



Alexey V. Postnikov, Kirill N. Diakonov, Tatiana Kharitonova
postnikov.1939@mail.ru
Russian Academy of Sciences S. I. Vavilov Institut
of the History of Science and Technology
Moscow, Russian Federation

General

FOUR HUNDRED YEARS OLD SOLOVETSKY ISLANDS MONASTERY'S CANALS SYSTEM AND ITS INFLUENCE ON THE ISLANDS' ENVIRONMENT: A UNIQUE EXAMPLE OF FAVORABLE CHANGES DUE TO THE LONG PERIOD AMELIORATION (RESULTS OF ARCHIVAL AND FIELD RESEARCH)

Introduction.

In Russia monasteries and convents have arisen in the Eleventh Century and acted not only as the religious centers, but also as centers of cultural and educational development. They compiled historical chronicles (летописи [letopisi]), stored huge collections of manuscripts and books. In the XIV-XVII century monasteries began to play an important role in development and Christianization of the North of Russia. A number of the most known monasteries had been founded on the territory of the East European (Russian) Plain: Ipatyevsky (Troitsk) in the mouth of the Kostroma River falling into the Volga River (1330); Savvino-Storozhevsky near Zvenigorod (1398); Kirillovo-Belozersky on the coast of the Siverskoe Lake (1397); Ferapontov on the Borodaeveskoe Lake in 20 km from the Kirillovo-Belozersky monastery; Bohr Pafnutyev near Borovsk in the Kaluga region (1444); Borisoglebsk in Rostov Veliky (Rostov the Great) on the River Ust'e (XIVth century); Iosifo-Volokolamsky 140 km from Moscow, in 20 km from Volokolamsk (1479); The Solovetsky Monastery dedicated to Holy Transfiguration of Our Lord Jesus on islands of the White Sea in 165 km to the south of the Polar Circle (Fifteenth century) .



Fig.1 View of the Solovetsky Monastery from the Sacred Lake

Role of monasteries and convents in the society of the Old Russia.

These religious communities owned their lands, forests, and waters, which they used for collecting of mushrooms and berries, agriculture, husbandry, reindeer breeding, wild-hive beekeeping, fishery, salt collecting (in sea waters), and so on. These activities, at least at the period under consideration, led to the prominent role of these communities in the economic life of the country

Specifics of natural environment of the Northern Russian monasteries.

A term North of Russia is not very strict. For those who leave in Central and Southern Europe natural zones of coniferous – broad-leaved forests, taiga, forest-tundra, and tundra are correct to see as “North”. The main characteristics of these zones are: excessive humidity, due to many rivers and huge marshlands, lakes, marshy forests, poor soils (excluding soils of floodplain meadows)



Fig.2: Big Zayatski Island near the entrance into the Great Solovestky inlet

Public functions of monasteries.

The monasteries on their lands developed agriculture and husbandry for their own use and trade. These activities made monasteries not only religious, defensive, charitable, and educational establishments but also economic centers. At an early stage of its existence the monastic economy has been focused on production for own consumption. But later on, they began to sell a part of their production. The range of production was various: products of agriculture and livestock production, salt production, fishery, reindeer breeding. The most successful in trade were monasteries

of the North – Solovetsky, Kirillo-Belozersky, Nicolo-Korelsky, etc.

Specifics of an environment of monasteries of the North of Russia.

The concept “North of Russia” - not really strict. For residents of Central and Southern Europe and the more so Mediterranean, it is quite correct to see the North of Russia as a zone of the coniferous and broad-leaved woods, a taiga, the forest-tundra and tundra. Within this huge area from the western borders of Russia to the Ural Mountains hilly moraine-glacial plains, with loams soils in combination with fluvio-glacial outwash (sandur) plains and lowlands are widespread. The main features of these zones are a redundancy of moistening: the annual rainfall fluctuates from 650 to 900 mm, and the greatest possible evaporation from 200 mm/year in a tundra zone to 620 mm/year in the zone of the coniferous and broad-leaved woods. It causes development of river network, wide areas of swamps, lakes, and the boggy woods, unproductive soils, except for floodplains.

These specifics of geographic conditions had defined in many ways an originality of monastery lands: need of carrying out cleaning of the territory of the wood and bush, leveling of a relief, creation of an artificial drainage. Archaeological researches in the territory of Novgorod, Pskov, Moscow and other ancient cities of Russia testify to ability of Russians to drain the over wetted lands 500-800 years ago, long before the beginning of the XVIII century when during the Peter I and Lomonosov era the state organized drainage of lands for town planning, forest and agriculture, development of the water transport has begun.

Monasteries cared for increase in fertility of an arable land and meadows, for their expansion due to drainage of boggy lands, elimination of stones and bushes; realization of these various ways of melioration assumed long-term effect on their lands fertility. Solovetsky Monastery in these measures acts as a striking example.

Solovetsky islands as an object of landscape-historical researches.

Solovetsky islands – the unique historical and cultural complex included in 1992 in the list of objects of the World Heritage of the UNESCO. The big Solovetsky island (length of 25 km, width of 16 km, the area of 246 km², Anzer, Big and Small Muksulmas, Big and Small Zayatskiys and a set of small islands make this largest archipelago of the White Sea with a total area about 300 km². Islands are outstanding in a unique beauty of their sea coasts and interior lakes' and forests' landscapes. On the Solovetsky had been discovered the following unique items: a complex of monuments of primitive culture, more than 170 monuments of



Fig. 4: Map

history and

architecture, various objects of the nature deserving special care and guard. More than anything else, Solovetsky Monastery ensemble undoubtedly acts as a backbone landscape and architectural, various object of the highest order. It plays the leading role in natural, economic and spiritual development of islands.

