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XXI Indian Antarctic Expedition - Assignments and Achievements

R.P. **Lai**
Leader & Station Commander

The **Scientific objectives** for the summer and winter period of XXI IAE are as follows:

(I) Atmospheric Sciences

(1) Climatological & Meteorological Studies, a continuous program by **India Meteorological Department** with the aim to built a climatological data set of Antarctica. This climatology will provide weather services/meteorological support to Antarctica Operations. Since Antarctica is a large continent, climatic features of the Indian region are being delineated. IMD will continue its operational program of surface observations, Ozonesonde & Radiometersonde ascents, Radiation measurements, Satellite data receptions and real time synoptic data transmission as in the previous years.

IMD's program has centered on the monitoring of the ozone hole phenomena. Balloon borne ozonesonde ascents are being taken on a weekly basis along with continuous monitoring of surface ozone. IMD has installed a versatile **Brewer Spectrophotometer** for the measurement of Total Ozone, UV Radiation, total N02 and S02 with additional facility for vertical profile of some parameters.

(2) Monitoring of Green House Gases programme of **National Physical Laboratory** has been planned using **Gas Chromotograph.** Monitoring of methane will start from this year. In addition to this measurement of UV-B radiation, radiation budget and monitoring of water vapour and ozone also will be taken. A ship borne **SODAR** will be used to monitor boundary layer characteristics associated with dynamics-air sea boundary movement.

(3) Fluxgate magnetometer studies by **Indian Institute of Geomagnetism** is an ongoing program to understand the dynamics of mobile current system in Antarctic atmosphere with emphasis on looking

at ionosphere and magnetosphere as active element which can modulate the global electric current. Program of three station magnetometer and Rio meter observation along with microbarograph will continue during summer. The atmospheric electricity measurements will be continued.

(II) Biology & Environmental Conservation

(1) Bio-diversity studies: As a part of ongoing program on studies on bio-diversity of Antarctica, **Zoological survey of India** will carry out the assessment of **invertebrate fauna and flora** to bring out a monograph on **Arthropods** of Antarctica.

(2) Biopotential studies: Rajiv Gandhi Centre for Biotechnology will study the exploration of the **Biopotentialities of snow dwelling and epiphytic bacteria** of Antarctica.

(Ill) Earth Sciences, Glaciology & Global Change

(1) Geological mapping and Glaciological studies: As a part of the ongoing project **Geological Survey of India** will carry out:

- **Geological mapping** in eastern part of **Muhlig Hoffmannfjella** between longitude 6000'to 6020'E and latitude 71040' to 72010'S. An area 1000 sq. km. on 1: 50,000 scales are proposed. The recce of the area was done during 17th IAE.
- Thematic mapping of Gruber Anthrosites (First year of three year program).
- **Glacio-morphological studies in** western part of **Schirmacher Oasis.**
- The northern margin of the Schirmacher Oasis and other areas within the Oasis to be studied for collecting evidences of **Neo-tectonic** activity.

Glaciological studies are aimed to decipher the ice dynamics and history of the polar ice front movements and to prepare a geomorphological glacial map of the area. During the voyage, GSI team carried out systematic monitoring of the icebergs following the guidelines of Norwegian Polar Institute.

(2) Snow drift and albedo studies: This an ongoing program to be continued by **Snow and Avalanche Study Establishment** (SASE) for understanding the net energy exchange budget between the atmosphere and the different types of snow-ice surfaces in Antarctica. The albedo, which most crucial factor in controlling the energy balance, will be

measured through a number of experiments under different physical and atmospheric conditions.

These studies are aimed to determine the dependence of snow albedo on snow surface parameters like age of snow, grain size and type of snow, cloud cover, solar elevation etc.

The strong winds over the snow surfaces causes a shear, resulting into a snowdrift from the continent into the surrounding oceans. This plays a significant role in the heat balance of Antarctica. The transport of snow under various conditions will be enumerated in this study in order to under stand the drift density profile under various conditions like temperature, snow hardness, free water content and surface features. AWS will be operated at different locations for these measurements.

SASE will also continue the crack propagation studies on ice shelf using GPS, GPR and satellite imagery.

(3) Tele-seismic and Planetary geodetic studies: The ongoing program being carried out by **National Geophysical Research Institute** using a permanent digital broad band seismographic observatory with following objectives:

- Monitoring & study the frequency and strength of seismic activity in Antarctica.
- Record seismic shocks originating over the Indian Ocean region for delineating the deep crustal structures of the earth.

A permanent GPS Observatory is established at Maitri with a Turbo Rogue GPS receiver with following objectives as a part of the international **GIANT project (Geodetic Infrastructure in Antarctica).**

- To provide accurate positions in the global reference frame, as also a fundamental frame for (relative) positioning in the operation area of each Antarctic Expedition.
- To study tectonic movements of the Antarctic plate in relation to other plates.

To link sea level changes with vertical motions of plates.

(4) Topographical Mapping: The **Survey of India** will carry out close contour topographical mapping (1 meter contour) on the scale of 1:1000 of the area east of the area surveyed during XX IAE. The exact area for survey has to be demarcated in consultation with GSI and NCAOR, which is important in view of the search for new location for Maitri .In addition, SOI will also assist GSI in the study of glacial dynamics by providing geodetic survey aids.

(5) Hydrographic Survey: The **Naval Hydrographic Office** will conduct the hydrographic survey work. Reconfirm the quality of in the

previous area of work so as to check repeatability of data collected for publication of nautical charts of the area.

(6) Amravati University's objectives are to study the **grain morpho metry** including shape and size analysis. Surface texture of the grains with the help of high-resolution microscope. **Petrology** of the grains in order to ascertain the mineralogical variation, diagenetic effects. XRD analysis of finer fragments/clay and heavy mineral analysis of the silt size sediments etc.

(7) M.S. University, Baroda's objectives are to measure the **lateral isotopic variation** in the surface snow on Antarctica and to understand the surface mixing of snow and its implication on the isotopic variation.

(IV) Engineering & Communication

(1) Communication technology: The **Defence Electronics & Application Laboratory** (DEAL) will be responsible for the maintenance and up gradation of the communication facilities at Maitri apart from routine operation. They will also improve the communication system to provide HF data communication.

Department of Telecommunication/ **Bharat Sanchar Nigam Limited** (BSNL) and **Videsh Sanchar Nigam Limited** (VSNL) will provide their support to maintain and operate the communication equipments made available at Maitri and do feasibility studies for further augmentation.

(2) Wind energy utilization in Antarctica: The **National Aerospace Laboratory** (NAL) has already established portable wind turbine system for specific use in Antarctica. As a part of the ongoing project, they will install indigenous windmills of 140 watt each during XXI IAE. They will continue to measure specific wind parameters on a year round basis.

The **Logistic objectives** for the summer and winter period of XXI IAE are as follows:

(1) Up-keep of Maitri Station: Maitri station was constructed during the summer season of 1988/89 and is in regular use since then Due to aging and also being subjected to severe blizzards snow ingression has started at some parts of the Building. It has also resulted in poor thermal insulation and leakage etc.

Up keep of the station infrastructure and all life support system will be the part of regular maintenance task to the XXI IAE Logistic team.

(2) Maintenance of Generators and power supply system: Three powerhouses provide power supply to the Maitri station. Maintenance and

efficient operation of all these generators and the power lines is a part of regular maintenance task to the XXIIAE Logistic team.

