STABLE ISOTOPE STUDY OF FORMATION OF SEGREGATED ICE AND PALAEOCLIMATIC IMPLICATIONS

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The mean isotopic composition of annual precipitation in polar regions is highly correlated with the mean annual air temperature near the ground surface and this robust correlation constitutes a solid basis for using stable isotopes as an indicator of ground moisture origin in the active layer.

The isotope composition of oxygen of recent ground ice from seasonally frozen unlithified sediments has a complex nature. In permafrost areas freshly deposited snow is subjected to great deflation and drifting by wind. Moreover, melting and freezing within the snow cover and the active layer of the ground can lead to isotopic fractionation. However, these considerable isotopic differences are evidently smoothed out by snow melt and runoff. Our isotopic investigations of recent ground ice revealed systematic variations with topographic position and sediment lithology, as well as organic content. In winter freeze-drying decreases moisture content of the active layer and creates favorable conditions for penetration of snowmelt into frozen sediments. In spring and early summer, as well as during the thaw period, additional ice can form in the frozen part of the active layer. This new ice has low isotopic values due to the movement of snowmelt into the frozen zone. The importance of winter precipitation in forming ground ice sharply increases due to migration of this water.

Despite the above mentioned processes altering the original isotopic (temperature) signal, we proposed to correlate the averaged oxygen isotope ratios (up to 55 single isotopic analyses) for recent ground ice (segregated ice and ice cement) with the mean temperatures of the cold (frosty) season, of January, and of the calendar winter in 17 polar regions, extending from the mouth of Lena River area to Chukotka. The correlation coefficients are 0.953, 0.883 (Fig. 1) and 0.875, respectively. These results allow us to calculate $\delta^{18}O/T$ slopes. We also recalculated slopes for primary ice veins using previously published data.

These slopes for both segregated ice and primary ice veins range from 0.83 to 0.86 ‰ per ^{o}C in the case of mean temperature of frosty season and about 0.5–0.6 ‰/^{o}C in the case of mean temperature of January and winter values. The obtained data are in good agreement with a simple Rayleigh model for precipitation allowing us to calculate Pleistocene palaeotemperatures (Table 1).

From our results, we also conclude that the dominant source of moisture for ground ice is snowmelt. This is not obvious, as discussed in recent cryological literature.

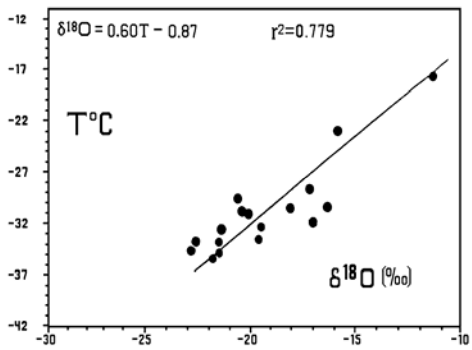

Fig. 1. Mean $\delta^{18}O$ of recent ground ice (ice cement and segregated ice) from Yakutia versus mean temperatures of January.

Table 1. Difference between present and reconstructed Pleistocene temperatures in January

Regions	Glaciation		Interglaciation
	cold stage	interstadial	
Recent Arctic coast and islands	-18÷20	?	+10
Interior Yakutia	-10÷14	-3÷4	+2

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