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STUDIES OF PALSAS IN FINLAND, NORWAY AND SWEDEN, 1964—1966

This report is intended to give a review of recent investigations concerning palsas in Scandinavia. Since a summary on this subject covering the years 1960—1963 already exists (Rapp and Rudberg, 1963) the review has been restricted to the years 1964—1966.

GENERAL DESCRIPTION OF PALSAS

Palsas seem to be the most obvious signs of sporadic permafrost. They are structures of very different shapes, containing a core of permafrost. The simplest shape is that of a more or less circular mound, which occurs separated from other mounds (Pl. 1). Another type is the isolated and fairly straight ridge, usually lower than the mounds (Pl. 2) and yet another type is the winding ridge, which is connected with other ridges, so that an anastomosing system of ridges is formed (Pl. 3).

The sizes of the palsas are just as variable as their shapes. While their widths are fairly constant, with values between 10 m and 30 m, their lengths differ very much but usually vary between 15 m and 150 m. The heights of the palsas are also very divergent and values of less than 1 m up to 7 m have been observed.

The formation and existence of the palsas are usually ascribed to low temperatures in connection with a thin snow cover in winter. Some investigators also consider an abundant supply of ground water to be necessary. These conditions restrict the distribution of palsas in Scandinavia to the northernmost parts of Finland, Norway and Sweden, and here they occur in depressions, especially in those with bogs.

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DIFFERENT TYPES OF STUDIES OF PALSAS

Although palsas were observed in northern Scandinavia as early as the beginning of this century, no detailed studies, with a few exceptions, were carried out before the sixties. During the last few years a couple of detailed investigations have been started along different lines. Almost all of them involve structural studies, combined with climatological, geohydrological, botanical and other studies.

THE STRUCTURE OF PALSAS

In order to understand and explain the processes responsible for palsa formation and the preservation of existing palsas, as well as to understand and explain their destruction, it is necessary to know their structure very well.

On the basis of the material in the frozen cores of the palsas, they can be devided into two categories. One category comprises palsas with cores mainly of frozen mineral soil. The other consists of palsas with the greater part of the cores built up of frozen peat.

Minerogenic palsas have been reported from different parts of Scandinavia. Fries (1964) investigated a 4.5 m high palsa in Laivadalen, Swedish Lapland (Fig. 1; all places mentioned in the future are shown in Fig. 1). By making a cutting on one side of the palsa, a layer of peat 1.5—2 m thick was found to be underlain by frozen clay or silt. In the mineral soil the ice-lenses are conform with the upward—convex boundary between the mineral soil and the peat above. Since the peat in the surrounding bog has the same thickness as on the palsa, most of the elevation of the palsa is ascribed to frost-heaving in the mineral soil.

Fries' investigation in Laivadalen was continued by Wramner (1965), who also examined palsas in Taavavuoma. These studies were performed on eroded sides of palsas or in cuttings made with an ice-pick. In all, about 50 palsas were examined and all of them had cores of mineral soil consisting of silt or fine silt (0.062—0.02 or 0.02—0.002 mm respectively). The vaulting of the palsas above the surface of the bog is due to a corresponding vaulting of the surface of the mineral soil. In the mineral soil ice-lenses often as thick as 10—15 cm, were observed. In most cases a thick ice-layer was observed at the boundary between the peat and the mineral soil. Thinner ice-layers exist in the frozen peat, their regularity and conformity with the vaulted surface of the palsa growing with depth.

