THE PARABOLIC BLOWOUT DUNE OF KANGASJÄRVI IN SAARIJÄRVI, CENTRAL FINLAND

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This study describes the morphology, internal structure, sediment and origin of a parabolic blowout dune located at Kangasjärvi in Central Finland. The U-shaped dune is an isolated feature situated on a sand plain close to an esker ridge. It is from 350 to 650 m long, from 30 to 40 m wide and from 2 to 4 m high. The sand in the dune originates from a large deflation basin situated west from the dune. The dune sediment is composed of well sorted fine grained sand. The grain size, the mineral composition and the roundness of the mineral grains of the dune sand do not differ from those of the source sediment.

The formation of the dune began when the underlying sand plain rose above the level of Ancylus Lake at the end of the Preboreal chron around 9400...9350 years BP. The location of the deflation basin to the west of the dune, the parabolic form of the dune, the asymmetry of the dune head and the internal structure of the dune suggest that the dune was formed under periglacial climate by winds blowing from the west and northwest. Because the dune has retained its parabolic shape, it was probably gradually vegetated during its formation. It is believed that dune formation lasted for only a short time. The dune is now densely vegetated.

Key words: eolian features, dunes, geomorphology, sand, genesis, Holocene, Saarijärvi, Finland.

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Introduction

In addition to coastal dunes, numerous old inland dunes are found in Finland. These are now entirely bound by vegetation (e.g. Lumme 1934, Ohlson 1957, Okko 1964, Aartolahti 1967, 1973, 1976, 1979, Seppälä 1971, Lindroos 1972, Donner 1978). Stabilized inland dunes occur often as large dune fields or colonies with tens, even hundreds of dunes. Sporadic single dunes are found as well. The most common inland dune type is the parabolic type (Aartolahti 1979).

Our purpose is to describe the morphology, internal structure, sediment and origin of the Kangasjärvi dune. We have compared our results with earlier Finnish dune studies.

The geochronologic units which we use in this paper are described by the North American Commission on Stratigraphic Nomenclature (1983).

Study area

The Kangasjärvi dune is located in the north-eastern corner of the Saarijärvi Commune in Central Finland (Fig. 1). The dune is an isolated landform which — as most dunes in Finland — stands beside an esker ridge. The dune is situated on a heathy sand plain close to the Liimattala-Kannonkoski esker chain (Fig. 1).

The surrounding area to the north of the dune is flat, the areas to the west and to the south are undulating. The highest points in the area rise from 180 to 190 m a.s.l., the lowest points from 130 to 140 m a.s.l.. The bedrock of the study area is part of the large granitoid complex of central Finland.

Methods

The Kangasjärvi dune was found on the basic map when this map was interpreted for hydrogeological studies. The contour lines on the map show clearly the U- shape of the dune (Fig. 2). The map interpretation was checked in the field in the summer of 1986. The dune and the surrounding area were more thoroughly studied between May and October 1988. The Kangasjärvi dune was named after the lake nearby.

The absolute elevations of the Kangasjärvi dune and the surrounding area were measured with a theodolite and a detailed geomorphological map was drawn at a scale of 1:1000.

The internal structure of the dune was examined from three pits which were dug with a spade (depth from 1.0 to 1.4 m) (Fig. 3).

Six sediment samples were taken with a spade from below the soil horizons (depth from 0.7 to 1.0 m). One sample was taken from the central deflation basin with a piston corer (Fig. 3). The grain size distribution of these samples was determined by dry-sieving at the Soil Laboratory of Roads and Waterways District of Central Fin-

