PALAEOECOLOGICAL RESEARCH ON THE LATE-GLACIAL AND HOLOCENE SEDIMENTS IN SVALBARD (RESULTS AND PERSPECTIVES)

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SUMMARY

In order to inform specialists from other branches engaged in the research on the nature of Svalbard (Spitsbergen), a survey of the existing palaeoecological studies done in this archipelago was prepared. The paper presents the results obtained and their utilization in further research on living and non-living nature of Svalbard. Preliminary results of the palaeoecological research of the author are briefly reported. The information is intended for specialists from the ranks of natural scientists who are occupied with the research on Arctic regions.

KEY WORDS

Svalbard - Arctic regions - palaeoecology - pollen and macroremains analyses - Late-Glacial and Holocene

INTRODUCTION

The scientific research in Arctic regions contributes to the solution of principal problems in many fields which are concerned to the study of individual components of nature. Glaciologists, geomorphologists, hydrologists, climatologists, speleologists, and other specialists may study the processes there and observe the phenomena which ran in Europe during the Glacial periods. Geologists and palaeontologists observe subjects of their interest easily there because the land is without vegetation cover. For biologists, the Arctic regions are a source for answers to the most fundamental questions associated with the life of plants and animals.

The center of interest of European scientists in the research on the Arctic have become, above all, Svalbard. It was possible due a relatively easy availability of these Arctic islands. The international scientific research has developed in Svalbard because of that it is under Norwegian administration. Until recently, the majority of Arctic regions north of Europe and Asia was closed for other than Soviet scientists.

Palaeogeobotanists participated in the research on Svalbard, as well. They were concerned to pollen analyses of lake and semiterrestrial sediments mostly of the Holocene age.

A SURVEY OF PALAEOBOTANICAL RESEARCHES IN SVALBARD

The main aim of palaeobotanical, mostly pollen-analytical, studies is to obtain basic data for the reconstruction of the development of vegetation cover. At the pollen analyses of sediments from Svalbard and other regions of the Arctic, a number of problems appeared soon which complicated the realisation of this our main aim. It was difficult to find a sediment in which pollen grains were conserved. As far as such a sediment was found, its thickness was mostly small and thus its age was low. A small amount of pollen grains up to their absence in the sediments of Arctic regions is caused mostly by lower pollen production in the majority of Arctic plants and as well as by sporadic vegetation cover. Some plant species produce nearly no pollen because as they mostly reproduce vegetatively under unfavourable climatic conditions. Problems appeared concerning determination of palaeobotanical finds and interpretation of results. First it was necessary to develop new methodological approaches.

In 1957, Środoń (1960) studied the long-distance pollen and spore transport in Svalbard. He proved that these microscopic objects are transported to distance of hundreds and thousands kilometres. Both the previous pollen-analytical observations and results (Kuprianova, 1951) from Franz-Josef Land, Severnaya Zemlya and Novaya Zemlya demonstrated that in Arctic regions the long-distance pollen transport asserted in the pollen spectrum the more intensively the more northwards the locality under study was situated. The pollen frequency of local vegetation in the pollen spectrum decreases with increasing geographical latitude as a result of sporadic vegetation cover. The pollen production of Arctic plants is low, also. The research from the territory of the High Arctic contributed to precision of pollen-analytical interpretations for the reconstruction of Glacial and Late-Glacial vegetation conditions not only in this region but also in Europe. Środoń (1960) studied the relation between the composition of vegetation cover and present-day pollen spectrum determined in eleven localities. Furthermore, he carried out the pollen analysis of a 60 cm thick profile from Hornsund (Rålstranda) region whose basal sample was aged 1390 ± 70 years (Blake et al., 1965). The first notes on the finds of pollen grains in the lake deposits of Svalbard in Nordaustlandet were published by Häggblom (1963). The results of pollen- and Diatomae analyses from the lake sediment profiles of Bjørnøya Island were reported by Hyvärinen (1968). The same author (Hyvärinen, 1969) reconstructed the history of Lake Trulvatnet in Nordaustlandet on the basis of pollen-analytical studies and determined the phases of marine, lagoon, and lake sedimentations. Hyvärinen (1970) evaluated the results of pollen analyses from five lake sediment bores in Bjørnøya Island, Spitsbergen, and Nordaustlandet. The profiles under study represented the last 10,000 years. The palaeobotanical analyses were focused on the solution of stratigraphic questions in connection to glaciological problems. In addition, the author was concerned to the problems of long-distance pollen transport and determination of some difficult pollen types. The results of his research (Hyvärinen, 1968, 1969, 1970) are discussed by Tobolski (1975). On the basis of pollen-analytical data, Hyvärinen (1972) reconstructed also climatic changes.