(3) Central Heating System: The Central heating system of Maitri station is catered to by four hot-water Boilers, pipe line to all the utility areas and living rooms and forty hot-water room radiators. The pipeline over the years has become rusted at many joint resulting leakage and insufficient hot-water flow through room radiators. Replacing the complete pipeline and the defective / in-efficient radiators is the task of XXI IAE team to be completed during the summer period of expedition. Maintenance and efficient running of the central heating system is part of regular maintenance task to the XXI IAE Logistic team.

(4) Water Supply System: Water supply to the Maitri station and summer huts is catered to by a pump house in Priydarshani Lake through a trace heated ducted pipe line of about 255 meters. Maintenance and efficient operation of pump house, trace heating and duct is a part of regular maintenance task to the XXI IAE Logistic team.

(5) Convoy operation and maintenance of Vehicles/ Cranes/ Bulldozers: A large fleet of snowmobiles, four cranes, two Dozers are in use at Maitri. Four Piston Bulley Snow Mobiles are reported off the road due to some major problems. The Polar Bear vehicle re-inducted after major repairs is still to be put to use at Maitri. Repair of all the defective snowmobiles and activating the Polar Bear vehicle is a task to the XXI IAE Logistic Team.

(6) Cargo handling at shelf: The expedition cargo is twelve containers. There will be about 300 KL of JET-A-1 fuel sent to Maitri for year-round consumption. Convoy operation to shift the containerized cargo and JET-A-1 fuel and from shelf to Maitri and from ship to shelf with help of Ship's crew is a part of regular task to the XXI IAE Logistic team.

(7) Field Camps: For executing the scientific tasks of some of the Scientific Organizations field camps are established at Dakshin Gangotri point and at one or two locations in mountains. Establishing the field camps and winding-up them at the end of the experimentation is a routine task of the XXI IAE Logistic Team.

(8) Fire Fighting System: Various types of fire extinguishers are available at Maitri station for fire safety. The fire alarm system provided at Maitri building became faulty and being replaced with a complete new system. Installation of fire-alarm system and maintenance of all types of fire extinguishers is a task to the XXI IAE Logistic Team.

(9) Environmental Tasks: In compliance with the environmental Protocol requirements Maitri Station is well maintained with proper up-

keep of containerized store yard, fuel storage yards etc.Up-keep and restoration of the natural habitat of Maitri and its surroundings is a regular task to the XXIIAE Logistic Team.

(10) Any other task: For successful completion of the scientific tasks assigned to the participating scientists, any task assigned by the Expedition Leader as per the priorities fixed is a regular task to the XXI IAE Logistic Team.

MAITRI and Infrastructure

India's second Antarctic Station, Maitri was constructed during the summers of 1988 and 1989. Indigenously built, the Station is in regular use since 1989. The Station is built on stilt foundation with telescopic adjustable columns. Pre-fabricated panels of marine plywood, filled with polyurethane as insulating material, is used for the construction.

The Station comprises of four blocks, the main Block, A-Block, B-Block and C-Block. The main Block houses living accommodation, Medical room and Meteorological Laboratory. A section of A-block is used as a store and sports room/Gymnasium and remaining portion has been developed as Hospital complex. It earlier housed the generators, which were later shifted to Surya generator complex behind the Station. Two walk-in type deep freezers are installed at the rear end of this block to stores the frozen food for the entire wintering period. B -Block houses central heating system, water supply control & storage tanks, kitchen, lounge and washing rooms. C-Block houses the five incinerator type dry toilets. The loft area is used for storage of essential commodities. The central portion of the loft is raised to accommodate Communication room, fitted with a Satellite Terminal. Small deep freezers are provided in the loft for storing frequently required perishable food items. They were not operated during our wintering period.

Separate summer accommodation and basic facilities are provided for the summer team in the summer camp area. During the summer of 2003 for 22nd IAE, we provided heating system to all places in living area.

Power Supply

Three Power Houses namely ADITYA, BHASKARA and SURYA provide power supply to the station. The electrical power supply is of standard 3 phase, AC, 415 Volt, 50 Hz.

Aditya Power House: Commissioned during Feb 1993, it consists of three modules. This powerhouse consists of 4 X 62.5 KVA, brush-less type diesel engine driven generating sets, installed in two modules. The

third module houses the control panels. One of these generators was off road for want of alternator part spares.

Bhaskara Power House: Commissioned in 1994 and renovated in 2000 consists of two modules. The each module consists of one 125 KVA water-cooled generating sets. The central module houses the control panels. One of these generators was off road for want of engine.

Surya Power House: Consists of two modules containing 3 X 62.5 KVA and one 75 KVA brush type generating sets. These generators have outlived their life and should be immediately replaced by higher capacity 125 KVA generating sets. All four are presently operational.

Two generators are run simultaneously during summer and peak winters to cater to the electrical load of the Station. One generator feeds to installed loads in the Boiler room, pump house, electrical trace heating. The second generator caters to the Station load, summer camp and communication. The arrangement of the changeover switches facilitates use of any two generators simultaneously. The main supply cable is brought to the Station on a raised duct line casing for protection against strong winds, blizzards and snow accumulation. A distribution panel is installed in A-Block, with easy access to carry out repairs/maintenance.

All efforts have been made to balance the load in three phases and have to be constantly monitored due to fluctuations. All generators maintained and monitored regularly, provided trouble free operation with minor incidence of fire due to oil leakage and seizing of engines due to defective spare pulleys and belts.

In addition to above, 2 X 75 KVA, 3 Phase, 115 V, containerized generating sets of German make are available. They are used to provide power to the workshop with a step up transformer to change the voltage from 115 V to 415 V.

2 X 30 KVA, 415 V, 3 phase, diesel engine driven generating sets are also available. One of them is installed at Dakshin Gangotri to supply power to DG camp as and when required. The other is installed in Jeevan Jyoti, the power supply module for the containerized living module Banjara, used during convoys. Both Banjara and Jeevan Jyoti need maintenance from time to time.

CENTRAL HEATING SYSTEM

A central heating system is provided for comfortable stay of the members. Four hot water boilers of 2 lakh cal/hr capacity are connected to hot water radiators 1000 K cal/hr installed in living rooms and at appropriate places. The boilers are normally run at 70,000 K cal by using smaller fuel nozzles. A close loop pipeline is provided for hot water

circulation and to maintain the inside temperature. Safety indicators and hooters are provided on the boilers to indicate failure of any subsystem. Two fuel tanks of 2500 KL capacity are provided to store fuel for boiler operation.

All the available hot water radiators functioned satisfactorily where as some rooms need new radiators.. The air lock needs to be cleared from time to time for smooth operation of these radiators. The pipeline over the years has become rusted from inside. Some of them will need replacement in the near future. They need to be monitored constantly for any leaks. In the absence of any spare pipes, improvisation was carried out on ruptured pipes through gas welding.

Routine maintenance and repairs of the complete system has been carried out. The system had given trouble free service through out the wintering period. We erected one air lock door in B-Block to avoid entry of cold air through C- Block. Even during peak winters and windy conditions, only one boiler was run to provide the adequate heating to Station. The heating system can be put off for some duration during the summer period. This will give rest to the machinery, increase its life span and in turn save considerable quantity of fuel.

WATER SUPPLY SYSTEM

Water supply to the Maitri Station is provided by pumping water from the nearby Priyadarshani lake, approximately 255 m away to the north of the Station, through a specially designed pipeline. A pump House is erected about 80 m from the edge of the lake. A multistage centrifugal pump (7350 lit/hr at 30 m head) and a multistage submersible pump as a standby (KSB make, 3000 lit/hr at 30 m head) with two concentric steel jackets and electric trace heating are installed in the pump house to enable pumping of water throughout the year. The water is pumped into two stainless steel tanks 2500 lit capacity, located in the boiler room and distributed utility points through pipe lines and circulation pumps. Necessary control panel with safety system and indicators is installed in boiler room for observation and safe operation.

