Memoirs of the Soil Survey of Scotland

The Soils of Orkney

(Sheets Orkney – Hoy, Orkney – Mainland and Orkney – Northern Isles)

By F.T. Dry (Ed. J.S. Bell)

The James Hutton Institute, Aberdeen

2016

Contents

Preface

The soils of Orkney were surveyed between 1971 and 1978 by Mr F.T. Dry, assisted at different periods by Mr C.G.B. Campbell, Mr N.A. Duncan, Mr D.J. Henderson, Mr B. Kerr and Mr J. Mackay; the soils of Stroma by Mr D.W. Futty and Mr J. Mackay. Soil correlation was by Mr J.W. Muir.

Members of staff from other departments of the Macaulay Institute for Soil Research have contributed to the memoir in various ways, notably Mr J. Logan and staff of the Department of Mineral Soils, and Dr R.O. Scott and Dr A.M. Ure and their staff of the Department of Spectrochemistry. Mr J. Logan also checked the section on standard analytical data. Dr D.C. Bain of the Department of Mineral Soils contributed the section on total soil analysis. Dr M.L. Berrow of the Department of Spectrochemistry wrote the section on trace elements. Mr W.S. Shirreffs, Mrs R.M.J. Fulton, Miss P.R. Carnegie and Mr A.D. Moir of the Department of Soil Survey, Cartographic Section, prepared the maps and diagrams.

The original manuscript was written by Mr F.T. Dry. Mr D. W. Futty read the manuscript and offered much helpful advice, and Mr J. W. Muir gave a deal of assistance in the preparation of the memoir. The material was compiled in 2012 by Mr J.S. Bell from original, typed and edited manuscripts dating from the late 1970's and early 1980's, including the section on climate based on historical datasets. Compilation into a more complete memoir was not possible as standard sections on the vegetation and peat were not available. Forestry and agriculture chapters written in the late 1970's were considered inappropriate for inclusion. The soil classification also follows the 1984 version.

This memoir should be considered as a means of eliciting general information about the soils of Orkney, their distribution, parent materials, formation, characteristics and chemical properties and how the landscape, climate and geology have influenced their development and spatial distribution. It is intended as an accompaniment to the three published 1:50,000 scale soil maps (Orkney – Hoy, Orkney – Mainland and Orkney – Northern Isles).

Acknowledgements

The material for the section on climate was provided by the Meteorological Office, Edinburgh. Acknowledgement is also made to farmers and landowners in the district without whose co-operation the survey could not have been completed.

1. Description of the Area

Location and Extent

The soils of the Orkney Islands, and Stroma, which is actually part of Caithness, are described in this memoir. The archipelago comprises some 90 islands and skerries (Figure 1) extending 80 kilometres from north to south and 62 kilometres from east to west with a land area of approximately 975 square kilometres. The area is represented by three 1:50 000 maps: Orkney - Northern Isles, Orkney - Mainland and Orkney - Hoy. Orkney - Hoy encompasses part of north Caithness, the soils of which are described in the memoir The Soils of the Country round Wick (Futty and Dry, 1977).

The Orkney Islands are separated from the mainland of Scotland by the often-turbulent waters of the Pentland Firth, but communications are maintained by regular ferry and freight services from Scrabster, near Thurso, and from Aberdeen. Internal ferries link the individual islands. Orkney supports an airport with services between Glasgow, Edinburgh, Aberdeen and Shetland as well as inter-island services.

In a widely dispersed agricultural community Kirkwall and Stromness are the principal towns, with respective populations of 4617 and 1646 out of a total population of 17077 (Census 1971; 1973).

Agriculture, its ancillary trades, distilling and tourism are the main industries, but fishing, boat-building, and the manufacture of knitwear and silverware help to boost the economy of the islands. The exploitation of North Sea oil has led to the establishment of an oil and gas terminal on Flotta in Scapa Flow.

Physical Features

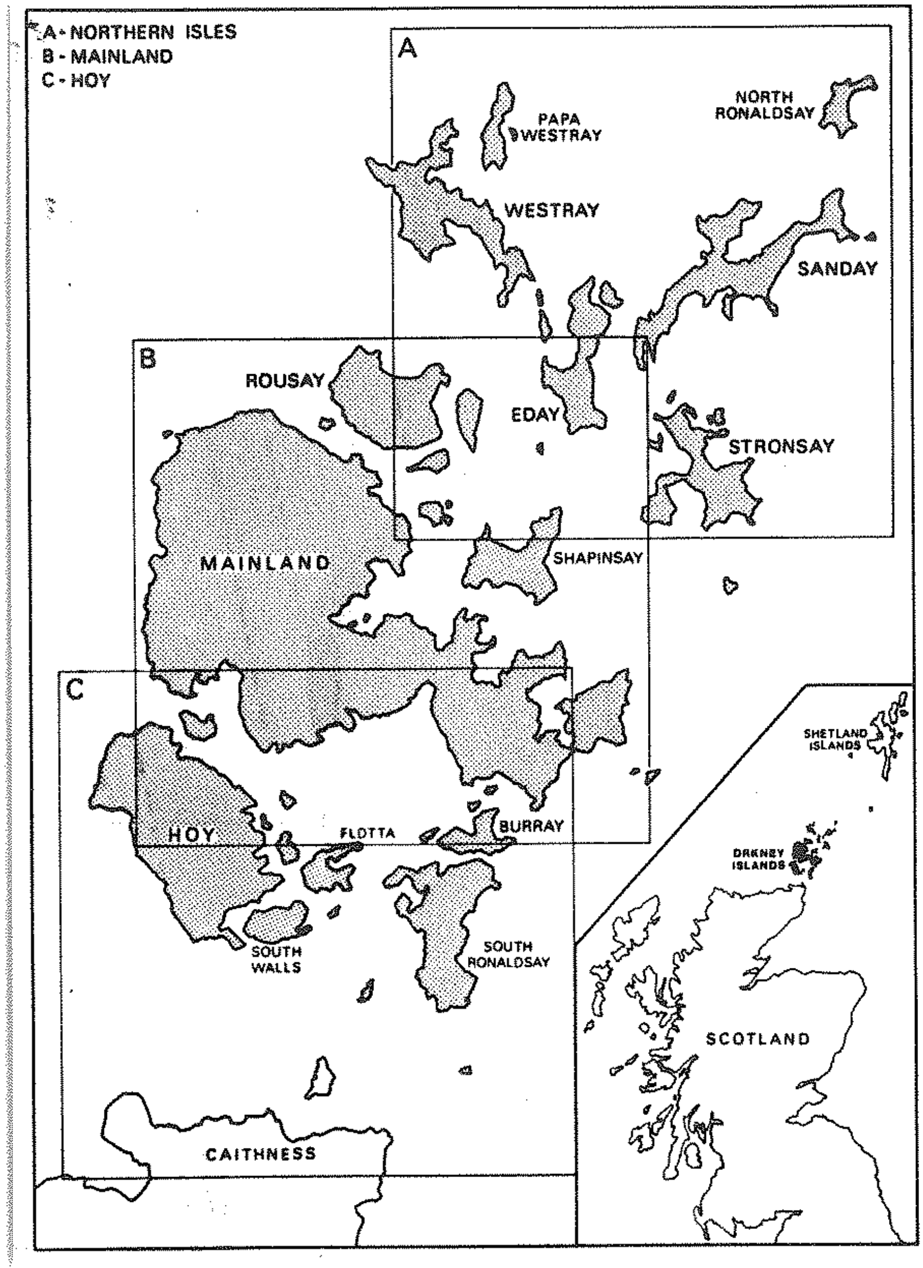
With the exception of western Hoy, Rousay and western Westray, the Orkney Islands have a greatly undulating landscape of subdued relief (Figure 2). The dominant characteristic of the topography is its drowned appearance (Miller, 1976). The hills of north Hoy apart, most hill slopes are convex, the lower, normally concave, slopes being submerged, with the many bays and sounds representing drowned valleys. Submersion was such that river systems were severely truncated and only small streams remain.

For descriptive purposes the island group can be divided into four regions:

1. East Mainland, the south isles, the Longhope district of the parish of Walls, Hoy and the north isles with the exceptionof Rousay and western Westray
2. West Mainland
3. Western Hoy
4. Rousay and western Westray

    1. East Mainland has a gently rolling landscape of low and open relief with geological influences on topography much modified by drift cover. A number of ridges and escarpments trending south-west to north-east, or south to

Figure 1. Location of Area



north, reflect the influence of geology, particularly the thick resistant beds of sandstone, on the topography; these features are developed most noticeably in South Ronaldsay with the Sandy Hill - Ward Hill and the Kirkie Hill - Vensilly Hill ridges, and in Eday with the Ward Hill - Flaughton Hill and Stennie Hill - Vinquoy Hill ridges.

Areas of hummocky moraine occur in the south-western part of the parish of Holm and in the Toab area of the parish of St Andrews and Deerness. It would seem that these moraines are a product of a final phase of glaciation and probably the result of wastage of dead ice. The islands of Sanday and North Ronaldsay are particularly low-lying with much of their area below 15 metres.

2. West Mainland has an amphitheatre-like appearance, a low-lying interior with a mean height of about 15 metres occupied by the Loch of Harray and the Loch of Stenness, and a surrounding girdle of rounded hills. The highest of these hills are Mid Hill (193 metres) and Mid Tooin (221 metres) in the Evie hills to the east, and Ward Hill (268 metres), the highest hill in Mainland Orkney, to the south. The hills of the western edge are somewhat lower, with Vestra Fiold (127 metres), Hill of Miffia (158 metres) and, Hill of Lynedardy (136 metres) being the major hills. The eastern hills, broken by the Finstown gap and the Settascarth gap, have striking east-facing escarpments.

   It has been suggested (Wilson *et al*, 1935) that the interior lowland is a pre-glacial feature, the remnant of a late-Tertiary river system which drained to the east-south-east and which was only slightly modified by ice during the Pleistocene Period, the main effects of ice action resulting in the gouging out of the basins of the lochs of Harray and Stenness. Wilson *op. cit.* (1935) also suggests that Orkney owes its isolation from the mainland of Scotland and its island configuration to the late Tertiary river system, the Pentland Firth, Scapa Flow, Westray Firth and similar south-east-trending straits being flooded remnants of that system. Wilson op. cit (1935) believes that the watershed for such a river system must have been far to the west and possibly over a line running along the course of The Minch to the Faroes.

   Areas of hummocky moraine occur on the central lowland feature. The most extensive extends westwards from the head of the Finstown gap for some 3 kilometres along the Stromness road and for approximately 2 kilometres north-westwards between the Loch of Harray and the Dounby road; other large areas of moraine are found along the Dounby road in the vicinity of the Loch of Bosquoy and The Shunan. Wilson (Wilson. *et al*, 1935) suggests that during a stage of ice-retreat the ice was restricted mainly to the sounds and firths and that most of the land to the west of the eastern range of hills was clear of ice. A slight readvance would then result in ice pushing westwards through the valleys at Finstown and Settascarth. Alternatively, the deposits may have been laid down with the gradual shrinkage of a mass of dead ice that at one time filled the central lowland.

3. Western Hoy consists of a range of rounded and relatively steep-sided hills extending from The Berry (199 metres) in the south to Cuilags (433 metres) in the north. Much of the central part is over 300 metres in height and rises to

479 metres on Ward Hill, the highest point in Orkney. Ward Hill is an isolated, steep-sided eminence bounded by the glacial valleys of the South Burn and the Ford of Hoy. The north and north-east slopes of Ward Hill exhibit dramatic crag and scree features, products of differential weathering of the sandstone country rock, and small but well-formed corries have been preserved on the flanks of Ward Hill and Cuilags. The plateau summit of Ward Hill is noteworthy for patterned-ground features such as terraces and stripes (Goodier and Ball, 1975). Similar features, varying in their degree of development, are found on Cuilags, Knap of Trowieglen and plateau summits of heights above about 280 metres.

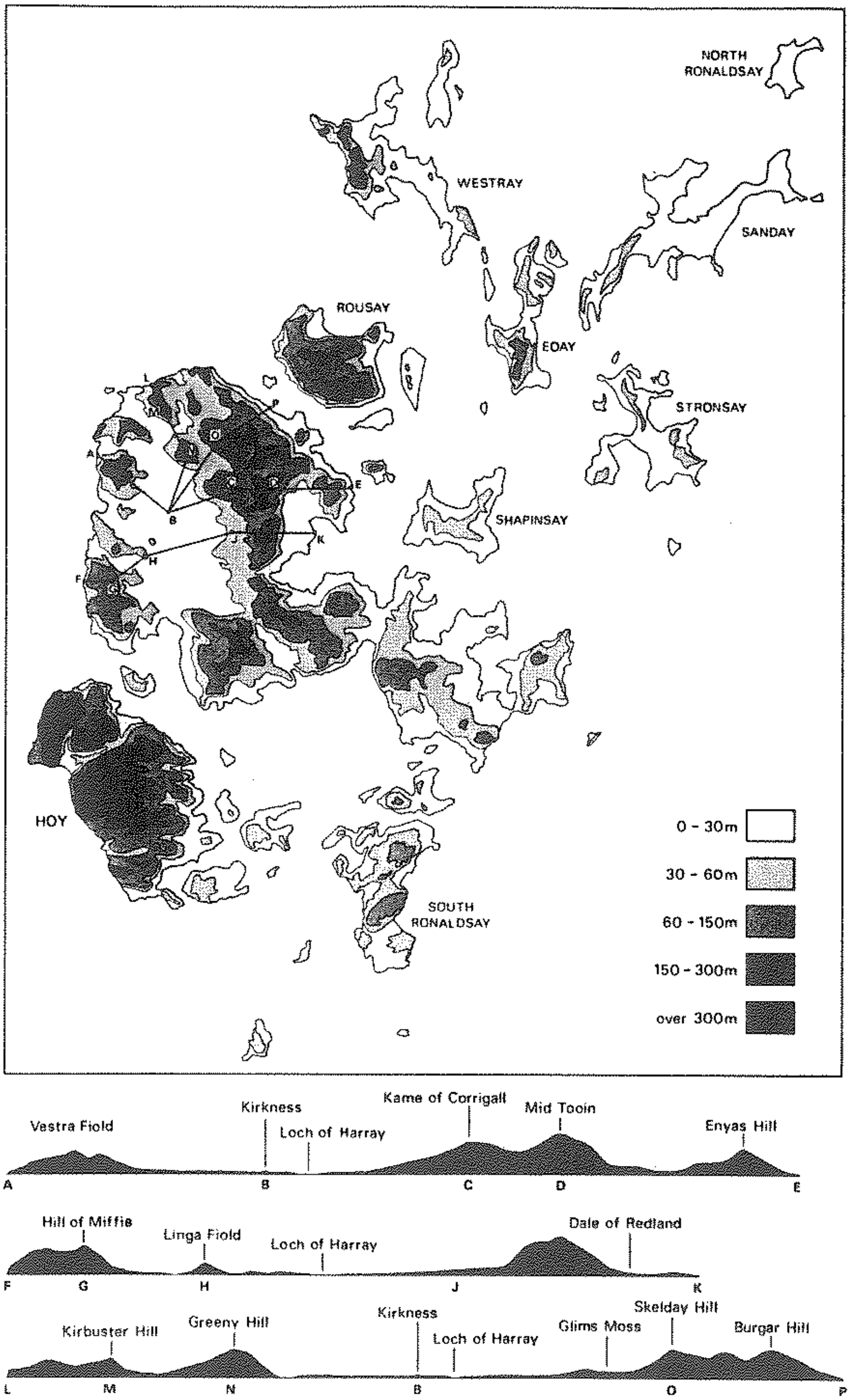
The hills are truncated by magnificent, commonly vertical, cliffs on the west and north-west coasts, the cliffs at St Johns Head reaching a height of 335 metres.

4. Rousay and western Westray display a strikingly rugged topography, yet markedly dissimilar from that of western Hoy as a consequence of differing geology. The bedrock of Rousay and Westray consists of gently dipping sediments, basically flagstones and sandstones, of varying resistance to weathering. Differential weathering and erosion has resulted in stepped hillsides, often with craggy risers (hamars). This type of landform is found in its most extreme development along the south-east facing hillside between Frotoft and Mansemass Hill, on Faraclett Head, on the north-west face of Kierfea Hill on Rousay and on the south-facing slopes of Fitty Hill on Westray.

Many of the broad, open bays of the islands have an extensive hinterland of windblown sand, the sand often having a high finely comminuted shell content. Approximately one-third of Sanday is covered in blown shelly sand, most usually as a gently undulating area of low relief behind a narrow fringe of dunes, but at Warsetter the sand has advanced up a moderately steep slope to a height of about 50 metres.

If the landward scenery of Orkney is, with some exceptions, of a subdued nature, then the coastal scenery is most impressive, with the red and yellow cliffs of Hoy, the grey cliffs of Marwick Head and Noup Head, the sea stacks, of which the Old Man of Hoy must be the most often photographed, the ‘geos’, long, narrow openings weathered out along lines of weakness, and the ‘gloups’ or blowholes, such as the gloup at Marka Ber in Deerness and the Kilns of Brin-Novan on Sacquoy Head on Rousay. The awesome power of the sea during gales is clearly marked by the occurrence of high-level storm beaches, cliff-top deposits often with rock debris of boulder size; a good example of such a deposit occurs at a height of about 20 metres on the west side of Sacquoy Head on Rousay.. The erosive potential of strong winds is seen in the scarred and stripped hillslopes of the western seaboard around Yesnaby, on Fitty Hill, Westray and on Mull Head, Papa Westray. Such dramatic cliff and cliff-top features contrast with the broad sweeps of white sand on Sanday and the intriguing ‘ayres’ or spits and tombolos.

Figure 2. Relief



2. Climate

The climate of the Orkney Islands is governed basically by three factors, namely, the intimate relationship with the sea, an open, gently undulating topography and its high latitude.

Orkney lies at a mean latitude of 59° North but the more extreme climatic aspects of such a latitude is ameliorated by the influences of the sea, particularly the warming effects of the North Atlantic Drift. A striking feature is the close relationship between the various aspects of climate. The relatively low evaporation associated with low summer temperatures and high relative humidity makes the annual average rainfall of about 950 millimetres relatively excessive. Add to this the high incidence of strong winds and lack of natural shelter and the climate can assume a bleak and inhospitable aspect, but the area suffers no great extremes of heat or cold, and the very severe, cold winters of more southerly eastern coastal regions generally do not occur. The area has a good sunshine record and during the summer months experiences prolonged daylight which compensates for the shorter hours of daylight during winter. Overall, the climate is cool but equable in nature and not nearly as severe as in some regions of similar latitude.

There is little basic data for the area apart from the extensive and complete information for the Meteorological Office weather station at Kirkwall Airport (Plant and Dunsire, 1974), where observations began in February 1950. Computed theoretical average values of temperature and sunshine duration for the comparable period 1951 to 1972 are available from the co-operating climatological station in Stenness (personal communication Meteorological Office, Edinburgh). Both the Kirkwall Airport station and the Stenness station are coastal (Figure 3) and of low and similar altitude and there is an unfortunate lack of information from the more elevated parts of west Mainland and from Hoy.

Rainfall

The average annual rainfall varies from approximately 800 millimetres along the southern and eastern seaboards to over 1000 millimetres on the hills of Rousay, west Mainland and Hoy, and to over 1200 millimetres on the highest hills exposed to the south-west. Much of the archipelago, and the greater percentage of arable ground, has an average annual rainfall of between 900 millimetres and 1000 millimetres (Figure 3). Table 1 shows the monthly and annual computed averages of rainfall for number of recording stations within the area (personal communication Meteorological Office, Edinburgh). Rainfall is distributed more or less evenly throughout the year with June marginally the driest month and December the wettest, the winter ‘half-year’ rainfall accounting for 60 per cent of the annual total.

Figure 3. Climate Stations

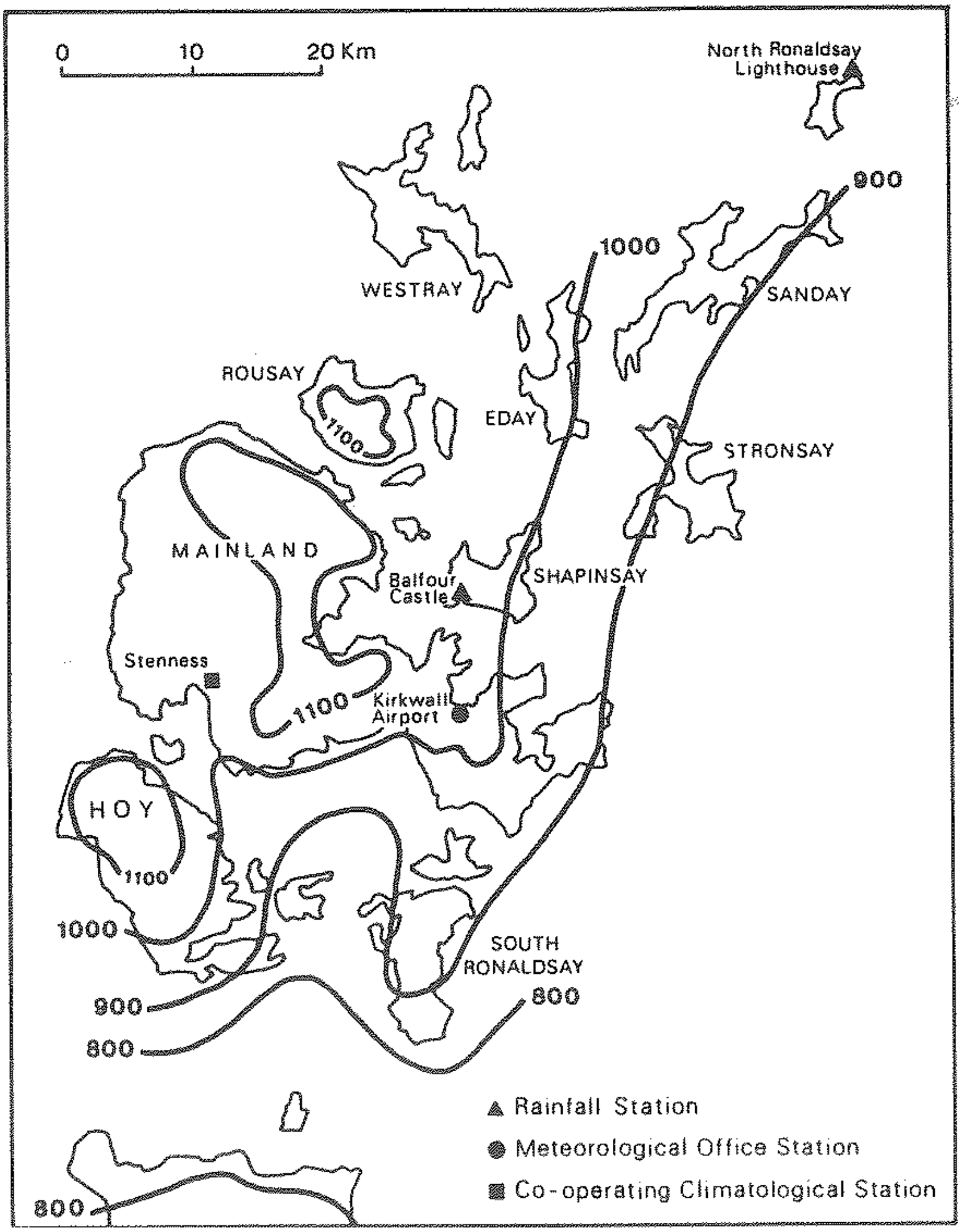


Table 1. Monthly and Annual Computed Averages of Rainfall (in Millimetres) (1941-1970)

Station	Altitude (m)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
Kirkwall Airport	26	105	80	74	59	59	55	65	75	98	113	119	124	1026
Stenness	23	107	80	75	60	59	56	65	77	99	114	121	125	1038
Balfour Castle	15	104	79	73	60	59	55	65	74	97	112	118	123	1019
N. Ronaldsay	7	93	71	66	52	52	49	58	67	87	100	106	110	911

One of the significant features of the climate is the high number of days with rain (Table 2). There is a remarkable constancy of monthly totals over the summer and winter periods and on average rain falls on more than half the days of the month during the summer period and on about 80 per cent of the days of the month in the winter period (October to March). With an annual rainfall of between 900 millimetres and 1000 millimetres it would appear that little and often describes aptly the intensity and distribution of the rainfall of Orkney. Plant and Dunsire (1974) show that in a 20-year period at Kirkwall Airport, 25 millimetres or more of rain fell on only 36 days, 15 millimetres or more on 155 days, 5 millimetres or more on 1393 days, but that 0.2 millimetres or more fell on 4860 days.

Table 2. Mean Number of Days with Rain at Kirkwall Airport (1951-1972)

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
25	20	19	18	16	16	18	19	19	22	24	25	142

Snow

Considering its high latitude the area is remarkably snow-free, with Kirkwall Airport, the only station in the area with snow records, experiencing an average of 64 days per year with snow or sleet falling. Most of the snowfall occurs in the months from December to February but snow or sleet has been recorded for every month of the year (Plant and Dunsire, 1974). The fall of snow or sleet in the months of June to September is a rare occurrence and snow falling in May and October seldom provides more than a thin, temporary ground cover. The moderating influences of the sea on the climate is reflected in the relatively low number of days with snow lying; in contrast to the average of 64 days per year with snow or sleet falling, snow lies only on an average of about 15 days (Plant and Dunsire, 1974). The number of days with snow falling will increase fairly rapidly with increasing height above sea level (as a rough guide, one day more per year for each 15 metres of elevation above 61 metres can be expected) and will depend on distance from the coast and on aspect. The geography of Orkney is such that the figures for Kirkwall Airport can be regarded as being typical of most of Orkney, but major increases in snowfall must be expected over the Hoy hills in particular.

Orkney is open to winds from the sector between north-west and north-east, and it is when northerly winds bring polar air into the region that heavy snowfalls are most likely to occur. Falls of snow are often accompanied by high winds and therefore even relatively light falls of snow can lead to severe local drifting.

Thunderstorms

Although squally showers of rain, hail or snow are by no means uncommon in Orkney, the islands have a relatively low frequency of thunderstorms and damaging hail, with an average of about 4 to 5 days per year with thunderstorms (Plant and Dunsire, 1974).

Temperature

The available values of average temperatures are shown in Table 3. For Kirkwall Airport, the annual range of average mean monthly temperature is around 8.9° C, increasing from 3.4° C in the coldest month of February to 12.3° C in August. The area tends to escape the very low temperatures of severe winters which affect the eastern seaboard of the more southerly regions of Britain. Due to the much longer track over the North Sea, the cold winds from the continent of Europe responsible for these extreme conditions in the south are modified by the surface temperatures of the winter seas, which are higher than ground-surface temperatures.

Table 3. Average Values of Temperature (°C)

Kirkwall Airport (26 metres) (1951-1972)													
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
Average Daily Minimum	1.9	1.4	2.3	3.2	5.6	7.8	9.4	9.7	8.7	7.1	4.1	2.7	5.3
Average Daily Maximum	5.3	5.5	6.9	9.2	11.3	13.9	14.9	15.0	13.8	11.3	7.9	6.1	10.1
Average Daily Mean	3.6	3.4	4.6	6.2	8.5	10.9	12.2	12.3	11.2	9.2	6.0	4.4	7.7
Stenness (23 metres) (Computed comparable averages 1951-1972)													
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
Average Daily Minimum	1.3	0.9	2.0	3.1	5.7	7.9	9.5	9.8	8.8	7.0	3.6	2.1	5.1
Average Daily Maximum	5.6	5.8	7.2	9.7	12.0	14.6	15.6	15.5	14.2	11.6	8.1	6.5	10.5
Average Daily Mean	3.5	3.3	4.6	6.4	8.9	11.3	12.5	12.6	11.5	9.3	5.8	4.3	7.8

The northerly latitude and the proximity of the sea play important roles in governing the temperature patterns of the area. In the early part of the year, the very slow rise in sea temperature and the onset of cold easterly winds result in a slow build-up of temperature over the land so that spring is late arid cool. The high latitude of the area and the maritime influence are further reflected in the narrow diurnal range of temperature (Plant and Dunsire, 1974). Comparison of the values of Kirkwall with those of Stenness illustrates the lower winter maxima and the higher summer maxima of Stenness, figures consistent with the reduced maritime influence.

Air frost

The number of days of air frost averages about 37 days per year at Kirkwall Airport and about 41 days per year at Stenness (Table 4) but will be greater inland and at higher elevations.

Table 4. Mean Number of Days with Air Frost* (1951-1972)

Station	Altitude (m)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
Kirkwall	26	8.0	10.1	6.0	3.9	0.5	Nil	Nil	Nil	Nil	0.3	2.6	5.7	37.1
Stenness	23	9.4	10.1	6.2	4.4	0.5	Nil	Nil	Nil	Nil	0.2	3.5	6.4	40.7

* Since January 1, 1963, a day with air frost has been defined as a day on which the minimum air temperature falls to below 0°C. Before this date, a day with air frost was defined as a day on which the minimum air temperature fell to 0°C or below (Plant and Dunsire, 1974).

Sunshine

The sunshine average for Kirkwall Airport is about 1177 hours annually and for Stenness about 1216 hours (Table 5), but from the monthly averages it can be seen that the total for the first six months of the year exceeds that for the second half of the year by between 165 and 175 hours. June is the sunniest month, with about 167 hours (Kirkwall Airport), 10 hours more than May. The sunshine values recorded for the summer months are undoubtedly affected by sea fogs, particularly the values for Kirkwall Airport, where the May, June and July figures are some 10 to 12 hours down on the Stenness figures. The figures from Kirkwall Airport and Stenness for the winter months show, however, a marked similarity.

Table 5. Mean, Daily and Annual Durations of Sunshine (hours)

Kirkwall Airport (26 metres) (1951-1972)													
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
Daily Mean	1.02	2.22	3.12	5.22	5.07	5.55	4.43	4.01	3.51	2.50	1.23	0.79	3.22
Monthly Mean	31.6	62.9	96.6	156.6	157.1	166.6	137.4	124.2	105.4	77.5	36.9	24.6	1177.4
Stenness (23 metres) (Computed comparable values 1951-1972)													
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
Monthly Mean	31.1	62.1	97.1	157.1	167.6	178.0	147.6	129.4	106.8	78.4	37.5	23.0	1215.7

The effect of the high latitude of the area is demonstrated in the prolonged daylight of the summer months, up to 20 hours in mid-summer when, cloud-cover permitting, the sky never really darkens.

The Growing Period

The growing period is defined as that part of the year during which the average daily temperature exceeds 5.6° C. It is recognised that plant growth depends on other factors such as soil temperature, degree of exposure and potential water deficit, but the growing period has proved a useful measure for temperate regions. The growing period at Kirkwall Airport is about 230 days, but any rise in altitude (i.e. drop in average daily temperature) will result in a marked shortening of the season. From a practical farming view-point, when other climatic factors are taken into account, soil management exercised and animal physiology considered, the potential ‘growing period’ is reduced to some 175 days. Another guide to the length of the annual period of growth is given by the averages of accumulated temperature. Accumulated temperature is defined by Shellard (1959) as the integrated excess or deficiency of temperature with reference to a fixed datum, usually called the base temperature, over an extended period of time. The base temperature in relation to plant growth is taken as 5.6° C and the period of time as one year. Table 6 shows the values of monthly accumulated temperature in day-degrees above 5.6° C. There is a slow rate of accumulation of warmth in the spring, but an equally slow loss in the autumn.

Table 6. Average Monthly Accumulated Temperatures (Day-Degrees above 5.6°C)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
Kirkwall Airport	13	13	39	42	95	159	205	207	169	114	40	26	122
Stenness	13	14	39	45	105	170	214	217	177	116	36	22	1168

Wind

Wind, and the high frequency of strong winds and gales, is possibly the most noteworthy facet of the climate of Orkney. The most frequent wind directions have a marked southerly component (Table 7) with the highest frequencies occurring from the sector between south-east and west. The easterly winds are particularly prevalent in the spring and early summer when south-easterly winds are generally more frequent than winds from other directions. Although the incidence of north-westerly or northerly winds is not particularly high, it is from these directions that the most severe gales and storms have often emanated. Gales are experienced on an average of some 30 days per year (Plant and Dunsire, 1974) with 80 per cent of the gales occurring in the winter ‘half-year’. Wind records are available for Kirkwall Airport only, which is unfortunate because many locations are undoubtedly more exposed; the western seaboard of the archipelago, the northernmost islands, and parts of South Ronaldsay, almost certainly experience a higher frequency of strong winds and gales.

Table 7. Annual Percentage Frequency of Wind direction and Speed, Kirkwall Airport (1963-1972)

	Wind Directions in Degrees (True)													
Hourly Mean Wind Speed (m/s)	350-010	020-040	050-070	080-100	110-130	140-160	170-190	200-220	230-250	260-280	290-310	320-340	320-340	All Directions
<1.8														6.3
1.8 to 5.4	1.7	1.8	1.8	2.3	2.8	2.9	4.1	3.5	2.4	3.4	2.4	1.6	1.6	30.7
5. to 10.7	3.0	2.2	1.3	2.0	4.4	6.3	7.1	4.6	4.7	5.4	3.7	3.2	3.2	47.9
10.8 to 17.1	1.0	0.5	0.3	0.5	1.5	1.8	0.8	0.6	2	2.3	0.9	1.3	1.3	13.5
>17.2	0.2	0.1	x	x	0.1	0.1	x	x	0.3	0.5	0.1	0.2	0.2	1.6
Total	5.9	4.6	3.4	4.8	8.8	11.1	12.0	8.7	9.4	11.6	7.1	6.3	6.3	100.0

x denotes a frequency of less than 0.05% (m/s = metres per second)

1.8 to 5.4 m/s = Light Winds
5.5 to 10.7 m/s = Moderate and Fresh winds
10.8 to 17.1 m/s = Strong Winds
17.2 m/s or more = Gale

Relative humidity and fog

In general, the highest values of relative humidity occur in association with the lowest air temperature of the day, whilst the lowest values of relative humidity are usually associated with the highest air temperature of the day. In June, July and August, the months when the incidence of sea fog (haar) is most common, the relative humidity show an early maximum, but as the day progresses, the heat of the sun tends to disperse any haar and the relative humidity falls. There is a marked constancy in relative humidity at all times of the day during the winter months (Plant and Dunsire, 1974), except for a slight fall caused by the marginally higher afternoon temperatures. The relative humidity is higher for a longer period during the winter months because temperatures are low and daylight is short. The periods of low relative humidity values are most prolonged in the spring months of March, April and May, rather than in the summer as might be expected, because of the low spring rainfall and high incidence of dry, cold, east winds.

The principal fogs of the area are sea fogs or haar. Haar, the inflow of fog, often accompanied by drizzle or extremely low stratus cloud, is a climatic phenomenon of considerable importance along the eastern coast of Scotland. It is a characteristic of the northern seas in the summer months, although theoretically it can occur at any time during the year whenever warm, moist air is cooled by passage over the relatively cold sea until the dew-point is reached and condensation begins. Haar is most prevalent in June, July and August and is mostly associated with gentle south-east and easterly winds.

Evapo-transpiration and potential water deficit

There is little information available regarding levels of evapo-transpiration; estimates of water loss due to evaporation and transpiration can only be approximate, dependant as they are on temperature, relative humidity and degree of exposure. The most useful index of effective wetness of the climate is perhaps potential water deficit (Green, 1964), defined as the excess of potential evapo-transpiration over rainfall. The basic period is taken as one year, but only the months in which evaporation exceeds precipitation, that is, where there is a potential water deficit, need be considered. Table 8 shows long-term averages of potential evapo-transpiration for Kirkwall Airport (1956-1975), calculated by means of a Penman combination formula (personal communication, Meteorological Office Edinburgh). The potential evapo-transpiration rate increases steadily from January to a maximum in June of 75.4 millimetres, and by the end of July the average potential water deficit is about 30 millimetres (Kirkwall Airport, Stenness and Balfour Castle) but exceeds 50 millimetres at North Ronaldsay. The conditions of potential drought may be lessened by summer haar and in most years the water balance is redressed by late-summer rains.

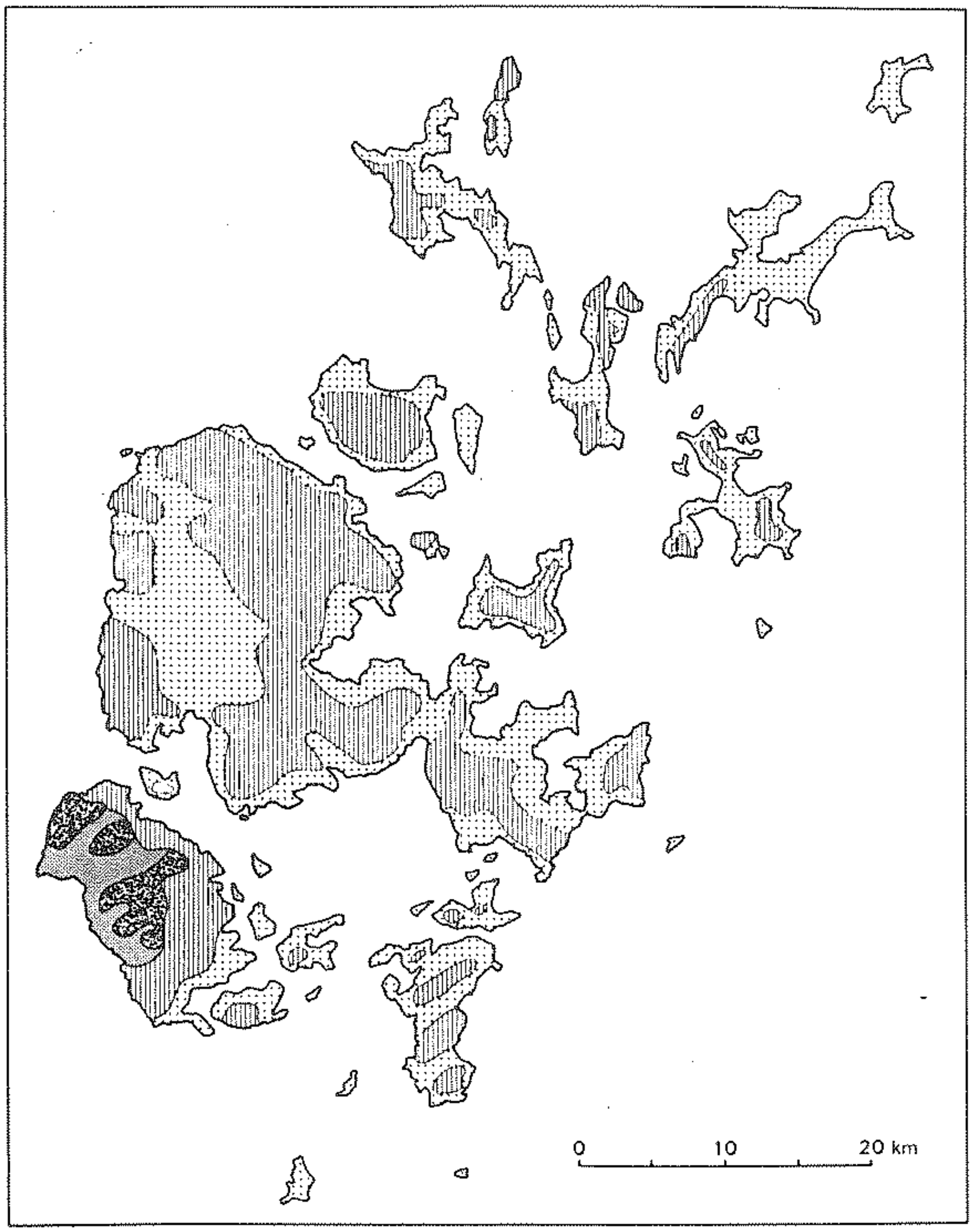
Table 8. Long-term Averages of potential Evapo-transpiration (in millimetres) for Kirkwall Airport, (1956-1975)

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
8	11	30	45	64	75	70	55	36	19	11	10	434

Climate regions

Birse and Dry (1970) devised a scheme of climatic assessments based on accumulated temperature (day-degrees above 5.6° C), potential soil water deficit and altitude to establish a national system of climate regions. Figure 4 is based on this scheme and shows the distribution of climate regions in Orkney. The figure reflects the generally equable nature of the climate in that the moderately dry component of the scheme dominates and no extremes of temperature are recognised. The values of accumulated temperature illustrate the narrow annual range in temperature, with the absence of hard winters being offset by the low accumulated temperatures of the summer months. Only on the higher hills of north-west Hoy does the climate become more intimidating. The principal areas of arable agriculture lie within the fairly warm moderately dry region, experiencing an annual accumulated temperature of 1100 to 1375 day-degrees C and an annual potential water deficit in excess of 25 millimetres.

Figure 4. Modified Birse and Dry Climatic Regions



fairly warm and moderately dry

cool and moderately dry

cool and wet

cold and wet

Accumulated Temperature Divisions

RANGE (day °C)	DESCRIPTION
1100 - 1375	fairly warm
825 - 1100	cool
550 - 825	cold

Potential Water Deficit Divisions

RANGE (mm)	DESCRIPTION
›25	moderately dry
‹25	wet

The moderately dry division incorporates the 'dry', 'rather dry' and 'moist' divisions of Birse and Dry; the wet division incorporates the 'rather wet' and 'wet'

Modified from Birse and Dry (1970)

3. Geology and Parent Materials

The Orkney Islands consist almost entirely of relatively gently inclined sedimentary rocks and subordinate lavas and tuffs of Middle and Upper Old Red Sandstone age (Figure 5). Detailed accounts of the geology of the Orkney Islands can be found in Wilson *et al*, (1935) and Mykura (1976).

Basement Complex

A crystalline basement complex composed of metamorphic rocks of Moinian type intruded by Caledonian granites (Wilson *et al*, 1935) crops out as a series of inliers within a north-west-trending belt extending from the island of Graemsay to Yesnaby, the largest outcrop forming the hilly ground immediately north and west of Stromness where it reaches a height of 94 metres. A high proportion of the complex is made up of coarse, pink or greyish, poorly foliated granite which grades locally into granite-grieiss. The granite contains enclaves of biotite-gneiss and siliceous, micaceous and hornblendic schist (Mykura, 1976).

Lower Old Red Sandstone

At Yesnaby there is a small area of sandstones, conglomerates and breccias which may be of Lower Old Red Sandstone age (Fannin, 1970) and which Fannin terms the Yesnaby Sandstone Group. Within the group, Fannin describes two formations which may be in part contemporaneous; the Harra Ebb Formation consisting of inter-bedded sandstones and siltstones with lenses of breccia and conglomerate near the base, and the Yesnaby Sandstone Formation composed of two distinct facies, a lower rusty-weathering well-graded sandstone with large-scale cross bedding - features suggestive of an aeolian origin - and an upper facies of pebbly sandstone with siltstones and shales and of a suggested water-laid origin. South from Yesnaby at Warebeth, two kilometres west of Stromness, a succession of purple siltstones and sandstones of a possible similar Lower Old. Red Sandstone age was encountered during drilling (Mykura 1976).

