Observations of palsas within the continuous permafrost zone in eastern Siberia and in Svalbard

H. JONAS ÅKERMAN

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Observations from the area north of Chernychevsky, Yakutia, USSR (63°N 112°E) are described. In the area several palsa bogs of a »Nordic type«, containing well developed palsas of the dome, plateau and complex types, are found. In Svalbard four types of palsa-like features has been observed, including: 1) »Traditional palsas«, 2) injection ice turf mounds, 3) active layer turf mounds and 4) vegetative turf mounds.

H. Jonas Åkerman. Dep. of Physical Geography, University of Lund, Sölvegatan 13, Lund, Sweden.

The term palsa is a Fennoscandian word for a round or elongated hillock or mound in a bog and of a maximum height of about 10 m, composed of a peat layer overlying mineral soil. It has a perennially frozen core, which extends from within the covering peat layer downward into or toward the underlying mineral soil (Lundquist 1969, Salmi 1970, Seppälä 1972, Washburn 1956, Zoltai & Tarnocai 1971). The characteristic costituent of the palsas is peat containing a perennially frozen core with thin ice lenses, which generally are 2-4 cm thick although locally lenses can be considerably thicker (Forsgren 1968, Schunke 1973, Åkerman 1973).

Palsas are characteristic of the Subarctic and commonly occur in the discontinuous permafrost zone. In this zone they are often the only reliable surface evidence of permafrost (Brown 1973). During the last two decades several reports of palsa-like forms from the continuous permafrost zone have been published (Brown 1973, Salvigsen 1977, Spolanskaya & Evseyev 1973, Mackay 1965, French 1971, Svensson et al 1973).

Despite the fact that palsas are one of the most thouroghly studied periglacial features, there still remain unsolved questions especially regarding intermediate forms between palsas and pingos, minerogenetic »palsas«, palsas and other palsa-like features with different genetic background, the occurrence of palsas and palsa-like features within the continuous permafrost zone and the terminology connected with these problems. This paper will describe palsas or palsa-like forms which have been observed well within the continuous permafrost zone and also an attempt to discuss whether they should be called palsas or be given other names.

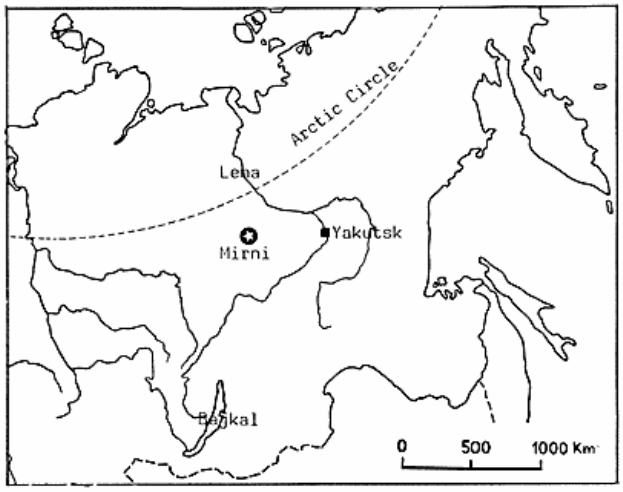

Fig. 1. Orientation map of the eastern parts of the USSR where palsalike feature were observed in the area north of Mirni.
Fig. 1. Oversigtskort over den østlige del af USSR, hvor palslignende former er fundne nord for Mirni.

WESTERN YAKUTIA, USSR

Observations

During field work in Western and Central Yakutia, USSR, in Oct. 1980 and June 1981, which mainly concerned other periglacial features, palsa-like features were observed at several localities. Most of the observations were made from the air during flights but since photographic documentations could not be made, these observations, which mainly were made between Yakutsk and Mirni, can not be discussed any further but only support the ground observations. However, in the area north of Mirni (62°30'N 114°01'E) and north of Chernyshevsky (63°05'N 112°30' E) several bogs which contained palsa-like features were studied in the field (Fig. 1).

In this area bogs are very frequent and along the road from Mirni to Chernyshevsky and about 260 km north (totally about 440 km) sixteen bogs containing palsa-like features were observed. Out of these four bogs have been visited and cursorily examined in the field. As maps and air photographs of the area are not available to a foreigner, the following description can only be regarded as very preliminary and simple.

