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EROSION SURFACES, RIVER TERRACES, AND RIVER CAPTURE IN THE LAUNCESTON TERTIARY BASIN

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(With 2 plates and 2 text figures).

ABSTRACT

An erosion surface probably of Pliocene age, extends throughout the Launceston Tertiary Basin at elevations between 550 and 1050 feet and is here named the Woodstock Surface. It slopes gently eastwards from Deloraine and north-westwards from Tunbridge and is developed across Tertiary sediments, dolerite and basalt. Lateritic podzolic soils are typical of it on the sediments, and lateritic krasnozems with outcrops of laterite (bauxite) on the dolerite and basalt. It is a possible time marker, younger than the basalts at Deloraine-Westbury and at Campbell Town but of uncertain relationship to the basalt at Evandale.

Several gently sloping surfaces can be recognised at levels below the Woodstock. The Cataract Gorge between Hadspen and Launceston separates these surfaces into two unrelated systems, the South Esk system above it and the Tamar system below. The former system comprises the present floodplains (Canola), and the Brumby and Brickendon Terraces, respectively 8 to 18, and 40 to 120 feet above the floodplains. Local base levels for this system are set by the dolerite at the head of the Gorge. The Canola soils are humic gleys; the Brumby meadow podzolics or solods; and the Brickendon lateritic podzolics, distinguished from Woodstock soils by the prevalence of siliceous gravels in them. In places windblown sands are superimposed upon each terrace. Climatic fluctuations, variations in resistance of dolerite to corrasion, and renewed faulting are considered as possible causes of terrace formation. The Brickendon Terraces are younger than the Evandale basalt and are thought to be Pleistocene. Their lateritization is ascribed to interglacial phases. The Tamar system which has not been fully investigated includes terraces at elevations of 300-330 feet and 100-140 feet near Launceston and 130 feet near Georgetown, and a bench at 450 feet in the valley of Rose Rivulet.

Instances of river capture, involving the South Esk River, Liffey River, Brumby Creek and other streams are noted. A reconstruction of the late Cainozoic history of the Basin is attempted.

INTRODUCTION

Soil surveys in the Launceston Tertiary Basin have shown that the various soils are closely related to geomorphic units, and that maps of soils are in fact also maps of these units. Consequently a study of geomorphology has been made in an attempt to explain the pattern of soils and to throw light on their genesis, because the history of the landscapes is also the history of the soils. The study shows that the floor of the Basin is a stepped landscape, throughout which may be traced a sequence of distinct levels, each with characteristic soils. Soil maps of the Longford and Quamby rectangles are available (Nicolls, 1958*a*, 1959) and this paper is to be read in conjunction with them.

Johnston (1873) to whom the name Launceston Tertiary Basin is due, believed that the Tertiary sediments were deposited in a large lake, and Carey (1946) follows this. However, the nature of the sediments and the absence of remnants of a seaward barrier to the lake raise serious objections to the lake theory. Davies (1959) pictures the whole of this area as one part of a much more extensive "Lower Coastal Surface" developed within and by erosion of a "Higher Coastal Surface" which preceded it. The present paper is not concerned with the correctness or otherwise of either of these views; the history which it attempts to unravel starts, probably towards the end of the Tertiary Period, with the *Woodstock Surface*—a very gently sloping surface occupying the floor of the Launceston Basin between the Ben Lomond Plateau to the north-east and the Central Plateau to the south-west. For the most part the Woodstock Surface was developed in Tertiary sediments, but whether these sediments and been deposited in a lake or as a piedmont plain would appear not to have affected the subsequent developments discussed here.

The term "surface" is used with a more restricted meaning than that of Davies, and corresponds rather with his term "phase". The surfaces described below all represent phases in the later development of Davies' "Lower Coastal Surface". However, in the terminology of Butler (1959) the older of them may include more than one "groundsurface".

Where figures for the elevations of particular points are quoted, they refer to measurements from bench marks based on State Datum.

OUTLINE OF THE SURFACES AND TERRACES

The Woodstock Surface has been largely removed by erosion, and is now represented by discontinuous remnants, recognisable by their

elevation (550-1050 feet) and by the lateritic soils upon them. The name Woodstock is that given by Stephens et al (1942) to the series of soils they found to be characteristic of these remnants in the neighbourhood of Longford and Cressy. The largest remnant of the Woodstock Surface is traversed by the Midland Highway between Conara and Epping. As a whole the Woodstock Surface slopes gently north-westwards from the vicinity of Tunbridge to the valley of the Tamar River, and eastwards from Deloraine to Hadspen. Though details are obscure, it is clear that the rivers of its time had the same general direction as today, reaching the sea via the Tamar Valley. The surfaces below the Woodstock are recognisable as river terraces related to the streams of the present day. The Cataract Gorge with its head near Hadspen at an elevation of 410 feet, and its foot near sea level at Launceston, separates the river terraces into two unrelated systems. Those upstream from Hadspen, along the South Esk River and its many tributaries, will be referred to as the South Esk system. Those along the Tamar River, the North Esk, and the tributaries of the North Esk will be referred to as the Tamar system. The Tamar system has not been fully studied, and is treated only briefly here.

