Can the Arctic be saved for the next generations? Study of examples and internships in Murmansk District

Milosz Huber\textsuperscript{1,5}, Olga Iakovleva\textsuperscript{2}, Galina Zhigunova\textsuperscript{3}, Marija Menshakova\textsuperscript{4}, and Ramziya Gainanova\textsuperscript{4}

\textsuperscript{1}Department of Geology, Soil Science and Geoinformacy, Faculty of Earth Science and Spatial Management. Maria Curie – Skłodowska University, 2d/107 Kraśnickie Rd, 20-718 Lublin, Poland.
\textsuperscript{2}Department of Applied Linguistics, Faculty of Humanity, Maria Curie Skłodowska – University. 5 Maria Curie – Skłodowska Sq, Poland.
\textsuperscript{3}Department of Philosophy, Social Sciences and Social Security Law, Murmansk Arctic State University, 183038, Murmansk, Kapitan Yegorova, 15, Russia, galinazhigunova@yandex.ru
\textsuperscript{4}Laboratory Monitoring and Preservation of Natural Ecosystems of the Arctic, Murmansk State Arctic University, Murmansk, Russia

E-mail: \textsuperscript{5}mhuber@poczta.umcs.pl

Abstract. This text highlights the environmental aspects of the Arctic in the Murmansk District. Its geographical, natural, geological, and historical characteristics are presented. Examples of environmental protection facilities have been shown and aspects of their features that make the region attractive for tourists have been indicated. Proposals for the development of tourist infrastructure were shown, models for the development of the cultural and industrial landscape of cities were proposed, as well as the exhibition of natural and post-industrial heritage in the context of the possibility of its protection and exhibition for visitors. The influence of social awareness of inhabitants and the role of their quality of life in the context of the possibility of effective nature protection was indicated. Examples are also shown that allow for the sustainable development of these areas also through the diversification of income with the participation of the tourism industry, economic recovery of post-industrial areas, and the possibility of further protection of the Arctic for future generations.

1. Introduction

The Arctic is the term given to areas beyond the North Arctic Circle. In this area, there are also territories belonging to the European part of Russia, including the Murmansk District, located in the north-eastern Scandinavia. It covers the area of the Kola and adjacent areas on the west side [1]. It is an important area of Russia from the raw material, strategic, and historical point of view. Due to its location and the operation of the northern gulf stream, Murmansk District has a relatively mild climate, characterized by moderate frosts and rains. This also translates into plant cover and numerous lakes, the number of which exceeds 100,000. In addition to the amazing nature, the ground that is the northern part of the Baltic Shield is also interesting, and it is rich in interesting rock formations which are nearly 4 Ga old [2-10]. In addition to inanimate nature, an interesting accent is also the centuries-old history of this area, together with the original peoples (Saami), which also leave behind numerous geographical names accentuated on the maps. There are many interesting archaeological sites in this area (e.g. Sami
labyrinths) and the nearby towns have a long history dating back to the 13th century. Monuments of petroglyphs, labyrinths, and other objects together with the cities such as Kolvitza, Umba, Varzuga, Kuzomien, Kola, Piechenga constitute the interesting tourist attractions of this land. All these forms together with the interesting nature show the extraordinary character of the area, which carries great potential for geo-tourism and historical heritage. This potential is being discovered, as shown by the systematically growing visit statistics, and the Khibina region has been identified as one of the top ten winter sports accidents by Russians. On the other hand, people living in the Murmansk District also want to develop and increase the comfort of their lives. Could these goals coexist with the fragile nature ecosystem of the Arctic? Is it possible to develop by increasing tourist traffic at the same time without increasing damage to the environment? Finally, is it possible in the era of changes in the 21st century to save and pass the Arctic to the next generations? This publication tries to answer these questions by presenting also examples of solutions that allow for sustainable development while increasing the quality of life.

2. Methods
The authors conducted their observations in the discussed area in the period 1999-2020, visiting the discussed area many times. An inventory of objects, rock sampling, and photographic documentation was carried out. The team of authors also carried out several ethnographic, historical, and ecological works as well as economic considerations. The experience of the acquired knowledge along with examples from other regions of the Arctic allows us to propose a reasonable scenario for the development of Murmansk District while maintaining respect for the environment of this part of the Arctic.

3. Results
Below is a brief description of the Kola region along with an overview of its natural values, examples of their use and protection.

3.1. Characteristic of the Kola Peninsula

3.1.1. Geography. The Kola Peninsula extends in the northeastern part of Scandinavia, lying between longitude 28°25’– 41°26’ east longitude and 66°03’– 69°57’ north latitude, entirely beyond the North Arctic Circle. Administratively, the Kola, together with the adjacent areas on the western side up to the Russian border, belongs to the Murmansk District. Geographically, the Kola region is separated from Scandinavia by the Kola River and the Kola Lagoon of the Barents Sea in the north, Lake Imandra in the central part, and the Niva River in the south [11]. Lapland extends along the western part of this border. The entire area in question falls within the administrative scope of the Murmansk District.

The Kola Peninsula belongs to the group of cool, arctic climates with Atlantic domination. As a result, this manifests itself in a milder winter temperature with much higher humidity. The average annual temperature ranges from 1°C to even -3°C for mountain top surfaces. Average temperatures in January are -2°C, while in July they are respectively + 10°C. The lowest temperature recorded in the Murmansk region in winter is -39.4°C (January 27, 1985), and the highest + 32.9°C (July 9, 1972, and 2018)[11]. The climatic conditions in Murmansk District are very diverse. They strongly depend on the influence of the Gulf Stream and air masses from mainland Russia. The direct effect of this action is the Murmansk harbor that does not freeze in winter. This contributes to the high variability of the temperature and precipitation interval. There are cases where snow falls even on summer days, and vice versa, snowless winters even in December. Snow remains on average 210 days. In the mountains, glaciers are formed that may remain for several years. The snow cover is numerous and sometimes in the mountains, it reaches a thickness of up to 20 m (in snowdrifts and hollows), lingering for 80-160 days. Overall, winter ends in the last days of April (snow lies until May) and begins to appear in the first days of November, snowstorms were recorded in the mountains even in July (e.g. in 2018). The sum of rainfall is 450–900 mm per year. The number of cloudless days rarely exceeds 20. The polar day lasts a
maximum from May 22 to July 22, and the polar night from December 2 to January 11, with areas where the sun appears for a few minutes above the horizon even during this period (e.g. on peaks). the southern part of Khibina)[11].

The Murmansk District region is flat, rarely exceeding several hundred meters. The highest point is Mount Takhtarvumchgorr in the Khibiny Mountains at 1,200 meters above sea level. In the Monchetudnra massif, Khippik Mountain is about 1000m above sea level. and in the Kandalaksha region, the highest elevations reach 900m above sea level (fig. 1,3). In the Murmansk District, the number of lakes reaches 100,000, and rather short rivers also dominate. The largest of these is the Kola River in the north and the Niva River in the south [11,12].

