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A New Map of Lewis Glacier, Mount Kenya
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Source: *Erdkunde*, Bd. 31, H. 2 (Jun., 1977), pp. 85-87
Published by: [Erdkunde](#)
Stable URL: <http://www.jstor.org/stable/25641866>
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A NEW MAP OF LEWIS GLACIER, MOUNT KENYA

With 1 map (suppl. V) and 1 table

ROBERT A. CAUKWELL and STEFAN HASTENRATH

1. Introduction

The Lewis Glacier is the largest ice body on Mount Kenya. Its catchment area being reasonably well defined, it seems suited for a study of mass and heat budget as related to secular variations in climate. The state of the glacier during the late 1900's and the early decades of the 20th century is documented by photographs, sketches and expedition reports. The first detailed mapping of the glacier was performed by

TROLL and WIEN (1949) in May 1934 based on ground photogrammetry; a reduced reproduction of the map at the scale 1:13,333 has been published. During the International Geophysical Year, the IGY Mount Kenya Expedition (CHARNLEY, 1959) established numerous control points in the peak region by theodolite triangulation, and in January 1958 mapped Lewis Glacier tacheometrically at the scale 1:2,500. Only the original unpublished map exists. E. SCHNEIDER and H. SCHRIEBL carried out a ground photogram-

metric survey in January 1963, and connected their triangulations with the IGY network of control points. This formed the basis for the excellent published map of the entire peak area at the scale 1:5,000 (Forschungsunternehmen Nepal Himalaya, 1967).

As part of a field project in 1973–74 concerned with the mass budget and secular behaviour of the Lewis Glacier, the present map reflecting the modern ice conditions was constructed.

2. IGY Control Points

Precision surveyed control stations established by the IGY Expedition on rock outcrops outside the glacier served as reference points in our 1974 mapping. Table 1 lists all IGY survey stations in the vicinity of the glacier, in terms of x and y coordinates and elevation, horizontal coordinates conforming to those used in the present map. Most of these bench marks could be identified in the field and were used in the mapping; exceptions are indicated in Table 1.

Table 1: IGY control points in the vicinity of Lewis Glacier.

Marks not identified and not used in the 1973–74 survey are indicated by asterisk. South-North (+Y), East-West (+X) coordinates, and elevation (h) in m.

	+Y	+X	h
L 1*	1,508.0	3,373.9	4,823.1
L 2	1,450.4	3,210.6	4,797.2
L 3	1,791.8	2,884.0	4,792.7
Little John*	1,306.1	2,577.7	4,628.4
Lenana	1,847.9	3,622.1	4,985.0
Melhuish	1,630.6	2,742.2	4,876.5
S 3	1,206.3	2,745.5	4,600.6
Thomson	2,031.0	3,159.7	4,955.1
Top Hut*	1,361.4	3,177.5	4,809.4

3. The 1973–74 Survey

At the outset IGY survey marks in the surroundings of the Lewis Glacier were identified in the terrain; poles were erected that could be sighted as targets in subsequent theodolite work on the glacier; and the control points were marked with white paint in order to make them visible in anticipation of an airborne photogrammetric survey.

Lines of wooden pegs were laid out across the glacier and repeatedly surveyed by theodolite, so as to measure the surficial ice flow. The IGY marks "L 2" and "L 3" served as a theodolite base for the upper one of the two profiles, consisting of pegs B 1 through B 9. For the lower transect, sub-points for the theodolite were established from the IGY network, at rock sites "A" and "A'" overlooking the glacier. Pegs of this transect are labelled A 1 through A 10, Points A, B, B', C, D and E near the glacier snout were surveyed tacheometrically from IGY station S 3.

Numerous additional points on the glacier were surveyed by tacheometric methods, mainly along rep-

resentative transects. Pegs L+5 to L-5 form a longitudinal transect, and pegs D 1 to D 4 are on a line from L 3 to Point Lenana. The intention was to acquire minimal documentation on modern ice topography, in case the hoped-for air photography should not materialize.

On 20th February 1974, at the height of the dry season and under ideal weather conditions, a Caribou of the Kenya Air Force flew a mission over Mount Kenya with the objective of an aerial photogrammetric survey of the Lewis Glacier. A total of four strips were flown along the longitudinal axis of the glacier, that is with bearings of 30 and 210 degrees, two of which were at 20,000 and two at 18,000 feet. Three frames from the better of the two 18,000 feet passes were chosen for photogrammetric evaluation. Mapping at the scale 1:2,500 was done on the Thompson-Watts First Order Plotter of the University of Nairobi, using the identified IGY survey marks (Table 1) as control.

