

CHANGES OF ARCTIC LANDSCAPE DUE TO HUMAN IMPACT, NORTH PART OF BILLEFJORDEN AREA, SVALBARD

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ABSTRACT. This study present indications of human impact on selected components of environment in the vicinity of Petunia Bay, Billefjorden, central Spitsbergen. The area is easy accessible and has low restriction of human activity so it is a need for monitoring of the human impact there. Three groups of objects were inventoried. Large-scale objects are attached to industrial impacts (mainly mining and transport of natural resources) – mines, warehouses, blocks. They are clustered around the west side of the bay – Pyramiden settlement. Medium-scale objects (mainly linear forms – path, tracks) were created by transport as well as scientific and tourist activity. Small-scale impacts (campsites, firesites) were created mainly by scientists and tourists and scattered around whole study area. Industrial activity in this area took place between 1927 and 1998, but its tracks are persistent and hard to remove. Scientific and tourist movements also started at the beginning of the XX century, but nowadays the activities become more and more intensive.

KEYWORDS: landscape transformations, human impact, Spitsbergen, Arctic.

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Introduction

Svalbard archipelago is located in Norwegian High Arctic. 2/3 of the archipelago is covered by snow and ice. Only the west part (Spitsbergen Island) is free of ice during majority of the year, what is the reason that this area, despite of northern localization, is quite easy accessible to different types of human activity. Arctic environment is highly sensitive mainly due to the severe climate condition. Therefore, human impact, although relatively not intensive, can caused serious transformations of the environment.

Infrastructure and related human activity is the clearest visible footprint of human expansion. Changes in land surface and plant communities are other common indicators of human presence in the North. The very short summer season causes that the tundra is extremely sensitive to trampling. Arctic plants and lichens are easily destroyed and they can take decades to recover (Monz, 2002). Apart of the visual impact (*i.e.* trampling vegetation cover), researches point out that trampling causes a reduction in the number of species and compositional changes in plant communities (Kuss & Hall, 1991; Monz *et*

al., 2000). The deterioration of vegetation cover leads to soil exposition, which is the beginning of the process of soil degradation. Bare soil is more prone to natural geomorphic processes (Chappell, 1996) and different types of human activities can accelerate the natural processes (Arrowsmith & Inbakaran, 2002). Wind and flowing water removes fine sediments and hinder developing of new vegetation cover. Moreover, traces of human impacts like footsteps or vehicular tracks may become more aggravated and still visible long after they were created (Jónsdóttir, 2005). Arctic terrestrial ecosystems subjected to anthropogenic disturbance return to their original state only slowly, if at all. (Forbes, 1996; Forbes & Jafferis, 1999).

Soil is another element of arctic environment, which is subjected to human pressure. Contamination and permanent changes of soil texture and physical-chemical properties was described for Petuniabukta region (Gulińska *et al.*, 2003), as well as for other areas (Krzyszczowska, 1981; McDonald *et al.*, 2001).

Another problem are litters on Svalbard's coasts – which are mainly drifts in from other countries, passengers cruises or from fishing-related activities. Moreover some amount of rubbish is left at inland areas by trekkers and scientists. Litters are preserved for a long time, because at low temperatures they decompose very slowly, and permafrost processes prevent from their burying. Additionally, waste relate with long term human staying (*e.g.* in Longyearbyen or Polish Polar Station in Horsund) can be a source of water and soil pollution (Krzyszczowska, 1981).

The unique arctic environment and its high sensitive are the reasons that more than half area of Svalbard archipelago is protected by law in form of different kinds of national parks, reserves etc. Human presence in these areas is possible only with permission of governor of Svalbard. Visiting the rest (*i.e.* unprotected) part of the archipelago is possible but also restricted by special rules.

The objective of the study is to show traces of human activity for selected components of the environment. Main emphases is laid to landscape changes.

Study area and methods

The research were conducted in the Petuniabukta (Petunia Bay) - northern reaches of Billefjorden - the innermost branch of Isfjorden (78°40' - 78°50' N and 16°15' - 17°00' E) - in the central part of Spitsbergen Island (Fig. 1). This area is easily approachable by boat (1.5 h ride) from Longyearbyen, the capital of Svalbard. Near the western coast of Petunia Bay a Russian mining town Pyramiden is located, but now it is abandoned. Eastern part of the study area comprises of Ebba valley with a Polish summer research station. In the study area 10 glaciers are situated, among them the Nordenskiöld glacier, which is the biggest one and the only one tide-water glacier.