Middle Old Red Sandstone

The Middle Old Red Sandstone can be divided into two major groups (Table 9). The lower group, comprising the Stromness Flags and the Rousay Flags (the Rousay Beds of Wilson *et al*, 1935), consists largely of flagstones and is made up of rhythmic sequences of thinly bedded and, in part, laminated, grey and black, carbonate-rich siltstones and silty mudstones alternating with generally thin beds of fine-grained sandstones or sandy siltstones (Mykura, 1976). On lithological criteria alone it is extremely difficult to separate the Stromness Flags from the Rousay Flags and differentiation is based to a major degree on fossil assemblages and particularly the fish remains that are incorporated in the rhythmic sequences. Flett (1898) first effected a separation and established the 'Rousay Beds' as a separate formation. Mykura (1976) offers some minor distinguishing lithological features:

Figure 5. Geology

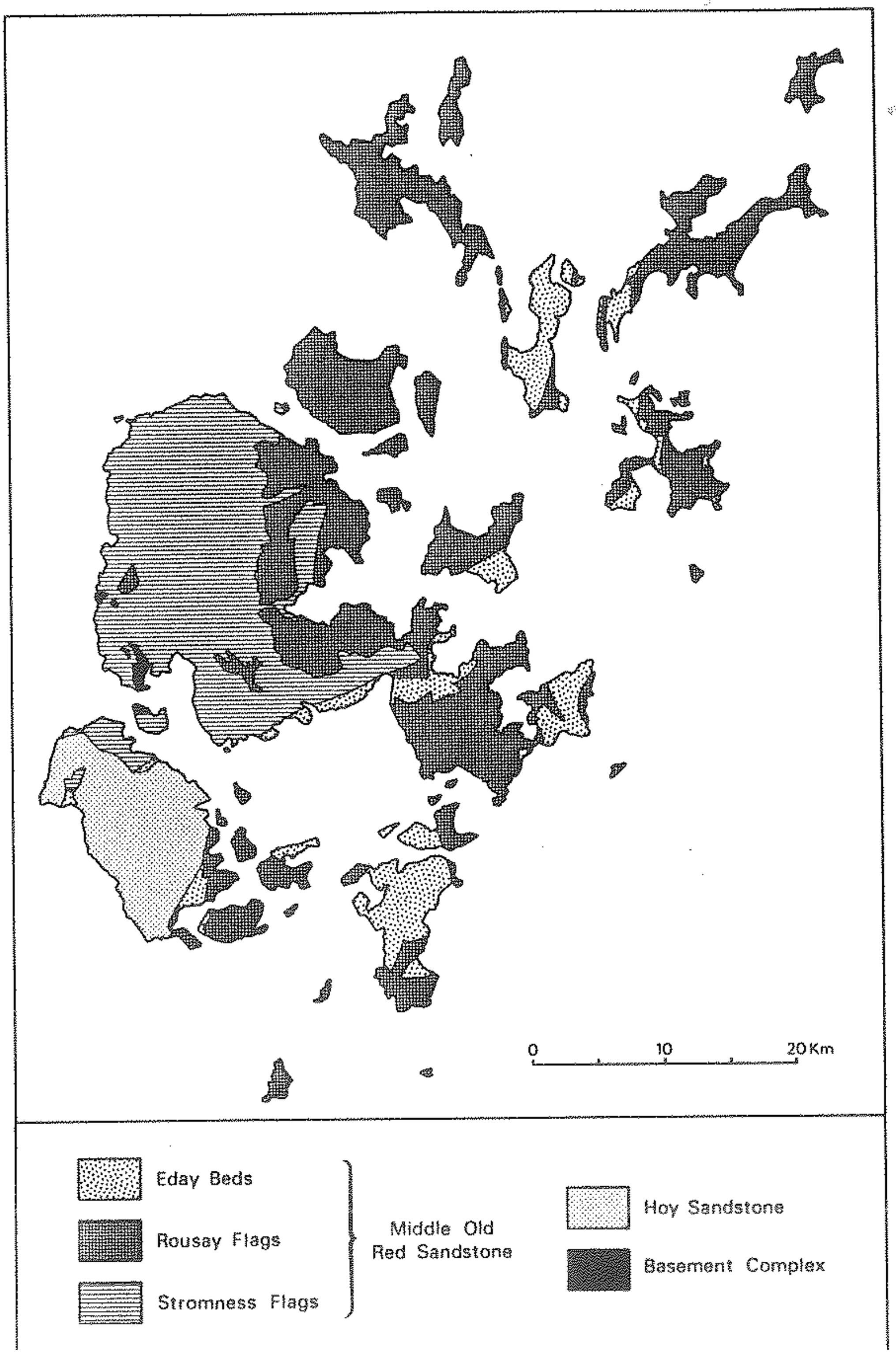


Table 9. Summary of Geology

Summary of Geology				
Period	Lithostratigraphic Unit			
				Superficial deposits
Pleistocene and Recent				Wind-blown sand
				Alluvium
				Peat
				Frost debris
				Fluvioglacial sands and gravels
				Moraine and till
Upper Old Red Sandstone	Hoy Sandstones			
	Hoy volcanics			
		Unconformity		
			Upper Eday Sandstones	
			Eday Marls	
	Eday Beds		Middle Eday Sandstones	
			Eday Flags/lavas	
			Lower Eday Sandstones	
Middle Old Red Sandstone	Rousay Flags			
	Upper Stromness Flags			
	Lower stromness Flags			
		Unconformity		
Lower Old Red Sandstone?	Warebeth Red Bed / Yesnaby Group formation			
		Unconformity		
Moinian	Basement Complex			

1. The Rousay Flags weather to a grey colour in contrast to the predominant ochreous-weathering of the Stromness Flags and suggests that their carbonate content is mainly calcite and not ferroan dolomite.

2. The fish-bearing facies of some of the Rousay Flags cycles weather to a purplish colour and some are sufficiently lime-rich as to be described as impure limestones.

The upper group, the Eday Beds, consists of three sequences of yellow and red sandstones with pebbly lenses and marly bands; the Lower, Middle and Upper Eday Sandstones separated respectively by the Eday Flags and the Eday Marls. The Eday Flags show cyclic sedimentation, but in contrast with the Stromness Flags and Rousay Flags the yellow or red sandstone phases are usually thicker and more coarsely grained. The basal beds of the Eday Flags contain a number of thin flows of alkaline olivine-basalt lava with bands of tuff (Mykura, 1976); intrusive rocks of similar petrography occur in Deernes and Copinsay (Flett, 1898; Kellock, 1969).

The Eday Marls again show a rhythmic sequence of sedimentation and consist principally of beds of bright red and pale green calcareous sandy siltstone alternating with beds of red and yellow sandstone (Mykura, 1976).

Upper Old Red Sandstone

The only Orkney rocks of Upper Old Red Sandstone age are the sandstones and underlying volcanic rocks which occupy much of Hoy and rest on an irregular eroded surface of faulted and folded Middle Old Red Sandstone rocks. The Hoy volcanics consist of tuffs and tuffaceous sandstone, brownish red sandstone with angular blocks and pebbles of basalt and olivine-basalt lavas (Mykura, 1976). The Hoy Sandstones comprise a series of red and yellow sandstones with subordinate marl bands. There appears to be some variation in the lithology and resistance to weathering of the sandstone in different parts of the sequence. In north Hoy the lower beds of the Hoy Sandstone are soft, friable and readily weather to a loose sand, whereas the overlying beds are much more resistant to weathering and form the prominent crags on the upper slopes of some of the Hoy hills. It is this configuration of rocks that has given rise to the steep-sided hills in this part of Hoy.

Pleistocene Glaciation

The first complete account of the glaciation of the Orkney Islands was offered by Peach and Horne (1880). They showed that ice which streamed eastwards from eastern Sutherland was deflected north-westwards over Caithness and Orkney by the pressure of the great Scandinavian ice-sheet. Their hypotheses, have met only with refinement over the years (Wilson *et al*, 1935; Mykura, 1976).

Orkney must have been glaciated in all four episodes of the Pleistocene Ice Age, but evidence only of the last (Devensian) glaciation now remains. Wilson (Wilson *et al*, 1935) deduces from his study of striae that in the earliest stages of the Devensian glaciation the Scandinavian ice moved westwards across Orkney towards the Atlantic Ocean, being diverted locally south-westwards by the hills of Hoy into the Pentland Firth, which, he suggests, must have been free from ice. At a later stage the pressure exerted by the Scandinavian ice lessened and Scottish ice was able to force its way north-westwards over Orkney. This relief of pressure may have occurred more than once and there may have been times when Orkney was partly or completely free from ice. Wilson suggests a final stage of glaciation when the Scottish ice passed northwards over the isIand group and was deflected along the sounds and firths. The general distribution of drift leaves no doubt that the principal ice movement was in a north-westerly direction.

Evidence for the existence of local glaciers is found in north-west Hoy where they occupied small but well-developed corries, for example Nowt Bield, Quoyawa, Red Glen and Enegars, and where there are traces of deposits that can be assigned definitely to the action of local valley glaciers, the most spectacular depositional feature being the terminal moraine of a small valley glacier which filled the corrie below the crags of Enegars.

The general topography of the Orkney Islands was much modified b y the passage of ice. In the flagstone country the hillsides before glaciation probably exhibited well-marked terracing with rocky escarpments and scree, products of the differential weathering of the lithological units of the Flagstone groups. The passage of ice has, in most areas, filled the depressions between escarpments with drift and removed any projecting rock, leaving only indistinct ledges. In a few areas, where the direction of ice movement was parallel to the face of the terrace-features, a proportion of the scree material was removed and the terracing emphasised (Wilson *et al*, 1935). As the passage of ice modified the landscape, so did the retreat and the melting of the ice with the further deposition of drift and the introduction of fluvioglacial materials. The post-glacial development of peat, the establishment of stream and loch systems .and the encroachment of wind blown sand further modified the topography. These post-glacial deposits, together with the glacial deposits, provide a number of different parent materials for soil genesis.

Superficial Deposits

Superficial deposits cover more than 95 per cent of the area, till (75 percent) and peat (15 per cent) being the most extensive. Wind blown sand covers 5 per cent of the area while alluvium (1 per cent) and fluvioglacial materials (less than 1 per cent) are of minor extent.

Four types of till, the unsorted material laid down by the ice, have been recognized.

1. Till of moderately fine texture is generally widespread throughout the island group. It occurs extensively in east Mainland and South Ronaldsay, on Shapinsay, Stronsay and Westray; less commonly it is present in Stenness, Orphir, Rousay and Eday. The material is firm, compact, has a sandy clay loam or clay loam texture, and usually contains strongly weathered stones throughout. Shell fragments are often encountered at depth in till-cliff sections.

2. Till of a coarse or moderately coarse texture is found extensively on Hoy and locally on Eday and west Mainland.

3. Till of moderately coarse or medium texture is common throughout the west Main land and of local occurrence on east Mainland and Burray. The till occurs quite extensively throughout the northern isles.

4. Till, of a morainic nature and landform, with a moderately coarse or medium texture, occurs locally on Mainland, the deposits being well defined and extensive in the parish of Holm around the farm of Hestwall, in the parish of St. Andrews, around Deerness at Toab and in the parish of Stenness, around the farm of Moa.

A widespread feature of the last two types of till is the presence of an indurated horizon in the upper part of the deposit. This indurated layer is compact, brittle and often has a platy structure, sometimes with iron or manganese stainings on the faces of the plates. The presence of fine pores and fine sand or silt linings to stone cavities or as cappings on the stones, are further common features. The degree of induration is characteristically strongest at the top and decreases in intensity with depth; the upper horizon boundary is sharply defined, commonly with a thin iron pan, but the lower boundary is usually less well defined. In this area the average depth to the top of the induration (from the surface of the mineral soil) is usually between 20 and 30 centimetres, and the thickness is commonly about 35 centimetres, although thicknesses in excess of 60 centimetres have been recorded. The indurated horizon is considered by Fitzpatrick (1956) to be a fossil permafrost layer which formed when periglacial conditions prevailed. Glentworth (1944) and Romans (1962), however, believe the horizon to be a product of soil-forming processes.

Peat

Peat is an accumulation of organic material which has formed under conditions of excess surface moisture, low temperature and high acidity, factors which cause a reduction in the rate of microbiological activity and, consequently, inhibits the decomposition of plant remains. Blanket peat is extensive on Hoy, on the Evie and Rendall hills, on the Orphir hills and on Rousay and Eday. Basin and valley peat occurs locally throughout the area, in some instances underlain by marl - a light grey calcareous silty loam which occasionally contains gastropod shells.

Windblown Sand

Windblown shelly sand deposits occur round many of the more open, shallow bays of the area. Deposits are particularly extensive around the Bay of Skaill, Birsay Bay, Newark Bay (Deerness) and on Burray, around the farm of Bow. Approximately one third of Sanday and of North Ronaldsay is covered by shelly sand and there are extensive deposits on Westray. Windblown sand of an essentially noncalcareous nature is much less extensive, deposits occurring at Rackwick on Hoy and around the Loch of Doomy on Eday. The calcium carbonate contents of most of the windblown sand deposits of Orkney are given by Leask (1938). Accumulations of windblown quartzose sand occur on the plateau summit of Ward Hill, Hoy (Goodier and Ball, 1975).

Alluvium

In the absence of any major river systems, alluvial deposits are of relatively minor extent. They are found as narrow tracts along many of the small burns of the area and as fringes to the lochs. Small areas of alluvium, possibly associated with former lake sites, do occur locally. The deposits vary somewhat in texture and drainage class but are predominantly medium textured, more or less stone-free and poorly drained.

Deposits consisting of bands of organic and mineral layers, or of mineral material, containing a high amount of organic matter are considered as complexes of peat and alluvium. They are often closely associated with areas of basin peat and are in many instances similarly underlain by marl. They are also present alongside many of the streams traversing the areas of blanket peat.

Marine alluvium, in the form of saltings, is widespread although its areal extent is small. Alluvial fans are found on Hoy at the mouths of deeply incised stream valleys which scar the generally steep hill-slopes.

Fluvioglacial Deposits

Fluvioglacial deposits, comprising stratified sand and gravel, are of very minor extent in the area. They occur, firstly, as ridges and terraces in the valley of the South Burn at Rackwick on Hoy, and as small, isolated mounds, a constituent of the Rackwick Complex, at the Ford of Hoy and, secondly as a series of small, isolated mounds extending westwards from Stromness along the Innertown - Outertown road. The proportion of sand and gravel is very variable in the Rackwick deposits, but the deposits to the west of Stromness appear to be free of gravel.

Frost Debris

Frost debris occurs as scree deposits on the north and north-eastern flanks of Ward Hill, Hoy, and as a component of the patterned-ground on the summits of Ward Hill, (Goodier and Ball, 1975), Knap of Trowieglen and Cuilags.

Goodier and Ball (1975) offer the suggestion that the summit of Ward Hill is free from glacial drift and that the soil parent material is derived directly from the sandstone bedrock under the influences of frost-sorting. Stephens and Edwards (in Wilson *et al*, 1935) state that the whole island of Hoy appears to have been glaciated at some stage of the Pleistocene and offer the possibility of a residual ice-cap on Ward Hill at a late stage of the Pleistocene. A profile collected from the summit of Ward Hill (Profile No.17) suggests that the soil parent material is drift rather than rock, although it has been undoubtedly affected by frost action, as indicated by the patterned-ground. Evidence of frost action, increases the difficulty in differentiating between the drift and rock debris, when both are derived from the relatively easily weathered sandstone.

4. Soil Formation, Soil Survey Methods and Classification

A soil body is a natural three-dimensional object whose limits are decided by considerations of soil and non-soil. Soils have many different forms and their properties show wide variation; they consist of mineral and organic materials and are formed by the breakdown of rock and mineral deposits through the agencies of physical and chemical weathering in conjunction with the actions of plants, animals and their organic remains. During soil formation the degradation products of organic and inorganic breakdown are removed or redistributed to form horizons which differ in appearance and properties. The soil profile, a vertical section of the soil body, is the principal unit for soil study and is fundamental to the characterisation of mapping units. It has more or less well-developed horizons roughly parallel to the surface of the ground and it is the character of these horizons which determines the soil group to which the profile belongs. The soil body, and therefore the soil profile, is a product of natural agencies and man, the soil-forming factors, namely, Parent Material, Climate, Organisms, Time and Topography (Jenny, 1941).

Soil Forming Factors

Parent Material

The properties of parent material most significantly affecting soil formation are texture and mineralogical composition. Texture is important in determining the natural drainage of the soil, coarse materials generally giving rise to well-drained soils and fine materials to poorly drained soils, although drainage in the coarser material can be influenced by the presence of indurated or compact horizons.

There is usually a close relationship between major soil subgroup and texture. In Orkney the podzols and peatv podzols are developed on parent materials of coarse, moderately coarse and medium texture, and the noncalcareous and peaty gleys mostly on materials of medium and moderately fine texture. The texture of the parent material also influences the structure and consistence of the soils, coarse materials resulting in weakly cohesive soils with fine structures and fine materials resulting in strongly cohesive soils with coarse or massive structures.

The base status of the parent material is closely related to its mineralogy and thus mineralogical composition exercises profound control over soil development. In base-rich materials, the bases, as well as being abundant, are also more readily and rapidly released in the soil and the appearance of characteristics, typical of leached soils is retarded. In Orkney, however, leaching is so strong that almost all types of parent materials give rise to soils that are naturally base-deficient, at least in the upper horizons, and have a surface accumulation of acid organic matter.

Climate

The most important climatic elements affecting soil genesis are rainfall and temperature, because they govern the amount of water available for leaching or gleying, and the energy available for weathering and biological activity. Not all the rainfall is involved because some is lost by run-off and some by evaporation and transpiration. The amount of run-off depends on slope, the permeability of the surface material and the intensity of the rainfall; loss by evaporation and transpiration is largely dependent on temperature d exposure. With a lowering of average temperatures evapo-transpiration is reduced and more water is made available to the soil system. Leaching is intensified, soils become acid more quickly and a surface layer of organic matter is more readily accumulated.

Wind must be considered as a climatic factor influencing soil formation in Orkney, particularly as a causal agent for salt-spray and sea-gusting. Much of the western seaboard of the archipelago is affected markedly by salt-spray and this has distinctive effects on soil properties.

Past and present rigours of climate on soil formation are illustrated by the patterned-ground on the plateau summits of Ward Hill, Hoy (Goodier and Ball, 1975) and Trowieglen, Hoy.

The climate has determined to a great extent the overall soil pattern in Orkney, the combination of the relatively low summer temperatures and the high relative humidity being largely responsible for the predominance of gleys and blanket peat.

Topography

Topography influences soil formation through its effect on the water relationships of the soil and through its effect in locally modifying the climate. The hydrologic conditions in the soil are influenced in two ways, firstly by the degree and configuration of slope at any site on rainfall and infiltration and secondly by the role of relief in controlling the position of the water-table.

Organisms

Both botanical and zoological agencies can be considered. The natural and semi-natural plant communities, dependent as they are on climatic and soil conditions, are not a truly independent variable (Jenny, 1941). Nevertheless, an established plant community does affect the soil in which it grows, particularly in determining the form of humus in the soil and the rate of acidification. Broadleaved woodland, herb and grassland vegetation are associated with moder or mull humus forms and coniferous forest and ericaceous vegetation are associated with mor or peaty forms of humus. The acid nature of these latter humus forms probably plays a significant part in increasing the rate of leaching (Crompton, 1956).

Man is probably the most significant of the zoological influences and his actions, within certain limits, are independent of soil and other conditions and come within Jenny's definition of an independent soil-forming factor (Jenny, 1941).

Man's agricultural activities on the land have affected natural soil bodies in a number of ways. Drainage and ditching activities changes the soil-water regime and, to some degree, the drainage status of the soil. Stripping and ploughing destroys the upper horizons of the profile and creates new ones. The use of lime and fertilisers raises the nutrient status of soils and thereafter maintains it against losses from leaching.

The cultivated parts of the area have been broken in mostly from peaty moorland and evidence of their origin is retained in the profiles of many soils. Some of the cultivated soils can be clearly recognized as peaty gleys because the horizons of the soil, apart from a modified surface, are intact. Others, such as the Tresdale Series, are noncalcareous qleys, but gradations are found between this profile type and the corresponding peaty gley, indicating that over a period of time the process of cultivation can convert a peaty gley into a noncalcareous gley. Similarly, with the peaty podzols, cultivation over a period of time alters the upper horizons completely. The presence of a thin iron pan immediately below the plough-layer, or fragments of an iron pan within the surface horizon, are often the only remaining pieces of evidence to indicate the soil was formerly a peaty podzol.

The degrees of modification of the peaty gley are very varied even within the confines of a single field and the soil pattern can be highly complex. Generally the full range of cultivated peaty gleys is mapped as noncalcareous gleys; the range being more fully discussed in the memoir under the individual soil series.

Time

The time factor is the length of time that the soil-forming processes have been operating. The Pleistocene glaciation destroyed the pre existing soils, new surfaces were exposed and new materials deposited on which the soil-forming processes could act. Consequently, the soils date, in general, from the end of the Ice Age. Younger soils, developed on recent deposits such as wind-blown sand, do not generally have the well-developed profiles of the soils on older materials.

Soil Survey Methods

The primary aim of a soil survey is to identify and describe soil types and to record their distribution on a map. The soil profile, a vertical section from the surface of the ground to the soil parent material at a point on the landscape, is the study unit for the soils of an area. Soil types are identified on the basis of profile morphology, that is, by a comparative study of their appearance. The features considered are colour, texture, structure, consistence, organic matter, roots, stones, moisture, mottles and thickness of each horizon in the profile. Although no two profiles are exactly alike, it is possible to group those that are very similar into primary profile-taxa called series. The series as defined by the Soil Survey of Scotland comprises soils with similar type and arrangement of horizons developed on similar parent material. Any area mapped as a given series is predominantly, but not exclusively, composed of profiles belonging to the profile-series of the same name. The phase is a subdivision of the series based on a single profile characteristic such as shallowness, stoniness or thickness of the surface horizon.

The Soil Survey of Scotland also places soil series into soil associations according to the parent material on which they are developed. The soil association is a group of soils developed on similar parent materials which characteristically occur together on the landscape; it is a compound mapping unit in which the distribution of each component is delineated. The complex is exclusively a mapping unit which is used when the soil pattern on the landscape is too intricate for the individual mapping units to be shown separately for the given scale of mapping.
Soil series and soil complexes are generally named after the locality in which they were first described. The soil association usually has the same name as its most common series. Phases of series are not given separate names but have a qualification added to the series name.

The variant is used in this memoir to identify those areas where a component of the Frotoft and Ulbster complexes is not typical and is, in fact, sufficiently different to warrant the creation of a new complex. The total area involved, however, is so limited that a new complex is not justified.

During a survey, soil profiles are examined at numerous points on the landscape, in response to changes in slope or vegetation, by means of small pits, auger borings or any natural exposures. Similarly, confirmatory pits are dug within a landform or vegetation unit and any correlations established between soil type and external factors such as slope or vegetation assist greatly in the placing of boundaries between mapping units. Larger pits are dug at selected sites typical of each soil series, and from these detailed profile descriptions are made and samples collected for further laboratory analysis.

Soil Classification

The system of classification used in the memoir is similar to that used in previous memoirs. Soil series with very similar profiles are assigned to the same major soil group and subgroup. Table 10 lists the soil series found in the area arranged in the appropriate major soil group and subgroup.

The more important field properties of each major soil group and subgroup are given below.

DIVISION OF IMMATURE SOILS

Immature soils are characterised by indistinct or weakly developed horizons which are generally restricted to surface organic horizons or A horizons resting directly on little-altered parent material or rock.

Major Soil Group: Lithosols

Lithosols are restricted in depth and have continuous, coherent and hard rock within 10 centimetres of the surface. Only an H, O or A horizon is likely to be present above rock.

Major Soil Group: Regosols

Regosols have a thin, weakly developed A horizon, which rests directly on unconsolidated material. The soils are generally on parent material of windblown sand.

Subgroup: Noncalcareous regosols

Noncalcareous regosols lack free calcium carbonate in the parent material.

Major Soil Group: Alluvial Soils

Alluvial soils are developed on recently deposited freshwater, estuarine or marine alluvium and exhibit little profile differentiation or modification to the parent material. The presence of an A or an O horizon together with some mottling and weak structure in the subsoil, are characteristic features.

Subgroup: Saline alluvial soils

Saline alluvial soils have high exchangeable sodium and the effects of gleying are clearly evident. The soils are developed on marine or estuarine alluvium found between the normal high-water mark and the limit of hioghest spring tides.

Subgroup: Mineral alluvium

Mineral alluvial soils have an A horizon and the effects of gleying can be present. The soils are developed on freshwater alluvium.

Subgroup: Peaty alluvial soils

In peaty alluvial soils the characteristic fe ature is an O horizon which usually occurs at the surface but can be interbedded with freshwater alluvial sediments. The soils may have a high water-table.

DIVISION OF NON-LEACHED SOILS

Non-leached soils are characterised by the presence of free lime and have a neutral or alkaline reaction. Their lower horizons may show some gleying

Major Soil Group: Calcareous Soils

The calcareous soils are freely drained soils containing free calcium carbonate throughout the profile. The content of free carbonate usually exceeds 5 percent.

Subgroup: Brown Calcareous Soils

In brown calcareous soils, the B horizon has a brighter colour than the A or C horizons, but there is no morphological or chemical evidence of translocated sesquioxides.

DIVISION OF LEACHED SOILS

Leached soils are characterised by an absence of free lime and by an acid reaction in their A and B horizons. Their lower horizons may show some gleying expressed as mottling.

Major Soil Group: Brown Earths

Brown earths have an A horizon, a uniformly coloured B horizon and a moderately acid reaction. Ideally each horizon merges into the one below.

Subgroup: Peaty Brown Soils

The peaty brown soils have an H or Ah but otherwise the characteristic features of the peaty brown soils are identical to those of the major soil group. There is no morphological evidence of translocated sesquioxides.

Major Soil Group: Podzols

Podzols have an H or O horizon, an E horizon and a strongly acid reaction. There is usually morphological and chemical evidence of translocation of sesquioxides.

Subgroup: Humus-iron Podzols

The humus-iron podzols have an H surface horizon. Below the E horizon there is a dark Bh horizon. The Bs horizon is more brightly coloured than the BC horizon.

Subgroup: Podzols (Cultivated)

The subgroup contains soils reclaimed from peaty podzols. An Ap horizon replaces the O and A horizons. An iron pan (Bf), or trace of one, is sometimes present. A Bx horizon is common.

Subgroup: Alpine Podzols

The alpine podzols have an HA surface horizon up to 10 centimetres thick. An Ah horizon overlies relatively unweathered parent material.

Subgroup: Peaty Podzols

The peaty podzols have an O horizon up to 50 centimetres thick. The E horizon is generally gleyed and stained with organic matter. The Bf horizon, a thin iron pan, is often continuous and usually impermeable to water and roots. The Bs horizon is brightly coloured, while the Bx horizon is paler; some gleying may be present in these horizons. If the Eg horizon is strongly developed, the soils are sometimes termed peaty gleyed podsols.

DIVISION OF GLEYS

Gleys are mineral or peaty soils which have developed under conditions of intermittent or permanent water-logging. Often prominent in uncultivated soils is a pale-coloured eluviated and gleyed Eg horizon beneath which the horizons are grey with a greenish or bluish tinge with ochreous mottling. These colours are secondary and mask the colour inherited from the parent material.

Major Soil Group: Surface-water Gleys

Surface-water gleys are soils which exhibit strongly gleyed surface horizons, the intensity of gleying diminishing with depth. The soil colour inherited from the parent material is more apparent in the Bg and Cg horizons,

Subgroup: Noncalcareous Gleys

The noncalcareous gleys have no free calcium carbonate in the upper horizons of the profile and there is little or no development of an O layer.

Subgroup: Saline Gleys

The saline gleys have a thin O horizon up to 10 centimetres thick or an Ah horizon. The Eg and Bg horizons usually have a strong columnar structure but can be massive; the Cg horizon is generally massive. The soils have very high sodium contents throughout.

Subgroup: Peaty Gleys

The peaty gleys have no free calcium carbonate in the upper horizons of the profile and there is an O horizon up to 50 centimetres thick. The Eg horizon is prominent and stained with organic matter.

Major Soil Group: Ground-Water Gleys

Ground-water gleys are soils which have developed under the influence of a high ground-water table. In these soils the effect of gleying increases with depth.

Subgroup: Calcareous Gleys

The calcareous gleys contain free calcium carbonate throughout the profile.

Subgroup: Noncalcareous Gleys

The noncalcareous gleys have no free calcium carbonate in the upper horizons of the profile and there is little or no development of an O layer although an Ah horizon is usually present.

Organic Soils

Organic soils are formed under waterlogged conditions and contain very high amounts of organic matter down to an arbitrary specified depth. Peat is an organic soil which contains more than 60 percent organic matter and, in this area, exceeds 50 centimetres in thickness.

Blanket Peat

Blanket peat is associated with areas of moderate to high rainfall, low mean annual temperature and high relative humidity. There is little variation in the botanical composition of the peat with depth.

Basin and Valley Peat

Basin and valley peat develops initially under the influence of ground-water in depressions or badly drained basins and channels. It shows a vegetation sequence which reflects the changing environmental conditions under which the deposit formed. The deposits are commonly underlain by marl.

Table 10. Classification of Soil Series

Division	Major Soil Group	Major Soil Subgroup	Soil Series
Immature Soils	Lithosols	Undifferentiated	Thurso Skeletal, Dunnet Skeletal, Fraserburgh Skeletal
	Regosols	Noncalcareous regosols	Dornoch, Eigie, Morrich
	Alluvial soils	Mineral alluvial soils	Innes, Lochside, Undiff alluvium
		Saline alluvial soils	Saltings
		Peaty alluvial soils	Peat-alluvium
Non-Leached	Calcareous soils	Brown calcareous soils	Fraserburgh
Leached	Brown earths	Peaty brown soils	Tomtain
	Podzols	Podzols (cultivated)	Bilbster, Ocklester
		Humus-iron podzols	Boyndie
		Peaty podzols	Camster, Dunnet, Flaughton, Millfield, Rackwick, Stromness, Warth
		Alpine podzols	Knitchen, Trowieglen
Gleys	Surface-water gleys	Saline gleys	Fletts, Gessan, Mousland
		Noncalcareous gleys	Midgarth, Ness, Thurso, Tresdale
		Peaty gleys	Canisbay, Dalespot, Lynedardy, Olrig
	Ground-water gleys	Calcareous gleys	Whitelinks
		Noncalcareous gleys	Gaira, Hunster

In Orkney field mapping was done largely with aerial photographs (1:10,000, 1:7,500 and 1:25,000 scales), the soil boundaries being transferred to Ordnance Survey maps at 1:10,000, 1:10,560 and 1:25,000 - as they were, or became, available, from which the published maps (1:50,000) were compiled. The smallest area that can be shown on the 1:50,000 scale is approximately 2.5 hectares.

5. Soils

Introduction

The soil map of the area represents a total land area of 975 square kilometres. Of this 67 percent has been mapped as soil series, 15 percent as soil complexes, 15 percent as organic soils and the remainder comprising alluvial soil (1 percent), miscellaneous soils including hill dunes, alluvial fans, saltings and mixed bottom land (<1 percent) and non-soil, i.e. built-up areas, disturbed ground and quarries (1 percent). The extent of the individual mapping units is shown in Table 11.

Twenty-eight soil series, excluding the alluvial soils, have been mapped of which fifteen are new series and. the remainder are series established during previous surveys in other parts of Scotland. Fourteen soil complexes, four of which have been described previously, have been mapped. The soil series and soil complexes are grouped into ten soil associations, four being described for the first time in a memoir. Shallow phases of some of the soil series in the Thurso Association have been established on the basis of depth to bedrock, and a deep-topped phase of one soil series, the Bilbster, has been separated according to the thickness of the Ap horizon. A cut-over phase and an eroded phase have been assigned to the organic soils.

The Tresdale Series (17.5 percent) is the most extensive soil series, followed by the Bilbster Series (17 percent) and the Thurso Series (9 percent).

The Thurso Association accounts for 46 percent of the area and the Canisbay Association for 25 percent; the Dunnet Association covers 6 percent of the area and the Fraserburgh Association, 5 percent. The Orkney landscape is thus dominated by the Thurso, Canisbay, Dunnet and Fraserburgh Associations and peat.

The most extensive major soil subgroup is the noncalcareous gleys with a total of 26 percent of the area, followed by the podzols at 19 percent. The peaty podzols amount to 8 percent, peaty gleys to 6 percent and calcareous gleys to 1 percent of the area. The saline gleys account for 2 percent and poorly drained alluvial and links soils for 1 percent. The least extensive major soil subgroup is the peaty brown soils with an area of less than one square kilometre. The above figures do not include the soil series present in the soil complexes.

In the following chapter the associations and their constituent soils, including complexes, are described. The associations are considered alphabetically.

The links soils, alluvium and miscellaneous soils are discussed at the end of the chapter and mention is made of the organic soils and their distribution.

Table 11. Areas of Mapping Units

AREAS OF SOIL SERIES (SQ KM)

ASSOCIATION	Brown Calcareous Soils	Peaty Brown Soils	Podzols		Alpine Podzols	Peaty Podzols	Calcareous & Noncalcareous Gleys	Saline Gleys	Peaty Gleys	Noncalcareous Gleys	Peaty Gleys	Soil Complexes	Skeletal Soils
SERIES													
	Freely Drained	Freely Drained	Freely Drained	Imperfectly Drained	Freely Drained	Freely Drained or Imperfectly Drained below thin iron pan	Poorly Drained	Poorly Drained	Poorly Drained	Very Poorly Drained	Very Poorly Drained		
STROMNESS (1)						Stromness (<1)						Groval (1)	
LYNEDARDY (3)						Millfield (<1)	Midgarth (<1)	Fletts (<1)	Lynedardy (1)				
THURSO (444)			Bilbster (shallow phase) (38)		Knitchen (<1)	Camster (shallow phase) (4)	Thurso (84)		Olrig (shallow phase) (5)	Hunster (1)		Sordale (31)	Un-named THz (<1)
			Bilbster (121)			Camster (20)	Ness (1)	Mousland (17)	Olrig (30)			Ulbster (16)	
			Bilbster (deep-topped phase) (6)									Ulbster (Canisbay variant) (14)	
												Frotoft (15)	
												Frotoft (Canisbay variant) (2)	
												Warehouse (1)	
												Eskishold (16)	
												Huntis (18)	
												Aglath (4)	
CANISBAY (247)			Ocklester (25)			Warth (25)	Tresdale (171)	Gessan (6)	Canisbay (18)	Gaira (1)	Dalespot (1)		
FLAUGHTON (2)						Flaughton (2)							

AREAS OF SOIL SERIES (SQ KM)													
	Brown Calcareous Soils	Peaty Brown Soils	Podzols	Alpine Podzols	Peaty Podzols	Calcareous & Noncalcareous Gleys	Saline Gleys	Peaty Gleys	Noncalcareous Gleys	Peaty Gleys		Soil Complexes	Skeletal Soils
	SERIES												
ASSOCIATION	Freely Drained	Freely Drained	Freely Drained	Imperfectly Drained	Freely Drained	Freely Drained or Imperfectly Drained below thin iron pan	Poorly Drained	Poorly Drained	Poorly Drained	Very Poorly Drained	Very Poorly Drained		
DARLEITH (<1)		Tomtain (<1)											
DUNNET (61)					Trowieglen (8)	Dunnet (28)						Cuilags (15)	Un-named DZz (3)
												Scarsa (5)	
												Whitefowl Hill (1)	
												Vow Randie (1)	
RACKWICK (2)						Rackwick (1)						Ford of Hoy (1)	
BOYNDIE (<1)			Boyndie (<1)										
FRASERBURGH (44)	Fraserburgh (24)						Whitelinks (10)					Heilin (2)	Un-named FRz (8)
805	**24**	**<1**	**190**		**8**	**81**	**266**	**24**	**54**	**2**	**1**	**143**	**12**

ALLUVIAL SOILS						LINKS SOILS			ORGANIC SOILS	
	Poorly Drained	Very Poorly Drained	Undiff	TOTAL		Freely Drained	<1		Blanket Peat (50-100 cm)	67
Sandy		Innes (<1)				Imperfectly Drained	<1		Blanket Peat (>100 cm)	52
Loamy	Lochside (1)					Poorly Drained	2		Undifferentiated	6
Peaty			PAL (5)			**TOTAL**	**3**		Basin & Valley Peat	18
Undifferentiated			AL (4)						**TOTAL**	**143**
TOTAL	**2**	**<1**	**9**	**11**		MISCELLANEOUS SOILS				
						Hill Dunes	<1		Built-up areas, Disturbed ground, Airports & Quarries	10
						Alluvial Fans	1		**TOTAL**	**10**
						Saltings	1			
						Mixed Bottom Land	<1		Lochs	33
TOTAL LAND AREA		**975**				**TOTAL**	**3**			

Soil Associations

Boyndie Association

The Boyndie Association, described initially in Banffshire (Glentworth, 1954), consists of soils developed on fluvioglacial sands. The association is not extensive, covering less than one square kilometre, and its distribution extremely local. The parent material is a reddish yellow or brown sand of indeterminable origin; stones are few, small and principally derived from rocks of Middle Old Red Sandstone.

One soil series, the Boyndie Series, a humus-iron podzol, has been mapped.

Boyndie Series

Boyndie Series occurs on a sequence of small, isolated, gentle or moderately sloped mounds extending north-westwards from Stromness along the Innertown to Outertown road. The soils are all cultivated, a typical soil profile being described below.

Profile Description

Slope : Moderate
Vegetation: Arable crop or ley
Drainage Class: Free

Horizon	Depth (cm)	
Ap	0-20 cm	Very dark greyish brown (10YR3/2) sand, weak medium subangular blocky; friable; moist; no mottles; moderate organic matter; frequent roots; few small stones but many bleached sand grains. Clear change into
E	20-25	Brown (10YR5/3) sand; weak fine subangular blocky or single grain; friable or loose; moist; no mottles; low organic matter; frequent roots; no stones. Clear change into
B	25-50	Dark reddish brown (5YR3/2) with black (5YR2/1) sand; moderate medium subangular blocky; friable; but firm and cemented in patches; moist; no mottles; moderate organic matter; few roots; no stones. Clear change into
BC	50-110+	Reddish yellow (7.5YR6/6) with brown (7.5YR5/4) and strong brown (7.5YR5/8) sand; weak fine subangular blocky or single grain; friable or loose; moist; no organic matter; no roots; no stones.

In some instances the E horizon is absent, apparently incorporated within the Ap horizon, and the B horizon is much reduced in thickness. The soils on gently sloping ground sometimes show mottling in the BC horizon.

The Canisbay Association

The soils of the Canisbay Association, first described in north-east Caithness (Futty and Dry, 1977), are developed on reddish brown, occasionally red, till derived from strata of the Stromness Flags, Rousay Flags and the Eday Beds of the Middle Old Red Sandstone. The Canisbay Association dominates the landscape of the East Mainland, South Ronaldsay, Shapinsay and Stronsay but occurs throughout the archipelago. Its distribution on the West Mainland is limited to a narrow coastal zone fringing Scapa Flow. The association is the second most extensive in the islands and. covers 247 square kilometres.

The texture of the till is usually sandy clay loam, although clay loam and, to a lesser extent, sandy loam textures occur locally. The colour has usually a 2.5YR hue. The stone fraction of the till, particularly in the gley soils, is often strongly weathered. The weathered sandstones and flagstones tend to break down under laboratory preparation and laboratory textures sometimes differ markedly from field textures, the proportions of the sand and silt fractions being increased.

Till cover rarely exceeds 120 centimetres in thickness and bed rock is usually encountered within profile depth. Deep till, with thickness ranging from approximately 3 metres to 10 metres, forms the cliffs of many bays and minor inlets within the island group. These deep-till sections are calcareous at depth and contain usually fragmented, smoothed and striated marine shells (Peach and Horne, 1880). The upper part of the till in which the soil profiles are developed is invariably leached and does not contain shell fragments. A number of profiles are found to be caloareous at a minimum depth of 120 to 140 centimetres.

The soils of the association occur under a mean annual rainfall of about 900 millimetres. Seven soil series have been identified within the association: Ocklester Series (podzols), Warth Series (peaty podzols), Tresdale and Gaira Series (noncalcareous gleys), Gessan Series (saline gleys) and Canisbay and Dalespot Series (peaty gleys).

Ocklester Series

The Ocklester Series results from the continued cultivation of peaty podzols, the intensity of cultivation being such that most of the evidence of their former nature has been destroyed. The usual presence of an indurated Bx horizon, sometimes with a thin iron pan marking its upper surface, is generally the only remaining physical feature linking these soils to the peaty podzols. The thin iron pan when present is seldom continuous, having been disrupted by cultivation. Often it is destroyed completely and incorporated into the Ap horizon where identifiable fragments are sometimes seen.

The Ocklester Series is distributed widely throughout the association and totals 25 square kilometres. The soil is a major component of' the Canisbay variant of the Ulbster Complex as found on North Ronaldsay.

The parent material is a reddish brown till of sandy loam or occasionally loam texture. The soil is generally thin and occurs on gentle or moderate slopes. Bedrock is often encountered within profile depth. The drainage class of the soils is free or imperfect and it can vary over short distances. Thus, no attempt has been made to effect a series separation based on drainage and the soils of both drainage classes are considered as forming one soil series.

Profile Description

Slope:	Moderate
Vegetation:	Arable crop or ley
Drainage Class	Free

Horizon	Depth (cm)	
Ap	0-25	Dark greyish brown (10YR4/2) sandy loam; moderate medium subangular blocky; firm or friable; moist; no mottles; moderate organic matter; frequent fine roots; frequent small stones. Sharp change into
Bf	25	Thin iron pan
Bx	25-55	Reddish beown (2.5YR4/4) sandy loam with few fine distinct yellowish red (5YR5/8) mottles and few medium patches of manganiferous staining; moderate medium platy; very firm; strong induration; moist; low organic matter; few fine roots; frequent subangular and tabular stones. Clear change into
BC(x)	55-80	Reddish brown (5YR4/4) loam; massive or weak medium platy; firm; weak induration; moist; no organic matter; no roots; many subangular and tabular stones. Sharp change into
R	80+	Shattered flagstone.

The Ap horizon sometimes has a higher percentage of organic matter and. a dark grey or black colour. Fine ochreous mottling is sometimes apparent. Some profiles have an E(g) horizon consisting of a few centimetres of brown, mottled and organic stained sandy loam between the Ap and Bx horizon. Characteristic features of the Bx horizon are platy structure with reddish iron staining or black manganiferous staining sometimes occurring on the faces of the plates, fine pores and fine sand or silt linings to stone cavities. The degree of induration decreases with depth, and at the base of the horizon induration is usually only weakly .developed. Ochreous mottling within the peds is sometimes present. TheBC(x) horizon is similar in colour to the Bx but induration is less pronounced. In the more stony parent materials the BC(x) horizon is massive with a tendency for the stones to be orientated parallel to the ground surface. The contact between the drift and the bed-rock is usually sharply defined; the rock is generally hard, although occasionally it is soft and weathered in the upper few centimetres.

Warth Series

The Warth Series consists of peaty podzols. The series is distributed widely throughout the association and totals 25 square kilometres.

The parent material is a reddish brown till of sandy loam texture. The soils occur on moderate, moderately steep or steep slopes under moist Atlantic heather moor. On the more exposed sites the vegetation cover is often stunted and broken. Drainage below the thin iron pan is generally imperfect, while above the pan it is poor.

Profile Description

Slope:	Moderate
Vegetation:	Moist Atlantic heather moor
Drainage Class	Imperfect below iron pan

Horizon	Depth (cm)	
L and F	trace	*Calluna* and moss remains
O	0-12	Black (5YR2/1) slightly humified fibrous peaty humus; firm; moist; many roots. Sharp change into
Ah	22-21	Black (5YR2/1) loamy sand with dark reddish brown (5YR2/2) patches; weak medium subangular blocky; firm; moist; high organic matter; frequent fine roots; frequent bleached sand grains. Sharp change into
Eg	21-34	Light brownish grey (10YR6/2) sandy loam with few medium distinct dark brown (7.5YR4/2) patches of organic staining; weak medium subangular blocky; friable or firm; moist; low organic matter; few roots; few small stones. Sharp change into
Bf	34	Thin iron pan with root mat
B(g)	34-57	Reddish brown (2.5YR5/4) sandy loam with frequent fine distinct strong brown (7.5YR5/8) mottles and pinkish grey (5YR6/2) gley streaks; weak medium subangular blocky; firm; moist; no organic matter; few fine roots; frequent stones predominantly sandstone and flagstone, many weathered. Clear change into
C(g)	57-112+	Reddish brown (2.5YR5/4) sandy loam with few fine distinct strong brown (7.5YR5/8) mottles and black manganiferous streaks; massive; very firm; moist; no organic matter; no roots; frequent stones mainly of sandstone and up to boulder size.

Profiles of the Warth Series are typical of peaty podzols, except that they have mottled B(g) horizons. The Eg horizon is usually relatively thin but in rare cases its thickness can be as much as 45 centimetres. The texture of the parent material is varied, with sandy loam dominating but sandy clay loam common and clay loam rare. A strongly indurated Bx horizon so characteristic of most other peaty podzols in the area is not a common feature of the series but it is found in those soils developed on the more coarse-textured parent materials. In such soils the drainage below the thin iron pan tends to be free rather than imperfect.

Tresdale Series

The Tresdale Series, consisting of poorly drained noncalcareous gleys, is the dominant series covering 171 square kilometres of the association. The parent material is a reddish brown, or occasionally red, till of sandy clay loam or clay loam texture, and the soils occur on gentle slopes.

Profile Description

Slope:	Gentle
Vegetation:	Arable crop or ley
Drainage Class	Poor

Horizon	Depth (cm)	
Ap(g)	0-25	Dark greyish brown (10YR4/2) loam with few fine distinct dark reddish brown (2.5YR3/4) mottles; moderate medium subangular blocky; friable or firm; moist; moderate organic matter; frequent roots; few small stones. Sharp change into
Bg1	25-42	Reddish brown (2.5YR5/4) sandy clay loam with frequent medium distinct strong brown (7.5YR5/8) mottles and coarse pinkish grey (5YR6/2) patches; greyish brown (10YR5/2) sandy coatings on ped faces; moderate coarse prismatic; firm; moist; no organic matter; few fine roots; frequent stones of sandstone and flagstone, many strong weathered. Clear change into
Bg2	42—85	Reddish brown (2.5YR5/4) sandy clay loam or clay loam. Similar to horizon above, but massive and no roots.
C(g)	85—110+	Reddish brown (2.5YR5/4) sandy clay loam or clay loam with few fine distinct yellowish red (5YR5/8) mottles. Similar to horizon above.

