Pollen- and Non Pollen Palynomorphs- Analyses from Svalbard

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Abstract

We analysed fifteen samples of a shallow profile "Sverrefjellet Volcano ", located in the NW part of Svalbard – Bockfjord region (*see* Fig.1). Frequency of pollen grains, spores and NPP (Non Pollen Palynomorphs) was quite low. Only the local taxa (*e.g. Salix* and Cyperaceae) produced pollen in greater abundance. The pollen spectrum was considerably varied, although pollen grains and spores of most taxa were present in low abundances. This was due to low pollen and spores productivity of the Arctic flora, which propagates mostly in a vegetative way. To obtain as much information from the profile under study as possible, we analysed the non- pollen palynomorphs as well. We succeeded above all in determination of eggs, buccal tubes and claws of the Tardigrada phylum (Jankovská 1991). The determination has been recently verified by specialists in the field, prof. L. Kaczmarek and dr. M. Roszkowska (in Jankovská et al. 2016). The results of the pollen- and NPP analysis are presented in pollen- and NPP diagram, which represents a picture of the species-poor Arctic flora.

Key words: Palaeoecological analysis, vegetation and climate history, Tardigrada, Bockfjord, Svalbard.

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Introduction and previous palaeoecological research

In 1988, several specialists of various scientific fields (bryologist, lichenologist, hydrologist, palaeoecologist, geologist and phycologists) and also a cameraman, film director and journalist maintained a short expedition to Svalbard (*see* Fig. 2: Expedition Svalbard 1988 (a-c), Expedition Svalbard 1988 retro (d-f). The aim of this expedition was to estimate future research possibilities in this arctic region. The future pollen analytical research was planned to shed new light on the palaeoecological re-

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constructions for the Central Europe during the Late Pleistocene. Previous palaeoecological surveys was made, with the few exception, mainly for the studies, publicated at about to the half of 90 years of the past century.

One of the first palaeoecologists to do a research in Svalbard was Środoń (1960). He studied the long-distance pollen and spore transport. His research was analogical to those of Kuprianova (1951) who did research in the other regions of the High Arctic (Franz-Josef Land, Severnaya and Novaya Zemlya). Age of the 60 cm deep profile analysed by Środoń (1960) was estimated to 1390 ± 70 uncal. BP (Blake et al. 1965).

Fig. 1. Svalbard - area under study.

The first pollen analyses of lake sediments were presented by Häggblom (1963) and then later by Hyvärinen (1968) who analysed pollen and diatoms in the profiles from the Bjørnøva Island. He also reconstructed the history of the Lake Trulvatnet in Nordauslandet, based on the pollen-analytical studies (Hyvärinen 1969). Together, Hyvärinen analysed five lake sediments profiles from the Bjørnøya Island and Nordauslandet, which represented the last 10,000 years of the regional history (Hyvärinen 1970). He focused on the studies of the problematic pollen types and reconstructions of climatic changes as well (Hyvärinen 1972). His results are thoroughly discussed by Tobolski (1975).

Another step in the palaeoreconstruction of the vegetation and climatic changes was brought about by Zelikson (1971) who analysed a 170 cm deep profile of the Semmeldalen valley. The profile was radiocarbon-dated to 2800 – 1900 uncal. BP.

It is important to note the less-known results of the palaeoecological and vegetation research from the High Arctic regions of the Russian (past Soviet) territory (Kildyushevsky 1955, Krenke et Fedorova 1961, Kudryashov 1925, Sokolovskaya 1958, Tikhomirov 1950, Yuryev 1925). Serebryanny et al. (1984) presented a detailed study of the origin and development of peat-bogs at high geographical latitudes. Surova et al. (1982, 1986) also studied the pollen analysis of the Svalbard region, and she analysed a 250 cm deep profile from Colesdalen (Surova et al. 1988). The main part of this profile originated in the Middle Sub-Boreal (between 4300 – 3400 uncal. BP).

Thanks to the meticulous glaciological and other research activities of the Russian researchers in the past, a nearly 700-cm deep profile from Grøndalen was found. Various analyses were performed (pollen, macroremains, fluvial, lake and marine sediments, solifluction). The changes in the past vegetation cover and climatic conditions were reconstructed from the end of the Late Glacial to the Sub-Atlantic period (Serebryanny et al. 1993).

Remarkable part of the palaeogeobotanical research of the Holocene sediments in Svalbard is represented by works of Knaap (1985, 1986, 1987, 1988 a, b, c, 1989, 1990, 1991; et al. 1989). Typical problems of the palaeoecological research and analysis of the sediments originating in the High Arctic regions inspired this author to utilize unorthodox materials for analysis and original ways to interpret the results. Knaap did research in various places of Svalbard, *e.g.* Smeerenburg, Brøggerhalvøya Island,

Fig. 2. a-c: Expedition „Svalbard 1988" (Photo: P.Volf), **d-f:** Expedition „Svalbard 1988 - retro" (Photo: V. Jankovská).