Two copper pipelines of 40 mm dia, one for regular use and one as a standby, are installed in a closed wooden duct. The spare pipeline was used at regular intervals to keep it in working condition.

The system worked without any major problem throughout the wintering period except two cases of fire due to electrical short circuit, which was result of carelessness and lack of knowledge. The minor defects like leakage at the flexible wire braided rubber pipe, short circuits in the trace-heating etc were immediately attended to. A close watch needs to

be kept on the temperature of pipeline, monitored at various points and displayed on control panel in the boiler room. This should be strictly followed for trouble free service. After the fire incidence we switched off trace heating system and the same was powered only two hours before the pumping of water and then switched off after two hours of finishing the work. This will save the power and also chance of short circuit.

VEHICLES

A large fleet of foreign make vehicles is held at Maitri. The user manual and repair manual must be thoroughly studied for safe and trouble free operation of these vehicles. The vehicles are electronically controlled and malfunction of these systems causes erratic behavior of the vehicle and this may result in serious injuries to persons around.

Numerous problems are encountered with vehicles at temperatures below -25° C. The low battery efficiency, thickening of various oils etc cause starting problems. Cold starting facilities exist in most vehicles. The use of ether for starting is not recommended for PB 330D vehicles. The self-starter must not be used for more than recommended duration to avoid damage to the assembly.

Proper care must be taken while driving the vehicles at Maitri. The low ground clearance and rocky terrain may damage the pipe connections and assemblies underneath the vehicle. Particular attention may be given to Mantis crane as it may be operated away from the main tracks. The use of convoy vehicles should be avoided at Maitri. The dozers should be used for pulling/shifting any loads. The PB 170 vehicles should be used for local transportation and carrying lighter loads.

CONVOYS

Maximum number of convoys should be completed before second week of May. No convoys are recommended beyond this time for low temperature and short duration of daylight. The number of vehicles taken with the convoys will depend on loads to be brought back to Station. In any case, no more than 8 persons are recommended to accompany a convoy to avoid problems of living space in living module 'Banjara'. Convoys should be undertaken (to and fro) on clear weather days with forecast of clear weather for at least next 24/36 hours. Aim should be to reach DG/shelf while the good weather lasts and vice versa.

Radio sets to be provided in all vehicles for communication with each other. Proper care may be taken for use of these sets for fast battery discharging. The portable INMARSAT terminal along with all its

accessories must be carried. This set is to be used only in emergency situations and all calls to be properly logged. A repeater station was erected during the XVIII expedition for regular trouble free VHF contact with convoy.

While towing loads on steep climbs especially near dozer point and approach to Sankalp point, the tracks tend to slip. It is advisable to shifts the loads including Banjara module to Sankalp a day or two prior to scheduled convoy.

The convoy must never halt on up-slopes. In case of any vehicle halting on an upslope due to any reason, the vehicles following should cross over and continue moving to the top of incline, shed their loads and come for help, if required.

The trailers and the sledges are often neglected during vehicle maintenance and can result in serious problems during the convoys. The towing attachments, wheels and mounting bolts of trailers, skis and cross chains of sledges must be checked before and after every convoy.

Any vehicle that breaks down en-route must be recovered by loading on to a sledge by making a snow ramp in the same or next convoy. In case of soft snow not available on blue ice, it can be recovered after a couple of blizzards, when sufficient snow would have accumulated around the vehicle. The recovery should not be inordinately delayed as the vehicle gets packed up in snow and recovery becomes time consuming.

Global Positioning System for convoy navigation: A very important tool for convoys during bad weather and blizzards. At present only one set is available at Maitri, which is highly inadequate. Demand was placed for three additional sets and should be fitted in the lead, rear and middle vehicles. GPS in all the convoy vehicles is preferred.

HALT AT DG AND SHELF

Always park the vehicles and trailers away from the main track to avoid snow accumulation and humps being formed on the track. These should be parked at sufficient distance apart to avoid excessive snow accumulation. The vehicles should be parked facing the wind direction and ensure that all the doors and windows are properly closed. Never switch on the cabin heater immediately during blizzards as snow could have leaked into the blower assembly and can damage the motor.

The temperature at DG is always lower than that experienced at Maitri and difficulties are faced in starting the vehicles. At least two vehicles have to be started initially for starting of other vehicles using jumper leads. These two vehicles (one of them preferably a PB 270 to allow ether starting) should have batteries in good condition.

The 30 KVA Generator is a vital part of the convoy and should always be maintained. The generator should be checked every hour during night operations. The storage fuel tanks and the accommodation modules should be relocated every year to avoid snow accumulation. The crane at DG/shelf should be sealed as much as possible.

While at DG kindly ensure that vehicles and trailers are not parked within the area of GSI Stakes (Bamboo Poles) monitoring network.

HANDLING OF FUEL

Fuel is the lifeline of Antarctic Stations and should be handled very carefully. The fuel used is ATF, brought in bulk by ship and decanted into storage tanks at shelf/DG. Some quantity of fuel is brought in barrels too. It is the most important cargo transported by convoys from shelf/DG to Maitri.

Sufficient quantities of fuel must always be stored at Maitri for daily consumption. The monthly consumption on an average at Maitri works out to roughly 25 KL. This includes consumption by generators, incinerators, boilers and vehicles. This figure may vary depending on the number of generators and boilers operated, number of convoys operated as well as efficiency in handling, prevention of wastage etc. The Station should maintain a safe reserve of fuel at all times. During the period convoys are not run, Station should keep a safe reserve of more than 150 KL of fuel to cater for this period in advance. Fuel is brought in transportation tanks from Shelf/DG and decanted in storage tanks behind the generator complex.

All EPI coated fuel barrels brought with the expedition should be shifted at Maitri and should be properly stacked at Helipad for use by helicopters during next summer period of expedition. These barrels should not be used for any other purposes.

LOGISTIC ACHIEVEMENTS DURING THE EXPEDITION

Replacement of Engines—This team had taken over only 05 vehicles in working condition from previous team. New engines were fitted in 03 vehicles and regular repairs and maintenance of vehicles achieved 100% serviceability of the fleet.

Repair of Trailers—Major overhauling of all the trailers has been carried out by this team. A total of 35 shock absorbers springs, 30 Grouser bars supporting plates and 03 Axle-assemblies were replaced. This was a major task carried out by this team thus enhancing the life /serviceability of the trailers.

Repairs and activating of Polar Bear vehicle-The Polar Bear vehicle which was re-inducted with the previous team after major repairs was shifted to Maitri station from the Shelf by this team and necessary repairs carried out to make it road worthy. The trailer of this vehicle, which was lying at Sankalp Point, was also shifted to Maitri station. The vehicle and the trailer were utilized for local duties.

Shifting of all assets from Shelf to DG—In view of danger of ice shelf breaking, an additional task of shifting all cargo containers, fuel tanks, crane & other assets was assigned to this team, which has been successfully completed. It took this team 21 days for retrieval of buried equipment and shifting of all the assets to DG. The team faced 04 blizzards during this period.

Retrieval of equipment at Shelf—02 damaged Trailers, 02 Sledges, a Snow mobile Scooter and a large number of fuel barrels that were buried under blue ice were recovered and shifted to DG. The Trailers were repaired at Maitri and made fully functional.

