

Management Plan for Antarctic Specially Protected Area (ASPAs) No 163 Dakshin Gangotri Glacier, Dronning Maud Land

Introduction

India introduced a Working Paper at XXV ATCM (WP47) on a draft management plan for a proposed site of Special Scientific Interest for Dakshin Gangotri Glacier Snout, Schirmacher Hills, Dronning Maud Land. The Committee noted that this should be termed an ASPA rather than SSSI. Accordingly, during XXVI ATCM India submitted a draft management plan for Antarctica Specially Protected Area (XXVI ATCM/WP-38) and thereafter submitted revised management plan during XXVII-ATCM (WP 33). The management plan was adopted by Measure 2 (2005) and designated ASPA 163 during XXVIII ATCM (WP 25). This Management Plan was further reviewed after five years with minor changes, while submitted to XXXIII-ATCM (WP055 rev1.) and adopted under Measure 12 (2010).

Dakshin Gangotri glacier has significant value in terms of glacier retreat monitoring. A snout is being monitored since 1983 to understand the effect of climate change on glacier. This area is also important for study of algae, moss, cyanobacteria and lichen which are wide spread in Schirmacher Hills and especially within the ASPA site. Cyanobacteria contribute significantly to the nitrogen fixation, and many species have been identified so far from this area. Many species of lichens are also identified in this area according to study conducted since 2003.

1. Description of values to be protected

Historic Value

Dakshin Gangotri Glacier is a small tongue of polar continental ice sheet, overriding the Schirmacher Hills in central Dronning Maud Land (CDML). It was identified by the second Indian Antarctic Expedition in 1982-83 and since then its snout is being monitored regularly for fluctuation w.r.t. retreat/advance.

Scientific Value

With the availability of the vast amount of data for the past two decades, it has become a valuable site for observing the changes in the movement of the Antarctic ice sheet under the impact of global warming. The area has primary scientific importance for glaciologists and environmental scientists. Due to the scientific values of the Area and the nature of the research, the area is protected as an Antarctic Specially Protected Area consistent with Articles 2, 3, 5 and 6 of Annex V of the Protocol on Environmental Protection to the Antarctic Treaty; to prevent interference with ongoing planned scientific investigations.

Global positioning system (GPS) campaigns were conducted during the 2003 and 2004 austral summer seasons to obtain insight into the velocity and strain-rate distribution on the margin of the continental ice sheet overriding southern part of Schirmacher Hills in CDML. GPS data were collected for two years at 21 sites and analyzed to estimate the site coordinates baselines and velocities. Horizontal velocities of the glacier sites lie between 1.89 ± 0.01 and 10.88 ± 0.01 m a⁻¹ to the north-northeast, with an average velocity of 6.21 ± 0.01 m a⁻¹. The principal strain rates provide a quantitative measurement of extension rates, which range from $(0.11 \pm 0.01) \times 10^{-3}$ to $(1.48 \pm 0.85) \times 10^{-3}$ a⁻¹, and shortening rates, which range from $(0.04 \pm 0.02) \times 10^{-3}$ to $(0.96 \pm 0.16) \times 10^{-3}$ a⁻¹ (Sunil et al., 2007).

Environmental Value

At the designated area, exploration showed abundant faunal diversity of the moss-inhabiting terrestrial invertebrate fauna. Schirmacher Hills is also an important area for the algae and cyanobacterial diversity. Terrestrial mosses are quite widespread in the Schirmacher Hills colonizing on a wide range of habitats. The mosses, because of their poikilohydric nature and alternative strategy of adaptation, are one of the plant groups which grow in Antarctica. Mosses play role in habitat modification, nutrient cycling and providing shelter and security to associated invertebrate animals. Studies on mosses in Schirmacher Hills revealed that distribution of mosses is significant at central part and at designated area as compare to eastern and western part.

Distribution of algae and cyanobacteria and flora of fresh water streams of the Hills at the designated area have been studied. The species reported are *G.magma*, *Chaemosiphon subglobosus*, *Oscillatoria limosa*, *O.limnetica*, *P.frigidum*, *P. autumnale*, *Nostoc commune*, *N.punctiforme*, *Calothrix gracilis*, *C.brevissima*, *Uronema sp.*, and *Cosmarium leave*. Among the cyanobacteria encountered in the stream of Schirmacher Hills, N₂ –fixing species might play a significant role in nitrogen economy of the ecosystem through N₂ –fixation. Studies on polar Skuas were also conducted at Schirmacher Hills and their nesting and breeding success have been reported around the designated place.