The Ap(g) horizons of some profiles have silty loams textures. The Bg1 horizon is usually reddish brown with mottles of high chroma and coarse greyish patches, but in some profiles gleying is more intense and a greyish brown or olive-grey Bg1 horizon is present. In a number of profiles the Bg1 and Bg2 horizons have a medium subangular blocky structure.

There can be little doubt that most soils of the Tresdale Series result from the long cultivation of peaty gley soils and many soils still possess relics of their natural state. The Ap(g) horizon has a high organic matter content and a very dark grey colour, and often a brown AB horizon enriched with organic matter is found between the Ap(g) and Bg1 horizon.

At the junction of the till with bed-rock there is little sign of weathering and the transition is usually sharp. In some cases the base of the till has been worked by water moving along the interface of till and rock, a process which has removed finer material from the till and has left behind a narrow zone of sandy loam material.

Gaira Series

The Gaira Series is the very poorly drained noncalcareous ground-water gley occurring in flush sites. The series is not extensive, covering 1 square kilometre, and has a localised distribution.

Profile Description

Slope:	Level or gentle
Vegetation:	Marsh marigold meadow or bog moss water track
Drainage Class:	Very poor

Horizon	Depth (cm)	
Ah	0-20	Dark grey (10YR4/1) humose sandy loam; weak medium subangular blocky; slightly plastic; wet; high organic matter; many roots; no stones. Sharp change into
Bg	20-50	Light reddish brown (5YR6/3) clay loam with many coarse distinct yellowish brown (10YR5/6) and prominent light olive brown (2.5Y5/4) mottles, many coarse light grey (10YR7/1) patches; massive; plastic; moist becoming wet; no organic matter; frequent roots; frequent stones, mostly strongly weathered. Clear change into
Cg	50-70	Light greenish grey (5GY7/1) loam or silt loam with frequent coarse distinct olive yellow (2.5Y6/6), few medium reddish brown (5YR5/4) patches; massive; plastic; moist becoming wet; no organic matter; no roots; frequent stones, mostly strongly weathered. Sharp change into
R	70+	Weathered flagstone.

Gessan Series

The Gessan Series comprises poorly drained saline gleys. The series occurs along the eastern seaboard of the archipelago from Stroma to Stronsay and covers 6 square kilometres. The soils are developed on gentle or moderate slopes on a clay loam or silt loam parent material. The soils are strongly influenced by salt-spray and sea-gusting.

Profile Description

Slope:	Gentle
Vegetation:	Sea plantain-crowberry heath or maritime grassland
Drainage Class:	Poor

Horizon	Depth (cm)	
FH	0-3	Dark brown (10YR3/3) slightly humified fibrous peaty humus; firm; moist; many roots; no stones but frequent bleached sand grains. Sharp change into
Ah	3-11	Dark greyish brown (10YR4/2) humose sandy loam;

		moderate medium subangular blocky; friable or firm; moist; moderste organic matter; many roots; no stones but frequent bleached sand grains. Sharp change into
Eg	11-38	Grey (10YR5/1) silt loam or silty clay loam wirg frequent medium distinct dark reddish brown (5YR3/2) patches of organic staining, the trans located organic matter similarly staining ped faces; moderate coarse prismatic or columnar; firm; moist, moderate or low organic matter; few roots; few stones. Clear change into
Bg	38-58	Weak red (2.5YR5/2) clay loam with frequent medium and coarse distinct yellowish brown (10YR5/4) mottles and grey (10YR5/1) patches; dark reddish brown (5YR3/2) staining on ped faces; moderate coarse prismatic; firm; moist; low organic matter; few roots; frequent stones mostly weathered. Merging change into
BCg	58-73	Similar to horizon above but massive; no organic matter; no roots. Sharp change into
R	73+	Flagstone rock

Occasionally the FH horizon of the described profile is replaced by a dark reddish brown O horizon, rarely exceeding 15 centimetres in thickness. A feature of the soils is the coarse prismatic structure of the Eg and Bg horizons, the structure units being vividly expressed by translocated organic matter staining the ped faces; in some profiles the structure of these horizons is massive. The parent material is strongly weathered and leached and such is the gleying that much of the reddish brown colour of the parent material is lost,

Canisbay Series

The Canisbay Series consists of poorly drained peaty gleys. It is of a limited extent, covering 18 square kilometres and is being further reduced by reclamation. The soils, which are developed on a reddish brown till of generally sandy clay loam texture, occur on gentle or moderate slopes.

Profile Description

Slope:	Gentle
Vegetation:	Moist Atlantic heather moor
Drainage Class:	Poor

Horizon	Depth (cm)	
L and F	Trace	*Calluna* and moss remains
O1	0-15	Dark reddish brown (5YR2/2) slightly humified fibrous peaty humus; strong vertical cracks; firm; many roots, particularly in cracks. Clear change into
O2	15-40	Black (10YR2/1) medium humified amorphous peaty humus; plastic; frequent roots. Sharp change into
Eg	40-58	Greyish brown (10YR5/2) sandy loam with very dark

		brown (10YR2/2) staining; moderate medium subangular blocky; firm; moist; moderate organic matter; frequent roots; few stones. Cear change into
Bg	58-90	Weak red (2.5YR5/2) sandy clay loam with frequent medium prominent yellowish red (5YR5/8) mottles and pinkish grey (7.5YR6/2) patches; massive; firm; moist; no organic matter; few roots; frequent stones of sandstone and flagstone, mostly weathered. Clear change into
C(g)	90-140+	Reddish brown (2.5YR5/4) sandy clay loam with few fine distinct yellowish red (5YR4/8) mottles and few fine pinkish grey (7.5YR6/2) patches, many fine black manganiferous streaks; massive; firm; moist; no organic, matter; no roots; frequent stones of sandstone and flagstone.

The colour of the Eg horizon is related to the amount of organic matter present and varies from very dark brown in the upper few centimetres immediately below the peat, to greyish brown in the lower part of the horizon; occasionally the dark brown organic staining occurs uniformly throughout. The degree of gleying in the Bg horizon is quite variable and often grey colours dominate; the colour of the parent material being weakly expressed. The structure of the Bg horizon is generally massive or weak subangular blocky but moderate prismatic structures sometimes occur. The texture of the C(g) horizon varies from sandy loam to clay loam and is related to the state of weathering of the stones and to the proportion of weathered sandstones in particular.

Dalespot Series

The Dalespot Series comprises very poorly drained peaty gleys and is often closely associated with peat. The soils are of minor extent covering 1 square kilometre. The soils occur on level or gentle slopes. The parent material is a reddish brown till of sandy clay loam texture.

Profile Description

Slope:	Level
Vegetation:	Moist Atlantic heather moor
Drainage Class:	Very poor

Horizon	Depth (cm)	
L and F	Trace	*Calluna* and moss remains
O1	0-20	Dark reddish brown (5YR3/2) slightly humified fibrous peaty humus; firm; strong vertical cracks; firm; many roots particularly in cracks. Clear change into
O2	20-40	Dark reddish brown (5YR2/2) medium humified amorphous peaty humus; plastic; wet; frequent roots. Sharp change into
Eg	40-60	Brown (10YR5/3) loam with dark been (7.5YR3/2)

		and very dark brown (10YR2/2) staining in the upper part of horizon; moderate medium subangular blocky; firm; moist; moderate organic matter; frequent roots; few stones. Clear change into
Bg	60-90	Greenish grey (5GY6/1) sandy clay loam with few medium prominent pinkish grey (7.5YR7/2) patches and few fine distinct greyish brown (2.5Y5/2.) mottles; few fine prominent dark brown (7.5YR3/2) organic streaks; strong coarse prismatic; firm, becoming plastic; moist, becoming wet; no organic matter; few roots; many roots along ped faces; few stones, mostly weathered. Clear change into
BCg	90-120	Reddish brown (5YR5/4) sandy clay loam with frequent fine distinct pinkish grey (7.5YR7/2) streaks; massive; firm; moist; no organic matter; no roots; frequent stones, mostly weathered. Clear change into
C(g)	120-145+	Reddish brown (2.5YR5/4) sandy clay loam. Similar to horizon but less gleyed.

The structure of the Bg horizon is usually prismatic but may be massive and the horizon is often wet, plastic and sticky. The stones are mainly sandstone and flagstone and in the Bg and BCg horizons, are strongly weathered and break down readily.

Ulbster Complex (Canisbay variant)

The Canisbay variant of the Ulbster Complex has been mapped onNorth Ronaldsay, Shapinsay and South Ronaldsay, and covers 14 square kilometres.

The unit is a complex of mineral soils on a low moundy or ridged, rock-controlled landscape. The constituent soils are:

1) Bilbster Series (shallow phase)
2) Ocklester Series
3) Tresdale and/or Canisbay Series
4) Soils developed on colluvium

Rock outcrops are a minor constituent of the complex.

The soils on the ridge-tops are usually the Bilbster Series and those of the Ocklester Series occur on the flanks: on subdued mounds the Bilbster Series may not be present. The hollows between mounds or the flats between ridges have soils of the Tresdale or Canisbay Series while colluvium and till fill the deeper hollows.

The composition of the complex varies according to differences in landform. The area of the complex on South Ronaldsay is dominated by the poorly drained soils, the rock ridges being narrow relatively well separated, whereas on Shapinsay and

North Ronaldsay the mosaic of mound and hollow is much more intimate and the freely or imperfectly drained soils predominate.

Frotoft Complex (Canisbay variant)

This complex is of minor extent (2 square kilometres) and is mapped on Fitty Hill in Westray and on Mull Head in Papa Westray. The complex consists of mineral and/or peaty soils on stepped topography, the constituent soil being:

1) Bilbster and/or Camster (Thurso Association) Series (shallow phases)
2) Tresdale and/or Canisbay Series
3) Soils developed on colluvium
4) Peat

Rock outcrops form a notable part of the complex.

The topography is markedly stepped with significant risers and treads; the overall slope is steep or very steep. The Bilbster and Camster Series are generally together on the risers, the peaty surface horizons of the Camster Series being thin and not well developed. The risers are often precipitous and craggy, offering little scope for soil profile development. The poorly drained Tresdale and Canisbay Series occupy the treads. Thin peat is encountered only rarely in the complex.

The Darleith Association

The Darleith Association was first described by Mitchell and Jarvis (1956) in north Ayrshire and mapped subsequently in the Midland Valley and on the west coast of Scotland. In Orkney it is of minor extent, amounting to less than one square kilometre in north Hoy. The soils are developed on brown drift derived from basic lavas and. Intrusions, and have formed under a mean annual rainfall of approximately 1000 millimetres. The soils are mapped at Rackwick, where they are related to a lava outcrop, and on isolated volcanic necks around The Witter.

There is only one series, the Tomtain Series.

Tomtain Series

This series is a peaty brown soil and it has been mapped on steep or very steep slopes.

Profile Description

Slope:	Steep
Vegetation:	Herb-rich Atlantic heather moor
Drainage Class:	Free

Horizon	Depth (cm)	
L and F	Trace	*Calluna* and moss remains.
A	0-15	Very dark grey (10YR3/1) humose sandy loam;

		strong medium and fine subangular blocky; friable; moist; no mottles; very high organic matter; many roots; frequent small stones. Sharp change into
B	15-40	Dark reddish brown (5YR3/2) sandy loam; strong medium subangular blocky; friable; moist; no mottles; low organic matter; frequent roots; frequent small and medium stones dominantly basic igneous rocks. Clear change into
BC	40-80	Brown (75YR4/4) sandy loam; moderate medium subangular blocky; friable; moist; no mottles; no organic matter; few roots; many large stones of basaltic igneous rock. Clear change into
R	80+	Shattered rock with brown (7.5YR4/4) interstitial material.

The lava flows often weather to give a weak red gritty sandy loam parent material and in such instances the soil generally has a red hue throughout.

The Dunnet Association

Soils of the Dunnet Association have been previously mapped on the Dunnet Head peninsula in Caithness (Futty and Dry, 1977) on sandstones of the Upper Old Red Sandstone. In Orimey the association is confined to Hoy where it covers 61 square kilometres. The soils are developed generally on a brownish yellow, yellow or reddish yellow loamy sand drift under a mean annual rainfall of approximately 1000 to 1100 millimetres.

Two soil series have been identified; the Trowieglen Series (alpine podzols) and the Dunnet Series (peaty podzols).

Trowieglen Series

The Trowieglen Series occurs on the plateau summits of the higher hills of Hoy such as Ward Hill Knap of Trowieglen, and on moderate slopes to levels of between 280 metres and 300 metres. The soils cover 8 square kilometres.

Profile Description

Slope:	Gentle or moderate
Vegetation:	Mountain azalea-lichen heath
Drainage Class:	Free or moderately well-drained

Horizon	Depth (cm)	
HA	0-8	Very dark grey (10YR3/1) humose loamy sand; weak medium subangular blocky; friable; moist; no mottles; very high organic matter; frequent roots frequent medium and large subangular sandstone stones. Sharp change into
A	8-25	Brown (10YR5/3) loamy sand with dark brown

		(7.5YR4/3) staining; weak medium subangular blocky; friable; moist; no mottles; low organic matter; frequent roots; few with depth; few small subangular sandstone stones. Clear change into
B	25-65	Strong brown (7.5YR5/6) loamy sand; weak medium subangular blocky; friable; moist; no mottles; no organic matter; few roots; few small subangular stones of sandstone, many weathered. Clear change into
B(g)	65-35	Brownish yellow (10YR6/6) sandy loam with frequent medium faint very pale brown (10YR7/4) patches; weak medium subangular blocky; firm and friable; moist; no organic matter; no roots; frequent medium and large subangular sandstone stones, many weathered. Clear change into
C(g)	85-110+	Brownish yellow (10YR6/6) loamy sand with yellow (10YR5/6) and few medium faint very pale brown (10YR7/4) patches. Similar to horizon above.

The vegetation cover is patchy with much of the ground bare. It is sometimes possible to subdivide the A horizon on the basis of an apparent increase in percentage organic matter in the lower part of the horizon, but the readily identifiable AB horizon of most alpine podzols does not usually appear in these soils. The A horizon shows a change in colour from brown to dark brown with depth, but laboratory figures fail to indicate a significant increase in the percentage of organic matter. The B(g) horizon contains pockets of sandy clay loam which cause some drainage impedance. The material below the A horizon shows generally little differentiation. Stones become more frequent with death and often show coatings of fine sand. on their upper surfaces, the lower surfaces remaining clean.

Although the parent material is usually brownish yellow or yellow, light reddish brown and reddish yellow parent materials do occur.

Dunnet Series

The Dunnet Series is found on moderately steep and steep slopes and on mounds in areas of humrnocky moraine. The soils cover 2 kilometres.

Profile Description

Slope:	Moderately steep
Vegetation:	Moist Atlantic heather moor
Drainage Class:	Free below iron pan

Horizon	Depth (cm)	
L and F	Trace	*Calluna* and moss remains.
O1	0-10	Dark reddish brown (5YR3/2) slightly humified fibrous peaty humus; strong vertical cracks; firm: many roots, particularly in cracks; frequent bleached sand grains. Clear change into

O2	10-30	Black (10YR2/1) medium humified amorphous peaty humus; strong vertical cracks; firm; many roots particularly in cracks; few bleached sand grains. Sharp change into
Eg	30-50	Pale brown (10YR6/3) sand with brown (10YR5/3) patches; weak medium subangular blocky; friable; moist; no mottles; low organic matter; frequent roots; frequent small stones. Clear change into
Bh	50-65	Dark brown (10YR4/3) loamy sand with black (5YR2/1) staining; weak medium platy; firm; partially weakly cemented; moist; no mottles; moderate organic matter; few roots; frequent sandstone stones, mostly weathered. Sharp change into
Bf	65	Thin iron pan with root mat.
Bs	65-75	Reddish yellow (7.5YR6/8) sandy loam; weak medium subangular blocky; friable; moist; no mottles; no organic matter; few roots; frequent sandstone stones, mostly weathered. Clear change into
BC	75-140+	Brownish yellow (10YR6/6) loamy sand or sand with reddish yellow (7.5YR7/6) patches; weak medium subangular blocky; friable; moist; no mottles; no organic matter; no roots; frequent sandstone stones up to boulder size.

The Eg horizon varies from 15 to 30 centimetres in thickness. The horizon is stained with organic matter, the staining being particularly marked in the upper few centimetres immediately below the peaty horizon. The AB horizon varies free platy to angular blocky; the organic matter appears responsible for moderate cementation. The Bf horizon is usually a thin iron pan, often with a narrow zone of intense yellowish red iron staining beneath it, but on occasions the pan appears as a humus-iron pan. The Bs horizon is usually thin and sometimes absent. Although the drainage of the series is almost invariably free, the occasional profile with slight mottling and gleying of the Bs horizon does occur.

Four soil complexes have been established in the Dunnet Association; all are of limited extent confined to north Hoy.

Cuilags Complex

The Cuilags Complex covering 15 square kilometres occupies the very steep slopes of north Hoy. Dunnet Series and flusg colluvial soils are the major soils with subsidiary thin peat, the peat usually contains a high proportion of mineral matter. Rock outcrops or boulders form a minor constituent of the complex,

Scarsa Complex

The Scarsa Complex covering 5 square kilometres is mapped on very stony moderate and steep slopes and on the plateau summits of the lower hills of central Hoy. The principal constituents of the complex are Dunnet Series, podzolic rankers and rock outcrops or boulders.

Whitefowl Hill Complex

The Whitefowl Hill occupying 1 square kilometre, is a complex of Dunnet Series, peat and colluvial soils. It is found on the south-west slopes of Whitefowl Hill and in the valley of the South burn and occurs on moundy morainic deposits.

Vow Randie complex

The Vow Randie complex covering 1 square kilometre is confined exclusively to the plateau summit of Vow Randie. Dunnet Series, thin peat, Trowieglen Series and an undifferentiated gley soil are the constituent soils with rock outcrop or boulders a minor component.
Skeletal Soils

Skeletal Soils

Skeletal soils in the association are not extensive, covering 3 square kilometres. The mapping unit of bare rock or scree with flush colluvial soils in gullies and on stabilized scree occurs on the eastern slopes of Ward Hill, on the crags of Enegars and the Dwarfie Hamars, and on small areas of rock outcrop and scee on the slopes of Moor Fea.

Flaughton Association

The Flaughton Association is not extensive, covering 2 square kilometres, and occurs mainly on Eday with small areas on the West Mainland around Hobbister Hill in Orphir. The soils are developed on a yellow, pink or light reddish brown sand or loamy sand drift derived from sandstones of the Eday Beds of the Middle Old Red Sandstone or on the weathered sandstone rock itself. The soils occur under a mean annual rainfall of approximately 1000 millimetres. One soil series, the Flaughton Series, a peaty podzol, has been mapped.

Flaughton Series

Soils of the Flaughton Series are not cultivated; a typical profile is given below.

Profile Description

Slope:	Moderate or steep
Vegetation:	Moist Atlantic heather moor
Drainage Class:	Free below iron pan

Horizon	Depth (cm)	
L and F	Trace	*Calluna* and moss remains.
O1	0-15	Dark reddish brown (5YR2/2) slightly humified fibrous peaty humus; strong vertical cracks; firm; many roots, particularly in cracks; few bleached sand grains. Clear change into
O2	15-35	Very dark brown (10YR2/2) medium humified amorphous peaty humus; strong vertical cracks; firm; many roots, particularly in cracks. Sharp change into
Eg	35-70	Brown (10YR/3) sandy loam with frequent medium distinct dark reddish brown (5YR3/2 patches; moderate medium subangular blocky; firm or friable; moist; few medium dark yellowish brown (10YR4/4) mottles associated with weathered stones; moderate or low organic matter; frequent roots; few small stones. Sharp change into
Bf	70	Thin iron pan with root mat.
BC	70-90	Yellowish red (5YR5/6) loamy sand with strong brown (7.5YR5/5) patches; weak medium subangular blocky; friable; moist; no mottles; low organic matter; few roots; frequent small sandstone stones, some weathered. Clear change into
C	90-140+	Pink (7.5YR7/4) sand with light reddish brown (5YR6/4) patches; weak medium subangular blocky; friable; moist; no mottles; no organic matter; no roots; frequent sandstone stones, some weathered.

The organic staining in the Eg horizon is more intense in the upper part of the horizon immediately below the H horizon. Occasionally a few very pale brown gley patches and strong brown mottles are noted in the BC and C horizons. The stones in the BC horizon and the smaller stones of the C horizon are often strongly weathered. The soils, particularly in Eday, are developed sometimes on shattered rock with little drift cover. The profile is shallow and the B horizons generally absent. The upper few centimetres of rock is usually stained yellowish red or strong brown. A thin iron pan marks occasionally the upper surface of the hard rock.

Fraserburgh Association

Soils of the Fraserburgh Association, described oridinally in Aberdeenshire (Glentworth and Muir, 1963) are developed on the wind-blown deposits of shelly sand which occur locally around some of the more open shallow bays of the island group. Encroachment of the sand inland is often extensive especially on Sanday and Westray. On Sanday, at Quoy Ness, the deposits have advanced up a moderately steep slope to an elevation of some 50 metres. The association covers 44square kilometres, the greatest expanses being on Sanday, Westray, North

Ronaldsay and Burray. Extensive deposits occur also at the Bay of Skaill, :Birsay Bay, Sandside Bay and Newark Bay.

Deposits are of three major types - high, undulating mobile dunes of the coastal fringe, fixed dunes with a low moundy topography and flat areas of sand. The soils occur under a mean annual rainfall of 900 to 1000 millimetres. The mapping units consist of the Fraserburgh Series (brown calcareous soils), the Whitelinks Series (calcareous gley), the Heilen Complex (a complex of the two series) and skeletal soils.

Fraserburgh Series

The Fraserburgh Series consists of brown calcareous soils. It covers 24 square kilometres and its distribution is the same as for the association as a whole. The soils are developed on low fixed dunes and support a dune pasture vegetation.

Profile Description

Slope:	Gentle or moderate
Vegetation:	Eyebright - red fescue dune grassland, arable crop or ley
Drainage:	Free

Horizon	Depth (cm)	
A	0-15	Very dark greyish brown (10YR3/2) humose sand; weak medium subangular blocky; friable; moist; no mottles; moderate organic matter; many roots; no stones. Sharp change into
B	15-40	Brown (10YR5/3) sand; weak medium subangular blocky or single grain; friable or loose; moist; no mottles; no organic matter; frequent roots; no stones. Clear change into
C	40-100+	Very pale brown (10YR7/3) sand; single grain; loose; moist; no mottles; no organic matter; few roots; no stones.

Throughout the profile the structure, when present, is weak, soil aggregation being dependent on an abundance of extremely fine roots. Some mottling is occasionally seen at depth. Thin dark bands, usually less than one centimetre thick are sometimes present; these contain organic matter and are rudimentary A horizons formed during past periods of stability when a vegetation was briefly established.

Whitelinks Series

The Whitelinks Series comprises calcareous ground-water gleys. It occurs throughout the association on the flat areas of sand and in dune slacks. The series is particularly extensive on Sanday and North Ronaidsay, and has a total area of 10 square kilometres. Vegetation on these soils is generally a pasture extremely rich and varied in species.

Profile Description

Slope:	Level
Vegetation:	Eyebright - red fescue dune grassland, arable crop or ley
Drainage Class:	Poor

Horizon	Depth (cm)	
H	0-5	Very dark brown (10YR2/2); fibrous root mat; moist; many sand grains. Sharp change into
A1	5-20	Dark grey (10YR4/1) sand; weak medium subangular blocky; friable; moist; no mottles; moderate organic matter; many roots; no stones. Sharp change into
Bg	20-40	Pale brown (10YR6/3) sand with frequent coarse distinct strong brown (7.5YR5/8) mottles; weak medium subangular blocky; friable; moist; low organic matter; frequent roots; no stones. Clear change into
Cg1	40-60	Light brownish grey (10YR6/2) sand with frequent coarse distinct strong brown (7.5YR5/8) mottles; weak medium subangular blocky; friable; moist, becoming wet; no organic matter; few roots; no stones. Clear change into
Cg2	60-100+	Grey (5Y5/1) sand; weak medium subangular blocky; friable; wet; no organic matter; few roots; no stones.

The profile morphology of the Whitelinks Series reflects its development under a fluctuating ground-water table. The Bg horizon is somewhat paler than the B horizon of the Fraserburgh Series and has coarse mottles of high chroma; the horizon is occasionally waterlogged. The Cg horizon is greyer than the C horizon of the freely drained soil and contains mottles of high chroma at least in the upper part of the horizon; with depth, the horizon becomes darker, unmottled and permanently waterlogged. Till or peat is often encountered within profile depth. The structure units of the Bg and Cg horizons tend to be more stable than the units of the B and C horizons of the Fraserburgh Series; this is probably a consequence of the wetter state of the gley soils. Occasionally very poorly drained soils are encountered which have profiles waterlogged up to the base of the A horizon for much of the time. In such circumstances the Bg horizon loses its brown colour and its mottles and assumes the greyish colours of the Cg.

Heilen Complex

The Heilen Complex, formerly the Whitelinks Complex (Futty and Dry, 1977) covers 2 square kilometres and is most extensive on Burray Links. It occurs as a complex of mounds and flats.

Skeletal Soils

Skeletal soils covering 8 square kilometres have been mapped on the mobile dunes of the coastal fringes and on strongly eroded areas of blown sand where the vegetation is sparse and very fragmented. The dunes usually support a partial vegetation cover of *Ammophila arenaria* (marram grass).

Profile Description

Slope:	Steep
Vegetation:	Northern marram grass dune
Drainage Class:	Excessive or free

Horizon	Depth (cm)	
A	0-5	Very dark brown (10YR2/2) humose sand; weak fine subangular blocky or single grain; friable or loose; moist; moderate organic matter; many roots; no stones; sharp change into
C	5-100+	Very pale brown (10YR7/3) sand; single grain; loose; moist; no mottles; no organic matter; frequent roots; no stones.

A feature of interest common to a number of areas of the blown sand is cemented blown sand or aeolinate. The material is particularly well exposed on the Evie sands at Aikerness but occurs also at Newark Bay (South Ronaldsay), South Bay (North Ronaldsay) and Mae Sand (Westray). Such material is recorded only rarely in high latitudes. A detailed account of the geography of the beaches, sandy or otherwise, of Orkney is given in Mather, *et al* (1974).

Lynedardy Association

The Lynedardy Association comprises soils developed on a brown or yellowish brown sandy loam drift derived from flagstones and sandstones of Middle Old Rd Sandstone and granitic and schistose rocks of the crystalline basement complex of the Moinian. The association, covering 3 square kilometres, is of local distribution extending north-westwards from Stromness and forming the hinterland of Brinkies Brae. A small area of the association occurs on Graemsay. The soils of the association occur under a mean annual rainfall of 900 to 1000 millimetres. Four soil series, the Millfield Series (peaty podzols; the Midgarth Series (noncalcareous gleys), the Fletts Series (saline gleys) and the Lynedardy Series (peaty gleys) have been mapped within the association. Soils of this association also occur in the Croval Complex.

Millfield Series

The Millfield Series consists of peaty podzols. It is of minor extent covering less than 1 square kilometre and is developed on gentle to moderately steep slopes. Uncultivated soils carry a moist Atlantic heather moor vegetation, but most of the series is cultivated.

Profile Description

Slope:	Moderate	
Vegetation:	Arable crop or ley	
Drainage Class	Free below B1	

Horizon	Depth (cm)	
Ap	0-20	Dark grey (10YR4/l) sandy loam; moderate medium subangular blocky; friable; moist; no mottles; moderate organic matter; frequent roots; frequent small subangular stones of granite and. Sandstone. Sharp change into
Eg	20-35	Grey (10YR5/l) sandy loam with few medium distinct yellowish brown (10YR5/4) mottles; weak medium subangular blocky; firm; moist; low organic matter; few roots; frequent small and medium stones, many of the granitic stones are weathered. Sharp change into
Bf	35	Thin iron pan
Bsx	35-45	Strong brown (7.5YR5/8) gritty sandy loam with yellowish red (5YR4/8) staining; massive; very firm; strong induration; moist; no mottles; no organic matter; no roots; frequent stones. Clear change into
BC	45-85	Brown (7.5YR5/4; sandy loam to sandy clay loam with frequent fine distinct strong brown (7.5YR5/6) mottles and black manganiferous streaks; moderate medium subangular blocky; firm; moist; no organic matter; no roots; frequent graniote and sandstone stones, up to boulder size, some weathered. Sharp change into
R	85+	Granite-schist rock.

The texture of the parent material and the Eg horizon approaches a sandy clay loam, the clay content ranging from 15 to 20 percent. The soil has a gritty texture as a result of the breakdown of the weathered granitic stones. The Bsxm horizon appears as a narrow zone of indurated and strongly cemented material. Some fine mottling appears in the BC horizon. The drift is usually shallow and rock is encountered within profile depth.

Midgarth Series

The Midgarth Series, a noncalcareous gley, occurs on gentle or moderate slopes and is cultivated. The series is not extensive, covering less than one square kilometre.

Profile Description

Slope	Gentle
Vegetation:	Arable crop or ley
Drainage Class:	Poor

Horizon	Depth (cm)	
Ap(g)	0-20	Greyish brown (10YR5/2 loam with few fine distinct reddish brown (5YR4/4) streaks; moderate medium subangular blocky; friable moist; low organic matter; frequent roots; few stones, mainly sandstones but with some granitic stones. Sharp change into
Bg	20-35	Light grey (5Y7/1) sandy loam with frequent medium prominent strong brown (7.5YR5/6) mottles associated with weathered stones; weak medium subangular blocky; firm; moist; no organic matter; few roots; frequent small and medium strongly weathered granite, flagstone and sandstone stones. Clear change into
BCg	36-60	Yellowish brown (10YR5/6); gritty sandy loam with frequent medium distinct strong brown (7.5YR5/6) mottles and light grey patches; weak medium subangular blocky firm; moist; no organic matter; few roots frequent small and medium strongly weathered stones. Clear change into
R	60+	Flagstone rock.

Rock is usually encountered within profile depth.

Fletts Series

Fletts Series consists of saline gleys. It is of very limited extent, covering less than one square kilometre and of local distribution. The soil is influenced strongly by salt-spray and wind and water erosion. The vegetation is maritime heath but the cover is usually broken. Many stones of the crystalline basement complex are exposed on the eroded land surface.

Profile Description

Slope:	Gentle
Vegetation:	Sea plantain crowberry heath
Drainage:	Poor

Horizon	Depth (cm)	
O	0-6	Dark reddish brown (5YR2/2) slightly humified fibrous peaty humus; firm; many roots; no stones. Sharp change into
Eg	6-36	Greyish brown (10YR5/2) silt loam with frequent medium distinct dark reddish brown (5YR3/2) patches of organic staining and black (5YR2/l) organic staining on ped faces;

		strong coarse prismatic; firm; moist; low organic matter; few roots; few small strongly weathered stones. Clear change into
BCg	36-56	Dark grey (10Y4/l) silt loam; massive or weak angular blocky; firm; moist; no organic matter; few roots; few strongly weathered stones. Sharp change into
Rw	56+	Weathered flagstone rock.

Only few small stones, of the crystalline basement complex and sandstone, are apparent within the solum and yet frequent stones of up to boulder size appear on the eroded land surface; the solum is evidently very strongly weathered. The texture is silt loam with 50 to 60 percent U.S.D.A. silt. The Eg horizon displays a strong very coarse prismatic or columnar structure with the units clearly delineated by translocated organic matter which has been deposited on the ped faces. Rock is met usually within profile depth.

Lynedardy Series

The Lynedardy Series, a peaty gley, is the most extensive soil of the association covering one square kilometre. Its distribution is that of the association as a whole. The soil occurs on gentle or moderate slopes under moist Atlantic heather moor vegetation.

Profile Description

Slope:	Moderate
Vegetation:	Moist Atlantic heather moor
Drainage Class:	Poor

Horizon	Depth(cm)	
F and H	0-2	Dark reddish brown (5YR3/2) slightly humified fibrous peaty humus; many roots. Clear change into
O	2-10	Dark reddish brown (5YR2/2, slightly humified fibrous peaty humus; firm; many roots. Sharp change into
Eg1	10-20	Dark greyish brown (10YR4/2) sandy loan; weak medium subangular blocky; firm; moist; no mottles; moderate organic matter; frequent roots; frequent medium granite and sandstone stones. Clear change into
Eg2	20-25	Brown (10YR5/3) sandy loam with frequent Medium distinct dark brown (7.5YR3/2) patches of organic staining; weak medium subangular blocky firm; moist; no mottles; low organic matter; few roots; frequent medium granite and sandstone stones. Clear change into
Bg	25-45	Pale brown (10YR6/3) sandy loam or sandy clay loam with frequent medium faint yellowish brown (10YR5/4) mottles; weak medium subangular

		blocky; firm; moist; no organic matter; few roots; frequent stones. Clear change into
BC	45-85	Brown (75YR4/4) sandy loam or sandy clay loam; weak medium sabangular blocky; firm; moist; no mottles; no organic matter; few roots; frequent stones, granitic, flagstone and sandstone. Sharp change into
R	85+	Flagstone rock

The organic surface horizons are rarely more than 15 centimetres thick, as the soils occur on exposed sites where surface organic matter is slow to build up. The texture of the Bg horizon and the parent material approaches sandy clay loam with up to 20 percent clay. The structure of the soil is usually weak. Patches of iron staining are frequent in the BC horizon. Rock is encountered usually within profile depth.

Soils of the Lynedardy and Millfield Series are component soils of the Croval Complex. The complex is related to both the Lynedardy Association and the Stromness Association and is described under the Stromness Association.

Rackwick Association

The Rackwick Association is of minor extent, covering 2 square kilometres, and is confined to the Rackwick end of the valleys of the South Burn and Ford of Hoy in north-west Hoy. The parent material is fluvioglacial sands and gravels derived from sandstones of the Upper Old Red Sandstone. The sand and gravel deposits occur as isolated ridges, mounds, or level or kettle-holed terraces. The parent material varies in texture from loamy sand to coarse sandy gravel. The deposits are dominantly current-bedded sand with gravel and silt lenses. One soil series, the Rackwick Series (peaty podzols) has been mapped.

Rackwick Series

The Rackwick Series, a peaty podzol develops on a range of slopes, from gentle to steep, under moist Atlantic heather moor vegetation and a mean annual rainfall of around 1000 millimetres. The soils cover one square kilometre.

Profile Description

Slope:	Moderate
Vegetation:	Moist Atlantic heather moor
Drainage Class:	Free below iron pan

Horizon	Depth (cm)	
L and F	Trace	*Calluna* and moss remains.
O1	0-20	Dark reddish brown (5YR3/2) slightly humified fibrous peaty humus; strong vertical cracks; firm; many roots, particularly in cracks. Clear change into
O2	20-35	Black (10YR2/1) medium humified amorphous

		peaty humus; strong vertical cracks; firm; many roots, particularly in cracks; frequent bleached sand grains. Sharp change into
E1	35-45	Brown (7.5YR5/2) sand with dark brown (7.5Y4/2) patches; weak medium subangular blocky; friable; moist; no mottles; low organic matter; few fine roots; few small stones. Clear change into
E2	45-55	Dark brown (7.5YR3/2) sand with very dark brown (10YR2/2) patches; moderate medium subangular blocky; firm or friable; weakly cemented; moist; no mottles; low organic matter; few fine roots; few small stones.Sharp change into
Bf	55	Thin iron pan
Bs	55-75	Reddish yellow (7 .5YR7/8) sand with strong brown (7.5YR5/8) and light reddish brown (5YR6/4) patches; weak medium subangular blocky; friable; moist; no mottles; no organic matter; no roots; few small gravel stones. Clear change into
C	75-135+	Light brown (7.5YR6/4) sand with fine bands of reddish brown (2.5YR5/4) sand; weak medium subangular blocky; friable; moist; no mottles; no organic matter; no roots; few gravel stones.

The colour of the parent material varies from light brown to reddish brown and the percentage gravel content is very variable.

Ford of Hoy Complex

The Ford of Hoy Complex covers less than 1 square kilometre and occurs in the valley of that name. It is a complex of ridges, mounds and flats, with Rackwick series on the mounds and ridges, and peat with peat-alluvium on the flats.

Stromness Association

The soils of the Stromness Association are developed on a yellowish brown sandy loam drift derived from granitic and schistose rocks of the crystalline basement complex of the Moinian and coarse sandstones, breccias and conglomerates of Lower and Middle Old Red Sandstone. The extent of the association is small and its distribution very local. The greatest extent of the association occurs within the Croval Complex but as the complex is a dual association complex, encompassing soils of the Lynedardy Association, it is difficult to assess the exact areal extent of the Stromness Association within the complex. The area of the Croval complex is one square kilometre and the soils of the Stromness Association occupy approximately 25 percent of that. Small areas of the association occur to the south of Yesnaby, the deposits covering less than one square kilometre. One soil series (Stromness Series) is of sufficient extent for it to be mapped independently of the Croval Complex.

Stromness Series

Stromness Series, comprising peaty podzols, covers less than one square kilometre and is found on moderate to steep slopes under moist Atlantic heather moor vegetation and a mean annual rainfall of 900 to 1000 millimetres.

Profile Description

Slope:	Moderate
Vegetation:	Moist Atlantic heather moor
Drainage Class:	Free below iron pan

Horizon	Depth (cm)	
O	0-10	Very dark brown (10YR2/2), slightly humified fibrous peaty humus; moderate medium subangular blocky; firm; frequent roots; few small bleached stones, frequent bleached sand grains. Sharp change into
Eg	10-30	Light brownish grey (10YR 6/2) sandy loam with few medium distinct very dark greyish brown (10YR3/2) patches of organic staining; weak medium subangular blocky; firm; moist: no mottles; moderate organic matter; few roots; frequent stones of bleached coarse sandstone and stones of the crystalline basement complex. Sharp change into
Bf	30	Thin iron pan
Bs	30-60	Strong brown (7.5YR5/8) gritty sandy loam or loam; weak medium subangular blocky; friable; moist; no mottles; no organic matter; few roots; many medium and large stones of coarse sandstone, breccia and rocks of the crystalline basement complex. Clear change into
BCx	60-80	Yellowish brown (10YR5/6) gritty sandy loam massive; firm; moderate induration; moist; no mottles; no organic matter; no roots; many large stones, as above. Sharp change into
R	80+	Granite-schist rock.

Hard rock is usually encountered within 50-100 centimetres; The map unit includes some small areas of podzolic rankers where the rock lies closer to the surface; such soils have an O and Eg horizons overlying rock, with B horizons normally absent although a thin iron pan, or iron staining can sometimes be found on the rock surface. These podzolic ranke5rs are also a component of the Croval complex.

Croval Complex

The Croval Complex covers one square kilometre and occurs as the hinterland of Stromness and on Graemsay. The complex occupies a rocky, moundy or ridge landscape which is underlain by rocks of the crystalline basement complex. This complex contains soils belonging to both the Stromness and Lynedardy Associations.

The complex consists of the following soils:

1. Lynedardy series
2. Millfield series
3. Stromness Series
4. Ranker soils of the Stromness Association
5. Soils developed on colluvium with extensive rock outcrops

An estimated 20 percent of the complex is rock, 55 percent Lynedardy Association and 25 percent Stromness Association.

Thurso Association

The Thurso Association, previously described in eastern Caithness (Futty and Dry, 1977), comprises soils developed on parent material derived from rocks of the Stromness Flags and Rousay Flags of the Middle Old Red Sandstone. It is the second most extensive soil association in the area, covering 444 square kilometres, the soils being the dominant mineral soils of the West Mainland, Rousay and western Westray. The soils occur also as principal components of the landscape in South walls (Longhope), Sanday and North Ronaldsay and locally in the East Mainland.

The parent materials are a till of moderately fine texture, a drift of moderately coarse or medium texture and a morainic drift of moderately coarse or medium texture.

The moderately fine-textured till is a yellowish brown, brown or greyish brown compact deposit usually about one metre thick but thinner on higher ground and rarely exceeding 140 centimetres. Sections of thick till are few; a brown till section some 8 to 10 metres in thickness and containing shell fragments occurs near the Pier of Stursy in North Stronsay. A number of profiles have been found to be calcareous below 120 centimetres. The calcareous nature is due possibly to the presence of shell fragments but most probably to the presence of a significant proportion of limestone or carbonate-bearing rocks in the till. The till occurs locally throughout the West Mainland and more extensively on the eastern flats bordering the Firth and Evie and Rendall hills.

The moderately coarse or medium-textured drift is the dominant parent material of the association being distributed widely throughout the West Mainland and occurring extensively in the central lowland feature of the West Mainland on Sanday. The deposit is generally yellowish brown, stony and often indurated in its upper part. Its thickness is variable, ranging from 50 to 150 centimetres, with perhaps an average of between 85 and 105 centimetres.

The morainic drift occurs locally throughout the mainland of Orkney and is associated with moundy topography. The drift is yellowish brown or brown, stony and sometimes indurated in its upper part. The material is similar in many instances to the non-moraine drift but is specifically related to moundy, morainic topography. The drift is sometimes seen to overlie till of moderately fine texture.

The parent materials are usually underlain by hard unweathered rock but a sequence of soils over strongly weathered rock has bean identified along the western seaboard of the archipelago.

The soils of the association occur under a mean annual rainfall of between 900 and 10000 millimetres.

Eight soil series and seven soil complexes have been distinguished: the Bilbster Series (podzols; the Knitchen Series (alpine podzols) the Camster Series (peaty podzols), the Thurso, Ness and Hunster Series (noncalcareous leys), the Mousland Series (saline gleys) and the Olrig Series (Peaty gleys) and the Sordale, Ulbster, Frotoft, Warehouse, Eskishold, Huntis and Aglath Complexes. In addition, shallow phases of the Bilbster, Camster, Thurso and Olrig Series based on depth to bedrock and a deep-topped phase of the Bilbster Series based on the thickness of the Ap horizon, have been separated. Areas of skeletal soils of the association have also been mapped.

Bilbster Series

Both shallow and deep-topped phases of the Bilbster Series have been mapped.

The Bilbster Series comprises freely and imperfectly drained soils which have been reclaimed from peaty podzols, but a long history of cultivation has left little or no trace of their former surface horizons. Because the drainage class of these soils can vary over short distances, no separation into freely and imperfectly drained classes has been possible and the soils are considered as forming one soil series. The Bilbster Series covers 165 square kilometres, being distributed widely through the West Mainland and also occurring extensively on Sanday. The parent material is a stony drift of sandy loam, loam or sometimes sandy clay loam texture. The soils have been developed on a wide range of slopes from gentle to steep.

Normal Phase

Profile Description

Slope:	Moderate
Vegetation:	Arable crop or ley
Drainage Class	Free

Horizon	Depth (cm)	
Ap	0-20	Dark greyish brown (10YR4/2) loam; moderate medium subangular blocky; friable; moist; no mottles; moderate organic matter; many roots; few small stones. Sharp change into
Bx	20-45	Yellowish brown (10YR5/4) or brown (10YR5/3) loam; moderate or strong coarse platy; very firm; strong induration; moist; low organic matter; few

		roots; frequent medium subangular and tabular stones of sandstone and flagstone. Clear change int
BC	45-105+	Yellowish brown (10YR5/4) or brown (10YR5/3) loam or sandy loam; moderate medium subangular blocky; firm; moist; no mottles; no organic matter; no roots; frequent medium and large stones of sandstone and flagstone.

The colour of the Ap horizon relates to the amount of organic matter present and can range from dark grey to brown. A silt loam texture is common. A thin iron pan, or the traces of one, is occasionally present on the upper surface of the Bx horizon and some profiles have a narrow, brown or greyish brown E(g) horizon between the Ap and Bx horizon. The degree of induration of the Bx decreases with depth, and at the base of the horizon induration is only weakly developed. Ochreous mottling within the peds is sometimes present. The Bx horizon shows the typical characteristics of an indurated horizon, including platy structure with reddish iron staining or black manganiferous mottles on the faces of the plates, fine pores or pin holes, and fine sand or silt linings to stone cavities. The horizon forms an effective barrier to root penetration.

Shallow Phase

The shallow phase of the Bilbster Series occurs in relatively drift-free areas, and the profile consists essentially of an Ap horizon overlying rock. Usually the rock is present at depths of between 20 and 30 centimetres although occasionally as much as 50 centimetres. The phase is widely distributed throughout the association and covers 38 square kilometres.

Profile Description

Slope:	moderate
Vegetation:	Arable crop or ley
Drainage Class:	Free

Horizon	Depth (cm)	
Ap	0-20	Dark brown (7.5YR3/2) loam; strong medium granular or subangular blocky; firm or friable; moist; no mottles; high organic matter; many roots; frequent small stones and rock chips. Sharp change into
R	20+	Weakly weathered, ochreous stained, flagstone.

