

# The extreme Anthropogen of the Arctic: the formation of the Great Glacier, the emergence a man and the Arctic Ocean in the Early Holocene

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**Abstract.** The relevance of the article stems from the need to consider recent events in the Arctic in recent time, which are largely contradictory. The aim of the study is to show extreme environmental changes in the Arctic of anthropogenic nature, including the emergence of man and the Arctic Ocean in the Early Holocene. The territory of the Arctic was a landmass with high mountains, in the period preceding the Holocene, on which a large glacier formed 30-18 thousand years ago (Late Pleistocene). The glacier slid irrepressibly southward over great distances, where it covered vast areas of Europe and North America. In the years that followed, a dramatic warming and active melting of the glacier began. By the beginning of the Holocene, the glacier had melted, and a narrow strait of the Atlantic appeared at the foot of Greenland. Coniferous-deciduous forests, numerous rivers and the first human settlements appeared on the flat territory of the Arctic, and various animals – mammoths, horses, bulls - spread out. However, a major catastrophic event occurred by the middle of the Holocene (6.0 thousand years ago), after active volcanism in the Arctic: the collapse of the central part of the Arctic to a depth of about 5 km and the formation of the Central Arctic graben, associated with the appearance of a huge amount of endogenous water. There began a rapid movement of water on the flat parts of the Arctic and the formation of the modern huge, shallow (50-100 m) shelf - the Arctic Ocean. Many human settlements were flooded, animals escaped, in part, on high uplands. For example, huge animal cemeteries were preserved on the Novosibirsk Islands. A new cooling of the climate occurred 4 thousand years ago, and an ice sheet formed on the surface of the ocean, which led to the name of the North Glacial Ocean in Russia. Modern man began to explore the coastal territories of the Arctic shelf since the mid - Holocene, but active industrial development of the Arctic began in the 21st century.

## 1 Introduction

The Anthropogen (Quaternary) is the newest and very short stage in the geological history of the Earth - 1.6 million years (and its end, the Holocene - only 11 thousand years), but it is saturated with major climatic and oceanic logical events in the Arctic and human life history, including dramatic ones [10, 11, 13, 19]. However, it has been little discussed in science.

The modern literature focuses on various aspects of the movement of individual blocks of the Arctic territory in the Mesozoic and Early Cenozoic [23]. At the same time many researchers have missed the newest stage of the World Ocean's advance on the continents [25]. It should be added to this that the entire Anthropogenic period with its major climatic and ocean logical events has also fallen out of consideration and human exploration of the Arctic in the modern time [33].

The issues of changes in the Arctic environment during the Anthropogenic, the emergence of man and the

formation of the Arctic Ocean in the Early Holocene, as well as the modern industrial development of the Arctic are briefly discussed in this report.

## 2 Materials and methods

The materials of the study were the latest data on the evolution of the Arctic in the Anthropogenic, which bring some clarity on this issue [3, 8, 10–12, 15–21, 23–26]. The main method of research is the generalization of established modern and previous facts.

## 3 Results

### 3.1 Extreme changes in the Arctic environment at the end of the Pleistocene - Early Holocene and the emergence of man

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A long Paleozoic-Mesozoic stage of marine sedimentation is distinguished in the geological history of the Central Arctic. However, in the early Cenozoic, the territory rises and by the Neocene (25 million years ago) becomes completely dry, with the high Gakkel and Lomonosov ridges to the north [22, 26], adjacent to the highland ridges of Greenland.

The Quaternary (Anthropogenic) period was characterized by abrupt climatic changes. First of all, there were several epochs of sharp cooling and formation of large glaciers – 0.5 million years ago, 0.3 million years ago, and 70-18 thousand years ago. The location of glaciers is assumed to be in Canada, Scandinavia and on the islands of the Arctic [13]. However, a special study of this issue has shown that the place of formation of the giant glacier was the high mountain ranges of the Arctic (on Greenland and on the Central basin's territory – Gakkel and Lomonosov ranges), from where it slid over great distances to Europe and North America [33].

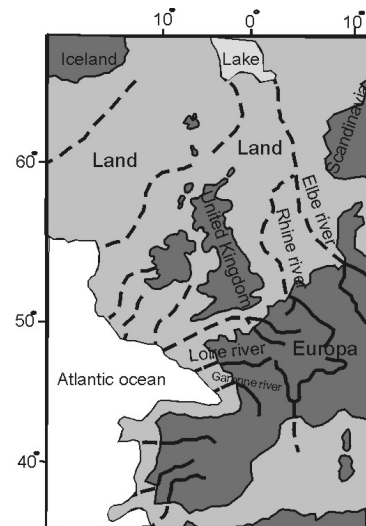
The final stage of the Pleistocene, the Valdai glaciations epoch (Worm – in Western Europe, Wisconsin - in North America), about 20-18 thousand years ago, was characterized by extremely harsh conditions when the global temperature dropped by 4-5°C [13].