Further study on the Lichens carried out since 2003-04 within the protected area site, revealed occurrence of species such as; *Acarospora geynii* , C.W.Dodge & E.D.Rudolph, *Acarospora williamsii*, Filson, *Amandinea punctata*, (Hoffm.) Coppins & Scheid, *Buellia frigida*, Darb., *Buellia grimmiae*, Filson, *Candelaria murrayi*, Poelt, *Candelariella flava* , (C.W.Dodge & G.E. Baker), Castello & Nimis, *Carbonea vorticsa*, (Florke) Hertel, *Lecanora expectans* , Darb., *Lecanora fuscobrunnea* , C.W. Dodge & G.E. Baker, *Lecanora geophila* (Th. Fr.) Poelt, *Lecidea andersonii*, Filson, *Lecidea cancriformis* , C.W.Dodge & G.E. Baker, *Lecidella sipleyi* , (C.W. Dodge & G.E. baker) May., *Lepraria cacuminum* , (A. Massal.) Lohtander, *Physcia caesia* , (Hoffm.) Furnr., *Pseudephebe minuscula* , (Nyl. Ex Arnold) Brodo & D. Hawksw., and *Rhizoplaca melanophthalma*, (Ram.) Luckert & Poelt (Olech et al. 2010).

2. Aims and Objectives

Management of Dakshin Gangotri Glacier is aimed to:

- avoid degradation of values of the Area by preventing undue human interference
- allow glaciological and environmental scientific research, while ensuring protection of observational accuracy from any sort of man-made inputs
- ensure that peripheral points along the snout are not adversely affected by human activity in the Area
- maintain the Area as a reference marker for studying the movement patterns of this part of the Antarctic ice-sheet under the influence of global warming
- allow visits for management purposes in support of the aims of the Management Plan for the Area
- minimize the possibility of introduction of alien plants, animals and microbes into the Area

3. Management Activities

The following management activities will be undertaken to protect the values of the Area:

- A detailed map showing the location and boundaries of the Area and stating the special restrictions that apply would be displayed prominently at Maitri (India) and Novolazarevskaya

(Russia) research stations; copies of this management plan will also be made available at both the stations.

- Two signs displaying the location and boundaries of the Area with clear statements of entry restrictions will be placed on prominent rocks near both the entrance points to the valley, the eastern end and the south-eastern end; to help avoid inadvertent entry.
- Copies of this management plan along with location and boundary maps of the Area will be provided to all the visiting ships/aircraft.
- Markers, signs, cairns and other structures erected within the Area for scientific and management purposes will be secured and maintained in good condition, and will be removed when no longer necessary.
- Visits shall be made as necessary (at least once every year) to assess whether the Area continues to serve the purposes for which it was designated and to ensure that maintenance and management are adequate.
- The management plan shall be reviewed no less than once every five years and updated as required.

4. Period of Designation

The ASPA is designated for an indefinite period.

5. Maps and Photographs

The following maps and photographs are enclosed for illustrating the Area and the proposed plan:

Map 1: Location of Schirmacher Hills in central Dronning Maud Land, East Antarctica.

Map2: Map of Schirmacher Hills, showing locations of Maitri Research Station (India) and Novolazarevskaya Research Station (Russia).

Map 3: Classification and Numbering of Lakes of Schirmacher Hills. (after Ravindra et al, 2001)

Map 4: Topographic map of the Area. (contour interval 10 m)

Map 5: Paths of Fossil Glaciers in Schirmacher Hills. (after Beg et al, 2000)

Map 6: Aerial view of the Dakshin Gangotri Glacier Snout.

Figure 1: Image showing the markers showing boundary location of ASPA

6. Description of the Area

i. Geographical coordinates, Boundary markers and Natural features

Schirmacher Hills is a rocky hill range, about 17 km long in E-W trend (bounded by Eastern longitudes 11° 22' 40" and 11° 54' 20") and about 0.7 km to 3.3 km wide (bounded by Southern latitudes 70° 43' 50" and 70° 46' 40"). Its elevation varies from 0 to 228 m above the msl. It is a part of central Dronning Maud Land in Eastern Antarctica. The proposed area is a fragment of the western part of Schirmacher Hills.

