

## **Assumption and realization of Arie catchment measuring system, Spitsbergen**

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### **Introduction**

Geoecosystems of polar areas are particularly sensitive to climate change. The fluctuations of mean annual temperatures of Svalbard areas recorded for many years and progressing glacier recession indicate unequivocally that the Arctic areas strongly react to long-term weather and climate changes. Energy released in the form of proglacial waters contributes considerably to the transformation of the biotic and abiotic systems. However, it is necessary to note that once the polar environment has changed, it is a very hard and long process to restore it to its former state. In this way natural processes accelerate for the next environmental changes (Zwoliński 2007). As suggested by Kostrzewski et al. (2006), of great significance in the terrestrial geoecosystems of the Arctic is the recession of glaciers and the decline of permafrost and snow covers.

The monitoring of the polar environment in the Svalbard area included periodic research in glaciated basins with areas considerably larger than that of the suggested Arie catchment. This means that the glaciated meso- and micro-basins omitted by the researchers may prove particularly important geoindicators of periodic weather changes for the polar zone. The dynamics of energy flow and matter cycle in a small-sized basin differs definitely from that in big catchments.

It is reasonable for balance investigations to use a river basin as the reference spatial unit. In many ar-

reas of the Arctic, glaciated and non-glaciated geoecosystems are basic spatial units in environmental investigations (Kostrzewski, Zwoliński 2003, Kostrzewski et al. 2004).

The measuring system of the glaciated Arie basin has been geared to the needs of the doctoral projects undertaken:

- Operation of the geoecosystem of the glaciated Arie catchment, and
- Impact of superimposed ice on runoff from a glacial catchment.

In the research, the Arie catchment is treated as an independent structure with an autonomous flow of energy and matter reflecting the mechanism of processes operating in the polar zone.

### **Location of the Ariedalen**

The drainage basin of the Arie glacier is located in the proximity of the Hornsund fjord, in the south-western part of West Spitsbergen Island belonging to the Svalbard Archipelago situated in the border zone between the Eurasian and American Arctic (Fig. 1). Glaciers and ice caps cover 36,600 km<sup>2</sup>, or about 61% of the Svalbard Archipelago area (Hagen et al. 2003). Situated at the mouth of the Rev valley, between two massifs, Skoddefjellet and Arieammen, and a short distance from Polish Polar Station, is a parallel firn field of the Ariebeen cirque glacier (Fig. 3). Small cirque glaciers are numerous

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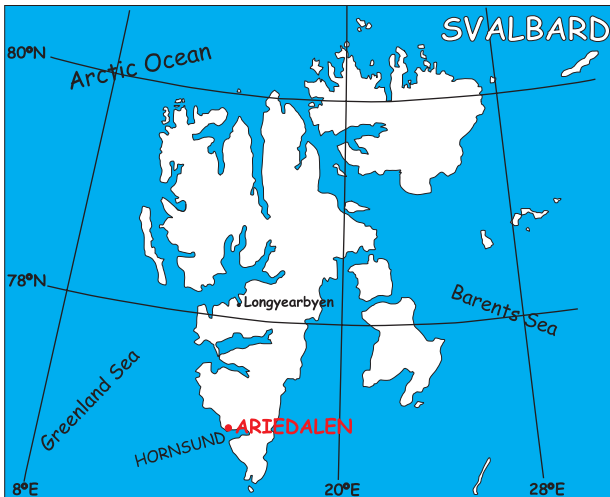


Fig. 1. Location Ariedalen in Svalbard Archipelago

and typical, especially in the alpine mountain regions of western Spitsbergen (Hagen et al. 2003).

The Arie cirque glacier belongs, in thermal terms, to the type of cold body glaciers. Its thickness does not surpass 75 metres, and its area amounts to 0.48 km<sup>2</sup>. Hagen et al. (2003) found that small glaciers ( $A < 10 \text{ km}^2$ ) are often not much more than 100 m thick and, therefore, the main body of those glaciers is cold. This is the case with the Arie area. Below the firn field the glacier surface is steep and narrows towards the valley mouth where the foreland of the glacier has the form of a regularly drained water body. Proglacial streams drain the Arie glacier catchment along channels inside front ice-moraine ridges with relative heights of up to 15 metres. Ice cores are covered by a 1- to 1.8-metre-thick stone ablation moraine layer with big blocks of rock. The marginal zone is drained by an external, high-hanging outwash trail which ends at the exit of the Arie valley with a steep rock bar (Karczewski 1984). A proglacial stream cuts into the bedrock and flows through a gorge creating a distinct alluvial fan on the foreland.