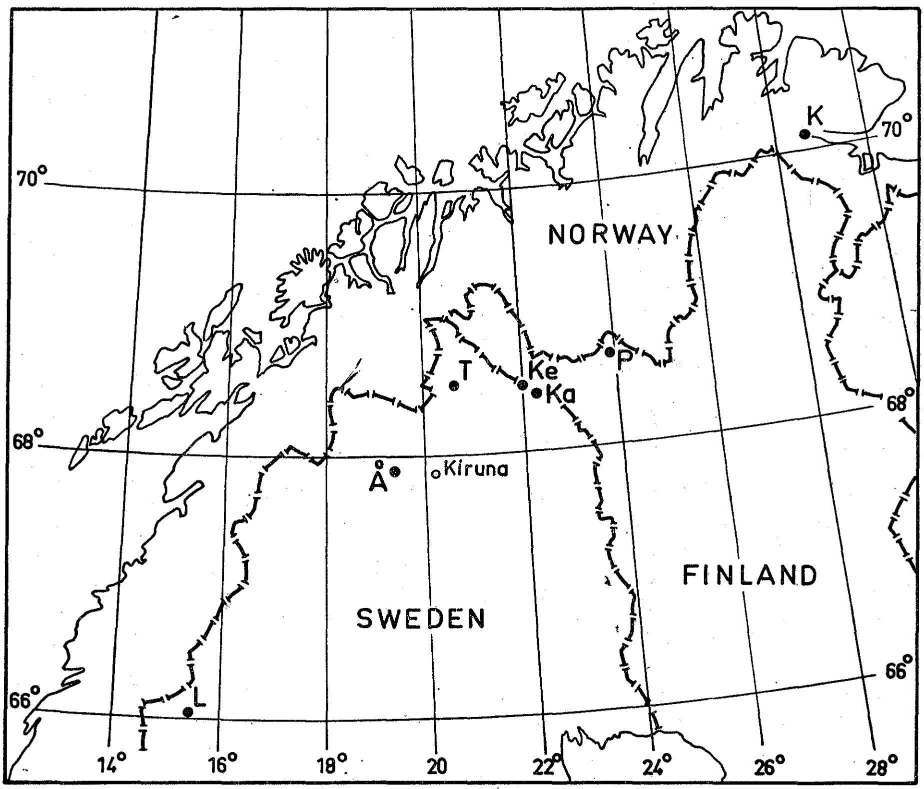

Fig. 1. Location map of places mentioned in the text

K — Karlebotn, Ka — Karesuando, Ke — Kelottijärvi, P — Pöyrisjärvi, T — Taavavuoma, L — Laivadalen, Å — Årosjokk

In Taavavuoma the palsas were less affected by destruction than those in Laivadalen. Many of the palsas in Taavavuoma have boulders on their tops. These boulders rest on the mineral soil and the overlying peat conceals much of their volume, many of them being 1—2 m^3.

Another structure in the frozen mineral soil has been described by Svensson (1964). By means of a motor drill a 2 m deep cutting was made from one side of a 5—6 m high palsa near Karlebotn. Only unfrozen peat (55 cm) overlies the mineral soil and the active layer goes 60 cm down into it. The surface layer of the mineral soil consists of sand with some gravel and a few stones and under this lies the minerogenic core proper, composed of finer fractions. In the permafrost, lamellae of ice occur, but most of them are not orientated horizontally or subhorizontally. On the contrary, they are vertical or subvertical. In addition, there are horizontally orientated biconvex ice-lenses connected with the lamellae.

From Pöyrisjärvi Ohlson (1964) reported the occurrence of ice-structures which deviated from the usual conception of ice-lenses in the frozen cores of palsas. In frozen mineral soil below frozen peat in palsas he observed what he designated as brecciated ground-ice (*brekziöser Bodenfrost*). This seems to have been the same type of structure as I sporadically found in fine-grained mineral soil (Pl. 4).

In the Karesuando area the internal structure of palsas has been studied by means of cuttings and drillings, using a SIPRE corer and a motor-driven chain-saw as a power unit (Forsgren, 1964). These studies show that, of 15 investigated palsas, all, except two, are lying on frozen mineral soil (Forsgren, 1966). However, the frozen mineral soil is only a small part of the total core of permafrost in most of the palsas. The ice-lenses and ice-veins are more developed in the peat than in the mineral soil (Pl. 5). Consequently, most of the height of the palsas must be ascribed to frost-heaving in the peat.

