PRELIMINARY REPORT ON THE GEOLOGICAL FEATURES OF K. BRODRIBB'S FRODSLEY ESTATE

Introduction

This estate, which is situated about seven miles east of Fingal, has been the scene of a number of experiments carried out under the auspices of the Council for Scientific and Industrial Research, Department of Animal Health. The experimental work has shown that there is some unknown deficiency, or limiting factor, affecting the general health of the stock. One of the possible solutions considered was that the soils may have had some bearing on this problem and the object of the present brief inspection was to determine if a more detailed geological examination of the property would be of some assistance in elucidating the problem. A further object was presented in the examination of some calcareous deposits which, it was thought, may have been suitable for agricultural lime.

Although no detailed work was carried out, a general examination of the property showed that there were several rock types and that the soils were largely residual, i.e. they were products of the disintegration and decomposition of the rocks in situ. The information contained in this report is based on brief observations made during the examination and on general information derived from departmental publications (principally Underground Water Supply Papers 1 - 4 by P.B. Nye) reports and analyses.

Topography

The Break o' Day River flows in a general westerly direction through the property. For a distance of one and a half miles to the south the country is comparatively level; it then rises sharply and the extreme southern portion of the estate is rugged and hilly. To the north of the river the country is gently undulating for a distance of a little over a mile but becomes somewhat rugged further to the north. Several small creeks enter the Break o' Day River both from the north and the south.

Geology

The following rock types occur on the estate, viz. Permo, Carboniferous limestones and mudstones, Trias Jura sandstones, Mesozoic diabase, Tertiary gravels and sands and Recent alluvium. The distribution of these rocks is shown in a general way on the accompanying sketch map.

Permo Carboniferous limestones and mudstones. - The limestones may be dense or crystalline. In the former case they are generally of a dark bluish colour and in the latter they may be bluish or light brown to yellow. They contain abundant fossil remains. The mudstones are fine grained rocks of a greyish or dirty-white colour and generally resemble a fine grained sandstone.

These rocks outcrop both on the northern and southern sides of the river. On the northern side they occupy a strip approximately 40 chains wide which parallels the western boundary fence and they extend westward into the Malahide Estate. In the Malahide Estate they are

seen to be horizontally bedded and consist mainly of mudstones with thin beds of limestone; this applies also to the rocks outcropping along the western boundary fence of the Frodsley Estate. On the other hand the outcrops further to the east indicate the presence of extensive beds of limestone with subordinate mudstones. From the very brief examination made it would appear that the bedrock of experimental plots Nos. 1 and 2 is probably limestone.

On the south side of the river horizontally bedded limestones outcrop definitely in a small creek in the "land" paddock at a point about 25 or 30 chains south of the road, and innumerable limestone boulders occur in the 25 acre and 78 acre paddocks situated along the western boundary fence. No definite outcrops of mudstones were observed on the south side of the river but some sands overlying the limestone outcrop in the "land" paddock may possibly represent disintegrated mudstones.

The chemical composition of the limestones is illustrated by the following analyses.

Table I

Analyses of limestones from Vicinity of Fingal

Locality	SiO_2	Fe_2O_3	Fe_2O_3 and Al_2O_3	Al_2O_3	$CaCO_3$	MgO	MnO_2	Total
Silkstone Leases	18.08	1.08		1.20	78.32	0.32		99.00
do.	7.80	1.00		1.72	89.38	0.21		100.11
do.	12.24	1.57		1.83	83.45	1.15		100.24
do.	11.52	1.43		2.27	83.90	1.15		100.27
do.	10.12	1.86		2.18	84.97	1.00		100.13
do.	8.60	1.72		1.52	87.38	1.00		100.22
do.	30.52		5.70		62.41			98.63
do.	26.11		2.60		70.10			98.81
do.	11.31		3.10		85.20			99.61
do.	10.20		4.60		82.87			97.67
do.	16.52		4.88		76.68			98.08
do.	23.26		3.10		71.96			98.32
do.	9.32		1.61		88.48			99.41
do.					86.73			86.73
Frodsley	16.64	2.07		3.89	76.22	0.43	0.82	100.07
Ransom's	8.72	0.36		2.88	87.73	0.11		99.80
Mt. Nicholas	23.00				69.28			92.28

Only one analysis of the Permo-Carboniferous mudstones is available. The locality is Mangalore Creek, near Pmntville. This analysis is quoted below as an illustration

of the general composition.