Fig. 2. Dome-shaped palsa in a bog 6 km north of the Viluij hydroelectric powers station, Yakutia, USSR.
Fig. 2. Dome-shaped pals, Yakutien, USSR.

Site I. Bog area 6 km north of the Vilyui hydroelectric power station. On the west side of the road there is a bog which is about 1 km wide and 3 km long stretching north south. Along the western margin of the bog there runs a small stream draining towards the south. The bog contains several palsas of which the majority are dome-shaped mounds varying in height from 0.5 m to 2 m. The diameter of the mounds rarely exceeds 15 m and the form is generally more or less circular (Fig. 2). In figure 3 the profile of six of the more characteristic features are shown. The mounds which in the upper parts contained a very thick, soft and uniform Sphagnum turf were generally covered with a dense scrub of *Betula nana* L. Some of the larger forms also had some birches (max. stem diameter 13 cm). Cracks were not very common in the »mature« mounds, but some of the mounds were in the process of degeneration scarred by large cracks, block erosion, marginal and central pools of water and so on. Several examples of collapsed forms, ring-shaped pools (Fig. 4), pools with a ring wall and so forth were also observed indicating the common cyclic characteristics of palsas and palsa bogs.

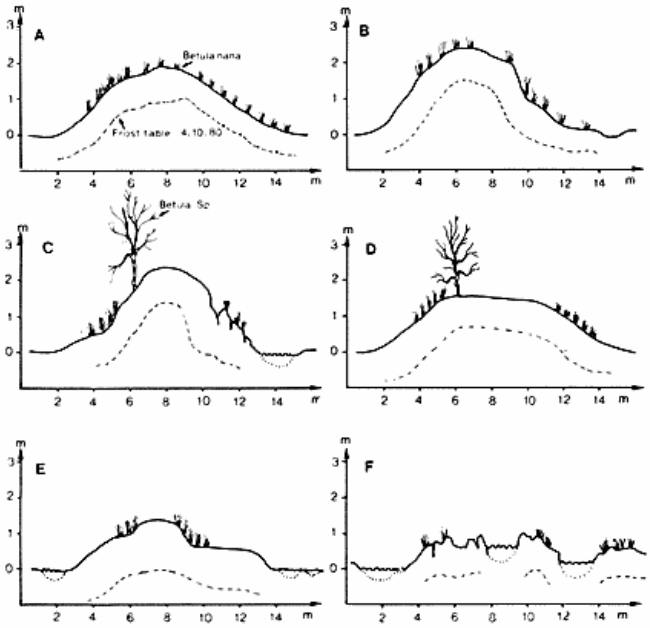

Fig. 3. Profiles of some of the palsa-like features found in a bog 6 km north of the Vilyui hydroelectric power station (Site I) Western Yakutia, USSR.
Fig. 3. Profiler gennem pals-lignende overfladeformer, vestlige Yakutien, USSR.

Site III. Bog area 15 km north of the Viljui hydroelectric power station. This bog area which is very extensive, more than 5x5 km, is situated on the east side of the road. The central part of the bog is wet, containing several open water surfaces and covered mainly with *Carex Sp.* The palsa forms are here found in the marginal area of the bog which are drier than the central ones. Here the mounds show a wider spectrum of shapes including both dome-shaped forms, plateau palsas and palsa complexes. Generally the forms are both higher, up to 3.5 m, and larger than in the other three bogs visited. Only some very simple profiles of the mounds could be measured and these are shown in Fig. 5. Also this bog displayed numerous examples of palsas in different growth and degeneration stages. In Table I some of the characteristics of the palsa-like forms observed in the area are listed.