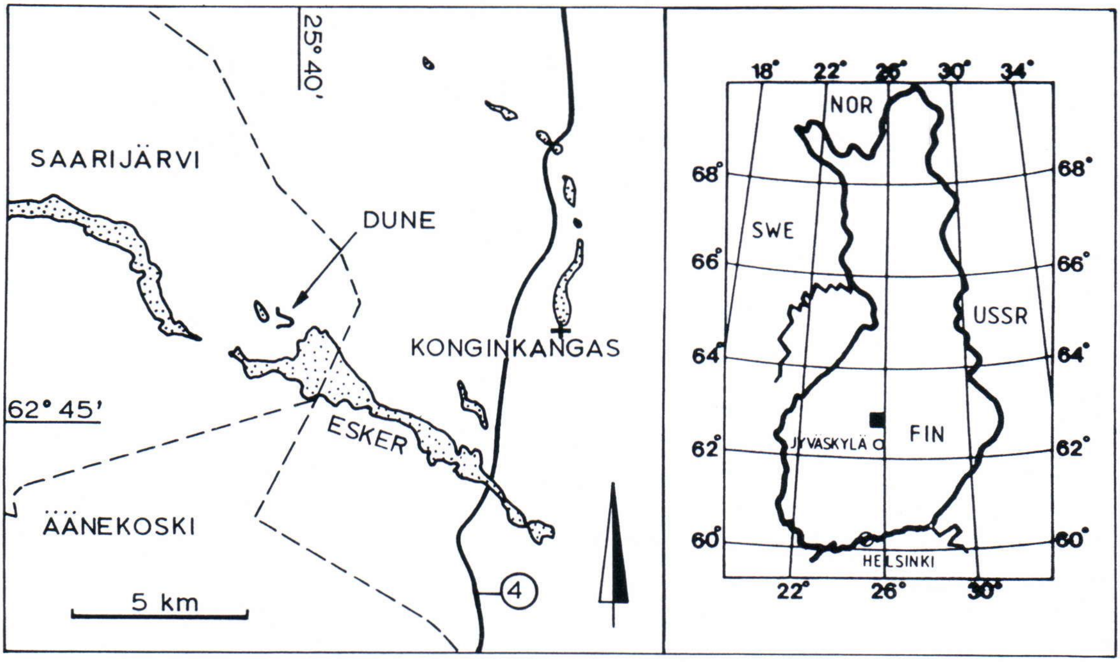

Figure 1. The location of the dune. The esker ridges are drawn from Niemelä (1979).

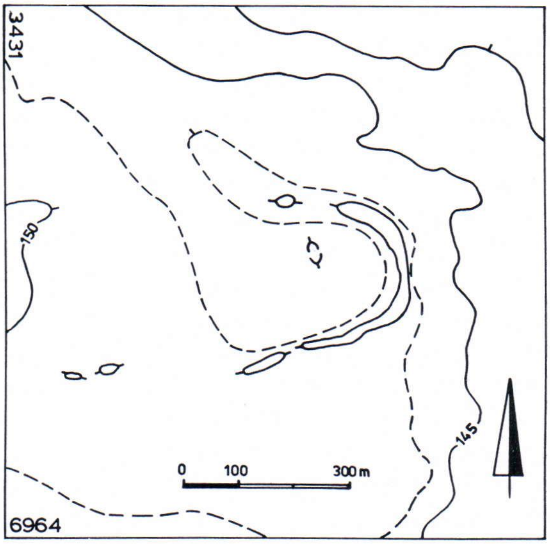

Figure 2. The Kangasjärvi dune. Basic map sheet 3222 05 Konginkangas.

land. The mineral composition and the roundness of sand grains (ø from 0.5 to 1.0 mm) were examined in two samples (1 and 5) under the microscope. More than 500 grains were identified and counted from both samples.

The thicknesses of the peat layers of the bogs (Fig. 3) were examined at 110 points using a survey rod. The absolute elevations of these points were also measured with a theodolite.

Five peat samples were taken from the central bog with a piston corer (Fig. 3). Pollen slides were prepared with the KOH method of Faegri and Iversen (1979). Three peat samples from one core were ^{14}C-dated by the Radiocarbon Dating Laboratory of the Geological Survey of Finland.

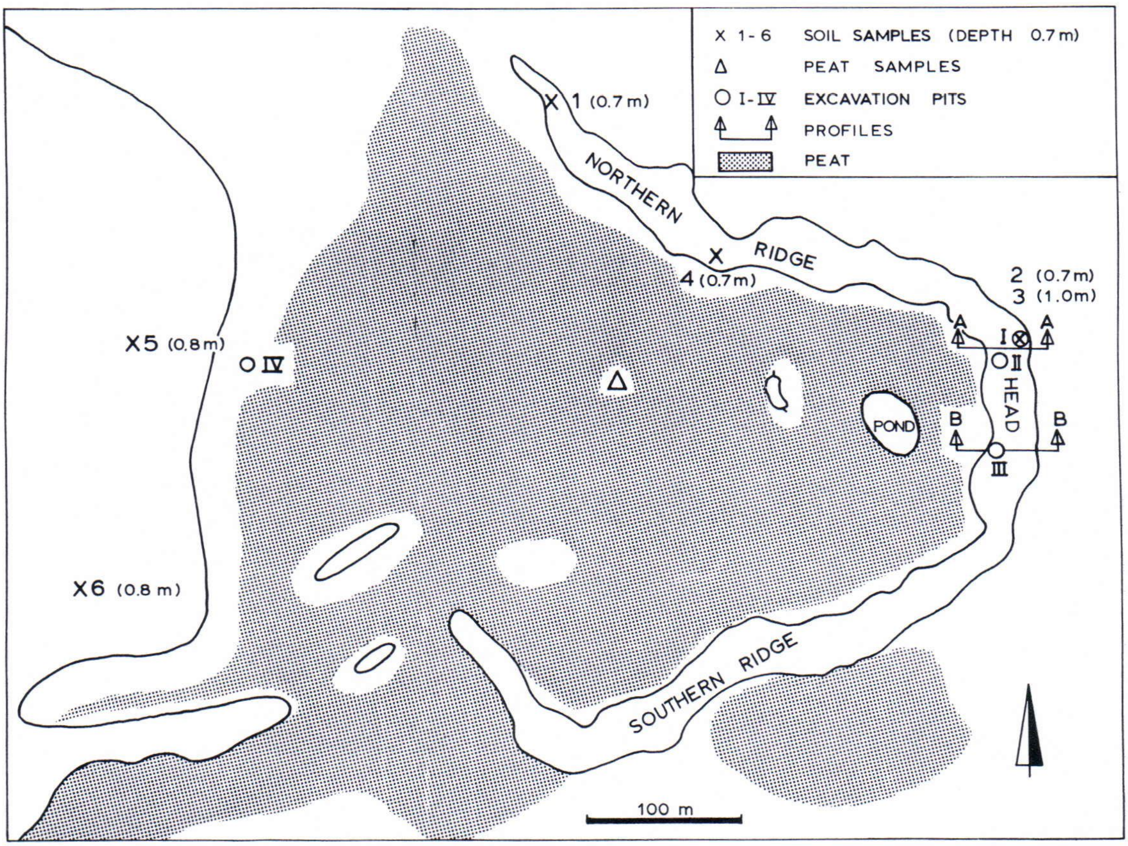

Figure 3. The sites of the sampling points, the excavation pits and the profiles A and B.

