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REVIEW ON THE BOOK BY R.B. KRAPIVNER "CRISIS OF THE GLACIAL THEORY: FACTS AND REASONS" (Moscow: GEOS Publ., 2018, 320 p.)

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Abstract. In 2018, GEOS Publishing House released a landmark monograph by R.B. Krapivner "Crisis of the Glacial Theory: Facts and Reasons" [1]. The book is grounded on the massive volume of evidence-based material collected by R.B. Krapivner in his numerous expeditions to the East European Plain, north of Western Siberia, Primorsky and Kamchatka Territories, Kola Peninsula, Caucasus, as well as to the shelves of the Sea of Okhotsk, the Kara Sea and, especially, the Barents Sea. The author comprehensively examines the signs and criteria that underlie the powerful and indisputable glacial theory, and concludes that the ice age theory is erroneous. According to Krapivner's analysis, the main geological, geomorphological and paleogeographic criteria, which are the pillars of the glacial theory, are actually not of the glacial, but mainly of geological and tectonic origin. At that, the author makes several fundamental discoveries that would dignify many academic institutions, the research fellows of which proudly bear the titles of honoured scientists. However, they disregarded the geological discoveries, thus giving the priority to the field production geologist. The most impressive discovery of R.B. Krapivner is determining the fault-tectonic origin of large glacial erratic masses and the fault-fold genesis of glacial dislocations, which are widely spread in the platform cover of the East European Plain and Western Siberia. For almost two centuries, these gigantic tectonic units have been shaping the entrenched views on the incredibly dynamic power of the

cover glaciers that have deeply penetrated into the upper layers of the Earth's crust and have extracted large glacial erratic masses with the thickness of many hundreds of metres and length of tens of kilometres. Moreover, the cover glacier (in the papers of scientists) transported these large glacial erratic masses for many hundreds of kilometres from the place of their original occurrence. But having analysed the drilling data, Krapivner established that the rocks composing the bodies of the large glacial erratic masses participate in the structure of the sedimentary cover in the neighbouring areas that are not disturbed by tectonics, and the distance of their movement (vertical and subvertical) is hundreds of metres, kilometres – they are extorted by tectonics from the cover section from these depths. Of equal importance for asserting the accuracy of the glacial theory are the glacial dislocations, which are also highly developed in the near-fault zones of the platform cover. Krapivner presents a tectonophysical model of their formation based on the data of drilling these structures, their geophysical study, geological and structural analysis. Although, the proponents of the glacier underreport the results of drilling and tectonophysical analysis, they are convinced that the cover glacier bit into the rocks of the platform cover to a depth sometimes even up to 2.6 – 2.8 km (Yugansky glacial erratic mass) and dragged the giant blocks of loose rocks at a distance of sometimes more than 600 – 650 km. It is significant that Krapivner came to this conclusion in his first monographs in 1986 [2], long before drilling of the cover glaciers in Antarctica and Greenland. The results of drilling are as follows: cover ice is incapable of tearing and dislocating anything, as the bottom layers of ice are tied-up, they adequately protect the subglacial bed from exaration. Ice does not trap blocks and boulders and it includes only dust-like particles, mainly volcanic ash. The results are amazingly illustrative so that the proponents of the glacial theory had to understand and refute the apparently erroneous theory. But they did not comprehend, they did not repent, they did not renounce – as before the large glacial erratic masses and glacial dislocations have been considered the most reliable foundations of cover glaciations. Keeping this in mind, R.B. Krapivner devotes a special chapter of the monograph under review to the issues of theoretical glaciology and detailed analysis of the results of subjacent drilling of cover ice in Greenland and Antarctica, ice caps of the Arctic islands. His conclusions are obvious: the cover and cap glaciers preserve their bed, they are not capable of exarating it, trapping and moving boulders. The body of glaciers contains minor inclusions of dust-like matter, mainly volcanic ash, which fundamentally undermines the basis of the glacial theory. Now even blocks and boulders, which are the part of the Quaternary moraine, challenge the glacial genesis of both boulders and moraine. The issues of non-glacial formation of boulder deposits, non-glacial origin of moraine on the European terrestrial area and on the shelf of the Arctic seas are explored in voluminous third, fourth, and fifth chapters in the monograph under review. A special case is the sixth chapter, which discusses several major hypotheses regarding the causes of marine transgressions (glacial eutasy) and glacial punching of the Earth's crust (glacial isostasy). Krapivner reveals the inaccuracy of glacial views and justifies the neotectonic nature of these global phenomena. This chapter provides evidence of the fault-tectonic origin of fjords and glacial exaration relief forms on the Baltic Shield. In conclusion, the main results are summarised and the recommendations on replacing the apparently outdated glacial paradigm with a new non-glacial theory based on the advances in the modern Earth sciences are given. R.B. Krapivner emphasises the need for the high-profile academic community to stop ignoring the latest papers of anti-glacialists and preventing the publication of fundamental developments in academic journals.

Key words: glacial theory, tectonics, glaciology, glaciotectonics, diamicton, moraine, roche moutonnée, sheep-like rock, glacial grooves, tectonic grooves, slickensides, glacial dislocation, large glacial erratic masses (glacial mass overthrust blocks), fiords.

Introduction and General Issues of the Glacial Theory

The monograph of R.B. Krapivner opens with a quote from A. Hallam's book "Great Geological Controversies" [3]: "It is hard to imagine a geologist who did not recognise as a incontrovertible fact that in the very recent past, cover glaciers 3.5 – 4.5 km thick several times have spread over the vast areas in Europe and North America, wiping out all life in these territories".

A. Hallam produces the reasonable idea that Western, Soviet and post-Soviet scientific communities fully and unconditionally support the glacial theory, consider it as a fundamental scientific achievement, a milestone doctrine that has been well established in all Earth sciences – from general geology and geography to geobotany and zoology, from paleogeography to geomorphology and Quaternary geology.

But unlike Western science, where the glacial theory is truly undeniable, the background in Russia is more complicated. Russian academic science and university glacial research schools keep pace with Western scientific communities: they are ardently following European and Canadian-American glacial schemes and developments, and they are obsequiously implementing them. It is worthless to lag behind the advanced Western science, especially since Russian scientists copied the glacial theory from the Western sources a century and a half ago.

Despite the overwhelming dominance of the glacial theory in Russia, there were researchers – geologists and zoologists who highlighted the lack of evidence in the glacial doctrine. There were few of them, sometimes they managed to release their works, but official science usually remained vigilant and successfully withheld the publication of critical anti-glacial papers, since all scientific academic journals were fully controlled by the academic institutions. However, production geological expeditions in Russia operated effectively; they were of geological filming, geological prospecting, and geological exploring nature. Through extensive field research, they contributed to the new and unique actual data that clearly contradicted the canons of the glacial theory. The papers of field geologists in institutional scientific proceedings could not comprehensively cover the issue, but there was an increasing awareness that undermining, or better, debunking of the glacial theory, requires deeper knowledge and as much factual evidence as possible.

It is Rudolf Borisovich Krapivner, the author of the reviewed monograph, who possesses a wide range of knowledge reinforced by many years of field geological work. Here is the information about his geological production and research activity: he is the graduate of Moscow Geological Prospecting Institute (former Sergo Ordzhonikidze Russian State University for Geological Prospecting), Candidate of Geological and Mineralogical Sciences (since 1967), Doctor of Geological and Mineralogical Sciences (since 1990), and the chief researcher in the Hydrogeological and Geoecological Company ZAO GIDEK.

His interests in production geology and research with extremely favourable outcomes include: Late Cenozoic geology, structural geology, neotectonics, hydrogeology, tectonophysics, glaciology, and ecology. But the most impressive is the scope of his field research: the central regions of European Russia, the Pechora and West Siberian plains, Primorsky and Kamchatka Territories, the Caucasus, the Kola Peninsula, and the islands in the Arctic Ocean. His sea expeditions to study the shelves of the Barents Sea, the Kara Sea, and the Sea of Okhotsk, as well as the coastal zone in the Sea of Japan are particularly remarkable.

