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A CONFIRMATION OF POLAR GLACIAL RECESSION BY MONITORING THE SNOUT OF DAKSHIN GANGOTRI GLACIER IN SCHIRMACHER RANGE

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Abstract

Dakshin Gangotri glacier in Schirmacher range is being monitored by the GSI since 1983. It was being monitored on an yearly basis from two survey stations. In the 15th expedition, 19 reference points were marked all along the periphery of the glacier and observations were taken on a monthly basis, for one full year. The cycle of advancing, bulging, calving and retreating of the glacial front were recorded. It is conclusively proved that the polar glaciers are also markedly retreating.

Introduction

The movement of a polar glacier tongue, named Dakshin Gangotri (70° 45'20" S lat. and 10° 35' 05" E long.) in Schirmacher range, is being constantly monitored since 1983 (Kaul *et al.,* 1985), to understand the dynamic changes in the continental ice front of Antarctica. This polar tongue **(Fig.1)** is a remnant of an earlier glacier, which was overriding the Schirmacher range and crossing it at this point towards north. Glacial striations on the rock surfaces display the palaeo- movement directions of the glacier.

Two permanent survey stations 'G' and 'H' had been established earlier and the observations of the snout were taken from these points. The snout was monitored every year in the months of polar summer, (Jan or Feb). The resultant comparative profiles were drawn to record the advance/retreat during the year. One such profile, comparing the outlines of 1995 and 1996, is shown in **Fig.2.**

During the 15th expedition, to enhance the accuracy of the observations, the margin of this snout was surveyed on 14th February 1996 and 19 more reference points were marked all along the periphery of the snout **(Fig.3).** These reference points are marked from 1 to 15, including some sub-points near points

Fig. 1: The snout of Dakshin Gangotri glacier in Schumacher range

4 and 5. The distances from the respective points have been recorded upto an accuracy of one cm. With this method of observation, seasonal variations in the glacier movement could be monitored during the polar winter period, even on a month-to-month basis.

Observations

It has been observed that the glacier constantly moves forward and this movement is quite evident during the months of polar winter. Again, since the upper layers of the glacier move faster than the basal layer, a bulging in the upper parts is observed **(Fig.4).** Finally, the bulge becomes so pronounced that it becomes unstable and the wall of the glacier develops a crack and collapses **(Fig.5).** This results in a net retreat of the glacial front. This is a continuous cycle.

To this process, with the arrival of polar summer, another dimension of melting **(Fig.6)** is added, culminating in a greater recession of the glacier front. The importance of the melting-factor is also confirmed by observing the differential recession between the two walls of the snout. The present position of the snout has a small proglacial lake facing the eastern wall (Ref- points 1 to 8). Almost perpendicular to it, is the northern wall of the glacier (Ref-points 9 to 15). Since, at the start of the polar summer, the sun rises in the north and also sets in the north; the northern wall receives more solar radiation than the