The parabolic blowout dune of Kangasjärvi

Morphology

The Kangasjärvi dune overlies a heathy sand plain close to an esker ridge. The dune rises sharply from this flat plain and its shape is nearly parabolic (Fig. 4).

The head of the dune is 150 m in length (Fig. 3 and 4). The northern ridge is about 350 m long, whereas the southern ridge is nearly twice as long, 650 m. This kind of asymmetry is common in parabolic dunes: one of the ridges is longer than the other (see e.g. Seppälä 1971:15, Lindroos 1972:12). The interridge distance is at its widest 350 m. The Kangasjärvi dune is large and can be compared with the parabolic dunes of Hietatievat in Enontekiö (Seppälä 1971) and those of North Karelia (Lindroos 1972) and those of Rokuanvaara in Vaala (Aartolahti 1973).

The highest point of the Kangasjärvi dune is about 4 m above the surrounding plain (Fig. 4). The dune is low compared with, for instance, the largest dunes in Hietatievat (12 m) and especially those in Rokuanvaara (24 m) (see Seppälä 1971 and Aartolahti 1973). The height of the dune head and that of the dune ridges are nearly identical. At the ends of the ridges, however, the dune gets lower and finally merges into the surrounding sand plain. The highest part of a parabolic dune is generally near its frontal portion and the dune gets lower toward the ends of the ridges (e.g. Seppälä 1971:16). The width of the dune does not vary: it is from 30 to 40 m except at the

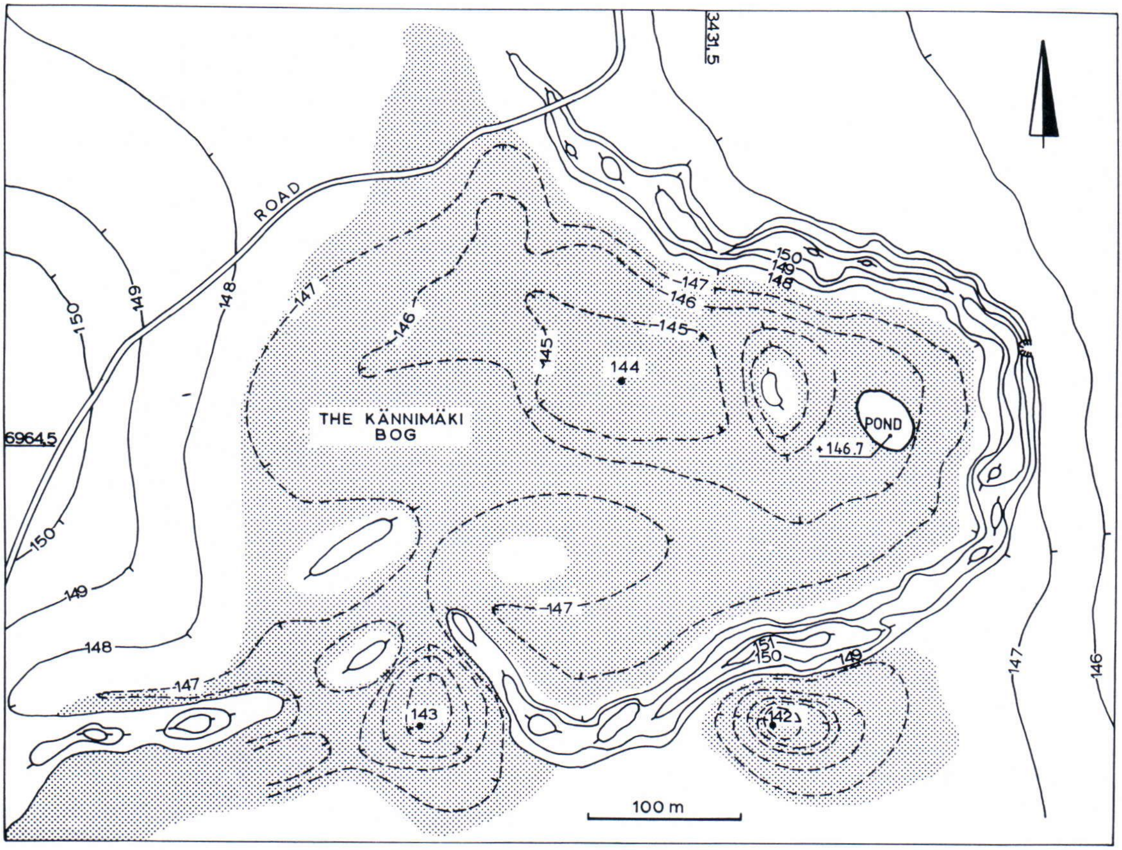

Figure 4. The parabolic blowout dune of Kangasjärvi and the deflation basins. Contour lines are drawn at one metre intervals.