3.1.2. Nature. In the Murmansk District, there is a taiga border, which gradually turns into the forest and tundra. The forest is located in the southern and central-western areas of the region, the forest-tundra dominates in the mountain ranges and the north-eastern areas, and tundra occurs in the extreme northern and eastern areas. The flora of this region includes about 360 species of vascular plants. The Arctic, subarctic and arctic-alpine species account for as much as 51% of flora, while boreal species account for 40%. Boreal (41%) and Arctoalpine species (16.7%) dominate. Arctic and sub-arctic species together account for 22%. Apart from vascular plants, the flora includes 400 species of mosses and 350 species of lichens [14-19]. The vegetation of the mountains of the Kola Peninsula consists of four floors: spruce forests reaching from 300 to 500 m above sea level, birch forests reaching from 450-600 m above sea level, alpine (tundra) forests reaching from 600-800 m above sea level, high-mountain arctic desert - above 800 - 900 m above sea level. Higher vegetation relatively quickly gives way to the shrub-shrub tundra (Fig. 3) in which dwarf birch (*Betula nana*), stunted willow species (*Salix nummularia, S. polaris,*...
S. reticulate, fig. 2) and eight-petalled oak (Dryas octopetala) are the most common. They are accompanied by numerous blueberries (Vaccinium vitis-idaea, V. myrtillus, Empetrum nigrum), cranberries (Empetrum hermaphroditum, Phyllodoce coerulae), and mushrooms - clearly visible from a distance. There are numerous mosses and lichens (Cetraria Iceland, Arctostaphylos uva ursi, Cladonia sp) in the undergrowth. Coniferous forests, tundra, meadows, coastal marches, and specific rock vegetation coexist in the southern coastal areas. The most transparent place is Barynya Rocks, where the cotoneaster Cotoneaster cinnabarinus, Daphne mezereum grows, and in a miniature cave in the rock - Asplénium septentrionale. A resident of more southern regions will be surprised to see the famous wild strawberry (Fragaria vesca L.) on a rock. In the vicinity of Kandalaksha, it can find one of the most spectacular northern orchids, the Common Shoe Cypripedium calceolus, which is found in soils rich in carbonates.

Figure 2. Net-leaved willow (Salix reticulate), Diapensia (Diapensia lapponica, A), and flowers of Castilleja pallida v lapponica (B), (photographs by Menshakova M. Y. and Gainanova R.I.).

In the Khibiny and Lovoziero Massif, tourists can encounter many rare and endemic plant species. If the route passes through the Karnasurt mine, it can see the "iron fern" growing on wet rocks - spear-shaped Polystichum (Polystichum lonchitis), and on drier rocks - colorful red cinnamon cotoneaster (Cotoneaster cinnabarinus), if the tourist walks along the proposed trail on the peaks In the Angwundaschorr, Singischorr and Alluiu mountains, a rocky desert opens in which the glacial bewitched (Beckwithia glacialis) [20-22] and the tetrahedral Cassiopeia (Cassiope tetragona) are the rarest species listed in the Red Book of Russia. book of the Russian Federation [21,22]. Conversely, flowers that bloom right in the snow are white first and turn pink as seeds are formed. A completely remarkable view opens in the eastern circus of Raslak: the cliffs of this natural amphitheater are covered with delicate rosettes of curly cryptogram leaves (Cryptogramma crispa), and in the valley adjacent to
the circus there are rare northern orchids with the mystical name Cache (*Listera ovata*) and Diapensia (*Diapensia lapponica*, Fig. 2B).

**Figure 3.** Typical landscape of the Murmansk District. Murmansk City on the Kola Gulf of Barents Sea (A), a block of flats in Oleniegorsk (B), Monchegorsk mountains (C), Lapland National Park (D), An small lake with forest-tundra in the north part of Kola (E), Waterfall in the Khibiny Mountains (F), Landscape on the Khibina Mountains (G), Kandalaksha Bay near Kolvitsa (H). (all photographs of the fig. 3-7 by Milosz Huber).
A relatively interesting place with a specific microclimate in the vicinity of Lake Sieidzioro (Fig. 2). In this place, sheltered by high mountain ranges on three sides, the climate is much milder. The air heats up from the sun's rays reflecting off the slopes, often creating a thermocline. Also, this massif is higher than the north than the south, which favors the supply of warmer air and some kind of protection against cold winds. As a result, in the vicinity of the lake, there is a zone of relatively high forest and marsh vegetation. The spruces growing here reach a height of up to 15-20 m, which is rare in this area. Besides, there are many species of plants that are not found in other places and endemics. The original (or close to the original) nature of the forests may also be related to the hard-to-reach nature of this place. It is located on the sidelines of important transport routes and cities, and the additional proximity of high mountains and lakes along with numerous marshy zones makes the possible transport of trees from this place difficult or unprofitable. This character has long been noticed, which contributed to the creation of the "Sieidjawt" reserve in this area in the 20th century. Mountain willows (Salix nummularia, S. polaris, S. reticulata) deserve special attention: they do not exceed the height of mosses and lichens, and their "trunks" are immersed in mossy clumps or in a thin layer of soil, which protects them against cold and dehydration. In the shallow waters of the lake, there is a lake spade (Isoetes lacustris) that lives only in crystal clear and cold waters. The endemic of the Kola Peninsula, the Lapland poppy (Papaver lapponicum) (Red Book of the Murmansk Region Tree, 2014), grows on sandy and rocky slopes. In these mountains, it can meet the buzzard (Plectrophenax nivalis L.), and the lemming (Lemmus lemmus L.), and even butterflies (Papilio machaon L.) [20,22]. Steep slopes can be a nesting place for a peregrine falcon. There is also a brown bear and an elk here, and from time to time it can meet a wolverine.