Table II

Analysis of Mudstone, Mangalore Creek

SiO_2	Fe_2O_3	Al_2O_3	CaO	MgO	Ignition Loss	SO_3	Total
82.25	1.25	12.00	0.50	0.44	2.80	0.55	99.79

In connection with the analysis of mudstone it is necessary to state that there is considerable variation in the character of the mudstones throughout the state. Some types are more calcareous and others more siliceous than the typical specimen analysed.

An interpretation of the above and other analyses with respect to the soil forming substances likely to be yielded will be given in a later section.

Trias Jura Sandstones. - Some sandstones outcropping on the hills in the south eastern portion of the estate, just beyond the cultivated land, probably belong to this system. The outcrops observed were principally quartz sandstones of the Ross series, but, from the fact that coal measures are known to occur in Cardiff Creek, it is probable that felspathic sandstones also occur in this vicinity. No other sandstone outcrops were observed, though the sandy nature of the soil in the cultivated paddocks, on the eastern portion of the property immediately south of the road, indicates that the bedrock is probably a sandstone.

In connection with the foregoing paragraph it is necessary to explain that in Tasmania the Trias-Jura system is composed of two great series of rocks, viz. a lower known as the Ross and an upper called the Felspathic. The former series is composed mainly of quartz-sandstones, mudstones and shales and the latter of felspathic sandstones mudstones shales and coal seams. The essential difference between the two series as soil formers is the presence of felspar in the Felspathic Sandstone series and its rarity or absence in the Ross.

The most common constituents of the Ross sandstones are quartz and muscovite. Of the felspathic sandstones, the main constituents are felspar, quartz and muscovite. No analyses of Ross sandstone are available but the chemical composition of the felspathic sandstone is indicated by the following analysis.

Table III

Analysis of Felspathic Sandstone

SiO_2	M_2O_3	Fe_2O_3	CaO	MgO	K_2O	Na_2O	Water	Total
65.90	12.20	11.00	1.20	0.01	3.10	2.85	3.50	99.76

Locality - North east slopes of Pikes Hill, east of Jericho.

Diabase - This is a medium to coarse grained igneous rock, of intermediate to basic composition, consisting largely of soda lime felspars and augite. It occurs as dykes and

sills intruding the rocks of the Permo-Carboniferous and Trias-Jura systems.

The most extensive outcrops of diabase on the estate occur to the north of the river and form a broad strip about 70 chains wide which extends parallel with the eastern boundary fence. Extensive outcrops also occur on the hills in the south western portion of the property, and a small hill of diabase occurs immediately south of the road. In addition to these, innumberable diabase boulders occur in the vicinity of the homestead and to the west of the milking sheds. At present no opinion can be hazarded as to whether these boulders were derived from underlying diabase, or whether they represent material derived from the diabase hills.

Only two analyses of diabase are available. These are shown in the following table.

Table IV

Analyses of Diabase

	(1)	(2)
SiO_2	52.49	52.31
TiO_2	0.62	n.d.
Al_2O_3	16.44	20.86
Fe_2O_3	2.60	1.40
FeO	5.30	7.88
MnO	Trace	-
MgO	6.18	3.64
CaO	11.71	10.28
Na_2O	2.06	2.56
K_2O	1.09	0.38
H_2O-(under 100°C)	0.15	1.18
H_2O+	1.42	0.30
P_2O_5	-	-
	100.06	100.79

Location (1) Launceston
(2) "

Tertiary gravels and Sands. - These occur principally along the railway line towards the western boundary fence. The outcrops were not examined but the occurrence of these rocks is indicated on the geological map accompanying "Underground Water Supply Paper No. 4".