Meodden and Agardhdalen, Rosenbergdalen, Sassendalen and Adventdalen and other localities (closer information in Jankovská 1994).

Birks (1991) studied macroremains in lake sediments taken from the surroundings of the Lake Skardfjørna (region of Isfjord Radio and Linné Lake). Johansenet et Hafsten (1986) published a study from the Ny-Ålesund locality, focused of the airborne pollen and spores. Results of palaeoethnobotanical research publicated Pals (1987) from the locality Smeerenburk.

Some part of the Svalbard research still stays unpublished, *e.g.* the pollen analyses and NPP analyses of the shallow profiles (30 cm and 70 cm) taken at the foothill of the Vardeborg ridge in Linnédalen and Bockfjord (as mentioned in Jankovská 1994) as well as profiles from the Revdalen *etc.* (Knaap et al. – unpubl.).

In 2007 Dorozhkina published the results of her pollen analyses of the Fuglechuken cape (78° 89´ N, 10°47´ E).

The analysed profile was 295-cm deep and originated in a uncovered shore. Pollen analysis spanned the periods of AT1, AT2, SB1a SB2 (Radiocarbon data: 5500±50 uncal. BP, 4670±45 uncal. BP, 4370±40 uncal. BP).

Methods: field and laboratory works

For palaeoecological research, we collected a 60 cm deep profile from an open terrain pit at the foot (10 m a.s.l.) of the Sverrefjelet Volcano – (507 m a.s.l., NW part of Svalbard, Bockfjorden region: 79° 25´ N; 13° 25´ E) (*see* Fig. 3). All 15 samples of this shallow profile consisted of a mixture of mainly volcanic ash and fine detritus. There were, unfortunately, no macro-remains suitable for radiocarbon dating. The important part of the field work was also observation of the vegetation in these climatically extreme and demanding conditions. We studied here the different conditions of changes in terrain, hydrology, amount of sunlight, nearness of permafrost, influence of erosion and fauna in this environment of High Arctic landscape. The aim of this observation was to specify palaeoecological interpretation of pollen analytical results from the sediments of glacial age originating from Central Europe.

Fig. 3. a: Localization of our profile (Photo: T. Sassvari), **b:** Sampling from open pit (Photo: P. Volf).

In the laboratory samples were prepared for pollen and NPP analysis with treatment in various chemical substances. Since the majority of the sample material was of a volcanic origin, this was treated at first by hydrofluorid acid. Cellulose was eliminated by standart acetolysis method (Moore et al. 1991, Erdtman 1960). Objects remained in the final preparated samples, had either a resistant wall of sporopolenin (pollen, spores, algae), chitin or like substances (Tardigrada, Rotifera, Rhizopoda). All palynomorphs were identified and quantified, each sample on several slides because of their low frequency of occurrence. Pollen identification follow Moore et al. 1991, Erdtman et al. 1963 and using comparing pollen slides collection. The results are summarised in the pollen and NPP diagram platted using program Tilia-Graph (Grimm 1991). The basic calculation is determined by the sum 100% = arboreal pollen (trees and shrubs = AP) + non-arboreal pollen (herbs = NAP). Quantities of other objects (Pteridophyta, Bryophyta, Tardigrada, Rhizopoda, Rotifera *etc.*) are related to this sum. The publications of Rønning (1979) and Porsild (1964) were used for identification of Svalbard flora.

Results of the pollen and NPP analyses of the Sverrefjellet Volcano profile (*see* Fig. 4. – pollen diagram)

Part of the pollen diagram (pollen grains and spores) represents a species-poor Arctic flora. Most abundant pollen grains in the AP sum (arboreal pollen) are the grains of autochtonous shrub willows, mainly *Salix polaris* and also *S. reticulata.* Sparse occurrence of *Betula*, *Alnus*, *Picea* and *Pinus* pollen is a result of the long-distance pollen transport from the continental part of Europe and Asia.

The pollen grains of Cyperaceae dominated the NAP (Non Arboreal Pollen) part of the pollen spectrum. Most of them can be determined as pollen of *Eriophorum scheuchzeri.* Presence of pollen of other herb species was determined mainly by occurrence of mother plants *in situ* or nearby, such as *Saxifraga* sp. div., *Dryas octopetalla*, *Oxyria digyna*, *Polygonum viviparum,* Cruciferae and Caryophylaceae.

