Polar Record

www.cambridge.org/pol

Research Article

Cite this article: Kavan J and Halašková B. The rise and fall of Pyramiden: The story of a town in a wider geopolitical and environmental context. *Polar Record* **58**(e10): 1–15. https://doi.org/10.1017/S0032247422000018

Received: 9 November 2020
Revised: 24 November 2021
Accepted: 28 January 2022

Keywords:
Environmental impact; Geopolitics; Infrastructure development; Pyramiden; Svalbard

Author for correspondence:
Jan Kavan, Email: jan.kavan.cb@gmail.com

CAMBRIDGE UNIVERSITY PRESS

The rise and fall of Pyramiden: The story of a town in a wider geopolitical and environmental context

Jan Kavan[1,2] and Barbora Halašková[3]

[1]Department of Geography, Faculty of Science, Masaryk University, Kotlářská 2, 611 37 Brno, Czech Republic; [2]Institute of Geography and Regional Development, University of Wroclaw, pl. Uniwersytecki 1, 50-137 Wroclaw, Poland and [3]Department of International Relations and European Studies, Faculty of Social Studies, Masaryk University, Joštova 10, 602 00 Brno, Czech Republic

Abstract

Climate change has become significantly pronounced in the Arctic over recent decades. In addition to these climate effects, the environment has experienced severe anthropogenic pressure connected to increased human activities, including the exploitation of natural resources and tourism. The opportunity to exploit some of the natural riches of Svalbard was promptly grasped by the Soviet Union well before the 1940s. In this paper, we present the story of Pyramiden, a mining settlement in central Svalbard. The Soviet town experienced its golden age in the 1970–1980s but fell into decline in the late 1990s which corresponds well with the overall economic and geopolitical situation of the Soviet Union. The impacts of past mining activities and related urban infrastructure development are illustrated with the use of historic aerial photographs. The most pronounced changes in the terrain configuration were connected to adjustments of the river network, construction of roads, water reservoirs, and obviously mining-related activities. The natural processes overwhelmed the city infrastructure rather quickly after the abandonment of the town in 1998, though some traces of human activities may persist for decades or centuries. Nowadays, Russia has been attempting to recover the settlement especially through support of tourism and research activities.

Introduction

The high Arctic is a region that has experienced not only significant changes of its environment due to enhanced climate change but which has also been subjected to important socioeconomic pressure with intensive mining activities and especially the boom of the tourism industry over the last two decades. The aim of this paper is to describe the physical development of Pyramiden (Пирамида, Piramida), a Russian mining settlement in central Svalbard, from its origin to the present. The paper assesses the transformation of the settlement vis-à-vis its adaptation to external factors, and the interactions of human activities with the environment. The physical development of the town (buildings and other infrastructure) reflects its adaptation to external factors and human–environment relations, and it is well illustrated on the historic aerial images. In conclusion, we elaborate on how these processes are related to the global geopolitical context. To achieve this, we used our experience from several summer fieldwork endeavours in the study area and historical aerial photograph analyses that helped reconstruct the past areal extent of the settlement. Such an approach has been widely used in the study area for reconstructing the past development of different landscape processes such as glacier retreat (Rachlewicz, Szczuciński & Ewertowstki, 2007; Kavan, 2020a) or coastal erosion/accumulation near Brucebyen (Kavan, 2020b) but also for assessment of recent glacier dynamics (Kavan & Haagmans, 2021). The English written literature lacks comprehensive overviews of the settlement development so far, which is rather surprising for a town of its past importance. This paper therefore aims to fill this gap and bring a detailed description of the town's history with its effects on the surrounding environment and discuss the wider geopolitical context of the Russian presence in the Artic.

Svalbard has experienced significant environmental changes since the termination of the Little Ice Age (around 1900) (Szczucinski, Zajaczkowski & Scholten, 2009) that were directly connected to increasing air temperatures (Nordli, Przybylak, Ogilvie & Isaksen, 2014). Climate change has been a driving factor for consecutive changes especially in the case of the massive retreat of central Svalbard's glaciers (e.g. Kavan, 2020a; Malecki, 2013; Rachlewicz et al., 2007). Such changes were commonly accompanied by the subsequent intensification of material transport, especially related to increased glacier melting. The material transport by fluvial processes was usually concentrated over a short period at the beginning of the melting season (Szpikowski, Szpikowska, Zwolinski & Kostrzewski, 2014). Permafrost

thaw and an increasingly active layer thickness lead to the intensification of slope processes such as solifluction or debris flows in the area (Jaskólski, Pawłowski & Strzelecki, 2017). In addition, terrain alterations and physical modifications of the landscape often go hand in hand with an increase of local pollution and the introduction of new invasive species.

In fact, these natural processes which reshape the local landscape are frequently accompanied and/or intensified by human activities. Pollution usually originates from transportation (e.g. Aamaas et al., 2011; Reimann, Kallenborn & Schmidbauer, 2009), fuel combustion in power plants (Marqués et al., 2017), or enhanced dust emissions due to mining activities (Dörnbrack, Stachlewska, Ritter, & Neuber, 2010). Indeed, besides pollution, the most visible effects are also related to the construction of transportation infrastructures and transportation itself (e.g. Kavan & Anděrová, 2020). The overall economic development of Svalbard with the intensification of mining activities led to a spread of the settlements, industrial zones, and related infrastructures.

The mining activities in the area date back to the very beginning of the 20th century when the first prospecting expeditions took place in Spitsbergen. Brucebyen (a small cluster of huts), located on the eastern side of the Billefjorden (10 km from Pyramiden), was used as a base for coal mining operations by the Scottish Spitsbergen Syndicate. The houses that were built in 1919 (Jaklin, 2003) were also used in scientific expeditions over the next decades (e.g. Harland, 1952). Originally, the coal field in Pyramiden, which got its name from the neighbouring triangle-shaped mountain, was owned by the Swedes, but mining activities did not reach an industrial level and the property was sold to the Soviet Union in 1927. In 1931, the state-owned company Trust Arktikugol became the owner of Pyramiden (note: the Barentsburg coal mine further southwest in Isfjorden was also bought by Trust Arktikugol from the Dutch in 1934). With maritime resources depleted by English and Dutch hunters (of whales and walruses, mainly), the interest of governments in the islands was marginal (Pedersen, 2020). Soviet communities, together with the Norwegians, were the only two left in the developments of the archipelago (Nilsen, 2018).

In 1998, Pyramiden was abandoned. One of the main reasons was the poor economic situation of the Soviet Union in the 1990s. All the Russian assets on Svalbard that were heavily subsidised by the government had to be reconsolidated, and Pyramiden was of the lowest priority. Furthermore, it proved impossible to maintain the town once the new Russia faced a financial crisis as the centralised Soviet economy switched to the free market (Anderson, 2009; Bykova, 2019). In addition, political support started to drop, and the coal reserves were almost depleted (Åtland & Pedersen, 2008). One of the final turning points consisted of an airplane accident in 1996 (operated by Arktikugol), when a plane from Moscow carrying 141 miners and their family members crashed during its approach to Longyearbyen airport. Everyone on board was killed (Nilsen, 2018). However, the main reason for closing the mine was its arguable economic rentability, especially after the occurrence of a fire during the mid-1990s.

Although mining operations in Pyramiden are a thing of the past now, Russia still maintains a presence in Svalbard through the Trust Arktikugol company and the Consulate General in Barentsburg. Russia has also renewed its ambitions in Pyramiden, which can be illustrated by numerous Russian officials' statements, the renovation of buildings, an increase in tourism, as well as the opening of new research sites. In 2009, Arthur Chilingarov (the Vice Speaker in the Russian State Duma and special representative to the President on International Cooperation in the Arctic and Antarctic) informed the Duma that a new scientific station is going to be opened in Pyramiden. "We are going to be all over the Arctic", claimed Chilingarov, "this is not just science: this is presence in the Arctic" (Barents Observer, 23 December 2009; Howard, 2009, p. 205). From a geopolitical perspective, Svalbard represents a strategic challenge for Russia. The archipelago (which belongs to Norway, a member of NATO) lies just outside of Russia's most important military bases on the Kola Peninsula and the Northern Fleet's base, as well as their most vital sea lanes of communication. Hence, the Russians are expected to keep a close eye on all activities in Svalbard (Pedersen, 2020).

Materials and methods

Study site

Pyramiden is located in the northernmost part of Billefjorden, in central Spitsbergen (Fig. 1). The town is strategically positioned on the coast of Mimerbukta, a shallow but well-protected bay suitable for marine traffic. Its position far north of 78° latitude predisposes it to its harsh climatic conditions, typical of the high Arctic. Ambrožová and Láska (2017) reported that the average air temperature in Petuniabukta in 2013–2015 was −3.7 °C, and the minimum temperature −28.3 °C (February 2015); the maximum temperature was 17 °C in July 2015. The ocean is covered by sea ice for most of the year. Unlike in the archipelago's capital, Longyearbyen, the local climate can be considered as continental, especially because of its isolation from open sea water during the winter season (Nilsen, Cottier, Skogseth & Mattsson, 2008). This results in lower winter temperatures, with higher summer temperatures and lower precipitation in comparison to areas adjacent to the Atlantic Ocean. The harsh climatic conditions in the vicinity of Pyramiden are demonstrated also in the local flora and fauna (e.g. Kavan & Anděrová, 2019).

