

INSTRUMENTS AND METHODS

ENGLACIAL INVESTIGATIONS RELATED TO CORE DRILLING ON THE UPPER TAKU GLACIER, ALASKA

As a part of the 1950 summer program of the Juneau Ice Field Research Project of the American Geographical Society a rotary Pioneer Straitline Drill Rig on loan from the E. J. Longyear Company of Minneapolis (see photographs p. 578) was employed to obtain samples of *névé* and undisturbed ice cores at a depth of nearly 300 ft. (91 m.), on the upper Taku Glacier, Alaska.* With this equipment three holes were drilled also for use in obtaining data on englacial movement and temperature during different seasons of the year. The more than seven tons of drilling equipment utilized was flown to the Juneau Ice Field and landed at 3640 ft. (1110 m.) elevation on the Taku Glacier, 16 miles (26 km.) above its tidewater terminus, by U.S. Air Force C-47 aircraft equipped with ski-wheels. With the help of Anders K. Anderson, an experienced diamond driller from the Longyear Company, experimentation in special aspects of the ice-drilling problem was carried out. These included comparison of methods used in drilling with or without sludging water; problems imposed by the use of steel casing, the technique of fishing lost casing and rods, the difference in drilling efficiency and rates when different drill bits were used, and the technique necessary for procurement of abundant supplies of water from crevasses and from the glacier surface. This is the first successful core drilling of a temperate glacier in the Western Hemisphere and the results and lessons learned, when fully reported upon, should serve as a valuable adjunct to the results of drilling in Polar ice being undertaken by the joint Norwegian-British-Swedish Expedition to Dronning Maud Land in the Antarctic during 1949-52.†

Petrofabric studies of ice cores were conducted by Dr. Henri Bader and Gerald Wasserburg in a cold laboratory dug into the *névé* near the site of the drilling. Their mineralogic and petrofabric analyses were concentrated on ice cores brought up from drilling to depths of 150-292 ft. (45-89 m.). The samples were thin sectioned and placed in a specially constructed universal stage immersed in ice water to keep the specimen from melting while being analysed under polarized light. Preliminary results in the field indicated a preferred orientation of crystals at low angle to the horizontal. The orientation of individual crystals was plotted on a stereographic net for further study. Also what appeared to be moderately uniform spacing between relatively equal-dimensioned air bubbles seemed to exist in samples of clear ice from the deepest cores. A study of the significance of these air bubbles was made by Bader and Wasserburg and will be reported in a paper in the *Journal of Geology* in 1951.‡

Englacial rates of flow were investigated by means of a 250 ft. (76.2 m.) length of 2 in. (50.8 mm.) I.D. aluminum pipe, in watertight coupled 10 ft. (3.05 m.) lengths, which was lowered into one of the drill holes. A determination of the initial alignment of this tubing was made with a single-shot bore hole survey instrument loaned by the Eastman Oil Well Company of Denver, Colorado. This instrument records simultaneously both the magnetic direction of the horizontal course of the drill hole and the deviation or inclination of the bore hole from the vertical. The meter encases a camera the trigger of which is pre-set by a clock mechanism so that photographs can be made of the position of a plumb bob with reference to a compass card within an angle-indicating unit. The total length of aluminum pipe, which it is anticipated will move according to different ice flow at

* Financial support for this phase of the program was also rendered by the Office of Naval Research and a grant from the Geological Society of America.

† Norwegian-British-Swedish Antarctic Expedition, 1949-52. *Nature*, Vol. 165, No. 4184, 1950, p. 8-9.

‡ See also *Journal of Glaciology*, Vol. 1, No. 8, 1950, p. 443-51.

depth, will be resurveyed during February and again in August 1951, for plotting a vertical velocity profile for the intervening periods of time. This information will then be compared with surface movement records obtained during these same periods by theodolite sights and will be useful in calculation of the volume transfer of ice to lower elevations by englacial as well as surficial glacier flow. The depth of the Taku glacier at the drilling site is approximately 900 ft. (274 m.) as determined by the expedition's geophysical crew during the summer of 1949.* The technique described above, in regard to method employed for obtaining englacial rates of flow, though new in some phases of its implementation, is actually a modification of the principle applied by Dr. Max Perutz in direct measurement of the velocity distribution in a vertical profile through the Jungfraufer, Swiss Alps, in 1948 and 1949.†

