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Grandiose volcanoes in the Arctic and their evolution from Hadean to Holocene

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ABSTRACT

Hadean initial stage of the formation of planet Earth was characterized the most basaltic volcanism in the geological history of the planet, which formed a thick (15-20 km) metabasalt layer of the modern continents. The height of individual volcanoes reaching heights of 40-60 km – the greatest height among volcanoes on terrestrial planets that is especially true for the earth's crust in the Arctic. Over the long-term geological history of the Earth many high volcano mountains have been greatly eroded - up to a height of 2-3 km. In the Pleistocene these mountain roots were covered with a thick cover of glaciers, while in the Holocene they collapsed on vertical faults and turned into deep-water grabens filled with the water of the young Arctic Ocean.

Keywords: Hadean, high mountains, long evolution, roots mountains

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1. INTRODUCTION

According to modern geological and geophysical data, the lower layer of the continental crust is characterized by metabasalts (granulite-basit) composition and a large capacity component under the ancient platforms of 15-20 km, and This layer formed in the initial, Hadean stage of development of the earth's crust (4.4-4.0 billion years ago) – in the longest stage of volcanism and powerful energy nuclear emissions of hydrogen, methane and other gases. So Hadean volcanism distinguished by grand volcanic emissions on the planet's surface and the large height of the emerged volcanoes (Muratov, 1975; Belousov, 1989; Orlenok, 2010; Zhirnov, 2014d).

On the planet Mars, for example, the height of ancient volcanoes reaches 27 km, while at the Ural mountain range (between Europe and Asia) reached even greater heights. Because they were not covered subsequent the granite-gneiss layer, for a long time were a highly elevated horsts who supplied the eroded material from their surface into the surrounding water basins of Archean, Proterozoic and Paleozoic age.

Tectonic evolution of the Arctic territory was considered in many works recently, but mainly for the Mesozoic and Cenozoic stages and on the basis on plate-tectonic assumptions (Rowley and Lottes, 1988; Bogdanov, 2004; Melankholina, 2008; Kulakov et al., 2013). But often these assumptions are not confirming of real data (Pushcharovsky, 1960; 1976; Serpuhov et al, 1975; Poselov et al, 1998; Orlenok, 1983; 2010; Kazmin et al., 2015). The problem is considered on the basis of real facts in works (Eardley, 1954; Pushcharovsky, 1960; Pogrebitsky, 1976; Zhirnov, 2014c). Hadean volcanoes and their evolution had not yet been considered in science.

2. MATERIALS AND METHODS

Materials for the study are the fundamental geological and geophysical data of the XX – XXI centuries about the structure and evolution of the continental crust, as well as data on the volcanism of Mars. The main research method is the synthesis of all empirical data.

3. RESULTS

3.1. The geological structure of the earth crust in the Arctic Ocean's bottom in modern times

In recent decades, in the territory of the Arctic Ocean it was made a huge amount of geological an d geophysical studies, due to which there concrete evidence of the geological structure of its submarine bottom were established. Consolidated geological cross-section of the central deep part of it is shown in Figure 1.

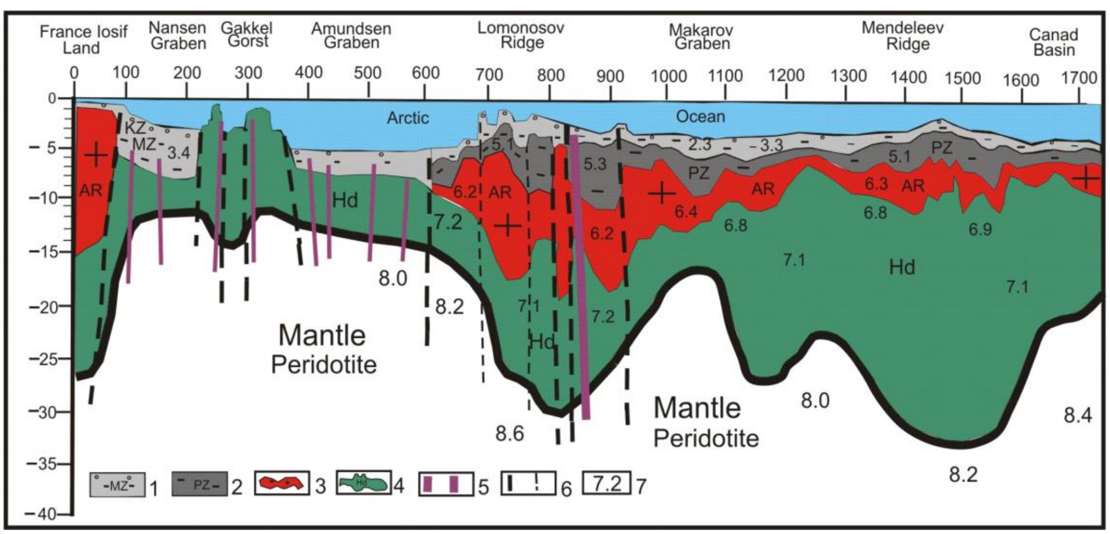

Figure 1

Geological and geophysical section of the earth crust of the central Arctic's bottom

(Poselov et al., 2000; Kabankov et al., 2004; Piskarev, 2004; Poselov et al., 2008).

1 - Mesozoic loose sedimentary rocks, covered with a thin layer of friable Quaternary rocks; 2 - compacted sedimentary rocks of Paleozoic age; 3 - granite-gneiss layer of Archean age; 4 - metabasalt (granulite-basic) layer of Hadean age; 5 - serpentinous peridotite dike; 6 - large vertical faults and reverse faults; 7 - the values of the velocity of longitudinal seismic waves in rocks of different composition.

The earth's crust under waters of the Arctic Ocean has a triple-layer geological structure characteristic of the Earth's continents. Ancient bedrock crust is represented by two conventional layers - lower metabasalt (granulite-basic) of different capacity (5-25 km) and average granite-gneiss layer ("granite" layer), but an unusually small thickness at the level of 3-10 km. Ancient foundation is covered by two sedimentary layers that make up the

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complex folding and covered sedimentary rocks. The lower layer is thick Proterozoic - Paleozoic rocks (seats folded and metamorphosed) and the upper layer is composed of sedimentary rocks of Mesozoic and Cenozoic age. At the top of the upper layer is set at a low power layer sands and clays youngest quaternary age, in which the longitudinal velocity of seismic waves is 1.8 - 2.4 km / sec. (Poselov et al., 2000).

However, in the structure of the crust is set very specific feature - the presence of a strong (20-25 km) of the lower metabasalt layer - ancient crystalline basement. Whereas, in deep basins (Nansen, Amundsen et al.), the power of this layer is typically a sharp decrease in the order of 5-7 km, and discovers some mountain ridges up to 3 km (Figure 1). Ancient pits covered with a surface by layer of Mesozoic sedimentary rocks, while the rock ledge - Ridge Gakkel, sedimentary rocks blocked only in some places. Therefore, we can conclude that in the Paleozoic these depressions were mountainous land, which comes with the eroded material in the cavity surrounding the Central water basin. While the Gakkel Ridge and in the Paleozoic and Mesozoic was a rock ledge - land. Accordingly, the height of the mountain geological structures while was significantly greater than at present, at least 3-5 km.

To restore the features of the geological development of the Arctic territory in the past geological epochs, and especially in Hadean, we need to turn to the known information on the subject.

