DEPARTMENT OF THE INTERIOR
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PERIGLACIAL SAND DUNES AND EOLIAN SAND SHEETS
AN ANNOTATED BIBLIOGRAPHY

by

Augusta C. H. M. Niessen
Eduard A. Koster
Physical Geography and Soil Science Laboratory
University of Amsterdam
Dapperstraat 115
1093 BS Amsterdam
The Netherlands

and

John P. Galloway
U.S. Geological Survey
345 Middlefield Rd.
Menlo Park, CA 94025

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ABSTRACT

This bibliography selectively summarizes investigations published between 1950 and 1981 dealing with the formation of eolian sand deposits under both fossil (Quaternary) or recent periglacial conditions. The main criterion for inclusion of studies in the bibliography is the occurrence of one or more key words (indicated below) in the title. Publications before 1950 are excluded, as well as studies published in languages other than English, French or German. Completeness of the bibliography has been strived for, but for the fossil periglacial domain of North America and Europe a selection of the most significant publications proved to be necessary. Therefore only those publications in which aspects of dune formation or eolian sand deposition form a substantial part have been annotated.

INTRODUCTION

"Cold climate" or "periglacial" eolian features are either disregarded or only briefly indicated in most textbooks which deal with eolian geology and geomorphology. To a lesser extent this also applies to textbooks on glacial, periglacial or Quaternary geology and geomorphology. (Flint, 1971; Tricart, 1975; French, 1976; Embleton and King, 1975; Washburn, 1979). Emphasis is usually placed on the role of the Pleistocene eolian phenomena for the reconstruction of Quaternary stratigraphy. For a better understanding of the depositional conditions and processes involved an obvious step is to look for recent analogues. However, the information on eolian processes and deposits in present-day periglacial environments is still scarce and scattered in publications not always easily obtainable. The rapid increase in knowledge of the periglacial domain - especially with the aid of airphoto interpretation - indicates the occurrence of eolian deposits throughout many "cold climate" regions is significantly more widespread than previously thought.

This bibliography evolved from a meeting of the Coordinating Committee for Periglacial Research of the International Geographical Union (now the IGU Commission on the Significance of Periglacial Phenomena) at the Xth Congress of the International Association for Quaternary Research (INQUA) in 1977, where M. Seppälä (University of Helsinki) and E. A. Koster (University of Amsterdam) proposed the formation of a working group on periglacial sand dune studies.

Seppälä (1975) declared: "In those regions of the northern hemisphere which were in the immediate vicinity of Quaternary glacial areas or even in actual glaciated areas themselves large dune fields are often to be found. Nowadays the dunes are mostly anchored by vegetation. These dune areas have long attracted the attention of scholars. Among those who have produced considerable works of this area special mention should at least be made of Högbom (1923) and Poser (1948, 1950) in Europe and of Black (1951) and Bird (1967) in North America. Because of the large areas involved, their work has been largely based on maps and photographic materials. No scholar working on his own can hope to provide an explanation of such phenomena, covering as they do whole continents, by means of field work. For this reason, but also because new research methods have made it possible to approach dune problems from completely new angles, I have given some thought to the ways in which an international research project might be set up to cover the whole region where periglacial dune fields are encountered. The final aim is to arrive at an explanation of the origin of periglacial dunes on a worldwide basis and to draw certain conclusions as to the paleo-climatic conditions existing at the time they were formed and as to changes occurring in the Quaternary period..." This bibliography represents a first step towards the formation of a working group on periglacial sand dune studies.

Helpful counsel during the course of the literature survey was provided by M. Seppälä (University of Helsinki), P. Tieleman (University of Amsterdam), P. Clinton (Memorial University, St. John's, Newfoundland), H. G. R. King (Scott Polar Research Institute, Cambridge) and many other colleagues and institutions.

DESCRIPTION OF THE BIBLIOGRAPHY

The papers listed in this bibliography were located by manual library techniques and by repeated literature searches at two data bases ("Georef" and "Geoarchive"). The main criterion for inclusion of a paper in this bibliography is the occurrence in the title of the key words: cold or arctic desert, cover sand, dune sand, eolian deposit or eolian sand, niveo-eolian deposit or niveo-eolian sand, periglacial environment, sand dune, sand sheet or sand sea. The choice of these key words indicates that only literature concerning eolian sand transport and sedimentation is reviewed.

The geographic foci of the compiled literature are those regions of the northern hemisphere which were in the vicinity of Quaternary Fennoscandian or North American ice sheets as well as the actual "cold climate" or "periglacial" regions. A few references regarding non-glaciated areas in Antarctica have been annotated. In North America the southern limit of Pleistocene dune and cover sand occurrences lies somewhere between the present-day mean annual isotherms of 12.5^{o} and 15^{o}C; and in Northwestern Europe between the present-day 7.5^{o} and 10^{o}C isotherms. Within Europe these isotherms more or less indicate the maximum extent of the Pleistocene ice sheets.

To the south of this European "sand belt" a large zone of silt[1] and loess[2] deposits occur. The eolian processes responsible for the loess and silt deposition and their geomorphology are different from those related to eolian sand transportation and deposition. Therefore the literature dealing with loess and silt deposits has not been dealt with in this bibliography. In the western part of the European "sand belt" (Belgium, The Netherlands, Federal Republic of Germany) extensive inland dune areas exist, which were formed by Late Holocene resedimentation of older terrestrial sand deposits under temperate conditions. Although it is not always easy to make a distinction between these eolian sand formations and those of a periglacial nature, they have not been treated in the bibliography.

Due to their magnitude the following subjects are regarded as topics on their own and therefore excluded from this bibliography:

1) Eolian phenomena directly related to present-day or former coastlines.
2) Eolian phenomena resulting from wind corrasion (the polishing and scouring of rock or soil surfaces by wind-carried grains) like desert pavements (armoured surfaces composed of angular or rounded fragments, usually one or two stones thick, set on or in matrices of finer material) and ventifacts (faceted and polished stones).
3) Geomorphological features caused by deflation (the winnowing out of sand and dust and their transportation) like rofbards (Icelandic word for mushroom-shaped, vegetated islands).
4) Geomorphological features caused by deflation and subsequent erosion by running water like coulees (a short, often straight, narrow, comparatively steep valley tributary to one of the perennial streams, initiated on windward, topographic surfaces by wind-driven snow or rain and enlarged by running water (Beaty, 1975).
5) All consolidated rocks which have initially been deposited by the wind (eolianites).

Although the literature on eolian features on Mars has greatly expanded, the results are still too inconclusive to be described in this bibliography. For an excellent reference on Martian eolian deposits see Breed and others, 1980.

Those papers or books written in a language other than English, French or German without a summary or abstract in one of these languages are excluded. Certain papers which were not fully indexed or only appeared as thesis or congress and symposia proceedings were also excluded. A weakness common to most summaries of periglacial topics is inadequate coverage of the Russian and Polish literature. This is partly remedied here by including a small selection of Polish papers which included an English, German or French summary.

Regional studies of fossil eolian sand dunes and sand sheets occurring within the formerly glaciated parts of North America and Europe are too numerous to be treated in detail here. A selection of the most significant papers giving an overall picture of larger regions was necessary. Reference should be made to R. Galon (1959, 1969) concerning the great number of relevant Polish studies for the majority of these publications are not included in this bibliography.

Comprehensive studies published before 1950 dealing with eolian phenomena are also excluded (Solger, 1910; Samuelsson, 1926; Enquist, 1932; Cailleux, 1942). In spite of the fact that none of the key words mentioned above occurred in the title a few studies in which the "eolian section" proved to be of great importance were annotated. General papers or manuals on glacial and periglacial environments are excluded from the annotated bibliography.

Annotations are regionally arranged, with each region arranged alphabetically by author. In several instances all or part of the author's summary or abstract is used. Where no summary or abstract was available an annotation was compiled. Abstracts and annotations are followed by a list of key words, based on the subjects described in the title or annotation. For the sake of brevity geographic terminology in the titles or in the annotations is not repeated in the key words.

The subject index (appendix I) to the bibliography keys the papers to several subject categories based on key words. In most cases the subjects are geographically subdivided. The study is concluded by an author index (appendix II).

AREAL EXTENT AND DISTRIBUTION

The areal distribution of the major sand seas and dune fields described in the bibliography is roughly indicated in figures 1 and 2. Extensive Weichselian eolian sands, (inland dunes and cover sands), occur in the "sand belt" of the West- and Central European Lowlands of which Poland forms the easternmost investigated part and the classical "cover sand region" of The Netherlands and Belgium form the westernmost part (Keilhack, 1917; Kádár, 1938; Poser, 1948, 1950; Maréchal and Maarleveld, 1955; Ducker and Maarleveld, 1958; Galon, 1959; Maarleveld, 1960; de Jong, 1967; Galon, 1969; Pyritz, 1972; Pissart, 1976; Nowaczyk, 1976; and Koster, 1982). Inland dunes and cover sands in this region cover an area in the order of several tens of thousands of square kilometers. This "sand belt" continues into the Baltic Republics of the U.S.S.R.

Eolian sediments of periglacial origin occupy only small areas in the central and eastern parts of Great Britain (Perrin and others, 1974; Williams, 1975; Catt, 1977). Periglacial inland dunes in France are rare.

The distribution of dune areas in Fennoscandia corresponds closely with that of unprotected glacial, fluvioglacial and fluvial deposits, which in certain cases were reworked by the sea. Högbom (1923) gives an overall picture of inland dunes in Fennoscandia. The largest and best developed dunes in Denmark are found scattered throughout Jutland (Hansen, 1965); in Sweden they are found in the central and northern parts (Bergqvist, 1981); in Norway they occur in the southern and central parts and in Eastern Finnmark (Klemsdal, 1969); in Finland large inland dunes occur in Karelia, Central Finland and Finnish Lapland (Lumme, 1934; Seppälä, 1971; Lindroos, 1972).

The map "Periglacial eolian deposits in the United States, Alaska and parts of Canada" by Thorp and Smith (1952) provided a review of dune occurrences in the United States as they were known at that time. Dune occurrences in the United States which meet the requirement for periglacial origin are widely but sparsely distributed. Large dune areas have been described from Nebraska, Wyoming and Colorado (fig. 2), covering many tens of thousands of square kilometers (Smith, 1964; Wright and Frey, 1965). Smaller areas of eolian sand occur in various parts of New England.

Dune sand is widely distributed in Alaska, but for the most part has been studied only in an exploratory or reconnaissance fashion. Known localities were mapped and briefly described by Black in 1951, Fernald, 1964, Péwé and others, 1965, and Péwé , 1975. Large areas with stabilized dunes occur along the Tanana, Kuskokwim, Yukon and Koyukuk Rivers, covering approximately 20,000 km^2. Large dunes cover 7,000 km^2 in the Arctic Coastal Plain (Carter, 1981).

In Canada, nearly half the dune fields are located in Alberta. Large areas of eolian deposits also occur in Saskatchewan and Manitoba (David, 1977; 1979). Today most of the Alaskan and Canadian dune fields are stabilized and generally restricted to areas which contain glacial, fluvioglacial and fluvial deposits.

Although in Iceland deflation is a major phenomenon actual dune fields rarely occur (Preusser, 1976). Sand dunes and sand deposits in arctic deserts in Greenland and Spitsbergen are rare and exist only in connection with rivers (Fristrup, 1952/53; Czeppe, 1966; Hansen, 1970). In the southern hemisphere actual periglacial eolian deposits are restricted to the ice-free valleys of southern Victoria Land (Selby and others, 1974; Calkin and Rutford, 1974).

[1]silt: an unconsolidated clastic sediment, most of the particles falling within the range of 1/16 mm (62.5 um) to 1/256 mm (3.9 um) in diameter.

[2]loess: an essentially unstratified, homogeneous and unconsolidated eolian deposit of light yellow color, consisting predominantly of silt size grains, but with minor amounts of fine sand and clay.

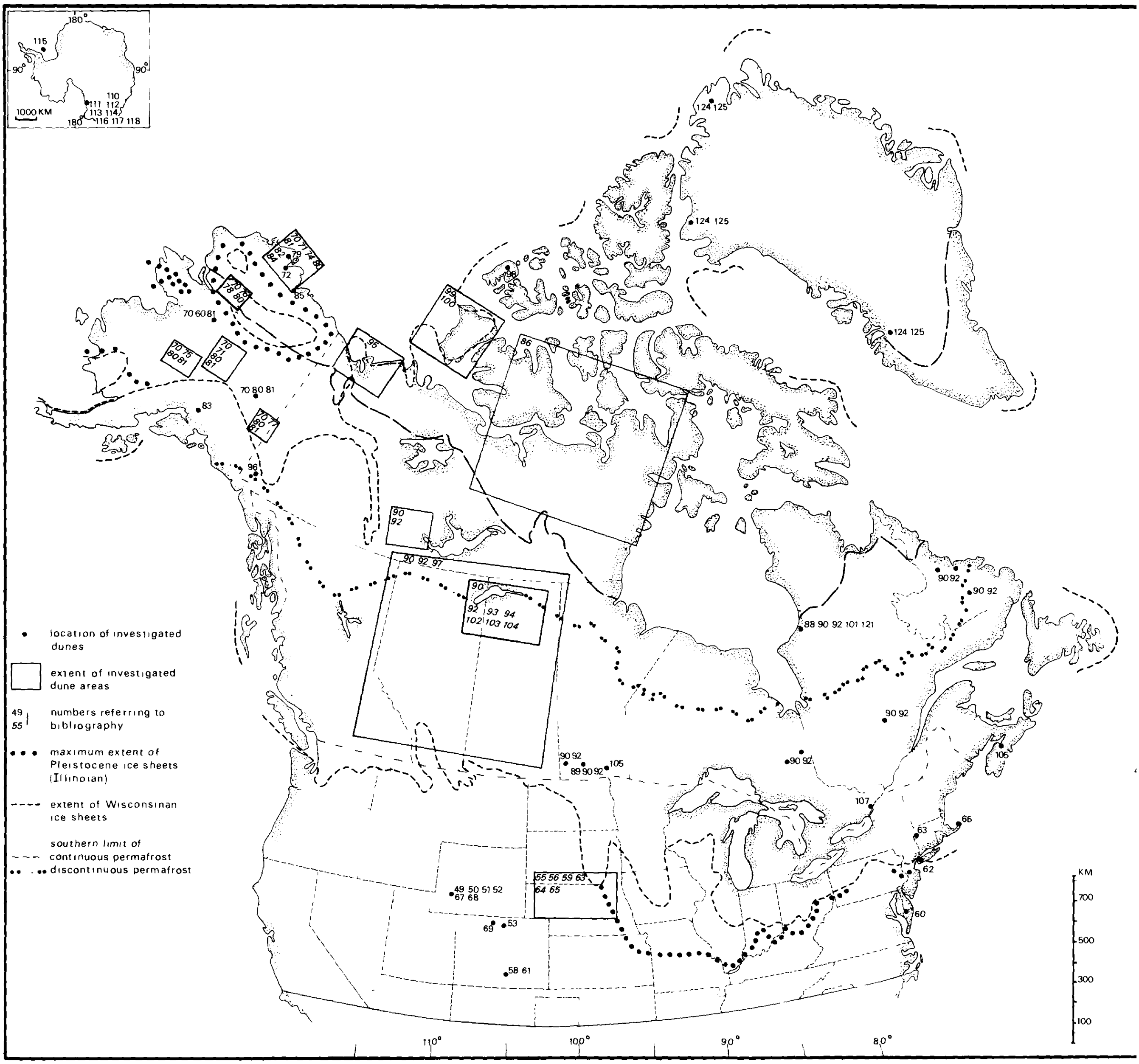

Figure 2. Areal Distribution Map - North America

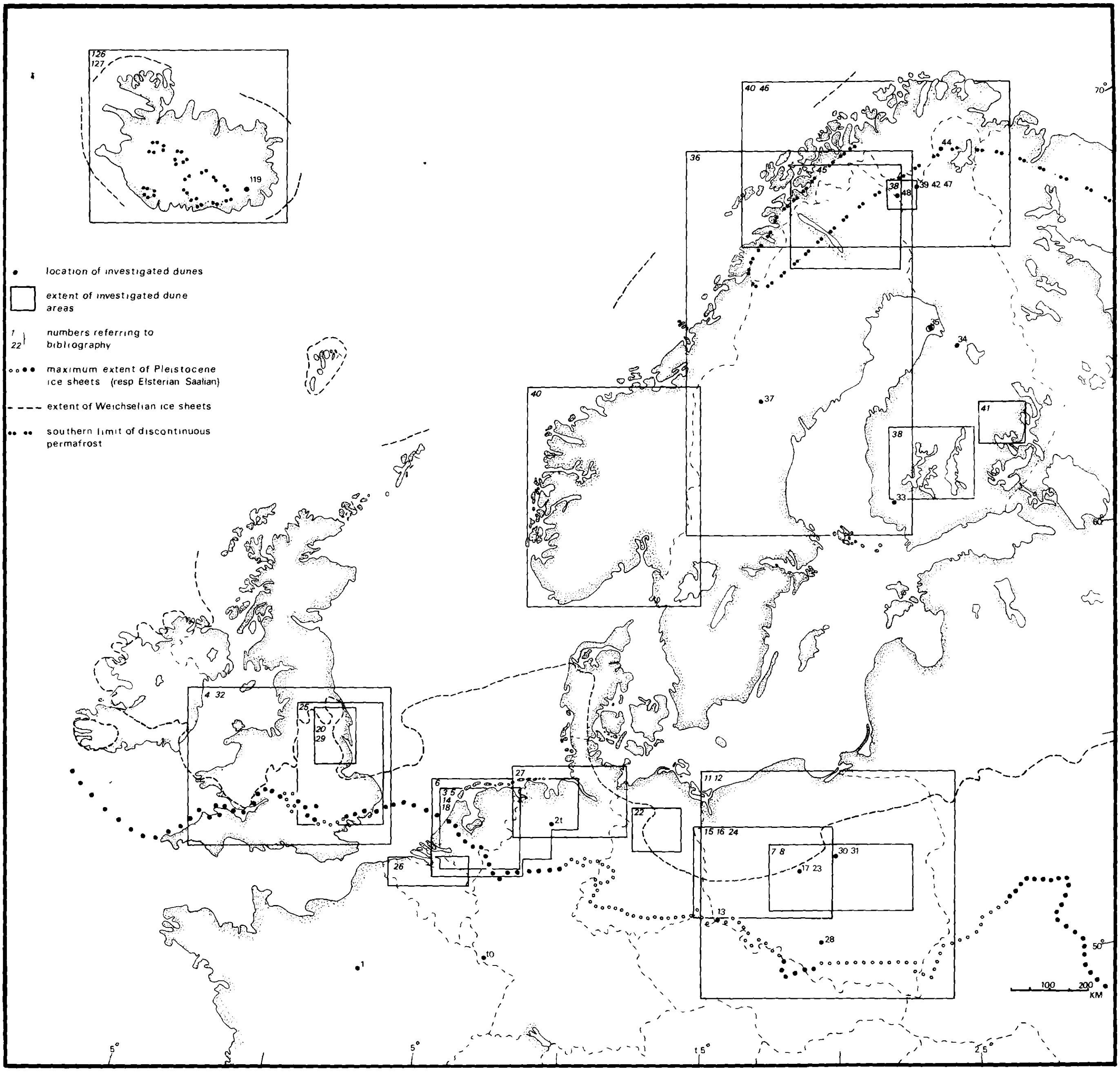

Figure 1. Areal Distribution Map - Europe

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1. Allier, C., 1966, Formation et évolution d'une dune continentale en forêt de Fontainebleau: Revue de Géomorphologie dynamique, v. 16, no.3, 101-113, 5 figs., 21 refs.