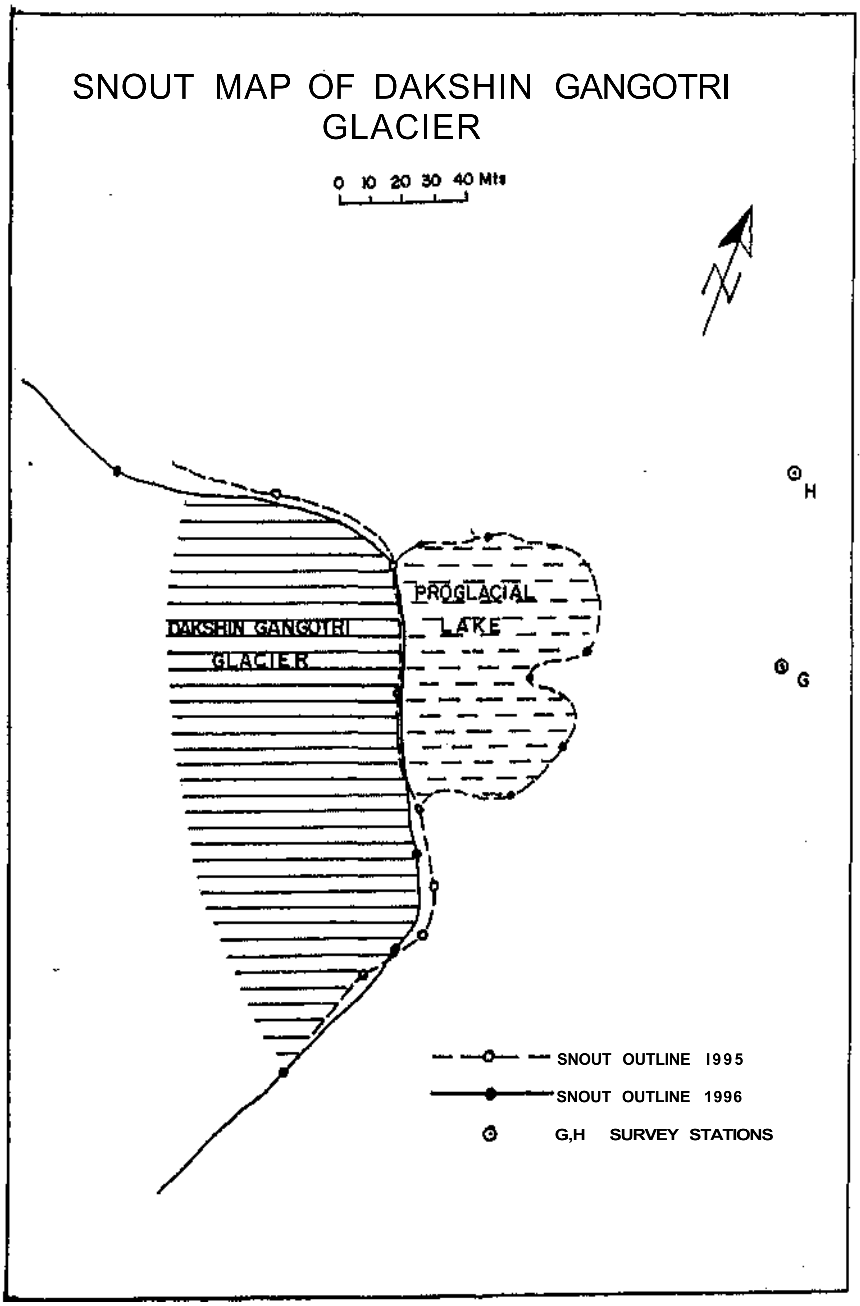

Fig. 2 : A comparison of the outlines of 1995 and 1996, the earlier method of yearly survey

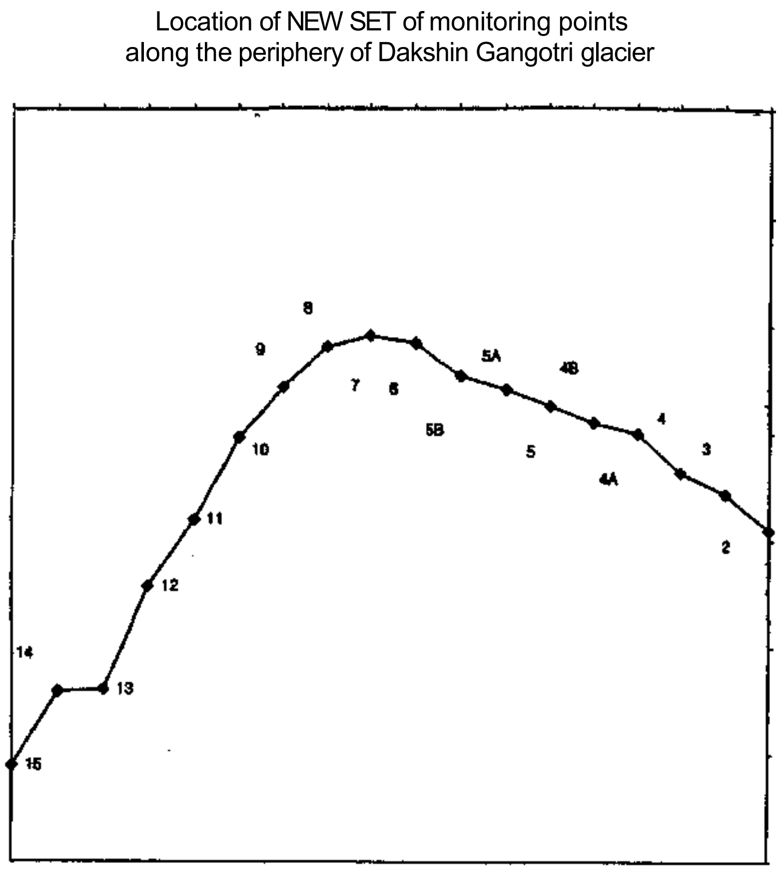

Fig. 3 : The location of 19 new reference points along the periphery of the snout

eastern wall. The result is that the melting, and hence the recession, is more pronounced on the northern wall of the snout.

