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PART I

THE PEDOLOGY OF A SOUTH AUSTRALIAN FEN

By C. G. Stephens, M.Sc., A.A.C.I.[1]

[Read 9 September 1943]

Plate XXVI

In January and February 1942 a soil survey was made for the Land Board of South Australia of an area known as Eight Mile Creek Swamp, which lies adjacent to the coastline in the lower South-East of South Australia. It comprises Sections 468, 469, 470, 471 and 472 in the Hundred of MacDonnell, and Sections 589, 590 and 591 in the Hundred of Caroline. The swamp is approximately 3,500 acres in area and is the largest of a series of swamps extending to beyond Cape Northumberland about eight miles to the west, and to the Nelson River a similar distance to the east. In the vicinity of Port MacDonnell some of the smaller swamps have been reclaimed, and the soil survey of Eight Mile Creek Swamp was undertaken during the initial stages of the clearing and draining of that formation. The purpose of the present paper is to discuss the pedology of the swamp soils and to point out that the physical and chemical characteristics of the peats are very similar to those of the English fens.

The swamp, like the greater part of the lower South-East of South Australia, overlies Miocene polyzoal limestone, which in the locality of the swamps appears to have been extensively faulted; for Eight Mile Creek Swamp and the other coastal swamps are characterised by lines of spring ponds which discharge several hundred million gallons of water per day. The alignment of the spring ponds along a series of eight almost parallel north-west to south-east lines suggests the presence of a series of stepped fault lines which have been planed off by erosion to their present almost common level.

In Eight Mile Creek Swamp the water from the ponds is carried by several permanent streams, of which Eight Mile Creek and Deep Creek actually discharge water naturally into the sea. The water in these streams comes from Ewen's Ponds and Deep Creek Pond respectively. Apart from two small ponds emptying by way of a small creek into Ewen's Ponds, the water from the other spring ponds is either directly absorbed by the swamp or flows a short distance as in the case of Bone and Badenoch Creeks before being absorbed. Water is also discharged into the sea by seepage and "bubblers" on the beaches.

The very wet conditions necessary for swamp formation have been caused by the partial restriction of the movement to the sea of the waters of these springs by a coastal barrier of flints and highly calcareous sand. This barrier is composed of wave terraces of flints shed from the Miocene limestone and aeolian sand partially covering these terraces and generally assuming a low ridge and swale dune topography. Dune formation is accentuated at the eastern end of the barrier. According to the level plan of the area prepared by H. L. Fisk of the Lands Department of South Australia, the swamp lies at an elevation of between four and ten feet above extreme high water mark. In general, the western two-thirds of the coastal barrier is up to ten feet above that datum, with a few higher ridges, and the eastern third of the barrier rises to heights of at least thirty feet above sea-level.

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The dry land on the north side of the swamp rises gently from its edge and is underlain by the Miocene limestone. In much of this area the flints shed from the limestone have accumulated in large amounts in the soil profile, and also characterise the soils of the many islands of dry land in the swamp.

Prior to the drainage of the swamp, the water table is reported to have been generally at or near the surface with much of the area under extensive sheets of water. The nature of the swamp water is revealed by analyses of samples from the creeks, drains and ponds. An analysis of water from near the outlet of the Eight Mile Creek is reported in Bulletin No. 19 of the Department of Mines of South Australia (7) and shows a total soluble salt content of 28·72 grains per gallon, 7·26 grains representing Cl and 10·15 CO_3. No reaction value is given but this is probably the best water available on the swamp. Water taken from a subsidiary eastern drain contained 83 grains of soluble salts per gallon and had a reaction of pH 7·63. Water from Deep Creek contained 74 grains per gallon and had a reaction of pH 8·09; water from the surface of a pond east of Bone Creek contained 60 grains per gallon and had a reaction of pH 7·23, and water from one of the western drains contained 82 grains per gallon and had a reaction of pH 7·74. In each case approximately half the soluble salt content was in the form of chloride.

Although much the greater part of the water of the swamp is telluric in origin and comes from the spring ponds in the swamp itself, there is, during the winter months, an influx of water from the north and north-west, where some surface drainage water enters and where there is also an inflow of water due to the rising of springs just off the edge of the swamp.

Apart from some transitional soils around the edge of the swamp and an area of highly saline brown fine fibrous peat at the eastern end of the swamp, four soil types have been named and mapped. They are as follows:

(1) Badenoch friable peat.
(2) Orwell coarse and fine fibrous peat.
(3) Milstead coarse fibrous peat.
(4) Hitchcox limey peat.

The aggregate area occupied by the swamp soils proper and the transitional soils is 3,514 acres. The areas of the individual types are shown in Table I.

