Lena Pillars Nature Park

Potential World Heritage Property

Fig. 1. Location of the Lena Pillars Nature Park on the map of Russia.

Each State Party to this Convention recognizes that the duty of ensuring the identification, protection, conservation, presentation and transmission to future generations of the cultural and natural heritage situated on its territory, belongs primarily to that State. It will do all it can to this end, to the utmost of its own resources and, where appropriate, with any international assistance and co-operation, in particular, financial, artistic, scientific and technical, which it may be able to obtain.

UNESCO Convention concerning the Protection of the World Cultural and Natural Heritage

Introduction

Adopted on November 16, 1972, the UNESCO Convention concerning the Protection of the World Cultural and Natural Heritage is the most efficient and representative among existing nature conservation conventions and programs. The primary purpose of the Convention is to unite the efforts of the international community to identify, protect and provide comprehensive support to cultural monuments and natural objects of outstanding universal value.

Established in 1976, the UNESCO World Heritage List is representative both of the diverse regions upon our planet and of a number of specific properties. Many natural properties of worldwide renown are protected under the World Heritage Convention, including the Great Barrier Reef, Galapagos Islands, Hawaiian Islands, Grand Canyon, Mount Kilimanjaro, Victoria and Iguazu Falls.

Russia is currently represented on the World Heritage List by fifteen cultural and nine natural properties. Russia's natural World Heritage properties are the Virgin Komi Forests, Lake Baikal, Volcanoes of Kamchatka, Golden Mountains of Altai, Western Caucasus, Central Sikhote-Alin, Uvs Nuur Basin, Natural System of Wrangel Island Reserve, and Putorana Plateau. Thirty-one of Russia's specially protected nature areas, among which twelve are nature reserves and five are national parks, have World Heritage status. The total area of Russian Natural World Heritage Properties comprises more than 22 million ha. Two of Russia's natural properties, Lake Baikal and Volcanoes of Kamchatka, are ranked in the top 10 largest properties worldwide and included in the World Heritage List according to all natural criteria requirements. Work is currently being carried out to present more of Russia's natural sites for inclusion in the World Heritage List. Magadansky Nature Reserve, Commander Islands, Daurian Steppes, Krasnoyarsk Pillars, Great Vasyugan Mire, Il'mensky Mountains, Bikin River Valley, and Bashkir Ural are all included on the Russian Federation's Tentative List.

Without a doubt, Russia possesses a wealth of unique natural complexes untouched by the economic activity of man (an important factor to note). Scientists have assessed that the country houses over 20 territories worthy of holding the status of World Heritage properties.

The present booklet contains materials from the Lena Pillars Nature Park nomination dossier prepared in 2006 – 2010, materials prepared in 2011 in reply to a request by IUCN experts were performing a field visit, a fossil check list, and a selection of support letters for the nomination from leading specialists in the field of Cambrian deposits and frozen ground karst to the Director General of the IUCN as well as the Chairman of the World Heritage Committee.

The nominated property of the Lena Pillars Nature Park tells us three key stories about our planet and the early evolution of life, namely: 1) a record of the Cambrian Explosion, 2) the story of the emergence of the frozen ground karst phenomenon, and 3) elements of the history of humans deifying a great natural monument.

The nominated area is an outstanding natural property providing an unmatched synthesis of Cambrian geological and palaeontological data, which serves as the basis for our understanding of the far past, the evolution of the Earth and of life on our planet during one of the most pivotal and dramatic points of its development.

The Lena Pillars Nature Park can make a claim for its inscription on the World Heritage List based on two criteria: vii and viii. Valuable geological sites (lower to middle Cambrian strata), paleontological sites (exceptional, rich fossils and biocenoses, including the earliest metazoan reef belt) and unique geomorphological sites (frozen ground karst, thermokarst and sand dunes-tukulans) are all combined in the region with incredible natural scenic attractions.

The Lena Pillars.

Panorama of the Lena River from the Lena Pillars.

Nomination

Lena Pillars Nature Park

(RUSSIAN FEDERATION)

Proposal for inscription on
The UNESCO World Cultural and Natural Heritage List

Prepared by:
Lena Pillars Nature Park
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Institute of Geography, Russian Academy of Sciences
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Institute of the Humanities and Indigenous People, Siberian Branch of the RAS
Karst Commission (C08-23) International Geographical Union
International Academy for Nature Conservation, Isle of Vilm, Germany

2012

1. Identification of the property

1a. Country (and State Party if different)	The Russian Federation.
1b. State, Province or Region	Nominated property is located in Khangalassky and Olekminsky Uluses (districts) of the Republic of Sakha (Yakutia).
1c. Name of Property	Lena Pillars Nature Park.
1d. Geographical coordinates to the nearest second	The borders of the nominated property are denoted by the following geographical coordinates: - extreme northern point: 61°16′30″ N, 128°46′20″ E; - extreme southern point: 60°06′30″ N, 125°58′35″ E; - extreme western point: 60°44′30″ N, 125°02′00″ E; - extreme eastern point: 61°13′20″ N, 128°53′00″ E.
1e. Maps and plans showing the boundaries of the nominated property and buffer zone	1. Location of the Lena Pillars Nature Park on the map of Russia. 2. Location of the Lena Pillars Nature Park on the map of Yakutia. 3. Topographical map showing the exact boundaries of the Lena Pillars Nature Park and its buffer zone. Zoning and ecotourism development. 4. Scheme of Specially Protected Areas in the southern reaches of the Republic of Sakha (Yakutia). 5. Geological map of the Lena-Aldan region. 6. Karst phenomena of the Lena Pillars Nature Park. 7. Geological map of the Lena Pillars Nature Park.
1f. Area of nominated property (ha.) and proposed buffer zone (ha.)	Total square of the property equals to 1 272 150 ha. As far as there is no economic activity around the nominated territory, a buffer zone is not required for the territory. Besides, the nominated territory borders on local SPAs in the south – Verkhneamginsky, Kyrbykan, Munduruchchu Resource Preserves, and republic SPAs – Verkhneamginsky and Amma Resource Preserves which function as buffer zone (see Fig. 4).

Fig. 2. Location of the Lena Pillars Nature Park on the map of Yakutia.

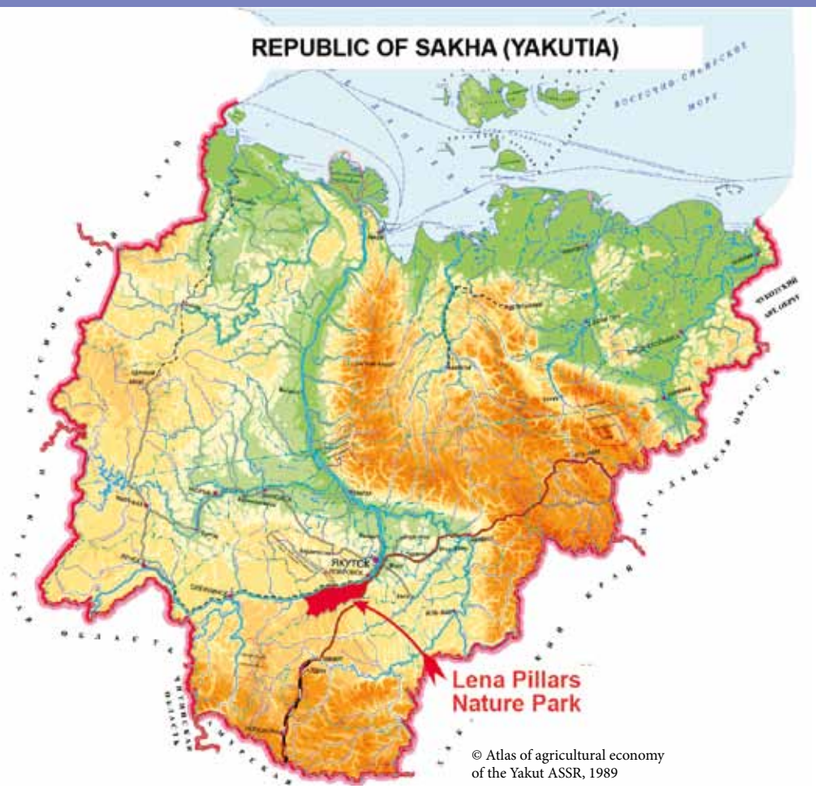

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Fig. 3. Topographical map showing exact boundaries of the Lena Pillars Nature Park. Zoning and ecotourism development.

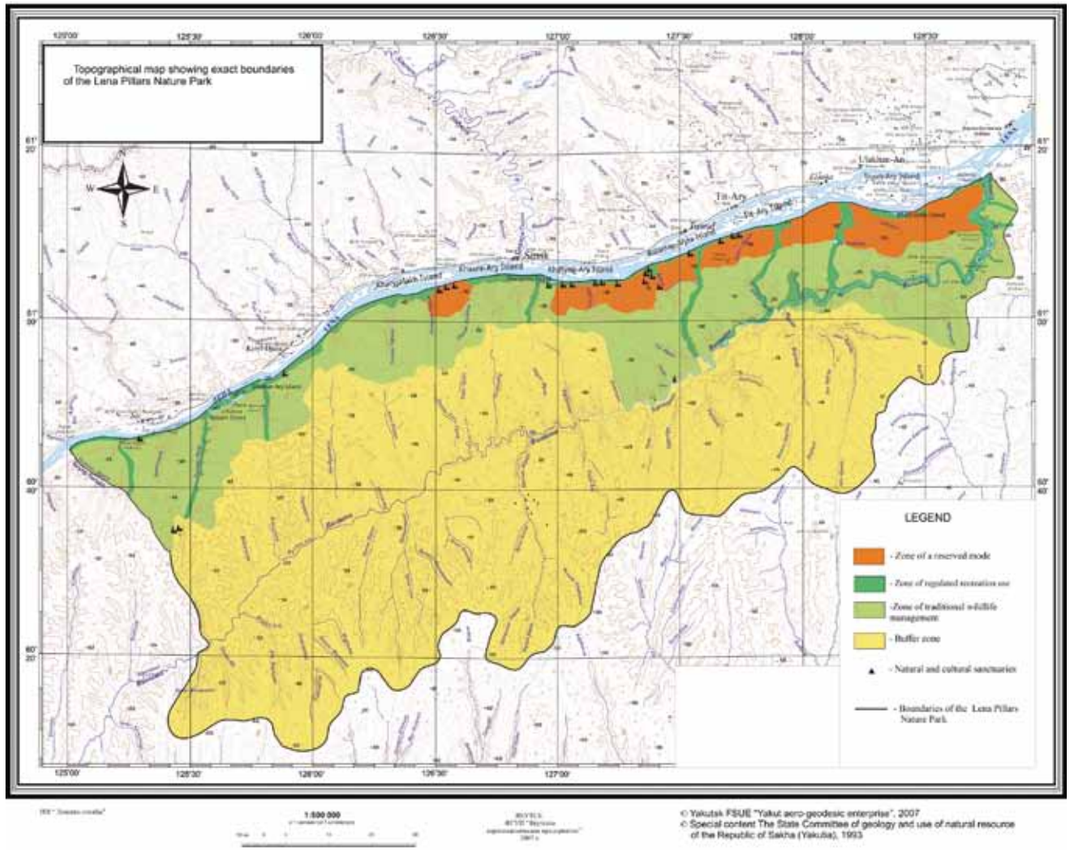
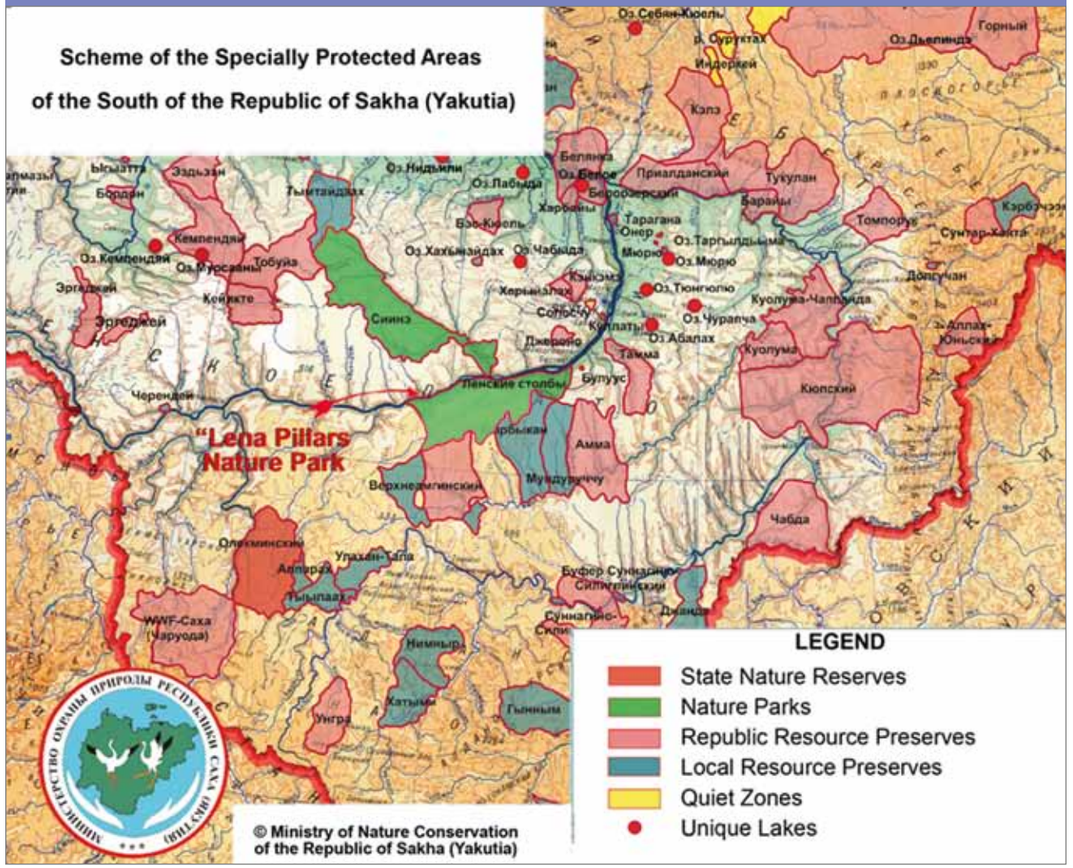


Fig. 4. Scheme of Specially Protected Areas in the southern reaches of the Republic of Sakha (Yakutia).



2. Description

2a. Description of Property

The territory of the Lena Pillars Nature Park is located between the middle reaches of the Lena River in the North and the Buotama River basin in the south, in the Khangalassky and Olekminsky Uluses of the Republic of Sakha (Yakutia).

Geology

The Lena Pillars National Park is situated upon the northern slope of the Aldan Anteclise at the south-eastern corner of the Siberian Platform. This region was involved in the entire sequence of processes undertaken by the platform as a whole. During its Phanerozoic geological development (since the shattering of the Pannotia supercontinent in the Neoproterozoic and until the formation of Gondwana supercontinent in the Late Palaeozoic), the Siberian Platform was an isolated craton known as Siberia, located largely at low latitudes and joined subsequently by a number of terranes which nowadays form its folded border (Altay-Sayan Foldbelt, etc.). The development of the sensu stricto platformal stage began in the late Mesoproterozoic. Since then the submerged eastern part of the Siberian Platform has been only lightly tectonically altered. As a result, the Neoproterozoic-Mesozoic succession outcroppings here mostly have dips of less than two degrees. The latest Ediacaran and Cambrian marine fossiliferous carbonates are most widely distributed here, while the Ordovician and Silurian ones were denudated during the pre-Jurassic uplift and the Jurassic transgression. Here the Jurassic system is represented by both shallow marine and continental siliciclastics containing in places dinosaur bones. The weak tectonic activity of this region in the Jurassic is likely related to collision of the Siberian Platform with terranes of the Verkhoyansk-Chukchi Foldbelt, which caused the formation of some thin dolerite dykes. However, they did not disturb the principal area of the Lower Palaeozoic platformal strata. The Cenozoic sediments are represented mostly by Late Neopleistocene alluvial deposits related to the development of a permafrost complex and containing a relatively rich assemblage of woolly mammoth fauna. The fact that the bony remains of these animals are found practically in the same place presents an important testimony of mammoth fauna evolution. This assemblage includes bones which are well-preserved for DNA analysis. The post-glacial Holocene complex includes alluvial, lacustrine, bog, and eolian deposits (for instance, "fossilized" sandy dunes called "tukulans"). The Lena River valley began to form by the late Neogene and finally brought out the present rocky relief, while the Pillars began to emerge during the Neopleistocene, their columnar appearance mostly being due to high diurnal temperature fluctuations and frozen ground karst processes.

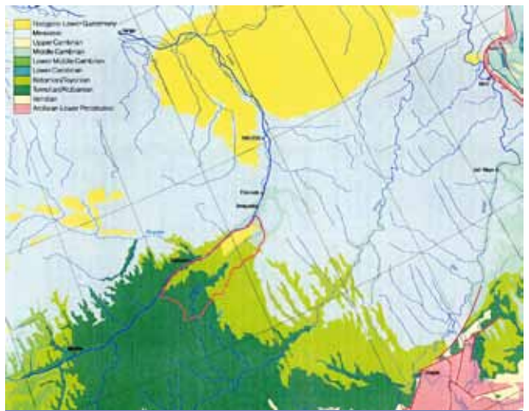


Fig. 5. Geological map of the Lena-Aldan region.

