Published in: MATERIALY GLYATSIOLOGICHESKIKH ISSLEDOVANIY, 99, 32-34, 2005

Akademii Nauk ice cap, Severnaya Zemlya - example of a glacier grown in Late Holocene

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- Extended abstract -

Резюме

Северная Земля является самым восточным архипелагом в евразийской Арктике, на котором развиты покровные ледники существенных размеров. С 1999 по 2001 гг. ледниковый керн длиной в 724 м был пробурен на "Академии Наук" - самом северном леднике архипелага. Бурение проводилось в рамке совместного проекта между институтом полярных и морских исследований им. Альфреда Вегенера (АВИ), Германии, Арктическим и Антаркическим научно-исследовательским интститутом (ААНИИ) и Горным институтом в Санкт-Петербурге, России. Изученный покровный ледник характеризуется процессами инфильтрации.

В данной статье изложены предварительные результаты датирования, базирующиеся на данных изотопного состава и электрической проводимости. В качестве надежных временных меток были исползованы антропогенновые загрязнения (авария на атомной электростанции в Чернобыле в 1986 г., наземные испытания атомных бомб в начале шестьдесятых годов).

При помощи комбинации данных $\delta^{18}O$ и дейтериевого эксцесса и горизонтов с высокой электрической проводимости, полученных методом диэлектрического профилирования (DEP) нами удалось определить временную скалу для верхних 350 м, охватывающий период до 1100 AD. Для базиза ледника установлен возраст приблизительной 2500 лет.

Наши результаты указывают на то, что этот покровный ледник не находится в равновесном состоянии, а продолжал расти до настоящего времени. Установлен ностьельный тренд развития температур для последних 2500 лет. Приводится подробная интерпретация изменения климата.

Introduction

In the Eurasian Arctic, the archipelago of Severnaya Zemlya is the easternmost one which is covered by considerable ice caps. This gives the opportunity to get regional paleo-climate information from ice core records. In 1986/87 the first ice core was drilled on Akademii Nauk ice cap, the northernmost one on Severnaya Zemlya [4, 8]. This core was analyzed with relatively low data resolution. A chronology was published indicating a Late Pleistocene bottom age [2, 8, 9]. From 1999 to 2001 a new 724 m long ice core was drilled on Akademii Nauk to proof the maximum resolution possible to be obtained and to check the time-scale published so far for this glacier [5, 6]. This project was carried out in co-operation between the Alfred Wegener Institute (AWI), Germany, the Arctic and Antarctic Research Institute (AARI) St. Petersburg and the Mining Institute St. Petersburg, Russia. The knowledge of annual layer thickness is the basis for the chronology of the core. One of the main problems is that infiltration processes caused by melting and even rain during summer time will smooth or destroy seasonal signals. The variation of stable isotopes of water (δD and $\delta^{18}O$) is the most common tool to reconstruct the annual layer thickness in such areas [11] but sometimes oscillations in D-excess values better resolve the annual variation [13]. We used D-excess and $\delta^{18}O$ for determination of layer thickness.

Data and discussion

A recent mean accumulation rate of about 460 $kgm^{-2}a^{-1}$ was found at the drilling site close to the summit of Akademii Nauk using horizons with increased ^{137}Cs radioactivity as time markers. Two such peaks were found coursed by nuclear weapon tests in the beginning of 1960s and by the accident of Chernobyl nuclear power station in 1986 [6, 10]. Zagorodnov et al. reported the same value of 460 $kgm^{-2}a^{-1}$ as mean accumulation rate of two years of observation (1986/87) in the area of station “Mir” at summit on the Akademii Nauk ice cap [1]. The data of electrical conductivity, $\delta^{18}O$ and melting content are published in high resolution for the upper 136 m of the new drilled ice core. These data cover about 275 years following the preliminary dating basing on counting of annual variations of D-excess and $\delta^{18}O$ supported by peaks in the electrical conductivity signal, assumed to be produced by historical volcano eruptions [7]. The highest peak in electrical conductivity was found in a depth of 25.79-25.94 m connected with huge increased nss SO_4^{-2} content observed by ion chromatographic analyses of the dissolvable constituents. This indicates that this horizon was influenced by a volcano event most likely the eruption of Bezimyanny in 1956. The recent

mean accumulation rate could be confirmed by studies of core chemistry [14]. The annual layer thickness is decreasing with depth because of thinning under the pressure of the upper layering ice. An annual layer thickness of app. 11 cm could be observed close to the bottom using stable isotope variations. We have calculated a basal age of app. 2500 years for the Akademii Nauk ice cap interpolating the annual layer thickness between the upper part of the core studied in detail [7] and the range close to the bottom were data are available in high resolution. In this calculation we assume that annual layers were never eroded by melting. This age and the annual layer thickness we found can be explained only giving up an equilibration assumption for the Akademii Nauk ice cap at least for the past. That means we assume that the glacier was growing up to its today's altitude from an initial stage almost at sea level. This has to be considered for paleo-climate interpretation of $\delta^{18}O$ data. The oxygen isotope data of the Akademii Nauk ice core drilled in 1999/2001 are shown in Fig. 1 using our preliminary chronology. The $\delta^{18}O$ values had been corrected assuming a continuous growing of the ice cap and an altitude effect of 4‰/100m. The data show the trend of temperature of the last 2500 on Akademii Nauk ice cap. They are indicating a relatively warm period about 2300 years BP followed by a relatively long lasting colder time span with minima at about 300 AD and 1800. The little ice age couldn't be found as a characteristically drop down in temperature but a dramatically warming was observed since app. 1800. For the same period this warming was found in surface temperatures reconstructed from temperature depth profile of the drill on Akademii Nauk in 1986/87 [3]. Since 1875 the warming is documented in meteorological data for the whole Eurasian Arctic [12]. Similarities like this warming were found in $\delta^{18}O$ values from Hans Tausen ice cap (North Greenland) and Akademii Nauk (Fig.1) which could not be observed in the record from Central Greenland (GRIP). It makes clear that summit of the Greenland ice cap has special climate conditions which not necessarily reflect climate changes in the maritime Arctic at least in Late Holocene. Such changes seem to be the stronger the lower the altitude of the ice cap.

Acknowledgements

The drilling project was funded by the German Ministry of Education and Research (03PL027A/3).

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Fig.1. Comparison between $\delta^{18}O$ records from Academii Nauk ice cap, Hans Tausen ice cap (North Greenland) and GRIP (summit of Central Greenland). For Akademii Nauk the data are corrected assuming an altitude effect coursed by a growing of the ice cap.

Рис. 1. Сравнение между данными $\delta^{18}O$ для кернов от покровных ледников Академии Наук, Hans Tausen (Северная Гренандия) и GRIP (вершина Центральная Гренландия). Данные для Академии наук корректировались принимая высотный эффект под влиянием растущего ледника.