TABLE I. Some observations of the characteristics of the palsa-like mounds found in bogs in the area north of Chernyshevsky, Western Yakutia, USSR

	SITE I	SITE II	SITE III	SITE IV
Mound form				
Dome	X	X	X	X
Plateau	-	-	X	-
Complex	-	X	X	X
Ridge-like	X	X	X	X
Height				
Max	2m	3m	3.5m	3m
Average	1m	1.5m	1.5m	1m
Diameter (max)	15 m	30 m	100 m	30 m
Stages				
Growing	X	X	X	X
Mature	X	X	X	X
Degenerating	X	X	X	X
Subfossil	X	X	X	X
Vegetation on the mound				
Betula nana	X	X	X	X
Birches	X	-	X	X
Only low veg.	few	few	-	-
Cracks in the surface	X	X	X	X
Signs of wind erosion	-	-	few	-
Depth of active layer				
4.10.80	85-105cm	-	90-100cm	-
15.6.81	60-75cm	50-75cm	50-75cm	50-75cm
Signs of mineral soil	X	-	-	-
Ground ice	Thin veins	-	Thin veins	-

SPITSBERGEN

Introduction

Apart from notes of minor turf hummocks in bogs and vegetation covered valley bottoms (Jersak 1968, Jahn 1975) the number of observations concerning palsa-like features from Spitsbergen is low. The first are probably the notes made by Åhman 1977, Åkerman 1973, 1980 and Salvigsen 1977).

Fig. 4. Palsas and a collapsed palsa in a bog 6 km north of the Viluij hydroelectric power station, Yakutia, USSR.
Fig. 4. Palser og sammensunkne palser i mose i Yakutien, USSR.

During the last years several research workes have reported observations, both new and old, of the same type of palsa-like features as those described by Åkerman (1973) and Salvigsen (1977) (Seppälä, Péwé, Jahn, Lagerlund, Engh and others, oral communication).

However, the palsa-like features in Spitsbergen include a variety of forms which by general appearance, form and composition resemble the traditional palsa but which may have a completely different genetic background. It is therefore important to make an inventory of these forms in order to obtain an adequate background for a discussion about the palsa and its occurrence in the continuous permafrost zone.

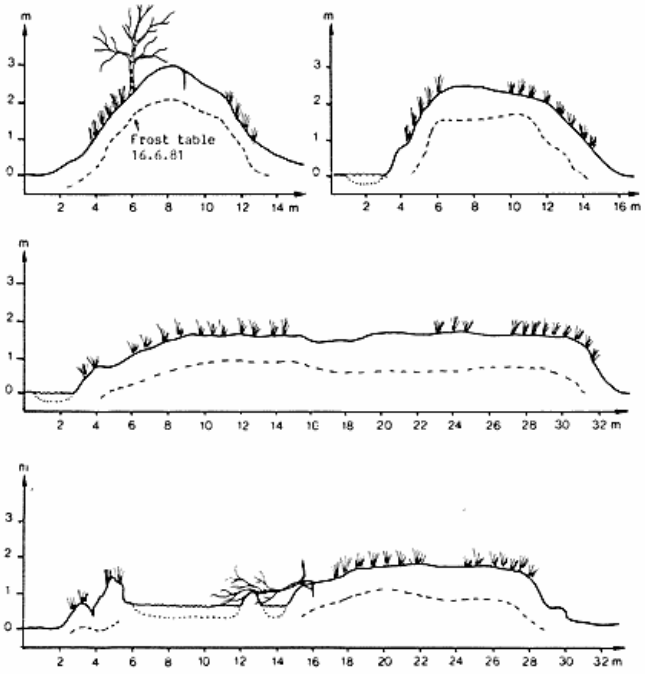

Fig. 5. Profiles of some of the palsa-like forms found in an extensive bog 15 km north of the Vilyui hydroelectric power station, Western Yakutia, USSR.
Fig. 5. Profiler gennem pals-lignende former, vestlige Yakutien, USSR.

Observations

During a detailed inventory of periglacial features in the outer part of the Isfjorden Fjord (Fig. 6) and additional studies in the Adventdalen Valley it was found that palsa-like features in this area are fairly common. It was also found that at least four different types of mounds could be differentiated. These four types are here called: 1. Palsas 2. Injection ice turf mounds 3. Active layer turf mounds 4. Vegetative turf mounds.