Landscape structure of the Big Solovetsky Island.

The main feature of landscape structure of the Big Solovetsky island is its concentricity which is caused by a layering of relief and the climate which is quickly changing from the center to the periphery. Summer temperatures increase from +12° C on the coast to +23° C in the central parts of the island. Other feature of the nature of islands is an absence of river network and as result – a high percentage of lakes and marshes. There are more than 500 lakes on the island, and they occupy about 10% of its all area. Swamps occupy about 12% of the Big Solovetsky Island's area, to 25% of the island Anzer and 60% of Big Muksalma.

Landscape complexes are changing from the center of the island to the coast in the following order: central, highland, parts of the island represent the ouval-swale with a lot of lakes moraine plains occupied on hills by middle taiga pine-fir forests on thin stony podzolic soil, and on foots of hills

– by sphagnum bogs of tundra type, with prevalence of the crowberry (*empetrum*), a heather and a dwarfish birch. Often on a chain of lakes it is possible to track beaded ancient hollows of a drain of thawed glacial snow on which now unloading of surplus of atmospheric moisture continues.

These hollows are often occupied by more hydromorphic versions of pine-fir forests, with soil cover of *Ledum*, Heather, horsetails and Sphagnum mosses.

Thanks to the heavily rugged terrain and difficult accessibility to vehicles in the central part of the island there has been preserved unique plots of untouched forest. According to G.A. Boguslavsky pine forests that survived on the tops of moraine ridges in the Central and Northern parts of the Solovetsky Islands, are more than 300 years old. The remaining tracts of forest are either secondary pine-fir-birch, or conditionally indigenous coniferous forests which age rarely reaches 80-100 years.

Lower down the terrain, on leveled marine terraces, the number of lakes decreases and wetlands area increases. It is remarkable that virtually no islands have any transition plantgrowing lakes: we met either open lakes with clear defined coastline, and such lakes are typical for high levels of terrain, or lowland herbal swamps in lakes basins, or old (up to 7500 years according to N.A. Nikishin), Sphagnum bogs of transitional and highland types with peat and peat bogs (with depth up to 2 m). Marshes of this type occupy also the arias of vast terraces. Relatively high and good drained surfaces of high terraces are occupied with North taiga pine-fir forests of low bonitet. The lower terraces experience the cooling influence of the sea, and on them there are places of a forest-tundra birch elfin woodland, and the coast is occupied with the typical low-shrub tundra with thin (up to 10 cm) stony tundra peaty soils. The area and strike line of tundra and forest-tundra complexes on islands are not so much connected with direct proximity of the sea as with a force and the direction of sea winds. This dependence is well traced on the island Big Zayatsky on which ledges in a relief are clear landscape boundaries: windward slops are the typical tundra with all variety of tundra low shrubs, and leeward slopes of the southern exposition are dense thickets of a birch elfin woodland. Within the wind's attainability, it controls also forest stand height: with distance from the sea a birch from creeping forms transforms to five-six meters multi stems groves. And as regards unwavering rare pines and fir trees, wind shaves their tops on the universal level.

In fight against wind the Solovetsky islands act as a unit: small islands and peninsulas protect the Big Solovetsky island, taking on them the main blow of the penetrating wind. The areas of the tundra and the forest-tundra on small islands are huge, they occupy 100% of a surface of Zaytski islands, to 40% of the island Anzer, being a habitat of a reindeer, 100% of Small Muksalma and 30-40% of Big



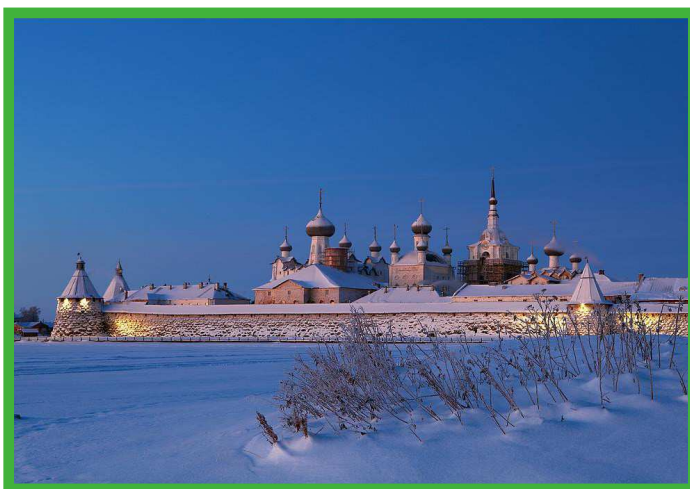
Muksalma. On the Big Solovetsky island the forest-tundra appears as a narrow strip along the coast unprotected by other islands while, for example, in the Long lip protected from all directions the taiga advances up to the sea.

Specifics of adaptive and constructive environmental management on the Solovetsky Islands.

Although the main aim of Solovetsky Monastery was praying in wilderness for wellbeing of the Moscow and her citizens, its functioning and development would be impossible without some material means. So, being far from any country's centers, the Monastery (as all other Northern Russian monasteries) had to develop communications for exchange of its products, which at that time had been salt, fish, flax, and some others, for grain, fabrics, clothes, metal wares, etc. So, it is understandable why the most old survived artificial hydrotechnical construction of the monastery is the harbour refuge on the Big Zayatski Island near the entrance into the Great Solovestky inlet (Picture 2). This harbor (middle of the XVI century) could be used not only as a refuge during storms, but, in case of need, monks could make there some small repairs of their ships in period of ebb tide which left the ships on the bottom of the harbor.