The terraces of the South Esk system, arranged in order from highest to lowest have been named as follows:—

Brickendon—40 to 120 feet above present floodplains;
Brumby—8 to 18 feet above present floodplains;
Canola—present floodplains, 5 to 10 feet above normal water levels in rivers.

Each terrace appears to have much the same gradient as the present rivers; that is, the ranges in elevation quoted above do not arise from any consistent increase or decrease of height of one terrace above another with distance along the stream. Rather they are due to a combination of two other factors. Firstly, while the distinction between Brickendon as a whole and Brumby as a whole is quite marked, Brickendon appears to represent more than one phase in terrace formation and Brumby may do likewise. Secondly, a section across a terrace perpendicular to a river may be slightly concave or convex rather than exactly horizontal, and the concavities of adjacent terraces may not coincide.

THE WOODSTOCK SURFACE

The Woodstock Surface is represented on the soil map of the Longford rectangle (Nicolls, 1958*a*), by the soils of the Woodstock Association together with certain of the small scattered occurrences of lateritic soils within the Eastfield, Breadalbane and Relbia Associations. The Woodstock and Relbia soil associations are on Tertiary sediments, the Eastfield on dolerite, and the Breadalbane on basalt. On the soil map of the Quamby rectangle (Nicolls, 1959) the Woodstock surface is represented by the Woodstock Association and by the lateritic krasnozems developed fairly extensively on basalt and locally on dolerite. South of the Longford rectangle soils of the Woodstock Association extend from Epping to Conara and are found in the valley of the Isis River and near Blackmans River four miles west of Tunbridge. Around Campbell Town several basalt hills are capped at the same level by outcrops of laterite or by lateritic krasnozem soils. These scattered remnants at comparable levels strongly suggest a surface, or perhaps a combination of two surfaces as discussed below, once continuous over the whole floor of the Basin, an area of some 1300 square miles.

Owen (1954) and Edwards (1955), reviewing outcrops of laterite and bauxite throughout Tasmania and elsewhere as potential sources of aluminium ore, considered several in the Launceston Basin. Those they described under the headings of Fordon, Epping, Campbell Town and Conara all belong to the Woodstock Surface and those designated Westbury, Lake River, and White Hills may also belong to it. Though Owen (loc cit, p. 199) accepted peneplanation elsewhere as accounting for the existence of laterite he discounted it in Tasmania, believing that laterite here is restricted to basalt and dolerite. However, the Woodstock Surface is either a peneplain or some other form of gently sloping erosional surface, and it is clear that the lateritic soils of the Woodstock Association on Tertiary sediments are the counterpart of the laterite occurring at the same levels on basalt and dolerite.

The Woodstock Surface may be divided into a higher and a lower part, called in this paper Woodstock A and Woodstock B respectively. Where both are present in the one locality, as in Fig. 1 (see page 4) and near Longford and Perth, Woodstock A stands about 200 ft. higher than Woodstock B.

Two views of this are possible. Firstly, the two levels may be separated considerably in time, Woodstock B having developed at the lower level after a period of erosion of Woodstock A. Secondly, the two may be contemporaneous, Woodstock A developing on benches of hard rocks such as the tops of dolerite sills or of basalt flows, while Woodstock B developed at a lower level, mainly on the softer Tertiary sediments. The first view would be more in keeping with the development of the younger surfaces to be discussed below, but the second cannot be dismissed on the evidence available so far. If there could be found close together, remnants at the two levels, developed in the softer sediments away from the influence of dolerite and basalt, the question would be resolved in favour of the first alternative, but such evidence is lacking. On the first view, the name Woodstock would be better reserved for Woodstock B, and a different name found for Woodstock A. However, in areas where the two levels are not represented together as for instance west of Westbury, there is difficulty in deciding between them, and it seems better to use the single name Woodstock and to designate A or B wherever possible.

Woodstock A. There are only isolated small remnants at this level. The soil map of the Longford rectangle shows a prominent bench in the dolerite forming the eastern wall of the Basin, running right across the sheet, parallel to and about six miles east of the course of the South Esk River. It is two to three miles wide and at a general elevation of 800-900 feet. Its top consists mainly of low rolling dolerite hills, with non-lateritic and presumably relatively young soils of

the Eastfield Association on their slopes. However at scattered points on the flatter hilltops and shoulders there are lateritic soils and some exposures of massive laterite, which appear to be the remnants of a formerly continuous surface. Those associated with dolerite or basalt are marked on the soil map with a red stippling. One of them is represented in Figure 1 (see page 4). Owen (loc cit) refers to three others, the laterite at "Fordon", and the lateritic krasnozem soils at Vineys Sugar Loaf and another small basalt hill on the Blessington road three miles east of White Hills. The soil map also shows several small areas of soils of the Woodstock Association on this bench. The bench continues northwards into the Launceston rectangle, and krasnozem soils on dolerite near Turners Marsh at about 800 feet elevation may be correlated with it. Lateritic soils occur at about the same elevation at scattered points on the dolerite hills around Mt. Arnon a few miles north of Perth.