A few centimetres of mottled weathered rock sometimes occurs below the Ap horizon. Soils with a Bx horizon are included in the unit provided that bedrock is found at a depth of less than 50 centimetres.

Deep-topped Phase

A deep-topped phase of the Bilbster Series is recognized when the thickness of the Ap horizon exceeds 75 centimetres. The phase covers 6 square kilometres and is most extensive in the parishes of Birsay and Sandwick.

Profile Description

Slope: Gentle
Vegetation: Arable crop or ley
Drainage Class: Free

Horizon	Depth (cm)	
Ap1	0-30	Very dark greyish brown (10YR3/2) silt loam; moderate medium subangular blocky; firm or friable; moist; no mottles; high organic matter; frequent roots; few stones. Clear change into
Ap2	30-50	Dark brown (7.5YR3/2) silt loam; moderate medium subangular blocky; firm; moist; no mottles; high organic matter; frequent roots; few stones. Clear change into
Ap3	50-80	Dark brown (7.5YR3/2) silt loam with brown (7.5YR4/4) pockets; moderate medium subangular blocky; firm; moist; no mottles; moderate organic matter; few roots; few stones. Sharp change into
BC	80-105+	Yellowish brown (10YR5/4) loam with few medium brownish yellow (10YR6/6) mottles; moderate medium subangular blocky or platy; firm; weak induration; moist; no organic matter; no roots; frequent stones.

A high silt content is common in the Ap horizons. The soils were first noted in fields immediately adjacent to long-established steadings, and their morphology would appear to owe much to man's influence.

The soils of the Bilbster Series occur also on moundy moraine. The parent material is a stony drift of sandy loam, loam or sometimes loamy sand texture which forms mounds or ridges. The Bilbster Series developed on morainic drift is invariably a component of the Sordale Complex. A profile description is given below:

Bilbster Series developed on moraine

Slope: Moderate
Vegetation: Arable crop or ley
Drainage Class: Free

Horizon	Depth (cm)	
Ap	0-20	Dark greyish brown (10YR4/2) sandy loam or

		loam; strong medium granular; friable; moist; no mottles; moderate organic matter; many roots; few stones. Sharp change into
Bf	20	Thin iron pan or trace of one
Bx	20-45	Yellowish brown (10YR5/4) and brown (10YR5/3) sandy loam or loam; moderate medium platy; firm; moderate induration; moist; no mottles; low organic matter; few roots; frequent small and medium and few large subangular and tabular flagstone and sandstone stones. Clear change into
BC	45-120	Brown (10YR5/3) sandy loam; weak subangular blocky or single grain; friable or loose; moist; no mottles; no organic matter; no roots; many flagstone and sandstone stones.

The upper part of the profile is very similar to that of the normal Bilbster Series, the main feature being the presence of an indurated horizon immediately below the Ap horizon. The textures of the subsurface horizons, however are generally coarser and this appears to affect other properties such as structure which is weaker, and induration, which is less strongly developed.

Knitchen Series

The Knitchen Series consists of alpine podzols developed on thin, very stony drift. The series is of very minor extent, covering less than one square kilometre, and is confine to Rousay. The soils occur on level or moderate slopes at an elevation of approximately 225 metres. The vegetation cover is predominantly *Rhacomitrium* heath but sometimes *Calluna*-lichen heath, and is often patchy in distribution,

Profile Description

Slope:	Gentle
Vegetation:	Brown bent-grass - woolly fringe-moss heath
Drainage Class	Free

Horizon	Depth (cm)	
L	Trace	Plant remains
H	0-15	Dark reddish brown (5YR2/2) slightly humified fibrous peaty humus; weak medium subangular blocky; firm; moist; frequent roots; no stones, but frequent bleached sand grains. Sharp change into
Ah	15-65	Very dark grey (10YR3/1) loamy sand; weak medium subangular blocky or single grain; friable or loose; moist; no mottles; high organic matter; few roots; many medium and large subangular and tabular stones. Sharp change into
R	65+	Solid but fissured rock.

The profile is noteworthy for the deep and organic matter-rich Ah horizon. The soils are associated closely with alpine ranker soils.

Camster Series

The Camster Series consists of peaty podzols developed on a loam or sandy loam drift. The soils occur on moderate to steep slopes under moist Atlantic heather moor vegetation. The soils cover 24 square kilometres and are of local distribution.

Profile Distribution

Slope:	Moderate or steep
Vegetation:	Moist Atlantic heather moor
Drainage Class:	Free below iron pan

Horizon	Depth (cm)	
L	Trace	*Calluna* and moss remains
O1	0-15	Dark reddish brown (5YR2/2) slightly humified fibrous peaty humus; strong vertical cracks; firm; many roots, particularly in cracks.
O2	15-30	Black (10YR2/1) medium humified amorphous peaty humus; plastic; frequent roots. Sharp change into
Eg	30-45	Pale brown (10YR6/3) loam with dark reddish brown (5YR2/2) staining; weak medium subangular blocky; firm;.; moist; no mottles; moderate organic matter; frequent roots; frequent small tabular stones. Sharp change into
Bf	45+	Thin iron pan with root mat.
Bs	45-65	Strong brown (7.5YR5/8) loam; weak medium subangular blocky; friable; moist; no mottles; no organic matter; few roots; frequent medium subangular an tabular sandstone and flagstone stones. Clear chanre into
BC(x)	65-100	Yellowish brown (10YR5/4) loam or sandy loam; moderate medium subangular blocky; firm; weak induration; moist; no mottles; no organic matter; no roots; many medium and large subangular and tabular sandstone and flagstone stones. Clear change into
R	100+	Shattered bedrock.

The Eg horizon is variable in thickness and degree of gleying. The thickness varies from about 10 to 50 centimetres with the deeper horizons showing a greenish grey or olive-grey zone of intense gleying immediately above the Bf horizon. The thin iron pan is almost invariably a feature of the profile. The Bs horizon is typically a strong brown, friable loam, usually mottle-free but sometimes with fine brownish yellow mottles. The BC horizon is normally indurated, but if it is very stony the structure is weak and the induration absent. Rock usually occurs within profile depth.

A shallow phase of the Camster Series occurs as an independent mapping unit of: limited extent, covering 4 square kilometres, and as a major component of the Frotoft and Warehouse Complexes. The profiles have H and Eg horizons but the B horizons are usually absent or very thin. Bedrock is encountered usually at depths of between 20 and 30 centimetres. The soils are essentially podzolic rankers.

Thurso Series

The Thurso Series comprises poorly drained noncalcareous surface-water gleys. The series is distributed widely throughout the association and covers 84 square kilometres. The soils are developed on a loam or sandy clay loam till on level to moderate slopes. The greater part of the series is cultivated or has been at some time.

Profile Description

Slope:	Gentle
Vegetation:	Arable crop or ley
Drainage Class	Poor

Horizon	Depth (cm)	
Ap(g)	0-25	Dark greyish brown (10YR4/2) loam or silt loam with frequent fine distinct yellowish red (5YR5 /8) mottles and dark brown (7.5YR4/4) streaks; moderate medium. subangular blocky; firm; moist; moderate organic matter; frequent roots; few small stones. Sharp change into
Bg	25-45	Greyish brown (2.5Y5/2) loam or sandy clay loam with frequent medium prominent yellowish brown (10YR5/4.) and strong brown (7.5YR5/8) mottles; moderate coarse prismatic or subangular blocky; firm; moist; low organic matter; frequent roots frequent small sandstone and flagstone stones, many weathered. Gradual change into
BCg	45-75	Yellowish brown (10YR5/4) loam or sandy clay loam with many medium distinct yellowish red (5YR5/8) and. strong brown (7.5YR5/8) mottles and grey (10YR6/1) patches; weak coarse subangular blocky or massive; firm; moist; no organic matter; few roots; frequent stones, some weathered of sandstone and flagstone. Gradual change into
C(g)	75-110+	Yellowish brown (10YR5 /4) or brown (10YR5/3) loam or sandy clay loam with frequent fine distinct yellowish red (5YR5/8) and strong brown (7.5YR5/8) mottles and fine prominent dark red (2.5YR3/6) streaks; massive; firm; moist; no organic matter; few roots; frequent stones, predominantly tabular flagstones and subangular sandstones.

The profile morphology of the Thurso Series is varied, particularly with regard to the horizon colour and the degree of ochreous and grey mottling, but it is typically that of a surface-water gley in which features duo to gleying have maximum development in the upper part of the B horizon.

The majority of the soils of the Thurso Series have resulted from cultivation of peaty-topped soils. Long cultivation has destroyed to a great extent evidence of the former nature of the soils, but the presence in some profiles of a very dark greyish brown or very dark grey A horizon with a high organic matter content offers a clue to the past morphology. Occasionally a thin, brown or dark brown AB horizon beneath the Ap horizon helps further the understanding of the genesis of these soils. In. a few cases a thin, grey or olive-grey Eg horizon is found below the Ap horizon. The Bg horizon, average thickness 20 to 30 centimetres, has a loam or sandy clay loam texture and a moderate prismatic or subangular blocky structure. The underlying BCg horizon is similar in colour and texture but mottles of high chroma predominate and the structure is weaker or absent. The structure of the BCg horizons are sometimes grey or greyish brown in colour. The structure of the C(g) or Cg horizon is most commonly massive but occasionally subangular blocky and rarely, in some C(g) horizons, platy; the horizons with platy structure tend: to show weak induration.

As the average depth of the till is about one metre, bedrock is most frequently met within profile depth. A shallow phase of the Thurso series, with bedrock at 50 centimetres or less, has been mapped. Such soils are not extensive, covering 1 square kilometre.

Soils of the Thurso Series appear as components of the Sordale, Ulbster, Frotoft and Eskishold Complexes.

Ness Series

The Ness Series consists of poorly drained noncalcareous gleys developed on yellowish brown or light yellowish brown sandy clay loam till over strongly weathered rock. It covers 1 square kilometre occurs to the south of Stromness and on Graemsay. The soils which are found on gentle slopes, are all cultivated.

Profile Description

Slope:	Gentle
Vegetation:	Arable crop or ley
Drainage Class	Poor

Horizon	Depth (cm)	
Ap(g)	0-20	Greyish brown (10YR5/2) loam with frequent fine distinct yellowish red (5YR4/6) mottles an dark red (2.5YR3/6; streaks; moderate medium subangular blocky; friable; moist; moderate organic matter; frequent roots; few small stones. Sharp change into
Bg	20-35	Yellowish brown (10YR5 /6) sandy loam with

		frequent nedium faint brownish yellow (10YR6/6) mottles; moderate medium subangular blocky; friable; moist; low organic matter; few roots; few strongly weathered sandstone and. flagstone stones. Clear change into
BCg	35-50	Yellowish brown (10YR5/4) and light yellowish Brown (2.5Y6/4) sandy clay loam with frequent medium and coarse distinct strong brown (7.5YR5/8) mottles and light grey (5Y7/1) patches; weak medium subangular blocky or massive; firm; moist; no organic matter; few roots; frequent sandstone and flagstone stones, mostly strongly weathered. Sharp change into
CRg	50-75	Brownish yellow (10YR6/6) and light grey (5Y7/l) silt loam; massive, or weak coarse platy due to bedded nature of rock horizon of strongly weathered flagstone); firm; moist. Clear change into
R	75+	Hard flagstone rock.

The CRg horizon has a layered appearance with generally alternating bands of brownish yellow or yellowish brown and light grey material. The rock is strongly weathered but apparently *in situ* as the original bedding of the rock is preserved. The texture of the horizon varies from loam to clay loam.

Hunster Series

The Hunster Series comprises very poorly drained noncalcareous gleys developed on a loam or sandy clay loam till. The soils are associated with flushed hollows and receiving sites and support wet *Juncus* or *Carex* pasture. The series is of minor extent, covering 1 square kilometre, and is distributed widely throughout the association.

Profile Description

Slope:	Level or gentle
Vegetation:	Wet *Juncus* pasture
Drainage Class:	Very poor

Horizon	Depth (cm)	
Ahg	0-25	Dark grey (10YR4/1) silt loam; weak medium subangular blocky; plastic; wet; high organic matter; many roots; few small stones. Sharp change into
Eg	25-50	Brown (10YR5/3) sandy loam with frequent medium distinct dark reddish brown (5YR3/2) patches of organic staining and olive yellow (2.5Y6/6) mottles; moderate medium subangular blocky; firm or friable; moist; moderate organic

		matter; frequent roots; few stones; mostly weathered. Clear change into
Bg	50-70	Light olive grey (5Y6/2 loam with frequent medium prominent yellowish brown (10YR5/8) mottles; weak medium subangular blocky; firm; moist; low organic matter; few fine and frequent roots; frequent small to large sandstone and flagstone stones, some weathered. Clear change into
Cg	70-120+	Bluish grey (5B6/1) loam with few medium distinct olive (5Y5/3) mottles and frequent prominent dark reddish brown (2.5YR3/4) root channels; massive; firm; moist; no organic matter; frequent roots; frequent medium and large stones.

The soils are ground-water gleys characterised by bluish grey colours in the Cg horizon and intense staining and perhaps cementation around old root channels.

Mousland Series

The Mousland Series, comprising poorly drained saline gleys, covers 17 square kilometres and occurs locally along the western seabord of the archipelago. The soils are developed under a harsh regime of wind, sea-gusting and salt spray on very strongly weathered drift and rock on level to moderate slopes. The soils support maritime heath or maritime grassland vegetation, the cover being often broeched by severe wind and water erosion.

Profile Description

Slope: Gentle
Vegetation: Sea plantain - crowberry heath or maritime grassland
Drainage Class: Poor

Horizon	Depth (cm)	
FH	0-5	Dark brown (10YR3/3) slightly humified fibrous peaty humus; felty; many roots; no stones, few bleached sand grains. Sharp change into
Ah	5-13	Dark greyish brown (10YR4/2) loam with very dark grey brown (10YR3/2) patches: moderate medium subangular blocky; firm; moist; no mottles; high organic matter; frequent roots; frequent small stones. Cear change into
Eg	13-30	Grey (5Y5/1) silt loam or loam with few medium distinct greenish grey (5BG6/1) weathered rock frequents and stones, prominent dark reddish brown (5YR3/2) staining along ped faces; strong coarse prismatic or columnar; firm; moist; low organic matter few roots; frequent small stones, strongly weathered. Clear change into
Bg	30-50	Greenish grey (5GY6/l) with grey (5Y6/l); silt loam

		with pockets of sandy loam;frequent fine and medium prominent strong brown (7.5YR 5/8) and brownish yellow (10YR6/6) mottles and weathered rock fragments; prominent dark reddish brown (5YR3/2) staining along ped faces; strong coarse prismatic; firm; moist; no organic matter; few roots; frequent small and medium stones, strongly weathered. Clear change into
Cg	50-95	Greenish grey (5GY6/1) silt loam or silty clay loam with many coarse prominent strong brown (7.5YR5/8) and brownish yellow (10YR6/6) mottles and bands; massive or weak platy; firm; moist, becoming wet sticky with depth; no organic matter; no roots; no stones. Clear change into
R	95+	Hard flagstone.

Similar soils are developed on strongly weathered light grey sandy loam, loam or silt loam drift. It proved impossible to separate those soils developed on weathered rock from those on drift and the two are mapped as one series.

The thickness of the FH horizon is variable but rarely exceeds 30 centimetres. This horizon is often absent and replaced by a trace of litter and a dark greyish brown Ah horizon. The surface horizons of these soils immediately adjacent to the cliff edge have a lower organic matter content, a brown colour, and a coarser texture which appears to be the result of modification of the original material by water; the horizon, up to 35 centimetres in thickness, has a succession of narrow bands of small, tabular, orientated stones.

A characteristic of the soils is the strong coarse and very coarse prismatic or columnar structures of the Eg and Bg horizon. The structure units occasionally show domed upper surfaces and are strikingly delineated by translocated organic matter which has been deposited on the ped faces. The horizons sometimes show an angular blocky structure while the Bg horizon can also be massive. The Cg horizon is usually massive although in rare instances a coarse prismatic structure is noted. The weathered rock is generally massive but has a tendency to platy structure related to the original bedding of the rock.

Olrig Series

The Olrig Series consists of poorly drained peaty gleys developed on a loam or sandy clay loam till on gentle to moderate slopes under moist Atlantic heather moor vegetation. The soils cover 35 square kilometres and are distributed throughout he association.

Profile Description

Slope: Gentle or moderate
Vegetation: Moist Atlantic heather moor
Drainage Class poor

Horizon	Depth (cm)	
L and F	Trace	*Calluna* and moss remains
O1	0-15	Dark reddish brown (5YR2/2) slightly humified fibrous peaty humus; firm; many roots. Clear change into
O2	15-25	Black (5YR2/1) medium humified amorphous Peaty humus; frequent roots; sharp change into
Eg	25-40	Brown (7.5YR5/2) sandy loam or loam with frequent medium and coarse distinct dark reddish brown (5YR3/2) patches of organic staining; moderate medium subangular blocky; firm: moist; high organic matter; frequent fine roots; few small stones. Clear change into
Bg1	40-65	Greyish brown (2.5Y5/2) loam or sandy clay loam with frequent medium distinct brownish yellow (10YR6/6) mottles and frequent medium prominent dark brown (7.5YR3/2) patches of organic staining; moderate medium subangular blocky; firm; moist; low to moderate organic matter; few roots; frequent small and medium sandtone and flagstone stones, many weathered. Clear change into
Bg2	65-105	Light brownish grey (2.5YR6/2) and light olive grey (5Y6/2) sandy clay loam with frequent medium prominent brownish yellow (10YR6/6) mottles; massive or weak medium subangular blocky; firm; moist; no organic matter; few roots; frequent stones of tabular flagstone and sandstone. Clear change into
Cg	105-130+	Greyish brown (10YR5/2) sandy clay loam with frequent medium prominent yellowish red (5YR4/8) mottles; massive; firm; moist; no organic matter: no roots; frequent stones of tabular flagstone and subangular sandstone, up to 60 centimetres diameter.

The O horizon varies in thickness from 10 to 50 centimetres. In some instances the peaty layers were originally thicker but peat extraction has reduced the depth. The colour of the Eg horizon varies from greyish brown to dark reddish brown and is dependent on the amount and the distribution of organic matter. In the Bg1 horizon grey colours predominate over mottles of high chroma. The texture is a loam or sandy clay loam and the structure is usually blocky, locally prismatic. In some profiles the degree of gleying increases down the profile and a dark grey or greenish grey Cg horizon with little mottling results.

A local variant of the Olrig Series comprises peaty gleys with an indurated B horizon. The soils are somewhat intermediate in character between peaty podzols and peaty gleys but lack a thin iron pan. The indurated horizon is usually yellowish brown with a few fine mottles. The soils are of minor extent and very local distribution, and have not been assigned series status

Bedrock is most frequently within profile depth and a shallow phase of the series is mapped when the depth to bedrock is less than 50 centimetres. The shallow phase is of minor extent (5 square kilometres) as a separate map unit but is a component of a number of soil complexes.

Soils of the Olrig Series are components of the Frotoft, Warehouse, Eskishold, Huntis and Aglath Complexes.

Skeletal Soils

The skeletal soils of the association amount to less than 1 square kilometre and are mapped along the western seaboards of the archipelago and on North Ronaldsay where extreme exposure has laid bare the drift or bedrock.

Sordale Complex

The Sordale Complex, formerly the Bilbster Complex (Futty and Dry, 1977), occurs on the moundy topography associated with areas of moraine. It is a complex of the following soils:

1. Bilbster Series
2. Soils developed on colluvium
3. Thurso Series
4. Olrig Series or peat

The complex occurs locally throughout the Mainland, covering 31 square kilometres with major areas in the Toab district of the parish of St. Andrews and Deerness, in the parish of Holm around the farm of Hestwall and in the parish of Stenness around the farm of Moa. The predominant soil of the complex is the Bilbster Series which occurs on the mounds. The intervening hollows contain poorly drained soils developed on colluvium, with the Thurso Series sometimes present. Where the moundiness is extreme, Olrig Series, very poorly drained variants or peat, occur in some of the hollows.

Ulbster Complex

The Ulbster Complex is a complex of mineral soils on a low, moundy, ridged or stepped, rock-controlled topography. The constituent soils are:

1. Bilbster Series (shallow phase)
2. Bilbster Series
3. Thurso Series, including the shallow phase
4. Soils developed. on colluvium

The complex covers 16 square kilometres. It is associated with a ridged or stepped topography on Egilsay, on the Aiker Ness peninsula in Evie, along the southern coastal fringe of Rousay and in western Westray, and with a low moundy topography in the Stany Hill area of the parish of Harray.

The soils on the rocky ridges and risers are mainly the shallow phase of the Bilbster Series: in the moundy landforms the shallow phase of the Bilbster Series occurs on the tops of the mounds and the Bilbster Series on the flanks. The intervening flats or hollows contain poorly drained soils of the Thurso Series or poorly drained soils developed on colluvium. Rock outcrops are a component of the complex, being particularly significant in the more markedly stepped areas.

Frotoft Complex

The Frotoft Complex is found principally in Rousay and in western Westray and covers 15 square kilometres. The complex occurs on stepped and often steep hillsides. The constituent soils are:

1. Camster Series (shallow phase)
2. Bilbster Series (shallow phase)
3. Olrig Series, including the shallow phase
4. Thurso Series, including the shallow phase
5. Soils developed on colluvium
6. Peat

Rock outcrops are a major component of the complex.

The soils of the shallow phases of the Camster, and to a lesser extent, the Bilbster Series occur on the often craggy risers, while soils of the Olrig or Thurso Series occupy the treads. Colluvial deposits occur commonly at the base of the risers and are often strongly flushed. Peat is a very minor component of the complex. The risers are often precipitous and craggy, offering little scope for soil profile development.

Warehouse Complex

The Warehouse Complex, formerly the Camster Complex (Futty and Dry, 1977), is a complex of rock ridges or knolls and peat. The complex is of limited extent, covering less than 1 square kilometre, and occurs along the Burn of Swartaback in the parish of Orphir. The component soils are:

1. Camster Series
2. Peat
3. Camster Series (shallow phase)
4. Olrig Series

The Camster Series is developed on the lower slopes of the rock ridges and knolls with the shallow phase on the upper slopes and tops. Olrig Series or shallow peat are found on the flatter tops and deep peat occurs between the rock ridges or knolls.

Eskishold Complex

The Eskishold Complex covers 16 square kilometres and is developed extensively to the north-west of Stromness and at Vestra Fiold in Sandwick: a small area of the complex occurs in north-west Rousay at Brae of Moan. The complex occurs on a low moundy or gently ridged rock-controlled landscape. The constituent soils are:

1. Olrig Series (shallow phase)
2. Olrig Series
3. Camster Series (shallow phase)

The landscape is thinly drift-covered and soils of the shallow phase of the Olrig Series dominate. Olrig Series occurs on the more extensive flats. Soils of the shallow phase of the Camster Series are a minor component and are found on the more prominent of the generally low ridges. Rock outcrops are rarely exposed. Areas of the complex have been reclaimed and with modification of the peaty surface horizons, a transition to the Ulbster Complex is effected.

Huntis Complex

The Huntis Complex is one of cut-over and eroded shallow peat with Olrig Series and some Camster Series. The complex is developed most extensively in Birsay and Harray and covers 18 square kilometres. The component soils are:

1. Shallow peat
2. Olrig Series
3. Camster Series

The complex occurs on relatively smooth or very gently ridged landscapes and results directly from the influence of man and his extraction of peat. Shallow peat and Olrig Series are the dominant soils, the Olrig Series being either an original soil or a soil resulting from a degree of peat removal. Narrow banks of peat still persist but the sharply cut edges of the banks have been mellowed by weathering and erosion. The relative proportions of peat and Olrig Series are dependent on the intensity of past peat cutting. Little or no peat cutting takes place within the complex today. Soils of the Camster Series form a minor component of the complex, occurring on the steeper slopes and on isolated ridges.

Aglath Complex

The Aglath Complex is mapped in hillsides depressional sites. The soils are strongly flushed and comprise:

1. Olrig Series
2. Peat
3. Peat-alluvium Complex
4. Soils developed on colluvium

Rock outcrops or boulders are a minor component of the complex. The comp0lex is of limited extent, covering 4 square kilometres and of local distribution. It is best displayed on the eastern scarp slopes of the Evie and Rendall hills.

Alluvial Soils

The soils developed on alluvium cover 11 square kilometres. They are varied in texture and drainage ochside Series, a poorly drained soil on loam or silt loam parent material and the Innes Series, a very poorly drained soil on sand parent material. In addition peat-alluvium complex and undifferentiated alluvium have been mapped. Areas of alluvial fans and saltings have also been distinguished.

Lochside Series

The Lochside Series consists of poorly drained soils developed on loam or silt loam alluvial material. The soils are of limited extent, covering one square kilometre, the principal deposits occurring in Orphir near the farm of Lingo. The soils are either cultivated or support wet pasture or marsh vegetation.

Profile Description

Slope:	Level
Vegetation:	Arable crop or ley
Drainage Class	Poor

Horizon	Depth (cm)	
Apg	0-20	Greyishh brown (2.5Y5/2) silt loam with frequent medium prominent reddish brown (5YR4/4) and a few fine prominent dark reddish brown (5YR3/2) mottles; moderate medium subangular blocky; firm; moist; moderate organic matter; frequent roots; few small stones. Sharp change into
Bg	20-45	Grey (5Y6/1) loam with many fine and medium prominent yellowish red (5YR5/8) and strong brown mottles; moderate medium subangular blocky; firm; moist; low organic matter; frequent roots; few small stones. Clear change into
Cg	45-105+	Grey (5Y6/1) silt loam with many medium and coarse prominent strong brown (7.5YR5/8) mottles; moderate medium subangular blocky; firm; moist; no organic matter; few roots; few small

Innes Series

The Innes Series comprises very poorly drained soils developed on sand alluvial material. The series is not extensive, covering less than one square kilometre, and is confined to Sanday, where it fringes existing lochs and occupies the sites of former lochs. The vegetation is wet pasture extremely rich in species.

Peat-Alluvium

Peat-alluvium, covering 5 square kilometres, is a mixture of peat and alluvium which occurs either as an interstratified deposit or as contiguous deposits. It is associated with former loch sites where basin peat has developed and with narrow stream channels in areas of peat. The deposits of the former loch sites are sometimes underlain by marl.

Profile Description

Slope:	Level
Vegetation:	Wet pasture
Drainage Class	Very poor

Horizon	Depth (cm)	
Ahg	0-25	Dark greyish brown (10YR4/2) humose silt loam with frequent medium distinct yellowish brown (10YR5/4) mottles; weak medum subangular blocky; firm; moist to wet; very high organic matter; many roots; no stones. Sharp change into
bO	25-35	Dark reddish brown (5YR2/2) and yellowish brown (10YR5/6) slightly humified fibrous peaty humus; laminated; many roots. Sharp change into
bAH	35-45	Dark greyish brown (7.5YR4/2) and dark grey (10YR4/1) humose silt loam; weak medium angular blocky; firm; moist to wet; very high or high organic matter; many roots; no stones. Sharp change into
Marl	45-60	Olive grey (5Y4/2) silt loam; weak medium angular blocky; firm; moist to wet; no organic matter; frequent roots; no stones. Clear change into
Marl	60-125+	White (10YR8/2)) silt loam; massive; slightly plastic; wet; sticky; no organic matter; few roots; no stones; frequent shells and shell fragments.

Alluvial Fans

Alluvial fans cover less than 1 square kilometre and have been mapped in North Hoy.

Saltings

The saltings map unit comprises soils developed on saline marine alluvium. It is not extensive, covering one square kilometre, but is widely distributed throughout the archipelago. The soils are subjected to frequent tidal flooding and support salt marsh vegetation.

Links

Links soils are found on windblown noncalcareous sand. They are not extensive, covering 3 square kilometres, and are confined largely to the area around the Loch of Doomy in Eday. Small areas have been mapped at Rackwick in Hoy and at the bay of Meil near Kirkwall. The soils of three drainage classes have been mapped: a freely or excessively drained soil (Dornoch Series), an imperfectly drained soil (Eigie

Series) and a poorly drained soil (Morrich Series). Undifferentiated Hill Dunes were mapped on the plateau summit of the hills of north Hoy

Dornoch Series

The Dornoch Series consists of freely or excessively drained soils developed under acid grassland vegetation on moderate to steep slopes. The soils are of limited, extent, covering less than one square kilometre.
Profile Description

Slope:	Moderate
Vegetation:	Acid-bent fescue grassland
Drainage Class	Free

Horizon	Depth (cm)	
A	0-20	Brown (7.5YR5/2) sand; single grain; loose; moist; no mottles; low organic matter; many roots; no stones. Sharp change into
B	20-50	Dark greyish brown (10YR4/2) sand; weak fine subangular blocky or single grain; loose or friable; moist; no mottles; low organic matter; frequent roots; no stones. Sharp change into
C	50-120+	Pink (7.5YR7/4) sand; single grain; loose; moist; no mottles; no organic matter; few roots; no stones.

Thin buried A (bA) horizons less than one centimetre thick: sometimes occur in the profile.

Eigie Series

The Eigie Series comprises imperfectly drained soils developed on gentle or moderate slopes generally under moist Atlantic heather moor vegetation. The soils are of minor extent, covering less than one square kilometre.

Profile Description

Slope:	Gentle
Vegetation:	Atlantic heather moor
Drainage Class:	Imperfect

Horizon	Depth (cm)	
L and F	Trace	*Calluna* and moss remains
A	0-8	Dark reddish brown (5Y R3/2) sand; single grain; loose; moist; no mottles moderate organic matter; many roots; no stones; clear change into
B(g)	8-25	Pale brown (10YR6/3) sand with frequent medium distinct yellowish brown (10YR5/6) mottles; weak subangular blocky or single grain; friable or loose;

		moist; no organic matter: frequent roots; no stones. Clear change into
C	25-50	Pale brown (10YR6/3) sand; single grain; loose; moist; no mottles; no organic matter; few roots no stones. Clear change into
C(g)	50-100+	Light brown (7.5YR6/4) sand with few medium distinct yellowish brown (10YR5/6) mottles; weak medium angular blocky; friable; moist; no organic matter; few roots, no stones.

Morrich Series

The Morrich Series is the most extensive soil of the Links soils, covering 2 square kilometres and dominating the deposits around the Loch of Doomy. The soils are poorly drained and occur on gentle slopes under moist Atlantic heather moor vegetation.

Profile Description

Slope:	Gentle
Vegetation:	moist Atlantic heather moor
Drainage Class:	Poor

Horizon	Depth (cm)	
L and F	Trace	Calluna and moss remains
O	0-25	Dark reddish brown (5YR3/2) slightly humified Fibrous peaty humus; firm; many roots; no stones; frequent bleached sand grains. Sharp change into
BC(g)	25-45	Light brownish grey (10YR6/2) sand with thin bands of brown (7.5YR4/2) staining; weak fine subangular blocky or single grain; friable or loose; moist; no mottles; low organic matter; frequent roots; no stones. Clear change into
Cg	45-85	Pale brown (10YR6/3) sand with frequent coarse faint light yellowish brown (10YR6/4) mottles; weak medium angular blocky or single grain; friable; moist to wet; low organic matter; few roots; no stones. Sharp change into
bAh	85-125	Very dark greyish brown (10YR3/2) humose sand; weak medium subangular blocky; slightly plastic; wet; no mottles; high organic matter; few roots; no stones. Sharp change into
bEg	125-140+	Greyish brown (2.5Y5/2) sandy loam with frequent coarse distinct brownish yellow (10YR6/6) mottles; moderate medium subangular blocky; firm; moist; low organic matter; few roots; few small stones.

Buried O horizons, up to 20 centimetres thick, are encountered frequently within the profiles.

Hill Dunes

Areas of wind-blown quartzose sand on the plateau summits of the highest hills of Hoy have been mapped as Hill Dunes. The deposits are not extensive covering less than one square kilometre. The nature and origin of these deposits are discussed in Goodier and Ball (1975).

Organic Soils

The organic soils of the area consist of peat, defined here as having an organic matter content of more than 60 percent and, for mapping purposes, a thickness of 50 centimetres or more. Peat covers 143 square kilometres.

The predominant type is blanket peat, basin and valley peat being less extensive. The blanket peat is divided into two mapping units, shallow and deep, on the basis of thickness of the deposit. Cut-over peat and eroded phases of the blanket peats and the basin and valley peats have been identified.

Shallow Blanket Peat

The shallow blanket peat has a thickness of 50 to 100 centimetres and is distributed widely, covering an area of 67 square kilometres. Bog heather moor or blanket and raised bog vegetation is common occurring on generally moderately steep slopes, although occasionally on steep slopes. Areas of peat that are cut on a regular basis or areas where cutting has recently ceased are mapped as the cut-over phase. Hagged peat deposits are mapped as the eroded phase.

Deep Blanket Peat

The deep blanket peat has a thickness in excess of 100 centimetres. It covers 52 square kilometres and dominates the hills of Hoy, Orphir, Evie and Rendall and Rousay. The deposits are associated with level to moderately steep slopes and usually support blanket and raised bog vegetation. Cut-over and eroded phases of the deposits are recognised.

Undifferentiated Blanket Peat

Undifferentiated blanket peat has been mapped where the variation in thickness of the peat is too complex for the two categories to be shown separately at the scale of mapping. The unit covers 6 square kilometres, the largest expanse occurring in the valley of the Summer Burn, Hoy.

Basin and Valley Peat

The basin and valley peat covers 18 square kilometres and is widely distributed throughout the islands. It is associated with sites where the configuration of the ground has been a prime factor in initiating peat formation. In some places the peat is underlain by marl, a. light ‘grey or white calcareous silt loam which occasionally contains gastropod shells. A cut-over phase of the basin and valley peat has been identified.

Mixed Bottom Land

Mixed bottom land is the mapping unit used to delineate the soil complexes in narrow, steep-sided stream channels. The unit is not extensive and covers less than one square kilometre. The soils are generally immature and often strongly eroded; flushing is sometimes a feature of the slopes, and rock outcrops or bare till patches are often present.

6. Analytical Data

During the period of the survey, soil samples were taken from profiles considered typical of the mapping units. Standard analytical determinations, namely loss on ignition, soil separates, exchangeable cations, percentage base saturation, pH, carbon, nitrogen and total phosphorus were carried out on each sample. The fine sand fractions from a few selected profiles were examined by gravimetric and optical methods and the clay fraction by X-ray, differential thermal analysis and selective dissolution techniques. Trace elements were determined by spectrochemical techniques,

Standard Analytical Data

Some 190 profiles were sampled, of which 65 were selected as representing both the areal extent of the soil classes and of variations within the classes. Standard analytical data for the 65 profiles are given in Appendix 2, each profile being numbered for ease of reference. The following discussion is concerned with the values and trends shown within the soil associations, major soil subgroups and soil series.

Loss on ignition

Loss on ignition measures the percentage weight lost when a sample of oven-dry (105°C) soil is heated at a temperature of 850°C for two hours. This weight loss is due chiefly to the oxidative destruction of organic matter to carbon dioxide and water, the loss of structural water from clay minerals and the loss of carbon dioxide from any free calcium carbonate present. In the surface horizon of noncalcareous soils of moderate clay content, the value for the loss on ignition gives an estimate of the organic content of the soil sample.

In general, the loss on ignition decreases with depth in the soil profile in all major soil subgroups. The highest values are in the organic soils (Nos. 57-59), in the organic horizons of the peaty podzols (Nos. 19-23 and 25-29), the peaty gleys (Nos. 49-52 and 55 and 56), the alpine podzol (No. 18) and the poorly drained Links soil, Morrich Series (No. 62). The high values in No. 1 - a freely drained brown calcareous soil developed on shelly sand - and in the marl horizons of No. 64 illustrate the weight losses due to the release of carbon dioxide from free calcium carbonate present.

Some of the podzols, whilst conforming to the general trend of decrease in loss on ignition with depth, show an increase in the C horizon (Nos. 11 and 13) while others have a low value at some mid-profile level followed by an increase in the immediately underlying horizon and then the usual decrease down the profile. Profile No. 4 has a low value in the E horizon and No. 8 in the Bx.

The peaty podzols, the noncalcareous gleys, the saline gleys and the peaty gleys often show similar increases at the base of the profile. In the peaty podzols, No. 21 shows an increase in the BC(g) horizon and No. 28 an increase in the BC2 horizon. The noncalcareous gleys, saline gleys and peaty gleys show increases in the BC(g) horizon (No. 33), the BCg (Nos. 37, 40 and 46), C(g) (Nos. 31, 34 and 36) and the Cg (Nos. 53 and 55). Some profiles have a low value at a mid-profile depth. In the peaty podzols, No. 22 has a low value in the Eg horizon and No. 25 in the E1. The gley soils show lows in the AB horizon (No. 35), the Eg1 (No. 44), the Bg (Nos. 31 and 36) and the Bg (No. 46).

Whenever there is an Rw horizon in the profile there is usually a marked increase in the loss on ignition (e.g. Nos. 26, 40, 43, 47 and 48).

The alpine podzol (No. 17) shows an increase in the B(g) horizon.

Soil Separates

Soil separates - sand, silt and clay - are determined by mechanical analysis, the values obtained being for the size limits laid down by the International Scheme of Mechanical Analysis (sand 20-2000 µm, silt 2-20µm and clay < 2 µm) and by the scheme of the United States Department of Agriculture (sand 50-2000 µm, silt 2-50 µm. and clay < 2 µm). The relative proportions of these fractions in a soil are referred to as texture. The two schemes are shown in more detail in Appendix 1 and both sets of values are quoted in Appendix 2.

In general, the texture of the drift deposits in the area ranges from moderately coarse to moderately fine. Extremes in texture are found in soils developed on wind-blown sand (Nos. 1, 2, 30 and 60-62), on fluvioglacial deposits (Nos. 4 and 25), on drift derived from sandstones of the Eday Beds (No. 23) and drift derived from the Upper Old Red Sandstone (Nos. 17 and 22) and in the Saltings profile (No. 65).

In the Canisbay Association, particularly the gley soils, the laboratory textures sometimes differ quite markedly from the field textures, probably a consequence of the strongly weathered nature of much of the Canisbay drift; the weathered sandstones and flagstones break down under laboratory preparation to affect the textural balance. The presence of free calcium carbonate in a glacial drift (e.g. Nos. 36 and 39) may affect dispersion adversely and consequently texture.

The podzols are developed on parent materials with a wide range of textural class. Those of the Thurso Association sampled from the Sordale Complex (Nos. 14 and 15) have clay values of 4 percent and 21 percent while those profiles outwith the moraine complex (Nos. 8-13) show clay values between 7 percent and 24 percent. The podzols of the Canisbay Association have a similar wide range of texture with 9 percent clay in No. 5 and 23 percent clay in No. 6. It is difficult to relate to any specific trends in the distribution of clay within the profiles of the podzol group; No. 10 has a constant clay content value throughout, Nos. 5, 6, 8 and 16 show an increase in clay content with depth and Nos. 9 and 14 a decrease. Profiles Nos. 12 and 15 have maximum clay values in the Bx(g) and Bx horizon respectively and No. 13 a maximum in the E(g) horizon. Profile No, 11 has a maximum clay content in the C horizon but also an increase in the B(g) horizon. A number of podzols (Nos. 6, 8, 9, 11, 12, 15 and 16) have high U.S.D.A. silt values in the surface horizon.

The textural range of parent material appears to be just as wide in the peaty podzols of the Canisbay Association with a clay content of 10 percent in No. 19 and a clay value of 31 percent in No, 21. The variation in texture is not so broad in the Thurso Association with clay contents ranging from 13 percent to 19 percent (Nos. 27-29). Profiles Nos. 19, 23, 24 and 29 show a maximum clay content in the Eg or E(g) horizon and No, 25 in the E2 horizon. Profiles Nos. 27 and 28 have a clay value maximum in the B(g) and Bs horizon respectively and No. 22 in the Bs horizon. An increase in clay content down the profile is exhibited by Nos. 20 and 21. Profile No. 26 has a high U.S.D.A. silt content in the 2C horizon.

The alpine podzol (No. 17) shows a marked increase, to a maximum of clay in the B(g) horizon.

The noncalcareous gleys and peaty gleys are generally developed on parent materials with more than 20 percent clay but with a range of 13 percent clay to 31 percent clay. A maximal clay content in the Btg horizon is a feature of a number of the noncalcareous gleys and peaty gleys (Nos. 35, 36, 39, 49, 50, 51 and 56) while No. 31 shows a maximum in the BCt(g) horizon and Nos. 32, 40 and 53 in the BCg. Profiles Nos. 33, 38, 41, 43, 54 and 55 show an increase in clay content with depth.

In the noncalcareous gleys, minimum clay values usually occur in the surface horizon but in Nos. 40 and 42 the minimum appears in the AB horizon. Profiles Nos. 34 and 37 have minimum clay content in the Bg2 and Bg horizons respectively. In the peaty gleys, clay values are usually at a minimum in the Ah (Nos. 48 and 55), Eg (Nos. 49, 50, 51) and Egh (No. 56) horizon.

Profiles Nos. 38, 39 and 42 have high U.S.D.A. silt values throughout and No. 51, has a high silt content in the Btg and BCg horizon. Profiles Nos. 32 and 41 have high U.S.D.A. silt values in the surface horizon.

The saline gleys show great variation in texture, with clay values ranging from 9 percent (No. 45) to 41 percent (No. 47) but are most noteworthy for their high U.S.D.A. silt values.

High U.S.D.A. silt values occur in the Ag and. Cg horizons of the alluvium profile (No. 63).

Exchangeable Cations

Exchangeable Calcium

Free calcium carbonate occurs in the brown calcareous soils (Nos. 1 and 2) and calcareous gley (No. 30) of the Fraserburgh Association and in the Cg horizon and marl deposits of peat-alluvium profile (No. 64). Free calcium carbonate is also noted in the C(g) horizon of the Tresdale Series (No. 36) and in the C(g)2 horizon of the Thurso Series (No. 39).

The presence of free calcium carbonate results in anomalous readings for exchangeable calcium as the analytical leachate not only displaces calcium from exchange sites within the organic matter and clay mineral complex, but is responsible for some dissolution of the free calcium carbonate. Residues of applied lime are undoubtedly to some degree responsible for the high exchangeable calcium figures of many Ap horizons.

High (>8 m.e./100 g) levels of exchangeable calcium are present in organic soils (Nos. 57, 58 and the upper horizons of No. 59) and in the O or O1 horizons of many of the peaty podzols and peaty gleys (Nos. 21, 23, 25, 27, 49, 50, 51, 55 and 56), the alpine podzol (No. 18), the saline gleys (Nos. 44, 45 and 47), Morrich Series (No. 62), the saltings (No. 65) and in the buried organic horizons of Nos. 60, 62 and 64. These values, unlike those for soils or horizons containing free calcium carbonate, are a true measure of exchangeable calcium, but before they are in any way used as a measure of nutrient status, it must be remembered that all such values are calculated on a weight basis (m.e./100 g), and in low-density organic horizons root systems can only draw on a small weight of soil.

The peaty brown soil (No. 3) has low (<3 m.e./100 g) exchangeable calcium in the Ah and B horizon, with a minimum in the B. The C horizon shows an increase to a medium (3-8 m.e./100 g) value.

The podzols show low and medium levels except in the Ap or Ap(g) horizon where generally high values are a reflection of fertiliser practices and crop husbandry both past and present. Some of them (Nos. 5, 6, 8, 9, 15 and 16) show a decrease in exchangeable calcium down the profile but others (Nos. 10-14) have a minimum in the Bx or Bx(g) horizon, the indurated horizon, followed by an increase in the C. Profile No. 4 has low exchangeable calcium throughout with a maximum in the Ap horizon and a general decrease down the profile.

The peaty podzols have very low exchangeable calcium values below the organic surface horizons. The values in the O horizons are usually from medium to high, the O1 horizon being invariably higher in exchangeable calcium than the O2 or O3 horizon. Some of the peaty podzols (Nos. 19, 24 and 27) show a decrease in exchangeable calcium down the profile, while others, (Nos. 22, 23 and 29) have minimum values in the E(g) or Eg horizon, followed by an increase in value down the profile. In Nos. 26 and 28, a minimum value occurs in the Bs horizon, while Nos. 20 and 25 show a decrease in values down the profile to the bottom, which shows an increase.

The Ap(g) or Apg horizons of the noncalcareous gleys have medium to high levels of exchangeable calcium, the high levels again a consequence of fertiliser practices. Below the surface horizon, values generally range from low to medium but high exchangeable calcium is recorded in the Cg horizon of No. 34 and, as noted previously, free calcium carbonate is encountered at depth in Nos. 36 and 39. Within the noncalcareous gleys there is a strong tendency for a minimum to occur in the Bg or Btg horizons (Nos. 31, 32, 34-37, 39 and 42), and Eg horizon in No. 41. Profiles Nos. 33, 38 and 40 show minimum values in the BCg horizon. None of the noncalcareous gley profiles show a straight decrease in exchangeable calcium down the profile. The very poorly drained noncalcareous gleys (Nos. 53 and 54) show high values in the Ahg horizon, doubtless the result of flushing, and. medium values in the other horizons.

