J. C. F. Tedrow
Rutgers University, U.S.A.

SOILS OF THE POLAR REGION OF NORTH AMERICA*

Abstract

For pedologic purposes the polar region of North America is divided into a polar desert soil zone, a sub-polar desert soil zone and a tundra soil zone. The polar desert soil zone centers around the Queen Elizabeth Islands, namely, Melville, Prince Patrick, Bathurst, Devon, Elif Rignes and Ellesmere Islands, plus the ice-free sectors of northern Greenland. The sub-polar desert soil zone centers around the Franklin District and is comprised largely of Banks, Victoria, Prince of Wales and Somerset Islands, northern Baffin Island and surrounding areas including parts of coastal Greenland. The tundra soil zone includes northern Alaska, the northern portion of Yukon Territory, District of MacKenzie, District of Keewatin, southern Baffin Island and southern Greenland.

This symposium deals with the problems of paleogeography and periglacial phenomena. By using fossil soils which had formed under a polar climate during an earlier episode, one should be able to utilize such information as an aid in reconstructing past processes and environments. This report undertakes such a problem and treats the nature of the various soils as they currently exist in the polar region of North America. Hopefully, some of the information may be used in reconstructing Quaternary events in certain localities, particularly those designated as periglacial.

When von Middendorf (1864) desribed the polar region of Eurasia, he used the term *tundra* to describe all land north of the tree line not covered by ice. Since von Middendorf's time, terms such as *tundra, polar*, and *arctic* have been used to characterize northern soils. We now know that not only is there great local variability in polar soils, but that northward through the polar regions the gross features of the landscape change from a wet marshy condition to one that is desert-like. These conditions were brought out in the great work of Gorodkov (1939).

As one proceeds northward through the polar regions, climate becomes more severe with decreasing summer temperatures; generally, there is less precipitation and slightly lower relative humidity. The universal marshiness of the landscape with a thick, wet, organic surface immediately north of the

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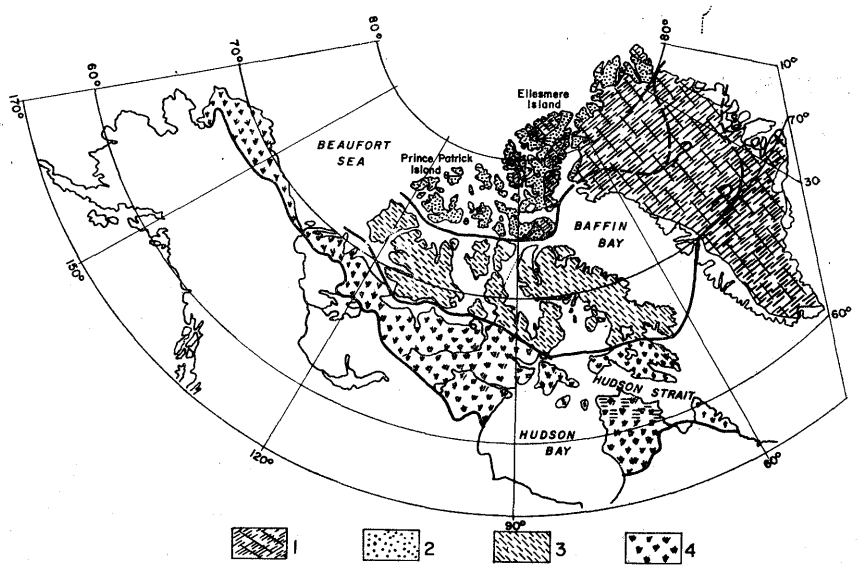


Fig. 1. Major soil zones in the polar regions of North America

1. ice; 2. polar desert zone; sub-polar desert zone; 4. tundra zone

forested sectors gives way to a striking desert-like condition with a near absence of vascular plants in the far north (Targulyan and Karavaeva, 1964; Korotkevich, 1967; Tedrow, 1968a; Tedrow and Thompson, 1969).