TABLE I

AREAS OF SOIL TYPE; BY PLANIMETER

Soil	Area in acres
Badenoch friable peat	1,798
Orwell coarse and fine fibrous peat	644
Milstead coarse fibrous peat	683
Hitchcox limey peat	86
Brown fine fibrous peat	12
Transitional peats and peaty loams	291
Total	3,514

The distribution of these soil types and some details of the transitional and dry land soils and of the coastal barrier are shown on the accompanying map (fig. 1). The soil types are typified by distinct vegetation associations which, along with the general ecology of the swamp, are described in detail by Miss C. M. Eardley (1) in a contemporaneous paper in this journal.

The Badenoch friable peat is the most extensive soil of the swamp. It is a black humified peat. The profile of this soil type, as illustrated in fig. 2, consists of a surface soil of jet black friable and granular peat, usually with very little

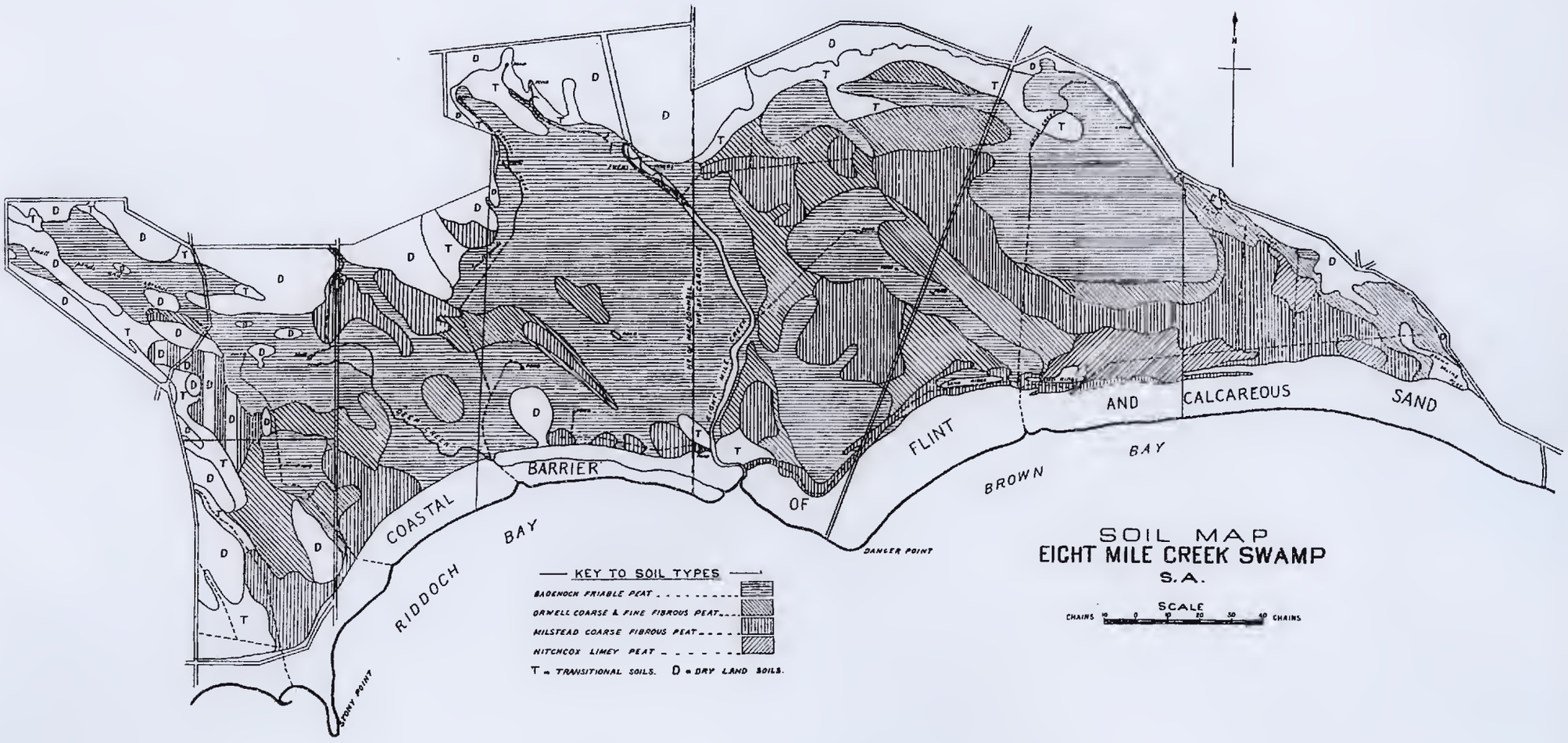

SOIL MAP
EIGHT MILE CREEK SWAMP
S.A.
KEY TO SOIL TYPES
BADENOCH FRIABLE PEAT
ORWELL COARSE & FINE FIBROUS PEAT
MILSTEAD COARSE FIBROUS PEAT
HITCHCOX LIMEY PEAT
T = TRANSITIONAL SOILS. D = DRY LAND SOILS.
SCALE
CHAINS
COASTAL BARRIER
RIDDOCH BAY
BROWN OF FLINT BAY
AND CALCAREOUS SAND
STONY POINT
DANGER POINT
EIGHT MILE CREEK
N

