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Guest Column

Polar research in India.

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India has great strides in Polar sciences since the first Indian Scientific Antarctic Expedition. It has bi-hemispherical approach to Polar science and have permanent stations at Antarctic. Recently, 'Himadri' the Indian research base at Arctic have been established in 2008. Atmospheric science, geosciences, biology, environmental sciences, human physiology, medical science, cold region engineering and communication are the prime programs pursued consistently as a part of Polar research. Monitoring of fluctuations of the Antarctic sea ice indicate an increase of about 2.4% increase per decade. Systematic geological mapping of about 20, 000 sq.km area of east Antarctica had been completed. Many scientific institutions like Geological Survey of India, India Meteorological Department, Survey of India, Zoological Survey of India, Botanical Survey of India, DRDO and CSIR are regular participants in annual Indian Scientific Expeditions to Antarctica. There is a substantial increase in the financial support to the Polar research. The National Center for Antarctic and Ocean Research established in April 1999 is mandated to plan, promote, coordinate and execute the polar research program of India, as the nodal agency.

Key words: Polar, Antarctica, Arctic, mapping, ozone, continent, expedition

Ministry of Earth Sciences is emerging as knowledge and information enterprise for the Earth System Science realm for societal benefits. It is our endeavour to provide the nation with best possible services in forecasting the monsoon, timing and non-timing components, weather advisories for agriculture, aviation, shipping, ocean state system, distress such as cyclone, earthquakes, tsunamis, coastal and marine eco-systems, polar science research and climate change. One of the major component of the Earth system is cryosphere and related issues.

India joined the leading nations of the world engaged in the Antarctic exploration in 1981 on the initiative of the then Prime Minister Late Smt. Indira Gandhi. Since then annual scientific expeditions have been continuing. India has made great strides in polar sciences. This has paved the way for the country to sustain its scientific endeavor in the icy continent on a year-round basis, from the Indian Permanent stations "Dakshin Gangotri" (1983-89) and "Maitri" (1989 – till date) (Figs. 1 and 2). The infrastructure available at the Indian station has enabled the scientist to conduct front-ranking research in the contemporary areas of polar science and technology. Several of these research programs have contributed directly to global experiments mounted under the aegis of the Scientific Committee on Antarctic Research (SCAR), and have had as active partners such as Germany, Italy, France, and the United States.

Fig. 1: First Indian research base in Antarctica "Dakshin Gangotri"

Fig. 2 : Second Indian research base in Antarctica "Maitri"

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Today the Indian Antarctic Research programme is one of the finest examples of a long-term research effort of key national research institutions. It is also an important component of international scientific community's effort to understand this remote continent which plays a key role in the global climate due to its pristine nature and being store house of ice that has archived records of global and regional significance for hundreds of thousands of years. Indian contributions to the knowledge of polar science, over last two and a half decades, have been significant, well recognized internationally and published in scientific journals. The scientific programs being pursued in the Antarctica broadly fall in eight major domains, viz: atmospheric science, geoscience, biology, environmental sciences, human physiology, medical science, cold region engineering and communication. The regular participating institutions in annual Antarctic expeditions are Geological Survey of India, India Meteorological Department, Survey of India, Zoological Survey of India, Botanical Survey of India, DRDO laboratories (Research and Development Establishment (Engineers), Defense Electronics and Application Laboratory, Defense Institute of Physiology Allied Sciences, Defense Agricultural Research Laboratory, etc.), CSIR laboratories (National Geophysical Research Institute, Centre for Cellular and Molecular Biology, National Botanical Research Institute, National Environmental Engineering Research Institute, National Physical Laboratory, Structural Engineering Research Centre, Central Food Technological Research Institute, National Institute of Oceanography, Regional Research Laboratory, National Aerospace Laboratories, etc.), DST laboratories (Birbal Sahni Institute of Paleobotany, Indian Institute of Geomagnetism, Wadia Institute of Himalayan Geology, etc.), academic institutions like IITs and Universities and other government departments (Fig.3).