The peaty gleys show low values of exchangeable calcium beneath the organic surface horizons where values are generally high. The profiles are similar to those of the noncalcareous gleys in that a minimum usually occurs in the Bg horizon. Profiles Nos. 51 and 56 show however a minimum in the Eg horizon and a maximum in the Btg and Bg horizons; No. 55 shows a minimum in the Eg horizon and No. 45 shows a decrease in exchangeable calcium down the profile.

Exchangeable calcium values are low in the Links profiles, excluding buried A (bA) horizons, (Nos. 60 and 61) and show a decrease with depth.

Exchangeable Magnesium

The brown calcareous soils have mainly medium values (0.3-5.0 m.e./100 g) or high values (>5.0 m.e/.100 g) occurring in the HA horizon and in the lower BC horizon of No. 1. The peaty brown soil (No. 3) shows a medium values in the Ah and B horizon and a high value in the C.

Values in the podzols are generally in the medium range but low values occur in some B horizons (e.g. Nos. 9, 10 and 13). Many of the podzols (Nos, 8, 10, 11 and 13-15) have minimum values of exchangeable magnesium in the Bx or Bx(g) horizon. Profiles Nos. 5 and 6 show an increase in exchangeable magnesium down the profile. Profile (No. 4) has low values below the Ap horizon, the values decreasing with depth; a similar decrease down the profile is exhibited by Nos. 9 and 12.

Very high and high values of exchangeable magnesium are seen in the organic surface horizons of the peaty podzols. Sub-surface horizons show generally values within the medium range with occasional low values e.g. in the E(g) horizon of No. 23 and in the Bs horizon of No. 22. Profiles Nos. 25 and 27 show low values below the E2 and Eg horizon respectively.

Many of the peaty podzols (Nos. 19, 20, 23, 24, 26 and 29) show a minimum in the Eg or E(g) horizon; No. 28 has a minimum value in the Bs horizon. Profiles Nos. 25 and 27 show a decrease in exchangeable magnesium down the profile.

The calcareous gley (No. 30) shows medium values throughout. In the noncalcareous gleys the distribution of exchangeable magnesium strongly parallels that of exchangeable calcium. Medium (0.3-5.0 m.e./100 g) values are general with a minimum in the Bg horizon (e.g. Nos. 31, 32, 37-39, 42 and 54). Profiles Nos. 35, 36 and 40 have a minimum in the AB horizon and No. 41 shows a minimum in the Eg horizon. Profiles Nos. 33 and 34 show a minimum in the Ap(g) horizon.

The noncalcareous gleys show usually an increase in exchangeable magnesium down the profile below the horizon of minimum value, but Nos. 36 and 39 show a decrease in value in those C(g)2 and C(g) horizon samples containing free calcium carbonate. Profile No. 33 shows a straight increase in exchangeable magnesium down the profile.

The saline gleys (Nos. 44, 45 and 47) have very high values of exchangeable magnesium in the organic surface horizons. Values below the surface horizons are within the medium range and tend to show a decrease with depth. The peaty gleys similarly show high exchangeable magnesium in the organic surface horizons but low to medium values in the mineral soil. These profiles show a minimum in the Eg or Bg horizon. Values tend to increase below the horizon of minimum value but Nos. 52 and 55 show a decrease in exchangeable magnesium in the lower Cg horizon. Values of exchangeable magnesium are very high in the organic soils (Nos. 57-59).

Excluding buried A horizons, the Links soils (Nos. 60 and 61) show low to medium values with low values in the C horizon and a tendency for a decrease in exchangeable magnesium down the profile.

Exchangeable Sodium

The brown calcareous soils show high (>0.25 m.e./100 g) values throughout but with no discernible distribution trends within the profile. In the peaty brown soil (No. 3) high values of exchangeable sodium are seen in the Ah and the BC horizon with a medium (<0.05-0.25 m.e./100g) value in the B horizon.

High values of exchangeable sodium are a constant feature of the surface horizons of the podzols of the area with levels ranging from 0.29 m.e./100 g to 0.54 m.e./100g. Beneath the Ap or Ap(g) horizon, values of exchangeable sodium are generally within the medium range. Profile No. 4 shows low values below the AB horizon and Nos. 5 and 15 have high values throughout. Profiles Nos. 6, 10, 11, 13 and 15 show a minimum in the Bx or Bx(g) horizon but Nos. 4, 5, 9, 12 and 16 show a decrease in values with depth.

High values of exchangeable sodium are found in the O horizons of the peaty podzols. Medium values are general in the mineral horizons but low (<0.05 m.e./100 g) values are seen in No. 25, a soil developed on fluvioglacial sand. Values in the B(g) and C horizons of No. 23 are on the limit between low and medium. In many of the peaty podzols (Nos. 19 and 22-27), exchangeable sodium values decrease with depth. In No. 26 however there is a marked increase in exchangeable sodium in the 2C horizon. Profiles Nos. 20 and 29 have a minimum in the Eg horizon and No. 28, a minimum in the Bs.

As in the podzol group, the noncalcareous gleys with the exception of No. 40, show high values of exchangeable sodium in the Ap(g) or Apg horizon; they range from 0.25 m.e./100 g to 0.90 m.e./100 g. Values in the sub-surface horizons are within the medium to high range and Nos. 35 and 36 show high values throughout. The noncalcareous gleys show generally a minimum in the Bg or Btg horizon (e.g. Nos. 31-36, 38, 42 and 43) and an increase in value in the C(g) or Cg horizon. Profiles Nos. 37, 39 and 54 shows a decrease in exchangeable sodium with depth and in Nos. 40 and 41 values below the Ap horizon appear to be more or less constant. The calcareous gley (No. 30) shows high values throughout but with a minimum in the Bg horizon.

Not surprisingly the saline gleys (Nos. 44-47) and the saltings profile (No. 65) show very high values throughout. Further analysis of Nos. 46 and 47 shows water-soluble sodium to be similarly very high and that much of the sodium labelled exchangeable is in fact not on exchange sites, the leachate containing not only exchangeable sodium but also water-soluble sodium. Nevertheless exchangeable sodium is high in these soils. Values show a tendency to decrease down the profile (e.g. Nos. 45 and 46). In No. 47 also, values decrease with depth but only down to the BCg horizon where there is a marked increase.

The peaty gleys show high values of exchangeable sodium in the organic matter-rich surface horizons and generally medium values in the mineral soil. Trends are difficult to identify but No. 50, shows minimum values in the Btg, whilst Nos. 52 and 55 show a similar pattern in the Bg with values tending to increase in the BCg or Cg horizons.

Very high values of exchangeable sodium are exhibited by the organic soils and the Links soils show generally medium values decreasing with depth (e.g. Nos. 60 and 61).

Exchangeable Potassium

In the surface horizons of the brown calcareous soils values of exchangeable potassium are within the medium range (0.1-1.0 m.e./100 g) but values decrease to low (<0.1 m.e./100 g) in the sub-surface horizons. No trends in the distribution of exchangeable potassium are apparent. Values of exchangeable potassium in the peaty brown soil (No. 3) lie within the medium range with a minimum in the B horizon.

Values in the Ap horizon of the podzols are in the medium range while values below the Ap horizon vary from low to medium. The coarse-textured profile No. 4 and Nos. 12 and 14 show low values below the Ap horizon. No consistent trends in the distribution of exchangeable potassium are apparent but Nos. 6, 8 and 15 show a minimum in the Bx horizon and many of the profiles show an increase in the BC or C horizon. Profiles Nos. 5, 9 and 16 show a decrease in exchangeable potassium down the profile. The O horizons of the peaty podzols show medium to high (>l.0 m.e./100 g) values - with the exception of No. 27, which has low exchangeable potassium in the O2. In the mineral horizons values are generally medium, but Nos. 19 and 25-27 show low values in the mineral horizons, the Rackwick Series profile (No. 25), developed on fluvioglacial sands, showing particularly low values, in the C horizon. Many of the peaty podzols show minimum values in the E or Eg horizon but otherwise no trends are apparent.

The noncalcareous gleys show generally medium values of exchangeable potassium throughout, with an occasional low value in an AB, or Bg horizon. There is usually a minimum in the Bg horizon with an increase in value in the Cg (e.g. Nos. 31 32, 34, 36, 38-40 and 42): Nos. 41 and 54 have a minimum value in the Eg horizon and No, 35 has a minimum in the AB, again with an increase in value in the Cg. Profile No. 33 shows an increase down the profile while No. 37 shows a decrease in value with depth. The saline gleys have high exchangeable potassium in their organic horizons and medium values in the mineral horizons with perhaps a tendency for decrease with depth.

The peaty gleys have medium values in the O horizons and low to medium values in the mineral horizons. Many of the profiles (Nos. 49, 50, 51, 55 and 56) have minimum values in the Eg or Egh horizon and No, 48 has a minimum in the lower AB. The profiles tend to show an increase in exchangeable potassium in the BC, BCg or Cg horizon.

High values of exchangeable potassium appear in the surface horizons of the blanket peat profiles (Nos. 57 and 58) but a decrease in value down the profile, the decrease in No. 57 being to levels below the limit of determination. The basin peat (No. 59) shows high levels throughout.

Values in the Links soils (Nos. 60-62) are generally low below the surface horizon and decrease with depth. Low values of exchangeable potassium occur in the Cg horizon and marl layers of the peat-alluvium profile (No. 64).

Exchangeable Hydrogen

Exchangeable hydrogen values in all major soil subgroups tend to decrease with depth. There are however profiles and horizons with free calcium carbonate and, consequently, no exchangeable hydrogen, e.g. the brown calcareous soils Nos. 1 and 2, the calcareous gley No. 30, the lower C(g) horizons of the two noncalcareous gleys (Nos. 36 and 39) and the Cg horizon and marl layers of No. 64.

The highest values for exchangeable hydrogen occur in the organic surface horizons of all the major soil subgroups and throughout all horizons of the organic soils. High values are seen in the organic horizons of Profile No. 64 (Peat-Alluvium).

In the podzols there is generally a decrease in exchangeable hydrogen down the profile although Nos. 8 and 12 show a minimum in the Bx and Bx(g) horizon respectively. Profile No. 13, whilst conforming in general to the decrease in value down the profile shows a slight increase in exchangeable hydrogen in the lower C horizon. The humus-iron podzol, Boyndie Series (No. 4), has a low value in the E horizon but a marked increase in the AB horizon. Below the AB horizon, the values decrease normally.

Values for exchangeable hydrogen in the peaty podzols conform generally to the recognised decrease down the profile, but a number of profiles (Nos. 21, 25 and 26) show an increase in exchangeable hydrogen in the basal horizons. The values for the Eg horizon are somewhat variable and are largely dependent on organic matter content and texture. Profile No. 29 shows an increase in exchangeable hydrogen in the Eg1 horizon.

The noncalcareous gleys follow the general trend with a decrease in exchangeable hydrogen down the soil profile, but in some profiles (Nos. 31, 33, 35, 36, 38 and 39) there is a decrease to a minimum in the Bg or upper Bg horizon horizon with an increase in the lower Bg or BCg horizon; this increase is followed by the normal decrease in value in the C(g) or Cg horizon. Profile No. 34 shows the standard decrease in exchangeable hydrogen with depth with an increase in the Cg horizon. The peaty gleys conform well to the general pattern of decrease in value of exchangeable hydrogen with depth.

Percentage Base Saturation and pH

The pH is measured electrometrically in 1:2.5 soil suspensions in water and in M/100 $CaCl_2$. The values obtained by the latter method are lower and are related to the organic matter content of the soil sample, hydrogen ions being more readily displaced from exchange sites in the organic matter fraction by the $CaCl_2$ electrolyte. These values are believed to be closer to the effective pH of the solution in immediate contact with the soil particles, and are also more reproducible and less affected by seasonal variations in the concentrations of the soil solutions,

The brown calcareous soils and the calcareous gley are fully saturated and have high values (>6.5 in water). The pH values are medium (5.0-6.5 in water) throughout.

The podzols show generally moderate percentage base saturation throughout the profile (20-60%) although profile No. 4 has low values (20%) in the Bh, B and the upper BC horizons but with a marked increase in the lower BC and No. 8 has a high values (>60%) throughout. There is a tendency for a decrease down the profile to be followed by an increase in the BC, C(g) or C horizon. Profiles Nos. 9 and 12 however show a decrease in percentage base saturation with depth. The pH values in the podzols are generally medium and follow no consistent trend with commonly little variation in value throughout the profile. A low pH (< 5.0 in water) is seen in the E horizon of No. 4 and a high pH is noted in the Ap horizon of No. 5 and in the C(g) horizon of No. 6.

The percentage base saturation values in the peaty podzols vary usually from low to moderate with a minimum in the E or Eg horizon and a general increase in value in the BC or C horizon. Profile No. 22 has high percentage base saturation in the Bs and BC horizon. The pH values are low in the O, A and Eg horizons but tend to increase to medium values with depth.

The noncalcareous gleys show moderate to high values for percentage base saturation throughout and exhibit a general tendency for an increase with depth (Nos. 31, 34, 37, 39, 41 and 53). Two profile show minimum values in the AB horizon (Nos. 36 and 42) and several in the Bg or Btg horizon (Nos. 32, 35, 38 and 40); No. 33 shows a maximum percentage base saturation value in the Bg and Nos. 41 and 54 show minimum values in the Eg horizon. Profile No. 43 shows a decrease in value with depth to the 2Cg horizon where the value increases. The pH values range generally from medium to high and closely parallel the trends displayed by percentage base saturation, that is a general increase in value with depth or a minimum in the Bg horizon. Low values for pH occur in the AB and Bg horizons of No. 36.

The saline gleys show moderate to high percentage base saturation, No. 46 showing high values throughout. The pH values are low in the organic surface horizons but otherwise medium. Both percentage base saturation and pH distribution appear to show no consistent trends. It should be remembered that the figures listed for exchangeable bases result not only from those cations displaced from exchange sites by the leachate but also from water-soluble bases and that the percentage base saturation levels shown are anomalous.

The percentage base saturation values in the peaty gleys range from low to moderate with high values in the Btg and BC horizon of No. 50. A minimum usually occurs in the Eg horizon. The pH values are low in the organic surface horizons but tend to increase down the profile to medium values in the .BCg horizon. The peaty gleys parallel the peaty podzols in the trends shown by the distribution of percentage base saturation and pH.

The organic soils (Nos. 57-59) show moderate values of percentage base saturation and low pH values with little variation in both throughout the profile. The pH values in the Links soils (Nos. 60-62) are low to medium and tend to increase down the profile.

Total Phosphorus

Total phosphorus values in the brown calcareous soils are generally low (<100 mg P_2O_5/100 g). The HA horizon of No. 1 shows a medium value (100-300 mg P_2O_5/100 g). The peaty brown soil has medium values throughout with a minimum value in the B horizon.

Values for total phosphorus in the Ap or Ap(g) horizon of the podzols range generally from medium to high (>300 mg P_2O_5/100 g) with very high values noted in the Ap, A1 and A2 horizons of No. 16 (the deep-topped phase of the Bilbster Series). The values in the B and C horizons vary from low to medium. Profile No.4 has low total phosphorus throughout. The podzols show two main trends in the distribution of total phosphorus, namely a minimum in the Bx or Bx(g) horizons (Nos. 6, 8, 12 and 14) or a decrease in value with depth (Nos. 5, 9, 10 and 16). Profile No.4 has a minimum in the E horizon and No.13, a minimum in the E(g). Profile No. 11 shows a minimum in the B(g) horizon.

The alpine podzol (No. 17) shows low values throughout with a minimum in the Ah and A horizons. Values in the organic surface horizons of the peaty podzols vary from low to medium while values in the mineral horizons are usually low. The peaty podzols show the general trend of a minimum in the E or Eg horizon followed by an increase in value down the profile to a mineral-soil maxima, which is found usually in the BCx, BC or C horizon; in No. 28 the maximum value is in the Bs horizon.

The calcareous gley (No. 30), shows low values of total phosphorus below the HA horizon. The noncalcareous gleys have medium values of total phosphorus in the Ap(g) or Apg horizon and generally low to medium values in the sub-surface horizons with a minimum generally in the Bg horizon; the BCg, C(g) or Cg horizon usually have medium values. Profiles Nos. 35 and 40 have a minimum in the AB horizon and No. 41 shows a minimum in the Eg horizon.

Values in the saline gleys are low below the surface horizons and show no distinct trends. The peaty gleys show low to medium values of total phosphorus in the organic surface horizons and generally low values in the mineral soil. Minimum values occur in the. Eg horizon (Nos. 49-52), in the Bg (No.55 or Btg horizon (No. 56) and are usually followed by an increase in total phosphorus to sometimes medium valise in the BCg horizon. Profile No. 48 has a minimum in the ABh horizon.

In the organic soils values for total phosphorus are generally low although the surface horizon can have a medium value. Distribution trends are not clear but there is a tendency for a decrease in value with depth. Values are usually low or very low in the Links soils and very low values occur in the marl deposits of the peat-alluvium soil (No. 64).

Silicon, Aluminium and Iron

The mineral horizons of a number of selected profiles were further analysed by X-ray fluorescence spectrometry on fused glass discs (Norrish and Hutton, 1969) to determine the distribution of total iron (Fe_2O_3), aluminium Al_2O_3 and Silicon (SiO_2) throughout the profile.

The results and the molecular ratios SiO_2/R_2O_3, SiO_2/Fe_2O_3, SiO_2/Al_2O_3 and Al_2O_3/Fe_2O_3 are presented in Appendix 3. Although these ratios differ from the normal silica-sesquioxide ratios which are calculated on the composition of the clay fraction they are still a measure of the leaching and differential movement of sesquioxides (i.e. oxides of iron and aluminium as compared with silica, and thus enable a comparison to be made between profiles of a hydrologic sequence due to differences in the weathering processes.

In the Ocklester and Bilbster Series there is little evidence of differential movement of silica and sesquioxides. Silica tends to increase towards the surface whereas iron oxide and alumina decrease, the latter only slightly. The SiO_2/R_2O_3, SiO_2/Al_2O_3 and $SiO_2/Fe2O_3$ ratios all increase towards the surface of the profile, but the values do ot change a great deal. Even in the profile (No. 13) with an E horizon, the SiO_2/Fe_2O_3 ratio is only a little higher in the E(g) than it is in the Bx(g) horizon.

In the peaty podzols, (Warth Series) (Profile No. 19) and Camster Series (Profile No. 28), podzolisation processes are much more evident. The SiO_2/Fe_2O_3 ratio rises sharply in the Eg(h) and Eg horizons respectively and the SiO_2/Al_2O_3 and Al_2O_3/Fe_2O_3 ratios are at a maximum. These trends, coupled with the Fe_2O_3 contents being at a maximum in the BCx, Bs and BC horizons, indicate translocation from the E horizon and deposition in the B and BC. The alpine podzol, Trowieglen Series (Profile No. 17) also shows a maximum Fe_2O_3 in the B horizon.

The SiO_2 content of the gleys tends to increase towards the surface except in Profile No. 54 (Hunster Series) where it decreases. The content of Al_2O_3 shows more variable trends, changing little from horizon to horizon but decreasing markedly towards the surface in Profile No. 43 (Thurso Series) and Profile No. 48 (Canisbay Series) and increasing towarss the surface in Profile No. 39 (Thurso Series). Iron oxide is also variable but generally decreases towards the surface, particularly in the peaty gleys (Profile Nos. 48, 50 and 52). In Profile No. 50 (Lynedardy Series) considerable leaching of iron is illustrated in the sharp increase in the SiO_2/Fe_2O_3 and the Al_2O_3/Fe_2O_3 ratios in the E horizons (Eg1 and Eg2) with particularly high values for SiO_2/Fe_2O_3. The SiO_2/Fe_2O_3 ratio tends to increase towards the surface in all the gleys, reaching a maximum in an E horizon. The SiO2/R2O3 ratio shows little change between horizons of many of the gleys but does increase a little towards the surface in some, for example Profile No. 43 (Ness Series), Profile No. 48 (Canisbay Series) and Profile No. 50 (Lynedardy Series). Mousland Series (Profile No. 47) clearly has an inherited compositional difference in parent material of the basal horizon compared to the horizons above – there is much less SiO_2 and considerably more Fe_2O_3 and $Al_2\ O_3$ in the basal horizon.

Trace Elements

The trace element contents of samples from thirty-five representative profiles of twelve different associations have been determined spectrochemically using the methods described by Mitchell (1964). For the purposes of this report, the total trace element concentration in a profile has been assessed from the results of analysis of the mineral B and C horizons. Trace element contents in the B and C horizons, unlike those of the overlying A horizons, are largely unaffected by additions of lime, fertilisers, manures, pesticides, herbicides, waste materials or trace element treatments. The overlying horizons, comprising Ap horizons in cultivated profiles, may be modified by cultivation and manuring, while in uncultivated profiles the Aor E horizons are modified by the accumulation of organic matter or by leaching, or both. The B and C horizons of both cultivated and uncultivated profiles within any one association are comparable and can be assessed together. The mean trace element content of the B and C horizons of a profile or group of profiles of the same association is therefore referred to as the total content unless otherwise stated.

The contents of trace elements extractable by 0.43 M acetic acid (cobalt, chromium, nickel, lead, titanium and vanadium), 0.05 M EDTA (copper, manganese and zinc) or neutral M ammonium acetate (molybdenum), especially from the upper horizons (0-25 cm), provide an indication of the plant-available fraction and can be used for assessing the likelihood of problems arising from deficiencies or excesses. In the following accounts of the values obtained for the various associations, the numbers quoted refer to the profiles listed in Appendix 2.

Canisbay Association

Ten profiles of the association were analysed. These represent freely drained peaty podzols (Warth Series, Nos. 19 and 21), freely drained podzols (Ocklester Series, No.5); poorly drained noncalcareous gleys (Tresdale SeriesNos. 31, 32 and 33), poorly drained peaty gleys (Canisbay Series Nos. 35 and 48); very poorly drained noncalcareous gleys (Gaira SeriesNo.53) and very poorly draining peaty gleys Dalespot Series (No.55).

Total **cobalt** contents in the thirty B and C horizons range from <3 to 15, mean 7.1 mg/kg which suggests that there is a moderate risk of cobalt deficiency on these soils. There is a general tendency for total cobalt contents within each profile to be lowest in the uppermost horizon and to increase with increasing depth. Extractable cobalt contents are generally low or very low (i.e. <0.7 mg/kg) throughout the profiles but values increase in the gleyed subsoil horizons of the poorly and very poorly drained series. The mean extractable cobalt content in the five topsoils from cultivated profiles range from 0.12 to 0.63, mean 0.35 mg/kg, confirming that there is a likelihood of cobalt deficiency affecting grazing stock unless supplements are given. The effect of impeded drainage in mobilizing cobalt is evident in the A-horizon of the very poorly drained gley of the Gaira Series (No.53) and in the C horizon of the peaty gley of the Dalespot Series (No.55) where extractable cobalt levels are increased to 2 to 3 mg/kg.

Total **nickel** contents range from 4 to 60, mean 31 mg/kg and show a tendency to increase with increase in depth. Extractable nickel contents range widely from 0.02

to 2.5 mg/kg and greatest amounts are generally found in the gleyed subsoil horizons of profiles of the poorly and very poorly drained series.

Total **copper** contents range from <3 to 40, mean 15 mg/kg suggesting a low risk of copper deficiency affecting cereal growth and this is confirmed by the values for extractable copper. Extractable copper in the five cultivated surface horizons ranges from 1.6 to 3.0, mean 2.3 mg/kg which is classified as moderate with no deficiency expected in cereal crops. The mobilisation of copper due to impeded drainage is clearly evident in the gleyed subsoils of the poorly and very poorly drained profiles and in the peaty gley of the Dalespot Series (No.55), a value as great as 7.1 mg/kg is found.

Total **manganese** contents range very widely from 30 to 10,000 mg/kg, the highest value being in a gleyed horizon of the Tresdale Series profile (No.31) which contains black manganiferous concretions and shows a maximum of manganiferous staining. The mean total manganese content is 590 mg/kg. Strong accumulation of manganese at concentrations of at least 1500 mg/kg also occur in the lower horizons of profiles No.5, 21, 48 of the Ocklester, Warth and Canisbay Series. Leaching of manganese has probably taken place under acid soil conditions, pH (H_20) values throughout profiles Nos.21 and 48 being within the range 4.0 to 5.2. Extractable manganese values also vary widely both between profiles and within individual profiles and range from <1 to 1500 mg/kg. Highest values are generally in horizons with high total manganese contents. Values in the upper horizons of the five profiles with cultivated topsoils range from 37 to 460 mg/kg with a mean of 146 mg/kg which suggests little likelihood of manganese deficiency affecting crops. The soil pH values in the upper horizons of all profiles are 6.7 or below.

Total **molybdenum** contents are not high and fall between <1 and 2 mg/kg with a mean of 1.0 mg/kg. Extractable molybdenum values in upper horizons of the ten profiles range from 0.01 to 0.04, mean 0.02 mg/kg which suggests that molybdenum contents in herbage should normally be below 2 mg/kg and problems due to induced copper deficiency in animals are not likely to arise.

Total **chromium vanadium** and **titanium** contents fall within the narrow ranges of 60 to 80, 30 to 100 and 2500 to 3000 with mean values of 67, 66 and 2800 mg/kg respectively. There is little variation in the contents of all three of these elements throughout the mineral horizons of all the profiles but lower values are generally found in surface horizons due to the accumulation of organic matter. Extractable chromium concentrations are normally 0.5 mg/kg or less but can increase to around 1.5 mg/kg in some E and B horizons. Extractable vanadium and titanium are generally less than 1 and 0.3 mg/kg respectively, throughout the ten profiles.

Total lead contents range from 6 to 40, mean 13 mg/kg. Values are normally greatest in the uppermost horizon of each profile and show little change with increase in depth in underlying horizons. Extractable lead in the uppermost horizons of the ten profiles ranges from 0.2 to 2.3, mean 0.87 mg/kg. There has been some mobilization of lead due to impeded drainage with values as great as 2.6, 2.3 and 3.4 in the gleyed subsoils of Profiles No.48, 53 and 55, respectively. Extractable **zinc** values range widely from 0.11 to 43 mg/kg, highest values normally being found in the uppermost horizons of the profiles. Mobilization due to gleying can sometimes increase extractable values in subsoils to greater than those in their respective overlying topsoils, as found in profiles Nos.31, 32 and 33 which are all cultivated and also in profile No.53.

Darleith Association

One profile of this association was analysed representing the peaty brown soils of the Tomtain series (No.3).

Total **cobalt** contents range from 6 to 20, mean 13 mg/kg and extractable cobalt in the A horizon is 1.2 mg/kg. Cobalt deficiency affecting stock would not be expected on these soils. Total **nickel** contents range from 40 to 100, mean 70 mg/kg and, like cobalt, increase with increase in depth. Extractable nickel values throughout the profile range from 0.24 to 1.4, mean 0.65 mg/kg. Total **copper** contents range from 6 to 20, mean 13 mg/kg. Extractable copper values are 1.3 mg/kg in the A horizon decreasing to 0.24 and 0.47 in the B and BC horizons.

Total **manganese** contents range from 400 to 3000, mean 1700 mg/kg and the extractable manganese value in the A horizon is 63 mg/kg.

Total **molybdenum** contents are low throughout the profile at <1 mg/kg and the extractable value in the A horizon is 0.02 mg/kg which suggests that problems of induced copper deficiency in animals due to excess molybdenum are unlikely.

Total **chromium**, **vanadium** and **titanium** contents are 60 to 80, 40 to 60 and 3000 to 4000 with mean values of 70, 50 and 3500 mg/kg, respectively.

Extractable values of all three elements are less than 0.5 mg/kg throughout the profiles.

Total **lead** contents are greatest in the surface A horizon (25 mg/kg) and range from 6 to 8, mean 7 mg/kg in the B and C horizons. Extractable lead values are low, and in the A, B and BC horizons are 0.25, <0.13 and <0.10 mg/kg, respectively. Extractable **zinc** values decrease with increase in depth and in the same horizons are 9.1, 0.49 and <0.10 mg/kg, respectively.

Dunnet Association

Two profiles of this association were analysed representing the freely drained subalpine podzols of the Trowieglen Series (No. 17) and the peaty podzols of the Dunnet Series (No.22).

Total **cobalt** contents range from <3 to 6, mean 2.7 mg/kg, these low contents being consistent with the composition of the parent material which is drift derived from sandstones of Upper Old Red Sandstone age. Extractable cobalt values are also low throughout both profiles and range from <0.01 to 0.47, mean 0.13 mg/kg. The low total and extractable values suggest that there is a high risk of cobalt deficiency affecting stock grazing on these soils.

Total **nickel** contents range from 4 to 25, mean 16 mg/kg and extractable amounts throughout the profiles ar&low, <0.01 to 0.7, mean 0.16 mg/kg.

Total **copper** contents range from <3 to 6, mean 3.0 mg/kg. Extractable copper contents are 1.1 and 7.3 mg/kg, respectively, in the peaty surface horizons of the profiles but decrease sharply to around 0.2 mg/kg in underlying horizons. Copper may have been applied to the surface of the Dunnet Series profile No.22 because the total and extractable contents of 30 and 7.3 mg/kg, respectively, appear anomalously high compared with the other horizons.

Total **manganese** contents range widely from 30 to 1000, mean 410 mg/kg and extractable values are low throughout the profiles ranging from <1.0 to 20, mean 5.7 mg/kg. Both soils are acidic with pH values of 5.2 or less so manganese deficiency in crops would appear likely if soils of the Dunnet Series were to be limed and brought into cultivation.

Total **molybdenum** contents are 1 mg/kg or less throughout both profiles and extractable values in the E horizons are <0.01 mg/kg so problems due to molybdenum excess affecting animals appear unlikely.

Total **chromium**, **vanadium** and **titanium** contents are within the ranges 25 to 80, 30 to 60 and 1500 to 2500, mean 47, 36 and 2200 mg/kg. Extractable values are low and do not exceed 0.30, 0.33 and 0.10 mg/kg respectively, throughout both profiles.

Total **lead** contents are moderately high at 60 and 40 mg/kg in the peaty surface horizons of the profiles but in the mineral B and C horizons range from <3 to 15 with a mean of 7.1 mg/kg. Extractable lead values in surface horizons are 2.5 and 0.63 mg/kg respectively, and decrease sharply with increase in depth. Extractable **zinc** values, like those of lead, are greatest in the upper organic horizons (5.3 to 24 mg/kg) and decrease sharply in the underlying mineral horizons (<0.1 to 0.52 mg/kg).

Flaughton Association

One profile of this association was analysed representing the peaty podzols of the Flaughton Series (No.23).

Total **cobalt** contents are very low throughout the profile and are 3 or <3 mg/kg in the B and C horizons. The peaty upper horizons contain 1 or <1 mg/kg. These very low contents are consistent with the composition of the parent material drift which is derived from sandstones of the Eday beds. Extractable cobalt values throughout the profile are 0.13 mg/kg or less and average 0.08 mg/kg. The very low contents of both total and extractable cobalt suggest a high risk of cobalt deficiency in grazing stock.

Total **nickel** contents are also very low and range from 6 to 10, mean 8 mg/kg while extractable values throughout the profile range from 0.05 to 0.21, mean 0.10 mg/kg.

Total **copper** contents range from <3 to 6, mean 3 mg/kg and extractable values range from 0.13 in the Eg horizon to 1.1 mg/kg in the surface horizon, mean 0.46 mg/kg.

Total **manganese** contents are as low as 10 mg/kg in the peaty upper horizons but in the mineral B and C horizons range from 40 to 400, mean 290 mg/kg. Extractable manganese values throughout the profile range from <1.0 to 8.4 and average only 4.1 mg/kg. Soil pH values are low and range from 4.1 to 5.5.

Total **molybdenum** values are 1 mg/kg or less throughout the profile and extractable Mo in the Eg horizon less than 0.01 mg/kg so problems due to an excess of molybdenum appear unlikely.

Total **chromium**, **vanadium** and **titanium** ranges are 30 to 40, 20 to 40 and 2500 to 3000 with mean values of 38, 30 and 2630 mg/kg respectively. Greatest extractable amounts of all three elements occur in the B horizon of the profile and mean values for the whole profile are 0.14, 0.21 and 0.11 mg/kg, respectively.

Total l*ead* contents are 15 mg/kg in the surface horizon but fall to 3 or <3 mg/kg in the mineral B and C horizons. Extractable lead values range from <0.04 to 0.36 and average 0.13 mg/kg. Extractable **zinc** values are greatest in the surface horizon at 27 mg/kg but decrease sharply to 3 mg/kg in the underlying horizon and decrease further with increase in depth to <0.1 mg/kg.

Fraserburgh Association

Two profiles of this association were analysed representing the freely drained brown calcareous soil of the Fraserburgh Series (No.1) and the poorly drained calcareous gley of the Whitelinks Series (No.30).

Total **cobalt** contents range from <3 to 4, mean 1.9 mg/kg and are very low throughout both profiles, such low total cobalt contents being anticipated in soils developed on shelly sand. The low extractable contents throughout both profiles of 0.04 to 0.39, mean 0.25 mg/kg, combined with the high soil pH values of 7.4 to 9.0, suggest that there is a high risk of cobalt deficiency affecting stock on soils of these two series. The vegetation on both soils was permanent or rough pasture.

Total **nickel** contents range from <4 to 20, mean 8.0 mg/kg and the extractable values are generally low, ranging from <0.02 to 1.1 with a mean of 0.34 mg/kg.

Total **copper** contents range from <3 to 6, mean 2.3 mg/kg and are very low throughout both profiles. Extractable copper values, are 2.0 and 4.2 mg/kg respectively in the surface horizons but if the soils were brought into cultivation for cereal growth problems of copper deficiency could arise.

Total **manganese** contents range from 100 to 300, mean 230 mg/kg and show little change in content with increase in depth. Extractable manganese values in the upper horizons are 24 and 27 mg/kg, respectively, and tend to decrease with increase in depth. These moderately low levels and the relatively high pH of the soils suggest a high risk of manganese deficiency in crops grown on these soils.

Total **molybdenum** contents are 1 or <1 mg/kg throughout the profiles while extractable molybdenum values in the A horizons of the profiles are 0.04 and 0.02 mg/kg, respectively. At these levels herbage would normally contain <2 mg Mo/kg IJM and problems due to molybdenum excess should not arise.

Total **chromium**, **vanadium** and **titanium** cover the ranges 4 to 60, 40 to 80 and 400 to 3000 mg/kg, respectively with mean values of 16, 55 and 880 mg/kg. These are at the low end of the range for these elements due probably to the sandy nature of these soils. Extractable amounts of all three elements throughout the profiles are low and average 0.25, 0.07 and <0.13 mg/kg, respectively.

Total **lead** contents range from <3 to 4, mean 2.2 mg/kg with slightly greater contents of 6 and 8 mg/kg respectively in the surface horizons. Extractable lead contents tend to decrease with increase in depth and range from 0.09 to 4.0, mean 1.0 mg/kg. Extractable **zinc** contents are also greatest in the A horizons and values throughout the profiles range from 0.17 to 6.9, mean 1.3 mg/kg

Lynedardy Association

Two profiles of the association were analysed representing peaty podzols of the Millfield Series (No.24) and peaty gleys of Lynedardy Series (No.50).

Total cobalt contents in the four B and C horizons ranged from 3 to 20, mean 8.3 mg/kg. The BC horizon of profile No.24 had an anomalously high cobalt content of 20 mg/kg and contained black manganiferous streaks and concretions. Total cobalt in horizons overlying the B and C horizons contained 4 mg/kg or less. This suggests that there is a high risk of cobalt deficiency affecting grazing stock and the extractable cobalt contents support this. Values throughout both profiles range from <0.01 to 0.97 with a mean of 0.19 mg/kg. There has been some mobilisation of cobalt due to gleying in the subsoil horizons of profile No.24 but values in the surface horizons of Millfield series 0.21 mg/kg) and of Lynedardy Series (0.14 mg/kg), respectively, which strongly suggest the possibility of cobalt deficiency problems arising on these soils.

Total **nickel** contents range from 15 to 40 with a mean of 26 mg/kg and values tend to increase with increase in depth. Extractable nickel contents are low and range from 0.07 to 0.37 mg/kg throughout the profiles.

Total **copper** contents range from 4 to 20 with a mean value of 12 mg/kg. Copper deficiency affecting cereal crops appears unlikely, however, because extractable copper values in the topsoils are 2.5 and 3.5 mg/kg respectively and there has been a marked mobilisation of copper due to gleying in the subsoils of both profiles with values as high as 3.9 and 5.1 mg/kg respectively. Copper deficiency affecting animals is still a possibility, however, depending upon the amounts of molybdenum and sulphur in the herbage.

Total **manganese** contents range from 40 to 600, mean 210 mg/kg and contents tend to increase with increase in depth in both profiles. Extractable manganese values are low (<1 to 12 mg/kg) throughout the uncultivated profile No.50 but because the soil pH values are 5.0 or below, manganese deficiency affecting crops appears unlikely. Extractable manganese values in profile No.24 are moderately high and in the basal horizon, which has manganiferous streaks and concretions, is as high as 170 mg/kg.

Total **molybdenum** contents range from 2 to 10 mg/kg with a mean of 4.5 mg/kg which is moderately high compared with a normal total content of about 2 mg/kg. Extractable molybdenum contents in the Ap (Profile No. 24) and Eg (Profile No.50) horizons of the two profiles are 0.08 and 0.03 mg/kg which suggests that herbage contents could be as high as 3 mg/kg and the possibility of molybdenum-induced copper deficiency affecting animals cannot be discounted.

Total **chromium**, **vanadium** and **titanium** ranges are 25 to 80, 60 and 1250 to 3000 with mean values of 61, 60 and 2440 mg/kg, respectively, while extractable amounts throughout the two profiles average 0.39, 0.97 and 0.17 mg/kg, respectively.

Total **lead** contents range from 100 to 400 with a mean value of 280 mg/kg. This is very high when compared with a normal background level in topsoils of about 30 mg/kg. Lead contents increase with increase in depth in both profiles to 400 mg/kg in the BC horizons. Total and extractable lead values increase with increase in depth in both profiles and in the BC horizons, extractable values are as great as 130 and 160 mg/kg respectively. Gleying may account for the high proportion (up to 50 per cent) of the total lead contents that are extractable by acetic acid in the subsoil horizons. The presence of rocks of the granite-schist complex of the Moinian which occur in the drift of this association probably accounts for these very high lead contents which appear to be due to local mineralization. Extractable **zinc** values throughout both profiles range from 1.1 to 3.2 mg/kg but in the uncultivated peaty upper horizon of profile No.50 is as great as 47 mg/kg.

Rackwick Association

One profile of this association was analysed representing the peaty podzols of the Rackwick Series (No.25).

Total and extractable **cobalt** values are extremely low throughout the profile at <3 and 0.01 to 0.06 mg/kg, respectively. This is consistent with the nature of the soil parent material which is fluvioglacial sand and gravel. The soil pH values increase with increase in depth but are as low as 4.4 in the surface horizon. Soils of this association would be expected to be deficient in cobalt for animal health.

Total and extractable **nickel** contents are also very low being <4 and 0.02 mg/kg or less thoughout the profile. Total and extractable **copper** contents are 3 mg/kg or less and <0.1 to 0.48 mg/kg, respectively, and copper deficiency would be anticipated on soils of this series.

Total manganese contents range from 150 to 200, mean 170 mg/kg and extractable manganese values throughout the profile are as low as <1.0 to 5.3, mean 2.2 mg/kg. Manganese deficiency might be expected if soils of this series were brought into cultivation.

Total **molybdenum** contents throughout the profile range from 0.4 to 2 mg/kg and the extractable amount in the E horizon is 0.01 mg/kg so problems of molybdenum excess would not be anticipated.

Total **chromium**, **vanadium** and **titanium** range from 15 to 30, 10 to 15 and 1500 mg/kg, respectively, which are at the lower end of the ranges for these elements in soils. Extractable values for all three elements are 0.15 mg/kg or less throughout the profiles.

Total **lead** contents are 3 mg/kg or less and extractable values throughout the profile range from 0.06 to 0.19, mean 0.11 mg/kg. Extractable **zinc** values are greatest in the surface horizon at 13 mg/kg but decrease sharply to 0.1 mg/kg or less in underlying horizons.

Stromness Association

One profile of this association was analysed representing the peaty podzols of the Stromness Series (No.26).

Total **cobalt** contents are 15 mg/kg and extractable values, like those of the total, tend to increase with increase in depth. Extractable values in the upper O and Eg horizons are low at 0.12 and 0.04 mg/kg which suggests that there is a high risk of cobalt deficiency affecting animals grazing on such soils.

Total **nickel** in the BCx horizon is 30 mg/kg and extractable values throughout the profile are low ranging from 0.06 to 0.42, mean 0.18 mg/kg.

Total **copper** content ranges from 130 to 300, mean 215 mg/kg which is very high compared with a normal range for total copper in soils of 2 to 100 mg/kg. Total copper in the underlying Rw horizon of the profile is 1.2 per cent which to date is the greatest total copper value found in a soil sampled by the Soil Survey of Scotland. Extractable copper values throughout the profile are high at 10 mg/kg or greater and in the Rw horizon of the profile is as great as 1300 mg/kg. These anomalously high copper values are probably related to metamorphic activity in the under-lying rocks, the parent material of the profile being drift derived from rocks of the granite-schist injection complex of the Moinian with some sandstones of the Middle Old Red Sandstone.

Total **manganese** contents range from 900 to 1000, mean 950 mg/kg and the total manganese content in the Rw horizon of the profile is as great as 1.6 per cent. Extractable manganese values in the O and Eg horizons are low at 1.9 and <1.0 mg/kg, respectively, but increase sharply to 2600 mg/kg in the Rw horizon.

Total **molybdenum** contents are <1 to 3 mg/kg and in the Rw horizon 8.5 mg/kg. Total contents in the two uppermost horizons are <1 mg/kg, however, and extractable Mo in the Eg horizon is 0.02 mg/kg so problems in animals due to molybdenum excess would not be anticipated.
Total **chromium vanadium** and **titanium** contents are in the range 40 to 60, 60 and 2000 to 2500 mg/kg, respectively. Greatest extractable Cr and V values are in the Eg horizon at 0.47 and 1.0 mg/kg, respectively.

Total **lead** contents are 10 to 25 mg/kg, with 60 mg/kg in the Rw horizon. Extractable lead values throughout the profile range from 0.11 to 2.2, mean 1.1 mg/kg. Extractable **zinc** values are greatest in the surface horizon at 8.7 mg/kg and decrease sharply to <0.25 mg/kg in underlying horizons. The Rw horizon sample of this profile contains 350 mg/kg total and 2.5 mg/kg extractable zinc.

Total **nickel** contents are also very low and are <4 mg/kg throughout the profile. Extractable nickel ranges from 0.03 to 0.10, mean 0.06 mg/kg.

Total **copper** contents decrease with increase in depth and range from 3 to 4, mean 3.3 mg/kg. Extractable copper is 0.56 mg/kg in the surface horizon and <0.25 mg/kg in the underlying horizons. At these very low copper levels copper deficiency affecting cereals would be anticipated and leafy summer herbage grown on such soils would be likely to contain <4 mg Cu/kg DM.

Total **manganese** contents are 40 to 100, mean 80 mg/kg. Extractable manganese in the A horizon is 16 mg/kg and in the underlying horizons less than 1 mg/kg. The soil pH values are low at 4.8 to 5.5 and if such soils were to be limed prior to bringing them into arable production, there would be a high risk of manganese deficiency affecting crops.

Total **molybdenum** contents are within the normal range at <1 to 1, mean 0.66 mg/kg, respectively. Extractable molybdenum in the A horizon is <0.01 mg/kg so no problems due to high molybdenum affecting animal health would be anticipated.

Total **chromium**, **vanadium** and **titanium** fall within the ranges 8 to 10, 3 to 4 and 630 to 1500 mg/kg, with mean values of 9.3, 3.7 and 1140 mg/kg. These low levels reflect the sandy nature of the soil parent material. Extractable values for all three elements are 0.12 mg/kg or less throughout the profile.

Total **lead** contents are also low ranging from 10 mg/kg in the A horizon to <3 mg/kg in the underlying B and C horizons. Extractable lead values are 0.24 mg/kg in the A horizon and 0.08 to 0.11 mg/kg in the subsoils. Extractable zinc is also greatest in the S-horizon at 9 mg/kg decreasing sharply to 0.54 mg/kg or less in the subsoils.