3.2. The geological evolution of the continental crust in Hadean

To date, it is proved that the lowest meta basalt (granulite-basic) layer in the bottom of the continents was formed in the early stage of the geological evolution of the Earth – in Hadean, between 4.4-4.0 billion years ago (Muratov, 1975; Rezanov, 2006; Zhirnov, 2014a). Hot peridotite magma in the original pits in the body of the planet (Zhirnov, 2014b; 2014c; 2015a), has been worked up by powerful streams of gases (H, N, CO, O, CH_4), rising from the Earth's core (Letnikov, 2008; Marakushev, 2004), which caused the formation of the primary continuous cover basalts. After quick cooling of basaltic magma and the formation of the primary hard crust on the surface, lifting the rising gas decreased. Began a long stage and the central fissure eruptions of basaltic magma "Hawaiian" type, creates a powerful shield covers - basalts (Nemkov et al., 1986). By the end of Hadean when formed very thick basaltic crust (5-10 km), a grand process of explosive volcanic eruptions and the formation of the central type (along with a cover) highest (50-60 km) long active volcanoes was began. As a result, a very thick cover of basalt (15-35 km), the composition of the lower basalt layer modern continents was formed. It was dotted with numerous high volcanoes.

This initial "moon" phase of the formation of the Earth's crust continued until the first Archean basins. From this time on the planet began a vigorous and lengthy process of denudation Hadean high mountains and removal of eroded material in the water basins. The signs of primary earth crust were largely erased (leveled) by these processes and flattened terrain was covered by subsequent sedimentary and igneous formations (Nemkov et al., 1986). Initial Hadean basalts were Archean granulite facies: under the influence of heat rising gas and fluids (700 -1000 ° C) and high pressure of (6-10 kb). Therefore, they were turned into pyroxene-plagioclase gneisses, schists and amphibolites (Muratov, 1975; Resanov, 2006). Powerful metabasalt broke as massive peridotite and gabbro intrusions.

The dynamics and duration of the volcanic processes were different. In places most of these processes are having the nucleus of ancient shields, where the power generated metabasalt layer reaches 20-30 km. The distance from the ancient core layer its thickness was less. In some linear zones and rounded areas with a long and powerful volcanism formed especially thick crust of metabasalt, reaching 40-50 km. An example can serve as a major tectonic zone of meridian Ural mountain range, a 2 thousand. km that separates the European and Asian ancient platforms. Here the power of the basalt layer reaches the axial zone of the main faults (near vertical peridotite dikes) 45-48 km. On the surface basalt layer is covered a thin (2-5 km) granite-gneiss and sedimentary layer (Figure 2).

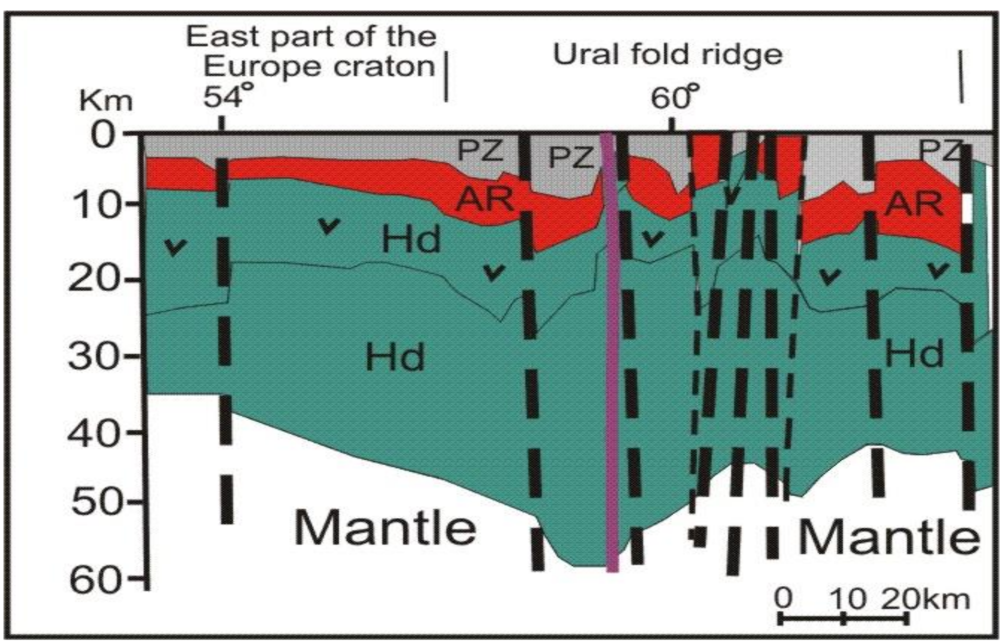

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Figure 2
Very thick metabasalt layer crust (Hd) under the Ural mountain range
(Zoloev et al, 1981; Ovchinnikov, 1990; Udoratin and Konanova, 2000; Druzhinin et al., 2013; 2014).
The upper part of the metabasalt layer is mainly gabbro-diorite composition. Violet body is giant peridotite dike.

In the course of a long stage of formation of the Archean granite-gneiss layer of the earth's crust many Hadean high mountains have been significantly eroded and covered on the surface with a thick granite-gneiss layer (Figure 3). In some places the original mountains were eroded even further, and their roots are relatively low altitude (5-10 km, sometimes - more), preserved only in the lower parts of the crust some deep tectonic depressions (South Caspian Sea, the Caribbean basin, and others).

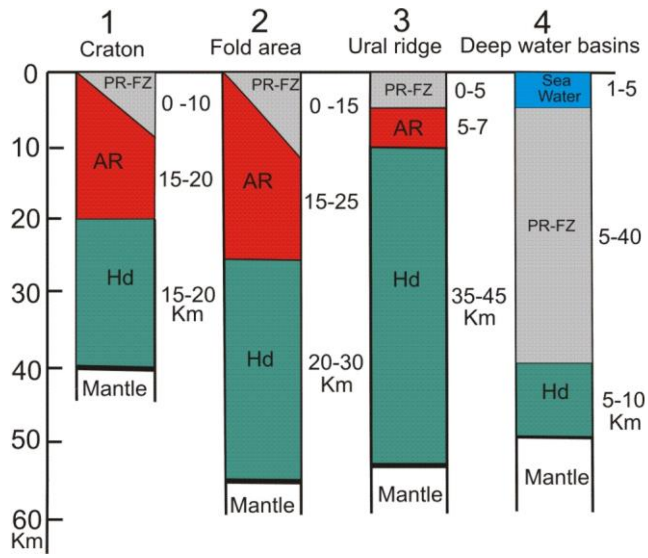

Figure 3
The thickness of the metabasalt layer (Hd) in tectonic structures of different genesis (Zlobin, 2006; Druzhinin et al., 2014).

Features manifestations of volcanism on the Earth's surface in Hadean we can restore only in certain rare cases, because the lower metabasalt layer covered of thick Archean granite-gneiss layer and later sediments. However, we can find these features on the surface of another planet, in particular, on the planet Mars. The planet Mars is close to Earth since formed an explosive ejection of the northern part of the Proto-Earth and her whole structure and composition like of the Earth's crust (Zhirnov, 2014b). With another hand, the evolution of the planet Mars ended in late Hadean stage or early Archean stage, when the first water basins appeared on it. Therefore, manifestations of volcanism on the planet, under oxygen-free atmosphere, survived intact.

