

# The Geothermal Gradient at Ivigtut, South Greenland

by

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## Abstract

*On basis of the accomplished measurements, the geothermal gradient at Ivigtut, South Greenland, might be given on the order of magnitude of 1° C for 60 to 75 meters.*

During the years 1948 and 1950, the late R. BØGVAD, M. Sc., geologist of the Cryolite Co., Copenhagen, conducted a series of temperature measurements in deep, vertical, diamond drill holes in the immediate neighbourhood of the cryolite deposit at Ivigtut. Since his sudden death in 1952, the results of these measurements have been recorded in the archives of the Cryolite Co.<sup>2)</sup>

Temperature measurements of this kind are exceptional for Greenland. That is why it was decided that the results should be published and contributed to the existing knowledge of the geothermal gradient in these regions.

The country rock in the neighbourhood of Ivigtut consist of banded biotite-hornblende gneisses. Steep mylonitic faulting is very common in the area. Many doleritic dykes intersect the country rock. The cryolite deposit itself is surrounded by a narrow zone of alkali granite.

Ivigtut lies outside the region of permafrost.

The measurements were carried out by means of a thermocouple aggregate.

The measurements were normally taken at intervals of 50 meters, both ways, up and down. After each measurement, the instrument was placed in melting ice, and a check was made as to the constancy of the measurements. According to the result of these control measurements, it could be deduced that the instrumental accuracy of measurement could be kept within 0.2° C. From differences in readings between the downward and upward measurements at the same depths, it could be ascertained that the precision was on the order of a magnitude of 0.5° C.

<sup>1)</sup> Compiled by J. BONDAM, by kind-permission of H. TUXEN, President of "Kryolitselskabet Øresund A/S".

<sup>2)</sup> The initiative to take the measurements was a result of a collaboration between the Cryolite Co. and the Geological Survey of Greenland (G.G.U.) who shared the costs of the necessary instruments.