Between Deloraine and Westbury there are several small exposures of laterite on the tops of the basalt hills, at elevations around 1000 feet (Plate 1 (*a*). These exposures closely resemble the "hard ferruginous posolitic bauxite" (Edwards, 1955) on basalt near Campbell Town. On the flatter hilltops appreciable areas of lateritic krasnozem soils surround these outcrops, as shown on the soil map of the Quamby rectangle. The elevations of the laterite exposures are consistent with a surface having a slope of about 18 feet per mile to the east. However it is a matter for conjecture whether such a surface would be accordant with Woodstock A or with Woodstock B in the neighbourhood of Longford and Perth. Tentatively, these western occurrences of laterite may be assigned to Woodstock A. Two miles south and south-east of Westbury, there is a suggestion of the presence of both surfaces on the basalt hills, A at about 900 feet and B at about 750 feet above sea level.

Woodstock B. The general elevation of Woodstock B falls from 700-750 feet near Campbell Town to 550-600 feet near Longford and Carrick. In places this surface may be remarkably flat over extents of one or two hundred acres, but commonly it is gently undulating with a relief of about 50 feet. Much larger remnants of Woodstock B exist than of Woodstock A, for instance that which the Midland Highway crosses between Conara and Epping. Most of the areas of soils of the Woodstock Association shown on the soil maps belong to this level. They are on the Tertiary sediments, but Woodstock B like Woodstock A may also cross dolerite and basalt. Where it does so, the soils are usually lateritic krasnozems, and outcrops of laterite may occur.

Woodstock B is well represented on basalt around Campbell Town by the several outcrops of laterite to which Owen and Edwards (loc cit) refer. A prominent example of a laterite pavement on dolerite on this surface may be seen 500 yards south-east of the Illawarra Church between Longford and Carrick.

THE SOUTH ESK SYSTEM OF TERRRACES

Figure 1 is a measured section across the South Esk valley near Clarendon, drawn to scale with vertical exaggeration. On the western side of the river the section shows typical development of Brickendon, Brumby and Canola surfaces. There are distinct levels in the Brickendon, at 90 and 60 feet above the floodplain; the flat Brumby terrace stands 12 feet above the floodplain, and sharp banks mark the limits of each. A knoll on the floodplain at the water's edge on this side accentuates the apparent entrenchment of the river. East of the river these three formations are not so typical in this secton, because on this side it traverses the valley of a tributary stream. Further east, remnants of both Woodstock B and Woodstock A are represented. Knolls of windblown sand rise above the floodplain east of the river.

Brickendon Terraces.—The name Brickendon is tht given by Stephens et al (1942) to the series of soils they found to be characteristic of these terraces in the neighbourhood of Longford. The Brickendon Terraces are very extensive, occupying 70 square miles of the Basin floor within the Longford rectangle alone. However, this large area of the Brickendon Terraces is partly a reflection of their complexity noted above. About the confluence of the South Esk and Lake Rivers, the Brickendon Terrace must have had at one time an uninterrupted width of some 10 miles. The Midland Highway traverses a Brickendon terrace almost continuously for 16 miles between Epping and Perth, while the Bass Highway crosses another for three miles from Carrick westwards.

The range in height of the Brickendon Terraces, 40 to 120 feet above adjacent floodplains, has already been mentioned. The higher level in Figure 1, and the extensive plain between Longford and Perth at approximately the same height above the river, are examples of the upper end of the range. The lower level in Figure 1, and the terrace west of Carrick, 50 to 70 feet above adjacent floodplains, illustrate the lower end.

Boundaries of the Brickendon Terraces with the Brumby are almost always marked by steep banks, as in Figure 1. Occasionally where the lower Brickendon terraces abut the Woodstock Surface, boundaries are similarly marked by relatively steep slopes, as for example across the Midland Highway one mile north of Epping. There the Brickendon Terrace appears to be a continuation of the 60 foot level in Figure 1, and the Woodstock Surface stands 40 to 50 feet higher. The higher Brickendon terraces stand only slightly below the general level of the Woodstock Surface in their locality, and meet it in gentle slopes. The lower Brickendon terraces may aiso meet the Woodstock Surface in gentle slopes, and in such situations the recognition of bcundaries depends mainly upon the presence of the siliceous gravels characteristic of the Brickendon. Small pebbles of quartz do occur on the Woodstock Surface, but they are rare, whereas on the Brickendon Terraces siliceous gravels are normally a major component of the deposits.