However, later, during the period 13-11 thousand years ago, rapid climate warming began, active melting of glaciers and formation of river valleys that flowed from the north to the south [10]. In particular: "in the first half of the Holocene, between 9 to 7 thousand years AGO (by 14 C), the average July temperature exceeded the modern temperature by 6-7°C [14]. The coniferous-deciduous forests grew in a warm climate, large herds of mammoths, horses, bulls, and sheep appeared, and there were settlements of Mesolithic people on some islands (Svalbard, etc.) [11]. There were also large human settlements on the east coast of Greenland [28].

The extensions of many modern rivers are established on the land between Iceland and Scotland, and in the North Sea, east of Great Britain (Figure 1).

### 3.2 Tectonic collapse of the Central Arctic Arch

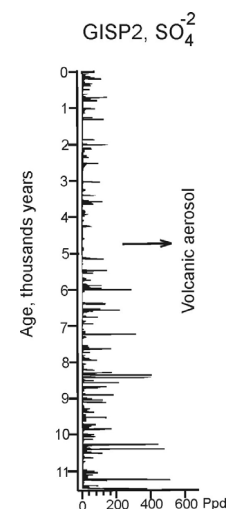
A sharp intensification of volcanism in the Arctic began in the first half of the Holocene, due to a decrease in the stability of the Earth's crust and upper mantle, after the repeated formation of giant upland glaciers in the Arctic. At this time, the largest volcanic eruptions took place over a period of 10-6 thousand years ago (Fig. 3). Large outbursts of magmatic material during volcanic eruptions led to disruption of isostatic equilibrium in the Earth's crust and collapse of large blocks of the Earth's crust to a depth of up to 5 km in the center of the Arctic, along vertical faults (Figure 4). Thus, deep grabens were formed – the Central Arctic, the Greenland, and the Norwegian graben [25, 26].



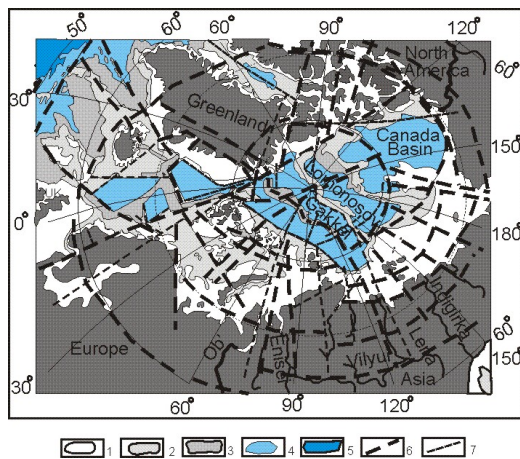
**Fig. 1.** Scheme of river network's position (dashed lines) on land between Western Europe and Iceland at the beginning of the Holocene [11].



**Fig. 2.** Scheme of rivers on the Barents Sea's territory in the Early Holocene [11].



**Fig. 3.** Large volcanic eruptions in the Arctic at the beginning of the Holocene; the last major eruption occurred 6 thousand years ago [2].



**Fig. 4.** Scheme of the Arctic's water basins, islands, underwater ranges and faults in the Late Holocene [3, 9, 25, 26].

Legend: 1 – Shallow shelf (50-100 m); 2 – Deep-sea shelf (200-600 m); 3 – Continental slopes of underwater ridges (1-2 km); 4 – Central Arctic deep-water (5 km) graben; 5 – Eastern edge of the Atlantic Ocean (in the north-western part of the figure); 6 – Major faults; 7 – Subordinate faults.

### 3.3 Catastrophic flooding of the Arctic plains and continental margins – the "Great Flood"

The formation of large grabens at the bottom of the World Ocean in the Mesozoic-Cenozoic is associated, as a rule, with the simultaneous arrival of endogenous waters and the beginning of sedimentation in them [6, 10]. The deep collapse of the southern part of the Arctic Arch, along rectilinear subvertical faults is the most large-scale geological event of the Holocene. The emerging Central Arctic, Greenland and Norwegian deep grabens, quickly filled with endogenous water, divided the formerly single megacontinent into two separate geographical continents – the American and the Eurasian-African (Fig. 4).

As a result of the rise of enormous amounts of water, rapid flooding of the vast plains of the Arctic and continental margins began. The water level in the World Ocean rose by 50-120 m [13, 25, and 30]. According to different data [7, 24 and 28], this event occurred in the period 6.5-5.5 thousand years ago, and has been preserved in the memory of the peoples of many countries as the "Great Flood".