   The observation of dune-like undulations in the "Flats" of Fontainebleau Forest near Paris, France, reveals a deposit of sand topping a substratum with a high grade of gravel. These dunes resulted from the sorting of sand on the surface of the substratum after the ice age but before any vegetation appeared. The ultimate stabilization of the dunes by vegetation, which presumably was the pinewood of the boreal period (8,000 B.P.), caused the appearance of a characteristic half-humic, half-ferrugineous podzol over the whole surface of the dune field. This podzol was partly destroyed after the forest was burned down 2000 years ago. Erosion of bare sand caused localized deposits in which a less atypical podzolic soil formed. The dunes were eroded in some places approximately a century ago, and at these sites soil formation is hardly discernible. Eolian abrasion is now still going on in places. (author, modified)
   Key words: dune development, soil formation, stabilized inland dunes.

2. Cailleux, A., 1969, Quaternary periglacial wind-worn sand grains in U.S.S.R., in Péwé, T. L., ed., The periglacial environment, past and present: Montreal,McGill-Queens University Press, p. 285-301, 1 fig., 3 tables, 41 refs.

   Beyond the maximum extent of the Würm-Valdai-Wisconsin glaciation, in a belt 500 to 1000 km wide, there occur many rounded-dull, wind-shaped grains of quartz which show that during cold Quaternary phases great areas with no vegetation existed as periglacial deserts. This periglacial northern European belt is known to extend to Moscow and Gorki, and from there north to the Timan Mountains near the Barents Sea. In Fennoscandia these grains are not found due to the rapid immigration of vegetation after deglaciation. Strong periglacial wind action also ocurred in those parts of Siberia that must have been partly desertic during several Quaternary phases. (author, modified)
   Key word: grain surface features.

3. Cate, J. A. M. ten, Koster, E. A., Meer, J. J. M. van der, and A. A. de Veer, 1981, Maarleveld and his significance to physical geography. A review of the published works of Prof. Dr. G. C. Maarleveld, dedicated to him on his retirement from the University of Amsterdam: Koninklijk Nederlands Aardrijkskundig Genootschap Geografisch Tijdschrift, v. 15, no. 5, p. 377-400, 6 figs., 1 table, 40 refs.

   One of the major topics that appears throughout the list of publications of Maarleveld is that of geomorphology, including the genesis and chronology, of eolian deposits within The Netherlands. More than twenty publications cover some aspects of cover sand morphology and stratigraphy. Besides geomorphology, genesis and age of the different cover sand forms, Maarleveld studied the prevailing wind direction during their formation. (see: Eolian deposits, p. 386-388, 1 fig., 1 table)
   Key words: cover sands, eolian phases, paleowinds.

4. Catt, J. A., 1977, Loess and cover sands, in Shotton, F. W. ed. British Quaternary studies; recent advances: Oxford, Clarendon Press, p. 221-229, 1 fig., 42 refs.

The areal distribution of cover sands in England and Wales is shown and the relevant literature is reviewed. Most of the cover sands in Lincolnshire, Yorkshire and Lancashire are equivalent in age to Younger Cover Sand II of the Netherlands. Older Cover sands occur in East Anglia.
Key words: areal distribution, cover sands.

5. Crommelin, R. D., 1964, A contribution to the sedimentary petrology and provenance of Young Pleistocene cover sand in The Netherlands: Geologie en Mijnbouw, v. 43, no. 9, p. 389-400, 2 appendices, 1 fig., 1 table, 13 refs.

In The Netherlands Young Pleistocene cover sands represent one of the most characteristic surficial sediments. The aim of the investigation was to examine the mineralogy of Young Pleistocene cover sands as related to their depositional environment and specifically to study the interrelationship between subsurface, Older and Younger cover sand, in terms of heavy mineral composition. Seventy-five profiles over the total cover sand area were sampled in pairs. Heavy mineral analyses were confined to the 210-150 micron fraction so as to minimize confounding provenance and grain size effects. The results permit a subdivision into three distinct regions, each showing a characteristic heavy mineral composition which appeared to be closely related to the mineralogy of the subsurface. Hence local provenance of the cover sand formation is advocated, "local" being taken in the opposite meaning to "conveyed over a long distance" as would be the case if the North Sea Basin was taken as the source area. The relation between Older and Younger cover sand was tested by the two-way analysis of variance method. Within the three regions there is often very significant locality contrast, whereas the stratum contrast is usually not significant. Local reworking of Older cover sand gave rise to Younger cover sand. (author, modified)
Key words: cover sands, mineral composition.

6. Dücker, A. and Maarleveld, G. C., 1958, Hoch- und spätglaziale äolische Sande in Nordwestdeutschland und in den Niederlanden: Geologisches Jahrbuch, Band 73, p. 215-234, 8 figs., 5 tables, 32 refs.

Based upon textural and structural properties of the cover sands, their areal extent and morphology in Schleswig-Holstein and Niedersachsen (German Federal Republic) it can be stated that their sedimentation began during the Weichselian Pleniglacial and lasted until the beginning of the Holocene. As in The Netherlands the interstadial Allerød soil horizon is well developed throughout the investigated area.
Key words: areal distribution, cover sands, eolian phases, grain size.

7. Dylik, J., 1969, L'action du vent pendant le dernier age froid sur le territoire de la Pologne Central: Biuletyn Peryglacjalny, no. 20, p. 29-44, 3 figs., 5 photos, 42 refs.

During a large part of the last cold age, at least during its climax, Central Poland was an area in which wind erosion and deflation were important. Windworn stones and sand grains indicate a strong eolian activity. A lowering of the permafrost table, during the Older Dryas, promoted

intensive water infiltration and consequently drying up of the surface. Under such conditions increasing eolian activity initially deposited sand sheets and later formed dunes of various forms. Grain surface features (eolian sands) are analized from Brorup interstadial to the beginning of the Holocene. The chronology of wind activities in the cold desert of Central Poland was almost the same as it was in the loess area of the southern Polish uplands. (author, modified)
Key words: cover sands, deflation, grain surface features, stabilized inland dunes.

8. Dylikowa, A., 1964, Les dunes de la Pologne Centrale et leur importance pour la stratigraphie du Pleistocène tardif: Report of the VIth International Association for Quaternary Research (INQUA) Congresss, v. IV: Periglacial Section, Lodz, 1964, p. 67-80, 2 figs., 1 table, 31 refs.

The development of inland dunes in Central Poland began in Older Dryas time and was the most important phase of eolian sand movement. A second phase of eolian sand transport consited of modification of existing dunes and lasted through the Younger Dryas, whereas a third, destructive, phase took place during the Holocene. Dune-building was not exclusively the result of eolian processes, but niveo-eolian processes also played an important role.
Key words: eolian phases, stabilized inland dunes.

9. Edelman, C. H., 1951, Niveo-eolische afzettingen (with a summary: Niveo-eolian deposits): Geologie en Mijnbouw, v. 13, no. 9, p. 288-300, 27 refs.

F.A. van Baren (1934) was the first to call attention to the veil of rather uniform sand covering most of the lower and middle Pleistocene sand deposits in The Netherlands. Further examinations made it clear that these cover sands were mainly due to wind action during a periglacial climate. As, however, melting snow will have played a role under periglacial conditions the term "niveo-eolian" has been proposed by Prof. Dr. V. van Straelen to indicate these deposits. A selected list of the more important references bearing on this subject is given. (author)
Key words: cover sands, niveo-eolian deposition.

10. Edelman, C. H., and Zandstra, K. J., 1956, Niveo-äolische Sande im Saargebiet. Koninklijke Nederlandse Academie van Wetenschappen-Amsterdam, Reprinted from Proceedings, Series B, v. 59, no. 3, p. 253-258, 2 figs., 6 refs.

Late Pleistocene periglacial conditions were responsible for the disintegration of the Middle Buntsandstein in the region of the Saar River, Western Germany. There were periods in which snow drifting dominated. Finely layered niveo-eolian sands were deposited along steep, dry valleys, on plateaus and in depressions, reaching a thickness of a few meters. Outside the Buntsandstein region niveo-eolian deposits more than 10 meters thick are found along rivers. The deposits can be grouped into cryoturbated deposits interlayered with loamy beds dating from the Pleniglacial and Late-Glacial before the Allerød interstadial, and other eolian deposits dating back to the Younger Dryas.
Key words: cover sands, niveo-eolian deposition.

11. Galon, R., 1959, New investigations of inland dunes in Poland: Przeglad Geograficzny, v. 31, Supplement, p. 93-109, 10 figs., 17 refs.

Galon presents a critical review of existing dune literature. In Poland an abundance of inland dunes occupy vast areas of ice-marginal streams, outwash plains and sandy ground moraine. Dune types are either parabolic or slightly crescentic, transverse or longitudinal, whereas barchans are rare. Very numerous are dunes of irregular shape (dune hummocks) and reworked (destroyed) dune forms. Problems dealt with in nearly every paper on Polish inland dunes are shape and structure of dunes in relation to the prevailing dune-forming winds, and number of dune periods, i.e. the age of dunes. In general, three dune periods are distinguished: a) formation of fundamental forms, i.e. parabolic dunes after retreat of the Weichselian ice sheet till Boreal times; b) the period of destruction of parabolic forms, and the formation of linear and irregular dunes during the Subboreal; c) the modern period of deflation. Winds from westerly directions played a dominant part in dune formation. The older dunes may have been partly formed by easterly winds on the forefield of the inland ice during the last glaciation. In view of granulometric and petrographic investigations it appears that, as a rule, dune sand did not undergo long distance transportation, and they are derived from various sediments. Based on average grain sizes (between 200 - 400 microns) the prevailing velocity of dune-forming winds must have been 4 - 8 m per second. The coarse sand fractions in the lower series of the dunes have a dull appearance due to a greater intensity of eolian processes during the principal dune phase (a). In Polish dunes approximately 60% of the sand grains are rounded, while approximately 30% are semi-rounded. However, similar percentages are found in sands of other origin.
Key words: areal distribution, eolian phases, stabilized inland dunes.

12. Galon, R., 1969, Procesy i formy wydmowe w Polsce (Dune processes and forms in Poland): Instytut Geografii Polskiej Akademii Nauk, Prace Geograficzne, no. 75, Warszawa, 390 p.

This book contains the following publications each with an English summary: 1) Galon, R., On actual problematics about inland dunes in Poland; 2) Okolowicz, W., An attempt at characterizing climatic conditions of the period of inland dune development in Poland; 3) Dylikowa, A., Problematics of inland dunes in Poland in the light of structural examinations; 4) Kobendzina, J., The effect of vegetation upon formation of inland dunes; 5) Tobolski, K., Dune-forming stages in the light of palynological examinations - problems dealing with the number of stages and the characteristics of their history; 6) Prusinkiewicz, Z., The soils of inland dunes in Poland; 7) Schild, R., On the archaeological stratigraphy of the inland dunes; 8) Roszko, L., Some comments on dunes in the western part of Grudziadz Basin; 9) Chruska, Z., Evolutionary phases of a dune situated at Czernikowo-Witowaz; 10) Urbaniak, U., Disturbances in the stratification of dunes in the Plock Basin; 11) Rotnicki, K. and Tobolski, K., Main phases of dune-forming processes in Grabów Basin based on the stratigraphy of a dune at Weglewice; 12) Gawlik, H., Les éoliennes dans le Bassin de Szczerców; 13) Manikowska, B., Fossil soil from the Allerød interstadial on the background of deposits of the waning phase of the Würm in the Lódź region; 14) Bogacki, M., The dunes of the Kurpie plain; 15) Urbaniak, U., Problematics of dunes in Poland. Moreover, a Polish bibliography on dunes compiled by J. Kobendzina and U. Urbaniak is given.

13. Jahn, A., 1972, Niveo-eolian processes in the Sudeten Mountains: Geographica Polonica, v. 23, p. 93-110, 8 figs. 9 refs.

In this paper niveo-eolian phenomena as observed in the mountainous area of the Sudeten (Poland) with its well-developed agriculture are critically examined. Niveo-eolian processes cause to some degree a mechanical segregation of the soil material. While carrying off the snow, wind deflates from the soil only part of the material which is less than skeletal size (1 mm). Segregation and redeposition of a dirt admixture takes place by gradual concentration within the snow. The process of snow ablation leads to the formation of an ablation crust of dirt upon the snow. The quantity of dirt contamination acumulated during one winter in the Sudeten averages about 0.5 kg/m^2. This figure equals a lowering of the soil surface by 0.0027 mm.
Key words: deflation, grain size, niveo-eolian deposition.

14. Jong, J. D. de, 1967, The Quaternary of the Netherlands, in Rankama, K. ed. 1967. The Quaternary, vol 2, p. 301-426, 4 figs. 1 table , many references.

Periglacial conditions prevailing in The Netherlands during the Weichselian caused the deposition of a series of fine-grained eolian sediments (cover sands) as a blanket over the country. Only in the southernmost part was loess deposited. The sub-horizontally bedded cover sands occasionally contain interstadial peat layers, gyttja layers or loamy layers and paleosols like the well-known layer of Usselo of Allerød age. The cover sands occur as: sand fillings of broad, glacial depressions; a relatively uniform layer with a thickness of a few meters in flat areas; and sand ridges in high hilly areas. The Older cover sands, deposited in the Pleniglacial Weichselian, are of regional origin, and the Younger cover sands are largely formed as a result of reworking of Older cover sands in the Early and Late Dryas time. Eolian sedimentation in the Late Glacial (Weichselian) was mostly in the form of younger cover sand ridges. These ridges display a nice pattern of parabolic forms, open to the northwest, west and southwest. (see: Weichselian; Eolian deposits, p.362-370, 4 figs., 1 table)
Key words: areal distribution, cover sands, eolian phases, paleowinds, stabilized inland dunes.

15. Kozarski, S., 1978, Das Alter der Binnendünen in Mittelwestpolen, in Beiträge zur Quartar- und Landschaftsforschung: Festschrift zum 60 Geburtstag von Julius Fink. Verlag F. Hirt, Wien, p. 291-305, 2 figs., 1 table, 45 refs.

Four phases of eolian activity and/or dune formation in Central-West Poland are distinquished based on pollen analysis and radiocarbon measurements of organic deposits intercalated in eolian sands in the lee side of dunes, as well as on dated fossil soils and artefacts. The first three phases between the end of the Pleniglacial (Weichselian) and the beginning of the Holocene were influenced by climate and the last one resulted from man's activity. During the first phase at the end of the Pleniglacial the severe periglacial conditions favoured deflation processes and presumably the formation of barchan dunes. In the second phase (oldest Dryas and Bølling) initially eolian cover sands were deposited, afterwards the formation of longitudinal, bow-shaped and parabolic dunes took place. In the third phase (Younger Dryas) the largest and best-shaped inland dunes originated in Central-West Poland. In the Preboreal, like in the the Allerød interstadial, the eolian processes were interrupted by forest development. The very strong

intervention of man with the natural vegetation cover on dunes since the Atlantic period (Neolithic agricultural revolution) locally caused the renewal of eolian processes and redeposition of dune sands took place which resulted in the accumulation of new sand portions on the lee sides of dunes.
Key words: cover sands, eolian phases, stabilized inland dunes.