We do not know any Russian geologist with such range of field research.

Back in 1960, R.B. Krapivner made it a priority to determine the true genesis and mechanism of moraine formation on the Russian northern plains and to trace the origin of glacial relief forms. Since then, he continues this labour-intensive work. However, in 1986, Nedra Publishing House featured R.B. Krapivner's first monograph "Rootless Neotectonic Structures" [2] in which he greatly undermined the foundations of the glacial theory, proving the fault-tectonic origin of large glacial erratic masses and establishing the plicative-tectonic genesis of glacial dislocations in the platform cover in the East European Plain and Western Siberia. Apparently, the proponents of the glacial doctrine should start reviewing it, but instead, glacial scientists declared this monograph to be "unreadable" and advised it to be "ignored" under the pretext that the book was released not in the academic, but in the institutional publishing house (Nedra Publ.).

In 1990, R.B. Krapivner submitted his doctor's thesis "Structure and Conditions for the Formation of Near-Surface Neotectonic Dislocations" on the academic council of the Institute of Physics of the Earth (Russian Academy of Sciences). Based on his geological studies, data from geophysical and drilling works, and materials presented in the 1986 monograph, he proved the fault-tectonic origin of large glacial erratic masses and the fold origin of glacial dislocations.

The academic council of the Institute of Physics of the Earth viewed the researcher's conclusions with scepticism and even with aggression, and only by happy coincidence the academic council did not obstruct the thesis defence. This landmark event will be fully covered in the part "On the origin of large glacial erratic masses and glacial dislocations".

In the early 21st century, an unexpected turn took place in the Earth sciences in terms of clear dominance of the glacial theory. Within the international projects, subjacent drilling of the most powerful ice sheets in Greenland and Antarctica was conducted with complete separation of ice core. Suddenly, it turned out that the boulders are completely absent in the sections of these ice sheets, instead there are scanty micron-sized dust-like particles, mainly volcanic ash. It was found that the bottom parts of cover ice are immobilised, and they do not fulfil any exaration function. For almost two centuries, the ice sheets have been considered performing the enormous ploughing role, while they are only preserving the topographic surface. This issue is explored by R.B. Krapivner in the second chapter, "Glacial theory and glaciology", which is saturated with extensive factual material. A specific part there is devoted to the evidence of the fault-tectonic origin of exaration glacial relief forms as the most distinct and generally accepted signs of cover glaciation. A particularly reliable criterion of cover glaciation is roche moutonnées and sheep-like rocks with scours and channels on the Precambrian rocks. The proponents of the glacial theory are right about one thing: the exaration relief forms – from fjords and skerries to roche moutonnées and channelled polished rock beds, are indeed the most vivid, accessible and visible for route study. This ruined the glacial idea of their origin: in fact, all glacial exaration relief forms have the fault-neotectonic genesis. Moreover, such relief forms as roche moutonnées with scours and channels continued to form in the postglacial (Holocene) epoch. R.B. Krapivner examines these issues in the sixth chapter. They are also considered in the first and other chapters of the book.

Postulates of the glacial theory and results of modern ice sheets drilling

Along with considering the theoretical foundations of dynamic glaciology, the author provides the unique data on subjacent drilling of the ice sheets in Greenland and Antarctica and of the ice caps on the Arctic islands, which were obtained within the international projects.

University and academic scientists united in glacial research schools constantly refer to the ice sheets in Antarctica and Greenland, which, in their opinion, mainly transformed the ancient surface of platforms and crystalline shields. It is believed that the very existence of these powerful glaciers testifies to the firmness and reliability of the glacial theory and that in the Quaternary period such glaciers exarated and demolished the crystalline rocks up to 200 m thick from the Baltic Shield, distributed the blocks and boulders of the bedrocks over thousands of kilometres and dragged the large glacial erratic masses for hundreds of kilometres.

For clarification, it is necessary to study the glaciological activity of these ice sheets that have been successfully fulfilling their glacial functions for many millions of years.

To date, glaciologists, geologists, drillers and geophysicists have explored the dynamics and patterns in the movement of cover glaciers throughout their entire mass and section. The results of subjacent drilling to the bedrock of ice in Antarctica and Greenland obtained within the international projects are of profound significance. Thorough studies of many kilometres of ice columns, as well as of vertical ice breaks and ice in tunnels punched at the base of the glaciers produced unexpected results. It turned out that only inclusions of sandy-clay and fine-grained substances are recorded in continental ice instead of masses of moraine-containing ice entirely filled with huge blocks and boulders (that is usually depicted in diagrams and drawings in the textbooks on general and Quaternary geology and on geomorphology). Even the bottom layers of glaciers, where the powerful bottom moraine stuffed with huge blocks and iron-like boulders is commonly placed (for example, in the schemes of V.M. Kotlyakov and N.V. Koronovsky), show only small lenses and clots of clay and sabulous matter, as well as sparse sandy grains. These mineral inclusions are contained in hundredths of a percent and are mainly represented by volcanic ash, microcosmic particles, aeolian dust from distant deserts, sparse inclusions of fine-grained terrigenous matter, as well as spores and pollen. Glaciologists also found that the bottom layers of ice in the cover glaciers (according to the canons of the glacial theory, they have to maintain all geological activity) do not participate in the general movement of ice masses, they have been tied-up for hundreds of thousands of years, thus protecting the underlying rocks from weathering and denuding. Moreover, cover ice preserves large palaeotectonic lakes with their very ancient relict water and saves them from the notorious glacial exaration.

Therefore, contrary to the canons of the glacial theory, cover ice does not cut off, plough and tear away the underlying rocks, as well as does not form the exaration relief forms and create any kind of glaciotectonic structures. Cover ice does not include blocks and boulders, and after melting it can leave only a thin intermittent cover of sandy-clay sediments. In fact, this is the main or bottom moraine of the cover glacier, but without any boulders.

A brief description of the results of drilling the ice caps in the Arctic and the ice sheets in Greenland and Antarctica is provided below.

Spitsbergen archipelago. The Spitsbergen glaciers are divided into two types. In Western Spitsbergen, the mountain-valley glaciers prevail. On their surface they carry blocks and boulders that have fallen from the mountain slopes. In Eastern Spitsbergen, the glaciation of the cover type is developed and the surface moraine does not naturally occur. The cover glaciers are drilled through several holes.

Amundsen plateau glacier. The 586.7 m deep hole reached the bedrock, near which ice consisted of alternating layers of transparent and opaque ice. In the opaque layers, mineral inclusions of micron dimension were recorded. These microinclusions were most noticeable at a depth of 511.6 and 566.7 m. According to the laboratory analyses, the mineral microinclusions were represented by mica flakes, quartz microparticles, volcanic ash and scoria, spores and pollen.

Lomonosov plateau. Although the Lomonosov plateau is located in Western Spitsbergen, its glaciation is of the cover type. The hole drilled the Fridtj of glacier reached the bed at a depth of 220m. Micron-sized dust-like inclusions were noted in the core of the bottom layers of ice, and the down hole was in the bedrock. Mineral inclusions of micron dimension were also noted in the drilled hole through the Grenfjord glacier reaching the ice bedrock at a depth of 211 m.

Ice cap on Devon Island (Canadian Arctic). Two holes with a depth of 298.9 and 299.4 m drilled through this glacier. At a height of 2.6 to 4 m from the bed in ice, microparticles in some concentration were recorded. Then, at a height of 1.2 m and up to the down hole, the concentration of microparticles was again established. The data on the mineral composition and percentage of microparticles in ice were not provided in the paper.

Greenland. The Greenland ice sheet is the most powerful in the Northern Hemisphere; the largest thickness of ice is 3416 m. Its dimensions are comparable with the hypothetical Scandinavian ice sheet. In different parts of the Greenland cover, ice was drilled through five deep holes with separation of ice core.

