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Glacier Inventory of the Langtang Valley, Nepal Himalayas

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I. Introduction

Distribution of glaciers is closely related to climate. Glaciers have, however, fluctuated in their dimensions and forms depending on climatic change through the Cenozoic Era. Continuous monitoring of the behavior of glaciers located in the different climatic regions is, therefore, believed to be one of the best means for understanding of the trend of global climatic change, provided we have enough knowledge on the relationship between glacier fluctuations and climatic variations.

In this connection, much effort has been made toward the collection and publication of the data on the world's glaciers since the mid-1970's. This was carried out by two international entities: the Permanent Service on the Fluctuations of Glaciers (PSFG) under the International Commission on Snow and Ice (ICSI) and others, and the Temporary Technical Secretariat (TTS) under UNESCO and others. In 1986, the activities of both entities were merged into one single service called the World Glacier Monitoring Service (WGMS) in the Global Environment Monitoring System (GEMS) established by the United Nations Environment Programme (UNEP). For that point, WGMS is now entrusted with the collection of standardized data on the extension of glaciers existing in the glacierized regions of the world for the production of a World Glacier Inventory (WGI) in order to provide a baseline for future monitoring of the world's glacierized regions. Hence, studies of long-term climatic change

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will be possible from the long-term monitoring of the glacier fluctuations.

An inventory of glaciers in the Nepal Himalayas was initiated in the Khumbu region by Müller (1970). This work was succeeded in the same region by Higuchi *et al.* (1978) in "Glaciological Expedition of Nepal (GEN)" as part of a contribution to the International Hydrological Programme (IHP) of UNESCO. The inventory work was expanded to the Langtang region in the Nepal Himalayas by GEN during the 1980's and early 1990's. A preliminary glacier inventory in the Langtang Khola (river) drainage was reported by Iida *et al.* (1984), using the data from flight observations performed in 1981 and from the data obtained in ground observations in 1981 and 1982. A more detailed glacier inventory was remained for future work due to the shortage of data and the lack of accurate topographical maps of this region.

The GEN activities have continued after 1982, and the data on glaciers have been collected in the Langtang region through GEN1985/86, 1987, 1988, 1989, 1990 and 1991. Especially, flight observation of glaciers, made on 22 April, 1991, provided more than 1,000 oblique color photos covering almost 95% of this region. Since relatively accurate topographical maps of the Langtang Himal were published by the Austrian Alpine Club in 1990 (Alpenvereinskarte, Langthang Himal, ost and west), we attempted to improve the glacier inventory provided by Iida *et al.* (1984), based on the aerial photos taken in 1981 and 1991, and on field observations and terrestrial photos taken during the GEN activities.

Although the glacier inventory has not been fully standardized yet because of difficulties in collecting detailed data, the present attempt at compilation will be useful and important as a step toward the complete glacier inventory in this region. It will also contribute to future glaciological studies as well as to the production of a World Glacier Inventory.

II. Glacier Inventory in the Langtang Khola drainage basin

The Langtang Khola drainage basin (Langtang Valley) is located in the central part of the Nepal Himalayas in the border region between Nepal and China, approximately 60 km north from Kathmandu, the capital city of Nepal (Fig. 1). The region is the upper reaches of the River Trisuli in the Narayani River System.

In the present glacier inventory, the clean-type glaciers and the debris-covered-type glaciers (Moribayashi and Higuchi, 1977) were mapped and tabulated. Permanent snow or ice patches and a rock glacier were mapped only.

Sources of data for the present glacier inventory work are as follows: a) aerial oblique color photos taken in 1991; b) aerial oblique monochrome photos taken in 1981; c) ground

survey data and terrestrial photos taken during the GEN activities in 1987, 1988, 1989, 1990 and 1991; d) 1/50,000 topographical maps published by the Austrian Alpine Club.

An identification system of the glaciers is based on the data format provided by the World Glacier Monitoring Service (WGMS, 1989), which was originally proposed by Müller *et al.* (1977). The following elements of the glacier are described in this inventory: identification number, glacier name, aspect of accumulation and ablation areas, morphological classification such as primary classification, form, frontal characteristics, longitudinal profile, major source of nourishment and activity of tongue as shown in Table 1, surface areas of accumulation and ablation areas, and highest and lowest elevations of glaciers (Table 2).

Three digits are adopted as a glacier identification number (ID No.). The third digit of an ID No. makes '0' due to a need for a future numbering capacity for undiscovered glaciers.

Large valley glaciers in this region are covered in their lower parts by thick debris. The lower-most parts are considered to be stagnant ice masses consisting of fossil glacier ice which has no direct relation to the present glacier flow. Present active termini may be situated in the middle part of the debris covered glacier tongues. Although the present active glacier termini are difficult to point out without any measurement of glacier flows, we located them tentatively by observing the surface structure of the glacier. The active glacier termini are located at the point where organized surface-structures, such as ogive and lineated longitudinal furrows and ridges in the upper part, meet with the disorganized and random surface-structures in the lower part.

Large valley glaciers such as the Langtang Glacier consist of many sub-glaciers (or tributary glaciers). The sub-glaciers flowing into the active part of the main glacier are judged as part of the main glacier. Since the sub-glaciers flowing into the stagnant part of the main glacier, or sub-glaciers with a fossil ice body in their termini, have no connection to the main glacier activity, we regard them as independent from the main glacier.

The photos of glaciers in this region are shown in Photos 1 to 38. Aerial oblique photos were taken on 22 April, 1991 except for Photos 24 and 26 which were taken in 1981 (GEN-1981). Terrestrial photos were taken from 1988 to 1991. The distribution of the glaciers is compiled on the attached map (Fig. 1).

Acknowledgment

We would like to express our heartfelt gratitude to all the staffs concerned in Water and Energy Commission Secretariat (WECS), and Department of Hydrology and Meteorology (DHM), both belonging to the Ministry of Water Resources, His Majesty's Government of

Nepal. We are, in particular, indebted to Dr. C.K. Sharma, Executive Secretary in WECS, and Dr. S.P. Adhikary, Director General of DHM, for their kind cooperation and extraordinary help. We also wish to express our thanks to the members of GEN 1981, 1982, 1985/86, 1987, 1988, 1989, 1990 and 1991 for providing the data for the inventory work. Thanks are also due to Dr. K. Ueno, University of Tsukuba; Mr. S. Yamashita, a member of Japan Overseas Cooperation Volunteers (JOCV); and Dr. B. Upadhyay in WECS for the laborious assistance given throughout the flight observation in 1991.

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ネパールヒマラヤ、ランタン谷の氷河台帳

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要　　旨

ネパールヒマラヤの中央部に位置するランタン谷において氷河台帳を作製した。ネパールヒマラヤの氷河台帳に関しては、クンブ地域についてMüller(1970)やHiguchi *et al*.(1978)のものがあるが、ランタン谷については基図となる正確な地形図がないため、Iida *et al*.(1984)による概報的なものに限られてきた。今回は、オーストリア山岳会が作製した正確な5万分の1地形図を基図とし、1991年春に新たに航空写真撮影を実施して氷河台帳を作製した。氷河台帳の作製にあたっては、World Glacier Monitoring Service (WGMS)のガイドラインに従った。WGMSは、これまで世界の氷河台帳の作製に関わってきた二つの機関、Temporary Technical Secretariat (TTS)とPermanent Service on the Fluctuation of Glaciers (PSFG)を統合した機関である。

今回の氷河台帳では、岩屑に表面を覆われない氷河、岩屑に表面を覆われる氷河、氷河としての流動は認められないが連続して存在する雪氷域、および岩石氷河を図に示した(付録　第1図)。特に、岩屑に覆われる部分に関しては、その形態的特徴から、活動的な部分と停滞氷であると考えられる部分とを区別した。また、すべての氷河について、同定番号、氷河名、涵養域と消耗域の方位、6つの番号からなる氷河の形態的特徴(第1表)、岩屑に覆われない部分と覆われる部分の面積、および氷河の上端と下端の標高を示した(第2図)。代表的な氷河に関しては、1981年、および1988年から1991年にかけて地上、空中から撮影した写真を添付した(写真1～38)。

Table 1. Morphological classification of inventoried ice bodies. (WGMS, 1989)

	Digit 1 Primary classific.	Digit 2 Form	Digit 3 Frontal charact.	Digit 4 Longitud. profile	Digit 5 Major source of nourishment	Digit 6 Activity of tongue
0	Uncertain or misc.	Uncertain or misc.	Normal or misc.	Uncertain or misc.	Uncertain or misc.	Uncertain
1	Continental Ice sheet	Compound basins	Piedmont	Even, regular	Snow and/or drift snow	Marked retreat
2	Ice-field	Compound basin	Expanded	Hanging	Avalanche ice and/or avalanche snow	Slight retreat
3	Ice cap	Simple basin	Lobed	Cascading	Superimposed ice	Stationary
4	Outlet glacier	Cirque	Calving	Ice-fall		Slight advance
5	Valley glacier	Niche	Confluent	Interrupted		Marked advance
6	Mountain glacier	Crater				Possible surge
7	Glacieret and snowfield	Ice apron				Known surge
8	Ice shelf	Group				Oscillating
9	Rock glacier	Remnant				

Table 2. List of glaciers in the Langtang Valley. Further information is shown in the text.