3.3. Features of volcanism on the surface of the planet Mars

Features volcanoes on the surface of the planet Mars is described in (Katz et al., 1978). Tectonics and volcanism of the planet Mars have been studied according to television images of the surface as a result of flight automatic interplanetary station "Mars", "Mariner" and "Viking" in the second half of the twentieth century. Much on the Martian surface was unexpected - grand volcanoes, distinct crust breaks, distinct traces of erosion in the form of meandering channels, large ravines, and lots of sand dunes (Katz et al., 1978).

The surface of Mars is clearly divided into the northern hemisphere with abundant basalt fields and the southern hemisphere - a continental dotted with numerous volcanoes and craters. Continental area of the northern hemisphere is raised relative to the southern part of the planet to 3-10 km. This area is characterized by negative anomalies of the gravitational field and inhomogeneous structure of the development of raised areas saturated with craters. It is assumed that the formation of the continental crust was completed by 4 billion years ago, the oceanic crust - later.

The most prominent is a large area of the Tharsis uplift trapezoidal-round form, timed to coincide with the boundary of the continental and oceanic parts of Mars. Its width is about 5-6 thousand kilometers, the height above the average level of Mars - 10 km, undoubtedly, this is one of the earliest nuclear units were formed of basalt cover. This lifting set series of ancient and young volcanoes of different heights. The oldest volcanoes have a greater width of 750-850 km and small heights of up to 0.5 km. Young volcanoes have a very great height. The largest of these is Mount Olympus - the height of 27 km, a width of 600 km, with a wide caldera at its apex with a diameter of 65 km. On the outskirts of the volcano lava flows extend radial pattern. To the south-east of the volcano is set narrower linear chain of volcanoes, 300 km wide, but also large (27 km) altitude (Katz et al., 1978). These include Arsk, Ascrey, Pavlin and the others (Figure 4). On the slopes of volcanoes visible fault system oriented radially with respect to volcanoes. It seems also to arc faults. These radial-ring faults are characteristic for many volcano-tectonic structures of the Earth (Gurevich, 2009).

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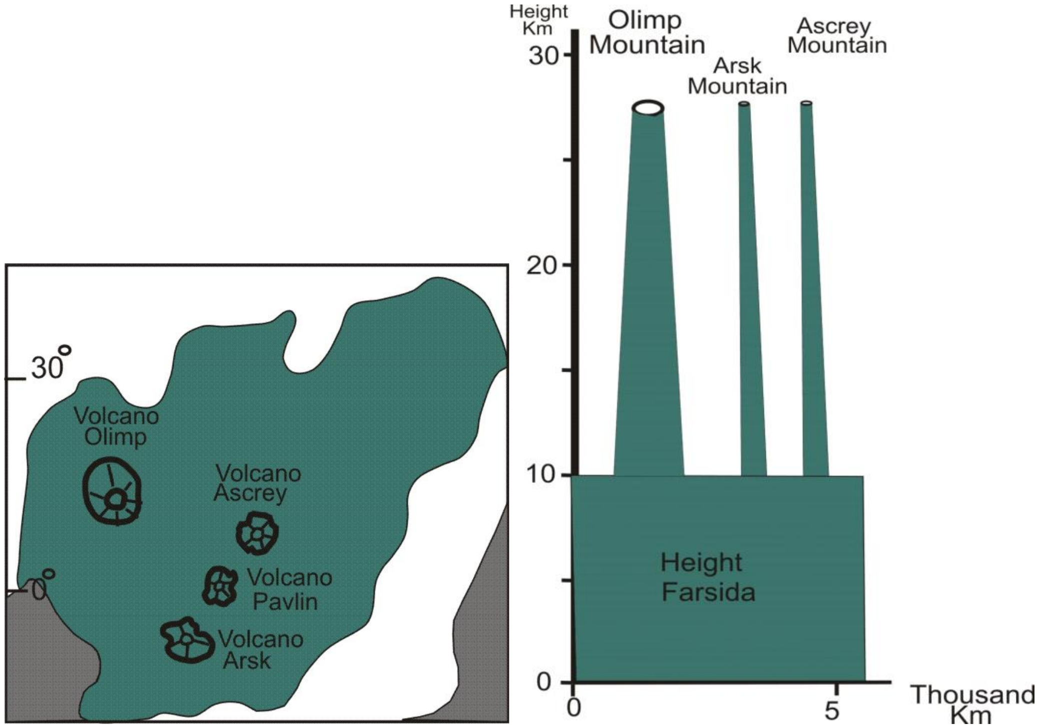

Figure 4
Volcanoes on the surface of the planet Mars: Left – height Tharsis (green) with the volcanoes, located on the border of basalt sea (white) with the mainland (dark) (Katz et al., 1978); Right - section of height Tharsis with volcanoes on it.

3.4. Formation of the Arctic volcanic mountains in Hadean and their subsequent evolution

Hadean volcanism of the Earth (and the Arctic, in particular) expressed quite strongly, as evidenced by the large capacity of the lower metabasalt (granulite-basic) layer in the structure of the crust of the territory. This layer is composed of pyroxene and plagioclase gneisses, amphibolites, gabbro-diorite, peridotite and eclogite intensely metamorphosed. The density of rock layer is typically 2.8-3.1 g / cm^3, the longitudinal velocity of seismic waves 6.6-7.4 km / sec (Muratov, 1975; Belousov, 1989). In the subsequent geological time this layer often been broken by powerful dikes and stocks of peridotite and granites, especially in the marginal parts of the Arctic territory (Filatova and Hain, 2010).

Meta basalt layer overlaps, as in other places of the planet, granite-gneiss layer that does not allow one to investigate its condition, with some exceptions (Aldan Shield and others.). However, in the Arctic, in contrast to other parts of the world, there are several large areas ("windows"), in which the granite-gneiss layer is absent, and the lower layer metabasalt is exposed. However, these portions are now represented in the abyssal grabens of Arctic Ocean, in which metabasalt layer is usually a small capacity (5-7 kilometers). In fact, we can see the remains of the former or the roots of volcanoes, survived after the long, for 4 billion years, their denudation under an oxygen atmosphere of the Earth and the constant extreme temperatures. About the same condition ancient Hadean volcanoes, we can judge only on the basis of their relationship with the surrounding rocks in the past geological epochs. . It is therefore necessary to consider paleo-reconstruction geology of the Arctic for the various stages of its development.

3.4.1. Manifestations Hadean volcanic mountains in the Archean

On the territory of the Arctic remained a few areas in which the granite-gneiss layer is absent. These are the territories of modern deep-water trenches - Norwegian, Lofoten and Greenland, between Scandinavia and Greenland, and the largest – Amundsen- Nansen Basin in the Central Arctic (Figure 5). The total length them approximately 4500 km, direction zone of the basins is longitude in the west (W 0-2°), and then - a cross in the polar part (Gakkel Ridge) and again meridional (120-126° E) in the Laptev Sea near the northern Asia.

Height Hadean volcanoes in the Arctic could reach by the end of this stage, of 50-60 km (Figure 5B), which is confirmed by high altitude Hadean metabasalt layer in the Urals tectonic zone - up to 45-48 km (Ovchinnikov, 1990) and high altitude volcanoes on Mars. Since the activity of the

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internal energy of the Earth is much greater than that of Mars, then, accordingly, the power and energy of volcanic earth (and the height of any volcanoes) was much larger.