North western part of the ice sheet. At the Camp Century station, the ice sheet was drilled through by the American drilling technicians in 1968. The hole reached the ice bedrock at a depth of 1391m. Ice throughout the section was clear, but at the bottom of the glacier, 15.7 m thick ice mass containing dust-like and fine-grained substances was revealed. This layer of ice was determined by the repeated alternation of thin layers of clean ice and fine-grained contaminated ice. Particle sizes of moraine material in this debris-containing ice (as the authors call it) varied from less than 2 microns to millimetre particles and small clots of these particles.

By weight, the average concentration of dust-like matter was 0.24%, and by volume, it was 0.10 – 0.12%. There were no fragments with the dimensions of boulders in this debris-containing ice (or bottom moraine in the terminology of V.M. Kotlyakov).

In another article, these authors describe the same core section as the 17-metre mass of debris-containing ice with a high content (0.24% by weight) of moraine material, with a slight increase in particle size to the upper parts of the mass. The authors again refer to the micron sizes of particles. Apparently, finding of the bottom moraine in the section of the cover glacier was crucially important, therefore microparticles and clots of microparticles were readily recorded in it. When such bottom moraine melted, a thin cover of dusty-clay substance about 1.5 – 2 cm thick was formed.

Southern part of the ice sheet. In 1981, drillings were completed at the station DYE-3 (US-European programme). According to the drilling data, the ice thickness at the station is 2037 m. The ice core at different depths, i.e. 500 m, 901 m and 2030 – 2035 m, contains mineral inclusions represented by volcanic ash in various concentrations from low to noticeable and high. The age of ice at the bed is estimated at 125 – 150 thousand years.

Central part of the ice sheet. In the centre of Greenland, the ice sheet was drilled through two holes – GRIP-1 hole (European project) and GISP-2 hole (US project). The first hole reached the subglacial bedrock at a depth of 3029 m in 1992. The GISP-2 hole is located 30 km southwest of the first hole; its drilling was completed in 1993. The hole has a total depth of 3053 m, of which 1.55 m passes through the rocks of the bed (thus, the thickness of ice is slightly more than 3051 m). Therefore, the mysterious central part of the ice sheet was drilled at once through two holes. Did ice form the powerful debris-containing mass and generate the bottom moraine in the centre of glaciation? No, it did not. In the bottom part of ice, only insignificant inclusions of dust-like matter in the form of separate spots were noted.

Northern part of the Greenland glacier. This important glaciological subarea is characterised by the hole drilled within the North Greenland Glacier Project. The hole is located in the centre of Northern Greenland at an altitude of 2921 m above sea level. Drilling began in 1996 and finished in 2004. As a result, the ice sheet 3091 m thick was drilled.

In 2003, reddish brown subglacial fresh water poured into the hole at a depth of 3085 m and rose up to 43 m. In 2004, after a break, the drill line reached the bed at a depth of 3091 m and partially drilled the underlying bedrock, i.e. red sandstones. According to the description of the core, the ice mass throughout the section was represented by ice that did not contain noticeable mineral particles.

Ice exposed in the bottom part of the glacier had an unusual reddish-brown colour (the same as water, subsequently frozen). But here drillers and glaciologists faced a great shock: a small piece of relict wood was discovered in the core of lake ice. Apparently, during drilling, water in the ancient lake was stirred and the lightest bottom fraction – a piece of wood, froze into newly formed lake ice.

TUTO ice tunnel. In the north western part of Greenland, a special TUTO ice tunnel was laid along the joint of the cover glacier and the bed. Mineral particles were detected in ice, and ice was referred to as debris-containing. The amount of mineral inclusions was not reported, but it was indicated that these inclusions had micron dimensions and that they were absorbed into the bottom of the glacier by freezing-sticking processes. The studies using an electron microscope showed that the identified smallest grains and flakes of minerals were related to quartz, feldspars and silica deposits, and they did not have any treatment, as all grains were weathered.

Thus, all 5 holes that were drilled through the Greenland ice sheet and the TUTO ice tunnel provided unique materials on the so-called bottom moraine and on debris-containing ice. Cover ice and even outlet glaciers did not carry any blocks or boulders, but only dust-like, fine-grained inclusions. This was the real bottom (main) moraine, i.e. it was a thin blanket of sandy-clay matter, dust-like in a dry state.

Antarctica

In the Antarctic ice sheet in its various regions, six deep holes reaching the bed have been drilled. In addition, the Ross, Ronne-Filchner, Amery, Lazarev, and Shackleton ice shelves have been thoroughly drilled.

Byrd Station (US). It is located in West Antarctica. In 1968, a hole was drilled through the ice sheet here and it reached the bed at a depth of 2164 m. The study of the ice core revealed that the bottom part of the glacier included a mass of debris-containing ice (bottom moraine according to V.M. Kotlyakov) with a thickness of 4.83 m. The mass was represented by the alternating layers of transparent ice and ice containing mineral inclusions of sand-clay dimensions. As for the fine earth, it was assumed that it got into ice during the freezing process, i.e. sticking of the bed sediment to the bottom part of the glacier.

Vostok Station (Russia). It is situated in the central part of East Antarctica. Drilling of the 5G-1 hole began in 1990. In February 2011, ice was drilled to a depth of 3720.4 m. The hole entered lake ice of the very large subglacial Lake Vostok, and most of this ice had already been drilled. According to media reports, the hole penetrated through entire lake ice and entered fresh water of Lake Vostok in late January 2012. The total thickness of drilled ice was 3769.3 m.

Lake Vostok is larger and much deeper than Lake Onega. According to the geophysical data, the depth of this Antarctic lake (i.e. the thickness of lake water) is 700 m and in some areas of the lake it is up to 1200 m and even 1500 m.

Glacial ice drilled through the 5G-1 hole contained mineral and organic inclusions at depths of 3311 m, 3538 m, 3608 m. The article by V.M. Kotlyakov (2004) describes these moraine inclusions (as they are called in the paper), namely, volcanic ash, microparticles of meteorites (cosmic dust), as well as spores and pollen of plants. The percentage of these dust-like particles was not given. Boulders or at least crushed stones were not noted throughout the section of the ice mass.

Kohnen Station (Germany). It is located in Queen Maud Land. According to the drilling data, the ice thickness is 2774 m. At this depth, water appeared in the hole in 2006 and rose to a height of 80 m. According to the reports, there were no inclusions of any mineral substance in the bottom layers of the glacier [5]. The age of ice in the down hole was 900 thousand years.

Dome F Station (Japan). It is situated in East Antarctica (from the Indian Ocean) on the so-called glacial cap F. The hole was drilled in 2003-2007. It reached the ice bed at a depth of 3044 m. Dust-like inclusions were noted near the down hole, and the ice age near the bed was estimated at 1 million years. This means that it had been tied-up without movement for the entire Quaternary period. Also, the entire Quaternary period – 900 thousand years, bottom ice had been lying at Kohnen station, thus completely preserving the preglacial surface.

Dome C Station (European programme). It is located in East Antarctica (from the Pacific Ocean) on the glacial cap C. Having passed through the thick mass of ice, the hole (it was drilled in 2000 – 2005) reached the bed at a depth of 3270 m. No mineral inclusions were detected along the ice section; there were no significant mineral or other inclusions in the bottom layers of ice. The age of ice in the down hole near the glacial bed was estimated at 800 thousand years.

Law Station (Australia). It is situated off the coast in East Antarctica. In 1993, the hole reached the bed at a depth of 1196 m. There were no moraine inclusions along the ice section, unless dust-like inclusions were regarded as them.

The fact was the complete absence of blocks and boulders in debris-containing ice of Antarctica (instead of them there were sparse inclusions of dust-like matter called debris). Scientists assumed the glacial grinding of non-existent coarse fragments into flour. What can be said? Firstly, "glacial flour" was contained in ice in scanty amounts, and secondly, the bulk of this "flour" was represented by volcanic ash, and some by microscopic terrigenous and cosmic matter. Was the glacier capable of grinding meteorites into flour? However, such glacial theory is refuted by the presence of subtle plants spores preserved in its original form in debris-containing ice. Or does it reveal the selective glacial grinding activity?

