

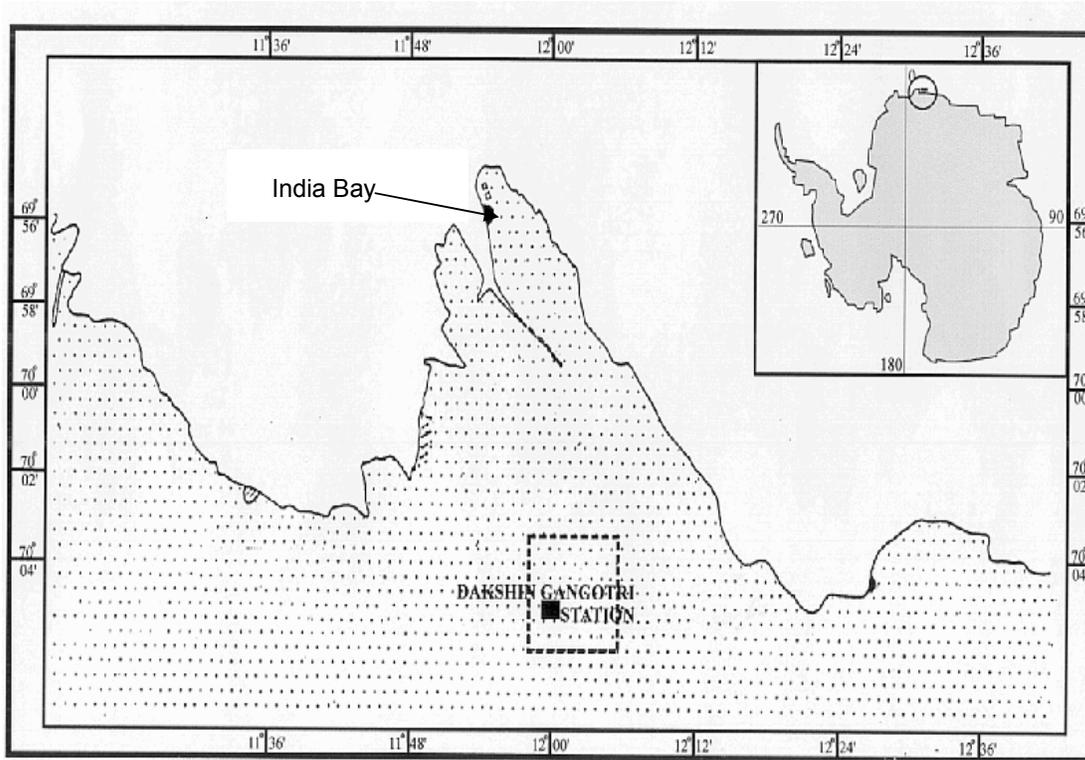
1. INTRODUCTION

1.1 History of Indian Antarctic Research

1.1.1 Dakshin Gangotri

The importance of Antarctica as a pedestal for front-ranking scientific research was recognized by India in 1981, when the first Indian Antarctic Expedition was launched. Since then, India has made great strides both in Polar Sciences and related logistics, through a judicious and harmonious blend of multi-institutional expertise, brought together under the umbrella of the Ministry of Earth Sciences (earlier Department of Ocean Development). This has paved the way for the country to sustain its scientific endeavor in the icy continent on year-round basis ever since 1983, when the first permanent Indian Antarctic Base “Dakshin Gangotri” ($70^{\circ} 5' 37''\text{S}$; 12°E) was commissioned on the ice shelf, off the Princess Astrid coast in Central Dronning Maud Land (Figure 1).

Figure 1 : Location of Dakshin Gangotri Station and India Bay



The station made of wood huts and built in the record time of an austral summer, continued to host the members of Indian expeditions to Antarctica till 1989, when it had to be decommissioned due to excessive snow accumulation (Figure 2). The area has since been designated as historical site, HSM 44.

Figure 2 : Dakshin Gangotri Station



(In 1983)



(In 1990)

1.1.2 Maitri

In the year 1988 an ice free, rocky area on the Schirmacher oasis was selected to build the Second Research Station “Maitri (70°45’52”S: 11°44’03”E). The building (Figure 3) was erected on steel stilts, and has since stood the test of time. The infrastructure available at the station has enabled the scientists to conduct research in various disciplines such as Atmospheric Sciences & Meteorology, Earth Sciences including Glaciology, Human Biology & Medicine, Biology & Environmental Sciences etc. Maitri also serves as a gateway to one of the largest mountain chains in central Dronning Maud land, located south of Schirmacher. About 20,000 sq. km. area in Wohlthat, Orvin, and Muhlig Hoffmann Ranges have been geologically mapped by Indian scientists, making Maitri as their base Station. Several research programs initiated by India in the Schirmacher oasis and its environs have also contributed directly to global experiments mounted under the aegis of the Scientific Committee on Antarctic Research (SCAR). Maitri has also provided a platform for collaborative studies with some Antarctic Treaty nations i.e. Germany, Italy, France, Poland and the United States of America. It has also facilitated scientists from Malaysia, Columbia, Peru and Mauritius to work in Antarctica. A collaborative research is also being planned with Norway and AFOPS member countries.