4. Concluding Remarks

The present map is the first to be based on aerial photogrammetry from purpose flown large scale photography and can claim to have mapped more topographic features than any previous chart. Thus, orientation and spatial arrangement of major crevasse systems are depicted in considerable detail. An ice ridge in the accumulation area displays an abrupt reversal in the aspect of its steepest slope, being approximately towards NNW in its upper and towards SSE in its lower portion. Such features are indicative of ice flow characteristics and the morphology of the glacier bed, and will in due course be evaluated in relation to seismological and other prospecting techniques. A steep transverse slope is apparent particularly on the NW margin of the tongue, a fact to be explained from radiation geometry. Large-scale undulations and concave vs. convex curvature in the ice topography, of interest in perspective with the equilibrium line of the mass budget, may be more faithfully depicted than by previous maps relying on ground photogrammetry or tacheometry only.

Making allowance for seasonal characteristics of ice flow and ablation, the points, surveyed tacheometrically during 1973 and 1974, are compatible within mapping accuracy with the airborne photogrammetric survey. Points along the very edge of the snout surveyed tacheometrically on 6th January 1974 fell well outside the ice cover in the airborne photogrammetric survey of 20th February 1974, thus reflecting the seasonal snout recession.

The present map was constructed in an effort to assess area and volume changes of the largest ice body on Mount Kenya since the turn of the century. This study is related to problems of long-term climatic variations in the Tropics, and is presently still under way. The map documents dry season ice conditions

for the epoch 1974. It is hoped that the air photogrammetric survey of the Lewis Glacier will be repeated by the early 1980's.

Acknowledgements:

Approval for this research was obtained from the Director of Kenya National Parks, Dr. Perez Olindo. The Assistant Warden of the Mt. Kenya Park, Phil Snyder, and the rangers under his charge were most cooperative in the course of the project. Data from the IGY survey were received from Frank Charnley, Nairobi. John Ng'ang'a of the Meteorology Department, University of Nairobi, and John Youngs, Mountain Club of Kenya, assisted in the theodolite survey. The Permanent Secretary, Ministry of Defense, Republic of Kenya, Mr. Jeremiah G. Kiereini, generously arranged for the air photogrammetric mission by the Kenya Air Force. In particular, we should like to mention with appreciation the following members of KAF: Major Mwangi, Flight Operations; Major

Thang'ate, Squadron Commander; Capt. Wachira, Pilot-in-Command; Lt. Kibui, Co-Pilot; Tech. Pvt. Mutinda, photographic lab; and especially Capt. Gathanya, in charge of air photography. The stereo-plotting was done by Samuel W. Kimani, Department of Surveying and Photogrammetry, University of Nairobi. Assistance from the East African Meteorology Department and financial support through Grant 670-226 of the Research Committee, University of Nairobi, and U.S. National Science Foundation Grant EAR 76-18881 are gratefully acknowledged.

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RECENT INDUSTRIALISATION IN SARDINIA: REBIRTH OR NEO-COLONIALISM?

With 4 figures and 1 table

RUSSELL KING

Zusammenfassung: Moderne Industrialisierung in Sardinien: Wiedergeburt oder Neo-Kolonialismus?