The Pyramiden settlement now consists mainly of abandoned buildings and scarcely used technical infrastructures. The core of the town with habitable buildings is in the western part of the settlement. These buildings are complemented by recreational infrastructures (e.g. cultural house, swimming pool) and public service buildings (school, canteen, hospital). The main square was constructed to represent an example of a successful socialist settlement in the Arctic with the inevitable statue of Lenin. The present state of Pyramiden town is illustrated in Figure 2 and the archival photos are presented in Figure 3.

Aerial images

The aerial images provide precise data about the settlement development over the time the images were acquired. It is therefore the most relevant source of information in contrast to different historic written sources that might be unprecise or even completely false. The aerial images were used here to map the housing, infrastructures, and traces of human activities in the close vicinity of the settlement. A set of aerial images provided by the Norwegian Polar Institute was used. Oblique aerial images from 1936 and 1938 were georeferenced to obtain upright aerial images. However, the images were taken from distances greater than 5 km, and therefore, the resolution was not sufficient to create a detailed map. The vertical aerial images from 1948, 1960, 1990, and 2009 were used to map and assess the state of the Pyramiden town infrastructure. The vertical images were acquired with a sufficient resolution to enable the

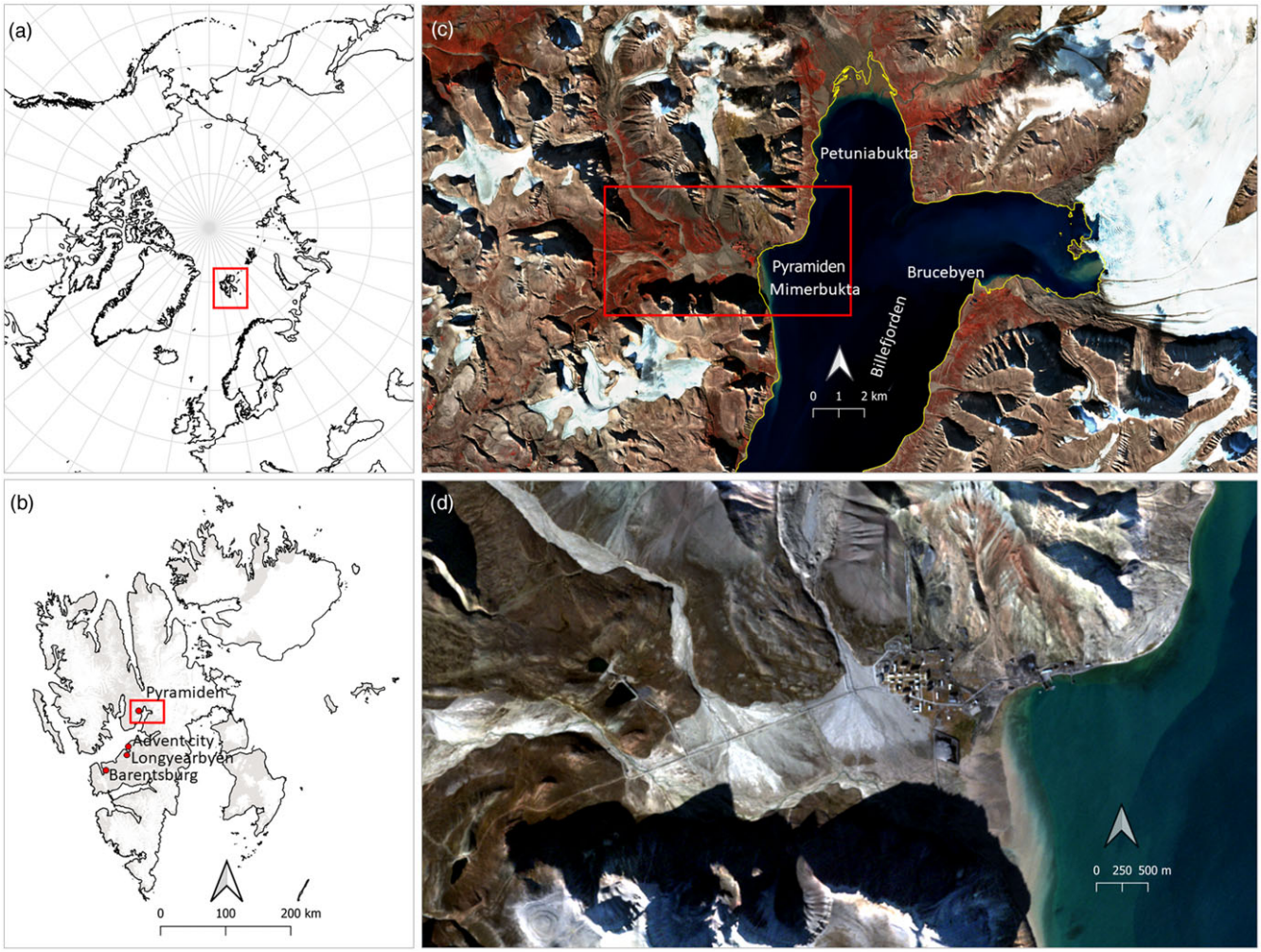

Fig. 1. The Arctic with location of Svalbard (a); Svalbard archipelago with location of Billefjorden (b), where Pyramiden is situated (c) with a close-up view of the Mimer valley with the settlement (d); the satellite images in (c, d) are acquired from Sentinel-2 (https://www.sentinel-hub.com/) and were taken on 25 August 2020.

direct identification of all infrastructural objects. This was also possible, thanks to a detailed knowledge of the area. Distinguishment between roads and pipelines was possible due to the distinct shadows of the above ground structures of the pipelines. The images were georeferenced with the use of distinct features recognisable both in the aerial images and a present aerial map from the database of the Norwegian Polar Institute (NPI, 2014). These georeferenced images were further used to manually create vector shapefiles of polygon (buildings) and line features (roads, pipelines) in the QGIS software. The schematic maps of the settlement area were then exported. The example of the 1990 aerial image is illustrated in Figure 4.

Based on the aerial images, three types of infrastructure were delimited: buildings, roads, and pipelines. The first two categories are rather clear; the pipelines are specific features of infrastructure development in the Arctic where due to the presence of permafrost all infrastructures (drinking water, waste water, electricity, heat transfer) need to be above ground.

Fieldwork

The settlement was inspected during several consecutive summer seasons between 2011 and 2019. This allowed us to observe the development of the area and document the infrastructures as well as wildlife taking control over the town. The fieldwork also served to identify key areas where the changes in infrastructure were the most pronounced. The environmental processes (such as slope movements and flooding) leading to the destruction of roads, buildings, or technical infrastructure were also assessed. The interactions between human settlement and wildlife were documented as well. The fieldwork also served in the verification of maps and aerial images used for description of the settlement.

Results

An analysis of the aerial images revealed that there were no visible infrastructures in the area in 1936, which, however, changed over the following two years. A few minor buildings were identified in the vicinity of the present harbour as early as 1938. The spatial resolution of the images from 1938 does not allow a judgement of the purpose or material of the buildings. Considering the present situation, it is highly probable that the buildings were built from wood and served both for accommodation and mining purposes.

The town infrastructure itself, including the buildings, roads, and pipelines, developed considerably between 1948 and 1960. This went hand in hand with the increasing population. As the Arktikugol official site states, in "August 1946, 609 polar explorers

Fig. 2. Pyramiden town with its characteristic features; the harbour crane (a); water and electricity pipelines covered by wooden structures (b); the statue of Lenin in front of the culture house and swimming pool (c); the last remaining wooden house constructed in the1950s (d); the Arktikugol sign on the main square (e); example of fluvial erosion caused by breaking of the protective dikes (behind the football pitch) (f); moving crane in the industrial zone close to the harbour (g); map of the town (2009) with indication of the photographs' positions (photos by Jan Kavan, 2011–2019).

Fig. 3. Archival photographs of the Pyramiden settlement illustrating the town during its growth; the overview of the town with the Pyramiden mountain in the background from the 1960/1970s (a); photo from the harbour with working power plant in the background (b); the main square with statue of Lenin, construction of the swimming pool is visible in the background (c); overview of the main square with Nordenskiold glacier in the background (d); aerial view of the harbour and most of the settlement in the background (e); the photos b–d are dated to the mid-1980s; photos by Grumant company (a, b, e) and Tory Melody (c, d).

arrived in Piramida, this is considered to be the beginning of the construction of the mine" (Арктикуголь [Arktikugol], n.d., para 5). Nevertheless, the initial infrastructure was rebuilt after 1960, with the construction of new buildings. This time, most of the habitable buildings originally made of wood were replaced by brick, multi-stage buildings. Little is left of the original wooden structures nowadays; apart from the buildings situated on the main square, there is only one last smaller cabin left from the set of habitable buildings in the eastern part of the town. The development of the core town area is illustrated in Figure 5, where the maps of buildings, roads, and pipelines are presented for each time frame.

