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International Polar Year and CSIR contribution to Antarctica research

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Polar regions have consistent task in molding the global environment. International scientific collaboration is inevitable for initiating research projects in Arctic and Antarctic for understanding several natural processes. Earlier explorers and scientist had conceived the idea of International Polar Year (IPY) for collective scientific ventures to explore the impact of polar region in sprouting the earth's environment. IPY is the biggest international collaborative scientific venture. IPY has the legacy of many pathbreking findings in science especially on earth and atmospheric sciences. The first Indian scientific expedition to Antarctica was during 1981. Council of Scientific and Industrial Research had specific prime assignments in developing Polar Research in India. NIO, a constituent establishment of CSIR was assigned a significant function in the first Indian Scientific expedition to Antarctica. Scientists working in CSIR laboratories have published more than 120 research papers in SCI journals on the biodiversity of flora and fauna of Antarctica, geology and geophysical aspects, atmospheric sciences and chemical characteristics of marine algae of Antarctica. CCMB one of the constituent establishment of CSIR owns 12.5% of the new species identified by global scientific community in Antarctica. NBRI, another constituent establishment of CSIR owns 12 new species of lichen from McLeod Island, Antarctica. National Physical Laboratory has been planning to setup a fully operational multi-instrument ionospheric real time monitoring facility both at Arctic and Antarctica and planned to run the facility for minimum 11 years. NGRI has achieved a globally major role in maintenance and improvement of a Global Reference Frame.

Keywords: Polar research, Arctic, Antarctic, lichen, cyanobacterium, geodesy, ionosphere

1 Polar Region and International Science Cooperation.

Polar region have enduring importance in the evolution, and changes of our planet. Polar Regions are active, highly connected components of earth. It carries the imprints and hold unique information on the past behavior of this planet and has a unique vantage point for a variety of terrestrial and cosmic phenomena. Polar region acts as the recipient of any changes in nature and echo's these changes elsewhere in the planet. They couple to global climate, sea level, biogeochemical cycles, ecosystems and human activities[1].

The International Polar Year is the idea of early explorers to the Polar Regions. Polar processes extend national boundaries and the fundamental solutions of meteorology and geophysics is indispensable without explorations in Polar Regions. The challenges of geophysical and other sciences are beyond the capabilities of one nation[2]. It requires coordinated international efforts. The principal legacy of International Polar Year is setting a precedent for international science cooperation.

Polar Year is a hall mark of international cooperation in science. First International Polar Year (IPY) was during 1882-83, 125 years ago. The IPY had been sponsored by International Meteorological Organisation (IMO), a predecessor of World Meteorological organization (WMO). By that time, fifteen expeditions to polar region, two to Antarctica and thirteen to Arctic had taken place. Twelve counties had participated in the first International Polar Year. The distribution of arctic stations of the First International Polar Year is shown in Fig 1[3]. The objective of the first IPY was the collective effort for survey of geophysical phenomenon of Polar Regions.

Second International Polar year was held during 1932-33. The International Meteorological Organisation (IMO) had proposed and promoted second IPY. This was the period of discovery of the existence of "Jet Stream". The global implication of newly discovered jet stream was the main streak of second IPY. Forty nations participated in spite of economic constrains due to great depression. Forty permanent research stations had been established in Arctic. First research station inland from the coast of Antarctica (on the Ross Ice Shelf at the southern end of Roosevelt Island) has been established at Antarctica. There was great striving in research in meteorology, magnetism, and atmospheric science during second IPY.

Eminent scientists had conceived the idea to celebrate the 75th and 25th anniversaries of the first

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Fig. 1 — Distribution of Arctic stations of the First International Polar Year

and second IPY. An informal gathering of scientists like Sydney Chapman, James Van Allen and Lloyd Berkner at Washington D C during 1950 had suggested this idea. The purpose was to redirect the technology and scientific advances achieved during the Second World War towards scientific research. The International Geophysical Year (1957-58) was celebrated during 1st July 1957 to 31st December 1958. The International Council for Science (ICSU), which has come into existence during 1931 and the World Meteorological Organization (WMO) jointly, supported the International Geophysical Year (IGY). Sixty seven nations participated with 60,000 researchers and technicians in this scientific venture. Many technologies developed during Second World War was utilized. The vast and consistent synoptic observations resulted from IGY had redrafted many existing thoughts / notions. The total size of Antarctic ice mass had been first estimated after the Geophysical traverses over the Antarctica icecap. The theory on continental drift had been confirmed and accepted. The Van Allen Radiation Belt encircling the earth was discovered. The prime achievement of IGY was the Antarctic Treaty in 1961. Achievements and spirit of scientific cooperation of IGY conferred one more extended year of research under IGY. Exemplary and dedicated venture of IGY pave way for three such committees at globally after IGY. Scientific committees for Antarctica, Oceanic and Space Research had been formed in the legacy of IGY. Unique cooperative scientific projects like 'international Year of the quite sun' were the outcome of IGY. IGY had received wide spread attention and appreciation of scientific community and the general public.

