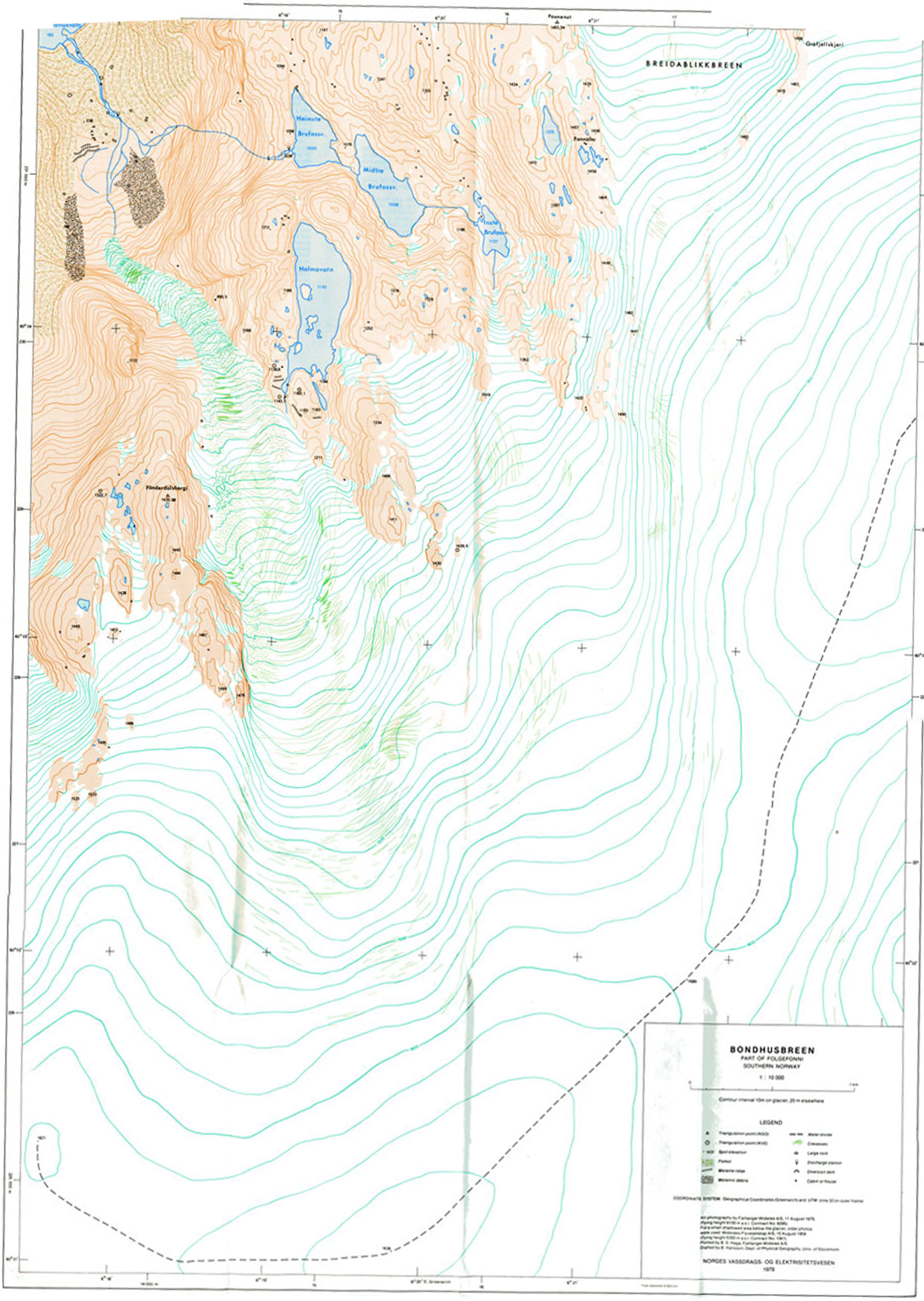

BREIDABLIKKBREEN
Heimste Brufossv.
Midtre Brufossv.
Inste Brufossv.
Holmavatn
Fonnanut
BONDHUSBREEN
PART OF FOLGEFONNI
SOUTHERN NORWAY
1 : 10 000
Contour interval 10m on glacier, 20 m elsewhere
LEGEND
Triangulation point (NGO)
Triangulation point (NVE)
Spot elevation
Forest
Moraine ridge
Morainic debris
Water divide
Crevasses
Large rock
Discharge station
Diversion dam
Cabin or house
COORDINATE SYSTEM: Geographical Coordinates (Greenwich) and UTM zone 32 (in outer frame)
NORGES VASSDRAGS- OG ELEKTRISITETSVESEN
1979

