

# Soils and Terrain Units Around Resolute, Cornwallis Island

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**ABSTRACT.** The soils around Resolute, southwest Cornwallis Island, are mapped and described. Polar Desert, Lithosol and Tundra gley are identified as the main genetic soils. Polar Desert Soils and Lithosols are found on dry, moisture-shedding sites whereas some Bog soils are inter-mixed with Tundra gleys in wet, poorly drained and plant colonized sites. Sub-divisions of soil series are associated with terrain units, which are regarded as a useful differentiating basis among arctic soils and as an aid in their mapping. Local variation within the three genetic soils is related to changes in parent material, terrain unit and per cent plant cover. Weathering and pedogenesis are those of a cold, arid environment, and the Polar Desert soils are dominant in the study area.

**RÉSUMÉ.** *Unités de sols et de terrain près de Résolute, île de Cornwallis.* L'auteur décrit les sols autour de Résolute, au sud-ouest de l'île de Cornwallis, et il les cartographie. Il identifie trois sols génétiques principaux: polaire désertique, lithosol et gley toundrique. Les sols polaires désertiques et les lithosols se retrouvent en des sites secs et ne retenant pas l'humidité, tandis que quelques sols de marécage sont mélangés aux gleys toundriques sur des sites humides, mal drainés et colonisés par la végétation. On associe les subdivisions des séries pédologiques avec des unités de terrain, qui sont utiles comme base de différenciation entre les sols arctiques et pour aider à les cartographier. A l'intérieur des trois sols génétiques, la variation locale est liée à des changements dans le matériau d'origine, l'unité de terrain et le pourcentage de couverture végétale. L'intempérisme et la pédogénèse sont ceux d'un milieu froid et aride et les sols polaires désertiques sont donc dominants dans la région.

**РЕЗЮМЕ.** *Типы почв в районе Резольют на о. Корнуоллис.* Дается описание почв в районе поселка Резольют на острове Корнуоллис, где основными генетическими типами являются северные пустынные, литогенные (скелетные) и тундровые почвы.

## INTRODUCTION

Information about arctic soils and pedogenic processes of cold environments has increased markedly since 1950, so that it is now possible to discuss pedogenic gradients based on field studies (Tedrow 1968). In general, genetic soils of the Arctic can be extensive, individually covering vast areas, and yet problems arise in any attempt to map them in detail. These are created by frost disturbance which disrupts the spatial continuity of soil profiles and horizons. Regional climate being uniform over considerable areas in the Arctic, the most significant soil-forming factors, within a small area of investigation, are usually parent material, vegetation and the depth of the active layer, albeit that they are modified by each other and by climate.

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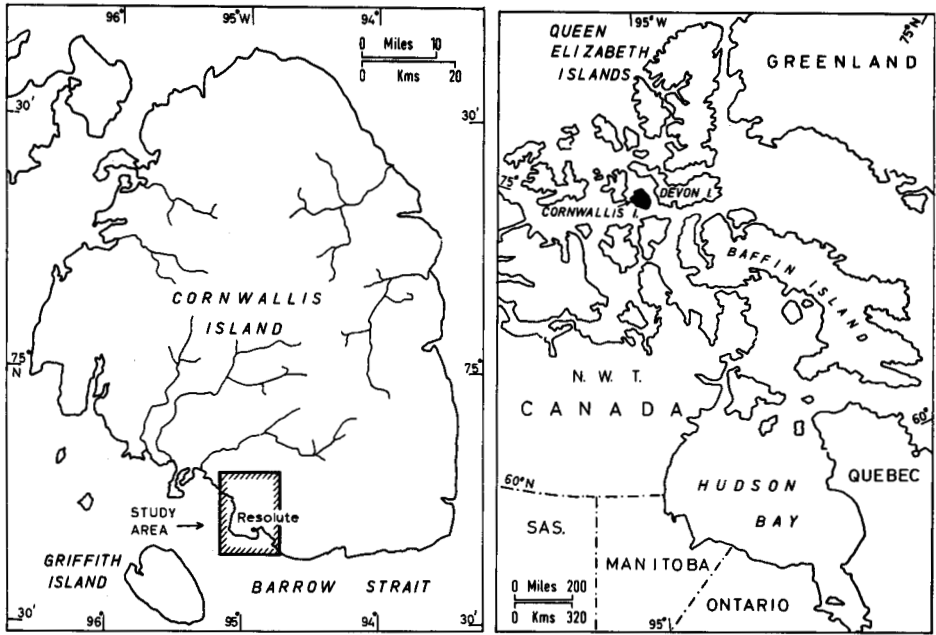


FIG. 1. Location maps of Cornwallis Island and the study area which is shown in Fig. 2.

This paper records a field program of soil survey in an area of 80 square miles (200 sq. km.) around Resolute, Cornwallis Island ( $74^{\circ}44'N.$ ,  $94^{\circ}55'W.$ ), and its aim is to demonstrate local distribution of genetic varieties of soil profile, and to associate their spatial variation with parent material, geomorphological features and per cent plant cover. An attempt is made to produce a soil map, usually avoided in field studies of arctic soils, and to overcome some of the difficulties involved, a system of terrain units has been used in the soil mapping.

