BASAL MORPHOLOGY OF ICY BASIN, JUNEAU ICEFIELD, ALASKA

by

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December, 1995

This paper was written as a final report for the:
National Science Foundation Young Scholars Program
Glaciological and Arctic Sciences Institute
M.M. Miller, Director
University of Idaho, Moscow, Idaho 83844

Specify the scientific field of research of your abstract, designating both the major scientific discipline and the sub-discipline.

Physics/Geophysics

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ABSTRACT TITLE: Basal Geomorphology of Icy Basin, Juneau Icefield, Alaska

During the summer field season of 1995, seismic reflection data were obtained in Icy Basin, Juneau Icefield, Alaska. Icy Basin is largely still covered by glacial ice, so its underlying shape is unknown. The purpose of the present study was to confirm the hypothesis that the basal morphology of Icy Basin is cirque-related, using state-of-the-art seismic reflection technology to provide a detailed picture of the basal topography of Icy Basin. The seismic results showed that Icy Basin as a whole comprises a multiple system of cirques. The elevations of these cirques correlate with an accepted regional interpretation of cirque and berm levels as effects of climatological patterns in glacial history. The study indicates that Icy Basin was strongly influenced geomorphologically by cirque glaciers in previous interglacial periods during the last several hundreds of thousands of years.

ABSTRACT FORM FOR NATIONAL JSHS STUDENT PARTICIPANTS

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INSTRUCTIONS: *Abstracts must be in typewritten form, standard 12 point style, and must be single-spaced. The Courier 12 type style is recommended. Use the spacing and capitalization style shown by examples on the reverse side of this sheet. If any diagrams are used, draw in black ink. The abstract should be adequate in length but not exceed 175 words.*

ABSTRACTS MUST BE SUBMITTED ON THIS FORM. DO NOT SUBMIT A PHOTOCOPY. TYPE WITHIN THE ABOVE 4-CORNER, BLUE-LINE FRAME.

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BASAL MORPHOLOGY OF ICY BASIN, JUNEAU ICEFIELD, ALASKA

INTRODUCTION

The Juneau Icefield is located in the Alaska-Canada Boundary Range of Southeast Alaska, at approximate latitude 59° north and longitude 134° west. The most dominant feature of this icefield is the Taku-Llewellyn glacier system, a transection glacier network spanning 75 miles across the coast range. For 50 years, the Juneau Icefield has been the focus of an intense study incorporating many disciplines under the aegis of the Juneau Icefield Research Program (JIRP). The southern end of the icefield is situated only 6 miles from Alaska's capital city, Juneau, providing an excellent base for logistics and support. Icy Basin, the area of the present study, is located on the Juneau Icefield near Camp 10 (Fig. 1). It is approx. 1.8 km north-south and 2.6 km east-west, bounded on the west by the Taku Glacier, and north, east, and south by nunataks Taku A, Taku B, and Vantage Peak (Fig. 2).

Icy Basin is largely still covered by glacial ice, so its underlying shape is unknown. The hypothesis of this study is that the basal morphology of Icy Basin is cirque-related. A cirque is a steep-walled, bowl-shaped depression created by valley glaciation. This hypothesis was first suggested, but not proven conclusively, by early reconnaissance seismic studies (Senstad, 1983). Supraglacial features of the basin, including a circular depression in the ice at the basin's northern end, an ephemeral ice-margin, a supraglacial lake, and vertical headwalls, are consistent with this hypothesis. The purpose of the present study was to confirm the cirque hypothesis with state-of-the-art seismic reflection technology to provide a detailed picture of the basal morphology of Icy Basin.

Previous geophysical studies on the Juneau Icefield have been conducted over the past 50 years. Several methods have been utilized, most notably Poulter's 1949 Stanford Research Institute seismic survey of profiles I, II, III, and IV on the Taku glacier (Poulter, Allen, and Miller, 1949). However, recent seismic surveys have questioned Poulter's results (Miller, Sprenke, Benedict, Adema, Auerbach, Pruis, and Volkening, 1994). Ice-

radar experiments have been performed on the icefield with some success also (pers. comm., W.R. Hammond, 1991). Gravimeters have also been used in recent geophysical surveys (Venteris and Miller, 1993).