Cuttings and bores on the Brickendon Terraces reveal that the siliceous gravels are generally present to depths of at least 12 feet, variously stratified with sands and clays. In the railway cutting one mile east of Longford Station gravelly deposits overlie basalt at a depth of 30 feet below the top of the terrace. Near Longford Station is

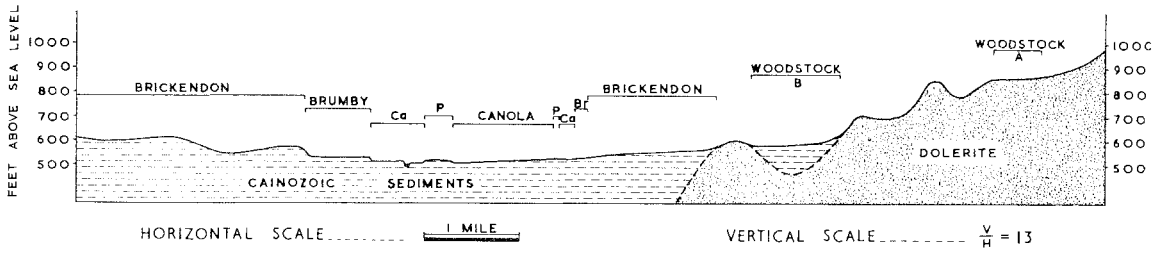

FIGURE 1.—Section across South Esk Valley near Clarendon. To the left (west) of the river there are two distinct steps in the Brickendon, and the Brumby terrace is well developed. To the right (east) of the river the section traverses the valley of a tributary, with development of Canola at the expense of Brumby and with bevelling of Brickendon. Small knolls of windblown sands (P) rise above the floodplain on the eastern side of the valley. Abbreviations: Ca, Canola; Br, Brumby; P, Panshanger.

another cutting exposing the siliceous gravels on a level 50 feet below their base in the first cutting, though this evidence by itself hardly justifies a conclusion of a total depth of 80 feet of gravelly deposits in this locality. Three miles east-north-east of Cressy there is a bluff at the edge of an extensive Brickendon terrace, standing 70 feet high above a sharp bend in the Lake River. The section is largely obscured by debris, but the gravels do not extend more than 20 feet below its top; probably their depth is appreciably less. The sediments below are without gravels except in debris at the bottom of the section, and are interpreted as Tertiary (pre-Evandale basalt).

The Brickendon gravels are strongly water-worn, some times faceted, and vary from one quarter to three inches in diameter with occasional ones up to six inches. The great majority are quartz or quartzite. Waterworn fragments of silicified wood are common, as noted by Johnston (1873) and by Carey (1946). In places there are occasional pieces of sandstone, and of hardened mudstone with Permian fossils. The quartz or quartzite gravels are believed to be the glacial erratics and other pebbles weathered from the Permian rocks of the river catchments. Alluvial fans at the base of the Western Tiers near Meander are strewn with such pebbles from the adjoining Permian strata. Except in the immediate neighbourhood of outcrops, pebbles of dolerite and basalt are either absent from or at least very rare in the Brickendon gravels. This is a remarkable feature particularly in view of the prevalence of dolerite in all of the river catchments. Lateritization of the Brickendon Terraces would account for their absence by weathering from the surface of the terraces, but at depth traces of weathered pebbles might be expected to remain. The Brickendon Terrace near Bracknell (Fig. 2, page 9), crosses a low ridge of dolerite. Typical soils occur there, but with frequent boulders of dolerite among them.

Brumby Terraces.—The name Brumby is taken from the type locality in the valley of Brumby Creek south of Cressy, though other streams have developed more extensive terraces at corresponding levels. Where the Nile River joins the South Esk the Brumby Terrace is five miles wide. A good view of this extensive terrace can be seen to the east from the Midland Highway three miles north of Powranna. Meandering streams have cut into the Brumby Terraces and have established the Canola Floodplains at the next lower level, but apart from this the low relief of the Brumby Terraces has protected them very largely from erosion. They are flat, with little bevelling and generally join the Canola Floodplains in sharp banks (Fig. 1, Plate 2). Most observations of the height of Brumby above Canola fall within the narrow range 10 to 12 feet. However there is occasional evidence of small areas of subsidiary terraces at levels a few feet higher or lower. Unusually high floods reach Brumby level.

Borings and the few cuttings in the Brumby Terraces show stratification with sandy clays, sands and gravels to depths of at least eight feet, but whether this represents the filling of valleys through the Brickendon or the re-working of Brickendon and earlier Tertiary deposits by river planation is not known. In general, dolerite is absent from the gravels of the Brumby Terraces as it is from the Brickendon, but in some places, as near the confluence of the South Esk and Nile Rivers dolerite pebbles are abundant. On the soil maps, such areas with dolerite gravels at the level of the Brumby Terraces have been distinguished from those without. Most of the floor of the long trough between the McRaes Hills ridge and the foothills of the Tiers has been regarded as Brumby Terrace, but its origin may be somewhat atypical, since Permian rocks underlie it at shallow depth (G. E. A. Hale, personal communication).