Retrieval of Assets at DG—This team has recovered a total of eight 24 KL fuel tanks from the ice, out of which 04 were totally buried under ice. It was an extremely difficult task carried out after a number of attempts using own-resources & innovative means. The previous team had suggested NCAOR to seek official help of Russians to extricate/ retrieve these fuel tanks. The 30 KVA Generator "Jeevan Jyoti" along with the sledge buried under ice was recovered & brought to Maitri. The complete overhaul of this Generator was carried out thus enhancing its life. The Mantis Crane at DG, which was buried under ice and was in nonfunctional condition, was recovered after a lot of efforts and made functional.

Repair to D-50 Dozer—One of the D-50 Dozers that was off-road for a long time due to broken track frame was repaired with the help of a Russian welder. This Dozer was got repaired earlier in India for the same defect, but the quality of welding being poor the axle had broken. This Dozer is now fully operational and is being utilized for dozing work.

Repair & Overhaul of Generators—Three 62.5 KVA Generators and one 30 KVA Generators were completely overhauled involving replacement of all the cylinder liners, pistons, piston rings, inlet & exhaust valves, big end & main bearings.

Establishment of new Fuel Dump—As the main Fuel Dump is located in an area prone to accumulation of water during summers, a new Fuel Dump has been established on the rocky ground.

Repair of PB-270 Vehicles—15 damaged Axle tubes of two PB-270 vehicles were replaced by the axle tubes cannibalized from discarded PB-

170 vehicle. It was a major task carried out to improve the condition of the vehicles.

Retrieval of Fuel from Dozer Point—30 KL of fuel was retrieved from barrels buried at Dozer point & shifted to main Fuel dump at Maitri.

ENVIRONMENTAL PROTOCOL AND WASTE MANAGEMENT

The environment of Maitri and surroundings is to be maintained as per the Environmental Protocol of Antarctic Treaty. According to this Treaty, all the Antarctic Stations can be visited and inspected by Treaty members. As such, it should be ensured that Maitri and its environ are maintained as per the laid down norms. The team members should be made aware of all the contents for strict compliance.

An environmental cleaning drive was launched during our wintering. The scrap and garbage was shifted into Containers complex for back loading to India. All containers and half bins along with other materials lying around the station were picked up and properly stacked in container complex.

The New incinerator HOLIKA was commissioned during our wintering and was used effectively to minimize the generation of waste. All kitchen waste, paper and small cardboard boxes were incinerated regularly. The garbage burning in open is against the Antarctic protocol. Therefore open burning was stopped during our expedition and all wooden cartons were compacted and sent back to India for recycling. Glass, Plastic, Tin cans and wires etc were collected in a container in drums and back loaded.

The Klargesters are giving regular problems and have outlived their life. They need to be replaced immediately with ones of higher capacity. A constant and vigilant watch needs to be kept on the trace heating connected to the Klargester pipelines. Short-circuiting in the trace heating was observed on some occasions during the wintering period.

WASTE DISPOSAL

Five dry type toilet modules are available at the Station for the wintering members. Separate toilet modules are provided for the summer camp. Oil fired burners are used to burn the waste. Ash from the incinerators is to be collected in bags/barrels and back loaded. The non-combustible waste is compacted, bottles crushed and collected in barrels and back loaded for disposal. Empty barrels and toxic materials are to be collected and back loaded.

The wastewater from the Kitchen, bathrooms, washbasins etc. is directed to two Klargesters. The two Klargesters are capable of treating

1000 and 5000 lit of effluent per day respectively. The sludge from the primary and the bio-sludge zones collects and consolidates at the base of the unit. The sludge is to be cleared at regular intervals and back loaded. The treated water is collected in a storage pit and pumped to an uphill location roughly 300 m from the Station as and when needed.

COMMUNICATION SYSTEM

INMARSAT-A terminal (DEBUG) is the oldest terminal available at the station with ID No. 00 873 1640522 (Phone) / 1640523 (Fax) and 00 583 1640522 (Telex), installed at rooftop of the Maitri Station (Main Block). This terminal is working satisfactorily in all modes. The antenna dome is fitted above the Radio room and a hatch is available to access to the dome during winter and blizzards.

INMARSAT-B terminal (SAILOR) is the second terminal installed in the communication room with ID No. 00873 341900381 (Phone) / 341900382 (Fax) and 00 583 341900384 (Telex) with data speed of 9.6 kbps. The system is being used at present for telephone calls and telex for IMD data only. Fax facility is not working for want PAX card. This card was damaged during last wintering and spare cards were not received with new team.

INMARSAT-C terminal (SAILOR) is installed in the communication room with ID No. 00 4419001670 is meant for data communication only with data speed of 0.6 kbps. At present system is not in use. The system uses store and forward facility for slow speed data transmission. The system can be used for telex and e-mail. E-Mail account with VSNL may kindly be registered for this terminal so that the terminal could be used effectively.

This terminal is working in all mode, for checking the status of this terminal we make a telex, fax and data call in fixed schedule. A DOS based software system "CAPSAT" was provided for its computer interfacing. It is a Menu driven program and is used for sending telex, fax and data. We have not faced any problem with this system during the XXI Expedition.

INMARSAT-M TERMINAL : This is the most modern, portable and advance communication equipment for remote camping and convoys. This set is connected to Atlantic East Satellite and enables communication with India, Maitri and most other countries covered by this satellite. The battery of this set discharges fast during low temperature. It is advisable to keep the battery fully charged and carry spare batteries at all times. The system can also be operated by external 12/24 V DC by changing the ON/

OFF switch to external battery position. Proper log of this set should be maintained separately. This set is to be used only during emergencies.

During 5th convoy SMPS of this terminal became faulty. We have gone through the manual, rectified the fault and repaired it. In our expedition, we have used this terminal only for convoy, but in XXIIIASE, summer field party may use it. Before convoy starts we hand over it to convoy chief and advice to use it in emergencies. In order to remain operational the terminal; a call has to be placed every 25 days.

Following are the IDs for INMARSAT-M terminal.

TEL: 684040246 FAX: 684040247 DATA: 684040248 PABX: 684040249

E-MAIL TERMINAL

INMARSAT-B terminal (SKANTI) is installed in Girnar Hut with ID No. 00 873-341900348 (Phone) / 341900349 (Fax) / 00583-341900350(Telex). The system with data speed of 9.6 kbps is being used at present exclusively for E-Mail facility with e-mail **ID maitribase@maiI.stationl2.com.** FAX facility of the system was not working due to wrong setting of hardware. The defect was rectified during our period and all facilities are operational. Log generation facility of the system is not working therefore no log is being generated.

INMARSAT-M maritime terminal (NERA Saturn M) with ID No. 00 873 641902723 (Phone) / 641902724 (Fax) was brought by XXIIAE Team and was installed in Nandadevi Hut by VSNL member on 26 January 2002. The newly acquired telemedicine software doctoranywhere.com and Intel camera software is also installed with this system. The system is ready for E-Mail facility with VSNL value added service e-mail ID 641902723@inmarsat.vsnl.com. The speed of date transfer is 2.4 kbps maximum for this system. Therefore a lot of time is being consumed for data transfer and fax facility. The voice quality and connectivity of this system with India is very good. At present the system is being used for official telephones and fax. Weekly down loading of e-mail messages is also being done on experimental basis. Due to un-serviceability of fax facility at INMARSAT-A and INMARSAT-B terminals this system is being operated round the clock for incoming fax messages. The doctoranywhere.com facility was tested successfully along with Intel camera. Video conferencing facility was also tested and can be used whenever required with speed limitation. Due to non-availability of log creation facility the system was not opened for public in general however limited private calls were allowed in case of problem in terminals installed in communication room.