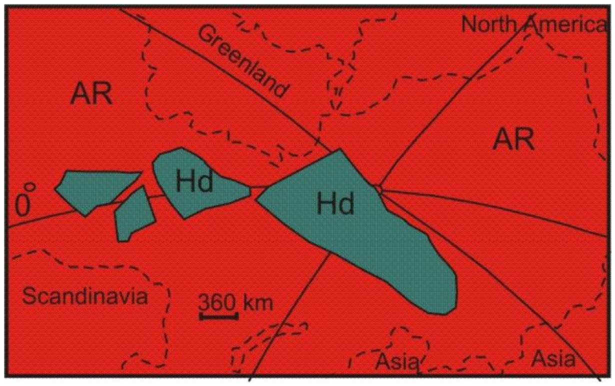

Figure 5A
Layout Hadean Mountains in the Archean basement of the Arctic

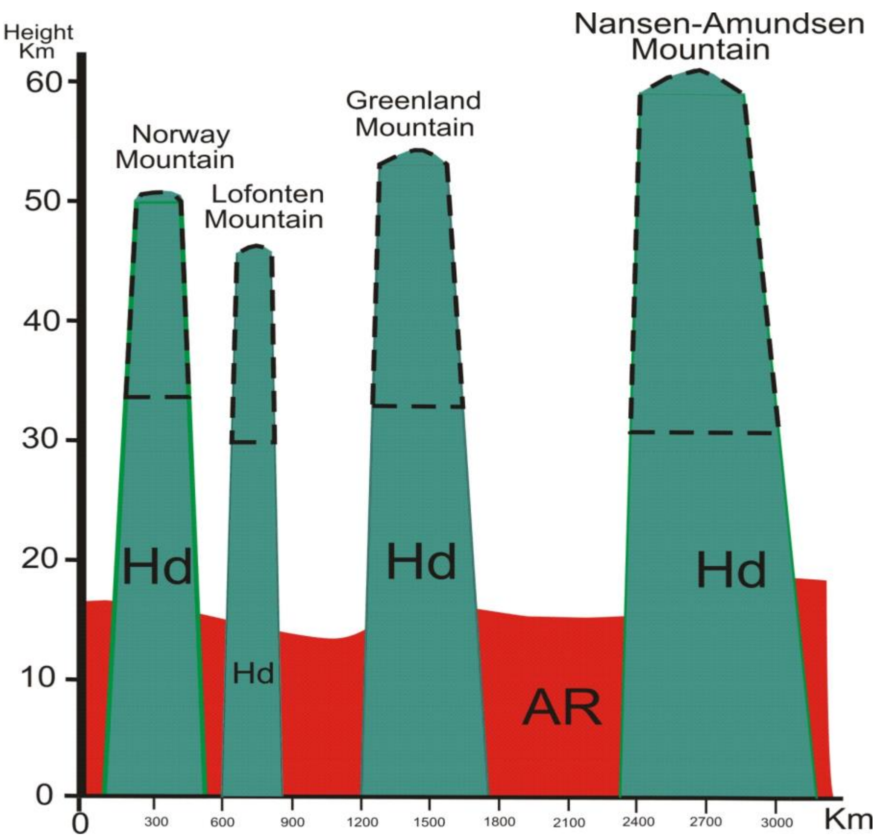

Figure 5B
Section of Hadean volcanic mountains in the Arctic' Archean plinth

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However, over a long period of formation of the Archean granite-gneiss layer (2 billion years) volcanoes height has been reduced by at least half due to erosion and demolition of damaged material in many water basins (Figure 5B).

3.4.2. Manifestations Hadean volcanic mountains in the Mesozoic

The Arctic territory has been fundamentally divided in geological history after Archean into the North-American and European-Asian (southern) parts. North American Archean craton remains in a stable steady state to date. Only in its northern part, including the edges of Greenland, there were narrow sedimentary basins along the major faults, in which formed sedimentary rocks of Riphean-Early Paleozoic time. In these basins gets sedimentation, completed by mid-Paleozoic folded dislocations introduction of granites and metamorphic sedimentary rocks. Layer thickness of sedimentary rocks reached 3-5 km on the western and northern fringes of Greenland and 12 km - in the eastern part of it (Pushcharovsky, 1960). While the southern part of the Archean Arctic, with the central units Hadean mountains, has undergone profound and long dives during the subsequent geological time - from the Proterozoic to Cenozoic (Figure 6).

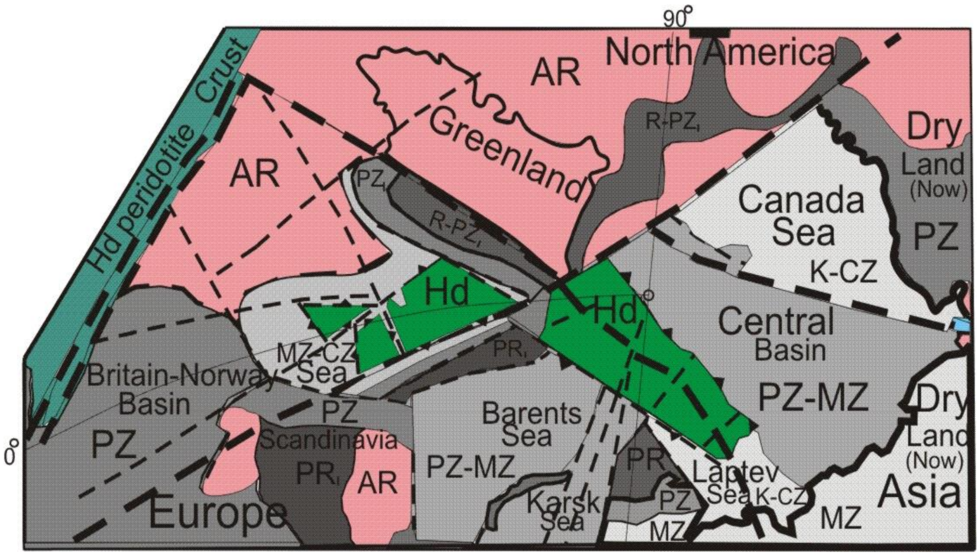

Figure 6

Layout Hadean Mountains in Paleozoic-Mesozoic deep grabens (sedimentary basins) and some of the major faults of the crust.

In view of the data (Eardley, 1954; Pushcharovsky, 1960; Muzylev, 1975; Udintsev, 1987; Belyi, 1996; Gramberg and Naryshkin, 2000; Bogdanov, 2004; Filatova and Hain, 2010).

Proterozoic metamorphic rocks are now known in a few places - in Scandinavia, on the island of Spitsbergen, on the Taimyr Peninsula and the islands of Severnaya Zemlya (west of the Laptev Sea). Sometimes the platform cover of these rocks is at the base of the Paleozoic sedimentary rock complexes. All the rest of the space south of the Arctic in Paleozoic and Mesozoic represents the area of the local or continuous immersion. In the western part it was formed in the Paleozoic largest British-Norwegian basin sedimentary rocks. Most of it is represented at present by land. In the south a long time (the entire Paleozoic and Mesozoic) continuously deepened Barents and Kara seas. In the eastern part of the Southern Arctic deepened two large basins- the Central, during the Paleozoic and Mesozoic, and Canada basin, Eastern - during the Cretaceous and Cenozoic (Kabankov et al., 2004; Filatova and Hain, 2009).