Thurso Association

Ten profiles of the association were analysed. These represent the freely or imperfectly drained podzols, (Bilbster Series, Nos. 8, 11, and 15) and the peaty podzols (Camster Series, No.28); poorly drained noncalcareous gleys (Thurso series, Nos.38 and 39 and Ness Series, No.43), very poorly drained noncalcareous gleys (Hunster Series, No.54), the saline gleys of Mousland Series(No.46) and the peaty gleys of Olrig Series (No.51). All the profiles were under grass or heath vegetation.

Total **cobalt** contents in the twenty eight B and C horizons ranged from <3 to 30, mean 11.6 mg/kg which suggests that there could be a moderate risk of cobalt deficiency affecting stock grazing on these soils. Total contents tend to increase with increase in depth. The highly organic surface horizons of profiles Nos.28 and 51 are very low in total cobalt and contain 1 mg/kg or less. Extractable cobalt throughout the profiles ranges widely from 0.01 to 2.7, mean 0.70 mg/kg. The mean extractable cobalt content in the seven A horizons is 0.63 mg/kg which is low to moderate and suggests that cobalt deficiency affecting animals could arise particularly on the more freely draining series. There has been some mobilisation of cobalt due to gleying in the poorly drained subsoils of profiles Nos.38 and 39 of the Thurso Series and in No.43 of the Ness Series.

Total **nickel** contents range from 15 to 100, mean 49 mg/kg. Total contents tend to increase with increase in depth. Extractable values range from 0.05 to 2.6, mean 0.67 mg/kg and tend to decrease with increase in depth in the freely drained profiles and increase with increase in depth in the poorly drained profiles.

Total **copper** contents range from <3 to 40, mean 23.6 mg/kg which suggests that there is a low risk of copper deficiency on these soils. The horizons with lowest total copper contents are usually surface horizons particularly those rich in organic matter. Extractable copper values throughout all the profiles range widely from 0.20 to 11.0, mean 2.5 mg/kg and in the seven A horizon samples analysedm, averaged 2.7 mg/kg. This supports the figures for total copper and suggests that copper deficiency in cereals is unlikely if this crop were to be grown.

The mobilisation of copper due to poor drainage conditions is striking, as was found in soils of the Thurso Association in Caithness. The freely drained subsoils of the Blibster and Camster Series profiles contain around 1 mg/kg extractable copper, whereas in the gleyed subsoils of profiles Nos.38, 39, 43, 46, 51 and 54 extractable copper values are as great as 3.4, 4.6, 5.1, 2.6, 11.0 ad 6.4 mg/kg, respectively. In the two lowest horizons of the peaty gley (No.51) of the Olrig Series at least 50 per cent of the total copper contents are extractable by 0.05 M EDTA.

Total **manganese** contents range widely from 25 to 2000, mean 330 mg/kg which is at the lower end of the range for total contents in soils. Most values in Scottish soils fall within the range 50 to 4500 with an arithmetic mean of 800 mg/kg. The high value of 2000 mg/kg is in the BCg horizon of the profile No.43 (Ness Series) which contains frequent black manganiferous concretions - the next highest value being 800 mg/kg. Extractable manganese values also vary widely from <1 to 310, mean 34 mg/kg, the very high value of 310 mg/kg also being from the horizon in profile No.43 with frequent manganiferous concretions. Extractable manganese in the seven A horizon samples varies from 29 to 150 with a mean of 56 mg/kg. Most of the soils, including the upper horizons of all the profiles have soil pH values of below 6.5 so manganese deficiency problems in crops appear unlikely unless the soils are over-limed.

Total **molybdenum** contents range from <1 to 4, with a mean of 1.1 mg/kg. Most values throughout the profiles are 2 mg/kg or less although values as high as 5 and 6 mg/kg occur in the Ah horizon of the saline gley No.46 and in the Rw horizon of the non-calcareous gley No.43 respectively. Extractable molybdenum in the upper horizons of the profiles range from 0.01 to 0.04 mg/kg which are categorised as low and molybdenum contents in leafy herbage grown during August to October should not contain more than 2mg Mo/kg DM. The occasionally high total molybdenum found in profiles Nos. 43 and 46 suggest, however, that molybdenum-excess problems affecting animals could arise locally particularly on poorly drained soils or after liming.

Total **chromium**, **vanadium** and **titanium** contents fall within the narrow ranges of 60 to 100, 60 to 100 and 2000 to 4000, with mean values of 88, 91 and 3210 mg/kg, respectively. Total contents of all three elements change little with depth but do increase in value from low levels in the organic horizons. Extractable chromium throughout the profiles ranges from 0.02 to 1.4, with a mean of 0.40 mg/kg. Extractable vanadium ranges from <0.02 to 6.7 mg/kg and is often greatest in the uppermost horizons of the profiles. In the subsoils of all four freely drained profiles of the Bilbster and Camster Series extractable vanadium is <0.02 mg/kg but in the gleyed subsoil horizons of the poorly drained soils values can be as great as 5.6 mg/kg. Mobilisation of vanadium due to gleying is most marked in profiles No.51 of the Olrig Series and profile No.54 of the Hunster Series. Nearly all of the extractable titanium values are below the limit of detection of about 0.15 mg/kg and none exceeds the value of 0.45 mg/kg in the Ap(g) horizon of profile No.38 of the Thurso Series.

Total **lead** contents in nine of the profiles ranges from <3 to 40, mean 11 mg/kg. Profile No.43 of the Ness sSries is quite exceptional with the two lower horizons containing 1000 mg Pb/kg. This profile was sampled south-west of Stromness and its parent material may have been affected by the same mineralization which has increased the lead contents in profiles of the Lynedardy Association (Nos.24 and 50) to the north-west of Stromness. Extractable lead contents throughout the nine profiles range from 0.08 to 3.0, mean 0.83 mg/kg, whereas in profile No.43 it exceeds 80 mg/kg. There is some indication of mobilisation of lead due to gleying in the poorly drained subsoils of profiles Nos.38, 39, 51 and 54 where values increase to about 2 mg/kg compared with around 0.5 mg/kg in the corresponding freely drained soils. There has also been strong mobilisation of lead in the gleyed horizons of profile No.43. Extractable **zinc** values vary widely from <0.25 to 22, mean 2.1 mg/kg and values are generally greatest in the surface horizon of each profile. Mobilisation of zinc due to gleying is most evident in profiles Nos.43 and 51 of the Ness and Olrig Series respectively.

Alluvial Soils

Two profiles of this association were analysed representing the poorly drained No. 63 (Lochside Series) and the very poorly draine No. 64 (peat Alluvium).

Total **cobalt** in the seven B and C horizons analysed ranged from <3 to 15, mean 7.7 mg/kg. Extractable cobalt values in the upper horizons are 0.41 and 1.3 mg/kg, the former figure suggesting that cobalt deficiency is a possibility on soils of the Lochside Series. There has been considerable mobilisation of cobalt due to impeded drainage in the gleyed subsoil horizons of both profiles where values reach 1.7 and 6.6 mg/kg, respectively.

Total **nickel** contents range from <4 to 60, mean 31 mg/kg: the two lower horizons of profile No. 64 have anomalously low contents of <4 mg/kg but both are calcareous. Extractable nickel values, like those of cobalt, are generally lower in profile No. 63

than in profile No. 64 due probably to differences in drainage impedance. Extractable values range overall from 0.40 to 5.6 with a mean of 1.5 mg/kg.

Total **copper** contents range from 4 to 30 with a mean of 19 mg/kg suggesting that there is a low risk of copper deficiency affecting cereal growth on these soils and this is confirmed by the extractable copper values. In the uppermost horizons of both profiles, extractable copper values are 3.3 and 4.5 mg/kg, respectively, and these moderately-high values are maintained with increase in depth probably due to gleying. About 40 per cent of the total copper content is extractable in the gleyed subsoil horizons of the peat alluvium No. 64.

Total **manganese** contents range from 80 to 600, mean 270 mg/kg and contents tend to decrease with increase in depth in profile No. 63 and increase with increase in depth in profile No. 64. The soil pH values are much greater (6.2 to 7.1) in the three upper horizons of profile No. 63 than in corresponding horizons of profile No. 64 (3.3 to 5.4). Extractable manganese values, like those of the total, decrease with increase in depth in profile No. 63 but show the opposite effect in profile No. 64. Values throughout the profiles range from 0.45 to 41, mean 16 mg/kg and manganese deficiency in crops appears unlikely unless the soils are over-limed.

Total **molybdenum** contents range from <1 to 3, mean 1.3 mg/kg. The two lowest horizons of profile No. 64 which are calcareous contain 3 and 2 mg/kg. The moderately high extractable molybdenum value in the uppermost horizon of profile No. 64 suggests that leafy summer herbage could contain up to about 3 mg Mo/kg DM so the possibility of molybdenum excess affecting animals cannot be excluded on these soils.

Total **chromium**, **vanadium** and **titanium** contents cover the ranges 2 to 150, 40 to 100 and 250 to 4000 with mean values of 88, 77 and 2560 mg/kg, respectively. There appears to have been some mobilisation of chromium and vanadium due to gleying in both profiles, where extractable values are 0.24 to 0.91, mean 0.60 mg/kg and 0.40 to 7.2, mean 2.1 mg/kg, respectively. Extractable titanium values are all less than the limit of detection of around 0.15 mg/kg.

Total **lead** contents range from 2 to 8, mean 3 mg/kg and tend to be slightly greater in the uppermost horizons of the profiles. Extractable lead values throughout both profiles range from 0.09 to 1.27, mean 0.48 mg/kg.

Extractable **zinc** vales are very low throughout profile No. 63 (<0.25 to 0.40 mg/kg) while in profile No. 64 they range from 1.9 to 33 mg/kg.

Links Soils

One profile of this association was analysed representing the imperfectly drained Eigie Series (No.61).

The soil is developed on blown sand with little or no shell fragments and would be expected to have very low trace element contents. Total **cobalt** contents are <3 mg/kg throughout the profile and extractable cobalt values decrease with increase in depth from 0.26 mg/kg in the A horizon to 0.01 mg/kg in the Cg horizon. There would be a high risk of cobalt deficiency affecting animals grazing herbage growing on such soils.

Organic Soils

Two profiles representing the basin peats (No.59) and the hill peats (No.57) were analysed. Four samples of each peat were taken down to a depth of 115 cm and the loss-on-ignition values were 95 per cent or greater for all samples so all horizons of the profiles are included in calculating mean values.

Total and extractable **cobalt** values are all extremely low at <1 and 0.02 to 0.06 mg/kg, respectively. Both peats are very acid with pH values of 3.9 to 4.2. Total **nickel** contents are about 1 and extractable values <0.01 to 0.09 mg/kg. Total **copper** contents are within the range <1 to 3 mg/kg and extractable values are about 1.5 mg/kg in the surface horizons and close to 0.6 mg/kg in the underlying horizons.

Total **manganese** contents are extremely low and range from 2 to 10, mean 5 mg/kg, whereas extractable values range from 1.1 to 5.9 with a mean of 2.6 mg/kg.

Total **molybdenum** contents range from 0.2 to 0.5, mean 0.3 mg/kg and extractable values in the surface horizons were <0.01 and 0.02 mg/kg respectively.

Total **chromium**, **vanadium** and **titanium** contents were all extremely low relative to contents in mineral soils and averaged 1, 1.4 and 36 mg/kg, respectively. Extractable values for all three elements were generally less than 0.1 mg/kg.

Total **lead** contents showed the greatest changes with increase in depth in the two profiles. The two surface horizons contained 15 and 50 mg/kg, respectively, and these decreased to 6 mg/kg or less in underlying horizons. Extractable lead values ranged from 0.1 to 0.55 with a mean of 0.21 mg/kg. Extractable **zinc**, like extractable lead, was greatest in the surface horizon of the hill or blanket peat No.57 at 16 mg/kg, while in all other horizons it ranged from 0.35 to 0.91 mg/kg.

Summary

Owing to the nature of their parent material soils of the Dunnet, Flaughton, Fraserburgh, Rackwick and Links Associations and also the Organic soils have very low mean total cobalt and copper contents of 5 mg/kg or less, and deficiencies of cobalt affecting animals or copper affecting cereal growth could be anticipated on these soils. Although the mean total cobalt contents are greater in the much more extensive Canisbay and Thurso Associations, cobalt deficiency could also arise, particularly on soils of the more freely drained series. There is some risk of induced copper deficiency in animals caused by an excess of molybdenum on soils of the Lynedardy and Thurso associations. In none of the soils examined are problems due to excess uptake of nickel or lead by vegetation likely to arise.

Summary of Analytical Methods

1. The soil separates were determined by a modification of the hydrometer method (Bouyoucos, 1927a, 1927b)

2. The exchangeable cations were determined in a neutral normal ammonium acetate leachate, calcium, sodium and potassium being determined by flame photometry (Ure, 1954) and magnesium by direct photometry (Scott and Ure, 1958).

3. Exchangeable hydrogen was determined by electrometric titration of a neutral normal barium acetate leachate (Parker, 1929). pH was determined in an aqueous suspension and in M/100 calcium chloride by means of a glass electrode.

4. Total carbon was determined either by a wet combustion method using standard potassium dichromate solution (Walkley and Black, 1934), or by using a CHN analyser.

5. Total nitrogen was determined either by a semi-micro Kjeldahl method (Markham, 1942) or by using a CHN analyser.

6. Total phosphorus was determined by a colorimetric method using hydrazine sulphate, after fusing the soil with sodium carbonate (Muir, 1952).

7. Readily extractable amorphous and weakly crystalline siliceous and sesquioxidic materials were investigated by (a) extraction of the whole soil with potassium pyrophosphate solution (Bascomb, 1968) and (b) extraction of the clay fraction with 1M cold sodium carbonate solution (Mitchell *et al*,1971).

8. Hydroxyl activity was measured by the fluoride exchange test (Bracewell *et al*, 1970).

9. The trace elements were determined spectrochemically according to the method described by Mitchell (1964).

10. The mineralogy of the clay fractions was determined by differential thermal analysis and X-ray diffraction. Differential thermal curves were determined according to methods described by Mitchell and Mackenzie (1959).

References

Bascomb, C.L. (1968). Distribution of pyrophosphate-extractable iron and organic carbon in soils of various groups. J. Soil Sci., 19, 251-268

Birse, E.L. and Dry, F.T. (1970). Assessment of climatic conditions in Scotland. 1 Based on accumulated temperature and potential water deficit. Aberdeen: The Macaulay Institute for Soil Research

Bouyoucos, G.J. (1927a). The hydrometer as a new and rapid method for determining the colloidal content of soils. Soil Sci., 23, 319-329

Bouyoucos, G.J. (1927b). The hydrometer as a new method for the mechanical analysis of soils. Soil Sci., 23, 343-339

Bracewell, J.M., Campbell, A.S. and Mitchell, B.D. (1970). An assessment of some thermal and chemical techniques used in the study of the poorly-ordered alumino-silicates in soil clays. Clay Miner., 8, 325-335

Butler, B. E. (1980). Soil Classification for Soil Survey. Monographs on Soil Survey. Oxford. Clarendon Press.

Census 1971, Scotland - County Report - Orkney (1973). Edinburgh: H.M.S.O.

Crompton, E. (1956). The environmental and pedological relationships of peaty gleyed podzols. Trans. 6th Int. Congr. Soil Sci., Paris, E., 155-161

Fannin, N.G.T. (1970). The sedimentary environment of the Old Red Sandstone of western Orkney. Ph.D. thesis, University of Reading

FitzPatrick, E.A. (1956). An indurated soil horizon formed by permafrost. .J. Soil Sci., 7, 248-253

Flett, J.S. (1898). The Old Red Sandstone of the Orkneys. Trans. Roy. Soc. Edinb., 39, 383-424

Futty, D.W. and Dry, F.T. (1977). The soils of the country round Wick (Sheets 110, 116 and part 117). Mem. Soil Surv. Scot. Aberdeen: The Macaulay Institute for Soil Research

Glentworth, R. (1944). Studies on the soils developed on basic igneous rocks in central Aberdeenshire. Trans. Roy. Soc. Edinb., 61, Pt. 1, No. 5, 149-170

Glentworth, R. (1954). The soils of the country round Banff, Huntly and Turriff (Sheets 86 and 96). Mem. Soil Surv. Scot. Edinburgh: H.M.S.O.

Glentworth, R. and Muir, J.W. (1963). The soils of the country round Aberdeen, Inverurie and Fraserburgh (Sheets 77, 76 and 87/97). Mem. Soil Surv Scot. Edinburgh: H.M.S.O.

Goodier, R. and Ball, D.F. (1975). In The natural environment of Orkney. Ed R. Goodier. Edinburgh: Nature Conservancy Council, 47-56

Green, F.H.W. (1964). A map of annual average potential water deficit in the British Isles. J. Appl. Ecol., 1, 151-158

Hodgson, J.M. (Editor) (1974). Soil Survey Field Handbook. Soil Survey Technical Monograph No. 5. Harpenden

Jenny, H. (1941). Factors of Soil Formation. New York: McGraw Hill

Kellock, E. (1969). Alkaline basic igneous rocks in the Orkneys. Scott. J. Geol., 5, 140-153

Leask, A. (1938). Shell sand deposits in Orkney. J. Orkney Agri. Disc. Soc., 13, 55-56

Markham, R. (1942). A steam-distillation apparatus suitable for micro-Kjeldahl analysis. Biochem. J., 36, 790-791

Mather, A.S., Ritchie, W. and Smith, J.S. (1974). Beaches of Orkney. Report for Countryside Commission for Scotland: Department of Geography, University of Aberdeen

Miller, R. (1976). Orkney. London: Batsford

Mitchell, B.D. and Mackenzie, R.C. (1959). An apparatus for differential thermal analysis under controlled-atmosphere conditions. Clay Min. Bull., 4, 31-43

Mitchell, B.D. and Jarvis, R.A. (1956). The soils of the country round Kilmarnock (Sheet 22 and part 21). Mem. Soil Surv. Scot. Edinburgh: H.M.S.O.

Mitchell, B.D., Smith, B. F.L. and de Endredy, A.S. (1971). The effect of buffered sodium dithionite solution and ultrasonic agitation on soil clays. Israel. J. Chem., 9, 45-52

Mitchell, R.L. (1964). The spectrographic analysis of soils, plants end related materials. With addendum. Tech. Comm. Bur. Soil Sci., Harpenden, No. 44A

Muir, J.W. (1952). The determination of total phosphorus in soil with particular reference to the control of interference by soluble silica. Analyst, 77, 313-317

Munsell Color Company Inc. (1954). Soil Color Charts. Baltimore: Munsell Color Company Inc.

Mykura, W. with contributions by D. Flinn and F. May (1976). Orkney and Shetland. British Regional Geol. Surv. Edinburgh: H.M.S.O.

Norrish, K. and Hutton, J.T. (1969). An accurate X-ray spectrographic method for analysis of a wide range of geological samples. Geochim. Cosmochim. Acta, 33, 431-453

Parker, F.W. (1929). The determination of exchangeable hydrogen in soils. J. Amer. Soc. Agron., 21, 1030-1039

Peach, B.N. and Horne, J. (1880). The glaciation of the Orkney Islands. Q. J. Geol. Soc. Land., 36, 648-663

Plant, J.A. and Dunsire, A. (1974). The climate of Orkney. Clim. Memo. Met. Off. Edinb., No. 71

Romans, J.C.C.R. (1962). The origin of the indurated B3 horizon of podzolic soils in north-east Scotland. J. Soil Sci., 13, 141-147

Scott, R.O. and Ure, A.M. (1958). The determination of magnesium in solution by direct photometry. Analyst, 83, 361-369

Shellard, H.C. (1959). Averages of accumulated temperature and standard deviation of monthly mean temperature over Britain, 1921-1950. Prof. Noles. Met. Off., Lond., No. 125.

Soil Survey Staff (1951). Soil Survey Manual, U.S.D.A. Handbook No. 18. Washington: United States Department of Agriculture

Ure, A.M. (1954). The application of electronics to spectrochemistry. Thesis, University of Aberdeen

Walkley, A. and Black, l.A. (1934). An examination of the Degtjareff method for determining soil organic matter, and a proposed modification of the chromic acid titration method. Soil Sci., 37, 29-38

Wilson, G.V., Edwards, W., Knox, J., Jones, R.C.B. and. Stephens, J.V. (1935). The geology of the Orkneys. (Sheets 117-122). Mem. Geol. Surv. Scot. Edinburgh: H.M,S.O.

Appendix 1: Methods and Definitions

Soil Classification

The system of soil classification used in this publication is described in many of the Soil Survey of Scotland's previous publications. It is based principally on the recognition of typical examples of soil subgroups rather than on the definition of properties discriminating between groups; such types of classification are typological, as opposed to definitional (Butler, 1980).

Soil Profile Descriptions

The standard terms used in the descriptions of soil profiles are listed and defined briefly. They are mainly those of Soil Survey Staff (1951) and Hodgson (1974).

Slope

The terms used to describe slope are: gentle (0-3°), moderate (3-7°), strong (7-11°), moderately steep (11-15°), steep (15—25°) and very steep (>25°).

Drainage class

Drainage class is assessed from profile morphology, particular attention being paid to the amount of grey and ochreous mottling present. In general, well-drained soils have horizons with a uniform colour and little or no mottling, whereas soils with impeded natural drainage have ochreous or grey mottling, or both. The drainage classes recognized are: free, imperfect, poor and very poor.

Colour

The names and notations of the soil colours are those of the Munsell Soil Color Charts (Munsell Color Company, Inc. 1954).

Texture

Soil texture is a measure of the relative amounts of sand, silt and clay present in the mineral soil material of less than 2 millimetres in diameter. Texture is assessed in the field by working a moistened sample between finger and thumb and checked in representsative profiles by particle-size analysis in the laboratory.

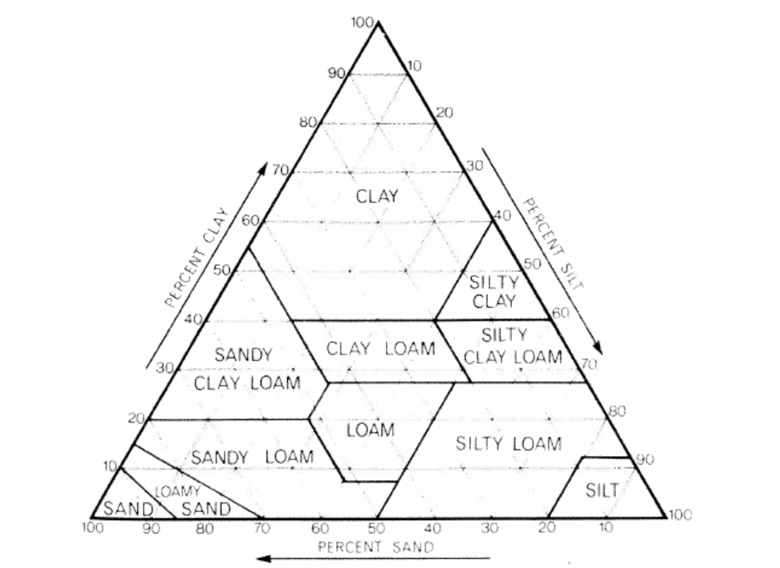
Two textural classifications based on different particle-size grades were in use at the time of the survey: United States of America Department of Agriculture (USDA) and the International Scheme. Early samples (approximately pre 1954) were analysed using solely the International size fractions, but post 1954 both schemes were adopted. The size fractions of each scheme are given in Table 11 below.

Table 12. U.S.D.A. and International Size Fractions

	U.S.D.A. Scheme		International Scheme
Name of Separate	Effective Diameter (range) µm		Effective Diameter (range) µm
Sand	2000-50		2000-20
Silt	50-2		20-2
Clay	<2		<2

The textural class names are ascertained from the triangular diagram (Figure 9) used in conjunction with the range of grain sizes established by the United States Department of Agriculture (USDA). Soil textures are assigned by noting the area in which the size grade composition occurs when plotted on the diagram.

Figure 6. Percentages of clay (<2 µm), silt (2 - 50 µm) and sand (50 – 2000 µm) in the basic U.S.D.A. soil textural classes



Stones

Terms describing frequency are: none (0 per cent volume), few (1 - 5 per cent), common (5 - 15 per cent), many (15 - 35 per cent), abundant (35 - 70 per cent) and very abundant (>70 per cent).

Sizes of stones are: very small (<6 millimetres diameter), small (6 millimetres - 2 centimetres), medium (2 - 6 centimetres), large (6 - 20 centimetres), very large (20 - 60 centimetres) and boulders (>60 centimetres).

Shape can be rounded, subrounded, subangular, angular or platy (tabular).

Structure

Structure is the aggregation of the primary soil particles into compound units (peds). Grade, size and shape are described. Grade refers to the degree of development: terms are structureless, weak, moderate and strong; soil horizons which are structureless are either massive or single-grain.

There are four main shapes of structure unit, each with five size classes.

Angular and subangular blocky structures have peds with three axes of about equal length. Neighbouring peds interlock. Sizes are very fine (<5 millimetres diameter), fine (5 - 10 millimetres), medium (10 - 20 millimetres), coarse (20 - 50 millimetres), and very coarse (>50 millimetres).

Crumb and granular structures also have peds with three axes of about equal length, but the peds do not interlock with their neighbours. The size ranges are very fine (<1 millimetre diameter), fine (1 - 2 millimetres), medium (2 - 5 millimetres), coarse (5 - 10 millimetres) and very coarse (>10 millimetres).

Prismatic structures have units in which the vertical axis is distinctly longer than the two horizontal axes. The sizes are very fine (<10 millimetres diameter), fine 10 -20 millimetres), medium (20 - 50 millimetres), coarse (50 - 100 millimetres) and very coarse (>100 millimetres).

Platy structures have units with the vertical axis much less than the two horizonal axes. Sizes are very fine (<1 millimetre thick), fine (1 - 2 millimetres), medium (2 - 5 millimetres), coarse (5 - 10 millimetres) and very coarse (>10 millimetres).

Consistence

Consistence is an expression of the degree of cohesion of the soil material. A different set of terms is used for each moisture state.

Consistence when wet is described in terms of plasticity (non-plastic, slightly plastic, plastic or very plastic) and stickiness (non-sticky, slightly sticky, sticky or very sticky).

Consistence when moist can be loose, very friable, friable, firm, very firm or extremely firm.

Consistence when dry (uncommon in Scottish soils) is either loose, soft, slightly hard, hard, very hard or extremely hard.

Cementation

Soil material can be cemented by substances such as calcium carbonate, humus, silica or compounds of iron, manganese or aluminium. The degree of cementation is described as weak, medium or strong.

Induration

Indurated horizons are compact, brittle, and are more resistant to vertical than to horizontal disruption. The terms for describing the degree of induration are weak, medium and strong.

Roots

The terms for describing size are: very fine (<1 millimetre diameter), fine (1 - 2 millimetres), medium (2 - 5 millimetres), coarse (5 - 10 millimetres) and very coarse (>10 millimetres).

Kind can be fleshy, fibrous or woody.

Root frequency, determined by estimating the number of very fine or fine roots in a l0 x 10 centimetres area of the vertical face of the soil profile, is described as: none (0 roots per l0 x 10 centimetres), few (1 - 10), common (10 - 25), many (25 - 200) or abundant (>200).

Horizon boundary

The boundaries between soil horizons are described as sharp (<2 centimetres), clear (2 - 5 centimetres), gradual (5 - 12 centimetres) or diffuse (>12 centimetres).

Soil Horizon Symbols

Master horizons

Master horizons are represented by capital letters. Arabic figures are used as suffixes to indicate vertical subdivision (e.g. Cl, C2).

Transitional horizons with properties of two master horizons are shown by the combination of two capital letters e.g. AE, EB, BC.

In layered parent materials Arabic numerals are used as symbol prefixes when it is necessary to distinguish lithological or textural contrasts (e.g. 2C when the C horizon differs from the material in which the solum (A and B) is presumed to have formed).

L Fresh annual litter, normally loose, plant structures obvious.
F Decomposed litter, only some of the original plant structures obvious.

H Well-decomposed organic matter formed under aerobic conditions.

Plant structures not visible. May be mixed with some mineral matter.(Mor humus).

O Peaty material formed under wet, anaerobic conditions.

A Mineral horizons formed at or near the surface that show an accumulation and incorporation of organic matter or which have a morphology acquired by soil formation but lack the properties of E or B horizons.

E Eluvial horizons underlying an H, 0 or A horizon from which they can be normally differentiated by a lower content of organic matter and lighter colour - particularly when dry. Usually they show a concentration of sand and silt fractions with a large component of resistant minerals resulting from a loss of clay, iron or aluminium.

B A mineral horizon in which there is little or no obvious rock structure and having one or both of the following:

(i) alteration of the original material involving solution and removal of carbonates; liberation or residual accumulation of silicate clays or oxides; formation of granular, crumby, blocky or prismatic peds; or (normally) some combination of these:

(ii) illuvial concentration of silicate clay or iron, aluminium or humus.

C A mineral layer of unconsolidated material from which the solum is presumed to have formed.

R Underlying consolidated bed-rock sufficiently coherent when moist to make hand digging with a spade impracticable.

Subhorizons

A lower case letter may be added to the capital letter to qualify the master horizon designation. More than one letter can be used if necessary, e.g. Bhs 1 indicates the first of the two horizons enriched in humus and sesquioxic material. Symbols may be bracketed if the feature development is weak.

b Buried (e.g. bA).

f Sharply defined thin iron pan.

g Horizon with gley features.

h Accumulation of organic matter in a mineral horizon (e.g. Ah or Bh).

m A cemented horizon, other than a thin iron pan.

p Disturbed by ploughing.

s Accumulation of sesquioxidic material.

t Accumulation of illuvial clay

w Alteration in situ in accordance with section (i) of the description of the B horizon.

x Indrated layer, compacted but not cemented.

APPENDIX 2: Standard Analytical Data

Brown Calcareous Soils – freely drained

Profile No. 1			Fraserburgh Association				Fraserburgh Series												Lab Numbers: 307707-12
			Soil Separates					Exchangeable Cations (m.e./100g.)						pH					
Horizon	Depth (cm)	Loss on Ignition	% Sand U.S.D.A.	% Silt U.S.D.A.	% Clay	% Silt Inter.	% Sand Inter.	Ca	Mg	Na	K	H	% Saturation	H_2O	$CaCl_2$	% Carbon	% Nitrogen	mg./100g. Total P_2O_5	Remarks
HA	1-8	37.7	N.D.	N.D.	N.D.	N.D.	N.D.	72.3	5.15	0.87	0.27	<0.1	100.0	7.6	7.2	13.50	0.93	172	High % loss on ignition except in 2Cg - the high losses resulting mainly from the destruction of free $CaCo_3$. Very high Ca and & Na throughout. High Mg in HA & BC2. Low K except in HA & 2Cg. High % saturation & pH throughout. Low total P_2O_5 except in HA and 2Cg.
Bh	12-16	32.2	N.D.	N.D.	N.D.	N.D.	N.D.	58.7	3.30	0.54	0.06	<0.1	100.0	7.8	7.5	9.12	0.71	98	
BC1	30-40	32.0	N.D.	N.D.	N.D.	N.D.	N.D.	56.1	3.65	0.59	0.06	<0.1	100.0	7.9	7.6	7.52	0.49	73	
BC2	65-75	43.7	N.D.	N.D.	N.D.	N.D.	N.D.	49.4	5.14	0.76	0.05	<0.1	100.0	8.2	7.7	8.99	1.25	59	
C	95-105	33.1	N.D.	N.D.	N.D.	N.D.	N.D.	40.1	3.12	0.49	0.07	<0.1	100.0	8.3	7.8	8.00	0.52	60	
2Cg	108-118	5.0	24	57	19	41	40	34.0	2.52	0.47	0.32	<0.1	100.0	7.9	7.5	1.51	0.21	106	

N.D. = No Data

Profile No. 2			Fraserburgh Association				Skeletal Soil												Lab Numbers: 267412-15
			Soil Separates					Exchangeable Cations (m.e./100g.)						pH					
Horizon	Depth (cm)	Loss on Ignition	% Sand U.S.D.A.	% Silt U.S.D.A.	% Clay	% Silt Inter.	% Sand Inter.	Ca	Mg	Na	K	H	% Saturation	H_2O	$CaCl_2$	% Carbon	% Nitrogen	mg./100g. Total P_2O_5	Remarks
A	3-9	8.2	95	3	2	1	97	50.7	2.90	0.71	0.13	0.65	100.0	7.5	7.2	4.69	0.25	69	High sand & low clay throughout. Very high Ca & high Na throughout. Low K below A. High % saturation & pH throughout. Low total P_2O_5 throughout. Free $CaCo_3$ throughout.
BC1	20-30	11.9	98	1	1	1	98	48.1	2.76	0.55	0.04	<0.1	100.0	8.3	7.7	6.32	0.05	44	
BC2	60-70	9.8	98	1	1	<1	99	45.8	2.66	0.51	0.03	<0.1	100.0	8.6	7.8	5.62	0.04	39	
C	100-110	10.1	98	1	1	<1	99	45.8	2.66	0.59	0.03	<0.1	100.0	8.5	7.9			38	

Peaty Brown Soils – freely drained

Profile No. 3			Darleith Association				Peaty Brown Soil												Lab Numbers: 301043-45
			Soil Separates					Exchangeable Cations (m.e./100g.)						pH					
Horizon	Depth (cm)	Loss on Ignition	% Sand U.S.D.A.	% Silt U.S.D.A.	% Clay	% Silt Inter.	% Sand Inter.	Ca	Mg	Na	K	H	% Saturation	H_2O	$CaCl_2$	% Carbon	% Nitrogen	mg./100g. Total P_2O_5	Remarks
Ah	3-13	23.0	89	7	4	6	90	1.69	2.69	0.58	0.60	28.6	16.4	5.1	4.4	11.00	0.50	154	High sand & low clay throughout. Low Ca in Ah & B. High Mg in BC. High Na in Ah & BC. Low % saturation in B
B	23-33	5.8	78	13	9	8	83	0.31	0.32	0.19	0.10	12.7	6.6	5.1	4.7	1.46	0.07	101	
BC	70-80	4.0	79	12	9	10	81	3.36	5.25	0.32	0.19	8.0	53.2	5.7	5.0			156	

Podzols – freely and imperfectly drained

Profile No. 4			Boyndie Association				Boyndie Series												Lab Numbers: 309028-33
			Soil Separates					Exchangeable Cations (m.e./100g.)						pH					
Horizon	Depth (cm)	Loss on Ignition	% Sand U.S.D.A.	% Silt U.S.D.A.	% Clay	% Silt Inter.	% Sand Inter.	Ca	Mg	Na	K	H	% Saturation	H_2O	$CaCl_2$	% Carbon	% Nitrogen	mg./100g. Total P_2O_5	Remarks
Ap	2-12	6.8	90	8	1	5	94	2.70	0.85	0.29	0.10	5.7	40.6	5.5	4.6	3.54	0.21	68	High sand & low clay throughout. Low Ca throughout; low Mg except in Ap. High Na in Ap but low Na in BC horizons. Low K below Ap. Low % saturation in Bh, B & BC1 horizon. Low total P_2O_5 throughout.
E	17-24	0.8	94	5	1	2	97	0.66	0.19	0.09	0.04	0.8	55.6	5.8	4.7	0.47	0.04	11	
Bh	28-38	3.7	91	5	4	3	93	0.74	0.19	0.15	0.05	9.1	10.8	5.2	4.2	1.69	0.06	34	
B	41-51	1.8	96	1	3	1	96	0.23	0.07	0.11	0.05	4.7	9.6	5.3	4.4	0.79	0.03	49	
BC1	70-80	1.0	97	2	1	<1	99	0.07	0.03	0.04	0.04	2.1	8.7	5.5	4.7	0.20	0.04	32	
BC2	100-110	0.9	97	3	<1	3	97	1.62	0.03	<0.03	0.07	2.0	45.9	5.3	4.7	0.17	0.02	38	

Profile No. 5			Canisbay Association				Ocklester Series												Lab Numbers: 257267-68
			Soil Separates					Exchangeable Cations (m.e./100g.)						pH					
Horizon	Depth (cm)	Loss on Ignition	% Sand U.S.D.A.	% Silt U.S.D.A.	% Clay	% Silt Inter.	% Sand Inter.	Ca	Mg	Na	K	H	% Saturation	H_2O	$CaCl_2$	% Carbon	% Nitrogen	mg./100g. Total P_2O_5	Remarks
Ap	10-20	7.1	60	33	3	18	76	6.9	1.07	0.52	0.45	7.2	55.4	6.6	5.9	3.91	0.39	311	Low clay throughout. High Na throughout. High pH throughout. High total P_2O_5 in Ap but low total P_2O_5 in BCx.
BCx	35-50	2.6	65	26	9	19	72	3.0	1.54	0.49	0.27	4.3	55.4	6.5	5.4			94	

Podzols – freely and imperfectly drained continued

Profile No. 6			Canisbay Association				Ocklester Series											Lab Numbers: 267530-32
Horizon	Depth (cm)	Loss on Ignition	Soil Separates					Exchangeable Cations (m.e./100g.)					% Saturation	pH		% Carbon	% Nitrogen	mg./100g. Total P_2O_5	Remarks
			% Sand U.S.D.A.	% Silt U.S.D.A.	% Clay	% Silt Inter.	% Sand Inter.	Ca	Mg	Na	K	H		H_2O	$CaCl_2$				
Ap	10-20	9.2	36	51	13	35	52	12.30	1.30	0.45	0.10	7.6	65.1	6.2	5.7	4.46	0.41	296	High U.S.D.A. silt in Ap. High Ca & Na in Ap. Low K in Bx. High pH in Bx and C(g). Low total P_2O_5 in Bx.
Bx	45-55	2.8	47	35	18	28	54	3.35	1.41	0.20	0.08	4.8	51.0	6.5	5.4	0.30	0.05	77	
C(g)	85-95	2.2	43	34	23	24	53	3.20	2.62	0.24	0.25	3.2	66.3	6.7	5.7	0.10	0.07	104	

Profile No. 7			Thurso Association				Bilbster Series (shallow phase)												Lab Numbers: 309062
Horizon	Depth (cm)	Loss on Ignition	Soil Separates					Exchangeable Cations (m.e./100g.)					% Saturation	pH		% Carbon	% Nitrogen	mg./100g. Total P_2O_5	Remarks
			% Sand U.S.D.A.	% Silt U.S.D.A.	% Clay	% Silt Inter.	% Sand Inter.	Ca	Mg	Na	K	H		H_2O	$CaCl_2$				
Ap	5-15	11.7	35	48	17	45	38	12.3	1.78	0.47	0.32	3.9	79.3	6.6	5.9	5.39	0.40	194	High U.S.D.A. silt. High Ca and Na. High pH.