METHODOLOGY

Seismic data were recorded on three profiles in Icy Basin: profiles IB1 and IB2 were oriented northeast-southwest, and IBL was northwest-southeast, perpendicularly transecting IB1 and IB2 (Fig. 2). Two static 115 meter lines of twelve geophones, spaced 10 meters apart, connected to a Bison 9024 24-channel stacking seismograph were used to record data. The seismograph was connected between geophones 12 and 13, the first geophone being the most southern or western. Geophones were placed 20 cm below the firn surface. The shot point was moved for each shot a distance of 230 meters, providing continuous subsurface coverage across the entire profile. Each explosive charge was buried approximately 1 m below the firn surface. The amount of explosives varied with each shot point. Successively larger charges were used as distance increased from the geophone line. Explosives were detonated using seismic detonator caps and a high voltage capacitor-discharge type blaster. Synchronous detonation of the explosives with the seismograph trigger was accomplished through the use of FM radios. The seismograph recorded 1.5 seconds of data (1500 samples) on each shot.

Seismic records were analyzed in the field by manually identifying seismic reflectors (Fig. 3). In base camp, a computer spreadsheet program was used to compute and plot the depth of the reflectors in their proper subsurface positions, creating depth profiles along the seismic lines. The velocity of the *P*-wave in the ice, an important parameter for converting seismic reflection times to depths, was found to be 3600±120 m/s, using a statistical linear regression computer program. This velocity was calculated from *P*-wave first arrivals on the seismic record (Fig. 3). This value is consistent with the ice velocity used in other seismic studies on the Juneau Icefield (Miller, Benedict, Sprenke, Gilbert, and Stirling, 1993).

Elevation control on the ice was provided by Global Positioning System measurements. A USGS topographic map, JUNEAU (C-1), provided elevation control on the surrounding nunataks. Computer programs SURFER™ and Generic CADD™ were used to construct computer models of the surface and basal morphology.

RESULTS

The surface topography of Icy Basin and the seismic data from profiles IB1, IB2, IBL, and Profile IV of the Taku Glacier were merged to create perspective views of Icy Basin with and without glacial ice (Fig. 4). The results show several geomorphic features of Icy Basin. Two cirques are apparent in the basal topography of Icy Basin. An upper cirque is at an elevation 700 m, about 380 m below the present ice surface. A lower cirque is at an elevation of about 540 m, over half a kilometer below the present ice surface. The lower cirque appears to be related to a berm of the Taku Glacier, which occurs at approximately the same elevation. The maximum depth of the Taku Glacier near Icy Basin is over 1400 meters, creating the steep slope to the southwest in Figure 4b.

It should be noted that the results are somewhat limited by the location and number of seismic lines used (Fig. 2). It was necessary to interpolate subsurface contours by hand between the control lines using surface contours as a guide. However, the interpretation between the control lines were reviewed by a professional glacial geomorphologist who provided helpful guidance (pers. comm., Roy Breckenridge, Idaho Geologic Survey, 1995).

DISCUSSION

A key factor controlling glacial flow is depth; therefore higher flow rates would be expected in the southwestern part of the basin than in the upper part. However, Icy Basin is glaciologically stagnant; a relatively small amount of mass transfer occurs at present in

the basin (pers. comm., Martin Lang and Peter Angus-Leppan, 1995), the flow possibly being impeded by the current advance of the Taku Glacier (Miller, 1985).

The overall basal morphology shown in Figure 4 clearly supports the hypothesis of this study. Icy Basin is certainly cirque-related. In fact, the seismic results suggest that Icy Basin as a whole comprises a multiple system of cirques. The elevations of these cirques correlate with an interpretation of the Alaska-Canada Boundary Range cirque levels as effects of climatological patterns in glacial history (Miller, 1961). The base elevation of the lower depression in the basal topography is consistent with the C3 cirque level, at a mean base elevation of 530 m. The base elevation of the depression in profile IB2 corresponds to the C4 cirque level at 747 m. This interpretation suggests that Icy Basin was strongly influenced geomorphologically by cirque glaciers in previous interglacial periods in the last several hundreds of thousands of years.

CONCLUSION

The basal topography as revealed in this study shows Icy Basin to be a hanging cirque-configured valley above the ancestral Taku Fjord, currently filled by the Taku Glacier. The overall basin morphology is consistent with an established regional cirque pattern of Alaska-Canada Boundary Range. The lowest cirque elevation correlates with a berm revealed in a previous seismic survey of the Taku Glacier.