Detailed documentary evidences of active development by monks, novices and monastic peasants of ways between Solovetsky Monastery, Vologda and Veliky Novgorod are available in materials of commercial agents of the English trade organization Muscovy Company. The Moscow Company - the English trading company which was also called the Russian Company represented alliance of the English merchants trading with Moskovia (The Russian state). The company was organized in 1555 by the English seafarer, the explorer and the cartographer Sebastian Cabot (1476-1557) and several London merchants, having received monopoly for the English-Russian trade. It was the first joint-stock English company. In 1553 Sir Hugh Willoughby (? - 1554) and Richard Chensler/Richard Chancellor (apprx. 1521 - 1556) moved off in searches of Northeast passage to China

and "East India" (The Indonesian archipelago - "islands of spices"). Willoughby's ship was lost, but Chensler came to Arkhangelsk (at that time the Mikhailo-Arkhangelsky monastery) and established commercial intercourses with Moscow. Development of these communications and also searches of Northeast passage were the initial purposes of the Moscow Company. Export to Moskovia included woollens, metals and the Mediterranean goods; the English merchants brought hemp, stearin, ropes (rigging) and other Russian goods through Arkhangelsk. Although the tsar Alexey Mikhaylovich cancelled privileges of the company in 1698, and in England



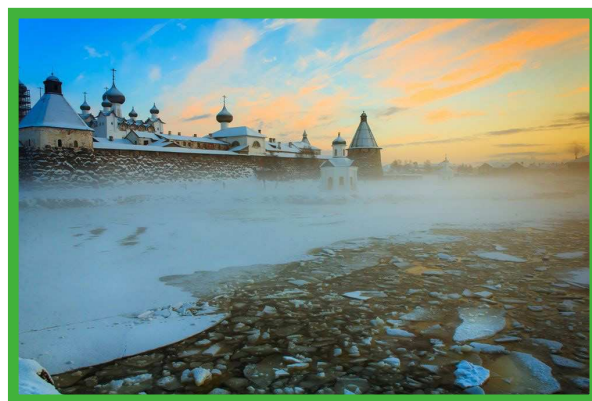
it lost monopoly for the Russian trade, the company remained the influential organization in the London City and in the Eighteenth century participated in revival of the English-Russian trade.

Geographical knowledge of British of the North of Moskovia has considerably extended during Richard Chensler's voyage. In 1553 the Richard Chensler's ship Edward Bonaventure having passed along coast of the Kola Peninsula, has entered the White Sea and dropped an anchor in the mouth of the Northern Dvina. In such way the Western seafarers had discovered the White Sea. The captain Stephen Borough (1525 – 1584) commandeered the Chensler's ship. This captain would visit the White Sea in 1557. As a result of these travels, approximately in 1558 the hand-written map of coast of the Northern Europe was compiled (scale 1:5800000). It was made by the younger brother of Stephen Boro, William who accompanied the brother captain in both voyages. Russian Pomors Gavril and Kirill connected with the Northern Orthodox Monasteries are mentioned in the diary of travel of 1556 as persons who had provided British sailors with information on coast of the sea for compilation of their chart. From 29 place names on the Kola Peninsula Borough's authorship can be

attributed only to 10. All others - Russian. On the chart there is no Kandalaksha Bay and the Onega peninsula. The White Sea has no name, but in diaries of voyage of Stephen Borough it is called Saint Nicholas's gulf (after the monastery in the mouth of Northern Dvina). Borough's chart has formed a basis for the image of this part of the White Sea on all contemporary European maps and charts.

During his second visit to Moskovia Richard Chensler has arrived to the mouth of Northern Dvina on June 23, 1555 and with all the goods has gone on barques up the rivers to Northern Dvina, Sukhona and Vologda to the city of Vologda and from there by land - to Moscow where British have arrived on October 4. Thus, the Russian monks and helmsmen have for the first time shown to British one of the ancient ways connecting Belomorye (bassin of the White Sea) with Moscow.

One of the first trade agents of the Moscow Company Thomas Southam and John Sparke in their description of the waterway from the village of Soroki [modern Belomorsk] on the coast of the White Sea to the Povenets on the coast of Lake Onega on which White Sea-Baltic Canal Route would be constructed 367 years later, proved that this way had been well-known and was actively used by the Russian people. In 1566 British aboard of three boats with twelve Russian oarsmen have passed all way from Soroki to Novgorod in one month. The vivid description of this travel, - The way discovered by water by vs Thomas Southam and John Sparke, from the towne of Colmogro, by the Western bottom of the Baie of S. Nicholas, vnto the citie of Nouogrod in Russia, containing many particulars of the way, and distance of miles, as hereafter foloweth. Anno 1566 - demonstrates not that its authors as they claimed "had opened" this way, but its old development and use by the Russian people for communication and trade between Belomorie, Novgorod and the Baltic



Sea. In the organization and providing means of communication for this way for a long time the main role were played by Pomors and northern monasteries (especially - Solovetsky) and the peasants belonging to them. From the first days of their travel British were convinced in this role.

Voyage from Holmogory down the Northern Dvina River and further across the White Sea through the Solovki to Soroka travelers successfully made aboard a lod'ya with weight displacement near the 25th tone with team of Pomors, who provided sailing by the rivers from the White Sea to Lake Onega under the supervision of Solovetsky Monastery, which had mastered this way long ago and actively used it in particular for trade in salt.

On the way to the Solovki, travelers waited for good weather in recently founded English trading station on the Rose Island opposite the St Nikolas Monastery.