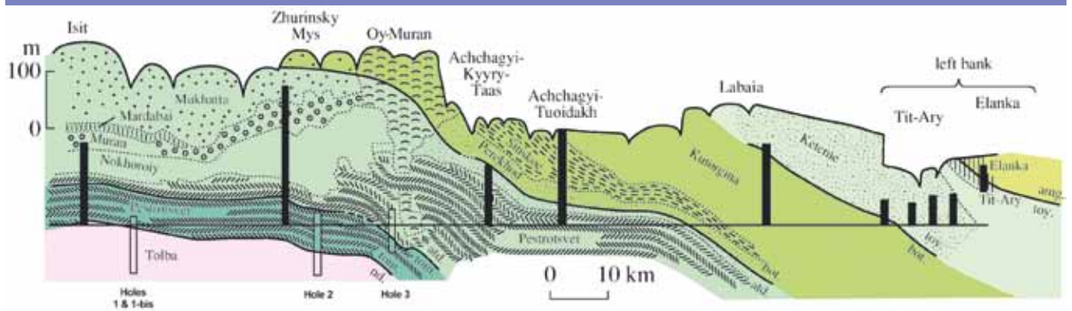
However, the principal sediments of this area are lower to lower middle Cambrian richly fossiliferous continuous carbonates of various marine genesis. These strata characterize the Fortunian Stage, Stage 2 (Terreneuvian Series), stages 3 and 4 (Series 2), and Stage 5 (Series 3) of the International Stratigraphic Chart issued by the International Commission on Stratigraphy (2010) and thus embrace an interval of c. 542-506 Ma. Those are the rocks that comprise the Lena Pillars as well as the Buotama Pillars themselves. The Cambrian sedimentary sequence commences with subtidal to intertidal mudstones from the Tolba Formation (Fortunian Stage) which is transgressively overlain by largely red argillaceous mudstones from the Pestrotsvet Formation (160-195m in thickness), which encompasses a large number of archaeocyathan-calcimicrobial reefs and reefal complexes of Cambrian stages 2 and 3. The 20-kilometer wide Oy-Muran Reef Massif forms a carbonate barrier on the border of the inner (western) and the outer (eastern) basins. The Oy-Muran Reef Massif itself is composed of multiple isometric archaeocyathan-calcimicrobial bioherms of dome-like shape up to 5 meters in diameter. (Archaeocyaths are extinct calcareous rigid aspiculate sponges and calcimicrobes are calcified probable cyanobacterians.) The inner basin facies are represented mostly by various back-reef limestones such as cross-bedded ooid-shoal from the Churan Member and shelly grainstones and calcimicrobial boundstones from the Marbaday Member and the Mukhatta Unit (80-120 m in total thickness), as well as by intensely burrowed lagoonal dolostones from the Nokhoroy Member (40-80 m in thickness). The outer basin facies comprise a deep subtidal Perekhod Formation (25-75 m in thickness) containing spongal clotted mud mounds and following dysoxic finely bedded calcareous mudstones from the Sinsk and Kutorgina formations (190-280 m in total thickness) bearing features of deep-water slope deposition. Later on (during Cambrian stages 4 and 5) due to ramp progradation, the reefal belt displaced eastward to the present coordinates and the uppermost Keteme, Tit-Ary, Elanka, and Kychik formations (up to 360 m in total thickness) are represented mostly by lagoonal dolostones and back-reef facies including abundant carbonate tempestites.

Karst Phenomena and Relief

The Ground Frozen karst of the Lena Pillars Natural Park, developing in an area of continuous permafrost, in conditions of extreme dry continental climate, possesses and outstanding and unique value. Karst developed in the limestones and dolimites from the lower Cambrian.

Despite the insignificant quantity of precipitation on the territory of the Lena Pillars Nature Park, karst processes are widespread here. The main reason is the role of the permafrost in relation to the water, which is a principal factor of karstification.

Fig. 6. Profile of the Cambrian formations along the Lena River (after Savitskiy & Astashkin, 1979). Black columns mark sections sampled for carbon isotopy and paleomagnetic properties, white columns mark drillholes, horizonal line shows a river water level.



Condensation processes during the warm part of the annual cycle is a notable feature of any region with continuous permafrost. On one hand, during spring and summer periods the soil layer actively condenses water moisture from the air because of considerable amplitudes of daily air temperature fluctuations, reaching 12,8°C on the territory of the Lena Pillars Nature Park. On the other hand, the condensation of moisture occurs on the lower part of the active layer as a consequence of big gradients (to 7,8°C per 1 m) between earth temperatures and lower situated perennially cryotic rocks. As per observations performed via a condensermeter, the average value of condensed water on the territory of Central Yakutia reaches 80 mm for the warm seasons. Moreover, the quick filtration of precipitation into karst massifs is blocked by perennially frozen carbonate rocks. That is the reason for the accumulation of water, which in turn causes the karst processes, being conducted on the surface.

Table 1. Calculations for the activity of karst processes on the territory of the Lena Pillars Nature Park.

Activity of recent karstogenese mm/ ka			
By J. Corbel	By M. Pulina	By Ph. Gombert	Average value
9,43	11,7	12,9	10,3

Water dissolved carbonic acid gas is the second factor responsible for karst development in the conditions provided by the Lena Pillars Nature Park. According to the laboratory experiments effected by L. Jakucs (1977), the solubility of CO_2 in the water decreases with the increase of the solution's temperature: at temperature 0°C the CO_2 absorption coefficient is 1,713, at temperature 10°C – 1,194, at temperature 20°C – 0,878, at temperature 30°C – only 0,665. Thus, the cold waters of permafrost regions, saturated by CO2, are characterized by the considerable aggressivity in respect to karstifying rocks.

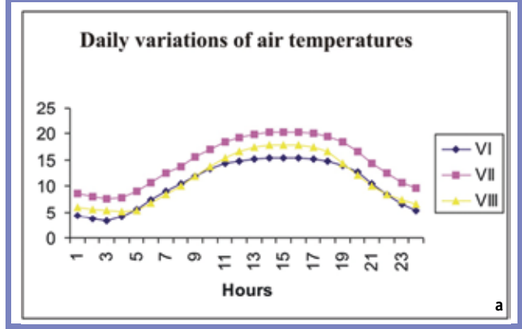
Lastly, more than that, the infiltration of summer precipitation along the deep fissures of carbonate rocks, condensation, and considerable snow accumulation all have warming impact on the cryolithozone, increasing its temperature to 3-4°C and creating conditions for the formation of supra- and intra-permafrost taliks.

Therefore the development of karst relief in permafrost regions sometimes requires less precipitation than its development in regions where permafrost is absent.

In general, the presence of recent karstogenesis in the framework of the Lena Pillars Nature Park is confirmed by calculating the recent activity index of karst processes: karst denudation. This was done both via the classic methods of J. Corbel and M. Pulina, and by using the new (for Russia) method of maximum potential limestone dissolution proposed by French karstologue Ph. Gombert and recommended specifically for extreme climatic conditions. Data for these calculations is presented in Table 1. As is seen from Table 1, the discrepancy in the figures received through different methods is insignificant.

Three main morpho-genetic types of karst are wide spread on the territory of the Lena Pillars Nature Park: naked, covered and soddy karst. Naked karst is observed mainly in the valley band of the right bank parts of the Prilenskoe Plateau and in the bedrock slope of Lena Valley adjacent to the where the karst rocks are bared immediately on the surface as a result of the rainwashing of loose deposits. Covered karst is noted both on the Lena erosion terraces and on the valley band of the Prilenskoe Plateau, as well as on the Lena watershed, Buotama and Amga, covered by cryogen-eolian sediments. Soddy karst is marked on the slopes of the valleys, where loose surfaces are usually negligible.

The following surface and underground karst forms are located within the framework of the Lena Pillars Nature Park. Numerous oval karst sinkholes, mainly cone-shaped, more rarely, asymmetric, and some saucer-shaped are observed here. The formation of the sinkholes occurs due to the karst process, as well as due to the pro-



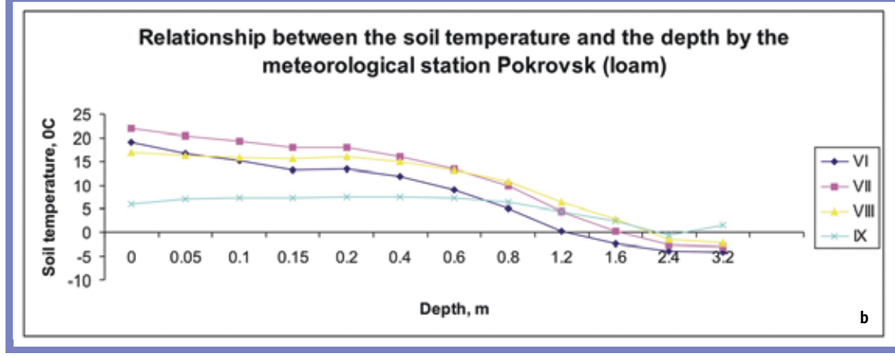


Fig. 7. Factors of condensed moisture formation: a – on the surface of karst massifs; b - on the lower part of the active layer.

Fig. 8. Distribution of karst manifestations on the territory of the Lena Pillars Nature Park.

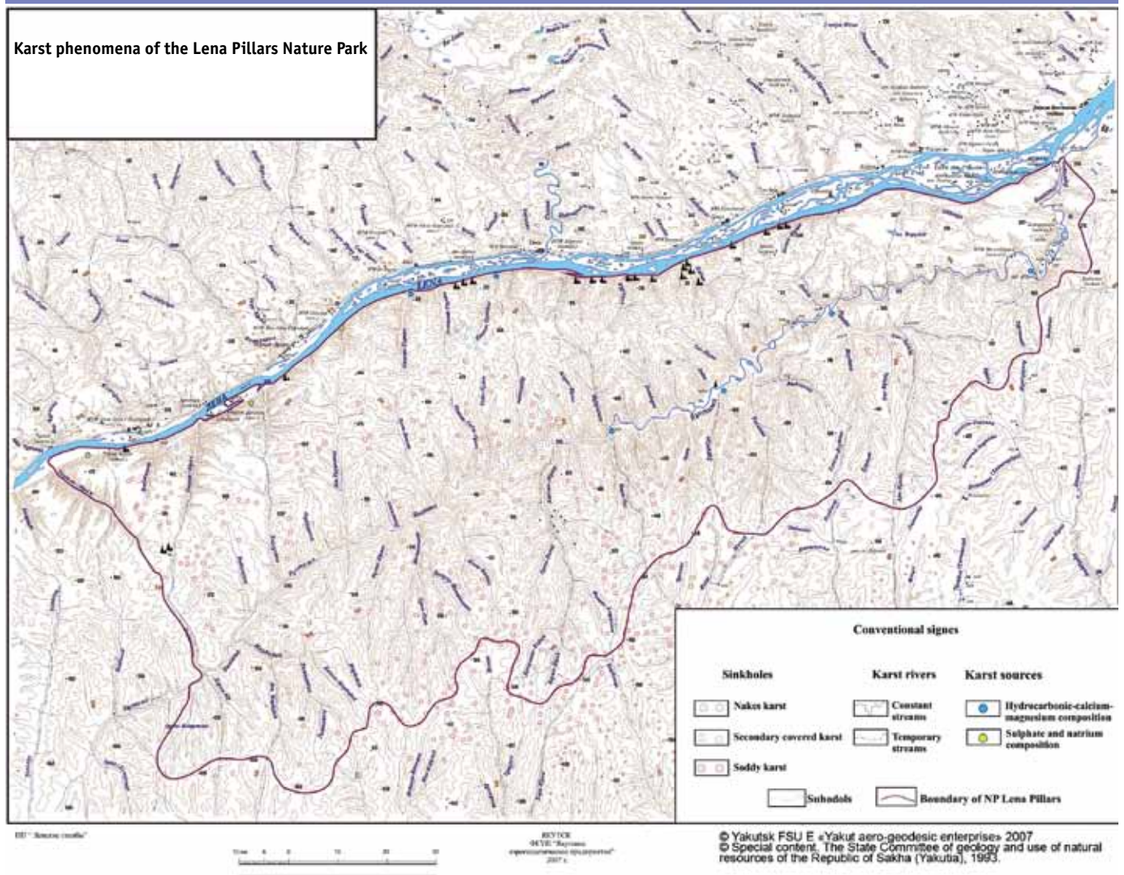


Fig. 9. Karst sinkhole.

Fig. 10. Ponor at the bottom of sinkhole (valley of Ulakhan-Taring).

cesses of frost and cryohydratation weathering, favorable to the increase of karst rock surface solution and the intensification of erosion processes. Diameter of sinkholes varies from 3-10 to 20-40 m, while the depth varies from 0,5 to 10 m. Some sinkholes achieve a diameter of 100 m. In naked karst conditions, the cleft ponors are very often located at the bottom of sinkholes. Ponors, found at the bottom of sinkholes in covered karst, indicate the presence of cleft karst limestones under sand deposits, which serves to drain surface waters. The latter serves as confirmation for recent karst processes.

The disposition of the sinkholes bears a certain peculiarity. A considerable part of the skinholes is concentrated along certain lines that coincide with small erosion depression patterns. According to observations, the orientation of these depressions corresponds to the main systems of karst rock tectonic fissuring on the territory of the natural park: diagonal and orthogonal. The fields of the sinkholes emerge on the surface of the plateau.

During dry seasons the sinkholes are without water, but a humid diluvium layer is observed at the bottom of the deepest ones. These sinkholes are bushy, with sedge growing at their deepest points. Water fills the sinkholes during rains and turns them into small lakes. As time goes on the water from these lakes penetrates into the clefts and they disappear.

The formation of karst-erosion valleys with the temporary flow, dry valleys, locally named *suhodol*, was caused by the coalescence of karst sinkholes, situated along main tectonic systems. From 42 watercourses falling into River Lena in the boundaries of the park only 4 streams are characterized by perennial flow. As uncovered by expedition explorations of the representative valley of the Labyia River (central park within the natural park), the density of karst sinkholes there reaches 13.3 pieces per 1 km dry channel. The explorations were carried out for the meridionally oriented part of the river valley spanning 5 km and situated 0.5 km from the mouth of the stream.

The length of suhodol is greater than 10 km: for the Kuuda River it is 21 km, for the Arga-Kinat Brook it is 15 km, for the Tigilyan Brook it is 10,5 km, etc. M. Pulina and J.N. Salomon consider the suhodol to be a classic form of cold karst.

Karst lakes are formed as a result of the coalescence of several neighboring karst sinkholes in conditions of karst cavities being filled by sandy-clay deposits. The largest lakes are located in the watershed areas of Lena, Buotama and Amga, occupying the depressions with sizes up to several kilometers in diameter. (Evidently, these depressions are a paleokarst relic). The shores and floors of the lakes are usually frozen, their depths not exceeding 2 m. But the majority of the lakes are small bodies of water (up to 10-30 m in diameter), situated in the valleys of rivers and brooks and connected via the shorter parts of the stream channels.

Small sizes, oval forms and steep high shores (up to 5 m) serve as confirmation of karst originating within the lakes. The limestones are frequently exposed on the shores of water bodies, while separate debris from the limestones is observed at the bottom of lakes. The processes of landsliding and solifluction are developed on the steep slopes of ponds. Mineralization of the waters in the lakes is at less 100 mg/l. The latter indicates the dampening of solution processes and the regeneration of lake waters only through atmospheric precipitation.

The future of the regional hydrographical network appears to profess the *disappearance of rivers and brooks*. With the

exception of the large Buotama River, all karst rivers and streams in the national park suffer from interrupted watercourses either at the head river or in the middle course and lower reaches, examples being the Marbaday River, the Nucha-Uryage Streams, the Arga-Kinat, etc., where the karstholes in the form of sinkholes and clefts, frequently including ponors, are located within the riverbeds.

Karst sources are split into two types: a) edge low-pressure ground waters of hydrocarbonic-calcium-magnesium composition (their mineralization at 200-400 mg/l) supplied by aquifers situated above and within permafrost and related to taliks in the slope foots; b) pressurized waters of sulphate and natrium composition (their mineralization reaching 2000 mg/l) supplied by deep aquifers situated inside and beneath permafrost, and unloaded to the bottom of the rivers and streams where the thickness of permafrost is negligible. Edge low-pressure sources are observed more often. As a rule, they are characterized by the rough change of regime and chemical composition throughout the year and by small debits. Pressurized sources are distinguished by a constancy of regime and chemical composition and by a considerable amount of debits (up to several ten liter volumes per minute and more).

Conditions of naked karst serve to facilitate specific forms of karst relief called karren, which forms due to the irregular dissolution of the surface of karstifying rocks. Cleft karren – named “limestone pavements” – (Kluftkarren) are located upon smooth surfaces where waters flow down slowly along the clefts dissecting the rocks. Sometimes one can observe shallow solution basins with flat floors and hanging over walls named kamenitza. The formation of kamenitza is due to the corrosion of limestones by rainwater. The sizes of kamenitza in diameter reach 10-15 cm at 5 cm depths. Marked here are small karren depressions, rainpits, with a depth of 1-3 cm, circular in plan view, and from semi-spherical to parabolic in cross-section view, with very sharp edges and very regular morphologies. There are (especially in the area of Zhurinsky Mys) plentiful amounts of debris from rocks with signs of microrelief formation within the caves: scallops, forming on the walls, ceilings and floors of the caverns by the corrosion and erosion of underground streams (the sizes of the scallops reach 3-4 cm in length), as well as dome pits (funnel-shaped hollows, formed mainly by chemical dissolution) with diameters of up to 5-10 cm. The vertical halls of the Lena Pillars reveal microforms of relief created by the biological corrosion. These microforms have the shape of small hollows and are created by endolithic (drilling) and epilithic (scraping) organisms.

The famous Lena and Buotama pillars are a peculiar form of underground (deep) karst, dissected by the Lena River and its right tributary, the Buotama, under episodic incision into the Prilenskoe Plateau. The pillars stretch along the shores of Lena and Buotama both in the form of separate pillars and in the form of cogged walls. The height of the pillars reaches 200 m. Development of deep karst is associated with aquifers situated inside and beneath permafrost.

The Lena Pillars were formed nearly 400 thousand years ago. By then the Siberian Platform was lifted to 200 m because of tectonic movements, which caused a deep incision of Lena and Buotama valleys and provoked the increase of karst pro-

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Fig. 11. Disappearance of the Labyia River runoff.

Fig. 12. Karst rock features, observed throughout numerous Lena Pillars fissures (Zhurinsky Mys used as an example): a) sinuous microrills formed by biokarstic processes; b) corallites of condensation dissolution genesis; c) shallow hollows formed by karst dissolution.

Fig. 13. Rainpits in the Diring-Uryakh Valley.

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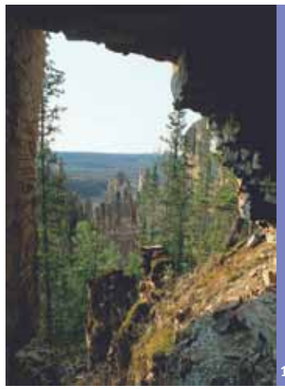

Fig. 14. Karst niche.

Fig. 15. Enrances to the Tit-Ary Cave.

Fig. 16. Scallops in the Tit-Ary Cave.

Fig. 17. Dead end in the Tit-Ary Cave.

Fig. 18. Undeground gallery in the Buotama River Valley.

