

1.—REPORT ON THE GEOLOGICAL FEATURES OF THE DENMARK AND NORNALUP FARMING AREAS, WITH SPECIAL REFERENCE TO THE "WASTING DISEASE" IN THE CATTLE ON THE DENMARK AREA.

(T. Blatchford, B.A.)

General Remarks.

For some considerable time past there has been a constant loss in the dairy herds of the farms of the Denmark area and extending as far west as Group 116. These losses have been confined mainly to the young stock, particularly to the calves after reaching an age of about three months. Young heifers are also affected to a less extent. On removing the affected stock to unaffected blocks they usually recover and on reaching maturity are, as a rule, immune. The loss in stock due to this cause has become so pronounced of late that the position of the dairy men settled on affected blocks has become more and more acute. Furthermore, as the disease appears to be spreading in the Denmark areas the danger became still more serious owing to the opening up of the western areas at Nornalup.

Realising the seriousness of the situation and to ensure that no avenue of investigation should be neglected, the Hon. the Minister for Lands requested a geological inspection of both areas to ascertain whether a study of the geological conditions might throw some light on the cause of the complaint, such as was done in the case of the "Bush Sickness" in New Zealand.

Geology.

The general geological features of the coastal areas extending from Denmark to Nornalup are extremely simple and are briefly as follows:—

From the shore line extending inland for usually not more than a very few miles we find a series of comparatively recent sand dunes, which no doubt have been formed from the beach sand blown inland by the ocean winds.

In places these sand deposits are calcareous, the origin of the lime being no doubt due to concentration from the fragments of sea shells included in the sand. Occasionally this concentration has gone far enough to create limestone deposits, "cap limestones" sufficiently high in lime contents to be of commercial value, where the difficulty of transport is not prohibitive.

Lying in the hollows between the sand ridges it is not uncommon to find accumulations of organic matter in sufficient quantity to form peaty swamps, and in one or two instances beds of brown coal have formed, the most noteworthy being that on the north-western edge of Nornalup Inlet. All these recent coastal deposits are shallow and rest directly on an underlying gneissic floor. To illustrate their extent a map* is attached showing how they occur in the vicinity of Nornalup.

Leaving these low-lying coastal deposits and passing inland a few miles from the seaboard, we find a series of irregular hills and ridges of considerably greater altitude. Sometimes these ridges are connected, but more often they occur as isolated groups, separated by valleys or level strips of low-lying country.

* Map not published.

Without exception these hills are composed of some form of granite, the prevailing type being a gneissic variety. Very occasionally narrow dykes of a more basic nature may be seen cutting through the granite, but these are so rare and small as to be negligible.

Much of the slopes, particularly towards the bases of the hills, is covered with ironstone gravels.

The Granites.—In hand specimens many of the granites show a gneissic or schistose structure, particularly when slightly weathered. On the other hand, some are true augen gneisses. These differences from a normal granite are purely structural and arise from the re-arrangement of the component minerals into bands, due either to pressure or flow structure during consolidation. There need be no difference in the chemical composition of the three rocks—granite, gneiss, or gneissic granite. Under the microscope the following minerals have been recognised:—

Quartz, biotite mica, orthoclase, microcline and plagioclase feldspars with minor quantities of the accessory minerals, hornblende, garnet, apatite and the oxides of iron.

All these are very commonly occurring minerals of the granite family throughout the world. Some little confusion, I find, was caused by concentrations of the mica in certain restricted areas, being confused with basic dykes. These basic segregations are very common in most granite areas and only indicate a preponderance of black mica—biotite.

In an investigation in New Zealand of the "Bush Sickness," which has many characteristics of the Wasting Disease in Denmark, some very close work has been done as regards the soils of their infected areas, particularly with regard to the physical qualities; it being claimed that healthy and unhealthy areas can be differentiated by investigating the texture of the soil.

I take the opportunity here to discuss briefly the characteristics of the New Zealand affected areas with those of our State. In New Zealand the affected soils may consist of granite wash (?), dune sands or pumice soils. When they contain less than 5 per cent. of clay that soil is considered to be near the danger zone of being "sick." All "sick" soils in New Zealand are almost devoid of clay particles; they range from fine gravelly sandy silts to coarse sands.