Figure 5. Part of the southern ridge of the Kangasjärvi dune.

ends of the ridges. The parabolic dunes of Rokuanvaara are on the average from 50 to 100 m wide (Aartolahti 1973:13).

The ridges run from the west to the east and the head faces east (Fig. 4). These features indicate that the dune building winds blew mainly from the west and northwest. The asymmetry of the dune head is also a sign of these wind directions. That is, at the head of the dune the upwind slope is gentle (6°...10°), whereas the downwind slope is steep (15°...20°). Some parts of the ridges are also asymmetric (Fig. 5) (see also Aartolahti 1973:13).

Few isolated low dune mounds rise in the central bog (Fig. 4).

Deflation forms

The central bog grows in a large deflation basin (Fig. 4). This basin is the blowout depression from which sand was carried away by the wind. The sand was deposited on the edge of the basin. In Finland, deflation basins are often paludified or filled with water (see Seppälä 1971:18—22, Aartolahti 1973:22).

The deflation basin is wide and has a gently sloping floor. An isolated dune mound rises in the centre of the basin. The basin is deepest to the west of this mound (about 4 m below the sand plain).

Two steep-sided and deep deflation depressions characterize the topography to the south of the Kangasjärvi dune (Fig. 4). Seppälä (1971: Fig. 7) has observed similar circular depressions in deflation basins in Enontekiö. According to Aartolahti (1973:22) these kind of depressions are at least partly kettle holes.

The winds have also eroded the dune of Kangasjärvi. Small blowout depressions and wind furrows are found on the dune. Because of the well-developed soil horizons in them, these blowout depressions were probably formed during or soon after the deposition of the dune sands (see Aaltonen 1952, Jauhiainen 1972). According to Aartolahti (1973:21) these kind of erosional features can be called primary deflation forms.

The Kangasjärvi dune has no secondary deflation forms or structures which could have formed later, after the appearance of vegetation (cf. Aartolahti 1973:24). Secondary deflation seems to have reworked, however, the strata in the western side of the deflation basin (pit IV, Fig. 3). At this site, a surficial organic layer overlies a loose, light-coloured fine grained sand layer (10 cm thick) which in turn is underlain by an older, hardened organic layer.

Dune structure

The original stratification of the dune appears under the soil horizons at depths of below 30 to 50 cm. The stratification is faint but yet sufficiently discernible for measurements.

There are light- and dark-coloured strata visible in the pits with the light-coloured ones being thicker than the dark-coloured ones. The thickness of the light-coloured strata varies from 2 to 5 cm, while the dark-coloured ones are less than 1 cm thick. The bedding planes are planar without any waves or folds. Cross-bedded strata (pit II) indicate a possible change in the wind direction during the deposition of the dune sand. In parabolic dunes cross-bedding is often the most common internal structure (Lindroos 1972:51; Reineck & Singh 1980:232).

The dips of the strata through a migrating dune are typically inclined in the direction of the slip face (e.g. Seppälä 1971:35; Heikkinen & Tikkanen 1987:252). The strata in the Kangasjärvi dune head are also inclined in the direction of the slip face in the downwind side (pit I). The strata in the upwind side (pit II), however, are inclined in the opposite direction (Fig. 6). Because of this, we conclude that the Kangasjärvi dune is a parabolic blowout dune. The excavation pit III which was dug also in the upwind side of the dune, however, shows strata dipping gently in the direction of the slip face (Fig. 6) suggesting that the dune has migrated at least in this area. Consequently, the Kangasjärvi dune may also be a subtype between a parabolic dune and a blowout dune (see McKee 1966:50; Aartolahti 1973:21).

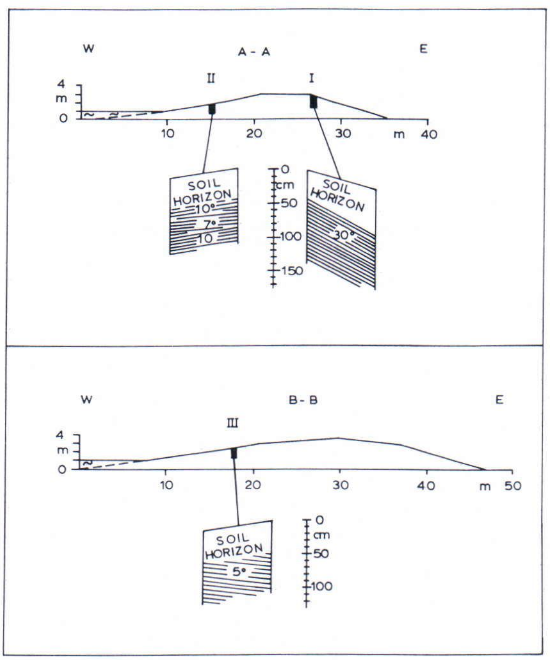

Figure 6. The stratification of the Kangasjärvi dune. The strata in the excavation pits (I...III) are drawn in a larger scale below the profiles.