The Area proposed under ASPA is bounded by Eastern longitudes 11° 33' 30" and 11° 36' 30" and by the Southern latitudes 70° 44' 10" and 70° 45' 30". The Area is 4.53 sq. km in aerial extent. The northeastern and northwestern corners of the Area are on shelf-ice, while the southwestern extremity is on polar ice-sheet. The southeastern end lies on a rocky outcrop.

Topographically, the Area can be divided into four distinct units- the southern continental ice-sheet, rocky hill slopes, a vast central proglacial lake (Lake-B7, Sbrosovoye Lake) and northern undulatory shelf ice.

The southernmost ice-sheet is bare 'blue ice', descending from 180 m contour to 10 m contour at the snout of the Glacier. It is crevassed and crisscrossed by NE-SW to NNE-SSW trending fractures. Two small and ephemeral supraglacial streams flow over the snout in a NNE direction.

The rocky terrain is uneven and has the minimum width of the Schirmacher Hills at the snout point; less than 50 m only. The eastern and western sides of the hills slope towards the snout, making a wide valley. The contours descend from 150 m to msl at the northern margin of the rock outcrops.

The central part of the Area is occupied by Lake B7. It is a lake of glacial origin. The dimensions of the lake are about 500 m x 300 m.

The northernmost part of the Area comprises shelf ice with pressure ridges, fractures and crevasses. The contact between shelf ice and eastern rocky slopes is marked by a prominent 3-km long, NNE-SSW trending lineament. The fractures in the ice are also aligned parallel to this lineament.

Schirmacher Hills exposes a granulite to amphibolite facies metamorphic terrain. The rock types are represented by charnockites, enderbites, garnet-sillimanite, gneisses, garnet-biotite gneisses, quartzofeldspathic augen gneisses with some foliated lamprophyres, amphibolites, dolerite, metagabbro and metabasalt. The rock suites dominantly fall under Grenvillian (1000 Ma) and Pan-African (550 Ma) events. Three phases of deformation are distinct.

The Area comprises mostly charnockite-Khondalite type of rocks (quartz-garnet-sillimanite-perthite±graphite gneisses) with some interlayering of garnet-sillimanite quartzites, calc silicate gneisses and mafic granulites. Two sets of faults (N30E and N50E) are quite prominent. One such major fault runs from the north-eastern corner of the Area; cutting all the three geomorphological units- shelf ice, rocks and continental ice-sheet.

Meteorological data from the nearby Indian Research Station Maitri shows that the Area has a dry polar climate. The extreme temperatures for the warmest and the coldest months range between 7.4 to -34.8°C. The mean annual temperature is -10.2°C. December is the warmest month of the year and August is the coldest. The blizzards touch a gale speed of 90 to 95 knots; the mean annual wind speed is 18 knots. The dominant wind direction is E-SE. Snowfall is quite frequent during the winter months, but gale force winds scrub the rocky surfaces clean and snow deposition is widespread on the leeward side of the hillocks.

Glaciological observations from 1983 to 1996 were carried out by surveys from two fixed points ('G' and 'H') using EDM or theodolite. The results showed that the Glacier is steadily receding every year at an average recession rate of 70 cm per annum.

In 1996, to enhance the accuracy of the observations, 19 peripheral points were marked encircling the snout of the Glacier. The average annual recession in the years 1997 to 2002 was 48.7 cm, 74.9 cm, 69.5 cm, 65.8 cm and 62.7 cm, respectively. This translates into an overall average recession of 65.3 cm per annum for the period 1996-2002; which is in conformity with the observations for the previous period (1983 – 1996) of a recession rate of 7 meters per decade.

Further monitoring were carried out and data revealed that average yearly recession for 2003, 2004, 2005 and 2006, gradually increased to 68.0, 69.4, 71.3, 72.8 centimeter per annum. However during the year 2006-2007, the average retreat of the Dakshin Gangotri polar ice front was only 0.6 m, but the data collected from the western margin of Schirmacher Hills showed an average annual retreat of around 1.4 m during the year 2006-07. The average annual retreat of the Dakshin Gangotri Snout was recorded to be about 1m in 2008, whereas the average annual retreat for the western extension of polar ice front was recorded to be about 2m. The maximum recession was observed at observation-point-14, which recorded a cumulative recession of 17.21 meters in ten years (1996-2006).

Observations carried out after 2008-09 every year till date. Results shows that the annual recession of the snout is computed to be 1.1m, 0.26m, 0.59m, 0.33m, 0.92m, 0.29m and 1.31m, respectively.