16. Kozarski, S., Nowaczyk, B., Rotnicki, K., and Tobolski, K., 1969, The eolian phenomena in West-Central Poland with special reference to the chronology of phases of eolian activity: Geographia Polonica, v. 17, p. 231-248, 8 figs. 40 refs.

Two main phases of eolian activity are distinguished in West-Central Poland; the older phase during the Oldest Dryas, Bølling and Older Dryas time, and the younger one during the whole Younger Dryas and the beginning of Preboreal time. Paleobotanical investigations reveal the phases were strictly conditioned by climate. Westerly winds were responsible for the formation of dunes and accumulation of cover sands. Besides the formation of dunes and cover sands that accompany the dunes, the Late Weichselian eolian processes are also responsible for the origin of a niveo-eolian sand cover extending across the slopes and the axial parts of denudational valleys. The eolian activity in the Holocene was neither cyclic in nature nor climate-conditioned, but continouous. Eolian activity was limited in space to those areas where man interfered with vegetation. It led to minor transformations of the Late Weichselian dunes, and only sporadically to formation of new, small dune forms.
Key words: cover sands, eolian phases, niveo-eolian deposition, stabilized inland dunes.

17. Krajewski, K., 1977, Późnoplejstocénskie i holoceńskie procesy wydmotwórcze w Pradolinie Warszawsko-Berlińskiej w widlach warty i neru (with a summary: Late-Pleistocene and Holocene dune-forming processes in the Warsaw-Berlin Pradolina): Acta Geographica Lodziensia, v. 39, Societas Scientiarum Lodziensis, 87 p., 22 figs., 26 photos, 139 refs.

Dunes have been investigated that are situated on different levels of the Warsaw-Berlin Pradolina between the Warta and Ner Rivers (Poland) and on the neighbouring interfluves. Distribution of dunes has been analyzed against morphology of the Pradolina. A gravelly-stoney horizon from the beginning of the waning phase of the Weichselian has been observed in the substratum of the dunes. The results obtained from examination of grain size distribution, abrasion of grains, directions and intensities of wind, and dating of fossil soils have permitted the determination of the stratigraphy of the dunes and the distinction of various periods of dune formation. (author, modified)
Key words: eolian phases, grain roundness, grain size, internal structures, stabilized inland dunes.

18. Maarleveld, G. C., 1960, Wind directions and cover sands in The Netherlands: Biuletyn Peryglacjalny, no. 8, p. 49-58., 6 figs., 2 plates, 1 table, 25 refs.

The term cover sand is applied to eolian deposits overlying older sediments in the shape of a cover. These sands are found north of the loess belt and south of the Würm-moraine area. Cover sands often show a distinct maximum grain size ranging from 105 to 210 micron and are mostly horizontally stratified. The finer sands with interlayering of loamy bands are

called Older cover sand which were deposited during Pleniglacial time. Overlying cover sands, mostly containing thin bands of coarse sand or fine gravel are called Younger cover sands, which were deposited in the Late Glacial after Bølling time. A thin bleached layer (Usselo layer) of Allerød age separates the Younger Cover sand I from the Younger Cover sand II. Parabolic and roughly U-shaped cover sand ridges can be distinguished. Investigations of prevailing wind directions during the Late Glacial and results of pollen analysis indicate a climatic change in The Netherlands during the Allerød. The change was from relatively continental to relatively oceanic and the prevailing wind directions changed from northwest/west into west/southwest.
Key words: cover sands, paleowinds, stabilized inland dunes.

19. Maruszczak, H., 1964, Problème de l'action éolienne dans la zone périglaciaire à la lumière des indices granulométriques: Biuletyn Peryglacjalny, no. 14, p. 257-273, 5 tables, 23 refs.

Based on previous analysis of A. Cailleux (1942) large differences in abrasion indices of samples of eolian sand grains from various areas in eastern Europe have been determined. Large variations in the proportion of wind-worn sand grains in the fractions between 100 to 1000 micron occur.
Key word: grain surface features.

20. Matthews, B., 1970, Age and origin of aeolian sand in the Vale of York: Nature, v. 227, no. 5264, p. 1234-1236, 3 figs., 1 table, 8 refs.

In the Vale of York, Central England, hummocky areas of fine sand with mounds up to 6 m high occur over Weichselian till and lacustrine deposits. These mounds are fossil longitudinal dunes trending north-west/south-east and north/south. The eolian sand was probably winnowed from coarser fluvioglacial drift. The material is homogeneous with little or no evidence of stratification. Much of the eolian sand was originally deposited between 10,700 and 9,950 years B.P., that is during the later part of the Weichselian glacial stage and early Flandrian (Holocene) time.
Key words: dating, stabilized inland dunes.

21. Meyer, H. H., 1981, Zur klimastratigraphischen und morphogenetischen Auswertbarkeit von Flugdecksandprofilen im norddeutschen Altmoränengebiet - erläutert an Beispielen aus der Kellenberg-Endmörane (Landkreis Diepholz): Bochumer Geographischen Arbeiten, Heft 40, p. 21-30, 3 figs. 5 photos, 1 table, 25 refs.

New information concerning the litho- and chronostratigraphy of the Upper Weichselian and the Late Glacial was obtained by interpretation of representative cover sand profiles from the area of the Kellenberg end moraine (N.W. Germany, "Rehburger Phase"). The results correspond well with stratigraphic interpretations published to date by authors from The Netherlands. Also specific information about morphodynamics and environmental factors was determined by considering sedimentological, paleopedological and structural data, thereby providing detailed material for reconstructing periglacial climate and morphology in the "Altmoränengebiet". (author, modified)
Key words: cover sands, eolian phases.

22. Mücke, E. and Linke, M., 1967, Zur Dünenbildung in der südöstlichen Altmark: Hercynia, v. 4, p. 426-438, 5 figs., 15 refs.

In the "Altmark" (Central German Democratic Republic) eolian sand sheets are widespread and parabolic dunes are common. Dune forms indicate dune-building winds from different directions. The first phase of dune formation started in the Weichselian whereas resedimentation of the material took place during various stages of the Holocene due to human influences.
Key words: deflation, human impact, stabilized inland dunes.

23. Nowaczyk, B., 1976a, Geneza i rozwój wydm śródladowych w zachodniej czésci Pradoliny Warszawsko-Berlinskiej w świetle badań struktury, uziarnienia i stratygrafii budujacych je osadów (with a summary: The genesis and development of inland dunes in the western part of the Warsaw-Berlin Pardolina in the light of examinations of the structure, granulation and stratigraphy of the deposits which built them): Prace Komisji Geograficzno Geologicznej Poznańskie Towarzystwo Przyjaciól Nauk, Tom 16, 108 p., 37 figs., 5 tables, 122 refs.

Investigations in two dune fields in the Kargowska Basin, Poland, are described. In this area parabolic, bow-shaped and a few longitudinal dunes and irregular hillocks occur, all formed by WNW winds. Transverse dunes formed by SW winds are also common. The variability of grain size of the dune deposits reflects the composition of the substratum which constitute the starting material for eolian processes. The dunes were formed during three dune-building phases described in earlier Polish studies.
Key words: eolian phases, grain roundness, grain size, internal structures, sand source, stabilized inland dunes.

24. Nowaczyk, B., 1976b, Eolian cover sands in Central-West Poland: Quaestiones Geographicae, v. 3, Adam Mickiewicz University, Poznan, p. 57-77, 5 figs., 2 photos, 1 table, 47 refs.

In Central-West Poland cover sands occupy extensive areas with a flat or undulating relief. They often accompany dunes over considerable distances and are composed of the same material as the dunes. There is an intimate relationship between grain size composition of substratum deposits and eolian deposits. The topmost part of the laminated, horizontal-to gently dipping beds of the cover sands is usually structureless possibly due to periglacial processes and bioturbation. Cover sands originated, like the dunes, in periods of intensified eolian action during the Late Glacial.
Key words: areal distribution, cover sands, eolian phases, internal structures.

25. Perrin, R. M. S., Davies, H., and Fysh, M. D., 1974, Distribution of late Pleistocene aeolian deposits in eastern and southern England: Nature, v. 248, no. 5446 p. 320-324, 3 figs., 4 tables, 21 refs.

Granulometric and mineralogical analysis of thin surficial layers of blown sand and cover sand in eastern and southern England permit a subdivision into four distinct provinces. These sands are of late Devensian age. No valid stratigraphical correlation can yet be made with the thick series of cover sands in Holland and Belgium.
Key words: cover sands, grain size, mineral composition.

26. Pissart, A, 1976, Les dépôts et la morphologie périglaciaires de la Belgique: in A. Pissart , ed., Géomorphologie de la Belgique. Laboratoire de Géologie et Géographie Physique, Université de Liège, p. 115-135, 9 figs., many refs.

Cover sands and loess deposits are the most important surficial periglacial deposits in Belgium. Dune sands and cover sands up to 20 meters in thickness occur in a west-east trending belt in the northern part of the country. The literature concerning the geomorphology and sediment analysis of these Weichselian eolian sands is summarized.
Key words: areal distribution, cover sands.

27. Pyritz, E., 1972, Binnendünen und Flugsandebenen im Niedersächsischen Tiefland: Göttinger Geographische Abhandlungen, Heft 61, 153 pp., 27 figs., many refs.

Inland dunes and areas of drift sand occupy about 12 % of the total area of the "Niedersächsischen Tiefland" in Western Germany. Dunes are separated into two generations; older and younger inland dunes ("Altdünen", "Jungdünen"). The development of the older dunes under prevailing westerly winds took place during the Late Glacial (Weichselian). Parabolic and longitudinal dunes commonly are found to be degraded by erosion and human activities. Grain size and grain form distribution of both the older and younger dunes generally reflect the sediment properties of the local substratum. The inland dunes of the western part of Niedersachsen usually attain heights of only a few meters and slope angles of a few degrees, whereas in the eastern part steeply sloping dunes up to 12 meters high, found. This is due to the greater influence of the contintental climate toward the east during the Late Glacial. Cover sands were also formed in the Weichselian, but they are often strongly influenced by human activities or have been reworked into younger dunes. On the basis of interstadial horizons and paleosols a stratigraphic correlation with the Dutch cover and dune sands and with the Polish cover and dune sands is established.
Key words: areal distribution, cover sands, deflation, eolian phases, grain roundness, grain size, human impact, stabilized inland dunes.

28. Rotnicki, K., 1970, Glówne problemy wydm śródladowych w Polsce w świetle badán wydmy w Weglewicach (with a summary: Main problems of inland dunes in Poland based on investigations of the dune at Weglewice): Prace Komisji Geografizno Geologicznej Poznańskie Towarzystwo Przyjaciól Nauk, Tom 11, no. 2, 146 p., 36 figs., 11 photos, 5 tables, 154 refs.

A parabolic dune within the dune field in the Grabow Basin near Weglewice (Poland) has been investigated in detail. The dune at Weglewice is built up of three sand series: the bottom one (Oldest Dryas, Bølling, Older Dryas), the middle one (Younger Dryas and the beginning of the Preboreal period) and the top one (Holocene). In all series the basic fraction is formed by material 0.16 to 0.5 mm in diameter. The best sorting of material is observed in the dune crest. In successively younger series the percent of round grains increases. The various series of different age do not differ in quartz grain abrasion. In the Weichselian phases the dune relief was shaped by winds from the western sector; in the last, Holocene phase a slow but further development of the dune form is caused by westerly and southwesterly winds.
Key words: eolian phases, grain roundness, grain size, internal structures, paleowinds, stabilized inland dunes.

29. Straw, A., 1963, Some observations on the "Cover Sands" of North Lincolnshire: Transactions of the Lincolnshire Naturalists Union, v. 15, no. 4, p. 260-269, 2 figs., 4 refs.

Cover sands of partly periglacial eolian origin are spread out over much of Lincolnshire, Central England. The cover sands were laid down intermittently over a period comprising much of the Last Glacial and early Post-glacial time, and were derived mainly from rocks of Triassic age west of the Trent.
Key words: cover sands, sand source.

30. Urbaniak, U., 1967, Wydmy Kotliny Plockiej (with a summary: Dunes of the Plock Basin). Prace Geograficzne, no. 61, Polska Akademia Nauk, Warszawa, 79 p., 43 figs., 8 photos, 3 tables, 71 refs.

The dune forms most commonly found in the Plock Basin (Poland) are ridges of W-E orientation and parabolic dunes. The internal structures of these dunes were investigated in some 50 transvers trenches. A number of dune types differing in structure and origin are distinguished. Moreover, several phases of dune development (dune resculpturing and dune destruction) are described.
Key words: eolian phases, internal structures, stabilized inland dunes.

31. Urbaniak, U., 1969, Les sables de couverture, les cryoturbations et les fractures dans les dunes du bassin du Plock (with a summary: Cover sands, cryoturbation structures and faults in the dunes of the Plock Basin): Biuletyn Peryglacjalny, no. 19, p. 399-422, 14 figs., 6 photos, 11 refs.

Investigations in the dunes of the Plock Basin (Poland) revealed secondary deformation structures in stratified sands, interruption of layers, as well as their complete destruction. These phenomena are classified in two groups: 1) cover sands and cryoturbation structures originated under periglacial conditions, 2) changes of the dip of layers and formation of fault-like structures due to the melting of dead ice blocks under the dunes or in their close vicinity. The cover sands are represented by the structure-less sands lying on top of all dunes and by marble-like sands occurring at their bottoms. In comparison with the stratified dune sands they are finer, less rounded, and richer in strongly resistant heavy minerals. The cryoturbation structures like fissures and solifluction forms exist in the dunes. Range and position of the disturbances in the parallel stratification of the dune sands show that the eolian processes preceded the melting of dead ice or that both processes sometimes overlapped. (author, shortened)
Key words: cover sands, internal structures, stabilized inland dunes.

32. Williams, R. B. G., 1975, The British climate during the last glaciation; an interpretation based on periglacial phenomena, in Wright, A. E. and Moseley, F., eds., Ice ages: ancient and modern. Proceedings of the 21th Inter-University Geological Congress, University of Birmingham, Jan. 2-4, 1974. Seel House Press, Liverpool p. 96-119, 1 fig., 62 refs.

In Britain wind-lain sediments of periglacial age are conspicuous only for their rarity. Dunes are low, rather shapeless hummocks occurring only in a few localities and cover sands are thin and patchy. They both were deposited by westerly winds. The wind-lain deposits are limited to eastern districts and

are probably an indication the ground became drier and less vegetated in this direction. The impression is gained of an anticyclone not merely obstructing the westerly circulation but also generating its own snow-bearing winds. Only few depressions from the west could reach Britain and brought the storm winds that shifted the sand and loess. The concept of a blocking anticyclone appears essential to explain the marked continentality of the climate so clearly demonstrated by ice-wedges and other permafrost structures, but evidence of its existence is surprisingly meager. (refer to section titled: Wind and pressure systems)
Key words: areal distribution, cover sands, paleoclimate.

Fennoscandia

33. Aartolahti, T., 1967, Über die Dünen von Urjala: Comptes Rendus de la Societé Geologique de Finlande, v. 39, p. 105-121, 4 figs., 20 refs.

Fossil inland dunes occur in southeast Urjala, southwestern Finland. They are partly of coastal origin. They are built up of fine to medium grained, well sorted sand originating from local morainic deposits. Dune orientation and internal structures indicate that the dunes were formed by northwesterly winds. Dune development began around 8200 years B.P. after deglaciation of the area and lasted only a few hundred years.
Key words: dating, dune vegetation, grain size, stabilized inland dunes, internal structures, mineral composition, paleowinds, sand source.

34. Aartolahti, T., 1973, Morphology, vegetation and development of Rokuanvaara, an esker and dune complex in Finland: Fennia, v. 127, 53 p., 23 figs., 3 plates, 49 refs.

The area of study, Rokuanvaara, is situated in the north-west of Oulujärvi, Finland. A detailed survey is given of the landforms of the area, its history, vegetation and groundwater table. Rokuanvaara is an esker whose surface has been shaped by the action of winds, waves, runoff water and earth flow. The upper part of the esker is covered by parabolic blow-out dunes consisting of fine to medium grained, well sorted sands, the orientation of which denotes deposition by W-NW winds. The various forms of blow-outs lying between the dunes mark the chief source of the dune material, which in general has travelled only a short distance. The dunes were deposited simultaneously throughout the dune field. Secondary deflation is practically confined to the slopes of the highest dunes. The dune field is bordered on the lower slopes by a narrow belt of complex beach ridges topped by deposits of blown sand. They differ from the dunes of the dune field in their orientation, form, size, internal structure and, to some extent, sand composition. The Boreal period was most significant for the development of the landforms, while the Atlantic period saw the onset of paludification and a rise in the groundwater table. (author, modified)
Key words: beach ridges, dating, dune vegetation, grain size, internal structures, littoral dunes, parabolic dunes.

35. Alestalo, J., 1979, Land uplift and development of the littoral and aeolian morphology on Hailuoto, Finland: Acta Universitatis Ouluensis, Series A, no. 82, Geologica, no. 3, p. 109-120, 6 figs., 17 refs.