ID No.	Glacier Name	Aspect		Class.	Surface Area(km²)			Elevation(m)	
		Acc.	Abl.		Clean	Debris	Total	Max.	Min.
L010		SW	SW	750120	0.12	0	0.12	5220	5140
L020		SE	SE	750120	0.06	0	0.06	5960	5180
L030		S	S	750120	0.12	0	0.12	6581	5040
L040		S	S	750120	0.1	0	0.1	5520	5120
L050		S	SE	633520	2.25	0	2.25	6680	4760
L060		SW	S	630520	3.13	0.29	3.42	7234	4320
L070		S	S	630520	1	0.09	1.09	7120	4800
L080	Lirung	SE	S	530320	5	1.33	6.33	7234	4120
L090	Khymjung	SE	S	633410	3.2	0	3.2	6760	4380
L100		SW	SW	630310	3.12	0.49	3.61	6690	4680
L110	Yala	SW	SW	630112	2.49	0	2.49	5749	5090
L120	Shalbachum	S	S	530310	3.66	2	5.66	6578	4240
L130		SW	SW	633110	2.4	0	2.4	5980	4960
L140		SE	SE	640120	0.56	0	0.56	5920	5020
L150		E	E	633120	0.1	0	0.1	5840	5180
L160		NE	SE	520320	0.77	0.62	1.39	5980	4760
L170		SE	SE	640110	0.79	0	0.79	6220	5300
L180		S	S	630110	0.13	0	0.13	5560	5300
L190		SW	SW	630110	0.29	0	0.29	5691	5240
L200		S	S	750120	0.12	0	0.12	5780	5360
L210		S	S	633120	0.36	0	0.36	5780	5300
L220		E	E	630120	0.23	0	0.23	5639	5000
L230		N	N	630110	1.34	0	1.34	5690	5120
L240		E	NE	520120	2.45	1.05	3.5	6578	4880
L250		E	E	630120	0.4	0	0.4	6220	5220
L260		E	E	750120	0.14	0	0.14	5840	5180
L270		N	NE	630110	1.6	0	1.6	6220	5060
L280	Langtang	S	S	510120	18.4	11.95	30.35	7205	4520
L290		S	S	630110	3.43	0.55	3.98	6325	5060
L300		W	W	630420	1.05	0	1.05	6758	4840
L310		SW	W	633420	0.39	0	0.39	6900	5280
L320		SW	NW	520310	5.53	1.09	6.62	6560	4680
L330		NW	NW	630520	1.35	0	1.35	6460	4680
L340		NW	NW	633220	0.14	0	0.14	6460	5000
L350		S	S	633410	2.36	0	2.36	6460	4840
L360	Langshisa	W	NW	510120	13.76	5.49	19.25	7083	4360
L370		N	N	630210	0.78	0	0.78	6078	5380
L380		N	N	630110	3.33	2.46	5.79	6387	4700
L390		E	E	640120	0.44	0	0.44	6180	5040
L400		W	W	633120	0.33	0	0.33	6000	4980
L410		W	W	633320	1.06	0	1.06	6387	4780
L420		W	W	633120	0.5	0	0.5	6387	5360
L430		W	W	630110	1.2	0	1.2	6240	5020
L440		NE	N	520110	2.2	0.61	2.81	5702	4780
L450		SE	N	623110	1.48	0	1.48	5930	5080
L460		SE	SE	630120	0.22	0	0.22	5930	5260
L470		NE	NE	750120	0.08	0	0.08	5930	5520
L480		E	E	630120	0.33	0	0.33	5930	5220
L490		NE	NE	630120	0.33	0	0.33	5800	5180
L500		N	N	630120	0.25	0	0.25	5800	4820
L510		N	N	750120	0.07	0	0.07	5800	5040
L520		N	N	620110	3.54	0	3.54	5940	4720
L530		NE	NE	030100	0	0.27	0.27	5000	4880
L540		E	E	630110	0.56	0	0.56	5846	5080
L550		N	N	630110	0.67	0	0.67	5846	4860
L560		N	N	753220	0.15	0	0.15	5640	5040
L570		NE	N	633110	0.74	0	0.74	5846	4880
L580		N	N	633110	0.16	0	0.16	5560	5080
L590		N	N	630110	0.15	0	0.15	5560	5080
L600		NE	N	630110	2.63	0	2.63	5862	4880
L610		NE	NE	630110	1.67	0	1.67	5825	5100
L620		N	N	750110	0.13	0	0.13	5460	5160
L630		N	N	750110	0.2	0	0.2	5460	5080
L640		N	N	630110	0.48	0	0.48	5822	4960
L650		N	N	750110	0.09	0	0.09	5280	5060
L660		W	W	750120	0.49	0	0.49	5822	5240
L670		N	N	620110	1.77	0	1.77	5580	5060
L680		N	N	750110	0.18	0	0.18	5392	5020
L690		N	N	750110	0.08	0	0.08	5360	5090
L700		N	N	630110	0.23	0	0.23	5534	5040
L710		N	N	750110	0.09	0	0.09	5200	5040
L720		W	W	750120	0.26	0	0.26	5534	4920
						TOTAL	137.50		

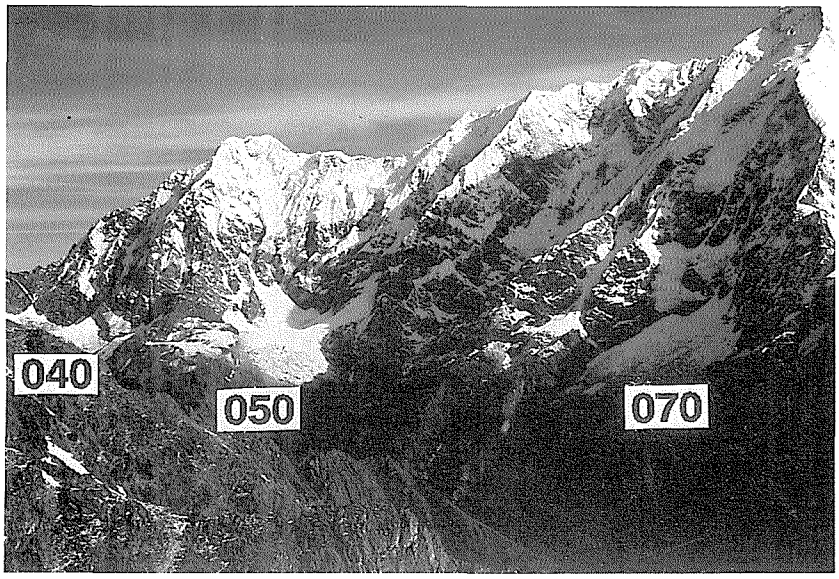

Photo 1. Glaciers L040, L050 and L070 on the south-facing slope of Mt. Langtang Lirung. (5 June, 1990)