The recession values computed from 1996-97 till date shows that the lowest recession has occurred in the year 2009-10 i.e 0.26 meter, whereas highest recession occurred during 2014-15 i.e 1.31 meter.

ii. Restricted and Managed Zones within the Area

Along the periphery of the Dakshin Gangotri Glacier, 19 observation points have been marked in February 1996. With reference to these points it was possible to record the movement of the Glacier with an accuracy of 1 cm. Precise monitoring on cm-scale is also available for the years 1996-2002. Access to this zone should be restricted. To protect the accuracy of scientific observations, it is proposed that a 100 m radius all along the periphery of the Glacier should have limited admittance.

iii. Structures within and near the Area

There are no structures present in the Area, apart from two cairns ('G' and 'H') marking the sites used for glaciological and topographical surveys.

In future, some signs and cairns will be erected notifying the protected status of the Area.

iv. Location of other Protected Areas within close proximity of the Area

In the entire Schirmacher Hills, there are no other protected areas.

7. Permit Conditions

i. Access to and movement within the Area

Entry into the Area would be prohibited except in accordance with a permit issued by an appropriate National Authority as designated under Annex V, Article 7 of the Protocol on Environmental Protection to the Antarctic Treaty.

A permit to enter the Area may only be issued for scientific research, or for essential management purposes consistent with the Management Plan's objectives and provisions; with the condition that the actions permitted will not jeopardize the scientific and environmental values of the Area and will not interfere with ongoing scientific studies. Access to the area is permitted only by foot, access to site using land vehicle or helicopter landing is prohibited within the area.

ii. Activities that are or may be conducted within the Area, including restrictions on time or place

The following activities may be conducted within the Area:

- Scientific research programmes consistent with the management Plan for the Area, including the values for which the Area has been designated; which can not be carried out elsewhere and which will not jeopardize the ecosystem of the Area.
- Essential management activities, including monitoring.

iii. Installation, modification or removal of structures

No structures are to be erected within the Area except as specified in a permit. Any equipment should not be installed if it is not essential for scientific research or for management activities, and it must be authorized in a permit. All scientific equipment installed in the Area must be clearly identified by country with name of principal investigator, year of installation and expected date of completion of the study. Details are to be included in the visit report. All such equipment should be made of materials that pose minimum risk of contamination and must be removed immediately after completion of the study. Removal of specific equipment for which the permit has expired shall be a condition of the permit.

iv. Location of field camps

Camping is not allowed in the Area. The field parties can camp either east of "Lake Kalika" at "VK-Ground" or beyond the western limit of the Area.

v. *Restriction on materials and organisms, which can be brought into the Area*

- No living animals, plant material or microorganism shall be deliberately introduced into the Area and precautions shall be taken against accidental introductions.
- No pesticides, herbicides, chemicals, radio-isotopes shall be brought into the Area, other than those permitted for scientific or management purposes. These authorized agents shall be removed from the Area at the conclusion of the activity.
- Visitors should also consult and follow as appropriate recommendations contained in the Committee for Environmental Protection Non-native Species Manual (CEP 2011), and in the Environmental Code of Conduct for terrestrial scientific field research in Antarctica (SCAR 2009).
- Fuel is not to be stored in the Area unless connected with authorized activity. Permanent depots are not to be built in the Area.
- All material taken into the Area shall be for a stated period only and shall be removed at or before the conclusion of that stated period.

vi. *Taking or harmful interference with native flora and fauna*

Any interference with the native flora and fauna of the Area shall be in accordance with the requirements of the Protocol on Environmental Protection to the Antarctic Treaty, 1991, annex II, Article 3. Where taking or harmful interference with animals is involved, SCAR Code of Conduct for Use of Animals for Scientific Purposes in Antarctica shall be used as a minimum standard.

vii. *Collection or removal of anything not brought into the Area by the Permit holder*

Material may only be collected or removed from the Area as specified in the permit and shall be limited to the minimum necessary to meet scientific or management requirements.

Material of human origin, not brought into the Area by the permit holder, but which is likely to compromise the values of the Area may be removed from the Area unless the impact of removal is likely to be greater than leaving the material in situ. If this is the case the appropriate authority should be notified.

viii. *Disposal of Waste*

All wastes, including human wastes, shall be removed from the Area.

ix. *Measures that are necessary to ensure that the aims and objectives of the management plan can continue to be met*

- Permits may be granted to enter the Area to carry out biological monitoring and area inspection activities.
- Specific sites of long-term monitoring shall be appropriately marked and GPS positions will be obtained for records with the Antarctic Data Directory System through the appropriate National Authority.

x. *Requirements for Reports*

The principal permit holder would submit to the appropriate National Authority a visit report describing the activities undertaken by those issued permit. Reports are due and shall be submitted as soon as possible after the expiration of the permit, and include the types of information contained in SCAR visit report form or as required by national laws. The Authority will maintain a record of such activities and make this accessible to interested Parties.