Fig. 1

unhumified material and about 15 inches deep; beneath the surface horizon lies black fine peat to an average depth of 42 inches. These first two horizons are discernible in plate xxvi A. Deeper lies a more variable black and brown mixed coarse and fine peat to an average depth of about 66 inches. This overlies limestone or grey calcareous sand. Sometimes between this last horizon and the lime-

Fig. 2
The Badenoch peat

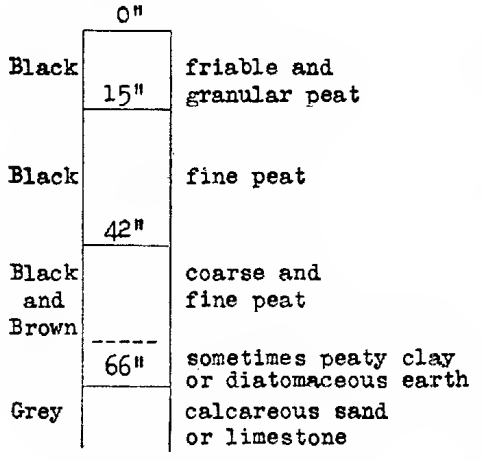


Fig. 3
The Orwell peat

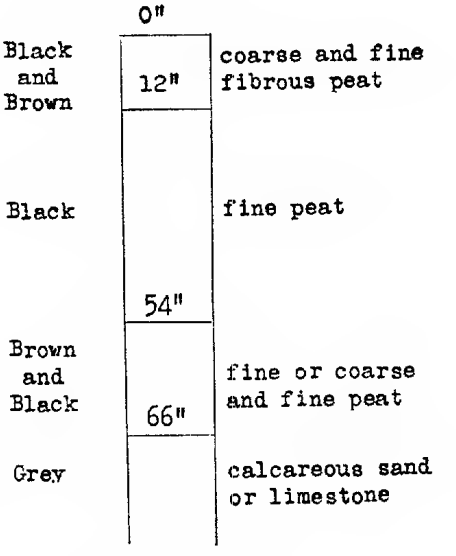


Fig. 4
The Milstead peat

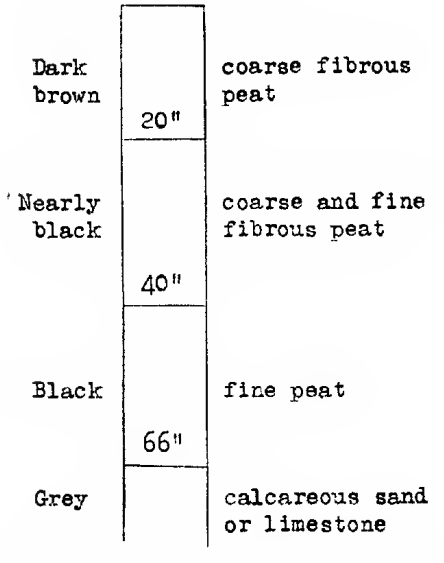
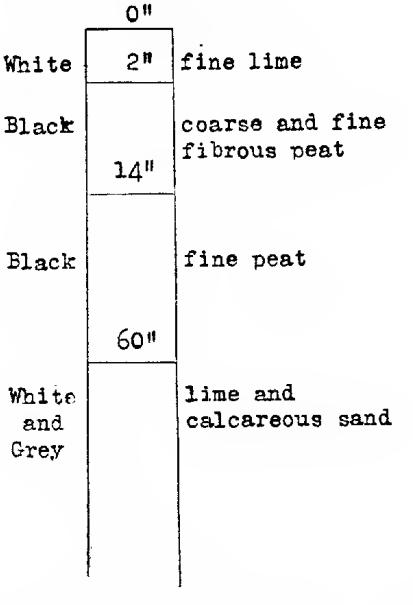


Fig. 5
The Hitchcox peat



stone there may be clayey horizons, and occasionally there is present a yellow pulpy material which bleaches on drying. This, on microscopic examination, proved to be diatomaceous earth. Genera recognised by the Zoology Department of the University of Adelaide in this material included *Navicula, Cymbella* and *Synedra.*

The soil type, which has been named the Orwell coarse and fine fibrous peat, consists of a surface soil of partly humified material about twelve inches deep. The colour is mixed black and dark brown and has a generally fibrous appearance. This overlies a black, fine peat with some roots to about 54 inches, and this in turn overlies black and brown, fine or coarse and fine peat. Beneath, at an average depth of 66 inches, lies either grey calcareous sand or limestone. The profile of this type is illustrated in fig. 3, and the two upper horizons are visible in pl. xxvi B.