#### THE PHYSICAL ENVIRONMENT

Cornwallis Island, 2,670 square miles (6,915 sq. km.), is one of the Parry Islands in the Queen Elizabeth group (Fig. 1). The climate of the island, and most of the Arctic Archipelago north of Barrow Strait, can be regarded as arid, as only a few stations on the eastern margin record mean annual precipitation of more than 8 inches (20 cm.). Resolute has a mean annual precipitation (1948-1963) of 5.31 inches (13.5 cm.), within a recorded range 3.2 to 6.7 inches (8.13 to 16.9 cm.). Snowfall comprises 3 inches (7.62 cm.) water equivalent of the mean annual precipitation. There is measurable precipitation of more than 0.01 inches (0.25 mm.) on about 100 days in the year, and 89 per cent of all showers bring amounts between 0.01 and 0.03 inches (0.25 to 0.75 mm.) water equivalent (Cook 1967). Even on the predominantly mineral surface of Cornwallis Island, rainfall is intense enough to produce erosion on the exposed soil surface only on two or three days in the year (Cook 1967). A more likely agent is snow melt which takes place within two weeks around the end of June and is responsible for 90 per cent of the annual surface run-off.

The summer weather at Resolute is distinguished by a high frequency of low cloud and mist, as a result of condensation caused as warm moist air from the south passes over the wholly or partly ice-covered surface of Barrow Strait. Although these conditions constitute a moderating maritime influence on the otherwise arid climate (Hagglund 1958), it is unlikely that they affect significantly the moisture balance of the active layer. Around Resolute, the active layer is shallow even at the time of greatest thaw, the maximum reported depth being 25 inches (63.5 cm.) in sandy soil (Cook 1958). In late July, the author measured 10 inches (25 cm.) as the average depth, in a range from about 5 to 6 inches (13 to 15 cm.) in organic soils to rarely more than 15 inches (38 cm.) in sandy soil.

The annual temperature regime shows that air temperatures promoting weathering and plant growth are limited to periods of days in June, July and August (Cook and Raiche 1962). July is the only month when a majority (23) of the daily maxima are above freezing, while the mean daily air temperature for the month is only 40° F. (4.5°C.). In June and August, freezing air temperatures occur on a majority of days (16 to 22 days in each month) so that plant growth and decay is arrested intermittently even in summer (Canada Department of Transport 1962). The air temperatures at this season may be low enough to initiate freezing in the thawed layer, and often low enough to halt deeper thaw into the upper surface of the perennially frozen ground. The thawed layer remains shallow, and pedogenesis, if confined to the period of frequent daily freeze-thaw cycles, is limited to three months (95 days average) in the year.

Because Cornwallis Island has low relative relief, a sporadic and discontinuous plant cover and a long annual period of soil freezing, parent material becomes relatively more important in the soil-forming environment. Areal soil variation appears to be associated mainly with a combination of rock type and surface morphology. In the study area, the Ordovician Allen Bay Formation (dolomite, and dolomitic sandstones and limestones) and the Silurian Read Bay Formation (limestones and calcareous sandstones and shales) are areally co-dominant (Thorsteinsson 1958). In the southern and eastern parts of the island, a plateau surface attains an average elevation of approximately 1,000 feet (305 m.), whereas in the study area, surviving summits provide evidence of a plateau surface at 500 feet (150 m.). There is also an extensive surface between 200 and 300 feet (60 to 90 m.), and a rock-planed surface at about 130 feet (40 m.) above sea level in the Resolute area.

There is evidence of glaciation on Cornwallis Island, but the presence of a continental ice sheet is uncertain. Examples have been given of glacial scouring and deposition on the island, but without an assessment of extent or date of glaciation (Thorsteinsson 1958). Whatever its glacial history, the area has long endured a periglacial environment, and a high degree of modification and reorganisation of glacial and periglacial deposits has taken place. There has been speculation also about the origin of a mantle of clay with stones which is widespread on the higher level surfaces. It contains a relatively high proportion of silt + clay (up to 45 per cent of the fine earth) and is of unknown depth as permafrost obscures its basal contact. It appears to be the regolith of the Silurian Read Bay limestone,

by its mineral composition, distribution and inclusions of freshly broken limestone. However, particle size distribution, supported by landscape morphology and exposed aspect, suggests the possibility of an aeolian origin. Raised shorelines are present as terraces up to 400 feet (120 m.) above present sea level, composed of medium to large size, rounded and sub-rounded stones. The stoniness of the beach materials makes a distinctive soil parent material, in which the greatest depths of summer thaw can be found.

#### THE SOILS

The classification used for the soils of the study area was that adopted for arctic soils by Tedrow and his associates since 1955 (see Tedrow and Cantlon 1958, Drew and Tedrow 1962).