The transportation infrastructure developed according to the overall increase of the settlement population. In the beginning, there were no regular roads with paved surfaces and the transport facilities were simply frequently used corridors on bare surfaces. Hence, the majority of the transportation infrastructure connected the port and the core of the town with the mining infrastructure. The transportation means often went outside the settlement area and used the braidplain or other surfaces. This changed after 1960, when a network of regular roads was established. This has largely persisted until today. The establishment of a regular road network has resulted in the diminishment of off-road transportation and the disappearance of physical tracks within the active zones of the braidplain. The most important change visible between 1990 and 2009 was the damage of the transport infrastructure, especially by flooding or slope processes. These events led to the destruction of bridges connecting the settlement with former drinking water supply reservoirs west of the settlement. Slope processes destroyed

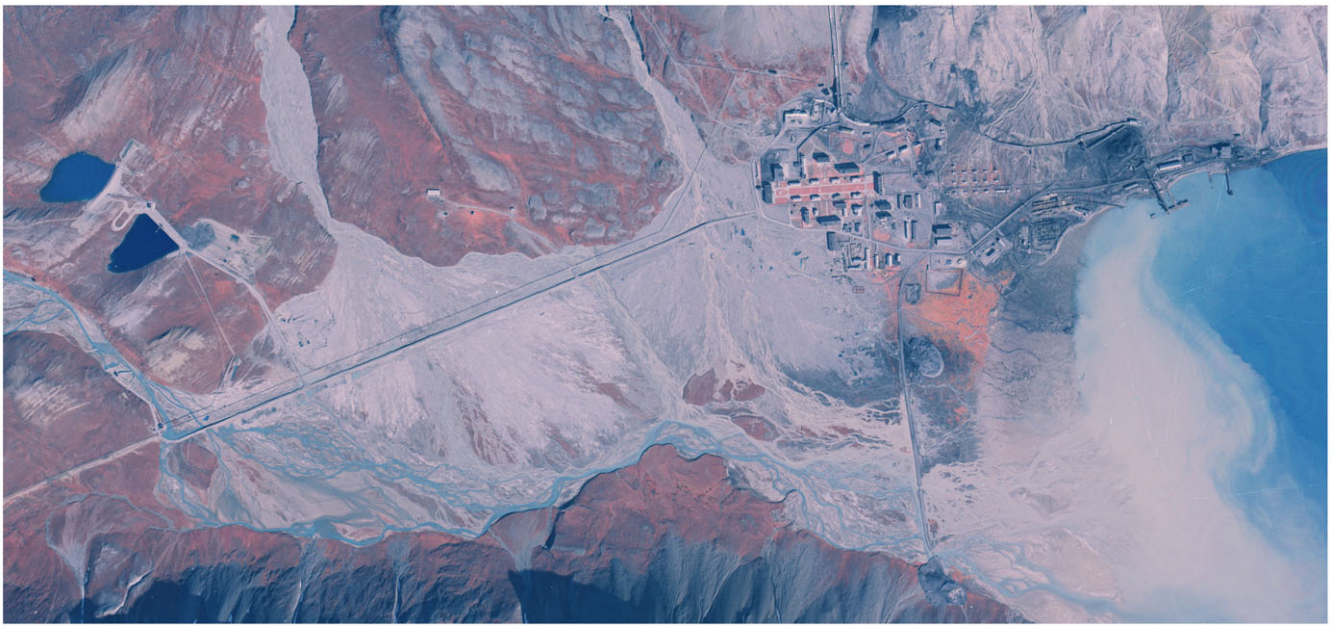

Fig. 4. Example of the 1990 aerial images capturing the Pyramiden settlement.

Fig. 5. 1948, 1960, 1990, 2009 schematic representation of existing buildings and infrastructure (maps were derived from aerial photographs provided by NPI).

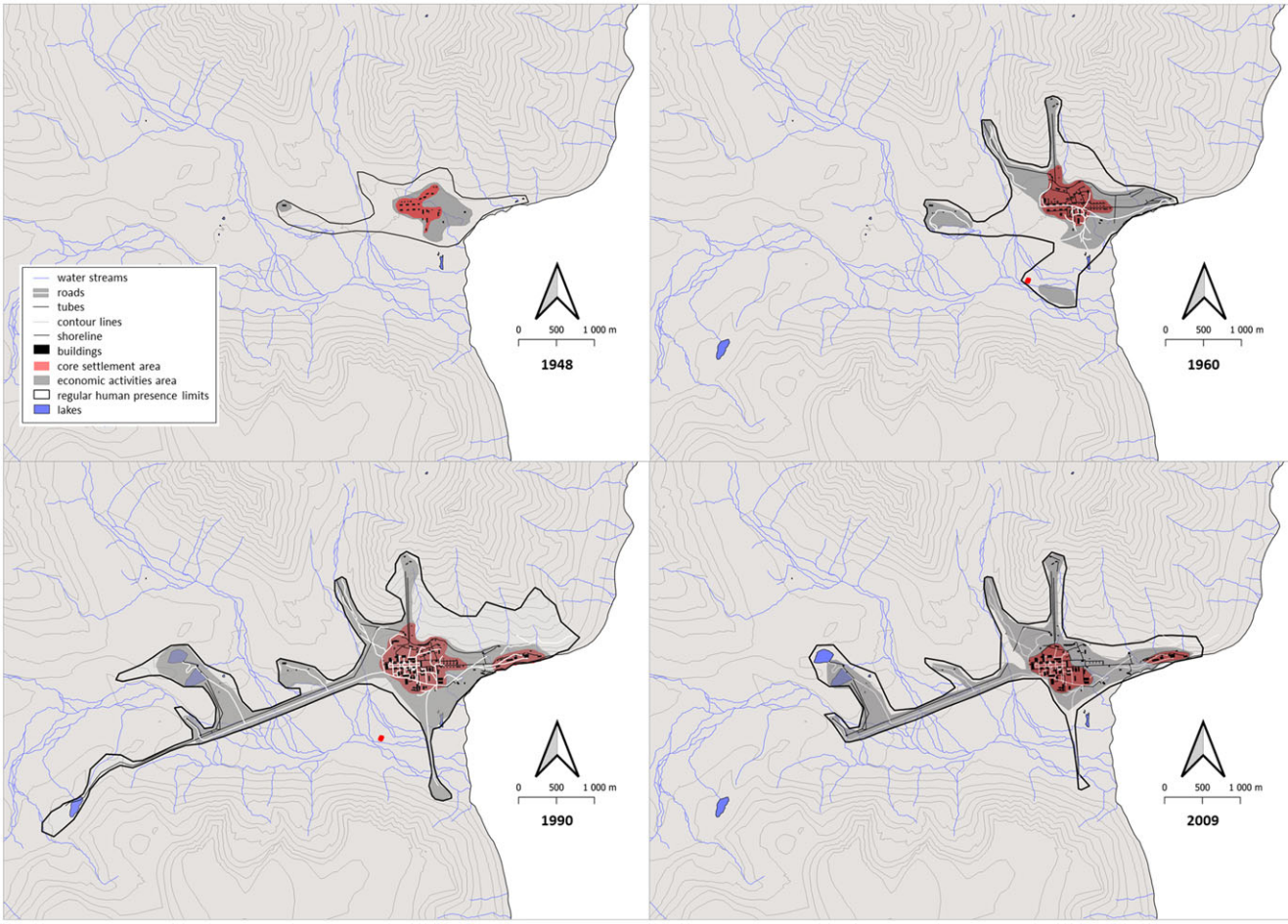

Fig. 6. Settlement and town development area in between 1948 and 2009.

part of the infrastructure connecting the town with its north-eastern neighbourhood on the slope of the Pyramiden mountain.

An interesting feature of polar settlements is their water supply system. The Pyramiden town has developed several drinking water supply systems throughout its history. An important source of water was the Bertil Glacier melt water. The water was collected directly at the glacier's front north of the town and transported to the town. This is well visible in the 1960 images, where the pipeline is shown to go towards the glacier. The pipeline is nowadays destroyed and only remnants of it are visible. After 1960, the town used the small lake about 2 km west of the town and constructed two water reservoirs at this place. These were connected to the town's water supply system with a pipeline. Roads were built in the Mimerelva braidplain to connect this infrastructure with the town.

The studied town, situated on the northern side of the large Mimer valley, was dominated by large alluvial fans and was located on the slopes of the Pyramiden mountain. The topography of the site predisposed the main geomorphical agents in shaping the towns' area. Indeed, fluvial processes were probably the main acting agents together with solifluction, mud flows, and other rapid slope processes. The highly dynamic environment of the valley side and adjacent slopes significantly influenced the development of the infrastructures and the town itself; in particular, the fluvial dynamics forced the construction of massive protection dikes. These were constructed mainly after 1960, when the town infrastructures had spread along both sides of the valley.

Figure 6 illustrates the development of the town and its impacts on the surrounding environment. The "core settlement area" represents the concentration of buildings – used for accommodation and economic activities. The "Economic activities area" is delimited by where permanent infrastructures (roads, pipelines) are visible and the "regular human presence area" is characterised by visible marks of human activities – for example off-road transportation and mining-related terrain alterations.

The growth of the town in its area has been clearly visible with the largest area occupied in 1990. The 1948 image represents the town at its beginning, with the absence of roads and only a minor core area with few habitable buildings and mining infrastructures. This had changed by 1960, when the town spread its industrial infrastructure towards the harbour and uphill. The 1990 image is characterised by major road and pipeline development towards the Mimer valley to ensure a drinking water supply from newly built reservoirs. The town core area decreased in 2009 especially due to the demolition of the old wooden cabins in the eastern part of the town and the destruction of roads by the easternmost drinking water reservoir. In general, it can be seen that the largest area was occupied in 1990. Since then, the town's area has been decreasing.