The thickness of sediments which may be used for pollen analyses is mostly small in the High Arctic regions and usually amounts to 30-60 cm. Organic sediments of greater thickness were found only rarely by scientists with long-term experience in the field under study. A peat-bog profile of 170 cm thickness was taken by a Soviet glaciological expedition in Semmeldalen. The samples evaluated by Zelikson (1971) were completed with radiocarbon data (2800-1900 B.P.). The results were used for pollen-analytical reconstruction of the development of vegetation cover in the locality under study and wider surroundings. Zelikson (1971) tried to do a reconstruction of climatic

fluctuation. It was used mostly for glaciological researches. The results of palaeoecological and geobotanical research in the High Arctic regions of the Soviet territory were also evaluated. Thus often unknown or inaccessible results of Soviet scientists (Kildyuschevsky, 1955; Krenke, Fedorova, 1961; Kudryashov, 1925; Kuprianova, 1951; Sokolovskaya, 1958; Tichomirov, 1950; Yuryev, 1925) were compiled here. On the basis of palaeogeobotanical research in the High Arctic region, Serebryanny et al. (1984) reconstructed the development of vegetation at these high geographical latitudes. They presented a detailed solution of the problems of the origin and development of peat-bog formation in the High Arctic regions. In addition, the authors attempted for palaeoclimatological reconstruction. In the profile from Semmeldalen sedimentation started at the beginning of the Sub-Boreal. They determined several warm phases of different terms. For this purpose, *Bryophyta,* which formed the sediment, were used above all. *Sphagnum rubellum* and, partially, *Palludella squarrosa* are considered as indicators of a relatively warm climate. The authors evaluated an increase in *Salix* pollen values as well as more frequent finds of *Lycopodium selago* spores, as an evidence of increasing solid precipitation in winter. The finds of *Bryophyta* in the profile were also used for a detailed reconstruction of trophic and hydrological conditions of the bogs under study during the past millennia. The occurrence of trophically more demanding plants is associated with warming of climate. The temperature rise was responsible for increased deposition of mineral material on the peat-bog area. Thus trophical enrichment of some biotopes appeared. The results of pollen analyses of the Soviet specialists are interpreted especially for the use in glaciological research. Palaeobotanical studies were performed for this purpose not only in Semmeldalen but also in Adventdalen, Reindalen, and Colesdalen (Zelikson, 1971; Serebryanny et al., 1984; Surova et al., 1982, 1986). The thickness of a palaeogeobotanically evaluated profile from Colesdalen was 250 cm (Surova et al., 1988). The results of pollen and macroremains analyses were used for the reconstruction of palaeoclimatic conditions in the Arctic. It was found that the main part of sediment originated in the middle of the Sub-Boreal between 4300-3400 B.P. Climatic changes, which was determined on the basis of palaeobotanical finds in the Sub-Boreal, is synchronous with the decline or, in the contrary, with the accumulation of Svalbard glaciers.

The new results of palaeobotanical analyses of a nearly seven metres thick profile from Grøndalen (Serebryanny et al., 1993) have a great value. Pollen- and macroremains analyses completed with radiocarbon data were performed in the materials of fluvial, solifluction, lacustrine, paludine and marine sediments. The data obtained were used complexly for the reconstruction of vegetation and climatic conditions from the end of the Late-Glacial to the Sub-Atlantic. Special attention was paid to the indication value of determined *Bryophyta.* The main stages of environmental development were correlated in Svalbard, Faroe Islands, Shetland Islands, East Greenland and Novaya Zemlya.