The remaining extensive soil type consists of an unhumified peat. It has been named the Milstead coarse fibrous peat. The surface material, which is up to 20 inches in depth, consists of a coarse fibrous peat, dark brown in colour. This overlies about the same depth of nearly black, coarse and fine fibrous peat somewhat similar to the surface horizon of the Orwell peat. Beneath, and to an average depth of 66 inches, lies black, fine peat, and beneath this lies either grey calcareous sand or limestone. As with the Badenoch and Orwell peats, there are some subsoil variants which have peaty clay horizons on top of the limestone and occasionally flint is present, more particularly in the subsoils of the shallow phases along the northern side of the swamp. The Milstead peat is illustrated diagrammatically in fig. 4, and the upper horizons are visible in pl. xxvi C.

In the eastern portion of the swamp there occur limited areas of an unusual peat. This has been named the Hitchcox limey peat, and it is illustrated in fig. 5. The surface consists of up to six inches (average two inches) of white, fine lime, which is pulpy when wet. It appears to be largely derived from the calcareous skeletal remains of *Chara.* Under the lime lies about a foot of black coarse and fine fibrous peat, which in turn overlies black, fine peat to a depth of 60 inches. Below this again lies an horizon of fine lime and calcareous sand, and lower still grey calcareous sand. A deep example of the lime surface horizon is clearly shown in pl. xxvi D.

At the eastern end of the swamp there is an area of brown, fine fibrous peat which is both highly calcareous and saline. The surface is covered with a film of calcareous material derived from *Chara,* and the subsoil is composed of black, fine peats and peaty clays with flint gravel and resting on limestone.

All around the landward edge of the swamp there are many areas of transitional soils which are variously related to each of the Badenoch, Orwell and Milstead peats. These transitional soils are generally shallower and less organic and sometimes more calcareous than the principal soils of the swamp.

In general, interspersed in the peat soils are shells about three-quarters of an inch long of the snail, *Lenameria pectorosa* (Conrad 1850), and these undoubtedly contribute to the alkaline reaction of the peat and have possibly contributed something to the lime surface of the Hitchcox peat, for occasional shells may be found in the surface lime horizon of that soil type. However, the original organic acidity of the peat has undoubtedly been largely neutralised by the alkaline reaction of the waters issuing from the various spring ponds. Frequently, in the subsoils of the peats, there are found shells about one-tenth of an inch long of *Austropyrgus buccinoides* (Quoy and Gaimard 1834).

In Table 2 is shown the calculated composition of typical profiles of the peats, the components being expressed as organic matter, calcium carbonate, mineral matter (other than calcium carbonate and soluble salts), soluble salts and water (105° C.) in the air-dry material. In addition the composition is shown in terms of organic matter, calcium carbonate, and mineral matter as above, re-calculated to a 100% basis. These latter data have been plotted on a triangular diagram (fig. 6) which shows the composition of complete profiles from each of the principal soil types, the Badenoch, Orwell, Milstead, and Hitchcox peats. The highly organic character of these is apparent, and the minor differences such as lime and mineral

matter content are also readily seen or estimated. Mineral matter increases steadily with depth in all four peats. Table IV records all the physical and chemieal data for the peat and other soil samples taken from the swamp and its vieinity.

Excluding ealcium carbonate, the ratio of organie matter to mineral matter in the peats varies up to above 10 and thus elosely resembles the peats of the English fens as described by Pearsall (3) and Tansley (5), who record values up to 4 for surfaee soils and 11·5 for subsoils. The apparent density ranges from 0·3 upwards, and generally increases with depth. The Badenoch peat is significantly denser than the Orwell, Milstead and Hitehcox peats, as is to be expected from its generally humified character. Water-holding capaeity is over 600% in the Milstead peat and approximately 400% in the others. Although no determinations of swelling and shrinkage were made, it was apparent from the Keen-Raczkowski boxes used in the above determinations that these properties were of the order of 100%.