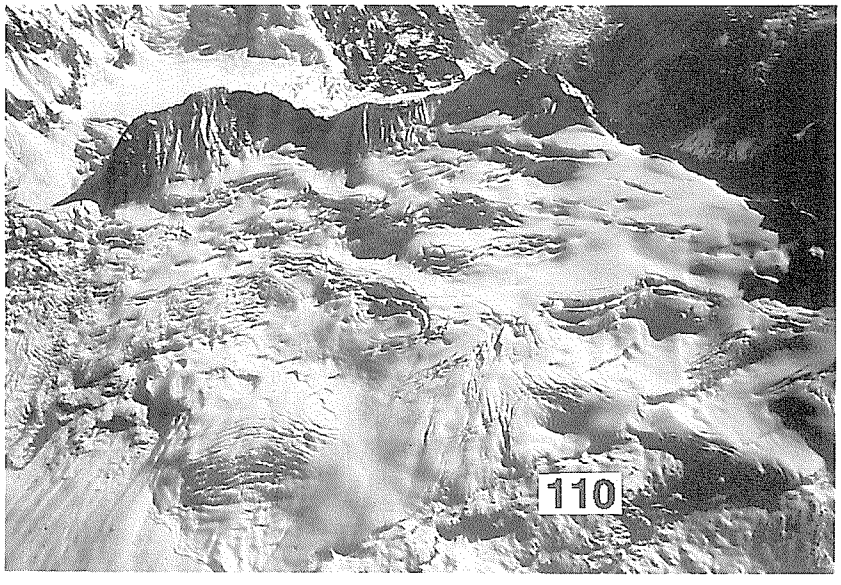

Photo 2. The Yala Glacier (L110). (22 April, 1991)

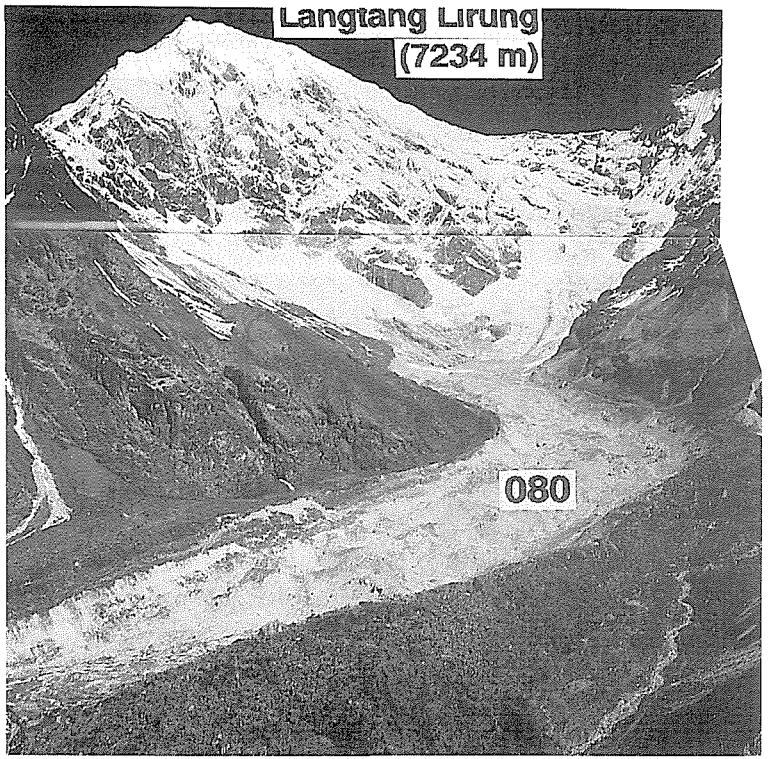

Photo 3. The Lirung Glacier (L080). (30 April, 1991)

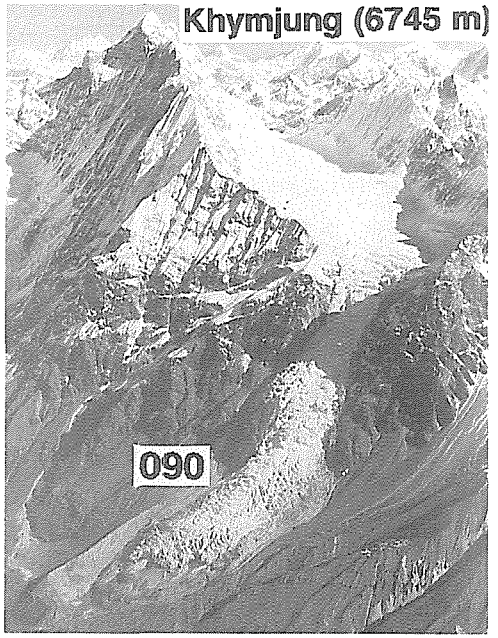

Photo 4. The Khymjung Glacier (L090). (22 April, 1991)

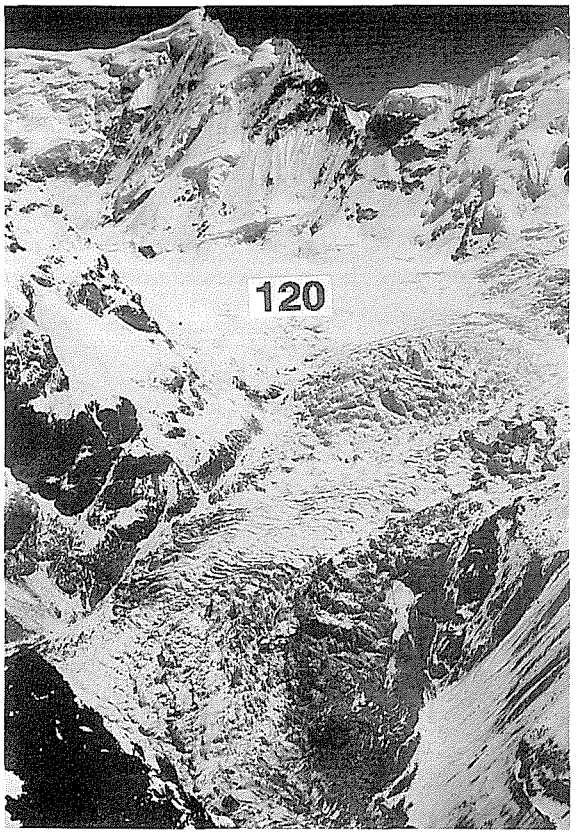

Photo 5. Icefall of the Shalbachum Glacier (L120). (6 May, 1991)

Photo 6. The termini of the Shalbachum Glacier (L120) in the foreground and the Langshisa Glacier (L360) in the background. (6 May, 1991)

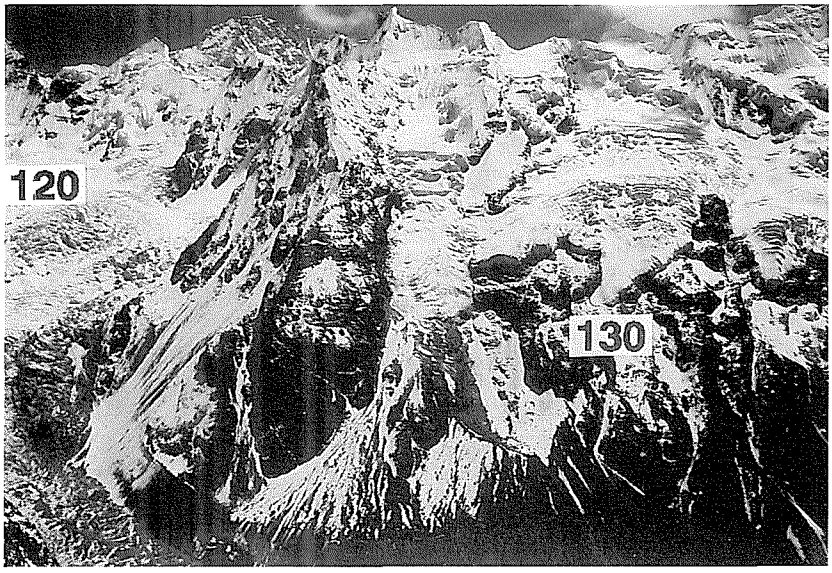

Photo 7. Glacier L130 and the Shalbachum Glacier (L120). (6 May, 1991)

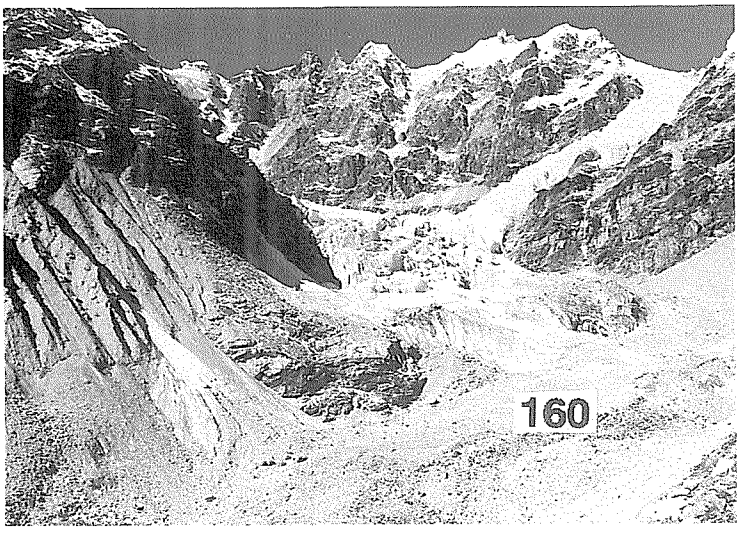

Photo 8. The middle part of the Glacier L160. The debris-covered part is still active. (11 December, 1989)