3.1.3. Geology. Geologically, this area is the north-eastern part of the Baltic Shield, the NE Block of Fennoscandia, which belongs to Eastern Europe (Fig. 4)[23-30]. The relief of the Kola region is determined by the nature of the ground rocks. It abounds in clearings and tectonic ditches related to drop and slide faults developing in crystalline rocks. Long-term erosion processes as well as glacial activity in the Pleistocene partially eliminated these dislocations. As a result, in NE Fennoscandia low elevations up to 300-350 m above sea level dominate. The exception, however, is the zone of the WNW-ESE course, characterized by much larger hills (about 1000 m above sea level) associated with tectonic rejuvenation, called the Lapland-Granulite mobile belt. This zone borders the coast of the White Sea in Karelia and extends to the area of Lapland and the Kola, disappearing under the Caledonian Scandinavian Mountains. In the north of the Kola, in the region of Murmansk, Archean granite gneisses are exposed, which form the oldest currently known link that builds the Kola series craton [2,24-26] (Fig. 4A). Exposures of these rocks occur in the area of the city, in the slopes of the Kola Gulf of the Barents Sea and the bypass ditches. These rocks are garnet - mica - pyroxene - quartz - plagioclase gneisses bearing traces of multiple metamorphisms, sometimes also migmatization, and are intersected by various vein formations of various compositions [29]. These rocks are accompanied by enderbites and granodiorites, various types of granitoides, also in the vein form, filling the spaces between these rocks in the fault zones, as well as mica-amphibole-pyroxene gneisses and amphibolites. They are included in the structure of the Central-Kola Block [29], the age of which is estimated at over three billion years [2,27-29]. From the south, there are rocks of the green belt of Imandra - Varzuga and the intrusions of Khibiny and Lovoziero, and from the west by the intrusions of monchetundra, monchepluton and the Lapland Granulite Belt of the Kola. To the south of these rocks, there are ferruginous BIF gneisses, which are exposed near Olenieigorsk. There are magnetite quartzites and garnet -biotite gneisses (Fig. 4B). These rocks were metamorphized into amphibolite facies in the Late Archaic. The age of this process was determined by dating one of the gabbronorite dyke to 2760 ± 7 million years (U/Pb [25]). These rocks were formed while there was no oxygen in the atmosphere. In these rocks sulfides of microbial origin were found [25] and polymetallic mineralization with admixtures of silver and gold [29]. Next to the south, there are Paleoproterozoic, alkaline, and ultra-alkaline intrusions. These are the intrusions of Monchepluton, Monchetundra, and Imandra. Their ages are 2507, 2450, and 2446 million years, respectively [29]. They are dominated by peridotite (Fig. 4E) and gabbroide rocks containing oxides (magnetite, chromites), sulfides (pentlandite, pyrrhotite,
chalcopyrite), and platinum metals (platinum and palladium tellurides and bismuths). The rocks of some of them are metamorphized into amphibolite facies. They create elevations up to 1000m above sea level. (Mount Khippik) and picturesque gorges, waterfalls (Vaikis). They are located in the vicinity of the city of Monchegorsk and have been the subject of exploration and exploitation of various types of ores since the beginning of the 20th century. To the south and east of them, there is a Proterozoic collision zone called the Lapland Granulite Belt, which was formed as a result of the overlapping of the Belamoryian and the Kola Blocks and the metamorphism of these rocks in the amphibolite and granulite facies. This zone was also tectonically active, contributing to the creation of many faults, readable in the field. In addition to granulites - meta-sediment origin, there is also a series of amphibolites (Fig. 4E) constituting metamorphized volcanic deposits as well as the intrusion of gabbroid rocks. These rocks are exposed in the Lappish part of Murmansk District and the Kandalaksha area. Younger than these deposits are various granitoids forming their massifs and numerous veins, sometimes also with interesting mineralization, as well as several Palaeozoic intrusive forms represented by Khibiny and Lvoziero - creating the highest elevations in the region (1200m above sea level, Fig. 4E,F) and such intrusions as Kovdor, Afrikanda (Fig. 4G,H) and many others built from alkaline rocks with carbonatites and an admixture of ultra-alkaline rocks [30]. Their occurrence is associated with an unusual, rare, and interesting mineralization, and they are now mostly exploited for their ores. In addition to the above-mentioned, there are many other interesting massifs in the area of Murmansk District, however, these examples are relatively easily accessible, being close to towns and roads. Moreover, a detailed description of the massifs of the Kola region is beyond the scope of this article.
Figure 4. An example of rocks (polarized light microphotographs). Archean rocks: Murmansk Gneisses with garnets (gar), quartz (qtz) orthoclase (kfs) and biotite (bt), sillimanite (sill) crystals (A), Oleniegorsk Banded Iron Formations with quartz, orthopyroxenes (opx) and clinopyroxenes (cpx), with cummingtonite (cum) and magnetite (mt) (B). Proterozoic rocks: Harzburgite from Monchepluton with olivine (ol) and orthopyroxene (opx) with talc (tc) (C) and amphibolite from Lapland Granulite Belt in Kandalaksha area with common hornblende (hbl), orthoclase and clinozoisite (czo) (D). Paleozoic rocks: Csyenite from Khibiny Mts with nepheline (ne) and aegirine (aeg) crystals (E), luavrite from Lovoziero with aegirine, loparite (lop) and orthoclase (kfs), phoscorite from Kovdor with clinopyroxene, calcite (cc) and magnetite (G) and perovskite ore from Africanda with perovskite (pre), magnetite and olivines (H).
3.1.4. History. In the period of 4–3 millennium BCE groups of northern peoples came to the Arctic, ethnically related to the tribes of the Volga-Okta. They settled along the banks of rivers and lakes in the inner part of the Kola Peninsula (Fig. 5)[1,32]. Since their walls were decorated with deep pits and comb stamps in the production of ceramics, they were called tribes of the pit pottery culture. They used boats and nets, bone hooks, and advanced harpoons (with a rotating tip) for fishing. They hunted for seals and seals in the bays and deer and elk on land. At the end of the 2nd - beginning of the 1st millennium BCE the Arctic climate became warmer and drier, deciduous trees covered the north as far as Khibiny[32].

At that time, the tribes of the asbestos-pottery culture came to the Kola Peninsula from the Northern Urals (in the manufacture of dishes, they added crushed asbestos to the clay, and a mesh-like ornament was applied to the walls), which belonged to the Finno-Ugric group. As a result of mixing the newcomers with the old people of the region, the Finnish-speaking nation gradually developed - the ancient Sami. Physically they looked like Europeans, but they also bore weakly Eastern traits. The first written information about the Saami came from the 9th-century Norwegian sailor Other who sailed along the shores of the Kola Region, but more detailed descriptions of Russian pioneers that the Saami did not have huts, lived "in stone clefts", ate "only animals, birds and fish. sea ", they knew neither bread nor vegetables; clothes were sewn from the skins of wild deer. Russians of Novgorod are the first Ruthenians who paved the way to the Far North. Thus, the chronicle reports on the Ulerz in Novgorod, which reached the White Sea in 1032 with its people. Following the industrialists, Novgorod officials came to the Terski coast, imposing a fief on the Sami people (Fig. 5)[32]. The first evidence of these relations is in the chronicles in 1216. The right of Veliky Novgorod to the Arctic was questioned by the Norwegians. In 1251, Alexander Nevski managed to conclude an agreement with them, which defined the procedure and the amount of tribute from the Saami people. But this agreement was often broken, as a result of which clashes broke out between Russians and Norwegians, like the Novgorodian campaign in 1323, when the Russians, Karelians, and Saami, following ships along the northern coast, made their way west, captured and burned the palace of the ruler of Norway. In the middle of the 15th century, the first Russian villages - Varzuga and Umba - appeared on the Terski coast. The settlers came from south-west Pomerania, which was part of the Nowogrodzka land. Russian settlers - Pomory - were noticeably ahead of the Saami in production and everyday life. They brought with them a more complex system of social relations. All this could have influenced the development of the Saami society. Thanks to the exchange of goods with the Russian population, metal products, fabrics, hemp yarn fishing gear, and agricultural products penetrated the Saami economy[1,32]. They had the opportunity to borrow production skills themselves, join Russian culture. As a result of communication with the Russian population, the Saami gradually change their religious beliefs, develop individual ownership of fisheries, and the tribal system weakens and collapses. The inclusion of the Kola Peninsula into the Novgorod land and the rapprochement of the Saami people with the Russian people became an important stage in the development of the region[1,32].
Figure 5. Reconstruction of the Piechenga monastery in Luostari (A), a small chapel in the Turiy Pen. (B), reconstruction of labyrinth stone (C) seid rocks monument (D) stone stela with historical information about Kolvitza (E), and the orthodox church in Murmansk (F).