Temperature recording with spaced thermistors (consisting of alloyed semi-conductors which have a 4.4 per cent negative change in electrical resistance per degree Centigrade change in temperature; measurements can be made to 1/100° C. by means of a specially designed Wheatstone Bridge), were installed in the upper Taku Glacier for precision measurement of englacial temperatures along one of the vertical drill profiles. These cables were supplied by the U.S. Geological Survey and are similar to the type being used in connection with permafrost studies by the Geological Survey at Point Barrow, Alaska. One 200 ft. (61 m.) string of thermistors was sealed into a drill hole and will permit a party visiting the ice field in mid-winter to record the depth of penetration of the winter cold wave beneath the glacier surface and may serve as a check on theoretical calculations of the pressure melting temperature of temperate glacier ice at depths considerably below the level of penetration of negative winter temperatures. Attached to a light weight frame tower erected on the surface of the upper Taku Glacier is another 35 ft. (10.7 m.) cable of thermistors by means of which it will be possible during the 1951 winter operation to record the amount and extent of sub-freezing temperature penetration in the 1950-51 layer of winter snow.

A full report of the results of these investigations will be published next autumn. This will incorporate data from the 6-month increment of time between August 1950 and February 1951, obtained by the winter party to the Taku Glacier, and will include records obtained next August by members of the fourth summer season of the Juneau Ice Field Research Project.

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MAYNARD M. MILLER

CORRESPONDENCE

The Editor,
The Journal of Glaciology

SIR, *The Formation of Forbes's Bands*

Professor Haefeli's note on the ogives of the Arolla Glacier (*Journal of Glaciology*, Vol. 1, No. 9, 1951, p. 498) interested me particularly. Haefeli is correct when he says that the number of such bands is a measure of the number of years for flow of ice over the interval. I checked that on the Mer de Glace last summer; a specially large boulder, which I had noted in 1912, and in 1950, had travelled just 38 bands in 38 years.

Haefeli and Streiff-Becker's idea that these bands are pressure waves, whose wave length is controlled by seasonal variations in the flow of the glacier, is very interesting. But seasonal variations in flow can only apply to the surface shell of the glacier—the 10 m. shell which alone is penetrated by

* Poulter, Thomas C., Allen, C. F. and Miller, Stephen W. *Seismic Measurements on the Taku Glacier*. Stanford Research Institute, Stanford, California, 1949.

† Perutz, M. F. Direct Measurement of the Velocity Distribution in a Vertical Profile through a Glacier. *Journal of Glaciology*, Vol. 1, No. 7, 1950, p. 382-83.

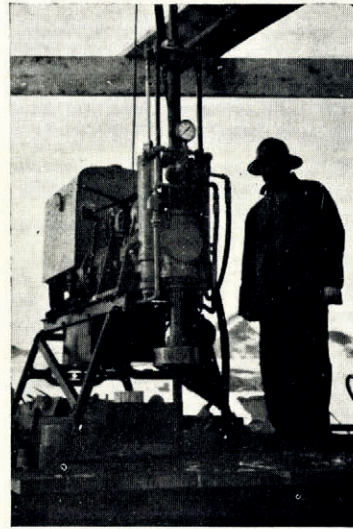
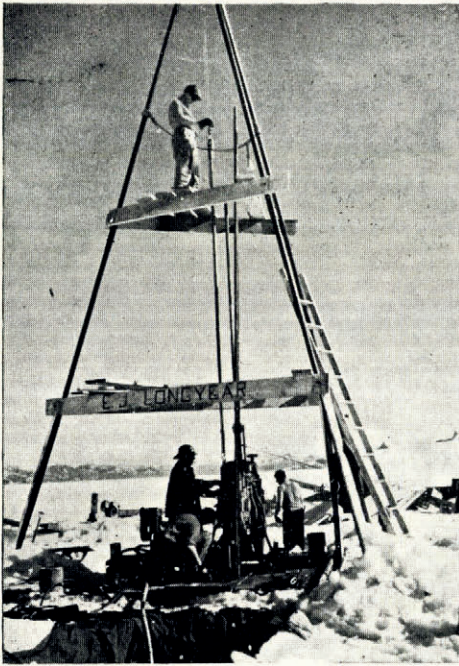


Fig. 1 (top left). Rotary pioneer drill rig and tripod erected at 3640 ft. (1110 m.) on upper Taku Glacier 1950

Fig. 2 (top right). 10 h.p. "Pioneer Straightline Diamond" core drill (E. J. Longyear Co.) used for ice cores

Fig. 3 (centre left). Research station constructed at Camp 10 on a nunatak near the centre of the Juneau Ice Field

Fig. 4 (centre right). Core samples of bubbly ice from Hole No. 1, 240 ft. (73 m.) deep. Taku Glacier, August 1950

Fig. 5 (bottom). Core drill rig. In foreground deep well pump over 70 ft. (21 m.) crevasse for water supply to drill