Intermediate terraces.—In the valleys of the Liffey River, Whitemore Creek, and a tributary of the latter, terraces have been found at heights of 20 to 30 feet above adjoining floodplains as for example one mile north of Bishopsbourne. Their soils most resemble the Brumby, but have features also of Brickendon. Since corresponding intermediate terraces have not been observed in other valleys it would appear that these may be the result of some conditions peculiar to tributaries of the Meander River.

Canola Floodplains.—These vary in development from intermittent narrow strips on one side of a stream, to extensive flats broken by numerous abandoned channels, as along the South Esk River east of Powranna where they reach widths of one and a half miles. Various stratification of clays, sands and gravels may be seen in the banks of rivers and small creeks, and borings along Brumby Creek have shown similar stratification continuing below the level of the creek bed. That there has

been some recent filling of the floodplains is shown by the partial burial of dunes of the windblown sands described in the next section. However the strata beneath stream channel level may belong to earlier phases.

Windblown sands.—The soil maps show discontinuous deposits of sand (Panshanger Association) along the eastern sides of most valleys in the Launceston Basin. Such deposits are common throughout east-central Tasmania (Nicolls, 1958*b*). Varying proportions of clay have accompanied these sands, presumably moving as aggregates of the same dimensions as the sand grains. In the Launceston Basin the great majority of the deposits are very low in clay, though there are also some high in clay. From the distribution and stratigraphy of these deposits it is evident that they have been moved from the valley floors by prevailing westerly winds. They overlie all formations above the Canola, including the slopes and tops of terraces, and hillsides of dolerite and basalt. Knolls of the sands also occur on the floodplains but there the relationship is different. Along Brumby Creek the sands have been found by boring to extend several feet below floodplain level and to be partially buried by finer textured sediments. The sands then are younger than the Brumby Terrace, but older than the present phase of the Canola. The aeolian origin of these sands has not always been recognised. Thus Nye (1926) and Edwards (1939) mistook them for waterlaid sediments where they overlie basalt between Campbell Town and Conara. Stephens et al (1942), while recognising the aeolian origin of lunettes around lagoons on the Woodstock Surface, referred to soils on the windblown deposits on the valley floors as " Alluvial Soils Type A ".

THE TAMAR SYSTEM OF TERRACES

A prominent bench at elevations of 300-330 feet runs from the vicinity of Relbia to the Carr Villa Cemetery. It has lateritic soils containing siliceous gravels and closely resembing those of the Brickendon Terrace. Further work is necessary before this bench can be satisfactorily correlated with other remnants, but it seems likely that it may have been formerly continuous with a terrace standing about 130 feet above the river between Bell Bay and George Town, which also has lateritic soils. The slope between is approximately the same as that of the Woodstock Surface between Campbell Town and Longford, though at lower levels. Soils closely resembling the Woodstock series, with outcrops of laterite, occur at 150-200 feet elevation two miles north-east of George Town, and these too may be related.

Carey (1946) noted the well developed terraces on both sides of the North Esk River near St. Leonards. They stand at elevations of about 140 feet, and probably correlate with another prominent terrace about 100 feet above sea level at Mowbray. They have not been traced further downstream in the present study, nor have their soils been examined. Green (1959) reports erosion surfaces and terraces near Beaconsfield, some of them with characteristic siliceous gravels. Further study is required to relate these to the valley as a whole.

Around the steep sided valleys of Rose Rivulet and its tributaries, a series of flat-topped spurs forms a discontinuous bench at about 450 feet elevation. This is too high to relate to the 300-330 foot terrace only four miles downstream. Moreover its soils resemble those of the Brumby Terraces, indicating comparative youth. It stands upstream from a bar of basalt on either side of Rose Rivulet three miles north of Evandale. Before it was breached, this bar may have perched a local base level at 400-450 feet, in a manner similar to that of the dolerite in the Cataract Gorge.

SOILS

Butler (1959) has recently pointed out that in landscapes which have had a history of cycles of erosion and/or deposition, there are " persistent zones " which having formed in one cycle escape removal or burial in later cycles. In these zones soil profiles continue to develop through two or more cycles virtually unaffected by either accession or physical removal of soil material. In the Launceston Basin, with the exception of gullies or shoulders locally eroding in the present cycle, areas shown on the soil maps as Woodstock, Brickendon and Brumby Associations represent such persistent zones.