Recent Alluvium. -Typical black river alluvium extends along some portions of the Break O' Day River. The principal occurrences noted were on the northern side of the river to the north and northwest of the homestead.

The Soils. - As stated above the soils are largely products of the disintegration and decomposition of the rocks in situ. While this statement generally holds good, there are certain transition zones covering many acres of land in which the soils of two contiguous rock types

may intermingle. Thus the soils of experimental plots Nos. 2 and 3 probably consist in part of a mixture of soils derived from diabase and limestone. The following notes refer mainly to the fairly definite soil types derived from underlying rocks but some reference will also be made to intermediate or transition types.

Limestone - The limestones yield a light coloured brownish or yellowish soil somewhat in the nature of a marl. In some places it is many feet deep and appears to consist mainly of clay. Experimental plots Nos. 1 and 2, the 25 acre and 78 acre paddocks referred to above and probably the bulk of the land in the "land" paddock are located mainly on limestone soil.

The analyses in Table I show that the limestones are impure. In the process of soil formation probably 80% of the calcium carbonate and the bulk of the magnesium carbonate (shown as oxide in the analyses) would be leached out. The resultant concentration of the remaining constituents accompanied by chemical and physical changes forms a soil composed mainly of quartz(sand), clay, limonite (hydrated ferric oxide) and calcium carbonate. Though such a soil would be rich in calcium carbonate the amount present relative to the other constituents would be comparatively small. The percentage of clay would be probably large.

From the point of view of plant and animal nutrition the chief deficiencies likely in such a soil would be potash and phosphates. With regard to potash a possible source of this material exists in the diabase and felspathic sandstones from which it is leached by the action of carbonated waters. As most soils have the power of absorbing alkaline bases (potassium or sodium) from percolating waters, and in view of the fact that most of the underground waters would be likely to contain potash, there would be in all probability no deficiency in this substance. However no similar source of phosphoric acid exists, the four tables of analyses indicating a complete absence of it.

Before concluding these remarks on the limestone soils it may be advisable to point out that on some undrained portions notably on or near experimental plot No. 1, precipition of calcium carbonate (calcareous tufa) is taking place. Apart from the water logged condition of the land the excess lime produced in this manner is injurious to the growth of many plants. Effective drainage would arrest the local precipition and tend to leach out the excess lime in the soil. Another condition likely to arise in such sails is the formation of ferrous carbonate, a substance poisonous to plant growth.

Mudstones. - With the possible exception of a small area of sandy soil overlying the limestone outcrop in the "lane" paddock, no definite soil types derived from these rocks were observed. Given complete disintegration the mudstones should yield a soil with a high clay content, the chemical composition

of which would approach closely to that of the original rock (see analysis Table II). Unfortunately complete disintegration is rather the exception than the rule with the mudstones and the soils derived from them often contain large angular blocks and pebbles (stony ground). Mudstones with a high lime content and these interbedded with shales are likely to form much better soils. In the former case the soil would be probably somewhat akin to that of the limestone. Some mudstones merging on sandstones yield a soil similar to that derived from the Ross sandstones.

With regard to deficiencies, lime may or may not be present in sufficient quantity depending on the composition of the original rock. The analysis indicates an absence of both potash and phosphorus but as shown above a possible source of potash is available.

Sandstone - As indicated in an earlier section of this report, the Trias Jura sandstones are divisible into two major groups, and it will be convenient therefore to deal separately with the soil types likely to be derived from the rocks of each group.

The Ross sandstones consist essentially of quartz grains and a little mica. The residual soils are therefore sandy. When these rocks contain beds of shale, the clay content of the resultant soils is increased and the soil is therefore of much better quality. The lime content is likely to be low and conditions as to potash and phosphorus would probably be similar to the cases outlined above. The soil of the cultivated paddocks on the eastern boundary, immediately south of the road, appeared to have been derived largely from Ross sandstones.

The felspathic sandstones yield a dark loamy soil of good quality. The decomposition of the felspar ensures a high clay content and abundant potash. Lime may or may not be present in sufficient quantity.