8. Supporting Bibliography

ASTHANA R., GAUR M.P., CHATURVEDI, A. (1996): Notes on Pattern of Snow Accumulation/ablation on ice shelf and Secular Movement of Dakshin Gangotri Glacier Snout in Central Dronning Maud Land, East Antarctica. In: *scientific Report of the Twelfth Indian Scientific Expedition to Antarctica*, Tech. Pub. No. 10 D.O.D., Govt. of India, New Delhi, pp.111-122.

BEG M.J., PRASAD A.V.K., CHATURVEDI, A. (2000): Interim Report on Glaciological Studies in the Austral Summer of 19th Indian Antarctic Expedition. In: *Scientific Report of Nineteenth Indian Expedition to Antarctica*, Tech. Pub. No. 17, D.O.D., Govt. of India, New Delhi, pp. 121-126.

BEJARNIYA B.R., RAVIKANT V., KUNDU A. (2000): Glaciological Studies in Schirmacher Hill and on Ice Shelf during XIV Antarctica Expedition. In: *Scientific Report of Sixteenth Indian Expedition to Antarctica*, Tech. Pub. No. 14, D.O.D., Govt. of India, New Delhi, pp. 121-126.

CHATURVEDI A., SINGH A., GAUR M.P., KRISHNAMURTHY, K.V., BEG M.J. (1999): A confirmation of Polar Glacial Recession by Monitoring the Snout of Dakshin Gangotri Glacier in Schirmacher Range. In: *Scientific Report of Fifteenth Indian Expedition to Antarctica*, Tech. Pub. No. 13, D.O.D., Govt. of India, New Delhi, pp. 321-336.

D'SOUZA M.J., KUNDU A. (2000): Glaciological studies during the Seventeenth Antarctic Expedition. In: *Scientific Report of Seventeenth Indian Expedition to Antarctica*, Tech. Pub. No. 15, D.O.D., Govt. of India, New Delhi, pp.67-72.

KASHYAP A.K. (1988.): Studies on Algal flora of Schirmacher Oasis, Dronning Maud land, Antarctica . In: *Proceedings of Workshop on Antarctic Studies*, D.O.D.,CSIR, Govt. of India, New Delhi, pp.435-439

KAUL M.K., CHAKRABORTY S.K., RAINA V.K. (1985): A Note on the snout of the Dakshin Gangotri Glacier, Antarctica. In: *Scientific Report of Second Indian Expedition to Antarctica*, Tech. Pub. No. 2, D.O.D., Govt. of India, New Delhi, pp. 91-93.

KAUL M.K., SINGH R.K., SRIVASTAVA D., MUKERJI S., JAYARAM S. (1998): Observations on the Changes in the Snout of Dakshin Gangotri Glacier, Antarctica. In: *Scientific Report of the Fifth Indian Expedition to Antarctica*, Tech. Pub. No. 5, D.O.D., Govt. of India, New Delhi, pp. 205-209.

MUKERJI S., RAVIKANT V., BEJARNIYA B.R., OBEROI L.K., NAUTIYAL S.C. (1995): A Note on the Glaciological Studies Carried Out During Eleventh Indian Expedition to Antarctica. In: *Scientific Report of Eleventh Indian Expedition to Antarctica*, Tech. Pub. No. 9, D.O.D., Govt. of India, New Delhi, pp. 153-162.

OLECH M., SINGH S.M. (2010) : Lichens and Lichenicolous Fungi of Schirmacher Oasis, Antarctica. *Monograph*, National Centre for Antarctic and Ocean Research, India. NISCAIR, New Delhi (In press).

PANDEY K.D., KASHYAP A.K. (1995): Diversity of Algal Flora in Six Fresh Water Streams of Scirmacher Oasis, Antarctica. In: *Scientific Report of Tenth Indian Expedition to Antarctica*, Tech. Pub. No. 8, D.O.D., Govt. of India, New Delhi, pp. 218-229.

