Climate variations last Late Pleistocene cryochron 40-10 Kyr B.P. in Northern Eurasia

Yurij K.Vasil'chuk[1] and Alla C. Vasil'chuk[2]

[1]Theoretical Problems Department. The Russian Academy of Sciences. Vesnina 12, 121002, Moscow. and [2]Institute of Cell Biophysics. The Russian Academy of Sciences 142292, Pushchino, Moscow Region.

Introduction

There are quite little data concerning paleoclimatic information for the vast areas of Northern Eurasia cryolithozone (*zone of permafrost* distribution). We have studied about 50 reference permafrost sequences of syngenetic Late Pleistocene sediments from Yamal and Gydan Peninsulas, North and Central Yakutia, Chukotka, Magadan and Transbaikal Regions. The combination of oxygen isotope analysis of syngenetic ice wedges with radiocarbon dating of organic matter of enclosing sediments (peat, wood, bones, allochthonous detritus), allowed to receive detailed temporal reconstructions of Late Pleistocene paleoclimate dynamics. The special interest of this study deals with the syngenetic permafrost sediments. In the northern Eurasia thick ice wedges, cutting through the entire stratum, are the dominant form of ice (its heights exceed 20-30 m).

Results and discussion

Our hypothesis consists of the new conception of formation mechanism for thick syngenetic ice wedges and has been worked out for Late Pleistocene and Holocene syngenetic (cyclesyngenetic) sediments. It is most possible to describe the ice wedge forming as periodic (and cyclic) or repeated injection of thin

elemental cuneiform veins having penetrated in just existed wedges. The active forming of ice wedges proceeded in subaerial conditions during the accumulation of peat or peat sedimentations. During the forming of ice wedges system the subaerial conditions some times were changed to subaqueous. At subaqueous regime (Fig.1) the accumulation of the most part of ice wedges stopped and for some of them decreased considerably. When subaerial regime returned the active accumulation of ice wedges renewed. If the thickness of previously sedimented subaerial strata is thin enough the tails of newly forming ice wedges penetrate into fossil ice wedges of previous phase with forming of large continuous (transit) ice wedges. If this subaqueous layer is great enough the multistage system of ice wedges is formed.

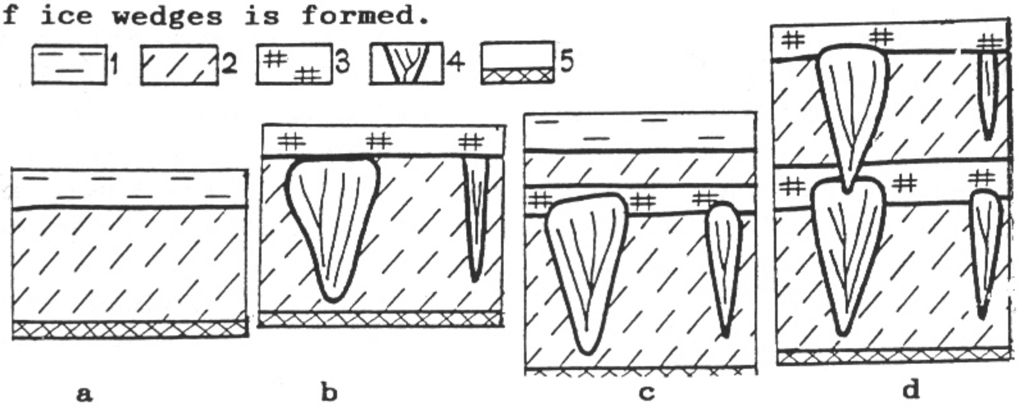

Fig.1 Schematic cycle of formation of thick syngenetic ice wedge. The intensive ice wedge development occurred in subaerial conditions ("b" and "d" stages), arrest of ice wedge development and intensive sedimentation in subaqueous regime ("a" and "c" stages): 1 - water, 2 - sandy loam, loam; 3 - peat, peaty sediment; 4-ice wedge, 5 - indigenous rocks. We consider the whole process of accumulation of ice wedges as macrocycling. Mineral layer thickness are 3-7 meters, as a rule subaerial organic interbanded thickness are 1-2 meters.