On the Solovki British had not found the abbot of the monastery, the Reverend Philip who later would leave a noticeable mark not only in the history of the monastery, but also in all Moscow state's history. In ten days prior to their arrival he had been ordered to come to the capital by Ivan the Terrible who appointed Philip to the post of the Metropolitan of Moscow. Below we shall tell about the tragic result of this appointment.

Even without their abbot, monks had hospitably received foreign guests and at once shown to British, how well they were familiar with and mastered a way by which British wanted to travel. The monks provided British with the official travel letter with sealing wax press of the monastery and sent with them one of servants safely to accompany them on the dangerous voyage. In the accompanying letter it had been said that the monastic peasants living there should had to give to travelers help in all dangerous places and where it would be necessary, to move their vessels and goods on portages between rivers and lakes. From the further narration it becomes clear that for these monastic peasants service of a way to Lake Onega was most likely one of the main works [poslushanii] in which they have reached quite notable qualification. In the village Quequenich on the coast of the Vyg Lake the employee of Solovetsky Monastery accompanying British left them, but not before he had employed for them boats and had written down names of people which had to bring

travelers further to Povenets. It is necessary to add that the employee did not charge British any fee for his works because so it had been ordered him by monks.

In Povenets British had also had no difficulties with hiring of seaworthy boats with crew for sail by Lake Onega, which short and realistic description is provided by them on the basis of their own observations and data received from locals. Across Lake Onega travelers have passed with stops, for spending nights and expectation of fair winds, in Tolvuye and on the islands Salasalmi, Voronii and Big Klimenetsky, having finished their voyage by the Onega in the place of a source of the river Svir from Lake Onega, at the monastery of Ascension (the modern village Вознесение [Voznesenie]). Spending two nights (in Vassiana and Selyukaks whose localization on the modern map isn't clear) going down the Svir River, British came to Lake Ladoga, reached the mouth of the Volkhov River and, with spending the night in the Nicolo Medvedsk Monastery, Gostinopolye (Gostinopolsky Nikolsky monastery), Myslov, Gruzino and a pogost Petrovsky, came to Veliky Novgorod. Let's repeat that for all way from Holmogory to Novgorod British spent only one month, and the fact that their Russian helmsmen and sailors surely brought them to all safe stops and shelters, confirms long development of this route by them and also - value of monasteries in providing travelers with transport, shelter and food. Let's notice that for monasteries maintenance of functioning of the way connecting them to the main ancient agricultural and trade centers of Russia was the integral element of their existence as the remote spiritual outposts of Orthodoxy which were carrying out missionary activity and were the attractive holy sites for pilgrims from every quarter of Russia. This way was of great importance also for economic activity both of monasteries, and of the country in general which was receiving salt mainly from the White Sea. By evidence of Russians written down by British, only in winter about 2000 sleds were used for transportation of salt by the frozen lakes. For future traders who would wish to use this way, British travelers pointed out that their goods should be sent from Novgorod till January sixth so that they were in Some by Candlemas [Sretenie] [on February 2/15], or soon after it because if their goods are late in way till February 15 when the sun gains strength, it is dangerous as

solar heat this day leads to cracks on deep lakes Ladoga and, especially Onega, and if in this case, there is sudden thaw as often happens at this time, then these lakes are opened and [ice] breaks, therefore perishes many people as sinks many both people, and horses though many rivers for a long time remain after that frozen.

Rapid growth of Solovetsky Monastery (founded in 1436) in the Sixteenth century has resulted in improvement of its internal means of communication and water supply of monastery, which measures had been put in force at the initiative of the abbot of the monastery, Saint Philip II. Taking into account an importance of this heroic clergiman in the history of Russia and for our theme, we would like to tell a little more about his life and activities.

He was born Feodor Stepanovich Kolychev [Федор Степанович Колычев] into one of the noblest boyar families of the Moscow State

in the city of Galich (in present-day Kostroma Oblast). However, according to some sources, he was born in Moscow. Grand Prince Vasili III took young Theodore into the royal court. It is said that since childhood Theodore was on friendly terms with Ivan IV of Russia ("Ivan the Terrible"). According to an official account in his житие (Life of the Saint) his decision to become a monk occurred on Sunday, June 5, 1537, while he was standing in church for the Divine Liturgy, on hearing the words of Jesus: "No man can serve two masters" (Matthew 6:24). According to this account, he secretly left Moscow dressed as a peasant, and for a while he hid himself away from the world in the village of Khizna, near Lake Onega, earning his livelihood as a shepherd, later joining the monastery at Solovetsk. At any rate, he entered the monastery at Solovki at the age of 30, and a year and a half



Fig. 5: Solovki canal

later he was tonsured (took monastic vows), receiving the religious name of Philip. In the monastery he worked at the iron forge and as a baker.



Eleven years later, Philip was made hegumen [игумен] (abbot) of the monastery. During his term in office, monks under his supervision constructed two cathedrals, a brick-yard, many water-mills (including a mill for washing monastic dresses [портомойня] and storehouses, and a network of canals connecting 72 lakes. It is said that Philip took part in all these toils together with other monks. As a result, the monastery experienced a spiritual revival. He also adopted a new monastic Rule (Typicon) for the community. Most of Philip's projects in Solovki survive to this day. The tsar heard about the

indefatigable monk and asked him to fill the vacant metropolitan see of Moscow. Philip agreed on condition that Ivan would abolish Oprichnina. On June 25, 1566 Philip was consecrated a bishop and enthroned as Metropolitan of Moscow and all Russia. After only two years, however, Ivan the Terrible persisted with committing murders under the aegis of Oprichnina. During Great Lent, on the Sunday of the Veneration of the Cross, March 2, 1568, when the Tsar came to the cathedral for Divine Liturgy, Philip refused to bless him and publicly rebuked him for the ongoing massacre. The Massacre of Novgorod ensued, and Philip's condemnation followed.