The geology of the study area is strictly related to the Billefjorden Fault Zone, which is running N-S (Harland *et al.* 1974). Main rock units are divided by the fault zone (Dallmann *et al.*, 1994; Szczuciński & Rachlewicz, 2007). The vegetation communities are diversified (Gulińska *et al.*, 2003). Main plant species are *Dryas octopetala*, *Saxifraga oppositifolia*, *Salix polaris*, *Polygonum viviparum*, *Cerastium arcticum*, *Carex misandra*, *Saxifraga azoides*, *Deschampsia cespitosa*, *Pedicularis hisuta*, *Saxifraga ceruna*, *Cardamine nymanii*. The permafrost active layer reaches 1.2 m depth near the seashore (Rachlewicz & Szczuciński, 2008) and varies between 0.5 and 2.5 m in the other parts of the vicinity of Petuniabukta (Gibas *et al.*, 2005).

The traces of human impact were mapped with GPS receiver during the summers of 2005 and 2007. Apart of this, topographical maps, air photos (1961 and 1999) and Aster images (2002) were analysed. Finally, information from different data source were integrated and GIS-database were created.

Results

Large amount of artificial objects and other human footprints were inventoried and mapped in the vicinity of the Petuniabukta (Fig. 2). Apart of the elements related to the direct human presence at the study area, there are also objects transported from other areas by sea currents and wind.