The polar region of North America was previously divided into a tundra zone and a polar desert zone (Tedrow and Brown, 1962; Tedrow, 1963). With more extensive observations in the Canadian Arctic Archipelago, it now seems more realistic to recognize three natural polar soil zones as indicated in Figure 1 and Table I. Table I is compiled from various climatic and botanical sources (particularly the work of Polunin, 1951; and Porsild, 1957), as well as personal field observations.

We now proceed with a brief discussion of soils found within the three zones. Detailed below are the more important genetic soils of the North American polar region, exclusive of those found in shallow conditions, active solifluction slopes, and those controlled altitudinally (Table I, Figs. 1 and 2).

Polar Desert Zone (All of the genetic soils in the polar desert zone will vary from mildly acid to alkaline in reaction. Saline and alkaline conditions not delineated)

Table I

Soil and Vegetation Zonation in the Polar Regions of North America

Major Soil Zones in Northern North America	Soils Separations in Northern USSR		Botanical Separations in North America	
	Gerasimov (1956)	Ivanova and Rozov (1957)	Polunin (1951)	Porsild (1957)
POLAR DESERT ZONE	–	–	High arctic	Rock desert or fell field
SUB-POLAR DESERT ZONE (Also known as Polar Desert-Arctic Brown Translation)	Polar tundra soil	Arctic (crypto-gley soils)	Mid arctic	Stony sedge-moss-lichen tundra
TUNDRA ZONE (Also known as Arctic Brown Soil Zone)	Grey soils of the sub--polar tundra	Arctic tundra soils	Low arctic	Dwarf shrub-sedge-moss--lichen tundra and mature sedge grass tundra

Polar Desert Soil
Tundra Soil
Soil of the Hummocky Ground
Soil of the Polar Desert-Tundra Interjacence

Sub-Polar Desert Zone (Some soils in the sub-polar desert zone are alkaline and a few saline)

Polar Desert Soil
Tundra Soil
Soil of the Hummocky Ground
Arctic Brown Soil (northern variant)

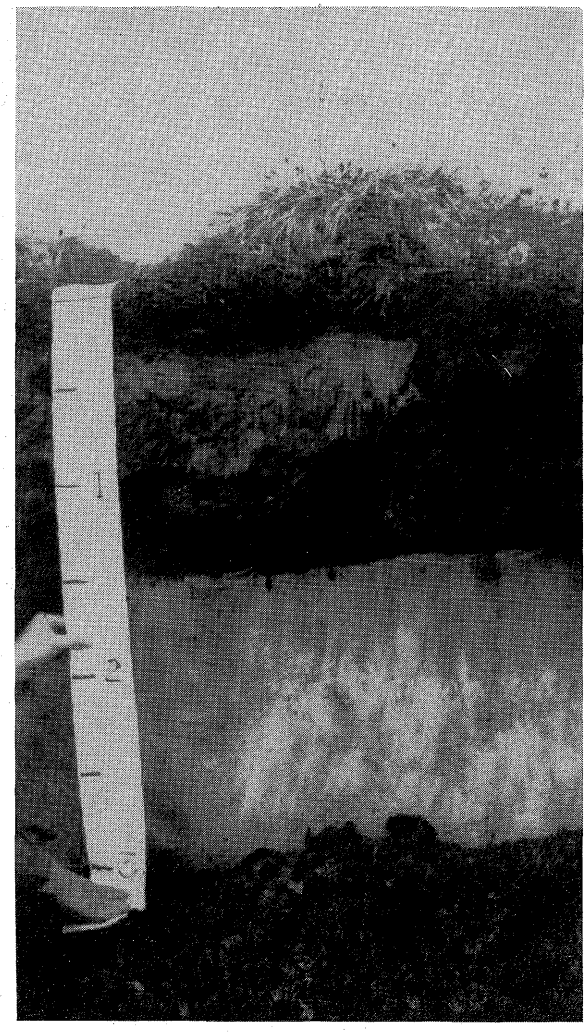
Tundra Zone

Tundra Soil (Upland and Meadow)
Bog Soil
Arctic Brown Soil
Dwarf Podzol and Podzol-like Soils
Rendzina Soil
Shungite Soil
Grumusol Soil