At the Symposium on the Ecology of Sub-Arctic Regions held in Helsinki, 25 July—4 August 1966, Salmi (1966) presented some investigations made at Kelottijärvi. By means of a Cobra motor drill and breaker and an ordinary carpenter's auger, drillings and several cuttings were made in two palsas which were 3 m and a little more than 1 m high, respectively.

The higher palsa has a core mainly consisting of frozen peat and below the peat lies more than 2 m of frozen silt, whereas in the smaller one the core consists of only frozen peat resting on unfrozen peat. In the lower part of the core of the higher palsa 5—10 cm thick layers of peat and ice alternate.

For the purpose of determining the stratigraphy of palsas, an earth-resistivity meter was tested (Jerkeman and Sandberg, 1965). The resistivities of the different layers composing a palsa were determined on palsas with known stratigraphy. On palsas with unknown layer conditions it seems difficult to obtain reliable values of the thicknessess of different layers and the authors recommend checking by drilling.

CLIMATOLOGICAL INVESTIGATIONS CONCERNING PALSAS

Since the palsas occur in the zone of sporadic permafrost, they are considered to be important climatic indicators. The investigations with the aim of determining their significance in this respect have hitherto been concentrated on temperature measurements in the palsas, connected with studies of the distribution of the snow on and around them.

Near Karesuando, Swedish Lapland, temperature measurements by means of 11 thermistors placed in different parts of a palsa were started in August 1963 (Forsgren, 1964). These measurements, which are continuing, gave a temperature amplitude for the year (1964) of 2.0 °C (extremes of —0.1 °C and —2.1 °C) in the uppermost part of the permafrost, that is, at —0.75 m. At —1.4 m the amplitude was 0.8 °C and at —2.1 m 0.1 °C. This means that the winter cold wave was hardly perceptible at this level. In 1964 the active layer was determined as being about 65 cm on this palsa.

In the neighbourhood of Karlebotn, Norway, similar temperature-measurements were carried out (Lindqvist and Mattsson, 1965). These measurements were made by means of 20 thermistors, read once a week from October 1964 to September 1965. The active layer was found to be a little less than 1 m. At —1.0 m the temperature varied during the year between approximately ±0 °C and —4 °C. At —4.0 m the extremes were —0.4 °C and —1.2 °C. While the winter cold wave occurred in April at — 1.0 m it reached — 4.0 m in the middle of June, and most of the delay was concentrated to the parts below —2.0 m.

At Karlebotn the snow cover on a palsa adjecent to the one in which the temperature was measuerd was less than 10 cm for most of the winter. On the flat heath immediately outside the palsa bog, the snow cover during the winter usually was 30—50 cm thick.

In Karesuando the thickness of the snow on the top of the „thermistor palsa" was thicker; for most of the winter it was 20—25 cm and in extreme cases for shorter periods as much as 45 cm. Outside the palsa the snow cover was 60—80 cm.

The general climatological conditions required for the formation of permafrost and its existence in general have been discussed by Ohlson (1964).

GEOHYDROLOGICAL INVESTIGATIONS

In 1965 a study of the tritium content of the water in palsas was started (Forsgren, 1966). Since the tritium content in precipitation has increased very greatly during the last fifteen years, it was assumed that, if such water had been added to the frozen core of a palssa, it should be possible to localize it. However, the tritium content of the ground-water adjacent to the frozen core of the palsa proved to be too low to allow such determinations.

In the study it was concluded that the influence of tritium-rich precipitation on the ground-water is restricted to the uppermost 2—3 m in the bog adjacent to the palsa. It is pointed out that studies of this kind have to be continued for several years before well-founded inferences can be made.

BOTANICAL INVESTIGATIONS

Palsas and palsa bogs offer many opportunities for botanical examinations, especially ecological ones. Many of the reports reviewed contain some information about botanical conditions, but in most of the papers the botanical studies seem to be a secondary interest of the investigators.