When a part of the glacial wall collapses, or when a part near the bedrock gets covered with wind blown snow, some points on the periphery of the glacial front may not be approachable. This results in loss of some data from a set of observations. All the monthly observations and the missing details, along with the reference-points and plot-points are shown in **Table-l.** This inaccessibility is greatly enhanced during the months of polar winter, hence there are more gaps in data during the winter period.

At four of the observation points, ref-5,6,7 on the eastern wall and ref-14 on the northern wall, almost a complete record for the entire year is available.

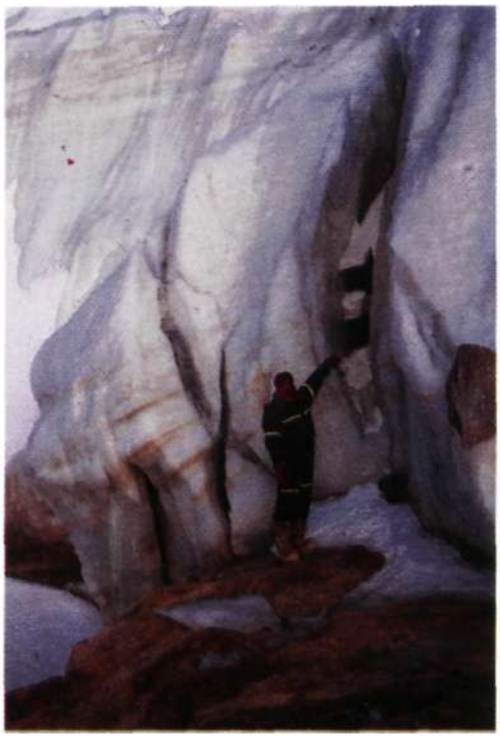

Fig. 4 : Bulging in the upper layers of the glacier, due to slower basal-layer movement

The movement of the glacial front at these four points is displayed in **Figs 7,8,9,10.** The monthly profiles of the glacier from April 96 to Jan 97 are shown in **Figs 11,12.** The overall comparative profile of the year 1997 (Feb) to the base level of 1996 (Feb) is drawn in **Fig** 13. A dramatic recession of more than two metres within an year, 96 to 97, is seen at ref-15. This is displayed in **Fig.14.**

Discussion

From **Figs 11 and 12,** the month-wise variations of the glacial front can be deduced. It may be mentioned beforehand that ref-15 has always shown a marked recession from the beginning to the end. The values at ref-15 vary between 136 cm to 244 cm of retreat. Even when it advanced during winter months, it still had a net recession of 92 cm. So in our discussion, we leave out this ref-point as a bit anomalous.

In the month of April 96, advancing front is seen at ref-5 of 30 cm, at ref-7 of 13 cm, at ref-6 of 6 cm. Otherwise many points like ref-9,10,11,12 are

Fig. 5 : Cracks developed along the margin prior to escarpment-collapse

Fig. 6 : Melting of the glacier walls, during the summer months

Table 1: Monthly observations along the periphery (in metres)

