The Insolation Change and the Last Glacial Maximum in Western Siberia

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The climate change on Earth depends on the amount of solar heat that enters the Earth. The amount of this heat or the Earth insolation depends on parameters of the Earth orbital and rotational motion. In the new Astronomical theory of climate change, large oscillations of the Earth's rotation axis were obtained: from 16.7° to 31°, whereas in the previous theory the oscillations of the Earth's axis varied from 22.26° to 24.32°. Such fluctuations of the Earth's axis lead to large fluctuations of insolation. The summer insolation at latitude 65° in the Northern hemisphere Q_s^{65N} is accepted for the characteristic of the climate. Over the last 50 thousand years its four extremes have been observed: 4.16, 15.88, 31.28, 46.44 thousand years ago (ka), which correspond to the middle of the Holocene period, the Sartan glaciation, the Kargin warming and the Yermakov ice age, respectively. As it is known, Ermakov and Sartan glacial periods correspond to two European glaciations of Late Weichselian and Early/Middle Weichselian, respectively.

The most consistent view of scientists has been formed about the last glacial maximum, the Sartan glacial period in Western Siberia. Geological information about it is still contained in the upper layers of the Earth. Therefore, it is possible to reconstruct the last glacial maximum. In the reconstruction of the paleoclimate, a number of criteria have been proposed for changing insolation I at equivalent latitudes to characterize the onset and end of the glaciation. Insolation I for certain latitude in the past shows the contemporary latitude with the same amount of heat in the summer.

Most researchers agree that at the time of the maximum cooling, the Barents and Kara ice sheets were united, and their center of glaciation was in the Kara Sea. The insolation period associated with the Sartan cooling began 22.08 ka This age is confirmed by geologists, for example, according to S.A. Arkhipov radiometric age of the Sartan glacial horizon is in the range of 23 - 10 ka

After two thousand years of continuous cooling, in epoch of 20.8 ka, insolation at equivalent latitudes reached the value $I = 80^o$ at latitude $\varphi = 70°$, and the glaciation of the territory extends to this latitude. Ice covered New Ground, partly Peninsulas of Yamal, Gydansky and Taimyr. Glaciation contributes to the reduction of heat in summer and increase heat in the winter: the snow falling on the islands and the coast does not have time to melt over the summer, and warmer winters lead to later freezing on the seas, which increases snowfall in winter.

After 500 years at the time of 20.3 ka insolation in equivalent latitudes reached values $I = 80^o$ at latitude 67.5°, which indicates the promotion of the glacier on the land and blocking the flow of rivers such as the Ob, Poluy, Nadym, Pur, Taz and Yenisei. Lakes form in the mouths of rivers.

The minimum of summer insolation $Q_s^{65N} = 5.36$ GJ/m^2 is achieved at the time point of 15.88 ka. Insolation at equivalent latitudes reaches a value $I = 80^o$ at a latitude of 61.5°. This happened for a short time, so the latitude of 61.5° is the boundary, to which the glaciation could reach. During this period, the glacial relief of Western Siberia was formed, including marginal moraines in the 65.5º-67º on the southern foot of the Salekhard Hadtaken and the Khadateisky ridge of the Taz peninsula. Since the epoch of 15.88 ka and before the opening of the drain into the Arctic ocean, forming the great West-Siberian sea.

After a minimum of 15.88 ka, insolation at equivalent latitudes in the epoch 9.8 ka reached the value $I = 80^o$ at a latitude of 67.5º. From this moment, intensive melting of the glacier began. The drain of rivers into the Arctic Ocean opens, and the volume of the West Siberian Sea decreases. After a minimum of insolation, the glacier begins to recede from the mainland. It leaves after itself the Taman and Yamalo-Gydan moraine formations. The height of the Kara ice sheet exceeded 1 km, so the ice flow from it occurred both on the continent and the Arctic Ocean. The largest northern submarine trenches with U-shaped profiles: Medvezhinsky, Franz-Victoria, St. Anne and Voronin diverted ice streams from the Barents-Kara glacier to the Arctic Ocean.

The main events of the Sartan glacial period in Western Siberia: the beginning of glaciations, the overlap of river flow, the formation of the West Siberian Sea, moraines left by the glacier and underwater troughs are consistent with changes in insolation.