On Hailuoto, the largest island in the northern section of the Gulf of

Bothnia, Finland, a number of parallel littoral dune ridges have been formed within an area of rapid land uplift. Among the most outstanding features in the highest part of the island are dune ridges forming a field of parabolic dunes. The prevailing dune-building wind directions varied between south and west. The parabolic dunes were primarily parallel shore dunes. The ridges have been subsequently reshaped by the wind. Some of these dunes continue to be subject to deflation processes and some are still migrating. The oldest ridge was formed about 1700 years B.P.
Key words: parabolic dunes, shore dune ridges.

36. Bergqvist, E., 1981, Svenska inlandsdyner. Översikt och förslag till dynreservat (with a summary: Ancient inland dunes in Sweden. Survey and proposals for dune reserves). Statens naturvårdsverk, Rapport SNV PM 1412, Naturgeografiska Institutionen, Uppsala Universitet, 109 p., 54 figs., maps, 17 refs.

The report deals with the assessment of the inland dunes with regard to their value for future research, especially on paleo-climate. A survey of Swedish dune areas is reported, and a dot map shows the location of known dune occurrences in the national Swedish co-oridinate grid. Most localities have been inspected in the field, and dune forms have been discriminated according to a standard procedure. In the assessment of the value, simple ranking has been preferred to other procedures.

Six dune fields are selected as the most important ones for future research, and some few others are likely to be added when some lesser known areas are surveyed in more detail. The size of these dune fields is such that they are well suited to form nature reserve units. The six areas are mapped in a uniform manner, and published in one scale 1:30,000. A number of examples of unplanned exploitation is reported, as well as observations on the effects of off-road vehicle traffic and concentrated trampling. In general, necessary protection measures would not significantly influence the present land use. (author)
Key words: areal distribution, deflation, dune conservation, dune vegetation, human impact, paleoclimate, stabilized inland dunes.

37. Bergqvist, E. and Lindström, E., 1971, Bevis på subrecent eolisk aktivitet på Brattforshedens inlandsdyner (with a summary: Evidence of subrecent eolian activity in the inland dunes at Brattforsheden): Geologiska Föreningen i Stockholm Förhandlingar, v. 93, no. 4, 782-785, 4 figs., 1 ref.

A buried podzol profile in one of the ancient inland dunes at Brattforsheden in central Sweden is described. Two C^{14} dates on this horizon gave ages of 2940 (3030) ± 90 B.P. and 500 (510) ± 70 B.P. Evidently, transformation of the dunes has occurred much later than the main dune-building period, which according to previous investigations ended shortly after the deglaciation of the area (about 10,000 B.P.). (author)
Key words: dating, soil formation, stabilized inland dunes.

38. Jauhiainen, E., 1970, Über den Boden fossiler Dünen in Finnland: Fennia, v. 100, no. 3, 32 p., 6 figs., 45 refs.

The paper deals with the soils in eight fossil dunes in northern Finland and five dune locations in southern Finland. The soil profiles in most dunes are

podzolic and show no clear regional differences. The mineralogical composition, the texture and the results of the chemical analyses of the dune material do not show great fluctuations between northern and southern Finland. Hovever, regional differences (temperature, rainfall, evaporation, permeability) could be indicated as influencing soil formation. Generally speaking, the soil type of Finnish fossil dunes depends on the mineralogical composition and texture of the dune material. (author, modified)
Key words: chemical analyses, grain size, podzolization, soil formation, stabilized inland dunes.

39. Jauhiainen, E., 1972, Rate of podzolization in a dune in northern Finland: Annales Academiae Scientiarum Fennicae, Commentationes Physico-Mathematicae, v. 42, p. 33-43, 5 figs., 31 refs.

The paper describes a study of the morphological and chemical structure, and age of two iron podzols which have developed on top of each other in a dune area in northern Finland, and the effect of time on podzol development. The results indicate that the profiles are analogous in terms of soil material. The C^{14} age of a coal layer between the soils is 220 ± 120 B.P. The age of the lower soil is about 9,000 - 10,000 years, but that of the upper one only about 100 - 350 years. The lower soil has had time to develop into a typical iron podzol with its distinctly visible horizons. The upper soil has also chemically differentiated into an iron podzol, but 100 - 350 years in those conditions is not adequate for the development of visible horizons. (author)
Key words: chemical analyses, dating, grain size, podzolization, soil formation, stabilized inland dunes.

40. Klemsdal, T., 1969, Eolian forms in parts of Norway: Norsk Geografisk Tidsskrift, v. 23, no. 2, p. 49-66, 16 figs., 24 refs.

The distribution of areas in Norway with eolian forms corresponds closely with that of unprotected glacial, glacio-fluvial, fluvial and older deposits, in certain cases reworked by the sea. The areas dealt with are in southern and central Norway and eastern Finnmark. The most important eolian areas are to be found along vegetation-free coastal beaches where a longer wind fetch is a decisive factor. Inland local topography and vegetation impose their limitations to eolian processes. In northern Norway and in the mountains, eolian activity is favored by climatic limitations upon vegetation. Fossil dunes are found in areas with large accumulations of glacio-fluvial and to some degree marine sediments where dune-building occurred before the immigration of vegetation was completed after the last glaciation. (author, modified)
Key words: areal distribution, deflation, sand source, stabilized inland dunes.

41. Lindroos, P., 1972, On the development of late-glacial and post-glacial dunes in North Karelia, eastern Finland: Geological Survey of Finland Bulletin 254, 85 p., 60 figs., 2 tables, 1 map, many refs.

In the ice-marginal formations of Salpausselkä II and Jaamankangas, in the region known as North Karelia, Finland, transverse, parabolic, longitudinal and barchanoid fossil dunes were investigated. The sand composing the dunes is fine grained: Md = 0.16 mm, S_0 = 1.36 and S_k = 0.93. Owing to the short duration of the eolian process, the quartz grains of the dune sand are only slightly rounded. The dark minerals and the rock fragments are distinctly more rounded than the corresponding grains of glaciofluvial material, from

which they are derived. Layers composing the ridge-shaped dunes generally dip parallel to one or the other flank. Cross-bedding occurs especially in the parabolic dunes. Dunes situated on the distal side of Salpausselkä II originated under periglacial conditions at approximately 8,000 B.C. At that time, the prevailing winds blew from between the northeast and the northwest. The youngest dunes in the region are shore dunes, which date back to about 6,800 B.C. Four C^{14} dates were determined on peat samples taken from interdune bogs. Along the edges of the dunes and of glaciofluvial formations as well as in the distal portions of marginal accumulations, cover sands occur, up to one meter in thickness. The dunes have undergone deflation. Their tops have been at times exposed and at other times almost completely covered with vegetation, as is the case at present. (author, extended)
Key words: cover sand, dating, dune development, grain size, grain roundness, internal structures, mineral composition, stabilized inland dunes.

42. Ohlson, B., 1957, Om flygsandfälten på Hietativat i östra Enontekiö (with a summary: On the drift sand formations at the Hietatievat in eastern Enontekiö): Terra, v. 69, no. 4, p. 129-137, 11 refs.

At the Hietatievat, about 10 km north-east of the village of Nunnanen, Finnish Lapland, there is a large area of drift sand with well-developed dunes. The sand of the dunes is fine and at present it is stabilized by a subalpine vegetation of birch-lichen heath type. On places exposed to the wind the sand has recently been moving, forming blow-outs on the western side of the ridges and "wind furrows" in the northeastern part of Hietatievat. The dunes at Hietatievat were probably developed under periglacial conditions, under the influence of glacigenic fall winds from the west and northwest. They are composed of glaciofluvial marginal deposits formed by an ice-sheet retreating westwards. (author, shortened)
Key words: active and stabilized inland dunes, deflation, sand source.

43. Seppälä, M., 1969, On the grain size and roundness of wind-blown sands in Finland as compared with some central European samples: Bulletin of the Geological Society of Finland 41, p. 165-181, 9 figs., 4 tables, 51 refs.

Ten eolian samples from Finland and four samples from central Europe were analysed by means of sieving and the mechanical graniformameter of Krygowski. The grain size and the sorting of wind-blown sands both in Finland and in the other investigated countries are quite similar. The quartz grains in Finland are usually angular and unworn, while the others are more rounded. However, the samples taken from southern Finland were best sorted. The origin of the parent material, and the influence of the earlier geomorphological processes on the roundness can be seen clearly in a comparison of the characteristics of the sands. (author, modified)
Key words: eolian processes, grain roundness, grain size.

44. Seppälä, M., 1971, Evolution of eolian relief of the Kaamasjoki-Kiellajoki river basin in Finnish Lapland: Fennia, v. 104, 88 p., 41 figs., 2 maps, 18 tables, many refs.

The aim of this study is to explain the dunes and deflation relief formed from sediments accumulated in an ice-dammed lake during the deglaciation in the Kaamasjoki-Kiellajoki river basin. The presence of the dunes to the east of the deflation basins, their parabolic form, the asymmetry of their slopes and

lamination indicate that they have been deposited as a result of the influence of winds blowing from between west-northwest and northwest. In the subarctic conditions prevailing today deflation is produced by west-to-southwest winds. The rise of the groundwater level during the Atlantic period caused deflation lakes to be formed in the spaces between the dunes. In granulometric composition and sorting the eolian material is normal blown sand. The sand contains considerable quantities of heavy minerals and the quartz grains are very slightly rounded. Radiocarbon dating on specimens taken from palsa bogs situated between dunes, and from a layer of coal buried in sand between podzol horizons, together with pollen, spore, seed and diatom analyses of samples taken from the bogs indicate that there was only one dune formation phase in the investigated area. Deposition of dune sands took place at the transition from the Younger Dryas into the Preboreal about 9700 years ago. The dunes became anchored by vegetation during the Preboreal. (author, modified)
Key words: dating, deflation, grain roundness, grain size, internal structures, mineral composition, parabolic dunes.

45. Seppälä, M., 1972, Location, morphology and orientation of inland dunes in northern Sweden: Geografiska Annaler, v. 54A, no. 2, p. 85-104, 12 figs., 1 table, 40 refs.

Periglacial inland dunes in the northernmost parts of Sweden were studied by interpreting aerial photographs. These dunes are now mostly stable. The most common type of dune is the parabolic dune. The dunes are situated on and in the vicinity of eskers, glaciofluvial deltas, outwash plains, valley trains and glacial drainage channels. Detailed geomorphological maps were made of different dune areas. There are both palsa and string bogs in the dune areas. In many of the deflation basins of parabolic dunes there are deflation lakes which have formed as a result of a rise in groundwater level after the formation of the dunes. The directions of the winds forming the dunes varied between N15°W and N80°W. The direction of the effective winds coincides fairly close with that of the edge of the melting ice sheet. Present-day eolian action is principally of a deflationary nature even though small parabolic dunes are forming. (author shortened)
Key words: areal distribution, deflation, paleowinds, parabolic dunes.

46. Seppälä, M., 1973, On the formation of periglacial sand dunes in northern Fennoscandia: IXth International Association for Quaternary Research (INQUA) Congress, Christchurch, New Zealand, p. 318-319, (abs.).

Methods used in studying the sand dunes in northern Fennnoscandia were interpretation of aerial photographs, field measurements, stratigraphic observations, sedimentological laboratory analysis, pollen analysis and radiocarbon dating. Glaciofluvial accumulation forms provided material of suitable grain size for eolian transport. The effective winds blew from W and NW and the most common type is the parabolic dune. The period of eolian activity was relatively short and stabilization of the dunes took place some hundreds of years after deglaciation. Local forest fires have reactivated deflation and redeposition in some dune regions. (author, shortened)
Key words: paleowinds, stabilized inland dunes.

47. Seppälä, M., 1974, Some quantitative measurements of the present-day deflation on Hietatievat, Finnish Lapland, in Poser, H., ed., Geomorphologische Prozesse und Prozesskombinationen in der Gegenwart unter verschiedenen Klimabedingungen. Abhandlungen der Akademie der Wissenschaften Göttingen, Mathematisch-Physikalische Klasse, v. 3, no. 29, p. 208-220, 7 figs., 3 tables, 13 refs.

Sand transport in a blow-out at the eastern edge of the Hietatievat dune region in northernmost Finland was measured during a period of 15 days. Local meteorological observations were made at the same time. Sand transportation and deflation is very weak in general but during strong winds sand moves fast, especially in daylight hours during summer dry periods. The effective winds were at least 6 m/sec two meters above the sand surface, blowing from the west and southwest. The average rate of sand transportation was about 0.150 g/cm/h; measured maximum was 24.87 g/cm/h. The mean annual accumulation rate at the edges of blow-outs has been 2.1 cm. The blown sands have a medium grain size a little under 0.2 mm, are very well sorted, and have a skewness near 1.0 and kurtosis about 0.25 (author, modified)
Key words: deflation, eolian processes, grain size, rate of sand transportation.

48. Seppälä, M., 1981, Forest fires as activator of geomorphic processes in Kuttanen esker-dune region, northernmost Finland: Fennia, v. 159, no. 1, p. 221-228, 6 figs., 24 refs.

Several soil profiles with up to 14 charcoal layers were found in a kettle-hole in the Kuttanen esker. Forest fires have activated deflation. In a nearby parabolic dune only one charcoal layer was found. It is possible that deflation has eroded the signs of old fires or that the fires on the esker were seldom able to jump the deflation basins. At the edge of a blow-out a 175 cm-high exposure was dug into the dune. The upper 120 cm was redeposited eolian sand without marks of soil formation or any visible stratification. At a depth of 120 cm a charcoal horizon with some unburned peat was found. Its C^{14} age was 1290 ± 130 B.P. The podzol profile beneath this layer was well-formed. The original dune sand beneath was somewhat coarser than the redeposited sand in the top layer, which indicates the effect of deflation on size sorting.
Key words: dating, deflation, forest fires, parabolic dunes, soil formation

Northern United States

49. Ahlbrandt, T. S., 1973, Sand dunes, geomorphology and geology, Killpecker Creek area, northern Sweetwater County, Wyoming: Ph.D. Thesis, University of Wyoming, Laramy, Wyoming, 174 p., 68 figs. 58 refs.

The Killpecker dune field encompasses approximately 170 square miles. The field extends for 55 miles east from Eden Valley in the Green River Basin across the Continental Divide (also called the Great Divide)into the Red Desert Basin. It is an unidirectional dune field due to the prevailing westerly winds which produce a sequence of active dunes from windward to leeward, respectively, of dome, transverse, barchan and parabolic dunes. Dormant dunes are found along the margins of the active belt and include dormant parabolic, barchan, reactivated and irregular dunes. The primary source for the field based upon heavy minerals, statistical parameters of grain size analyses, and outcrop locations of possible sand sources, is the Laney Member of the Green River Formation. Internal structures of dunes and the effects of

moisture and vegetation on them were investigated in trenches as well as wind ripple formation and wind flow over the dunes. The use of previously established textural parameters as criteria for depositional environments is not supported in this study; however, individual dune forms can be distinguished. A critical mean grain size of about 1.70 ϕ separates positively and negatively skewed samples and suggests dependence of skewness on mean grain size. The dunes correlate to terrace development in Eden Valley and glacial sequences in the Wind River Mountains. The dunes overlie gravels of the upper Farson terrace correlative with early to middle Pinedale glaciation ($\pm$ 20,000 B.P.). Dormant dunes contain three distinct horizons reflecting climatic fluctuations in the past 20,000 years. The field has been active during interstades of glaciations observed in the Wind River Mountains and was much less active or dormant during stades of glaciation from 20,000 B.P. to present. (author, modified)
Key words: active and stabilized inland dunes, dating, dune development, grain size, internal structures, mineral composition, sand source, wind ripples.

50. Ahlbrandt, T. S., 1974a, The source of sand for the Killpecker sand-dune field, southwestern Wyoming: Sedimentary Geology, v. 11, no. 1, p. 39-57, 15 figs., 16 refs.

The primary source of sand for the Killpecker sand-dune field is the Laney Member of the Green River Formation (Eocene) and not the glaciofluviatile deposits to the west as previously believed. This contention is based on data from heavy-mineral analyses, grain size parameters and outcrop locations of possible sand sources. Earlier studies indicated that textural parameters such as positive skewness define the eolian environment. The data of this study, however, indicate that skewness of the sand samples is directly related to the size of material reworked in the dune field and should not be used to define an eolian environment.
Key words: active and stabilized inland dunes, grain size, mineral composition, sand source.

51. Ahlbrandt, T. S., 1974b, Dune stratigraphy, archaeology and the chronology of the Killpecker dune field: Wyoming Geolocial Survey Report of Investigation 10, p. 51-60, 6 figs. 24 refs.

The Killpecker sand-dune field, located in south-central Wyoming, contains both active and dormant dunes over an area of 170 square miles. The active dune morphology forms an evolutionary sequence from windward to leeward respectively of dome, transverse, and parabolic dunes. Three sand horizons can be recognized in the dormant dunes. The dunes have existed since the early stade of Pinedale Glaciation (25,000 to 6,500 B.P.) and Neoglaciation (4,000 B.P. till present). (author shortened)
Key words: active and stabilized inland dunes, dating.

52. Ahlbrandt, T. S., 1975, Comparison of textures and structures to distinguish eolian environments, Killpecker dune field, Wyoming: The Mountain Geologist, v. 12, no. 2, p. 61-73.