So far, most of the "sick" farms in Denmark are on the crests or upper slopes of the granite hills. There has been no sorting of the rock waste, the pastures are on soil the result of the decomposition of the rock *in situ*. Three analyses of typical soils, taken from some of the blocks at Nornalup, all gave satisfactory clay results when compared with the unaffected New Zealand soils. (Appendix 3.) These samples should be representative of most if not all of the farms under consideration.

As the principal virtue of clay in soil is its power to conserve surface waters, the rainfall should also be considered. It will be seen from Appendix 2 that, on the average, rain falls every month of the year, both at Nornalup and Denmark.

Therefore, if the New Zealand experience regarding the physical conditions of soils be used as a criterion for comparison with those of Denmark and Nornalup, there is only one conclusion to arrive at, which is that the soils in the latter localities should not be affected.

Ironstone Gravel or Laterites.—The only other rock type found on the farms situated on the hilly country is laterite.

Laterite deposits are fairly common throughout, particularly on the lower portions of the slopes, near the crests of the hills they assume a character more of the nature of gravel beds, but on the lower portions the laterite mantle is distinctly massive. From the analyses of two typical samples (Appendix 4), it appears that at least some of these laterites are aluminous, though not to the extent to justify their being classified as bauxites.

The origin of these iron-bearing deposits is generally recognised as being due to the soluble ferrous salts rising by capillarity to the surface and there becoming oxidised to the corresponding insoluble ferric form. In the present case the iron oxides would have been derived from the decomposing biotite.

From the pastoral standpoint they play two important parts at Denmark. In the first place, under two conditions they would be a source of soluble iron salts for plant life: (1) in the presence of acid waters; (2) when subjected to acid generated during the decomposition of organic matter during the formation of humus in the soils. This would occur, no doubt, to a greater extent where the laterite is broken down into more or less gravel beds such as already referred to, as being the condition on the higher ground. On the lower portions of the slopes, where the laterites are more solid, they might very easily act in the same way as a "hard pan" and prevent the rainwaters soaking into the underlying weathered rock. I advance this as a possible cause for the karri timber growing on the crests and upper slopes in these areas, which is not its usual habit in other localities, on account of the soils containing more moisture there than in the lower slopes, where jarrah predominates.

Chemical Composition of the Soils.

Generally speaking, granites are not rich in all the mineral ingredients necessary for the development and maintenance of plant life. They, however, usually carry minerals which, on decomposition will liberate quite appreciable amounts of potash, iron, with lesser amounts of lime and phosphorus.

Of the potash-bearing minerals, biotite and orthoclase and microcline are the most important and are found in fair quantities in the Denmark granites or gneisses. There is a limited amount of lime-bearing feldspar but the phosphorus-bearing mineral—apatite—occurs comparatively only in very small quantities. No mineral which could on weathering produce a deleterious ingredient was discovered in any of the samples collected.

Except that the soil may be a little shallow on portions of some of the farms, my investigations are to the effect that the soil is a typical granite variety, well constituted to hold moisture and should retain limited amounts of natural potash, iron oxides, with minor quantities of phosphate and lime. By the addition of top dressings the cleared land has already produced excellent results.

Attached as Appendix 5 are several analyses of the soils of the Denmark farms, which have been taken by officers of the Agricultural Department. In con-

nection with these analyses I would like to draw the attention of the agricultural chemists to the importance attached to the pH values in soils, set out in a lecture by Professor Prescott of the Waite Agricultural Research Institute, at the meeting of the Australian Association for the Advancement of Science held in Hobart, 1928, entitled "The Agricultural Significance of Soil Reaction" in case the article has been overlooked.

Water.

The stock water supplies of both affected and non-affected farms are derived from wells, running streams, soaks and water catchments. The list of analyses in Appendices 6-9 does not clearly show to what extent any particular water has been used for stock on the individual farms.

Generally speaking there are two points to note regarding the analyses. In the first place the total solids in no instance exceeds the limit set for stock water for cattle. In fact they are far below that factor. The pH value of the waters, however, calls for careful thought, and though I admit that I am not in the position to give an opinion on what the effect of slightly acid waters would have on stock, I wish to draw attention to the fact that in the attached list the waters on the affected farms have a low pH value, whilst with one exception—the well water on the State Farm—the waters on the non-affected farms have a much higher value, and have been classified as neutral.