POLAR DESERT ZONE

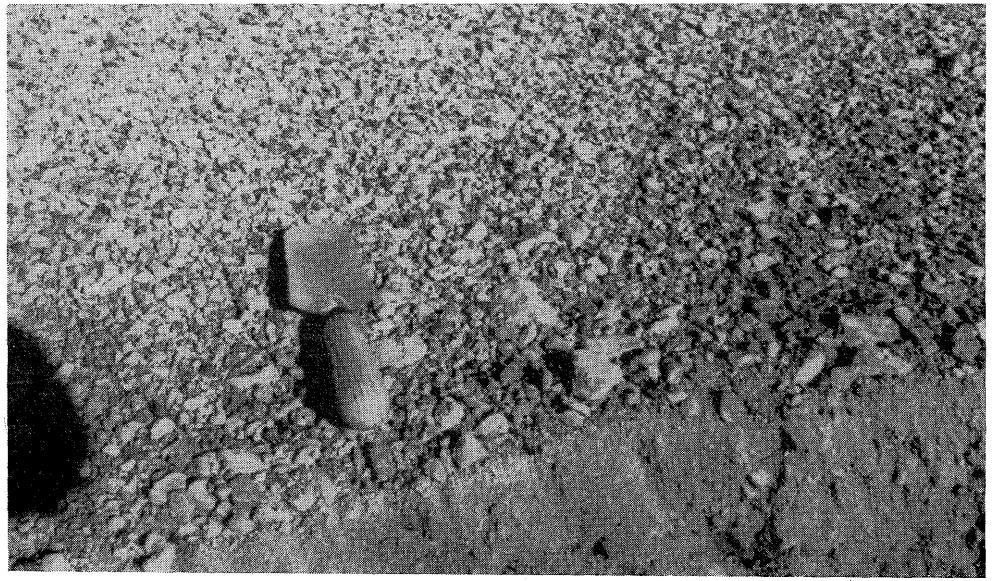
Polar Desert Soil is the most widespread soil of the northern Canadian Arctic Archipelago and northern Greenland (Fig. 2a). On the unconsolidated gravelly sands of the Beaufort formation Polar Desert Soil forms a continuous cover in some sectors (Tozer and Thornsteinsson, 1964).

Polar Desert Soils occupy as much as 80 to 90 percent of the landscape in sectors mantled with sandy deposits, but in the case of finer textured clay shales they approximate only 20 to 40 percent of the area. Polar Desert Soils are conspicuous in that they have desert pavements and a near absence of vascular plants (Pl. 1). Organic matter of the surface horizon, usually less than the one percent level, is contributed by algae and diatoms. Polar Desert Soil is characterized by a mineral appearance throughout, with development of a strong brown-colored solum. The frost table is relatively deep, often three to four feet, and conditions immediately above the frost table are generally quite dry. Base saturation and pH values are high, typifying the low degree of leaching (Mikhailov, 1962–1963; Tedrow, 1966). Some Polar Desert Soils are not only alkaline in reaction, but in many instances have also developed a degree of salinity. Certain barren sectors of the high mountains within the tundra zone also have a special variety of Polar Desert Soil,