Früher eine der industriell unterentwickeltesten Regionen Italiens mit einer im Niedergang begriffenen Wirtschaft, die auf Viehzucht und dem Kohlen-, Blei- und Zinkbergbau basierte, ist Sardinien jetzt die zweit-dynamischste Region Italiens, was die Wachstumsrate des regionalen Nettoeinkommens betrifft. Drei Antriebe liegen dieser jüngsten Entwicklung zugrunde: Der Einschluß der Region in den Bereich der *Cassa per il Mezzogiorno* (Fond für Süditalien), die Gründung einer besonderen industriellen Kreditagentur (*Credito Industriale Sardo*) und der „Wiedergeburtspian“ (*Piano di Rinascita*) der Insel. Die junge ökonomische Entwicklung ist in bestimmten Wachstumspolen (Cagliari, Porto Torres und Ottana) konzentriert, und zwar auf Industrien mit Ölbasis wie Ölraffinerien, Petrochemie und Kunstfasern, obwohl sich auch einige Manufakturen und Dienstleistungsindustrien entwickelt haben. Darüber hinaus haben sich Industrien in Porto Vesme (Metallverarbeitung), Arbatax (Papierherstellung), Oristano (neuer Hafenkomples), Villacidro und Macomer (Textilien) niedergelassen. So eindrucksvoll sie auch sein mögen, haben diese Industrien doch nicht die Emigration aufgehalten oder genügend Arbeitsplätze für die aus dem Agrarsektor Zuströmenden geschaffen. Nur ein Teil des Budgets des „Wiedergeburtspians“ ist ausgegeben worden. Die Arbeitsplätze in der Industrie haben auf Grund des kapitalintensiven Charakters dieser Betriebe zehnmal mehr als vorgesehen gekostet. Kritiker reden von einer Invasion der nationalen und multinationalen Petrochemie-Giganten auf die Insel. Diese Si-

tuation ist eine Wiederholung eines bekannten Musters der Geschichte Sardinien, nämlich der ständigen Kontrolle der Insel durch Kräfte von außen.

The Saga of Southern Italy – the Mezzogiorno – has many interesting aspects, not the least of which are the marked geographical contrasts within the region. Unfortunately, students of Italy's 'southern problem' frequently fail to bring out the differential spatial impact of the string of policies that have been applied since the mid 1950s to develop the Mezzogiorno industrially. In particular, the peripheral region of Sardinia is often ignored. Yet this island has witnessed over the past decade and a half the most profound economic changes of any other region in Italy. A traditional economic geography, based on pastoralism and mineral exploitation, has been radically altered by a mushrooming of oil-based refining, petro-chemical and artificial fibre complexes. Generous financial incentives to incoming industry and the rapid development of transport infrastructures have stimulated this industrial development, aided by the island's strategic location on major oil routes from North Africa and the Middle East. The results of this development, however, have not been entirely unequivocal. The highly capital-intensive nature of the industry leaves a considerable shortfall in planned employment; the effects of the development are highly

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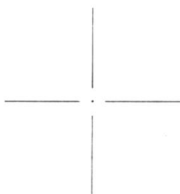
LEWIS GLACIER