The representative soil profile in the area is Polar Desert, as described previously in the Canadian Arctic (Tedrow 1966) and earlier in Siberia (Gorodkov 1939). The Polar Desert soil profile, associated with the arid High Arctic, is shallow, stony, and sandy in texture. Its plant cover is sparse and higher plants are sporadic in distribution. The soil is almost ahumic, well drained and alkaline in reaction. Carbonate deposits are found on the underside of stones. Cornwallis Island lies on the southern margin of the Canadian polar desert, and although Resolute's mean annual precipitation of 5.31 inches (13.5 cm.) may be regarded as high for this environment, most of the island's soils are Polar Desert.

The uniformity of the physical environment, and therefore the soil-forming conditions, over the central and western area of the Queen Elizabeth Islands suggests that Polar Desert soils are probably dominant in a considerable part of the Canadian High Arctic (McMillan 1960; Tedrow and Douglas 1964; Charlier 1969). In the study area of Cornwallis Island, the exceptions to the Polar Desert are skeletal soils and soils of water accumulation areas. The local environments of these soils produce Lithosols in the virtual absence of plants and Tundra gleys and Bog soils with a complete or nearly-complete plant cover. The soil map of the area around Resolute (Fig. 2) displays the areal relationship of these genetic soil varieties, and their association with terrain units.

#### TERRAIN UNITS AND SOIL MAPPING

Argument has been advanced that a distinction should be made between geomorphological and pedological processes in the Arctic (Tedrow 1962), that is, chiefly between patterned ground formation and soil profile development. While recognising the importance of frost action on soil formation, Tedrow has criticised any classification of arctic soils based on geomorphological features. Such a soil classification was not employed in this study, but types of patterned ground, surface morphology and parent material were introduced as criteria for terrain units, subsequently used as a ground framework in soil mapping. Others have adopted a similar solution to the problem of mapping arctic soils (Brown 1969), but some consider that frost disturbance disrupts soil formation and destroys the horizons of arctic soils so much that mapping is almost impossible

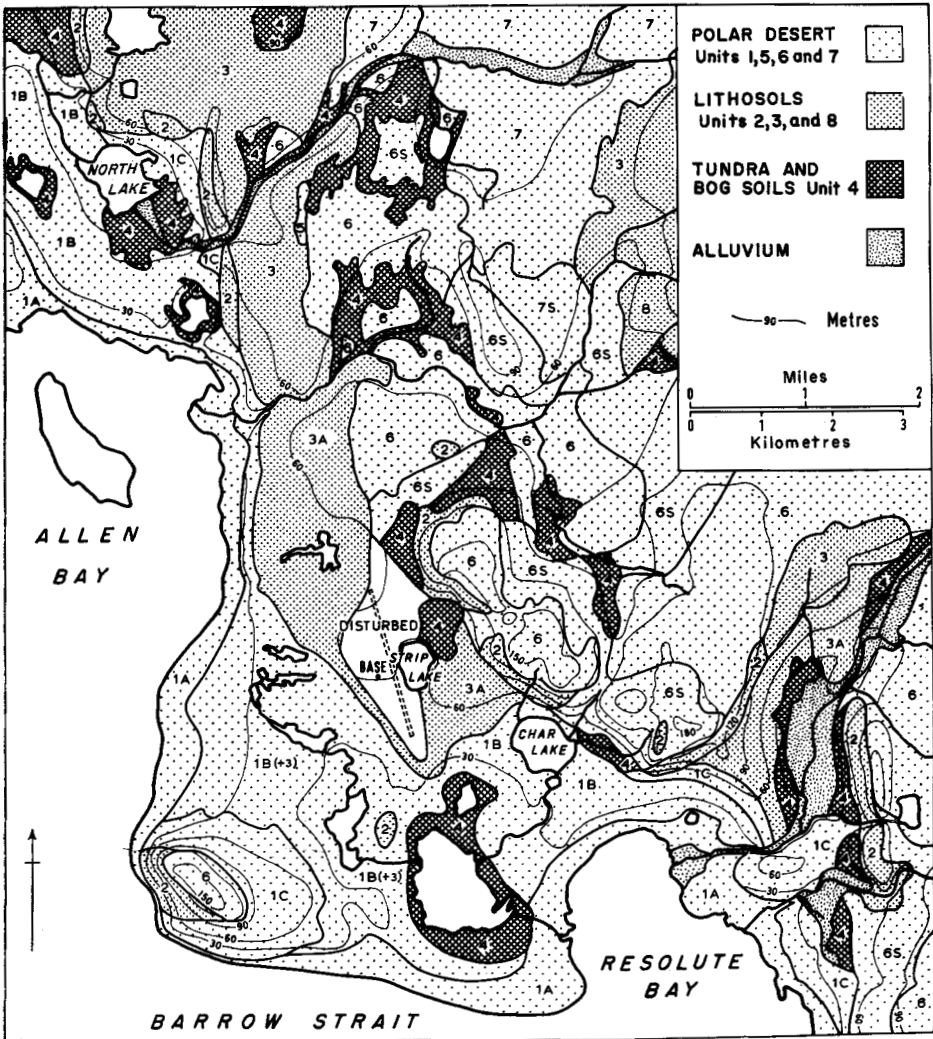


FIG. 2. Soil map of the study area around Resolute, southwest Cornwallis Island. Resolute base and air strip are at 74°44'N., 94°55'W. Numbers refer to the classification of terrain units.