3.2. Natural Heritage
The Murmansk District area is protected in several National Parks and Reserves. The largest of them - Lapland National Park covers the Monchetundra Massif with the Vaikis Lake area, the highest hill
(Khippik), and the hills to the west of it. It has recently been extended to include South-Western Khibina. The second region is the predecessor of the islands and the Kandakalsha coast with the regions adjacent to the Kolvitza Peninsula. It also includes several islands in the Barents Sea area from the north of the region (eg. Kildyn Island) [33]. The third region is the cross-border National Park of the Pasvik River located on the Norwegian-Russian border. In addition to these areas, there are numerous reserves, such as the above-mentioned Siedoziero region in the Lovoziero Massif or Gremia-Vyrmes west of Murmansk. It is worth mentioning that the discussed areas are lacking tourist infrastructure, there are no marked trails, there are no information boards or shelters, tables, camping centers, not to mention shelters. The huts are unmonitored and devastated. Many post-industrial areas are not protected at all, this is the case, for example, in the Monchetundra area where holes in the shafts and tunnels bleed, which could cause a tragedy for an inattentive tourist. It is similar in the Lovoziero Massif, where the shortest route to the massif's center leads through an active mining plant and a high-voltage mining railway line. This way of visiting creates a conflict between a site that should be subject to mining regulations and free-walking tourists who may pass through the site and have an accident. There is only one tourist base in Khibiny for the entire mountain range. Private initiatives arise, but today they are single centers that do not form a network. This is the case, for example, in the Kandalaksha or the Turij. The eastern areas of Murmansk District are inaccessible because there are no roads there. With a few exceptions, the seashore is closed to tourism. Many cities have no idea how to develop an increasing tourist interest. They are focused mainly on the industrial nature of work, often dependent on one source of income (eg Rievda). This also affects the financial condition of cities and their appearance, often with dilapidated houses even in central streets.

3.3. The revival of the economy of post-industrial areas

An important factor is understanding the opportunities and threats posed by the development of tourism. It is inevitable, as the statistics also show unless the entire area of Murmansk District is closed to visitors. Incoming tourists can become a source of income for cities, also contributing to the diversification of their income. In many areas of Murmansk District, more and more tourist companies are opening up, offering opportunities to explore the city and its surroundings. Sometimes museums are created of an interactive nature. The Kirovsk region in Khibina is the most developed (Fig 6). There are selected ski runs, in winter there is an ice village, there are a gondola lift and several chairlifts, as well as museums and hotels. There are also information boards for tourists, it can rent a snowmobile or quad bike. This initiative shows that the region has great potential and is recognized. Many other cities such as Rievda, Oleniegorsk, Monchegorsk, and others may also try to develop in terms of tourism (fig. 6). There are numerous interesting objects in the vicinity of these cities that can be shown to tourists. The former mining sites in the Monchegorsk area constitute a historical heritage, showing the development of human technical thought, some of these old drifts can be made available again for tourists, protected against destruction. The heaps near Oleniegorsk and Rievda can also be developed for tourism. In cities, it can lead thematic routes related to history, ethnography, and nature, including the geology of the ground of these cities. These cells do not have to be expensive, many buildings of the former administration are deteriorating, but maybe habitable again after a minor renovation. This is the case, for example, in Afrikanda or other cities. Thanks to these activities, it is possible to revive these regions, creating new jobs, and preventing their depopulation. An important element is to seize the grassroots social initiative, manifested, among others, by in spontaneous beautification of urban greenery. Various examples from other developed tourism regions are described below.
Figure 6. Present touristic infrastructure: interactive museum of Stones in Kirovsk (A), ski-center in Kirovsk Khibiny (B), pears and beach in Seiemonovskoe Lake in Murmansk (C, D), bicycle rides and touristic map in the Siemionovskoe Lake area in Murmansk (E, F), restaurants in Apatity (G) and Murmansk (H).

3.4. Qualified tourism

As shown by statistical data from the Murmansk Tourism Center, the number of visitors to the polar regions continues to grow. By 2019, the region of Murmansk District was visited by nearly half a million tourists, including 20,000 from China and nearly 10,000 from Thailand [34]. Taking into account the
location of the region on the map of Russia and the world, it can be considered that all tourists visiting Murmansk District are an example of qualified tourism. They are tourists interested in visiting the far north, tourists engaged in winter (skiing) and summer (trekking) sports, they are also fishermen who come to fish in the rivers and lakes of the north (Fig. 6). Among these tourists, a certain percentage may also be geo-tourists who want to visit the area because of its inanimate nature (mountains, waterfalls, river gorges, and rocks). This is the case, for example, in the case of Teribierka, where after the screening of the film it has become a well-known place, eagerly visited by tourists. Taking into account the nature of people visiting the Kola region, it is important to emphasize the development of infrastructure enabling and facilitating their spending time in the region. The flow of tourists must be controlled so that Arctic nature is not devastated. There are known examples of unjustified use of off-road cars or motorcycles in mountainous regions, crossing roads and paths, and even the use of explosives in places of exposure of interesting rocks and minerals. Rubbish and even car wrecks are common in various regions of District, including Khibiny. The lack of monitoring, designated routes, and protection of many areas contributes to their irretrievable devastation.

3.5. Proposition for the Murmansk District
The Murmansk District region, as shown above, has many interesting advantages, it is relatively the most accessible arctic area in Europe, where it is possible to reach by train, car, the plane in a relatively short time, the number of cities and towns ensures relatively safe travel in the central, axial part of the region, ensuring the possibility of accommodation, meals or medical care if necessary. The values resulting from the possibility of observing the Northern Lights, the polar day, or the Arctic nature, including inanimate nature, are favorable for the development of tourism in the region. It can bring income, which is not difficult to find out by observing such areas as Lapland in Finland, the fjords of Norway, or the geology of Iceland. There are no such magnificent fjords or geysers on the Kola Peninsula, but there are no less picturesque Kandalaksha mountains with several islands on the coast or the picturesque fjord of the Kola Bay with Murmansk on the slopes. Finally, the oldest known rocks in Europe and the unusual exposures of rocks formed when there was no oxygen in the atmosphere of rocks rich in chromium ore, copper, platinum, gold, diamonds, and alkali rocks, all these are the remarkable advantages of the area [35-44].

Its development should start with building the awareness of the inhabitants [35-44]. Tourist routes and museums should be marked out primarily because of the people living in cities to direct their curiosity to the areas they live in (Fig. 7). They, having learned the value of the place they are staying, will better protect it from devastation and encourage others to visit these places. Such a policy also does not require too much expenditure and its implementation is conducive to increasing the comfort and satisfaction of people living in the region, which in the long run translates into an increase in social initiatives promoting the so-called "Little homelands". This term has been known in Western Europe for a long time and is associated with attachment to one's place of residence, awareness of its values, and caring for the common good. Such an attitude is necessary because it also allows for social self-control of activities carried out in the region, hinders devastation and contributes to better protection, and thus also reduces the expenditure on services that can be spent, for example, on the development of tourist infrastructure (Fig. 7).