At the meeting on the Quaternary period in 2011, while discussing the report of one of the authors of this review, some scientists argued that when drilling the glaciers, the holes “sidestepped” and “circumvented” blocks and boulders, therefore the large fragments were not recorded. It turns out that if necessary, the drill line can snake around! But for how long will such reptile resembling drilling extend the predominance of the glacial theory?

It is interesting how glacial scientists will recognise such facts that the boreholes of core drilling of the glacial masses in Antarctica and Greenland were not transferred by moving ice, although drilling of each three-kilometre hole takes several years. This means that moving continental ice is not able to displace steel core pipes. And equally, it cannot move boulders, since moving ice just flows around steel pipes and boulders (if they are present on the subglacial topographic surface).

Dynamics of ice sheets. John Nye’s formula [4]

John Nye is the professor of physics at the University of Bristol and the fellow of the Royal Society in the UK. The Nye’s model is based on the theory of plastic movement of glacial masses; it is expressed by the famous mathematical formula of Nye:

$$\tau = \rho g h \bullet \sin\alpha,$$

where τ – stress of shear,

ρ – density of ice,

g – gravitational acceleration,

h – depth of ice,

α – slope angle of glacier surface,

pgh – weight of ice column.

R.B. Krapivner considers several glaciological hypotheses, but pays most attention to the theory of J. Nye, further substantiating its validity. Krapivner’s analytical conclusion is as follows: contrary to the canons of the glacial theory, the cover glaciers are unable to form boulder block moraines and to transfer boulders. It goes without saying that they also cannot tear away rock blocks (small and super-huge) and cannot displace rocks of the platform cover.

The Nye’s formula and the disclosed mechanism of ice sheets movement are viewed by glaciologists and academic scientists as the established model of movement of the ice covers and ice sheets. That is the conclusion of scientists of the All-Russian Geological Research Institute F.A. Kaplyanskaya and V.D. Tarnogradsky, which is given in their book “Glacial Geology” (1993): “An important universal evidence-based conclusion from the Nye’s formula is that glaciers move in accordance with the slope of their surface, but not with the shape of the bed”. This is precisely the process of flowing, sliding of the accumulated surface ice masses along the slope of the surface of the ice sheet itself. In case of the large thickness of cover ice, inequalities in the postglacial relief are irrelevant, as the glacier smoothly flows along the buffer bottom layer of ice, which levels the roughness of the relief.

This viscous and plastic spreading of ice over ice is the physical essence of the dynamics of the ice covers, i.e. the bottom mass of the glacier remains geologically inert and motionless and it is not engaged in the geological and tectonic activity that the glacial theory stipulates.

Who needs such “incompetent” ice covers? Was the Seligman Crystal undeservedly awarded to J. Nye? His famous formula undermines the glacial theory and shatters the usual tectonic activity of ice covers. The results of subjacent drilling of ice in Greenland and Antarctica perfectly confirm the Nye’s model.

Some proponents of the glacial theory seem to gradually understand this. However, they have not banned the Nye’s formula yet; within the selected audience they simply introduce the fact that, despite defamation, the glacier has to maintain ploughing and squeezing. Kaplyanskaya and Tarnogradsky assert just that the formula is a formula, and no one exempts the glacier from the geological and tectonic activity on destroying the subglacial crystalline rocks and transferring the blocks and boulders hundreds and thousands of kilometres away.

P.S. Voronov and M.G. Grosswald criticise the Nye’s model in the vivid way: “Ice viscously and smoothly flows down the slope of the glacier surface, and it is compatible with the movement of ice along the planes of internal fractures. Otherwise, the sliding of ice on ice cannot explain anything”. Here, the proponents of the glacial theory are right. Scientists are trying to resolve the deadlock, thus returning to the old theories about vigorous exaration of the bedrock by the bottom layers of ice. But they overlook the velocity diagrams of the ice movement in the vertical sections of the cover glaciers, which was empirically determined when drilling the glaciers. The glacier diagrams indicate that the zero velocity of the ice movement is recorded in the bottom layer of ice, along with its gradual increase up the section of the cover glacier. The incapacity of the glacier to plough the bed is confirmed by the absence of boulders or even isolated particles of crushed-stone dimension in its section, including in the bottom layers of the glacier. There is dust-like matter, albeit in scanty amounts, but its mineral composition is not presented, since it is mainly volcanic ash and dust from distant deserts. The aeolian processes are under way, while the glacial processes are extremely passive, as they were in the past and present. But, apparently, glaciologists do not want to accept these reasons. V.I. Astakhov and his colleagues diligently refer to the formula of J. Nye and the conclusion of F.A. Kaplyanskaya and V.D. Tarnogradsky: “In the ice sheets lying on the flat base, the movement of ice is determined by the slope (shape) of the glacial shell surface... In the ice sheets and caps, ice is slowly spreading according to the law of viscous and plastic bodies flow”. But these scientists assume that the glacier should be engaged in the significant exaration and tectonic activity.

Recently, the proponents of the glacial theory argued that the strongest glacial exaration and glacial ploughing took place in the central glacial zone and exemplified the Baltic Shield. And now the reverse is true, thin ice on the glacier periphery is the main zone for the robust activity of the glacier!

The glacial theory constantly shows extraordinary agility. R.B Krapivner emphasises: "The glacial theory is extremely outdated, but it is unusually resilient, since it has no boundary conditions and it is constantly changing, complicating its own principles and solid scientific guidelines". But at the same time, vague publications of glaciologists receive grants from the Russian Foundation for Basic Research!

Special long-term research of glaciologists, both Russian and foreign, showed that in the bottom layer of the cover glaciers – whether it is the central or peripheral glacial zone, the tangential stresses retain their scanty values. Based on the materials collected by P.A. Shumsky and M.S. Crass in different parts of the Greenland and Antarctic ice sheets, they range from 0.02 – 0.05 bar and up to 0.06 – 0.01 bar. According to the studies of prominent tectonist A.V. Lukyanov, the shear stresses at the joint of the ice sheets and the bedrock are within the range of 0.01 – 0.05 – 0.015 bar, i.e. they are also extremely low. In their monographs famous glaciologists W.F. Budd and W. Paterson provide the low values of the tangential stresses in the bottom layer of the ice sheets. Such scanty stresses reliably determine the immobility of the lower horizons in the cover glaciers, since they are unable to overcome the fundamental friction force. Only the overlying masses of ice move and spread, and here J. Nye is right.

Summing up this chapter requires the conclusions of modern Arctic and Antarctica glaciers researcher and prominent glaciologist D.Yu. Bolshiyanov "The Nye's formula generates one more view on the theoretical developments in glacial geology – these are considerations that the movement of the cover glaciers does not depend on the slope of the bed, but on the slope of the surface of the glacier". In addition, D.Yu. Bolshiyanov also concludes: "The main principles of glacial geology are not confirmed by the observations of modern glaciers. This, in turn, means that the theoretical developments in glacial geology are based on misunderstanding of the mechanism of the glacier movement" [5].

Against logic and common sense, the proponents of the glacial doctrine charged the cover glaciers with completely uncharacteristic functions and processes: fault and plicative tectonics, glacial earthmoving dislocation and tearing away of the bedrock, and formation of numerous glacial exaration relief forms that actually have the fault-tectonic origin. There is a great confusion in the glacial theory within capturing and transporting the boulder-block material. It is time to understand that it is not a case for the cover glaciers to transfer blocks and boulders. One way or another, subjacent drilling of the ice sheets in Greenland and Antarctica initiated trapping of the glacial theory. If it was allowed to drill ice, it was necessary to completely classify the results of drilling, in any case, to prevent their publication in scientific journals.