RAVINDRA R., CHATURVEDI A. AND BEG M.J. (2001): Melt Water Lakes of Schirmacher Oasis - Their Genetic Aspects and Classification. In: *Advances in Marine and Antarctic Science*, Ed. Sahu, DB and Pandey, PC, Dariyaganj, New Delhi, pp. 301-313.

RAVINDRA R., SRIVASTAVA V.K., SHARMA B.L., DEY A., BEDI, A.K. (1994): Monitoring of Icebergs in Antarctic Waters and a Note on the Secular Movement of Dakshin Gangotri Glacier. In: *Scientific*

Report of Ninth Indian Expedition to Antarctica, Tech. Pub. No. 6, D.O.D., Govt. of India, New Delhi, pp. 239-250.

RAVINDRA, R. (2001): Geomorphology of Schirmacher Oasis, East Antarctica. *Proc. Symp. on Snow, Ice and Glaciers*, Geol. Sur. India, Spl. Pub. No. 53, pp. 379-390.

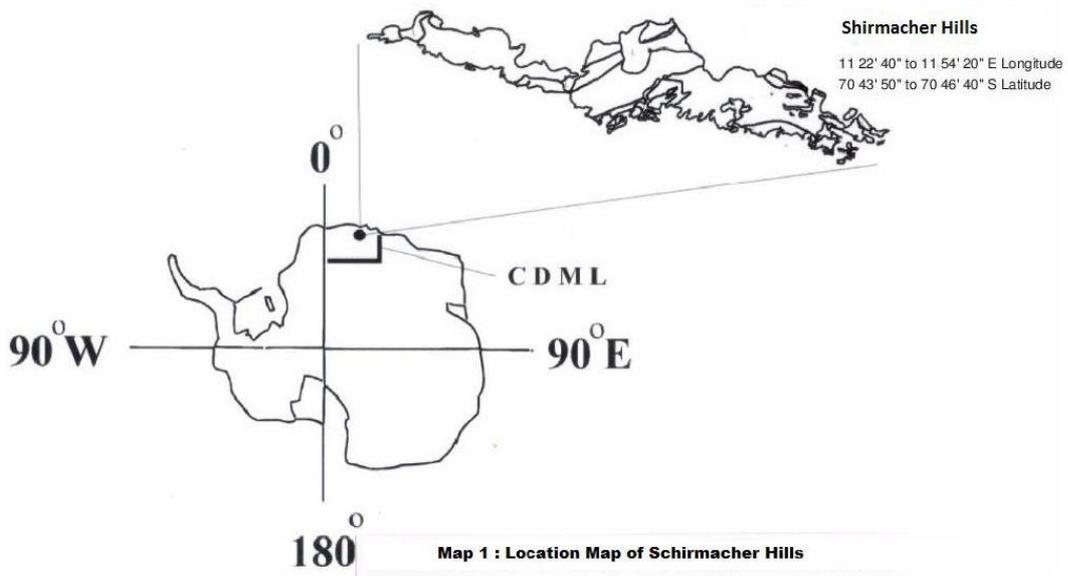
SINGH D.K., SEMWAL R.C. (2000): Bryoflora of Schirmacher Oasis, East Antarctica: A Preliminary Study. In: *Scientific Report of Sixteenth Indian Expedition to Antarctica*, Tech. Pub. No. 14, D.O.D., Govt. of India, New Delhi, pp.173-186

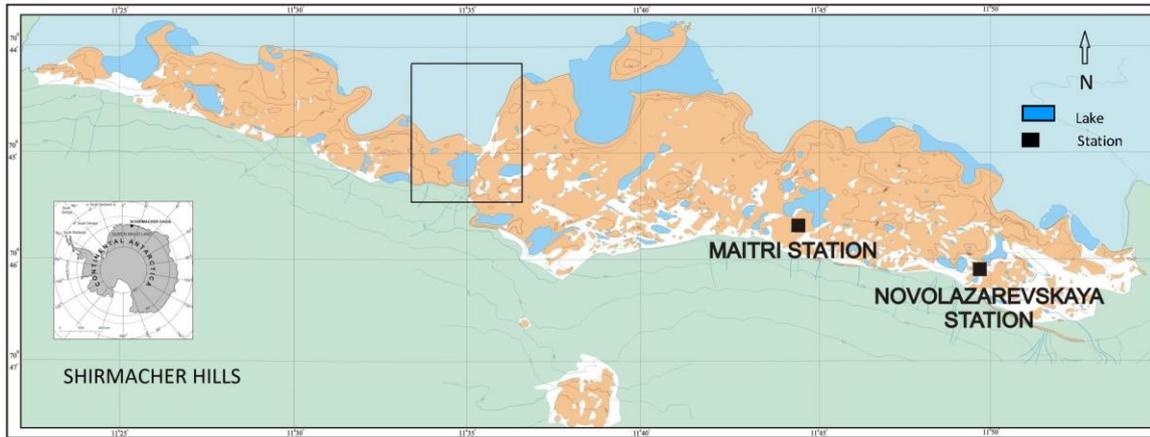
SUNIL P.S., REDDY C.S., PONRAJ M., DHAR A., JAYAPPAUL D. (2007) : GPS Determination of the Velocity and Strain-Rate Fields on Schirmacher Glacier, Central Dronning Maud Land, Antarctica. *Journal of Glaciology*, vol. 53, pp. 558-564.