Palsas

»True« palsas have been found only in the small bog areas on the strandflat area south of Kapp Linné. Within the detatil investigation area (Fig. 7) and also all along the strandflat southward palsas are common and typical features in the

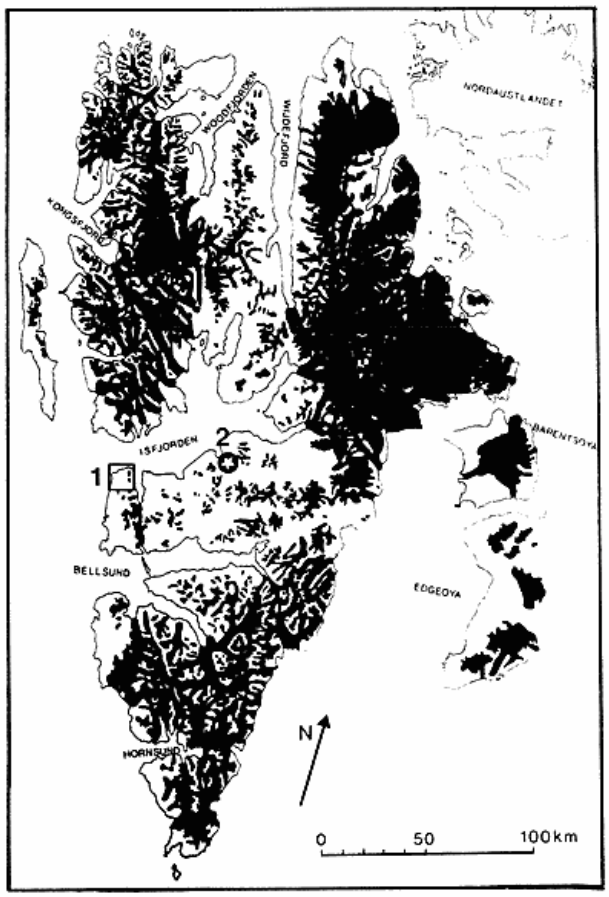

Fig. 6. Orientation map of Spitsbergen and its glacial cover. 1 = the investigation area at Kapp Linné 2 = the Adventdalen Valley.
Fig. 6. Oversigtskort over Spitsbergen. Sort viser den nuværende glaciation. 1 = undersøgelsesområdet ved Kapp Linné, 2 = Adventdalen.

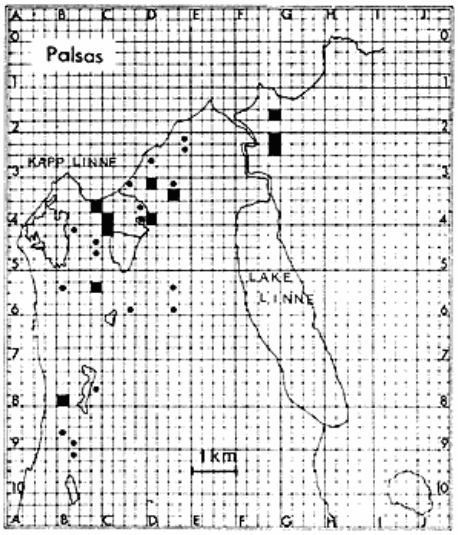

Fig. 7. Map showing the occurrence and distribution of palsas within the investigation area at Kapp Linné, Spitsbergen. Black unit square = several palsas, black dot = single or few observations.
Fig. 7. Palsforekomster ved Kapp Linné.

small bogs situated within the system of raised beach ridges. The features are generally small, not exceeding 1.3 m in height and 10 m in diameter (Fig. 8) and they are generally more or less circular (Fig. 9). The internal structure of the palsas is fairly uniform judging from the eight palsas which have been investigated by digging trenches through the entire palsa down to the underlying beach-gravel material. The palsas are built up by ice layers (2-15 cm thick) of segregation ice and the material from the surface down to the underlying material is turf with a low but increasing amount of mineral particles with depht. No signs of any mineral soil core has been found (Fig. 10 & 11).

The bogs of the area also show several examples of collapsed palsas. Small circular pools on the bog surface or turf rings with a small pool in the centre are common (Fig. 12).

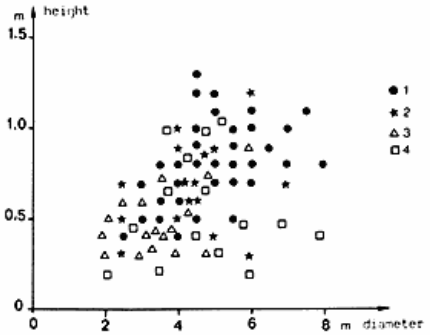

Fig. 8. The relation between the height and the diameter of the four palsa-like mound types studied in Spitsbergen. 1. Palsas 2. Injection ice turf mounds 3. Active layer turf mounds 4. Vegetative turf mounds.
Fig. 8. De fire pals-lignende former vist i et højde-diameter diagram.