Ivan eventually deposed Philip from office by raising incredible charges of sorcery and dissolute living. Philip was arrested during Liturgy at the Cathedral of Dormition and imprisoned in a dingy cell of the Theophany (Bogoyavlenskii) Monastery, fettered with chains, with a heavy collar around his neck, and was deprived of food for a few days in succession. Then he was transferred and immured at the Monastery of the Fathers (Otroch Monastery) at Tver. In November 1568, the tsar summoned the Holy Synod, which had Philip deposed. A year later, on December 23, 1569, he was strangled by the Tsar's minion, Malyuta Skuratov at Otroch, two days before Christmas. As if aware of his approaching death, Philip had asked to receive Holy Communion three days earlier. After his martyrdom, monks from Solovetsky Monastery asked for permission to transfer the body of St. Philip to their monastery. When they opened up the tomb they found the body of the hierarch was incorrupt, and various healings began to be reported. The transfer of his remains from Tver to the Solovetsky Monastery took place in 1590. In 1652, Patriarch Nikon persuaded Tsar Alexis to bring Philip's relics to Moscow, where he was glorified (proclaimed a saint) later that same year.

So, one of the main material memorials of St. Filipp II activities was construction of a uniform system of channels on the Big Solovetsky Island which have connected numerous fresh-water lakes to the Sacred Lake (Svyatoe Ozero) which is located under monastery walls from outside, opposite to the White Sea coast. The channels laid between lakes in many places passed across swamps and arias of the boggy tundra, providing thus melioration of these territories: lakes became flowing that interfered with their bogging, and swamps, being drained, freed the arias over time growing with the wood, or becoming the meadows and arable lands used by monks and monastic trudniks [трудники] (volunteer workers) for livestock production and agriculture. (Picture 4) Expansion of channel system resulted in need of its regulation by means of locks, and with navigation development, construction of dams, gates and sluices. In the beginning these technical actions were carried out by purely experimental methods of "tests and mistakes", and in XVIII - the beginning of the twentieth century, with arrival to the monastery of the monks with good secular education, design and construction of hydraulic engineering constructions at the technical level corresponding to the period began to develop (Pictures 5 - 7). Continuous intake of fresh water to the monastery has allowed monks to provide almost autonomous existence: have been constructed - a water supply system, baths, a water-mill, laundry and, at the beginning of the Twentieth century, one of the Russia's first hydroelectric

power stations.

On the basis of uniform hydrotechnical system a natural and economic complex of the monastery was formed, as well as gradually it led to a modern structure of types of environmental management which included water management (drinking water supply, transport), agricultural (crop production, livestock production), forestry and landscape. Energy of water streams was used. The adaptation direction of environmental management was fully shown in agriculture. The local population used very wise intra landscape conditions: specifics of local climates and even microclimate, character of a relief and natural fertility of soils. The Solovki cultural landscapes created by the beginning of the twentieth century were synthesis of traditional high-eco-friendly environmental management and urgent engineering decisions.

Now we, during our field research, have found gradual bogging of the territory of islands owing to neglect and in places even destruction after 1917 of extensive monastic hydraulic systems. Meadows on islands survived poorly: at rough calculation actually forb-cereal complexes occupy the space about 270 hectares on two islands. The largest apportionment, 105 hectares, has remained on the island Big Muksalma, the former livestock center of monastic economy. Here farmyards and the main areas of pastures were located. In spite of the fact that meadow areas are on a leveled surfaces of the second and third terraces, successfully created drying system almost century keeps the territory from secondary bogging though in places green mosses get into a meadow cover. On Big Solovki meadows have remained on small areas, they occupy in total 160 hectares on Kulikovo Field, near Isakovo, the Savvatiyevsky monastery, the Filippovsky Skete and around the Kremlin, including the modern airfield. Particularity in the region showed on the mentioned above Picture 4, during our field research we found relicts of monastic meadows.



At the end of the Nineteenth century the military doctor Peter Fedorovich Fedorov (1856 - ?) exploring history, ethnography and actual reality of the Solovetsky Islands had in details described monastic life and pointed out that, haying meadows of two islands – Big Solovki and Muksalma – gave on average for 1882-1885 2123 hay promezhekhs. Peter Fedorov himself determined one promezhek by volume as two carts of 30 poods each, that is 983 kg that means that an average meadows gave 2,086 tons of hay a year. At average productivity of natural hay meadows of 7,7-8 centner/hectare across the Arkhangelsk region for 1990-2002, it is possible to estimate the historical areas of only haying meadows at 2,658 hectares.

But every summer it was necessary to graze herd of cows to 113 heads, sheep – to 200 heads and about 180 horses. Thus, the historical areas of meadows exceeded modern by 10 times. There is an interesting geographical task of searching for the territories which had been cultivated in the Nineteenth century and then restored to the level of original vegetation during the Twentieth century.