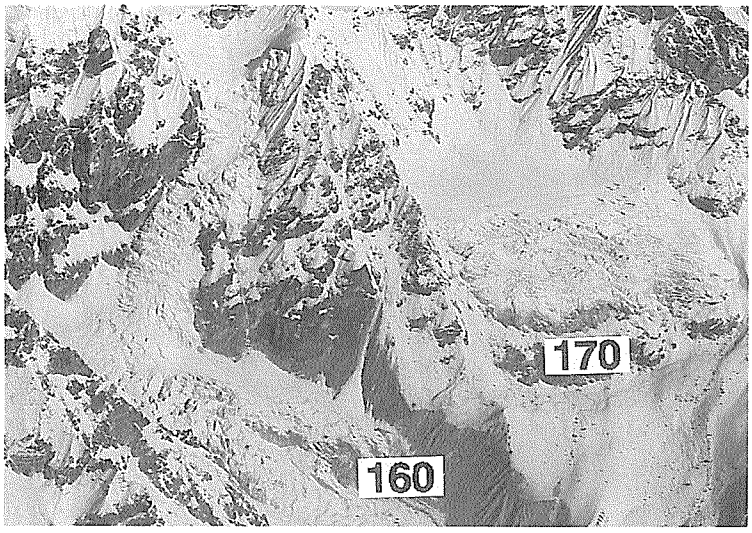

Photo 9. Glaciers L160 on the left and L170 on the right. (22 April, 1991)

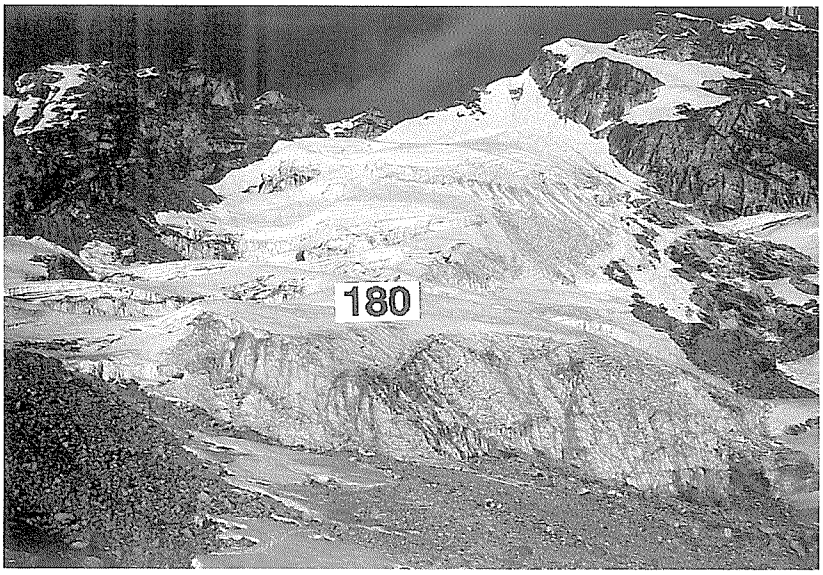

Photo 10. Glacier L180. (11 December, 1989)

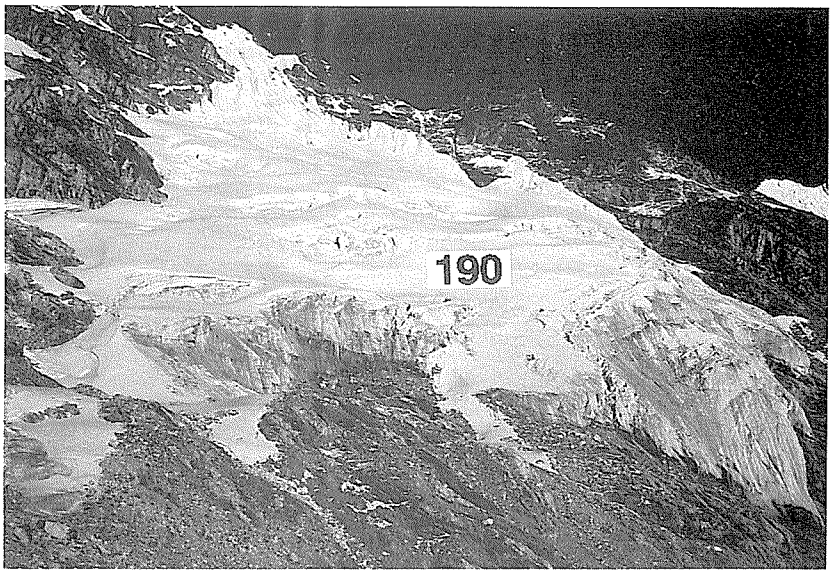

Photo 11. Glacier L190. (11 December, 1989)

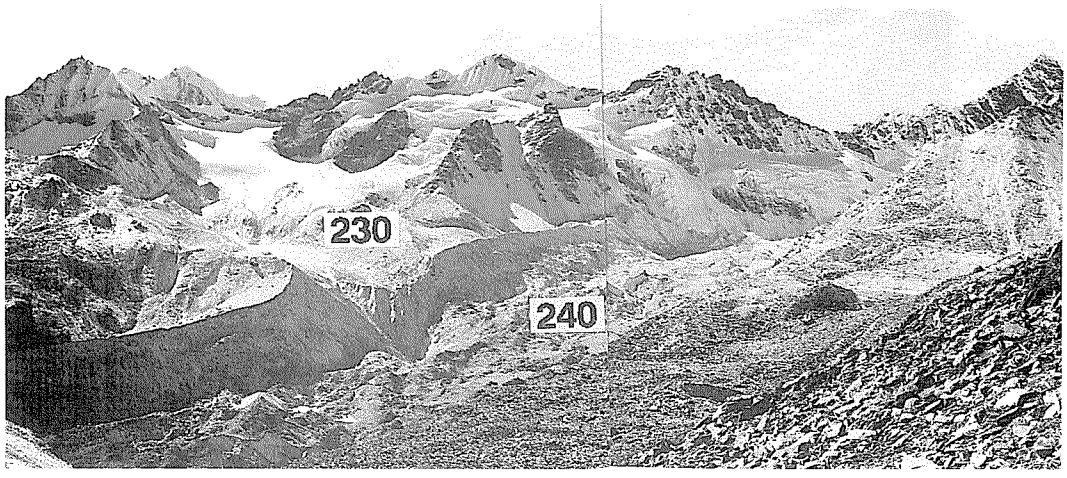

Photo 12. Glaciers L230 and L240. (14 December, 1989)

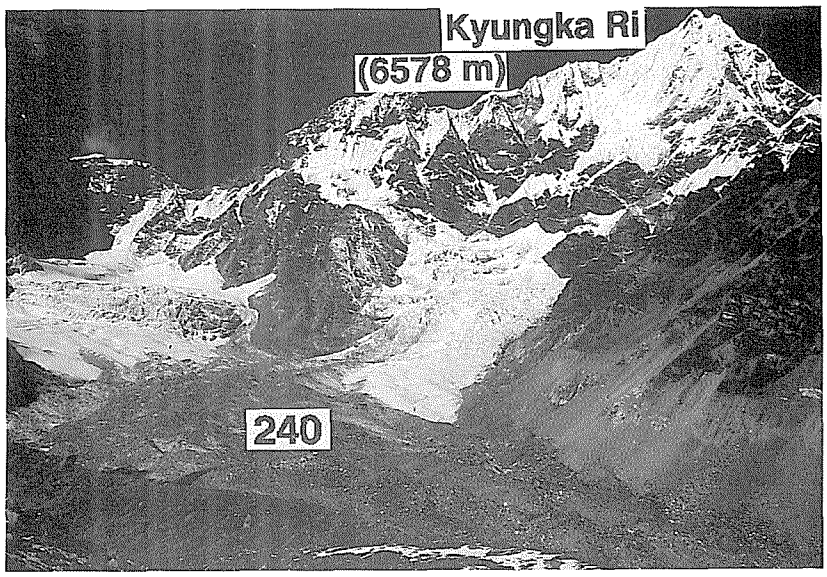

Photo 13. The active debris-covered part of the glacier L240. The pyramidal peak on the right is Mt. Kyungka Ri (6578m). (13 December, 1989)