Some of the major initiatives by these institutions include: continuous recording of weather parameters, monitoring of greenhouse gases and operation of seismic, geomagnetic and permanent GPS observatories, glaciological studies to monitor the health of glaciers and shallow ice core drilling to

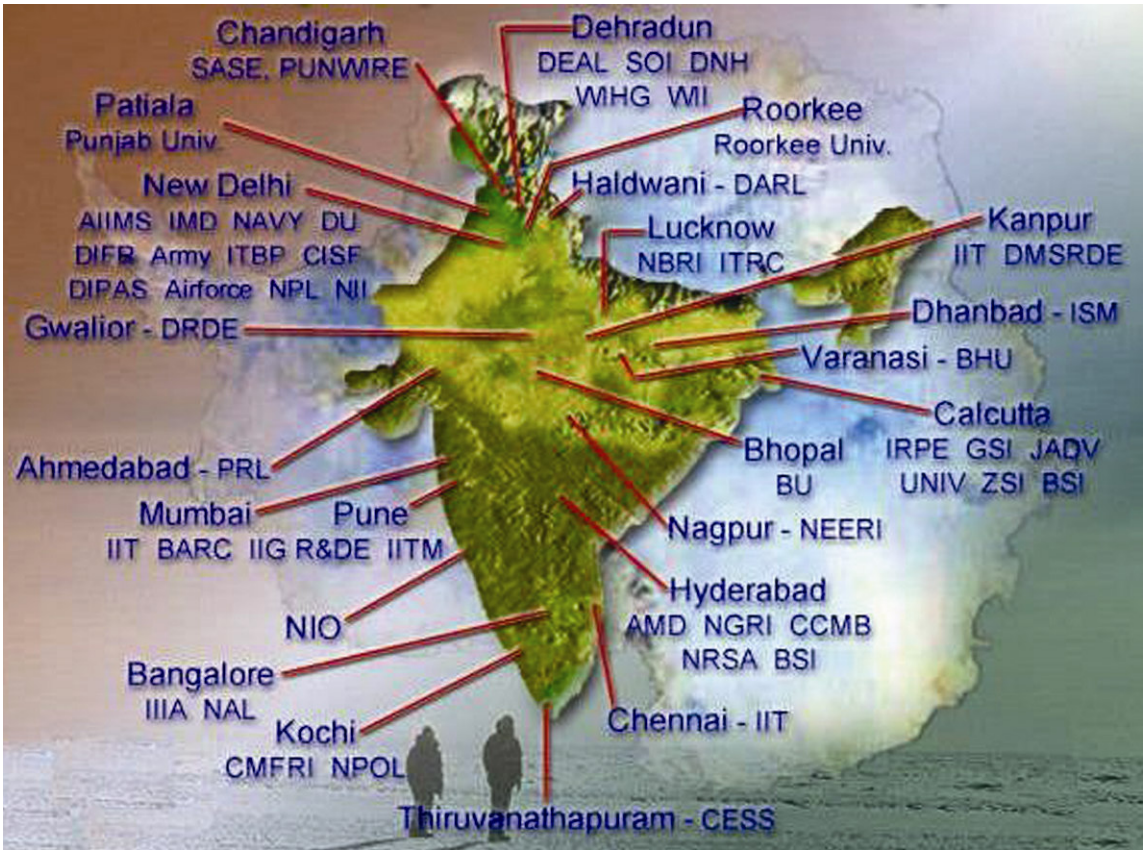

Fig. 3 : Participating organizations in the Indian Antarctic Expedition

decipher climate changes in the Holocene. Indian scientists are also working on cold adaptive microbes, mosses and lichens and have mapped the biodiversity in this region.

The major outcome of the Antarctic expeditions are as following;

(a) Systematic geological mapping covering an area of 20,000 sq km area in Central Dronning Maud land of east Antarctica. The following four geological maps have been brought out for the use of international scientific community.