It can start building tourist routes from thematic routes in cities. An example would be Murmansk. The proposed tourist route may show the diversity of the rocks of the city's bedrock, take into account geomorphological and tectonic forms, pay attention to vegetation, also combining historical and ethnographic aspects of the city. Such a route could be properly exposed, it can use horizontal markings, such as in Berlin to show the course of the Berlin Wall, or in Krakow, where the outline of the city walls is marked in this way (Fig. 7) [45-64]. There are many such examples in the world, they generally do not require large amounts of work, but they make the journey around the city more varied, also creating the opportunity for local people to get to know their place of residence, allowing them to see their place of work, rest, a school in a different light than before. This breeds curiosity, and it later pays off with other similar ideas. Undoubtedly, it would be important to build a geo-center where residents could
come to learn about the city's environment, geology, learn more about its protection, perhaps also present their ideas, or sign up for workshops. An important point is the ability to make and sell Murmansk souvenirs in the shape of seids, as well as stone tablets and magnets. This causes the demand for this type of product and will increase the interest in this type of rock. Construction of multisensory gardens, rockeries, exposition of natural rock refinements, informing passers-by about it will increase the social awareness of the place where Murmansk is located, also from the side of inanimate nature. The incorporation of rock exposures into the infrastructure of stops at houses, squares, and other facilities (amphitheaters), colored highlighting of rocks (partially already produced in the vicinity of the beltway) will show some new applications of this type of places and will increase interest in them[45-52]. Extreme and qualified amusement parks can be arranged in the old quarries within the city limits, and the exposure routes can be connected by hiking, cycling, and skiing (in winter). This will contribute to the development of urban tourism and at the same time affect the general condition of the inhabitants. Each of these goals can be treated separately as a challenge, it is enough to start taking them. To some extent, in the vicinity of the Siemionovskiy reservoir, a nature trail was created, but it does not pay attention to the bedrock, however, this is where it can start, and then expand the postulated routes and other tourist facilities gradually as the interest in this subject grows (Fig. 6,7).

It seems that building public awareness in cities and expanding urban tourism is the most natural initial choice. Such undertakings have positive features, which are people already living in the place, encouraging them to visit these places, building proposals for spending free time in different parts of the city will make them popular, which will translate into an increase in visits. Along with the development of urban tourism and the awareness of the inhabitants, emphasis should be placed on the development of tourism facilities in the region. Examples are the areas of Finnish Lapland, where there are various tourist attractions, at the same time integrated into nature. The first step should be to mark out the routes, for example in the form of closed circles around the city with forks in specific places. The next stage may be the construction of observation towers, terraces, shelters, huts, which will greatly facilitate exploring the area. An interesting solution is houses built in the vicinity of Kandalaksha on the hills, which can be rented using an application on the phone. Their cubature is not large, they are easy to clean and allow it to spend the night while wandering around the areas interesting for tourists (Fig. 7). An important factor is an increase in the range of mobile telephony and the Internet in less accessible areas. This will allow it to follow the trail in the application, receive information about the terrain, and call for help. In the most important places, it is worth considering the construction of telephones that allow it to call for help. They should be monitored similarly to other elements of tourist infrastructure, which is not difficult with the current technology development [53-64].

When paying attention to rock, vegetation, and other features of inanimate nature, it is worth placing QR codes in interesting places, directing the tourist to the appropriate link to the website. Such a code, engraved in a rock or reflected on a stiffened sheet metal, is difficult to destroy, even if it is smeared with paint, it is also relatively durable and cheap to build, it also allows to information about various elements of the landscape in a non-invasive way. The most interesting rock exposures can be made available to tourists - collectors, but only under the supervision of security. This will systematize the possibility of collecting specimens from the region without damaging the natural exposures. An example is a museum in Radenthein, Austria, where there are exposed rocks with cyanite and garnets [65]. There is an interactive museum and a souvenir shop here, and at the same time, it can walk up to the rock yourself and try to capture a piece, under the watchful eye of security, in a strictly designated place. This prevents the devastation of the surroundings and is a way for the museum to earn some income from this form of collecting. Such an approach may be prospective and important because the specimens in the Kola region reach high prices on international exchanges, are sold and exported from Russia, exploited in a vandals manner without the knowledge of the authorities, irretrievably destroying many of the scenes.
Figure 7. Examples of touristic attractions in the selected cities: Information table in the old tree in Zagnańsk (A) the grill place in a park in Chicago (B) post-industry historical manufacture in Samsonów (C) an observation tower near Rovaniemi (C) drone photographs of cities park in Krakow (E), House of Culture in Bern (F), an example of Lapland Park in Finland (G), viewing platform near Ojców (H).

Encouraging private initiative to build hotels, hostels, restaurants, rest areas, and other tourist attractions by facilitating business registration, transparency of regulations, relief should flow to the
development of infrastructure in the field (Fig. 6,7). However, one should bear in mind the declared postulates concerning the interpenetration of the space of human activity and nature, which allows for maintaining the balance of balance. A good example is several initiatives taken in the Scandinavian countries, while a bad one is the Podhale region in Poland, where the development of tourism has harmed the nature of the environment. The desire to satisfy tourists by building wood-fired houses caused smog in winter, significantly worsening the air quality in Zakopane [66]. There are known cases of death of horses carrying tourists along marked roads due to their excessive exploitation. This is an example showing that the development of tourism must be controlled by the regional authorities. The rebalancing changes that have been made seem to fix the problem, but bad practices are harder to fix than to counteract them.

An important goal, overlooked in many studies, is the cultural and industrial landscape. Many examples from all over the world show the great influence of cleanliness of the place where a person lives on his mental and physical condition. The quality of work and social initiatives depend on whether one cares about the individual, their feelings and quality of life, or whether they are left alone in a bland environment. An important aspect is tidying up the ruins, inactive buildings, if possible, they can be given a different purpose, reviving them. Production plants do not have to inform about their existence with rust, dirt, and smell. They can be painted nicely so that they blend in with the environment or, on the contrary, show some features according to the scheme of broadly understood order. If we start to take care of what is in our environment, we will become more aware of the value of the area. In the case of the Murmansk District, these issues are of great importance as they translate into the natural environment of the Arctic.

4. Discussion

The Murmansk District is an interesting area located in the Arctic at the same time in the European part of Russia where the urban and transport infrastructure is relatively well developed. Murmansk is the capital of the region, a city with high ambitions. Its driving force is numerous inhabitants, their daily work, and communication routes running through the port. This area is eagerly visited, the annual number of tourists is systematically increasing, making it an important point on the tourist map of the world. The advantages of this place are appreciated far beyond the borders of Russia, becoming a valuable place on the tourist map of the world. For the Arctic nature in the discussed area to be preserved for future generations, it is necessary to support social initiatives, development of tourism and awareness of the region's values, while controlling and directing this development. The fulfillment of these goals seems to be possible by harmonizing the vision of the development of the territory of the region's authorities, taking into account bottom-up initiatives, and supporting entrepreneurship in sectors with clearly delimited borders. Only in this way will elements of the tourist infrastructure be created, and further development of these areas will take place, also based on the private factor, while respecting the environment and preventing its devastation.