BRIEF COMMENTS ON THE MAP

The compilation of this glacier map, covering a part of the Folgefonni icecap in southwestern Norway, was based upon air photographs taken for this purpose on August 11, 1979, by Fjellanger Widerøe A/S. The photography was planned to cover the entire drainage basin of the river discharging into the Lake Bondhusvatn and this intention was completely fulfilled. However, it proved difficult to perform stereo compilation in a small area below the ice tongue due to insufficient illumination. This shadowed area was, however, clearly shown on a photo coverage from 1959, so a stereo-pair from this older photography was used for contour compilation in this particular area.

The plotting of the map was made solely for the purpose of making a glacier map. Consequently, certain features could be emphasized already at the compilation stage. All larger crevasses are directly depicted on the map as thin lines, whereas wide, deep openings are marked by a heavier line or a lense-formed area indicating the size and shape of these holes in the glacier surface. Note, however, that all the plotted crevasses may change their size and position from time to time. Extremely heavily crevassed areas on the tongue were given a particular pattern, as single crevasses could not be marked individually. All triangulation points, which are used for glaciological field work, were plotted as well as large and/or predominant rocks. The border line between ice-free areas and the glacier (or snow patches) was plotted with a minimum of generalization. A brown colour was used to indicate areas of »bare ground« at the time of photography.

The scale of 1 : 10 000, which was recommended for glacier maps at the International Symposium on Glacier Mapping held in Ottawa, Canada, in 1965, and the recommended contour interval 10 m, could be used. The Universal Transversal Mercator grid net, Zone 32, is marked in the outer frame, whereas Geographical coordinates are shown on the map as tick-marks.

A number of triangulation points were used in the construction of this glacier map. Some of them are established by the Norwegian Geographical Survey (NGO) and some are established and surveyed by NVE. These well-marked survey points on the ground were used for orientation of the stereo-models in the B-8 plotter. However, it was desirable to improve ground support for the models in the upper part of the glacier, i.e. in areas where no bedrock is visible, and, consequently, where no survey points are established. To overcome this problem it was decided to mark selected points on the glacier surface (some of the main ablation stake positions were used for this purpose). These marks were kept visible throughout the summer by a thin layer of powdered dye until the air photography was completed. The accurate position of them was repeatedly surveyed and it is assumed that their coordinates at the time of photography were accurate within a fraction of a metre. All these marks could be easily identified on the verticals, see examples shown below. They proved to be an important aid for the stereo-operator, but they were not plotted in the final map.

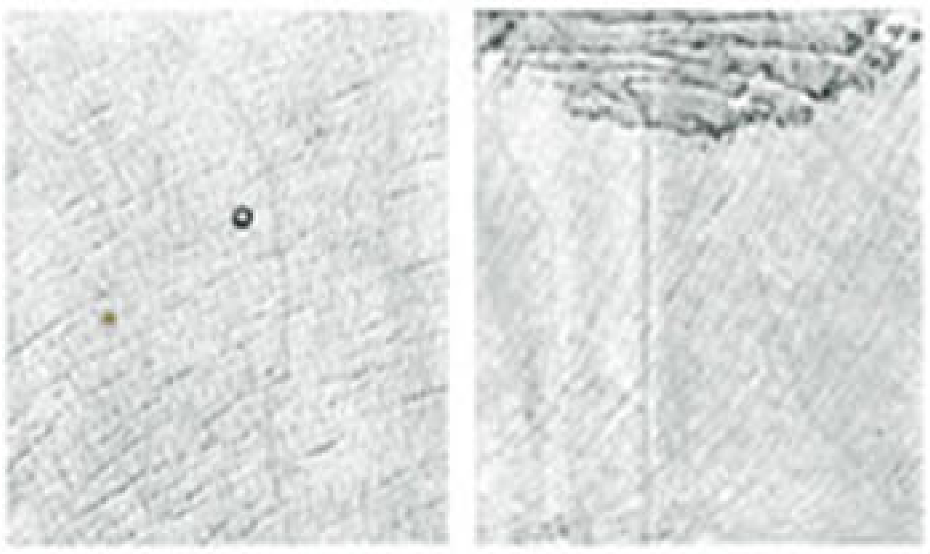
It is assumed that the plotting accuracy of this map is better than 3 m in both horizontal and vertical direction. For single points, e.g. rocks etc. the accuracy is better. The relative accuracy (between points within the map area) is better than 2 m.