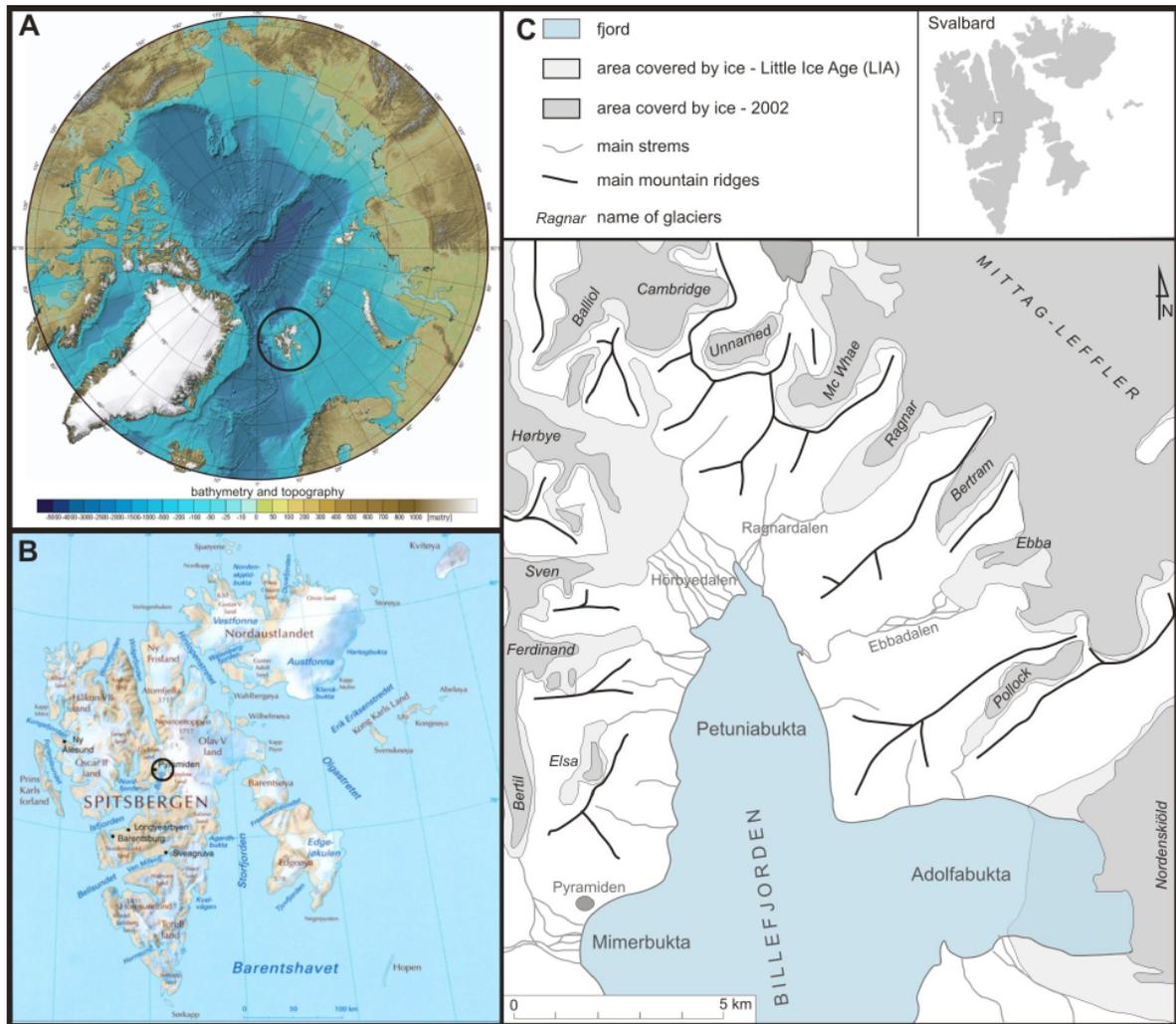


Fig. 1. Location of the study area. A – Location of the Svalbard archipelago (www.ngdc.noaa.gov). B – Location of the Petuniabukta (www.russia.no). C – Topography of the vicinity of the Petuniabukta (based on map from Rachlewicz *et al.*, 2007)

Objects linked with direct human activity in the study area were divided into three groups. The following criteria of identity have been taken into account: scale, type and permanence of human impact on landscape changes.

Large-format objects

This group of impacts concern landscape transformation of relatively extensive areas. Large scale landscape changes are observed in the west part of research area – near Mimmerbukta, where the abandoned Russian town Pyramiden is located (Fig. 3A). Pyramiden was a mining town, settled from 1917 to 1998. The main human activities were mining and transporta-

tion. A lot of blocks and industrial buildings are gathered inside the town limits. The whole area of the town is crossed by roads, pipes and transmission belts. Mines, dirt roads which were used to transport and mine slag heaps are scattered in the vicinity of Pyramiden town. Large intensity of human activities led there to extremely extensive changes of environment, which have a permanent character.

Linear objects

Linear object are mainly roads which were used by Russians is for exploration and mining purposes. Nowadays they are clearly visible in the landscape. The old Russian roads and tracks