The highly dynamic fluvial processes fed by the glacier melt water (especially from the Bertil Glacier) acted repeatedly each year. The protection dikes had to be restored every year to overcome the force of the spring flood or other extreme events during the summer season. After the abandonment of the town in 1998,

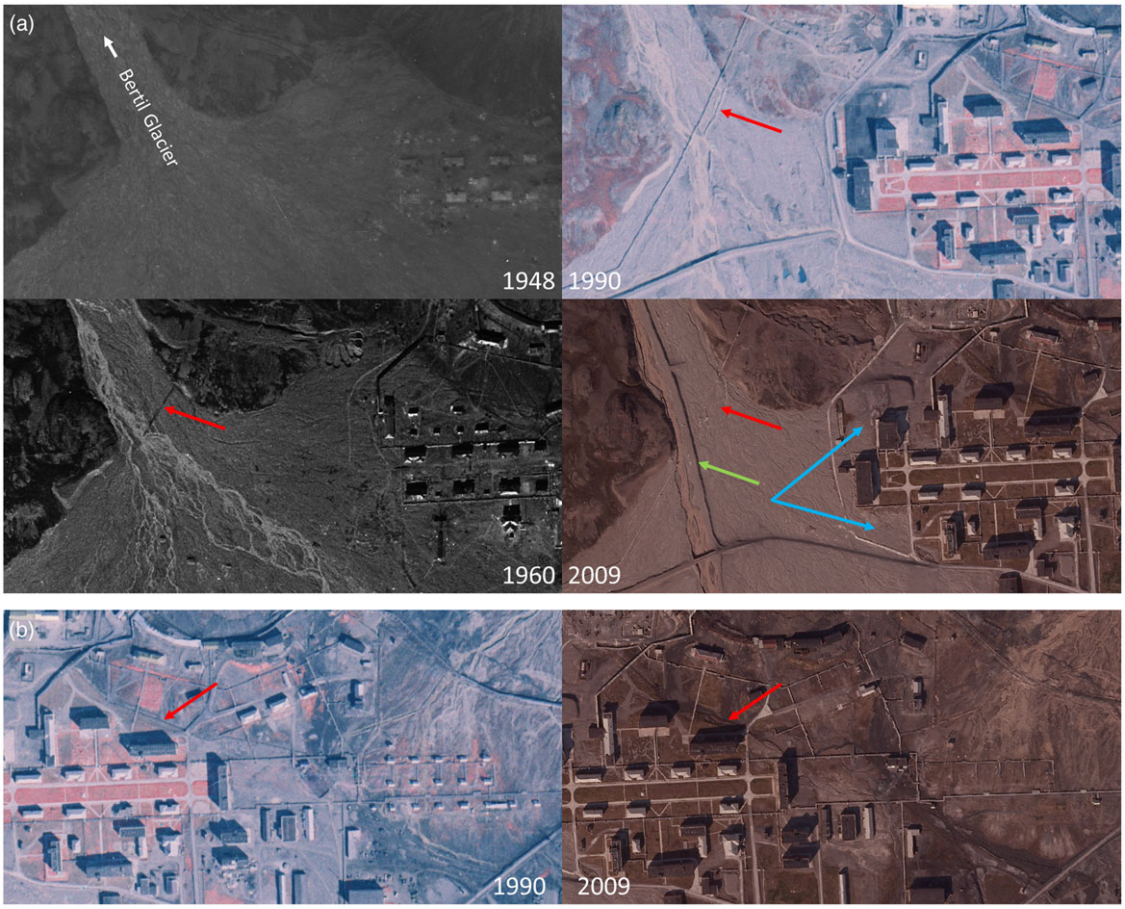

Fig. 7. Protective dikes against the glacier melt water flooding visible throughout the towns development (a) and destroying of the artificial channels by the 2006 flood as seen from 1990 and 2009 images (b); for explanation of the coloured arrows see the text.

these dikes were not repaired anymore which resulted in a major flooding of the town in 2006. The melt water from the Bertil Glacier entered the town in its northwestern part, flooding the football pitch, cultural house, and adjacent parts of the main square. Similarly, the protection dikes were destroyed along the Mimer valley taking lot of effort to repair the bridges and restore the roads. The so-called Blue Lake (indicated in the west in Fig. 6) was destroyed as well consequently leading to abandonment of the road connecting it with the town (compared the town extent in 1990 and 2009 in Fig. 6).

Figure 7 illustrates the situation of the protective dikes in the braidplain of the Bertil Glacier river. There were no protective measures in 1948 (Fig. 7a) – a situation which had already changed in 1960 and when the dike was already visible (red arrow). The same dike was still in place in 1990 but already gone in 2009. The old dike was replaced by a new, massive one, following the left bank of the river (green arrow). In the same image (2009), the damage caused by the flooding is marked with blue arrows pointing towards the football pitch (north) and one part of the main square (south). The two buildings surrounded by the fluvial sediments are the culture house (south) and swimming pool (north). The latter part of the Figure (7b) represents the complete damage of the artificial channels draining the melt water through the town. The red arrow in the 1990 image points to the channel, which was later absent in 2009. The melt water created a natural braided channel flowing through the town.

Discussion

Historical and geopolitical context

Throughout the early history of Svalbard, there have been heated discussions about who has the right to mine the land and own its surrounding waters. Since 1920, the Svalbard Treaty has recognised "full and absolute Norwegian sovereignty" over the archipelago. At the same time, citizens of all 44 signatory states have equal access and entry, and the same conditions for maritime, industrial, mining, or commercial activities on the islands and in their territorial waters (Pedersen, 2020, p. 272). Disputes over Arctic coal between rival claimants (mainly the Norwegians, Americans, and Russians) happened way before they were settled. It dated back to the 19th century when seal and whale hunters came ashore and discovered vast reserves of coal. Initially, they used the coal just to keep themselves warm, and later on as fuel for their steamships. In 1899, the first official attempt to exploit Svalbard's coal on a commercial scale was made by the Norwegians, followed by the Americans, British, and Russians (Howard, 2009, p. 94). A permanent Soviet settlement (Barentsburg) was established in the 1930s (Emmerson, 2011). During the same period, the Soviet Union opened an extensive mine at Barentsburg and in Pyramiden, which came into production in the 1940s (Howard, 2009).

At the beginning of Soviet mining activities in Svalbard, Moscow aimed to provide coal for the development of Russia's

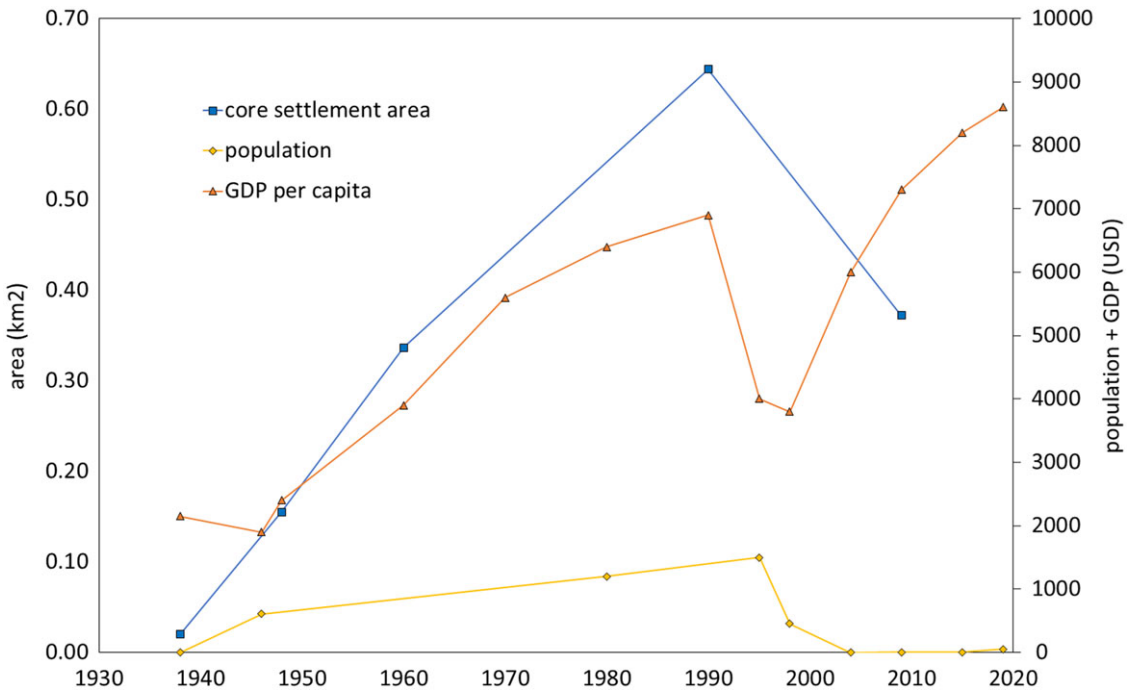

Fig. 8. Conceptual model of the economic growth/decline and its impact on population and spatial development of Pyramiden; the core settlement area was derived from aerial images analysis, population data based on literature review, Soviet Union/former Soviet Union GDP per capita data compiled from The World Economy: Historical Statistics (2003) and UN Statistics Division (https://unstats.un.org/unsd/snaama/CountryProfile).

northern regions (mainly Murmansk Oblast) and for Soviet shipping in the northern waters (Holtsmark, 1993). Indeed, the military-strategic value of Svalbard increased later with the acceleration of the Cold War tensions. Further development of the town throughout the 20th century corresponded well with the overall economic and political situation of the Soviet Union. The period of rapid growth of Pyramiden started in the 1950s and 1960s with increasing numbers of inhabitants. This intensified the need for coal for developing the heavy industry on the Russian mainland. Nevertheless, comparing Pyramiden with coal mines in Siberia, the former provided just a small proportion of the total coal production. Indeed, none of Svalbard's sites were ever profitable for most of their lifespan. In addition, the settlement was expensive to run and large parts of the extracted coal were burned there, in order to supply heating for buildings and keep the town running. As a result, Pyramiden soon became heavily subsidised by Moscow.