Permanent lands in southern Arctic were just Hadean Metabasite Mountains. They are constantly supplied decaying material in the surrounding water basins, in addition to the outskirts of the North American craton and the outskirts of the ancient projections in Europe and Asia. Of course, the height of the mountains at the end of the Mesozoic decreased significantly and amounted to about 2-4 km (Figure 7). The presence in the Paleozoic-Mesozoic time major mountains on the site of modern deep-sea basins of the Arctic allowed many researchers (Eardley, 1954; Pushcharovsky, 1960; Pogrebitsky 1976; Filatova and Hain, 2010; et al.). Such a conclusion is only possible when you consider the long Paleozoic-Mesozoic deepening basins on the flanks of the ancient Central Arctic Mountains as sources of material for collapsing these basins.

Note also the three major faults separating the Arctic with Archean time. This is North Greenland (Spitsbergen) fault, which separates Greenland from South Arctic, and continuing to south-west Europe. The second major fault - East Greenland, in which is formed the depth (over 12 km) rift-graben of ancient sedimentary rocks. This fault crosses the axis of the mountain system Nansen-Amundsen and continued further south at the bottom of the Laptev Sea and the eastern edge of the Siberian platform - in the Lena rift graben, under cover of Mesozoic sedimentary rocks (Naryshkin, 1987; Udintsev, 1987; Zhirnov, 2014c). There it supervised a wide body (100 km) ultramafic rock at a distance of 2.2 thousand km, discovered at the territory of the aeromagnetic survey (Novikov, 1987). The third fault, the Bering-Mendeleev, separates the Central Arctic sector to the northwest up hollows and ridges from Canada Basin (to north-east) deep depression with a series of faults and serpentinite dikes.

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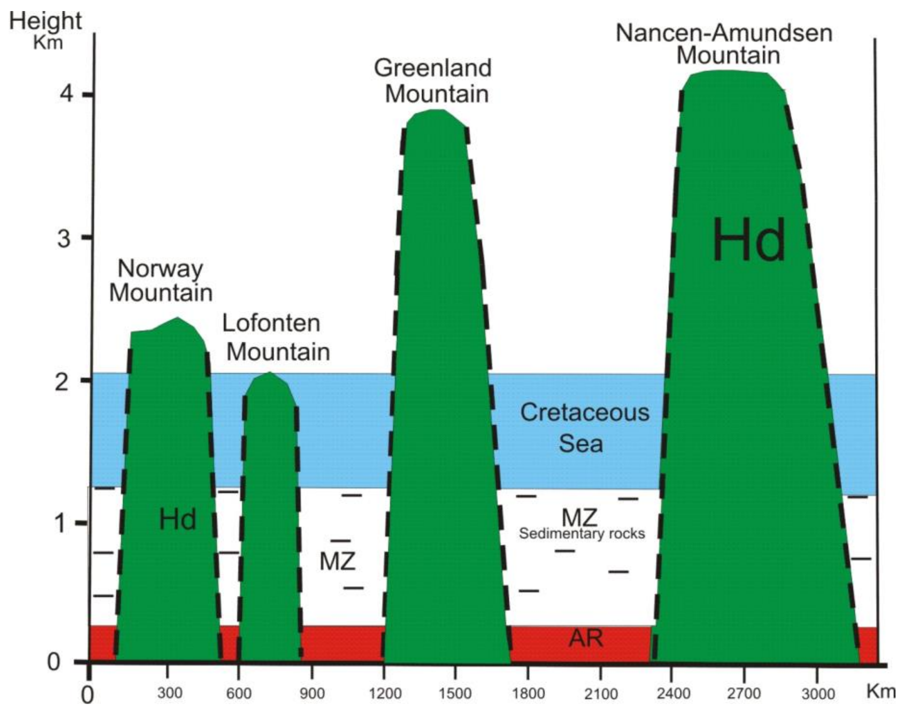

Figure 7
Height Hadean significantly eroded mountains at the end of the Mesozoic time.

3.4.3. Manifestations Hadean volcanic mountains in the Cenozoic

At the end of the Mesozoic - Cenozoic period beginning on the planet comes a sharp change in the geological development. At that time the vast territories of East Asia and Western America there were enormous tectonic and magmatic processes associated with the formation of Mesozoic folding, planetary zones of acid and basaltic magmatism and the introduction of giant zones of granites and granodiorites (Pushcharovsky, 1960; Itsikson, 1979; Belousov, 1989).

Deep changes began, and in the geological development of the Arctic. A very long descent of the southern ocean basins of the Arctic, during the Paleozoic and Mesozoic, are replaced at the end of the Cretaceous sharp movements of opposite sign - upward vertical movements. As a result, by the end of the Paleogene all marine sedimentary basins have undergone inversion and turned into vast areas of land, which in some places is only accumulated bog -lake continental deposits (Pogrebitsky 1976; Nalivkin, 1980, Poliakova, 2015). Many ancient vertical faults were intensely active and appeared new fractures. As a result, the territory acquired block-bloc "keyboards" structure, where some blocks of rock were highly elevated, and others - are immersed. The heights of vertical displacements of up-down were reached to several kilometers. For example, on the southern extension of the Gakkel Ridge - in the Laptev Sea, and elsewhere (Pogrebitsky 1976; Bogdanov, 2004; Pavlenkin and Poselova, 2006; Filatova and Hain, 2010). By the end of the Mesozoic sharply dismembered before Nansen-Amundsen single mountain massif metabasalt-peridotite composition. The central part of it remained in the form of High Mountain Gakkel Ridge, and the side parts have been immersed for deep vertical faults and grabens have become - the places of accumulation of the Cretaceous-Cenozoic sedimentary rocks.

Active movements of faults accompanied almost every where on the surface outpourings of basaltic lava, as on many other areas of the planet. There are two periods of active basaltic magmatism. The first period was in the Jurassic-Cretaceous time (145-114 million years ago), when the manifestation of basalt set in many locations around of the Arctic territory (Filatova and Hain, 2010). The second period of the formation of wide basalt fields typical for the beginning of the Cenozoic time (Paleocene), when there was a large British-Arctic province basalts (Tula Province) - mainly in ground conditions (Figure 8)