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cess activity. Every small fissure in the carbonate massif was exposed to the karst process, including the solution and the export of rocks. As a result of this, on the one hand, this led to the widening of the fissures and the separation of the next blocks from the main massif of rocks, while on the other hand, this led to the formation of numerous *niches, clefts and sheds*, as well as *small caves* (channels). The sizes of niches, clefts and sheds are insignificant: up to 1-2 m wide and up to 3-4 m in depth. The disposition of the groundwater flow channel fragments (small caves 20-30 m in length) on different levels indicates the periods of the decrease of Lena River incisions, which are characterized by highly favorable conditions for the horizontal circulation of underground waters.

Fig. 19. Karsthole.

Numerous split cavities situated along the clefts of unloading of the cliff face parallel to the river are widespread on the upper parts of the Lena River Valley. Their sizes reach up to 50-100 m in length and 0,5-2,0 m in width. Karst sinkholes are marked frequently at the bottom of these clefts, which serves as solid evidence of on-going karst processes.

At present the cryogenic weathering of the limestones, as well as the gravitational-slope, karst, fluvial and abrasion processes play an important role in the recent modelling of Lena Pillars relief.

Relief

The park is located mainly within a low bedded denudation plateau with absolute watershed points between 200 and 400 m. Smooth relief is interrupted at areas of original rock exposures upon the sides of the river valley. The park's area is located at the southwestern edge of the vast Central Yakutian plain, which gradually turns into a split Lena Plateau to the west of Erge-Echite Creek. The boundary between these geomorphologic structures lies along watersheds with absolute heights of about 300 m.

The relief of the Lena Pillars Nature Park is a bedded denudation plateau formed as the result of the transformation of ancient Paleozoic structures under influence of several erosion and denudation cycles after the Paleozoic era. Features of this prolonged continental development of the area are visible in the area's modern relief.

Along the Lena River Valley one can generally observe a low plateau level with absolute heights below 400 m (average of 200-300 m). A sharply expressed high plateau level is located in the west, outside the nominated property. Within

the area of the Nature Park the plateau is vastly denuded. Here valleys of rivers and creeks cut into the surface of separate round-loaf-like flat-topped massifs. In the area of the Buotama River mouth the water divides are narrowed and look like slender ridges.

In the valley part of the plateau, for instance, in the Lena Pillars area, Cambrian limestone is cut into series of blocks by a complex system of cracks. Along these cracks blocks break off into abrupt rocks. Depending on the degree of decay, the blocks fall apart into pillars, steeples, towers and separate skerries quite often corroded by small caverns and niches.

Ubiquitous spreading of cavernous limestone is responsible for karst meso-relief and micro-relief development. Karst is often found at separated parts of the plateau where it is actively developed at slopes and small creek beds. Besides this, karst is concentrated in areas where ground and subsoil waters circulate.

Thermokarst relief forms are confined to super flood plain terraces and to areas of talus accumulation, with polygonal vein ice taking part in the cryogenic construction of sediments. They are typical mostly for the left bank of the Lena River.

Where the Lena River cuts through limestone, riversides are typically rocky. In many places such banks are split by deep perched valleys – creek valleys and less deep erosive ravines. Their outfalls often do not reach the Lena River line and bear on either towpath, or on the surface of low terraces, creating debris cones there.

As a whole, the examined area is a transitional zone from the high western parts of the plateau to the multiple terraced surface of the alluvial valley in Central Yakutia.

The latest modern uplift of the area has led to the deep cutting in of small river valleys and to active denudation development at original slopes, which has caused the significant partitioning of relief in the valley parts of the plateau.

Relief forms related with the perennial permafrost

The most well-developed of the cryogenic processes are cryogenic weathering of rocks, permafrost karst, thermokarst, and frost shattering.

Cryogenic weathering is most intensive on the slopes. The recent lifting of the Lena Plateau contributed to the activation of cryogenic weathering, evidenced by the denudated rocky slopes of the Lena River and the large volumes of debris under them.

Permafrost karst is widespread. There is both deep underground and surface ground karst. Deep karst was most active before the appearance of permafrost. Deep caverns are usually filled with fine materials, however, at present they are

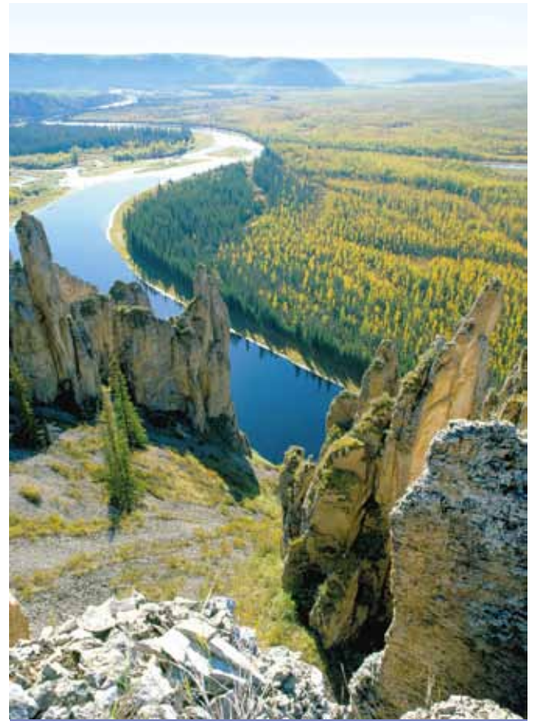


Fig. 20. The valley of the Buotama River – right tributary of the Lena River.

Fig. 21. A thermokarst lake in the park's territory.

frozen. Ground karst results in karst dolines and depressions. Their diameter can reach 20-40 m, and they can be as deep as 5-10 m (Korzhuev, 1961). They are usually covered in plant life and are filled with fine materials. Karst lakes are widespread in the region, especially at the Lena-Buotama interfluves.

Thermokarst is developed upon high terraces of the Lena River that consist of sandy-loam lake-alluvial deposits. Thermokarst relief forms are found at points of repeat-vein ice thawing. Such landscapes are represented by polygonal-subsidence forms of microrelief (called bylar in the Sakha language), primary thermokarst depressions (dyuedya), full-flowing thermokarst lakes (tympy), and upland thermokarst depressions (alases).

Frost shattering is common for flood plain areas and deal-luvial trails with the finest clay deposits. Processes of frost shattering going on in seasonally thawing and seasonally freezing layers are observed everywhere. Evidence of such processes on the ground can be seen in the formation of slightly uneven relief.

Fig. 22. Panorama of the Lena river from a viewing point.

HYDROGRAPHY

The nominated property is located on the right bank of the great Siberian river Lena. The drainage area of the Lena equals 2490 km2 and is the 8th largest in the world (Mostakhov, 1972). Starting from the Baikal Ridge branches, it runs to the Arctic Ocean, with a total length of 4,400 km. The Lena River is filled up with the waters of over 545 tributaries more than 10 km long, with an annual average water discharge of about 1700 m3/sec (Glushkov, 1996). Tremendous masses of water transfer great amounts of heat from the south to the north, where insufficient thermo-supply is the main limiting factor. In such a way the Lena not only forms unique mezzo-climatic conditions for plants and animals inhabiting its shores, but also provides a unique "ecological channel" for southern species of flora and fauna entering far to the North (Solomonov, 1998).

In the region of the Lena Pillars the river is 5-10 km wide. The Lena river bed changes its character from the given point. The sandbanks are home to numerous big and small towheads, and the left bank is isolated from the fairway by a nearly uninterrupted chain of islands. Due to the plentiful numbers of islands, sandy rifts and shoals the Lena has a very unstable fairway in this section. It is notable that many big islands are in fact chains of smaller ones (Korzhuev, 1959).

The Lena Pillars region houses a very peculiar drainage network associated with the main tectonic fractures that to a large extent determined the rectangular structure of the modern river drainage.

In contrast to other, more northern parts of Central Yakutia, lakes are not numerous and rather small here.

The main rivers are the Lena and its right tributary the Buotama. Other streams are mainly temporary ones and form visible run-off only during the spring period or during rainy seasons.

The large masses of water in the Lena River create peculiar conditions that leave their traces not only in the form of a deeply developed right bank, which is in fact the Lena Pillars, but also play an essential role in forming of the unique climate of this region.

CLIMATE

The climate of the Lena Pillars Nature Park is unique as well. The annual contrast in temperature reaches 100°C, precipitation is low (in the steppes and semi-deserts), and the amounts of solar energy available in summertime are as high as in Central Asia. All these factors result in a unique, sharply continental climate, yet this territory is at the same time covered by middle-taiga forests as well. The large masses of water in the great Siberian river Lena also contribute their share to the formation of unique meso-climatic conditions for Central Yakutia.

The strong continental climate is a prerequisite for the unique phenomenon of frozen ground karst (low precipitation, but additional water from air wetness condensation at frozen ground, Criteria VIII). It is also the reason for the considerable seasonal changes of landscape features (related to Criteria VII).

Considering its geographical location, the Lena Pillars Nature Park is situated in Central Yakutia with a severe and peculiar climate, which is stipulated by the region's geographical position and the character of prevailing relief. Due to considerable

Table 2. Pokrovsk meteorological observatory data for 1960-2009.

Parameter	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	Year
Monthly average atmospheric temperature, °C (1960-2009)	-40,2	-34,9	-21,9	-6,4	6,2	14,9	18,2	14,4	5,7	-7,8	-27,8	-38,4	-9,8
Absolute maximum of atmospheric temperature, °C (1931-2009)	-5	-2	8	20	31	36	37	35	29	17	3	3	37
Absolute minimum atmospheric temperature, °C (1931-2009)	-61	-60	-54	-42	-20	-10	-3	-9	-18	-43	-55	-60	-61
Monthly amount of precipitations, mm (1960-2009)	9	7	6	8	20	36	46	42	32	18	15	10	249

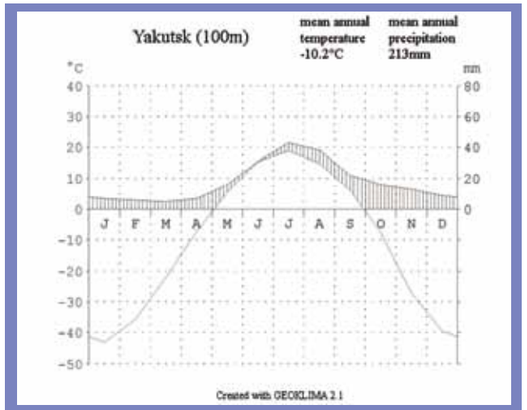


Fig. 23. Climate diagram using the format established by Walter and Lieth.

remoteness from the Atlantic Ocean and natural barriers from the Pacific Ocean (the high mountains in Southern and Eastern Siberia), the oceans produce practically no influence on the climate of Central Yakutia. At the same time this region is easily accessible to invasions of Arctic air masses from the Arctic Ocean that greatly influence its climate.

All these factors result in a rather distinctive, pronounced continentality of this region's climate, with considerable annual ranges (Korzhuev, 1959).

Winter in Central Yakutia is rather long (over 6 months) and cold (-40, -60°C). During this season a severe Siberian winter anticyclone is prevalent here. The anticyclone creates conditions for clear, frosty, dry and calm weather. The stagnation of air resulting from light breeze and clear skies produces great cooling and sharp temperature inversion. When the weather is clear and calm, the air temperature falls down to -50, -60°C (Gavrilova, 1973).

Spring is very short and late here. It is characterized with unstable weather, wind gain and precipitation occurring relatively more often. In spring the temperature grows quickly owing to the supply of warm air from the south and an intense influx of solar energy.

Summer in Central Yakutia lasts for 3 months (from June until August), during which time the continentality of the climate plays a great role. During this period the mean daily temperature of the air exceeds +10°C. During the day in summertime temperatures can reach +30, +35°C. The significant increase in warmth causes the formation of a diffuse depression. As a result of the strengthening of cyclonic activity and the enhancement of absolute air humidity, summer in the region sees maximum precipitation, which is still rather modest: about 120 mm per year (Gavrilova, 1973).

Autumn is also very short, like spring, lasting from late August till September. It is characterized by the strengthening of anticyclone activity that produces clear and frosty weather. Cyclones are accompanied with arctic air masses causing immediate lowering of temperature.

Average annual precipitation equals to 251 mm in Pokrovsk, close to the Lena Pillars Nature Park. The maximum depth of snow cover in the forests is 39 cm, with 33 cm in the fields. Average date of snow cover formation: 13.X, the earliest: 28.IX, and the latest: 26.X. Melting of seasonal snow cover occurs

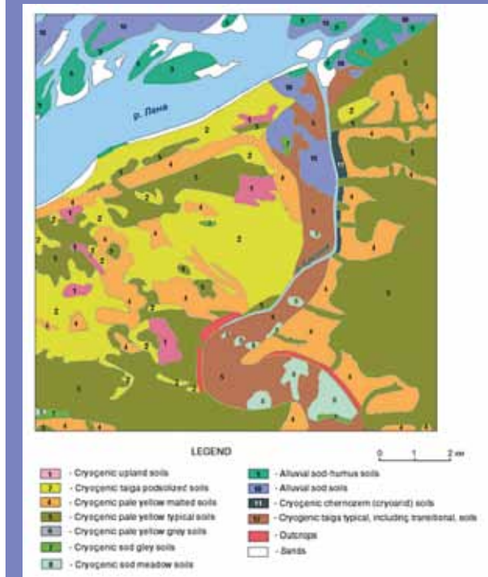
in the 1st ten days of May. The total number of days when snow cover is present amounts to about 203 (Kononov, 1982).

Soil cover

Soil cover at the Lena Pillars Nature Park is complex and diverse, including 16 sub-types of cryogenic soils. Here, within a relatively small area, it is possible to observe all the major soil types of Central and Southern Yakutia, from cryogenic taiga soils, pale, podzolic and sod-calcareous soils to cryogenic chernozem. The area also displays the spreading of spatial soils, evidently as a result of relief conditions and soil-forming rocks.

The middle and high Lena River terraces, flood plain parts along the Lena and Buotama rivers, as well as river valley and plateau slopes of different steepness, take part in the Buotama River outlet relief structure (Korzhuev, 1959). Vegetation cover in the area is presented by different types of larch and pine forests at watersheds, brakes over the narrows, meadows and bushes on flood plains and watersheds, and also by dry steppe areas along the slopes of the Buotama Valley.

Fig. 24. Map of soil cover at the Buotama River outlet.



Carbonate loam makes up the soil-forming rock upon high Lena terraces. At Bestyakh Terrace the soil-forming rock is made up of ancient alluvium sediments of loamy and regular sand. Along the river valleys, the soil-forming rocks are modern loamy and sandy-loamy sediments.

Given the big differences between the soil-forming rocks of zonal and intrazonal soils, and taking into consideration their spatial location and the complex structure of river valley soil cover (multicomponent structure, sharp syngenetic differentiation, contrast range, etc.), the soil cover of the area is considered to be a complicated mixture of flood land soils developed against a background of zonal soil combinations. 11 cryogenic soil types take part in forming the soil cover structure in the area.

Soil cover at the Saamys Kumaga tukulan also possesses a complex structure (multicomponent structure, contrast range, etc.) and is considered to be a complex combination of zonal soils in conjunction with flood land soils developed in the LenaValley. A distinguishing feature of this area is the presence of a significant mass of blown sands at the watershed. 10 cryogenic soil sub-types take part in the soil cover structure. The prevailing soil types are typical pale cryogenic soils in combination with solodized soils upon high terraces, and cryogenic taiga podzolic soils on middle terraces. The most prominent tukulan feature is the presence of cryogenic podzolic and cryogenic pale grey soils.

Vegetation

The peculiarities of the soil cover determine vegetation features in the area. The park's territory is covered mainly by low larch taiga with signs of pine forests, a relatively wide distribution of alassy in the eastern part, and meadow and steppe vegetation in river valleys. Among the forests, larch forests prevail, covering 87.0% of the area, with pine forests covering 7.6% and 5.4 % being covered by fir-woods, birch-woods and yerniks (dwarf birch bushwood). Valleys of the Buotama River, small taiga rivers and creeks are covered with large amount sof dwarf birch yerniks and *Betula divaricata*, moderate amounts of *Betula exilis* and sedge-grass meadows, and scarce amounts of forb meadows. Fragments of steppe vegetation are spread on the well warmed bedrock slopes of the Lena and especially upon the riverbanks of the Buotama.

This vegetation complex is in a primeval state and possesses a natural dynamic, nearly untouched by human influence. Deciduous larch taiga is typical for such a strong continental climate with semihumid conditions and permafrost in the eastern parts of the Eurasian Boreal zone.

Fig. 25. Autumn colours of the Lena Pillars.

Fig. 26. ***Redowskia sophiifolia*** **– a local endemic of the Lena Pillars.**

It contains a very specific and diverse flora of vascular plants, mosses, lichens and fungi, all adapted to the specific climatic conditions of Eastern Siberia.

The vegetation cover in the area is responsible for the proposed property's exceptional/exciting landscape characteristics. In combination with rock formations it forms unique landscape features with totally different aspects varied by season. In spring, the spectacular pillars are framed by the light green larch trees, in summer by colorful herb flowers, and in autumn they create the impression of being draped in a "golden coat" (Crit. VII).

So called "tukulans" (masses of windblown semistabilized and stabilized sands) occur in areas of rare psammophyte vegetation.

The occurrence of the local endemic plant species Redowskia sophiifolia (Brassicaceae) indicates the special biogeographical position of the Lena Pillars region from a biodiversity perspective.

Fauna

For the North-East of Russia, the zoogeographical complex of the Lena Pillars also has a number of unique features based on the special peculiarities of this region: an original climate that forms the distinct characters of the landscape, vegetation and fauna.

The region of the Lena Pillars, situated in the border area of Prilenskoe Plateaue and the Central Yakutian Plain, is characterized by a singular combination of faunistic complexes. Here, along with dominating forest elements, there also occur representatives of mountain-taiga (musk deer, maral) and mountain steppe (northern pika) complexes. The area also boasts a northern boundary of areals with many vertebrate species: reptiles and chiropterans.

Invertebrates

Among the animals inhabiting the territory of the Lena Pillars insects stand out for their great diversity, widespread in all the forest, open meadow and steppe biocenosis, as well as in stagnant-water and running water reservoirs.

In the course of a complex expedition with the goal of providing a bio-ecological justification for the necessity of establishing the park (1991-1992), the party responsible performed systematic studies into the faunistic diversity of insects at the Lena Pillars Nature Park. The published results of these and further investigations included a list of insects comprising 645 species from 96 families and 8 orders (Averensky, 2001; Bagachanova et al., 2001, Potapova, Zhirkov, 2001).