2 Indian Scientific Expeditions to Antarctica

Antarctica expeditions and research become indispensable to India after the confirmation of the theory of continental drift during the IGY. India and Antarctica are part of the Gondwanaland along with Africa, Australia, New Zealand and South America. Antarctica has the imprints of the early days of earth. The mystery of evolution and formation of Indian continent and the origin and diversity of life and land are closely related to Antarctica expeditions. Geo and

bioresearch on Indian sub-continent are incomplete without scientific expeditions to Antarctica. The Government of India launched Indian Scientific Expedition to Antarctica during the year 1981, after two decades of Antarctica treaty declaration at Canberra. India became a part of the Antarctic Treaty on 19th August 1983 and conferred consultative status on 12th September 1983. On 1st October 1984 onwards India is a member of Scientific Committee on Antarctic Research (SCAR). India became a member of Convention on the conservation of Antarctic Marine Living Resources (CCAMLR) in 1986. The environment protocol to the Antarctic treaty had been ratified by India in 1997. India had hosted the XXX Antarctic Treaty Consultative Meeting (ATCM) for the first time on 30th April 2007 at New Delhi. The legacy of International Polar Year is international cooperation in science. The prime dictum of Indian Scientific Antarctica expeditions is to anvil this legacy for scientific achievement and social benefits.

3 CSIR Contribution to Indian Scientific Expedition to Antarctica

Council of Scientific and Industrial Research (CSIR) was the flag-holder of the country in Antarctica during the first Indian Scientific Expedition to Antarctica. National Institute of Oceanography (NIO), the multidisciplinary institute for marine science had been hallmarked for the first Indian Scientific Antarctica Expedition. Dr S Z Qasim, then Director, National Institute of Oceanography was the leader of the first Indian Scientific Expedition to Antarctica. The expedition had been launched on 6th Dec 1981 and the team reached Goa from Antarctica on 21st February 1982. The team consisted thirteen scientists and eight were from the constituent establishments of CSIR. The leader of third expedition was Dr H K Gupta, former Director, National Geophysical Research Institute, and CSIR. The third expedition had successfully established and commissioned the first permanently manned Indian station, "Dakshin Gangotri" at Antarctica. Scientists from the constituent establishments of CSIR viz. National Institute of Oceanography, National Physical Laboratory and National Geophysical Research Institute were leaders of the team for nine Indian Scientific Expedition to Antarctica.

Scientists working in CSIR laboratories were associated with all the twenty-eight Indian scientific expeditions to Antarctica. The Compendium, Contributions of CSIR to Antarctica research, collected reprints brought out by CSIR during the year 2006 is a comprehensive document of the work done by CSIR scientists on Antarctica. The above Compendium consist 116 papers published in SCI journals. These papers consists contribution of Indian scientists on the ecology, physiology, taxonomy and molecular biology of the flora and fauna of Antarctica. CSIR scientists have identified many new species of bacteria, fungi, lichens, moss, algae, protozoan, nematodes, insects etc. Researchers have identified 240 new species of bacteria in Antarctica for the last 125 years. The Center for Cellular and Molecular Biology a constituent establishment of CSIR owns the identification of 30 new bacteria out of the above 240 new species i.e. contribution of 12.5% of the new species identified by global scientific community in Antarctica. National Botanical Research Institute (NBRI) had reported 12 species of lichen from McLeod Island, Antarctica those was new in record of the region.

Scientists from National Physical Laboratory and National Institute of Oceanography had done exhaustive studies on Antarctica related to atmospheric sciences. During the first Antarctica expedition an unmanned automatic weather station was established in the Schirmacher Oasis, Antarctica. Dobson photometer had been installed for ozone measurement in sixth expedition. After the year 1986, i.e., on the sixth expedition, CSIR scientists had established the presence of ozone hole over Antarctica after adducing data on vertical and surface ozone measurements. The measurements of green house gases like CO, CO_2, CH_4 etc had unraveled the climate change over Antarctica. CSIR scientists had published many studies related to the planetary boundary layer program, radiation budget studies and information related to the lower and upper part of the planetary atmosphere.

Scientists from NGRI had convened Geophysical survey and during the fourth expedition, established presence of water channels below ice shelf with thickness of 150-200 m of ice. Geo-chemical studies of shelf area of Antarctica reveal analogy of rocks with Mozambique region of E Africa. The 7th Antarctica expedition established the presence of rocks identical to Khondalites & Charnockites of South India on Humboldt area of Antarctica. There were detailed mapping on

Fig. 2 — Scientists working in Centre for Cellular and Molecular Biology (CCMB) along with other scientists

Humboldt mountains during the subsequent Antarctica expeditions. Survey, Geological cartography and thematic mapping of an area of 10,000 sq. km had been completed.

CSIR scientist's contribution towards the research papers published in SCI journal on Antarctica research

Scientists working in CSIR institutes had contributed consistently to augment the present intellectual resource, knowledge and understanding of Polar Regions. They had published many research findings in international and national scientific journals. The CSIR — Steering Committee on Antarctic Research had compiled papers published in SCI journals related to the scientific expeditions and research of CSIR scientists on Antarctica[4]. The title of the above research papers related to the biodiversity of flora and fauna of Antarctica, geology and geophysical aspects, atmospheric sciences and chemical characteristics of marine algae of Antarctica are ascribed below.