AVIATION BAND DITTEL VHF SETS

These sets are used for communication with Helicopters or any other aircraft in the vicinity, and nearby NOVO Station at 126.5 MHz Frequency. If the Helicopter is delayed by more than 5 min from it's ETA and out of communication, it should be treated as emergency. Alert the other Helicopter for launching a search immediately. In case of more than one Helicopter operating in the same area, their routes, height of operation, timings and operating frequency has to be communicated amongst them.

VHF 25-WATT WALKIE/TALKIE SETS FOR CONVOYS/ SHIP COMMUNICATION

The repeater station set up at Veteiah top greatly helped in communication with Ship and ice shelf (including Indian bay and Russian Bay). This could also provide uninterrupted communication with the convoys. Three vehicles were fitted with Motorola and Yesu VHF sets. The other vehicles were provided with Motorola Walkie/Talkie sets for inter communication. The battery of these sets drains fast with use and low temperature and needs to be charged repeatedly. The charge of these batteries can be improved by keeping them in warm conditions. The convoy is always in communication with Maitri and monitored. Punwire Walkie/Talkie sets are used for local communication during summer. They have a very low range and can be used for communication with summer huts.

SCIENTIFIC EXPERIMENTS

The details of various Scientific Institutions participating in Indian Antarctic Program and the various experiments carried out during winter are as follows:

CLIMATOLOGICAL AND METEOROLOGICAL STUDIES

The Climatological and Meteorological studies are being pursued by **India Meteorological Department** since the first Expedition with the aim to build up a climatological data set of Antarctica. This data will be used to generate meteorological models to understand the patterns of Antarctic circulation in the context of global and Indian weather systems. Synoptic observations are taken regularly every three hours to monitor and record Total Global Solar radiation, temperature, pressure, Wind direction and

speed and surface ozone and data transmitted to IMD, New Delhi every six hours. 52 Ozone sonde and 13 radiometer sonde ascents were taken during the year at regularly to monitor surface ozone conditions and different weather parameters.

The state of the art technology, Brewer Spectrophotometer was installed in the year 1999 to monitor total ozone content, $S0_2$, $N0_2$ and DUV measurements in the atmosphere. The instrument is operational since them and significant atmospheric data related with Total Ozone, Total $S0_2$ & $N0_2$, and DUV data has been collected during last four years.

During the year 2002 Ozone hole phenomena was unusual and there was significant change in the quantity of depletion. Ozone sonde profile and Total Ozone measurement by Brewer Spectrophotometer were complimentary to each other and detailed study is required to understand different processes and role of UV radiation and quantitative changes observed in the S02 and N02 measurements. Spectral analysis of UV radiation is required to study its influence on ozone depletion and vice-versa. Meteorological features were found as usual except the fact that the year 2002 was warmer and windier than normal and extreme atmospheric pressure recorded during the year.

LOWER AND MIDDLE ATMOSPHERIC STUDIES

This ongoing projects to study ozone hole, atmospheric turbidity, UV-B radiation and aerosol loading of the Antarctic atmosphere, with the aim to understand the overall global change phenomena, are pursued by **National Physical laboratory.**

In year 2002 the measurement of atmospheric $C0_2$ was made by online gas chromatography, using flame ionization detector for methane, CO and C02. In gas chromatography, chromatograms are recorded using physical method of separation of the components of a mixture by distribution between two phases and by an integrator or computer, which processes the output of detector electronically and analytically and further determines peaks height and area. Mixing ratios for the samples are determined relative to the standard calibration technique. The gas chromatograph established at Maitri during this expedition is a state of art technology consisting of an independent nitrogen generator producing nitrogen as carrier gas at site and directly connected to the system. It also has inbuilt hydrogen generator and air compressor for hydrogen and air needed to ignite the flame ionization detector.

The system was set up in last week of January 2002 and data was collected cyclically every day on half hourly basis during daytime and

occasionally night times after befitting stabilization of the system that takes nearly three hours to stabilize. Once a week 24 hourly data were also taken. The GC was calibrated using the PEAKNET software on regular basis with $C0_2$ (303 & 320 ppm) standards to obtain an error free data. The measurements carried out at Maitri, Antarctica in year 2002 shows the observed increase of $C0_2$ from about 280ppm in the pre-industrial era to about **366.0997ppm.** The average C02 during the year 2002 found out to be 366.0997ppm. The carbon dioxide was found to vary in the range 340 to 390ppm accompanied by infinitesimal day-to-day and monthly variation depending on the wind and other meteorological conditions.

Hand held microprocessor based sun-photometer have been used for monitoring of column ozone, water vapour, Aerosol Optical Depth, UV-B radiation at 300, 305 and 312 nm & near infrared solar radiation at 940 and 1020 nm.

At Maitri maximum ozone up to 320 DU has been recorded in the months of January and February while Highest concentration of Ozone 432DU was recorded on 25/10/02. After Feb. ozone column density started decreasing. Minimum measured ozone was about 173.8DU on 21/9/02, which confirms the continuity of ozone hole phenomenon at Maitri. Ozone hole period was observed during last two weeks of September and first two weeks of October. It was observed that total ozone column is very much dependent on the planetary wave conditions. Exceptionally high value of total ozone observed during ozone hole period may be attributed to the planetary wave phenomenon as Maitri; the Indian Antarctic Station is located on the fringe of the vortex.

The water vapour measurement is based on a pair of radiometric measurements in the IR band. The 940 nm filter (10 nm FWHM) is located in a strong water vapour absorption band while 1020 nm filter (10 nm FWHM) is affected only by aerosol scattering. The water vapour was found to be maximum in tropical latitudes while it was minimum at polar latitudes. This is due to very cold and dry condition at polar latitudes.During summer the water vapor was found to be maximum (0.8 cm) whereas during winter it was minimum (0.01 cm). It was observed that water vapor is very much dependent on the local meteorological conditions. The long-term database will go a long way for trend analysis and global change studies.

UPPER ATMOSPHERIC STUDIES

A Fluxgate magnetometer was continuously operated by **Indian Institute of Geomagnetism (IIG),** Mumbai to study a) Quiet time diurnal

and seasonal changes in the geomagnetic field, b) Geomagnetic field variations in response to electromagnetic disturbances, and c) Harang discontinuity features of the auroral oval over Maitri.

A Riometer is continuously operated to monitor the auroral ionosphere and to study the field-aligned currents. A Proton Precession Magnetometer (PPM) is operated to record the Total Field (F) variations. This will throw light on the rapid decrease of F in the Southern Hemisphere. These studies will throw light on the current processes in near and deep space

All above instrument setup is at Nandadevi hut. All these instruments are having single digital data acquisition system. 8-channel data logger is being used to store data in memory modules. Regularly after 5 days exchanging of memory modules and downloading of data from memory modules to computer were carried out during winter period. Preliminary data editing has been done from time to time. All above-mentioned instruments are supported with power backup unit containing inverters and batteries. This backup unit is useful for uninterrupted data acquisition during power failures. This year we changed old batteries with new more current capacity batteries. So this year we minimized any chances of data loss during power failures.