Summary and Conclusions.

1. In summing up the foregoing evidence there appears to be no doubt that the soils of the infected farms are solely derived from the weathering of granites and gneisses in situ. Consequently there has been no sorting of the material as in river flats or similar deposits.

2. Compared with the unaffected areas in New Zealand the physical conditions, particularly the percentage of clay in the soil, are very satisfactory.

3. Although of minor importance, there is a strong probability that natural useful plant minerals, such as potash, iron, with minor quantities of lime and phosphoric acid, still exist in the soil.

4. The waters used for stock purposes carry low salt contents, but on some of the affected blocks show slight acidity. This requires further investigation.

5. Statistics show an average monthly rainfall throughout the year, as seen in Appendix 2.

6. Some of the main difficulties which present themselves are the following:—

- (a) How two adjoining farms on apparently the same class of soil can be one affected, the other clean;
- (b) Why stock transferred from the first to the second recover;
- (c) Why the disease is gradually increasing.

7. In my opinion none of these difficulties can be attributed to the properties of the soils, which should remain constant in either case.

8. I therefore suggest that the cause of the Wasting Disease may be found in investigating—

- (a) possible malnutrition—in some cases at least this might be lack of both fodder and water;
- (b) the slight acidity of some of the stock waters;
- (c) exposure, particularly to the young stock;
- (d) a close study of the fodder, particularly as the complaint is said by some to be more pronounced at certain times of the year;
- (e) some disease, hitherto not diagnosed;
- (f) a possible deficiency in the fodder supplied to the stock.

AFFECTED HOLDINGS—DENMARK AREA—WASTING DISEASE—continued.

Group.	Loc.	Settler.	Remarks.
...	2627	Bidwell and Woolterton	Red Gum and Jarrah fringes, (recently affected)
...	4329	Parker ...	Karri, Red Gum and Jarrah
116	1702	E. Pascoc ...	Karri and Tingle, and little Red Gum and Jarrah (heifers affected)
...	1694	L. S. W. Boast ...	Karri and Tingle, Red Gum fringe. (heifers affected)
...	1706	H. Boast ...	Karri and Tingle. Red Gum fringe. (heifers affected)
93	4326	A. C. Swan ...	Karri, Red Gum and Jarrah fringes
41	551	F. C. Smith ...	Karri, Red Gum and Jarrah fringes
...	469	E. Thomas ...	Karri, Red Gum and Jarrah fringes, (heifers affected)
42	552	H. Harris ...	Karri, Red Gum and Jarrah fringes, (heifers affected)

AFFECTED HOLDINGS—DENMARK AREA—WASTING DISEASE.

Group.	Loc.	Settler.	Remarks.
41	553	Taylor ...	Karri, Red Gum and Jarrah
...	419/39	Mohr ...	High Karri mostly
...	463	Garland ...	Karri land, Red Gum and Jarrah fringes
...	436	J. Ilsley ...	Karri land, with moist depressions
...	469	G. Osborne ...	Karri land, (calves affected)
...	461	A. Watson ...	Karri land, Red Gum and Jarrah fringes
42	455	A. Holder...	Karri, Red Gum and Jarrah fringes
...	460	E. Bastiani ...	Karri, Red Gum and Jarrah fringes (calves affected)
...	574	Pearce ...	Karri and Jarrah, moist depressions
...	476	Burgoyne ...	Red Gum and Jarrah fringes
58	662/3/4	Narcanon ...	Red Gum and Jarrah fringes (heifers under two years affected)
93	2615	Lethlian ...	Karri, Red Gum and Jarrah fringes
...	2616	Hodgson ...	Karri, Red Gum and Jarrah fringes

APPENDIX 2.

AVERAGE MONTHLY RAINFALL.

	Nornalup.	Denmark.
	points.	points.
January ...	143	116
February ...	209	154
March ...	247	235
April ...	349	348
May ...	700	590
June ...	769	709
July ...	835	759
August ...	747	665
September ...	569	531
October ...	447	464
November ...	235	190
December ...	161	141
Yearly average ...	5,411	4,901

APPENDIX 3.

Report on Six Samples of Soil taken at Nornalup, W.A.