TABLE II

COMPOSITION OF PEATS FROM EIGHT MILE CREEK SWAMP, SOUTH AUSTRALIA

Soil type	Badenoch friable peat			Orwell coarse and fine fibrous peat				Milstead coarse fibrous peat				Hitchcox limey peat			
Soil number	7377	7378	7379	7380	7381	7382	7383	7373	7374	7375	7376	7350	7351	7352	7353
Depth in inches	0-14	14-58	58-80	0-12	12-50	50-66	66-84	0-14	14-28	26-63	63-84	0-6	6-15	15-60	60-80
	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%
Organic matter	71.4	69.9	67.0	75.4	63.7	60.2	0.6	79.7	73.4	56.7	0.6	6.9	62.1	51.1	3.7
Calcium carbonate	0.0	0.0	0.0	0.0	0.0	0.0	79.0	0.0	5.2	1.4	82.2	86.9	8.6	1.0	89.4
Mineral matter	10.0	11.4	16.0	9.3	15.1	23.5	19.6	5.7	6.0	25.9	16.8	4.1	13.7	33.8	6.0
Soluble salts	1.5	0.4	0.7	0.3	0.3	0.6	0.1	0.3	0.5	0.3	0.0	0.3	0.5	0.5	0.1
Water (105° C.)	17.1	18.3	16.3	15.0	20.9	15.7	0.7	14.3	14.9	15.7	0.4	1.8	15.1	13.6	0.8
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%
Organic matter	88	86	81	89	81	72	1	93	87	67	1	7	74	59	4
Calcium carbonate	0	0	0	0	0	0	79	0	6	2	82	89	10	1	99
Mineral matter	12	14	19	11	19	28	20	7	7	31	17	4	16	40	6
Total	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100

The peats are generally neutral to alkaline in reaction with some horizons, particularly in the Badenoeh peat, faintly acid in character. In this property the peats of Eight Mile Creek Swamp and the alkaline waters of the ponds and creeks closely resemble the peats and natural waters of the English fens and broads as described by Tansley (5) for the East Anglian fens, and by Godwin and Turner (2) for the waters of Calthorpe Broad. That such an unhumified, coarse, fibrous material as the Milstead peat should not be aeid in reaction ean only be due to its periodical inundation by the alkaline water from the spring ponds. As stated by Tansley (5) for the peats of the English fens, "The organic soil is formed by the decay of plant debris under relatively anaerobic conditions and is therefore *peat*. It is irrigated by water relatively rich in basic ions and often alkaline in reaction." In addition, the alkaline nature of the waters of Eight Mile Creek Swamp is undoubtedly primarily responsible for the abundance of the fresh-water shells and the *Chara* mentioned previously. Fresh-water shell marl oceurs under much of the Cambridgeshire fen land as beds 5-10 cm. thick and lying 30-40 cm. below the surface. Wilson and Staker (8) have described peat soils of New York which contain horizons of material derived from *Chara* calcareous remains, but none of these are on the surface. Teakle (6) has described soils from Herdsman's Lake in Western Australia which eontain horizons of calcareous material derived from land shell and other sources.

The total nitrogen eontent of the peats is very high. Phosphoric acid and potash were estimated by extraction with hot hydrochloric acid. The former is

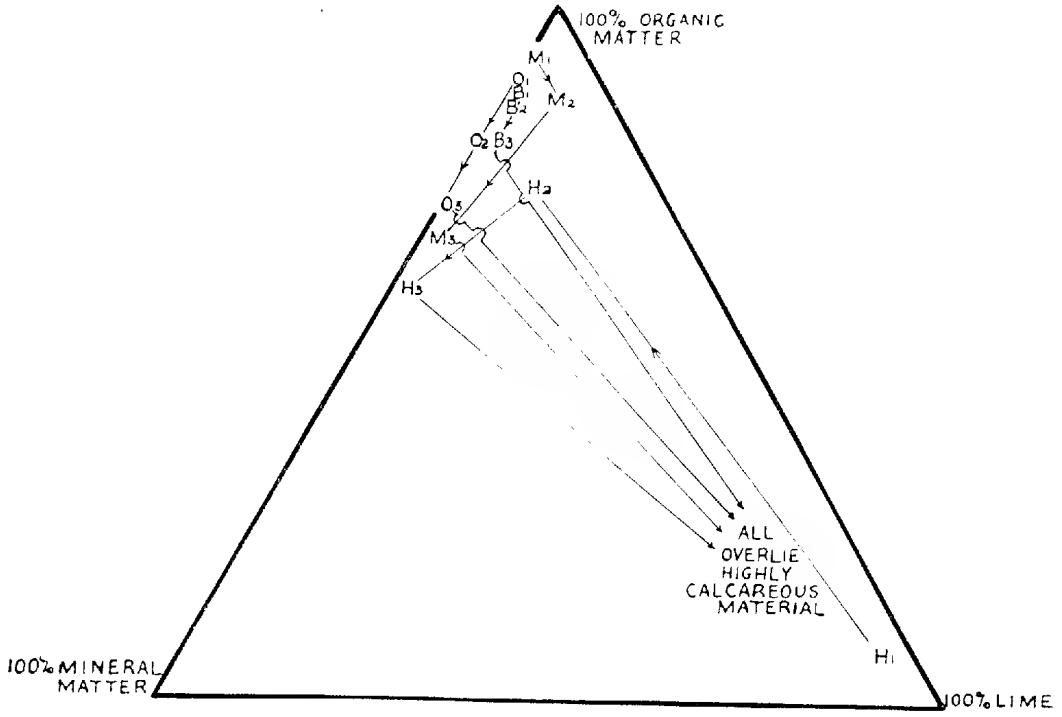


Fig. 6

Triangular diagram showing the composition of the various horizons of the Badenoch ($B_1B_2B_3$), Orwell ($O_1O_2O_3$), Milstead ($M_1M_2M_3$) and Hitchcox ($H_1H_2H_3$) peats.