Sediment

Grain size

The grain size composition of the dune sands was determined from four dry-sieved samples (Fig. 3). Two samples of glaciofluvial sediment (source sediment) were also examined for comparison. The results are shown as cumulative grain size curves plotted on a semilogarithmic diagram (Fig. 7). The grain size values (in mm) at the 90 % (P90), 75 % (Q3), 50 % (Md), 25 % (Q1) and 10 % (P10) levels were observed from each curve. These values were used in calculations which characterize the sorting of the sediment.

The dune sediment of Kangasjärvi is fine grained sand (Fig. 7). The grain size of the sand varies within narrow limits, from 0.05 to 0.5 mm. The median value (Md) varies between 0.12 and 0.17 mm and the arithmetic mean is 0.14 mm (Table 1). The diameter of the largest grain found was 3 mm (sample 1).

The dune sediment of Kangasjärvi is on the average finer grained than that of the coastal dunes and that of the inland dunes in Finland (see Seppälä 1969, 1971; Aartolahti 1973, 1976; Tikkanen 1981; Heikkinen & Tikkanen 1987). The average median grain size of the North Karelian dune sediment, however, is near the corresponding value of the dune sediment of Kangasjärvi

Table 1. Median grain size and sorting values of the dune sediment (1...4) and those of the source sediment (5 and 6).

sample	Md mm	So	Sk	K
1	0.17	1.39	1.10	0.22
2	0.12	1.37	1.06	0.26
3	0.15	1.43	0.91	0.29
4	0.12	1.50	0.93	0.29
5	0.09	1.51	1.03	0.21
6	0.13	1.52	0.88	0.28

(Lindroos 1972, Table 2). According to Seppälä's classification (1969:169) all the samples of Kangasjärvi are fine grained aeolian sands.

Two samples (5 and 6) were taken from the area to the west of the Kangasjärvi dune. These samples must represent the original glaciofluvial source sediment, because there were pebbles (ø up to 4 cm) near the ground surface in the same sediment and the samples were taken from below these pebbles. The grain size curves of these samples show that the source sediment of the dune is fine grained sand (Fig. 7). The median grain size of the source sediment (sample 5) is even lower than those of the dune sand samples.

One sediment sample was taken from the central deflation basin of the Kangasjärvi dune. The sample was also composed of fine grained sand and it did not contain any pebbles. Deflation ba-

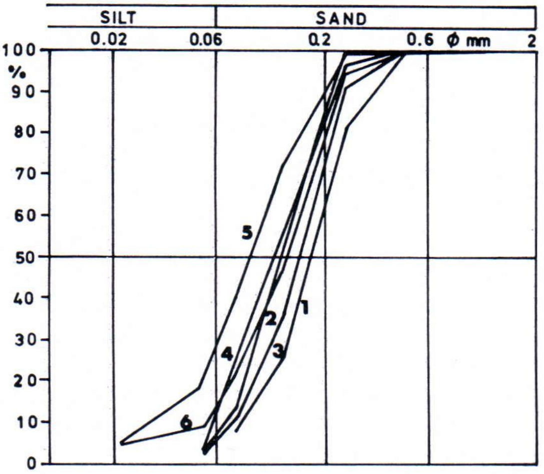

Figure 7. The grain size curves of the dune sediment (1...4) and those of the source sediment (5 and 6).

sins are generally characterized by a thin surface layer of coarse grained sand with small pebbles in it (Seppälä 1971:46, Aartolahti 1973:23, Heikkinen & Tikkanen 1987:249).

Sorting

The grain size curves (Fig. 7) show that the dune sediment is well sorted. The more vertical the curve is, the better the material is sorted. Three indexes which characterize sorting were calculated from the grain size values (Table 1).

Table 2. Average median grain size and sorting values of the Kangasjärvi dune sediment and those of other dune sediments in Finland.

	dune type	n	Md mm	So	Sk	K
Kangasjärvi	inland dune	4	0.14	1.42	1.00	0.26
Seppälä 1969	inland/coastal dunes	10	0.26	1.35	1.02	—
Seppälä 1971	inland dunes	50	0.20	1.32	0.99	0.27
Lindroos 1972	inland dunes	~100	0.16	1.36	0.93	—
Tikkanen 1981	coastal dunes	30	0.23	—	—	—
Heikkinen & Tikkanen 1987	coastal dunes	9	0.30	—	—	—

Sorting So $= \sqrt{\frac{Q_3}{Q_1}}$ (Trask 1932, Köster 1960)

Skewness or asymmetry Sk $= \frac{Q_3 \cdot Q_1}{Md^2}$

(Trask 1932, Köster 1960)

Kurtosis or peakedness K $= \frac{Q_1 - Q_3}{2 \cdot (P90 - P10)}$

(Krumbein & Pettijohn 1938)

The sorting varies between 1.37 and 1.50. The mean is 1.42. Therefore, the sediments are well sorted (sorting from 1.20 to 1.50; see Sindowski 1961:173, Seppälä 1969:169).