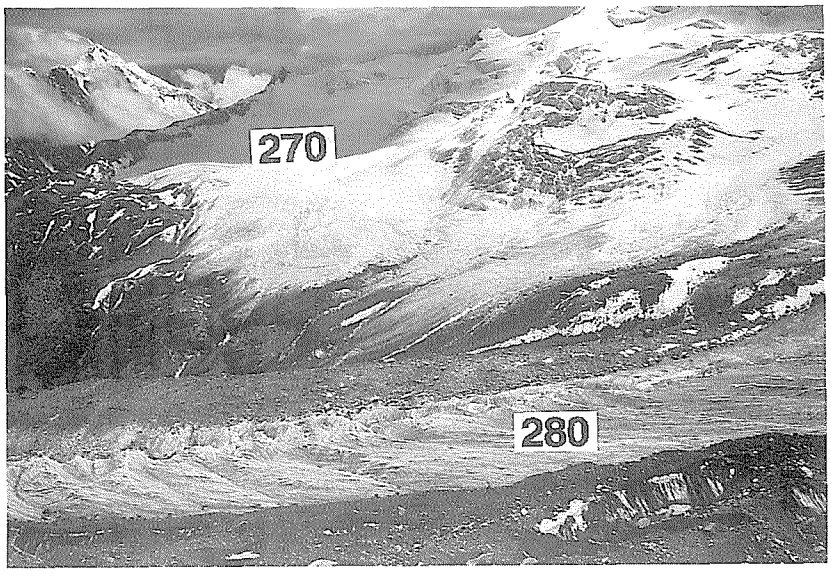

Photo 14. Glacier L270 and one of the tributaries of the Langtang Glacier (L280). Orgive structure can be seen on the surface of L280. (13 June, 1990)

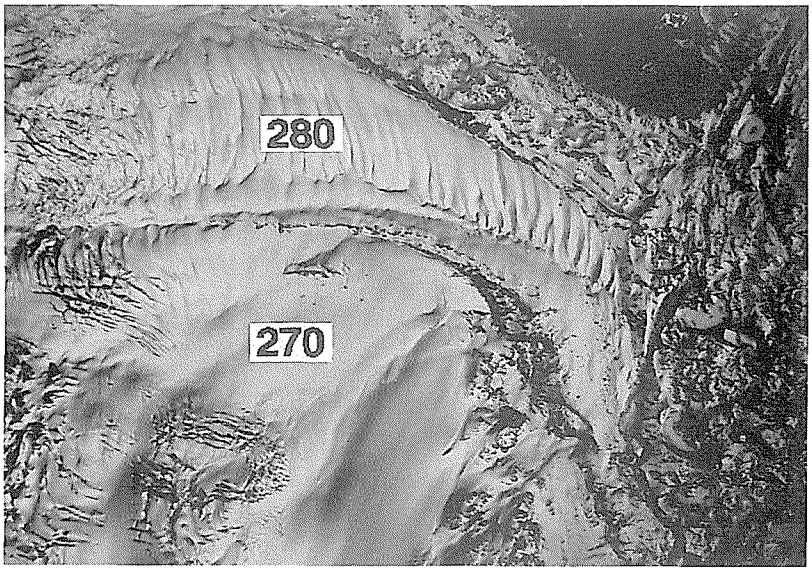

Photo 15. A vertical photograph showing the Glaciers L270 and a part of L280. (22 April, 1991)

Photo 16. Glacier L290 and Mt. Langtang Ri (7205 m). (14 May, 1991)

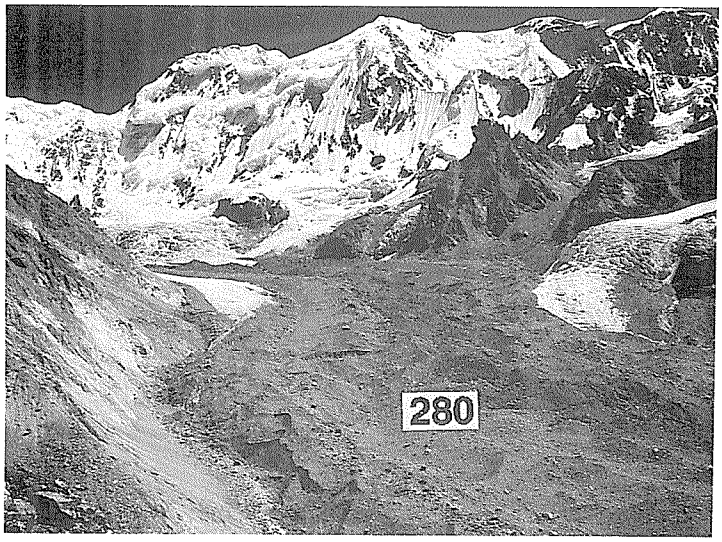

Photo 17. The upper most part of the Langtang Glacier (L280). (13 June, 1990)

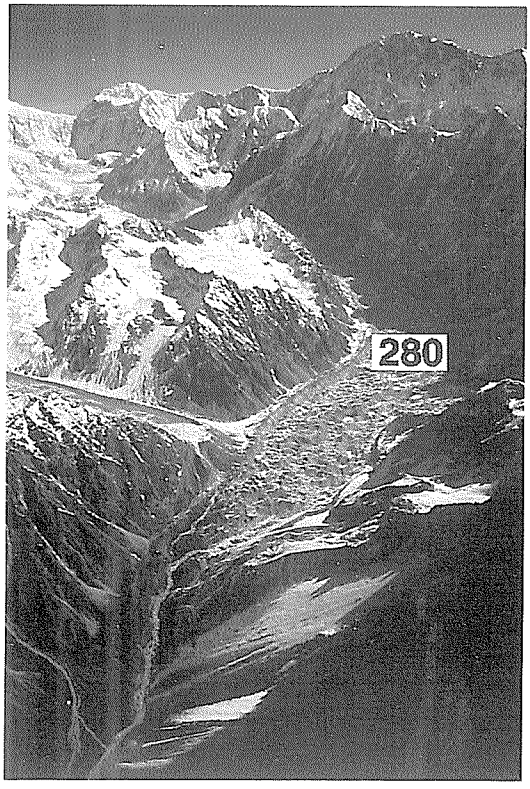

Photo 18. The terminus of the Langtang Glacier (L280). (22 April, 1991)

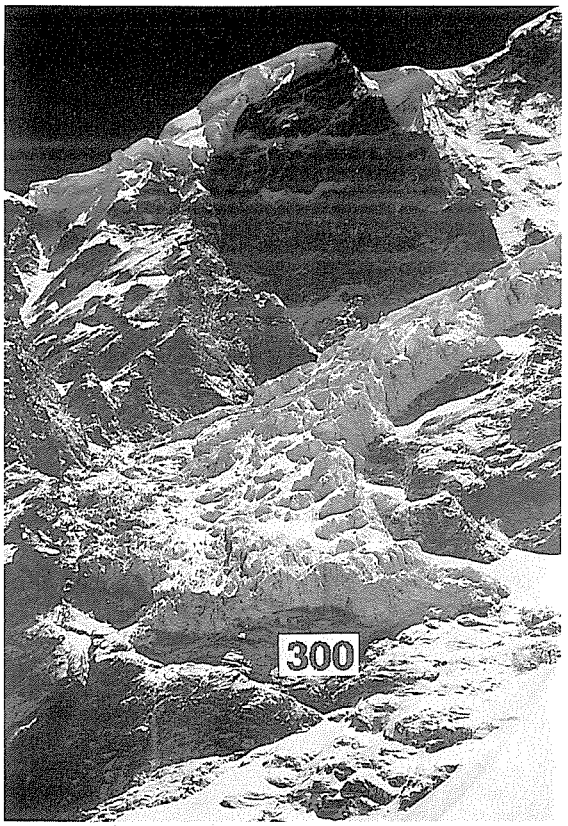

Photo 19. Icefall of the Glacier L300. (12 May, 1991)