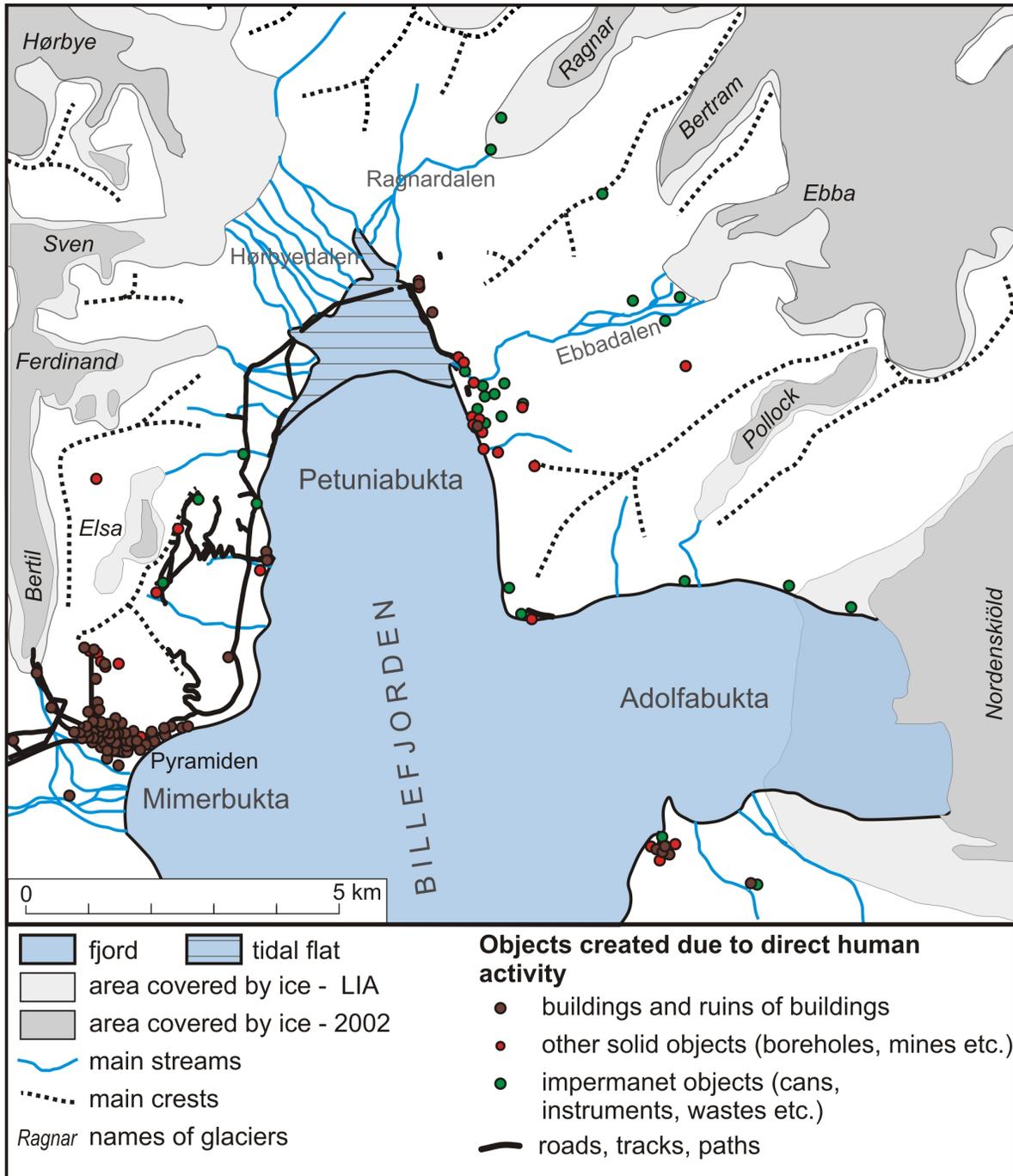


Fig. 2. Distribution of objects created by direct human activity

are concentrated in the west part of Petunia Bay, around the town Pyramiden and Pyramiden Mountain. Large sensitivity of arctic landscape causes that even single ride of truck or tractor impress sharp traces which can be visible for years (Fig. 3B, 3D). In the east part of the Bay another human traces are visible – there are trails trampled by tourists and scientists.

Point objects (small scale objects)

Houses and huts, mainly wooden, are scattered irregularly around the whole research area. One of the examples is the Skottehytta in Ebbadalen (Fig. 3C). The Skottehytta has been built in 1917 and now is used as a base for Polar Expedition organized by Adam Mickiewicz