The Killpecker sand-dune fields cover 170 square miles in northern Sweetwater County, Wyoming. It is an unidirectional field due to prevailing westerly winds that produce a sequence of dune forms downwind composed of dome, transverse, barchan, and parabolic respectively. A comparison of 79

sand samples shows progressively better sorting and finer grain size downwind in such a sequence. Skewness and kurtosis have questionable use, the former being dependent on mean grain size. Internal structures are most useful to differentiate dune, interdune, and associated deposits. Distinctive structures, in addition to high-angle crossbeds, include convex upward laminae in the parabolic dune, and low-angle ($< 10^{o}$ dip) crossbedding in dune and interdune deposits. Sometimes snow is preserved in the dunes, which affects their internal structures. (author, modified)
Key words: active and stabilized inland dunes, grain size, internal structures.

53. Ahlbrandt, T. S. and Andrews, S., 1978, Distinctive sedimentary features of cold-climate eolian deposits, North Park, Colorado: Paleogeography, Paleoclimatology, and Paleoecology, v. 25, p. 327-351, 13 figs., 2 tables, 18 refs.

The North Park dunes, Colorado, which developed east and northeast of the Canadian River, are largely stabilized. Two major active sand areas are the North and East Sand Hills with primarily large parabolic dunes migrating to the northeast and east. Distinctive tensional, compressional, and dissipation sedimentary structures related to freezing, thawing and snow melting characterize these dune deposits. The dunes do not migrate as rapidly as dunes of similar size and morphology in warm, dry climates due to freezing of moisture in the dunes, snow cover, and intercalation of snow in the dunes virtually half of each year. Bioturbation is common in both active and inactive dunes. The dune sand is compositionally immature and texturally heterogeneous related to close-by fluvial sand supply. The distinctive sedimentary features observed in this cold-climate (snow-related) dune field should aid in the interpretation of eolianites and the paleoclimates in which they formed.
Key words: internal structures, niveo-eolian deposition, stabilized inland dunes, parabolic dunes.

54. Ahlbrandt, T. S., Andrews, S. and Gwynne, D. T., 1978, Bioturbation in eolian deposits: Journal of Sedimentary Petrology, v. 48, no. 3, p. 839-848, 5 figs., 41 refs.

Bioturbation is a very common, if not ubiquitous, feature of eolian deposits occurring in inland dune fields in both cold and warm climates. The burrowing behaviour of selected invertebrates, particularly arthropods, is illustrated in the variety of burrows in dune fields. Bioturbation traces are recognizable and preserved in eolian sand that is cohesive, organism-reinforced, or rapidly buried. (author, modified)
Key words: active inland dunes, bioturbation.

55. Ahlbrandt, T. S. and Fryberger, S. G., 1976, Structures and textures of eolian deposits in the Nebraska Sand Hills, USA: 25th International Geological Congress, Sydney, Australia, 3, p. 826, (abs.).

The late Wisconsinan (?) Nebraska Sand Hills of the Great Plains is a large inactive sand sea covering approximately 34,420 km^2. The dune types recognized in the Sand Hills are barchan, barchanoid ridge, transverse ridge, blow-out, parabolic, dome (the small variety), and a few reversing (?) dunes. The dune sand ranges in size from very fine to medium grained sand, with a mode in the fine sand range. Primary eolian sedimentary structures observed

in the Sand Hills include normally graded bed, inversely graded beds, laminated beds, non-graded beds, ripples, and coarse deposits along unconformities. Most interdune deposits are lenticular and contain a variety of structures including laminated beds, low-amplitude ripples and adhesion ripples. Poorly sorted sediments ranging from mud to coarse sand and evaporites are well represented in interdune deposits. Approximately 1,000 strike- and-dip measurements were made of bedding exposed in trenches cut at one meter vertical intervals. These measurements indicate that the principle direction of dune sand movement was toward the southeast throughout most of the Sand Hills. In general, sedimentary structures can be used to indicate an eolian origin for strata and may also be used to define dune types. (author, shortened)
Key words: internal structures, stabilized inland dunes.

56. Ahlbrandt, T. S. and Fryberger, S. G., 1980, Eolian deposits in the Nebraska Sand Hills: U.S. Geological Survey Professional Paper 1120-A, p. 1-24, 18 figs. 46 refs.

The Nebraska Sand Hills are an inactive, late Quaternary, most probably Holocene, dune field (covering 57,000 km^2) that has been eroded along streams and in blow-outs. Eolian deposits of the Sand Hills occur as relatively thin (9-24 m) "blanket" sands, composed of a complex of dune and discontinuous, diachronous interdune deposits unconformably overlying fluviolacustrine sediments. The internal stratification of dunes in the Sand Hills (as high as 100 m) indicate that transverse, barchan, and blow-out dunes can be differentiated. A variety of secondary structures modify or replace primary eolian stratification, the more common of which are dissipation structures and bioturbation. Cross-bed measurements indicate a general northwest-to-southeast drift of sand, with a more southerly drift in the southeast part of the Sand Hills. A large area of small dunes are interpreted as transverse-ridge dunes that were generally moving to the south. Interdune deposits differ from nearby dune sands in color, thickness, texture, internal structures, and composition. (author, modified)
Key words: grain size, internal structures, paleowinds, stabilized inland dunes.

57. Ahlbrandt, T. A., and Fryberger, S. G., 1981, Sedimentary features and significance of interdune deposits: Society Economic Paleontologist and Mineralogists Special Publication 31, p. 293-314, 16 figs., 50 refs.

Interdunes occur between dunes in most dune fields, but they have not been adequately studied. Interdunes among dunes formed in unimodal wind regimes are fundamentally different than interdunes formed in bimodal or complex wind regimes. The mechanism of alternate dune and interdune development producing lenticular, diachronous and relatively thin (< 2 m) interdune deposits among unimodal dunes is strongly supported in our experience. Interdune deposits among dunes formed in bimodal or complex wind regimes, i.e. linear or star dunes respectively, seem to be thicker and more areally extensive than among unimodal dune regimes. Interdunes broadly can be classed as deflationary or depositional; these in turn can each be informally subdivided, based upon water content, into dry, wet and evaporite interdunes. Wet interdune areas and evaporite interdunes occur in the Nebraska Sand Hills and in the Killpecker dune field. Many interdune deposits are virtually structureless due to secondary processes. (author, modified)
Key words: eolian processes, interdune deposits, internal structures.

58. Andrews, S., 1981, Sedimentology of Great Sand Dunes, Colorado: Society of Economic Paleontologist and Mineralologist Special Publication 31, p. 279-291, 10 figs., 24 refs.

Eolian and adjacent deposits of Great Sand Dunes, Colorado, form a small but sedimentologically complex deposit. Eolian sediments can be subdivided into three provinces trending downwind (northeast); 1) low, alkali-cemented dunes forming discontinuous rings around broad, flat-bottomed, ephemeral lakes; 2) undulating, vegetated dunes as high as 10 m, of barchan, parabolic shrub-coppice, and transverse type, with varying interdune types; 3) high (as much as 200 m) transverse dunes with little or no vegetation and no true interdune deposits. Analysis of a 40-year span of aerial photographs and field observations of sand transport and cross-bedding dip directions indicate that the main dune mass (province 3) is accreting vertically and that dune types are growing in complexity, in particular the star dunes. This change from lateral migration to vertical growth most probably reflects Holocene changes in wind regime. The Great Sand Dunes are an example of a localized, cool-climate, intermontane eolian deposit, characterized by extensive fluvial reworking. (author, shortened)
Key words: active and stabilized inland dunes, internal structures.

59. Bradbury, J. P., 1980, Late Quaternary vegetation history of the central Great Plains and its relationship to eolian processes in the Nebraska Sand Hills: U.S. Geological Survey Professional Paper 1120-C, p. 29-36, 4 figs., 1 table, 14 refs.

During the late Pleistocene boreal coniferous forests containing substantial amounts of spruce (Picea) existed in the Sand Hills. The eolian mechanisms that produced the present Sand Hills topography could not operate compatibly with forest vegetation, and it is hypothesized that the latest major epoch of sand dune formation occurred after the forests left, in the middle Holocene. Perhaps this eolian activity coincided with the Altithermal, a warm and dry period between 8,000 and 4,000 B.P. (author, modified)
Key words: dating, dune vegetation, stabilized inland dunes.

60. Denny, C. S. and Owens, J. P., 1979, Sand dunes on the central Delmarva Peninsula, Maryland and Delaware: U.S. Geological Survey Professional Paper 1067-C, 15 p., 20 figs., 4 tables, 26 refs.

Inconspicuous ancient sand dunes are present in parts of the central Delmarva Peninsula, Maryland and Delaware. Many dunes are roughly U-shaped, built by northwesterly winds, especially on the east side of some of the large rivers. On the uplands, the form and spacing of the dunes are variable. A surficial blanket composed mainly of medium and fine grained sand, the Parsonsburg Sand, forms both the ancient dunes and the broad plains between the dunes. Quartz is the dominant mineral constituent of the sand. The heavy-mineral assemblages are more mature than in most of the possible source rocks. The soil profile in the dune sand is weakly to moderately developed. At or near the base of the Parsonsburg Sand are peaty beds that range in age from about 30,000 to 13,000 B.P. Microfloral assemblages in the peaty beds suggest that the dunes on the uplands formed in a spruce parkland during the late Wisconsin glacial maximum. The river dunes may also be of late Wisconsin age, but could be Holocene. (author, shortened)
Key words: internal structures, mineral composition, parabolic dunes, sand sheets, soil formation, U-shaped dunes.

61. Fryberger, S. G., Ahlbrandt, T. S., and Andrews, S., 1979, Origin, sedimentary features, and significance of low-angle eolian "sand sheet" deposits, Great Sand Dunes National Monument and vicinity, Colorado: Journal of Sedimentary Petrology, v. 49, no. 3, p. 733-746, 12 figs., 20 refs.

Low-angle eolian deposits of a sand sheet constitute an areally extensive (710 km^2), transitional facies between high-angle eolian dunes and non-eolian deposits near Great Sand Dunes National Monument, Colorado. The bulk of the low-angle eolian deposits of the sand sheet lie in a 15 km-wide belt between the main dune mass at Great Sand Dunes and the Rio Grande River 45 km to the southeast, or "upwind". These low-angle eolian deposits have a number of distinctive textural and structural features which are extensively described. Low-angle eolian deposits of the sand sheet originate mainly by gentle deceleration of wind, in the lee of small topographic features, which produces a different style of deposition compared to the more extreme flow separation at the brink of the dune slipface. Low to moderate velocities, typical of those observed during this study, generally remove fine sand from exposed areas, and deposit the sand in nearby topographically lower or sheltered places. Recognition of low-angle eolian deposits may assist in identification of margins of ancient dune fields. (author, shortened)
<u>Key words</u>: eolian processes, grain size, internal structures, sand sheets.

62. Krinsley, D. and Cavallero, L., 1970, Scanning electron microscopic examination of periglacial eolian sands from Long Island, New York: Journal of Sedimentary Petrology, v. 40, no. 4, p. 1345-1350, 2 figs., 12 refs

A sand deposit in Nassau county, Long Island, New York, has been determined as Pleistocene rather than Cretaceous in age by the use of scanning electron miroscopy. Additionally, using the same techniques, a method has been established for distinguishing periglacial eolian sands in the fossil record from other types of glacial and eolian deposits. On most of the grains examined, dune features were superimposed on glacial features. No relationship was found between roundness and percentage of eolian features, indicating that wind action generally was not extensive enough to modify the roundness of this group of sand grains. Desert dune sands are generally more rounded than periglacial dune sands.
<u>Key words</u>: grain roundness, grain surface features.

63. Smith, H. T. U., 1964, Periglacial eolian phenomena in the United States: Report of the VI International Association for Quaternary Research (INQUA) Congress, Warsaw 1961, vol 4, p. 177-186, 42 refs.

Periglacial eolian effects in the United States are represented by ventifacts, eolian sand and loess, occurring both separately and in association with one another. Except in parts of Alaska, all are "fossil" phenomena, dating back to Wisconsin or earlier glacial stages. Not all occurrences are of truly periglacial character, and each must be appraised individually. Occurrences which do seem to meet the requirements for periglacial origin are widely but sparsely distributed, in association with both continental and alpine glaciation. Only in northeastern United States are they known in sufficient number, in such associations, and so distributed as to demarcate a geographic belt having a distinctive periglacial climatic environment. (author)
<u>Key word</u>: areal distribution

64. Smith, H. T. U., 1965a, Nebraska dunes compared with those of North Africa and other regions, in Schultz, C. B. and Frye, J. C., eds., Loess and related eolian deposits of the world. Proceedings VIIth International Association for Quaternary Research (INQUA) Congress, v. 12, Boulder, Colorado, p. 29-47, 6 figs., 17 refs.

The largest area of sand dunes in North America occurs in the state of Nebraska. At present, the dunes are almost entirely stabilized by a relatively thin cover of sod, but if that cover were destroyed, sand drifting by wind would begin again and the surface appearance quickly would become like that in the great arid deserts. Comparison of the Nebraska dunes with those in several desert areas are considered in terms of areal extent, characteristics of the individual dune forms, the development sequence, and the associated geomorphic phenomena. These comparisons provide important evidence of past climate and wind direction.
Key words: dune development, dune fields, stabilized inland dunes.

65. Smith, H. T. U., 1965b, Dune morphology and chronology in central and western Nebraska: Journal of Geology, v. 73, no. 4, p. 557-579, 5 figs., 4 plates, 38 refs.

The stabilized dunes of central and western Nebraska cover approximately 22,000 square miles and represent the largest dune area in North America. The dunes are of three different types, formed at three different times. The oldest dunes are broad massive forms of great size, generally elongate, which are interpreted as having originated as compound transverse dunes under desert conditions when wind action was particularly strong, persistent, and widespread, probably during early Wisconsin time. When climatic conditions changed, they were stabilized by vegetation. The dunes of intermediate age are narrow, less symmetrical subrounded linear ridges of intermediate length, superimposed on the older dune topography. They are interpreted to have developed as non-migratory upsiloidal forms transitional into "longitudinal" types, in the presence of some vegetation, during an episode of moderately intense wind action under semi-arid conditions, probably in late Wisconsin time. Wind direction was similar to that of today but different from that indicated by the older dunes. The youngest dunes are blow-outs of various sizes and shapes, omnipresent on all older dunes. They are believed to have been formed mainly during the Hypsithermal interval. (author, shortened)
Key words: deflation, dune development, dune fields, paleowinds, stabilized inland dunes.

66. Smith, H. T. U. and Messinger, C., 1959, Sand dunes and shore-line history in the Provincetown area, Cape Cod, Massachusetts: Geological Society of America Bulletin, v. 70, no. 12, pt. 2., p. 167 (abs.)

Dunes in the Provincetown area cover about 10 square miles and have a local relief of up to 100 feet. Two broad divisions are distinguishable: 1) At the south is a zone of predominantly stabilized dunes in irregular belts discordant to present shorelines and to active dunes at the north. These dunes are the oldest in the area, appear unrelated to former shore-lines, and are interpreted provisionally to have been formed under periglacial conditions, at a lower stand of sea level, in late Wisconsin time. 2) At the north is a zone of

predominantly active dunes, occurring in broadly arcuate belts subparallel to one another and to the Atlantic shore. Dunes within the belts range from elongate sand ridges to chains of upsiloidal dunes, and are extensively modified by blow-outs. These belts are attributed to the effects of changes in sea level due to the combined action of isostatic and eustatic processes. (author, shortened)
Key word: shore dune ridges.

67. Steidtmann, J. R., 1973a, Ice and snow in eolian sand dunes of southwestern Wyoming: Science, v. 179, no. 4075, p. 796-798, 2 figs., 11 refs

Snow becomes incorporated in eolian sand dunes of southwestern Wyoming when snow cornices on dune crests begin to melt, slide down the lee slope, and are covered by sand during subsequent lee-side deposition. In some cases burial is rapid enough to provide the insulation necessary to preserve the ice and snow within the dune throughout the year. Deformed laminae associated with the incorporated snow are preserved, and these features may be of value as paleoclimatic indicators in ancient sandstone. (author)
Key words: internal structures, niveo-eolian deposition, transverse dunes.

68. Steidtmann, J. R., 1973b, Structures in the moist, cold-climate sand dunes of southwestern Wyoming: Wyoming Geological Association, 25th Field Conference Guidebook, Symposium and Core Seminar on the Geology and Mineral Resources of the Greater Green River Basin, p. 209-213

The sand dunes of the Killpecker dune fields in southwestern Wyoming, provide an excellent place to observe the effects of cold-climate and high-moisture content on dune structures. Snow is buried by blowing sand incorporated in the dunes. Subsequent melting and slumping of some of this snow causes collapse and deformation of the dune stratification. In some cases the snow is preserved throughout the year. Truncated ripples are formed when the crests of moist ripples are dried and blown away. The high moisture content of the dune prevents the formation of avalanche faces. (author, modified)
Key words: internal structures, niveo-eolian deposition, transverse dunes.

69. Thorn, C. E. and Darmody, R. G., 1980, Contemporary eolian sediments in the alpine zone, Colorado Front Range: Physical Geography, v. 1, no. 2, p. 162-171, 3 figs., 5 tables, 19 refs.

Particle-size distribution, mineralogy, sphericity, and weathering characteristics from eolian material deposited on four snow patches are reviewed against information available on the role of eolian transport. The eolian deposits exhibit properties intermediate between those of loesses and cover sands. (author, shortened)
Key words: grain size, grain surface features.