Fig. 9. Palsa in a small bog 3 km south of Kapp Linné, Spitsbergen.
Fig. 9. Pals i lille mose 3 km syd for Kapp Linné, Spitsbergen.

Small growing palsas, mature and totally collapsed forms are found but I have so far not observed any forms which just started to degenerate or any other stage between the mature and the totally collapsed. The present palsas show a high degree of stability. Either the collapse process is very rapid, which is highly unlikely, or it may be speculated that the collapse features existing are the result of earlier less favourable climatic conditions. In order to develop a discussion about this matter more field work and several C14 datings are required.

Injection ice turf mounds

This type of mound can in many cases have the same size, form and general appearance as the earlier described palsas of the area (cf. Fig. 8). But they are generally smaller and

Fig. 10. Detail of a trench in a 90 cm high palsa situated 1 km south-east of Kapp Linné, Spitsbergen.
Fig. 10. Udgravning i 90 cm høj pals ved Kapp Linné, Spitsbergen.

the form is often more irregular. Often the injection ice turf mound has steeper sides and cracks occur more frequently in the surface. Their position in the terrain is also often different from the palsas as they are generally found in the marginal part of bogs, along small streams, near springs etc. The association with flowing water is in most cases evident. The greatest difference between this type and the palsas is the internal structure which is here dominated by one (or rarely a few layers) massive ice core (Fig. 13). The turf cover is generally thin, 10-30 cm and the ice is often visible in the cracks (Fig. 14). The form appears to be less stable than the palsas as melting and collapsing forms are frequently found. Fossil or subfossil remnants of this type of mounds have not been observed.

Active layer turf mounds

This type of mound has only been found on the valley bottoms of the large valleys in central Spitsbergen but here they are very common. They have in some reports been called small palsas which is not correct. Their form and general appearance can be similar to those of the palsas but they are in most cases smaller (Fig. 8) and their internal structure is

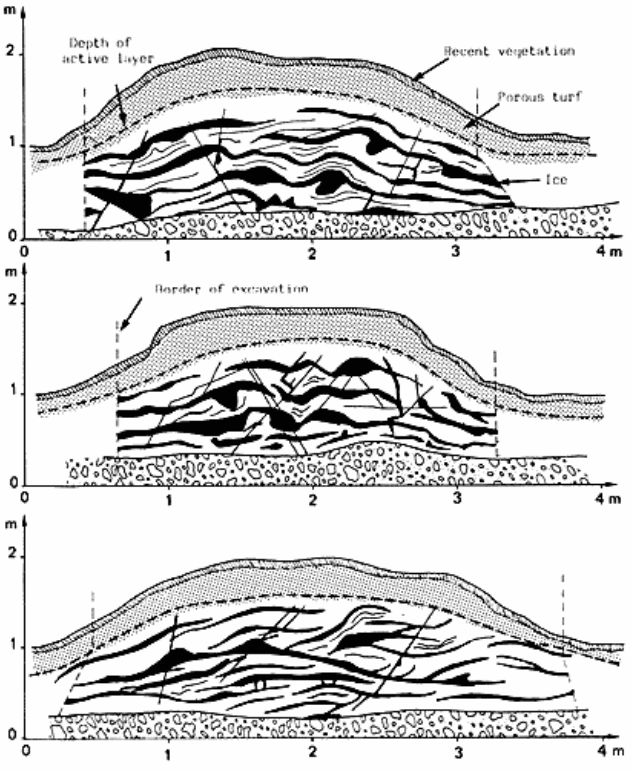

Fig. 11. The internal structure of three palsas from bogs south of Kapp Linné, Spitsbergen. The turf in the porous layer (within the active layer) is brown and the turf below is more compact and reddish brown and has a increasing amount of mineral particles with depht. The bottom material is beach gravel.

Fig. 11. Profiler gennem tre palser ved Kapp Linné, Spitsbergen.

Fig. 12. Remnants of collapsed palsas in a bog 3 km south-east of Kapp Linné, Spitsbergen.