Biological Sciences

Biological investigations in Antarctic ecosystems; Studies on Antarctic Krill: I – length weight relationship in adult, *Euphausia superba*, Dana 1850; Biochemical composition of some benthic marine

algae of the Vestfold Hills, Antarctica; Animal associations with the dominant species of shallow water macrophytes along the coastline of the Vestfold Hills, Antarctica; Isolation and Identification of *Micrococcus roseus* and *Planococcus* spp. from Schirmacher Oasis, Antarctica; Isolates of *Arthrobacter* from the soils of Schirmacher Oasis, Antarctica; Yeast strains from the Schirmacher Oasis, Antarctica; Isolation and identification of *Pseudomonas* spp. From Schirmacher Oasis, Antarctica; Benthic marine algae of the inshore water at the Vestfold Hills, Antarctica; Regeneration of nutrients and biological productivity in Antarctic waters; Identification of *Janthinobacterium lividum* from the soils of the Islands of Scotia Ridge and from Antarctic peninsula; The major carotenoid pigment of a psychrotrophic *Micrococcus roseus* strain: Purification, structure and interaction with synthetic membranes; Plasmids from the soil bacteria of Schirmacher Oasis, Antarctica; Extracellular protease from the Antarctic yeast *Candida humicola*; *Spingobacterium antarcticus* sp. Nov, a psychrotrophic bacterium from the soils of Schirmacher Oasis, Antarctica; Production of organic matter in Antarctic ice shelf; An unusual giant pycnogonid (Pycnogonida-Colossendeidae) *Decolopda qasimi* sp. nov from Antarctica waters; Zooplankton biomass and abundance of Antarctic krill *Euphausia superba* DANA in Indian Ocean sector of the southern ocean; Limnology of Freshwater Lakes at Schirmacher oasis, East Antarctica; Growth and pigmentation in *Sphingobacterium antarcticus*, a psychrotrophic bacterium from Antarctica; Thermolabile ribonucleases from antarctic psychrotrophic bacteria: detection of the enzyme in various bacteria and purification from *Pseudomonas fluorescens*; Occurrence and expression of *cspA*, a cold shock gene, in Antarctic psychrotrophic bacteria; Tyrosine phosphorylation of a cytoplasmic protein from the Antarctic psychrotrophic bacterium *Pseudomonas syringae*; Phosphorylation of membrane proteins in response to temperature in an antarctic *Pseudomonas syringae*; Phosphorylation of lipopolysaccharides in the antarctic psychrotroph *Pseudomonas syringae*: a possible role in temperature adaptation; Thermolabile alkaline phosphate from *Sphingobacterium antarcticus* a psychrotrophic bacterium from Antarctica; Biochemical composition of antarctic zooplankton from the Indian Ocean sector; Summer abundance and activities of bacteria in the fresh water lakes of Schirmacher Oasis, Antarctica; *In vivo* characteristics and localization of carotenoid pigments in psychrotrophic and mesophilic *Micrococcus roseus* using photoaccoustic spectroscopy; The major carotenoid pigment of a psychrotrophic *Micrococcus roseus* strain: Fluorescence properties of the pigment and its binding to membranes; Carotenoids pigments of an Antarctic psychrotrophic bacterium *Micrococcus roseus*: Temperature dependent biosynthesis, structure and interaction with synthetic membranes; Bacterial carotenoids. $55^{*}C_{50}$ — carotenoids. [†]Revised structures of carotenoids associated with membranes in psychrotrophic *Micrococcus roseus*; Molecular evidence for cryptic species among the Antarctic fish *Trematomus bernacchii* and *Trematomus hansoni*; Adaptation to low temperature and regulation of gene expression in antarctic psychrotrophic bacteria; Ecobiological assessment of a fresh water lake at Schirmacher Oasis, East Antarctica with reference to human activities; Siderotyping of fluorescent pseudomonads: characterization of pyoveridines of *Pseudomonas fluorescens* and *Pseudomonas putida* strain from Antarctica; Histidine utilization operon (*hut*) is upregulated at low temperature in the antarctic psychrotrophic bacterium *Pseudomonas syringae*; Transcriptional activity at supraoptimal temperature of growth in the antarctic psychrotrophic bacterium *Pseudomonas syringae*; A RNA polymerase with transcriptional activity at 0°C from the antarctic bacterium *Pseudomonas Syringae*; Studies on the cytoplasmic protein tyrosine kinase activity of the antarctic psychrotrophic bacterium *Pseudomonas syringae*; Truce with oxygen — Anaerobiosis outcompete aerobiosis in the antarctic lacustrine bacteria; *Arthrobacter flavus* sp. nov., a psychrophilic bacterium isolated from a pond in McMurdo Dry valley, Antarctica; Carotenoids of an antarctic psychrotolerant bacterium, *Sphingobacterium antarcticus*, and a mesophilic bacterium, *Sphingobacterium multivorum*; Assessment of viability in the bacterial standing stock of the Antarctic Sea from the India side; *Planococcus Antarcticus* and P*lanococcus psychrophilus* spp. nov. isolated from cyanobacterial mat samples collected from ponds in Antarctica; *Arthrobacter roseus* sp. Nov., a psychrophilic bacterium isolated from an Antarctic cyanobacterial mat sample; *Halomonas glaciei* sp. nov isolated from fast ice of Adelie Land,