Marks :—Block 10185, depth 0 — 6in.
" 10185 " 6 — 12in.
" 10107 " 0 — 3in.
" 10107 " 3 — 11in.
" 10211 " 0 — 6in.
" 10211 " 6 — 12in.

Results of Analysis :—

Lab. No.	...	...	5335.	5336.	5337.	5338.	5339.	5340.
Depth	...	...	0—6 in.	6—12in.	0—3 in.	3—11 in.	0—6 in.	6—12 in.
			%	%	%	%	%	%
Roots	...	...	—	—	4.0	2.5	—	—
Stones above 2 mm.	...	...	15.0	—	8.0	16.0	60.0	58.0
Fine soil below 2 mm.	...	...	85.0	100.0	88.0	81.5	40.0	42.0
Mechanical Analysis of — 2mm. samples :								
Loss on ignition	...	...	10.2	7.6	9.2	7.3	4.4	4.3
Moisture	...	...	3.8	3.0	3.9	2.6	1.3	0.9
Loss on acid treatment	...	...	3.1	1.9	4.2	2.4	1.1	1.0
Coarse sand (2 — 0.2 mm.)	...	...	35.4	34.5	28.3	29.8	45.3	39.9
Fine sand (0.2 — 0.02)	...	...	25.5	25.0	36.6	36.2	37.8	40.4
Silt (0.02 — 0.002)	...	...	11.2	10.2	10.0	9.4	3.6	4.5
Clay (below 0.002)	...	...	15.3	23.4	11.5	16.3	5.7	8.1
Chemical Analysis of — 2 mm. samples :								
Water soluble salts	...	...	0.082	0.050	0.202	0.050	0.066	0.05
Sodium chloride calc. from chlorine	0.020	0.017	0.100	0.017	0.008	0.013
Reaction, pH.	6.08	6.17	5.86	6.28	5.98	5.78

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APPENDIX 4.

Report on two Samples from Nornalup.

Lab. No.	5333/30	5334/30
Reg. No.	1/5028	1/5040
Acid Soluble Alumina (Al_2O_3)	...	...	...	...	13.94	25.57
Acid Soluble Iron Oxide (Fe_2O_3)	...	...	...	...	39.69	10.13

NOTE.—These laterites are too low in soluble alumina to be classed as bauxites.

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APPENDIX 5.

Material: Eight samples from the Denmark District—(1) Soil, Burgoyne, Group 42. (2) Subsoil, Burgoyne. (3) Soil, Osborne, Group 42. (4) Subsoil, Osborne. (5) Soil, Kingdon. (6) Subsoil, Kingdon. (7) Soil, Marwick. (8) Subsoil, Marwick.

Lab. No.	...	...	...	1571/28	1572/28	1573/28	1574/28	1576/28	1577/28	1579/28	1580/28
				(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
				Soil.	Subsoil.	Soil.	Subsoil.	Soil.	Subsoil.	Soil.	Subsoil.
				Burgoyne (476).		Osborne (469)		Kingdon.		Marwick.	
Soil reaction, pH	...	...	...	6.0	5.2	5.6	6.4	6.2	6.8	6.2	7.0
				%	%	%	%	%	%	%	%
Total sol. salts	...	...	...	0.68	0.27	0.23	0.31	0.17	0.37	0.03	0.13
Sodium chloride	...	...	...	0.66	0.26	0.13	0.19	0.09	0.12	0.01	0.12
Acid Soluble:											
Iron, Fe	...	...	...	7.68	3.25	2.98	2.03	3.05	2.44	5.41	1.01
Lime, Ca	...	...	...	0.25 N	0.13	0.13 L	0.13	0.21 L	0.11	0.25 N	0.29
Phosphoric oxide (P_2O_5)	0.07 L	0.11	0.06 L	0.09	0.20 G	0.12	0.15 N	0.20
Potash, K_2O	0.42 R	0.09	0.19 N	0.40	0.04 P	0.05	0.14 L	0.08

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APPENDIX 6.

Material:—Twelve samples of Water in connection with the Denmark Cattle Disease marked as below.

Results of Analysis.