Ref-Pt.	Plot Pt.	14.2.96	12.4.96	13.5.96	26.6.96	30.7.96	31.8.96	27.9.96	24.10.96	19.11.96	18.12.96	16.1.97	4.2.97	10.2.97
1	-1	2.00												
2	-2	4.50	4.50									4.62	4.93	5.04
3	-3	1.00	1.02							0.81	0.99	1.24	1.28	1.35
4	-4	2.00											1.80	1.93
4A	-5							2.00	2.01	2.07	2.07	2.19	2.26	2.15
4B	-6							2.60	2.53	2.57	2.60	2.70	2.84	3.16
5	-7	7.00	6.70	6.68	6.73	6.84	7.60	6.65	6.69	6.74	7.33	7.54 .	7.16	6.82
5A	-8							1.20	1.11	1.13	1.38	1.49	1.63	1.53
5B	-9							1.20	1.10	1.18	1.21	1.42	1.52	1.38
6	-10	1.50	1.44	1.39	1.27	1.22	1.20	1.18	1.14	1.28	1.27	1.34	1.36	1.51
7	-11	1.50	1.37	1.26	1.22	1.08	0.98	0.86	0.94	0.98	1.16	1.55	1.72	1.81
8	-12	3.00	2.95								4.29	4.68	5.09	5.29
9	-13	2.00	2.19	2.12	1.99	1.98	2.04	2.04	2.00	2.31	1.95	2.89	3.49	3.75
10	-14	4.00										3.90	4.10	4.16
11	-15	2.00	2.30									1.74	2.09	2.21
12	-16	3.50	4.20								4.15	4.59	5.01	4.84
13	-17	1.00	1.17									1.49	1.84	1.90
14	-18	1.50	1.59	1.57	1.37	1.56	1.59	1.53	1.54	1.69	1.78	1.95	2.22	2.18
15	-19	6.50	7.86	8.37	7.90	7.57	7.42			7.77		8.16	8.41	8.94