Fig. 12. Sammensunkne palser ved Kapp Linné, Spitsbergen.

quite different. They often lack a distinct turf layer and they are exclusively found in the wet central parts of low centre ice wedge polygones. Their internal structure is characteristic with a massive ice core of segregation ice mostly situated 15-25 cm below the surface between the vegetation or turf mat and the underlying mineral soil. Cracks and ruptures are common and the form is unstable, as a rule surviving only one or a few summers. The characteristics of this mound type is apparently identical with the features described by French (1971, p. 32-38) from Banks Island, and his suggestion about their genesis is probably valid in this case too.

Vegetative turf mounds

This type of mound is quite different from the other three since frost and ground ice formation are not responsible for their formation. The general appearance, size and form are often similar to the palsas of the area and the turf material and structure also show many similarities with the palsas. The position in the terrain, however, is quite different. They are generally found at dry localities, upon raised beach ridges and other exposed localities without any connection with bogs or running water (Fig. 15). When digging trenches in the central part of these mounds their genetic background is often easily discovered. Six large and a number of smaller

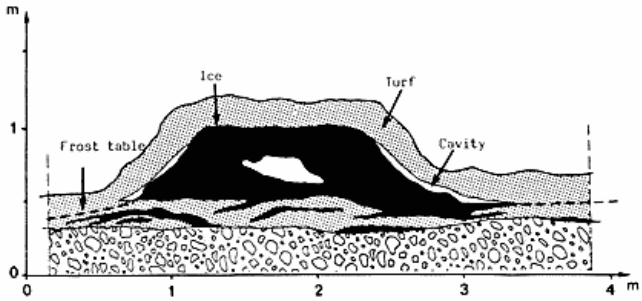

Fig. 13. The internal structure of a representative »injection ice turf mound« from the margin of a small bog 4 km south of Kapp Linné, Spitsbergen.

Fig. 13. Profil gennem en typisk »injection ice turf mound« ved Kapp Linné, Spitsbergen.

Fig. 14. Collapsing injection ice turf mound from a small bog 5 km south-east of Kapp Linné, Spitsbergen.
Fig. 14. Kollaberende injection ice turf mound ved Kapp Linné, Spitsbergen.

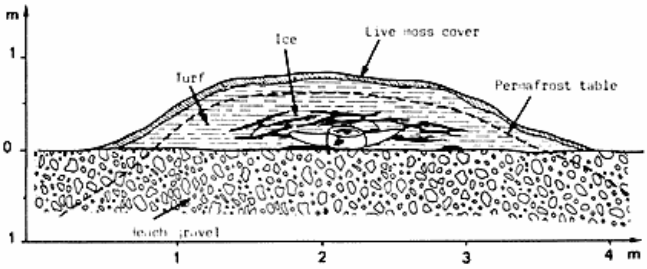

Fig. 16. The internal structure of one of the »vegetative turf mounds« found upon a raised beach ridge 4 km south-east of Kapp Linné, Spitsbergen. The feature in the centre of the mound is a vertebra from a whale.
Fig. 16. Profil gennem »vegetativ turf mound« på hævet strandvold ved Kapp Linné, Spitsbergen. Den hvide genstand centralt er en ryghvirvel fra en hval.

mounds of this type have been investigated in detail and all showed the same result. In the central part of the mound, resting upon the underlying original surface there could always be found a piece of driftwood, a whale bone or a reindeer sceleton. The salts and minerals released have accelerated the growht of mainly mosses and a turf mound has been created. When about 30 cm thick the insulating effect is strong enough to permit the formation of a frozen core in the central part and some ice segregation will take place (Fig. 16). This will enhance the mound formation. The form is apparently stable as no signs of degeneration or degenerative forms have been observed. Some slight effects of wind erosion have been observed.

Fig. 15. An example of the »vegetative turf mounds« situated upon a raised beach ridge 5 km south-east of Kapp Linné, Spitsbergsn. The mounds is 75 cm high and the diameter is 5 m. In the central part a reindeer sceleton was found.
Fig. 15. Vegetativ turf mound på hævet strandvold ved Kapp Linné, Spitsbergen. Centralt i højen fandtes et rensdyrskelet.