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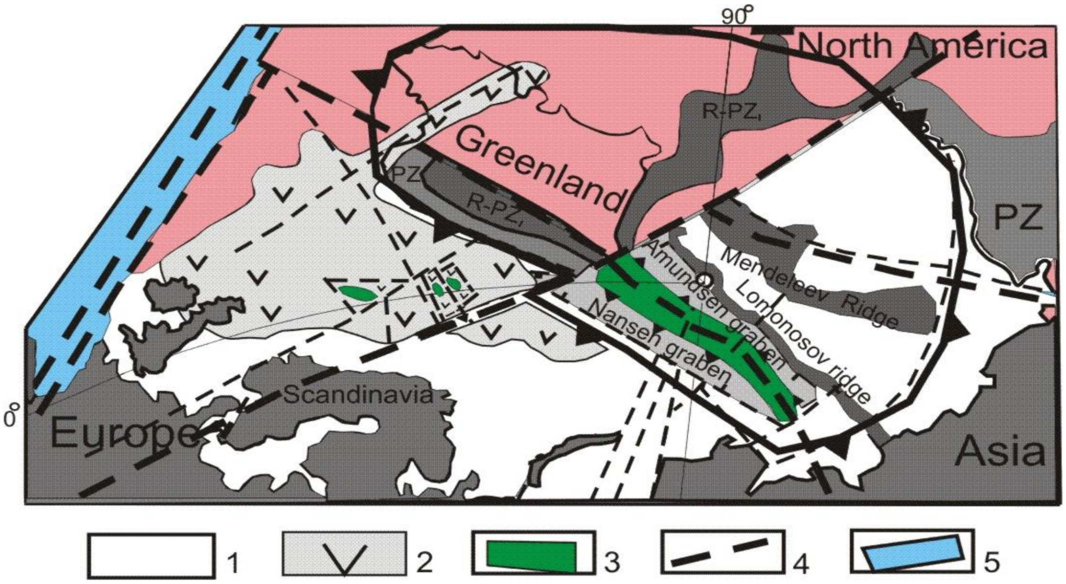

Figure 8
Arctic mountain arch in the Neocene - Pleistocene.
In view of the data (Eardley, 1954; Pushcharovsky, 1960; Pogrebitsky 1976; Nalivkin, 1980; Udintsev 1987; Naryshkin, 1987; Harin et al., 2003; Polyakova, 2015; Kazmin et al., 2015; Zhirnov, 2015b).
1 – The land area with separate parts of shallow coastal deltaic basins; 2 –Paleocene basalt cover and some shallow grabens; 3 - mountain ridges of ancient basite-ultrabasite rocks; 4 - the main faults; 5 - the northern edge of the Atlantic Ocean.

At the end of the Paleocene and Neocene on the territory of the Central Arctic was a mountain ridge vault. Only Nansen and Amundsen grabens and the Norwegian-Greenland area are a partial shallow pools where the accumulated sediments and the individual layers of basalt. In the Pleistocene, they occasionally rose above the shallow pools and were accompanied in some places, terrestrial volcanic outpourings of basalts (Harin et al., 2003).

At the end of the Pleistocene Alpine Arctic vault has become a place of formation of the great glaciers slipping into North America and Eurasia (Figure 9).

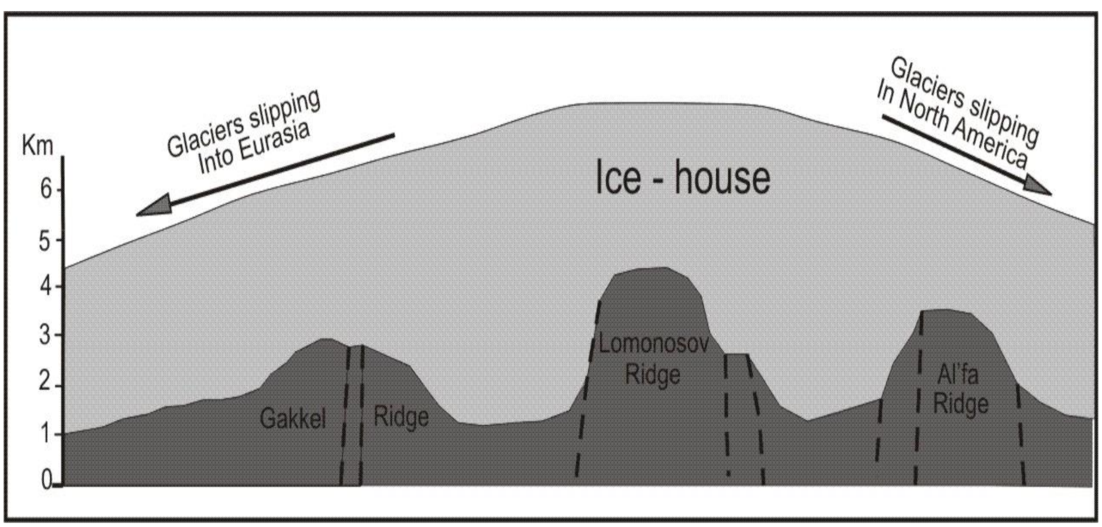

Figure 9
Cross-section of the Arctic Mountain arch and the Main Arctic Glacier (on it) - in the middle of the Pleistocene (Zhirnov, 2015b).

3.4.5. Collapse roots Hadean volcanic mountains in the Holocene

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In the early modern period, in the Holocene (9-7 thousand years ago), the world took a sharp new stage tectonic activity caused by large vertical movements of blocks rocks (2-5 km) along vertical fractures to form deep grabens and individual high horst . In particular, deep depressions and grabens formed in the Black and Mediterranean Seas (Stanley et al, 1974) and deep depressions and grabens within the Norwegian-Greenland territory, accompanied by active volcanism (Udintsev, 1987; Harin et al., 2003). In Southeast Asia deep grabens and height horsts arose within the Indonesian island arc (Stille, 1964, Serpukhov, et al, 1975; Belousov, 1989).

On the territory of the Arctic there was another major phase of restructuring relief at this time. It was the largest collapse of the entire southern part of the Arctic vault to form a modern deep basins - Nansen, Amundsen and Makarov, the Canada Basin (Pavlenkin and Poselova 2006; Zhirnov, 2015b). In connection with the melting of the great glaciers a modern Arctic Ocean formed, as occurred flooded shallow layer of water (50-150 m), all adjacent to the Eurasian continent Plains (Orlenok, 1983; 2010; Rosenbaum and Shpolyanskya, 2000; Zhirnov, 2015b). The roots of the highest volcanoes mountains of the Hadean age survived after for 4 billion years denudation were hidden in any new deep-water basins (Figure 1, 10).

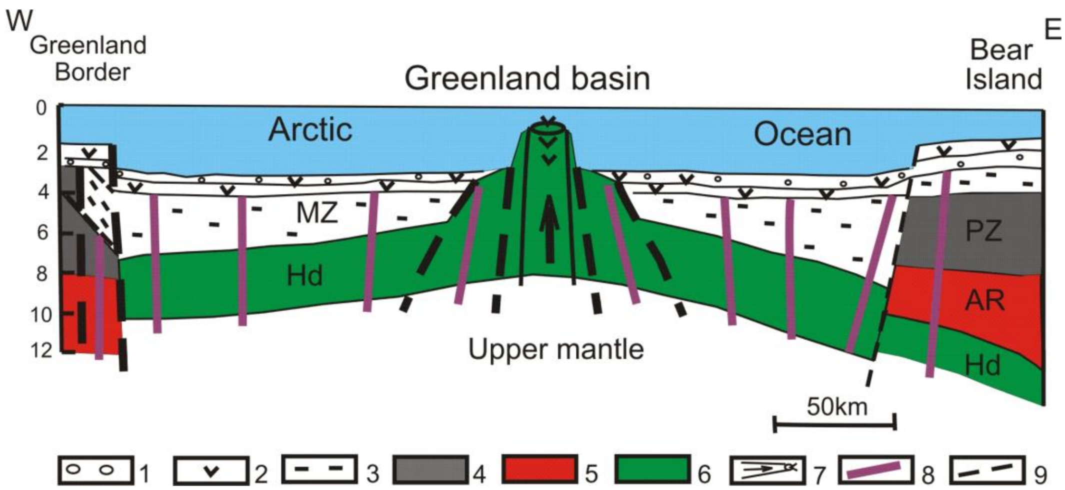

Figure 10

Geological section of the earth crust in the bottom of the Greenland Sea

In view of data (Milanovsky, 1979; Harin et al., 2003; Melanholina, 2008; Pushcharovsky, 2012; Kazanin et al., 2015) and Hinz, 1972 from (Belousov, 1989).