(James 1970). The latter applied to some degree in the area around Resolute, and while the mapped soil units would be found to have a relatively low continuity or purity of soil profile, the impurity comes from frost disturbance and not from the inclusion of other profiles. It was decided to exclude the spatial determination of frost action in soil mapping, and to that extent, the soil map units are generalisations. The effect of frost action on soil morphology is not included in the scope of this paper.

Although the soils around Resolute were identified as three genetic varieties (Polar Desert, Lithosol and Tundra gley), a much greater number of soil series, soil type and soil phase sub-divisions became apparent at an early stage in soil

mapping. It was decided to accommodate these differences into a system of terrain units or landscape units. Of the 8 categories of terrain unit in the study area, 4 became series sub-divisions of the Polar Desert soils, 1 was associated with Tundra soils and 3 with Lithosols. The 8 terrain units were related also to the main rock types or soil parent materials, 1 being coincident with raised shoreline formations, 1 with red sandy dolomite and 6 with limestone rocks. The units were established by visible surface features such as rock type, degree and scale of surface patterning and sorting of material, wetness, stability, colour and percentage of plant cover. Sub-divisions of some of the 8 units were necessarily introduced on the basis of stoniness, or degree of frost sorting, but these sub-divisions were pedologically significant only at the level of type or phase sub-divisions. Soil series separation was limited to the full terrain unit level.

The following summary describes the characteristics of the terrain units.

### *Unit 1*

Raised marine shorelines

*1A (1)*: lowest level, active beach, recent marine deposits, stones angular or sub-angular, ice push features, unsorted material, height range to 10 to 12 feet (3 m.) above mean sea-level.

*1A (2)*: raised marine features with fresh form, usually with rounded or sub-angular stones, shelly and fine sand materials, patterned and sorted on level areas, no plants, height range up to 50 to 60 feet (18 m.) above mean sea-level.

*1B*: higher marine terrace features, stones of variable roundness, sandy fine material, sorted and patterned ground, sporadic lichen and moss plants, solifluction modification on slopes, height range 50 to 300 feet (17 to 90 m.).

*1C*: raised marine materials and terraces merging with solifluction material from higher slopes, includes scree and solifluction material, frost shattered debris, sorted and patterned ground, <5 per cent plant cover, 200 to 400 feet (60 to 120 m.) above mean sea-level.

### *Unit 2*

Rock outcrop and associated scree slopes; also shattered rock and outcrops on level ground at lower elevation; very few plants.

### *Unit 3*

Rocky, patterned and sorted stony ground, level or almost level ground, large rock fragments in large dimension rock polygons, usually 10 to 15 feet (3 to 4 m.) diameter, <10 per cent plant cover.

### *Unit 3A*

Variation of 3 in which fine earth material is present in polygon centres to about 30 to 40 per cent total, and where polygons tend to be about 3 feet (1 m.) in diameter, on level or almost level ground, outlined by large stones. Rock outcrop is found in places within 3 and 3A.

*Unit 4*

Seepage areas with shallow active layer, usually less than 10 inches (25 cm.). Organic surface horizon Ao 2" or less, and surface colonized by black lichens and mosses. Occurs on sloping sites and frequently develops on solifluction lobes, and soil stripes. High proportion of material is fine sand size.

*Unit 5*

Non-sorted, patterned and frost-disturbed ground that has been heaved into hummocks, usually found on gently sloping or level ground, almost no plants.

*Unit 6*

Silt-clay mantle found generally on elevated level ground, patterned, sometimes frost heaved and contains small limestone chips, weakly sorted or non-sorted. 6S is the very stony phase. Few plants present in either.

*Unit 7*

Red sandy dolomite material — similar to unit 6 in texture, but appears to be a little more sandy (usually about 70 to 80 per cent sand in fine earth) and contains fewer stones — patterned and frost disturbed, but only weakly sorted. Polygons were not a feature of unit 6 or 7. 7S is the very stony phase. About 50 per cent cover of lichens and mosses gives the unit a distinctive appearance.

*Unit 8*

Shattered limestone — broken into fragments 4 to 10 inches (10 to 25 cm.) in diameter — patterned but only weakly sorted. Occurs on level or nearly level ground. Very few plants present.

## SOIL PROFILES AND SOIL SERIES AROUND RESOLUTE

*Lithosols — Soil series of terrain units 2, 3 and 8*

The Lithosols of rock outcrop and screes (unit 2) were not sampled as all the rock fragment material was much larger than fine earth size, and usually larger than 2 inches (5 cm.) in diameter. Plant life was restricted to rock-surface lichens and an occasional flowering plant. There were no accumulations of humus or fine earth, and consequently field moisture-holding was negligible. Areas mapped as units 3 and 8 were also dominated by large fragments of shattered limestone. The rock fragments of unit 3 had been sorted into different fragment sizes and arranged in polygonal patterns. In unit 8, the fragments were not sorted, but did form morphological patterns. In both cases the rock material was more stable than that of the unit 2 screes, but otherwise the soils were similar and regarded as Lithosols. Seven profiles were examined in the unit 3A areas, selected in polygons that contained material finer than 5 cm. in diameter. Despite this attempt to select sites, the fine earth fraction of the samples fell in a wide range of 16 to 80 per cent. There was very little variation in per cent fine earth with depth at any one site. The clay fraction was always less than 10 per cent of the fine earth, and the textures

sandy loam, loamy sand and sand. The per cent field moisture of the dry weight was less than 10 unless there was some humus present. The pH values were in the range 7.2 to 7.8. Lithosols occurred on both sorted and non-sorted ground, but large stone size and shallow depth rather than degree of sorting were their main characteristics. Surface patterns and frost sorting were found in several terrain units and soil series.