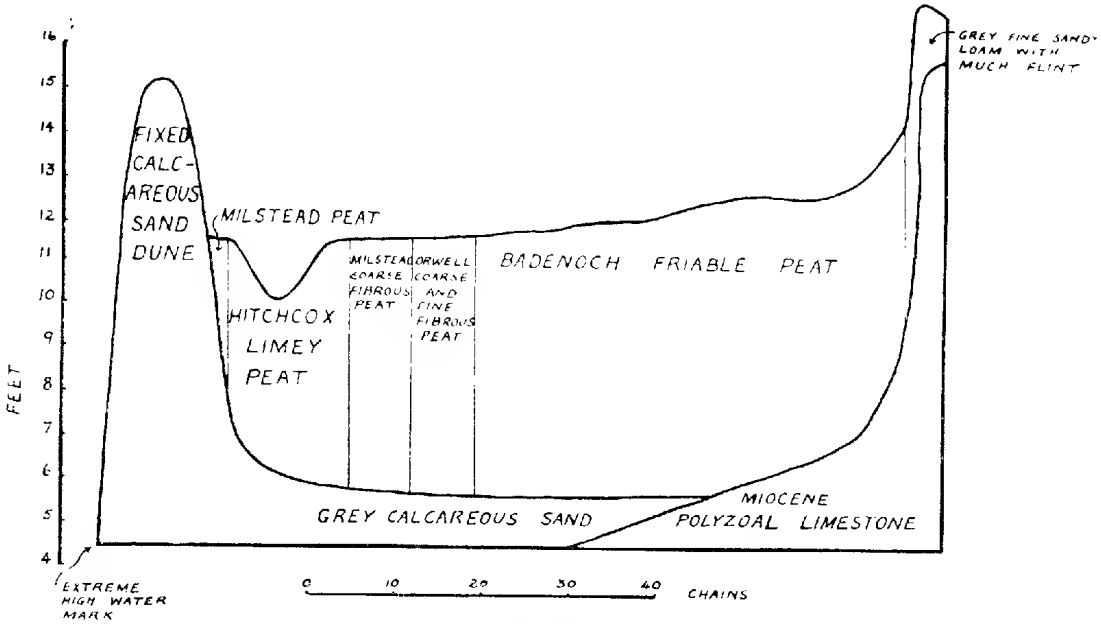


Fig. 7

Section across the eastern end of Eight Mile Creek Swamp about 20 chains east of Bone Creek. (Partly based on levels by H. L. Fisk.)

present in moderately large amounts, and the latter in what would appear to be small quantities. In this connection they resemble the highly productive peat soils of Egg Lagoon on King Island, Tasmania, as described by Stephens and Hosking (4), which soils are also high in nitrogen and phosphate.

Organic carbon, which was determined by dry combustion, accounts for over 40% of some of the peats. It seems on the average to be a little lower in the Badenoch peat than in the other named types. Carbon: nitrogen ratios are set out in Table III, and from them it is seen that the more humified character of the Badenoch peat is reflected in lower values than in the Milstead and Orwell peats.

TABLE III

CARBON : NITROGEN RATIOS

Soil	Values for surface soils		
Badenoch peat - -	17·5	17·5	15·0
Orwell peat - -	26·2	22·7	
Milstead peat - -	28·2	26·2	
Hitchcox peat - -	13·3 (lime horizon)	18·7 (upper peat horizon)	

Included in Table IV are estimations of total soluble salts and chloride radicle. At first sight some of these figures may appear somewhat high, but these estimations are on air dry soils with moisture contents up to about 20%. In the field these values will be diluted many times by the high proportion of water held in the peat. However, the salt content of the Orwell and Milstead peats may be marginal for some agricultural plants until decreased by the drainage system. The brown, fine fibrous peat is definitely highly saline.

Pot experiments on the Badenoch, Orwell and Milstead peats indicate that they may be deficient in copper, manganese, zinc and boron for optimum plant growth. Responses to phosphate and potash were also obtained.

The peat soils described above are all due to the accumulation of organic matter under the past and prevailing ecological conditions on the swamp. That there has been some variation in these conditions is indicated by the occasional presence of the horizon bearing diatomaceous material. Recent variation is reflected in the vegetation, and thus particularly in the nature of the surface horizon in the different soil types. The simplest illustration of the structure of the swamp, and of the relationship of the different peats to topographical detail, is given by a north-south section (fig. 7) through the eastern end of the swamp, some 20 chains east of Bone Creek. From this diagram can be seen the reason for the variation in the nature of the basal material on which the peats lie—either highly calcareous sand or polyzoal limestone. Also, it is apparent that the Badenoch peat has developed on the best-drained sites, with the Orwell peat intermediate between it and the lower situated Milstead peat. The Hitchcox peat, with its *Chara* lime surface is confined to definite depressions in the floor of the swamp. Other sections reveal that the Badenoch peat is not necessarily confined to the highest sites but also occurs on slopes. As would be expected from its humified character, favourable drainage rather than elevation is the determining factor.