The possibility of visiting various areas with the use of a quad, motorcycle, or car, and in winter a snowmobile, is an integral part of the development of extreme sports. By itself, this alternative does not pose a threat to nature, as long as it has a clear operating framework. There must be marked trails for these sports, compliance with nature protection regulations, along with penalties for crossing designated roads. On the other hand, thinking about valuable areas as areas closed to a wider group of tourists is nowadays anachronistic thinking. The complete isolation of these areas is not feasible today, and the lack of marked out routes means that everyone explores these areas wherever they want, irretrievably destroying plant sites or rock exposures. The example of Radenthein in Austria and many other similar sites shows that it is possible to distinguish several rock exposures for tourists - gatherers, without damaging the remaining rock exposures.

In the case of marking out tourist routes, infrastructure is essential. In the case of openings in the city, there is no problem with the loss of the tourist or lack of communication. It is also not difficult to monitor or operate law enforcement services. However, in this case, the challenge is to draw the tourist's attention to what is in front of his eyes (under his feet). Exposing buildings, views, rocks, highlighting
them, appropriate arrangement of squares, pavements so that objects such as natural walls, exposures, and polishes become their integral planned part. Especially, in this case, the way of perceiving vegetation and rocks is important. Until now, they were rather perceived as an obstacle in the construction of the city, efforts were made to get rid of them, cover them with concrete or smear them with asphalt. If they are to attract attention, they must be a desired element that is integrated into the city's infrastructure. Such a solution is known in many other places and is possible to obtain, it does not require a lot of work but rather an ingenuity. It can make a sensory garden, where the different texture of the stone and its different varieties will affect the aesthetic and physical experience of visitors. Building rock gardens in the city, incorporating natural rock outcrops into the facades of buildings, and finally, appropriate information boards and souvenirs made of stone will change the perception of the ground by residents and they will start talking about their next attraction. In this case, it will not take much to pay attention to the uniqueness of the rock formations located in the Kola region. Therefore, in this case, the first step is to build awareness and indicate the value of these places for the city.

It is obvious to create information about the entire Arctic environment in a given place, about the interaction of various components of the landscape, including the cultural landscape. The above-mentioned QR code can be placed in these places, but this is not the most important goal. Talking about the environment, exposing it, building social awareness so as not to treat these places as potential rubbish or unnecessary places, on the contrary, as important, essential places will make them discover, exposed, and cared for by the residents themselves. There is strength in the inhabitants, which can be seen by looking at the lawns, which, at their own expense, despite others, are sometimes beautified with anything that accidentally becomes a kitschy but better than neglected appearance. If residents voluntarily create gardens from used bottles, old tires, and toys, then when their initiative is supported, the gardens will change, and so will the social awareness. The proposed solutions are general and should be adapted to the specificity of the inhabitants according to the needs, but the main goal is to awaken the public awareness of the beauty of the landscape in which they live. If this is successful, many more such sites will be created, and this will contribute to the effective protection of the Arctic for future generations.

5. Results
The Kola region is a very interesting and interesting place with a considerable history, large cultural mosaic, and an interesting temperament emphasized by the beautiful and expressive culture of the Russians living in this area. It is a beauty in itself that must be protected. In addition to these features, there are significant landscape values, a relatively mild climate, and the existing transport infrastructure that makes it relatively easy to visit these places. Perhaps that is why, taking into account the Arctic environment in this region, the unique biotope, and the unusual exposures of rare rocks and minerals, it is worth attention and protection. This protection must be carried out with the awareness that tourism can be an important supplement to District budget revenues, it can also be a force influencing positive changes, but it must be controlled, directed, and clearly defined. A tourist should be able to observe these unique places but respect them according to certain rules. At the same time, due to its safety and nature protection, everything should be done to ensure the most complete tourist infrastructure in the visited area. These goals are also possible to achieve through the gradual development of social awareness and the maintenance of grassroots initiatives. Improving the quality of life of the inhabitants of this area will mean that they will start paying more attention to their surroundings. This is the only way to build public awareness of the valuable landscape and hope for its permanent protection in the future.

6. References
[1] Ushakov I F 1972 Kola land (Murmansk History Book Murmansk publishing house of the Commercial Sea Port) (in Russian)
[2] Bayanova T B, Kunakkuzin E L, Serov P A, Fedotov D A, Borisenko E S, Elizarov D V, Larionov A V 13–15 January 2018 Precise U-Pb (Id-Tims) and SHRIMP-II ages on single zircon and Nd-
Sr signatures from Achaean TTG and high aluminum gneiss on the Fennoscandian Shield 32nd Nordic Geological Winter Meeting Helsinki Finland p 172

[3] Bayanova T B 2002 Age of the geological complexes of the Kola region and magmatism processes (Moskwa Autoreferat) (in Russian)

[4] Balashov J A, Bayanova T B, Mitrofanov F P 1993 Isotope data on the age and genesis of layered basic-ultrabasic intrusions in the Kola Peninsula and northern Karelia northern Baltic Shield Precambrian Research vol 64 pp 97–205

[5] Bibikova E V, Bogdanova S V, Postnikov A V, Popova L P, Kirnozova T I, Fugzan M M and Glushchenko V V 2009 Sarmatia-Volgo-Uralia Junction Zone: Isotopic-Geochronologic Characteristic of Supracrustal Rocks and Granitoids Stratigraphy and Geological Correlation vol 17 no 6 pp 561–573 DOI: https://doi.org/10.1134/S086959380906001X

[6] Glebovitsky V A 2005 Early Precambrian of the Baltic Shield (Nauka St Petersburg) pp 710

[7] Huber M, Bayanova T B, Serov P A and Skupiński S 2018 Archean gneisses of the Murmansk Oleniegorsk region (NE Fennoskandia) in the light of the petrographic and geochemical analysis Sciences Publisher pp 181 (in Polish)

[8] Huber M, Halas S, Serov P A, Ekinova N A and Bayanova T B 2013a Stable isotope geochemistry and Sm-Nd U-Pb dating of sulfides from layered intrusions in the northern part of Baltic Shield Central European Geology vol 56: 2 3 pp 134–135

[9] Petrovskaya L S, Mitrofanov F P, Bayanova T B, Petrov V P and Petrovski M N 2010 Neoarchean enderbites-granulite complex of the Puloziero-Polnek-Tundra region, Central Kola Block: stages and the thermodynamic regime of evolution (Kola Peninsula) (Kola Science Centre RAS) 78 p

[10] Pozhilenko V I, Gavrilenko B V, Zhirov C V and Zhabin S V 2002 Geology of mineral areas of the Murmansk Region (Aпатит, RAS) pp 360

