter hemispheric phase linkages is critical for any predictive modeling of future climate changes. Shallow ice cores from Antarctica have also yielded information on the anthropogenically induced perturbations to atmosphenc conditions since the era of industrialization.

Clearly Antarctica has proved itself as a continent for science offering insights into issues possessing both a contemporary and future significance.

The papers in this volume represent an attempt to bring together some synthesized concepts and real examples of the contributions by the Indian geoscientific and atmospheric science communities over the past two odd decades. The bias is certainly on Antarctic geoscience and on the atmosphere over Antarctica given the significant contributions of the Indian scientists in these realms. However the papers are not restrictive in scope and content. Indeed a conscious effort has been made towards providing a freewheeling assemblage of scientific work ranging from relevance of Antarctic Geoscience in the Indian context to forecasting storm surges to the groundwater potential in parts of Maharashtra. The common thread linking all these contributions is proclivity of the scientist to be curious about his surroundings, to ponder over

the whys and hows and the dispassionate way in which the seemingly mundane is transformed into exciting scientific literature.

The volume is divided into six parts .The first eight papers are devoted to the geology glaciology and environment of Antarctica .The scene is set by Rasik Ravindra who provides an overview of the significant strides made by the Indian scientific community in the field of Antarctic geoscience over past two odd decades. The geoscientific component has been an integral part of every Indian Scientific Expedition to the icy continent leading to an acquisition of wealth of data pertaining to the geology geomorphology geophysics and glaciology of the central Dronning Maud land of east Antarctica .The six papers that follow dwell at length on some of the pioneering work and significant results of the studies undertaken by the geoscientists from the Geological Survey of India the Jadavpur University, Wadia Institute of Himalayan Geology and the Physical Research Laboratory. This section is rounded off with in outline of the Environmental Code of Conduct for Antarctica and of India s endeavors in contributing to Specially Protected Areas and Specially Managed Areas in Antarctica as dictated by the provisions of the Protocol on Environmental Protection to the Antarctica Treaty.

Geomagnetism and the havoc that intense and super intense geomagnetic storms can wreak on space weather and for technological systems on ground is covered in the next paper by the scientists the Indian Institute of Geomagnetism. Utilizing the ground magnetic data from the Alibag Observatory and from Maitri Antarctica as well as the magnetic field and plasma data from the NASA' s ACE spacecraft the authors have computed the energetics of 9 intense geomagnetic storms that occurred during the period 1998-2001. Some of the catastrophic consequences of intense and super intense magnetic storms on telecommunication navigation etc are also discussed highlighting the relevance of such studies for a technologically dependent society as ours.

Appreciatmg the importance of Antarctica as a focal point for global change research India like many of the other Treaty Nations with a sustained presence in Antarctica has set up state of the art instrumentation systems for continuous monitoring of such atmospheric parameters. such as the greenhouse gases column ozone water vapour, UV- B radiation aerosol optical depth vertical profiles of ozone etc .Jain describes the salient features of some of the highly sophisticated systems such as laser heterodyne, ozonometer,sun photometer and the gas chromatograph installed at the Indian Antarctic base Maitri and some of the significant results of ozone profiling averaged total water vapor column atmospheric CO, CO_2 and CH, undertaken by the National Physical Laboratory between 1997 and 2004.

The first unequivocal signs of global warming may well appear in Antarctica Few parts of the world would remain unaffected by any melting of

the vast Antarctic ice sheet, given its capacity to raise sea levels by some 55-80 metres Certain countries, like the Maldives, might disappear, while the low-lying areas of all countries would be severely affected P. C Sinha in his paper provides an overview of the global warming scenario and its potential impacts on the sea level, both on a longer-term as well as shorter term perspective, with special reference to the Indian coastline. Global warming is also expected to increase the frequency of tropical cyclones, which have an important bearing on instantaneous sea level rise, better known as storm surges Such sudden rises in the sea level can now be estimated quite accurately by several models which have been developed for many parts of the World One such real time storm surge prediction system for the east coast of India which has been developed at ET Delhi is described by Dube (this volume), who also provides the results of the model-computed storm surges associated with October 1999 Orissa cyclone.

The papers grouped under *Paleoclimatology* draw attention to the tools available for reconstructing the paleo-environment, be it from the archives of the ice core or the lake sediments of Antarctica, or the speleothems or the sediment records of the Arabian Sea. While Bera and Sinha touch upon the various aspects of paleoclimatic information from the Antarctic archives, Yadava and Ramesh as well as Thamban and Rao, dwell on the past variabilities in monsoon intensity over India, as deciphered from the proxy records of variations in the stable isotopic composition of stalactite carbonates, and from variations in clay mineral composition, respectively. In contrast, Nigam highlights an interesting aspect related to the use of variations in isotopic composition of planktonic formaniferal tests as a proxy for paleoclimatic variabilities, namely, the species longevity .Since the longevity of foraminifera would (might?) decide the physicochemical parameters at which they had incorporated the isotopic signals, this hypothesis, if tenable, will have far reaching consequences for planktonic forammifera based paleoclimatic reconstructions.

The final six papers included in this volume offer some thoughtful insights into geoscience in India, and relating to India .The canvas is fairly vast, ranging from Vaidhyan paleomagnetism through computer programs for P .T calculations to Precambrian geochemistry and suspended sediment - flux studies .These papers represent some of the most interesting presentations made at the Seminar, under the General Theme Topics While site-specific case studies may seem anachronistic in a book dealing with the broader facets of Antarctic and Ocean Science, the wide lange of techniques and approaches detailed in these papers would certainly be of immense use to the Antarctic geologist as well.

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