Origin and mechanism of typical exaration relief formation

R.B. Krapivner considers the issues relating to the genesis of the glacial exaration relief in three chapters of the book – in the first, second and sixth. In the first chapter, he explores this issue in some detail and refers to his unpublished review of the monograph by V.G. Chuvardinsky "On the Glacial Theory. Origin of Glacial Formations" (1998). Here is an excerpt from the review. "The work of V.G. Chuvardinsky is particularly interesting because it is largely devoted to the results of his research over the several decades on the Kola Peninsula and in Karelia. It is believed that the typical signs of glacial exaration are displayed there clearly, such as roche moutonnées, sheep-like rocks, glacial scouring and rocks polishing, skerry and fjord relief, etc., which have not been previously disputed. The author provides convincing evidence to substantiate the tectonic nature of these phenomena, including the photographs showing that the surfaces, which have been channelled and polished as a result of supposed exaration, extend under the allochthonous tectonic plates in the bedrock. Most often, such facts are established in outcrops illustrating the structure of roche moutonnées, drumlins, fjords and skerries. The conclusion about the tectonic origin of the listed phenomena is confirmed by the data on the extensive development of neotectonic faults of various kinematic types on the Baltic Shield that are visible in the demonstrated aerial and satellite images, as well as in the photographs of roche moutonnées, which are widespread on the shields and ancient platforms in the extra-glacial areas.

The monograph justifiably criticises the proposed within the glacial theory hypotheses on the origin of specific ridge relief forms and the geological bodies that form them, the so-called eskers and drumlins, which are widespread in Karelia and on the Kola Peninsula. The author focuses on the relations of these formations with faults, which have been established by many researchers, and offers the models of their tectonic origin. Analysing the fans of boulders scattering within Finland, Karelia and the Kola Peninsula, V.G. Chuvardinsky substantiates the unconventional concept of tectonic distribution of coarse-grained material along the rise and extension of fault zones of shear type, as a result of which the orientation of these fans turns out to be subparallel to the directions of tectonic scouring, usually taken as the glacial one. The distance of tectonic transportation of coarse-grained material from bedrock sources determined by guide boulders is usually measured in hundreds of metres and several kilometres.

In his book, R.B. Krapivner reports that the review was submitted for publication to the journal “Stratigraphy and Geological Correlation”, but was rejected by the editors following the note written by internal editorial reviewer and staunch proponent of the great glaciations Yu.A. Lavrushin. The note stated: “The review of Chuvardinsky’ book written by R.B. Krapivner represents an advertising article and publishing of this advertising spot means downgrading the scientific rating of the journal”.

Nevertheless, R.B. Krapivner tried to publish his review and sent a well-reasoned letter to chief editor of the journal and member of the Russian Academy of Sciences B.S. Sokolov. Here are the last lines in the letter: “I earnestly request you to reconsider the possibility of publishing my review in your journal. The right moment to render it to another journal has been missed. The 6.5-page review was received by the journal on 2 March 1999 and was rejected on 4 November 1999. The monograph of V.G. Chuvardinsky came out in 1998”. There was no reply to the letter. The tactic of suppressing the fundamental anti-glacial work played out successfully.

In the sixth chapter, R.B. Krapivner specifically considers the issue of forming fjords on the Baltic Shield, but primarily he covers the origin of the hypothesis on glacial ploughing in the crystalline rocks of the deepest fjords and their unjustified transformation into one of the main foundations of the powerful glacial theory. R.B. Krapivner conducted works on the Murmansk coast of the Kola Peninsula – an area of large and small fjords. Using satellite images and ground-based studies, he came to an unambiguous conclusion: the fjords on the Kola Peninsula and in Fennoscandia in general have the fault-tectonic genesis, and neither cover glaciers, nor gletchers took any part in their formation.

As far as the presence of scours and channels on the granite slopes of fjords, polishing of rocks, and development of skerry relief with roche moutonnées and sheep-like rocks in the outlines of fjords are concerned, their fault-tectonic genesis only reinforces the conclusions about the fault origin of fjords.

But since the proponents of the glacial doctrine are not going to abandon their glacial origin, it is useful to summarise evidence of the fault-tectonic genesis and other forms of exaration relief. 20 years have passed since the academic editors rejected releasing the review by Krapivner (he published it in his 2018 book). But now we can see that the issue of the fault-tectonic genesis of this relief was clarified back in 1998.

Further studies led to the most important addition: the formation of medium and small forms of exaration relief – roche moutonnées, sheep-like rocks, scours and channels, polishing of rock surfaces on several tectonically active structures (especially in the Northern Lake Ladoga area) continued in the Holocene, i.e. after the hypothetical glacier disappeared. Chuvardinsky will explore this issue in a new monograph.

The conclusions on the genesis of the exaration relief (based on the works of V.G. Chuvardinsky) are generalised below.

Studies on the Baltic Shield, an area of classical and diverse forms of exaration relief, confirmed that this relief is of the fault-tectonic origin. The widespread use of aerial and satellite images, in combination with thorough groundwork, showed paragenetic relations between the exaration relief and neotectonic faults, as well as the zones of recent tectonic activity. Summing up the data collected over many years, the main conclusions are as follows:

1. The crystalline basement of the eastern part on the Baltic Shield is broken by the dense network of neotectonic faults, among which deep, regional, and near-surface faults are distinguished: shift thrusts, up-thrusts, down-thrusts, over-thrusts, and expansion thrusts.

2. The systems of deep and regional neotectonic faults and large exaration relief forms, such as fjords, skerries, lake basins in crystalline rocks form single parageneses. The indicated forms of exaration relief geomorphologically reflect the latest fault formation and neotectonic dislocation along the faults against the background of the Precambrian crystalline shield experiencing the horizontal tectonic compression.

3. Paragenetic relations have been established between smaller exaration relief forms (roche moutonnées, sheep-like rocks, polishing of rocks, scours and channels systems) and such structures as over-thrusts, up-thrusts, down-thrusts, and shift thrusts. The large-scale development of these relief forms is observed at the ends of major shifts. In fact, they represent the fault displacement planes and slickensides of the listed disturbed structures, especially near-surface over-thrusts and numerous shears, their displaced elements were destroyed by small block material, which was subsequently displaced to the base of the slopes in line with the law of gravitation. The formation of channels, scours, and roche moutonnées continued in the Holocene.

The fault-tectonic genesis of these structures is additionally confirmed by the following data:

a) The outline of large outcrops displays the immersion of polished and channelled slopes of roche moutonnées and sheep-like rocks under the upthrown walls of over-thrusts, up-thrusts, and smooth down-thrusts.

b) The polished surfaces of typical roche moutonnées of the intra-block origin are massively exposed in intrusive massifs during the gravitational sliding of rock blocks.

c) The slickened surface of roche moutonnées is covered with a film of milonised rocks, while the systems of channels and scours have a parallel and subparallel arrangement typical of tectonic structures.

The presented diverse morphostructures and tectoglyphs of slickensides are included in the range of consequences and signs of the latest tectonic dislocations, which is essential for geodynamic studies and paleogeographic reconstructions, as well as for the reliable abolition of the glacial theory. Materials on the tectonic genesis of fjords, skerries, and lake basins also contribute to this objective.

The largest types of exaration relief – fjords, lake basins, bedrocks, and skerries, are laid along to the system of regional and deep faults of the crystalline basement. The confinement of these formations to neotectonic faults is clearly traced in space images, their configuration is associated with the system of orthogonal faults. Fjords, skerries, and lake basins, often oriented in four directions, have sharp knee-shaped or cross-type folds, their greatest depths are recorded at the intersection of orthogonal faults.

The relief forms laid along the faults of tectonic compression are distinguished. In this case, numerous shears, secondary over-thrusts, tectonic slickensides, scours and channels are developed on their sides. The relief forms laid down along the extension faults are characterised by the separations and dislocations, while polishing and scouring are not typical of them.

When assuming the tectonic genesis of fjords, skerries and lake basins, there is no need to resort to unrealistic ice structures, to glacial ploughing in the crystalline rocks of deep basins, ravines and valleys. It is customary to accept especially deep glacial exaration during the formation of fjords – up to 2.5 – 3 km (!).

Large glacial erratic masses and glacial dislocations, their origin and formation mechanism

Large glacial erratic masses and glacial dislocations have always been a stronghold of the glacial doctrine. In scientific papers, the largest, sometimes giant, glacial erratic masses from the platform cover have always been used to illustrate the enormous glaciotectonic, earthmoving and cutting activity of the ice sheets. Ordinary geologists and academic scientists could not even think that the continental glaciers bear no relation to this natural wonder.