At the bottom of the profile, isolated pollen grains of *Centaurea cyanus*, Cerealia-*Triticum* type and *Scleranthus annuus* were found. These taxa (allochtonous for Svalbard – Liška et Soldán 2004) were used as indicators for a rough estimation of the profile's age, as they might have been transported to Svalbard into the Backfjord region with cereals, hay or straw, most probably by fishermen or whalers around the 16th or 17th century. These pollen taxa were the sole source of information on the age of the profile, since we found no other object suitable for radiocarbon dating in the volcano ash and fine detritus of the profile.

The obtained pollen spectrum was considerably varied, even though most taxa were present in lower abundances. This was due to the low pollen productivity of the Arctic flora. Lot of Arctic plants propagate mostly in a vegetative way (*e.g. Poa alpigena*, *Polygonum viviparum*, *Saxifraga cernua* and others), *see* Rønning 1979, Porsild 1964.

Quite abundant were the spores of Bryales. A special category in the NPP was represented by remarkable objects, later determined as remains of the minuscule Tardigrada (eggs, bucal tubes, claws). This determination was later verified by the specialist (L. Kaczmarek and M. Roszkowska).

Studying fossil remains of Tardigrada in sediments is still in its beginning. Findings of Tardigrada from the Svalbard and their identification could work as a poke to other pollen analysts to give more attention to these non-pollen objects. So far, we can venture to infer basic information on Tardigrada's ecology and distribution.

For example, *Paramacrobiotus richtersi* group is probably restricted to the Paleo- or Holarctic regions. The same is partly true for *Macrobiotus peterseni* (Maucci 1991).

Richtersius coronifer (Richters 1903) is frequent in the present time in the Arctic, sub-Arctic and partly in mountain regions. This taxon is strongly associated with carbonate bedrock. In contrast, we consider *Macrobiotus hufelandi* group to be cosmopolitan. For palaeoecological reconstruction of the past environments, findings of this taxa have quite low informational value.

Dactylobiotus ambiguus (Murray 1907) is a typical lacustrine or hydrophilous, and in general Boreal- mountain taxon. More information in Jankovská et al. (2016).

If more palaeoecologist tried to identify Tardigrada and draw conclusions from the findings, it could bring another piece of information to the mosaic of palaeoreconstructions and be of value for to-date zoology as well.

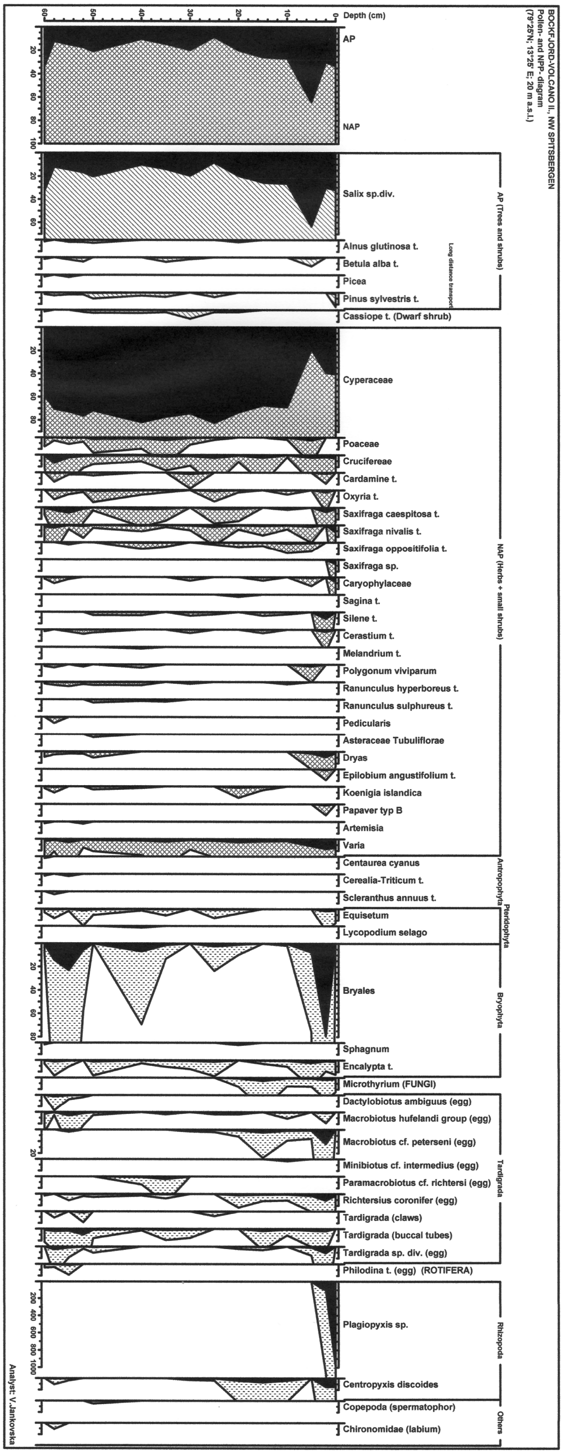

Fig. 4. Pollen and non-pollen palynomorphs diagram Sverrefjellet Volcano.