Antarctica; Conserved temperature–dependent expression of RNA-binding proteins in cyanobacteria with different temperature optima; Psychrophilic *Planococcus maitriensis* sp. nov. from Antarctica; *Sporosarcina macmurdoensis* sp. nov., from a cyanobacterial mat sample from a pond in the McMurdo Dry Valleys, Antarctica; *Kocuria polaris* sp. nov., an orange–pigmented psychrophilic bacterium isolated from an Antarctic cyanobacterial mat sample; *Leifsonia rubra* sp. nov. and *Leifsonia aurea* sp. nov., psychrophiles from a pond in Antarctica; Role of membrane lipid fatty acids in cold adaptation; *Arthrobacter gangotriensis* sp. nov. and *Arthrobacter kerguelensis* sp. nov. from Antarctica; Bacterial diversity of a soil sample from Schirmacher Oasis, Antarctica; *Psychrobacter salsus* sp. nov and *Psychrobacter adeliensis* sp. nov. isolated from Fast Ice Adelie Land, Antarctica; *Pseudonocardia antarctica* sp. Nov. an Actinomycetes from McMurdo Dry Valleys, Antarctica; Psychrophilic *Pseudomonas syringae* requires trans-monounsaturated fatty acid for growth at higher temperature; Psychrophilic pseudomonads from Antarctica: *Pseudomonas antarctica* sp. nov.,; *Pseudomonas meridiana* sp. nov. and *Pseudomonas proteolytica* sp. nov; *Psychrobacter vallis* sp. nov. and *Psychrobacter aquaticus* sp. nov., from Antarctica; *Cis-trans* isomerase gene in psychrophilic *Pseudomonas syringae* is constitutively expressed during growth and under conditions of temperature and solvent stress; *Marinobacter maritimus* sp. nov., a psychrotolerant strain isolated from seawater off the subantarctic Kerguelen islands; Marinomonas *ushuaiensis* sp. nov., isolated from coastal sea water in Ushuaia, Argentina, sub-Antarctica; Distribution, abundance and vertical migration pattern of krill-*Euphausia superba* Dana at fishing area 58 of the Indian Ocean sector of Southern Ocean; Zooplankton studies with special reference to krill *Euphausia superba* Dana from fishing area 58 of Indian Ocean sector in southern Ocean; Extremophilic microbes: Diversity and perspectives; Metal and antibiotic-resistance in psychrotrophic bacteria from Antarctic Marine waters; *Marinomonas polaris* sp. nov., a psychrohalotolerant strain isolated from coastal sea water off the subantarctic Kerguelen islands; *Clostridium schirmacherense* sp. nov., an obligately anaerobic, proteolytic, psychrophilic bacterium isolated from lake sediment of Schirmacher Oasis, Antarctica

Geological/Geophysical Sciences

Foraminifera from the deep lake terraces, Vestfold Hills, Antarctica; Ostracoda from Vestfold Hill Lake Terraces, Antarctica; Magnetic anomalies — India and Antarctica; Geology and Structure of the Astrid Ridge, Dronning Maud Land Antarctica; The nature of bedrock at Petermann I, Wohlthat Range, Antarctica; Comment on paper — Granites of Peterman Ranges, East Antarctica and implications of their Genesis; The Cretaceous — Tertiary sea floor off Dronning Maud Land, Antarctica; Precambrian bimodal volcanism in Weddell Sea, West Antarctica; Marine Magnetic Anomalies as a link between the granulite belts of east coast of India and Enderby Land of Antarctica; Rb-Sr Ages of Lamprophyre Dykes from Schirmacher Oasis, Queen Maud Land, East Antarctica; Teleseismic delay-time tomography of the upper mantle beneath southeastern India: Imprint of Indo-Antarctica rifting; Crustal structure based on gravity-magnetic modeling constrained from seismic studies under Lambert Rift, Antarctica and Godavari and Mahanadi rifts, India and their interrelationship; Reply to the comments by S K Acharyya on “Crustal structure based on gravity magnetic modeling constrained from seismic studies under Lambert Rift, Antarctica and Godavari and Mahanadi rifts, India and their interrelationship”; Geochemistry of Komatiitic basalt dyke from Schirmacher Oasis, Queen Maud Land, East Antarctica; Shear zones in the central part of the eastern ghats mobile belt, India and their continuity through East Antarctica; India-East Antarctica conjugate margins: rift-shear tectonic setting inferred from gravity and bathymetry data; A rare earthquake in Antarctica; Seafloor spreading magnetic anomalies in the Enderby Basin, East Antarctica; Occurrence of Quench olivine crystals in a basaltic Dyke from Schirmacher Oasis, Queen Maud Land, East Antarctica; Structural and Thermal Studies of Graphite from East Antarctica.