Modern meadows are characterized by the highest on islands vegetation indices, what is connected with high fertility of soils. And indeed, in literature on life of Solovetsky Monastery the authors repeatedly mentioned how monks had cared for fertilization and increase in efficiency of the meadows and kitchen gardens. Thus, it is possible to assume that rather fertile soils and the considerable efficiency of ecosystems displayed by high value of the vegetative NDVI index will also be characteristic of the left meadows. The ash-content of undisturbed riding peat is minimum: 0,8-2,5%. At drainage the ash-content of riding peat grows because in the drained horizons decomposition processes amplify. So, on Kulikovo Field the ash-content of peat thickness increases from 4,5-5,0% in the lower horizons up to 10-12 (even 16,4) % on top. The analysis of territories

with high values of vegetative indexes and the raised ash-content of peat has allowed us to reveal the missing areas of meadows and to carry, for example, the leveled territory of the second sea terrace near the lake Besednoye occupied now with the young pine and birch wood to the degrading monastic agricultural grounds. Here peat thickness is low (23 cm), and an ash-content of the lower peat horizon reach 20%. It is obvious that this natural complex has undergone not one transformation – originally grass swamp as a result of artificial drainage has been transformed to a meadow complex, and then as a result of recovery succession – to the modern wood.

Modern meadows are characterized by the highest on islands a vegetative index (Picture 8), what is connected with high fertility of soils. And it is confirmed by authors of works on life of Solovetsky Monastery who repeatedly mentioned how monks cared for fertilizer and increase in efficiency of the meadows and kitchen gardens. Thus, it is possible to assume that rather fertile soils and the considerable efficiency of ecosystems displayed by high value of the vegetative NDVI index will also be characteristic of the left meadows. The ash-content of undisturbed higher lays of peat is minimum: 0,8-2,5%. At drainage the ash-content of higher lays of peat grows because in the drained horizons decomposition processes amplify. So, on Kulikovo Field the ash-content of peat thickness increases from 4,5-5,0% in the lower horizons up to 10-12 (even 16,4) % on top. The analysis of territories with high values of vegetative indexes and the raised ash-content of peat has allowed us to reveal the missing areas of meadows and to qualify as degraded monastic agricultural fields, the leveled territory of the second sea terrace near the lake Besednoye occupied now with the young pine and birch wood. Here peat thickness is low, 23 cm, and an ash-content of the lower peat horizon reach 20%. It is obvious that this natural complex has undergone not one transformation – originally grass swamp as a result of artificial drainage has been transformed to a meadow complex, and then as a result of recovery succession – to the modern wood.

We found another kind of antropogen transformation in the regions with poor humus (less than 1%, content of nitrogen less than 0,75%), acid and the high acid (pH 4,6-5,6) soils where monks developed high-yielding kitchen gardens on which monastic gardeners grew up all necessary (potatoes, cabbage, a radish) and exotic (tomatoes, water-melons) vegetables. Monastic kitchen gardens are also well identified in space pictures in the maximum size of biological efficiency. Monks had chosen for their kitchen gardens gentle slopes of runnels of drain and dried hollows of ancient lakes' bottoms. Such choice is explained by the fact that here processes of carrying out of useful elements are slowed down and peat, rather rich in contents, collects. As a result of drainage and additional fertilizer peat was processed into humus which yielded a good crop of vegetables. It is known that the most part of provisions was being delivered to islands from the continent: it was necessary to support about 200 constant monks of the monastery and up to 1500 voluntary trudnik during the whole summer. But fresh vegetables arrived on a monastic table only from their own kitchen garden beds. Therefore special attention was paid to truck farming, and monks had applied then all possible types of melioration, which were (in modern terms):

drying, chemical, and even irrigation!

But irrigation there had been aimed not at moistening, but at the improvement of climate of the soil: on kitchen gardens of the Makaryevsky Skit (nowadays Botanical garden) hot water was pumped by pipes from the wax bleaching plant and candle factory. Near monastery walls the old lake's hollow with humus soils is still used by locals for private kitchen gardens, generally under potato, but humus is gradually degrading, and in some parts one could see already the sand which is slightly painted by black organic matter.

Expeditions of the Russian Academy of Sciences and Lomonosov Moscow State University.

In 2007 the S. I. Vavilov Institute of History of Natural Sciences and Technology



Fig. 6: Solovki canal

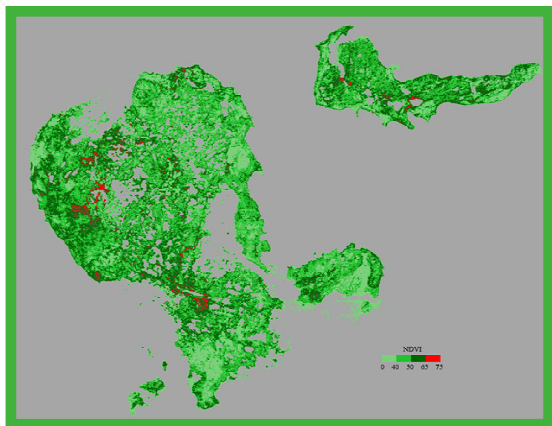


Fig. 7: Vegetation indice (NDVI)

and functioning of landscapes dendrochronology methods were used. In typical geosystems of the island drill cores of trees whose ages were of 90-100 to 210 years had been selected. The standard technique of data processing was used. Width of wood rings is determined by the scanner and the computer on automatic system of measurement "Lintab 5" then cross dating with finding of an index of dating (CDI) and cross-correlation was carried out. The technique of standardization (indexing) and creation of the generalized chronology has been applied to processing of ranks of an annual growth. The contribution of various factors of a gain, first of all climatic, was determined by ex-potential model of a curve of growth in the ARSTAN program.

For fir-trees the important role of air temperature of June is established. We could not trace a strict connection of size of a year gain with an atmospheric precipitation of the vegetative period. At the majority of pines in abnormally low air temperature years from May to September the gain was characterized by low values, and the maximum gains of pines were typical for years with high summer temperatures. V. V. Matskovsky pointed out that the stable positive response of a gain of pines to summer temperatures falls on 1910-1975. We have found some intra landscape distinctions of connections between a gain and climatic factors depending on remoteness from the seashore and an exposition of slopes.