Scale 1:2 500

Plotted from photographs taken
20th February 1974

+2000

+1750

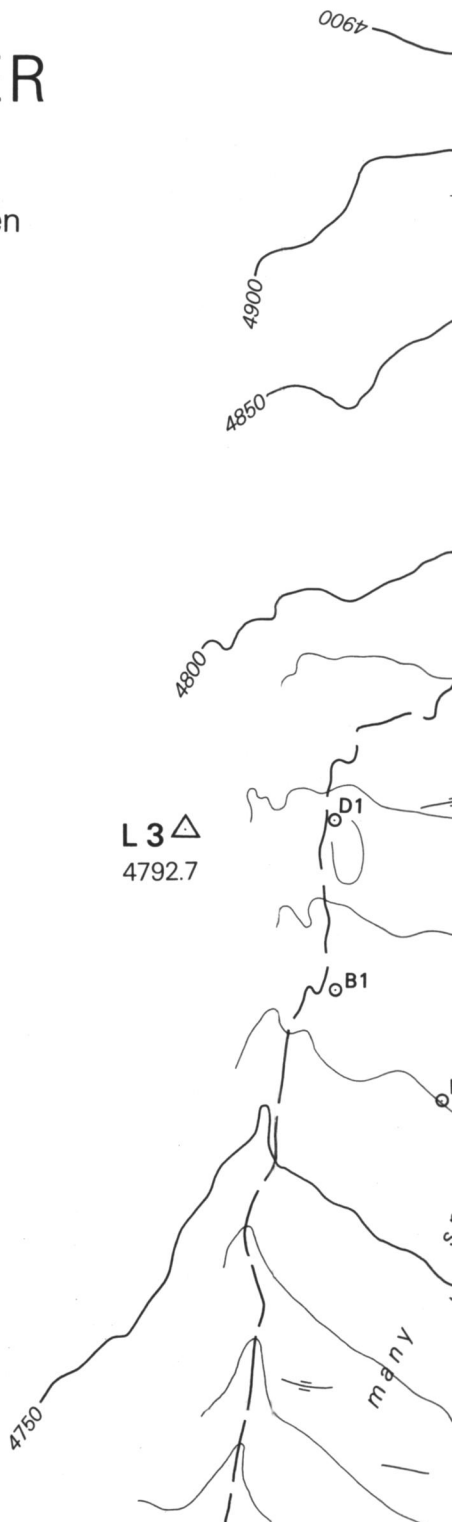


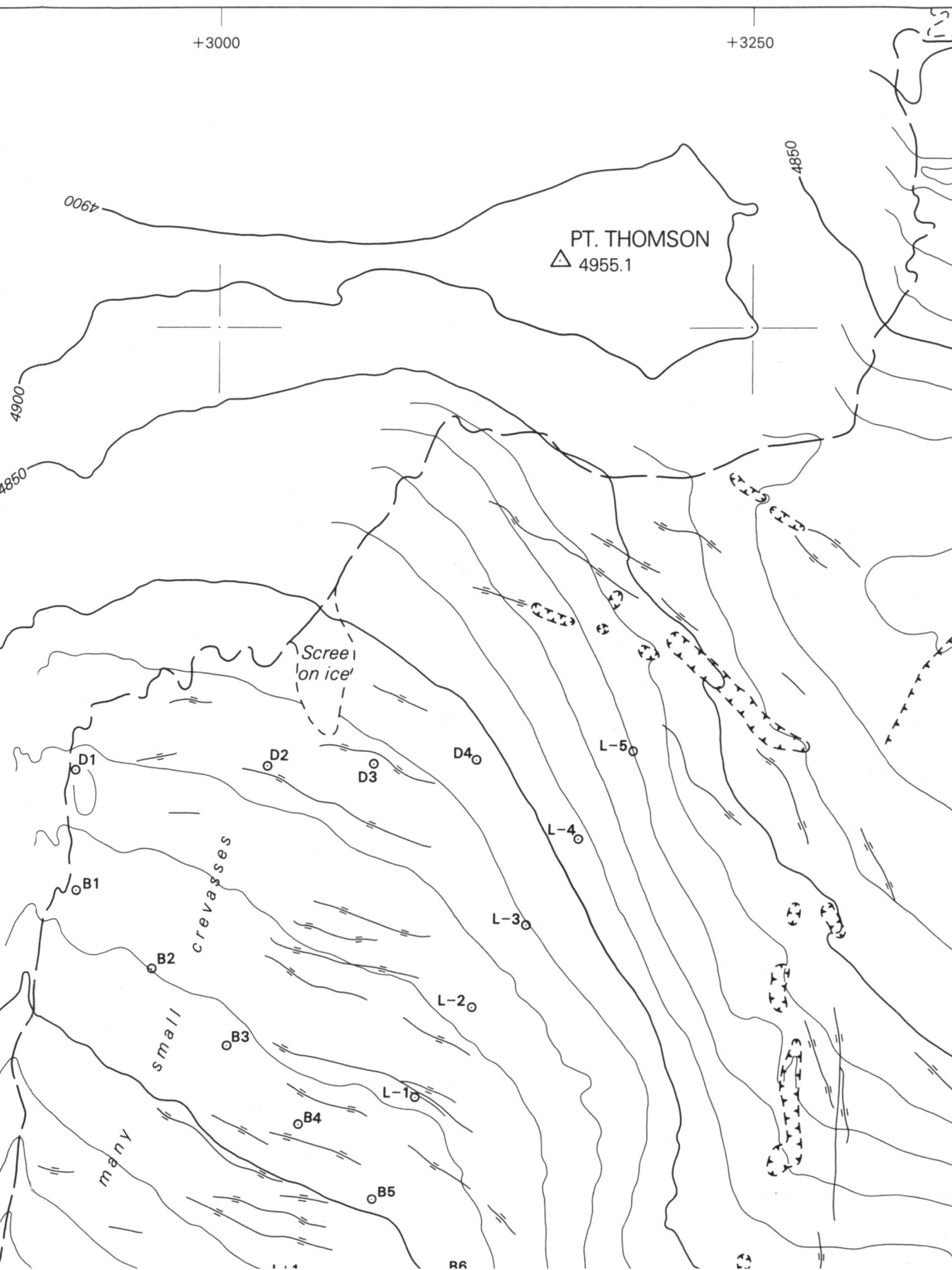