A topographic map of Folgefonni and its immediate surroundings was produced by Norges Vassdrags- og Elektrisitetsvesen (NVE) in 1959. A part of this map was enlarged to the scale of 1 : 10 000 and it formed a base for glacier studies during the years 1963 to 1968. For the location of this map and previously published glacier maps in Norway, see the location map below.

The production of this map was organized through the Hydrology Division within the Norwegian Water Resources and Electricity Board (NVE). The Western Norway Hydroelectric Power Plants (NVE-Vestlandsverkene) and the Building Division of the State Power System contributed financially, whereas the final drafting was made at the Department of Physical Geography, University of Stockholm.

G. Østrem

Location map showing areas covered by detailed glacier maps produced and published by NVE. More complete maps of all existing glaciers are found in the glacier inventory publications: Østrem & Ziegler (1969) and Østrem, Haakensen & Melander (1973).



Left
One of the temporary survey points in the upper firn basin, as seen on an air photograph. The mark was made by dusting a 0.5 m wide ring, 6 m in diameter, on the snow surface.
Note the crevasses and the melt features on the snow surface. These slightly darker stripes are always running at a right angle to the contours.

Right
The special melt features on the snow surface are well detectable on most of the verticals. They always indicate the slope direction, and may be an aid in determining local »water divides« on the glacier surface. Note, however, that such features do not necessarily coincide with subglacial drainage patterns.

The small settlement Sundal (at Mauranger Fjord, an arm of the Hardanger Fjord) and the valley Bondhusdalen. The icecap Folgefonni and the outlet glacier Bondhusbreen in the background. A recently uncovered area (since 1940) can be clearly identified. (Photo Fjellanger Widerøe 42939).

GLACIER VARIATIONS DURING RECENT YEARS

It has been assumed that Norwegian glaciers in general had their greatest extent about 1750 and that no greater advance has occurred since then. However, for parts of the icecap Folgefonni this does not seem to be the case. In several places signs are found, indicating that the largest extent was reached in the last part of the 19th century. The southern part of the icecap has now a size and areal extent which seems to coincide with the maximum extent during historical time (Tvede & Liestøl, 1977). The following information is, in general, taken from Tvede (1972), whereas data from the front variations have been supplied by Norsk Polarinstitutt.

In the case of Bondhusbreen it has been assumed that a large amount of big rocks resting just outside the moraine ridges marked on the map must have been deposited by the glacier during the 1750 advance (Rekstad, 1905). However, Tvede (1972) proposes that these rocks are possible remnants from an old rock fall originating on the east side of the valley, possibly influenced by a postglacial, relatively large Bondhusbre.