Having faced with these phenomena in Western Siberia and then in European Russia, field production geologist Rudolf Borisovich Krapivner decided to thoroughly study them in order to establish their true origin. He managed to explore the outcrops of a number of these structures and to analyse the available drilling materials, geological and geophysical data. Additional drilling of the most indicative large glacial erratic masses and glacial dislocations was carried out, and as a result, thorough evidence of their fault-tectonic and plicative-tectonic genesis was collected.

Works on studying the disturbance neotectonics, especially deep faults, and original tectonophysical models of Krapivner greatly clarified the mechanism of forming these intra-platform structures.

The monograph "Crisis of the Glacial Theory: Facts and Reasons" examines the origin and formation mechanism of large glacial erratic masses and glacial dislocations in different parts and chapters. The author uses materials on Quaternary geology, geomorphology, and especially on the dynamics of modern ice covers in Antarctica and Greenland.

The previous monograph by R.B. Krapivner "Rootless Neotectonic Structures" (Moscow: Nedra Publ., 1986, 204 p.) and his significant publications in the journal "Geotectonics" may prove useful for readers.

In the introduction of the book under review, Krapivner informs: "The striking point has long been the origin of the surface (rootless) dislocations of the Quaternary and pre-Quaternary sediments, as well as allochthonous rock blocks, which are considered as large glacial erratic masses". The doctor's thesis of R.B. Krapivner "Structure and Conditions for the Formation of Near-Surface Neotectonic Dislocations" (1990) is devoted to solving this problem using the methods of tectonophysical analysis. The defence took place at the Institute of Physics of the Earth (Russian Academy of Sciences). The extracts from the transcript of defence are given below.

Having curtained the hall walls with geological sections and diagrams, the speaker valiantly substantiated the tectonic origin of the glacial dislocations and large glacial erratic masses, explained the mechanism of these geological phenomena formation.

In his book "Cold on the Traces" (1975), famous science communicator R.K. Balandin wrote on this topic: "If anti-glacialists managed to explain the origin of the large glacial erratic masses and glacial dislocations one way or another, a dangerous gap would have appeared in the glacial theory".

Krapivner did not explain the origin of these formations "one way or another". He gave a rigorous tectonophysical justification of the conditions for the formation of the large glacial erratic masses and glacial dislocations, showed their geological and tectonic structure on the structural diagrams and sections, built on the results of drilling specific natural sites and their geological and geophysical study.

The conclusion of R.B. Krapivner was pronounced: the glacial dislocations and large glacial erratic masses from the platform cover are associated with the deep faults of the Earth's crust; they formed as a result of discontinuous tectonic dislocations and manifestations of diapirism in the neotectonic era. Readers might be advised to read the book by R.B. Krapivner

“Rootless Neotectonic Structures” (Moscow: Nedra Publ., 1986), which thoroughly and reasonably examines the formation of these tectonic structures underlying the glacial theory.

Meanwhile, R.B. Krapivner was at a disadvantage. The clerks were not in his favour: two official opponents (out of three) wrote up the report for his thesis. Collective negative reviews were read (positive reviews were not released; they were present, but their contents remained unknown). Many council members disapproved of the conclusions of the applicant: “How can one deny the glacial nature of these giant formations? Everyone knows that this results from the glacier activity, no other force can disturb the layers of rocks, tear them away”. It vibrated in their questions and speeches. They clearly wanted to prevent a gap in the usual paradigm. However, it had already been opened by the aforementioned book. The thesis though reinforced the book, but did not change the matter.

Suddenly in the midst of discussion, member of the Russian Academy of Sciences M.A. Sadovsky appeared in the conference hall and took the floor. Pointing to the numerous geological sections and structural diagrams, he highlighted the significant evidence basis of the thesis and summarised: “This is an outstanding structural and tectonic work, and the author’s innovative approach to the issue and the controversial nature of the thesis only strengthens his reasons”.

Hardly, but the necessary two-thirds of favourable votes were gained.

The large glacial erratic masses and glacial dislocations will be considered further. The study and revision of their genesis are directly conducted by R.B. Krapivner.

Large glacial erratic masses

The Vyshnevolotsky-Novotorzhsky shaft is widely known in the literature on geology. It is the range of the largest glacial erratic masses in Europe. In papers, this shaft is usually featured as an example of the enormous dislocating and transporting activity of the glacier. Indeed, the phenomenon is remarkable. The length of the almost meridional ribbon of the large glacial erratic masses is 120 km (from Lake Mstino to the town of Staritsa), the width is 10 – 15 km, and the relative height is 70 – 87 m. The glacial erratic masses of the shaft are represented by rocks of different ages and diverse lithological composition. They are sands, limestones and carbonaceous clays of the Lower Carboniferous, deposits of the Upper Devonian, and rocks of the Silurian (Ordovician) and Lower Cambrian. The structure of the shaft also involves limestones of the Middle Carboniferous (the shaft is located in this territory) and boulder-block deposits underlying the large glacial erratic masses.

According to the conclusions of several researchers, the large glacial erratic masses were transported by the glacier from two main areas. Limestones, sands and carbonaceous clays of the

Lower Carboniferous were moved from the Valdai Hills 150 km away (A.I. Moskvitin, D.B. Malakhovsky, E.Yu. Sammet, and Yu.A. Lavrushin). The sediments of the Silurian (Ordovician) and Lower Cambrian were dragged by the glacier from the region of the Finnish glint 330 km away. No one indicated the place of origin of the torn deposits of the Upper Devonian. However, all these rocks are local and the undisturbed section of the platform cover in this area was opened by the hole in Kuvshinovo, 30 km west of the shaft. It can be stated that all rocks in the section of the sedimentary cover are involved in the structure of this belt of glacial erratic masses: clays of the Lower Cambrian, deposits of the Ordovician and Upper Devonian, rocks of the Lower Carboniferous – limestones, sands, carbonaceous clays, limestones and marls of the Middle Carboniferous, and boulder-block deposits.

According to R.B. Krapivner, the belt of large glacial erratic masses is associated with the neotectonically active Torzhok fault of the up-thrust and shift thrust type, which joins the Kresttsovsky aulacogen in the north. The torn position of the rocks of the Lower Carboniferous, Upper Devonian, Ordovician, and Lower Cambrian is connected with their surfacing by secondary up-thrusts and shift thrusts from the upper, middle, and lower horizons of the sedimentary cover – from a depth of 100 – 150 m (limestones, clay, and sand of the Lower Carboniferous) and from a depth of 1000 – 1200 m (clays of the Lower Cambrian).

Apparently, the boulder-block formations constitute the tectonic breccia of the basement and cover, and they were brought to the surface along the same faults.

The statement of famous geologist V.D. Sokolov voiced back in the 1930s is quite reasonable: “The Vyshnevolotsky-Novotorzhsky shaft is the geotectonic axis of the Kalinin region, i.e. its minerals turned to the surface”.

Large number of the glacial erratic masses of the Cambrian and Ordovician rocks (their specific blocks reach 8 million m^3) and tectonic breccias (referred to as glacial breccias) from the Devonian, Ordovician and Cambrian rocks are mapped in southern Lake Ilmen area along the Lovat, Polist and Porusya Rivers. D.B. Malakhovsky and E.Yu. Sammet believe that the glacier brought these large glacial erratic masses from the area near the southern coast of the Gulf of Finland. A.P. Karpinsky identified the considered ribbon of glacial erratic masses as a large fault-tectonic structure, i.e. the Polistovsky-Lovatsky shaft with a length of 90 km. Having analysed data on tectonics and geology in this region, R.B. Krapivner came to the conclusion about the actual existence of this neotectonically active structure, also associated with the Kresttsovsky aulacogen.

It can be emphasised that the set of glacial erratic masses from this submeridional fault zone also corresponds to the section of the sedimentary cover in this area. Obviously, there is no need for a hypothetical glacial movement of the large glacial erratic masses over hundreds of kilometres. The distance of their transposition is only a few hundred metres, a thousand times smaller than attributed to the glacier. They are removed from the dislocated section of the cover along the up-thrusts and shift thrusts, which make up the structure of the Polistovsko-Lovatsky shaft.