- Geology of the Schirmacher – Wohlthat region, central Dronning Maudland, Antarctica (scale 1 : 2,50,000)
- Geological map of the Schirmacher oasis, central Dronning Maudland, east Antarctica (scale 1 : 25,000)
- Geological map of Orvinfjella, central Dronning Maudland, east Antarctica (scale 1 : 1,50,000)
- Geomorphological map of Schirmacher oasis, central Dronning Maudland, east Antarctica (scale 1 : 25,000)

(b) Monitoring of fluctuations of the Antarctic sea ice extent pattern of the Antarctic shelf using Scanner Multi Channel Microwave Radiometer (SMMR) data (1979-87), Special Sensor Microwave/Imager (SSM/I) data (1988-98) and brightness temperature derived from 18GHz channel with horizontal polarization of Multi-frequency Scanning Microwave Radiometer (MSMR) during June 1999 to September 2001. The results are indicative of an increase of about 2.4 % per decade in sea ice since the last 15 years.

(c) Satellite-based GPS monitoring of the continental ice indicates that the velocity of the ice sheet in this area ranges from 1.2 to 8.5 m per annum. Also, the Schirmacher Oasis acts like an obstruction and the ice sheet flows around it.

(d) Palaeoclimate studies during Holocene in the state of the art ice core laboratory at NCAOR, Goa. High-resolution glacio-chemical analyses, carried out for a 62.2 m long ice core (representing the last ~500 years) recovered from the Central Dronning Maudland revealed the existence of several outstanding peaks that can be attributed to the sulphate aerosol deposition during large volcanic events as recorded in the Antarctic and elsewhere

(e) Discovery of about 25 new species of microbes hitherto not reported from the Antarctic region. Some of these microbes do have biotechnological potential.

(f) Continuous monitoring of ozone in Antarctica (Figs.4 a-b; Table 1). The results reveal Tropospheric ozone below 250-hPa levels has remained practically unchanged. The lowest Tropospheric values of 10 nb occurs between 300 and 500 hPa. Drastic changes in ozone amount occur between 100 and 30 hPa year after year. This is the region where maximum ozone (~ 150-170 nb) is usually recorded from

Fig. 4a : Ozonesonde launching in process at Maitri.

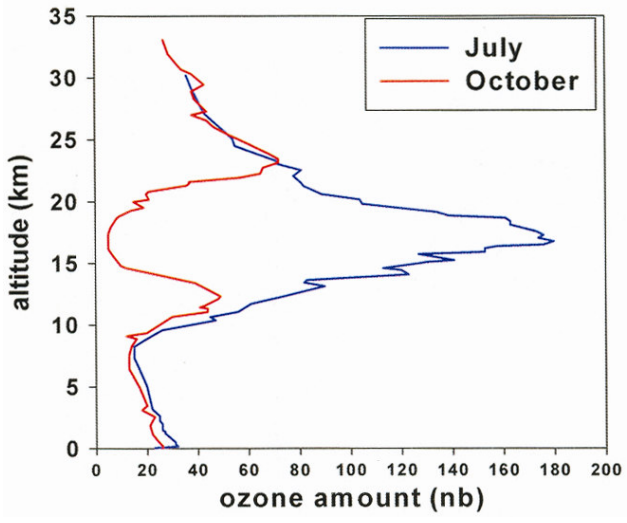

Fig. 4b : Average vertical profile of ozone for the month of July (Normal) and October (Depletion).

January to June every year. However a region of low ozone (10-50 nb) concentration is also reported at the same level during the month of September- October every year. This is popularly called "Ozone Hole". During the depletion period atmospheric ozone was found considerably depleted at some levels between the levels 110 hPa and above. The minimum ozone value in this layer which was of the order of 50 nb during 1987-88 has further decreased to 5-10 nb during recent years and the vertical depth of ozone hole and period of occurrence has been increasing from year to year. The ozone observations from other stations over Antarctica also support above view that ozone hole has been increasing in horizontal and vertical area and total column ozone is becoming thinner.