*Tundra and Bog soils of seepage hollows — Soil series terrain unit 4*

Tundra gleys mixed with organic Bog soils occurred in topographically controlled sites where moisture had collected by slope drainage or snow melt. These included hill foot seepage zones beyond the limits of screes, solifluction lobes or talus fans, and at the foot of minor slopes or in depressions (Fig. 3). These soils were so wet in summer that water was running over the surface, and they could be mapped by their cover of black lichens, mosses, sedges and grasses (Fig. 4). It was not possible to measure the organic content in the field laboratory, but it was estimated to be 10 to 20 per cent dry weight in surface horizons. Bog soils

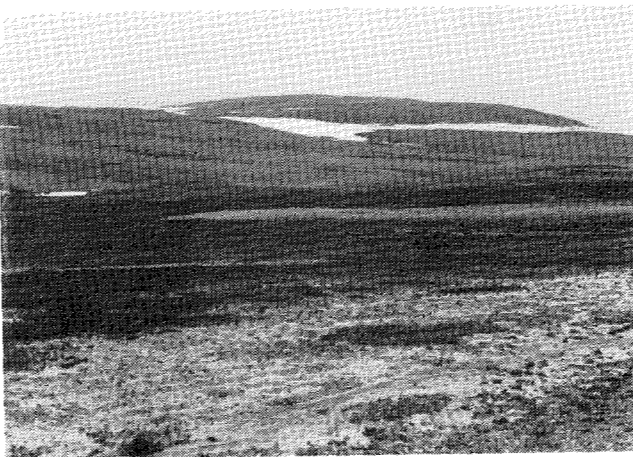


FIG. 3. Shallow Polar Desert soils on the slopes of the limestone upland (unit 6) grade into Tundra gley and Bog soils in the hill-foot seepage zone, unit 4.



FIG. 4. High per cent cover of sedges, grasses and mosses on fine earth and water accumulation areas of Tundra gley soils.



TABLE 1. Tundra gley profile of terrain unit 4.

Layer depth	Munsell colour	per cent fine earth <2 mm.	per cent field moisture	per cent sand 2-0.02 mm.	per cent silt 0.02-0.002 mm.	per cent clay <2 $\mu$	Texture class	pH 1:5 H <sub>2</sub> O
0-2 in.	10YR 5/2	74.2	36.2	57.2	27.7	15.1	sandy loam	7.1
0-5 cm.	greyish brown						loam	
2-4 in.	5Y 5/2	80.0	24.8	63.5	22.8	13.7	sandy loam	7.2
5-10 cm.	olive grey						loam	
4-6 in.	10YR 5/2	81.5	21.9	63.7	20.3	16.0	sandy loam	7.3
10-15 cm.	greyish brown						loam	
6-8 in.	10YR 5/2	75.5	17.8	64.2	21.5	14.3	sandy loam	7.2
15-20 cm.	greyish brown						loam	
8-10 in.	10YR 5/2	83.7	19.7	60.2	27.2	12.5	sandy loam	7.2
20-25 cm.	greyish brown						loam	

were not common, and generally the Tundra gleys were only slightly humic in the surface horizon. On sloping sites, downslope washing of mineral particles over the soil surface maintained a relatively low humus content and sometimes produced a layered deposit.

Six profiles were examined, their depths (from 15 to 25 cm.) varying inversely with humus and moisture. The shallow 6-inch (15 cm.) active layer was associated with 60 to 80 per cent field moisture, and an estimated 30 to 40 per cent organic matter of total dry weight. These shallow and humic soils have been classed as Bog soils, being limited in area and forming a minority part of the seepage gleys, or Tundra soils. All soils of the unit 4 terrain have a sandy loam texture in the fine earth, and the per cent silt is in all cases greater than percentage of clay. The silt fraction is regarded as high, in the 20 to 40 per cent range. The properties of Tundra and Bog soils are variable (pH 7.0 to 8.0, per cent fine earth 20 to 100) because they have developed on diluvial, surface wash deposits.

All soils were sampled at 2-inch (5 cm.) intervals as the total depth of the thawed profile was so small. Properties were measured by standard methods in a field laboratory (see Table 1).