The Ariedalen, according to Pulina's classification (2004), belongs to glaciated basins in a residual stage which include valleys of coastal mountains. In such an area water circulates exclusively in summer, but it stops in the polar winter time entirely. Because of its small area (2.3 km<sup>2</sup>), relief (a valley surrounded by tall rock walls) and the rapid recession of the Arie glacier (0.48 km<sup>2</sup> in area), the Arie drainage basin is a model research field with only a minimal human impact.

## Polar monitoring of the Arie catchment

The organization and implementation of the monitoring of polar geoecosystems should rest on a comprehensive concept of the operation of glaciated and non-glaciated geoecosystems (Zwoliński 2005).



Fig. 2. Monitoring system of Arie basin. Werenskiold-breen Orthophotomap (Kolondra 2002) change by authors

Thus understood, the research procedure can be defined as an integrated monitoring of the natural environment of polar geoecosystems (Kostrzewski et al. 2006).

The Ariebreen terminates on land, with the outlet stream, Arieelva, collecting the whole runoff and flowing out through a lateral moraine. The Arieelva has a closed catchment with only one outflow channel, which offers the possibility of calculating its complete water balance. It is a rare situation in the Hornsund area, and therefore gives the researcher an opportunity for a more precise estimation of water cycle parameters unavailable for other glaciated catchments.

Because of the great diversification of the fluvial system caused by the geomorphological structure of the valley, the Arie catchment was divided into two sub-catchments. Important information about mechanical and chemical denudation is provided by three measuring points (Fig. 2). Samples are taken from them twice a day (AZ) and once a day (AM, AC). In the laboratory of the Polish Polar Station water samples undergo chemical analyses and their content of suspended material is determined. Major

ions are analysed for cations and anions by ion chromatography on a Methrom 761 Compact IC. The temperature, pH and specific electric conductivity are measured in situ near the measuring points.

The water level in the Arieelva is measured with a POLON L-04p/01 automatic gauge at 10-minute intervals. The gauge is situated on an old marine terrace, just upstream of a bifurcation. Actual runoff is calculated with a rating curve, calibrated by tracer methods and current meter measurements. A staff gauge has also been installed at the site to provide independent information about the Arieelva water level. Runoff measurements are also taken in a few locations on the Arieelva between the glacier snout and the automatic gauge.

The elevation of ablation sticks is measured once a week. Fourteen ablation sticks are inserted nine metres deep in the ice (Fig. 2). The data from the ablation sticks provide information about the ablation rate, snow accumulation, and the dynamics of ice flow. Once a month the limits of the glacier are measured with a differential GPS Leica System 1200.

Radon  $^{222}\text{Rn}$  concentrations in the outlet stream are measured once a week. Samples are taken to the laboratory and  $^{222}\text{Rn}$  activity is measured with a liquid scintillator. It provides information about the origin of water - whether it comes directly from precipitation or from the glacier bed, originating from the melting of glacier ice.

A weather station situated on the Ariebreen at an altitude of 400 metres above sea level and another automatic temperature logger on a moraine provide information about temperature, wind, humidity, pressure, and rain. Data from the meteorological station of the Polish Polar Station and weather stations situated on the Hansbreen near ablation sticks number IV (200 metres a.s.l.) and IX (400 metres a.s.l.) are very important for making comparisons.

## Conclusions

In answer to the "Rapid Landscape Change and Human Response in the Arctic" declaration of 17 July 2005 signed in Whitehorse, a systematic integrated monitoring of the Arie catchment has been set up. A correct identification of the natural processes in polar geoecosystems and determination of corresponding geoindicators will provide a basis for an estimate of the condition of and direction of change in selected High Arctic areas. In the light of the anticipated climate change, it will be important to gain a better understanding of the effect of refreezing of meltwater in snow and firn, and the extent and amount of superimposed ice formation

(Hagen et al. 2003). The research undertaken by the authors in the glaciated Arie catchment will fill a scientific niche and allow comparing the glaciated areas of Svalbard as to energy change in the context of climate change.

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