Future research in Icy Basin should include a detailed survey of present-day surface elevations using GPS instrumentation to study the relationship between surface and basal morphology. Further seismic work on the Juneau Icefield should involve surveys of other basins to verify the overall consistency of subglacial cirque levels in the Taku-Llewellyn Glacier system.

ACKNOWLEDGMENTS

Logistical support and transport of equipment and personnel on the icefield was provided in cooperation with the Juneau Icefield Research Program by Thiokol model 1400 Imp over-snow vehicles and sleds. The survey operations were conducted from JIRP Camp 10. Survey data for locations of geophone lines and shot locations were provided by the 1995 JIRP survey team using GPS.

The author would like to thank Dr. Maynard M. Miller, director, Glaciological and Arctic Sciences Institute, for the support, both financial and logistical, of this project, and directing the overall seismic project, as well as giving helpful suggestions for this report. Gratitude is extended to Dr. Kenneth Sprenke who was instrumental in providing technical advice in the analysis of this survey. Also, thanks to Guy Adema, Baruch Laskin, Kirk Lurvey, and the rest of the 1995 geophysics crew, and to the National Science Foundation Young Scholars Program for the opportunity to participate in the Juneau Icefield Research Program. And lastly, I am indebted to all of the other JIRPers of 1995 who made this field season a memorable experience.

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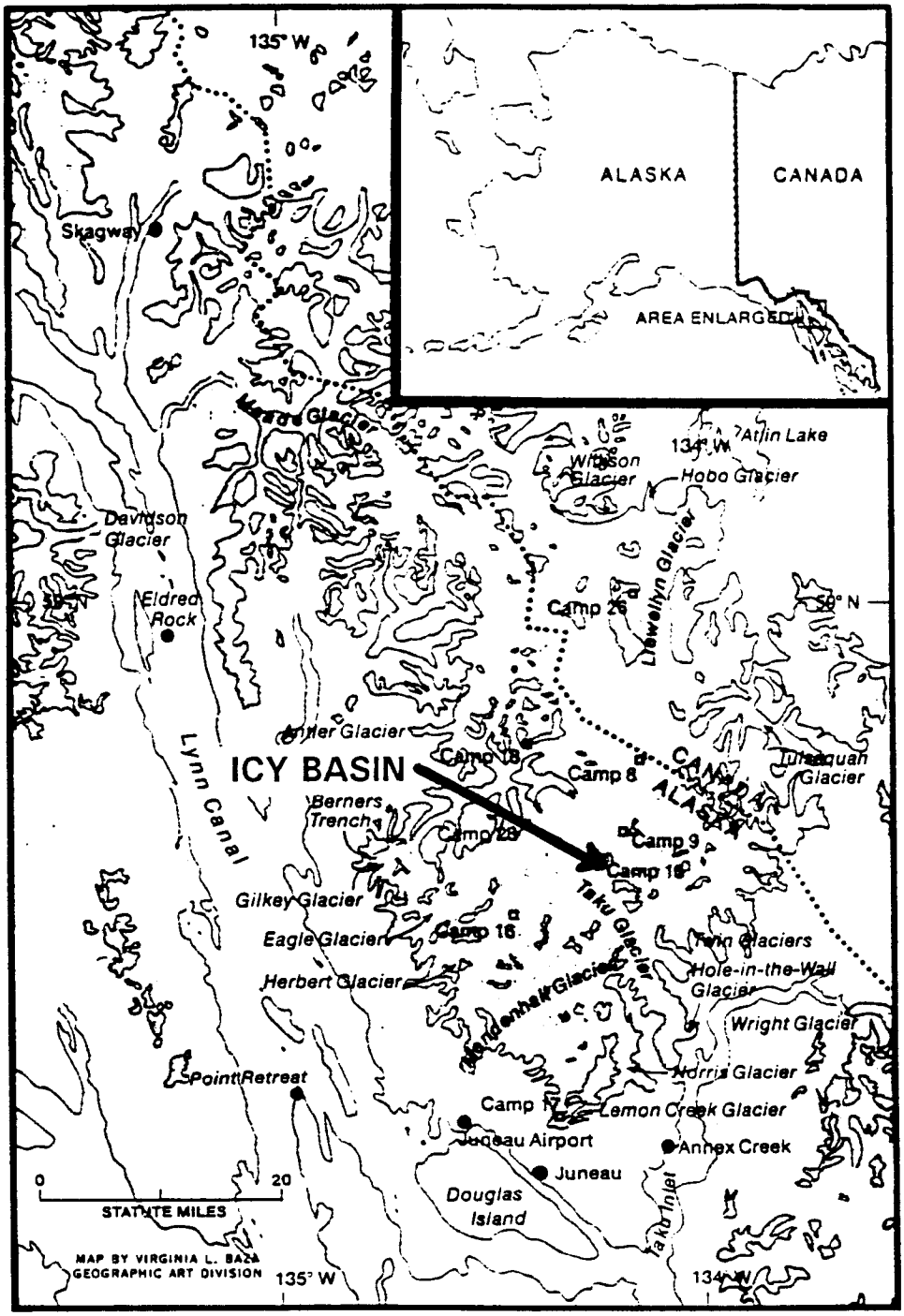