When the skewness is 1, then the grain size curve is symmetric about the median. When the skewness is greater than 1, then the fine fractions are better sorted than the coarse ones. When the skewness is below 1, then the coarse fractions are better sorted than the fine ones: the fine fractions dominate in the sediment (Seppälä 1971:48). The skewness of the Kangasjärvi dune sediment varies between 0.91 and 1.10. The mean is 1.00. Therefore, the fine and coarse fractions are on the average equally well sorted. In general, the skewness of dune sediment is slightly below 1 (see Reineck & Singh 1980:137, Table 2).

If the kurtosis is high, then the tails of the grain size curve lying outside the quartiles (Q_1 and Q_3) are short, while if the kurtosis is low, then the tails of the curve are long and the curve is gently curving (Krumbein & Pettijohn 1938:238—239, Seppälä 1971:48—49). The kurtosis of the Kangasjärvi dune sediment varies between 0.22 and 0.29. The mean is 0.26. The kurtosis is nearly as large as that of Seppälä's (1971) material (Table 2).

The source sediment in Kangasjärvi is on the average less well sorted than the dune sediment. The skewness and the kurtosis of the source sediment, however, vary between the same limits as those of the dune sediment (Table 1).

The silt content should also separate aeolian sediments from non-aeolian sediments. The source sediment (samples 5 and 6) contains more silt than the dune sediment which confirms that the dune sediment is better sorted than the source sediment (Fig. 7).

The average median grain size and sorting of the source sediment suggest that it has not been sorted by wave action. Neither has the dune sediment been sorted by wave action. The average beach ridge and shore dune sediments have higher median grain sizes and lower sorting values than the samples from Kangasjärvi (e.g. Aartolahti 1972:21, 1973:20) (Table 2).

Mineral composition

The mineral composition and the roundness of the sand grains of samples 1 and 5 were examined under the microscope. Sample 1 represents the dune sediment and sample 5 the source sediment. The sand grains were taken from the 0.5 to 1.0 mm grain size fraction. The mineral compositions are shown in Table 3.

The dominant light-coloured mineral in both samples is quartz accompanied by lesser amounts of plagioclase and alkalifeldspar. The most abundant dark-coloured mineral in both samples is biotite with lesser amounts of amphiboles. Both samples have also polylithologic rock fragments. The dominant minerals in these fragments are either quartz and biotite or quartz and plagioclase reflecting the composition of granodiorites in central Finland (see Wilkman 1938).

If the wind abrades and sorts the mineral grains effectively, the mineral composition of the dune sand should differ from that of the source sediment. If the wind blows strongly for a very long time, the amount of quartz in the windblown sediment should increase and the amount of feldspars decrease. Because of this change in mineral composition, a dune sand is said to be more mature than its source sediment (see e.g. Pettijohn 1975:491—493). The dune sediment of Kangasjärvi contains slightly more quartz than the source sediment. The amounts of feldspars and dark-coloured minerals are nearly identical in both sediments. The dune sediment has less rock fragments than the source sediment. Lin-

Table 3. The mineral composition of the dune sediment and that of the source sediment from Kangasjärvi.

	Dune sediment				Source sediment			
	sample 1			Lindroos 1972	sample 5			Lindroos 1972
Light-coloured minerals								
quartz	332	62%			287	55%		
plagioclase	58	11%	74%	67%	61	12%	69%	60%
alkalifeldspar	3	<1%			9	2%		
Dark-coloured minerals								
biotite	29	5%			32	6%		
muscovite	4	<1%	8%	5%	7	1%	10%	4%
others	12	2%			13	3%		
Rock fragments	97		18%	28%	110		21%	36%
Total	535		100%	100%	519		100%	100%

droos (1972) has obtained similar results from North Karelia (Table 3).

The best way to express the change in the mineral composition from the source sediments to the dune sands is by comparing the quartz/feldspar ratios in them (see Pettijohn 1975:491—493). This comparison is appropriate because ultimately both sediments originate from the same feldspar-rich plutonic rocks. The quartz/feldspar ratio of the Kangasjärvi dune sand (5.2) is higher than that of the source sediment (3.9) indicating that it is a more mature sediment. These differences in the degree of maturity of the two sediments become more evident, when the above ratios are compared with those of mineralogically similar sedimentary rocks, namely, sandstones (Pettijohn 1975:491—493). The dune sediment has a quartz/feldspar ratio close to that of an average sandstone (5.8) whereas the source sediment has a quartz/feldspar ratio between an average sandstone and an average arkose (1.1).

The mineral compositions and the calculated ratios show that the winds have only lightly abraded and sorted the sand grains of the Kangasjärvi dune sediment. Therefore, it is probable that the formation of the dune was of relatively short duration and that the dune sediment has travelled only a short distance.

Roundness of the mineral grains

Quartz grains are usually the only mineral grains which are examined when the degree of wind abrasion of mineral grains is estimated. According to Cailleux (1942:109), however, quartz grains must be abraded by aeolian processes for a very long time before most of them become fully rounded. In addition, Kuenen (1960) thinks that the quartz grains must be carried by the wind for hundreds of kilometers before they are completely rounded (cit. Seppälä 1969:177).

In Finland, dune sediment has generally been blown by wind only for short distances (e.g. Lindroos 1972:74, Aartolahti 1973:50). Therefore, quartz grains should not be solely used when the effectiveness of aeolian processes is estimated (cf. Seppälä 1969, 1971). Mineral grains which are less resistant to wear will probably show more distinctly the rounding effect of short-term aeolian processes. Lindroos (1972:39) has also set forth the same idea.