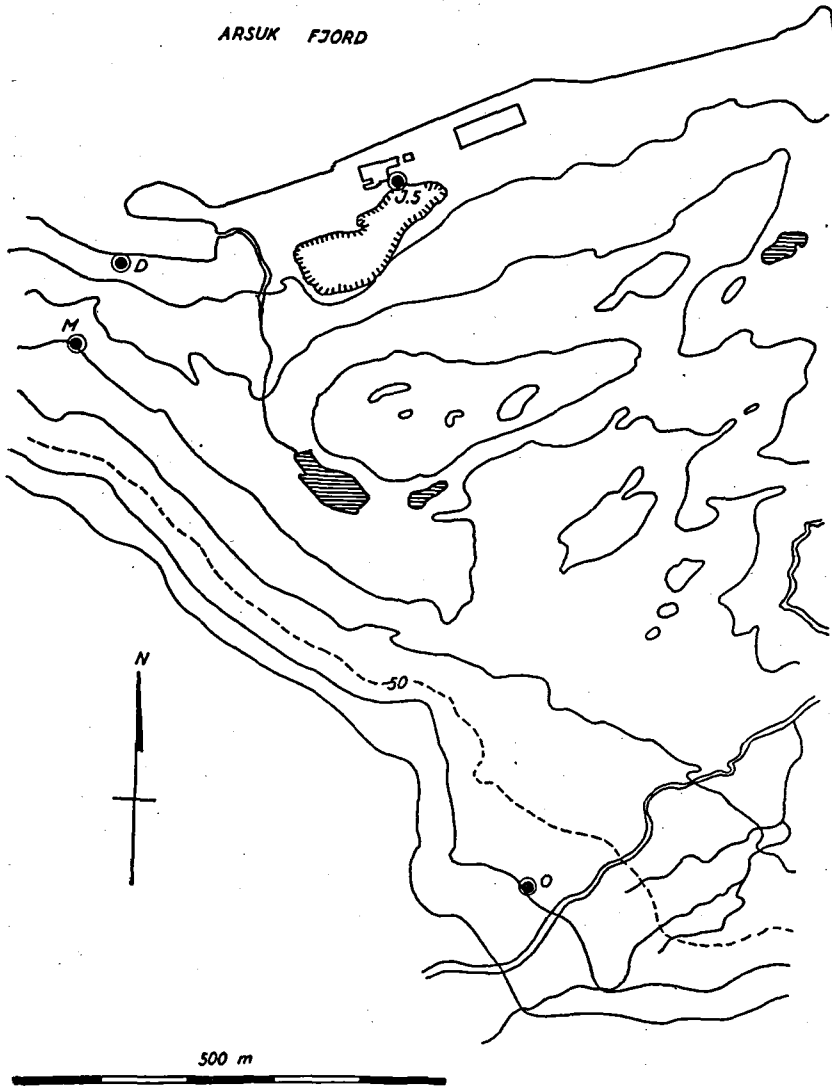


Fig. 1. The position of the diamond drill holes J-5, D, M and O.

An important factor in the precision of the measurements was shown to be the temperature of the contacts between the conducting wire and the ampere-meter, which, in its turn, was dependent on the air temperature. Another factor of inaccuracy is supposed to be the heat capacity of the instrument.

The position of the diamond drill holes, in which temperature measurements have been carried out, has been outlined in figure 1. Figure 2 shows

the actual position of the respective drill holes, projected on a vertical plane, which strikes north. The drill holes have subsequently been brought onto the same zero-level, in order that the actual variation of the temperature with depth could be compared.

All drill holes are vertical, thereby increasing the depth accuracy. Deviations of the vertical, though not measured, have comparatively small influence on the accuracy of the depth determinations by simple means.

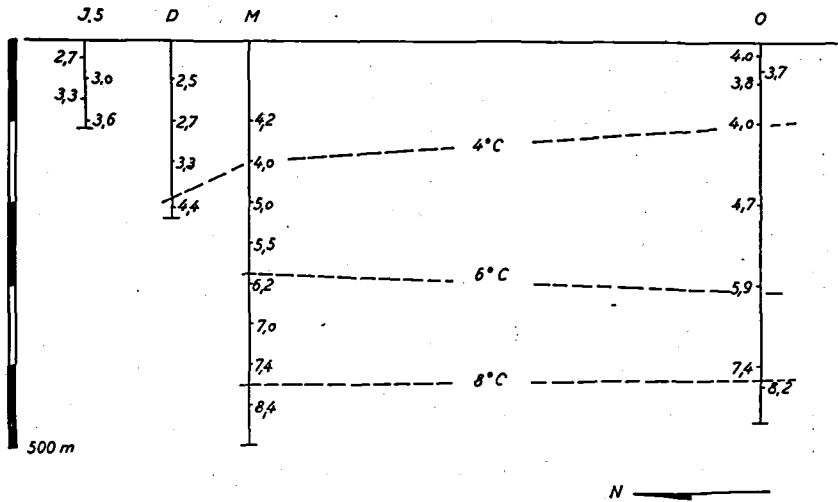


Fig. 2. Vertical projection of the diamond drill holes in a plane striking north. The drill holes have been brought onto the same zero-level.

Of the four drill holes, only two permit a determination of the geothermal gradient (diamond drill holes M and O). No actual control has therefore been possible. Curves with an interval of two centigrades have tentatively been drawn between the respective drill holes, as shown in figure 2.

The temperature-decreasing effect of the Arsuk fiord is very marked in the drill holes J-5 and D. As a matter of fact, this influence is extreme in diamond drill hole D, which is situated adjacent to the waterfront. In diamond drill hole J-5, which is placed some 50 meters from the waterfront, its influence is already diminished to about 0.5° C per 100 meters' depth. The 4° C line has been chosen as the first stability range, because of the greatest density of water at this temperature, which must be expected in the deeper parts of the fiords.

The interval between 4° C and 6° C varies between the diamond drill holes O and M from 220 meters to 140 meters, and between 6° C and 8° C between 120 meters and 145 meters. A rather constant temperature depression, from about 5° C until about 7° C, can be observed in diamond drill hole O, compared with the same temperature at the same intervals of depth in diamond drill hole M.