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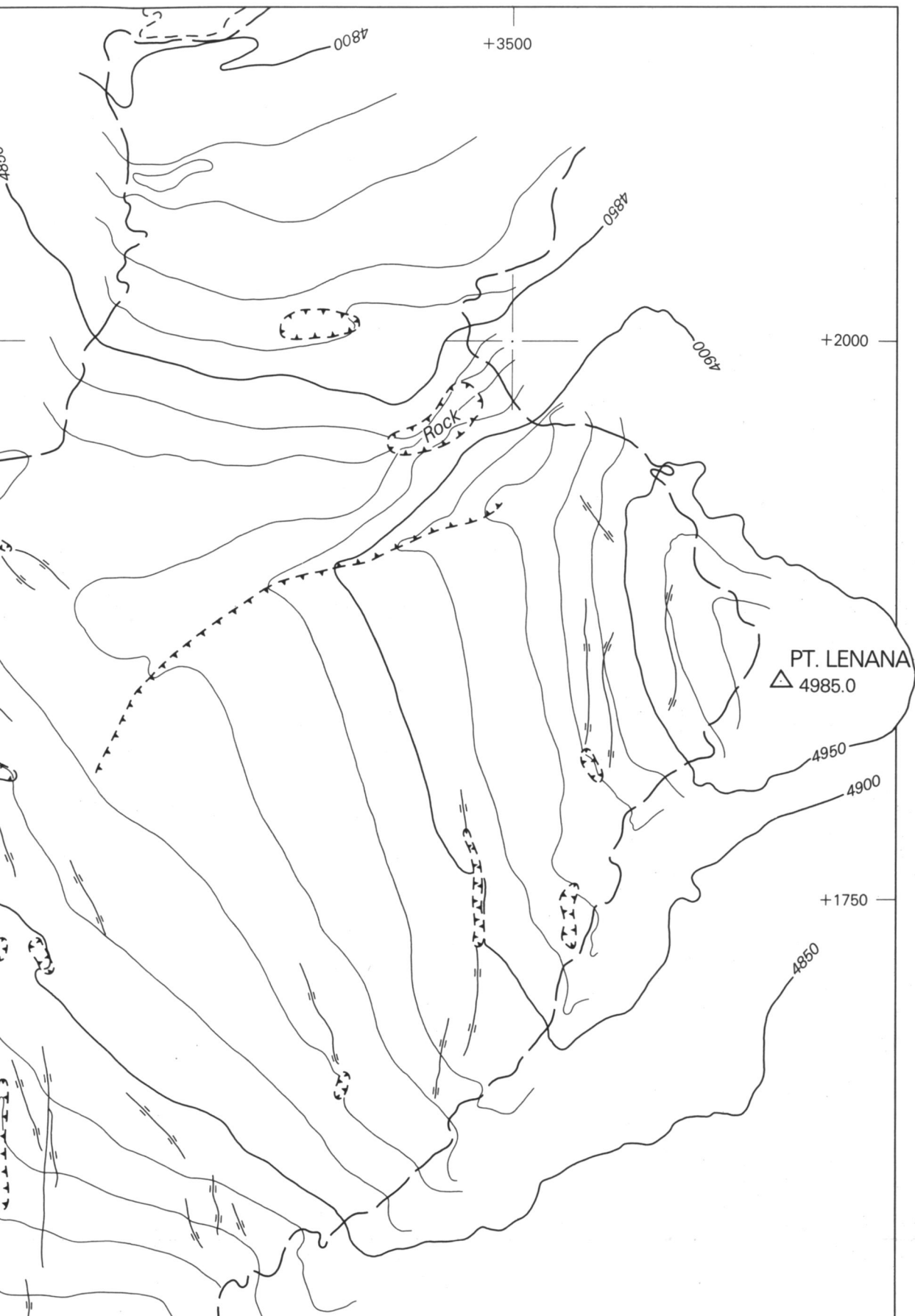
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A'