Physical Sciences

Antarctic Communication; Apparent Relationship between thermal regime in antarctic Waters & Indian Summer monsoon; Water characteristics and transport of the Antarctic circumpolar current in the Indian Ocean; Latitudinal Variation of air-sea Fluxes in the western Indian Ocean during austral summer and Fall; Surface heat budget of a polynya in the coastal waters off Queen Maud Land, Antarctica, during austral

summer; Evaluation of the structure parameter C_n^2 over the sea-surface; Characteristics of atmospheric turbulence in the surface layer over Antarctica; Multi wavelength Measurements of atmospheric turbidity and determination of the fluctuations in total ozone over Antarctica; Ultraviolet radiation received in Antarctica in comparison with the Indian Region; Evaluation of Turbulent Fluxes over Maitri, Antarctica; Acoustic sounder measurements of the planetary boundary layer at Maitri, Antarctica; Erythemal and aerosol studies at Maitri, Antarctica during Austral Spring of 1995; On the structure of horizontal wind flow in the surface layer of Maitri, Antarctica; XBT fall rate in waters of extreme temperature: A case study in the Antarctic Ocean; Signature of early ozone hole recovery during 2002; Comparative study of the total ozone column over Maitri, Antarctica during 1997, 2002 and 2003; Signature of increasing total column water vapour and surface temperature at Maitri, Antarctica; Continuous observations of surface air concentration of carbon dioxide (CO_2) and Methane (CH_4) at Maitri, Antarctica; Oceanic fronts along 45°E across Antarctic Circumpolar Current during austral summer 2004; Temporal and spatial variability of surface ozone at Delhi and Antarctica

Chemical and Environmental Sciences

Chemical and environmental studies in ice and waters in and along Antarctica; Hydrocarbons in benthic marine algae of the Vestfold Hills, Antarctica; Heavy Metals in some parts of Antarctica and the southern Indian Ocean; PCBs and organochlorine pesticides in krill, birds and water from Antarctica; Hydrographic characteristics of the Indian sector of the Southern Ocean; Influence of air-sea fluxes on chlorine isotopic composition of ocean water: Implications for constancy in $\delta^{37}Cl$ — A Statistical inference

CSIR Institutes associated with Indian Scientific Expedition to Antarctica

(a) National Institute of Oceanography (NIO)

In the year 1981 NIO served as a launching pad for the first Indian Expedition to Antarctica. Of the researchers who participated in the expedition, six were from NIO. They initiated work on lakes of the polar region and on biology of the continent. The latter included studies of mosses, lichen, algae and nematodes dwelling in moss beds. The studies on lakes dealt with description of physical and chemical conditions, and effect of glacier melt water on biogeochemistry of the lakes.

Fig. 3 — Underwater diving survey in Antarctic Lake

Fig. 4 — Oceanographic sampling in Antarctica

In 1982 researchers from NIO established an unmanned weather station, which recorded temperature, wind speed and wind direction throughout the year. The data were used in designing of India's first permanent station "Dakshin Gangotri". It allowed members of the Indian contingents to over winter (i.e. stay at Antarctica for more than a year at a stretch). Scientists from NIO over wintered during 1983-85, 1984-86, and 1985-87. These long periods of stay in the polar continent helped them to study biology and environment of lakes. These studies form the baseline data to monitor future changes in the lakes are expected to be noted. Antarctica is going through a rapid change. Many freshwater lakes, in the vicinity of glaciers that are now receding, have dried up. As a result, many organisms are living on the edge of extinction.

Fig. 5 — Limn logical studies in Antarctica lake

(b) National Physical Laboratory (NPL)

The International Polar year has completed its one-year. National Physical Laboratory has contributed robustly to its scientific programs. The projects commenced at NPL during the current IPY will continue in the year 2008-09 and beyond.

Snow-pack production of carbon monoxide and its diurnal variability

A series of field and laboratory experiments have shown that many chemical species such as NOx, HCHO, C_2H_2 and CO are produced photo chemically from snow-pack. The composition of Polar Regions Troposphere is influenced by snow to air exchange of key trace chemicals followed by homogeneous and heterogeneous reactions. The phenomenon of tropospheric ozone and mercury depletion occur over a period of days to weeks in Arctic and Antarctica during spring. The chemistry of ice covered region is complex and may control the boundary layer chemistry of large region of the world. Much work is needed in the field as well as in the laboratory with different environmental conditions to understand the factors controlling the release of these chemicals from snow pack and their impacts on global chemistry and climate.

- The study of snow-pack production of carbon monoxide and its diurnal variability were started during First Indian Arctic Winter phase Expedition. Also the studies on Black carbon aerosols, aerosol number-size distribution, Aerosol Optical Depth and Water vapor were also performed at NPL. In continuation of above said ongoing project, during second phase summer Indian Arctic Expedition, carbon monoxide and surface ozone analyzers have been installed for the measurement of ambient air CO and 03 concentrations during Arctic summer period and Aerosol optical spectrometer for measurements of particle size distribution. These measurements have been carried out at the base of Zeppelin Hill, Ny-Alesund to avoid local interference due to traffic and tourist's ships.