Many millions of people died then [21]. For example, a layer of rocks 6-5 thousand years old with numerous remains of human skeletons was discovered on the east coast of Greenland [28].

In particular, the Old Testament of the Christian religion says: "and the Earth opened its mouth and swallowed them, and all the people of Karee, and all their possessions" [19]. For example, a layer of rocks 6-5 thousand years old with numerous human skeletal remains was discovered on the east coast of Greenland [28].

The great French paleontologist J. Cuvier considered the "Great Flood" as the last major catastrophe of the

Earth, which occurred no earlier than 6 thousand years ago and caused the death of people in many countries [11].

The rapid rise of water in the Arctic caused animals to flee in masses to higher elevated areas, where they subsequently perished, when the higher elevations were surrounded by water on all sides and turned into islands. An example is the Novosibirsk Islands near the southern edge of the modern Central Arctic graben, where a giant cemetery of bone remains of mammoths, horses, bulls, and sheep was discovered [11].

Modern man began to inhabit the coastal parts of the emerging Arctic Ocean from the mid-Holocene.

## 4 Industrial development of the Arctic in the modern time

The active industrial development of the Arctic by man began in the 21st century. This is due to two main reasons. Firstly, the Arctic has become the most important sea route for cargo deliveries to the northern regions of the country, to Chukotka and Kamchatka. Secondly, many deposits of important minerals have been identified in the Arctic and coastal areas. In particular, projected hydrocarbon resources are estimated at 250 billion tons of oil equivalent, including ~43 billion tons of oil and condensate and 206 trillion m<sup>3</sup> of natural gas in the western regions of the Arctic, in the Pechora-Barents Sea and others [5]. Oil and gas production is now the backbone of the country's economy. Deposits of gold, silver and other metals are being developed in the coastal areas [1, 20]. But some problems have appeared in the development of the Arctic.

Many coastal islands are sandy, which makes it very difficult to build production facilities on them. Therefore, a progressive method of preliminary creation of modular piles is proposed, which greatly facilitates the development of such areas [17]. During the development of ore deposits, rivers and lakes are polluted with toxic elements, such as manganese, which is dangerous for the population [20]. A special approach based on innovation is needed for the sustainable development of the Arctic [4]. To increase production efficiency, it is recommended to actively introduce digital technologies which are still underused [29]. The most important issues are environmental protection, ethics, and safety of work. Therefore, increased requirements for higher qualifications of engineers and management of mining companies are needed [18].

## 5 Discussions

The location of the great glacier, on the high ridges of the Arctic, was not known before the new work [33]. There is a lot of research on the warm climate of the Early Holocene and the emergence of humans and many animals [7, 10, 11, 13, 28]. However, there is very little information about the location of human settlements at this time, since during the catastrophic flooding of the

territory 6.0 thousand years ago, they were mostly destroyed.

There is still little research on the grandiose collapse of the Central Arctic and the appearance of a huge Central Arctic deep-sea graben, about 6 thousand years ago [15, 16, 27]. This problem demands further comprehensive research by many scientists.

Human settlements are best preserved in the south of Europe, where many coastal cities and settlements of the Mediterranean and Black Seas are now at a depth of 10-20 m or more [10].

Whereas many settlements of Early Holocene in the Arctic are now at a depth of 5 km, in the central part of it, and at a depth of 50-100 m in a shallow shelf. The task of researching them is a matter of the future. The Arctic has become the most important industrial region of the country in modern times, as a source of oil, gas and solid minerals. But some problems have appeared during the development of the region, for the elimination of which various measures are proposed.

## 6 Conclusions

A very short Pleistocene-Holocene geological history of the Earth turned out to be exceptionally rich in geological, anthropological and ocean logical events.

Firstly, giant glaciers formed three times on the high-altitude arch of the Arctic in the second half of the Pleistocene, which uncontrollably slid southward, over huge distances - up to 3 thousand km, to the territory of almost all of Europe and North America [13, 33].

Secondary, a very warm climate came in the Early Holocene after the melting of the last glacier, and human settlements appeared on the plains of the Arctic, near rivers, and numerous herds of various animals.

Thirdly, the level of the World Ocean rose sharply (by 50-120 m), after the collapse of the southern part of the Arctic arch, at the end of the Early Holocene (6.0 thousand years ago) and the rapid rise of a large volume of endogenous water. As a result, oceanic waters flooded many marginal, flat parts of the Arctic and continents, creating a widespread shallow shelf with a depth of 30-50 to 200 m or more [8, 10, 15, 25].

And, finally, the Arctic Ocean, which appeared around the middle of the Holocene, divided the single megacontinent of the Earth into two large parts of the geographical lands – the American and Eurasian-African continents [26].

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