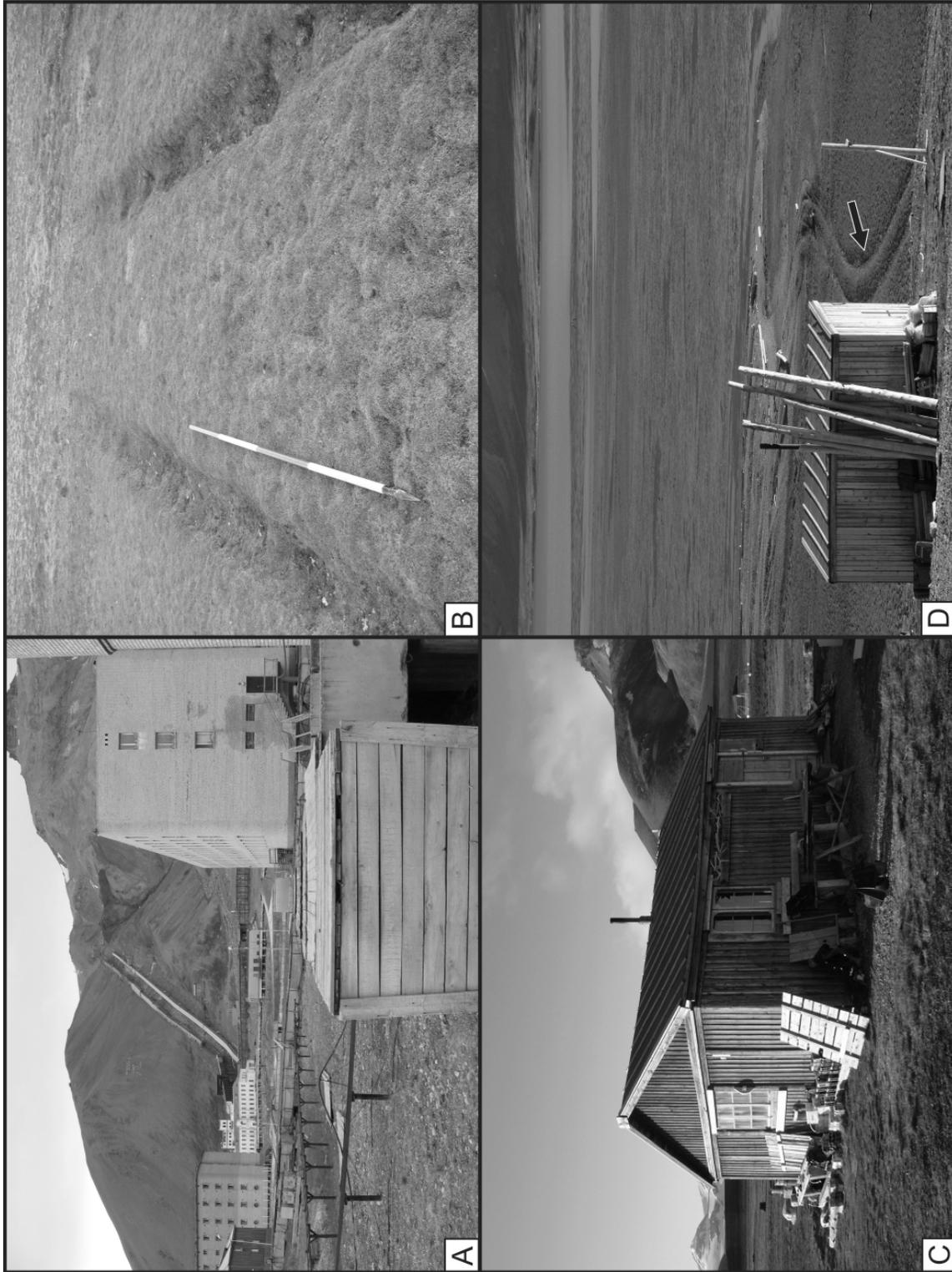


Fig. 3. A – Pyramiden town in the west coast of Petunia Bay. In the background mine and transmission belt are visible. B – Track of vehicles on tundra has remaine for c. 50 years. C – Skotehytta – one of the hut in the Ebba valley. D – Tracks of vehicles on tidal plane. On the foreground one of the huts