The $\delta^{18}O$ trend in Late Pleistocene ice wedges is more negative from West to East by 8-10 promilles, from -19 to -25 promilles, in Western Siberia ice wedges to -30 to -35 promilles, in Northern Yakutia. Than it reaches the value as high as -28 to -33 promilles, in North Chukotka and central areas of Magadan Region, and up to -23 to -29 promilles, in the East of Chukotka. These data suggest that the air mass transport was similar to the modern one at the end of the Late Pleistocene through whole Asia Subarctic. The $\delta^{18}O$ values in modern ice wedges in Northern Yakutia are oscillated from -28 to -24 promilles, in the North of Western Siberia from -20 to -16 promilles. Paleotemperature reconstructions are based on equation of regression which is received for modern ratio of winter temperatures and $\delta^{18}_{iw}O$ in recent ice veinlets (Vasil'chuk, 1992):

$$t^{o}_{mean\ winter} = \delta^{18}_{iw}O \quad (\pm 2\ ^{o}C)$$

The mean winter temperatures during the 40-10 Kyr B.P. were about 6-8 ^{o}C less, than the modern ones (from -22 ^{o}C in Western Siberia to -33 ^{o}C in Northern Yakutia), and the total winter temperatures were less than modern ones by 2000-3000 ^{o}C in Late Pleistocene cryochron. The mean summer temperatures which are reconstructed by palynological method were about 1-5 ^{o}C less than modern ones. The mean annual surface air temperatures were about 5-9 ^{o}C lower during Late Pleistocene cryochron (40-10 Kyr B.P.).

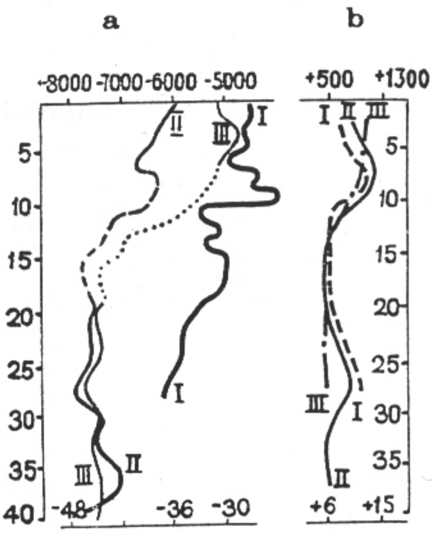

Fig.2. The paleotemperature records plotted for the 40-10 Kyr B.P.: a - b - total negative (a-winter seasons) and total positive (b - summer seasons) near soil air temperatures in some regions of Northern Eurasia cryolithozone: I - in north of Western Siberia, II - in North Yakutia, III-in North Chukotka; bottom horizontal scale shows values of mean January and mean July air temperatures(approximately)

We have studied the dependence between permafrost area and temperatures of air and permafrost ground for different periods:Late Pleistocene cryochron (pal.) and the present(mod.) at the main regions of Eurasia (Tab.)

Table

The dependence between width of permafrost area (l) and temperatures of the permafrost ground (t_{gr}) of different regions in 40-10 Kyr B.P. (pal.) and the present (mod.)

area of ice wedge distr.	$\delta^{18}O_{iw}$, ‰		l, km		t_{mw}, °C		t_{gr}, °C		l/t_{gr}, km/°C	
	mod.	pal.	mod.	pal.	mod.	pal.	mod.	pal.	mod.	pal.
E.Eur.	-15	-18	240	2000	-15	-21	-6	-9	60	220
W.Sib.	-18	-23	800	3000	-18	-25	-10	-15	80	200
N.Yak.	-26	-32	2500	5000	-26	-33	-13	-21	190	270
N.F.E.	-17	-26	1200	3200	-16	-27	-8	-16	170	200

Note: E.Eur.-Eastern Europe, W.Sib.-Western Siberia, N.Yak.- Northern Yakutia, N.F.E.-Northern Far East

The Late Pleistocene cryolithozone was similar to Yakutia type. Just as modern Yakutia cryolithozone it had vast extension from North to South and rather moderate gradient of mean annual ground temperature increase in the same direction. The dominantly continental climate of Western Europe and corresponded climate of permafrost conditions were determined in Late Pleistocene by Northern Atlantic iciness. By this means Yakutia type cryolithozone extended from Atlantic to Pacific and had the width which was varied from about 2000 in Western Europe to 5000 km in Siberia.

References

Vasil'chuk, Yu.K. (1992) Oxygen isotope composition of ground ice (application to paleogeocryological reconstructions). Moscow. Vol.1.- 420 p.p. Vol.2.- 264 p.p. (In Russian, with English the contents, all figure captions and appropriately summary).

Publications of the Academy of Finland 6/95

Pirkko Heikinheimo (Ed.)

INTERNATIONAL CONFERENCE ON PAST, PRESENT AND FUTURE CLIMATE

Proceedings of the SILMU conference held in Helsinki, Finland, 22–25 August 1995

Ministry of Education
The Academy of Finland

Painatuskeskus