[11] Aune S, Hofgaard A and Lars Söderström L 2011 Contrasting climate- and land-use-driven tree encroachment patterns of subarctic tundra in northern Norway and the Kola Peninsula Can J For Res vol 41 pp 437–449 DOI: https://doi.org/10.1139/X10-086

[12] Meer J J, Yevzerov V Y, Kolka V V and Corner G D 2001 Holocene raised-beach ridges and sea-ice-pushed boulders on the Kola Peninsula northwest Russia: indicators of climatic change The Holocene vol 12 (2) pp 169–176 DOI: https://doi.org/10.1191/0959683602hp1532rp

[13] MOOO I R ROSOHOTRYBOLOVSOYUZ 1999

[14] Kashulin N A, Dauvalter V A, Denisov D B, Valkova S A, Vandysh O I, Terentjev O I and Kashulin A N 2017 Selected aspects of the current state of freshwater resources in the Murmansk region, Russia Journal of Environmental Science and Health Part A vol 52:9 pp 921–929 DOI: https://doi.org/10.1080/10934529.2017.1318633

[15] Kashulin N A, Sandimirov S S, Dauvalter V A, Kudryavtseva L P, Terentjev P M, Denisov D B, Vandysh O I and Valkova S A 2011 Annotated ecological catalogue of lakes of the Murmansk Region: southeast area (basin of the White Sea) 2 vol (KSC RAS: Apatity)

[16] Konstantinova N A (Ed) 1999 Flora and vegetation of Murmansk Region (Kola Science Centre, RAS, Apatity) pp 175 (in Russian)

[17] Konstantinova N A (Ed) 2001 Bryophytes and vascular plants of the territory of Polar Alpine Botanical Garden (khibiny Mountains, Kola Peninsula) (Kola Science Centre, RAS, Apatity) pp 92 (in Russian)

[18] Koroleva N E 1994 Phytosociological survey of the tundra vegetation of the Kola Peninsula J. Veget. Sci. vol 5 pp 803–812

[19] Petrova I I, Ivanova E E and Sidorova U U 2004 Botanic excursions in Khibiny and Lovozero Mountains (Kola Science Centre RAN) pp 121

[20] Konstantinov N A, Koryakin A S, Makarova O A and Bianki V V (Ed) 2014 Red Book of the Murmansk Region 2nd ed (Kemerovo, Asia-print) 584 p (in Russian)

[21] Trutnev Yu P and others (Eds) Comp Kamelin RV and et al 2008 Red Book of the Russian Federation (plants and mushrooms) (M: Partnership of scientific publications KMK) 855 p (in Russian)
[22] Pokhilko A A, Vasilevskaya N V and Menshakova M Yu 2001 Additions to the flora of the Lovozero mountains (Murman region) Botanical Journal vol 86 (7) pp 121–122 (in Russian)

[23] Baluev S, Morozov J A, Terekhov N, Bayanova T B and Tyupanov S N 2016 Tectonics of the articulation region of the East European craton and the West Arctic platform Geotectonic vol 5 pp 3–35 (in Russian)

[24] Bayanova T, Korchagin A, Mitrofanov A, Serov P, Ekimova N, Nitkina E, Kamensky I, Elizarov D and Huber M 2019 Long-Lived Mantle Plume and Polyphase Evolution of Palaeoprotero zoic PGE Intrusions in the Fennoscandian Shield Minerals vol 9 (59) pp 3–22

[25] Bayanova T B, Pozhylienko V I, Smolkin V F, Kudryshov N M, Kaulina T V and Vetrin V R 2002 Catalog of the geochronology data of N-E part of the Baltic Shield (Apatity) pp 53 (in Russian)

[26] Bayanova T B 2004 Age of benchmark geological complexes of the Kola region and magmatism process action (Sankt Petersburg, Nauka) 174 p (in Russian)

[27] Britvin S N, Ivanov G Yu, Yakunenchuk V N 1995 Mineralogical accessory on the Kola Peninsula World of stones pp 5–6 (in Russian)

[28] Dolivo-Dobrovol’skii D V, Skublov S G, Glebovitskii V A, Astafe’ a B Yu, Voinova O A and Shecheglova T P 2013 Age U-Pb, SHRIMP-II Geochemistry of Zircon, and Conditions of the Formation of Saphhirine Bearing Rocks of the Central Kola Granulite-Gneiss Area

[29] Mitrofanov A F 2000 Geological characteristics of the Kola peninsula (Apatity, Russian Academy of Science Pub) pp 166

[30] Arzamastsev A A, Arzamastseva L V, Bea F and Montero P 2009 Trace Elements in Minerals as Indicators of the Evolution of Alkaline Ultrabasic Dike Series: LA-ICP-MS Data for the Magmatic Provinces of Northeastern Fennoscandia and Germany Petrology, vol 17:1, pp 46–72 DOI: https://doi.org/10.1134/S0869591109010032

[31] Aleksandrova A and Ekaterina Aigin E 2014 Ethno-Tourism Research in Lovozero Murmansk Region Russia SHS Web of Conferences vol 12: 010 DOI: https://doi.org/10.1051/shsconf/20141201036

[32] Available at http://region.murman.ru/history/kola_land/

[33] Aleksandrova A and Ekaterina Aigin E 2014 Ethno-Tourism Research in Lovozero Murmansk Region Russia SHS Web of Conferences vol 12: 010 DOI: https://doi.org/10.1051/shsconf/20141201036

[34] Murmansk Visitor center Available at: https://visitmurmansk.info/en/

[35] Cayla N 2014 An Overview of New Technologies Applied to the Management of Geoheritage Geoheritage vol 6 pp 91–102 DOI: https://doi.org/10.1007/s12371-014-0113-0

[36] Cela A, Lankford L and Knowles-Lankford J 2009 Visitor Spending and Economic Impacts of Heritage Tourism: A Case Study of the Silos and Smokestacks National Heritage Area Journal of Heritage Tourism no 3

[37] Druget E, Rahimi A, Carreras J, Castaño L M and Sánchez-Sorribes I 2015 The Geoheritage of Kerdous Inlier (Western Anti-Atlas, Morocco): Pages of Earth History in an Outstanding Landscape DOI: https://doi.org/10.1007/978-3-319-10708-0_19

[38] Erfurt-Cooper P 2011 Geotourism in Volcanic and Geothermal Environments: Playing with Fire? Geoheritage vol 3 pp 187–193 DOI: https://doi.org/10.1007/s12371-010-0025-6

[39] Fang W, Xiaolei Z, Zhaoping Y, Fuming L, Heigang X, Zhaoguo W and Hui S 2014 Analysis of spatial distribution characteristics and geographical factors of Chinese National Geoparks Cent Eur. J. Geosci vol 6 (3) pp 279–292 DOI: https://doi.org/10.2478/s11533-012-0184-x

[40] Gürer A, Gürer Ö F and Sangu E 2019 Compound geotourism and mine tourism potentiality of Soma region, Turkey Arabian Journal of Geosciences vol 12 p 734 DOI: https://doi.org/10.1007/s12517-019-4927-6