(g) Establishment of satellite connectivity between Indian research base Maitri in the Antarctic and NCAOR, Goa. This was made operational by installing 3.2 meters C-band antenna enclosed in a RAYDOME at Maitri. With the installation of a corresponding 7.2 mts C-band antenna at NCAOR, Goa, it is providing 24X7 @ 1 mbps connectivity with facility of video conferencing and real time data transfer between Maitri and NCAOR (Fig. 5).

In order to catalyse and consolidate the gains accrued from the various Indian Antarctic Expeditions and to stimulate research in the frontier areas of Polar and Ocean Sciences, the erstwhile Department of Ocean Development (presently, the Ministry of Earth Sciences), as per the recommendations of an Expert Study Group constituted by it in 1984, established the "Antarctic Study Centre" at Goa in 1988. Subsequently, on the 25th May 1998 the attached office was registered as an autonomous society under the Societies Registration Act of Goa. The "Antarctic Study Centre" was renamed as "National Centre for Antarctic and Ocean Research" on April 5th 1999.

This premier polar laboratory of the Ministry of Earth Sciences is mandated to plan, promote, co-ordinate and execute the entire gamut of polar science in order to ensure a perceptible and influential presence of India in the Antarctica and to uphold our strategic interest in the global framework of nations in the Southern Continent and the surrounding oceans (Fig. 6). The Centre has also a well-focused scientific mandate of initiating and supporting basic and

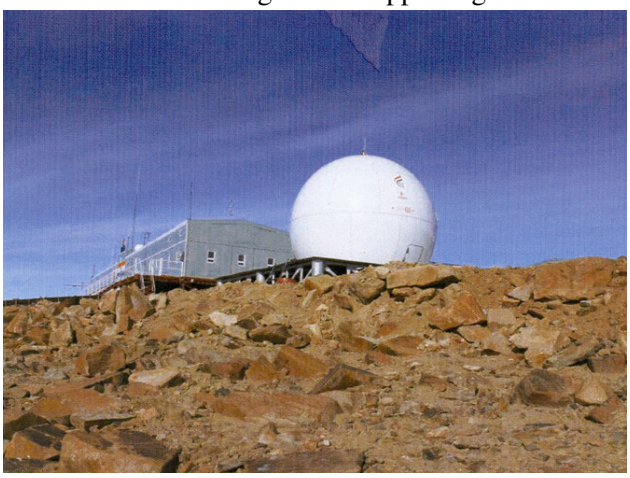

Fig. 5 : Earth station at Maitri to provide 24 X 7 connectivity with NCAOR, Goa

Fig. 6 : The National Centre for Antarctic and Ocean Research, Goa,(Nodal agency for Indian Antarctic programme)

Table 1—Frequency distribution of ozone values during ozone hole period (August to December) observed over the Maitri by TOMS

Year	Days of observations	Values less than 135 DU	Values less than 150 DU	Values between 150-220 DU	Values above 220 DU	Days of Ozone
1997	135	1 (0.74%)	11 (8.1 %)	50 (37 %)	73	45.1 %
2002	140		0 %	29(20.7 %)	111	20.7 %
2003	138	4 (2.8 %)	22 (15 %)	65(47.8 %)	66	62.7 %
2004	125	0 %	4 (3.2 %)	71 (56 %)	50	60 %

applied research in a variety of scientific disciplines and themes in the contemporary areas of polar science and technology. This scientific mandate recognizes, the need to understand the relationships of the polar, atmospheric and southern ocean realms vis-à-vis global processes, the importance of the Antarctic and Southern Ocean regions for our understanding of the global environment, the need to understand these regions as unique entities, and the opportunities presented by these realms as research platforms.

With the growing concern world over on the global climate change, the study of the physical and environmental parameters in polar regions, especially Antarctica has become vital. The ice core drilling program, study of various proxies on palaeoclimate available in ice cores, melt water lake sediments, terraces, glaciers and pollens, microbial biodiversity and effect of temperatures and environment on delicate ecosystem of the Antarctica are some of the issues that will form the focus of study in years to come. The Indian interest in the Antarctica is also of immense geo-political significance because of India's geographical location and its proximity to the icy continent through the Indian Ocean.