Discussion

The results of the pollen and NPP analysis of the Sverrefjellet Volcano profile (NW part of Svalbard-Bockfjorden region) make another contribution to the palaeoecological research of Svalbard, despite the profile being relatively shallow (60 cm) and only 15 analysed samples. The pollen analysis gives a picture of the species-poor Arctic vegetation. The majority of the pollen production represents the local taxa (*Salix*, Cyperaceae – especially *Eriophorum scheuchzeri*). The other scarcely recorded pollen taxa mainly proove the presence of the plant species, such as *Dryas octopetala*, *Königia islandica*, *Cassiope tetragona*, *Polygonum viviparum*, *Pedicularis* sp., *Papaver dahlianum* and other species of families Saxifragaceae, Cruciferae, Caryophylaceae. These plant species occur regularly near the profile.

The sporadic pollen grains of trees and shrubs (*Alnus glutinosa* type, *Betula alba* type, *Picea* and *Pinus sylvestris* type) have an unambiguous origin in the long-distance pollen transport. Dorozhkina (2007) claims a relatively high abundace of *Pinus haploxylon* type pollen grains (*e.g. Pinus sibirica*) and *P. diploxylon* type pollen grains (*e.g. P. sylvestris*) in a 293 cm deep profile (AT1 – SB2). There is a chance that in the Middle Holocene, the long-distance pollen transport was more intense. The area occupied by these tree- and shrub species reached further north in Europe as well as in Siberia during the climatic optimum in the Holocene.

Surova et al. (1988) analyzed pollen in a 250 cm deep profile (Kolsdalen) and suggested a palaeoreconstruction of the climatic changes. “Phase 1” was characterized as a period with high snow precipitation, inferred by higher amount of *Salix* in the analysed pollen samples. In “Phase 2”, the steep increase in amount of *Betula nana* and *Rubus chamaemorus* pollen and *Sphagnum* spores is interpreted as warming and melting of glaciers. “Phase 3” has brought decrease in the amount of *Betula nana* and *Salix* pollen and increase in the Poaceae and Cyperaceae, which is interpreted as climatic cooling. In “Phase 4” there is again a notable increase in pollen of *Salix*, *Betula nana,* various herbs and pollen grains subject to the long-distance pollen transport, which is interpreted as another warming. According to the above-mentioned facts, Surova et al. (1988) have divided the Subboreal period into three phases of climatic cooling and one of climatic warming. These phases were synchronized with the phases of growth and receding of the Svalbard glaciers.

In our 60 cm deep profile, it is not possible to separate the changes of the vegetation conditioned by climatic changes clearly and reliably. Even though the representation of *Salix* pollen increases approximately from the middle of the profile upwards, it cannot convincingly prove the climatic cooling. The climatic cooling could be confirmed by more analysed profiles. The interpretation of the occurrence of *Centaurea cyanus*, Cerealia – *Triticum* type and *Scleranthus annuus* pollen remains similarly ambiguous. These indicators of human activity might have been transported into the studied region with some plant material (hay, straw, grain) brought by whalers and fishermen around the 16th and 17th century. During these times, the area around the foothills of the former volcano Sverrefjellet was climatically favourable. There were hot springs and the water created cascades of calcareous crusts. In the 1988, even in these high-arctic area, the water temperature in adjacent pools was 16°C. It is important to study how the actual climate changes influence this geologically and climatically specific region.

Because of the low occurrence of pollen in the analysed samples, we focused on the Non-Pollen Palynomorphs as well. There were noticeable structures of characteristic form and with specific protrusions that were tentatively specified as belonging to the Tardigrada (eggs, buccal tubes). These were studied in detail and determined by specialists (L. Kaczmarek, M. Roszkowska). Some eggs of Tardigrada were later found by pollen analysis of the Central European regions, however, these were rather sparse and relatively young findings. This may mean, that the Tardigrada eggs in the older layers of sediment from climatically auspicious Europe are prone to decay and therefore can be found only in the younger layers. Then we might ask, why so many intact Tardigrada eggs were found in the sediment of an Arctic region. The preservation could be enhanced by climatic coolness and occurrence of permafrost. Or it could mean, that these hardy and resilient animals have preferred the Arctic and Antarctic regions to the temperate zones?

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