Figure 3: Maitri Station at Schirmacher Oasis, East Antarctica



1.1.3 Scientific Studies in Antarctica

Ever since 1981, the Indian endeavors in the icy continent have continued uninterrupted and annual scientific expeditions to Antarctica have remained one of the high priority scientific activities of the country. Till date, twenty-six expeditions have been successfully launched. In addition to these, four special expeditions to the Southern Oceans and Antarctic waters

have also been undertaken. These expeditions have provided an avenue for over 1600 scientists and logistics personnel from more than 60 national laboratories, universities, and research institutes to conduct experiments/studies in some of the frontier areas of polar sciences. The studies have contributed significantly to a better understanding of the state of the Antarctic environment in general and of the central Dronning Maud land in particular. Many of the scientific studies have continued uninterruptedly since 1985 and have produced important results and a substantial database

Salient highlights of the Indian scientific activity in Antarctica are as follows:

Earth Science

Indian geologists have systematically mapped about 20,000 sq km of the area in central Dronning Maud land on 1:50,000 scale. Three geological maps of Schirmacher Oasis, Wohlthat and Orvin Mountains (GSI, 1991,1999,2006) and a geomorphological map of Schirmacher Oasis (GSI, 2006) have been released so far. Monitoring of glacier snout and the continental ice margin, on a regular basis has revealed significant retreat of the ice margin in last two decades (Chaturvedi & Ravindra 2001).

A permanent GPS station at Maitri is contributing to understanding the inter-plate motion and crustal deformation between India and Antarctica (Ravikumar and Malaimani, 2000). The station has been tied up geodetically with other ITRF reference stations. The Seismological Observatory at Maitri is a part of the Global Seismological Network and contributes the data to USGS, ISC (UK) and AnSWER. Absolute gravity measurements too have been initiated to address the crustal deformation studies in conjunction with GPS for complementary verification, determination of geoid, glacial rebound and determination of sea level rise.

Ice cores drilled from the continental ice, south of Maitri, have been analyzed to evaluate the temporal changes in environmental characteristics during past few centuries. Results show that temperatures at the beginning of this period were about 2^o C cooler than today (Nizampurkar et al., 2002). The ice core studies also indicate that the sulfate aerosol deposition is related to the volcanic eruption (Thamban et al, 2006). The nitrate profile reveals a systematic negative shift since mid 18th century, suggesting a possible change in the zonal wind transport and an apparent solar modulation of the same.

Upper Atmosphere and Astronomy

Ozone profile by Laser heterodyne and Radio spectrometer has shown a 3% to 68% depletion in ozone concentration in the height range of 13 to 40 km. Effect of planetary wave on dynamical behaviour of the polar vortex has also been established (Jain et al, 2004). Sunphotometer, UV related studies and optical astronomical experiments have been conducted for monitoring auroral emission. Regular monitoring of the greenhouse gases such as CO₂, CH₄ and CO is also being done at Maitri. The results have shown that there is an increase of 1.3 ppm of CO₂, whereas CH₄ concentration is relatively stable with an average value of 1.699 ppm.

During the total solar eclipse over Antarctica on 23 November, 2003, shadow-band activity resulting from the illumination of the turbulent atmospheric boundary layer was studied. The results reveal that the average width of the bands is in the range of 20-50 cm with comparable separation between bands and the speed of their movement at about 5-10 meters per second (Bagare et al., 2005).

Meteorology

Micrometeorological data is recorded hourly and transmitted on real-time basis. Indian station Maitri is included in the WMO network of synoptic stations and has been assigned the index number 89514. Ozone monitoring has been continuing since 1987.

Geomagnetism

Interaction of sun's atmosphere with earth magnetic field and magnetic storms that are produced by the solar activity, affect the technical aspects of satellite operation and communication systems. Instruments like Radiometer/Flux gate Magnetometer have been installed to observe the geospace interaction. Statistical occurrence of storms and sub storms with intensification of auroral electro jet currents is being studied. It has been established that during quiet time, the Indian station occupies a sub-auroral position (Rajaram et al., 2002). Since Antarctica is recording a greater drop in the Total Magnetic Field Intensity than the global average, and Maitri falls in a 'region of Reverse magnetic Flux', continuous monitoring of 'F' values as recorded here is of significance.