CONCLUSIONS

The observations of well developed palsas from eastern Siberia and from Spitsbergen together with earlier observations of palsa-like forms from other parts within the continuous permafrost zone show that, as expected, palsas do occur within this environment. Especially the palsa bogs and palsas of eastern Siberia are almost identical with the »classical« palsas and palsa localities in northern Scandinavia. However, the great number of palsa-like mound forms which are found parallel with the palsas in for example Spitsbergen show that great care must be taken when using the term palsa in the continuous permafrost zone and that the internal structure, type of ice etc. must be investigated carefully before applying this term. Concerning the terminology of the group of palsa-like mounds described in this and other reports there still remain several unsolved questions and the terms here used should only be regarded as very preliminary.

RESUMÉ

Der redegøres for observationer fra østlige Sibirien og Spitsbergen af »traditionelle« palser samt andre pals-lignende former. Iagttagelserne fra Chernychevsky, Yakutien, USSR (63°N 112°E) omfatter flere pals-moser af »nordisk type«, indeholdende veludviklede palser af dome-type, plateau-type samt complekse typer. Beliggenhed, størrelse, form, isindhold, hydrografi, vækst og degenerationsstadier tilfredsstiller alle kriterier i pals-definitionen.

Fra Spitsbergen beskrives fire pals-lignende overfladeformer. Disse morfologiske elementer er små, ikke højere end 1 m, 6 m i diameter, og med hensyn til form ret ensartede. Fire typer er identificeret: 1) »Traditionelle palser«, 2) injection ice turf mounds, 3) active layer turf mounds og 4) vegetative turf mounds.

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Naledi i Grønland. Flyfotografisk inventering af perennerende flod- og kildeis i grønlandske permafrostområder; foreløbige resultater

OLE HUMLUM
HARALD SVENSSON

Humlum, Ole og Svensson, Harald: Naledi i Grønland. Flyfotografisk inventering af perennerende flod- og kildeis i grønlandske permafrostområder; foreløbige resultater. Geografisk Tidsskrift 82: 51-59. Copenhagen, October 15, 1982.

Preliminary results on the distribution of naledi/icings/aufeis in Greenland are reported. The investigation is based on examination of aerial photographs from three selected areas. Naledi are aboundant in areas with glaciers of the temperate type, while they are rare in areas with cold glaciers.

Ole Humlum, Ph. D. and Harald Svensson, Fil. dr., professor, Department of Geomorphology, Geographical Institute, University of Copenhagen, Haraldsgade 68, DK 2100 Copenhagen Ø, Denmark.

I arktiske områder optræder mange steder et udstrakt isdække i forbindelse med floder og kildevæld (fig. 1). Isforekomsterne smelter eventuelt bort i løbet af sommeren, men mange er så mægtige, at de kan overleve sommeren og er således perennerende. Isforekomster af denne art er i litteraturen omtalt med anvendelse af forskellige betegnelser. I engelsksproget litteratur er termen icing almindelig (se f.eks. French 1976, Washburn 1979), mens termen aufeis især har været anvendt i tysksproget litteratur. I russisk litteratur anvendes alene betegnelsen naled (plur. naledi), der synes at være den oprindelige sibiriske betegnelse for disse isforekomster, og som i de senere år gradvis har fundet stadig større anvendelse internationalt (Svensson 1973, Jahn 1975, Åkerman 1980).

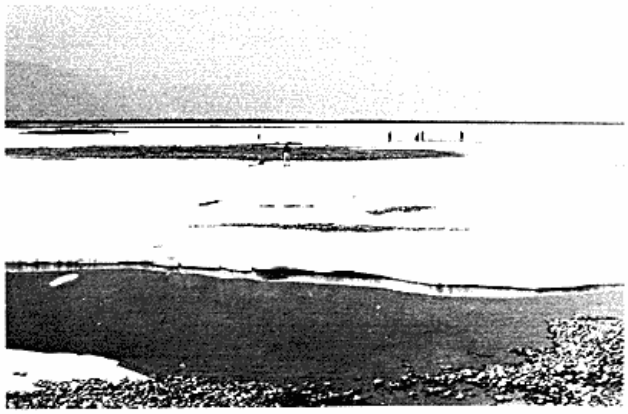

Fig. 1. Naled i Momskaja-området, Jakutien, Sibirien. Billedet er optaget 26. juli 1973.
Fig. 1. naled in the Momskaja-area, Sibiria. 1973.07.26.