PERMAFROST THICKNESS ALONG MERIDIONAL PROFILE FROM EAST SIBERIAN SEA TO SEA OF OKHOTSK

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ABSTRACT

A profile of about 600 miles in length goes approximately along a meridian of 164°E. The permafrost thickness (H) was determined by direct current sounding (subpermafrost water are supposed to be fresh). Apparently there are seen from the graph of H two tendencies: 1) the lower boundary of permafrost follows surface relief and 2) the permafrost thickness decreases to the south. For the northern and southern parts of the profile altitude marks of surface relief (h) and the permafrost lower boundary (h_m) are distributed in agreement with the normal law. The correlation coefficient is 0.96 and the regression equation is as follows:

$h_m = 0.97\ h - 140;$ $\quad 60\ m \leq h \leq 950\ m$

The correlation coefficient between H and latitude is 0.51; the regression equation is

$H = 15{,}4\varphi - 880;$ $\quad 62^0\ 30' < \varphi < 70^0$

The profile about 600 miles in length goes approximately along a meridian of 164^0 longitude on the north to 163^0 on its southern end through the territory which can be considered as a white spot. The most part of it belongs to the Verkhoyan-Chucotski folded area and is formed by different terrigenous and igneous, mostly effusive, rocks. Subpermafrost waters are supposed to be fresh and, consequently, the lower boundary of frozen rocks coincides with the temperature boundary.

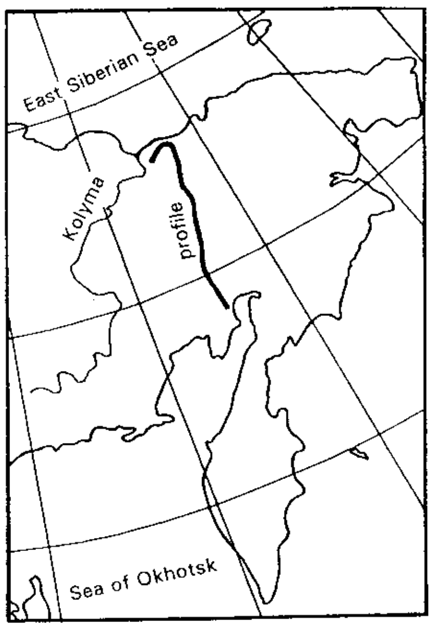

Fig.1. The situation of the profile on the map North-Eastern Asia.

The frozen rocks thickness was determined by vertical electric sounding (VES), the basis and the experience of using this method for such purpose and the results of the comparison of the obtained data with the geothermal data are given in (Kalinin, Yakupov, 1989). Observations along the profile were made approximately every 10 miles. But the conditions to determine the thickness of the frozen strata were not everywhere favorable, therefore, the sites with the needed data are situated not regularly (fig. 1). One to four VES were performed on each site on a distance of several hundred meters between them. That makes it possible to estimate the measurement error of the frozen rocks thickness determination. By numerous data the mean relative error is 10% and root-mean-square error is thrice less than the frozen strata thickness standard deviation (Kalinin, Yakupov, 1989).

It is clear (fig. 2) that the lower boundary of the frozen rocks follows the land surface. So it is expedient to examine the possible correlation between marks of the land surface (h) and of the lower boundary of frozen rocks (h_m) excluding the clearly distinguished middle part of the profile (sites 20-29). Taken together, the northern and southern parts of the profile h and h_m are distributed according the normal law: modules of the standardized skewness and kurtosis values of them simultaneously are less than three (1,1 and 1,18; 0,92 and 0,9). The correlation coefficient between h and h_m is 0,96 and essentially differs from 0; the regression is as follows:

$$h_m = 0{,}97\ h - 140 \qquad \text{for } 60\ m \leq h \leq 950\ m \qquad (1)$$

The regression line with confidential boundaries with a probability of 0,95 for mean and local values h_m is given on figure 3. The position of the lower boundary of frozen rocks according the equation (1) is shown on figure 2. From the equation (1) it follows that for the examined parts of the profile, the frozen rocks lower boundary smoothly repeats the surface relief. From the comparison of the position of the lower boundary of frozen strata and the experimental data it can be seen that the difference between them is growing to the south. That allows us to suppose the meridional change of the frozen rocks thickness which is not taken in account in the equation (1). Let us estimate it quantitavely basing on the data for the both northern and southern parts of the profile. The frozen strata thickness is distributed according the normal law: modules of the standardized skewness and kurtosis values for it are simultaneously less than three (1,36 and 0,3).