Alaska

70. Black, R. F., 1951, Eolian deposits of Alaska: Arctic v. 4, no. 2, p. 89-111, 9 figs., 42 refs.

Eolian deposits of Pleistocene to Recent age in Alaska are widespread. Only higher parts of mountain ranges and local areas in the lowlands have

escaped eolian deposition. The eolian deposits are discussed in three major groups: 1) Stabilized longitudinal, parabolic and "multicyclic" dunes occur on the coastal plain west of the Colville River. Discontinuous and isolated dune fields are active along most of the rivers, along part of the coast northward from Cape Beaufort, and on the higher banks of many of the oriented lakes. The dunes vary in size and composition from place to place. The majority of the dunes were probably formed in the post-Pleistocene optimum. 2) Numerous areas of sand dunes of various types are associated with glacial stream valleys. They occur along river banks, sea bluffs, river bluffs, past and present shorelines of the larger lakes, in the vicinity of cliff-heads and at the lee-sides of "badland" areas. Dune dimensions and source material of both stabilized and active dunes vary. They are often scarred with blow-outs. 3) Coastal margins are characterized by fore dunes and small blow-outs. Isolated or continuous dunes of various types are common. Location and size of the dunes or dune belts are determined by the direction and velocities of seasonal winds, the degree of protection from marine erosion and the supply of sand.
Key words: areal distribution, stabilized and active inland dunes.

71. Carter, L. D., 1981, A Pleistocene sand sea on the Alaskan Arctic Coastal Plain: Science, v. 211, no. 4480, p. 381-383, 2 figs., 15 refs.

A ridge and thermokarst-basin landscape on the Arctic Coastal Plain consists of large longitudinal or linear Pleistocene dunes, covering more than 7000 km^2, that have been modified by younger eolian activity and thermokarst processes. This is the most extensive area of large stabilized dunes yet reported in the North American Arctic. The large dunes are now obscured by a thin cover of younger eolian sand that includes small stabilized longitudinal dunes. Landsat winter imagery reveals symmetrical, parallel to subparallel ridges as long as 20 km trending ENE-WSW to NE-SW. The source is believed to be Pleistocene marine and alluvial sand east of the sand sea. (author modified)
Key words: dating, paleowinds, sand sea, longitudinal dunes.

72. Carter, L. D., and Robinson, S. W., 1978, Eolian sand and interbedded organic horizons at Kealok Creek on the Arctic Coastal Plain of Alaska: possible regional implications: U.S. Geological Survey Open-File Report 78-320, 26 p., 8 figs., 2 tables, 19 refs.

A terrain consisting of low, broad and generally elongated (ENE-WSW) hills that rise from 20 to 30 m above intervening troughs to elevations of from 35 to 50 m, extends from the southern tip of Teshekpuk Lake southward for 75 km to Price River, and from near the Kogasukruk River westward at least 110 km to beyond the Ikpikpuk River. Kealok Creek transects one of these low hills exposing 27 m of clean, pebble-free, eolian sand and four interbedded organic horizons. Cross-bedding occurs in the lower part of the exposure. The hills are interpreted as a field of predominantly longitudinal dunes formed by ENE winds with no control by bedrock structure. The dune system is Late Wisconsin in age, as suggested by radiocarbon dates from the Kealok Creek exposure. The Colville River flood-plain is believed to be the major source for the dunes. Thaw lakes and drainage development did not begin until after stabilization of the dunes.
Key words: dating, paleowinds, sand sea, sand source, soil formation, longitudinal dunes.

73. Collins, F. R., 1958, Vegetated sand dunes in Central Alaska: Geological Society of America Bulletin, v. 69, no. 12, pt. 2, p. 1752 (abs.)

Sand dunes occupy most of the southwestward-trending lowlands northwest and southeast of the Kuskokwim Mountains in a triangular area between Ruby, Nenana, and the Alaska Range. The southern dune area is 160 miles long and 50 miles wide, and the northern one is nearly 100 miles long and 30 miles wide. Long narrow sand ridges and V-shaped dunes, all trending southwestward, are the most common forms, but wavelike sheets of sand are also present. The sand, which is overlain by a thin blanket of loess, consists mostly of fine-grained, well-rounded quartz with some multicolored chert. No consistent variations in size, composition, or heavy mineral content have been found vertically within a dune or geographically over the southern region. Dune orientation, steep lee slopes, and apices of V-shaped dunes all indicate deposition by a northeasterly wind, but time and deposition and source of material are uncertain. (author, shortened)

Key words: paleowinds, sand sheets, stabilized inland dunes.

74. Everett, K. R., 1979, Evolution of the soil landscape in the sand region of the Arctic Coastal Plain as exemplified at Atkasook, Alaska: Arctic, v. 32, no. 3, p. 207-223, 4 figs., 2 tables, 16 refs.

The Meade River region around the village of Atkasook, Alaska, typifies much of the Arctic Coastal Plain underlain by eolian sands. The forms and patterns of the landscape are formed mainly by ancient and active dunes and by channel shifts of the Meade River. Among the oldest and most stable landforms are low, broad dune ridges. Soil development shows that these dune surfaces were stable for at least several thousands of years. Younger surfaces associated with the present course of the Meade River consist of alluvial terraces and active or partially stabilized sand dunes. The soils show little profile development. Their maximum age is in the order of 1,000 years. (author, modified)

Key words: dating, river bank dunes, sand sea, soil formation.

75. Fernald, A. T., 1960, Geomorphology of the upper Kuskokwim region, Alaska: U.S. Geological Survey Bulletin, 1071-G, p. 191-279, 37 figs., 2 plates

Among the surficial deposits of the upper Kuskokwim region, southwest central Alaska sand dunes occur in great parts of the lowland. Two major periods of dune formation are separated by a considerable time interval. The "old dune fields" are represented by greatly modified dunes that were probably active during and after the Selatna glaciation. Only remnants of these fields are left. The "younger dune fields" are represented by prominent dunes initiated during the Farewell (Wisconsin) glaciation. The old fields show no clearly recognizable types of dunes. They may be similar to the northwest trending arcuate dunes of the younger fields which are concave to the southeast and have the steeper slope to the northwest. They belong to the phytogenic class of dunes and were formed by repeated shifting of strong (summer) winds from southeast to south and southwest. All of the dunes are stabilized and covered with vegetation, and an incipient soil profile has developed. (see: Eolian activity and sand deposits: p. 233-247, 4 figs., 3 tables, 7 refs.)

Key words: dune development, paleowinds, soil formation, stabilized inland dunes.

76. Fernald, A. T., 1964, Surficial geology of the central Kobuk River Valley, northwestern Alaska: U.S. Geological Survey Bulletin, 1181-K 31 p., 7 figs., 1 plate.

The Kobuk River Valley is covered with surficial deposits that are principally of glacial, eolian, and fluvial origin. Active and stabilized dune fields cover more that 300 square miles in the central valley, mainly on the south side of the Kobuk River. The two greatest active fields are the Great Kobuk Sand Dunes and the Little Kobuk Sand Dunes. Smaller fields, all stabilized except for one near the mouth of the Hunt River, are present on the flood plain and low terraces of the Kobuk River. The fields of the Great and Little Kobuk Sand Dunes show a complete transition in dune type from the phytogenic class, characterized by parabolic dunes to the vegetation-free class, characterized by barchans. The glacial periods provided conditions most favorable to formation of dunes. Present dune-building winds are easterly, as were those in the past. Sand transport is effective during winter months. The dune sands range from very fine to very coarse (1-2 mm) sand sizes. Grains are well-rounded and frosted. Mineral composition is principally quartz, feldspar and opaque minerals. (see: Dune fields, p. K16-K24, 4 figs., 2 tables, 1 ref.)
Key words: active and stabilized inland dunes, dune development, paleowinds.

77. Fernald, A. T., 1965, Recent history of the upper Tanana River lowland, Alaska: U.S. Geological Survey Professional Paper 525-C, p. 124-127, 2 figs., 4 refs.,

Surficial deposits that cover the northwest-trending lowland of the upper Tanana River in east-central Alaska include dune sands. Eolian sand occurs in scattered and completely stabilized dune fields, some of them now eroded by expansion of the floodplains of the Tanana and tributary rivers. Stabilization of dunes was initiated in late Wisconsin and postglacial times. All dunes with well-developed soil profiles in their crest, were probably stabilized more than 5,000 years ago.
Key words: dating, soil formation, stabilized inland dunes.

78. Fernald, A. T., and Nichols, D. R., 1953, Active sand dunes in the Kobuk River valley, northwestern Alaska: Geological Society of America Bulletin, v. 64, no. 12, pt. 2, p. 1421 (abs.)

Two areas of active sand dunes occupy 50 square miles in the central part of the east-trending Kobuk River valley. Small active blow-out dunes are scattered over other parts of the valley. Stabilized dunes cover more than 300 square miles. Both the active and stabilized dunes exhibit a variety of forms, most of which are genetically related to the parabolic type. Vegetation-free, barchan-like dunes commonly occur where moving sand encounters streams or springs. The overall shapes of the dune areas and the morphology and bedding of individual dunes indicate southeast and east winds as the effective present and past dune-forming winds. Summer field observations show that steady easterly winds cause active dune migration. The original source of the sand is from the tremendous quantities of sandy outwash and alluvium in the Kobuk River valley. Previously deposited dune sand is the immediate source of the currently active dunes. The degree of dune activity and extent of vegetation

cover have varied with climatic changes and occasional fires. (author, shortened)
Key words: active and stabilized inland dunes, sand source, wind directions.

79. Peterson, K. M., and Billings, W. D., 1978, Geomorphic processes and vegetational change along the Meade River sand bluffs in northern Alaska: Arctic, v. 31, no. 1, p. 7-23, 8 figs., 1 table, 12 refs.

Old windward-facing bluffs are rounded in form and have a number of small but active elliptical blow-outs. Caribou and ground squirrels augment wind erosion of the bluffs by disturbing the vegetation while grazing, trampling or burrowing. Young bluffs are often capped with "climbing" dunes. Eventually, wind blows the higher climbing dunes into larger, flattened, parabolic forms or even into flat tongue-shaped deposits (sand tongues), which may support a tundra vegetation. Stabilization is generally facilitated by rising permafrost. Mass-wasting and polygon-forming processes can ultimately obscure dune forms.
Key words: cliff-head dunes, deflation, dune vegetation.

80. Péwé, T. L., 1975, Quaternary Geology of Alaska: U.S. Geological Survey Professional Paper 835, 145 p., 1 plate, 45 figs., 14 tables, many refs.

The literature on eolian deposits is compiled. They cover a large part of the low-lying areas of Alaska and are of either Illinoian or Wisconsin age; only some are of Holocene age. The deposits include large areas of stabilized dunes and smaller areas of active dunes being formed under periglacial conditions. The two largest areas of active dunes are not along modern beaches but are in the Koyukuk and Kobuk River valleys within larger areas of stabilized dunes. Dune locations and the areal extent are described and mapped. (see: p. 34 - 37)
Key words: active and stabilized inland dunes, areal distribution.

81. Péwé, T. L., Hopkins, D. M., and Giddings, J. L., 1965, The Quaternary geology and archaeology of Alaska, in Wright, H. E., and Frey, D. G., eds., The Quaternary of the United States. New Jersey, Princeton University Press, p. 355-373, many refs.

The location and areal extent of eolian sand dunes, stabilized and active, are described and mapped. The existing literature on eolian deposits is reviewed. (see: Eolian deposits, p. 361-362.)
Key words: active and stabilized inland dunes, areal distribution.

82. Rickert, D. A., and Tedrow, J. C. F., 1967, Pedologic investigations on some aeolian deposits of northern Alaska: Soil Science, v. 104 no. 4, p. 250-262, 8 figs., 4 tables, 18 refs.

In northern Alaska the largest area of dunes occurs in an irregular pattern from the vicinity of the Meade River eastward to the distributary system of the Colville River. Narrow belts of active dunes line the major portion of the landscape adjacent to the Meade River. Most dunes have a longitudinal form and are aligned ENE-WSW. The broad flood-plain adjacent to the river is the major source area of dune sand. Soil profiles in various landforms were sampled and analyzed. Particle-size analyses indicate that the dune materials are unimodal and very well sorted. Mineral analyses show the fine sands to consist of about 95 percent quartz and chert. The very fine sand

fractions contain less than 2.5 percent heavy minerals. Buried organic horizons are a common and outstanding feature in dune soils along the Meade River. Like the Meade River area, the Ikpikpuk River and Killik River areas are mantled with dunes; some of these dunes are stabilized and others are undergoing active erosion, transport and deposition.
Key words: active and stabilized inland dunes, grain size, mineral composition, sand source, soil formation.

83. Trainer, F. W., 1961, Eolian deposits of the Matanuska Valley, agricultural area, Alaska: U.S. Geological Survey Bulletin, 1121-C, 34 p., 6 figs., 43 refs.

Wind-blown silt and sand in the Matanuska Valley agricultural area of south-central Alaska constitute widespread deposits that are still being formed. The blowing of snow and sand is only locally important. The modern eolian sediment is blown chiefly from bare glacial-outwash flood-plains, and locally from exposures of older eolian deposits and sandy glacial drift. The eolian mantle near major flood-plain source areas is made up of sand in the form of dunes and horizontal beds locally forming a low ridge along the upper end of the river bluff. Both active and stabilized dunes occur and all are downwind from long reaches of flood-plain or terraces or abandoned drainage courses. The dunes occur singly and in clusters and their long axes trend west or northwest. Cliff-head dunes locally fringe the top of the west bluff of the Matanuska River. Alternating layers of conspicuously different textures are shown by dune sections. Deposition of the eolian sediment began during or after recession of the last glacial ice (probably of late Wisconsin age) and there has been no major interruption of deposition since it began. Thin buried humus bands in the deposits may indicate repeated brief episodes of flood-plain stability. (author, modified)
Key words: cliff-head dunes, dating, grain size, sand sheets, sand source, soil formation.

84. Walker, H. J., 1965, Arctic sand dunes: process and form: Association of American Geographers Annals, v. 55, no. 4, p. 654, (abs.)

The Arctic Coastal Plain possesses many areas which contain numerous active and stabilized sand dunes. Active dunes are found along the western banks of many rivers and lakes. One of the areas of best dune development north of the Brooks Range is in the Colville River delta. The sand bars are a source of sand to the prevailing northeast winds for only a few months because of the seven-months protection offered by a durable, even though thin snow cover. Dune form is affected by factors not common outside the Arctic including permafrost. One unique feature found in such dunes is the perched lake which results from restricted drainage and low evaporation (author, shortened)
Key words: active and stabilized inland dunes, sand source.

85. Walker, H. J., 1967, Riverbank dunes in the Colville delta: Coastal Studies Bulletin 1, Louisiana State University Press (Baton Rouge), p. 7-14, 4 figs., 3 refs.

Conditions in the Colville delta, northern Alaska, are almost ideal from the standpoint of the formation of foredunes along riverbanks. The prevailing, rather persistent, northeast winds are not impeded by any natural windbreaks, and they have an abundant, annually renewed, source region in the extensive sandbars and mud flats which are formed along much of the western bank of

the river. Effective dune building occurs only primarily in spring and early summer after break-up. (author, modified)
Key words: riverbank dunes, sand source, wind directions.

Canada

86. Bird, J. B., 1967, The physiography of Arctic Canada - with special reference to the area south of Parry Channel. Baltimore, John Hopkins Press, 336 p.

Wind erosional features under periglacial conditions are of minor significance in northern Canada. Landforms produced entirely by deflation are rare and usually consist of shallow depressions. There is deflation from moraines and outwash deposits having a partial vegetation cover. The great sand sheet of central Victoria Island, the sand plains north of middle Back River, and the moraine between Great Bear Lake and Amundsen Gulf are in this category. Isolated patches of sand dunes are widely distributed in northern Canada. The main dune areas are restricted to the western Arctic where a combination of suitable surficial deposits, and drier, warm summers result in a sparse tundra cover on sandy soils. The largest area of eolian deposits in northern Canada is between the middle Thelon and middle Back rivers. Sand dunes also occur on lake shores, along esker systems and on the deltas of many rivers in the western Canadian Arctic. (see: Fluvial and aeolian processes p. 237-241).
Key words: areal distribution, sand sheets, stabilized inland dunes.

87. Cailleux, A., 1973, Eolisations périglaciaires Quaternaires au Canada (with a summary: Quaternary eolian deposits in Canada): Biuletyn Peryglacjalny, no. 22, p. 81-115, 1 fig., 4 tables, 30 refs.

The paper deals with the interpretation of shape and aspect of windworn sand grains, 0.5 to 1 mm in length, in eolian sediments in Canada.
Key word: grain surface features.

88. Cailleux, A., 1976, Formes et dépôts nivéo-éoliens sur le pied de glace, à Poste-de-la-Baleine, Québec Subarctique (with a summary: Niveo-eolian forms and deposits on an icefoot, Poste-de-la-Baleine, subarctic Quebec): Revue Géographie Montreal, v. 30, nos. 1-2, p. 213-219, 12 figs., 1 table, 6 refs.

On an icefoot at Poste-de-la-Baleine various niveo-eolian deposits and denivation forms have been studied. On the snow-covered pack-ice, niveo-eolian sand was deposited as far as 130 m from the shore. Near the shore niveo-eolian beach ridges have been built up. As the snow melts away or sublimates in spring the niveo-eolian cover evolves into fields of sharp cones or soft rounded hillocks (author, modified)
Key words: denivation forms, niveo-eolian deposition.