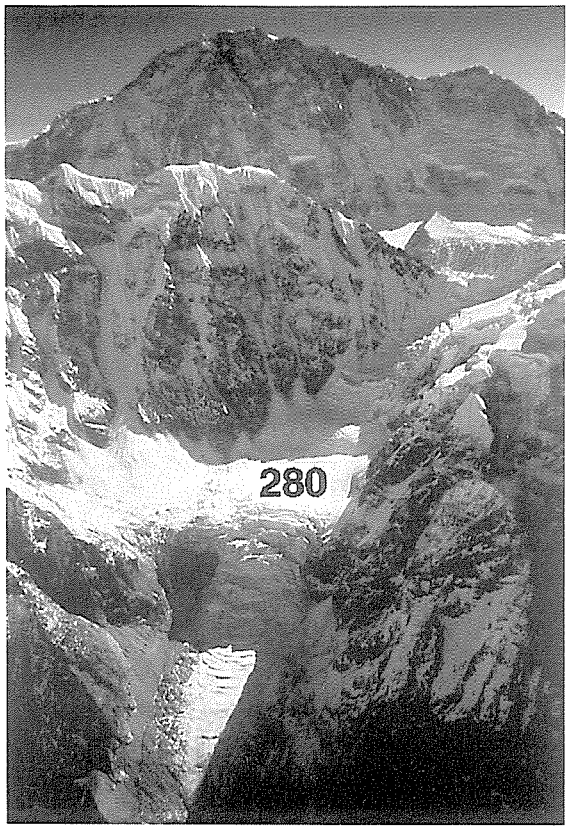

Photo 20. One of the tributaries of the Langtang Glacier (L280). Mt. Shishapangma (8013m), located in China, is seen on the background. (22 April, 1991)

Photo 21. Permanent ice-cone at the left bank of the Langtang Glacier. Dead ice of the Langtang glacier (L280) can be seen below. (11 May, 1991)

Photo 22. Icefall of the Glacier L310. (11 May, 1991)

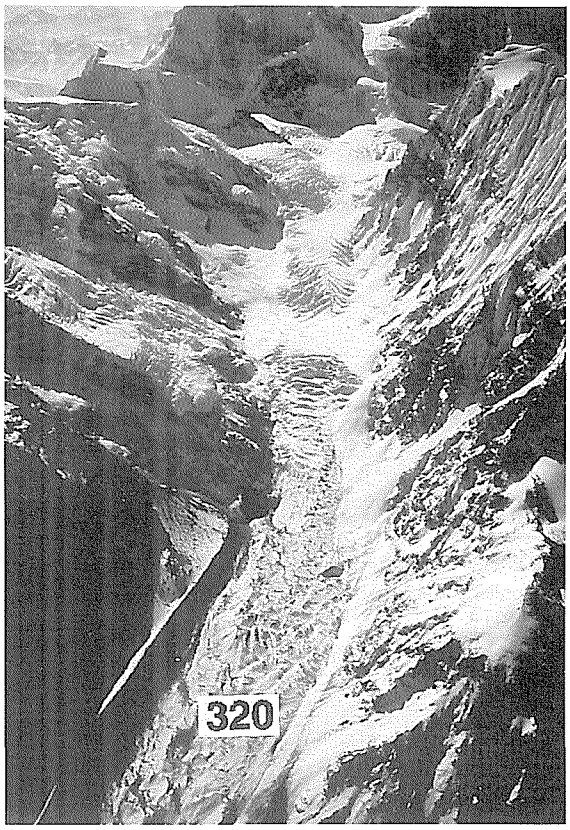

Photo 23. Glacier L320. Ogive structure can be seen below the icefall of the glacier. (22 April, 1991)

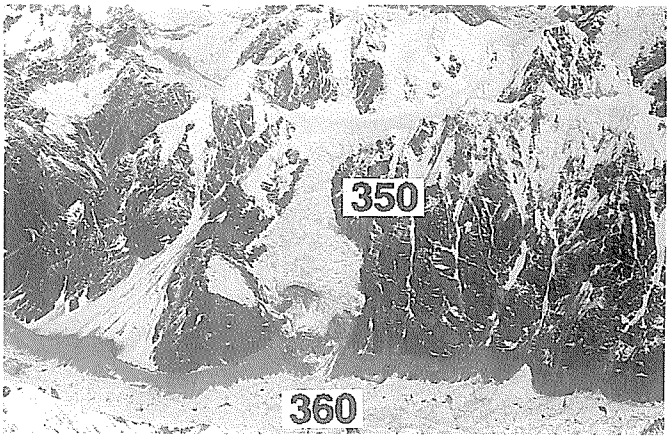

Photo 24. Icefall of the Glacier L350. The Langshisa Glacier (L360) is seen in the foreground. (Courtesy of GEN 1981)

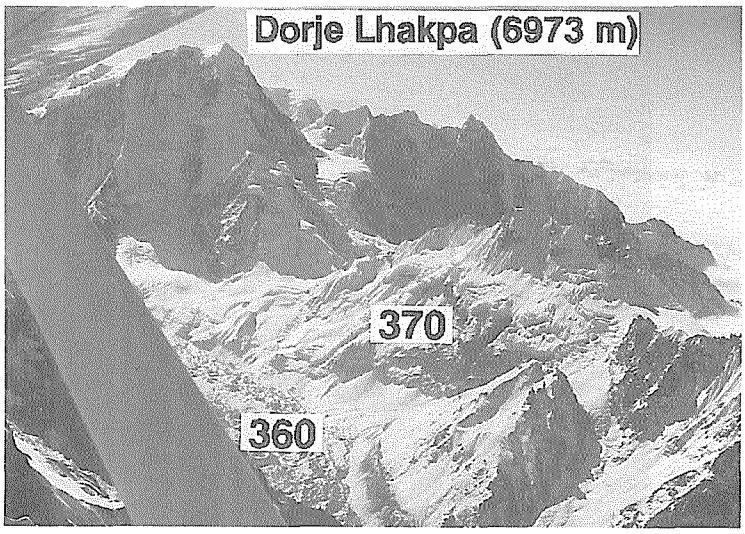

Photo 25. Glacier L370 and the Langshisa Glacier (L360). The pyramidal peak on the left is Mt. Dorje Lhakpa (6973m). (22 April, 1991)

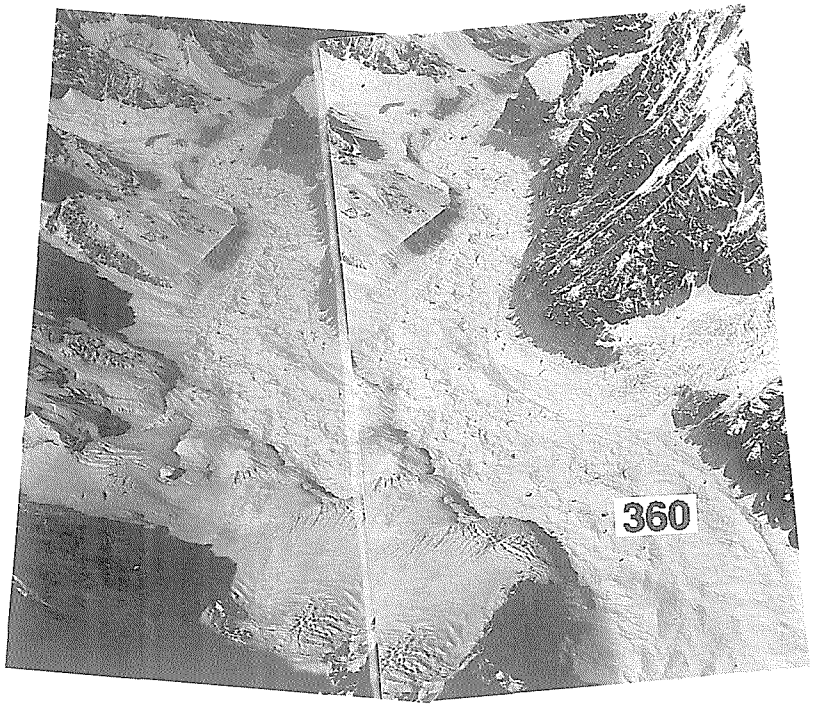

Photo 26. Stereo-pair of the middle part of the Langshisa Glacier (L360) (Courtesy of GEN 1981)