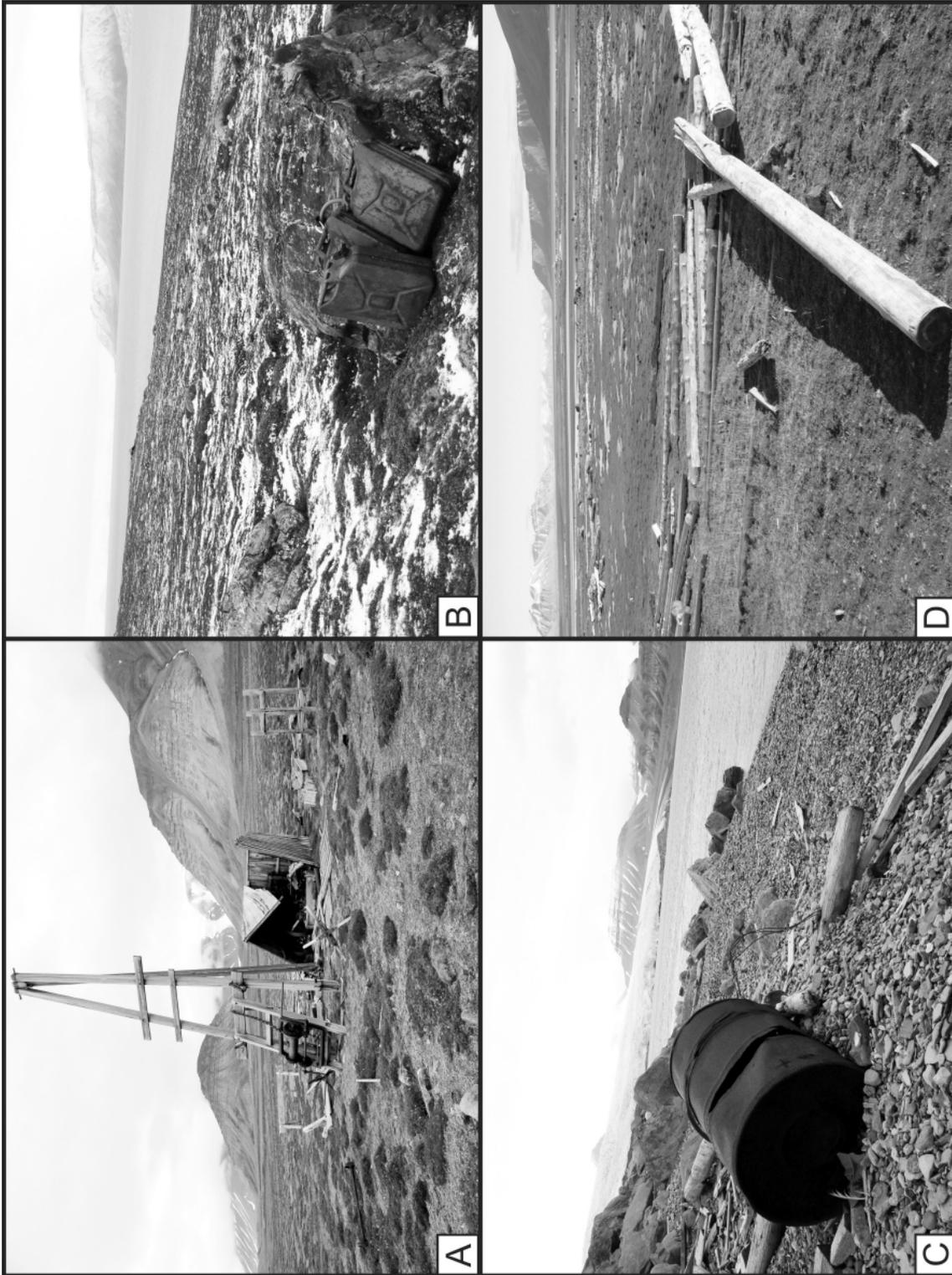


Fig. 4. A - Drilling hut and equipment. B - Petrol cans. C - Oil barrel throwed out by the sea. D - Wooden beams bring by oceanic water

University from Poznań, Poland. Another larger complex of infrastructure (four huts, fragment of old railway and other pieces of mining equipment) is the Brucebyen – former mining settlement founded in 1919.

Besides the buildings, a lot of other permanent objects were mapped too. One can mention about such objects like old concrete boreholes, abandoned coal-carts, remains of drilling huts,

Intensity of landscape changes

Hunting and trapping, mining and transportation, scientific research and tourism are four main human activities, which have or had direct influence on landscape transformation in the vicinity of the Petuniabukta. Intensity of different types of human activities has been varying through the time (Fig. 5).