The Ministry of Earth Sciences, Government of India is committed to support Antarctic Programme of the country. There has been a steady rise in funding the country's polar programme during the last 28 years (Fig. 7) with a budget of Rs. 44.50 crores during current financial year (2008-09). The setting up of another station at the Larsemann Hills region of East Antarctica (Fig. 8) has been a significant move towards strengthening of the Indian Antarctic Programme.

It is a known fact that Arctic Ocean and the surrounding regions are one of the most important areas that not only govern the earth's climate but also faithfully record its past climatic history. Any change in extreme Northern hemisphere (Arctic region) can affect the global climate, sea level, biodiversity, etc. The region is also of special significance to the Indian subcontinent as several studies have shown that there exist a tele-connection between the northern polar region and Indian monsoon intensity, which forms the backbone of Indian economy. The exact mechanism by which this tele-connection exists is still open to debate and is a topic of ongoing research

Realizing the scientific importance of the Arctic

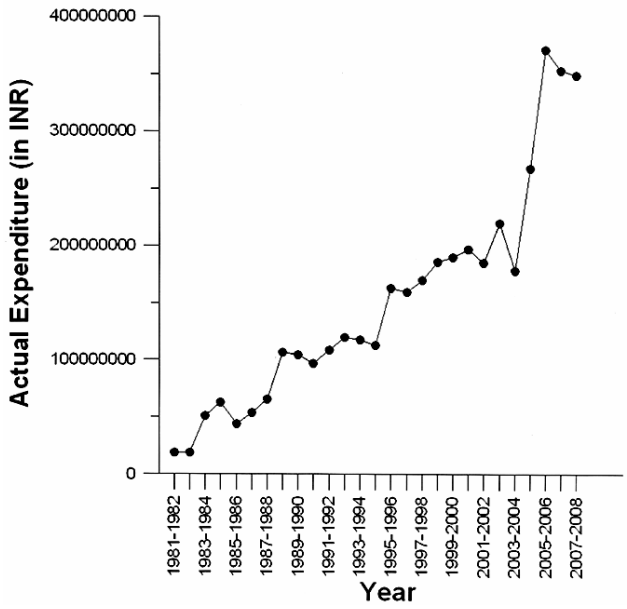

Fig. 7 : Yearly expenditure incurred on Indian Antarctic Expeditions for the period 1981 - 2007

Fig. 8 : Location of third Indian research base at the Larsemann Hills in East Antarctica. Artist's impression of the proposed research base (Inset)

the Ministry decided the extension of the country's scientific endeavors to the Arctic realm as well so as to have a bi-hemispherical approach to country's Polar Sciences. To begin with scientific programes like inventorisation of microbes from various habitats of Arctic, as well as an evaluation of their population dynamics as biological indices of change in season, anthropogenic factors, simultaneous and continuous measurements of atmospheric electrical field, conductivity, and the concentrations and size distribution of atmospheric aerosols; study of space weather effects on polar ionosphere; understanding the geological and geomorphological evolution of the area; study of glacial landforms of the area;

Fig. 9 : The Indian research base 'Himadri' at Ny-Alesund (Arctic).

parameterization of glaciers in the Northern Hemisphere to variations of climate; study on carbon monoxide and its diurnal variability; paleo-oceanography of the Arctic Ocean for exploring possible linkages with tropical (Indian) climate changes, etc. are being addressed.

In order to support the Arctic research of the country, Indian research base 'Himadri' (Fig. 9) at Ny-alesund (Arctic) was established in 2008. This is India's first full fledged research station in the Arctic region. The research base will be used for conducting round the year scientific research in contemporary fields of the Arctic science with special emphasis on climate change. With the opening of the Indian research base in Arctic, NCAOR has become the 15th institution to have its permanent station at Ny-Alesund. India has become the 10th country to have established its research station at Ny-Alesund (Arctic).