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A Study of Dakshin Gangotri Ice-shelf

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ABSTRACT

The part of the ice shelf where Indian station *Dakshin Gangotri* is located forms part of an unnamed ice-shelf. Snow studies pertaining to this ice-shelf, carried out during 1983-'85 and the studies carried out in the past are described in this paper.

During the period of study, the central part of this ice-shelf, where *Dakshin Gangotri* is located, experienced severe blizzards and substantial amount of snow accumulation. The net snow accumulation in this region is 70 to 80 cm/year. This part is a fairly stable ice-shelf, the rate of flow of which is not very appreciable. Measurements on ice thickness, carried out in the past, indicate the average thickness in the region of the station as about 390 m.

INTRODUCTION

The area where *Dakshin Gangotri* is located forms part of an unnamed ice-shelf. Some snow studies pertaining to this ice-shelf have been carried out in the past (Korotkevich, 1978; Richter and Strauch, 1982). In order to understand further this shelf for planning future explorations, snow studies pertaining to this shelf was taken up by the author during 1983-'85.

GEOGRAPHICAL LAYOUT

The study area extends from 69°50'S to 70°45'S and 08°30'E to 13°E within Queen Maud Land. It has Fiambul ice-shelf on the west and an unnamed ice-shelf on the east. The complete ice-shelf, 150 km long with an average width of 70 km, runs along the Princess Astrid coast in a zigzag manner. It is flat-topped having gradual southward ascent of approximately 80 m in 90 km from sea-edge to its point of origin at the foot of the Schirmacher Oasis. The total area of the shelf is about 10,000 sq.km.

There is no station functioning at present on this shelf except the Indian station *Dakshin Gangotri.* The other station, which earlier operated in this region is the USSR station Lazarev (69°59'S : 12°55'E), which was abandoned in early sixties.

TOPOGRAPHY

The shelf originates from Schirmacher Oasis which extends from 11°49'E to 11°26'E with a total area of about 35 sq.km. This includes 27 sq. km of bedrock, 3 sq. km of lagoons, 3 sq. km of firm/ice-fields and 2 sq.km. lakes. Due to the presence of many fresh water lakes the area of Schirmacher Oasis has been named as Schirmacher lake district (Richter and Strauch, 1982). The depth of lakes in this region varies from 5 to 13 m with water availability practically throughout the year. The Soviet station *Novolazarevskaya* is located in the Oasis at an altitude of 105 m at the foot of a glacier. The ice-shelf under study starts from the foot of the north wall of Schirmacher Oasis which can rightly be termed

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as the hinge point or the strand track area of the shelf. All along the southern edge of this shelf, there are large lakes having depths as much as 100 m. Prominent among these are lake Ozhidanrya with a maximum depth of 105 m and lake Zigzag with a maximum depth 122 m. These lakes are permanently covered with ice (Richter and Strauch, 1982). In this region, there are also some shallow fresh water seasonal streams running from west to east, which makes this area inaccessible for snow vehicles during summer months. In addition, there are a number of crevasses covered by snow bridges during most of the year. The crevasses are surface fractures caused by movement of the shelf due to tidal waves about the hinge point of the strand track region.

In the lower region of this shelf, near the coast, there are two high grounds permanently covered with snow/ice which are named as Kurklaken and Leningrad kollen. The height of these features varies from 50 to 100 m. The general layout of the shelf is shown in Fig 1.