Profile No. 8			Thurso Association				Bilbster Series												Lab Numbers: 309058-61
Horizon	Depth (cm)	Loss on Ignition	Soil Separates					Exchangeable Cations (m.e./100g.)					% Saturation	pH		% Carbon	% Nitrogen	mg./100g. Total P_2O_5	Remarks
			% Sand U.S.D.A.	% Silt U.S.D.A.	% Clay	% Silt Inter.	% Sand Inter.	Ca	Mg	Na	K	H		H_2O	$CaCl_2$				
Ap	5-15	13.1	35	54	11	39	50	17.00	1.70	0.53	0.24	4.1	82.6	6.4	6.0	6.65	0.59	212	High U.S.D.A. silt in Ap; high Na in Ap & Bx. High % saturation throughout. Low total P_2O_5 in Bx & C
Bx	20-30	4.1	40	41	19	28	53	5.72	0.51	0.26	0.13	1.7	79.5	6.4	6.1	0.63	0.09	84	
BC	35-45	4.2	45	34	21	28	51	4.51	1.13	0.20	0.16	2.4	71.5	6.3	5.8	0.64	0.10	101	
C	69-75	3.7	33	43	24	32	44	4.50	1.42	0.22	0.13	1.7	78.8	6.4	5.7	0.39	0.11	93	

Podzols – freely and imperfectly drained continued

Profile No. 9			Thurso Association				Bilbster Series												Lab Numbers: 290655-56
			Soil Separates					Exchangeable Cations (m.e./100g.)						pH					
Horizon	Depth (cm)	Loss on Ignition	% Sand U.S.D.A.	% Silt U.S.D.A.	% Clay	% Silt Inter.	% Sand Inter.	Ca	Mg	Na	K	H	% Saturation	H_2O	$CaCl_2$	% Carbon	% Nitrogen	mg./100g. Total P_2O_5	Remarks
Ap	5 -15	14.0	39	50	11	36	53	16.8	1.37	0.43	0.14	8.7	68.2	6.2	6.0	5.39	0.64	397	High U.S.D.A. silt in Ap. High Ca & Na in Ap. Low Ca, Mg & K in BCx. High total P_2O_5 in Ap.
BCx	35-45	4.3	63	27	10	18	72	1.8	0.25	0.13	0.07	4.9	31.9	6.0	5.5	0.84	0.12	140	

Profile No. 10			Thurso Association				Bilbster Series												Lab Numbers: 279707-10
			Soil Separates					Exchangeable Cations (m.e./100g.)						pH					
Horizon	Depth (cm)	Loss on Ignition	% Sand U.S.D.A.	% Silt U.S.D.A.	% Clay	% Silt Inter.	% Sand Inter.	Ca	Mg	Na	K	H	% Saturation	H_2O	$CaCl_2$	% Carbon	% Nitrogen	mg./100g. Total P_2O_5	Remarks
Ap	10-20	13.2	50	43	7	37	56	9.78	0.84	0.41	0.19	11.8	48.7	5.8	5.2	7.22	0.71	483	Low clay throughout. High Ca & Na in Ap. Low Ca, Mg & K in Bs & Bx. High total P_2O_5 in Ap.
Bs	28-38	5.3	56	34	7	28	62	2.29	0.16	0.15	0.04	6.9	27.4	5.7	4.9	1.09	0.12	153	
Bx	50-60	5.1	71	22	7	20	73	1.22	0.11	0.13	0.07	6.1	19.7	5.4	4.7	0.73	0.12	144	
C	90-100	4.2	71	22	7	18	73	3.36	1.20	0.15	0.10	5.6	46.2	5.4	4.5			117	

Profile No. 11			Thurso Association				Bilbster Series												Lab Numbers: 267510-13
			Soil Separates					Exchangeable Cations (m.e./100g.)						pH					
Horizon	Depth (cm)	Loss on Ignition	% Sand U.S.D.A.	% Silt U.S.D.A.	% Clay	% Silt Inter.	% Sand Inter.	Ca	Mg	Na	K	H	% Saturation	H_2O	$CaCl_2$	% Carbon	% Nitrogen	mg./100g. Total P_2O_5	Remarks
Ap	5-15	12.5	40	48	6	29	40	16.30	1.97	0.54	0.10	8.7	68.5	6.3	5.7	6.16	0.69	133	Low clay & high U.S.D.A. silt in Ap. High Ca in Ap & low Ca in Bx & C. High Na except in Bx; low K in B(g). Low total P_2O_5 in B(g).
B(g)	25-35	5.5	34	43	20	8	34	3.20	0.91	0.34	0.07	9.4	32.4	5.6	4.8	1.56	0.13	86	
Bx	45-55	2.8	41	42	17	28	41	1.06	0.75	0.18	0.17	5.6	28.2	5.3	4.4	0.17	0.07	126	
C	80-90	3.0	43	36	21	28	43	1.22	2.41	0.31	0.27	5.4	43.8	5.5	4.4			134	

Podzols – freely and imperfectly drained continued

Profile No. 12			Thurso Association				Bilbster Series												Lab Numbers: 279749-51
			Soil Separates					Exchangeable Cations (m.e./100g.)						pH					
Horizon	Depth (cm)	Loss on Ignition	% Sand U.S.D.A.	% Silt U.S.D.A.	% Clay	% Silt Inter.	% Sand Inter.	Ca	Mg	Na	K	H	% Saturation	H_2O	$CaCl_2$	% Carbon	% Nitrogen	mg./100g. Total P_2O_5	Remarks
Ap(g)	5-15	9.2	39	53	8	37	55	7.53	1.10	0.30	0.18	5.6	61.9	5.6	5.1	4.62	0.45	223	Low clay & high U.S.D.A. silt in Ap(g). High Na in Apg. Low K in Bx(g) and C. Low total P_2O_5 in Bx(g) & C.
Bx(g)	40-50	4.1	51	29	20	23	57	3.04	0.50	0.22	0.08	1.5	71.6	6.4	5.4	0.42	0.06	69	
C	80-90	3.0	54	30	16	27	57	3.34	0.50	0.13	0.08	3.3	55.4	6.1	5.2	0.22	0.05	95	

Profile No. 13			Thurso Association				Bilbster Series												Lab Numbers: 290701-05
			Soil Separates					Exchangeable Cations (m.e./100g.)						pH					
Horizon	Depth (cm)	Loss on Ignition	% Sand U.S.D.A.	% Silt U.S.D.A.	% Clay	% Silt Inter.	% Sand Inter.	Ca	Mg	Na	K	H	% Saturation	H_2O	$CaCl_2$	% Carbon	% Nitrogen	mg./100g. Total P_2O_5	Remarks
Ap(g)	2-8	18.7	49	38	13	27	60	15.20	2.88	0.46	0.83	13.1	59.6	5.6	5.5	8.67	1.46	168	High Ca in Ap(g) but low Ca below Ap(g). Low Mg in Bx(g). High Na in Ap(g). Low % saturation in Bx(g) & C1. Low total P_2O_5 in E(g) and Bx(g).
E(g)	12-18	5.4	44	41	15	30	55	1.20	0.59	0.17	0.13	7.3	22.3	5.5	4.7	1.42	0.22	74	
Bx(g)	35-45	4.3	49	37	14	27	59	0.21	0.21	0.08	0.16	5.8	10.8	5.2	4.6	0.67	0.21	90	
C1	80-90	4.4	59	31	10	27	63	0.25	0.43	0.09	0.20	5.2	16.1	5.2	4.6	0.46	0.25	103	
C2	140-150	3.7	57	33	10	27	63	0.61	1.42	0.18	0.29	5.3	32.1	5.4	4.4			128	

Profile No. 14			Thurso Association				Bilbster Series												Lab Numbers:2990630-33
			Soil Separates					Exchangeable Cations (m.e./100g.)						pH					
Horizon	Depth (cm)	Loss on Ignition	% Sand U.S.D.A.	% Silt U.S.D.A.	% Clay	% Silt Inter.	% Sand Inter.	Ca	Mg	Na	K	H	% Saturation	H_2O	$CaCl_2$	% Carbon	% Nitrogen	mg./100g. Total P_2O_5	Remarks
Ap	5-15	13.5	56	36	8	28	64	10.20	1.39	0.38	0.14	11.5	51.3	5.6	5.4	5.90	0.91	289	Low clay throughout. High Ca in Ap but low Ca below Ap. High Na in Ap. Low K except in Ap. Low total P_2O_5 in Bx(g).
Bx(g)	40-50	4.3	60	32	8	30	62	1.76	0.36	0.11	0.04	5.6	29.1	5.6	4.9	0.60	0.11	95	
C1	70-80	2.2	53	41	6	31	63	2.07	0.96	0.12	0.06	3.6	47.1	5.5	4.8	0.25	0.05	111	
C2	95-105	2.0	60	36	4	29	67	2.37	1.21	0.09	0.04	2.7	57.8	5.8	4.8			112	

Podzols – freely and imperfectly drained continued

Profile No. 15			Thurso Association				Bilbster Series												Lab Numbers: 267470-72
			Soil Separates					Exchangeable Cations (m.e./100g.)						pH					
Horizon	Depth (cm)	Loss on Ignition	% Sand U.S.D.A.	% Silt U.S.D.A.	% Clay	% Silt Inter.	% Sand Inter.	Ca	Mg	Na	K	H	% Saturation	H_2O	$CaCl_2$	% Carbon	% Nitrogen	mg./100g. Total P_2O_5	Remarks
Ap	5-15	12.6	33	51	16	43	41	11.70	2.21	0.48	0.24	10.4	58.4	6.0	5.4	5.39	0.45	225	High U.S.D.A. silt in Ap. High Ca in Ap; high Na throughout. High pH in Bx. Low total P_2O_5 in Bx & C.
Bx	40-50	5.2	45	32	23	23	54	3.83	0.71	0.32	0.17	6.5	43.5	6.5	5.6	0.86	0.13	92	
C	80-90	4.6	32	37	21	29	50	3.21	1.29	0.34	0.22	4.4	53.7	6.3	5.5	0.37	0.09	92	

Profile No. 16			Thurso Association				Bilbster Series												Lab Numbers: 290683-87
			Soil Separates					Exchangeable Cations (m.e./100g.)						pH					
Horizon	Depth (cm)	Loss on Ignition	% Sand U.S.D.A.	% Silt U.S.D.A.	% Clay	% Silt Inter.	% Sand Inter.	Ca	Mg	Na	K	H	% Saturation	H_2O	$CaCl_2$	% Carbon	% Nitrogen	mg./100g. Total P_2O_5	Remarks
Ap	5-15	14.0	35	54	11	42	47	15.10	1.54	0.44	0.22	9.6	64.3	6.4	6.0	5.73	0.79	660	High U.S.D.A. silt in Ap, A1 & A2 horizons. High Ca in Ap but low Ca below A1. Low Mg in A2. High Na in Ap. Low K in BCx. Very high total P_2O_5 in Ap, A1 & A2; high total P_2O_5 in B.
A1	30-40	11.2	31	55	14	45	41	3.09	0.35	0.23	0.21	15.8	19.8	5.6	4.9	5.98	0.53	700	
A2	50-60	8.6	24	59	17	44	39	1.69	0.18	0.23	0.27	16.6	12.6	5.4	4.8	3.65	0.40	1024	
B	80-90	6.8	50	32	18	29	53	1.68	0.31	0.14	0.13	11.6	16.5	5.5	4.9	1.53	0.26	426	
BCx	125-135	3.8	44	38	19	28	53	1.65	0.43	0.09	0.08	4.8	32.4	5.8	5.0			140	

Alpine Podzols – freely drained

Profile No. 17			Dunnet Association					Trowieglen Series											Lab Numbers: 290284-89
			Soil Separates					Exchangeable Cations (m.e./100g.)						pH					
Horizon	Depth (cm)	Loss on Ignition	% Sand U.S.D.A.	% Silt U.S.D.A.	% Clay	% Silt Inter.	% Sand Inter.	Ca	Mg	Na	K	H	% Saturation	H_2O	$CaCl_2$	% Carbon	% Nitrogen	mg./100g. Total P_2O_5	Remarks
HA	0-8	21.4	84	15	1	13	86	2.41	1.14	0.20	0.21	8.3	32.5	4.9	3.7	9.07	0.05	61	Low clay & high sand except in B(g). Low calcium throughout; low Mg, Na & K below HA. Low % saturation in A. Low pH except in C(g). Low toral P_2O_5 throughout.
A(h)	8-14	2.8	68	28	4	14	82	0.20	0.18	0.04	0.06	2.3	17.9	4.5	3.9	0.87	0.10	48	
A	14-24	2.1	90	8	2	6	92	0.08	0.09	<0.03	0.05	2.6	7.1	4.6	4.0	0.66	0.07	48	
B	40-50	1.4	84	8	8	5	87	0.15	0.07	<0.03	0.05	1.5	16.7	4.8	4.2	0.16	0.03	81	
B(g)	68-90	2.3	72	12	16	7	77	0.12	0.23	0.04	0.07	2.3	17.9	4.9	4.1	0.13	0.03	74	
C(g)	90-100	0.9	88	5	7	2	91	0.1	0.16	<0.03	0.04	0.5	37.5	5.2	4.4			65	

Profile No. 18			Thurso Association					Knitchen Series											Lab Numbers: 310962-63
			Soil Separates					Exchangeable Cations (m.e./100g.)						pH					
Horizon	Depth (cm)	Loss on Ignition	% Sand U.S.D.A.	% Silt U.S.D.A.	% Clay	% Silt Inter.	% Sand Inter.	Ca	Mg	Na	K	H	% Saturation	H_2O	$CaCl_2$	% Carbon	% Nitrogen	mg./100g. Total P_2O_5	Remarks
H	5-15	88.9	N.D.	N.D.	N.D.	N.D.	N.D.	10.00	15.70	4.49	2.14	112.5	22.3	3.9	3.0	48.00	1.86	219	Low clay & high sand in A. High exchangeable cations in H & high Na in A, low Ca in A. Low % saturation in A, low pH throughout. Low total P_2O_5 in A.
A	30-50	9.0	84	14	2	7	91	0.43	0.38	0.32	0.13	16.6	7.2	4.4	3.3	5.05	0.60	88	
N.D. No Data																			

Peaty Podzols – freely or imperfectly drained below pan

Profile No. 19			Canisbay Association				Warth Series												Lab Numbers: 267427-30
			Soil Separates					Exchangeable Cations (m.e./100g.)						pH					
Horizon	Depth (cm)	Loss on Ignition	% Sand U.S.D.A.	% Silt U.S.D.A.	% Clay	% Silt Inter.	% Sand Inter.	Ca	Mg	Na	K	H	% Saturation	H_2O	$CaCl_2$	% Carbon	% Nitrogen	mg./100g. Total P_2O_5	Remarks
O	3-12	76.4	N.D.	N.D.	N.D.	N.D.	N.D.	6.20	12.00	3.59	1.41	82.7	21.9	4.2	3.5	43.70	1.41	133	Low clay in BCx. High Mg, Na & K in O; high Na in Eg(h). Low Ca & K below O. Low % saturation in Eg(h) and Eg. Low pH in O & Eg(h). Low total P_2O_5 in Eg(h) & Eg.
Eg(h)	17-27	8.5	43	41	12	21	63	0.61	0.62	0.32	0.06	17.5	8.4	4.5	3.9	3.41	0.17	47	
Eg	32-42	4.0	55	28	15	20	63	0.15	0.33	0.15	0.08	8.0	8.1	5.2	4.2	1.18	0.14	52	
BCx	62-72	2.7	60	30	10	20	70	0.07	0.50	0.07	0.08	5.6	14.3	5.2	4.2			120	
N.D. = No Data																			

Profile No. 20			Canisbay Association				Warth Series												Lab Numbers: 267436-41
			Soil Separates					Exchangeable Cations (m.e./100g.)						pH					
Horizon	Depth (cm)	Loss on Ignition	% Sand U.S.D.A.	% Silt U.S.D.A.	% Clay	% Silt Inter.	% Sand Inter.	Ca	Mg	Na	K	H	% Saturation	H_2O	$CaCl_2$	% Carbon	% Nitrogen	mg./100g. Total P_2O_5	Remarks
O	1-10	30.8	N.D.	N.D.	N.D.	N.D.	N.D.	3.42	5.73	1.10	0.49	36.9	22.5	4.2	3.3	17.40	0.76	47	Low clay & high sand in Ah. High Mg & Na in O. Low Ca below O. Low Mg in Eg & low K in Ah & Eg. Low % saturation in Eg. Low pH in O & Ah. Low total P_2O_5 throughout.
Ah	17-27	3.7	85	8	7	19	74	0.40	0.57	0.15	<0.02	8.2	11.8	4.9	3.7	1.50	0.28	30	
Eg	30-34	2.5	58	30	12	12	76	0.17	0.20	0.07	0.03	6.2	7.5	5.0	4.1	0.57	0.04	40	
B(g)	38-48	2.5	58	24	18	14	68	0.15	0.33	0.11	0.16	6.6	10.8	5.1	4.1			66	
C(g)1	72-82	2.2	62	19	19	12	69	0.12	0.37	0.09	0.10	5.4	11.5	5.2	4.1			87	
C(g)2	112-122	2.0	62	22	16	16	68	0.20	0.75	0.11	0.10	4.9	19.7	5.2	4.2			88	
N.D. = No Data																			

Peaty Podzols – freely or imperfectly drained below pan continued

Profile No. 21			Canisbay Association				Warth Series												Lab Numbers: 257332-37
			Soil Separates					Exchangeable Cations (m.e./100g.)						pH					
Horizon	Depth (cm)	Loss on Ignition	% Sand U.S.D.A.	% Silt U.S.D.A.	% Clay	% Silt Inter.	% Sand Inter.	Ca	Mg	Na	K	H	% Saturation	H_2O	$CaCl_2$	% Carbon	% Nitrogen	mg./100g. Total P_2O_5	Remarks
O	2-12	93.8	N.D.	N.D.	N.D.	N.D.	N.D.	8.54	13.91	3.39	1.88	95.8	22.4	4.0	3.4	49.30	0.82	106	Low clay & high sand in Ah. High Ca, Mg & K in O; high Na throughout. Low Ca below O. Low % saturation in E. Low pH except in BC(g). Low total P_2O_5 in Ah, E & B(g).
Ah	12-17	14.8	70	16	7	6	80	0.81	1.50	0.58	0.23	17.2	15.4	4.1	3.4	10.20	0.36	57	
E	17-22	4.7	63	20	15	12	71	0.13	0.42	0.38	0.10	10.3	9.1	4.4	3.7	2.69	0.28	42	
B(g)	26-35	2.6	49	24	27	16	57	0.05	0.38	0.36	0.22	7.5	11.9	4.8	4.0			86	
BC(g)	46-56	3.6	27	43	31	14	55	0.13	0.80	0.47	0.33	15.3	10.2	5.0	4.0			113	
Rw	67-77	3.9	21	47	33	39	29	0.13	0.96	0.39	0.32	7.8	18.8	4.9	4.1			121	
N.D. = No Data																			

Profile No. 22			Dunnet Association				Dunnet Series												Lab Numbers: 301031-35
			Soil Separates					Exchangeable Cations (m.e./100g.)						pH					
Horizon	Depth (cm)	Loss on Ignition	% Sand U.S.D.A.	% Silt U.S.D.A.	% Clay	% Silt Inter.	% Sand Inter.	Ca	Mg	Na	K	H	% Saturation	H_2O	$CaCl_2$	% Carbon	% Nitrogen	mg./100g. Total P_2O_5	Remarks
O1	2-7	51.9	N.D.	N.D.	N.D.	N.D.	N.D.	3.20	6.65	1.26	0.90	48.1	20.0	4.5	3.6	22.90	0.86	105	Low clay & high sand in Eg & BC. High Mg in O1; high Na in O1 & O2. Low Ca below O1; low Mg in Bs & low K in Eg. Low % saturation in Eg but high % saturation in Bs & BC. Low pH in O1, O2 & Eg. Low total P_2O_5 below O1.
O2	15-25	61.1	N.D.	N.D.	N.D.	N.D.	N.D.	2.25	4.11	0.97	0.65	47.3	14.5	4.6	3.6	32.50	1.23	96	
Eg	42-52	1.9	82	8	10	7	83	0.20	0.31	0.13	0.08	7.9	8.1	4.6	3.9	0.44	0.04	48	
Bs	79-89	2.1	71	11	18	8	74	0.23	0.22	0.09	0.10	<0.1	92.9	5.1	4.3	0.12	0.02	74	
BC	127-137	1.3	85	6	9	5	86	0.28	0.54	0.09	0.10	<0.1	95.5	5.1	4.4			44	
N.D. = No Data																			

Peaty Podzols – freely or imperfectly drained below pan continued

Profile No. 23			Flaughton Association					Flaughton Series											Lab Numbers: 279605-11
			Soil Separates					Exchangeable Cations (m.e./100g.)						pH					
Horizon	Depth (cm)	Loss on Ignition	% Sand U.S.D.A.	% Silt U.S.D.A.	% Clay	% Silt Inter.	% Sand Inter.	Ca	Mg	Na	K	H	% Saturation	H_2O	$CaCl_2$	% Carbon	% Nitrogen	mg./100g. Total P_2O_5	Remarks
O1	1-9	93.1	N.D.	N.D.	N.D.	N.D.	N.D.	12.60	18.10	4.20	2.97	99.4	27.9	4.1	3.5	49.10	1.94	167	High sand & low clay throughout. High Ca & K in O1; high Mg in O1 & O2, high Na throughout organic horizons. Low Ca below O2; low Mg in E & E(g). Low % saturation in E & E(g). Low pH above B(g). Low total P_2O_5 below O1.
O2	13-19	94.4	N.D.	N.D.	N.D.	N.D.	N.D.	6.79	11.80	2.81	0.89	89.8	19.9	4.3	3.5	53.80	2.03	87	
O3	24-34	64.2	N.D.	N.D.	N.D.	N.D.	N.D.	1.93	3.99	1.22	0.39	54.8	12.0	4.7	3.5	37.10	0.90	97	
E	40-50	5.9	72	21	7	15	78	0.41	0.69	0.22	0.08	13.4	9.5	4.6	3.7			33	
E(g)	59-69	3.8	75	16	9	14	77	0.15	0.19	0.11	0.05	7.7	6.1	4.9	4.2			30	
B(g)	84-94	1.3	83	10	7	7	86	0.29	0.48	0.06	0.17	3.2	23.8	5.4	4.3			40	
C	114-124	0.8	90	7	3	5	92	0.34	0.52	0.05	0.14	2.3	32.3	5.4	4.3			45	
N.D. = No Data																			

Profile No. 24			Lynedardy Association					Millfield Series											Lab Numbers: 309024-27
			Soil Separates					Exchangeable Cations (m.e./100g.)						pH					
Horizon	Depth (cm)	Loss on Ignition	% Sand U.S.D.A.	% Silt U.S.D.A.	% Clay	% Silt Inter.	% Sand Inter.	Ca	Mg	Na	K	H	% Saturation	H_2O	$CaCl_2$	% Carbon	% Nitrogen	mg./100g. Total P_2O_5	Remarks
Ap	5-15	9.8	60	28	12	18	70	8.38	1.40	0.36	0.16	7.8	56.9	5.6	5.2	5.69	0.33	151	High Ca in Ap but low Ca below Ap. High Na in Ap and Eg. Low total P_2O_5 in Eg.
Eg	30-40	3.2	61	21	18	16	66	2.99	0.52	0.26	0.13	3.6	52.0	6.0	5.0	0.71	0.06	81	
BC	75-85	2.1	60	25	15	16	69	2.10	0.55	0.13	0.13	2.5	53.7	5.9	5.1	0.21	0.03	106	

Peaty Podzols – freely or imperfectly drained below pan continued

Profile No. 25			Rackwick Association				Rackwick Series												Lab Numbers: 301053-59
			Soil Separates					Exchangeable Cations (m.e./100g.)						pH					
Horizon	Depth (cm)	Loss on Ignition	% Sand U.S.D.A.	% Silt U.S.D.A.	% Clay	% Silt Inter.	% Sand Inter.	Ca	Mg	Na	K	H	% Saturation	H_2O	$CaCl_2$	% Carbon	% Nitrogen	mg./100g. Total P_2O_5	Remarks
O1	10-20	94.2	N.D.	N.D.	N.D.	N.D.	N.D.	8.79	23.40	3.15	1.95	93.3	28.6	4.4	3.5	42.40	0.71	91	High sand & low clay throughout below O2. High Ca, Mg, Na & K in O1 & high Mg & Na in O2. Low Ca & K below O2; low Mg & Na in Bs, C1 & C2. Low % saturation in C2. Low pH above Bs. Low total P_2O_5 throughout.
O2	30-40	71.6	N.D.	N.D.	N.D.	N.D.	N.D.	3.21	14.20	2.52	0.38	65.5	23.7	4.6	3.4	38.90	0.67	40	
E1	47-53	1.5	88	7	5	6	89	0.17	0.57	0.11	0.06	7.0	11.4	4.9	3.8	0.73	0.04	31	
E2	57-63	3.2	88	6	6	6	88	0.15	0.37	0.11	0.06	6.0	10.5	4.9	3.9	1.04	0.03	40	
Bs	70-80	0.6	98	1	1	1	98	0.07	0.12	0.03	0.03	1.8	14.3	5.2	4.4	0.13	0.02	15	
C1	95-105	0.6	98	2	<1	2	98	0.06	0.08	0.04	0.04	1.5	11.8	5.7	5.0	0.12	0.02	13	
C2	145-155	0.4	99	1	1	<1	99	0.14	0.04	<0.03	<0.02	2.0	9.1	5.8	5.3			17	
N.D. = No Data																			

Profile No. 26			Stromness Association				Stromness Series												Lab Numbers: 317212-16
			Soil Separates					Exchangeable Cations (m.e./100g.)						pH					
Horizon	Depth (cm)	Loss on Ignition	% Sand U.S.D.A.	% Silt U.S.D.A.	% Clay	% Silt Inter.	% Sand Inter.	Ca	Mg	Na	K	H	% Saturation	H_2O	$CaCl_2$	% Carbon	% Nitrogen	mg./100g. Total P_2O_5	Remarks
O	1-5	61.0	N.D.	N.D.	N.D.	N.D.	N.D.	3.45	5.28	1.71	0.80	80.4	12.2	4.3	3.6	33.90	1.48	137	High silt in Rw. High Mg & Na in O. High Na in Rw. Low Ca & K below O. Low % saturation in Eg; low pH throughout. Low total P_2O_5 in Eg, Bs & Rw.
Eg	13-23	5.8	49	39	10	27	61	0.42	0.45	0.21	0.09	12.6	8.7	4.6	4.2	2.40	0.44	62	
Bs	36-46	3.2	54	29	17	21	62	0.31	0.45	0.20	0.09	5.3	15.9	4.6	4.4	0.49	0.08	99	
BCx	58-68	2.5	58	29	13	21	66	0.36	0.52	0.17	0.09	2.8	28.2	4.8	4.5	0.33	0.06	102	
Rw	101-111	16.0	15	66	19	59	22	0.89	0.66	0.33	0.04	5.2	26.8	4.7	4.8	5.91	0.31	55	
N.D. = No Data																			

Peaty Podzols – freely or imperfectly drained below pan continued

Profile No. 27			Thurso Association				Camster Series												Lab Numbers: 279741-45
Horizon	Depth (cm)	Loss on Ignition	Soil Separates					Exchangeable Cations (m.e./100g.)					% Saturation	pH		% Carbon	% Nitrogen	mg./100g. Total P_2O_5	Remarks
			% Sand U.S.D.A.	% Silt U.S.D.A.	% Clay	% Silt Inter.	% Sand Inter.	Ca	Mg	Na	K	H		H_2O	$CaCl_2$				
O1	3-13	95.2	N.D.	N.D.	N.D.	N.D.	N.D.	9.48	18.70	3.15	0.50	111.0	22.2	4.2	3.3	55.20	1.67	109	High Ca, Mg & Na in O1; high Na in O2 & Eg. Low Ca & K below O1. Low Mg in B(g) & BC. Low % saturation below O1. Low pH throughout. Low total P_2O_5 below O1 except in B(g).
O2	17-23	82.0	N.D.	N.D.	N.D.	N.D.	N.D.	1.97	3.58	1.43	0.06	104.7	10.8	4.3	3.4	47.30	1.50	90	
Eg	26-33	17.1	66	23	11	16	73	0.24	0.30	0.25	0.04	33.2	2.4	4.2	3.7	9.38	0.44	92	
B(g)	36-42	5.5	49	28	23	24	53	0.18	0.22	0.11	0.07	10.0	5.7	4.7	4.1			103	
BC	49-59	5.1	51	30	19	22	59	0.13	0.12	0.09	0.05	6.6	4.3	4.9	4.4			96	
ND = No Data																			

Profile No. 28			Thurso Association				Camster Series												Lab Numbers: 309007-11
Horizon	Depth (cm)	Loss on Ignition	Soil Separates					Exchangeable Cations (m.e./100g.)					% Saturation	pH		% Carbon	% Nitrogen	mg./100g. Total P_2O_5	Remarks
			% Sand U.S.D.A.	% Silt U.S.D.A.	% Clay	% Silt Inter.	% Sand Inter.	Ca	Mg	Na	K	H		H_2O	$CaCl_2$				
O	6-16	94.4	N.D.	N.D.	N.D.	N.D.	N.D.	3.60	11.20	2.35	1.27	89.2	17.1	3.9	3.3	48.80	1.81	99	High U.S.D.A. silt & low clay in Eg. High U.S.D.A. silt in Bs. High Mg, Na & K in O. Low Ca below O. Low Na in Bs & BC2.. Low pH above BC1. Low total P_2O_5 in O & Eg.
Eg	23-29	11.6	42	50	8	31	61	2.05	0.66	0.21	0.12	23.1	11.5	4.2	3.5	6.69	0.35	55	
Bs	41-51	3.6	35	46	19	30	51	0.34	0.40	0.04	0.20	5.3	15.9	4.9	4.2	0.60	0.09	153	
BC1	71-81	2.0	45	40	15	28	57	2.03	1.23	0.07	0.23	3.4	51.4	5.7	4.8	0.19	0.06	113	
BC2	101-111	2.1	47	40	13	30	57	2.94	0.98	0.04	0.13	2.5	62.1	6.3	5.6	0.16	0.06	143	
N.D. = No Data																			

Peaty Podzols – freely or imperfectly drained below pan continued

Profile No. 29			Thurso Association				Camster Series												Lab Numbers: 267498-503
			Soil Separates					Exchangeable Cations (m.e./100g.)						pH					
Horizon	Depth (cm)	Loss on Ignition	% Sand U.S.D.A.	% Silt U.S.D.A.	% Clay	% Silt Inter.	% Sand Inter.	Ca	Mg	Na	K	H	% Saturation	H_2O	$CaCl_2$	% Carbon	% Nitrogen	mg./100g. Total P_2O_5	Remarks
O1	7-17	69.2	N.D.	N.D.	N.D.	N.D.	N.D.	3.65	5.66	1.22	2.16	74.3	14.6	4.3	3.4	40.10	1.55	166	High Mg, Na & K in O1. High Mg in O2 & high Na in O2, E(h) & BC. Low Ca below O2 & low K in E(h). Low % saturation in E(h), Eg1 & Eg2 horizons. Low pH above Eg2. Low total P_2O_5 except in O1 & BC.
O2	25-35	78.1	N.D.	N.D.	N.D.	N.D.	N.D.	3.33	6.33	1.22	0.63	84.9	11.9	4.1	3.2	45.20	1.27	92	
E(h)	42-52	13.3	49	33	11	26	56	0.51	0.94	0.35	0.09	14.2	0.1	4.3	3.6	7.01	7.01	80	
Eg1	54-64	8.3	43	39	14	25	57	0.25	0.44	0.19	0.14	18.6	5.1	4.7	4.1			69	
Eg2	72-82	6.5	50	26	21	13	63	0.23	0.58	0.22	0.16	12.9	8.5	5.1	4.3			57	
BC	107-117	4.7	49	34	17	25	58	0.3	0.67	0.27	0.16	9.6	12.7	5.4	4.5			175	
N.D. = No Data																			

Calcareous Gleys – poorly drained

Profile No. 30			Fraserburgh Association				Whitelinks Series												Lab Numbers: 257356-60
			Soil Separates					Exchangeable Cations (m.e./100g.)						pH					
Horizon	Depth (cm)	Loss on Ignition	% Sand U.S.D.A.	% Silt U.S.D.A.	% Clay	% Silt Inter.	% Sand Inter.	Ca	Mg	Na	K	H	% Saturation	H_2O	$CaCl_2$	% Carbon	% Nitrogen	mg./100g. Total P_2O_5	Remarks
HA	1-5	20.8	77	9	4	4	82	107.97	3.67	1.58	0.63	<0.1	100.0	7.4	7.1	15.10	0.95	145	High sand & low clay throughout. Very high Ca & high Na throughout. Low K below A(h). High % saturation & pH throughout. Free $CaCo_3$ throughout. Low total P_2O_5 below HA.
A(h)	5-8	11.9	88	3	4	2	89	95.10	3.25	0.96	0.13	<0.1	100.0	7.8	7.3	10.90	0.24	83	
Bg	20-30	6.9	93	2	1	<1	95	69.21	2.99	0.64	0.08	<0.1	100.0	8.6	7.6			58	
Cg1	45-55	7.9	93	2	1	1	94	72.89	3.33	0.68	0.05	<0.1	100.0	8.9	8.0			59	
Cg2	90-100	6.8	93	2	1	1	94	71.39	2.84	0.70	0.08	<0.1	100.0	9.0	8.1			48	

Noncalcareous Gleys – poorly drained

Profile No. 31			Canisbay Association				Tresdale Series												Lab Numbers: 257238-43
			Soil Separates					Exchangeable Cations (m.e./100g.)						pH					
Horizon	Depth (cm)	Loss on Ignition	% Sand U.S.D.A.	% Silt U.S.D.A.	% Clay	% Silt Inter.	% Sand Inter.	Ca	Mg	Na	K	H	% Saturation	H_2O	$CaCl_2$	% Carbon	% Nitrogen	mg./100g. Total P_2O_5	Remarks
Ap(g)	5-15	6.3	71	20	6	14	77	4.42	1.54	0.36	0.12	6.7	49.0	6.2	5.7	3.27	0.40	157	Low clay in Ap(g). High Na except in Bg. Low Ca & K in Bg. High % saturation below Ap(g). High pH below Ap(g). Low total P_2O_5 except in Ap(g) & C(g)2
Bg	25-35	1.4	73	17	10	13	77	2.26	0.95	0.24	0.09	1.7	67.6	6.9	6.4			56	
Bt(g)	45-55	2.6	56	26	17	18	64	7.16	2.66	0.41	0.30	2.4	81.4	7.1	6.7			57	
BCt(g)	70-80	2.4	51	29	20	19	62	6.87	2.76	0.41	0.27	2.0	83.8	7.3	6.3			77	
C(g)1	94-104	1.8	61	27	13	18	69	4.39	1.54	0.26	0.18	1.5	80.9	7.5	6.5			98	
C(g)2	125-135	2.2	55	28	18	19	63	6.09	2.24	0.32	0.22	1.5	85.5	7.6	6.6			116	

Profile No. 32			Canisbay Association				Tresdale Series												Lab Numbers: 257376-80
			Soil Separates					Exchangeable Cations (m.e./100g.)						pH					
Horizon	Depth (cm)	Loss on Ignition	% Sand U.S.D.A.	% Silt U.S.D.A.	% Clay	% Silt Inter.	% Sand Inter.	Ca	Mg	Na	K	H	% Saturation	H_2O	$CaCl_2$	% Carbon	% Nitrogen	mg./100g. Total P_2O_5	Remarks
Apg	5-15	10.7	26	51	18	31	45	13.83	0.92	0.27	0.13	7.3	67.5	6.4	5.9	5.33	0.45	173	High U.S.D.A. silt in Apg. High Ca & Na in Apg; high Na in BCg & Cg. Low Ca below Apg. Low total P_2O_5 in Bg1 & Bg2.
Bg1	25-35	3.1	34	38	28	26	46	2.43	0.91	0.20	0.10	7.4	33.0	5.6	4.6			47	
Bg2	50-60	2.6	34	39	27	26	47	1.22	1.63	0.24	0.22	7.7	30.1	5.0	4.1			81	
BCg	70-80	2.3	37	34	29	24	47	1.53	2.62	0.26	0.23	6.6	41.3	5.2	4.2			108	
Cg	115-125	2.0	46	33	21	23	56	1.67	3.58	0.29	0.23	4.6	55.6	5.6	4.5			103	

Noncalcareous Gleys – poorly drained continued

Profile No. 33			Canisbay Association					Tresdale Series											Lab Numbers: 317198-01
			Soil Separates					Exchangeable Cations (m.e./100g.)						pH					
Horizon	Depth (cm)	Loss on Ignition	% Sand U.S.D.A.	% Silt U.S.D.A.	% Clay	% Silt Inter.	% Sand Inter.	Ca	Mg	Na	K	H	% Saturation	H_2O	$CaCl_2$	% Carbon	% Nitrogen	mg./100g. Total P_2O_5	Remarks
Ap(g)	10-20	5.6	41	42	17	21	62	4.91	0.66	0.25	0.08	3.5	62.8	6.2	5.5	2.76	0.28	142	High Na in Ap(g) & BCg2. Low Ca below Apg. Low K in Ap(g). High % saturation throughout. Low total P_2O_5 below Ap(g).
Bg	40-50	3.0	47	24	29	20	51	2.93	1.95	0.18	0.13	1.0	83.9	5.6	5.0	0.25	0.04	58	
BCg1	70-80	2.7	45	28	27	23	50	2.32	3.45	0.21	0.17	1.8	77.2	5.7	5.2	0.14	0.05	72	
BCg2	95-105	2.8	43	28	29	22	49	2.93	3.94	0.25	0.20	1.8	80.2	6.1	5.5			83	

Profile No. 34			Canisbay Association					Tresdale Series											Lab Numbers: 267450-54
			Soil Separates					Exchangeable Cations (m.e./100g.)						pH					
Horizon	Depth (cm)	Loss on Ignition	% Sand U.S.D.A.	% Silt U.S.D.A.	% Clay	% Silt Inter.	% Sand Inter.	Ca	Mg	Na	K	H	% Saturation	H_2O	$CaCl_2$	% Carbon	% Nitrogen	mg./100g. Total P_2O_5	Remarks
Ap(g)	5-15	4.0	56	25	19	19	62	6.42	1.29	0.36	0.16	5.0	62.1	6.4	6.0	1.48	0.19	131	High Ca in Cg. High Na except in Bg1. High % saturation throughout. High pH below Ap(g). Low total P_2O_5 in Bg1.
Bg1	25-35	2.1	47	32	21	23	56	4.27	1.75	0.24	0.16	2.3	73.6	6.9	6.3	0.23	0.06	62	
Bg2	40-50	2.0	54	29	17	25	58	4.57	1.58	0.29	0.17	2.0	76.7	7.3	6.6	0.09	0.03	107	
C(g)	95-105	2.4	43	31	26	25	49	6.43	1.71	0.27	0.30	1.6	84.5	7.7	7.1			137	
Cg	125-135	3.5	33	43	24	39	37	11.90	2.09	0.30	0.37	2.0	88.0	7.8	7.5			145	

Noncalcareous Gleys – poorly drained continued

Profile No. 35			Canisbay Association					Tresdale Series											Lab Numbers: 257257-63
			Soil Separates					Exchangeable Cations (m.e./100g.)						pH					
Horizon	Depth (cm)	Loss on Ignition	% Sand U.S.D.A.	% Silt U.S.D.A.	% Clay	% Silt Inter.	% Sand Inter.	Ca	Mg	Na	K	H	% Saturation	H_2O	$CaCl_2$	% Carbon	% Nitrogen	mg./100g. Total P_2O_5	Remarks
Ap(g)	5-15	9.1	77	16	3	8	85	14.84	1.10	0.45	0.20	5.1	76.5	6.7	6.1	6.25	0.36	138	Low clay & high sand in Ap(g). High Ca in Ap(g). High Na throughout. Low Ca below Bg. High pH in Ap(g). Low total P_2O_5 below Ap(g).
AB	18-24	2.0	71	18	11	12	77	4.38	0.84	0.37	0.16	3.8	60.3	6.3	5.7	0.59	0.04	32	
Bg	25-35	2.8	59	25	16	17	67	3.35	2.02	0.47	0.24	6.3	49.4	5.6	4.8	0.47	0.03	45	
Btg	40-50	2.2	61	19	20	13	67	0.91	1.51	0.38	0.26	7.2	30.3	5.1	4.1			56	
C(g)1	70-80	1.9	67	16	18	10	73	1.22	2.72	0.47	0.34	5.7	45.6	5.2	4.2			75	
C(g)2	95-105	1.9	63	19	19	13	69	1.83	4.19	0.60	0.42	4.3	61.8	5.4	4.4			86	
C(g)3	130-140	1.7	61	22	17	13	71	2.44	4.69	0.60	0.42	3.0	73.0	5.8	4.7			93	

Profile No. 36			Canisbay Association					Tresdale Series											Lab Numbers: 257232-37
			Soil Separates					Exchangeable Cations (m.e./100g.)						pH					
Horizon	Depth (cm)	Loss on Ignition	% Sand U.S.D.A.	% Silt U.S.D.A.	% Clay	% Silt Inter.	% Sand Inter.	Ca	Mg	Na	K	H	% Saturation	H_2O	$CaCl_2$	% Carbon	% Nitrogen	mg./100g. Total P_2O_5	Remarks
Ap(g)	5-15	15.1	64	26	3	22	72	13.36	2.94	0.90	0.16	10.7	61.9	5.6	5.2	9.50	0.48	150	Low clay & high sand in Ap(g). High Ca in Ap(g); very high Ca in C(g)2. High Na throughout. Low Ca in AB & Bg. High % saturation Ap(g), C(g)1 & C(g)2 & high pH in C(g)2. Free $CaCO_3$ in C(g)2. Low pH in AB, Bg & Btg. Low total P_2O_5 except in Ap(g) & C(g)2.
AB	23-33	2.7	68	19	11	13	74	1.82	1.41	0.37	0.16	7.5	33.4	4.9	4.1	0.83	0.05	20	
Bg	40-50	1.6	67	21	13	15	73	1.21	1.70	0.31	0.13	5.2	39.2	4.7	4.1	0.38	0.04	19	
Btg	63-73	2.3	51	29	20	22	58	3.35	3.45	0.47	0.30	6.1	55.4	4.7	4.3			90	
C(g)1	98-108	1.5	65	19	17	11	73	4.86	3.70	0.52	0.40	3.0	76.0	5.8	5.5			97	
C(g)2	140-150	2.8	67	19	15	14	72	42.5	2.53	0.47	0.31	<0.1	100.0	7.6	7.2			101	

Noncalcareous Gleys – poorly drained continued

Profile No. 37			Lynedardy Association					Midgarth Series											Lab Numbers: 309038-40
			Soil Separates					Exchangeable Cations (m.e./100g.)						pH					
Horizon	Depth (cm)	Loss on Ignition	% Sand U.S.D.A.	% Silt U.S.D.A.	% Clay	% Silt Inter.	% Sand Inter.	Ca	Mg	Na	K	H	% Saturation	H_2O	$CaCl_2$	% Carbon	% Nitrogen	mg./100g. Total P_2O_5	Remarks
Ap(g)	5-15	5.3	46	37	17	19	64	3.30	0.89	0.33	0.16	2.2	68.1	5.4	4.9	2.02	0.17	200	High Na in Ap(g). Low Ca below Ap(g). High % saturation throughout. Low total P_2O_5 below Ap(g).
Bg	22-32	1.4	70	17	13	13	74	1.47	0.43	0.18	0.12	<0.1	97.8	5.8	5.2	0.20	0.04	33	
BCg	45-55	2.2	55	30	15	22	63	2.38	0.56	0.15	0.10	<0.1	98.4	6.2	5.6	0.28	0.03	94	

Profile No. 38			Thurso Association					Thurso Series											Lab Numbers: 309069-72
			Soil Separates					Exchangeable Cations (m.e./100g.)						pH					
Horizon	Depth (cm)	Loss on Ignition	% Sand U.S.D.A.	% Silt U.S.D.A.	% Clay	% Silt Inter.	% Sand Inter.	Ca	Mg	Na	K	H	% Saturation	H_2O	$CaCl_2$	% Carbon	% Nitrogen	mg./100g. Total P_2O_5	Remarks
Ap(g)	5-15	13.1	19	64	17	51	32	8.61	1.53	0.41	0.18	14.3	42.8	5.8	5.0	7.45	0.38	127	High U.S.D.A. silt in Ap(g), Bg & BCg1. High Ca & Na in Ap(g); high Na in BCg2. Low Ca below Ap(g). Low total P_2O_5 in Bg.
Bg	25-35	3.5	26	53	21	41	38	2.37	0.33	0.18	0.12	5.2	36.6	5.0	4.2	0.34	0.06	39	
BCg1	60-70	3.1	30	48	22	35	43	1.16	2.84	0.22	0.16	5.3	45.4	5.4	4.2	0.18	0.04	133	
BCg2	90-100	3.1	34	44	22	35	43	2.08	3.47	0.27	0.17	4.8	55.6	5.6	4.3	0.16	0.05	144	

Noncalcareous Gleys – poorly drained continued

Profile No. 39			Thurso Association					Thurso Series											Lab Numbers: 290613-17
			Soil Separates					Exchangeable Cations (m.e./100g.)						pH					
Horizon	Depth (cm)	Loss on Ignition	% Sand U.S.D.A.	% Silt U.S.D.A.	% Clay	% Silt Inter.	% Sand Inter.	Ca	Mg	Na	K	H	% Saturation	H_2O	$CaCl_2$	% Carbon	% Nitrogen	mg./100g. Total P_2O_5	Remarks
Ap(g)	5-15	10.4	20	65	15	48	37	10.60	1.20	0.28	0.14	5.1	70.5	6.0	5.7	5.36	0.47	153	High U.S.D.A. silt throughout. High Ca in Ap(g) & very high Ca in C(g). High Na in Ap(g). Low K in Bg. High % saturation throughout. High pH in C(g). Free $CaCO_3$ in C(g). Low total P_2O_5 in Bg & Btg.
Bg	25-35	3.3	23	48	29	36	35	3.87	1.02	0.20	0.08	1.6	76.5	6.3	5.6	0.48	0.10	54	
Btg	45-55	2.8	22	46	32	37	31	4.20	2.40	0.20	0.13	1.8	79.3	6.2	5.4	0.35	0.09	97	
Cg	70-80	2.7	24	47	29	35	36	6.02	2.48	0.18	0.17	1.3	87.3	6.3	6.2	0.29	0.07	122	
C(g)	95-105	4.3	28	46	26	39	35	71.20	2.36	0.17	0.18	>0.1	100.0	7.9	7.4			109	

Profile No. 40			Thurso Association					Thurso Series											Lab Numbers: 309063-68
			Soil Separates					Exchangeable Cations (m.e./100g.)						pH					
Horizon	Depth (cm)	Loss on Ignition	% Sand U.S.D.A.	% Silt U.S.D.A.	% Clay	% Silt Inter.	% Sand Inter.	Ca	Mg	Na	K	H	% Saturation	H_2O	$CaCl_2$	% Carbon	% Nitrogen	mg./100g. Total P_2O_5	Remarks
Apg	5-15	4.8	67	22	11	16	73	7.07	0.63	0.18	0.10	1.3	85.6	6.4	5.8	2.64	0.19	100	Low clay & high sand in AB. Low Ca in Bg, BCg1 & BCg2. Low K in AB & Bg. High % saturation in all except Bg horizon. Low total P_2O_5 except in Apg & Rw.
AB	25-29	3.2	82	11	7	8	85	5.86	0.42	0.11	0.08	2.5	71.9	6.4	5.7	0.37	0.04	55	
Bg	35-45	1.9	67	22	11	18	71	2.36	0.58	0.11	0.05	0.7	45.9	6.1	5.2	0.32	0.04	65	
BCg1	60-70	2.5	50	28	22	15	63	2.06	1.50	0.13	0.10	1.5	71.3	5.6	4.6	0.27	0.04	63	
BCg2	80-90	2.5	46	29	25	17	58	2.67	1.79	0.11	0.13	0.8	85.9	5.9	5.0	0.26	0.04	94	
Rw	100-110	3.4	54	28	18	18	64	3.12	1.41	0.15	0.13	1.0	82.6	6.7	6.1	0.66	0.05	152	

Noncalcareous Gleys – poorly drained continued

Profile No. 41			Thurso Association					Thurso Series												Lab Numbers: 290647-50
Horizon	Depth (cm)	Loss on Ignition	Soil Separates					Exchangeable Cations (m.e./100g.)					% Saturation	pH		% Carbon	% Nitrogen	mg./100g. Total P_2O_5	Remarks
			% Sand U.S.D.A.	% Silt U.S.D.A.	% Clay	% Silt Inter.	% Sand Inter.	Ca	Mg	Na	K	H		H_2O	$CaCl_2$				
Ap	5-15	10.9	36	54	10	42	48	10.10	1.10	0.27	0.07	7.2	61.5	6.1	5.7	5.82	0.57	298	High U.S.D.A. silt in Ap. High Ca & Na in Ap. Low Ca in Eg. Low K above C(g). High % saturation throughout & high pH in C(g). Low total P_2O_5 in Eg & Bg.
Eg	35-45	3.9	42	33	15	32	53	2.99	0.43	0.14	0.02	2.3	61.0	6.4	5.8	0.58	0.13	77	
Bg	60-70	3.5	43	38	19	29	52	3.75	0.84	0.15	0.06	2.3	67.6	6.4	5.8	0.33	0.09	87	
C(g)	105-115	2.8	44	44	22	35	43	5.89	1.60	0.17	0.11	1.7	82.1	6.8	6.2			115	

Profile No. 42			Thurso Association					Thurso Series												Lab Numbers: 290618-21
Horizon	Depth (cm)	Loss on Ignition	Soil Separates					Exchangeable Cations (m.e./100g.)					% Saturation	pH		% Carbon	% Nitrogen	mg./100g. Total P_2O_5	Remarks
			% Sand U.S.D.A.	% Silt U.S.D.A.	% Clay	% Silt Inter.	% Sand Inter.	Ca	Mg	Na	K	H		H_2O	$CaCl_2$				
Ap(g)	5-15	15.0	27	61	12	46	42	13.30	1.43	0.38	0.14	9.5	61.7	6.2	5.6	7.32	0.77	220	High U.S.D.A. silt throughout. High Ca & Na in Ap(g); high Na in AB. Low Ca in Bg. Low K in Bg & Cg. High % saturation in Ap(g) & Cg & high pH in Cg. Low total P_2O_5 in Bg.
AB	25-33	8.9	31	58	11	38	51	6.55	0.78	0.29	0.11	8.7	47.0	6.2	5.5	3.51	0.46	123	
Bg	40-50	3.2	27	56	17	40	43	2.21	0.77	0.15	0.05	3.0	51.6	6.0	5.2	0.46	0.09	57	
Cg	70-80	2.5	34	50	16	34	50	4.48	1.48	0.17	0.09	1.3	82.7	6.9	6.1			125	