The study of global electric circuit (GEC) provides a platform for understanding the solar-terrestrial relationship and changes in surface weather with the solar output. For this, understanding of near-Earth atmospheric electrical environment is needed. To accomplish the above objectives of understanding near-earth electrical environment, measurement of electrical parameters namely, Air-Earth current, surface vertical electric field and the electrical conductivity were made during winter period with the help of Maxwell long wire antenna installed at Kamet hut.

During this winter period good quality uninterrupted Geo-magnetic and atmospheric electricity data has been acquired in both digital as well as in analog format. This year was most active period of solar atmosphere, so more magnetic activities were recorded. We have recorded very good strength magnetic storms-substorm and geomagnetic pulsations within this year, which are more useful for further research, related to our projects.

SNOW DRIFT AND ALBEDO STUDIES

Snow and Avalanche Study Establishment carried out these studies to understand the net energy exchange budget between the environment

and the snow cover. The studies are aimed to determine the dependence of snow albedo on snow surface parameters like age of snow, grain size and type of snow, cloud cover, solar elevation etc. This will establish the correlation between the energy exchange processes and heat conduction, temperature profiles and snow metamorphism. Automatic Weather Station was set up over Polar Ice at Sankalp point. Sensors namely, wind speed and wind direction, relative humidity, air temperature, atmospheric pressure; snow depth and albedometer sensors were integrated with the automatic weather data logger. The sensors were logged to record the data on hourly basis. The charging of battery for data logger is through solar panel. An albebometer was installed nearby area of Maitri to carry out the reflectance studies on drifted snow.

For **Micro structural Studies** about one hundred samples were collected from continental ice, glacier ice and even of frozen Priyadarshini Lake. To prepare thin section of ice sample is quite challenging and needs patience. A method known as hot plate technique was adopted to prepare the thin section of ice. Adequate number of photographs has been taken at different time exposure. The detailed results can only be discussed after development of film.

SEISMOLOGICALAND GPS STUDIES: NGRI

A permanent digital broad band seismographic observatory was established by National Geophysical research Laboratory (NGRI), Hyderabad, in the XVII expedition. The monitoring and recording of frequency and strength of seismic activity in Antarctica were continued during this expedition. The seismic shocks orginating over Southern Oceans and Indian Ocean regions were recorded and will be used in delineating the deep crustal structures of the earth.

Daily about 16 MB of digital seismic data is recorded and the data after archiving and formatting transferred to CDs and Data tapes in two copies each. In total in this reporting period SIX (6) GB of valuable high quality seismic data acquired with no loss of data at all in all the 365 days of the year considering the Antarctica nature like the severe blizzards, polar nights, gusty winds and very severe bad weather in majority of the wintering days in this expedition.

A permanent GPS Observatory was also set during the XVII expedition to carry out high precision geodetic measurements. A Turbo Rogue GPS receiver was installed by NGRI as a part of International GIANT project (Geodetic Infrastructure in Antarctica) to study tectonic movement of the Antarctic plate in relation to other plates; to link sea level

changes with vertical motions of plates; and to generate a data link between India and Antarctica. The studies were continued throughout the expedition.

During 19th and 20th Indian Scientific Expeditions to Antarctica, continuous GPS monitoring was carried out with the help of Ashtech Z XII GPS Geodetic receiver. In this expedition New TURBOROGUE SNR-8000 system was installed and good quality of data collected with a sampling rate of 1 sample per 15 sec. The data is stored on cds and dat tapes on weekly basis. In this reporting period more than 800 MB of data was generated and stored. Daily this data was converted to Rinex Format and stored in CDS and Data tapes. The final analysis shall be carried out at headquarters and the results and final report will be submitted to the concerned authorities.

RAJIV GANDHI CENTRE FOR BIOTECHNOLOGY

During the XXI Indian Antarctic Expedition bacterial samples have been collected from different habitats of Antarctica. A total of 150 pure isolates were obtained by streak plate method. Of these, 64 isolates are marine. Morphological, biochemical, physico-chemical and molecular characterization of the all the strains have been completed. Studies on the salt and temperature tolerance of the marine isolates indicate that all the strains are halotolerant psychrotrophs. Studies on the pH tolerance revealed that they are neutrophiles and tolerated a pH range of 4 to 11.8. PCR based RFLP analysis of various strains indicate that there are 13 genetically different marine species. Partial sequencing of 16 S rRNA of all the RFLP differentiated strains have been completed. Blasting and species identification will be possible only after sequencing the complete 1538 bp gene, which is in progress.

ZOOLOGICAL SURVEY OF INDIA

Total 26 species of birds were observed during onward voyage between 50° 19' to 69° 51' Latitude (S) & 10° 05' to 16° 00' Longitude (E) and return voyage from 68° 07' to 37° 58' Latitude (S) & 18° 06' to 28° 06' Longitude(E). The distribution, habit and abundance at various locations were also incorporated in the present paper. The observations on South Polar Skua were also recorded in Schirmacher Oasis. Their habit, nesting sites and population in Schirmacher Oasis was also studied.

GEOLOGICAL SURVEY OF INDIA

Coarse grained porphyritic charnockite and coarse porphyritic granite are exposed in the northern and southern parts respectively of central Muhlig-Hofmannfjella. Detailed petrography reveals that their mineral assemblage is markedly different. Hypersthene, ferrosilite, fayalite, diopsidic augite and biotite are the ferro-magnesium minerals in charnockite, while biotite and hornblende are the only ferromagnesium minerals in granite. The charnockite has signatures of a Charnockite Magmatic Suite (CMS) as well as that of A-type granite derived from fractionation of tholeiitic basalt. While presence of inverted pigeonite, high K, Ti and P, low Ca are indicative of CMS, the presence of ferrosilite and fayalite are features of A-type granite fractionated from a tholeiitic magma. Harker plots of $Si0_2$ vs. CaO, K_20 and $Ti0_2$ for both granite and charnockite are almost identical. In the light of these results, it is surmised that although granite and charnockite occur in the field as distinct entities albeit closely associated, they share common crystallization history and perhaps are parts of a single pluton.

Studies on the Ice shelf, polar ice and monitoring of the ice bergs have been a part of long-term glaciological data acquisition programme of Geological Survey of India ever since India launched her First Antarctic expedition in 1981. Observations made on the ice berg distribution in Antarctic waters, snow accumulation/ablation on the ice shelf and fluctuations in the polar ice margin are in agreement with the broad conclusions drawn using data accumulated over two decades.

M.S. UNIVERSITY OF BARODA, VADODARA

8^{18} O variations and processes responsible for the post depositional isotopic changes in the samples from ice wall, location specific surface snow and ice; collected on different days from the continental ice sheet after snow/ snow drift events and fresh water from lake 'Priyadarshini' located near Maitri station are presented. The highly depleted values of 8^{18} O in the samples of continental ice wall sampled from top to the base, implies a non-local, high altitude source for the ice.

Three distinct 'climate change' events are observed in the 8^{18} O data; at 5,18 and 19 m depths respectively, the enriched 8^{18} O values at these sample locations indicate relatively warmer events. Similar abrupt short duration events have been reported by Delmas (1997) in the ice cores from Greenland .We need to provide proper chronology to such records.

Out of the five locations selected for the surface ice and snow sampling from one location, surface ice has shown highly negative 8^{18} O value (location 4, -40.92‰); the other four locations have shown higher 8^{18} O values between -22.12 *‰* to -24.82 *‰* . The ice core represents insitu accumulation of recent times over the older transported sheet ice surface; the missing record could be understood only by more detailed investigations in future. The data from surface ice samples agree well with the data from the shallow ice core, barring the location no. 4; the sample from this location appears to be of an older ice block caught up with the younger ice.