Environmental Science and Biology

Psychrophilic bacteria play an important role in sub zero activity in Antarctica. So far around 125 new species have been discovered from Antarctica of which India has contributed around 20 new species. (Shivaji et al., 1989; Reddy et al., 2002a,b, 2003 a,b,c,d). Two new species, *Arthobacter Gangotriensis* and *Planococcus Maitriensis*, are named after Indian station Dakshin Gangotri and Maitri respectively (Alam et al., 2003; Gupta et al., 2004).

1.2 Planned Scientific activities at the new base

The proposed research base is expected to cater to a myriad scientific activities in some of the frontier areas of atmospheric, earth, ocean, biology and environmental sciences. The close proximity of the base to the Australian, Chinese, Romanian and Russian stations would go a long way in fostering significant collaboration and co-operation in polar science.

1.2.1 Meteorological and atmospheric studies

Meteorological data acquisition shall be with real time data transmission capability to be used worldwide for various studies. A high resolution multi-parameter AWS shall be installed to acquire the data. Other atmospheric studies to be conducted are as follows:

- Aerosol Radiative Flux estimation using Sky Radiometer
- Aerosol size distribution using multi-channel sun-photometer for solar terrestrial effects and transportation of aerosols.
- Establishment of a geomagnetic observatory and installation of instruments like DFM, DIM, PPM.

1.2.2 Earth Science studies

The Prydz Bay is considered as a key in the India-Antarctica link during Gondwanaland, as the area of Prydz Bay of Antarctica and the Eastern Ghat Mobile belt of India once formed a contiguous landmass. Geologically, the area offers possibilities of detailed correlation between the rocks exposed all along the eastern coast of India (high grade granulite, charnockites, khondalites) with rocks of Prydz Bay area (Kanao et al., 1994, Rao et al. 1995, Yoshida et al., 1999, Brauo and Kriegsman, 2003, Ghosh et al 2004, Mishra et al 2006). Apart from this:

- Integrated geophysical-geological studies will help understanding India-East Antarctic rifted margins and its role in the crustal evolution during Grenvillian and Pan African events

- The study of Lambert Glacier, the fastest moving glacier in Antarctica, opens an exciting new vista in glaciological studies.
- The movement of the continental ice margins along the Ingrid Christensen coast as also the accumulation and ablation pattern of the snow on the coast will be monitored.
- Late Quaternary glaciations in the Vestfold and Larsemann Hills areas remain a topic of intense academic interest.
- The studies on the sediment records available in the lakes of the area will supplement the research pertaining to palaeoclimate by earlier workers (Gillieson et al., 1990; Hodgson 2001, 2005, 2006) beyond Holocene.
- The new research base offers an ideal location for yet another geomagnetic observatory in Antarctica, linking it with the Maitri research station as well as India. GPS will be operated for studies of crustal deformation and atmospheric sciences such as TEC, Scintillation and water Vapor content. Studies on the measurement of current drift of the Indian sub continent with respect to this region of Antarctica will complement similar studies being undertaken by the Indian scientists at Maitri. The GPS station operational at Maitri, which contributes to the International Earth Rotation Services (IERS) for the realization of ITRF 2000, will be linked to this GPS station as well as with the one existing at Davis, under the SCAR-GPS campaign.

1.2.3 Oceanographic studies

Physical chemical and biological oceanographic studies in the Indian Ocean sector of Southern Ocean will receive impetus. A long term and systematic approach regarding the time series observations of hydrographic parameters at different locations in the Prydz Bay area will be carried out to understand the quantity, causes and year to year variability of freshwater input in the Prydz Bay area.

1.2.4 Environmental studies

Supplementing the ongoing studies at the Maitri station to understand the impact of anthropogenic activities on the pristine Antarctic environment, similar studies would be initiated at the new site. Impact not only due to local activity but also due to land-based anthropogenic impact shall be studied, as Antarctic coast is becoming a sink for the aerosol deposition. Aerosol spectrometer, Aethalometer and Multistage Impactor shall be operated around the new site to collect long-term data. Study of particulate matter in water and sediment will provide useful tool to assess the environment.

Determination of other environmental indicators i.e. studies of fauna, their population trends and anthropogenic impacts on other biotic and abiotic factors on the coastal Antarctic ecosystem shall be carried out. These studies will thus generate a spatial spread of data in two widely separated coastal oasis of Antarctica.

1.2.5 Biological studies

Biological studies at the new site have potential to explore new vista in:

- Biodiversity study of sea-ice microbial community
- Conservation of terrestrial & aquatic biota (fungi, lichens, bryophytes, micro fauna like protozoans, nematodes, tardigrades), aerobic bacteria
- Monitoring of wild life population and behavioural studies

Even while using Antarctica as a platform for conducting scientific research, India has always recognized the importance of preserving the pristine nature of the continent, which

modulates the intricate global climate processes. To uphold these commitments, India ratified the Protocol on Environmental Protection to the Antarctic Treaty in April 1998.

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