Pl. 1. Tundra soil near Umiat, Alaska

scale in feet



Pl. 2. Polar desert soil in Inglefield Land, Greenland

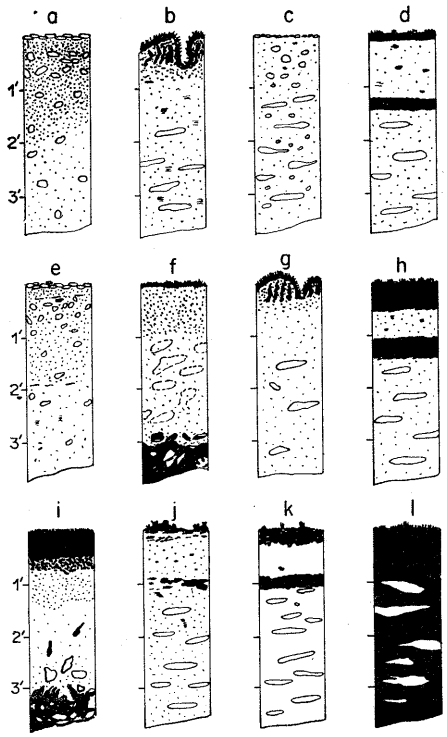


Fig. 2. Major genetic soils of the polar regions of North America

but in the location because of greater precipitation and strong winds, the soil material is not very stable and erodes quite easily. The result is profiles with little genetic horizonation (Tedrow and Brown, 1962).

Tundra Soils (Fig. 2d) are present in the high arctic, even in the northern--most extremities of ice-free land. As a rule, however, they are confined to the narrow swales and depressions, and hence comprise only a minor part of the landscape. Whereas Tundra Soil of the high arctic generally possesses morphology similar to that in the main tundra zone, the entire profile in the former is shallower, and the gley process is not well manifested. Further, Tundra Soil of the high arctic is near neutral to alkaline in reaction (Tedrow, 1968b). On the western flank of Prince Patrick Island, Tundra Soil, the most primitive as seen by this author, consists of a thin layer of black gelatinous lichens over water-logged grey sands (Tedrow, *et al.*, 1968).

Soils of the Hummocky Ground occur mainly on sloping positions peripheral to Polar Desert Soil or dry, rocky areas. The soil has a pronounced

hummocky appearance and is the scene of intense frost action (Fig. 2b). Whereas these soils approximate an Upland Tundra Soil condition, the morphology is somewhat different (Tedrow, *et al.*, 1968).

Soils of the Polar Desert – Tundra Interjacence occupy the low positions peripheral to the vegetated swales with Tundra Soil (Fig. 2c). Here there is only a sparse cover of vascular plants. During the early summer the soils are supersaturated with water, but as field conditions become progressively drier during the summer months these soils also become quite dry and a salt-encrusted layer forms on the surface. There are no discernible pedogenic horizons present except for the salt crusts. For lack of a more appropriate designation, these soils are referred to as Soils of the Polar Desert – Tundra Interjacence (Tedrow, 1968b).

Within the polar desert soil zone there are many boulder fields, talus slopes and bedrock exposures without soil development. Also, Arctic Brown Soil is found within the polar desert zone but only in rare occasions.

SUB-POLAR DESERT ZONE

Between the tundra and the polar desert zone is a broad diffuse sector extending from Banks, Victoria, and Northern Baffin Islands on across the ice-free sectors of coastal Greenland between c. 73 and 78°N. This sector is best described as a sub-polar desert soil zone. Soils in this sector form under slightly less frigid conditions and slightly more precipitation than they do to the north. Vegetation is thin to nearly absent in the uplands and seldom forms an organic mat on the surface.

Polar Desert Soil in the sub-polar desert zone is similar to that described in the far north. The main variations are that the former contain slightly more organic matter in the solum, have a poorly developed desert pavement, and have slightly lower pH values and more moisture at depth (Fig. 2e). Tundra Soils (Fig. 2h) represent an intermediate condition between the Tundra Soils of the polar desert and those of the tundra soil zone. Soils of the Hummocky Ground (Fig. 2g) within the polar desert zone are virtually identical in morphology as their equivalents found within the polar desert zone. Arctic Brown Soil (Fig. 2f), similar in morphology to that found within the tundra zone to the south, here forms under more arid condition and has high pH values and pedogenic carbonate accumulation within the solum (Tedrow and Douglas, 1964).