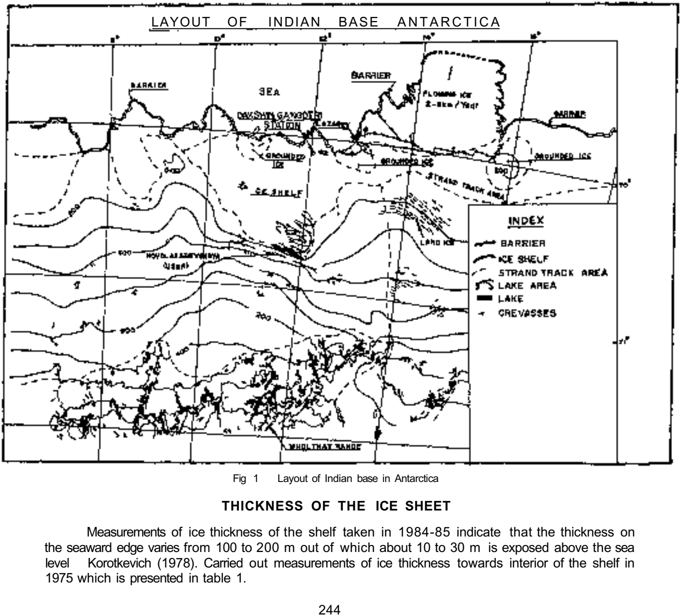

Fig 1 Layout of Indian base in Antarctica

THICKNESS OF THE ICE SHEET

Measurements of ice thickness of the shelf taken in 1984-85 indicate that the thickness on the seaward edge varies from 100 to 200 m out of which about 10 to 30 m is exposed above the sea level Korotkevich (1978). Carried out measurements of ice thickness towards interior of the shelf in 1975 which is presented in table 1.

TABLE 1

Measurements of ice thickness in different locations

No. of hole	*Location*	*Date of drilling*	*Depth observed (in m)*	*Remarks*
1.	70°22'8"S 12°21'4"E	Jan. Aug.1975	374	
2.	70°13'2"S 11°53'3"E	Oct. 1975	357	Depth of sea under the glacier 203 m
3.	70°23'6"S 11°39'6"E	Aug. 1976	447	

Verma and Mittal (1985, personal communication) carried out measurements of ice thickness in the region of *Dakshin Gangotri* by seismic studies. Preliminary analysis of their studies suggest an average thickness of 300 m.

MOVEMENT OF THE SHELF

No factual data on rate of flow of the shelf are available. However, from the coast-line of the shelf it is observed that the shelf movement is not very significant, though a number of icebergs of small size are formed every year. The slow movement is attributed to its origin which is from the foot of the Schirmacher Oasis and the presence of high grounds on the northward edge which restrict the movement of the central part of the shelf. On the other hand, in the shelves located to the east and west of the two highgrounds, the movement is reported at the rate of 1 to 3 km/year (Personal communication, Igor Simonov, 1984).

CRATERS ON THE SHELF

The Norwegian scientists, have reported crater formation in the general area of this shelf. According to them, large areas of the shelf have been seen sinking into the sea in the past and as such the shelf is not suitable for occupation. However, during reconnaissance, no evidence of such craters is found.

SNOW ACCUMULATION ON THE SHELF

Pattern of snow accumulation in the central part of this shelf was studied during 1984-'85 by erecting wooden poles. Depths of fresh snow accumulation and depletion on these stakes were measured from time to time. A preliminary analysis of this data suggests the following pattern.

(a) There is no accumulation or negligible accumulation on the stakes in the region 5 to 6 km from the shelf-edge.

(b) In the rest of the area, the maximum and minimum accumulation are 120 and 60 cm/year respectively.

(c) The maximum accumulation is seen during blizzards in Feb-Mar and Sept-Oct. The accumulation during peak winter blizzards is minimum.

(d) From Feb to Oct, the average accumulation is 90 cm. The accumulated snow suffers a depletion of 10 to 15 cm during Nov-Dec. Thus for planning of structures, the average yearly accumulation may be taken as 70 cm.

Density profiles of the shelf during 1984- 85 indicate the following pattern

(a) The density of newly accumulated snow on stakes during a blizzard varies from 0 4 to 0 43 gm/cc

(b) The top layer exposed to sun at the end of the winter transforms into suncrust which after freezing gives an average density of 0 7 to 0 8 gm/cc. This layer later forms the foundation for the snow, in succeeding years.

(c) The density profile during summer indicates a top layer (50 to 60 cm thick) with an average density of 0 42 gm/cc. This is followed by a layer of hard buried ice sheet/crust with average density of 0 75 gm/cc. The layer of hard buried ice sheet is underlain by snow (40-50 cm thick) of density 0 42 to 0 5 gm/cc.