Figure 1. Location map showing the Juneau Icefield and Icy Basin.

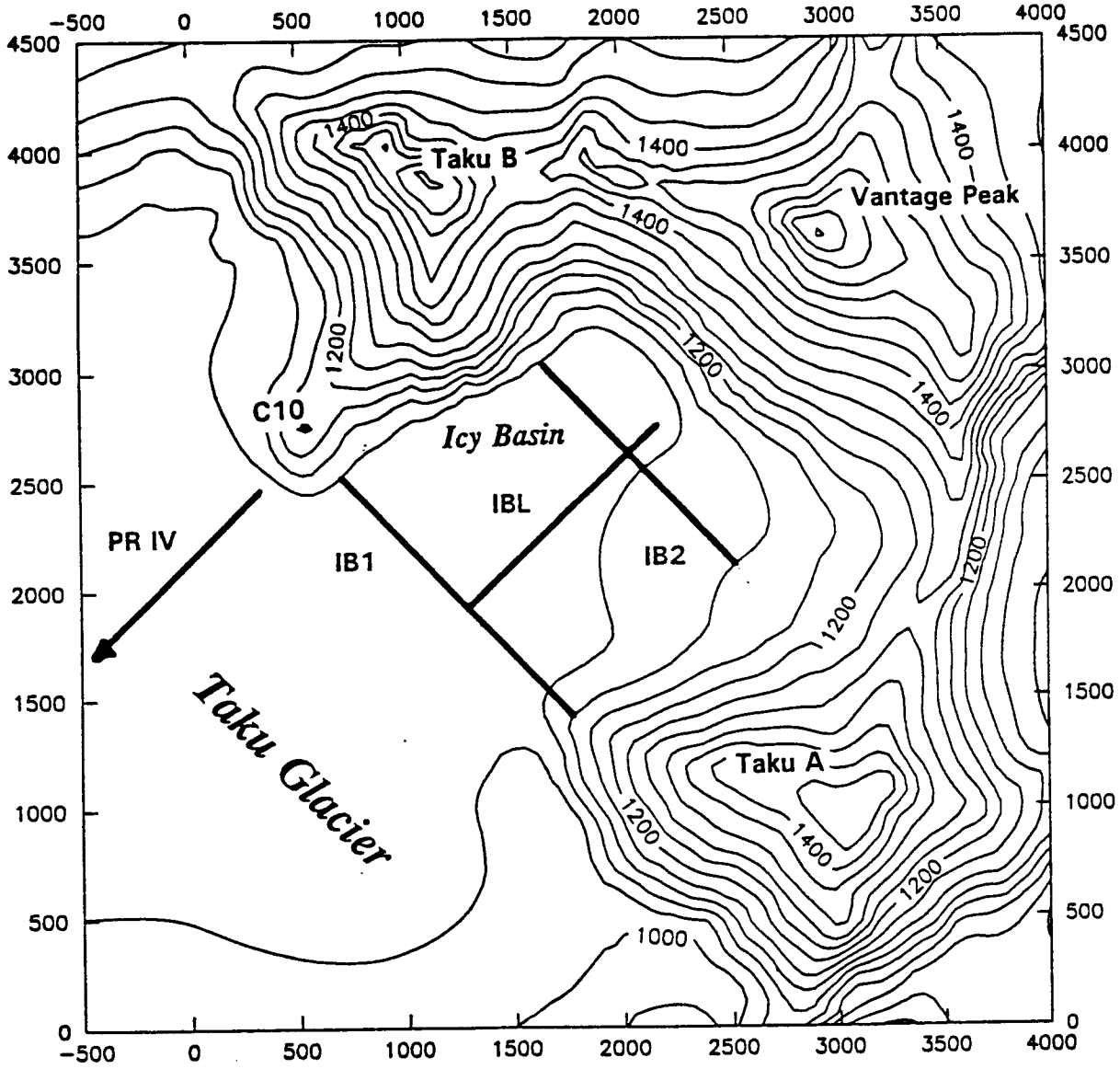

Figure 2. Location map showing the study area, including seismic profiles IB1, IB2, IBL, and profile IV. Also shown is the location of Camp 10 (C10), a research station of JIRP. The contour interval is 40 m. The coordinate system shown is also in meters. North is at the top of the map.

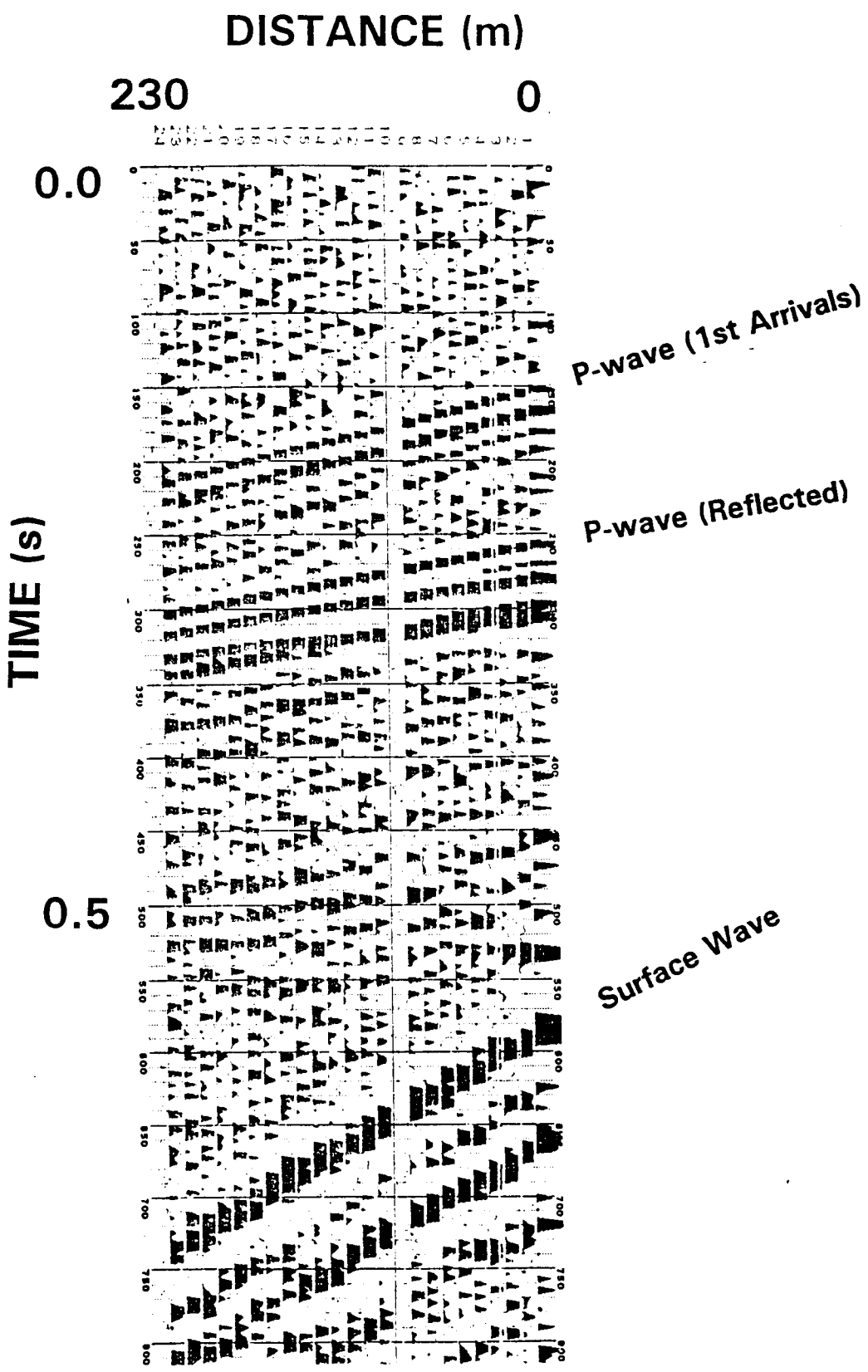

Figure 3. A typical seismic reflection record from Icy Basin.