According to R.B. Krapivner and I.L. Zayonts, the formation of the well-known Samarovsky and Yugansky large glacial erratic masses in Western Siberia is associated with the tectonic surfacing of blocks and scutes of the Lower Eocene silica clays (Samarovsky large glacial erratic mass) and Jurassic silt stones and clays (Yugansky large glacial erratic mass). The amplitudes of the vertical tectonic movements of the allochthonous blocks of the silica clays reach several hundred metres, and those of the Jurassic clay rocks in the Yugansky large glacial erratic mass – up to 2.6 – 2.8 km.

In general, the studies show that clay diapirism processes are most extensive in Western Siberia. The large-amplitude intra-cover dislocations and glacial erratic mass blocks of the Jurassic, Cretaceous, and Paleogene rocks surfaced by the clay diapirism processes are identified in different areas of the West Siberian Plain. For example, it is proved that the large glacial erratic masses of the Upper Cretaceous rocks were brought to the surface along the Lyamin River from a depth of 850-900 m as a result of the clay diapirism processes, and evidence is provided of the surfacing of the large glacial erratic mass of the Upper Cretaceous rocks from a depth of 900 – 1000 m during the formation of the massive diapir structure (the area of the Siberian ridges).

Dislocations

Kanevsky dislocations. R.B. Krapivner and A.I. Yudkevich, based on the detailed analysis of data from the previously performed drillings and electric explorations and their own research, also came to the conclusion about the tectonic nature of the Kanevsky dislocations. According to their materials, dislocations are represented by a series of allochthonous plates of the northwest extension, in which Mesozoic and Cenozoic sediments, including alluvial, are involved. The amplitude of the horizontal overlap of the Quaternary alluvium is 400 – 450 m, and the vertical displacement of the scutes is up to 200 – 250 m. The available data show that dislocations are part of the extended zone of dynamic influence of the Dnieper fault. In the neotectonic era, it functioned as a left shift with the up-thrust component of the walls displacement. As a result, the near-surface part of the cover section (to a depth of 200 – 250 m) over-thrusted to the right bank of the Dnieper River, forming the Kanevsky ridges consisting of a series of over-thrust scutes, i.e. skibs.

It is time to explore what the studies of the ice sheets in Greenland and Antarctica and data on their subjacent drilling contribute to. Was the earthmoving effect in real (and not imaginary) glaciers identified? These materials and conclusions on them are presented in the initial sections of the book by R.B. Krapivner. It is useful to summarise the main ones.

1. Cover ice in Antarctica, Greenland, and on the Arctic islands do not exarate and do not dislocate the underlying rocks; their section, including the bottom layers of glaciers, reveals only dust-like fine-grained inclusions, mainly of the ash and volcanic origin.

2. The lower bottom layers of glaciers do not participate in the general movement of ice; for hundreds of thousands of years they have been tied-up for hundreds of thousands of years and have been protecting and preserving the preglacial geological surface.

Nowadays, it is becoming apparent that cover ice converts from the stronghold of the glacial doctrine into the driver of its debunking, while the theory of earthmoving and cutting glacial effects transfers to the category of erroneous and ridiculous assumptions.

Field geologists need to remember the conclusion of French tectonists J. Goguel, which is supported by R.B. Krapivner: “In the vast majority of cases, the sedimentary cover tectonics is caused by the deformations of the basement”.

Pechora and West Siberian Plains

The origin of the relief and boulder loams on the Pechora and West Siberian Plains is considered by R.B. Krapivner in the third chapter. Of particular interest is the layering of the relief in the vast valley of the Pechora River, as well as the spread of marine transgressions of the Quaternary period. Much attention is paid to marine transgression, which left sea terraces and barrier beaches at 90 – 120 m above sea level. The author refers to this limit of the sea as the Chuleysky mass (coastline of the Chuleysky basin).

In the papers on the glaciation of the Pechora Plain, this sea level is usually interpreted as preglacial Lake Komi. But the findings in the sections of the 100-metre marine terrace of marine borer shells and foraminifera complexes refute the entire paleogeography of the proponents of the great glacier, though they keep repeating their version that the glacier dragged marine fauna from the shelf of the Arctic seas. Allegedly, this ice shelf also blocked the flow of the Pechora River, having formed huge Komi Lake, but glaciologists cannot explain the presence of natural marine complexes of foraminifera and findings of shells with closed flaps in the sections of the 100-metre terrace and in the mass of the glacial-marine boulder loams (or diamicton, according to Krapivner).

In 1966, the landmark collective monograph “Geology and Prospects of Oil and Gas Potential in the Northern Part of the Timan-Pechora Plain” [6] was published. Based on solid factual material, the authors concluded that there were no continental glaciations in the basin of the Pechora River. They were the first to map the sea levels at marks of 90-120 m. The geologists led by P.N. Safronov attributed these levels to marine transgression, called the Keynmusyursky, i.e. the marine phase of the Boreal Sea. It is this phase that is most evident on the slopes of the uplands (the so called musyurs), ranging from the Pechora Sea to the middle reaches of the Pechora River.

P.N. Safronov in the chapter “Relief geomorphology and development” states: “The position of the sea level in the Keynmusyur phase was most stable during the reliction of the Boreal Sea, which is confirmed by the clear forms of abrasion and aligned coastline of large lagoons due to the barrier beaches and coastal shafts”.

The third chapter of the book “Crisis of the Glacial Theory” presents data on the tectonic genesis of glacial dislocations on the right bank of the Lower Pechora River – large outcrops of Vastiansky Kon and Markhida – the stronghold of glaciation in the Pechora area. This chapter provides evidence of the ice-sea genesis of diamicton (former moraine) and points to the extension of the valleys of the Pechora and Ob Rivers and the shelf of the Barents and Kara Seas. This also indicates that the shelves of these seas were drained at certain stages of the Quaternary, but were not a ground for the hypothetical cover glaciations of the shelf in the Arctic seas.

Shelves of the Barents and Kara Seas

R.B. Krapivner collected extremely vital and extensive factual data during marine expeditions to study the shelves of the Kara and especially Barents Sea. These issues are examined in the fourth and fifth chapters of the book. During these studies, the main emphasis was placed on exploring the processes of Quaternary and modern sedimentation, analysing lithological types of sediments, and determining the facies composition of poorly consolidated modern silts.

The following discoveries of R.B. Krapivner are particularly interesting for marine geologists and Quaternary geologists. The results of offshore drilling and studies of core from numerous soil samplers indicate that the composition of the upper structural layer on the shelf is dominated by massive, poorly sorted sand-clay deposits mixed with erratic and local coarse-grained material. These deposits sometimes reach great depth (hundreds of metres), but usually amount to tens of metres. The glaciologists used to consider these sediments as glacial, moraine, and till. R.B. Krapivner regards them under the term “diamicton” and gives crucial evidence of their marine (glacial-marine) genesis. R.B. Krapivner specifies: “Diamicton, like diamicton silt, almost everywhere contains the foraminifera fauna, which forms regular thanatocoenosis”, indicating the normal salinity of seawater during the formation of diamicton and diamict silt.

In addition, a pinniped bone was found in the section of diamicton in the Pechora Sea.

Another discovery by Krapivner is establishing the marine genesis of belt-layered silts and varved clays, which have always been viewed as generated by the glacier, its fluvio-glacial waters. But glacial waters are not evidenced by rich foraminifera complexes contained in belt sediments. This microfauna also forms regular thanatocoenoses.

Lithological and paleogeographic studies of R.B. Krapivner on the shelves of the Barents and Kara Seas and on the Arctic islands prove that the shelves of these seas were not covered by continental ice in the Quaternary, and the Arctic islands had ice caps, similar to the present ones.

Norwegian marine geologists also contradict the ideas of cover glaciation on the Barents Sea shelf in the Late Cenozoic. According to their materials, even in the area of the Spitsbergen archipelago, the Barents Sea was ice-free and it was characterised by high productivity and abundance of planktonic foraminifera. At that, the temperature of seawater was +3 – +4°C [7].