Typical representative density profiles taken during summer and winter 1984 in the close vicinity of the station on the shelf, are shown in Fig 2.

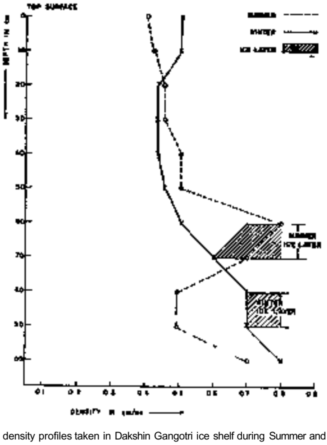

Fig 2. Typical density profiles taken in Dakshin Gangotri ice shelf during Summer and Winter 1984

STRENGTH PROFILE

The strength profiles of 1 m depth of snow taken with Ramsonde during 1984 indicate the following pattern -

(a) Strength of snow increases rapidly with the onset of winter in March and attains very high values during the peak winter period between June and October. The strength decreases rapidly in November with the onset of summer.

(b) The highest average value of 304 kg corresponding to 8 56 kg/cm^2 of unconfined compressive strength is obtained in June 84. The lowest average value of 133 kg corresponding to 5 20 kg/cm^2 of unconfined compressive strength is obtained in December 84. These values give a fair indication of trafficability of the shelf snow.

(c) The top surface of ice shelf has high average strength from March to October and below average strength during the remaining period.

The average values are presented in table 2 and Fig 3.

TABLE 2

Values of average Ram Hardness (R) during 1984

Month	*Ram Hardness in Kg*			*Remarks*
	Maximum	*Minimum*	*Average*	
Jan	328	110	207	
Feb	395	55	172	
Mar	434	50	256	
Apr	307	197	205	Fresh snowfall observed
May	229	89	168	Fresh snowfall observed
Jun	304	304	304	Only one profile recorded
July	380	89	219	
Aug	489	167	293	Coldest month
Sep	455	192	247	
Oct	300	190	242	
Nov	220	151	180	
Dec	254	49	133	

SNOW PRECIPITATION

Snow precipitation measurements could not be carried out during 1984 due to non-availability of proper instruments. However, most of the precipitation takes place during blizzards, though some snow precipitation was observed during non-blizzard, days. Taking into account an average accumulation of 70 cm of snow on the stakes with an average density of 0 4 gm/cc, the precipitation in terms of equivalent water, works out to approximately 28 cm. However, this figure may be very deceptive for realistic estimates as most of the snow is carried to coastal regions by katabatic winds.

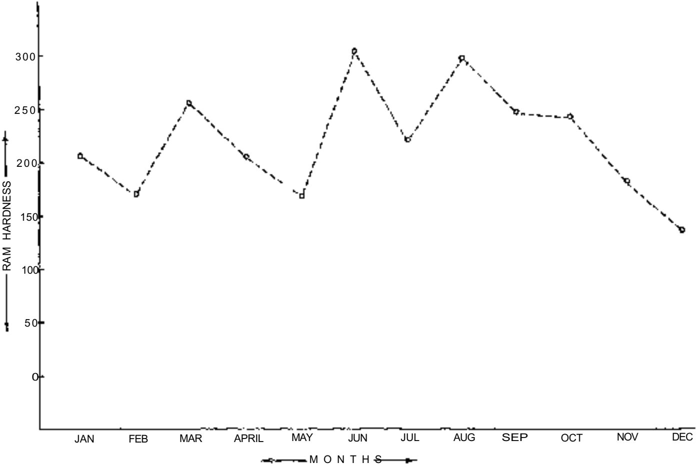

Fig 3 Variation of average values of Ram hardness in kg with time in Dakshin Gangotri ice self during 1984

CONCLUSION

The above snow studies on the Dakshin Gangotri ice-shelf were carried out in the first year of stay by the Indian team. The data obtained are useful for designing foundation and lay out of structures, estimating trafficability of the shelf and in further understanding of the shelf for future explorations. However, there is need to continue the studies on more scientific lines with proper instrumentations suited to polar regions.

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