Noncalcareous Gleys – poorly drained continued

Profile No. 43		Thurso Association					Ness Series												Lab Numbers: 309034-37
			Soil Separates					Exchangeable Cations (m.e./100g.)						pH					
Horizon	Depth (cm)	Loss on Ignition	% Sand U.S.D.A.	% Silt U.S.D.A.	% Clay	% Silt Inter.	% Sand Inter.	Ca	Mg	Na	K	H	% Saturation	H_2O	$CaCl_2$	% Carbon	% Nitrogen	mg./100g. Total P_2O_5	Remarks
Ap(g)	5-15	6.5	48	41	11	24	65	7.42	3.85	0.43	0.20	2.7	81.5	6.5	6.1	3.25	0.28	259	High Na in Ap(g) & Rw. High % saturation & high pH throughout. Low total P_2O_5 in Bg & BCg.
Bg	22-32	2.8	62	26	12	20	68	3.74	0.85	0.24	0.13	2.1	70.4	6.5	4.8	0.90	0.12	84	
BCg	40-50	2.8	53	26	21	18	61	2.99	0.77	0.24	0.12	1.9	68.3	6.7	5.9	0.34	0.05	42	
Rw	60-70	3.2	44	29	27	26	47	3.14	1.30	0.29	0.20	1.7	74.2	6.7	6.1	0.63	0.09	115	

Saline Gleys – poorly drained

Profile No. 44			Canisbay Association				Gessan Series												Lab Numbers: 267455-58
			Soil Separates					Exchangeable Cations (m.e./100g.)						pH					
Horizon	Depth (cm)	Loss on Ignition	% Sand U.S.D.A.	% Silt U.S.D.A.	% Clay	% Silt Inter.	% Sand Inter.	Ca	Mg	Na	K	H	% Saturation	H_2O	$CaCl_2$	% Carbon	% Nitrogen	mg./100g. Total P_2O_5	Remarks
O	2-12	61.7	N.D.	N.D.	N.D.	N.D.	N.D.	10.60	21.80	34.10	2.55	40.7	62.9	4.7	4.4	34.80	1.84	44	High Ca, Mg & K in O. High Na throughout. Low Ca below O. Low pH in O. Low total P_2O_5 throughout.
Eg1	16-24	2.4	56	30	14	21	65	0.64	1.69	1.78	0.29	2.9	60.3	5.5	4.7	0.82	0.09	23	
Eg2	24-34	5.3	45	33	22	31	47	1.23	2.89	2.54	0.39	8.9	44.4	5.6	4.7	2.04	0.17	38	
BCg	49-59	4.4	37	37	26	27	47	0.68	2.50	2.01	0.37	6.5	46.3	5.5	4.7			53	
N.D. = No Data																			

Profile No. 45			Lynedardy Association				Fletts Series												Lab Numbers: 309017-20
			Soil Separates					Exchangeable Cations (m.e./100g.)						pH					
Horizon	Depth (cm)	Loss on Ignition	% Sand U.S.D.A.	% Silt U.S.D.A.	% Clay	% Silt Inter.	% Sand Inter.	Ca	Mg	Na	K	H	% Saturation	H_2O	$CaCl_2$	% Carbon	% Nitrogen	mg./100g. Total P_2O_5	Remarks
LF	0-4	88.5	N.D.	N.D.	N.D.	N.D.	N.D.	12.60	19.80	10.10	2.83	62.3	42.1	4.7	3.8	47.30	1.37	117	High U.S.D.A. silt in Eg & BCg. High Ca, Mg & K in LF & O. High Na throughout. Low Ca below O. Low pH throughout. Low total P_2O_5 below O.
O	4-10	78.3	N.D.	N.D.	N.D.	N.D.	N.D.	13.70	20.60	12.20	2.09	71.3	40.5	4.4	3.7	40.40	1.32	119	
Eg	20-30	12.8	35	50	15	36	49	1.63	2.85	2.03	0.45	15.2	31.5	4.6	4.0			73	
BCg	40-50	8.5	33	58	9	44	47	0.57	1.31	1.11	0.29	9.2	26.4	4.7	4.0			50	
N.D. = No Data																			

Saline Gleys – poorly drained continued

Profile No. 46			Thurso Association				Mousland Series												Lab Numbers: 301008-12
			Soil Separates					Exchangeable Cations (m.e./100g.)						pH					
Horizon	Depth (cm)	Loss on Ignition	% Sand U.S.D.A.	% Silt U.S.D.A.	% Clay	% Silt Inter.	% Sand Inter.	Ca	Mg	Na	K	H	% Saturation	H_2O	$CaCl_2$	% Carbon	% Nitrogen	mg./100g. Total P_2O_5	Remarks
Ah	4-14	14.2	53	35	12	21	67	2.41	5.48	6.61	0.87	2.4	86.5	5.8	5.2	8.17	0.75	112	High Na throughout. High Mg in Ah. Low Ca throughout. High % saturation throughout. Low total P_2O_5 below Ah.
Eg	20-28	4.3	28	55	17	33	50	1.15	2.77	3.05	0.41	1.5	83.1	6.0	5.4	1.73	0.16	65	
Bg	35-45	2.5	46	29	15	23	62	0.59	1.95	2.18	0..25	0.8	86.2	5.8	5.2	0.81	0.09	89	
BCg1	70-80	2.9	54	31	15	21	64	0.88	1.89	2.07	0.29	<0.1	99.0	5.9	5.2			56	
BCg2	95-105	3.5	41	37	22	26	52	0.88	2.02	1.96	0.29	1.1	82.5	5.8	5.1			94	

Horizon	Depth (cm)	Water-soluble ions (m.e./100g.)					Remarks
		Cl	Ca	Mg	Na	K	
Ah	4-14	3.51	0.25	0.29	4.46	0.40	High percentages of Na & K water soluble. Ca:Mg ratios reversal of norm.
Eg	20-28	2.36	0.16	0.21	1.79	0.26	
Bg	35-45	1.66	0.14	0.15	1.84	0.21	
BCg1	70-80	1.92	0.15	0.15	1.26	0.17	
BCg2	95-105	1.62	0.05	0.05	0.98	0.08	

Saline Gleys – poorly drained continued

Profile No. 47 | Thurso Association | Mousland series | Lab Numbers: 301013-17

Horizon	Depth (cm)	Loss on Ignition	Soil Separates: % Sand U.S.D.A.	% Silt U.S.D.A.	% Clay	% Silt Inter.	% Sand Inter.	Exchangeable Cations (m.e./100g.): Ca	Mg	Na	K	H	% Saturation	pH: H_2O	$CaCl_2$	% Carbon	% Nitrogen	mg./100g. Total P_2O_5	Remarks
FH	1-4	58.6	N.D.	N.D.	N.D.	N.D.	N.D.	16.30	31.50	55.40	4.54	17.8	85.8	5.8	5.5	29.30	1.91	300	High U.S.D.A. silt in Rw. High Na throughout. High Ca, Mg & K in FH; high Mg & K in Ah. Low Ca below Ah. High % saturation throughout except in BCg. High total P_2O_5 in FH but low total P_2O_5 below.
Ah	8-16	18.7	52	38	10	19	71	5.12	9.63	9.61	1.38	6.6	79.6	5.8	5.4	8.90	0.78	99	
Eg	19-25	4.2	31	44	25	32	43	1.64	3.03	3.40	0.84	3.2	73.6	5.6	5.1	1.72	0.16	48	
BCg	30-40	2.6	38	41	21	34	45	0.72	2.27	2.62	0.98	7.1	48.1	5.8	5.1			36	
Rw	60-70	5.8	7	52	41	42	17	1.65	3.69	4.60	0.67	0.5	95.5	5.7	5.2			90	

N.D. = No Data

Horizon	Depth (cm)	Water-soluble ions (m.e./100g.): Cl	Ca	Mg	Na	K	Remarks
FH	1-4	24.00	0.94	3.41	26.40	2.2	High percentage of Na water-soluble i.e. not on exchange sites.
Ah	8-16	10.30	0.51	1.10	8.00	0.6	
Eg	19-25	2.96	0.20	0.21	2.87	0.2	
BCg	30-40	2.42	0.15	0.16	1.90	0.1	
Rw	60-70	4.42	0.18	0.24	4.04	0.2	

Peaty Gleys – poorly drained

Profile No. 48			Canisbay Association					Canisbay Series											Lab Numbers: 257325-31
			Soil Separates					Exchangeable Cations (m.e./100g.)						pH					
Horizon	Depth (cm)	Loss on Ignition	% Sand U.S.D.A.	% Silt U.S.D.A.	% Clay	% Silt Inter.	% Sand Inter.	Ca	Mg	Na	K	H	% Saturation	H_2O	$CaCl_2$	% Carbon	% Nitrogen	mg./100g. Total P_2O_5	Remarks
Ah	0-10	14.9	45	39	9	20	65	1.20	2.09	0.52	0.37	14.4	22.5	4.5	3.8	8.77	0.32	70	High U.S.D.A. silt in Rw1, Rw2 & Rw3. High Na in Ah & Rw1, Rw2 & Rw3. Low Ca throughout. Low K in AB(h). Low % saturation & pH in ABh & AB(h). Low pH in Ah & Rw2. Low total P_2O_5 above Rw1.
ABh	11-21	5.6	58	27	12	14	72	0.33	0.58	0.20	0.10	11.8	9.3	4.6	3.9	3.26	0.30	46	
AB(h)	25-35	4.8	53	30	15	18	65	0.20	0.33	0.11	0.09	10.4	6.6	4.8	4.1	1.83	0.09	51	
BCg	45-55	3.0	42	27	31	20	49	0.35	1.28	0.20	0.22	6.4	24.3	5.0	4.1			91	
Rw1	70-80	3.7	29	51	21	35	45	0.23	1.25	0.49	0.30	6.4	26.2	5.0	4.2			129	
Rw2	90-100	3.8	14	61	25	43	33	0.28	1.55	0.47	0.33	7.8	25.2	4.9	4.3			145	
Rw3	110-120	3.4	19	63	19	43	39	0.40	1.91	0.48	0.35	6.3	33.3	5.2	4.2			128	

Profile No. 49			Canisbay Association					Canisbay Series											Lab Numbers: 279679-84
			Soil Separates					Exchangeable Cations (m.e./100g.)						pH					
Horizon	Depth (cm)	Loss on Ignition	% Sand U.S.D.A.	% Silt U.S.D.A.	% Clay	% Silt Inter.	% Sand Inter.	Ca	Mg	Na	K	H	% Saturation	H_2O	$CaCl_2$	% Carbon	% Nitrogen	mg./100g. Total P_2O_5	Remarks
O1	10-20	94.9	N.D.	N.D.	N.D.	N.D.	N.D.	8.52	21.40	3.86	0.85	121.9	22.1	3.9	3.2	51.80	1.54	58	Low clay & high sand in Eg. High Ca, Mg & Na in O1; high Na in O2. Low Ca below O1. Low Mg in Btg & low K in Eg. Low % saturation in O2, Eg, Btg & BCg. Low pH above Cg. Low total P_2O_5 above Cg.
O2	26-36	79.0	N.D.	N.D.	N.D.	N.D.	N.D.	2.07	2.38	1.59	0.13	80.6	7.1	4.0	3.1	44.70	0.75	47	
Eg	45-55	11.9	90	7	3	5	92	0.21	0.37	0.15	0.08	17.4	4.4	4.4	3.6	4.34	0.16	28	
Btg	70-80	3.0	66	11	23	9	68	0.10	0.19	0.11	0.16	5.5	9.8	4.6	4.0			35	
BCg	110-120	2.0	78	9	13	7	80	0.15	0.44	0.07	0.17	3.9	17.0	4.8	4.0			71	
Cg	145-155	2.2	72	15	13	13	74	0.45	1.54	0.11	0.21	2.1	52.2	5.3	4.2			109	
N.D. = No Data																			

Peaty Gleys – poorly drained continued

Profile No. 50			Lynedardy Association					Lynedardy Series											Lab Numbers: 301026-30
			Soil Separates					Exchangeable Cations (m.e./100g.)						pH					
Horizon	Depth (cm)	Loss on Ignition	% Sand U.S.D.A.	% Silt U.S.D.A.	% Clay	% Silt Inter.	% Sand Inter.	Ca	Mg	Na	K	H	% Saturation	H_2O	$CaCl_2$	% Carbon	% Nitrogen	mg./100g. Total P_2O_5	Remarks
O	3-5	86.4	N.D.	N.D.	N.D.	N.D.	N.D.	8.55	18.20	5.15	2.47	75.4	31.3	4.0	3.5	32.60	1.05	158	Low clay in Eg1. High Ca, Mg, Na & K in O; high Na in Eg1. Low Ca below O. Low Mg in Eg2 & Btg & low K in Eg2. Low % saturation in Eg1 & Eg2. High % saturation in Btg & BC. Low pH above Btg. Low total P_2O_5 except in O & BC.
Eg1	7-15	11.0	63	29	8	22	70	0.44	0.93	0.47	0.24	17.8	10.6	4.0	3.6	4.85	0.20	76	
Eg2	17-25	4.1	71	19	10	12	78	0.12	0.20	0.18	0.08	14.4	4.0	4.7	4.1	1.47	0.07	53	
Btg	30-40	2.5	62	20	18	19	63	0.04	0.11	0.11	0.10	<0.1	87.5	5.0	4.4	0.40	0.03	58	
BC	53-63	2.3	61	25	14	19	68	0.30	0.51	0.13	0.13	<0.1	95.0	5.0	4.3			116	
N.D. = No Data																			

Profile No. 51			Thurso Association					Olrig Series											Lab Numbers: 279697-01
			Soil Separates					9.21						pH					
Horizon	Depth (cm)	Loss on Ignition	% Sand U.S.D.A.	% Silt U.S.D.A.	% Clay	% Silt Inter.	% Sand Inter.	Ca	Mg	Na	K	H	% Saturation	H_2O	$CaCl_2$	% Carbon	% Nitrogen	mg./100g. Total P_2O_5	Remarks
O1	5-15	93.5	N.D.	N.D.	N.D.	N.D.	N.D.	9.21	14.90	2.65	0.95	110.5	20.0	4.1	3.3	52.40	1.37	96	High U.S.D.A. silt in Btg & BCg. Low clay & high sand in Eg. High Ca, Mg & Na in O1; High Mg & Na in O2. Low Ca below O2. Low % saturation in O2, Eg & Btg. Low pH throughout except in Btg. Low total P_2O_5 throughout.
O2	19-26	79.0	N.D.	N.D.	N.D.	N.D.	N.D.	4.54	6.12	1.57	0.25	98.4	11.3	3.8	3.1	44.60	0.96	67	
Eg	37-47	7.2	85	9	6	7	87	0.28	0.65	0.15	0.10	17.4	6.5	4.1	3.5	3.42	0.11	20	
Btg	57-67	4.8	19	59	22	42	36	0.31	1.18	0.20	0.34	9.3	17.7	5.0	4.2			24	
BCg	82-92	3.1	35	48	17	36	47	0.28	1.17	0.20	0.34	5.6	26.3	4.9	4.1			26	
N.D. = No Data																			

Peaty Gleys – poorly drained continued

Profile No. 52			Thurso Association				Olrig Series												Lab Numbers:309043-48
			Soil Separates					Exchangeable Cations (m.e./100g.)						pH					
Horizon	Depth (cm)	Loss on Ignition	% Sand U.S.D.A.	% Silt U.S.D.A.	% Clay	% Silt Inter.	% Sand Inter.	Ca	Mg	Na	K	H	% Saturation	H_2O	$CaCl_2$	% Carbon	% Nitrogen	mg./100g. Total P_2O_5	Remarks
O	1-11	87.2	N.D.	N.D.	N.D.	N.D.	N.D.	4.61	9.83	2.40	0.61	74.7	19.0	4.0	3.2	49.50	1.64	180	High Mg & Na in O; high Na in Eg(h). Low Ca below O. Low Mg in Bg1 & Bg2. Low K in Bg2. Low % saturation in O, Eg(h), Bg1 & Bg2. Low pH above Cg1. Low total P_2O_5 in Eg(h) & Bg2.
Eg(h)	18-26	16.3	36	43	13	33	46	0.43	0.79	0.46	0.23	33.7	5.3	4.2	3.4	8.91	0.44	74	
Bg1	30-40	9.0	44	46	10	30	60	0.15	0.22	0.23	0.13	15.5	4.3	4.9	4.0	5.20	0.27	100	
Bg2	46-56	3.4	36	43	21	28	51	0.19	0.21	0.09	0.08	3.7	14.0	4.9	4.1	0.58	0.06	75	
Cg1	73-83	3.2	35	38	27	31	42	0.63	1.34	0.13	0.13	4.9	31.0	5.1	4.0	0.39	0.05	134	
Cg2	96-100	3.1	31	39	30	31	39	1.00	1.21	0.22	0.39	4.6	37.8	5.3	3.9	0.30	0.05	143	
N.D. = No Data																			

Noncalcareous Gleys – very poorly drained

Profile No. 53			Canisbay Association					Gaira Series											Lab Numbers: 317190-92
			Soil Separates					Exchangeable Cations (m.e./100g.)						pH					
Horizon	Depth (cm)	Loss on Ignition	% Sand U.S.D.A.	% Silt U.S.D.A.	% Clay	% Silt Inter.	% Sand Inter.	Ca	Mg	Na	K	H	% Saturation	H_2O	$CaCl_2$	% Carbon	% Nitrogen	mg./100g. Total P_2O_5	Remarks
Ahg	5-15	15.9	65	29	6	18	76	14.90	5.97	0.67	0.46	5.0	81.5	6.6	6.0	8.38	0.60	134	Low clay in Ahg. High Ca, Mg & Na in Ahg. High % saturation & pH throughout. Low total P_2O_5 in BCg.
BCg	25-35	2.4	52	27	21	19	60	4.13	1.31	0.17	0.16	0.3	95.1	7.6	6.6	0.32	0.06	80	
Cg	55-65	2.6	39	41	20	29	51	4.43	1.40	0.18	0.21	<0.1	99.2	8.0	7.3			139	

Profile No. 54			Thurso Association					Hunster Series											Lab Numbers: 290696-700
			Soil Separates					Exchangeable Cations (m.e./100g.)						pH					
Horizon	Depth (cm)	Loss on Ignition	% Sand U.S.D.A.	% Silt U.S.D.A.	% Clay	% Silt Inter.	% Sand Inter.	Ca	Mg	Na	K	H	% Saturation	H_2O	$CaCl_2$	% Carbon	% Nitrogen	mg./100g. Total P_2O_5	Remarks
Ahg	5-15	16.0	35	51	14	20	66	13.40	2.89	0.50	0.24	8.1	67.7	6.2	5.8	8.22	0.95	140	High U.S.D.A. silt in Agh & Bg. High Ca & Na in Agh. High Mg in Cg1. low K in Eg & Bg. High % saturation throughout except in Eg. Low total P_2O_5 except in Agh & Cg2.
Eg	30-40	8.0	56	30	14	24	62	6.90	2.36	0.23	0.06	8.4	53.3	6.1	5.6	3.15	0.31	96	
Bg	60-70	3.7	32	49	19	31	50	3.78	1.08	0.15	0.08	2.2	69.9	6.4	5.9	0.63	0.13	74	
Cg1	80-90	3.2	41	38	21	30	49	3.01	9.46	0.12	0.17	2.2	85.3	5.7	5.4	0.33	0.19	98	
Cg2	110-120	2.8	34	45	21	24	55	3.62	0.92	0.12	0.13	1.9	71.6	6.3	5.8			132	

Peaty Gleys – very poorly drained

Profile No. 55			Canisbay Association					Dalespot Series											Lab Numbers: 267491-97
			Soil Separates					Exchangeable Cations (m.e./100g.)						pH					
Horizon	Depth (cm)	Loss on Ignition	% Sand U.S.D.A.	% Silt U.S.D.A.	% Clay	% Silt Inter.	% Sand Inter.	Ca	Mg	Na	K	H	% Saturation	H_2O	$CaCl_2$	% Carbon	% Nitrogen	mg./100g. Total P_2O_5	Remarks
O	2-10	85.1	N.D.	N.D.	N.D.	N.D.	N.D.	12.60	15.60	3.22	2.67	87.6	28.0	4.4	3.7	49.30	2.14	245	Low clay in Ah. High Ca, Mg & K in O; high Na throughout except in Bg1. Low Ca below O. Low Mg & K in Eg. Low % saturation in Ah, Eg, Bg1 & Bg2. Low pH above Bg1. Low total P_2O_5 in Ah, Eg, Bg1 & Bg2.
Ah	10-20	18.1	49	35	2	18	66	1.25	1.24	0.66	0.39	23.8	12.8	4.5	3.8	10.40	0.55	97	
Eg	20-28	4.4	39	42	17	20	61	0.12	0.25	0.26	0.07	10.6	6.2	4.9	4.2	1.95	0.12	55	
Bg1	30-40	3.3	29	42	29	3	68	0.20	0.58	0.22	0.13	8.8	11.1	5.1	4.2			39	
Bg2	55-65	2.6	35	36	29	22	49	0.26	0.96	0.32	0.17	8.8	16.2	5.0	4.0			50	
Cg1	75-85	1.6	35	36	29	24	47	0.46	2.64	0.25	0.18	7.0	33.3	5.3	4.1			106	
Cg2	110-120	1.9	31	38	31	22	47	0.61	1.84	0.36	0.32	6.6	31.3	5.4	4.0			132	
N.D. = No Data																			

Profile No. 56			Canisbay Association					Dalespot Series											Lab Numbers: 279618-24
			Soil Separates					Exchangeable Cations (m.e./100g.)						pH					
Horizon	Depth (cm)	Loss on Ignition	% Sand U.S.D.A.	% Silt U.S.D.A.	% Clay	% Silt Inter.	% Sand Inter.	Ca	Mg	Na	K	H	% Saturation	H_2O	$CaCl_2$	% Carbon	% Nitrogen	mg./100g. Total P_2O_5	Remarks
O1	6-16	91.2	N.D.	N.D.	N.D.	N.D.	N.D.	13.20	19.70	3.32	1.42	109.2	25.6	3.9	3.3	52.30	1.62	114	Low clay & high sand in Egh. High Ca, Mg, Na & K in O1. High Ca, Mg & Na in O2; high Na in Egh. Low Ca below O2. Low % saturation in Egh & Eg. Low pH above Btg. Low total P_2O_5 below O1.
O2	21-31	95.1	N.D.	N.D.	N.D.	N.D.	N.D.	9.12	16.00	2.77	0.61	122.8	18.8	3.7	3.1	54.50	1.60	83	
Egh	37-45	20.8	78	18	4	10	86	0.37	0.98	0.30	0.17	28.2	6.0	3.9	3.4			40	
Eg	47-52	9.3	53	24	18	14	64	0.22	0.83	0.17	0.19	20.7	6.3	4.3	3.8			41	
Btg	61-71	2.8	60	18	22	17	61	0.39	1.02	0.18	0.23	5.0	26.5	5.0	4.1			29	
Cg	91-101	2.4	67	17	16	13	71	0.22	0.85	0.11	0.25	3.7	27.5	5.2	4.1			55	
C(g)	111-121	2.0	75	9	16	7	77	0.22	0.77	0.08	0.24	4.0	24.5	5 .1	4.0			70	
N.D. = No Data																			

Blanket Peat

Profile No. 57			Balnket Peat																Lab Numbers: 308999-002
			Soil Separates					Exchangeable Cations (m.e./100g.)						pH					
Horizon	Depth (cm)	Loss on Ignition	% Sand U.S.D.A.	% Silt U.S.D.A.	% Clay	% Silt Inter.	% Sand Inter.	Ca	Mg	Na	K	H	% Saturation	H_2O	$CaCl_2$	% Carbon	% Nitrogen	mg./100g. Total P_2O_5	Remarks
O1	5-15	95.4	N.D.	N.D.	N.D.	N.D.	N.D.	9.33	23.10	3.49	1.03	97.6	27.5	3.9	3.3	48.90	1.46	147	High Ca, Mg & Na throughout. High K in O1 but low K in O3. Low pH throughout. Low total P_2O_5 below O1.
O2	45-55	98.1	N.D.	N.D.	N.D.	N.D.	N.D.	15.20	19.80	2.40	0.33	52.6	41.7	4.4	3.5	52.20	1.34	54	
O3	75-85	97.9	N.D.	N.D.	N.D.	N.D.	N.D.	9.26	28.80	2.87	<0.02	96.6	29.7	4.0	3.4	53.10	1.21	49	
O3	100-1110	97.8	N.D.	N.D.	N.D.	N.D.	N.D.	8.56	26.60	3.83	<0.02	89.2	30.4	4.1	3.4	48.80	0.99	46	
N.D. = No Data																			

Profile No. 58			Blanket peat																Lab Numbers: 309053-57
			Soil Separates					Exchangeable Cations (m.e./100g.)						pH					
Horizon	Depth (cm)	Loss on Ignition	% Sand U.S.D.A.	% Silt U.S.D.A.	% Clay	% Silt Inter.	% Sand Inter.	Ca	Mg	Na	K	H	% Saturation	H_2O	$CaCl_2$	% Carbon	% Nitrogen	mg./100g. Total P_2O_5	Remarks
O1	2-12	95.6	N.D.	N.D.	N.D.	N.D.	N.D.	15.10	24.70	3.83	1.14	101.2	30.7	3.9	3.2	50.40	1.64	76	High Ca, Mg & Na throughout. High K in O1. Low pH throughout. Low total P_2O_5 throughout.
O2	25-35	97.3	N.D.	N.D.	N.D.	N.D.	N.D.	12.40	25.20	2.86	0.49	100.1	29.1	3.9	3.3	50.60	1.59	66	
O2	40-50	97.4	N.D.	N.D.	N.D.	N.D.	N.D.	12.40	25.30	3.05	0.49	109.2	27.3	4.0	3.3	52.20	1.56	51	
O3	80-90	98.0	N.D.	N.D.	N.D.	N.D.	N.D.	11.10	32.60	11.80	0.27	114.0	32.9	4.1	3.3	54.30	1.35	58	
O3	100-110	98.1	N.D.	N.D.	N.D.	N.D.	N.D.	10.70	32.60	3.19	0.20	106.9	30.5	4.1	3.4	56.80	1.61	59	
N.D. = No Data																			

Basin Peat

Profile No. 59			Basin Peat																Lab Numbers: 309049-52
			Soil Separates					Exchangeable Cations (m.e./100g.)						pH					
Horizon	Depth (cm)	Loss on Ignition	% Sand U.S.D.A.	% Silt U.S.D.A.	% Clay	% Silt Inter.	% Sand Inter.	Ca	Mg	Na	K	H	% Saturation	H_2O	$CaCl_2$	% Carbon	% Nitrogen	mg./100g. Total P_2O_5	Remarks
O1	15-25	96.0	N.D.	N.D.	N.D.	N.D.	N.D.	9.18	20.10	3.56	1.50	81.3	29.6	4.1	3.1	50.00	1.49	117	High Mg, Na & K throughout. High Ca in O1& upper O2. Low pH throughout. Low total P_2O_5 below O1.
O2	50-60	97.1	N.D.	N.D.	N.D.	N.D.	N.D.	9.16	18.70	3.55	1.13	83.6	28.0	4.1	3.2	56.20	2.19	70	
O2	70-80	99.1	N.D.	N.D.	N.D.	N.D.	N.D.	6.51	15.30	4.27	1.34	64.8	29.7	4.2	3.2	53.20	1.76	48	
O2	105-115	97.9	N.D.	N.D.	N.D.	N.D.	N.D.	6.50	17.30	4.64	1.41	94.2	24.0	4.1	3.2	53.40	1.39	51	
N.D. = No Data																			

Links Soils – freely drained

Profile No. 60			Links Association					Dornoch Series											Lab Numbers: 279657-60
			Soil Separates					Exchangeable Cations (m.e./100g.)						pH					
Horizon	Depth (cm)	Loss on Ignition	% Sand U.S.D.A.	% Silt U.S.D.A.	% Clay	% Silt Inter.	% Sand Inter.	Ca	Mg	Na	K	H	% Saturation	H_2O	$CaCl_2$	% Carbon	% Nitrogen	mg./100g. Total P_2O_5	Remarks
Ap	5-15	2.9	97	<1	3	<1	97	0.90	0.47	0.17	0.09	1.5	51.6	5.5	4.4	1.44	0.13	29	High sand & low clay throughout. Low Ca & K except in buried A (bA); high Ca in bA. High Mg & Na in bA. High % saturation throughout, except in Ap; high pH in bA & C. Low total P_2O_5 except in bA.
B	40-50	1.0	97	<1	3	<1	97	1.66	0.55	0.11	0.08	1.2	66.7	6.3	5.2	0.42	0.04	49	
bA	79-81	23.0	92	4	4	3	93	25.50	8.65	1.10	0.37	10.4	77.4	6.6	5.5	12.00	0.50	101	
C	115-125	0.2	97	<1	3	<1	97	0.90	0.18	0.07	0.05	0.2	85.7	6.7	5.7			16	

Links Soils – imperfectly drained

Profile No. 61			Links Association					Eigie Series											Lab Numbers: 301022-25
			Soil Separates					Exchangeable Cations (m.e./100g.)						pH					
Horizon	Depth (cm)	Loss on Ignition	% Sand U.S.D.A.	% Silt U.S.D.A.	% Clay	% Silt Inter.	% Sand Inter.	Ca	Mg	Na	K	H	% Saturation	H_2O	$CaCl_2$	% Carbon	% Nitrogen	mg./100g. Total P_2O_5	Remarks
A	1-4	6.9	98	1	1	1	98	1.17	1.63	0.45	0.25	6.2	36.1	4.8	3.8	3.95	0.19	42	High sand & low clay throughout. High Na in A. Low Ca throughout. Low Mg & K below A. Low Na in Cg. Low % saturation below A. Low pH in A. Low total P_2O_5 throughout.
B(g)	6-16	0.4	98	1	1	1	98	0.14	0.16	0.07	0.04	4.1	8.9	5.5	4.4	0.18	0.02	15	
C(g)	30-40	0.3	98	1	1	1	98	0.09	0.11	0.07	0.04	3.5	8.0	5.5	4.8	0.08	0.03	17	
Cg	70-80	0.2	98	1	1	1	98	0.04	0.09	0.04	0.03	3.0	6.3	5.3	4.8			11	

Links Soils – poorly drained

Profile No. 62			Links Association				Morrich Series												Lab Numbers: 327550-54
			Soil Separates					Exchangeable Cations (m.e./100g.)						pH					
Horizon	Depth (cm)	Loss on Ignition	% Sand U.S.D.A.	% Silt U.S.D.A.	% Clay	% Silt Inter.	% Sand Inter.	Ca	Mg	Na	K	H	% Saturation	H_2O	$CaCl_2$	% Carbon	% Nitrogen	mg./100g. Total P_2O_5	Remarks
O	10-20	79.1	N.D.	N.D.	N.D.	N.D.	N.D.	9.36	21.10	4.72	1.60	50.1	42.3	4.1	3.2	45.30	1.37	170	High sand in Cg & bAh. High Ca, Mg, Na & K in O. High Mg & Na bO & bAh. Low Ca & K below bO. Low % saturation in 2Cg. Low pH above 2Cg. Low total P_2O_5 below bO.
bO	30-40	74.1	N.D.	N.D.	N.D.	N.D.	N.D.	4.60	7.05	4.49	0.34	40.8	28.8	4.0	3.3	38.90	1.34	109	
Cg	45-55	1.1	94	4	2	<1	98	0.18	0.50	0.19	<0.02	2.4	27.3	4.8	3.9	0.57	0.05	6	
bAh	65-75	15.6	92	5	3	3	94	2.56	6.82	1.50	<0.02	31.4	25.8	4.6	3.9	8.87	0.81	38	
2Cg	105-115	2.9	55	35	10	14	76	0.38	0.73	0.24	<0.02	7.7	15.4	5.4	4.6			42	
N.D. = No Data																			

Alluvium – poorly drained

Profile No. 63			Alluvium					Lochside Series											Lab Numbers: 290678-82
			Soil Separates					Exchangeable Cations (m.e./100g.)						pH					
Horizon	Depth (cm)	Loss on Ignition	% Sand U.S.D.A.	% Silt U.S.D.A.	% Clay	% Silt Inter.	% Sand Inter.	Ca	Mg	Na	K	H	% Saturation	H_2O	$CaCl_2$	% Carbon	% Nitrogen	mg./100g. Total P_2O_5	Remarks
Ag	5-15	7.4	32	60	8	29	63	8.87	0.59	0.15	0.08	2.5	79.5	6.2	5.9	2.94	0.64	214	High U.S.D.A. silt in Ag, Cg1 & Cg2. High Ca in Ag. Low K throughout. High % saturation throughout & high pH below Ag. Low total P_2O_5 in Bg & Cg1.
Bg	25-35	2.7	42	41	17	29	54	5.30	0.67	0.13	0.07	<0.1	99.2	7.1	6.4	0.32	0.09	66	
Cg1	50-60	2.4	29	52	19	28	53	4.23	1.17	0.09	0.08	<0.1	99.1	7.1	6.5	0.2 3	0.09	79	
Cg2	80-90	2.2	33	51	16	31	53	3.62	1.13	0.09	0.08	<0.1	99.0	7.1	6.4	0.21	0.09	105	
2Cg	110-120	1.9	53	38	9	36	65	3.00	0.79	0.06	0.06	<0.1	98.8	6.9	6.4			146	

Peat-alluvium – very poorly drained

Profile No. 64			Peat - Alluvium																Lab Numbers: 317206-11
			Soil Separates					Exchangeable Cations (m.e./100g.)						pH					
Horizon	Depth (cm)	Loss on Ignition	% Sand U.S.D.A.	% Silt U.S.D.A.	% Clay	% Silt Inter.	% Sand Inter.	Ca	Mg	Na	K	H	% Saturation	H_2O	$CaCl_2$	% Carbon	% Nitrogen	mg./100g. Total P_2O_5	Remarks
Op	10-20	41.9	N.D.	N.D.	N.D.	N.D.	N.D.	10.10	6.39	1.83	0.47	28.4	39.8	5.2	4.7	22.40	2.15	212	High % loss on ignition in marl resulting from destruction of free $CaCo_3$. Low clay in 2Cg. High Ca in Op; very high Ca below Op. High Mg in Op & O1. high Na throughout. Low K in 2Cg & marl. High % saturation in 2Cg & marl. High pH in marl. Free $CaCo_3$ in 2Cg & marl. Low pH in O2. Low total P_2O_5 in 2Cg & marl.
O1	26-32	69.3	N.D.	N.D.	N.D.	N.D.	N.D.	46.10	11.60	3.64	0.15	45.1	57.7	5.4	5.0	36.90	2.72	170	
O2	35-43	31.3	N.D.	N.D.	N.D.	N.D.	N.D.	36.90	4.60	1.47	0.14	35.9	54.6	3.3	3.2	10.50	0.14	139	
2Cg	47-53	14.6	57	40	3	22	75	62.70	3.52	0.83	0.08	<0.1	99.9	6.0	4.0	7.30	1.00	92	
Marl	60-70	45.5	N.D.	N.D.	N.D.	N.D.	N.D.	110.70	4.18	0.55	0.02	<0.1	99.9	7.9	7.5	14.00	0.48	5	
Marl	105-115	45.5	N.D.	N.D.	N.D.	N.D.	N.D.	113.40	4.80	0.43	0.02	<0.1	99.9	8.0	7.6	11.80	0.57	3	
N.D. = No Data																			

Miscellaneous Soils – Saltings

Profile No. 65			Saltings																Lab Numbers: 279613-17
			Soil Separates					Exchangeable Cations (m.e./100g.)						pH					
Horizon	Depth (cm)	Loss on Ignition	% Sand U.S.D.A.	% Silt U.S.D.A.	% Clay	% Silt Inter.	% Sand Inter.	Ca	Mg	Na	K	H	% Saturation	H_2O	$CaCl_2$	% Carbon	% Nitrogen	mg./100g. Total P_2O_5	Remarks
O	1-9	55.1	N.D.	N.D.	N.D.	N.D.	N.D.	24.00	44.60	89.20	6.31	21.0	88.6	5.7	5.5	29.40	2.36	320	Low clay throughout with high sand in 2Cg1 & 2Cg2. High Ca in O. High Mg & K in O, Cg1 & Cg2. High Na throughout. Low Ca in 2Cg1 & 2Cg2. High % saturation in throughout. Low pH in 2Cg1 & 2Cg2. High total P_2O_5 in O; low total P_2O_5 in 2Cg1 & 2Cg2.
Cg1	15-25	17.3	45	33	9	27	51	7.32	13.60	31.50	1.71	8.8	86.0	5.8	5.5	8.21	0.66	202	
Cg2	33-41	8.3	45	42	9	28	59	4.48	8.43	1.05	1.13	5.1	65.0	5.8	5.5	4.03	0.34	127	
2Cg1	50-60	1.2	96	1	3	1	96	1.81	2.71	12.30	0.11	5.5	75.4	3.1	3.1			16	
2Cg2	95-105	0.7	96	1	3	1	96	1.81	2.25	5.20	0.14	2.8	77.0	3.7	3.7			12	
N.D. = No Data																			

Appendix 3: Silicon, Aluminium and Iron by X-ray fluorescence spectrometry

Association	Series	Profile No.	Horizon	SiO_2 (%)	Al_2O_3 (%)	Fe_2O_3 (%)	SiO_2/R_2O_3	SiO_2/Fe_2O_3	SiO_2/Al_2O_3	Al_2O_3/Fe_2O_3
Canisbay	Ocklester	5	Ap	81.41	9.71	2.43	12.30	89.0	14.20	6.26
			BCx	76.53	12.01	4.09	8.88	49.7	10.80	4.60
	Warth	19	Eg(h)	79.63	12.12	0.56	10.80	378.0	11.10	33.90
			Eg(h)	74.16	13.65	2.71	8.18	72.7	9.22	7.89
			BCx	73.56	12.51	4.88	7.99	40.1	9.98	4.01
	Tresdale	31	Ap(g)	82.39	9.45	2.06	13.00	106.0	14.80	7.18
			Bg	82.20	8.72	2.46	13.50	88.8	16.00	5.55
			Bt(g)	74.20	11.69	4.10	8.80	48.1	10.80	4.46
			BCt(g)	73.47	12.45	4.95	7.99	39.4	10.00	3.94
			C(g)1	77.08	11.87	3.36	9.33	61.0	11.00	5.53
			C(g)2	75.20	12.54	4.05	8.44	49.3	10.20	4.85
	Canisbay	48	Ah	83.06	9.51	0.70	14.20	315.0	14.80	21.30
			Abh	85.14	8.71	0.50	16.00	452.0	16.60	27.30
			AB(h)	81.28	10.92	1.18	11.80	183.0	12.60	14.50
			BCg	74.29	13.88	4.69	7.47	42.1	9.08	4.64
			Rw1	67.34	17.44	6.52	5.29	27.4	6.55	4.19
			Rw2	65.19	18.76	6.02	4.89	28.7	5.89	4.88
			Rw3	66.67	19.22	4.65	5.10	38.1	5.89	6.47

Association	Series	Profile No.	Horizon	SiO_2 (%)	Al_2O_3 (%)	Fe_2O_3 (%)	SiO_2/R_2O_3	SiO_2/Fe_2O_3	SiO_2/Al_2O_3	Al_2O_3/Fe_2O_3
Dunnet	Trowieglen	17	HA	94.60	2.48	0.52	57.10	483.0	64.70	7.50
			A(h)	92.96	4.04	0.79	34.70	313.0	39.00	8.00
			A(h)	92.66	4.27	0.96	32.20	256.0	36.80	7.00
			B	90.58	4.20	3.32	24.30	72.5	36.60	1.98
			B(g)	84.97	9.58	1.37	13.80	165.0	15.00	10.90
			C(g)	89.01	4.61	0.68	29.90	348.0	32.80	10.60
Lynedardy	Lynedardy	50	Eg1	82.73	9.18	0.35	14.90	628.0	15.30	41.10
			Eg2	86.94	8.00	0.63	17.60	367.0	18.40	19.90
			Btg	80.80	10.54	1.69	11.80	127.0	13.00	9.77
			BC	78.27	10.52	4.04	10.10	51.5	12.60	4.08
Thurso	Bilbster	8	Ap	68.39	16.20	5.71	5.85	31.8	7.16	4.44
			Bx	65.81	17.53	6.15	5.20	28.4	6.37	4.46
			BC	65.70	18.19	6.65	4.97	26.3	6.13	4.28
			C	65.42	18.75	7.21	4.75	24.1	5.92	4.07
	Bilbster	11	Ap	76.66	12.84	1.49	9.43	137.0	10.10	13.50
			B(g)	69.35	14.91	5.84	6.31	31.6	7.89	4.00
			Bx	69.45	15.48	4.83	6.35	38.2	7.61	5.02
			C	66.88	16.55	6.08	5.55	29.2	6.86	4.26
	Bilbster	13	Ap(g)	67.96	17.11	5.43	5.60	33.2	6.70	4.90
			E(g)	65.89	16.98	6.18	5.40	28.2	6.60	4.30
			Bx(g)	64.85	17.35	6.83	5.10	25.1	6.40	4.00
			C1	61.77	18.25	7.48	4.10	21.9	5.80	3.80
			C2	64.62	17.57	7.02	5.00	24.5	6.30	3.90

Association	Series	Profile No.	Horizon	SiO_2 (%)	Al_2O_3 (%)	Fe_2O_3 (%)	SiO_2/R_2O_3	SiO_2/Fe_2O_3	SiO_2/Al_2O_3	Al_2O_3/Fe_2O_3
Thurso	Bilbster	15	Ap	68.30	16.84	6.02	5.60	30.2	6.88	4.38
			Bx	64.44	20.56	8.24	4.23	20.8	5.32	3.91
			C	64.45	19.35	8.26	4.44	20.7	5.65	3.67
	Camster	28	Eg	77.68	14.86	0.64	8.65	323.0	8.89	36.40
			Bs	67.12	16.08	6.56	5.63	27.3	7.10	3.85
			BC1	64.84	17.71	6.58	5.03	26.3	6.22	4.22
			Bc2	65.19	17.80	6.39	5.07	27.2	6.23	4.37
	Thurso	39	Ap(g)	69.13	15.22	4.29	6.55	43.0	7.73	5.56
			Bg	70.94	16.21	5.13	6.19	36.8	7.43	4.95
			Btg	69.35	15.49	5.24	6.26	35.2	7.61	4.63
			Cg	69.55	15.14	5.01	6.46	37.0	7.83	4.73
			C(g)	66.74	14.44	5.91	6.22	30.1	7.84	3.84
	Thurso	42	Ap(g)	74.34	14.42	3.31	7.63	59.7	8.75	6.82
			AB	74.27	14.72	3.70	7.38	53.3	8.56	6.23
			Bg	70.23	14.55	4.79	6.77	39.0	8.19	4.76
			Cg	71.45	13.92	4.47	7.23	42.5	8.71	4.88
	Ness	43	Ap(g)	78.97	9.97	3.03	11.30	69.6	13.50	5.18
			Bg	81.78	8.68	2.55	13.50	85.7	16.00	5.35
			BCg	77.75	10.18	5.81	9.52	35.7	13.00	2.75
			Rw	67.97	16.19	2.87	6.39	63.8	7.10	8.99
			Rw	53.87	20.07	15.01	3.09	9.6	4.56	2.10
	Olrig	52	Eg(h)	76.21	16.10	0.79	7.81	257.0	8.05	32.00
			Bg1	73.15	15.36	2.86	7.24	68.2	8.09	8.42

Association	Series	Profile No.	Horizon	SiO_2 (%)	Al_2O_3 (%)	Fe_2O_3 (%)	SiO_2/R_2O_3	SiO_2/Fe_2O_3	SiO_2/Al_2O_3	Al_2O_3/Fe_2O_3
	Mousland	47	Ah	70.82	15.31	2.91	7.01	64.9	7.86	8.25
			Eg	73.05	16.36	2.66	6.88	73.0	7.59	9.61
			BCg	72.38	16.22	2.74	7.18	70.4	7.59	9.28
			Bg2	68.80	15.64	4.80	6.26	38.2	7.48	5.11
			Cg1	67.70	15.64	6.62	5.79	27.3	7.36	3.71
			Cg2	66.64	15.79	6.84	5.50	25.0	7.18	3.62
	Hunster	54	Ahg	76.37	13.55	1.71	8.85	119.0	9.56	12.40
			Eg	68.74	15.74	5.61	6.04	32.6	7.41	4.39
			Bg	68.53	15.33	5.78	6.11	31.5	7.58	4.15
			Cg1	69.37	15.84	4.66	6.26	39.6	7.43	5.32
			Cg2	69.89	15.41	4.96	6.38	37.4	7.70	4.86