1 – Friable Cenozoic sedimentary rocks; 2 - basalt cover of early Cenozoic (Paleocene); 3 - Mesozoic sedimentary rocks; 4 - Paleozoic sedimentary rocks; 5 - granite-gneiss layer of Archean age; 6 - metabasalt layer of Hadean age; 7 - Cenozoic volcanic vents; 8 - the dike of peridotite-serpentinite composition; 9 - faults, reverse faults.

4. DISCUSSION

Many of the great geologists predecessor (E. Suess, A. Erdely, N. Shatsky) in the early twentieth century assumed the presence in the northern hemisphere of a single vast continent, hidden in its polar part beneath the waters of the Arctic Ocean. This Arctic Ocean is of great complexity for geological research, being almost constantly covered with thick ice cover. And only in the second half of the twentieth century and the new twenty-first century it became possible to obtain specific geological, geomorphologic and geophysical evidence (facts) about the structure of the crust in the bottom of the harsh ocean. The decisive factor was the widespread use of new methods for the study of underwater parts of the oceans, including the use of underwater drilling and the study of bottom topography using submarines.

Since that time, considerable material collected in this field, as summarized in this article briefly. However, to obtain a full complete picture of the whole process of formation of the Earth's crust in the bottom of the Arctic Ocean was required to investigate the very initial stage of this process - Hadean stage of formation of the Earth's crust over the world when the world was dominated by long-term and ambitious processes of volcanism, the outpouring of basaltic lava and the formation of the highest volcanoes mountains, 50-60 km height.

This was only possible on the basis of an analysis of some very powerful projections Hadean metabasalt layer (in the Urals, Russia) and bringing data grandiose volcanism on the planet Mars, where the highest volcanoes have survived to the present day. Then it required to research follow evolution of high Hadean volcanic mountains, together with the general evolution of the earth's crust. Very significant help in solving the problem given the new evidence on the recent geological history of the Arctic - in the Late Pleistocene and Holocene, when there were the great glaciations in the northern hemisphere, and took new, anthropogenic, the stage of active tectonic excitation subsoil to form a deep-water Arctic grabens and Mediterranean Sea (Stanley et al., 1974; Zhirnov, 2015b).

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5. CONCLUSION

The earliest, Hadean, Stage of development of the earth's crust was characterized by a long and uneven development, high energy volcanic processes and high altitude encountered volcanic mountains. After 4 billion years, all the high mountains towering over later formed granite-gneiss layer of the earth's crust, it has been completely eroded. Some high ridges are preserved only in some places covered with a thin top layer of granite-gneiss (the Ural Mountains in Russia).

The giant area (length 4500 km) of contiguous high mountains of basalt-peridotite composition occurred in the Arctic - the northern polar part of the globe on a large projection of the upper mantle. This bands of high mountains there almost the entire geological history, gradually decreasing in height due to erosion. At the beginning of the Cenozoic in place these mountains appeared shallow grabens with separate high mountains, up to 2-3 km altitude. In the Pleistocene, the largest glaciers formed on them and then slipping into Eurasia and North America. At the end of the Cenozoic, in the Holocene, shallow grabens with individual mountains and mountain ranges were collapsed down on the vertical fractures and turned into modern deep-water basins.

SUMMARY OF RESEARTH

1. 4 billion years ago, at the end of Hadean era in the Arctic, formed the highest mountains peridotite-basalt composition, up to 50-60 km.
2. After 2 billion years, by the end of the Archean, these mountains were eroded by half.
3. After another 2 billion years, by the end of the Cenozoic, the site of the former mountains formed shallow basins - grabens, which rose (3 km), only the remnants - roots of the great mountains - the Gakkel Ridge, a mountain Vesteris and the others mountains.
4. 9 - 7 thousand years ago, due to a sharp acceleration in the vertical tectonic movements and the melting of glaciers, shallow troughs with individual mountains were deeply lowered by vertical faults and transformed into a modern deep-sea basins of the young Arctic Ocean

FUTURE ISSUES

I believe that many scientists in sphere of sciences about Earth have to pay attention to the real geology-geophysical data obtained for last 50 years and summarized a little in this work. Like areas with a metabasaltic crust, covered from top to sea water, there are in other places of the Earth's Northern megacontinent. They deserve careful study in the light of the concept.

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REFERENCES

1. Belousov VV. Bases geotectonic. *Nedra*. Moscow, 1989 (in Russian)
2. Belyi VF. By the tectonics of the northern sector of the Pacific belt. *Pacific Geology*, 1996, 5, 3-19 (in Russian)
3. Bogdanov NA. The tectonics of the Arctic Ocean. *Geotectonics*, 2004, 3, 13-30 (in Russian)
4. Druzhinin VC, Martyshko PC, Nachapkin NI, Osipov VU. The structure of the upper part of the lithosphere and the oil and gas potential of mineral resources of the Ural region. *Geophysical Institute*, Ekaterinburg, 2014 (in Russian)
5. Druzhinin VC, Martyshko PC, Nachapkin NI, Osipov VU. The scheme of tectonic zoning of the Ural region on the basis of geological and geophysical data on the structure of the upper part of the lithosphere. *Native geol.*, 2013, 1, 43-58 (in Russian)
6. Eardley A. Structural Geology of North America. *Foreign Liter*., Moscow, 1954 (in Russian, translation from English)
7. Filatova NI, Khain VE. Kraton Arctida and the neo-Proterozoic - Mesozoic orogenic belts of circumpolar region. *Geotectonics*, 2010, 3, 3-29 (in Russian)
8. Gramberg IC, Naryshkin GD. Features of the bottom topography of the Arctic deep-water Arctic Ocean basin. *VNIIOkeangeologia*, SPb. 2000, 53-77 (in Russian)
9. Gurevich DV. Ring structures: the most important mechanisms of. *Reg. geol. and metal*, 2009, 39, 14-23 (in Russian
10. Harin GS, Udintsev GB, Chernyshova EA. Modern alkaline magmatism and hydrothermal activity on seamounts of the Greenland Sea. *Dokl. Russian Academy of Sciences*, *series Geology*, 2003, 392, 3, 375-378 (in Russian)
11. Itsikson MI. Metallogenic zoning of the Pacific segment of the Earth. *Nedra*. Moscow, 1979 (in Russian)
12. Kaban'kov VA, Andreeva IA, Ivanov VN, Petrova VI. About geotectonic nature of the Central Arctic morphostructures and geological significance of bottom sediments in its definition. *Geotectonics*, 2004, 6, 33-48 (in Russian)
13. Kats YG, Kozlov VV, Kuznetsov VV, Saulidi-Kondratyev ED. Tectonics and volcanism of the planet Mars. *Nature*, 1978, 10, 27-39 (in Russian)
14. Kazanin GS, Tarasov GA, Redkina TY, Shlykova VV, Matishov GG. West Spitsbergen continental margin: geological structure, oil and gas. *Dokl. Russian Academy of Sciences*, *series Geology*, 2015. 460, 2, 204-209 (in Russian)
15. Kazmin Y.B, Lobkovsky LI, Kononov MV. Geodynamic model of the Arctic basin's evolution in the Cretaceous and Cenozoic. *Dokl. Russian Academy of Sciences*, *series Geology*, 2015. 462, 5, 565-571(in Russian)
16. Khain VE. Regional geotectonics: North and South America, Antarctica, Africa. *Nedra*, Moscow, 1971 (in Russian)
17. Kulakov I.Y., Hayna K., Dobretsov N.L., Vasilevsky A.N., Bushenkova N.A. Reconstruction of the movement of plates in the Arctic region on the basis of a comprehensive analysis of gravity, magnetic and seismic anomalies. *Geophysics*, 2013, 54, 8, 1108-1125 (in Russian)