Fries (1964) gives information about the vegetation and also a short description of the different kinds of peat in the palsa. Salmi (1966) has presented two pollen diagrams from one of the investigated palsas and the adjacent bog at Kelottijärvi.

Studies in which the primary interest is in the botanical conditions of palsa bogs and palsas have been started in northern Norway by scientists from the Tromsø Museum (O. Skifte, personal communication) and in the Karesuando area by Britt Forsgren (Department of Morphological Botany, University of Stockholm; personal communication).

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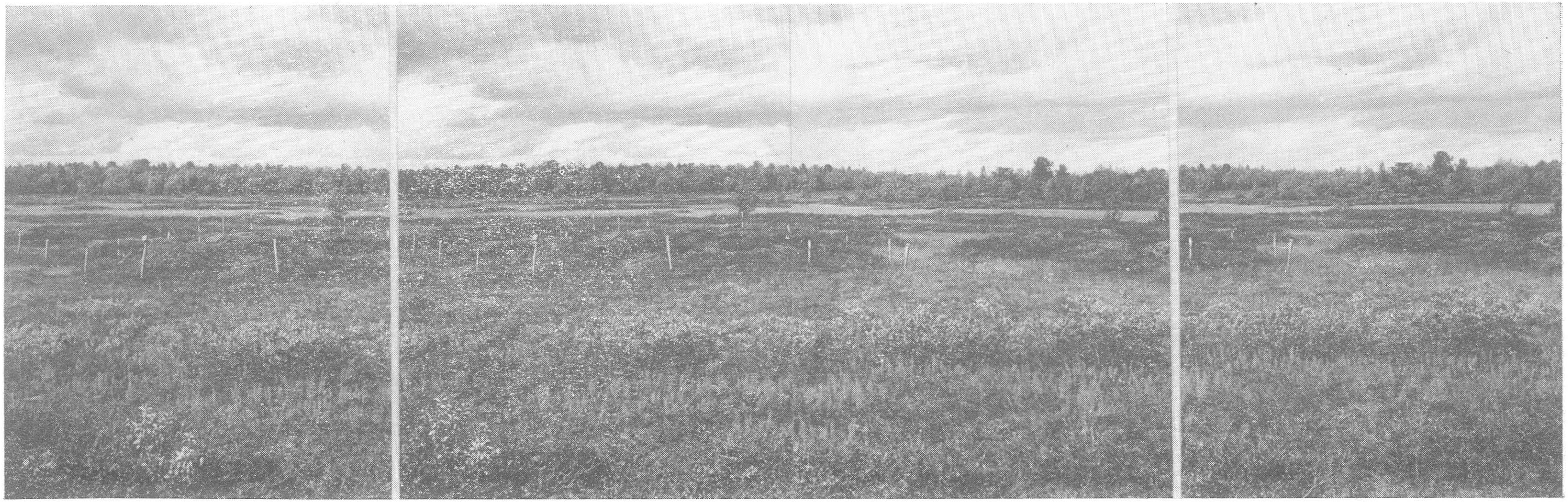
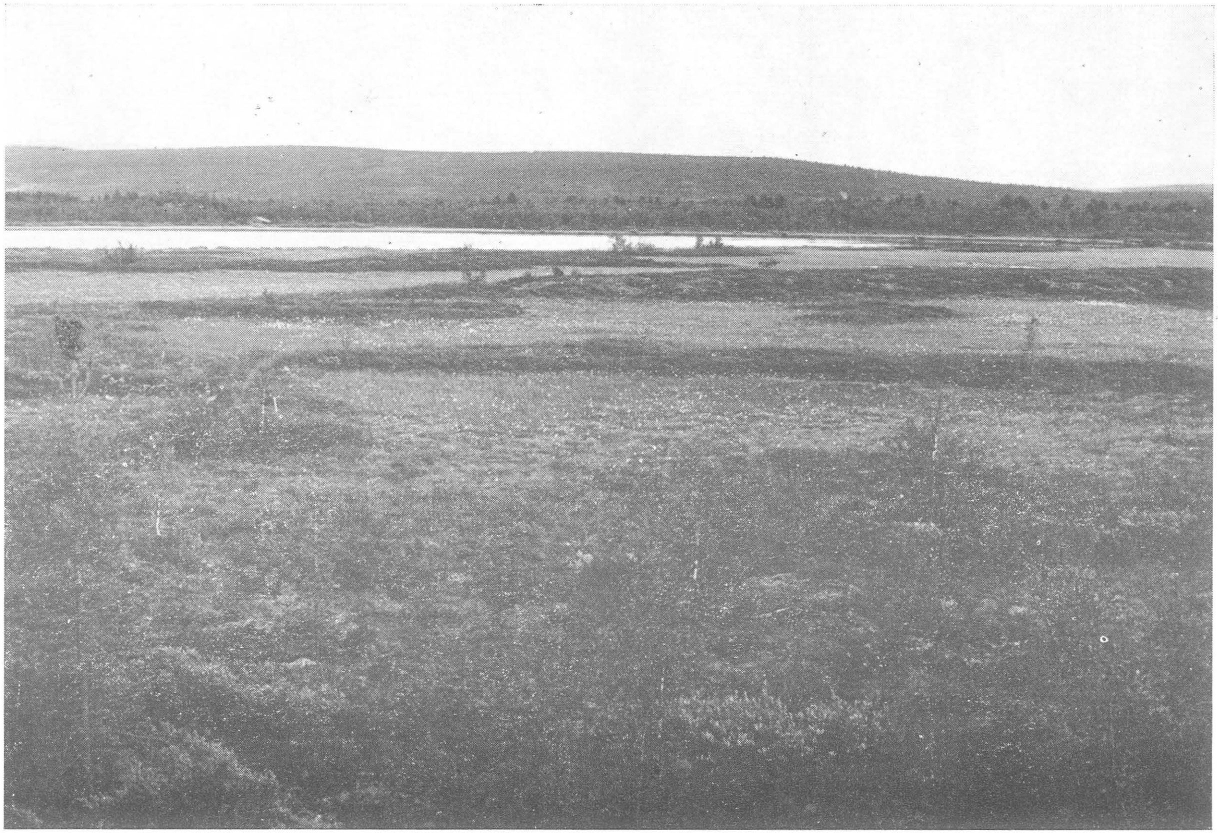