The Kremlin's main idea with the settlement was not purely economic, although this was not stated publicly. The town started to serve an entirely political and strategic purpose for the Soviet Union. The coal mining cover gave them a foothold on Svalbard (Bykova, 2019; Nilsen, 2018). It served as Soviet distant enclave in this NATO territory. In the 1960s, the USSR established a helicopter base just outside of Barentsburg, which was supposed to serve only for prospecting; however, it was also run as a military unit. In a state of war, the mandate was to seize control of the Svalbard Airport Longyearbyen (Pedersen, 2020). The Kremlin made a great effort to construct a monumental Soviet town outside the Iron Curtain. They built an entire infrastructure which combined both family life and cultural life. The Soviet-style apartments were quite similar to those in cities on the Russian mainland. They also had a school, kindergarten, canteen, and hospital, alongside recreational buildings like a museum, cultural palace, heated swimming pool, or gym (Bykova, 2019; Haugdal, 2020). Thousands of tons of soil were brought in from Murmansk for green grass, vegetables, and flowers grown in coal-heated greenhouses. Even cattle and pigs were brought here for breeding (Anderson, 2009; Andrassen, Bjerck & Olsen, 2010). Indeed, Haugdal confirmed that this "was quite an exotic motif in the Arctic" (Haugdal, 2020, p. 107). All of this was done with the intention of making "the workers feel at home in the inhospitable environment" (Bykova, 2019, para. 10). Interestingly, Norwegian cities in Svalbard were supplied externally from the mainland; Pyramiden, however, "was stocked and almost entirely self-sufficient" (Bykova, 2019, para. 10). Miners and their families had fresh meat, dairy products, fruits, and vegetables right at their doorstep. Moreover, there was even a factory that "transformed the garbage into bricks, which were then used to build some of the newer housing blocs in the settlement" (Bykova, 2019, para. 10).

Pyramiden was truly meant to be an exhibition of the best of the Soviet Union – a communist showroom to the West of an idealistic model of Soviet society (Andrassen et al., 2010; Haugdal, 2020; Nilsen, 2018). In fact, even such a remote place as Pyramiden was not excluded from the Soviet propaganda; on the contrary, a variety of posters and signs were displayed throughout the town in order to "communicate ideological messages both to the local inhabitants and to visitors from the West" (Haugdal, 2020, p. 115). One of them, for example, informed about the "Five-year Plans" for the economic growth of the settlement or the Soviet mainland. Another portrayed "a smiling woman milking a cow in the barn of Barentsburg or feeding hens in the yard" (Haugdal, 2020, p 116). Some of them can still be found in the abandoned town today. Among the most well-known slogans is "миру мир" (peace to the world), written on the slope of the Pyramid mountain high above the Russian settlement (Haugdal, 2020, p. 115). The symbolic power of these images and messages was strong, "considering the fact that most inhabitants in the Soviet

settlements were better taken care of than the Norwegian inhabitants of Svalbard" (Haugdal, 2020, p. 116). This perfect image of Pyramiden was also reported by Russian newspapers, mainly Pravda, which described the settlements and its production in unsurprisingly heroic terms. The newspapers informed readers about the rising quotas for coal production and the town's growing population of proud Soviet – mainly Ukrainian and Russian – citizens (Bykova, 2019).

Despite the government's efforts to produce perfect living conditions for Russian miners and their families in Pyramiden, life in the North was tough, especially given its harsh environment and cold climate. For some, living in Pyramiden was also seen as a possible escape plan to the West, as the closest Norwegian settlement was just about 50 km away from the town. Especially, given the situation right after the collapse of the Soviet Union, the dramatic change caused sudden "shortages, low salaries and poor living standards" (Nuwer, 2014, para 15). Hence, the population started to shrink rapidly. The development of the population is illustrated in Figure 8. The town reached its peak in the late 1980s, with the population numbering 1000 Soviet citizens, including officers of the State Security. This was right before the collapse of the Soviet Union (Emmerson, 2011; Nilsen, 2018). After 1990, the Arktikugol's operations in Pyramiden were closed down and the population declined resulting in the complete abandonment of the town in 1998.

The population decline also reflected the deep economic changes of the transforming Russian market (expressed as GDP per capita in Fig. 8) and the uncertain political situation in Russia, as well as in the former socialist bloc of countries. Moscow "had to reconsolidate its assets on Svalbard" (Nilsen, 2018, para 15). Clearly, the state-owned company Trust Arktikugol was not able to maintain both settlements, and "priority was given to Barentsburg" (Nilsen, 2018, para 15). First, because it is "strategically located on the ice-free west coast" (Nilsen, 2018, para 15). Second, "in order to continue mining in Pyramiden, they would have to make big investments to get to new coal layers that were deeper inside the mountain" (Nuwer, 2014, para 18). Eventually, Barentsburg also faced its own crisis as described by McFarlane and Marson (2017, para 5): "By 2006, Barentsburg was on the edge of collapse and Norway was providing food aid".

A comparison of population growth and Soviet GDP per capita as a proxy for the overall economic situation in Russia shows a significant resemblance between the two. We argue that Pyramiden as a showroom of socialist wellness collapsed in a similar way as the whole socialist economy after 1990. Thus, Pyramiden became a victim of the vast economic crisis of the post-Soviet era. The core settlement area, delimited based on the aerial images, followed this trend with some delay (see Fig. 8) as the buildings and infrastructures obviously persisted for some time despite being abandoned and not being maintained anymore. Pyramiden might thus be viewed as an indicator of the overall economic fitness of the socialist bloc. The reason for the close relationship between the town's development and socioeconomic status of the Soviet Union (providing the external support of the town) can be found in the isolation of the town. The settlement did not have any social or economic connections with Longyearbyen; moreover, it was literally isolated by glaciers, fjords, and mountains with no physical connection (roads, pathways) to other settlements. The coal mining as the principal (and officially the only) purpose of the settlement has also made the town vulnerable to fluctuation of coal price after the economic transition in the early 1990s. The development of the town was driven by environmental conditions affecting the possibilities of infrastructure construction and by available resources provided by the central government in Moscow. This, together with absence of political will to keep the coal mine working, has led to the collapse and abandonment of the town in 1998 as can be seen in Figure 8.

Human–environment interactions

The position of the town within the Mimer valley has brought not only benefits but also constraints to it. The Bertil Glacier represents a good example of such contradictory processes. On the one hand, it provided a major source of water during the early phase of the town's development. On the other hand, the large amount of melt water, especially during the early summer season, led to important flooding and consequent damage to infrastructure. Natural hazards such as floods, erosion, slope processes, or avalanches are rather frequent in Svalbard. Coastal erosion affects a large part of the old settlements (Nicu, Stalsberg, Rubensdotter, Martens & Flyen, 2020). Jaskólski et al. (2017) reviewed the natural hazards of the Pyramiden and also emphasised the vulnerability of the coast, especially in the zone with port and shore protection infrastructures.

The wildlife has quickly recovered and regained the settlement after its abandonment in 1998. The inhabited buildings offered ideal nesting places for birds and terrestrial mammals such as polar foxes (Fig. 9). The colony of kittiwakes that has populated the two buildings represents a perfect example of environmental imprinting. The buildings resemble natural cliffs; moreover, they offer considerably safer places since animals may avoid the presence of predators. However, the interaction between human settlements and wildlife does not always bring positive effects to the species inhabiting the area. Elevated levels of certain environmental pollutants were observed in different species, for example, in reindeer (Pacyna-Kuchta, Wietrzyk-Pelka, Wegrzyn, Frankowski & Polkowska, 2020). Warner et al. (2019) found samples from Pyramiden to have the highest concentrations of persistent organic pollutants among the Svalbard settlements. Similarly, Krajcarová, Novotný, Chattová & Elster (2016) reported excessive levels of Fe, Zn, Cd, and Cr in *Salix polaris* samples from Pyramiden. The high levels of pollution were attributed to local sources within the settlement as a legacy of past industrial activities. This was also supported by Marqués et al. (2017) who found extremely high concentrations of polycyclic aromatic hydrocarbons, especially in the vicinity of the former power plant. The development of the town (including building constructions, import of domestic animals, soil, and forage from continental Russia) is directly connected to the import of several invasive species of plants (Belkina et al., 2015; Coulson et al., 2015; Liška & Soldán, 2004) or even soil invertebrates (Coulson et al., 2015). In fact, plants were also introduced in the form of seeds carried on the shoes of visitors arriving to Svalbard (Ware, Bergstrom, Muller & Alsos, 2012).