The snow samples collected on different days after snow/ snow- drift events have shown a wide variation in 8^{18} O. To understand the post-snow drift 8^{18} O variations in the snow samples, a location near Maitri was selected for collecting the falling snow during three snow/ drift events. The 8^{18} O variation in these samples ranged between -15.00‰ to -16.28%c. Majority of snow samples showed 8^{18} O signatures similar to the values of Maitri samples, the more negative 8^{18} O observed in a few surface samples is attributable primarily to the melting of snow; the enriched values in some samples is thought to be on account of drifted snow from the ice shelf. The snow sample collected on the ship anchored near the Indian Bay has a $\mathbf{8^{18}0}$ of -13.15‰.

NATIONAL HYDROGRAPHIC OFFICE DIRECTIVES - NAVY

The on-going research activities at Antarctica were successfully carried out during 21st IAE by participating and contributing data to the Global data centers. Both GPS and Seismic Observatory at Maitri, Antarctica have gone global and working in tandem aid mutually, the studies on tectonic processes, analyzing the seismic activities in and around Antarctica, yield a comprehensive picture on Indian Plate Kinematics. Acquisition of uninterrupted good quality Broad Band digital seismic data as well as GPS data continued. The seismic data was processed and analysed at NGRI using SEISAN software, up to September 2002 and reported to International Seismological Centre, United Kingdom. This data is quite useful in global epicentral determination, particularly about the earthquakes of South of Africa, Indian Ocean and South Sandwich Islands. About 314 events have been reported to ISC out of which 3 earthquakes of above 7 magnitude, 30 earthquakes of above 6 magnitude and the rest are of magnitudes 5 and 4. The nearest region of South Sandwich Islands region also experienced with 27 major earthquakes and this data will be useful for further research activities.

S G B AMRAVATI UNIVERSITY, AMRAVATI

The present work emphasizes on the study of on going sedimentological processes in Schirmacher area as well as the detailed study of product of the same i.e., glacial debris and sediments. Physiographically, the Schirmacher area is divisible into continental ice, main Schirmacher land and shelf area. A clear distinction of the dominating physical agencies and their work in above mentioned three areas can easily be noticed. However, in a limited period of time, the present emphasis is given on various statistical analysis of the sediment samples collected from various sub-environments of the glacial environment. The common parameters like graphic mean, graphic skewness, graphic kurtosis, graphic standard deviation etc. have been calculated and interpreted for environmental reconstruction. In addition, a preliminary report of heavy minerals identified is also presented.

SURVEY OF INDIA

The scientific team of Survey of India during the XXI Indian scientific expedition, Austral Summer 2002, reached Antarctica with the objectives to prepare a large scale map covering an area of 500m x 400m on scale 1:1,000 with lm contour interval, for establishing the new Indian Research Station. One site was already surveyed by survey team during XX Expedition. This site, which was about 5 Km west of Maitri has undergone physiographical changes, was not found suitable for the proposed station. A new site which is adjacent to the Priyadarshini Lake was finally selected jointly by Director, NCAOR, Goa, who was an observer of DOD and by the team leader of XX ISEA.

DEFENCE ELECTRONICS APPLICATIONS LABORATORY (Communication)

Defence Electronics Applications Laboratory (DEAL), Dehradun is playing a vital role in the field of communication. This is the prestigious communication laboratory of DRDO, to provide adaptive HF Voice and Data communication to the XXI st IASE. To improve the convoy communication, we had made an extra effort by adding HF communication for the first time in convoy with VHF and mobile terminal like other neighboring station. It was our trial bases efforts, station commander and convoy chief are also satisfied with it, and we feel that HF mobile antenna with proper specification is necessary. After specific modification of the adoption of HF communication in convoy, it will boost the morals of our convoy team. This report briefs the achievement of communication team

to provide the lifeline communication at Antarctica scenario, details of communication facility available at Maitri and some suggestions for enhancing the total communication support for future.

BHARAT SANCHAR NIGAM LIMITED

Bharat Sanchar Nigam Limited participated in 21st Indian Antarctic Expedition by deputing one personnel from Department of Telecommunication / Bharat Sanchar Nigam Limited as Winter Member for maintaining the telecom setup in Indian Base Station, Maitri in Antarctica. Broad objectives were as follows.

1. Day to day operation and Maintenance of Telecom Equipment in Maitri.
2. Exploring new possibilities for improvement.
3. Day to day misc works assigned by the Team Leader

VIDESH SANCHAR NIGAM LIMITED

The newly installed and commissioned Inmarsat - M maritime Terminal IMN 641902723 which has been installed and commissioned at Maitri by VSNL is ready for the providing following services through Arvi LES India and other LES (if require).This terminal is working for both the IOR and AOR (E) satellite. At present it is working with IOR satellite for the following services.

1. Voice
2. Fax
3. Data
4. **Internet e-mail by using 28# through** Arvi LES
5. Doctoranywhere.com facility

DEFENCE ELECTRONIC APPLICATION LABORATORY-RADARSAT

Images gathered from the active sensor of a remote sensing satellite, are rich in textural information. The wavelength of the sensor of active satellite is large in comparison to optical one. In the case of RADARSAT satellite the sensors wavelength is 5.6 cm. In this paper we have presented a scheme to detect anthropogenic features from the remotely sensed images of Schirmacher oasis, Antarctica, taken by RADARSAT satellite. This is achieved with the help of Weibull density distribution. We have tried to classify the SAR image in man-made and non man-made regions.

Fig. 1: XXI Team Members with Dr. H. K. Gupta, Secretary, DOD on board ship at Cape Town

Fig. 2: Under slung cargo operation from ship

Fig. 3.

Figs. 3 & 4: Taking over of Station from Sh. Sri M. J. D'Souza , Leader of XXIAE

Figs. 5: Crane Buried in ice at Dakshin Gangotri Base

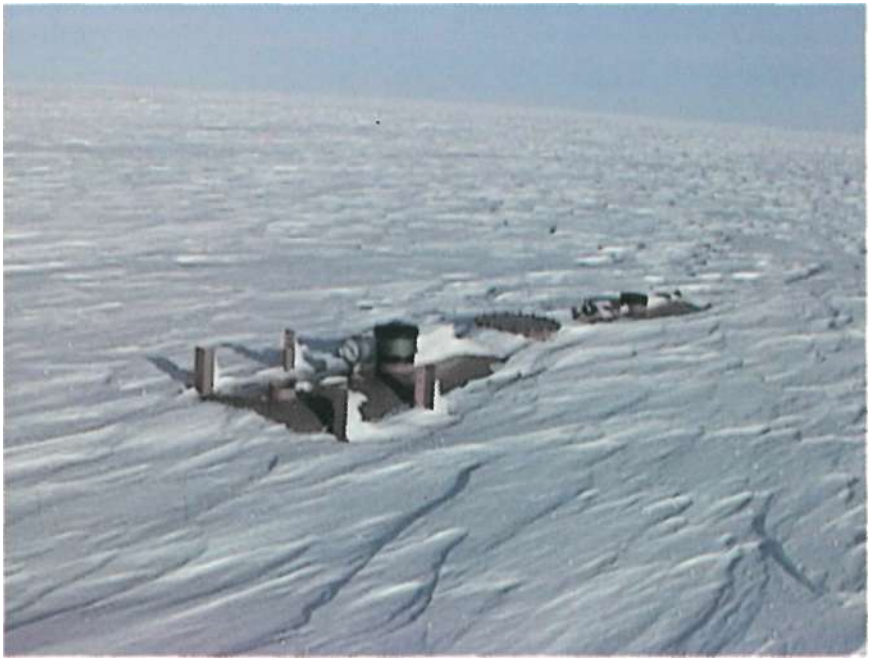

Fig. 6: Fuel Tanks Buried in ice at Dakshin Gangotri Base

Fig. 7: Polar Bear Retrieved from Dakshin Gangotri Base, Repaired and in use at Maitri