Photo. B. Forsgren

Pl. 1. Karesuando, Swedish Lapland. Stereogram showing the simplest type of palsa (the mound), about 1.5 m high. In this palsa temperature measurements were started in 1963



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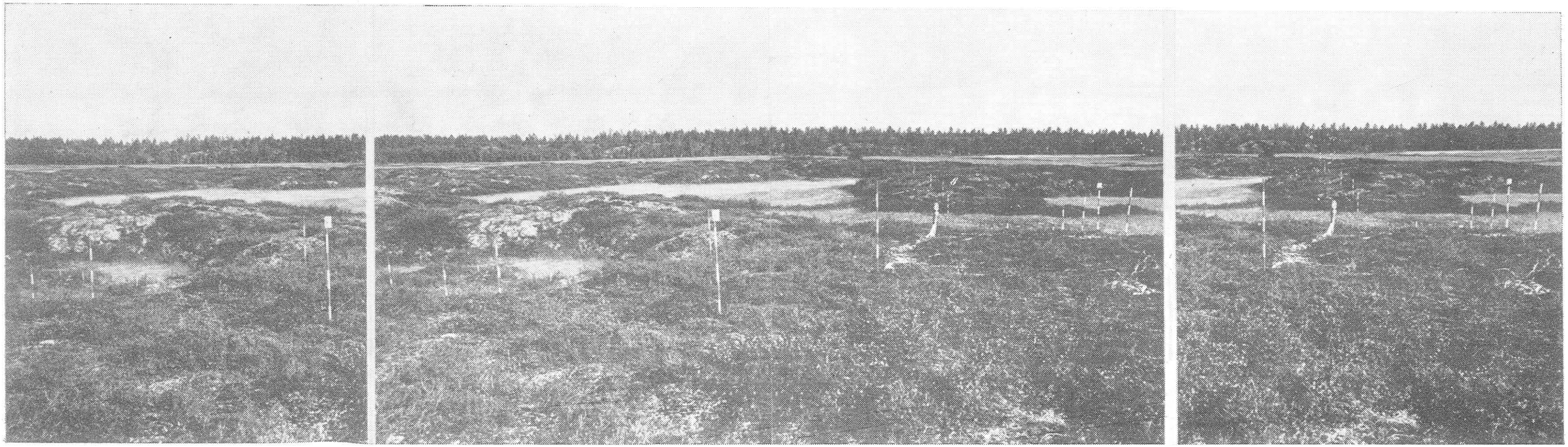
Pl. 2. Karesuando, Swedish Lapland. Palsas of the straight-ridge type, about 2 m high