Remnants of the Brumby Terraces are flat and have been bevelled by erosion, or covered by windblown deposits, only locally. On the flat surfaces, soil profiles must be of the same age as the terraces themselves. These soils have continued to develop beyond the influence of the erosison due to the subsequent phases of lowering of base level and formation of the Canola Floodplains. Soils of the Brickendon Association are still older. They extend down gentle slopes as well as over the flat tops of the Brickendon Terrace remnants and it is suggested that the erosion which produced these slopes took place early in the history of the Brickendon Terraces. These slopes have been affected little if at all by later cycles of erosion—that is, they are part of an early groundsurface (Butler, 1959) which existed before the formation of the Brumby Terraces and has persisted in these places since. The case of the Woodstock soils is less clear, and it cannot be established that they were unaffected by the early phases of erosion of the Brickendon Terraces. However they are at least as old as the soils of the Brickendon Association; some if not all of them are considerably older. The differences between these associations of soils reflect both the total passage of time, and the differing climatic conditions to which the older and higher surfaces may have been exposed before the younger ones were formd. In addition, they are partly due to differences in the nature of the terrace deposits, particularly the prevalence of siliceous pebbles on the Brickendon Terraces.

The Woodstock soils where developed on Tertiary sediments are lateritic podzolics (Stephens, 1956) with friable, brightly coloured clays overlain by sandy A horizons containing ferruginous pisolites and sometimes pieces of laterite, or aggregations of the ferruginous nodules, up to a foot or occasionally more in diameter. Where the Woodstock Surface crosses dolerite or basalt which supplies more iron on weathering, the soils are generally lateritic krasnozems (Stephens, 1956). These are red-brown very friable clays with little contrast of texture

down the profile, and containing irregular pieces of semi-hard laterite or bauxite. Occasionally amongst the lateritic krasnozems may be found small outcrops or pavements of laterite, in boulders up to four feet deep.

The Brickendon soils are lateritic podzolics like the Woodstock on Tertiary sediments, with similar friable though sometimes rather duller coloured clay B horizons. They differ from the Woodstock in that most profiles contain large quantities of the siliceous gravels, concentrated with the ferruginous nodules in the sandy A horizons. Where, as occasionally happens, the siliceous gravels are missing from the profile, other profiles within a short distance on the same level will be found to contain them. Where pieces or boulders of laterite occur on the Brickendon Terraces, they are usually studded with the siliceous gravels.

The soils of the Brumby Terraces are not lateritic, either because the climatic conditions to which they have been exposed have been unfavourable, or because they are too young. In the classification of Stephens (1956) these soils may be placed as meadow podzolics or as solods. They have grey sandy A horizons usually with a strongly bleached A_2, and with a sharp contrast of texture to a clay B horizon. The clay lacks the bright colours of the Woodstock and Brickendon, is tough or plastic, rather than friable, and sometimes shows columnar structure. Below, there is sometimes a little carbonate. Ferruginous nodules or siliceous gravels may occur throughout the profile.

The Canola Floodplains are characterised by humic gley soils—dark coloured, organic clay loams or clays overlying mottled dark grey and yellow plastic clays which are usually wet.

Table 1 summarises the main features of these characteristic soil profiles by which, together with their topographic positions, the Woodstock Surface and the terraces of the South Esk system may be recognised.

[*For Table I, see facing page.*]

Parts of the former Woodstock Surface and of the Brickendon Terraces have suffered extensive erosion at some period or periods subsequent to the formation of soils of the Woodstock and Brickendon Associations. These eroded parts have distinct soils, shown on the soil maps as Cressy and Newham Associations. The Cressy soils are mainly on eroded parts of the Woodstock Surface, but particularly west of the Liffey River they are also developed upon eroded Brickendon terraces. Their genesis by truncation of Woodstock soils is discussed by Stephens et al (1942). They are virtually restricted to the portion of the area west of the Lake River. The Newham soils are found on eroded Brickendon terraces to the east of the Lake River. Remnants of the Woodstock Surface in that portion of the area have not been eroded in the same way as have their counterparts to the west. The reason for this zoning of the Cressy and Newham Associations is obscure, but may relate to erosion at different periods, or to the slightly wetter climate of the western part of the area, or to both these factors.

A full account of the soils of the area is being published elsewhere.

RELATIONSHIP OF THE WOODSTOCK SURFACE AND THE BRICKENDON TERRACES TO THE BASALT AT EVANDALE

The basalt overlies the early Tertiary sediments and is therefore younger than them. The lowest elevation at which basalt outcrops in this district is 275 feet above sea level at "Talisker", three miles north of Evandale. There are some indications that this may represent a point of eruption, but even if so, basalt rests on the Tertiary sediments at several points in the vicinity at elevations not much higher. This accords with Carey's (1946) view that before extrusion of the basalt the South Esk River or its predecessor flowed northwards past Evandale. This seems a more likely course than the Cataract Gorge for the waters of the Lake and the Meander Rivers as well as of the South Esk at this time. According to Carey, the outpouring of basalt near Evandale blocked this path and turned the South Esk River along its present course westwards to enter the Cataract Gorge at Hadspen. Subsequently "extensive deposits of post-basalt gravels . . . over 100 feet thick near Longford" accumulated because of the damming of the river. This may be taken as a reference to the Brickendon Terrace.