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S3
△ 4600.3

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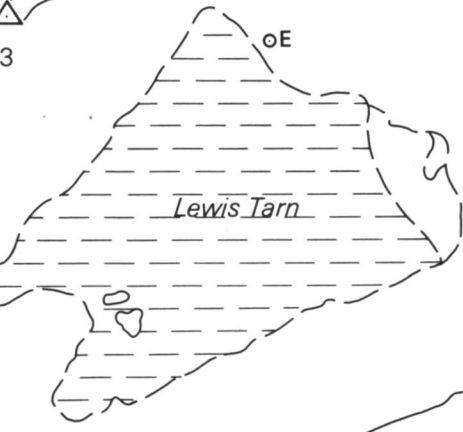
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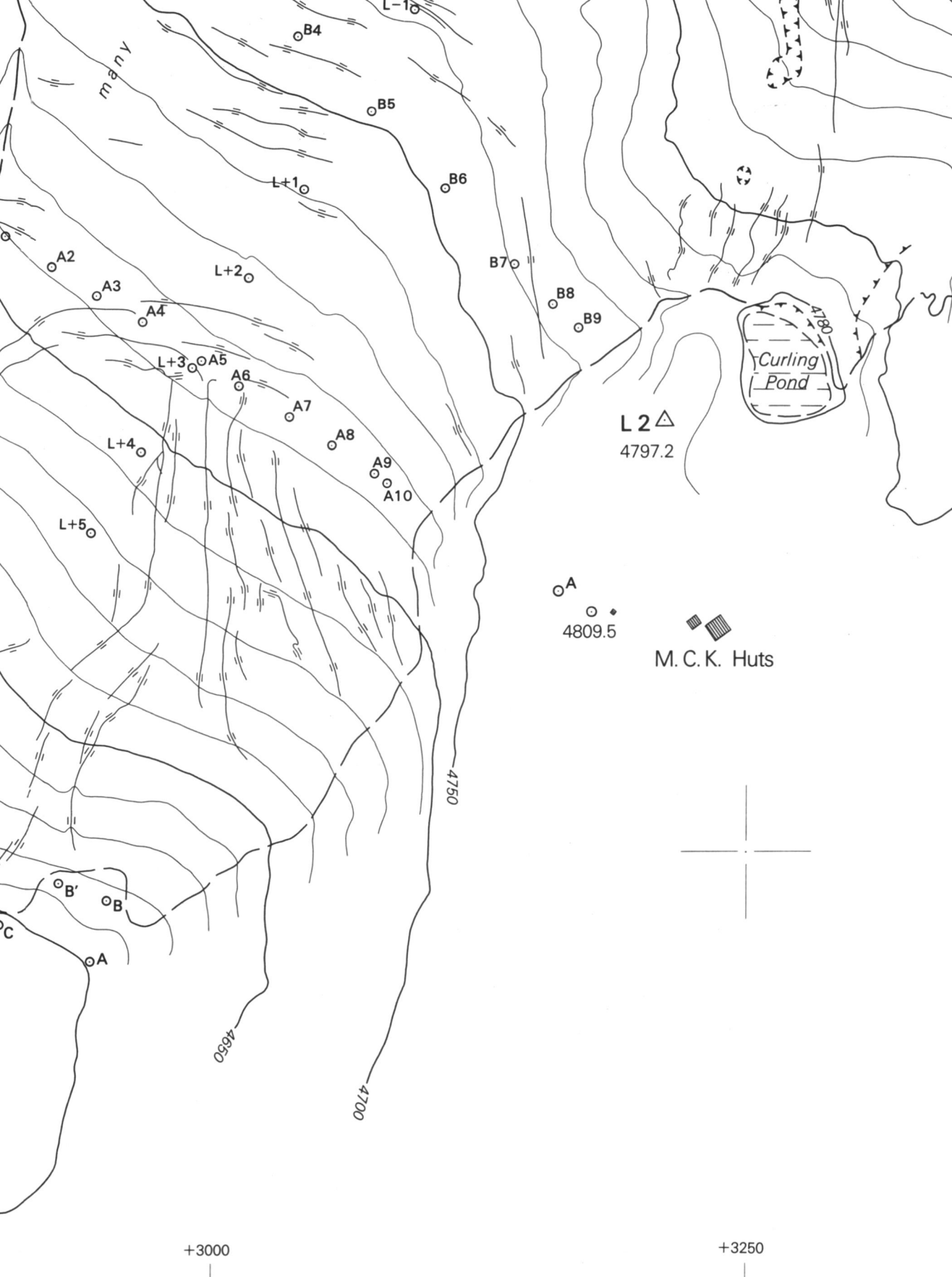
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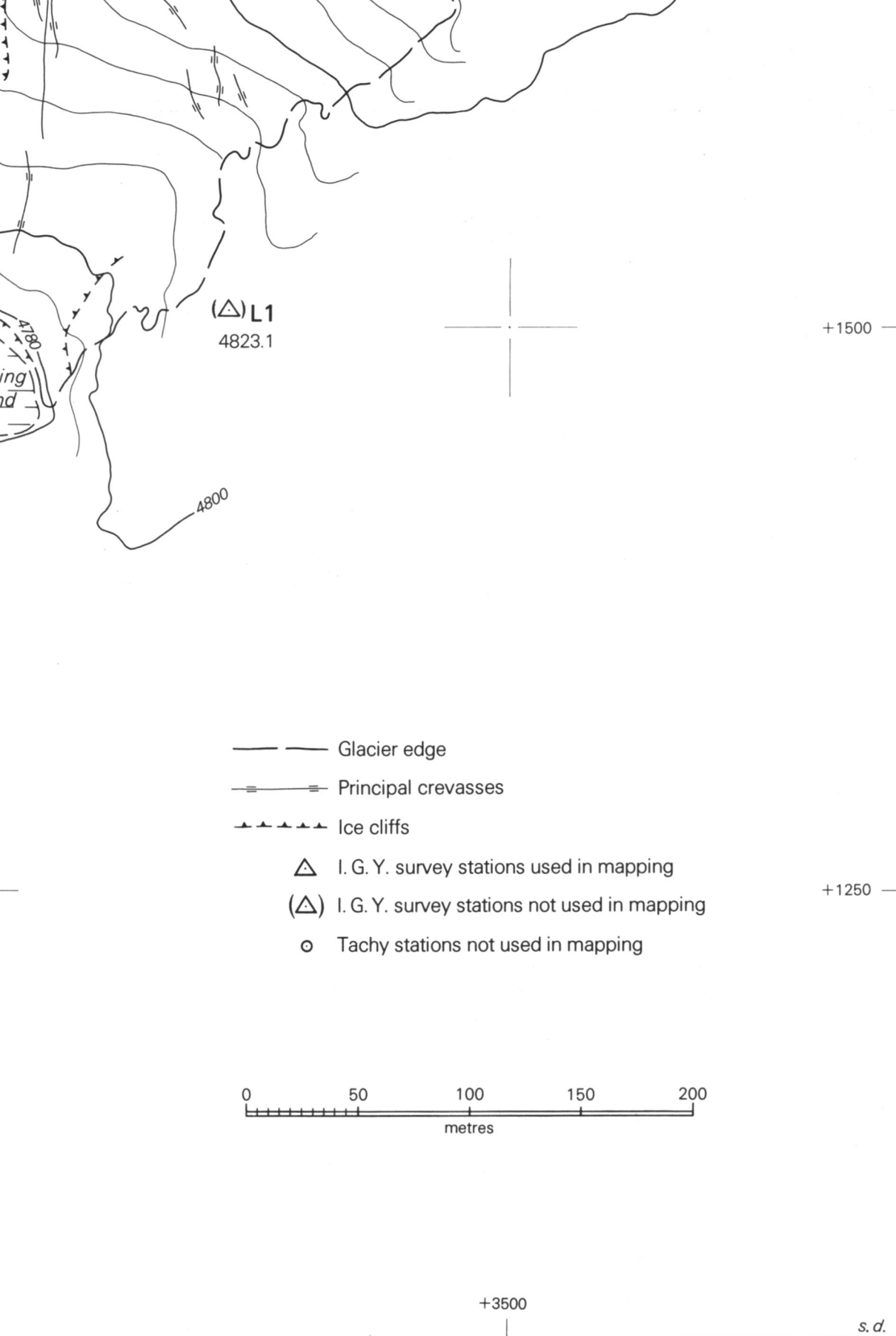
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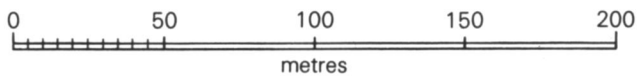
(Δ) L1
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+1500

4800

- — — — — Glacier edge
- — — — — Principal crevasses
- ▲ ▲ ▲ ▲ ▲ Ice cliffs
- △ I. G. Y. survey stations used in mapping
- (△) I. G. Y. survey stations not used in mapping
- Tachy stations not used in mapping

+1250



+3500

s. d.