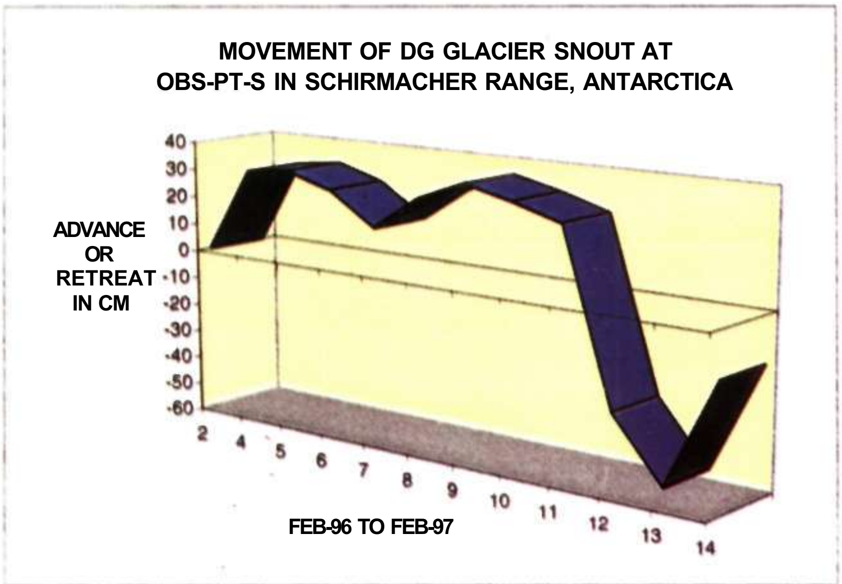

Fig. 7 : Yearly movement of the glacier along point ref-5

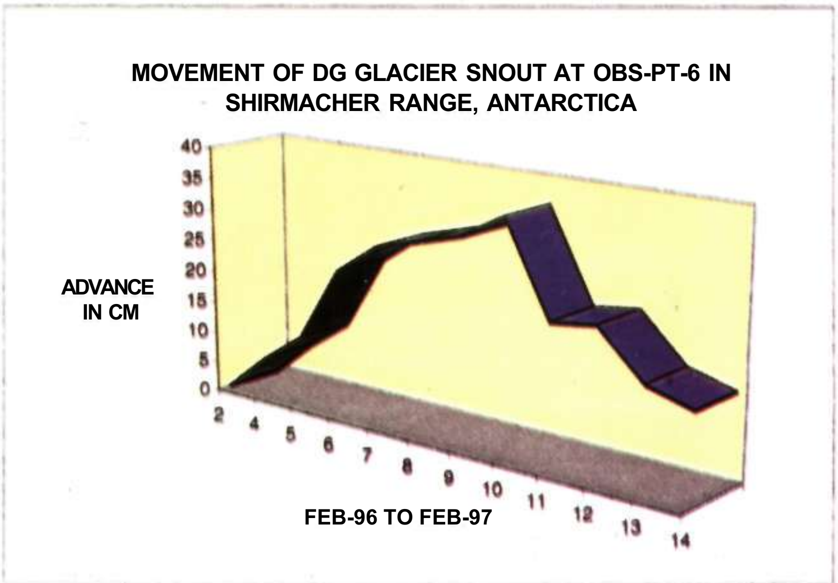

Fig. 8 : Yearly movement of the glacier along point ref-6

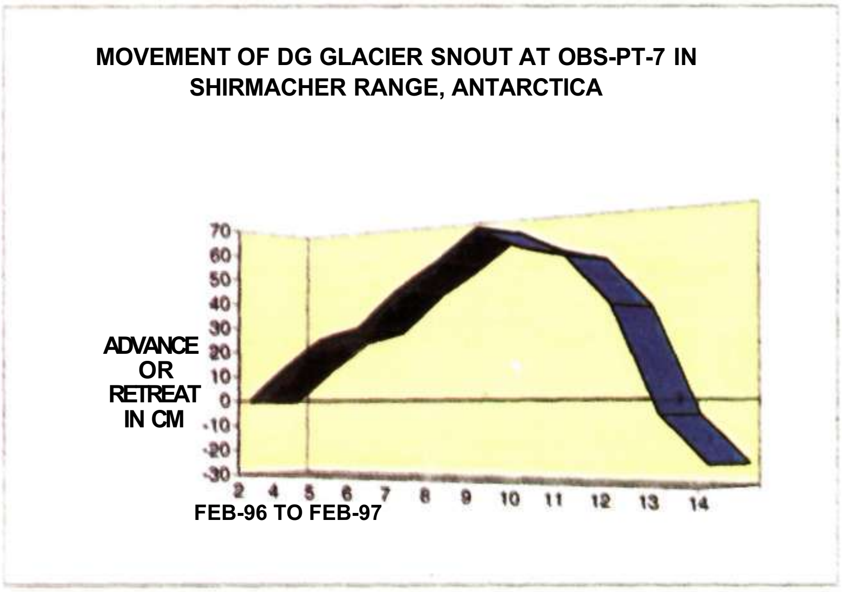

Fig. 9 : Yearly movement of the glacier along point ref-7

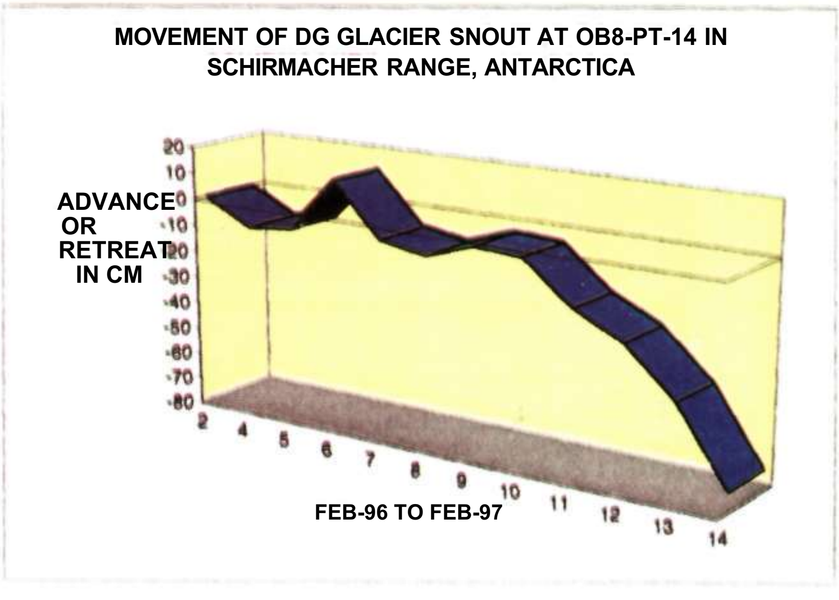

Fig. 10: Yearly movement of the glacier along point ref-14