In Kangasjärvi, the roundness of quartz grains in the dune sand does not differ from that of the source sediment; both sediments contain weakly and well rounded quartz grains. Neither are there any differences in the roundness of the other mineral grains nor in the roundness of rock fragments.

It is safe to conclude that the sand in the Kangasjärvi dune originates mainly from the nearby deflation basin. The wind did not abrade the mineral grains effectively because of the short travelling distance and the short time. The similarity in the mineral compositions of the dune sand and source sediment further supports these conclusions. The mineral grains, especially quartz grains, may have, at least partially, been shaped by other processes, such as glaciofluvial transport, prior to wind transport. According to Seppälä (1969:179) the shape and surface texture of dune sands are not necessarily of the same age as the enclosing dunes. In general, aeolian material contains mat quartz grains whereas shiny grains are typical of glaciofluvial and weathered material (e. g. Cailleux 1942, 1952). The samples of Kangasjärvi contain both mat and shiny quartz grains which also confirms the aforementioned conclusions.

^{14}C-dates

Three peat samples obtained from one of the cores were ^{14}C-dated (Fig. 3 and Fig. 8). One sample was taken from above the sand/peat boundary and the two other from depths characterized by major changes in pollen stratigraphy.

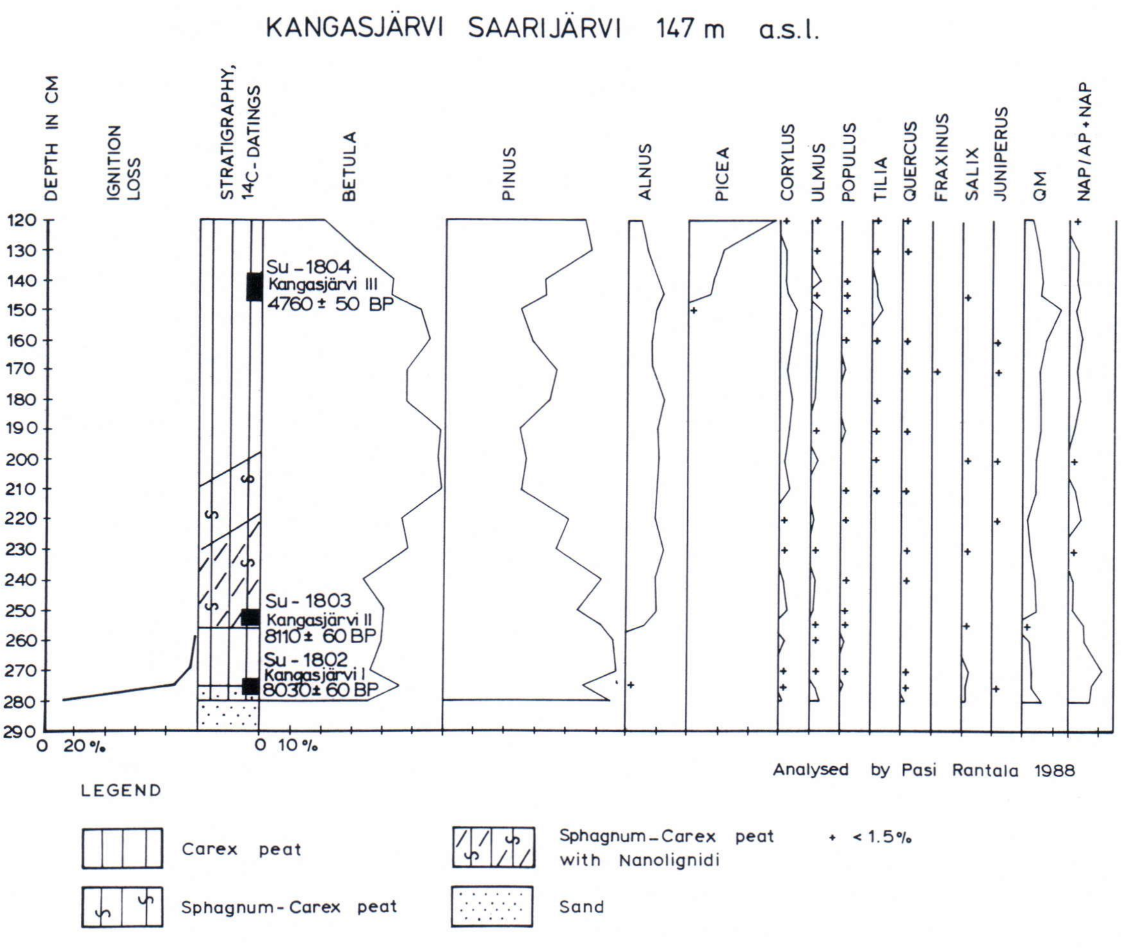

Figure 8. The pollen stratigraphy of the central bog of Kangasjärvi.