The Arctic ecosystems are rather fragile and sensitive to disturbances. Kruse et al. (2021) studied the impacts of mining activities on the environment in Advent City (close to Longyearbyen) and concluded that, after more than 100 years of spontaneous restoration, the physical proof of human presence would still be visible and the influence on local flora would still persist. Nevertheless, the original disturbances were rather limited and the environment was able to recover. On the contrary, it is necessary to keep in mind that Pyramiden was a modern settlement with

Fig. 9. Wildlife has overwhelmed the town after abandonment in 1998; kittiwake nesting on the mining building (a); polar foxes often using the old wooden covered pipelines for their dens (b); Svalbard reindeer prefers rich vegetation in the town (c) (photos by Veronika Kavanová, 2017 and 2018).

a population reaching 1000 inhabitants and mining extraction techniques were far from the rather primitive mining techniques and equipment of the beginning of the 20th century. Therefore, some of the physical disturbances will certainly persist for decades or centuries and the invasive species brought from mainland Russia are likely to survive even longer. The long-term negative impacts of mining on the environment were also highlighted in Tolvanen et al. (2019). Marqués et al. (2017) pointed out the importance of hydrocarbon pollution, which can also persist for decades. Indeed, not only the visible traces of human activities but also the presence of different types of pollutants may be crucial to local organisms. Tomczyk and Ewertowski (2010) described the traces of human activities in the wider neighbourhood of Pyramiden and identified ongoing, visible impacts mainly of the mining and transportation infrastructures up to a 10 km distance from the settlement. They also emphasised the impact of recent tourism and research activities.

Tourism and research: The new direction

With the end of mining operations and the abandonment of the town, Moscow lost its connection to Pyramiden. “Both the mining operation and the population were considered instruments in the Svalbard policy, and also part of foreign policy” (Haugdal, 2020, p. 107). Hence, not having any economic activity nor the population in Pyramiden at the beginning of the 2000s, Russia needed to adapt to the new situation. In order to do so, Moscow started to display some activities in Svalbard simply to maintain a claim to Pyramiden. Russia started with a vision for Pyramiden to be reborn as a tourist destination. The location of Svalbard makes it “perhaps one of the most accessible parts of the High Arctic, as it is relatively cheap and easy to reach from both Oslo and Helsinki, unlike parts of the Canadian, Greenlandic, and Russian Arctic” (Bykova, 2019, para 19). Also, due to “significant sea ice reduction”, the areas have become more easily accessible. Because of that, “the cruise ship

season commences earlier and extends longer into the autumn" (Hovelsrud, Kaltenborn & Olsen, 2020, p. 435). Moreover, the locality itself offers a unique combination of Arctic nature and Soviet-style industry to visitors. Hence, Russia wants to reshape the business orientation of Pyramiden from a coal mining site to become a modern Russian hub for adventure travellers (Nilsen, 2018).

As the report of the Norwegian Ministry of Justice and Public Security informs, "Pyramiden had its first land-use plan approved by the Governor of Svalbard in 2014, [with the aim] to develop Pyramiden for tourism and research purposes. Trust Arktikugol is the responsible planning authority and has performed maintenance work in the planning area since 2007 (Norwegian government, 2016, p. 64). Currently, there are around 40 people living in the town (summer season) to secure and run the tourism business and maintain the buildings and infrastructure (Nilsen, 2018). In 2015, Trust Arktikugol established a tourism branch named GoArctica, which offers guided tours to Pyramiden both in winter and summer. GoArctica runs a hotel, a brewery in Barentsburg, and a combined bar and restaurant (Nilsen, 2018). Some authors argue that "in Russia's Svalbard settlements, visitor numbers have doubled in the past four years, and income from tourism stood at 2.4 million USD (in 2016). [In addition], Arktikugol received 8 million USD in government subsidies in 2016" (McFarlane & Marson, 2017, para 6). Others claim that the income from Svalbard's tourism is considerably lower "around 1.5 million USD, generated by some 32,000 visitors to Barentsburg and Pyramiden in 2017" (Nilsen, 2018, para. 27).

Besides GoArctica, Norwegian tour operators also promote the Soviet ghost town for adventurous tourists (Nilsen, 2018). In fact, Norway addresses the "growth in the travel and tourism industry in Svalbard" in its 2014 Arctic Strategy, highlighting that "Visit Svalbard AS is today the only travel and tourism company that receives annual support directly from the Ministry of Trade, Industry and Fisheries" (Heininen, Everett, Padrtova & Reissell, 2019, p. 81). This is because Svalbard has "special safety and environmental challenges and the travel and tourism industry has a central position in society in Svalbard and is important for settlement" (Norway MFA, 2014, p. 25). The Norwegian government further promises to "develop the tourist industry with a focus on profitability and sustainable management of the natural environment and cultural heritage" (Norway MFA, 2014). Interestingly, tourism is very briefly and vaguely mentioned in the newest 2020 Norwegian Arctic strategy *"The Norwegian Government's Arctic Policy: People, Opportunities and Norwegian Interests in the Arctic"*, compared to the 2014 strategy.

Having the label "northernmost", which applies to the majority of the attractions in Svalbard including the brewery, hotel, or museum, Pyramiden attracts tourists' attention and a willingness to spend relatively lot of money on their Arctic adventure. In 2018, cruise tourism alone brought Svalbard around 12 million USD in earnings (Visit Svalbard, 2019). The Visit Svalbard Report illustrates that the income from cruises resulted in an average of 474 USD per passenger. That included "personal spending by passengers while they are ashore as well as all the goods and services that the operator purchases locally, such as supplies, shore and sea-based excursions, accommodation, port facilities and fees" (Visit Svalbard, 2019). Clearly, the income from increased tourism has had a positive effect on Pyramiden itself, too. The hotel in Pyramiden was reopened in 2013, and other accommodation facilities were installed in the harbour during the following season. Part of the culture house was reconstructed with a brand new café made out of the old library in 2019. This was financially supported by the Norwegian authorities through the Svalbard environmental protection fund. The number of visitors was increasing rapidly until 2020, which was also expressed by the increasing number of tourist vessels. Shortly after Pyramiden was reopened in 2007, there were only two small tourist vessels operating sporadically throughout the season, resulting in approximately 5–6 vessels per week during the peak season. In 2019, there were already four vessels with the two new vessels having a significantly higher capacity of passengers. Such an increase meant a higher frequency of visits (15–20 vessels per week in a peak season). Interestingly, there was only one tourist guide in Pyramiden back in 2010, whereas there were at least four in 2019.

Since the 1990s, the tourism and hospitality industry has grown rapidly. Until the end of 2019, Svalbard received 60,000 visitors annually, equalling to an income of around 32 million USD (CIA World Factbook, 2018; Kavan & Anděrová, 2020). However, the rapid increase of tourism activities has ceased recently due to the impact of the COVID-19 pandemic travel restrictions applied to foreigners travelling to Svalbard. As a result, local tourist agencies are focusing mainly on Norwegian clients nowadays. It is questionable how fast the tourism industry in Svalbard can recover once the pandemic is under control and borders opened again.

Apart from tourism, Moscow's mission to strengthen its presence in Svalbard is based on considerable support for research. Ten years ago, Russia had a plan to open a scientific station in Pyramiden, which is also included in the Pyramiden area plan (LPO, 2014). Since 2009, Russia has been working on the establishment of the "Russian Scientific Center on Spitsbergen (RSCS)" in Barentsburg. The scientific centre was opened in 2016 as a consortium that coordinates the activities of 11 Russian institutes of different branches of research on the archipelago. The centre can host over 40 researchers at a time with 7 personnel as permanent staff members (Nikulina, 2016; Russian government, 2016). According to Artur Chilingarov, "Russia has to prove its entitlement to the Arctic Shelf through presence in the area", as reported by the news agency Strana reports (Barents Observer, 23 December 2009). The Kremlin has been intensively working on the fulfilment of its desire to re-establish a network of polar stations across the Arctic. Pyramiden provides an advantage by offering already existing buildings for the new scientific station and an observatory (Barents Observer, 23 December 2009). To support this, in 2016, Russia established an official government commission, the "Commission on Russian Presence in the Spitsbergen Archipelago", that should oversee renewed Russian activities in Svalbard, including touristic and research-related ones (Pedersen, 2020, p. 274).

Several decades of Soviet political isolation and lack of communication with other Arctic states are rather difficult to overcome. Russia's plan to develop a strong scientific presence in Svalbard thus brings a positive spillover for all actors involved in observations and future developments of the Arctic. Despite commercial and political rivalries, countries do cooperate in the field of research. Through scientific research, states are then able to overcome their disagreements and engage in strong international scientific cooperation, as has been evidenced through several successful research collaborations in Svalbard. A well-established view is that scientific cooperation in the Arctic is one of the oldest and most important areas of international cooperation in this part of the world, including many initiatives of a strictly exploratory or competitive nature (the race to the North Pole) (Łuszczuk,

Padrtova & Szczerbowicz, 2020). Currently, there are 13 countries from all around the world that have permanent research bases in Svalbard and closely cooperating researchers. Eventually, the lure of the Arctic's resources might bring several countries together instead of being a source of conflict and division (Howard, 2009). Indeed, "international scientific cooperation, regardless of its form, contributes to the cooperative nature and stability of the region" (Everett & Halašková, 2021, p. 35).