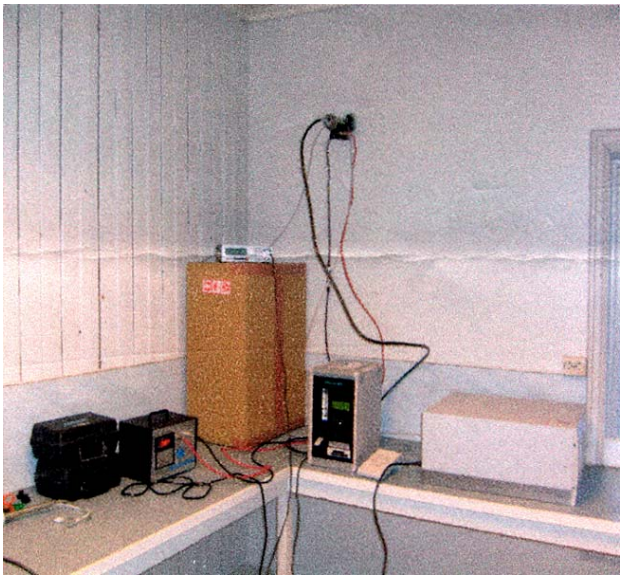

Fig. 6 — Aerosol Optical Spectrometer and CO analyzer at Indian Arctic Station (Himadri)

Ionospheric studies at Antarctica

- National Physical Laboratory is setting up lonosonde for Ionospheric research at Indian Antarctic Station to study Ionospheric dynamics over polar region during quiet and disturbed periods. The project is initially aimed to setup facilities for multi-technique probing of the polar ionosphere to generate a long time series data archive like electron density profile, critical frequencies and virtual heights of each layers and further the data will be used to study the coupling between high and low latitude ionosphere during different geo-physical conditions. On long term these studies will help in higher performance communication, better navigation, positioning & other applications through improved ionosphere modeling. In lieu of the plan for the installation of ionosonde the site preparation is already done during the 27th Indian Antarctic Expedition.

- NPL is planning to setup a fully operational multi-instrument ionospheric real time monitoring facility both at Antarctica and Arctic and planned to run the facility at Antarctica for minimum 11 years i.e. during 24th solar cycle period. For these studies NPL needs one winter and two summer berths during 28th to 38th Indian Antarctic Expeditions.
- Very low frequency remote sensing of the ionosphere and the radiation belts using a VLF beacon transmitter at South Pole has been undertaken during 26th Expedition to Antarctica. To study global linkages using VLF beacon transmission monitoring similar set of equipment has been set up at Delhi.

(c) National Geophysical Research Institute (NGRI)

NGRI is one of the CSIR Research Organizations that has been participating in all the Indian Scientific Antarctic Expeditions (IAEs) since the first expedition in 1981 focusing the research on earth sciences. The scientists from NGRI are a part of the team of all Indian Scientific Expedition to Antarctica.

Field of Activities:

GPS/GNSS and Seismic Studies, Magnetotelluric Studies, Absolute Gravimetry and G^3 investigations

Areas of key Competence:

Space Geodesy, Crustal Deformation and Plate Tectonic Studies and all Geophysical studies

Instrumentation:

State-of-the-art GPS/GNSS geodetic receivers, Digital Broadband seismometers, MTS equipment and Absolute Gravity meter.

Major Scientific Programs undertaken and significant Contributions to Antarctic Research

NGRI has been carrying out integrated geophysical, geological and geochemical (**G^3**) investigations in Antarctica from the second Indian Antarctica Expedition. The objective of geological and geochemical studies is for the reconstruction of Greater Gondwanaland by finding out the nature of composition of lithosphere, their field configuration, the P-T conditions, nature of metamorphism, deformation, and time of formation. The geophysical studies included heli-borne, magnetic, EM, seismic, gravity and paleomagnetic surveys. Total 60 line-km magnetic profiles over the ice-shelf revealed the magnetic characteristics of the bedrock beneath the ice-cover and based on these and in conjunction with the early seismic studies a crustal structural model had been evolved.

The interest in Geodynamical processes in the south of Indian Peninsula that are of prime concern to the Indian Plate kinematics and Indian Plate motion has grown multifold. Since the Indian Plate is bound by the Plates Arabia, Somalia, Antarctica, and a diffuse India-Australia boundary in the Indian Ocean Basin, it becomes significant to kinematically describe the plates and their boundaries to address the following queries:

1. How rigid is the Indian Plate?
2. Does its relatively high level of Intra Plate Seismicity indicate internal deformation in excess of other plates?
3. Is this related to Indo-Eurasian collision and generation of Himalayas?

Hence NGRI has launched the following studies from XVII IAE onwards and it is continuing as long-term research activities.