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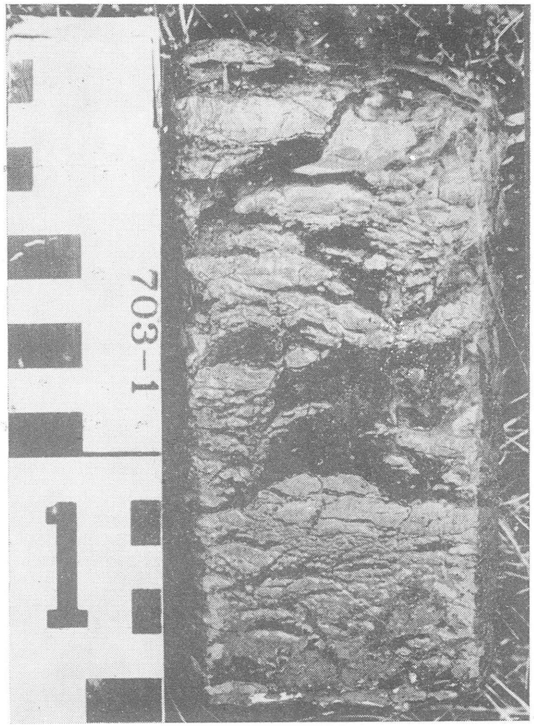
Pl. 3. Karesuando, Swedish Lapland. Stereogram showing palsas of the winding, connected, ridge type. Height about 3 m



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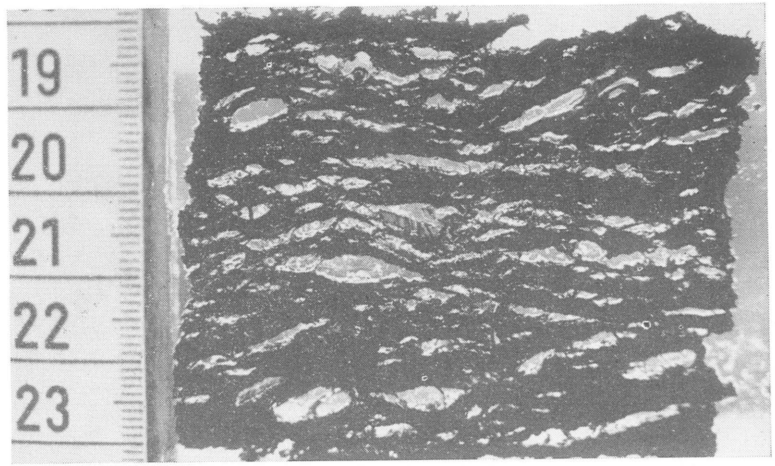

Photo. B. Forsgren

Pl. 5. Karesuando, Swedish Lapland. Thin section made in the field from a core obtained from a palsa with a SIPRE corer. The black area is frozen peat and the light areas are ice. Scale in centimetres and millimetres to the left

Pl. 4. Årosjokk, Swedish Lapland. Core of frozen mineral soil with segregated ice. Scale in centimetres