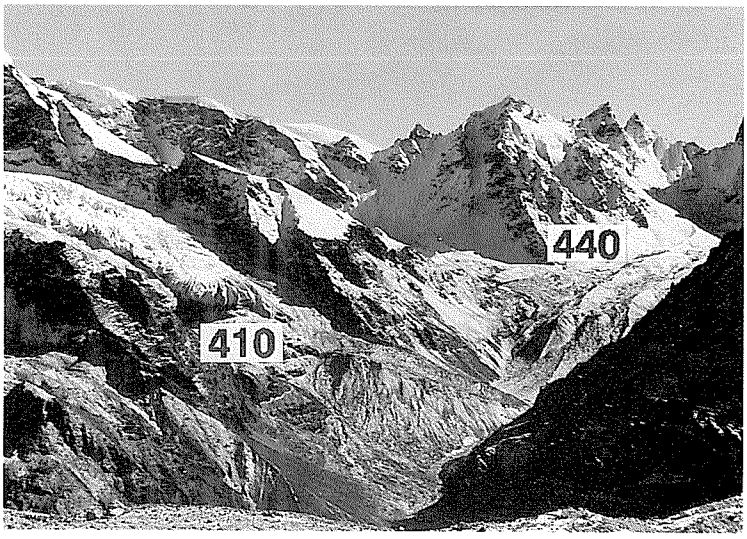

Photo 27. Glacier L410 and the terminus of L440. (27 May, 1988)

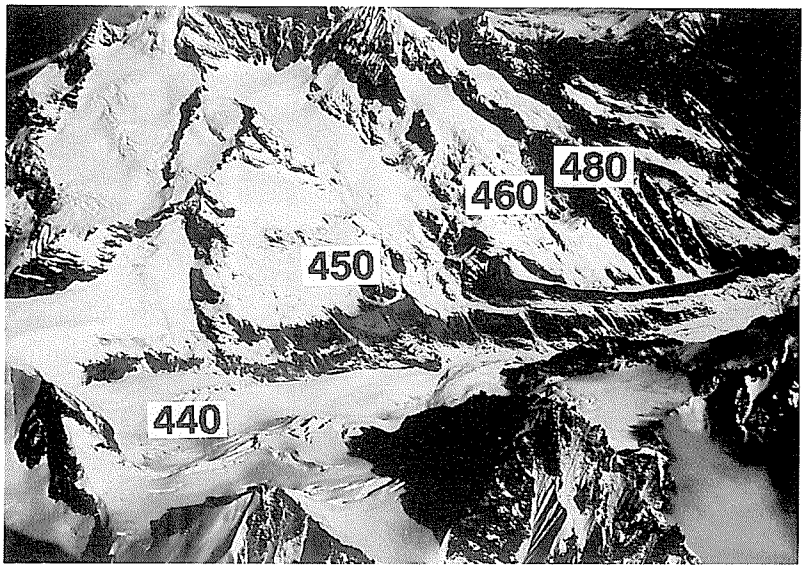

Photo 28. Glaciers L440, L450, L460 and L480. (22 April, 1991)

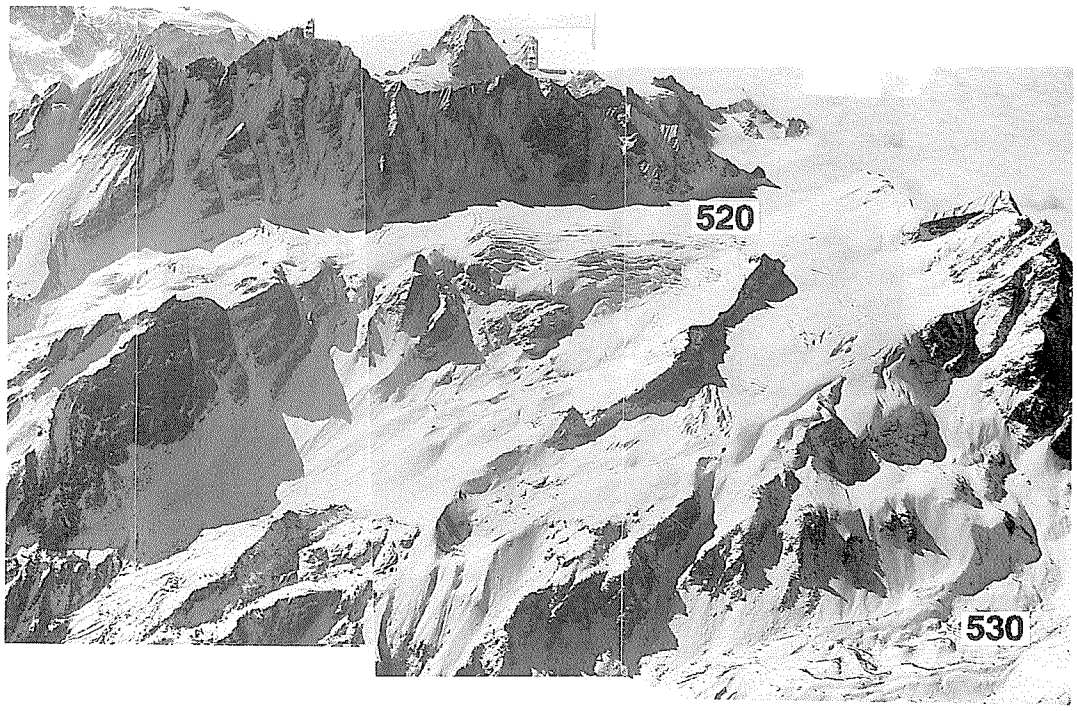

Photo 29. Glaciers L520 in the background and L530 in the foreground. (22 April, 1991)

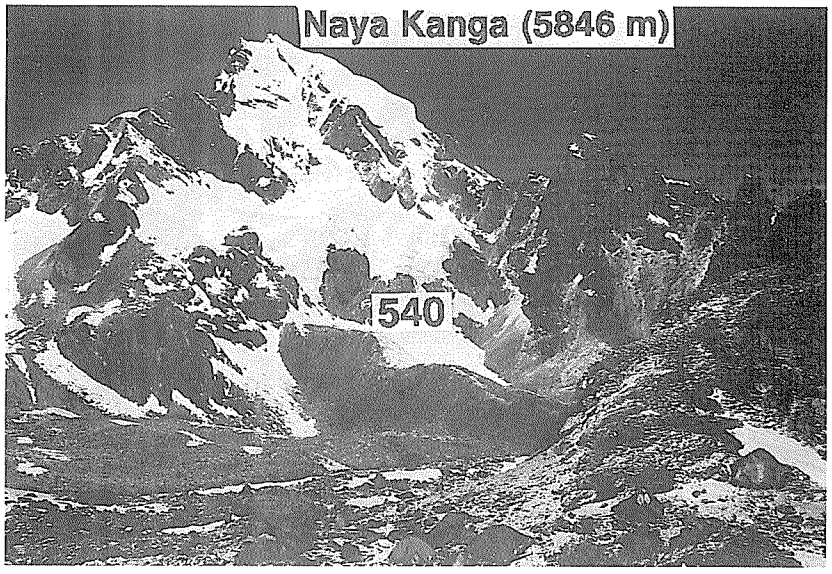

Photo 30. Glacier L540 develops on the eastern slope of Mt. Naya Kanga (5846m). (6 June, 1990)

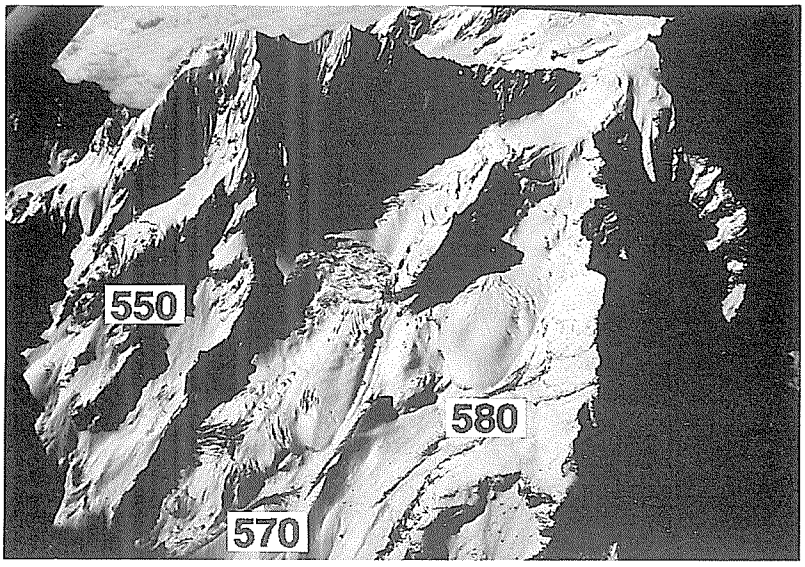

Photo 31. Glaciers L550, L570 and L580. (22 April, 1991)