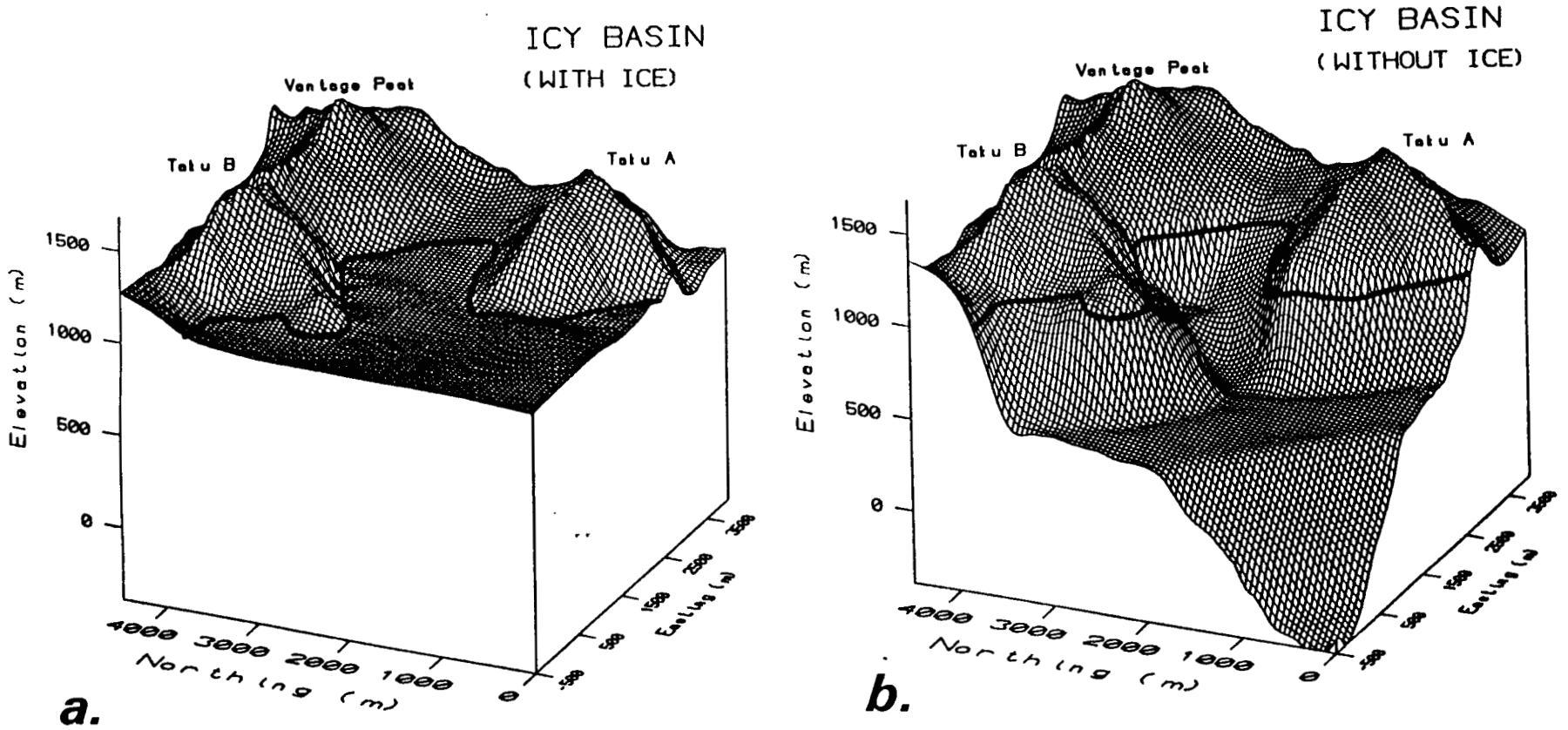

Figure 4. (a). Computer model of Icy Basin with glacier ice present. (b). Computer model of icy basin without glacial ice, as interpreted from the seismic data. The heavy line in both diagrams indicates the present margin of glacial ice.