VENKATARAMAN K. (1998): Studies on Phylum Tardigrada and Other Associated Fauna, South Polar Skua and Bird and Mammal Ligning during 1994-1995 Expedition. In: *Scientific Report of Fourteenth Indian Expedition to Antarctica*, Tech. Pub. No. 12, D.O.D., Govt. of India, New Delhi, pp.220-243

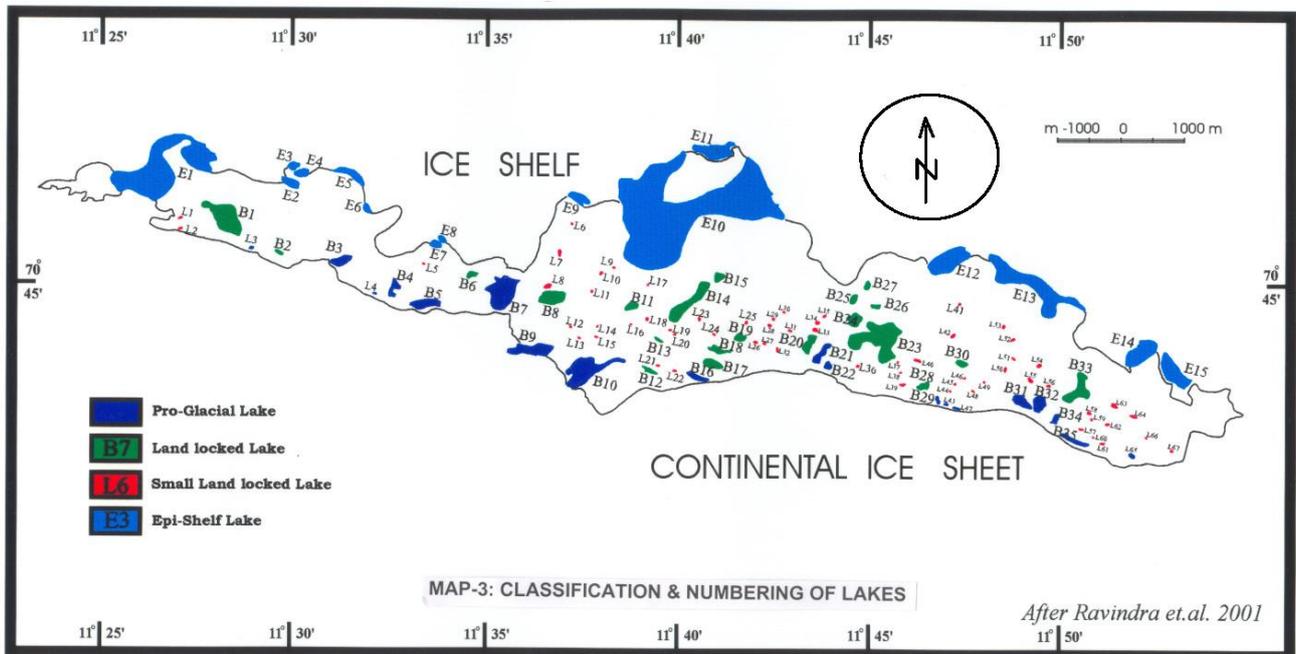