[41] Hose T A 2012 3G’s for Modern Geotourism Geoheritage vol 4 pp 7–24 DOI: https://doi.org/10.1007/s12371-011-0052-y
Huang Song 2010 The geological heritages in Xinjiang China: Its features and protection J. Geogr. Sci. vol 20:3 pp 357–374 DOI: 10.1007/s11442-010-0357-9

Jamorska I, Sobiech M, Karasiewicz T and Tyllmann K 2020 Geoheritage of Postglacial Areas in Northern Poland – Prospects for Geotourism Geoheritage vol 12:12 pp 1–13 DOI: https://doi.org/10.1007/s12371-020-00431-0

Joao Carlos Nunes 2014 The Azores Archipelago: Islands of Geodiversity In: Erfurt-Coooper P. (ed.) Volcanic Tourist Destinations Geoheritage Geoparks and Geotourism Springer-Verlag Berlin Heidelberg pp 57–67 DOI: https://doi.org/10.1007/978-3-642-16191-9_4

Kershaw S, Chitnarin A, Noipow N, Forel MB, Junrantanamane S and Charoenmit J (2019) Microbialites and associated facies of the Late Ordovician system in Thailand: paleoenvironments and paleogeographic implications Facies vol 65 p 35 DOI: https://doi.org/10.1007/s10347-019-0579-y

Mhend AS, Maaté A, Amri A, Hili R, Chakiri S, Maaté S and Martin-Martin MA 2019 The Geological Heritage of the Talassemtane National Park and the Ghomara coast Natural Area (NW of Morocco) Geoheritage vol 11 pp 1005–1025 DOI: https://doi.org/10.1007/s12371-019-00347-4

Moufti M R, Németh K, El-Masry N and Qaddah A (2015) Volcanic Geotopes and Their Geosites Preserved in an Arid Climate Related to Landscape and Climate Changes Since the Neogene in Northern Saudi Arabia: Harrat Hutaymah (Hai’il Region) Geoheritage vol 7 pp 103–118. DOI: https://doi.org/10.1007/s12371-014-0110-3

Nakada S 2018 Volcanic Archipelago: Volcanism as a Geoheritage Characteristic of Japan In: Chakraborty A, Mokudai K, Cooper M, Watanabe M, Chakraborty S (Eds) Natural Heritage of Japan Geological Geomorphological and Ecological Aspects (Springer) pp 19–28

Németh K and Moufti MR 2017 Geoheritage Values of a Mature Monogenetic Volcanic Field in Intra-continental Settings: Harrat Khaybar Kingdom of Saudi Arabia Geoheritage vol 9 pp 311–328 DOI: https://doi.org/10.1007/s12371-017-0243-2

Pogodina V and Matveevskaya A 2017 Geography of Tourism of the European Part of Russia In Widawski K, Wyrzykowski J (eds) The Geography of Tourism of Central and Eastern European Countries (Springer International Publishing AG) pp 375–435 DOI: https://doi.org/10.1007/978-3-319-42205-3_13

Popa R G, Popa D A and Andrașanu A (2017) The SEA and Big-S Models for Managing Geosites as Resources for Local Communities in the Context of Rural Geoparks Geoheritage vol 9 pp 175–186 DOI: https://doi.org/10.1007/s12371-016-0192-1

Sinnyovsky D, Sachkov D, Tsvetkova I and Atanassova N 2020 Geomorphosite Characterization Method for an Aspiring Geopark Application Dossier on the Example of Maritsa Cirque Complex in Geopark Rila Rila Mountain SW Bulgaria Geoheritage vol 12 p 26 DOI: https://doi.org/10.1007/s12371-020-00451-w

Vdovets M S, Silantiev V V and Mozzherin V V 2010 A National Geopark in the Republic of Tatarstan (Russia): a Feasibility Study Geoheritage vol 2 pp 25–37 DOI: https://doi.org/10.1007/s12371-010-0010-0

Zangmo G T, Kagou A D, Nkouathio D G, Gountié M and Kamgang P 2017 The Volcanic Geoheritage of the Mount Bamenda Calderas (Cameroon Line): Assessment for Geotouristic and Geoeeducational Purposes Geoheritage vol 9 pp 255–278 DOI: https://doi.org/10.1007/s12371-016-0177-0

Farsani NT, Esfahani M A G and Shokrizadeh M 2019 Understanding Tourists’ Satisfaction and Motivation Regarding Mining Geotours (Case Study: Isfahan Iran) Geoheritage vol 11 pp 681–688 DOI: https://doi.org/10.1007/s12371-018-0318-8

Farsani NT, Mortazavi M, Bahrami A, Kalantary R and Bizhaem F K 2017 Traditional Crafts: a Tool for Geo-education in Geotourism Geoheritage vol 9 pp 577–584 DOI https://doi.org/10.1007/s12371-016-0211-2
[57] Kavčič M and Peljhan M 2010 Geological Heritage as an Integral Part of Natural Heritage Conservation Through Its Sustainable Use in the Idrija Region (Slovenia) Geoheritage vol 2 pp 137–154 DOI: https://doi.org/10.1007/s12371-010-0018-5

[58] Pijet-Migoń E and Migoń P 2019 Promoting and Interpreting Geoheritage at the Local Level-Bottom-up Approach in the Land of Extinct Volcanoes Sudetes SW Poland Geoheritage vol 11 pp 1227–1236 DOI: https://doi.org/10.1007/s12371-019-00357-2

[59] Koizumi T and Chakraborty A 2016 Geocotourism and environmental conservation education: insights from Japan GeoJournal vol 81 pp 737–750 DOI: https://doi.org/10.1007/s10708-015-9660-4

[60] Piranha J M, Del Lama E A and La Corte Bacci D 2011 Geoparks in Brazil – strategy of Geoconservation and Development Geoheritage vol 3 pp 289–298 DOI: https://doi.org/10.1007/s12371-011-0043-z

[61] Fuming L, Fang W, Heigang X, Zhaoguo W and Baofu L 2016 A Study on Classification and Zoning of Chinese Geoheritage Resources in National Geoparks Geoheritage vol 8 pp 247–261 DOI: https://doi.org/10.1007/s12371-015-0157-9

[62] Gravis I, Németh K, Twemlow C and Németh B 2020 The Case for Community-Led Geoheritage and Geoconservation Ventures in Māngere South Auckland and Central Otago New Zealand Geoheritage vol 12 p 19 DOI: https://doi.org/10.1007/s12371-020-00449-4

[63] Gajek G, Zglobicki Z and Kołodyńska-Gawrysiak R 2019 Geoeeducational Value of Quarries Located Within the Małopolska Vistula River Gap (E Poland) Geoheritage vol 11 pp 1335–1351 DOI: https://doi.org/10.1007/s12371-019-00395-w

[64] Grosbois M, Weg F B and Eder E 2008 International viewpoint and news Environ Geol vol 55 pp 465–466 DOI: https://doi.org/10.1007/s00254-008-1340-y

[65] Available at: https://www.granatium.at/de/

[66] Available at: https://www.o2.pl/informacje/w-tatrach-znowu-padl-kon-szokujace-zachowaniewoznicy-6531001704061632a