Lab. No.	Sample No.	Block No.	Condition.	Reaction pH.	Sodium Chloride.	Total sol. salts.	Iron, Fe. Parts per million.
					Grains per Gallon.		
66/30	1	512	...	6.8 Neutral	52.60	60.76	9
67	2	503	...	7.0 do.	103.84	124.02	8
68	8	Kingdon	...	6.8 do.	29.02	41.16	10
69	10	S.S.F.	...	6.8 do.	64.84	80.36	6
70	11	Scotsdale Creek	...	6.8 do.	34.47	42.28	7
71	12	S.S. Farm well	...	5.0 weakly acid	35.82	48.72	4
72	3	454	...	5.4 do.	22.67	32.48	15
73	4	Burgoyne, 476...	...	5.0 do.	8.61	13.72	8
74	5	648	...	4.6 do.	16.32	24.36	3
75	6	Bastiani, 460	...	4.8 do.	19.50	28.28	7
76	7	Holder, 455	...	5.6 faintly acid	11.34	16.80	11
77/30	9	Mohr, 439	...	4.8 weakly acid	11.79	18.76	4

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APPENDIX 7.

Material.—Two samples of water marked—(1) Kingdon, Denmark ;
(2) Marwick, Denmark.

Lab. No.	1575/28				1578/28			
Result of Analysis :—	(1)				(2)			
	Kingdon.				Marwick.			
	%				%			
Calcium oxide, CaO	0.0024	...	...	0.0008	
Sodium chloride (from chlorine)0073	...	...	.0219	
Silica0016	...	...	.0006	
Iron and aluminium oxide0032	...	...	.0006	
Potash, K ₂ O	trace	...	...	trace	
Phosphoric acid	unable to detect a weighable quantity	
Reaction pH.	7.4	7.5	

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APPENDIX 8.

Material.—Thirteen Samples of water in connection with Denmark Cattle Disease, marked as below.
Result of Analysis.

Lab. No.	Source.	Condition.	Reaction pH.		Total Sol. Salts.	
			January.	May.	January.	May.
1628/30	Crellin, soak ... ..	...	6.8	6.4	(Grains per gallon.) 60.8	30.8
1629/30	Deal, soak	Healthy	7.0	6.6	124.0	99.4
1630/30	Kingdon, soak	do.	6.8	6.3	41.2	57.4
1631/30	State Farm Creek	do.	6.8	6.5	80.4	88.2
1632/30	Scotsdale Creek	do.	6.8	6.3	42.3	44.8
1633/30	State Farm, well	do.	5.0	6.3	48.7	126.0
1634/30	Russell, soak	Affected	5.4	6.1	32.5	29.4
1635/30	Holder, soak	do.	5.0	5.6	13.7	9.8
1636/30	Osborne, well	do.	4.6	6.1	24.4	15.4
1637/30	Bastiani, soakage	do.	4.8	5.5	28.3	32.2
1638/30	Burgoyne, soakage	do.	5.6	6.4	16.8	21.0
1639/30	Mohr, spring	do.	4.8	5.8	18.8	9.8
1640/30	State Farm, tank	do.	...	6.6	...	2.1

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APPENDIX 9.

Material.—Two samples of water marked—(1) N. Kingdon, Denmark ; (2) W. Marwick, Denmark.
Two samples of pasture grass.

Result of analysis :
Waters :—
Iron, Fe (grains per gallon) Kingdon. Marwick.
0.005 0.022

Both samples smelt strongly of hydrogen sulphide combined with a putrid smell probably due to dirty tomato sauce.

Pasture grasses.—Percentage of constituents in ash and dry material.

Lab. No.	...	...	...	...	...	116/28	117/28	118/28	119/28
						Kingdon.		Marwick.	
						Ash.	Steam dried material.	Ash.	Steam dried material.
Total ash ... ..	...	...	...	...	...	...	17.66	...	14.05
Lime, CaO ... ..	...	...	...	...	...	22.20	3.92	22.24	3.12
Magnesia, MgO ... ..	...	...	...	...	...	3.53	0.62	4.66	0.65
Potash, K ₂ O ... ..	...	...	...	...	...	28.68	5.07	27.86	3.91
Soda, Na ₂ O ... ..	...	...	...	...	...	1.27	0.22	3.23	0.45
Iron, Fe	0.275	0.048	0.300	0.042
Phosphoric oxide, P ₂ O ₅	5.10	0.90	4.52	0.64
Chlorine, Cl	9.31	1.64	8.92	1.25

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