It is known that planetary process of bogging of landscapes of Europe and Western Siberia had begun in the Holocene approximately 7900 – 7000 years ago. It happend at the beginning of the Atlantic optimum when the climate became warmer (summer temperatures were higher then modern on 1.5-3°C), and rainfall rise for 10-25% . Using radio carbonic datings (by C14) of peat bogs it has been established that bogging of hypsometric levels of the island land higher than 50 m has begun about 7000 years ago. At lower hypsometric levels (32-35 m) – 3800 years ago.

We performed dendrochronologic researches in a zone of influence of a drainage. Main result: development of hydrotechnical system has led to increase in productivity of the woods and their bonitet, the environment of the island on which at disembarkation of the first monks dominated tundra, had changed to forest-tundra and North taiga landscapes, which now transformed in places, even to South taiga. But on the other hand we should take into consideration some global trends of climat changes, therefore the dinamics of natural landscapes could not be connect only with partial drainage of the island.

Technique of researches

Field researches of landscapes of the Solovetsky islands were performed in June, 2007 and included detailed descriptions of natural complexes (a relief, deposits, soils, vegetation) and getting of soil samples and wood cores. Soil samples were collected in meadow complexes and on the drained swamps from the organogenic horizons; as a whole we collected 21 tests. Wood cores we got in the central parts of islands Solovetsky and Anzer in relatively old age forest stands using Preszler's drill, twice from each tree in grupp of 5-6 trees on each explored locality.

Analytical researches. In vitro, using Tyurin's method, the volume of a humus was found in soil samples , and by means of incideration the gross content of organic substance has been determined at a temperature of 500 °C Sizes of an annual radial gain of trees were determined by the selected cores on the Lintab device. In group of trees from each local area cross dating of cores was carried out

of the Russian Academy of Sciences with the assistance of the Department of Physical Geography of the M.V. Lomonosov Moscow State University had organized the International Historical-Geographic Expedition to the Solovetsky Islands (the research supervisor prof. Alexey V. Postnikov). The program of our research included two blocks of the interconnected directions: cultural and historical and landscape and geoecological, paleogeographical. The main objects of the social and economic structure of the islands have been studied, described and catalogued as monuments of history of science and technology. Studying of dynamics of landscapes, specifics of their development in the Holocene and a research of influence of canal system on change of its natural landscapes were very important part the expedition's activity. For studying of dynamics

and samples with low indicators of synchronism were discarded to cut trees which dynamics of gain is defined more not by climate, but by autochthonic factors (a disease, intrushes of the near trees and so forth). Further, with help of the Statistica program, we checked an influence of climatic parameters on our compiled generalized chronologies on each locality.

Methods of remote sensing. For identification of the ecosystems which are characterized by the highest biological efficiency and, most likely, felt the beneficial influence of human activities, we used Landsat space pictures. In the program Erdas Imagine we calculated the normalized differential vegetative index (NDVI) equal to the relation of a difference of reflection of the land surface in near infrared and red ranges of a range to their sum. Further the received NDVI values have been correlated to indicators of fertility of soils.

Conclusion.

Expansion of channel system caused requirement to its regulation by means of creation of locks, and with navigation development – construction of dikes and dams. Drainage led to expansion of arable, pastures and haying grounds, as well as forested the territories. Based on single hydro technical system there was formed a natural and economic complex of the monastery; gradually a modern structure of types of environmental management developed which included water management (drinking water supply, transport), agricultural (crop production, livestock production), forestry and landscape. Energy of water flows was used. The adaptation direction of environmental management was fully shown in agriculture. The local population was used precisely according to the intra landscape conditions: specifics of local climates and even microclimate, nature of a relief and natural fertility of soils. The Solovetsky cultural landscapes created by the beginning of the XX century were synthesis of traditional high-eco-friendly environmental management and actual engineering decisions. catalogued by us as monuments of history of science and technology during our expeditions.



Fig. 8: Solovki canal

Main conclusion of these researches: development of channel system has led to significant improvement of the environment of the island on which at disembarkation on it the first monks, the forest-tundra dominated and now middle taiga and in places even South taiga landscapes prevail. It should be pointed out, that after Bolsheviks closed Solovetsky Monastery in 1920 they would not care for its channel system. During our expeditions we found out that such neglect caused a real damage to the system and depending on it technical constructions. Our continuing explorations showed that locks and gates can not work and difficult to revive, which fact make it impossible to navigate the channels. The water supply system also suffered very much, because the regular monks' control of levels in the lakes (and especially in the Svyatoe [Sacret] lake) had stopped, the locks and gates opened, or destroyed which facts would lead to the permanent flow of water through the whole system down to its destination – the walls of Solovetsky Monastery. Before 1920, the water was accepted under the walls by system of pipes (initially – wooden) to be

transported to different consumers (mechanical and human) inside the monastery. With time, without a proper supervision, the overflowing of the system led to drastic consequences: the pipes had rusted, got littered and collapsed. As a result, water from the lake found its own ways to the White Sea under the walls and the territory of the Monastery. These ways with time led to very dangerous developments, which we studied in details during our expeditions. First, we discovered frost mounds in places on corner of the wall where water from the lake froze underground in winter. On the lake embankment near monastery walls we found sink-holes. It happened in 2007. At that time we raised an alarm in the Monastery's Museum, pointing out that the development of this process could lead to large scale sinks and destruction of walls. In summer of 2016 we were sad to find out that nothing was done and situation

became worse for such a measure that all cars traffic by the embankment between walls and the lake is impossible and forbidden.