89. David, P. P., 1971, The Brookdale Road Section and its significance in the chronological studies of dune activities in the Brandon Sand Hills of Manitoba: Geologic Association of Canada Special Paper 9, p. 293-299, 5 figs., 2 tables, 11 refs.

The Brookdale Road Section, a road-cut, 3.6 m high, made through a small stabilized blow-out type dune in the northwest part of the Brandon Sand Hills of Manitoba, contains at least five buried paleosols characterized by

feeble profile development. The original soils developed on former dune surfaces during periods of moist climate and were buried by subsequent dune activities during periods of increased drought. Radiocarbon age of the total humus extracted from the upper few centimeters of the buried paleosols indicate that the first dune became stabilized prior to 3700 C^{14} years ago and that subsequent dune activities occurred some time after 3700, 2100, 1500, 900 and 400 C^{14} years ago. These periods of dune activity are considered to be of major magnitude and probably affected most of the stabilized dunes of the Brandon Sand Hills. (author)
Key words: dating, soil formation, stabilized inland dunes.

90. David, P. P., 1977, Sand dune occurrences of Canada: a theme and resource inventory study of eolian landforms in Canada: National Parks Branch, Department of Indian and Northern Affairs, Canada, Contract 74-230, Report, 183 p., 54 figs., many refs.

This report on the Canadian eolian theme study consists of two parts. The first part is a general discussion of the basic principles which are involved in the formation and development of Canadian dune areas and of the dunes occurring therein. The second part is a repertoire listing all the Canadian dune occurrences by provinces, which attain or exceed ten square miles in surface area. (author)
Key words: active and stabilized inland dunes, areal distribution.

91 David, P. P., 1978, Why dunes are parabolic: the wet-sand-hypothesis: Geological Society of America Annual Meetings, Toronto, Ontario, Abstract with Programs v.14, no. 10, p. 385.

The parabolic dune form which characterizes sand dunes of regions with climates ranging from humid to semi-arid, developes in response to the continuous presence of ground-moisture in the dunes. This moisture causes apparent cohesion of the sand grains, and consequently increases the shear strength of the sand. The parabolic dune form causes the local near-surface air flow to be compressed both vertically and horizontally and the velocity gradient above the dune is increased. Both vegetation and wind pattern affect the detailed configuration of the parabolic dunes, but do not cause the development of the basic parabola form. The parabolic dunes are initiated either by the break-up of primary transverse dunes formed on dry sand lacking vegetation cover, or by the development of blow-out depressions in areas already covered by vegetation. (author, shortened).
Key words: dune development, parabolic dunes.

92. David, P. P., 1979, Sand dunes in Canada: Geos, (Spring), Department of Energy, Mines and Resources, Canada, p. 12-14, 6 figs.

Sand dunes cover 0.3 % of the land surface of Canada. They are widely dispersed from coast to coast. Most of the dunes are stabilized by vegetation; an exception is made by the large active dune fields near Lake Athabasca. The active and stabilized sand dunes are mostly parabolic, due to the development in non-desert environments. Transverse dunes have been observed in the northern part of Alberta. There are no barchans nor longitudinal dunes in

Canada. Groundwater is the principal environmental factor determining dune type, and that is a function of the local climate.
Key words: active and stabilized inland dunes, areal distribution, dune development, parabolic dunes.

93. David, P. P., 1981, Stabilized dune ridges in northern Saskatchewan: Canadian Journal of Earth Science, v. 18, no. 2, p. 286-310, 20 figs., 4 tables, 73 refs.

Morphological, structural and sedimentary investigations reveal that stabilized dune ridges occurring in northern Saskatchewan form a particular group within the parabolic dune association, namely the "Cree Lake type" dune ridges. The dunes and associated eolian features were formed by southeasterly paleowinds (of adiabatic origin) of uniform direction. The dune ridges developed from primary parabolic dunes of simple and composite types through the process of dune elongation. The period of eolian activity began around 10,000 B.P. and lasted till 8800 years ago. The development of the dune ridges came to an end when a sudden climatic change evoked the rapid stabilization of dunes. Extensive data concerning form development, grain size properties and sedimentary structures are presented. (author, shortened)
Key words: dune development, grain size, internal structures, paleowinds, parabolic dunes.

94. Hermesh, R., 1972, A study of the ecology of the Athabasca Sand Dunes with emphasis on the phytogenic aspects of dune formation: M.S. Thesis, Saskatoon, Saskatchewan, 158 p., 60 figs., 17 tables, 91 refs.

The Athabasca Sands are situated along the south shore of Lake Athabasca between Dumville Creek and McFarlane Rivers. Although much of the sand is stabilized by vegetation, there are two large areas of open sand near the William and McFarlane Rivers. The vegetation of the open sand is adapted to a harsh dune environment. Accretion and deflation of sand and unusual moisture conditions are the main factors influencing vegetation growth. The building and maintenance of the different dune types is related to wind, sand and vegetation interaction. The dune morphology is related to the life forms of the associated vegetation. The transverse dunes are associated with shrubs and trees, the rolling dunes with grasses and herbs, while the longitudinal dunes lack vegetation. The building, maintenance and final destruction of many dunes is a cyclic phenomenon dependent on changes in the interacting factors. Chains of large longitudinal dunes on a desert pavement surface are found in the interior of the largest sand area. Dunes of this type have not previously been reported for Canada or any location at this high latitude. Transverse dunes are subdivided into beach dunes, willow dunes, birch dunes and precipitation ridges. Parabolic dunes and blow-outs also occur. The dune fields are at least 5,000 years old, and likely date back to the recession of the last glaciation. (author, modified)
Key words: active and stabilized inland dunes, dune development, dune vegetation.

95. MacKay, J. R., 1963, The Mackenzie delta area, N.W.T.: Canadian Department of Mines and Technical Surveys; Geographical Branch Memoir 8, 202p.

Wind action has built stabilized parabolic dunes and cliff-head dunes in the Mackenzie delta area. Active dunes and drifting sand are atypical of the area, despite the prevalence of sandy sediments. Wind-driven snow at low

temperatures acts as an abrasive agent. (see: Wind Action, p. 43-46, 5 figs.)
Key words: cliff-head dunes, parabolic dunes.

96. Nickling, W. G., 1978, Eolian sediment transport during dust storms: Slims River Valley, Yukon Territory: Canadian Journal of Earth Science, v. 15, no. 7, p. 1069-1084, 11 figs., 7 tables, 17 refs.

The amount of sediment transported by wind in surface creep, saltation, and suspension was measured during 15 dust storms in the Slims River Valley. The quantity of sediment transported in creep and saltation varied approximately with the cube of shear velocity, which supports theoretical and empirical models presented by other investigators. The suspended sediment flow rate seemed to be more directly controlled by the degree of air turbulence than by shear velocity. Surface moisture content and presence of soluble salts at or near the surface were controlling factors on the total sediment transport rate. High saltation-creep flow rates and major dust storms are associated with a distinct set of atmospheric conditions. (author, shortened)
Key words: eolian processes, rate of sand transportation.

97. Odynsky, Wm., 1958, U-shaped dunes and effective wind directions in Alberta: Canadian Journal of Soil Science, v. 38, no. 1, p. 56-62, 8 figs., 6 refs.

The presence of U-shaped, V-shaped and blow-out parabolic dunes indicate the direction of the effective wind responsible for their formation. Descriptions, pictures of such dunes and a sketch map showing the probable effective wind directions from the southwest and from the northwest are included. (author, shortened)
Key words: paleowinds, parabolic and U-shaped dunes.

98. Pissart, A., 1966, La rôle géomorphologique du vent dans la région de Mould Bay (Ile Prince Patrick - N.W.T. - Canada) (with a summary: The geomorphological effects of wind action in the Mould Bay region (Prince Patrick Island - N.W.T. - Canada): Zeitschrift für Geomorphologie, v. 2, p. 226-236, 3 figs., 7 refs.

The absence of wind-faceted stones and the rarity of wind polished pebbles, like the general lack of deflation surfaces on Prince Patrick Island, indicate that direct action by wind is of minor importance in this arctic region with a periglacial climate. Nevertheless, the existence of niveo-eolian deposits on the valley floors of braided rivers suggests that deflation occurs.
Key words: deflation, niveo-eolian deposition.

99. Pissart, A., 1975, Banks Island, N.W.T.: pingos, wind action, periglacial structures: Geological Survey of Canada Paper 75-1A, p. 479-481, 1 fig.

Along the Thomsen River large surfaces of wind-blown sand free of vegetation occur; deflation and accumulation appear to be very active. It is clear that the wind is now reworking old wind-blown sand deposits.
Key words: deflation, sand sheets.

100. Pissart, A., Vincent, J. S., and Edlund, S. A., 1977, Dépôts et phénomenes éoliens sur l'île de Banks, Territoires du Nord-Ouest, Canada (with a summary: Eolian deposits and phenomena on Banks Island, N.W.T., Canada): Canadian Journal of Earth Science, v. 14, no. 10, p. 2462-2480, 12 figs., 3 tables, 27 refs.

At the present time, eolian processes are active in many localities on Banks Island. Sediments of outwash plains and alluvial plains, especially the lower terraces of the Thomsen and Bernard Rivers, previously stabilized areas of eolian sands and areas where sandy Mesozoic and Tertiary deposits crop out, are subjected to deflation. The vegetation cover of surfaces subject to eolian activity is described. Eolian activity possibly began around 4000 years ago and may have been the result of a drier and cooler climate on Banks Island.
Key words: dating, deflation, niveo-eolian deposition, sand sheets.

101. Rochette, J. C., and Cailleux, A., 1971, Dépôts nivéo-éoliens annuels à Poste-de-la-Baleine, Nouveau-Québec (with a summary: Annual niveo-eolian deposits at Poste-de-la-Baleine, New-Quebec): Revue Géographie de Montreal, v. 25, no. 1, p. 35-41, 13 figs., 13 refs.

At Poste-de-la-Baleine, on the east coast of Hudson Bay, mixed, annual deposits of wind-driven sand and snow are observed. Internally these deposits are made up of consolidated snow often recrystallized in small pellets, rarely with interlayered sand beds. These deposits cover less than 1 percent of the territory and are located near the deflation areas. The surface of these deposits is in the form of sharp cones or soft rounded and cracked hillocks. Man has enhanced the deflation and the mixed deposition. (author, modified)
Key words: deflation, denivation forms, niveo-eolian deposition.

102. Rowe, J. S., and Hermesh, R., 1974, Saskatchewan's Athabasca Sand Dunes: Nature Canada, v. 3, no. 3, p. 19-23, 6 figs.

The largest active dune fields in continental Canada are found along the southern shores of Lake Athabasca, only 250 miles south of the tree line. The development of a desert landscape with transverse and longitudinal dunes as well as extensive desert pavements is the result of the interaction between the lake and the northflowing streams that feed it, or of local fires. The sand source is the Athabasca Sandstone. From it, streams such as the William and McFarlane Rivers transport large quantities of sand to deltas in Lake Athabasca. The deltas are episodically attacked by storm waves that redistribute the sand along the shores where it is exposed at low water.
Key words: active inland dunes, deflation, sand source.

103. Smith, D. G., 1978, The Athabasca sand dunes: a physical inventory: Indian and Northern Affairs, National Parks Branch, Canada, Contract no. 77-31, p. 27-45, 23 figs., many refs.

The Athabasca sand dunes are divided into east and west fields, separated by the William River. In late Pleistocene time it was probably the William River that deposited the thick accumulation of lacustrine sand in deltaic and offshore environments. The lacustrine sand pile, which became exposed when Lake Tyrrell drained, provided the raw material for the formation of eolian landforms. Deposition along the margins has enlarged the overall surface of the sand pile. The enlarging process is very active today along the southeast side of the east dune field. Eolian landforms can be

classified as either deflational or depositional. Four dune types can be identified. They include the parabolic, large and normal transverse, phytogenic and rolling dunes.
Key words: active and stabilized inland dunes, deflation, sand source.

104. Smith, D. G., 1980, Saskatchewan's sand dunes; a touch of Araby: Canadian Geographic, v. 100, no. 5, p. 24-29, 12 figs.

Besides their odd location within the boreal forest the Athabasca dune fields, extending along the south shore of Lake Athabasca, contain many desert-like landforms such as wind-deflated pebble covered surfaces, angular faceted stones, dune ridges, stabilized rolling dunes with sheets of sand, and unusually large parabolic dunes. The two dune fields, separated by the northward flowing William River, are active. The parabolic dunes are moving northeastward. The William River transports deflated dune sand into Lake Athabasca where waves, currents and wind redistribute it into a classic wave-dominated delta.
Key words: active inland dunes, wind directions.

105. Swift, D. J. P., Byers, D. S., and Krinsley, D. L., 1969, Eolian periglacial sand in northern Nova Scotia, Canada: Geological Society of America Special Paper 101, p. 279 (abs.)

Excavation of a paleo-Indian site at Debert, Nova Scotia, has revealed an eolian, periglacial sand body consisting of 2 m of laminated to very thin-bedded, reddish-brown fine-grained sand. Thirteen radiocarbon dates from cultural materials in the soil zone average 8635 ± 47 B.C. The sand was generated in situ from the underlying sandy till. Dune-like undulations are at many points draped over knobs on the surface of the till. Free-moving transverse dunes failed to develop, partly because of stabilization by a sparse plant cover, and partly because the now continuous blanket insulated itself from the underlying source. (author, shortened)
Key word: sand sheets.

106. Teller, J. T., 1972, Aeolian deposits of clay sand: Journal of Sedimentary Petrology, v. 42, no. 3, p. 684-686, 4 figs., 1 table, 4 refs.

Wind erosion of granular clay soils in fallow fields occurs during the winter months in southern Manitoba. The eroded clay grains first accumulate in and on snowdrifts and are later left as elongate low ridges of sand-sized aggregates of clay particles. Although these clay aggregates may eventually break down and form a uniform clay deposit, they remained as distinct aggregates throughout the summer following deposition. Such deposits may be formed in the glacial or periglacial environment or adjacent to areas such as flood-plains, dry lagoons, or dry lake plains where clay-rich materials are subjected to fragmentation but are not stabilized by vegetation. (author)
Key words: clay-sand ridges, denivation forms.

107. Terasmae, J., and Mott, R. J., 1959, Notes on sand dunes near Prescott, Ontario: Revue Canadienne de Géographie, v. 13, p. 135-141, 7 figs., 9 refs.

Numerous parabolic dunes occur near Prescott, Ontario. A study of their physiography and structure showed that they were formed by winds from the east. Palynological studies, coupled with radiocarbon dating, indicate that

these dunes were formed about 8,000 to 9,500 years ago, when the level of the Champlain Sea, east of Prescott, stood about 100 to 110 meters above the present sea level. (author, modified)
Key words: dating, paleowinds, parabolic dunes.

Antarctica

108. Aubert de la Rue, E., 1959, Phénomènes périglaciaires et actions éoliennes aux Iles de Kerguelen: Mémoires de l'Institut Scientifique de Madagascar, Série D, Tome 9, p. 1-21, 12 plates.

On the Kerguelen archipelago in the Indian Ocean the wind plays a dominant role in modelling the surface despite the humid climate. Rabbits help to destroy the vegetation cover (Aceana) and ice needles loosen the soil particles which are removed by the wind. Small hillocks of volcanic material, heaped by the wind, are found on valley floors and lower hill slopes. They are stabilized by vegetation. On several flat and weakly inclined surfaces blow-outs are numerous. In some valleys these blow-outs occur in a linear, elongate pattern.
Key word: deflation.

109. Bowler, J. M., 1978, Glacial age aeolian events at high and low latitudes: A Southern Hemisphere perspective, in van Zinderen Bakker, E. M., Antarctic glacial history and world palaeoenvironments. Proceedings of Xth INQUA Congress, Birmingham, U.K. p. 149-172, 10 figs., 104 refs.

Reconstruction of glacial age environments in semi-arid southern Australia has demonstrated the reality there of a wet phase (45,000 to 25,000 B.P.) followed by a long dry interval (25,000 to 14,000 B.P.). The transition from wet to dry is identified by a fall in lake levels, by the construction of lake shore clay-rich dunes (lunettes) and by renewed activation of longitudinal desert quartz dunes. The peak aridity occurred between 18,000 and 16,000 B.P. coincident with the maximum advance of global ice sheets. The cause of the major changes that occurred at 25,000 B.P. may be due to a large increase in meridional temperature gradients due to the major expansion of high latitude sea ice and ice sheets. It is also possible that increased vigour of atmospheric circulation produced widespread dusty environments and consequent effects of both increased advective heat transfer and dust-induced thermal modifications stimulated deglacial retreat and final return to interglacial conditions (author, modified)
Key words: eolian phases, paleoclimate, paleowinds.

110. Cailleux, A., 1962, Sables. Formes sur le Terrain. In: Etudes de géologie au détroit de McMurdo (Antarctique): Comité National Francais pour les Recherches Antarctiques, no. 1, p. 5-14, 10 figs., 1 table.

In Victoria Valley there are not only sand dunes, but also niveo-eolian covers made up of an interstratification of sand and snow. This type of deposit has been described, until now, only in Greenland and explains many deposits of Quaternary age in western Europe. Wind action is strong and responsible for the wearing of sand grains (partly of volcanic origin) and dissemination of small pebbles.
Key words: active inland dunes, grain surface features, niveo-eolian deposition.