Ichthyofauna

Due to the enhanced protection regime on the territory of the Lena Pillars Nature Park, and particularly at the Buotama River, this area plays a significant role in the conservation of the central Yakutian Ichthyofauna, which contains lake and (mainly) river types. The area is home to non-migratory as well as semianadromous species of fish.

Amphibia and reptilia

Amphibia and reptilia are presented with two species: the Siberian salamander *Salamandrella keyseplingii*, Dybowski, 1870 and the Siberian frog *Rana amurensis* Boul, 1888, the common lizard *Lacerta vivipara* Jacquin, 1787 and the common northern viper *Vipera berus* Linnaeus, 1758.

The territory of the Lena Pillars is located along the northern boundary of the reptile areals in that cold region.

Avifauna

The territory of the Lena Pillars plays a significant role in the recovery of species diversity and resources for the considerably transformed avifauna of Central Yakutia.

Nesting bird fauna is presented with 105 species (that is about 80% of fauna of all the nesting birds of Central Yakutia). Ornitho-complexes of meadow, skirt and forest birds are presented here completely or almost completely. The wetlands complex is rather modest, however, a considerable increase of their numbers and diversity has been registered after the introduction of a protection regime. The basis of the winter avifauna in the studied region consists of nonmigratory birds (26 species). The baikal teal, osprey, golden eagle and peregrine are listed in the Annex to the CITES Convention as being protected species of international importance.

Mammals

The species diversity level for mammals at the Lena Pillars Nature Park is quite high considering the regional scale, and represents over 56% of the total composition of Yakutian mammals. According to preliminary data, this region of the Middle Lena valley can be considered a center of biodiversity for the studied group of animals in Yakutia.

The park territory is inhabited by 38 species of mammals. On the whole, the complex of mammal species in the area is typical fauna for a Palaearctic middle-taiga subzone.

Wood Bison

The wood bison is inscribed in Appendix II of the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES). It is included in the IUCN (International Union for Conservation of Nature) Red Book, which is recognized as a worldwide catalogue for endangered animal species.

On April 6, 2006, 30 wood bison (mainly underyearlings: 15 females and 15 males) were transported from Elk Island National Park, Canada, to Lena Pillars Nature Park, Yakutia, which has a specially constructed farm named Ust'-Buotama that includes a network of pens and a number of both specially designated and residential buildings.

The main aim of the mission is elaboration of theoretical, methodical and applied approaches to the project on restoration of historic wood bison habitats on the territory of Yakutia, thus enriching the bio-diversity of northern ecosystems and increasing their productivity and stability.

Since the creation of the brood stock on the territory of Lena Pillars Nature Park, it now can be said that the first stage of wood bison re-acclimatization in Yakutia has been accomplished and the next stage has begun, entailing the re-settlement of the species across the territory of Yakutia.

LANDSCAPES

The territory of the park is located at the interface of three landscape provinces: the Leno-Amginskaya alas province, the Leno-Amginskaya sandstone province, and the Leno-Aldanskaya karst province (Permafrost & Landscape Map …, 1991). This factor provides for a fairly wide range of conditions influencing the functioning and evolution of genetically and structurally diverse typological geographical landscapes.

The lands of the provinces within the territory of the park house two types of landscapes: mid-taiga continuous perennially frozen rocks (PFR) and intrazonal mid-taiga continuous PFR with understream taliks. They are presented by the following types of localities: uplands, slopes, old-terraced, sandy-ridge type, mid-altitudinal terraces, inter-alases, and low-terraced, shallow valleys (Permafrost Landscapes …, 1989).

The upland locality is distinguished by a non-homogeneous lithogenic base and can be divided into two sub-types. The karst upland sub-type with low-bush and low-bush-moss larch forests as well as sporadic spruce is distributed in Cambrian rock eluvium. Meanwhile, the Jurassic eluvium shows a sandy upland sub-type with lichen-low-bush and low-bush pine forests.

Shallow valley localities with alluvial sediments are covered with valley forests, yerniks, and willow-shrubs.

The carbonaceous Cambrian rock underlay slope type is mainly represented by low-bush-alder larch forests. On warm aspect slopesthese forests are replaced by steppificated meadows and low-bush pinewoods, and by rock vegetation at plots with active denudation processes and Cambrian rock outcroppings.

Inter-alas type localities with sabulous-argillaceous sediments are occupied by low-bush and low-bush-moss larch forests; such types can be found in the eastern part of the park.

The park also contains a sandy-ridge type locality, displayedupon mid-altitudinal sandy terraces of the Lena River with low-bush, lichen-low-bush, and low-bush-lichen pinewoods.

Alluvial sediments within the boundaries of low-terrace localitytypically contain valley forests, willow-shrubs, and meadows.

A study of the Lena Pillars Nature Park landscape structure was held within three of the most tourist-prospective plots of the park: the Labyia River influx, the Saamys Kumaga tukulan (drift sands), and the Buotama River influx. Field study results and remote sensing data interpretation provided information on the current state of landscapes, revealed regular patterns to the distribution of natural complexes, and provided materials for 1:500 000 scale landscape maps.

The quantitative composition and peculiarities of landscape complex differentiation, as well as differences in their genesis and components, show that the territory of the Lena Pillars Nature Park has quite a complex landscape structure. Areas of the park that are presently used for recreational purposes are distinguished by the composition of the main elements of their landscape structures (table 3).

Study of landscape differentiation features allowed for the identification of landscape complexes on the territory of these recreational zones that are of high educational or aesthetic value and are rarely found in other regions of Russia. Such unique landscapes are a valuable part of recreational potential.

The most remarkable landscapes that attract tourists with their beauty are presented in the form of structural elements (facies, stows) of higher rank typological natural and territorial complexes (group types ofstows and location types). Analysis of landscape structures on the territory of recreational zones led to the identification of a number of remarkable and noteworthy sites (table 4). Such landscapes on the territory of the Lena Pillars Nature Park include:

- Cliff, eolian, cryogenic, karst, and erosive formations
- Steppe slopes and dry riverbeds characteristic of karst regions
- "Warm" valley complexes of talik zones with their associated plant communities (poplar forests)
- "Cold" valley complexes with spruce forests
- "Kyrdal" steppe communities typical for regions with sharp continental climate
- Park pine forests, promising in a recreational sense

Landscape research results were used toprepare justification for the establishment of tourist routes at theLabyia, Saamys-Kumaga and Labyia River mouth locations. This resultedin the development of 6 routes containing 25 landscapes of special notein terms of ecotourism, which reflect the natural and landscape structure features of the park territory. Maps for the tourist routes were put together with scales of of 1:100 000 and 1:25 000. All of the information gathered was used for the publication of The Lena Pillars pamphlet in 2000.

Excursions into the Labyia area reveal the remarkable natureof karst landscapes where they are represented by rock forma-

Table 3. Landscape pattern of the Lena Pillars Nature Park.

Landscape types	Recreational lands		
	Mouth of the Labyia River	Mouth of the Buotama River	Saamys-Kumaga tukulan
Lena River Floodplain	+	+	+
Medium-height Lena River terraces	-	+	+
High Lena River terraces	-	+	+
Near-watershed portions of the plateau	+	+	-
Hard-rock outcrops	+	+	-
Steep river valley slopes	+	+	-
Medium-gradient slopes	+	+	+
Low-gradient slopes	+	+	+
Drainage rills and creek valleys	+	+	+
Small river valley floors	+	+	-
Drift sands	-	+	+

Table 4. Notable natural landscapes within the territory of the Lena Pillars Nature Park.

Notable landscape	Recreational lands		
	Mouth of the Labyia River	Mouth of the Buotama River	Saamys-Kumaga tukulan
Steppificated meadows on slopes	+	+	-
Steppificated meadows in valleys	-	+	-
Spruce forests in valleys	+	+	-
Poplar forests in valleys	+	-	-
Suffosion lows	-	+	+
Lena Pillars geological nature monument	+	-	-
Drift sands	-	+	+
Hard-rock outcrops	+	+	-
Karst funnels	+	-	-
Cryogenic landscapes	-	+	-
Pine forests	-	+	+

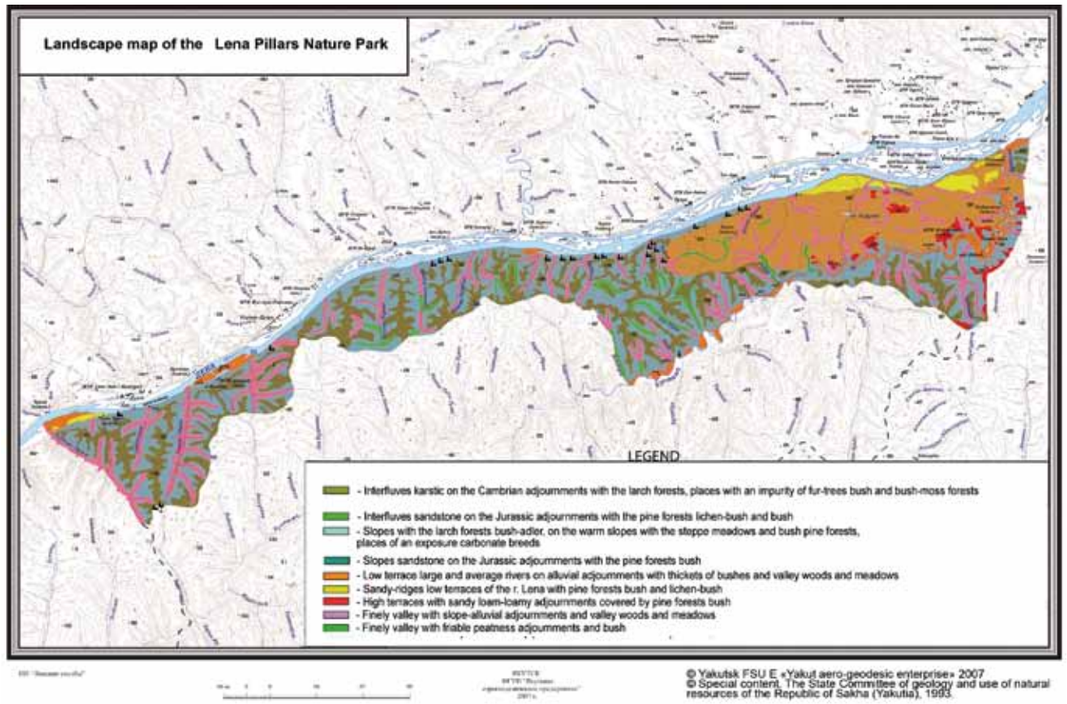


Fig. 27. Landscape map of the Lena Pillars Nature Park.

tions, “mountain” elements that break the monotony of the plain-based taiga landscape of Central Yakutia, steppe regions, dry riverbeds in small valleys, etc. Excursions to the Saamys-Kumaga Tukulan, the “desert” element of middle taiga landscape, underline the uniqueness of the park’s nature elements, introducing tourists to the eolian landscapes of Yakutia and the conditions of their formation. Excursions to the remarkable landscapes at the Buotama River mouthonly serve to enrich the knowledge and ideas about the nature of the park gained in the aforementioned locations.

The landscape approach allows for an even representation and complex reflection on specific features of geological, geomorphological, botanical and other natural monuments, using information about the history of their development, place and role in the present day natural environment and the evolution of natural objects. Using this method when developing excursion content leads to tourists forming a coherent picture about the nature of the park, raises the informational content and attractiveness of the trip, and helps people develop an ecologically friendly way of thinking.

One of the most prospective directions for landscape research is the study of the peculiarities in the formation, morphology, and dynamics of eolian landscapes in the park. Research into thegeomorphologic and climatic conditions responsible for the formation of the eolian landscape were researched on the basis of data analysisusing climate reference books, maps and aerial surveys from different years (Vasiliev, Samsonova, 2000).

Field research throughout the 1998-2000 period entailed the exploration of the surrounding areas and the top of Saamys-

Fig. 28. A Christmas tree on the Lena Pillars.

Kumaga Ridge, as well as the ridge bank, eolian formations on the brow side, and the base of the Lena River 4th terrace fragment ledge near the Buotama River mouth. Information was gained on meso- and microforms of eolian relief, as well their spatial distribution. Dynamics of eolian processes activatedin the north-eastern part of the Saamys-Kumaga massif after a fire that destroyed a forest there are being monitored.

It has been confirmed that the 4th terrace of the Lena River has often been a site for forest fires in the past. Digs at the lithogenic base of the sand-ridge type of locality at the mouth of the Buotama River down to the depth of 3.5-4.0 meters have yielded horizons with traces of fires at depths of 1.0, 2.0, and 2.5 meters. This fact serves to present fires as one of the main factors for the formation of eolian relief at this location on the Lena River. Results of research into eolian landscapes significantly add to and expand the contents of existing excursion materials for the Saamys-Kymaga and the Buotama River mouth locations.

Study of the canyon (specific fragment of a river valley typical for karst regions) at the Oldokun River mouth showed that this location has valuable recreational resources for the development of tourism and can be used to expand the existing excursion program. In order to provide the necessary information for organizing excursions in this part of the park and the Labyia stream mouth, it is necessary to organize and conduct research based around the study of karst formations.

The study of landscape behavior in modern climatic conditions is of notable priority. Ideas given to tourists by guides on the basis of such research will help to create ecologically conscious behavior in everyday professional andrecreational activities. With an aim of studying the present day landscape dynamics on the territory of Yakutia, the area of the Lena Pillars Nature Park is used as one of several research areas. Dendroclimatologic materials enrich excursions with information on climate change on the territory of the park and Central Yakutia as a whole, which is of particular importance considering climate warming and changes to the landscape.

The next priority in the creation of a complex landscape basis for the planning and organizing of nature conservation and recreational activities on the territory of the park lies in physical-geographical zoning with an aim of regulating recreational nature management. Such efforts will reveal principal patterns of the distribution and dynamics of landscapes in each physical-geographical zone, defining the number of recreationalobjects for each, as well as evaluating their recreational potential and capacity, and identifying types of recreational nature management.

Research into the nature of the Lena Pillars Nature Park continues, and use of all possibilities offered by the landscape method to study its specifics will in the future expand the list of remarkable landscapes on the territory of the park, as well as increase the geographic spread of sites for educational tourism, taking into account the recreational capacity of natural complexes.

Major cryogenic ecosystems

The nominated area contains a spread of the most important modern cryogenic ecosystem types with peculiar soil cover, vegetation and fauna, and with a large number of rare and disappearing species.

Steppe ecosystems are developed over unique soils from extra-continental climate, specifically cryogenic chernozem. Specific features of cryogenic chernozem soils are: presence of icy permafrost and slight gleization indications (rusty spots)

Fig. 29. The Central Yakutian tukulan on the Lena River background.

in the profile; traces of a former flood plain soil-formation stage; intense dehydration of the upper horizon (0-30 cm) during almost the entire vegetation period; and, at the same time, increased humidification of the super-cryogenic horizon; close deposition of the carbonate horizon; foliate structure; tongue-like humus and carbonate horizons; significant humus content in the upper horizon (0-20 cm). Vegetation is presented by petrophyte communities notable for their systematic and ecological flora composition with a constant ecological vegetation structure. Vertebrate species composition is not very diverse and is presented by open landscape birds (kestrel, skylark, etc.); as for mammals, the typical inhabitants are the narrow-skulled vole and the Siberian roe.

Forest ecosystems are presented mainly by ecosystems of spruce, pine and larch taiga. Larch forest ecosystems prevail. These are characterized by a relatively thick (for the region concerned) surface (20-30 cm) of cryogenic pale solodized soils. The main forest-forming species is Kajander's larch, with the underbrush dominated by red whortleberry, bearberry, great bilberry and wild rosemary. Vertebrate population is presented by typical taiga complex species.

Tukulan ecosystem. The soil cover of tukulan has a complex multi-component, contrasted structure and is considered as an aggregate combination of zonal soils in conjunction with flood plain soils from the Lena Valley. A distinguishing feature of this area is the presence of a significant mass of weaving sands over the watershed. Vegetation here is very poor and is presented by psammophytes. Here grows the endemic *Koeleria skrjabinii* of the Central Yakutian tukulan. Here and there, one can meet single specimen or small groups of xerophyte species: *Equisetum arvense, Artemisia commutate, Aconogonon ocreatum, Thymus mongolicus, Corispermum sibiricum* etc. There are no terrestrial vertebrate animals typical for the given landscape element present in the area. As open stations among dense forest, they attract a number of insectivore birds.

Rocky outcrop ecosystem. Cryogenic sod-carbonate immature soils are developed upon the steep slopes of the Lena Pillars. These are characterized by rubbleness, thin silt profile (up to several centimeters) and close dislocation of dense rocks. Total vegetation coverage does not exceed 10%. Floristic composition is mainly presented by steppe species. At rock benches and ledges are noted single plants with participation of xerophilous and petrophilous species. Here grows *Redowskia sophiifolia* – local endemic of the Lena pillars. Rocks and crevices house *Cystopteris fragalis* and *Woodsia glabella* firns. The area is home to birds of prey (peregrine, kestrel, etc.), the swift and the house martin; as for mammals, the musk deer is a typical inhabitant.

2b. History and Development

Nominated territory is situated within the Khangalassky and Olekminsky uluses where the Lena River flows along with its numerous big and small tributaries, forming one of the biggest water arteries of Northern Eurasia. That's why the Lena River remains the main route for people travelling from the south to the north. According to some sources of information, the population process in particular began during the Paleolith along the Lena River, and then, step by step, people subdued the whole Asian North-East, and then populated America straight across the Bering neck.

In 1982 the Diring-Yuryah site became home to a unique antique monument consisting of archeological monuments varied by time, including tools from the Early Paleolith similar to Oldoway tools from Africa. This allowed Yakut archeologists to put forward a hypothesis on the extra-tropical descent of man and deepen their understanding of the history of the area's development. However, monuments from the follow-up periods of Early and Middle Paleolith have not yet been found. Thus, we can suggest only Late Paleolith culture, evidence for said suggestion (monuments) having been found throughout the whole territory of the republic, as well as at the Sink IV-V and Diring-Yuryah sites. Pioneer settlers responsible for the development of vast areas in the region hunted Pleistocene animals. This is evidenced by the burials of mammoth, bison, woolly rhinoceros, Lena horses and reindeer near the Lena Pillars and along the Kuranah, Labyya and Buotama rivers.

As a result of new human entry from the south and mammoth extinction, the primary inhabitants began hunting moose (Alces alces), reindeer and other taiga animals in ensuing millennia. Neolith people started to craft a bulk of multifaceted tools that helped to improve hunting efficiency, as well as fishing tools. The main prey on the hunt appeared to be big taiga animals, especially the moose (Alces alces). The moose also holds a central position in numerous petroglyphs found within the nominated territory along the cliffs of the Lena and the Buotama.