Figure 1: Images of Secured Markers at two Locations at the Boundary of ASPA-163





MAP 2: MAP SHOWING LOCATION OF MAITRI AND NOVOLAZAREVSKAYA STATION



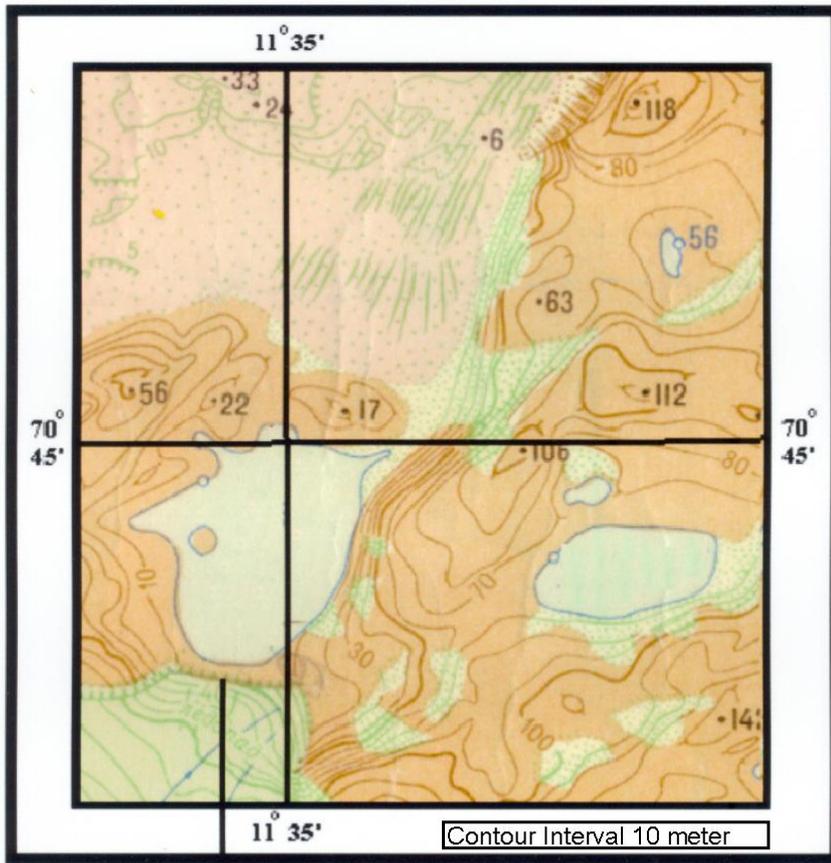
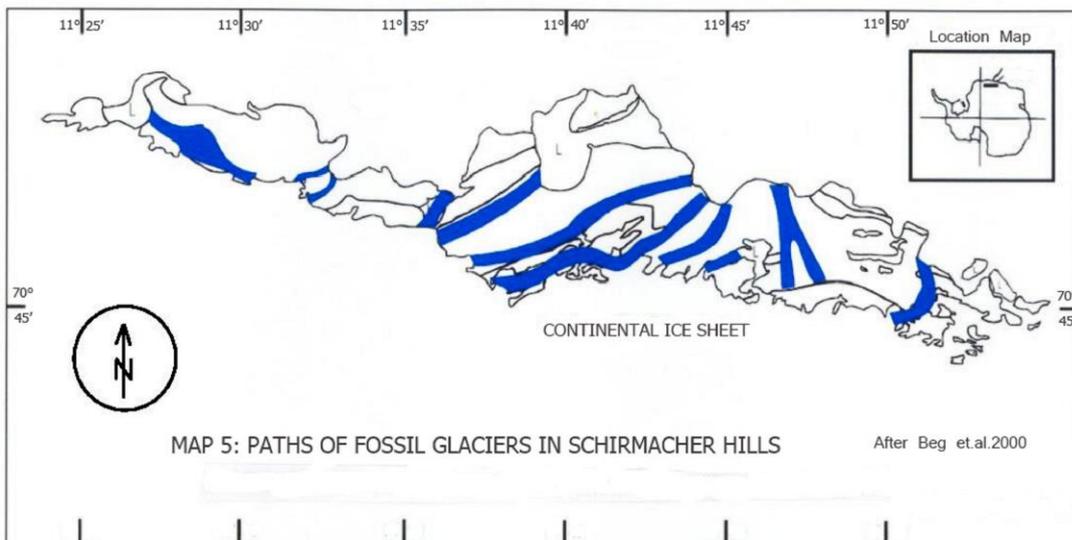


Plate - 4

Dakshin Gangotri Snout



MAP-4: TOPOGRAPHIC MAP OF THE AREA





MAP-6: DAKSHIN GANGOTRI SNOUT (MARCH 2013)