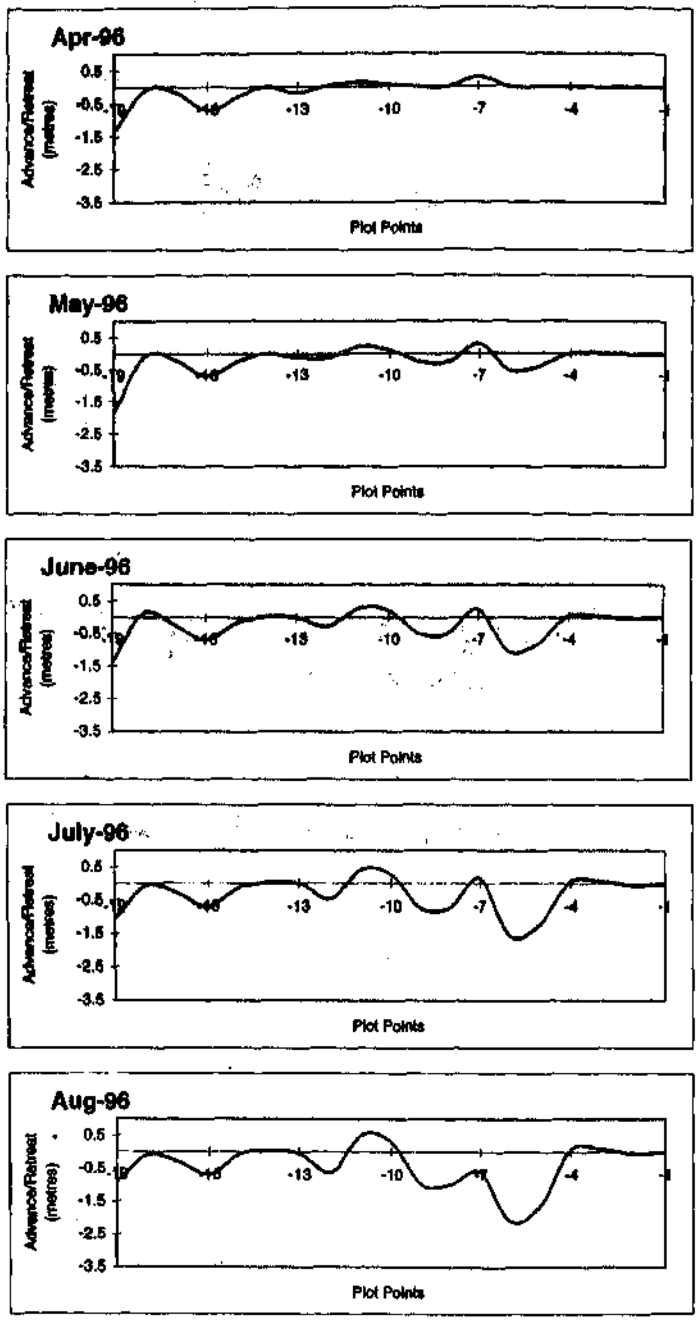

Fig. 11: Monthly profiles from April 96 to August 96

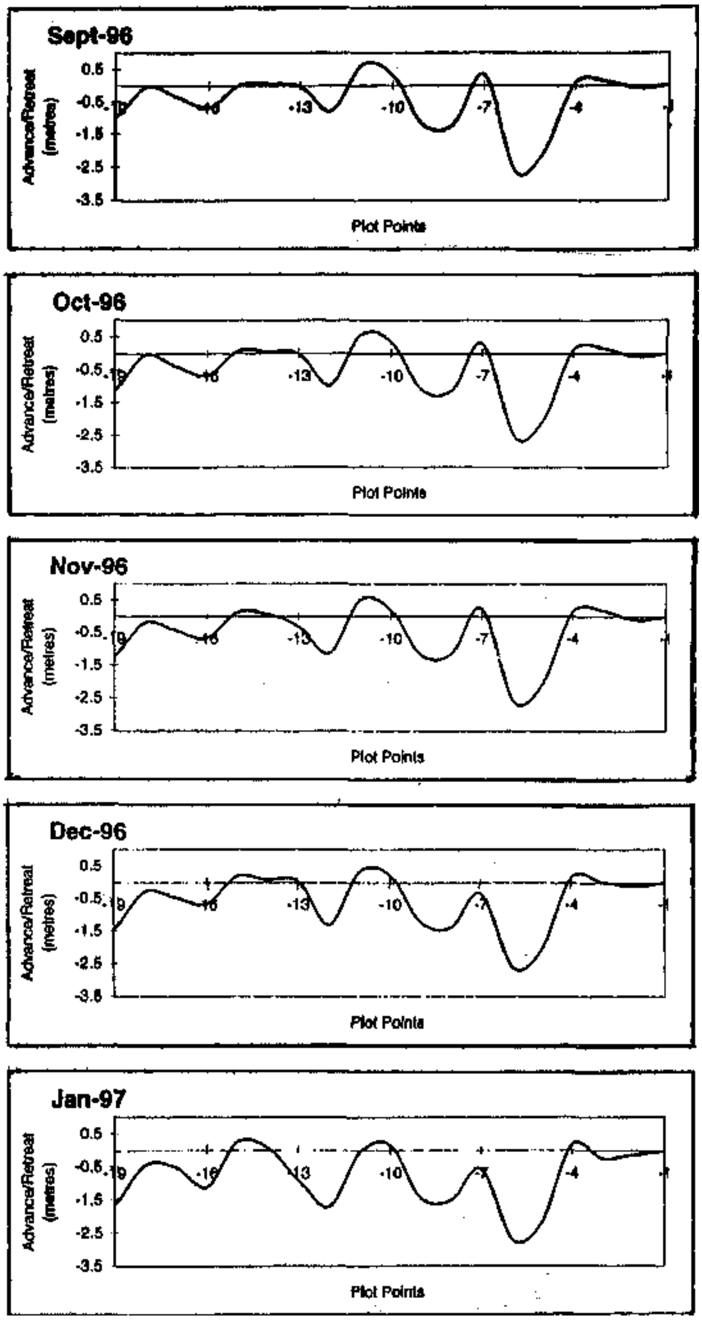

Fig. 12 . Monthly profiles from September 96 to January 97

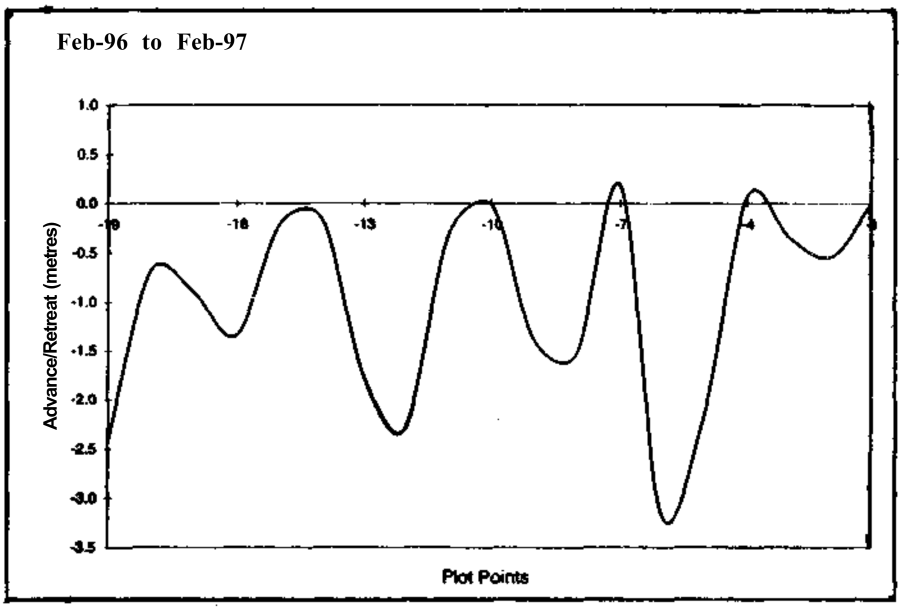

Fig. 13 : Yearly comparison of the profile of February 97 to baseline of February 96.

Fig. 14 : A glaring recession seen at point ref-15 in February 1997; the stake represents the position of the glacier wall in 1996

receding. The maximum recession is 70 cm at ref-12. The overall profile registers a recession of 13 cm.

The trend in May 96 is similar. Advance is recorded at ref-5 of 32 cm, at ref-7 of 24 cm, at ref-6 of 11 cm; while recession is registered at ref-12 of 69 cm, at ref-4b of 52 cm. The overall profile is of an average recession of 22 cm.