With the advent of carriers of Ust-milsky culture (from the end of the IV millennium B.C. until the middle of the II millennium B.C.) came the development of the fishing trade. Tool development methods and ceramics were greatly improved as well. The Bronze Age began in the middle of the II millennium B.C. and was replaced by the Early Iron Age in the V century B.C. In such a way, Middle Lena inhabitants, conserving their aged system of survival, got into iron. Iron techniques and ironmongery were wide spread and developed during following centuries. This was assisted by iron deposits along the Buotama and Lyutenga rivers. Ferriferous concretions found at that time within the nominated territory were related to sedimentary deposits and cannot be considered characteristic of large iron-ore deposits.

According to scientists, bearers of Ust-milsky culture were the forefathers of Yukaghirs: a primordial North-Asian nation. Small groups of Tungus-language tribes began appearing in the Iron Age. A stronger migration of Evenk forefathers began in the second part of A.D., and they in turn started up riding and pack reindeer breeding, which served as a new type of economic activity in the region. From that point on, part of the park's territory became a pasture area for deer breeding. Besides, a rich collection of wild animals and plants remained to be an important extra source of life necessities that ensured the survival Evenks and other people.

A ranking place in the history of the region's development belongs to Yakuts, whose forefathers, the far from abundant Turcoman-language people, appeared during the VI-VII centuries. Yakuts populated the far bank of Lena River and its tributaries where they were able to maintain and adapt a horse-breeding and stock-raising economic structure despite extreme natural and climatic conditions, which ensured the development of trades, especially smithing. They widely used ironstone from the Lyutenga and Buotama river watersheds for trade tools and other economic needs.

Fig. 30. Stamp from 1959.

Fig. 31. View of a Yakutsk town and the Lena Pillars. Charle de Lespinass (after Julio Ferrario "Il costume antico e modern, o, storia di tutti I popoli antichi e moderni" (Asia. Volume 4. Milan. 1818).

A new step in the economic development of the territory began with the appearance of Russian people. The spreading of agriculture was the most important product of the region's economic development. Hunting trade tools were greatly improved, firearms appeared. Household items and clothes, dwellings and eating habits were all changed. Old Russian dwellers (Prilenie) not only introduced innovation to the economic structure, but also pioneered many elements of material and spiritual culture for the indigenous people in the region.

During the II Kamchatka Expedition under the command of V. Bering along the Tamma River in 1735-1744 (Megino-Kangalassky ulus), the Tamginsky iron foundry was situated on the river and was supplied by means of iron ore from the current territory of the park, as that particular iron ore contained 45.5% iron. Small co-operative reindeer farms, the "Buotama" and the "Combine", were organized in the XX century within the territory of park, at the mouth of the Buotama River and in the Dikimde region at the end of 1920 an survived until sixties of the XX century. On top of traditional crafts and trades (reindeer breeding, hunting, fishing) those co-operative farms also trafficked loads for the gold mining effort on Aldan.

In sight of all this, in the past millennium and currently, the nominated territory is one responsible for the traditional survival of the Evenks, who upheld traditional types of economic activity based on smart consumption limitations and environmentally friendly use of natural resources.

3. Justification for inscription

3a. Criteria under which inscription is proposed (and justification for inscription under these criteria)

The Lena Pillars Nature Park is nominated under the following criteria:

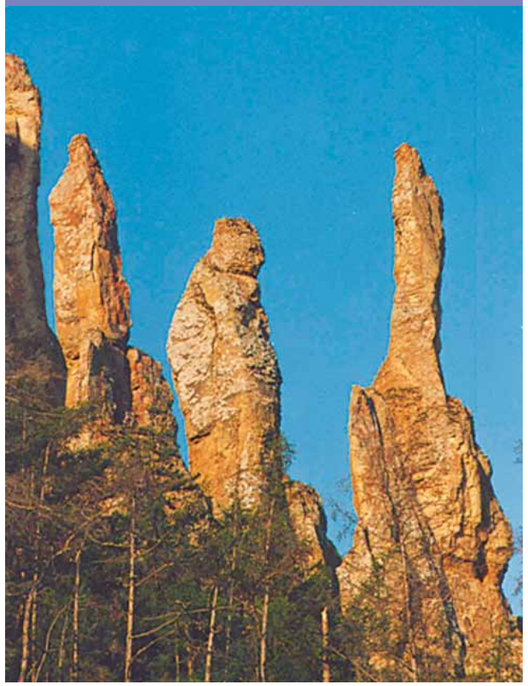
vii Contains unique natural objects of outstanding beauty and aesthetic significance

The Lena Pillars Nature Park is a unique natural monument and a monument of the coldest and most severe habitable regions in the world. It occupies more than 1,272,000 ha which include a range of unique and outstanding aesthetical value sites, including the famous cliffs which are lined up as solid walls along the right bank of the great Siberian Lena River and its tributary the Buotama River. Fabulous rocky statues up to 100 m high stretch almost 40 km along the Lena River. Lonely cliffs, standing against rockslides and green forested slopes, can be seen along around 200 km. During more than half a billion years the light-brown, brown-grey laminated limestones eroded. Within the previous 2 million years, fluvial masses of red sands deposited here after karst and erosion processes formed various fanciful cliffs.

There are many outstanding karst landscapes around the World, with unique outcrop formations, different geologic structure and age, criteria and spatial structure. The most valuable landscapes are already inscribed into World Heritage List (see Comparative analysis chapter), most of them are, for example, much higher than the Lena Pillars. But if we take into account the exceptional variety of the outcrop formations, and the fact that they continuously stretch along such a significant distance (such phenomena, according to our knowledge, have never been noted around the already inscribed World Heritage Sites), then the global value of the Lena Pillars becomes obvious.

Thus we can claim that the Lena Pillars have a relief with completely unique features and with exclusively high aesthetic potential. With wind and water, heat and cold, nature, as the world's artist, has created a genuine masterpiece made of colonnades, towers, cathedrals, caves and holes. These forces morphed the rocky formations in the area into fantastic human and animal-like statues.

Fig. 32. Stone monuments of mysterious creatures.



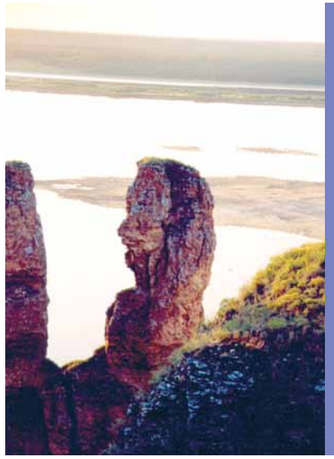


Fig. 33. Kihi-Taas – the stone man.

Fig. 34. Neolithic rock painting with a moose family.

The nominated territory boasts very rich and diverse vegetation, which contributes to the landscape diversity and enhances the aesthetic evaluation of the Lena Pillars Nature Park: larch taiga with pine forest inclusions and alases on the watersheds, that image turning into meadows and steppes in the Lena and Buotama River valleys, then numerous islands with amazing sceneries full of flowers, shrubby and grassy plants (more than 300 species). The area also demonstrates the exotic phenomena present in Yakutian nature: tukulans, real sand dunes in a sea of endless taiga.

The variety and surprising combination of Lena Pillars rocky forms has attracted the attention of humans since days of old and continues attracting people today. Since 2000 BC these voiceless rocky giants became bystanders and treasurers of vanished and existent civilizations, expressed in the ancient art of petroglyphs. The virgin soil gave birth to new centers of civilization, which contributed to the further development of human culture in the north lands and exploration of its immense space. Thousands of years of living in extreme natural and climatic conditions formed the special strategy of sustenance used by the native people of the region, which is based on optimal functionality for the system of "nature – human – production – ecologic traditions". That's why all native people treated every natural site and phenomena as divinity and perceived them as having spiritual overlords. Special meaning in the traditional outlook was given to the Lena Pillars, which have been treated as sacred and which acted as places for worship, ceremonies and rituals. People used rock painting on Lena cliffs to deliver to descendants their vision of world order, spiritual and cultural experience, as well humanistic ecologic traditions, which now present outstanding scientific and aesthetic value.

With its glamorous beauty the Lena Pillars dazzled many travelers, explorers, artists and writers. I. Standling, a Swedish journalist, who visited the Lena Pillars in the late 19th century, noted exceptional natural beauty.

"Colossal rocks of red sandstone alternating with forested hills are reflected in the waters of the giant river. Here rise Cyclopean sandstone walls brought one against another by some supernatural forces… Here under the low-browed cliff is the eternal giant whirlpool, while away there are dominating kind of countless spires of temples and minarets or ruins of colossal castles made of pale-gray limestone. Columns of slender larches and Siberian firs stand in the ravines as if armies ready to assault a fortress towers over them, while far away, at its highest, there are lonely firs, like soldiers, climbing uphill to the fortress. Then slaty layers flash and give the river shores a fantastic view. Here and there one can see a dark hole to an underground grotto, in other places there are warm sulfurous springs spouting from the mountain."

Fig. 35. The Boutama River mouth area.

Bewitched by the amazing beauty and greatness of the Lena Pillars, the Siberian poet Anatoly Olkhon wrote (Anatoly Olkhon, 1903 - 1950):

"Rocks? No, there are no rocks,
There are ancient creatures in a line,
Raising their bared teeth,
Burning with the rainbow colors.
Mountains? No, they are not like mountains,
They are towers, castles, chambers,
Colonnades, terraces, cathedrals,
Minarets, tombs, houses…
Will you say to me – cliffs? Indeed,
This is a herd of flying horses,
Rhinoceros, elephants, hippopotamus…"
(Olkhon, 1951)

The essential part of the Lena Pillars Nature Park is virtually untouched, a virgin region, which by itself is a significant factor of high aesthetic value. Prof. O.N. Tolstikhin, writes, "Maybe the main function of nature is to give people rest, return them to the world of beauty and happiness, lead them off from the misery and heavy worries which befall our society. By conserving nature we conserve ourselves, our souls and not only resources necessary for expanded reproduction". This nature made masterpiece is glorious during any season and in day or night. It is especially impressive in the evenings, when cliffs, covered in twilight, are ignited, growing pink as if they rise from their reflections in the calm water, and coming to life from churning waters caused by light winds or passing ships and boats. The aesthetic value is intensified by the rich colors of the four seasons which are exceptionally well pronounced by the strong continental climate. The impressive beauty of

Fig. 36. Gigantic pillars of the valley of Lena.

the nominated territory is a permanent object for famous artists, photographers, writers and tourists. The fabulous statues of rocky boulders, numerous rifts and rapids of the Buotama River, sand dunes, endless taiga with seasonally changing coloration from light to dark green in spring and summer to yellow in autumn and black and white in winter, and the integrity of multifaceted virgin nature in this wonderful place have been echoed in many movies, pictures, paintings, books and folklore.

Being a Special Protected Area with unique natural landscapes, rich flora and fauna, conserved traditional aboriginal activities (reindeer breeding, fishery, subsistence hunting, cattle breeding), cultural and ethnographic sights, the Lena Pillars Nature Park has been Yakutia's "business card" for many years. To date, the Lena Pillars Nature Park is one of the main tourist destinations for Russians and foreigners in Siberia, much like Lake Baikal and the Volcanoes of Kamtchatka.

"My admiration is endless, and I am standing still before this beauty. The Lena river banks, the unbounded Lena Pillars….and silence. The beauty of rough nature. I feel quite small standing before the Lena Pillars. I dare not to touch this nature for fear to disturb it. I look at all this in wonderment. I am fine here. I breathe in air which is so clean! I've absorbed this nature so deep in myself that it will always be kept in my soul" (Bruno Alend, France).

And this is another exceptional aesthetic value of the nominated territory with unmatched and mythic beauty: when a human of modern post industrial civilization begins (as our ancient ancestors) to feel himself as an integral part of nature, a grain of sand in the Universe, and directly joins the circle of nature.

Such values can be regarded as "transformative values" as per Bryan G. Norton, which stand in contrast to plain demand values. Nature in its diversity and beauty – as represented by the Lena Pillars Nature Park – can function as a central transformative value: "Through experiences of nature, a new sense of value emerges" (Norton 1987, p. 192).

The Lena Pillars Nature Park has not only demand value for humans for satisfying needs and preferences. The awe-inspiring Lena Pillars Nature Park also possesses transformative value by providing occasions for us to examine, deliberate over, and revise our own values, that is, to grow as human beings.

viii Presents an outstanding example representing major stages of the Earth's history, including records of ancient life, significant on-going geological processes in the development of landforms, or significant geomorphic and physiographic features.

The Lena Pillars Nature Park possesses an outstanding universal value, being the most significant natural monument of the "Cambrian Explosion" itself. Due to its platformal type of carbonate sedimentation within the tropical belt without a subsequent metamorphic and tectonic reworking, the Lena Pillars preserve the most continuous and richest Cambrian record of the diversification of animals and other organisms from their first appearance until the first mass extinction event and subsequent recovery interval. This is Siberia only where this interval is represented by marine carbonates, as carbonates are the best sediments for skeletal fossil preservation. The "Cambrian Explosion" process is observable here in parallel in three types of sedimentary

basins during c. 35 m.y. (542–506 Ma). The high quality of preservation of both skeletal and soft-bodied fossils being coupled with high precision isotope and palaeomagnetic records as well as with various well-preserved sedimentary fabrics allows researches to solve diverse ecological and evolutionary problems with a precision comparable with the study of modern biotas and communities. Due to its palaeogeographic position, unique for the early Cambrian sedimentation, the Lena Pillars houses the earliest and the largest, in both temporal and spatial senses, fossil metazoan reefal massif. This massif being a site of Cambrian diversification is comparable in its significance to the Great Barrier Reef in the modern world: both are the sites of the highest faunal diversity in the world, of the early Cambrian and of the modern times, respectively.

Nowadays, these Cambrian carbonates continue to serve unique geological processes, namely, the frozen ground karst. The karst of the Lena Pillars Nature Park is the only example in the world of an ongoing development of a frozen ground karst on a plain plateau. The entire rock complex is covered by the karst phenomena under perennially cryonival conditions. The Lena and Buotama pillars are the only place at a global scale where the processes of fine disintegration of rocks – cryohydratational weathering – are dominated in modelling of a carbonate karrenfeld relief. On the park territory, these phenomena are enriched by thermokarst topography, such as cave-in lakes, thaw depressions, and alases typical of permafrost areas. The alases are almost unique Yakutian features and the term itself is derived of the Yakutian language. Other rare natural phenomena of the Lena Pillars Nature Park are "fossil" sand dunes – tukulans – and relic steppes of the Neopleistocene Age.

Both Cambrian and recent natural processes finally created the Lena and Buotama pillars which are famous for their exceptional beauty at least from the Neolithic time. The aesthetic impact of these enormous in scale high rocky riverside banks has no analogues in the whole world. Improbable stone sculptures in the form of fantastic pillars, steeples, towers with niches, passages, caves stretch for dozens of kilometers along the steep banks of the middle Lena River and its tributaries. The Lena River itself, which is one of the biggest rivers in the world, is served as a magnificent animated and all times different pedestal for this tremendous scenery in the frame of the continuously changeable taiga and mountain steppe vegetation bearing an aesthetic impact on people that has no analogues in the world.

Thus, a considerable geological (lower to middle Cambrian outcrops), palaeontological (rich unique fossils and entire fossil communities including the first metazoan reefs of the world), and geomorphological value (frozen ground karst, thermokarst, and sandy dunes-tukulans) are combined here with outstanding picturesque sights. The nominated area is of outstanding universal value featuring a unique synthesis of various geological, biological, and geomorphological phenomena, which is the basis for our understanding of the far past of our planet, evolution of the Earth and of life on it at a major stage of Earth's history. This territory nowadays as an area of exceptional natural beauty and aesthetic importance.

viii (a) Be outstanding example representing major stages of Earth's history, including the record of life.

The Lena River and its tributaries provide natural cuts of the uppermost Ediacaran (Precambrian) to middle Cambrian strata of a total thickness from 980 to 1370 m along a distance of over 150 km. The high quality of preservation of both skeletal and soft-bodied fossils being coupled with high precision isotope and palaeomagnetic records as well as with various well-preserved sedimentary fabrics allows researches to solve diverse ecological and evolutionary problems with a precision comparable with the study of modern biotas and communities. Due to its low latitudinal palaeogeographic position and an absence of large land masses Siberia only accumulated fossiliferous early Cambrian carbonates. As a result, the Lena Pillars house the earliest and the largest, in both temporal and spatial senses, fossil metazoan reefal massif. This massif being a site of Cambrian diversification is comparable in its significance to the Great Barrier Reef in modern world: both are the sites of the highest faunal diversity of the world, of the early Cambrian and of the modern times, respectively.

Fig. 37. Palaeogeography of the Siberian Platform in the early Cambrian (based on Savitskiy & Astashkin, 1979).

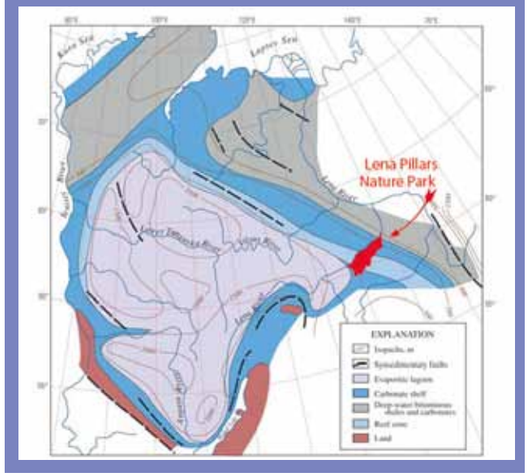


Fig. 38. Thin plan-parallel lamination of Cambrian strata.

Fig. 39. The Zhyrinsky Mys section of Cambrian series 1 and 2 boundary strata.

Fig. 40. The Kisi-Taas section of Cambrian stages 3 and 4 boundary strata.