A Bog soil of terrain unit 4 has developed on a wind-blown deposit on flat ground beside North Lake. The area in question is small, but it is reasonable to assume a wide general distribution in the Polar Desert environment for such deposits. Their occurrence will be localised to lee sites, where accumulation and

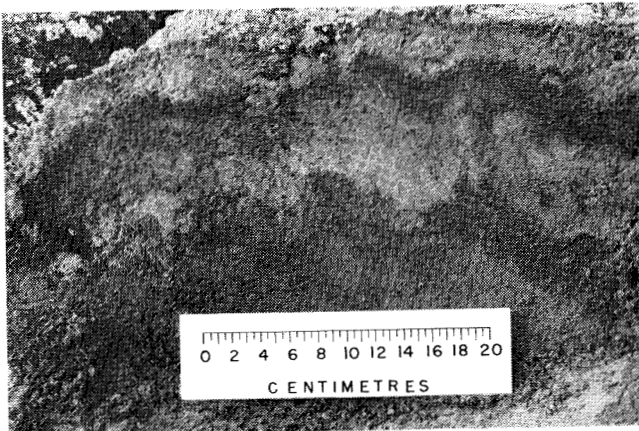


FIG. 5. Wind-blown sand and buried humic horizons (30 cm. deep) of Tundra gley profile at North Lake.

alternation of sand and organic horizons (former vegetation surfaces) may achieve several feet in thickness. The wind-blown material at North Lake was thawed to about 10 inches (25 cm.) in late July (Fig. 5). The alternating strata of organic matter and wind-blown fine sand were disturbed by frost heave, and the whole area divided into micro-polygonal patterns with the permafrost rising into ice-filled wedges between the hummocks. The analysis (Table 2) confirms the highly organic and uniformly sandy nature of the alternating layers, but frost contortion means that the depth of a particular layer is not predictable below the present surface.

TABLE 2. Layered wind-blown sand at North Lake.

Layer depth	Munsell colour	per cent fine earth <2 mm.	per cent field moisture	per cent loss on ignition*	per cent sand 2-0.02 mm.	per cent silt 0.02-0.002 mm.	per cent clay <2 $\mu$	Texture class.	pH 1:5 H <sub>2</sub> O
0-1/2 in. 0-1 cm.	5YR 3/2 dark reddish brown	100	111.0	58.2			organic		7.4
1/2-2 1/2 in. 1-6 cm.	7.5YR 3/2 dark brown	100	41.2	45.0	90.2	6.2	3.7	sand	7.6
2 1/2-3 in. 6-8 cm.	5YR 3/2	100	109.5	56.6			organic		7.5
3-4 in. 8-10 cm.	5YR 3/2	100	86.2	44.3	75.4	14.8	9.9	loamy sand	7.4
4-5 1/2 in. 10-14 cm.	5YR 4/4	100	34.2	34.3	75.6	15.8	6.6	loamy sand	7.5
5 1/2-7 in. 14-17 cm.	10YR 3/3	100	71.0	45.6	81.0	12.4	7.6	loamy sand	7.6
7-10 in. 17-25 cm.	10R 2/1	100	103.0	60.4	74.3	18.0	7.7	loamy sand	7.3

\*may include loss of carbonates

#### *Polar Desert soils of raised shorelines — terrain unit 1 (A, B and C)*

Islands of a recently deglaciated environment, particularly smaller islands like Cornwallis, have a significant proportion of their total area in raised shorelines. In the south-west part of the study area, the presence of two once-connecting embayments has produced a large area of isostatically recovered land. The present location of former Eskimo stone-houses, close to the shore when built and now elevated to approximately 100 feet (30 m.) above and 500 yards (450 m.) inland from the shore, emphasizes the youthfulness of raised shorelines as sites for soil formation. The Polar Desert soils of these shorelines are distinguished by particularly high pH values and carbonate accumulations due to concentrations of shell fragments. Twenty-five samples were analysed from 5 profiles. The pH values were in the range 7.5 to 8.0, and at least 8.0 wherever shell fragments were present. The soil was usually stony, the fine earth fraction comprised 25 to 75 per cent of each of the samples taken. The textures of the 2 mm. soil fraction were remarkably uniform down each profile, and were sandy loam, loamy sand and sand. The percentage of field moisture was low, being less than 20 per cent (mostly 7 to 12 per cent) except where surface humus was present. Soils were usually devoid of organic matter and the occurrence of plants was rare. Exceptions were found around whale bones, carcasses of muskoxen, lemming mounds and former habitations. At these sites, nutrient concentration promoted a strikingly lush growth of mosses and flowering plants (*Dryas*, *Saxifraga* and *Draba* spp.), with a slightly humic surface horizon.

*Polar Desert soils — Soil series of terrain units 5, 6 and 7*

Polar Desert soils are associated in particular with terrain units 5, 6 and 7 which are all composed of material weathered from the underlying carbonate rocks. In most cases, the texture of the fine earth is a sandy loam, but in a few sites within unit 6, the combined silt and clay almost equals the per cent sand, and textures are sandy clay loam and loam. The particle size distribution in all these Polar Desert soils shows a marked increase in the silt + clay fraction compared with those of the raised shorelines, Lithosols and Tundra soils, demonstrating the influence of parent material.