Accordingly, the lowermost sample (Su-1802/Kangasjärvi I: 8030 ± 60 years BP) should give the minimum age for the appearance of vegetation, the middle sample (Su-1803/Kangasjärvi II: 8110 ± 60 years BP) should date the appearance of alder (the Pinus/Betula-Alnus-Corylus-Ulmus -boundary of SW Finland) and finally, the topmost sample (Su-1804/Kangasjärvi III: 4760 ± 50 years BP) should correspond to the appearance of spruce (the Betula-Alnus-Corylus-Ulmus/Picea-Pinus -boundary of SW Finland).

The ages of Kangasjärvi II and Kangasjärvi III samples are consistent with the Pollen Assemblage Zone -boundary ages given by Ristaniemi (1987:24—26). The age of Kangasjärvi I sample, however, is questionable in two ways. First, the Kangasjärvi I sample is younger than the pollen data suggests. Second, the Kangasjärvi I sample is of the same age or younger than the Kangasjärvi II sample. These discrepancies could have been caused by contamination during the Kangasjärvi I sampling and/or root penetration (see Olsson 1979:13) which is typical of Carex peat. In spite of these problems, the appearance of vegetation is probably older than 8000 years BP as the pollen data (Pinus Assemblage Zone of SW Finland) suggest.

Origin

The study area became free of ice during the final phase of the last Weichsel glaciation (9600...9500 years BP) (Ristaniemi 1987:Fig. 30). The highest shoreline of the Baltic Sea in the study area was wave-built during the Yoldia stage and it is now at 163 m a.s.l. based on the level of an esker delta located nearby. The Ancylus limit is slightly above 155 m a.s.l. (Ristaniemi 1987:49 and his appendix I).

The level of the sand plain under the dune lies slightly below 150 m a.s.l. and, consequently, it is about 15 m below the highest shoreline of the Baltic Sea and perhaps 8 or 9 m below the Ancylus limit. Calculations made with the aid of the shoreline displacement curves of Ristaniemi (1987:Fig. 73) show that the sand plain must have risen above the level of Ancylus Lake around 9400...9350 years BP. Central Finland became free of ice at the same time except for its westernmost and northernmost parts (Ristaniemi 1987; Mäkelä 1988).

When dune formation began in the Kangasjärvi area, the retreating ice margin was only less than one hundred kilometers to the northwest. Because of the high air pressures above the ice sheet, strong winds blew almost continually towards the drying sand plain. The prevailing periglacial climate was also in other respects favourable for dune formation. It was dry and cold and, therefore, vegetation was sparse and slowly growing. According to Aartolahti (1976:91) most of the largest dunes in Finland were formed during the Ancylus Lake stage.

After the sand plain rose above the water level of Ancylus Lake and dried enough, the wind began to deflate the unvegetated sand surface. This wind action was probably most effective during the summer when the ground was not frozen. Gradually, large deflation basin developed in the sand plain and the windblown sand was deposited at the margin of the deflation basin to form the dune.

The growing dune was eroded by the wind until it was stabilized and finally bound by vegetation at its present location.

Because the wind could lift and remove only dry sediment, the depth of deflation was controlled by groundwater. The deepest point of the deflation basin is now about three metres below the groundwater table. This value is estimated from the level of water in a nearby lake. If one assumes that the deepest depressions (possible kettle holes) were eroded by aeolian processes, then the Preboreal groundwater table must have been at least five meters below the present groundwater table. Seppälä (1971:19) has also set forth a similar estimation.

The position of the dune to the east of the deflation basin, the nearly parabolic shape, the asymmetry of the dune head and the dips of the strata indicate that the dune sediment was deposited by winds from west and northwest (e.g. Jennings 1957, Seppälä 1971:75). The dune is located in a region where winds are known to have blown from the northwest during the early phases of dune building period (see Aartolahti 1976:Fig. 7). With time, the wind directions may have changed gradually and by the end of the period, winds blew probably from the west.

Because the Kangasjärvi dune has retained a roughly parabolic shape, it was probably gradually vegetated during its formation. According to Seppälä (1971:74), the parabolic shape of the Enontekiö dunes indicates that they were partly vegetated during their formation. Also McKee (1966) believes that the arms (≃ dune ridges) of parabolic dunes are anchored by vegetation, which slows down the movement of the arms while the central parts of dunes (≃ dune heads) move faster forward. If the dune forming processes had lasted longer in Kangasjärvi, then two parallel dune ridges would have formed instead of the parabolic blowout dune (e.g. David 1981). Therefore, the favourable conditions for the dune formation must have prevailed only for a relatively short time: from the drying of the sand plain to the appearance of the vegetation cover.

The primary deflation forms of the Kangasjärvi dune were formed during the Preboreal chron. Secondary deflation has not taken place after that, not even during the Little Ice Age (500...300 years BP) (cf. Aartolahti 1976:91). This is shown by the well developed soil horizons which in Finnish climate take at least from 500 to 1000 years to develop (Aaltonen 1952:70, Jauhiainen 1972). The dune has no signs of forest fires (ash layers), human activities or other physical changes which could have provoked secondary deflation of the dune (cf. Seppälä 1971:28).

The parabolic blowout dune of Kangasjärvi is presently densely vegetated (e.g. pines, heathers, lichens). The deflation basin is paludified. According to the ^{14}C-dates, the most active growth of peat took place during the humid Atlantic chron probably because groundwater table began to rise then.

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