Research Studies*:*

"Studies on Seismotectonics and Geodynamical Processes between Antarctica and Southern Indian Peninsula"

(1) "Continuous GPS monitoring between India and Antarctica"

(2) "Continuous Operation of Seismological Observatory at Maitri, Antarctica"

(1) Continuous GPS Monitoring between India and Antarctica

Significant Contributions:

NGRI has initiated GPS-Geodesy program by establishing a permanent GPS station at Maitri, in 1997 to understand the tectonic activity and crustal deformation in the south of Indian peninsula, the driving mechanisms and response of the Indian Ocean Lithosphere and holistically compound the Indian Plate kinematics. The permanent GPS station was upgraded during the XXVII IAE with the new state-of-the-art GNSS receiver Topcon GB-1000. The upgraded GNSS Receiver can track minimum of 31 GPS and 11 GLONASS satellite systems. Also the

receiver is configured to track GALILEO satellite system once they become operational.

The permanent GPS station is continuously operational since installation and by virtue of which Maitri continues to be one of the SCAR stations and remain in the global scenario of GPS- Geodesy.

By contributing and processing a high quality geodetic data from Maitri, NGRI have achieved a globally major role in maintenance and improvement of a Global Reference Frame.

To holistically understand the geodynamical and crustal deformation processes in the south of Indian peninsula between India and Antarctica, two global networks (IND and ANT) have been chosen that geodetically connect the two continents. The IGS Station at Diego Garcia (DGAR) is the common station between the two networks. 10 years of data from 1997 to 2007 were used. By these global networks' analyses, the stations HYDE and MAIT are geodetically tied through DGAR. Very long baselines have been estimated from HYDE and also from Kerguelen (KERG) to other chosen IGS stations in and around India and Antarctica. Our analysis and results using ANT network show an increase in the baseline lengths between Kerguelen in Antarctica plate and other stations such as SEY1, DGAR and COCO and shortening of baseline lengths between HYDE in Indian plate and all these above stations using IND network.

(2) Continuous Operation of Seismological Observatory at Maitri, Antarctica

A permanent Seismic Observatory with the state-of-the-art Broadband Digital Seismometer has been established at Maitri in 1997 with a primary objective of monitoring the seismicity in and around Antarctica. The observatory houses GURALP CMG-3ESP Broadband Seismometer of Reftek make, with a processor based Data Acquisition System.

The observatory was upgraded during XXV IAE with the new Broadband Seismometer, Geotech KS-2000M on the newly constructed pier inside the seismometer vault and the recording media Geotech-Smart 24R Digitizer.

New GURALP Seismometer and Reftek DAS-130-1, had been installed and commissioned during the XXVII IAE.

Now both the Reftek and Geotech KS-2000M seismometers are in operation.

The 3-Component short-period seismometers are also in operation by making use of the RT 121 System with the Reftech DAS unit.

The data acquisition is at the sampling rate of 50 samples per second. Collocation of GPS and Seismic stations would mutually aid the studies on seismotectonics, plate kinematics, plate boundary reorganizations, and crustal deformation between India and Antarctica.

Significant contributions and achievements:

Continue to contribute Seismic data to NEIC, USA and ISC, UK to remain in the Global Scenario of Global Seismographic Network at Antarctica. Also contribution of Permanent Seismological Observatory at Maitri, Antarctica to AnSWeR (Antarctic Seismic Web Resource) continues. The broadband seismic data recorded between 2001 and 2007 have been analysed completely.

Magnetotelluric Studies (MTS):

MT studies have been carried out with for mapping the electrical conductivity structure in Schirmacher Oasis, East Antarctica from 24th IAE as a project for 3 years. During the 24th Indian Antarctic Expedition 10 MT stations have been completed covering Schirmacher Oasis (8 MT stations) & Polar ice region (2 MT stations). During 25th IAE a total of 10 MT stations along North-South transect passing through Schirmacher Oasis were completed, with Maitri as a central point. During 26th IAE, 2 stations have been completed.

Absolute Gravity Measurements:

During the XXIII IAE, Absolute Gravity measurements were carried out for the first time in Antarctica by NGRI. Gravity field of the earth is sensitive to both vertical position and mass distribution and thus provides a powerful tool to study the crustal dynamics. High precision (~5 μGal) absolute gravity measurements in time and space domain are essential to understand the redistribution of mass and vertical crustal motions caused due to several geodynamic processes such as earthquakes, plate convergence, isostatic rebound etc. The basic requirement of any gravity survey is the absolute value, at least at one point. National Geophysical Research Institute (NGRI) in collaboration with Department of Ocean Development (DoD) has acquired first Absolute Gravity Meter (AG) in the

country for addressing the problems of vertical deformation near tide gauges along the Indian coast and establishing of reference gravity stations in India and Antarctica.

(d) Centre for Cellular & Molecular Biology (CCMB)

Research in Antarctic Microbiology was initiated by the Centre for Cellular and Molecular Biology, Hyderabad, with the dual purpose of establishing the bacterial biodiversity at Dakshin Gangotri and Maitri, the Indian stations at Antarctica and to understand the Molecular basis of survival and growth of life forms at low temperatures. The significant research contributions of CCMB in Polar Biology are as follows:

Bacterial biodiversity of Antarctica

Psychrophilic (cold loving) microorganisms have the unique capability of growing and multiplying at temperatures close to the freezing point of water, thus defining the lower limits of temperature at which life forms can survive and multiply. A study of these cold loving organisms with respect to their diversity, distribution, seasonal variation and identity would lead to identification of new species of bacteria with unique biotechnological potential.