According to Tansley (5): ". . . . the term *marsh* is applied to the 'soil-vegetation' type in which the soil is water-logged, the summer water-level being close to or conforming with the surface but not normally much above the ground level, and in which the soil has an inorganic (mineral) basis: *fen* to a corresponding type (whose vegetation is closely similar) in which the soil is organic (peat) but is somewhat or decidedly alkaline, nearly neutral or somewhat but not extremely acid. *Bog* . . . . forms peat which is extremely acid. *Swamp* is used for the type in which the normal summer level is above the soil surface." Also,

TABLE IV

ANALYTICAL DATA ON THE PEATS AND SOILS OF EIGHT MILE CREEK SWAMP

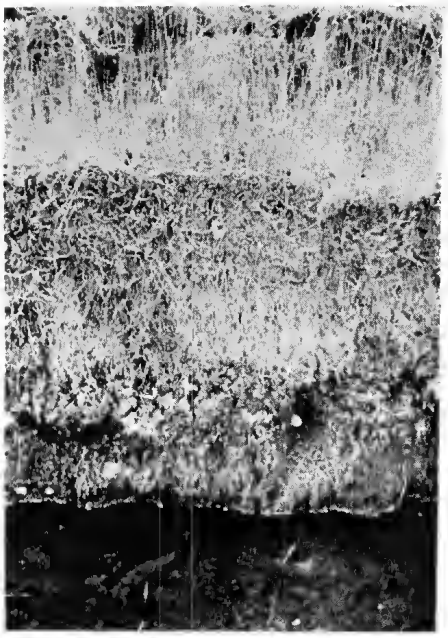
Soil type	Badenoch friable peat				Badenoch friable peat			Badenoch friable peat			Badenoch friable peat				Orwell coarse and fine fibrous peat			
Soil number	7367	7368	7369	7370	7377	7378	7379	7384	7385	7386	7387	7388	7389	7390	7363	7364	7365	7366
Depth in inches	0-16	16-40	40-54	54-62	0-14	14-58	58-80	0-15	15-52	52-63	0-12	12-38	38-63	63-84	0-10	10-20	20-60	60-82
Organic carbon	-	-	-	-	40.3	41.1	40.4	34.1	-	-	32.9	41.9	42.1	16.4	39.6	-	-	-
Calcium carbonate	-	-	-	-	0.0	0.0	0.0	0.0	-	-	0.0	0.0	0.0	0.0	2.9	-	-	-
Moisture	-	-	-	-	17.1	18.3	16.3	24.3	-	-	23.3	18.6	16.1	9.3	15.0	-	-	-
Loss on ignition	-	-	-	-	73.5	69.9	67.0	60.7	-	-	58.0	70.3	70.4	28.8	73.3	-	-	-
Water holding capacity	-	-	-	-	417	267	216	-	-	-	332	265	221	522	-	-	-	-
Volume weight	0.6	0.7	0.7	1.2	0.5	0.6	0.6	0.6	0.7	0.7	0.6	0.7	0.6	0.2	0.3	0.5	0.4	0.7
Nitrogen %	1.35	-	-	-	2.30	2.30	1.59	1.95	-	-	2.19	2.18	1.72	0.89	1.51	-	-	-
% K_2O) HCl extract	-	-	-	-	-	-	-	-	-	-	0.17	-	0.12	-	-	-	-	-
% P_2O_5)	-	-	-	-	-	-	-	-	-	-	0.22	-	0.09	-	-	-	-	-
Total soluble salts	0.42	0.32	0.88	0.09	1.53	0.41	0.72	0.23	0.22	0.53	0.19	0.44	0.65	0.67	0.90	0.63	0.59	0.48
Chloride Cl'	0.10	0.10	0.13	0.01	0.31	0.09	0.09	0.07	0.07	0.09	0.04	0.17	0.22	0.11	0.35	0.23	0.23	0.11
Reaction pH	7.8	6.9	5.8	7.1	6.3	6.3	6.2	7.6	7.3	6.4	7.8	6.6	6.3	6.7	7.6	7.9	7.6	6.6