Fig. 8: MV Magdalena at India Bay

Fig. 9: Auroral Display at Maitri, Antarctica

Fig. 10: Wind mill generator at Maitri

Fig. 11: The ship parked in pack ice near India Bay

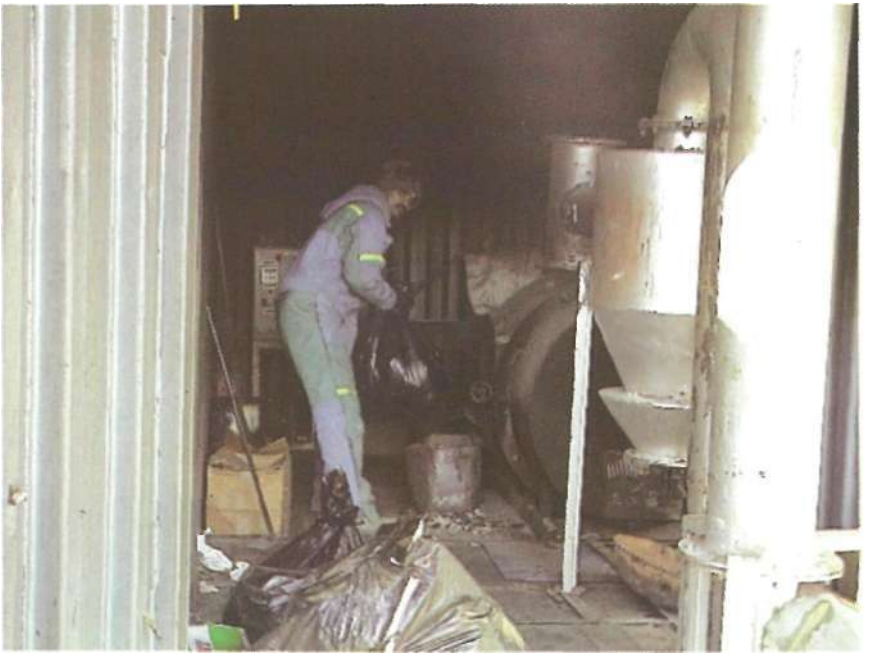

Fig. 12: Newly installed incinerator "HOLIKA" at Maitri

Fig. 13: Logistic support provided for IL-76 landing operation

Fig. 14: Launching of Ozonesonde by IMD for ozone studies

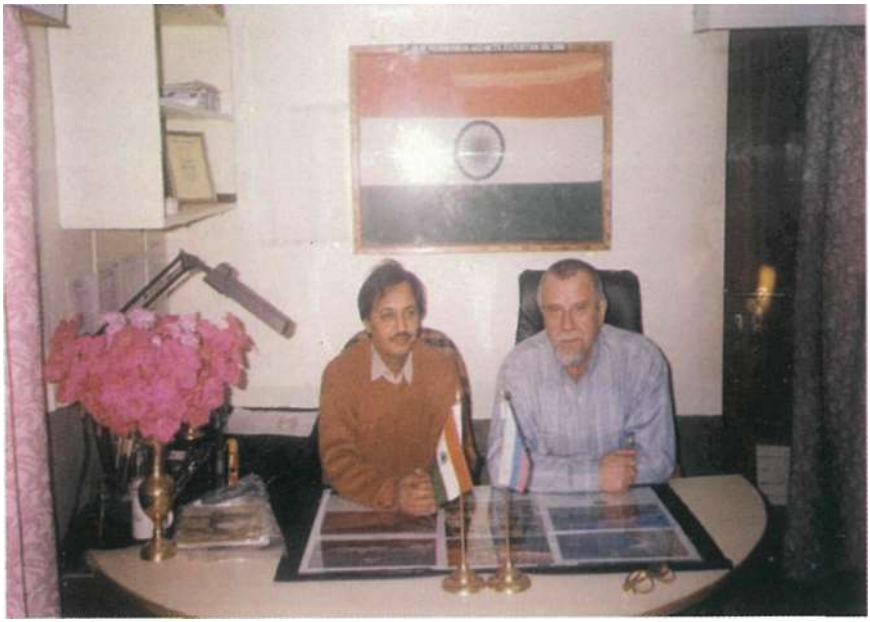

Fig. 15

Figs. 15 & 16: Dr. RP Lai with Leaders of Russian Antarctic Station, NOVO

Fig. 17: Visit of Dr. Valery Lukin, Deputy. Director, Arctic & Antarctic Research Institute, Russia

Fig. 18: Visit of EPICA Team Dr Frank Wilhelms, Chief Scientist and Drilling Project In-Charge EPICA

Fig. 19: Visit of Ms Izabella Eli Base Commander, Neumayer the German station

Fig.'20: Visit of Prof. S Rasuka, Director, Department of Antarctic Biology, Polish Academy of Sciences along with IL-76 Crew

Fig. 21: Visit of Dr Maxim Yu. Moskalevsky, Principal Research Associate Glaciology, Russain Academy of Sciences and member of SCAR

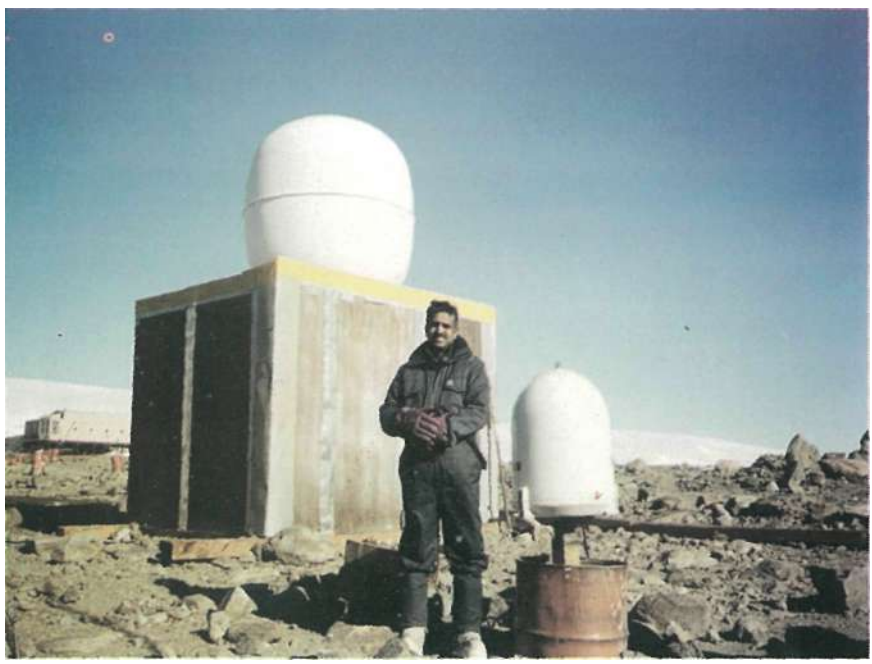

Fig. 22: New INMARSAT Antenna installation - Final set up

Fig. 23

Figs. 23 & 24: Handing over of the station to Dr. Arun Hanchinal, leader of XXIIIAE