The significant findings of CCMB are:

Microbiologists world over, have identified only about 240 new species of bacteria from Antarctica. Out of this CCMB's research has led to the identification of 30 new species thus contributing to 12.5% of the new species.

A few of the isolates have been identified to have great biotechnological potential with applications in Biotech industries.

Research achievements related to Antarctic bacterial diversity has attracted worldwide recognition as evidenced by collaborations both within the country and countries abroad such as in Japan, Germany and France.

CCMB's expertise in bacterial diversity also served as the basis for an international effort to explore the possibility of life forms in upper atmosphere funded by ISRO, India. CCMB identified four new species of bacteria from the Stratosphere for the first time in the world.

Molecular basis of survival at low temperature

Understanding the molecular basis of survival of life forms at low temperatures would be very crucial in unraveling the molecular mechanisms with respect to temperature sensing, perception and the downstream events involving up or down regulation of the genes. With this in view, bacteria from Antarctica have been used as model systems due to their unique ability to survive at low temperatures. The significant contributions of CCMB are:

1. A new desaturase gene, *des* C_2, was characterized from a cyanobacterium from Antarctica. It was demonstrated that desaturase genes which are transcriptionally unregulated in mesophilic bacteria at low temperatures are constitutively expressed in psychrophilic bacteria implying that these desaturase genes are essential for survival of life forms at low temperature.
2. It was also demonstrated for the first time that in pigmented bacteria membrane fluidity was modulated by the differential synthesis of polar and non-polar carotenoids. This highlighted a new function for carotenoid pigments, which may be crucial for low temperature survival.
3. A few cold active genes like genes for aspartate aminotransferase and t-RNA modification GTPase have been shown to be essential for survival at low temperature.
4. Enzymes with biotechnological potential such as cold active proteases, lipases and ribonucleases have been characterised from Antarctic bacteria.

(e) National Botanical Research Institute (NBRI)

NBRI was identified by Ministry of Earth Sciences (then Department of Ocean Development), Govt. of India as the centre for carrying out investigation on one of the major plant groups (Lichens) in the Schirmacher Oasis, East Antarctica in 1991. Since than NBRI has participated in 11^{th}, 19^{th} and 22^{nd} Indian Scientific Expeditions to Antarctica during the years 1991, 2000 and 2003, respectively and a large number of lichen samples were collected from the Schirmacher Oasis and nearby nunataks. The collected samples are identified up to the species level and are preserved in herbarium of NBRI (LWG). The study revealed the occurrence of 48 species of lichens from the area with several new distributional records. Out of these, 19 are endemic to Antarctica, 15 are bipolar and 14 are cosmopolitan in distribution. The distribution pattern of lichen species, carotenoid contents and heavy metals accumulation studies carried out by NBRI in Schirmacher Oasis will be

Fig. 7 — Common Lichens of Schirmacher Oasis

utilized for future biomonitoring studies in the area as lichens are very sensitive to environmental changes.

Apart from the Schirmacher Oasis NBRI has also conducted lichenological investigation in the locality of third Indian Antarctic Station at Larsemann Hills. A total of 141 lichen samples collected from McLeod Island resulted in 25 species of lichens among which 12 were new records to the region.

NBRI is participating in the 28th expedition to Antarctica in November 2008, to study the water relation and photosynthetic activity of Antarctic lichens with special reference to desiccation tolerance and survival strategies in the harsh climatic conditions of the continent.

Conclusion

Scientists from multidisciplinary research disciplines of sixty three countries are relinquishing two hindered and twenty eight research and outreach projects in the current International Polar year. This is the largest international coordinated scientific event with in the last five decades. One of the themes of the current IPY is to use the unique vantage point of Polar Regions to develop and enhance observations from the interior of Earth to the Sun and the Cosmos beyond. The present IPY consist six themes and many unique research projects. Three Indian research proposals have been included in the IPY research projects. The constituent establishments of CSIR like National Physical Laboratory have initiated projects to run facilities to collect data consistently for more than a decade in both Arctic and Antarctic regions. Polar research of India has seeded before twenty-eight years from National Institute of Oceanography with 13 scientists from five scientific organizations. Since then Indian Polar Research Program has thrived with permanent research stations at Arctic and Antarctic regions. Also researchers from many scientific Institutes, Indian Institute of Technologies and Universities of India are associated with the multidisciplinary research in polar region. The contribution of CSIR scientists in Antarctica for the last twenty-five years has been brought out as collected reprints by the initiative of CSIR Scientific Committee of Antarctic Research (CSIR-SCAR) during the year 2006. Indian Journal of Marine Sciences has facilitated two special issues on Polar Research in collaboration with scientists of Antarctic Climate and Ecosystems of Cooperative Research Center, Australia and Ministry of Earth Sciences, Government of India. The above ventures will advance our knowledge and understanding on the significant changes occurring in Polar Regions.

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