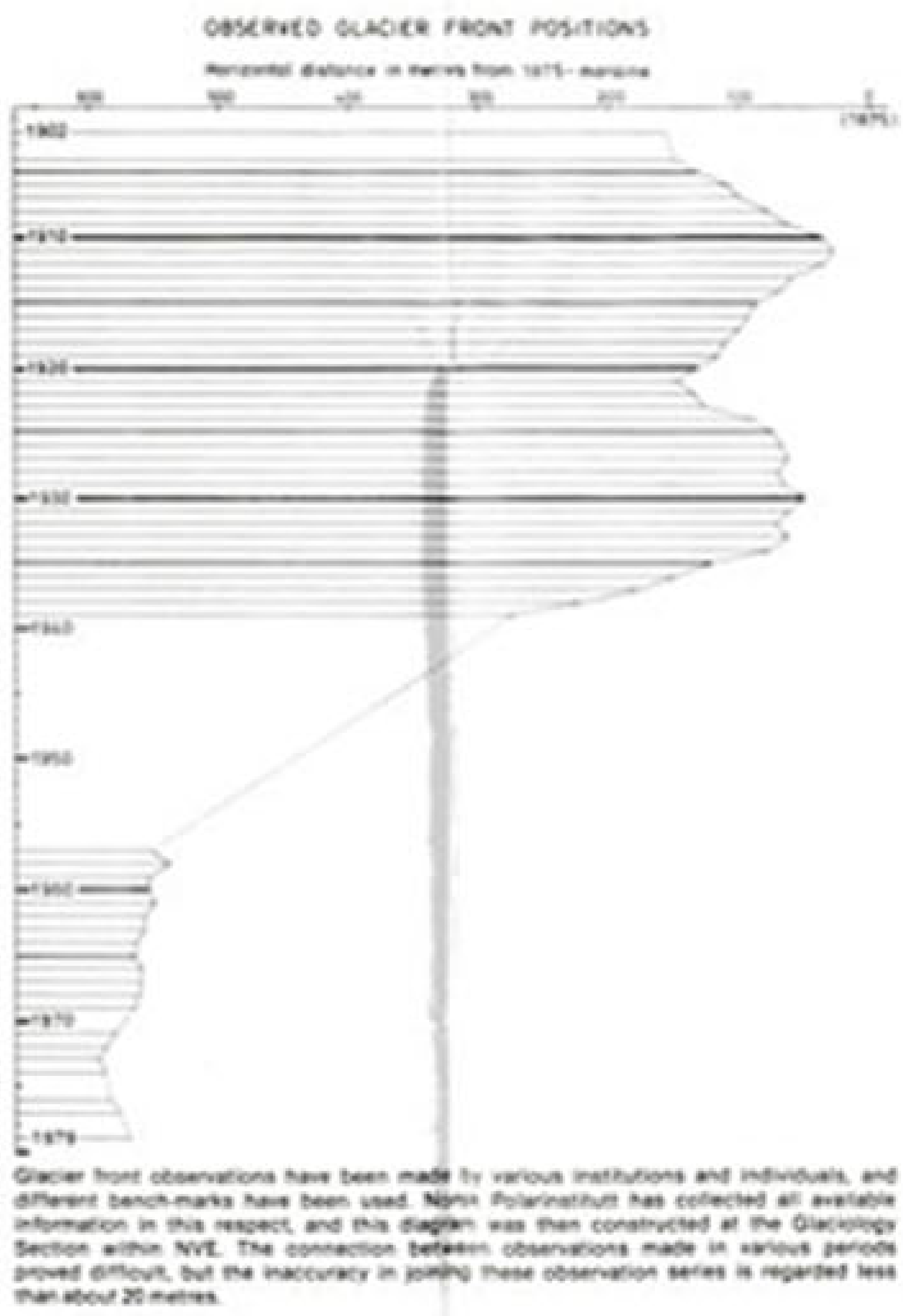
A local inhabitant in the area, Lars K. Bondhus, has told (Tvede, 1972) that his grand-grand-father could remember that threes were growing on the plain in front of the glacier until the ice pushed forward and covered the plain.

An early written description of the glacier was given by Sexe (1864) who visited the area about 1860. He does not describe details which can be used to locate the front position at that time, but he made a sketch which indicates that the ice front covered most of the plain mentioned above. Rekstad (1905) says that the outermost of the 3—4 arch-formed moraines was a result of a glacier advance between the years 1865 and 1875. Some other moraine ridges which are situated very close to the outermost one must have been formed in the 1880-ies and 1890-ies. (These ridges are not shown on the map due to scale limitations). He also says that a photograph taken by K. Knudsen (probably in 1891, see below) shows a greater glacier extent than on a photograph taken in 1869. On Knudsen's photograph it is quite clear that the ice front is situated just at the outermost ridge.

Rekstad made some measurements of the ice front and he says that it had retreated about 150 m from the 1875 moraine (the outermost one) in the year 1904. Since then, routine observations have been made of the front position and the data are plotted in the diagram shown below. From this diagram it is obvious that the glacier has advanced markedly during two main periods, with maxima in 1911 and 1930. These two advances may have formed the two innermost end moraine ridges.

A period of very rapid retreat occurred during the 1930-ies and the 1940-ies. Unfortunately no measurements were taken during the 1940-ies due to practical difficulties. Then the glacier retreated up a very steep hill so that any measurements would have been uncertain and even dangerous to perform.

The lower part of Bondhusbreen has been photographed from almost the same point by various photographers: K. Knutsen 1891, J. Rekstad 1904, and O. Liestøl 1971. Comments on the glacier variations are given in the text.



Glacier front observations have been made by various institutions and individuals, and different bench-marks have been used. Norsk Polarinstitutt has collected all available information in this respect, and this diagram was then constructed at the Glaciology Section within NVE. The connection between observations made in various periods proved difficult, but the inaccuracy in joining these observation series is regarded less than about 20 metres.