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18. Marakushev AA. Fluid regime of renovation crust of Earth and other planets and moons of the solar system. *XII Scientific Seminar, Moscow State University*, 2004, 268-283 (in Russian)
19. Melanholina E.N. Tektonotip volcanic passive margins in the Norwegian-Greenland region. *Geotectonics*, 2008, 3, 73-96 (in Russian)
20. Milanovsky EE. Iceland and the Mid-Atlantic Ridge: geomorphology, tectonics. *Nauka*, Moscow, 1979 (in Russian)
21. Muzylev SA. Geological Map of the USSR. St. Petersburg, *VSEGE*I, Scale 1:10000000, 1975 (in Russian)
22. Nalivkin DV. Essays on the geology of the USSR. CPb. *Nedra*, 1980 (in Russian)
23. Naryshkin GD. Central Range of the Eurasian Basin of the Arctic Ocean. *Nauka*, Moscow, 1987 (in Russian)
24. Nemkov GI, Kevitskiy EC, Grechishnikova IA, Muratov MV, Tseisler VM. Historical Geolog*y*. *Nedra*, Moscow, 1986 (in Russian)
25. Novikov EA. Planet puzzles. *Nedra*, Moscow, 1987 (in Russian)
26. Ovchinnikov LN. Applied Geochemistry. *Nedra*, Moscow, 1990 (in Russian)
27. Orlenok VV. Paleography World Ocean in late Phanerozoic. *Pacific geology*, 1983, 4, 88-100 (in Russian)
28. Orlenok VV. Global Volcanism and oceanization the Earth and planets. *Univ. of name of Immanuel Kant*, Kaliningrad, 2010 (in Russian)
29. Pavlenkin AD, Poselova LG. Neotectonic collapse Arctic vault. *VNIIOkeangeologia*, SPb. 2006, 210, 6, 194-200 (in Russian)
30. Piskarev AL. The structure of the Eurasian basin's foundation and the central ridge of the Arctic Ocean. *Geotectonics*, 2004, 6, 49-66 (in Russian)
31. Pogrebitsky YE. Geodynamic system of the Arctic Ocean and its structural evolution. *Soviet geology*, 1976, 12, 3- 22 (in Russian)
32. Polyakova ID. Oil source layers of the Arctic. *Lithology and Mineral Resources*, 2015, 1, 30-54 (in Russian)
33. Poselov VA, Butsenko VV, Pavlenkin AD. An alternative to the spreading nature of the Eurasian Basin of the seismic data (for example, geotransekt Gakkel Ridge, the Lomonosov Ridge) *VNIIOkeangeologia*, St. Petersburg, 1998, 2, 177-183 (in Russian)
34. Poselov VA, Pavlenkin AD, Pogrebitsky YE, Butsenko VV, Sorokin MY. The structure and evolution of the lithosphere of the Arctic. *VNIIOkeangeologia*, St. Petersburg, 2000, 94- 109 (in Russian)
35. Poselov VA, Kaminsky VD. , Verba VV, Poselova LG, Glebov VB. Stages of research on the problem of the legal continental shelf of the Russian Federation. *VNIIOkeangeologia*, St. Petersburg, 2008, 249-262 (in Russian)
36. Pushcharovsky YuM. Some of the common problems of the Arctic's tectonics, *Dokl. Russian Academy of Sciences*, *series Geology*, 1960, 9, 15-28 262 (in Russian)
37. Pushcharovsky YuM. The tectonics of the Arctic Ocean. *Geotectonics*, 1976, 2, 3-14 (in Russian
38. Pushcharovsky YuM. Tectonic types of deep-sea trenches and structural segmentation of the North Atlantic. *Geotectonics*, 2012, 2, 29-41 (in Russian)
39. Resanov IA. Stages of evolution of the Earth. *Herald of the RAS*, 2006, 76, 1, 918-926 (in Russian)
40. Rosenbaum GE, Shpolyanskya NA. Late Cenozoic history of the Arctic permafrost zone and the tendency of its future development. *Scientif. World*, Moscow, 2000 (in Russian)
41. Serpuhov VI, Bilibina TV, Shalimov AI. Course of general geology. *Nedra*, Moscow, 1976 (in Russian)
42. Shkarubo CI, Shipilov EV. Tectonics of the Western Arctic Platform, *Razvedka and mineral resources*, 2007, 9, 32-47 (in Russian)
43. Stille H. Selected papers, *World*. Moscow, 1964 (in Russian, translation from German)
44. Udintsev GB. Relief and structure of the ocean floor. *Nedra*, Moscow, 1987 (in Russian)
45. Udoratin VV, Konanova NV. Deep structure of the lithosphere along the profile MEZTIMPECH. *Native geology*, 2000, 1, 44-50 (in Russian)
46. Rowley BR, Lottes AL. Plate-cinematic reconstructions of the North Atlantic and Arctic: Late Jurassic to present, *Tectonophysics*, 1988, 155, 73-120
47. Stanley D, Got H, Leenhardt O, Weiler Y. Subsidence of the western Mediterranean basin in Pliocene– Quaternary time: further evidence, *Geology*, 1974, 7
48. Zhirnov AM. Geological history and mechanisms of formation of the Far Eastern margin of the Eurasian continent. *GEOS,* Moscow, 2013, 70-74 (in Russian)
49. Zhirnov AM. The geological law of the continents and 'oceans' autonomous development: from plate tectonics to Global cosmogeotectonic. *Discovery Science*, 2014a, 8(18), 6-15
50. Zhirnov AM. Birth of Earth, Moon and Mars, owing to explosive disintegration Proto-Earth. *Discovery*, 13(33), 2014b, 15-24
51. Zhirnov A. Northern three–radial megacontinent of Earth: Outstanding geologic-geophysical discovery of the XXI century. *Discovery*, 2014c, 22 (74), 72-85
52. Zhirnov A. The law of decreasing dynamic pulsation activity of the Earth's core as the main factor of the planet's evolution. *Discovery*, 2014d, 24(84), 71-91
53. Zhirnov AM. Fixed vertically mobile continents: The birth and growth in deep pits on the planet's surface. *Discovery*, 2015a, 33(147), 48-55
54. Zhirnov AM. Arctic mountain arch as a place of great glaciers slipping in the Late Pleistocene. *Discovery*, 2015b, 42(194), 132-143
55. Zlobin TK. Physics of Earth. *Sakhalin State. U.,* South-Sakhalinsk, 2006 (in Russian)
56. Zoloev KK, Rapoport MC, Popov VA. The geological development and metallogeny of the Urals. *Nedra*. Moscow, 1981 (in Russian)

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