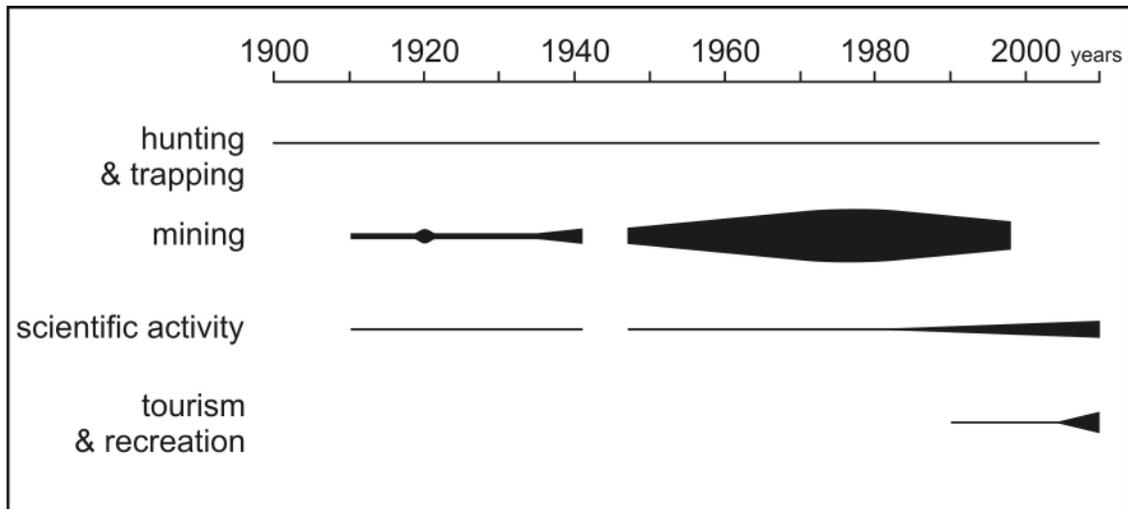


Fig. 5. Relative intensity of different type of human activity in the vicinity of the Petuniabukta

mining tools and bores (Fig. 4A) which are located usually in eastern part of the research area. Triangulation points, a radio lighthouse and foundations of buildings are also scattered irregularly. Fire-sites and campsites are linked with tourist activity and located along a popular trekking route around Petunia Bay from Pyramiden to Nordenskiöld glacier.

For the group of impermanent objects which can be easily removed belong petrol cans for snow scooters (Fig. 4B). The cans are scattered in the whole research area. Apart of them some remains of scientific instruments (hobo dataloggers, sediments traps, etc.) are also present mainly in Ebba valley. Some elements of scientific instruments have been destroyed and spread around by animals or nature forces.

Except of direct human influence, the traces of indirect impact are also visible in the landscape. Ocean currents bring wooden beams (Fig. 4D) and different types of waste (oil and petrol cans, plastic elements, nets, etc) (Fig. 4C).

The strongest landscape changes were made by mining and transport. Effects of these kind of activities are observed in the whole research region and have an impact on large areas. The mapped objects are traces of industrial activity which took place in this area between 1927 and 1998 (Fig. 5). Nowadays, these objects are usually unused and partly destroyed or demolished.

Lately, main factors leading to landscape changes are tourism and scientific activity (Fig. 5). Objects linked to them are scattered around the Bay with the biggest concentrations near Pyramiden and Ebba valley. Four main manifestation of tourist activity in the study area are:

- degradation of historical sites
- degradation of vegetation cover or geological formations – mainly creating visible trails and erosion
- littering
- degradation of vegetation cover – mainly trampling, changes in vegetation composition, creating visible trails and erosion

The potential impact on the environment of scientific and tourist activities is mostly dependent on group size, knowledge about most sensitive elements of environment and vulnerability of specific locations.

Conclusions

Human presence in the vicinity of the Petuniabukta is clearly visible in the landscape transformations. Moreover, the number of visitors, which exploring the region, is increasing. The main reasons for popularity of Petuniabukta area are:

- occurrence of natural resource deposits (mainly coal, but also gypsum and oil);
- easy access – ca. 1-2 hours by boat from Longyearbyen (capital of Svalbard);
- abundance of tourist attractions – different type of glaciers (including tidewater glacier Nordenskiöld) and cultural heritage (Pyramiden, Brucebyen);
- features interesting for scientists – different types of glacier, interesting geological formations;
- lack of low protection (i.e. national park or reserves) of the area – it allows to relatively free access of visitors.

Enhancing availability of the Svalbard Archipelago, increasing of spare time and wealth of people lead to growing of numbers of visitors in the Polar areas. The amount of given overnight accommodations in Longyearbyen has increased from 23 854 in 1993 to 83 049 in 2006 (Tourism Statistics for Svalbard, 2006). Moreover, the number of cruises and smaller boat sailing around the Svalbard also increase significantly. The similar tendency is visible in Petunia Bay. In 2005 from July to the half of September Ebba valley was visited by 30 tourists. Whereas only in one month (July 2007) Ebba valley was visited by around 100 people.

Contrary to popular opinion, the environment of the Arctic areas is not virgin and traces of human impact are clearly visible. Future changes in climatic conditions in the Arctic combined with increasing amount of visitor will increase pressure on natural and cultural areas. The circumstances depicted above should be an important

reason for better protection of the environment and monitoring of landscape changes in the Arctic environment.

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