As with soils derived from other rock types there is a deficiency of phosphorus. In Underground Water Supply Paper No. 1, P.B. Nye, describes the felspathic sandstone soil as being the best occurring in the Midlands. No soil of this type was observed on Frodsley but it is possible that some may occur in the extreme south eastern portion of the estate, i.e. towards Cardiff Creek.

Diabase - This produces a dark red or brown, heavy soil with a high clay content. As the rate of disintegration and decomposition of the diabase is but little in excess of that of erosion the depth of soil on diabase country is shallow hence most of it is poor and stony. The greatest depth of such soil is likely to be found around the foot of diabase hills. Under certain conditions the soil is of fair to good quality.

The analyses (Table 4) show that phosphorus is likely to be the only serious deficiency. The weathering of the augite and felspars provides an adequate amount of lime and the felspars also provide potash. As mentioned previously the potash derived from diabase and that from felspathic sandstones is probably also the main source of the substance for residual soils of which the parent rocks contain little or none.

Tertiary Gravels and sands - Owing to the wide

variation among the several types of these formations there is likely to be a similar variation in the nature of the soils. The gravels are likely to be composed of pebbles of diabase, limestone, mudstone, and probably quartz and sandstone, hence the soils may be analogous to a mixture of soils derived from the four rock types. A predominance of pebbles derived from any single rock type would of course produce a soil type closely approaching that of a normal residual soil derived from that rock. Thus a Tertiary formation, in which diabase pebbles predominated, would produce a soil closely resembling that of the diabase.

Alluvium - The alluvial soil occurring along the banks of the Break o' Day River is composed of a mixture of mineral fragments derived from the various rock types traversed by the drainage system of that river. It may therefore be described as a mixture of all the soil types described. It probably contains a high percentage of organic material. Such as was observed was black and heavy.

Transition Types - It would be impossible to discuss other than in very general terms, the characteristics of the various types of soil likely to be formed by the intermingling of the more or less definite types derived directly from the rocks. With regard to the mechanical nature of the various soils those derived from Ross sandstones are the only ones likely to lack an adequate amount of clay, hence the addition of material from any of the other types would tend to correct this defect to some degree. As regards the chemical constituents an addition of diabase or felspathic sandstone soil to that derived from quartz sandstones or mudstones would increase the potash content, while an addition of limestone or diabase soil to the other types would result in an increase in lime.

Agricultural Lime

Some deposits of calcarious tufa were examined in view of their possibilities as a source of agricultural lime. The principal deposits occur on the north side of the river in the Malahide Estate just beyond the western boundary fence of Frodsley. The calcareous material forms small irregular mounds and, undoubtedly, has been deposited from springs exuding from the horizontally bedded Permo-Carboniferous mudstones and limestones occurring in the immediate vicinity. The material is soft and friable and could be readily worked but unfortunately only a very small quantity is available. Present indications are that the amount is insufficient to warrant the expense likely to be incurred in extracting it.

Conclusions

The principal object of the present inspection was to ascertain if a more detailed geological survey of the estate would assist in the elucidation of the problem presented by the unknown limiting factor which is affecting the health of the stock. The results which could be achieved by such work are:

(1) An accurate geological map of the estate.

(2) A soil map based mainly on (1) but which would also take into consideration the intermediate or transition soil types.

(3) An investigation of the chemical and physical composition of the several soil types.

(4) An examination of the soils from the point of view of their mineralogical composition.

(5) Examination of the surface and underground waters.

It is suggested that (3) and (4) could be carried out with the co-operation of the Department of Agriculature.

The interpretation of the data so obtained, in so far as the information is likely to be of use in its application to the subject of animal health, would be beyond the province of the geologist and must be left to those competent to deal with it.

Geological work along similar lines has been carried out in Western Australia and, I think, also in New Sealand. In Western Australia the results have been negative in the two cases of which I have read, but a negative result does not necessarily mean that the information so obtained is valueless, rather does it suggest the undertaking of other lines of investigation.

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