TUNDRA ZONE

Tundra Soil is dominant areally within the tundra zone. It is characterized by a fibrous organic layer which is underlain by a wet, olive to gray-brown silt loam with prominent gley (Figs. 2j, 2k, and Pl. 2). At a depth of some 18 to 36 inches, buried organic layers are usually encountered which, in northern Alaska, generally yield C-14 age values of 8,000 to 11,000 yr. B. P. and show pollen spectra quite similar to that now being produced in the tundra zone (Douglas and Tedrow, 1960; Tedrow, 1963).

The lower, flatter positions of this area which have greater moisture contents and thicker organic surface layers have been designated Meadow Tundra. The more sloping positions which have slightly less moisture and thinner organic surface layers have been designated Upland Tundra (Figs. 2j and 2k) (Tedrow, *et al.*, 1958; Tedrow and Cantlon, 1958).

Bog Soil is widely distributed throughout the tundra zone. In Alaska, along the Colville River, it attains a thickness of over 30 feet, but as a rule the organic layer is only two to four feet thick (Fig. 2l). The organic matrix is usually a sedge-sphagnum mixture, acid and reddish brown to black in color.

Arctic Brown Soil occupies many small, isolated, well-drained positions within the polar regions (Fig. 2i). It is deep and well-drained to depths of three or more feet, but the solum seldom attains a thickness of more than 20 inches. Under a one-inch organic mat is an eight-inch thick A horizon dark brown to dark reddish brown, friable loam which grades into a dark yellow-brown loam at depth. The surface is generally strongly acid, but pH values increase with depth (Tedrow and Hill, 1955; Drew and Tedrow, 1957; Hill and Tedrow, 1961).

In the southern fringes of the tundra zone the sandy, quartzose glacial deposits commonly have soils with podzol-like features (Gorodkov, 1939; Brown and Tedrow, 1964; Brown, 1966). I have seen Dwarf Podzols on sands of the Quaternary deposits as far north in Alaska as the Kogosukruk River at 69°44'N.

Apart from the problem of physical displacement due to frost action and ground ice formation, there is little in the way of unique qualitative pedogenic processes operating in the polar regions. Among other processes, solution, precipitation and synthesis of new compounds proceed in the north as elsewhere. In order to show that a variety of genetic soils which occur in the more temperate climates also exist under some polar climates, it is pertinent to note that Rendzina Soils (Ugolini and Tedrow, 1963) and Shungite

(Olonetzky chernozem) Soils (Ugolini, *et al.*, 1963) have been recorded in the Brooks Range. Soils with Grumusol features have been identified on the bentonite-rich clays in Alaska at 69°23'N (MacNamara and Tedrow, 1966).

CIRCUMPOLAR DISTRIBUTION OF SOILS

These natural zones as delineated in North America can be extrapolated into northern Eurasia. The tundra soil zone, as shown in Figure 1 approximates the gley soils of the sub-polar tundra of Gerasimov (1956), the arctic tundra soils of Ivanova and Rozov (1962), or the tundra soil zone of Turgulyan and Karavaeva (1964). The soils of the sub-polar desert zone (Fig. 1) correspond to the polar tundra soils of Gerasimov, the arctic (crypto-gley) soils of Ivanova and Rozov, or to the arctic soil zone of Turgulyan and Karavaeva which in the eastern hemisphere would be found in Svalbard, Novaya Zemlya, Severnaya Zemlya, Novo Sibirskie and Wrangel Islands, and portions of the Yamal and Taimyr Peninsulas.

With the brief discussion it is hoped that, as Quaternary investigators consider the problem of fossil polar soils, they will not look for only a universal paleo-tundra soil but that they will consider also the many other possibilities that exist. Space limitations do not permit discussion of the problem of type of patterned ground associated with the various genetic soils of the polar region. A brief account of this problem was given by Drew and Tedrow (1962) and a more comprehensive treatment by Brown (1966).

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