On glacial isostasy of the Baltic Shield

The idea of downwarping of the Earth's crust of Fennoscandia caused by the glacial load has become increasingly common among glaciologists. Conversely, when this load disappeared due to melting of the glacier, the crust lifted hypsometrically. Scientists differ in measuring the glacial isostatic rebounds within the Baltic Shield: M. Sauramo as 500 – 700 m, A.A. Nikonov as 400 m, and B.I. Koshechkin as 1200 – 1300 m. The Earth's crust downwarped by the same value, when the cover glacier was approaching again. What initial data are used in these calculations? First of all, they are based on the idea that Fennoscandia in the Quaternary was covered by the glacier 3 – 3.5 km thick. Therefore, scientists conducted the most basic arithmetic operations based on the density of ice, its thickness and the density of crystalline rocks and assumed that the crust downwarped under ice by one-third of the thickness of the glacier, i.e. on average by 1 km, if the thickness of ice was 3 km. By the same value, i.e. 1 km, the Earth's crust lifted when the glacier melted. Different figures among scientists depended on the thickness of ice, which was taken as a basis by some proponents of the glacial theory.

In the part 6.3.1 of the sixth chapter, R.B. Krapivner consistently shows the inaccuracy of the glacial isostatic theory and provides calculations of the viscosity of the asthenosphere, which is several orders of magnitude higher and the vertical glacial load cannot cause the asthenosphere to spread and the Earth's crust to downwarp. In addition, according to Krapivner, the glacial static nature of the upheaval of Scandinavia contradicts the stable orientation of the maximum horizontal compression of the Earth's crust, which coincides with the direction of spreading in the northern part of the Mid-Atlantic Ridge.

In recent years, tectonics geologists began to recede from the glacial isostatic hypothesis and to explain the downwarping and upheaval of the Earth's crust, including on the Baltic Shield, as the ordinary neotectonic movements. This sparked the unrest among glaciologists: one group of scientists began to tacitly abandon the odious theory, others continued to postulate it and kept mirroring the glacial static schemes of worthy specialists. The record for copying now belongs to Head of the Laboratory of Quaternary Geology (Kola Science Centre, Russian Academy of Sciences) V.V. Kolka, who shamelessly reproduced everything from the old textbook of M.A. Lavrova, who, in turn, borrowed the glacial isostatic scheme of the Kola Peninsula from Finnish scientist M. Sauramo.

Nevertheless, one must pay tribute to one of the former staunch proponents of the glacial isostasy, namely A.A. Nikonov, who dared to abandon the prevalent key glacial hypothesis. In the last decade papers, Nikonov calls this glacial concept "invalid" and not corresponding to the tectonic data, and even views Fennoscandia, instead of the stronghold of the glacial isostasy, as the "underestimated seismic-generating province". This scientist has other new ideas, including: "movements on the Baltic Shield were not caused by the glacial isostasy, but were initiated by pan-regional intra-crust driving forces" [8].

However, the most crucial thing is the acknowledgment among scientists that the Earth's crust on the Baltic Shield is in the state of horizontal tectonic compression, which directly refutes the influence of vertical glacial stresses.

The withdrawal of A.A. Nikonov from the canonical hypothesis is not an ordinary case, particularly because he grounded his doctor's thesis on the glacial isostatic basis and this work was published in the book form in 1977. There was no indication that the basis would be unstable and the doctoral candidate and persistent proponent of the glacial theory would suddenly shift to ordinary neotectonics.

In general, these actions look like the repentance, but other adherents to the glacial doctrine are not going to repent, fearing that the thesis committees and strict Higher Attestation Commission will regain consciousness and require handing over the previously endorsed and awarded doctor of sciences diplomas.

However, R.B. Krapivner warns that there is no need to unanimously renounce the glacial isostasy, it was not present on the Baltic and Canadian Shields due to the absence of glaciation, but in Greenland and Antarctica it can prove out. There is an issue to be addressed.

The papers of prominent geophysicist and member of the Russian Academy of Sciences F.N. Yudakhin can set scientists on the right non-glacial path. He reveals the inconsistency of the theory of the glacial isostasy for Fennoscandia. He writes: "The main reason for the modern upheaval of Fennoscandia is not the glacial isostatic floating, but the presence of the asthenospheric lens in the bottom Earth's crust, i.e. upper mantle. Another factor is the horizontal tectonic compression in the upper layers of the Earth's crust, which directly contradicts the assumptions about the vertical glacial downwarping of shields and platforms. Numerous measurements of stresses in the Earth's crust indicate that in Fennoscandia the horizontal stresses are 10 to 20 times higher than the vertical ones" [9].

Conclusion

In the introduction R.B. Krapivner states: "Once I happened to hear a well-known high-ranking geologist-tectonist saying: "In the past, the cover glaciations undoubtedly existed. I am absolutely sure of this, and do you know why? They exist even now, which means that the glacial theory is absolutely correct".

The conviction of the senior scientist, the tectonist as well, in the accuracy of glacial teachings is remarkable. Nevertheless, he acts as an independent authoritative expert. His conclusion is inescapable, and it sounds the death knell for anti-glacialism.

This obviously inspires the proponents of the glacier and makes some marinists contemplate, who place above all else their personal safety and ability to smoothly defend their theses. But the natural selection does exist, as R.B. Krapivner remains the icon of anti-glacialism, and he even published the landmark book, which in fact abolishes the powerful glacial theory.

At the face of it, the statement made by the high-ranking scientist is mediocre, boring, if not null. Anti-glacialism has never denied the modern ice sheets, on the contrary, the study of glaciological processes has been the essential task. This case, i.e. the subjacent drilling of the ice sheets in Antarctica, Greenland and the ice caps on the Arctic islands carried out within the international projects, produced the long-awaited significant results. It was found that the bottom layers of the ice sheets and ice caps do not participate in the general movement of glacial masses, but the glaciers preserve the subglacial bed and protect it from weathering, and even from the notorious exaration. And yet, the cover glaciers do not penetrate into the bed rocks, do not tear away the boulders and blocks, do not plough, and cannot carry the boulders across the European and American plains. According to the data of drilling and examining the ice outcrops, only sparse inclusions of dust-like matter, mainly volcanic ash, are recorded in the cover glaciers.

Where would anti-glacialists collect facts and reasons for their monographs, if there were no rosy ice sheets, but there would be the continuous interglacial period? It is not clear enough, why R.B. Krapivner did not explain to the high-ranking scientist that the glacial theory is based on the real geological and geomorphological criteria: erratic boulders, moraines, vivid forms of exaration relief, large glacial erratic masses and associated glacial dislocations, esker and pressure ridges. The Krapivner's monograph proves their fault-tectonic and plicative-tectonic origin. All interested will only have to find and explore his books and papers.

In addition, it would be useful to inquire other prominent tectonists, honoured scientists and professors of Moscow State University A.G. Ryabukhin and N.V. Koronovsky about the person, who led them to the iconic conclusion: "The discovery of the ice sheets in Greenland and Antarctica completely dispelled all doubts about the existence of the glacial periods". Did they draw this conclusion on the tip from the brilliant high-ranking tectonist? Oddly enough, many other glacial scientists introduced same assumptions into the glacial theory back in the 1950s. That is the way E.V. Shantser and Yu.K. Efremov inspired scientists at the meeting in Moscow in January 1953: "How can we doubt the continental glaciations of the past when we see the great ice sheets in Antarctica and Greenland?"

What contribution do these ice sheets really make to science? They grant the anti-glacialism a new lease of life and enable better debunking of the glacial doctrine. It is fortunate that the geological creator generated the ice sheets in the polar and circumpolar areas of the Earth. Without their study and subjacent drilling, it would have been much more difficult to explain the effect of the "emperor having no clothes". Although, it took so long to attain.

Let us hope that the outstanding and solid work of Rudolf Borisovich Krapivner and extensive factual data collected in his numerous expeditions will sustain debunking of the glacial theory and its abolition.

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