At several points along the bank of the South Esk River near Evandale, at Perth, and just over one mile east of the confluence of the South Esk and Lake Rivers, basalt outcrops at water level at the foot of the Brickendon Terraces. In the deep railway cutting east of Longford 30 feet below the local level of the top of the Brickendon terrace, basalt is exposed with the siliceous gravels resting upon it. It seems reasonable to assume that these exposures of basalt are linked with the main body of basalt at Evandale and represent an old valley filling since buried by the Brickendon Terraces. Moreover the pattern of Brickendon Terraces disclosed by the soil map and their slope between Evandale and Hadspen strongly suggest that during their formation the South Esk River flowed, as it does now, westwards from Evandale to Longford. The Brickendon Terraces then, are younger than the basalt, though how much younger is not clear.

One mile north of Evandale, the Brickendon gravels, at an elevation just over 550 feet, are on the divide between the South Esk and North Esk drainage. It is therefore conceivable that for some time after the basalt eruption, during or after the establishment of the highest Brickendon Terraces, the river found a course northward across the basalt. This might explain the flatness of the basalt sheet at this elevation around Western Junction. However it seems unlikely that the river having established such a course would abandon it for the apparently more difficult one via the Cataract Gorge. The obviously imminent capture of the South Esk River by the North Esk near Evandale (Nye and Blake, 1938; Carey, 1946) is in fact in the reverse direction.

The relationship of the basalt at Evandale to the Woodstock Surface is uncertain. The laterite and lateritic krasnozem soils capping basalt hills in the Deloraine-Westbury district around 1000 feet elevation are interpreted as remnants of the Woodstock Surface developed on basalt; that is, the

TABLE I.

TYPICAL SOIL PROFILES.