The principal sediments of this area are the lower to lower middle Cambrian richly fossiliferous continuous carbonates of various marine geneses. This strata embraces over a half of the Cambrian System (Cambrian Series 1 to middle Cambrian Series 3) and two thirds of the Cambrian time scale (36 m.y. of 54 m.y.) according to the International Stratigraphic Chart issued by the International Commission on Stratigraphy. Those are the rocks that make up the Lena Pillars as well as the Buotama Pillars themselves. The Cambrian sedimentary sequence commences with subtidal to intertidal mudstones of the lower Cambrian Series 1, which is overlain by argillaceous mudstones, which encompasses a large number of archaeocyathan-calcimicrobial reefs of Cambrian stages 2 and 3. The 20-kilometers wide Oy-Muran Reef Massif forms a barrier on the border of inner and outer basins. The Oy-Muran Reef Massif itself is composed of multiple isometric archaeocyathan-calcimicrobial buildups. The inner basin yields various back-reef carbonates. The outer basin comprises relatively deep-water limestones bearing a soft-bodied fauna and fleshy algae of extraordinary preservation levels.

The Lena Pillars' sections allow scientists to estimate the "Cambrian Explosion" in its full diversity and dynamics. It should be emphasized that among approximately 2,000 early Cambrian genera, which are known today, about 350 are described from the area in question, and that is a really amazing number. This list grows almost every year. These genera include the first archaeocyaths (rigid aspiculate calcified sponges), radiocyaths, coralomorphs (primitive corals), brachiopods, hyoliths, and some other groups of animals with mineralized skeletons while the contemporary general diversity of this region was the highest in the early Cambrian of the world. This is the area where, starting in the 19th century, occurred the systematics of archaeocyaths, hyoliths, and many other problematic groups, which comprise the core of the animals involved in the Cambrian skeletal revolution. For some of the aforementioned groups, this area was also the center of their origin. The fossil species diversity in the area is over 500 species. This is the diversity of taxa (species and genera) only, which allows us to quantify the "Cambrian

Explosion" phenomenon and, thus, to obtain a scientific understanding of this process.

Reefs are some of the most amazing objects in the Lena Pillars and worldwide. Excellent preservation, high diversity, and multiple localities of reefal fauna in the Lena Pillars provide a firm basis for detailed palaeoecological and population dynamics studies of the earliest metazoan reefal biota. These studies are comparable in precision with research on modern reefs. However, if modern reefs represent a single fragment of time only, the Lena Pillars provide over 20 such time fragments, which grant researches an understanding of the evolutionary processes that shaped communities of organisms from their very beginning. Such studies are possible because metazoan reefs initially appeared here, and during first 10 million years existed on the Siberian Platform only. Additionally, such features of communities can be studied for the significance of different diversity factors, hub-species and their influence on the community structure, interspecific and intraspecific interactions, ecological successions, trophic webs, and many others. These studies have drastically changed our understanding of reef evolution and their results are now cited in text-books and treatises.

The Lena Pillars are an entirely unique site in sight of representing a complete early to middle Cambrian record by continuous carbonate succession bearing rich fossils. The Oy-Muran and other Lena Pillars reefs are especially important because they represent the earliest record of metazoan reefs in the world. The establishing of the metazoan reef ecosystem was delayed in other regions for about 10 m.y. and this was the territory of modern southern Sakha (Yakutia) where principal Cambrian reefal groups of animals originated. Although there are a number of important Cambrian sites in the world, only the Lena Pillars contribute fully to the understanding of the total story of the Cambrian skeletal explosion especially in reefal facies.

Both the rich fossil record of the Lena Pillars and the continuous carbonate succession expressed by excellent outcrops allowed geochemists and geophysicists to develop palaeomagnetic and stable isotope records of the highest fidelity for the early to middle Cambrian interval. Carbon and strontium isotope curves as well as the palaeomagnetic scale established on the Lena Pillars serve as reference scales for the whole world.

Data of such high precision is necessary for the understanding of the co-evolution of Earth's lithosphere, hydrosphere and atmosphere, and is very important for global Cambrian stratigraphy, as well as for palaeogeographic and general geological and ecological implications that are already developed. An accumulation of such statistical data brought about a distinguishing of the fist mass-extinction events in Earth history, known as the Sinsk and Toyonian extinction events, and even the very names of these events are borrowed from the toponymy of the Lena Pillars area. It had been shown that these events were as significant in animal evolution as the well-known Permo-Triassic extinction.

Moreover, the Lena Pillars carbonate allowed researches to analyze palaeoclimate alternations on the eve of the first Greenhouse Epoch in the Phanerozoic because only the given area makes it possible to gather in concert enough wholesome statistical data on faunal diversification, reliable data on carbon and strontium isotopes, and correct data on diverse carbonate mineralogies. In turn, these studies brought about a new concept of global climate trends, showing a general cooling during the last 540 million years. Even the exact time of the inception of the first Phanerozoic Greenhouse Epoch is clarified here, which was a conundrum since seminal Sandberg's paper (1983) pointed to this problem. This data also allow us a better understanding of the fate of modern reefs due to a possible global warming, because akin to their early Cambrian analogies, modern reefs are built by organisms possessing volatile aragonite and high-magnesium calcite skeletons and by sedimentary fabrics of the same composition. The extinction of the earliest metazoan reefal biota can be directly tied to the rise of carbon dioxide and the following commencement of the first Phanerozoic Greenhouse Epoch.

The Lena Pillars site provides a large area for further discoveries of incredibly well preserved fossilized soft-bodied organisms, larvae, and embryos. Each new expedition brings out new fossils and large amounts of data for sedimentology, geochemistry, and other disciplines. Multiple time-slice analyses of reefal palaeocommunities will provide further large data sets for challenging of major current evolutionary and ecological paradigms. In general, the nominated area is an outstanding natural property providing a unique

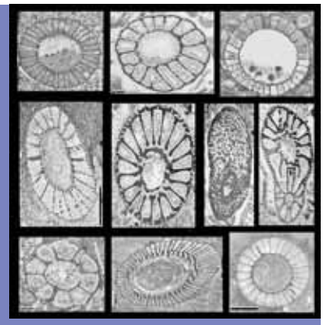


Fig. 41. Thin sections of archaeocyaths (calcified aspiculate sponges) from lower Cambrian reefs of the Lena Pillars Nature Park.

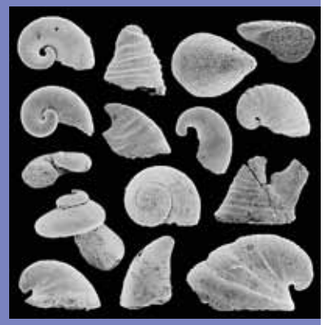


Fig. 42. Mollusc shells from lower Cambrian strata of the Lena Pillars Nature Park.

Fig. 43. Small shelly fossils from the lower Cambrian of the Lena Pillars Nature Park.

Fig. 44. A Cambrian bioherm of the Oy-Muran Reef Massif.

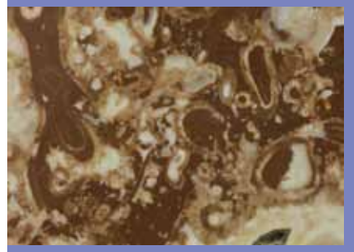


Fig. 45. A longitudinal polished section of an Oy-Muran reefal sample with in situ archaeocyaths and other reefal organisms. Cambrian Stage 2.

Fig. 46. Intact complete giant arthropods *Phitophylaspis* of the Sinsk Biota. Cambrian Stage 3.

Fig. 47. Ooid shoal of Cambrian back-reef facies.

Fig. 48. Tempestites of Cambrian back-reef facies.

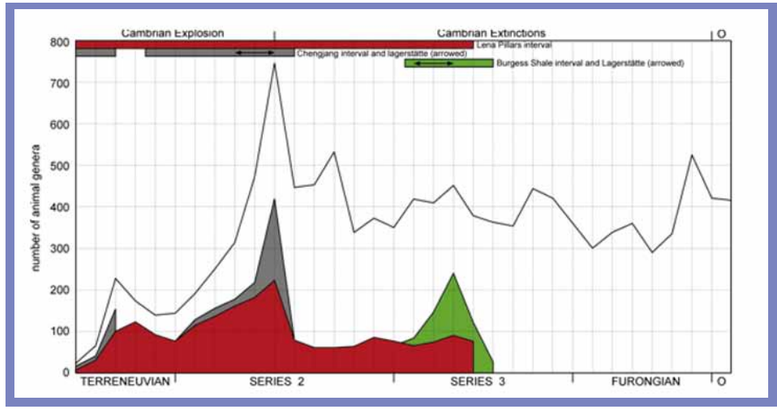


Fig. 49. Generic diversity of the Cambrian fauna in the Lena Pillars' area (red), the Chengjiang Fossil Site (gray), and the Burgess Shale, Canada (green) on the overall generic diversity.

unmatched synthesis of Cambrian geological and palaeontological data that serves as a basis for our understanding of the ancient past, evolution of the Earth and of life on our planet during one of the most pivotal and dramatic intervals of its development.

viii (b) Presents an outstanding example representing significant on-going geological processes in the development of landforms, or significant geomorphic or physiographic features.

Frozen ground karst

The karst at the Lena Pillars Nature Park is the only example in the world of the recent development of frozen ground karst on a plain plateau at 200-600 m above sea level, constituted by the limestone and dolomites from the Lower Cambrian. All rock mass is covered by the karst process in conditions of the perennially cryotic rocks up to 500 m in thickness. Karst is developed in conditions characterized by a Sub-Arctic extreme continental and dry climate. (See Chapter 2a "Karst phenomena of the Lena Pillars Nature Park" for detailed information).

Frozen ground karst in the nominated territory is divided into a) surface karst (associated with supra permafrost aquifers) and b) underground karst (related to aquifers originating inside and below permafrost). Classic superficial and underground karst forms: karst sinkholes, ponors, suhodols, karst lakes, disappearances of rivers, karst sources, karren, karst niches and karst pillars all serve as clear confirmation of karstification. Activity of recent karst processes on the territory of the Lena Pillars Nature Park is estimated to be at 10.3 mm per 1000 years.

The on-going development of Lena Pillars is controlled considerably by gravitational-slope processes, conditioned, on the one hand, by ancient tectonic joints, on the other hand, by the unloading of the cliff face parallel to the river. Generally, the development of recent Lena Pillars karsts is related to the cliff face unloading fissures.

Recent fluvial processes play a peculiar role in the formation of the pillars' relief. The moving valley's talus, serving as evidence of on-going weathering processes upon limestone pillars, are wide spread along the bedrock shores of Lena River. The waters of these rivers undermine the shores and carry off weathering material. New products of the cover, creeping from above, are accumulated in exchange of the creeped and washed talus. Thus, the process of slope disintegration occurs constantly, on the whole, due to the widening of the river valley.

3b. Proposed Statement of Outstanding Universal Value

The nominated property of the Lena Pillars Nature Park tells us three key-stories about our planet and the early evolution of life, namely: 1) the record of the "Cambrian Explosion", 2) the story of the emergence of the frozen ground karst phenomenon, and 3) the history of humans deifying a great natural monument.

1a) The site possesses remarkable world-wide value, being the most significant natural monument of the Cambrian Explosion, which was one of the pivotal points in the evolution of life on Earth. Due to the platformal type of carbonate sedimentation within the tropical belt without subsequent metamorphic and tectonic reworking but with impressive outcrops, the nominated property preserves the most continuous, fully documented, and richest record of the diversification of skeletal animals and calcified algae from their first appearances until the first mass extinction event, which is really well documented as occurring parallel in three types of sedimentary basins during the first 35 m.y. of the Cambrian evolution.

1b) The Lena Pillars comprise the earliest and the largest, in both temporal and spatial senses, fossil metazoan reef of the Cambrian world. This reef being a site of Cambrian diversification is comparable to the Great Barrier Reef in the modern world. The high preservation quality of both skeletal and soft-bodied fossils being coupled with high resolution isotope and palaeomagnetic records as well as with various well-preserved sedimentary fabrics allow researches to solve diverse ecological and evolutionary problems with a precision comparable with the study of modern biotas and communities.

2) Situated within the nominated territory, Cambrian carbonates remain a place of unique ongoing geological processes to this day – the only model of recent frozen ground karst on karst plateaus. The entire rock massif is affected by karst processes of perennially cryotic rocks under extremely continental semihumid climate conditions. The Lena and Buotama pillars are the only area on the globe where the processes of the fine disintegration of rocks – cryohydration weathering – dominate in the shaping of carbonate pillar relief. These karst phenomena are enriched by thermokarst processes developed in the area of great permafrost thickness (up to 600 m), which led to appearances of alases – thermokarst features of almost exclusively Yakutian affinities. Frozen ground karst in combination with thermokarst is a unique worlwide phenomenon of Eastern Siberia and is thoroughly documented on the proposed property. It is quite different from all karst sites in the World Heritage List, which are located in humid areas. In turn, the semihumid

Fig. 50. View of the Lena Pillars across the Lena River in middle November.

continental climate conditions are expressed in a formation of tukulans, which are eolian sand dunes being developed at almost polar latitudes.

3) Cambrian and present-day natural processes eventually created the Lena and Buotama Pillars known for their unmatched beauty. The aesthetic effect of these large-scale rock river banks has no analogue anywhere else in the world. Improbable stone sculptures in the form of uncountable fantastic pillars, steeples, towers with niches, passages and caves stretch for dozens of kilometers along the banks of the Lena River and its tributaries. The Lena River itself, one of the biggest rivers in the world, serves as a magnificent, animated and ever-changing pedestal for all this amazing scenery framed by the seasonally changing features of taiga and mountain steppe vegetation.

The nominated area is an outstanding natural property providing an unmatched synthesis of Cambrian geological and palaeontological data, which serve as the basis for our understanding of the far past, evolution of the Earth and of life on our planet during one of the most pivotal and dramatic points of its development.

The Lena Pillars Nature Park could make a claim for its inscription on World Heritage List according to two criteria: vii and viii. Valuable geological sites (lower to middle Cambrian strata), paleontological sites (rich and exceptional fossils and biocenoses, including the earliest metazoan reef belt) and unique geomorphological sites (frozen ground karst, thermokarst, and sand dune-tukulan) are combined here with incredible natural scenic attractions.

3c. Comparative analysis (including the state of conservation of similar properties)

1. GEOGRAPHICAL ANALYSES

1.1. The Udvardy scheme analyses – biogeographical realms level

The Eastern Palaearctic is one of the greatest biogeographical realms allotted upon the prominent M. Udvardy natural demarcation scheme (1975). However, it houses a small number of World Natural Heritage Sites – about 15 – in comparison with other regions of the Earth. Moreover, they are distributed very irregularly. As such, most of the sites are accumulated in the southern and south-eastern parts of Eastern Palaearctic (in China, Northern India, and Nepal). Another three sites are located in its central part, in the mountains and plateaus of southern Russia (Golden Mountains of Altai, Uvs Nuur Basin, Lake Baikal). There are some more sites in the eastern part of the region, in its coastal zone: two in Japan and two in Russia (Central Sikhote-Alin, Volcanoes of Kamchatka). One more Russian site stands apart: it is the "Wrangel Island" in the Chukchi Sea, being the northernmost of World Natural Heritage Sites. At the same time, practically the entire northern part of the Eastern Palaearctic (tundras, open woodlands, Russian Siberian taiga and the Far East) presents a vast region with not a single World Natural Heritage Site until now. This disproportion is only partly corrected by the Russian World Heritage site Putorana Plateau, inscribed in 2010.

The Lena Pillars Nature Park is situated in Central Yakutia, i.e. in the north-eastern sector of the Eastern Palaearctic, and in such a way can partially cover that significant gap clearly seen on the global scheme of World Natural Heritage Sites.

2. COMPARISON WITH OTHER WNH SITES

The nominated property comprises a segment of the Lena River about 200 km long that plays the role of a primary natural axis, "the frame" of the protected area. And from this point of view the concerned region is a rather interesting one. If we consider World Natural Heritage Sites that also comprise rather extensive sections of large rivers, it turns out that there is only a small number of such sites in the world (at that, small rivers are abundantly represented in WNH sites).

Some of the large rivers are plain, slowly running, sometimes meandering greatly (like Jau and Rio-Negru – at the Central Amazonia, Niger site – in the W National Park). Other rivers run through canyons (Grand-Canyon of the Colorado River in the USA, Nakhanny in Canada) or deep gorges ("Three Parallel Rivers" in China). There are also segments of rivers with giant waterfalls (Iguasu, Victoria at the Zambezy river).

CRITERION VII

The pillars stretching along the Lena River channel are famous for their fanciful and fantastical contours and embody the main aesthetic resource of the park. They are easily visible from long distances. This magnificent decoration of nature alone makes the region a prime candidate for high appreciation, given criterion vii.

Table 5 presents a comparison of the Lena Pillars with a number of World Natural Heritage sites (both natural and cultural-natural) which also comprise a series of skerries and were included into the World Natural Heritage List specifically in sight of criterion vii, as in, they were recognized as being extremely picturesque and exotic. Some of them are

Table 5. Comparison of the Lena Pillars with rock pillar landscapes in other World regions (including WH properties).

Name of property/status	Short description	Genesis	Height of skerries
The Lena Pillars Nature Park (Russia)/Property, nominated for inscription into the World Natural Heritage List	A many kilometer "chain" of skerries, formed with ancient limestones, along the Lena River's right bank, housing graceful and wondrously diverse forms of rock pillars.	Frozen ground karst, erosion and cryohydratation weathering	Up to 50-100 m
Meteora (Greece)/World cultural-natural Heritage property	Massive in width and height rocks of sandstone with flat apexes and steep slopes, located in a compact group.	Ancient tectonics, erosion and weathering	Up to 200-300 m
Uishan Mountains(China)/ World cultural-natural Heritage property	A series of massif sandstone mountains/skerries with steep slopes and rounded domelike apexes along the channel of "Nine Turns River"	Ancient tectonics, erosion and weathering	Up to 50 m
Ulin-Yuan' (China)/World Natural Heritage property	Hundreds of high peaks with steep slopes made of sandstone and located in a rather compact group.	Erosion and weathering	Up to 200 m
Shilin (China)/Cluster of World Natural Heritage property, South China Karst	A unique "stone forest" with exceptional diversity of forms and colors of spire-shaped limestone pillar rocks and outcrops around a lake.	Early tectonics, karst, erosion and weathering	Up to 30-50 m
Ha-Long Bay (Vietnam)/ World Natural Heritage property	Hundreds of small limestone island-mountains in a shallow coastal zone of the Gulf of Tongking.	A classic example of tropical "tower" karst	Up to 150-200 m
Cindjy-du-Bemarakha (Madagaskar)/World Natural Heritage property	Limestone "stone wood", located on a high bank of the Manombolo River and forming a rather compact massif.	Swallow holes – one of the most widespread forms of karst relief	Up to 20-30 m

Name of property/status	Short description	Genesis	Height of skerries
Nahanni (Canada)/World Natural Heritage property	High mountain landscape (up to 2,972m a.s.l.), massive forms of rocks, waterfalls, canyons and outcrops (limestone, sandstone) along the Nahanni river channel.	Karst, erosion and cryogenic weathering	Up to 100-200 m
Bryce Canyon (USA)/National park	Picturesque compact massif of red sandstone outcrops (towers, pillars, spires, “stone forest”).	Erosion and weathering	Up to 100-150 m
Arches (USA)/National park	Unique stone statues of red sandstone upon a mountainous plateau.	Erosion and weathering	Up to 50 m
Cévennes (France)/on the Tentative List (Cultural landscape)	Mountainous cultural landscape with separate outcrop relief forms allocated on the vast territory (limestone steeps, towers, pillars, spires, “stone forests”).	Karst, erosion and weathering	Up to 100-200 m

also situated along river banks, while tothers are geographically isolated and have no connection to any rivers.