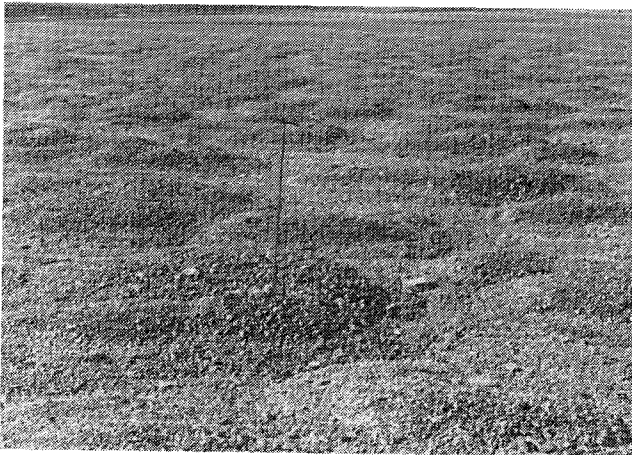


FIG. 6. Frost-disturbed Polar Desert soils of unit 5 on limestone.

Unit 5 terrain is restricted to low angle slopes and is ground that has been frost-heaved into ice-cored hummocks (Fig. 6). A distinctive surface pattern has developed, but the material is not sorted. The soil surface is covered with limestone fragments (maximum dimension 5 to 10 cm.) although samples have high proportions of fine earth. Plants are rare and the soil is ahumic. Apart from the hummocks, the terrain is similar to unit 6 and the soils should be regarded as part of the same series.

Unit 6 is the silt-clay mantle over limestone. The terrain is almost level both on a macro- and micro-scale, and occurs on the higher ground between 200 and 500 feet (60 to 150 m.) above sea level. The material is very weakly sorted or unsorted, and displays only a weak pattern of slight rises between polygonal cracking. Small fragments of limestone, 2 to 4 inches long (5 to 10 cm.), are exposed on the surface (Fig. 7). Although there is evidence of local glaciation on Cornwallis Island, the diagnostic properties of glacial till could not be established on the material of the silt-clay mantle. Glacial striae were confirmed on the low-lying rock plain southwest of the Resolute base, but were not seen on higher ground; this may have been due to the limestone rocks easily losing the impression of striae. There was no evidence of layering of material, but the uniformly high proportion of silt size particles in the fine earth might include wind-blown particles. The soil was thawed to a maximum of 10 inches (25 cm.) in depth, but "the mantle" was undoubtedly deeper in many places.



FIG. 7. Soil surface of the clay-silt mantle over limestone (unit 6). Limestone fragments are angular, 2-4 cm. and lie just within the soil surface of Polar Desert profiles.

Twenty-four samples were taken from 7 sites in the Polar Desert soil of the silt-clay mantle series. The weight of fine earth was low (mostly between 25 and 30 per cent) and the textures were sandy loam, sandy clay loam and loam. The percentage of sand was relatively low for the soils of the study area, being in the 50 to 60 per cent range. Silt was around 20 per cent in most cases, in the range 15 to 40 per cent. The percentage of clay (like the silt fraction) was regarded as high in the 12 to 25 per cent range, and mostly around 15 per cent. The pH was between 7.4 and 7.7. The soils of the silt-clay mantle were well drained, and despite the relatively high proportions of silt and clay, field moisture was always less than 15 per cent, and usually about 10 per cent of total dry weight. In this respect, the soils were as dry in the field state as the Polar Desert soils of the raised shorelines, but not so dry as the Lithosols. Both the silt-clay mantle and the raised shoreline soils were equally deficient in plant life and soil humus. The high proportion of stones and gravel-size material in the silt-clay mantle compensates for the texture of the fines, encourages moisture movement, and may explain the deficiency in plant cover (see Polar Desert soil profile, Table 3).

The landscape morphology of terrain units 6 and 7 is similar. Both form plateau surfaces above 200 feet (60 m.), in which streams cut broad, open valleys. Soils are also Polar Desert but there is a contrast in properties associated with parent

TABLE 3. Polar Desert soil profile.

Layer depth	Munsell colour	per cent fine earth < 2 mm.	per cent field moisture	per cent sand 2-0.02 mm.	per cent silt 0.02-0.002 mm.	per cent clay < 2 $\mu$	Texture class	pH 1:5 H <sub>2</sub> O
0-2 in.	2.5Y 4/2	62	10.2	58.5	23.0	18.0	sandy loam	7.7
0-5 cm.	dark greyish brown							
2-4 in.	2.5Y 4/2	62	11.3	58.0	19.0	22.0	sandy loam	7.7
5-10 cm.							sandy loam	
4-6 in.	2.5Y 5/2	52	11.4	55.4	20.0	22.0	sandy clay loam	7.8
10-15 cm.	greyish brown						loam	
6-8 in.	2.5Y 5/2	55	10.2	59.0	18.5	21.0	sandy clay loam	7.8
Permafrost at 12 in. (30 cm.)								



FIG. 8. Smooth landscape of red sandy dolomite (unit 7). Polar Desert soils have a nearly complete cover of lichens.

material. Unit 7 is only slightly patterned and almost unsorted loamy sand of a bright red colour, derived from red sandy dolomite and supporting a 30 to 60 per cent surface cover of non-vascular plants (Fig. 8). Black lichens and mosses give the soil surface a distinctive appearance, and on many profiles provide a thin surface humus horizon.