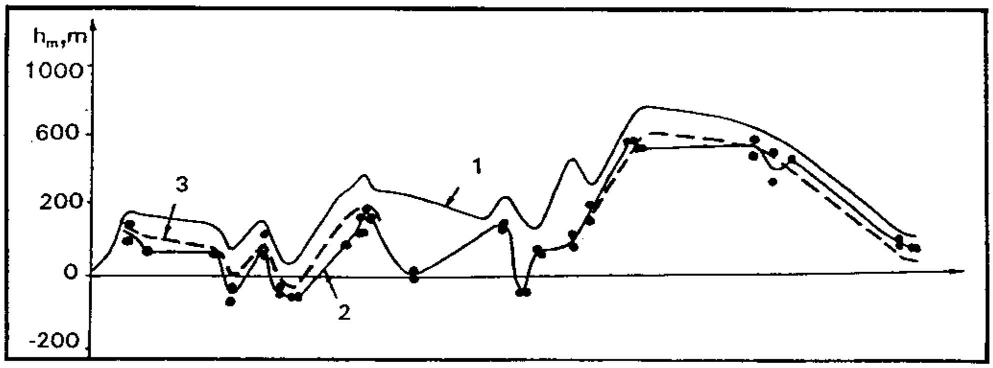

Fig.2. The frozen strata thickness along the profile:
1 - the relief of the land surface; 2 - the average position of the frozen rocks lower boundary according to the VES data (points are the separate determinations); 3 - the position of the frozen rocks lower boundary according to the equation (1).

The estimation of the mathematical expectation of the thickness is 154 m, its standard deviation - 12 m, the estimation of the local values standard deviation - 72 m. The correlation coefficient between the frozen rocks thickness H and the latitude φ is 0,51 and essentially differs from 0: its critical value for the 5% level of the significance and the given number of the freedom degrees - 37 - is 0,315 (Nalimov, 1960). The regression equation H on φ is:

$$H = 15{,}4\ \varphi - 880 \qquad \text{for } 62^0 30' \leq \varphi \leq 70^0 \qquad (2)$$

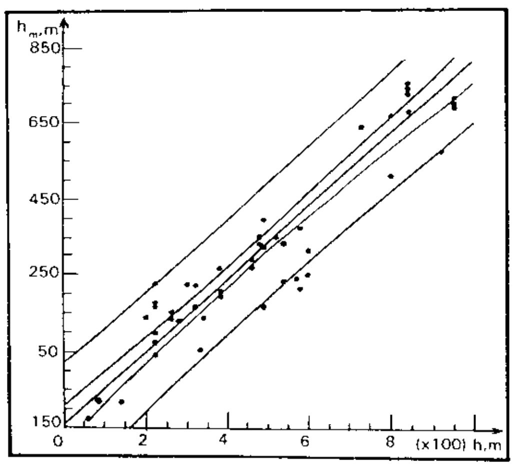

Fig.3. The line of the regression of h on h_m with the confident boundaries for average and separate values h with the probability 0.95.

So, going northwards for every degree of latitude the mean value of the frozen rocks thickness increases an average of 15 m. On 62^{0}N the mean value of the frozen strata thickness is 75 m, on 70^{0}N - 200 m.

Deviations from the lines of the regressions according to equations (1) and (2) display the stochasting nature of the relationships. They are caused by variations of the conditions of the heat changes on the land surface, which determine the mean annual temperature of rocks and are connected with the latitude and the height of the observation point above the sea level, and the measurement errors.

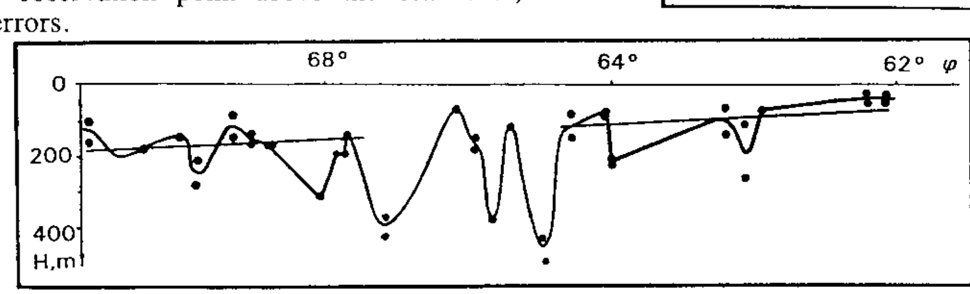

Fig.4. The frozen strata thickness along the profile:
1 - the average position of the frozen rocks lower boundary according to the VES data; 2 - the position of the frozen rocks lower boundary to the equation (2).

In the middle part of the profile, on Oloy depression in Anuy low mountain land, the frozen strata thickness is nearly twice as much - its mean value is 300 m. Accordingly, it fluctuates in more wide limits and also does not depend practically from the height of the land above the sea level in the observation point. According to these three features, this site is similar to the basin of the middle flow of the Omolon River (up and down the mouth of the Kedon River) and far to Jukagir plateau on the west and, perhaps, to the east (Kalinin, Yakupov, 1989; Yakupov, 1968). It may be supposed that according to the morphology of the frozen strata thickness, this is the one area, laying in the zone of low mountains lands, in which the mean value of the frozen rocks thickness decreases gradually from 400 m on the west (the Jukagir plateau) to 300 m on the middle part of the profile and to 230-240 m on the east (the Peculney ridge and the Belsky depression). Nowhere does it depend practically on the height of the land.

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