111. Cailleux, A., 1967, Periglacial of McMurdo Strait (Antarctica): Biuletyn Peryglacjalny, no. 17, p. 59-65, 1 fig., 6 plates, 1 table.

In the Victoria Valley one can observe asymmetric sand dunes and thin niveo-eolian covers which pass laterally into dunes. The niveo-eolian covers are recent and they occupy five times more space than the dunes; they both are without vegetation. On the surface the niveo-eolian covers show small and big asymmetric ripples, the latter being grouped in a parallel direction with a gentle slope towards the east. In summer winds blow from the east; in winter the prevailing wind comes from the west and southwest.
Key words: active inland dunes, grain surface features, niveo-eolian deposits, wind directions.

112. Cailleux, A., 1972, Les formes et dépôts nivéo-éoliens actuels en Antarctique et au Nouveau-Québec (with a summary: Contemporary niveo-eolian formations in Antarctica and New Quebec): Cahiers de Géographie de Québec, v. 16, no. 39, p. 377-409, 6 figs., 24 photos, 18 refs.

In Antarctica, McMurdo region, Victoria Valley, niveo-eolian deposits, made up of alternating layers of wind-driven snow and sand 0 - 2 m thick are perennial. In Poste-de-la-Baleine, New Quebec, Canada, niveo-eolian deposits are annual with the snow melting down every year. They contribute to the nourishment of the first sandy raised beach and of dunes. Denivation forms like sharp cones, soft rounded hillocks, the sandy surface of which is typically cracked, sand pellets, sand rolls (denivation micromoraines) and sand nets are extensively described and illustrated., (author, modified)
Key words: denivation forms, niveo-eolian deposits.

113. Calkin, P. E., and Rutford, R. H., 1974, The sand dunes of Victoria Valley, Antarctica: The Geographical Review, v. 64, no. 2, p. 189-216, 12 figs., 2 tables, 70 refs.

Transverse-barchan dunes, together with flanking sand sheets and whaleback sand mantles, stretch more than 8 kilometers between the Victoria Lower Glacier and the perennially frozen Lake Vida, forming the largest sand accumulation in Antarctica. The cold desert climate, persistent and strong summer easterly winds, thick sandy ground moraine, and a broad valley train favor dune formation, though ubiquitous snow strata included in the sand deposits may limit movement. The dunes show short-term slip-face movements of up to 12 centimeters a day in mid-summer. Sand from the dunes is generally coarser and more poorly sorted than that from beach-derived dunes, but is similar to that of many interior deserts. An unusually uniform and generally high degree of roundness of sand grains throughout lower Victoria Valley may be explained by inheritance of round Beacon sandstone grains and/or by a related kilometer-long cyclical grainpath maintained in the valley by the combined action of winter and summer winds. (author)
Key words: barchan dunes, grain size, rate of sand transportation, sand sheets, wind directions.

114. Lindsay, J. F., 1973, Reversing barchan dunes in lower Victoria Valley: Geological Society of America Bulletin, v. 84, no. 5, p. 1779-1806, 5 figs., 13 refs.

Approximately 30 reversing barchan dunes occur along the northern side of lower Victoria Valley. Laminae which dip steeply upwind suggest that much

of the internal structure of the dunes develop during periods when the wind reverses itself, possibly during winter. This wind reversal and the fact that the dune cores are frozen suggest that migration of the dunes is small. The dune sands are well sorted and contain a large proportion of relatively dense dark minerals. (author, modified)
Key words: barchan dunes, grain size, internal structures.

115. Rex, R. V., Margolis, S. W., and Murray, B., 1970, Possible interglacial dune sands from 300 m water depth in the Weddell Sea, Antarctica: Geological Society of America Bulletin, v. 81, no. 11, p. 3465-3472, 6 figs., 1 table, 18 refs.

Sediments collected from Berkner Bank (Antarctic continental shelf of the Weddell Sea) contained several well-sorted sand samples including both striated and fractured quartz grains with a considerable degree of polish. The very good sorting, size, and surface features suggest that these are dune sands. These data indicate that Berkner Bank was exposed at the surface during an interglacial period when the Antarctic land surface stood approximately 300 m higher with respect to sea level than it does today. (author, modified)
Key words: grain size, grain surface features.

116. Rutford, R. H., and Calkin, P. E., 1974, Reversing barchan dunes in lower Victoria Valley, Antarctica: discussion: Geological Society of America Bulletin, v. 85, no. 6, p. 1011-1012, 16 refs.

The unique dune field in lower Victoria Valley described by Lindsay (1973) was also studied by Rutford and Calkin. Lindsay's theme that the dunes are "reversing" is criticized in this paper.
Key words: barchan dunes, wind directions.

117. Selby, M. J., Rainst, R. B., and Palmer, R. W. P., 1974, Eolian deposits of the ice-free Victoria Valley, southern Victoria Land, Antarctica: New Zealand Journal of Geology and Geophysics v. 17, no. 3, p. 543-562, 15 figs., 22 refs.

The most widespread eolian deposits of the southern Victoria Land dry valleys are ripples which occur in sediments ranging in grain size from fine sand to pebbles. There does not appear to be a simple, direct relationship between ripple index and grain size. The high winds and high density cold air of Antarctica appear capable of moving the largest pebbles which have a diameter of 19 mm. Sand forming transverse and whaleback dunes in the Victoria Valley is derived from the outwash from the Victoria Lower Glacier. The sand in the dunes is interbedded with snow, and moisture from this allows the dunes to be permafrosted except for a thin surface layer of dry mobile sand. The mobile sands of the transverse dunes are seasonally reversing. The sands of the dunes are well sorted and there is no selective deposition of a particular grain size in any area of the dunes. (author, shortened)
Key words: barchan dunes, grain size, grain surface features, transverse dunes, wind ripples.

118. Smith, H. T. U., 1966, Wind-formed pebble ripples in Antarctica: Geological Society of America Special Paper 87, p. 160 (abs.)

In ice-free areas within a radius of 125 miles from McMurdo Station, Victoria Land, Antarctica, eolian ripples are characterized by unusual size and

unusual coarseness of their material. The ripples are asymmetric in profile, and subparallel in plan. Height ranges up to more than 1 foot, and distance between crests, up to more than 5 feet. Ripple surfaces are covered continuously by pebbles. Movements of this coarse material is attributed to the effect of very low temperatures on the force of the wind. (author, shortened).
Key word: wind ripples.

Miscellaneous

119. Bogacki, M., 1970, Eolian processes on the Forefield of the Skeidarárjökull (Iceland): Bulletin de l'Acádemie Polonaise des Sciences, Série Géologie et Géographie, v. 18, no. 4, p. 279-287, 4 figs., 8 photos.

The complete lack of vegetation cover promotes the activity of winds on the outwash plains of the Skeidarárjökull, Iceland. In summer the northerly winds, coming from the glacier, are dry and of great velocity, causing silt-sand storms of volcanic material with a specific gravity noticeably lower than that of quartz. The sand and silt are deposited in moist places and in depressions and fill up the channels of outwash streams. Near vegetation clusters, small hillocks arise with their longer axis running in a N-S direction parallel to the prevailing wind. In winter sand and silt are periodically deposited on the snow cover in the outwash plains resulting in interbedding of snow and sand-silt layers. The rate of thawing is higher in places where there is a concentration of silt, resulting in a differentiated relief with numerous negative concave forms.
Key words: deflation, denivation forms, eolian processes, niveo-eolian deposition.

120. Cailleux, A., 1973, Répartition et signification des différents critères d'éolisation périglaciaire: Biuletyn Peryglacjalny, no. 23, p. 51-63, 13 refs.

Various criteria for periglacial wind action are mentioned, including deflation, wind polishing, sand transport and sedimentation, and niveo-eolian deposition. In the Quaternary periglacial wind action has contributed to the modification of the relief and has led to extensive deposition. The study of these phenomena in actual polar regions is useful for the understanding of Quaternary history.
Key words: polar deserts, deflation, niveo-eolian deposition, wind polishing.

121. Cailleux, A., 1974, Formes précoces et albédos du nivéo-éolien (with a summary: Early forms and albedos of niveo-eolian deposits): Zeitschrift für Geomorphologie, v. 18, no. 4, p. 437-459, 3 figs., 15 photos, 2 tables, 15 refs.

Mixed deposits of snow and wind-driven sand or other detritus, and the forms and micro-forms generated by them, are called niveo-eolian. At Poste-de-la-Baleine (Canada) the melting of sand/snow layers generates a highly irregular topography with all sorts of stripes, hillocks, pinnacles, etc. On sand dunes, ridges of 2 mm granules are eolian rather than niveo-eolian. The niveo-eolian sand is as well sorted as the dune sand. The albedo of the niveo-eolian deposits varies from that of pure snow (0.85) to that of wet pure sand (0.16). A very small amount of sand (10%) is sufficient to let the albedo drop heavily (from 0.85 to 0.50). (author, modified)
Key words: denivation forms, grain size, niveo-eolian deposition.

122. Cailleux, A., 1975, L'histoire du nivéo-éolien et ses enseignements: Bulletin de Géographie de la Société Neuchateloise LIV, v. 4, no. 20, p. 3-14, 2 figs., 30 refs.

The history of references concerning the niveo-eolian character of certain deposits in Sweden, Spitsbergen, Iceland, Greenland, The Netherlands and other European countries is discussed. Various examples of actual niveo-eolian deposition and denivation forms are mentioned.
Key words: denivation forms, niveo-eolian deposition.

123. Czeppe, Z., 1966, Przebieg głównych procesów morfogenetycznych w poludniowo-zachodnim Spitsbergenie (with a summary: The course of the main morphogenetic processes in Southwest Spitsbergen): Uniwersytetu Jagiellońskiego, Prace Geograficzne Zeszyt, v. 13, p. 122-123.

During the winter (the period of strongest winds) of 1957-1958 the author collected samples of snow from snowdrifts in Spitsbergen, melted them and weighed the mineral content. The samples contained 0.2 to 0.85 gram of sediment per liter of water and up to 2 gram in the surface horizons, mostly composed of coarse sand (0.3 - 2.0 mm). The calculation of the amount of eolian deposit per unit of surface gives a rough approximation of 300 - 400 g/m^2 per year. These figures show that eolian transport carries a considerable amount of material and, although it does not create any forms of relief, merits a greater attention than it has so far recieved. (see: Eolian processes)
Key words: niveo-eolian deposition, rate of sand transportation.

124. Fristrup, B., 1952/1953, Wind erosion within the arctic deserts: Geografisk Tidsskrift, v. 52, p. 51-65, 6 figs., 5 tables, 30 refs.

Wind erosion in arctic regions is especially strong in the continental areas in front of the inland ice. The extent of high-arctic deserts is small and they are to be found in arctic North America and Greenland, especially around Søndre Strømfjord and in Peary Land. The climate is extremely continental with relatively high temperatures during summer, extremely low temperatures in winter, and violent wind erosion. The total quantity of snow in winter is small, and the snow cover is discontinuous. Wind polishing in the lowlands during winter storms by ice needles in drifting snow is very pronounced. At all times of the year drifting of sand may occur. In most arctic regions loess deposits are playing an important role, but sand deposits and especially sand dunes are rare.
Key words: polar deserts, deflation, snow transportation, wind polishing.

125. Fristrup, B., 1953, High arctic deserts. Congrès Géologique International, Comptes Rendus de la XIXe Session, Alger 1952, S. 7, F. 7, p. 91-99, 11 refs.

High arctic deserts are found in North Greenland in Peary Land. Wind erosion is very pronounced. Loose material is carried away and even the hardest stone is polished and faceted by wind-driven sand, snow and ice-needles commonly derived from western directions. Sand is found only in the very narrow beach along the coast and along the rivers. Real sand dunes exist only in connection with rivers, where they may be as high as 2 meters. The snow cover in winter is discontinuous because of the extraordinary aridity of the high arctic climate. This aridity is also the cause of thick salt crusts

formed by strong evaporation in summer. Deserts of almost the same type are found in continental parts of West Greenland, especially in the area around Søndre Strømfjord. (author, modified)
Key words: polar deserts, crust formation, deflation, snow transportation, wind polishing.

126. Låg, J., 1955, Litt om innvirkning av vinderosjon og eoliske sedimenter på jordsmonnet i Island (with a summary: On the influence of wind erosion and aeolian sediments on the soils of Iceland): Norsk Geografisk Tiddskrift, v. 15, nos. 1-2, p. 20-28, 20 refs.

Owing to strong winds, barren coastal tracts, flood-plains and alpine regions, volcanic activity, high content of fine sand and silt in the soil material, and destruction of the vegetation by man, serious damage has been caused by wind erosion in Iceland. Eolian sediments have great influence on the soil properties. On the whole, pH in the upper strata lies considerably higher than in the other regions in Northern Europe with a corresponding humidity of climate. (author, shortened)
Key words: deflation, human impact, soil formation.

127. Preusser, H., 1976, The landscapes of Iceland: types and regions: The Hague, W. Junk, 363 p., many refs.

Deflation is one of Iceland's most serious problems. Deflation occurs only after a period of heavy accumulation. Icelandic soils consist for the most part of loess-like deposits(móhella) with coarser grains and different chemical composition than European loess. Numerous embedded layers of tephra occur. The eolian material originates in the tuff and lava regions, the sandur area and fluvioglacial deposits and in the sands along the coast. The largest quantities come from those areas in which the plant cover has just been destroyed, leaving a deep layer of móhella to be blown away. Because of the frequently changing wind directions true dunes are rarely found. Shortly after the "Landtaking" eolian accumulation began, increasing steadily in intensity until the corresponding deflation attained catastrophic proportions, especially during the last 200 to 300 years. Two phenomena caused by deflation are particularly characteristic: rofbards and wind-sickels. Rofbards are mushroom-shaped, vegetated islands, 1 to 2 meters in height. Wind-sickels or halfmoon-shaped bare patches occur where dry winds blow fairly constantly in one direction. (see: Deflation, p. 50-56)
Key words: deflation forms, human impact, sand source.

128. Sarnthein, M., 1978, Sand deserts during glacial maximum and climatic optimum: Nature, v. 272, no. 2, p. 43-46, 2 figs., 92 refs.

Active sand dunes were extensive during the glacial maximum at about 18,000 B.P. and were generally dormant during a climatic optimum centered about 6,000 B.P. This fits the concept of "ice-age aridity" in the tropics, the middle and higher latitudes around 18,000 years ago, which has recently replaced that of "ice-age pluvials". Changes in precipitation seem to be a driving function controlling the distribution of sand dunes. The mid-latitude climate during the Pleniglacial in North America is controversal. Cool pluvial lakes contrast with synchronous sand deserts. The dunes were formed by northwesterly winds surrounding the Laurentide ice-sheet, and are comparable to the permafrost-influenced Alaskan polar deserts. A similar situation exists for the widespread European sand dunes near the Scandinavian ice cap. About 6,000 B.P. the only active, but minor dune fields were reported from North Alaska and the Great Basin of North America, Canada and North Minnesota. Key words: active inland dunes, areal distribution, eolian phases.

129. Seppälä, M., 1975, International research programme for periglacial sand dune studies - a recommendation: Quaestiones Geographicae, v. 2, Adam Mickiewicz University, p. 139-143, 1 fig., 20 refs.

In those regions of the northern hemisphere which were in the immediate vicinity of Quaternary glacial areas or even in actual glaciated areas large dune fields are often to be found, mostly anchored by vegetation. The final aim of an international research programme to be set up is to arrive at an explanation of the origin of periglacial sand dunes on a worldwide basis and to draw certain conclusions as to the paleoclimatic conditions existing at the time they were formed and as to changes occurring during the Quaternary period. The first step is to assemble a bibliography of works dealing with periglacial dunes. Attached to the bibliography there should be an easily read map indicating dune areas already studied. The first task in the actual research programme would be a general definition of areas where dunes exist. In field work attention should be given to the morphology, stratigraphy and the material of the dunes to construct models of dune development. By combining the results obtained from different dune areas general conclusions as to climatic conditions in the world during the dune-forming period could be made. Furthermore, it would be possible to delimit areas in which dune formation occurred simultaneously in the world. (author modified)

APPENDIX I

Subject Index
(Citations in parenthesis)

APPENDIX II

Author Index

APPENDIX III

Map References

Ice limits and permafrost boundaries, as indicated in figures 1 and 2, were compiled from the following references:

1. Soil Map of the World, II-1, II-2, V-2, scale 1:5,000,000. Compiled by FAO, Rome, Published by UNESCO, Paris, 1972-1978.

2. International Quaternary Map of Europe, scale 1:2,500,000. Compiled by Bundesanstalt für Bodenforschung, in co-operation with the INQUA. Published by Bundesanstalt für Bodenforschung and UNESCO, Paris, 1967-1975.

3. Denton, G. H., and Hughes, T. J., eds., 1981, The Last Great Ice Sheets. John Wiley and Sons, New York, 484 p.

4. Wright, H. E., and Frey, D. G., eds., 1965, The Quaternary of the United States. New Jersey, Princenton University Press, 922 p.

5. Die nordischen Vereisungen in Mitteleuropa, scale 1:1,000,000. Entwurf: H. Liedtke, 1969: in, Forschungen zur deutschen Landeskunde, Band 204, 1975. Bundesforschungsanstalt für Landeskunde und Raumordnung. Selbstverlag-Bonn-Bad Godesberg, 160 p.