The red sandy dolomite series was sampled at two sites, and proved remarkably uniform in properties down to the permafrost at 10 inches (25 cm.). The soil was much less stony than the silt-clay mantle of unit 6, about 80 per cent of the sample being fine earth. The texture was sandy loam in every case, 77 to 82 per cent of the fine earth being in the sand class. Percentage of clay was particularly low and the average pH was 7.5 (see Table 4). The soil may have been reworked glacial till, but its characteristics were very similar to weathered bedrock. The weathering was probably mainly a physical disintegration by frost of the quartz-rich dolomite. Soil particles displayed only a surface veneer of chemical weathering when examined in thin section (Fig. 9). Only the outer layer of carbonates had been dissolved and removed, and the iron oxidised to form a distinct rim outline on sand-size particles. Weathering would progress differently under a surface horizon of humus and in other climatic conditions (Hill and Tedrow 1961).

TABLE 4. Polar Desert profile of the quartz-rich dolomite series, unit 7.

Layer depth	Munsell colour	per cent fine earth < 2 mm.	per cent field moisture	per cent sand 2-0.02 mm.	per cent silt 0.02-0.002 mm.	per cent clay < 2 $\mu$	Texture class	pH 1:5 H <sub>2</sub> O
0-2 in. 0-5 cm.	5YR 3/4 dark reddish brown	89.0	17.8	78.5	12.2	8.2	sandy loam	7.4
2-4 in. 5-10 cm.	5YR 3/4 dark reddish brown	85.3	16.3	77.2	15.6	7.1	sandy loam	7.5
4-6 in. 10-15 cm.	5YR 3/4 dark reddish brown	80.5	13.3	78.5	14.0	7.0	sandy loam	7.5
6-8 in. 15-20 cm.	5YR 3/4 dark reddish brown	77.2	13.0	74.6	17.5	7.0	sandy loam	7.6
8-10 in. 20-25 cm.	5YR 3/4 dark reddish brown	56.0	9.75	77.5	16.5	5.5	sandy loam	7.6

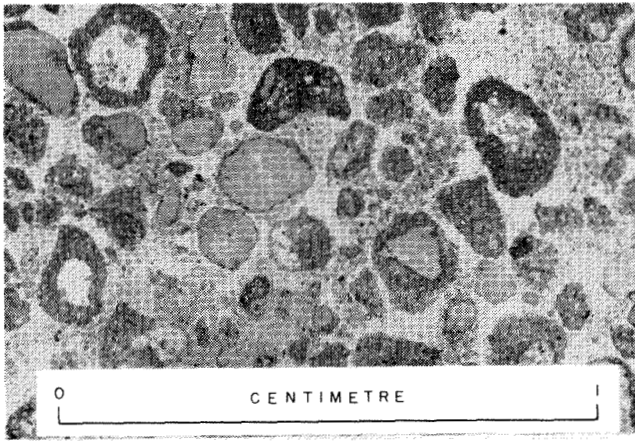


FIG. 9. Thin section of soil detritus. Sample is from 5 to 10 cm. below surface, in red sandy dolomite material, terrain unit 7. Photograph shows iron-stained rim-weathering of sand-size particles.

#### CONCLUSION

The soils around Resolute are Polar Desert profiles, Lithosols, Tundra gleys and Bog soils, but soil properties within each genetic variety are sufficiently variable to warrant sub-division into soil series based on terrain units. Polar Desert soils in the study area may be divided into 3 series — of the raised shorelines, of the limestone, and of the sandy dolomite rocks. Even the Lithosols fall into 3 soil series on the terrain unit criterion. However, Tundra gley and Bog soils belong to the single terrain unit of unit 4, the seepage areas with shallow active layer. Stony and other variations of terrain units could be used to create soil type and soil phase sub-divisions, although such detail has not been considered in the mapping or discussion of this paper.

The soils of the study area display a number of features which can be associated with an arid and wind-swept environment. Generally they lack plants and humic surface horizons, and although permafrost now obscures the real contact between superficial deposits and rock, there is evidence to suggest wind-blown origin for the layered deposit at North Lake and even the silt-clay mantle on the limestone plateau. The distinctive form of rim weathering on the particles from both limestone and dolomite soils is notable because of its similarity with desert varnish. The scale of the phenomenon may be different, but in both there is a surface veneer of iron-stained weathering. The thawed layer of Polar Desert soils is remarkably dry and has little capacity to hold moisture compared with the organic Bog soils.

Most previous studies of arctic soils have considered the morphology and properties of genetic soils, and in some cases, the effect of frost action on soil formation. As only a few genetic soils of the Arctic have been discussed in the literature, the impression may be created that vast areas of each can be readily mapped. In reality they occur, in the High Arctic at least, as a mixture or complex with frost disturbed ground and rock outcrop so that only general soil maps can be constructed. Few studies of arctic soils have reported on the spatial arrangement of genetic soils by presenting a soil map. A small contribution to this end is made here, but much remains to be done in this neglected field in the study of arctic soils.

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