Soil type	Orwell coarse and fine fibrous peat				Milstead coarse fibrous peat					Milstead coarse fibrous peat				Hitchcox limey peat			
Soil number	7380	7381	7382	7383	7358	7359	7360	7361	7362	7373	7374	7375	7376	7350	7351	7352	7353
Depth in inches	0-12	12-50	50-66	66-84	0-10	10-18	18-42	42-58	58-80	0-14	14-26	26-63	63-84	0-6	6-15	15-60	60-80
Organic carbon	40.9	37.4	54.9	-	39.8	-	-	-	-	43.2	40.3	32.6	-	4.0	36.0	29.6	-
Calcium carbonate	0.0	0.0	0.0	77.0	2.7	-	-	-	-	0.0	5.2	1.4	82.2	86.9	8.6	1.0	89.4
Moisture	15.0	20.9	15.7	0.7	12.3	-	-	-	-	14.5	14.9	15.7	0.4	1.8	15.1	13.6	0.8
Loss on ignition	75.4	63.7	57.3	0.6	79.2	-	-	-	-	79.7	75.6	76.7	0.2	8.0	69.2	50.8	3.8
Water holding capacity	456	261	215	54	-	-	-	-	-	649	537	286	45	154	420	212	77
Volume weight	0.3	0.6	0.7	1.1	0.3	0.4	0.7	0.8	0.8	0.3	0.4	0.8	1.2	0.6	0.4	0.7	0.9
Nitrogen %	1.80	1.80	1.70	-	1.41	-	-	-	-	1.65	1.64	1.64	-	0.30	1.92	1.69	-
% K_2O) HCl extract	0.20	-	0.18	-	-	-	-	-	-	0.12	-	0.13	-	-	-	-	-
% P_2O_5)	0.11	-	0.15	-	-	-	-	-	-	0.06	-	0.15	-	-	-	-	-
Total soluble salts	0.27	0.38	0.60	0.10	0.69	0.61	0.26	0.11	0.06	0.25	0.46	0.32	0.05	0.26	0.52	0.45	0.10
Chloride Cl'	0.05	0.09	0.13	0.02	0.22	0.21	0.07	0.03	0.15	.05	0.10	0.09	0.01	0.07	0.12	0.10	0.02
Reaction pH	6.9	6.8	6.5	8.9	7.6	8.0	8.2	8.6	7.7	6.4	7.6	7.5	8.8	7.9	7.6	7.1	8.4

Soil type	Shallow calcareous phase Milstead peat			Transitional peaty soil			Brown, fine, fibrous peat			Grey calcareous flinty loam				Fixed calcareous sand			
Soil number	7394	7395	7396	7391	7392	7393	7347	7348	7349	7397	7398	7399	7400	7354	7355	7356	7357
Depth in inches	0-5	5-27	27-40	0-6	6-14	14-30	0-7	7-30	30-42	0-7	7-16	16-24	24-33	0-8	8-30	30-52	52-84
Organic carbon	22.6	-	-	11.8	-	-	17.0	12.4	7.6	7.4	-	-	-	4.0	-	-	-
Calcium carbonate	31.0	-	-	25.5	51.1	31.1	45.5	35.2	23.8	40.2	31.4	25.0	66.1	74.4	85.7	84.8	86.5
Moisture	19.7	-	-	8.6	4.9	4.1	8.0	7.5	5.4	4.8	2.3	-	-	1.8	0.4	0.2	0.3
Loss on ignition	39.4	-	-	23.5	12.0	6.5	33.2	24.4	14.2	21.8	2.6	3.3	2.0	8.2	1.2	1.8	1.0
Water holding capacity	-	-	-	-	-	-	-	-	-	-	-	-	-	70	58	34	39
Volume weight	0.5	0.7	1.3	0.8	0.8	1.1	0.4	0.7	0.9	0.8	1.0	1.3	1.2	1.0	1.1	1.4	1.3
Nitrogen %	1.17	-	-	0.74	-	-	1.29	0.80	0.32	0.47	-	-	-	0.37	-	-	-
% K_2O) HCl extract	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
% P_2O_5)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Total soluble salts	1.26	0.53	0.20	0.33	0.43	0.15	4.64	0.72	0.28	..10	0.08	0.08	0.08	0.07	0.11	0.03	0.03
Chloride Cl'	0.44	0.17	0.04	0.11	0.16	0.04	2.40	0.35	0.11	0.02	0.02	0.02	0.02	0.02	0.03	0.00	0.01
Reaction pH	7.7	7.7	7.9	8.5	8.3	8.4	7.7	8.0	8.2	8.3	8.7	8.7	8.8	8.2	9.2	9.5	9.3

A
The upper horizons of the Badenoch friable peat.

B
The upper horizons of the Orwell coarse and fine fibrous peat.



C
The upper horizons of the Milstead coarse fibrous peat.

D
The upper horizons of the Hitchcox limey peat.

"In marsh, fen and swamp the water is telluric in origin, in bog it may or may not be."

In view of the above definitions and the similarity between the waters and soils of Eight Mile Creek Swamp and the English fens, there is no doubt that it is a characteristic fen formation.

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GENERAL INDEX

[Generic and specific names in italics indicate that the forms described are new to science.]