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The Mikhailo-Arkhangelsky monastery — the orthodox monastery founded in the 12th century by the Novgorod archbishop Ioann in the mouth of Northern Dvina and which later would be has named Arkhangelsk. In the early 1930s the monastery has been destroyed.

Originally the monastery was on the cape Pur-Navolok. In 1419 had been ruined by Norwegians, but was restored on the former place. For two hundred years was one of the centers of the Russian North. In 1584 under the decree of the tsar Ivan the Terrible, the voivode Nashchokin and Zaleshanin within a year have constructed around the monastery the wooden fortress called New Holmogora who has given rise to Arkhangelsk. The five-domed cathedral temple has been erected in 1685-89 practically in at one time with a cathedral in Holmogory. For more details see: Soykin P. P. Archangel Michael Monastery in Arkhangelsk//Orthodox Russian monasteries: The complete illustrated description of Orthodox Russian monasteries in the Russian Empire and on Athos. (SPb.: Revival, 1994): 55-57; V. I. Suvorov Monastery, Arkhangelsk for the sake of Saint Michael the Archangel, //Orthodox encyclopedia. Volume II. (M.: Orthodox Encyclopedia church scientific center, 2001): 487-489.

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Hamel, Iosif Khristianovich, 1788-1861; Leigh, John Studdy, tr.

England and Russia; comprising the voyages of John Tradescant the Elder, Sir Hugh Willoughby, Richard Chancellor, Nelson, and others, to the White Sea, etc. (London: R. Bentley, 1854): 137.

For the first time this description had been published by the English clergyman and historian of geographical exploration and discoveries Richard Hakluyt (1553-1616) in 1589 (Hakluyt, Richard (1589). The Principall Navigations, Voiages, and Discoveries of the English Nation: Made by Sea or Over Land to the Most Remote and Farthest Distant Quarters of the Earth at Any Time within the Compasse of These 1500 Years: Divided into Three Several Parts According to the Positions of the Regions Whereunto They Were Directed; the First Containing the Personall Travels of the English unto Indæa, Syria, Arabia ... the Second, Comprehending the Worthy Discoveries of the English Towards the North and Northeast by Sea, as of Lapland ... the Third and Last, Including the English Valiant Attempts in Searching Almost all the Corners of the Vaste and New World of America ... Whereunto is Added the Last Most Renowned English Navigation Round About the Whole Globe of the Earth. London: Imprinted by George Bishop and Ralph Newberie, deputies to Christopher Barker, printer to the Queen's Most Excellent Majestie. In 1598 - 1600 was published enlarged and upgraded edition of the same book in three volumes: Hakluyt, Richard (1598-1600). The Principal Navigations, Voiages, Traffiques and Discoveries of the English Nation, Made by Sea or Overland ... at Any Time Within the Compasse of these 1500 [1600] Yeeres, &c. London: G. Bishop, R. Newberie & R. Barker. 3 vols.; folio. In our work we use the recent web edition: The principal navigations, voyages, traffiques and discoveries of the English nation Collected by RICHARD HAKLUYT, Preacher and Edited by EDMUND GOLDSMID, f.r.h.s. This web edition published by eBooks@Adelaide. Last updated Friday, March 7, 2014 at 19:47. eBook@Adelaide. The University of Adelaide. South Australia 5005 <http://ebooks.adelaide.edu.au/h/hakluyt/voyages/v03/chapter49.html>: The way discovered by water by vs Thomas Southam and Iohn Sparke, from the towne of Colmogro, by the Westernne bottome of the Baie of S. Nicholas, vnto the citie of Nouogrod in Russia, containing many particulars of the way, and distance of miles, as hereafter foloweth. Anno 1566.

Old traditional Russian boat with sail (s) and ors.

The island lying opposite to the Nicolo-Karelian monastery located between Pudozhemsky and Nikolsky mouths of Northern Dvina River, according to documents is known since 1501. This island which is among the most ancient Novgorod possession in descriptions and on mapss of the XVI-XVIIth centuries was called differently: Yagra, the Yagorsky island, Agra - Big or Nikolsky. In the XVI-th century the island had great trade value and it could be called the first trade port of Russia. After Richard Chensler's trip to Moscow in 1553 Ivan the Terrible has issued to British the diploma in which has allowed them to trade bezdanno, [duty-free] all over the Russian and has allowed to found trade pier in the mouth of the Northern Dvina. They had chosen the island Yagry and in 1555 constructed pier, trading house, barns on this island, and the island was nicknamed "Rose" as it was covered with thickets of the blossoming dogrose. Details see: http://www.yagri.ru/Story_Chkr/Story_Of_Jagr.html

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Iconography

Fig. 1: Fig.1 View of the Solovetsky Monastery from the Sacred Lake

Fig. 2: Big Zayatski Island near the entrance into the Great Solovestky inlet

Fig. 3: Map by William Borough, /1536-1599/ Sailing plat MS 1560

Fig. 4: Solovki canal. Photo by Photo by Sergei Mikhailovoch Prokudin-Gorsky (1915). Library of the Congress (USA) Collection.

Fig. 5: Solovki canal. Photo by Photo by Sergei Mikhailovoch Prokudin-Gorsky (1915). Library of the Congress Collection (USA)

Fig. 6: Vegetation indice (NDVI), calculated on base of Landsat survey on June 28, 2000.

Fig. 7: Solovki canal. Photo by Sergei Mikhailovoch Prokudin-Gorsky (1915). Library of the Congress Collection (USA)



Alexey V. Postnikov



Kirill N. Diakonov



Tatiana Kharitonova