Conclusions

In this paper, we have described the physical development of the town of Pyramiden with its infrastructure, based on aerial images and field observations. The town experienced significant growth in its area during the 20th century accompanied by the development of housing, industrial facilities, and logistical infrastructure. These infrastructures were mainly developed in the 1970s and 1980s, following the population increase of the town. However, with the end of the Soviet Union, the economic situation did not allow the Kremlin to keep both mining settlements in Svalbard, and the more prosperous Barentsburg was given priority. This meant the end of mining operations in Pyramiden, followed by a massive decline in the town's population during the early 1990s, until its abandonment in 1998. The infrastructures then started to degrade, as an outcome of protective dike damage and the town's position on the slope of the Pyramiden mountain and on the edge of the Mimer valley, entailing intensive slope processes. Consequently, we were able to observe some of the physical disturbances in the environment (caused by the development of infrastructure) that will certainly persist for decades or centuries, as well as the survival of the invasive species brought to Pyramiden from mainland Russia.

As the title of this paper promises, we present the story of the town of Pyramiden in a wider geopolitical and environmental context. One side of the story tells us about the once-prosperous mining settlement with perfect living conditions situated far away from the mainland. Pyramiden was the place, where all possible infrastructures were built and the standard of living was far more enjoyable than that of the people living in other parts of the Soviet Union. The other side of the story, however, illustrates the town, which was clearly not economically beneficial, but had a strategic geopolitical location which was so crucial for the Kremlin, that they were willing to subsidise its existence. Eventually, the collapse of the Soviet Union also meant the fall of Pyramiden. We argue that the development of the town is in line with the global geopolitical situation and the economic development of the Soviet Union (later the Russian Federation). In particular, we provide a comparison of the population growth/decline and Soviet GDP per capita as a proxy for the economic transformation in Russia. We see a parallel of Pyramiden's collapse with the fall of the socialist economy after 1990. Thus, Pyramiden (an idealistic model of Soviet society) might be viewed as an indicator of the overall economic fitness of the socialist bloc.

With the end of mining operations and the departure of the last family from the town, Moscow lost its connection to Pyramiden. To reclaim its presence there, Russia started to invest in the restoration of the town, with the ambition for Pyramiden to be reborn as a tourist destination. Nowadays, the Kremlin's approach to Pyramiden is twofold and driven by two key factors: a) the adaptation to the economic transition from coal production towards tourism, education, and research and b) the continuity of the Russian presence in Svalbard. This is part of Moscow's Arctic strategy, and it goes hand in hand with the growing importance of the Arctic globally and the Russian need to maintain its geopolitical position in the region.

Pyramiden represents a perfect example of settlement with past geopolitical importance which is reflected in its 20th century development and long-term economic support from the former Soviet Union. It illustrates the harsh environmental conditions that all Arctic settlements are facing, and its continuous interactions with wildlife and natural processes. Over the last decades, the town has been turning from its industrial nature to become an important tourism and research location, which goes hand in hand with the overall development of other Arctic settlements.

Acknowledgements. The field work of JK in 2018 and 2019 was carried out with the support of the Adam Mickiewicz University polar station in Petuniabukta. JK is also grateful to the staff of the Pyramiden town for their long-lasting support during the summer fieldwork. We also acknowledge Steve Riley and Alexander Floyd for English language corrections.

Financial support. This work was supported by the project "ARCTOS MU" (MUNI/G/1540/2019), funded by the Grant Agency of Masaryk University (GAMU); and the Arctic Field Grant project 'Glacier mass balance – central Svalbard' (RiS ID 10903), funded by The Research Council of Norway and InterAct project n. 387 "GlacSedRun".

References

Aamaas, B., Bøggild, C. E., Stordal, F., Berntsen, T., Holmén, K., & Strùm, J. (2011). Elemental carbon deposition to Svalbard snow from Norwegian settlements and long-range transport. *Tellus B: Chemical and Physical Meteorology*, *63*(3), 340–351. doi: 10.1111/j.1600-0889.2011.00531.x

Ambrožová, K. & Láska, K. (2017). Air temperature variability in the vertical profile over the coastal area of Petuniabukta, central Spitsbergen. *Polish Polar Research*, *38*(1), 41–60. doi: 10.1515/popore-2017-0004

Anderson, A. M. (2009). *After the ice: life, death, and geopolitics in the new Arctic*. New York: Harper Collins Publishers.

Andrassen, E., Bjerck, H. B., & Olsen, B. (2010). *Persistent Memories: Pyramiden – A Soviet Mining Town in the High Arctic*. Tromsø: Tapir Academic Press.

Åtland, K., & Pedersen, T. (2008). The Svalbard archipelago in Russian security policy: Overcoming the legacy of fear – or reproducing it?, *European Security*, *17*(2–3), 227–251. doi: 10.1080/09662830802642470

Barents Observer. 23 December 2009. *Russia to reopen scientific station on Svalbard*.

Belkina, O., Konstantinova, N., Koroleva, N., Konoreva, L., Davydov, D., Savchenko, A., & Likhachev A. (2015). *Bryophytes, lichens and cyanoprocaryotes in surroundings of Pyramiden (Svalbard): a concise guide-book*. 254 pp. Apatity: N.A. Avronin Polar-Alpine Botanical Garden Institute.

Bykova, A. (2019). The Changing Nature of Russia's Arctic Presence: A Case Study of Pyramiden. *The Arctic Institute*. 9 December 2019. https://www.thearcticinstitute.org/changing-nature-russia-arctic-presence-case-study-pyramiden/ (accessed 2 October 2020)

CIA World Factbook. (2018). *Europe: Svalbard*. https://www.cia.gov/library/publications/the-world-factbook/geos/print_sv.html (accessed 2 October 2020)

Coulson, S. J., Fjellberg, A., Melekhina, E. N., Taskaeva, A. A., Lebedeva, N. V., Belkina, O. A., Seniczak, S., Seniczak, A., & Gwiazdowicz, D. J. (2015). Microarthropod communities of industrially disturbed or imported soils in the High Arctic; the abandoned coal mining town of Pyramiden, Svalbard. *Biodiversity and Conservation*, *24*, 1671–1690. doi: 10.1007/s10531-015-0885-9

Dörnbrack, A., Stachlewska, I. S., Ritter, C., & Neuber, R. (2010). Aerosol distribution around Svalbard during intense easterly winds. *Atmospheric Chemistry and Physics*, *10*, 1473–1490. doi: 10.5194/acpd-9-16441-12009

Emmerson, C. (2011). *The future history of the Arctic: how climate, resources and geopolitics are reshaping the North, and why it matters to the world*. London: Vintage Books.

Everett, K., & Halašková, B. (2021). Is it real? Science diplomacy in the Arctic states' strategies. *Polar Record*, [Manuscript submitted for publication].

Harland, W. B. (1952). The Cambridge Spitsbergen expedition, 1949. *The Geographical Journal*, *118*(3), 309–329.

Haugdal, E. (2020). Photographs of the Soviet settlements on Svalbard. *Nordlit*, (45), 104–138. https://doi.org/10.7557/13.5029

Heininen, L., Everett, K., Padrtova, B., & Reissell, A. (2019). *Arctic Policies and Strategies – Analysis, Synthesis, and Trends*. Laxenburg: IIASA, 2019. 263 pp. ISBN 978-3-7045-0156-1.

Holtsmark, S. 1993. *A Soviet Grab for the High North? USSR, Svalbard, and Northern Norway 1920–1953*. Forsvarsstudier no. 7/1993.

Hovelsrud, G. K., Kaltenborn, B. P., & Olsen, J. (2020). Svalbard in transition: adaptation to cross-scale changes in Longyearbyen. *The Polar Journal*, *10*(2), 420–442. https://doi.org/10.1080/2154896x.2020.1819016

Howard, R. (2009). *The Arctic gold rush: the new race for tomorrow's natural resources*. London: Continuum.

Jaklin, G. S. (2003). *The Place Names of Svalbard*. Norwegian Polar Institute. 537 pp. Oslo: Norwegian Polar Institute.

Jaskólski, M. W., Pawłowski, Ł., & Strzelecki, M. C. (2017). Assessment of geohazards and coastal change in abandoned Arctic town, Pyramiden, Svalbard. In: *Cryosphere Reactions Against the Background of Environmental Changes in Contrasting High-Arctic Conditions in Svalbard*; Institute of Geoecology and Geoinformation A. Mickiewicz in Poznan Polar Reports; Rachlewicz, J., Ed.; Bogucki Wydawnictwo Naukowe: Poznan, Poland, 2, 51–64.

Kavan, J. (2020a). Early twentieth century evolution of Ferdinand glacier, Svalbard, based on historic photographs and structure-from-motion technique. *Geografiska Annaler: Series A, Physical Geography*, *102*(1), doi: 10.1080/04353676.2020.1715124

Kavan, J. (2020b). Post-little ice age development of coast in the locality of Kapp Napier, central Spitsbergen, Svalbard archipelago. *Marine Geodesy*, *43*(3), doi: 10.1080/01490419.2019.1674429

Kavan, J., & Anděrová, V. (2019). Svalbard reindeer (Rangifer tarandus platyrhynchus) antler characteristics reflecting the local environmental conditions. *Folia Oecologica*, *46*(1), 16–23. doi: 10.2478/foecol-2019-0003

Kavan, J., & Anděrová, V. (2020). Impacts of increased tourism on polar environment – case studies from Svalbard and Iceland. *Czech Polar Reports*, *10*(1), 59–68. doi: 10.5817/CPR2020-1-6

Kavan, J. & Haagmans, V. (2021). Seasonal dynamics of snow ablation on selected glaciers in central Spitsbergen derived from Sentinel-2 satellite images. *Journal of Glaciology*, *67*, 961–966. Doi: 10.1017/jog.2021.36

Krajcarová, L., Novotný, K., Chattová, B., & Elster, J. (2016). Elemental analysis of soils and Salix polaris in the town of Pyramiden and its surroundings (Svalbard). *Environmental Science and Pollution Research*, *23*, 10124–10137. doi: 10.1007/s11356-016-6497-4.