In June 96, advance is seen at ref-7 of 28 cm, at ref-5 of 27 cm, at ref-6 of 23 cm. Points of retreat are more dominant with recession of 104 cm at ref-4b, 80 cm at ref-4a and 69 cm at ref-12. Overall the profile has retreated by 26 cm.

In the month of July 96, advance of 42 cm is seen at ref-7 and of 28 cm at ref-6. Significant recession is at ref-4b of 156 cm, at ref-4a of 120 cm, at ref-5a&5b of 72 cm and at ref-12 of 68 cm. The average recession in the profile is of 33 cm.

In the peak of polar winter, August 96 displays advance of 52 cm at ref-7 and 30 cm at ref-6. Marked recession is at ref-4b of 208 cm, at ref-4a of 160 cm, at ref-5a&5b of 96 cm. The overall profile has retreated by 44 cm.

In September 96, the same trend continues. Advance of 64 cm is recorded at ref-7, 35 cm at ref-5, 32 cm at ref-6. Recession is pronounced at ref-4b of 260 cm, at ref-4a of 200 cm, at ref-5a&5b of 120 cm. The overall trend is of recession by 47 cm.

The month of October 96 is very similar to the previous one. Advance of 56 cm is seen at ref-7, 36 cm at ref-6, 31 cm at ref- 5. Significant retreat is of 253 cm at ref-4b, 201 cm at ref-4a, 111 cm at ref-5a, 96 cm at ref-8. The profile has an average recession of 47 cm.

In November 96, advance of 52 cm is observed at ref-7, 26 cm at ref-5, 22 cm at ref-6. While major recession of 257 cm is seen at ref-4b, 207 cm at ref-4a, 118 cm at ref-5b, 113 cm at ref-5a, 112 cm at ref-8. The average recession is 53cm.

With the peaking of polar summer, December 96 registers more retreat. Advance of 34 cm is recorded at ref-7, 23 cm at ref-6, 20 cm at ref-5. Major recession is at ref-4b of 260 cm, at ref-4a of 207 cm, at ref-5a of 138 cm, at ref-8 of 129 cm, at ref-5b of 121 cm. The profile has gone back by an average of 60 cm.

This trend becomes enhanced in January 97. Advance of 26 cm is recorded at ref-11, 16 cm at ref-6. Recession is significant at ref-4b of 270 cm, at ref-4a of 219 cm, at ref-8 of 168 cm, at ref-5a of 149 cm , at ref-5b of 142 cm and at ref-12 of 109 cm. The overall retreat of the profile is of 80 cm.

Finally, comparing the yearly values of February 97 to the baseline values of February 96, advance of 18 cm is seen at ref-5 and of 7 cm at ref-4. The recession stands out at ref-4b of 316 cm, at ref-15 of 244 cm, at ref-8 of 229 cm, at ref-4a of 215 cm, at ref-9 of 175 cm. The average overall yearly recession is 105 cm.

It is interesting to separately view the behaviour of the front at ref-6 and ref-7. These points displayed an advancing margin almost throughout the year. Ref-6 was positive all through the year, it registered an insignificant retreat of 1 cm in the final month. If the values of these two points are clubbed together and averaged, the result is an overall advance of 23 cm. These two points, ref-6 & 7, possibly represent the "spearhead zone" of the advancing snout. This has to be confirmed in future observations.

Conclusions

This is the first record of a month-to-month behaviour of a glacial front from Schirmacher range. It is accurate to the value of one cm of movement. The glacier is observed to advance in the winter months, bulge out due to faster movement of upper layers and break off" at margins to register a net retreat. This rate of recession is enhanced during polar summer due to melting of glacial escarpments. The maximum advancement recorded was 64 cm in September 96, at point ref-7. The maximum retreat registered was 316 cm in February 97, at point ref-4b. It is conclusively proved that the glacier kept on receding all through the year. Comparing Feb 97 to Feb 96, the glacial front has an average overall recession of 105 cm.

It is well known that the Himalayan glaciers are significantly receding due to global warming. Some experts argue that the global effect of warming should also be reflected on the polar fronts. This year-long study is a confirmation that even the Antarctic glaciers are receding and the phenomenon is truly global.

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