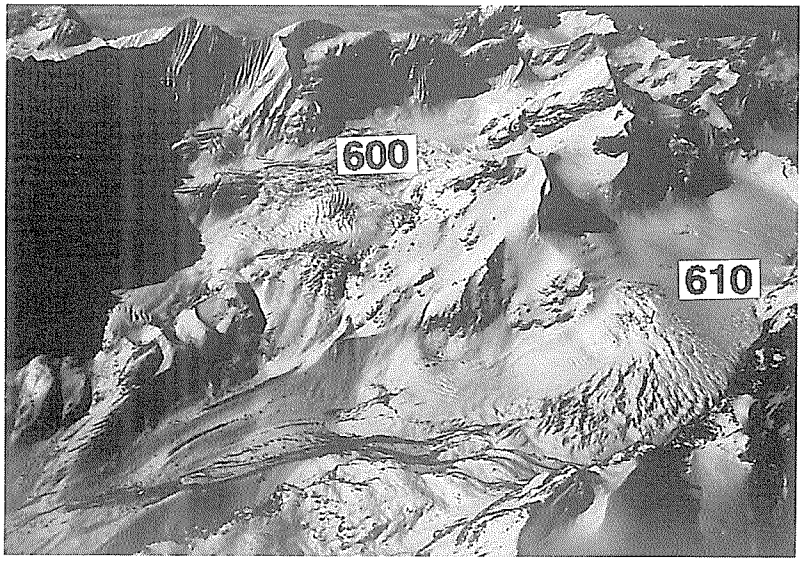

Photo 32. Glaciers L600 and L610. (22 April, 1991)

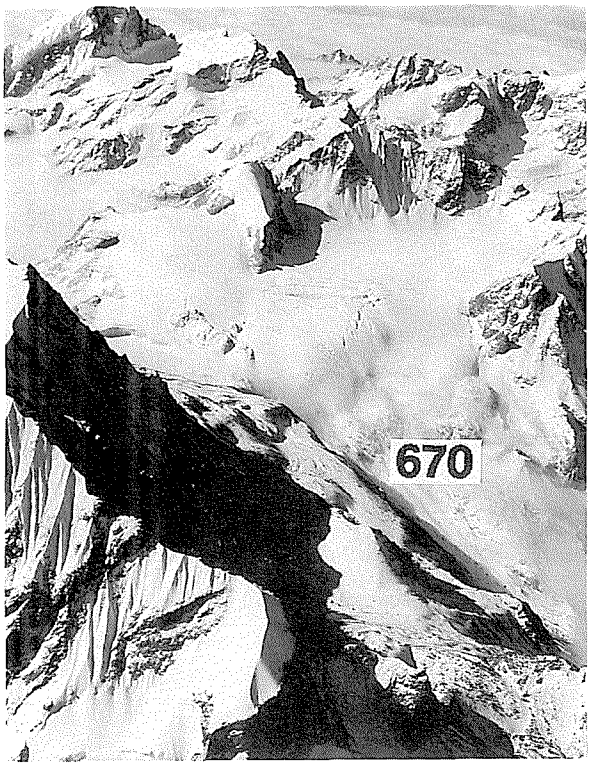

Photo 33. Glacier L670. (22 April, 1991)

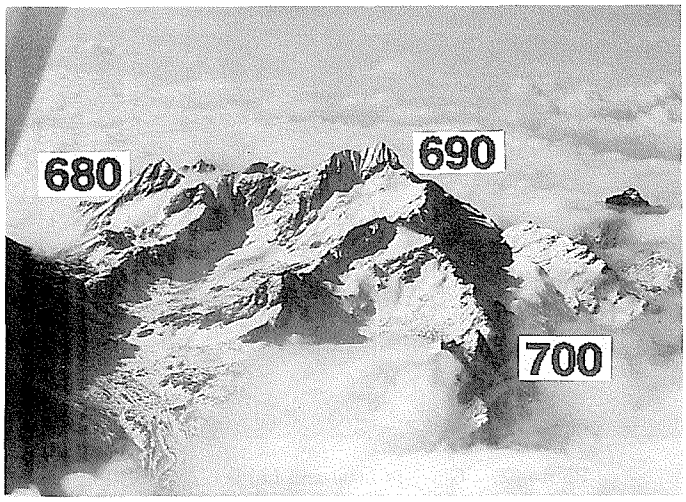

Photo 34. The western most glaciated mountain in the Langtang Valley. Glaciers L680, L690 and L700 can be seen. (22 April, 1991)

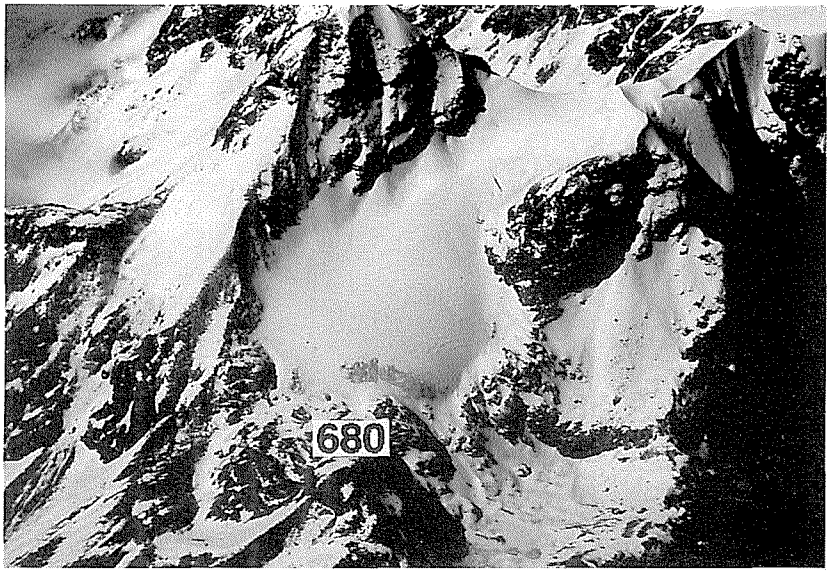

Photo 35. Close up of the Glacier L680. (22 April, 1991)

Photo 36. The western most glacier (L720) in the Langtang Valley. (22 April, 1991)

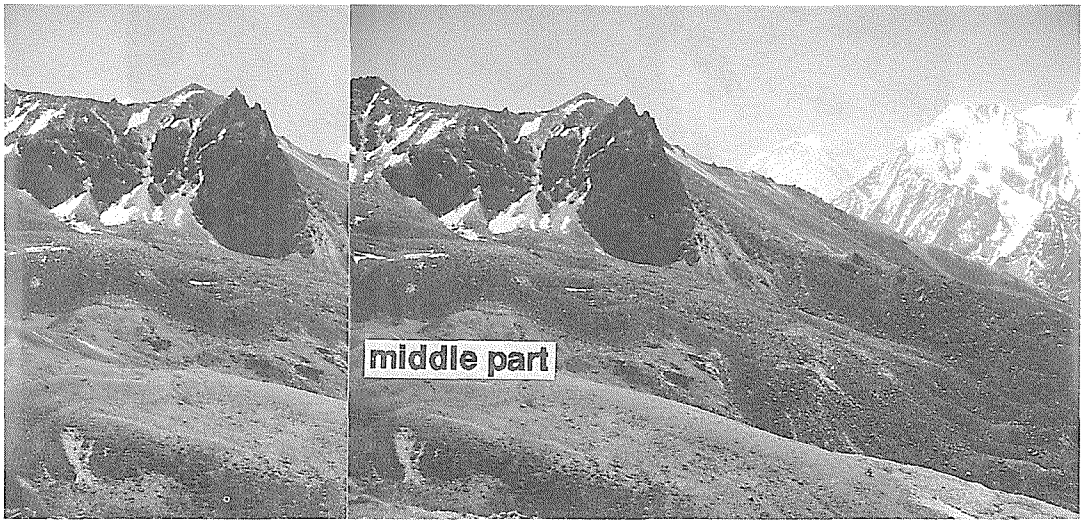

Photo 37. A fossil rock glacier can be found in the middle reaches of the Langtang Valley. Stereo-pair of the middle part. (27 May, 1988)

Photo 38. Stereo-pair of the terminus of the fossil rock glacier. The pyramidal peaks in the background are Mts. Dorje Lhakpa (6973 m) on the left and Gangchenpo (6387 m) on the right. (27 May, 1988)