Considering the immense length of the almost continuous rock pillar chain (about 40 km) spreading along the channel of a giant river several kilometers wide, one of the largest on the continent, we can surely acknowledge, that the present site does not have any analogues in the world. Indeed, the last majority of sites considered in the Tab.3 are geographically separated and do not have such a close connection with rivers (heavilly dissected high mountainous areas, dry canyons with erosion relief, compact groups of outcrops, both massif and smaller, “stone forests” and others). And only a few of these similar sites include river terrain with picturesque rock pillars along the banks as the described Russian site does; however, these rivers are relatively small compared to the Lena River, and the number of rock pillars along their channels is far smaller (Wuyi Shan, C vennes), or there are canyons instead of rock outcrops (Nahanni).

Moreover, the aesthetic value of the Lena Pillars is increased considerably in sight of two more facts, which gainfully outline this Yakutian phenomenon against other similar territories, namely:

- Excellent observational capability from two major perspectives: firstly, when watching from “inside”, downwards, i.e. from the outcrops’ side, with the Lena River, its islands and opposite bank in the distance; secondly, from the side of river (from the bank or shipboard) upwards. On top of that, there are some intermediate (lateral) observational perspectives. As one Russian proverb has it, “visible as if it were in your hands” (plainy visible). Meanwhile, not every similar site from those listed above has the same observational possibilities. Thus, in mountainous heavy-going areas observation is generally possible from defined routes and sightseeing points (Wulingyuan). The site of Tsingy de Bemaraha, a natural “karst badland”, is totally impassable. The most “visually accessible” are the American national parks of Arches and Bryce Canyon, open shallow Halong Bay, and the massif outcrops of Meteora dominating above a vast plain.

- Pronounced seasonalitythat enriches the landscape’s perception and notably increases its aesthetic potential. In the case of the Lena Pillars, the seasons have a number of notable effects: violent spring vegetation and summer nature blossoms, a short but very colorful “golden autumn” (mainly thanks to deciduous larch, which is abundant along the Lena River banks), and winter being the longest lasting season with thick snow cover serving as an essential part of northern taiga scenery for 7-8 months. This natural change of scenery is the result of the northern location of the site and its extremely continental climate. Meanwhile, many other sites listed above are located much more southward, in subtropic or tropic latitudes, sometimes in mild coastal climates (Halong, Meteora, Wuyi Shan, Shilin, Tsingy de Bemaraha). That is why we can not observe permanent and thick snow cover there as natural surroundings for unique outcrops, that specific, important aesthetic landscape component being absent here. The change of seasons in tropic and subtropic latitudes is different from how it plays out at high latitudes, specifically, no “golden autumn” as in Russia. There is only one similar site in this regard: the Canadian Nahanni Park, which is located in the same northern latitudes (61-62 degrees), in a taiga zone and in continental climate, the compositional basis of this park consisting of a relatively large river, the Nahanni. Bryce Canyon and Arches are also covered with snow for a certain period, but there is no “golden autumn” in those mountainous rocky territories.

Considering aesthetics, the most important aspect is the conservation of wild, untamed territory. Some of the analogues considered above are much more developed than the Lena Pillars region, which mostly resembles a wilderness area. The Cévennes site, for instance, is virtually cultural landscape, which has been intensively developed by humans for long.

CRITERION VIII

A) CAMBRIAN SYSTEM

Currently, there are only two sites representing the Cambrian System, which are either inscribed on or nominated for the UNESCO World Heritage List. These are the Grand Canyon National Park (U.S.A.; since 1979) and the Canadian Rocky Mountain Parks (since 1980). In addition, the Chengjiang Fossil Site (P.R. China) is inscribed in the World Heritage List due to natural criteria in 2012.

The Canadian Rocky Mountain Parks, namely the Yoho National Park, boast the Burgess Shale site as one of their attractions. The Burgess Shale site is one of the most significant fossil areas of the world, an iconic locality of extremely well preserved soft-body fossils (Lagerstätte) explored over the course of 100 years. However, this locality represents only the aftermath of the Cambrian diversification following the first mass extinction event which already took out a large number of Cambrian creatures including the entire reefal fauna. In general, the Burgess Shale site of the Canadian Rocky Mountain Parks does not contain any fossiliferous Cambrian reefal rock. Its skeletal fossil record being of low diversity, the fossils represent a single community only, and the strata representing the “Cambrian Explosion” itself are not present here.

The Grand Canyon being the most spectacular gorge in the world and retracing geological history from the past 2 billion years has little to offer in terms of the Cambrian. Here, the Cambrian System itself is represented by extremely poor fossiliferous and mostly non-marine strata, while the “Cambrian Explosion” interval, if present, lacks any fossils.

The Chengjiang Fossil Site represents the c. 2-3 m.y. Cambrian interval of siliciclastics. Although the Chengjiang site is recognized nowadays as one of the richest Cambrian sites (152 documented species according to a IUCN Technical Evaluation), which indeed represent practically all the phyla in conditions of extraordinary soft-tissue preservation (Lagerstätte), it does not contain any fossiliferous Cambrian reefal rock, its skeletal fossil record is poor, and the entire interval of Cambrian strata is much shorter here and does not represent the lowermost Cambrian strata. It should be emphasized that the site was tectonically and metamorphically distorted, contains a number of gaps in the stratigraphic record, and represents a single community only, which in many respects duplicates the Burgess Shale site and is c. 20 m.y. younger that that the oldest Cambrian strata of the Lena Pillars, thus, lacking sufficient information for the study of the Cambrian explosion in its completeness.

Volumetric Cambrian reefal rocks are known from Morocco (northern Africa), South Australia, western (MacKenzie Mountains) and eastern (eastern Labrador and western Newfoundland) Canada, western United States (Nevada and California), some European countries (Spain, France, Sardinia), and some others. However, in all these sites, the earliest Cambrian strata do not contain reefs and are mostly barren. None of them comprise the earliest Cambrian reefs which are most important for understanding the beginning of the evolution of the earliest reefal biota. None of them contain fossil assemblages richer than those of the Lena Pillars.

Of all these sites, the Lena Pillars alone has a continuous carbonate Cambrian record and the richest assemblages of skeletal fossils. In general, both Cambrian sites are inscribed/nominated into the UNESCO World Heritage List for the uniqueness of their local soft-bodied faunas representing very restricted intervals of 2–3 million years or less, thus lacking potential for an understanding of the Cambrian Explosion in its fullness. The Lena Pillars National Park is nominated as a site housing a complete succession of carbonate Cambrian strata, recording the entire “Cambrian Explosion” from its very beginning to its final stages rather than local soft-bodied biotas representing its peak (Chengjiang) and aftermath (Burgess Shale), respectively, and being restricted to siliciclastic rocks.

Table 6. World Cultural and Natural Heritage sites representing the Cambrian System including further important Cambrian sites.

Site	Principal sediments	Fossiliferrous Cambrian interval	Reefs	Generic diversity	Lagerstätte
Lena Pillars	carbonates	c.35 m.y. (542-506 Ma)	present, including the earliest examples	c.350	soft-tissue, cells, embryos
Rocky Mountains	siliciclastics	c.10 m.y. (516-506 Ma)	-	c.100	soft-tissue
Grand Canyon	siliciclastics	c.5 m.y. (511-506 Ma)	-	c.30	-
Chengjiang P.R. China	siliciclastics	c.2 m.y. (522-520 Ma)	-	c.150	soft-tissue
MacKenzie Mountains	siliciclastics carbonates	c.10 m.y. (520-510 Ma)	present	c.40	-
Eastern Canada	siliciclastics carbonates	c.5 m.y. (510-505 Ma)	present	c.20	-
Western U.S.A.	siliciclastics carbonates	c.30 m.y. (542-510 Ma)	present	c.40	-
South Australia	carbonates siliciclastics	c.25 m.y. (535-510 Ma)	present	c.100	-
Anti-Atlas Morocco	carbonates siliciclastics	c.15 m.y. (525-510 Ma)	present	c.50	-
South Europe	carbonates siliciclastics	c.15 m.y. (525-510 Ma)	present	c.40	-
Other areas of the Siberian Platform	carbonates	c.35 m.y. (542-506 Ma)	present	c.100	embryos

The “Cambrian Explosion” took place at the first half of the Cambrian Period, encompassing an interval of approximately 542–510 million years ago and representing one of the pivotal points in the evolution of life on Earth. This global event was expressed in an explosive diversification of multicellular animals belonging to modern phyla, the mass appearance of skeletal animals, the inception of entire modern type ecosystems (such as the metazoan reefal ecosystem) and global changes in climate from the Icehouse Epoch to the Greenhouse Epoch.

B) FROZEN GROUND KARST

1. Karst plateaus are classic forms of relief in karst regions, which comprise more than 30% of dry land. The term “karst” came from the name of the Karst or Kras Plateau (at 380-430 m above sea level) in Slovenia, formed by limestones dated by the Cretaceous. Karst plateaus are widely represented in different regions of the world: the Grands Casses Plateau rising to 700-1000 m made up of limestones and dolomites from the Jurassic System, the Vaucluse Plateau (338-950 m) made up of limestones from the Lower Cretaceous in France, the “Rock Sea” Plateau reaching 2500-3000 m made up of limestones and marles of Trias including carbonate rocks from the Jurassic and Cretaceous in Austria, the series of plateaus on the Slovac-Hungary boundary made up of limestones dated by Triassic: Coniar, Pleshivets, Silitskoe and Yasovskoe (at 650-950 m), the limestone Yarrangobilly Plateau (Silurian-Devonian) at latitudes of approximately 1100 m in Australia, the famous Mammoth Cave Plateau made up of Carboniferous limestones in North America, etc.

Karst from the Prilenskoe Plateau within the boundaries of the Lena Pillars Natural Park is the first example of recent karst development in plateau conditions and under an extreme continental dry climate. The climatic characters of the plateaus already recognized as possessing outstanding universal value are represented in Table 7:

Table 7. Climatic characters of karst plateau having outstanding universal value.

No	State Party	World Heritage Property	Environmental context
1	Austia	Hallstatt-Dachstein Salzkammergut Cultural Landscape	Humid temperate rising to subalpine and alpine
2	China	South China Karst	Continental humid subtropical (Wulong and Shilin) to subtropical monsoonal (Libo)
3	Cuba	Alejandro de Humboldt National Park	Humid tropical
4	UK: Pitcairn Islands	Henderson Island	Tropical humid
5	USA	Grand Canyon National Park	Warm temperature semi-arid mountain climate
6	Venezuela	Canaima National Park	Humid tropical
7	Vietnam	Phong Nha-Ke Bang National Park	Humid tropical monsoonal

Karstification with climatic conditions similar to those of the Lena Pillars Natural Park’s occurs only at the Nahanni National Park (Canada). But while the Nahanni National Park is characterized by a cold continental climate with an average annual temperature varying from -4 to -12°C and annual precipitation no higher than 400-600 mm, the climate of the Lena Pillars Nature Park is extreme continental and dry with an average annual temperature of -9,8° and annual precipitation at 249 mm. Moreover, the Nahanni National Park is situated in a high mountain region (the Mackenzie Mountains) with absolute amplitudes at 2972 m, where the mountain climate plays the principal role in karst development. But The Lena Pillars Nature Park is located at altitudes of 300-600 m.

2. Karst at the Lena Pillars Nature Park is a unique example of karst development in conditions of continuous permafrost (hence the new scientific term in world karstology: ground frozen karst) up to 500 m in thickness. The World Natural Heritage List currently contains two natural objects – the Nahanni National Park and the Canadian Rocky Mountain Parks , which are situated in an area of permafrost. But while the Nahanni National park displays discontinuous permafrost, the territory of the Canadian Rocky Mountain Parks is home to mountain permafrost (Canadian Rocky Mountain Parks located at 1036-3954 m).

The Lena Pillars Nature Park houses superficial (related with aquifers, situated above permafrost) and underground karst (related with aquifers, situated inside and beneath permafrost). Ground frozen karst is known for featuring the absence of the classic zone of vertical circulation of karst waters.

C) UNIQUE FORMS OF EOLIC RELIEF – TUKULANS

Tukulans, as they call hummocky sands in Yakutia, are spread only in the region of the Middle Lena course and in the basin of its big tributary, the Vilyui River. It is a true natural phenomenon: nowhere else in the world are such prominent eolic land forms (massifs of moving sands) developed under conditions of permafrost, in such high latitudes and in such continental climate (as is well known, dunes are most typical for estuaries and coastal regions, and, of course, for desert arid areas).

Results of tukulan comparative analyses at the Lena Pillars Nature Park and other dune complexes in Eurasia situated within World Natural Heritage Sites are presented in Table 5. The main conclusion is that the exceptional specificity of Yakutian tukulans as a natural phenomenon has no analogues in other regions of Eurasia and the world. Notably, they are interesting not in regards to their size but due to their genesis and conditions of origin.

Table 8. Comparative analyses of tukulans of the Lena Pillars Nature Park with other dune complexes of Eurasia, which are located in World Heritage properties.

Name of property	Dune height	Geogr. latitude	Conditions of origin
Yakutian tukulans (Lena Pillars Nature Park, Russia)	Up to 20-30 m	About 62° N	Boreal zone, permafrost, harsh continental climate
Kuronian spit (Russia/Lithuania)	Up to 70 m	About 55° N	Temperate zone, Baltic coast
Ubsunur Hollow (Russia/Mongolia)	Up to 15-20 m	About 51° N	Temperate zone, harsh continental arid climate, closed desert hollow in Central Asia
Danube Delta (Romania)	Up to 10 m	About 45° N	Boreal zone, river delta, the Black Sea coast
Dunes in the Gvadalkvivir river delta (park Koto-Donyana, Spain)	Up to 40 m	About 37° N	Meridional zone, river delta, Atlantic coast

Fig. 51. Shifting sands of a tukulan.

3d. Integrity and/or Authenticity

Integrity substantiation has been in accordance with the "Operational Guidelines".

Paragraph 88:
(a) The Lena Pillars Nature Park presents a single nature complex, its main components are inseparably tied to each other by common origin, history and the dynamics of natural development, and include all the elements necessary to express its outstanding universal value.
(b) By its size (1 272 150 ha) the nominated property is great enough to support the functioning of nature complexes and to ensure the complete representation of the features and processes which convey its significance. Besides, local and republic-based Resource Preserves adjacent to the park's boundaries give additional integrity guarantees for the nominated property.
(c) The territory proposed for inscription on the World Natural Heritage List presents an integral system. Natural ecosystems, numerous nature monuments, and also evidence of human activity from ancient times have been sustainably preserved in its limits over a long period of time. Practically the whole territory proposed for inscription on the WNH List lies in the limits of the Lena Pillars Nature Park and is thus professionally guarded by the park administration and its staff on the basis of laws and decrees of the Governments of the Russian Federation and the Republic of Sakha.
Traditional nature management and licensed use of biological resources by local residents from eight communities of minority nationalities from the North inhabiting the park territory (and absolute absence of permanent settlements) present the main condition for conservation of nature monuments and biological diversity of ecosystems in the concerned territory.

Paragraph 90:
The biophysical processes and landform features of the nominated area are intact (see Section 4 for detailed information).

Paragraph 92:
The nominated property includes all the elements essential for maintaining its aesthetic features, primarily, a great variety of skerry relief forms: fancy pillars, spires, towers, columns, complex grottos, passages and caves, stretching along the riverbanks of the Lena and Buotama for dozens of kilometers. All the components of the local landscape bring the Lena Pillars Nature Park an outstanding aesthetic significance and are in a natural internal relationship with each other due to the common genesis of the nominated property.

Paragraph 93:
The area of the Lena Pillars Nature Park has passed a long and complex period of geological development since the Early Cambrian. The nominated property reflects both significant geological processes of surface development and outstanding geomorphological relief features. All significant relief forms on the property are interrelated and interdependent elements in their natural relationships.

Fossil Check List

1. Does the site provide fossils which cover an extended period of geological time: i.e. how wide is the geological window?

The Lena Pillars Nature Park is marked by a high diversity of animal genera summed up at about 350, which is approximately one sixth of the entirety of early Cambrian generic diversity. Many of them were first established from the outcrops in the park. These fossils continuously cover an extended interval of geological time of about 35 m.y. (542-506 Ma). This geological window is one of the most important in the evolution of life on Earth, representing the so-called Cambrian Explosion from the first appearance of the many major groups of skeletal animals and algae until their first mass extinction and the beginning of the following recovery interval.

2. Does the site provide specimens of a limited number of species or whole biotic as-semblages: i.e. how rich is the species diversity?

The site provides a number of whole fossil biotic assemblages, both reefal and deep-water, preserved well enough to study such features of palaeocommunities, the significance of alpha, beta, and gamma diversities, hub-species and their influence on community structure, interspecific and intraspecific interactions, ecological successions, trophic webs, tiering, and many others with a high level of precision.

The entirety of the presented fossil species diversity is composed of over 500 species (Nomination Annex C).

3. How unique is the site in yielding fossil specimens for that particular period of geological time: i.e. would this be the "type locality" for study or are there similar areas that are alternatives?

The site is entirely unique in that it alone presents a complete early to middle Cambrian record by continuous carbonate succession bearing rich fossils. The Oy-Muran and other reefs are especially important because they represent the earliest record of metazoan reefs in the world. The establishing of a metazoan reef ecosystem was delayed in other regions for about 10 m.y., while this was the territory of modern southern Yakutia where principal Cambrian reefal groups of animals originated.

4. Are there comparable sites elsewhere that contribute to the understanding of the total "story" of that point in time/space: i.e. is a single site nomination sufficient or should a serial nomination be considered?