Kruse, F., Nobles, G. R., de Jong, M., van Bodegom, R. M. K., van Oortmerssen, G. J. M., Kooistra, J., van den Berg, M., Kuchelmann, H. C., Schepers, M., Leusink, E. H. P., Cornelder, B. A., Kruijer, J. D., & Dee, M. W. (2021). Human–environment interactions at a short-lived Arctic mine and the long-term response of the local tundra vegetation. *Polar Record*, *57*(e3), 1–22. doi: 10.1017/S0032247420000418

Liška, J., & Soldán, Z. (2004). Alien vascular plants recorded from the Barentsburg and Pyramiden settlements, Svalbard. *Preslia*, *76*, 279–290.

LPO arkitekter for Trust Arktikugol (2014). Arealplan for Pyramiden (in Norwegian). https://docplayer.me/5011172-Arealplan-for-pyramiden-plan beskrivelse-16-desember-2014-utarbeidet-av-lpo-arkitekter-for-trust-arktik ugol-arealplan-vedtatt-16.html (accessed 16 October 2020)

Łuszczuk, M., Padrtova, B., & Szczerbowicz, W. (2020). Political dimension of Arctic research. *Oceanologia*, *62*(4), 1–14. doi: 10.1016/j.oceano.2020.03.008

Małecki, J. (2013). Elevation and volume changes of seven Dickson land glaciers, Svalbard, 1960–1990–2009. *Polar Research*, *32*(1), 18400. doi: 10.3402/polar.v32i0.18400

Marqués, M., Sierra, J., Drotikova, T., Mari, M., Nadal, M., & Domingo, J. L. (2017). Concentrations of polycyclic aromatic hydrocarbons and trace elements in Arctic soils: A case-study in Svalbard. *Environmental Research*, *159*, 202–211. doi: 10.1016/j.envres.2017.08.003

McFarlane, S., & Marson, J. (2017, October 10). *Cold War in the Arctic: Russia, Norway Dig In*. The Wall Street Journal. https://www.wsj.com/articles/cold-war-in-the-arctic-russia-norway-dig-in-1507627802.

Nicu, I. C., Stalsberg, K., Rubensdotter, L., Martens, V. V., & Flyen, A.C. (2020). Coastal erosion affecting cultural heritage in Svalbard. A case study in Hiorthhamn (Adventfjorden)—An abandoned mining settlement. *Sustainability*, *12*, 2306. doi: 10.3390/su12062306

Nikulina, A. (2016). *Russian Scientific Center on Spitsbergen*. Federal Service for Hydrometeorology and Environmental Monitoring of Russia (Roshydromet) Arctic and Antarctic Research Institute. https://www.unis.no/wp-content/uploads/2016/11/AnnaNikulina_120916.pdf (accessed 13 October 2020)

Nilsen, F., Cottier, F., Skogseth, R., & Mattsson, S. (2008). Fjord– shelf exchanges controlled by ice and brine production: The interannual variation of Atlantic Water in Isfjorden, Svalbard. *Continental Shelf Research*, *28*(14), 1838–1853. doi: 10.1016/j.csr.2008.04.015

Nilsen, T. (2018). Pyramiden: A Soviet ghost town in Arctic Norway. *Journal of the North Atlantic & Arctic (JONAA)*. https://www.jonaa.org/content/2018/10/18/pyramiden (accessed 13 October 2020)

Nordli, Ø., Przybylak, R., Ogilvie, A. E. J., & Isaksen, K. (2014). Long-term temperature trends and variability on Spitsbergen: the extended Svalbard Airport temperature series, 1898–2012. *Polar Research*, *33*. doi: 10.3402/polar.v33.21349

Norway MFA. (2014). *Norway's Arctic Policy: Creating Value, Managing Resources, Confronting Climate Change and Fostering Knowledge. Developments in the Arctic Concern Us All*. Norwegian Ministry of Foreign Affairs (MFA). https://www.regjeringen.no/globalassets/departementene/ud/vedlegg/nord/nordkloden_en.pdf (accessed 16 October 2020)

Norwegian government. (2016). *Svalbard. Report to the Storting*. Meld. St. 32 (2015–2016) (white paper). Recommendation of 11 May 2016 from the Ministry of Justice and Public Security, approved in the Council of State the same day (White paper from the Solberg Government. https://www.regjeringen.no/contentassets/379f96b0ed574503b47765f0a15622ce/en-gb/pdfs/stm201520160032000engpdfs.pdf

Norwegian Polar Institute. NPI. (2014). *TopoSvalbard*. https://toposvalbard.npolar.no/ (accessed g16/10/2020)

Nuwer, R. (2014, May 19). *A Soviet Ghost Town in the Arctic Circle, Pyramiden Stands Alone*. Smithsonian.com. https://www.smithsonianmag.com/travel/soviet-ghost-town-arctic-circle-pyramiden-stands-alone-180951429/

Pacyna-Kuchta, A. D., Wietrzyk-Pelka, P., Wegrzyn, M. H., Frankowski, M., & Polkowska, Z. (2020). A screening of select toxic and essential elements and persistent organic pollutants in the fur of Svalbard reindeer. *Chemosphere*, *245*, 125458. doi: 10.1016/j.chemosphere.2019.125458

Pedersen. T. (2020). Security issues in the Svalbard area. In G. Hoogensen Gjørv, M. Lanteigne, & H. Sam-Aggrey (Eds.), *Routledge handbook of Arctic security* (pp. 270–282). London: Routledge, Taylor & Francis Group.

***Пирамида [Pyramiden]*. Арктикуголь [Arktikugol]**. (n.d.). https://www.arcticugol.ru/index.php/rudniki/piramida.

Rachlewicz, G., Szczuciński, W., & Ewertowstki, M. (2007). Post- "little ice age" retreat rates of glaciers around Billefjorden in central Spitsbergen, Svalbard. *Polish Polar Research*, *28*(3), 159–186.

Reimann, S., Kallenborn, R., & Schmidbauer, N. (2009). Severe aromatic hydrocarbon pollution in the arctic town of Longyearbyen (Svalbard) cause by snowmobile emissions. *Environmental Science and Technology*, *43*, 4791–4795. doi: 10.1021/es900449x

Szczucinski, W., Zajaczkowski, M., & Scholten, J. (2009). Sediment accumulation rates in subpolar fjords – impact of post-little ice age glaciers retreat, Billefjorden, Svalbard. *Estuarine, Coastal and Shelf Science*, *85*, 345–356. doi: 10.1016/j.ecss.2009.08.021

Szpikowski, J., Szpikowska, G., Zwolinski, Z., & Kostrzewski, A. (2014). Magnitude of fluvial transport and rate of denudation in a non-glacierised catchment in a polar zone, Central Spitsbergen. *Geografiska Annaler: Series A Physical Geography*, *96*(4), 447–464. doi: 10.1111/geoa.12070

The Russian government. (2016). О создании Российской научной арктической экспедиции на архипелаге Шпицберген. [*On the creation of the Russian scientific Arctic expedition on the Spitsbergen*

archipelago] 4 April 2016. http://government.ru/docs/22548/ (accessed 2 October 2020)

Tolvanen, A., Eilu, P., Juutinen, A., Kangas, K., Kivinen, M., Markovaara-Koivisto, M., Naskali, A., Salokannel, V., Tuulentie, S., & Similä, J. (2019). Mining in the Arctic environment: A review from ecological, socioeconomic and legal perspectives. *Journal of Environmental Management*, *233*, 832–844. doi: 10.1016/j.jenvman.2018.11.124

Tomczyk, A., & Ewertowski, M. (2010). Changes of Arctic landscape due to human impact, north part of Billefjorden area, Svalbard. *Quaestiones Geographicae*, *29*, 75–83. doi: 10.2478/v10117-010-0008-3

Visit Svalbard. (2019). *Cruise Study Svalbard: An examination of the economical impact of cruise tourism (expedition-and conventional cruise) in Svalbard*. Visit Svalbard & Association of Arctic Expedition Cruise Operators (AECO) Report. August 2019 https://www.aeco.no/wp-content/uploads/2019/09/2019-Epinion-Cruise-Study-AECO-and-VisitSvalbard-Final-report.pdf (accessed 16 October 2020)

Ware, C., Bergstrom, D. M., Muller, E., & Alsos, I. G. (2012). Humans introduce viable seeds to the Arctic on footwear. *Biological Invasions*, *14*, 567–577. doi: 10.1007/s13280-011-0218-5

Warner, N. A., Sagerup, K., Kristoffersen, S., Herzke, D., Gabrielsen, G. W., & Jenssen, B. M. (2019). Snow buntings (Plectrophenax nivealis) as bio-indicators for exposure differences to legacy and emerging persistent organic pollutants from the Arctic terrestrial environment on Svalbard. *Science of the Total Environment*, *667*, 638–647. doi: 10.1016/j.scitotenv.2019.02.351