A conspicuous period in the palaeogeobotanical research on Holocene sediments in Svalbard is represented by the studies of Knaap (1985, 1986, 1987, 1988a,b,c, 1990, 1991). The investigations of this Dutch palaeobotanist showed how to use considerably limited possibilities in the High Arctic regions. The complex of difficulties forced him to use non-traditional materials and led to a resourcefulness in the interpretation of the results obtained. New problems were revealed and answers to them were found. The author documented that even profiles of small thickness may be a source of interesting information not only for palaeobotanists but also for specialists in other branches. The study of the relation between the composition of the present-day vegetation cover is a contribution to the precision of interpretations of pollen analyses from high geographical latitudes (Knaap, 1990). Knaap (1985) used pollen analyses on the locality Smeerenburg (Amsterdamøya Island, NW Spitsbergen), where a contemporary settlement of Dutch whalers was in the first half of the 17th

century, to obtain information about the human impact on Arctic vegetation. The author found an increase of nutrients in the soils during the settlement phase and reconstructed climatic changes since 1600. In the pollen spectrum from the sediment, that was formed during the existence of the settlement, he recorded a great number of pollen grains of plants which were not native in the flora of Svalbard. It was the plant material introduced here by Dutch whalers with food for people and domestic animals and with other products of plant origin (see macroremains analyses - Pals, 1987).

Knaap (1988a) elaborated an one metre thick profile from the region of Brøggerhalvøya Island (near Ny-Ålesund, NW Spitsbergen). Local changes in vegetation and natural environment were reconstructed from the results of pollen analyses, lithology and chronology. The results were completed with radiocarbon data (ca. 4400 - ca. 800 B.P.). On the localities Meodden (Edge Island) and Agardhdalen (NW Spitsbergen), Knaap (1988b) used the sediment of the so-called skua-mounds (peat elevations forming in a flat tundra on sites used by *Stercorarius parasiticus* to observe its nest territory) for his palaeobotanical research.

The growth of vegetation was accelerated under the influence of increased nutrients and thus a larger amount of biomass was accumulated here in the comparison of surrounding tundra. During years the skua-mounds began to elevate above the surface of the tundra. Knaap (1988b) defined the skua-mounds as "guanogen peat- bogs" because their origin and further existence was directly dependent on bird manuring. He found that humolite production of these formations started as early as several thousands years ago. The vegetation changed in dependence on manuring intensity, i.e. the presence or absence of birds. Therefore, on the basis of pollen analyses, several phases of stagnation in the development of vegetation cover and sediment formation were estimated in these guanogen peat-bogs. The pollen-analytical results were used similarly as from classic peat sediments. In addition, Knaap (1988c) evaluated pollen-analytically the humolite formed below bird cliffs and compared these results with the conclusions of pollen analyses of the skua-mounds. The author estimated the age and reconstructed the vegetation stability of these formations which were influenced by birds. He concluded, that the vegetation and humolite formation below bird cliffs were more stable than in the skua-mounds. It can be explained by the fact that bird cliffs are a larger ecosystem which does not change under the influence of environmental changes so rapidly as a small ecosystem of the skua-mounds. The estimated age of the sediment studied below the bird cliffs on the locality of Søre Salatberget (Amsterdamøya Island, NW Spitsbergen) was about 500 years. The bird cliffs are at least of the same age. The age of the skua-mounds, whose origin was caused by solitary birds, was estimated up to 4500 years.