Although there are a number of important Cambrian sites in the world, only the Lena Pillars Nature Park contributes fully to the understanding of the total story behind the Cambrian skeletal explosion, especially in reefal facies (Nomination Paragraph 3c).

5. Is the site the only main location where major scientific advances were (or are) being made that have made a substantial contribution to the understanding of life on Earth?

The Lena Pillars served as the location where leading geochemists and geophysicists developed the most detailed records of palaeomagnetic and stable isotope shifts. A combination of fossil and isotope records in the area allowed researchers to identify the first mass-extinction events in the Earth's history known as the Sinsk and Toyonian. It was shown that these events were the pivotal points in animal evolution comparable with the well-known Permo-Triassic extinction event. In turn, a combination of fossil records with precise mineralogical data allowed scientists to analyze palaeoclimate changes on the eve of the first Greenhouse Epoch, as only the area in question makes it possible to use in concert a representative enough (for statistics purposes) collection of data on faunal diversification, reliable data on carbon and strontium isotopes, and understandable data on diverse carbonate mineralogy. These studies brought about a new global climate trend concept showing a general cooling during the last 540 million years.

Excellent preservation, high diversity, and multiple localities of reefal fauna in the Lena Columns provide a firm basis for detailed palaeoecological and population dynamics studies comparable in precision only with studies of modern reefs. However, while modern reefs represent only a single time slice, the Lena Columns represent over 20 such time slices, which provide researches with an understanding of real evolutionary processes from their very beginning, as they shaped communities of organisms, whether they were co-evolved entities or simply occasional sets of co-existing species.

6. What are the prospects for ongoing discoveries at the site?

The site provides a large area for further discoveries of fossil soft-bodied organisms, larvae and embryos of extraordinary preservation. Additionally, each new expedition brings about new skeletal fossils and large amounts of data on sedimentology, geochemistry and other disciplines. Multiple time-slice analyses of reefal palaeocommunities will provide further large data sets capable of challenging major current evolutionary and ecological paradigms.

7. How international is the level of interest in the site?

International teams of leading palaeontologists, sedimentologists, geochemists and geophysicists have been working at the Lena Pillars since the early 1970's, their efforts expressed in a large number of seminal books and papers (Nomination List of References, Cambrian).

8. Are there other features of natural value (e.g. scenery, landform, and vegetation) as-sociated with the site: i.e. does there exist within the adjacent area modern geological or biological processes that relate to the fossil resource?

Considerable Cambrian phenomena are combined here with remarkable geomorphological features (frozen ground karst, fossil sandy dunes—tukulans, and exceptional Yakutian thermokarst phenomena—alases), unique permafrost soils, some recent endemic plants and relic Neopleistocene steppes, Neolithic rock paintings and sacral sites, as well as amazing picturesque landscapes, all of which combine to create a truly outstanding natural monument of universal value.

9. What is the state of preservation of specimens yielded from the site?

The area yields complete and intact species of extraordinary preservation levels (with preserved soft tissues). These fossils represent the so-called Sinsk Biota, which contains a number of unique species serving in the developing understanding of relationships between major animal phyla. The Sinsk soft-bodied biota is the only one preserved in carbonate rocks, yielding soft tissue structures and even cell structures along with embryos due to a unique state of phosphatization.

Skeletal fauna is also extremely well preserved, allowing scientist to study their morphology, mineralogy, microstructure, geochemical and isotope compositions with a high level of resolution.

10. Do the fossils yielded provide an understanding of the conservation status of con-temporary taxa and/or communities: i.e. how relevant is the site in documenting the consequences to modern biota of gradual change through time?

The extinction of the earliest metazoan reefal biota was directly connected to the rise of pCO2 and the following commencement of the first Phanerozoic Greenhouse Epoch. The fate of the modern reefs, which are built by organisms using the same skeletal mineralogies as their early Cambrian predecessors, is thus predictable through comparison with early to middle Cambrian succession of biotic and abiotic events and their interplay recorded at the Lena Pillars.

Letters of support

Institute for Cambrian Studies
A nonprofit organization dedicated to international research in the earth sciences

Directors
A. R. Palmer - Boulder, Colorado
M. E. Taylor, Wheat Ridge, Colorado
L. E. Babcock, Columbus, Ohio
J. H. Stitt, Columbia, Missouri
J. H. Shergold, Massaret, France

April 2, 2007

Dr. Petr N. Kolosov
Institute of Geology
39 Lenina Str.
Yakutsk, Republic of Sakha (Yakutia)
677980 Russian Federation

Dear Dr. Kolosov:

This letter is in strong support for designation of the Pillars of the Lena as a World Heritage Site. I have had the privilege twice to visit that area on geological field trips in 1976 and 1990. It is a truly spectacular area. From the actual pillars downstream for many kilometers, dramatic exposures of Cambrian rocks in the river bluffs record some of the richest records of the earliest shell-bearing organisms on Earth. All of these exposures can be examined from any shallow-draft boat and are easily accessible. This is the only area on the planet that can be reached easily in which such an extensive development of nearly undisturbed, richly fossiliferous marine rocks of Early Cambrian age is exposed. The stratigraphic and paleontologic details are already well known from the classical publications of Khomentovskiy and Repina (1965) and later authors. The exposures also include some of the earliest reefs known on Earth.

My personal memories of the dramatic dolomite pillars rising from the forested shores of the Lena River left me with the thought that these pillars became part of the mythological lore of the early migrating peoples whose descendants crossed the Bering land bridge to inhabit the western coast of Canada and northwestern United States. In the absence of the pillars, and ancient stories about their images, they perhaps were inspired to create totem poles.

Thus, I am happy to recommend to Mr. Matsuuro that the Pillars of the Lena, already included in the Global Indicative List of Geological Sites by the International Union of Geological Sciences, be designated as a World Heritage Site

Sincerely,

Dr. Allison R. Palmer
President, Institute for Cambrian Studies

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October 4th, 2010

To Whom It May Concern

Subject: Lena Pillars on UNESCO World Heritage List

Dear Sir/Madam,

I strongly support the proposal to enter the Nature Park „Lena Pillars," together with its classic Cambrian exposures, on the UNESCO World Heritage List. This is the place, where almost half a century ago the idea of the "Cambrian Explosion" was born. It received a strong support from discoveries of unexpectedly diverse earliest Cambrian fossils by the team of Russian palaeontologists led by Aleksei Yu. Rozanov. The Lena River rock section, being the main source of information on the early history of animal life on our planet, is similar to the famous Canadian Burgess Shale and the Chinese Chengjiang and Meishucun localities. Moreover, unlike those well known geological sites, in the area of "Lena Pillars" abundant fossils documenting the origin of animals with mineral skeletons near the beginning of the Cambrian (like the Chinese Meishucun „fauna") can be collected in close proximity to exquisite fossils showing preserved soft internal organs (like in the Canadian Burgess Shale). The oldest trilobites in the world occur there.

It has to be stressed that Siberia is greatly undervalued as a tourist destination. It is not only a matter of picturesque pristine nature. The region played crucial role in the history of all nations of the former Russian Empire and the Soviet Union and has a great potential for both mass and qualified tourism, not only from there. Along with its scientific values, the Siberian „Lena Pillars" site may compete with the Canadian Rocky Mountains exposures in its beauty as a tourist attraction, showing a completely different context of tectonically undisturbed strata deeply cut by one of the largest rivers in the world. Although located in the centre of Siberia, the site is easily accessible, with a regular public ship communication between the international Yakutsk airport and the large villages Sinsk and Isyt' located on the other side of the river near the area of the proposed World Heritage Site. These settlements may provide base for visitors of the site. Entering it on the UNESCO list would offer a significant stimulus to the local economy and support the nature protection sensitivity among people of Siberia.

Yours sincerely,

Jerzy Dzik
Director of the Institute
corresponding member of the Polish Academy of Sciences

MONASH University

1 October 2010

School of Geosciences
Faculty of Science

"Lena Pillars" Nature Park Administration
nppls@mail.ru

Dear Nature Park Administration:

I would like to lodge my strong support for setting aside and protecting the area now part of the "Lena Pillars" Nature Park as a UNESCO World Heritage treasure. I would be wonderful if this beautiful and significant part of our Earth could be placed on the World Heritage list.

The rock sequences in this area are of utmost importance for recording the global events that occurred here during the late Precambrian and Cambrian times. It is clearly a global standard for the Lower Cambrian and the 4 stages that we geologists used globally. The sequence here is what we all refer to as the standard "book" when discussing and carrying out our research on global climate and major evolutionary steps that occurred during this ancient time past. What is most amazing about this section is that it is so very old, yet not greatly deformed, and contains an abundance of past life and records of the chemical nature of the seas and atmosphere of this ancient past – far better than most other places on the planet. The rock sequence here is also nearly continuous and complete, which is not often the case in other sections elsewhere on Earth.

It is critical that this area is preserved, protected and cared for and made accessible to researchers who are documenting this part of Earth's history – in a state as close to the original as possible so that the knowledge gained from in depth studies can guide us in the future.

I strongly support heritage listing and rigorous protection of this unique part of our geological record.

Regards

Patricia Vickers-Rich

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IGU
UGI

International Geographical Union
Karst Commission (C08-23)

H.E. Mrs. Mai Bint Muhammad Al Khalifa
The World Heritage Centre, 7, place de Fontenoy
F – 75352 Paris 07 SP, France
Matter: Lena Pillars National Park

Dear Mrs. Mai Bint Muhammad Al Khalifa,

Commission Karst of the International Geographical Union supports the inscription of Natural Park "Lena Pillars" at the List of World Natural Heritage.

Frozen ground karst of Natural Park "Lena Pillars" has the unique and outstanding importance for the world karstology. In spite of extreme continental and dry climate and the continuous permafrost up to 400 m thickness the classic forms of superficial and undergrounds karst are wide spread: karst sinkholes, ponors, dry channels, disappearances of the rivers, caves, etc.

Karst of Natural Park "Lena Pillars" corresponds to the UNESCO Natural Criteria VIII – be outstanding example representing significant on-going geological processes in the development of landforms and significant geomorphic and physiographic features.

Vice-president of Karst Commission IGU
Dr Nataša Ravbar

Nataša Ravbar

Kishore Rao
Director
World Heritage Centre
7, place de Fontenoy
FR – 75352 Paris 07 SP
France

No. 45/58-3/12
June 4th, 2012

Dear Mr. Rao,

After the presentation "Ground frozen karst" by Elena Trofimova and discussion among foreign scientists we would like to note the following:

Karst manifestations of Natural Park Lena Pillars is a new type of the karst in world karstology.

Karst landscapes of territory Natural Park Lena Pillars are developed in the conditions of extreme continental cold and dry climate (average annual temperature of the air –9,8°C at its annual amplitudes to 98°C and precipitations 249 mm) in the area of the continuous permafrost of the thickness up to 300-500 m. It is a unique and universal example of karst development in such natural conditions (see P. Williams, World Heritage Caves and Karst. A thematic Study, 2008).

IUCN experts proposed for the comparison National Park "Nahanni" (Canada), but the climate of NP Nahanni is cold continental - the average annual temperatures are -4 – -12°C and its annual amplitudes do not exceed 60-65°C and the value of precipitations 400-600 mm, i.e., the climatic conditions of NNLP is more humid comparing with the one of NPLP.

Moreover, NP "Nahanni" is situated in the area of discontinuous permafrost, that is why the karst manifestations there are of huge scales. Karst forms of the Natural Park "Lena Pillars" are characterized by the small scales because of the exceptional severity of natural conditions in which are developing.

There is a new scientific term proposed – ground frozen karst.

Dr. Tadej Slabe
Head of the Karst Research Institute ZRC SAZU

ZNANSTVENORAZISKOVALNI CENTER
SLOVENSKE AKADEMIJE ZNANOSTI IN UMETNOSTI
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GEOLOGICAL INSTITUTE, RUSSIAN ACADEMY OF SCIENCES
17.02.2012 № 13102-01-4402/1

Mrs. Julia Marton-Lefèvre
Director General
International Union for Conservation of Nature
Rue Mauverney 28
1196, Gland, Switzeland

Dear Madame Marton-Lefèvre,

The Lena Pillars Nature Park possesses an outstanding universal value being the most significant natural monument of the "Cambrian Explosion" itself. Due to the platform type of carbonate sedimentation within tropical belt without a subsequent metamorphic and tectonic reworking, the Lena Pillars preserve the most continuous and richest record of the diversification of many groups of skeletal and soft-bodied fossil animals and algae from their first appearance until the first mass extinction event and subsequent recovery interval during c. 35 m.y. (542–506 m.y. ago).

This is Siberia only where this interval is represented by marine carbonates while carbonates are the best sediments for the skeletal fossil preservation. As a result, the Lena Pillars house the earliest and the largest, in both temporal and spatial senses, fossil metazoan reef massif. This massif being a site of Cambrian diversification is comparable in its significance to the Great Barrier Reef in modern world: both are the sites of the highest faunal diversity of the world, of the early Cambrian and of the modern times, respectively.

This area is studied over a hundred years by leading specialists from entire the world and thousands of papers are published in top scientific magazines which are based on these studied of various biological and geological aspects of the Earth history.

The Lena Pillars National Park deserves to be nominated as a site housing a complete succession of carbonate Cambrian strata recording the entire "Cambrian Explosion" from its very beginning to the final stages while other (Chengjiang, China and Burgess Shale, Canada) contain local soft-bodied biotas representing aftermath of this event and are restricted to siliciclastic rocks accumulated during 2–3 m.y. only that lack both the earliest Cambrian strata, reef-building and other skeletal fauna.

Sincerely,

Mikhail A. Fedonkin,
Academician, Russian Academy of Science
Director of the Geological Institute of the Russian Academy of Sciences
Vice-President of the National Committee of Geologists

Russian Academy of Sciences

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To IUCN Director General
Julia Marton-Lefèvre

Dear madame Julia Marton-Lefèvre,

I got acquainted with the IUCN letter written by Tim Badman, the Director – World Heritage Program to Mrs. Eleonora Mitrofanova, Ambassador of Permanent Delegation of the Russian Federation to UNESCO. The letter contains IUCN Evaluation of the "Lena Pillars Nature Park" (Russian Federation) nominated for IUCN World Heritage List. Mr. Badman wrote that "nomination as presently put forward does not convey Outstanding Universal Value". In addition, he asked to clarify a number of issues regarding the nomination of the Lena Pillars Nature Park and emphasized that these issues can not be resolved in a short time and should be considered through a new nomination. In support of these words Mr. Badman attaches two letters by IUCN advisers, Tilman Jaeger from 2010 and Paul Williams from 2009. These older recommendation for current nomination contains several issues, which in major part have been considered in the final version of nomination of Lena Pillars Nature Park (LPNP). So, I am greatly surprised, that Mrs. Badman returned a negative verdict on nomination.

I should remind the following facts. The territory of LPNP contains the most complete and uninterrupted sequence of Early Cambrian sedimentary deposits with the richest and most diverse faunal content of all stages and zones without any exception embracing rather prolonged period of time, i.e. more than 30 million years. As a specialist who studies the Lower Cambrian deposits and its fossils for more than 50 years, being 30 years a member of International Subcommission on Cambrian Stratigraphy, and 8 years its chairman, I visited all significant Cambrian localities on all of the continents. So I take all responsibility to affirm, that there is no other geological section in the world that can even approach to the area under discussion by its stratigraphical completeness and / or the biodiversity of fossil remains. Only in this place, Lena Pillars, one can observe the undisturbed and complete sequence of strata aged from the Late Precambrian to mid of Middle Cambrian with engraved picture of origin and early development of the ancient skeletal organisms. In this sense the area is undoubtedly unique. The outstanding nature of Lena Pillars area was emphasized by famous paleontologists, with John Cowie, Stephan Bengtson, and Alison Palmer among them.

Including of the LPNP in the World Heritage List will significantly enrich the natural side of the World Heritage, representing major addition to the story of life development on the Earth. Obviously that Humanity will be considerably enriched when more various natural sites are included in the List and the wider their geographic coverage is. Because of that, paying attention to the minor and obviously secondary issues of the nomination and ignoring the general idea and primary significance of LPNP seems completely striking and incomprehensible. One can suppose that evaluation, like that presented by Mr. Badman, is a result of preconceived attitude towards Yakutian Republic, or a result of lack of expert professionalism. To my mind, both cases are unacceptable for UNESCO and contradicts the main idea of conservation and support of outstanding territories.

I hope that you will consider my opinion and will continue the work on evaluation of the Lena Pillars Nature Park as a nominee to the World Heritage List.

Academician of the Russian Academy of Sciences Alexei Yu. Rozanov

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The Natural Heritage Protection Fund was established in 2000 in compliance with article 17 of the UNESCO Convention concerning the Protection of the World Cultural and Natural Heritage. The Fund's priority is the overall support of World Heritage sites, as well as obtaining this status for new natural sites both in Russia and the CIS.

http://www.nhpfund.org/

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Approved for printing 07.06.2012
Printed by ANNIE, Moscow
500 copies

ISBN 5–88236–105–2

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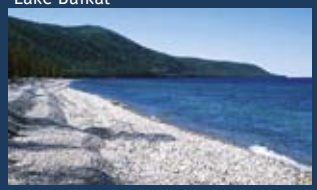

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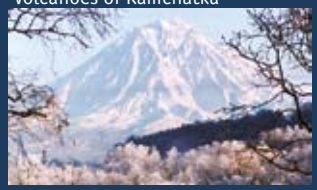

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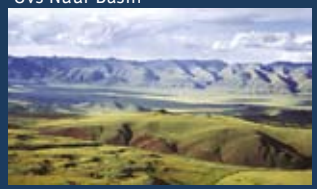

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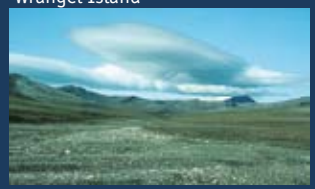

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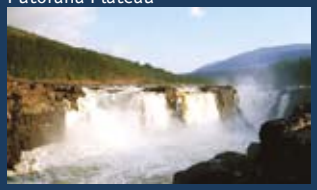

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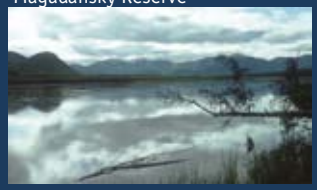

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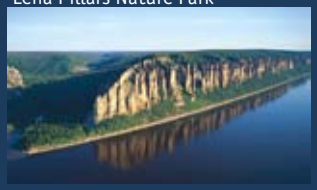
Commander Islands

Lena Pillars Nature Park



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