Two alternatives might explain this special feature. Firstly the cooling effect of the subarctic climate influence in these regions, with a mean temperature for January of  $-5.4^{\circ}\text{C}$  and for July of  $+9.8^{\circ}\text{C}$ , with regard to diamond drill hole O, which is placed far from the fiord. Secondly the tempering effect of the deeper parts of the fiord, with a temperature of  $4^{\circ}\text{C}$ , with regard to diamond drill hole M, which is placed in the neighbourhood of the waterfront.

The effect of these possible, outside influences seems to be repealed at the  $8^{\circ}\text{C}$ -level, which shows to be parallel with the zero level.

A rough estimation of the geothermal gradient seems to be justified on the basis of the accomplished measurements and might be given on the order of magnitude of  $1^{\circ}\text{C}$  for 60 to 75 meters.

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### DANSK RÉSUMÉ

I årene 1948 og 1950 foretog afdøde mag. scient. R. BØGVAD, chefgeolog ved Kryolitselskabet »Øresund« A/S, en række temperaturmålinger i fire dybe, lodrette diamantborehuller i den umiddelbare nærhed af kryolitbrudet ved Ivigtut.

Siden hans død i 1952 har resultaterne af disse målinger henligget i Kryolitselskabets arkiver.

Da målinger af denne art ikke tidligere er foretaget i Grønland, blev det besluttet at offentliggøre resultaterne, idet disse giver det omtrentlige geotermiske mål i området.

Ivigtut ligger i et gneissområde, som er gennemsat af myloniter og diabasgange. Permafrost forekommer ikke i området.

Målingerne udførtes med et termoelement. Instrumentets nøjagtighed bestemtes til at være  $0,2^{\circ}\text{C}$ . Målingernes reproducerbarhed ligger indenfor  $0,5^{\circ}\text{C}$ . Det normale måleinterval var 50 meter.

Beliggenheden af diamantborehullerne, hvori målingerne foretoges er angivet i fig. 1. Fig. 2 angiver et lodret NS-snit, hvorpå borehullerne er projekteret og bragt i samme nul-niveau, for at anskueliggøre temperaturvariationen med dybden.

Af de fire borehuller tillader kun de to (O og M) en bestemmelse af det geotermiske mål. Forsøgsvis er der igennem borehullerne angivet kurver med  $2^{\circ}\text{C}$  interval, begyndende med  $4^{\circ}\text{C}$ , som første stabile temperaturkurve. Denne temperatur er valgt fordi man må antage at vandet i Arsukfjorden har en afkølede virkning på de umiddelbare omgivelser, som vist i D og J-5. (Da vand har sin største vægtfylde ved  $4^{\circ}\text{C}$ , må vandet i Arsukfjordens dybere dele have netop denne temperatur).

Intervaller mellem  $4^{\circ}\text{C}$  og  $6^{\circ}\text{C}$  varierer mellem O og M fra 220 meter til 140 meter og mellem  $6^{\circ}\text{C}$  og  $8^{\circ}\text{C}$  fra 120 meter til 145 meter.

Temperaturdepressionen mellem  $5^{\circ}\text{C}$  og  $7^{\circ}\text{C}$  på samme niveau i borehul O i forhold til borehul M kan have sin forklaring i klimaets afkølede virkning m. h. t. borehul O, som ligger 900 meter ind i landet (gennemsnitstemperaturen for januar er  $-5,4^{\circ}\text{C}$  og for juli  $+9,8^{\circ}\text{C}$ ). En anden mulig forklaring for den relative depression i borehul O er fjordens regulerende virkning (konstant temperatur på  $4^{\circ}\text{C}$ ), m. h. t. borehul M.

På basis af målingerne kan en grov tilnærmelse af det geotermiske mål angives, med en størrelsesorden på  $1^{\circ}\text{C}$  pr. 60 til 75 meter.