The investigations of the animal kingdom is also associated with the results of the pollen analyses of subfossil excrements of reindeer (*Rangifer tarandus* L.) as related to the pollen-analytical evaluation of the sediment in which these finds originate (Knaap, 1986, 1989). The question of the immigration time of reindeer to Svalbard was investigated. The pollen-analytical results documented the presence of reindeer in the islands as early as 5000 B.P. After the evaluation of all palaeobotanical date, author concluded that reindeer (*Rangifer tarandus* L. ssp. *platyrhynchus* Vrolik) immigrated to Edge Island (and to Svalbard) approximately between 6700 B.P. and 5000 B.P. The finds of subfossil excrements of reindeer from Rosenbergdalen, Sassendalen, and Adventdalen suggest that its occurrence was continuous from the time of its immigration. Knaap (1989) agrees with the opinion of Hakala et al. (1985) that Svalbard reindeer immigrated to the islands from Greenland and not from Europa or Asia. It is, consequently, an opposite opinion than that which is reported in the Soviet literature. Knaap (1987) evaluated individual finds of pollen and spores from Svalbard and Jan Mayen Island originating from the long-distance transport. The study specifies interpretations of

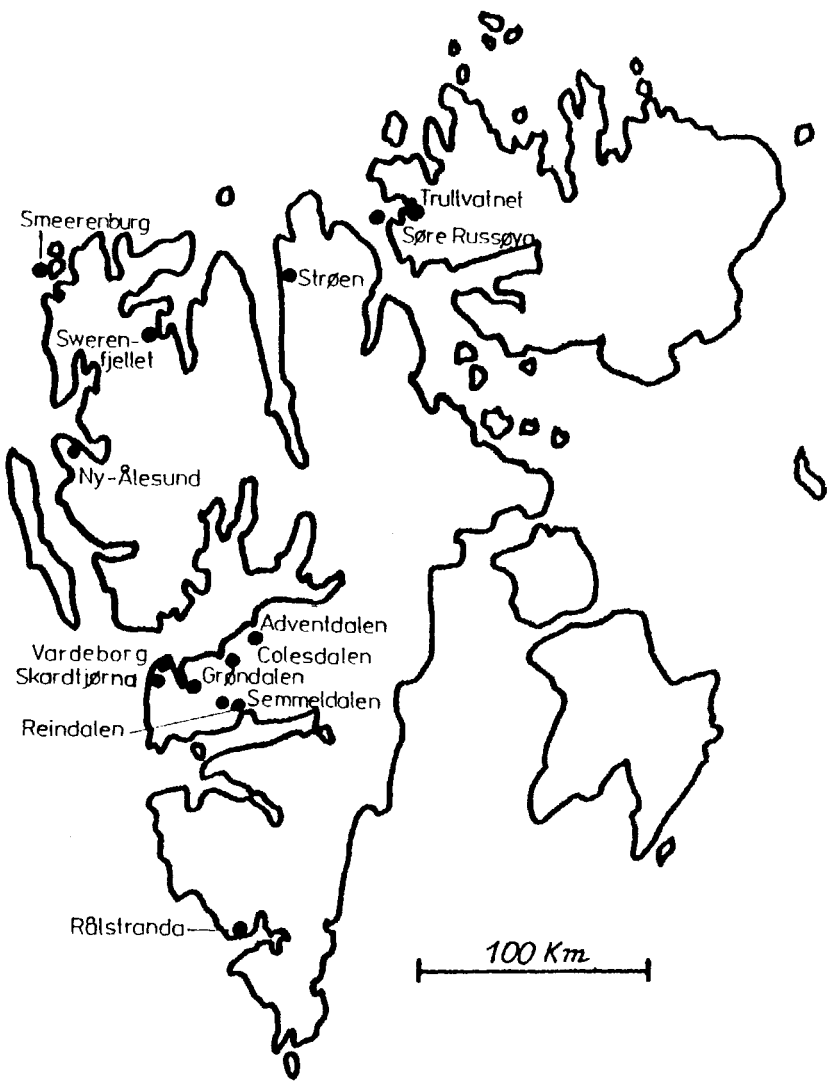

Fig. 1. Schematic map indicating the position of all localities examinated from palaeobotanical point of view (with the exception van der Knaap's studies): Smeerenburg (Pals, 1987); Strøn, Trullvatnet, Søre Russøya (Hyvärinen, 1969, 1970, 1972); Swerenfjellet (Jankovská and Knaap van der, msc.); Adventdalen, Colesdalen, Semmeldalen, Reindalen (Zelikson, 1971; Serebryanny et al., 1984; Surova et al., 1982, 1986, 1988); Grøndalen (Serebryanny et al., 1993); Rålstranda (Środoń, 1960); Vardeborgsletta (Jankovská and Knaap van der, msc.); Skardtjørna (Birks, 1991); Ny-Ålesund (Johansen and Hafsten, 1988)