VARIOUS INFORMATION ON FOLGEFONNI

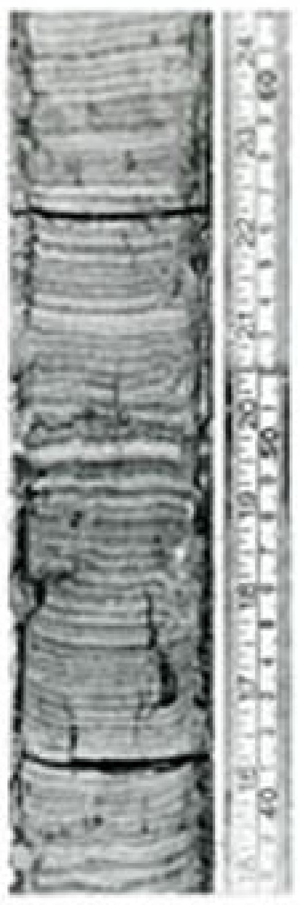
In historic time it has been reported that local people quite often walked across the icecap Folgefonni to visit people and the church on the other side. (Hoel & Werenskiold, 1962, p. 82—85).

From the beginning of the 19th century the first tourists started to cross the glacier. The number of tourists increased steadily and culminated about 1860—1890. To serve the present day requirements, the Bergen Tourist Association has built a small, self-service tourist cabin (Fonnabu) in the area.

Not only the tourist traffic gave the local people some income. Ice from Bondhusbreen was also sold abroad — the first ship loaded with glacier ice travelled to Scotland in 1822. To facilitate the transportation from the glacier down to the fjord, a small road was constructed between Lake Bondhusvatn and Sundal (Hoel & Werenskiold, 1962 p. 99—104).

Further, from Bondhusvatn a track was made to facilitate the tourist traffic up to the glacier — it was in fact possible to travel on horseback onto the glacier and further over to the other side. The construction of this track was financed from Germany, it is told that the German Emperor Wilhelm II was the main donator.

The economic importance of the glacier is even more pronounced today because the glacier provides water for a large hydro-electric power installation at Mauranger. Water from various parts of the icecap is diverted and collected in reservoirs through a system of tunnels and shafts. A gallery (an almost horizontal tunnel) has been constructed to collect water subglacially from the intake shafts in the bedrock under Bondhusbreen (just under the ice fall at 1100 m where the glacier is 150—170 m thick). This project has been very successful and is of great interest both for engineers and scientists. Before, under, and after the construction period it has been possible to perform many scientific studies under the glacier, as well as at the front and on the ice surface. The ice velocity just above the intake is in the order of 30 cm per day whereas the movement along the bottom is less than 15 cm/day. Various observations could be made in the ice caves which were melted at the ice/rock interface to find the best places for intake shafts. Studies were made also of the sediment carried by the glacier stream, see below. Several other glaciological and hydrological investigations will be carried out in the future — the production of this map is a part of this work. A review of investigations made so far is given in Wold & Østrem (1979 a, 1979 b). A bibliography of older litterature is given in Hoel & Norvik (1962).



In the planning stage of the hydro-electric power station at Mauranger, various technical and scientific investigations were made.

One problem was to determine the annual sediment transport in the glacier stream without taking numerous water samples from the stream during a series of years. Only two melt seasons were available for sampling, so these seasons' result must be compared with previous years' sediment discharges into the Lake Bondhusvatn. The annual sediment discharge is more or less related to the thickness of annual varves on the lake bottom.

Several undisturbed bottom samples were taken by a Kullenberg piston corer, a section of one of these samples is shown above — the sampling location for it is plotted (x) on the map. Annual deposits back to about 1895 were identified in most of the cores, and a good statistic was obtained for variations in sediment discharge into the lake. On an average some 6000—7000 metric tons of suspended sediment are carried annually by the glacier stream. Note that depths are shown in metres on the map above.

Sketch showing the main subglacial tunnel system: a, b and c are intake shafts, d is the sedimentation chamber, e the unloading tunnel, f the helicopter landing platform, g workshop, h the diverting tunnel leading water to the main reservoir.

Photograph taken in one of the artificial ice caves along the glacier bottom. The rocks are resting on bedrock. Note, however, a large embedded rock in the roof. The »walls« consist of clear glacier ice.

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