pollen spectra from high geographical latitudes with a view to palaeogeobotany and palaeoclimatology. The existence of a 7,500-year-old find the lichen *Peltigera aphtosa* from Edge-Island was confirmed by palaeobotanical researches and radiocarbon dating (Knaap et al., 1989). Considering the composition of the pollen spectra from the 3rd to the 13th centuries, Knaap (1991) estimated the rate of humolite formation and reconstructed the development of local vegetation.

The study of Birks (1991) is an important contribution to the palaeoecological research on Svalbard. The development of vegetation cover and climatic changes in the surroundings of Lake Skardtjørna (Isfjord Radio and Linné Lake region) was reconstructed on the basis of very precise determinations of plant remains from the lake sediments of Holocene age.

Three profiles were taken by the author of the present paper (30 to 70 cm thick) in the region of Isfjord in Linnédalen (Spitsbergen) at the foothill of the Vardeborg ridge in 1988. Other three profiles (30 to 75 cm thick) were collected in the north of Spitsbergen at Bockfjord. The purpose of this pollen-analytical research was to assess how the vegetation formation of Arctic tundra were reflected in the pollen spectrum separated from the sediments of Arctic regions. The recorded spectrum from Svalbard had some features like a pollen spectrum from oldest phases of the Late Glacial of Central Europe. The final interpretation of the palaeoecological results from the localities of Vardeborg and Bockfjord will be performed together with Dr. W.O. van der Knaap from Utrecht University.

A contribution of our pollen analyses from Svalbard (Vardeborg and Bockfjord) is the determination of microscopical objects unknown up to that time. They occurred regularly also in the sediment from other Arctic region - Devon Island in Arctic Canada (Jankovská, Bliss, 1972, 1977). These finds were determined as eggs of different species of the genus *Macrobiotus* from the animal tribe *Tardigrada* in the material from Svalbard (Jankovská, 1991). These objects were ignored by pollenanalysts up to that time. It was not clear whether they belong either to the animal or plant kingdom. These originally unexpected results enable to study the palaeoecology of *Tardigrada* and, simultaneously, they reduce a number of unknown objects which are found in pollen slides. Other objects undeterminated up to now were regularly found in pollen slides from both Svalbard and Devon Island. They were also recorded in Late Glacial sediments of Central Europe. Thus these objects, although they were not identified up to now, could be used for palaeoecological reconstruction as possible indicators of Sub-Arctic to Arctic conditions.

The study reported by Johansen and Hafsten (1986) performed at Ny-Ålesund is indirectly associated with palaeoecological research on Svalbard. The authors were engaged in airborne pollen and spore registrations. It can be of good use for palaeoecology, too.

The map of Svalbard (Figs. 1, 2) shows that a number of palaeobotanically, in particular, palynologically evaluated localities is relatively high. Nevertheless, it is quite insufficient because just the problems for which pollen analyses were originally carried out, have not been solved on the majority of localities. As far as I can speak about perspectives of palaeoecological research on Svalbard on behalf of myself, I can only recommend its continuation. This research should be, however, coordinated and concrete question should be ask to pollen-analytical research. A short time, for which the absolute majority of pollen-analysts worked in Svalbard, is not sufficient for finding suitable sediments. In addition, the absolute majority of palaeobotanists had not time enough to get acquainted thoroughly with these vegetation and other natural conditions of these Arctic islands.

Fig. 2. Schematic map indicating the position of localities pollen-analytically examinated by van der Knaap (see references in this paper)

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