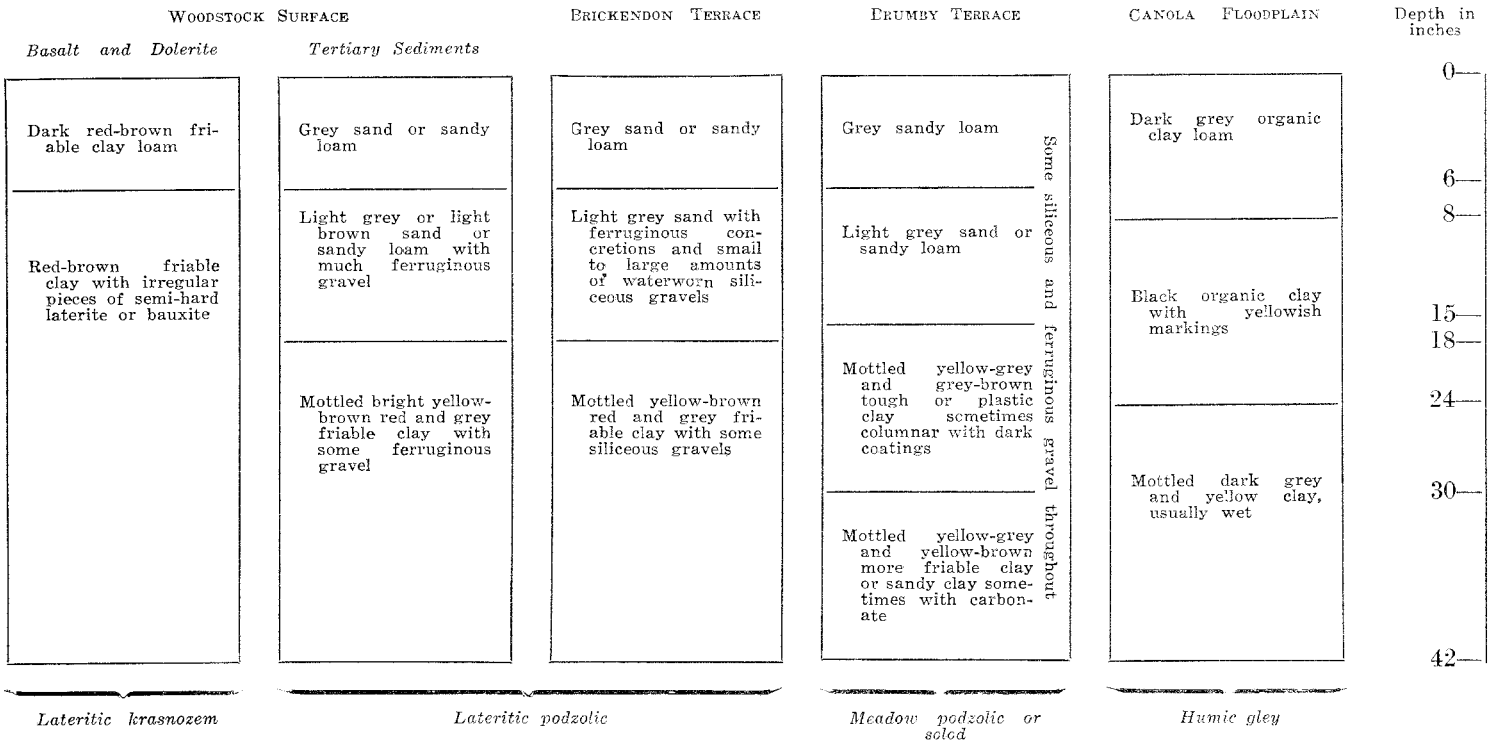

TABLE 1.—Simplified descriptions of soil profiles typical of the Woodstock Surface and of the South Esk system of terraces. Boulders of laterite may be associated with the Woodstock and Brickendon profiles.

basalt there predates the Woodstock Surface. At Campbell Town, laterite and lateritic soils occur on basalt at several points and Edwards (1955) has shown that this laterite has in fact been derived from basalt or from basaltic tuff. These occurrences are at the local elevation of the Woodstock B surface (700-750 feet) so that the basalt there too appears to be pre-Woodstock. Similarly, lateritic krasnozem soils overlie basalt at Vineys Sugar Loaf near " Fordon " at the elevation of the Woodstock A surface. Around Evandale the only occurrence definitely associated with basalt which may be ascribed to the Woodstock Surface is at the Woodstock A level on a small hill on the Blessington road five miles north-east of Evandale township. This hill, which is mentioned by Owen (1954), is capped at elevations from 900 to 990 feet with lateritic krasnozem soils containing boulders of basalt and pieces of laterite or bauxite. Laterite boulders and similar soils occur in small areas on two other hilltops, one just over 700 feet elevation four miles east of Evandale and the other at 790 feet elevation three and a half miles north-north-east of Evandale. In each case basalt occurs within a short distance at lower elevation but direct evidence that basalt underlies the laterite is lacking.

On the evidence available so far, the two possibilities therefore remain (*a*) that the Evandale basalt is older and the Woodstock Surface developed upon it and was subsequently almost entirely removed by erosion, or (*b*) that the basalt is younger and filled a valley that had been cut deeply into the Woodstock Surface. If (*a*) is correct it would mean that the formation of the Brickendon Terraces could not have followed immediately upon the blocking of the valley by the basalt, which Carey (1946) implies. On the other hand if (*b*) is correct the basalt eruption at Evandale could be regarded as having initiated the formation of the Brickendon Terraces. Further, if the basalt at Evandale is younger than the Woodstock Surface it is also appreciably younger than the basalts at Deloraine and at Campbell Town and Viney's Sugar Loaf.

The existence of basalts between Evandale and Longford, buried by the Brickendon Terrace raises the question of the possibility of a similar buried connection between the basalt at Evandale and that astride the South Esk River opposite Epping. However the petrological evidence of Edwards (1949, p. 98) makes such a connection doubtful.

RIVER CAPTURE

Two factors combine to make the Launceston Basin particularly prone to river captures. Firstly there is the alternation of bars of hard rock—chiefly dolerite—with areas of the soft unconsolidated Cainozoic sediments. Secondly, the interfluves often consist entirely of the soft sediments. A stream downcutting in soft sediments may become superimposed upon an underlying body of dolerite, which retards the further progress of corrasion. Meanwhile a more fortunate neighbouring stream, in a course which happens not to be underlain at comparable depth by hard rock, relatively quickly deepens its valley. Unless the interfluve is particularly resistant to erosion, the stage is set for the capture of the first stream by the second.

The impending capture of the South Esk River by tributaries of the North Esk near Evandale is a spectacular example which has been noted by previous authors (Nye and Blake, 1938; Carey, 1946). In the capture area, the South Esk River, perched by the dolerite bar across its path at Hadspen, is 480 feet above sea level. Only two and a half miles away Rose Rivulet, a tributary of the North Esk River, is at 150 feet. At its lowest point (co-ordinates E 513050, N 881450) the divide, consisting of a thin basalt capping over the Tertiary clays and sands, stands 540 feet above sea level, only 60 feet above low water level in the South Esk. A tributary of Rose Rivulet with a steep valley has almost breached the divide by erosion of the relatively unconsolidated sediments and undercutting of the basalt. However the possibility of capture during a flood seems more remote than is suggested by the authors quoted above; the record flood of April, 1929, according to local monuments, could not have been less than 20 feet below the divide.

The soil maps reveal several captures among the group of streams descending the Western Tiers between the Lake River in the south-east and Quamby Brook in the north-west. The " rock bar " factor with all of these is the long low ridge of dolerite running parallel to the Tiers escarpment along the Tiers Fault (McKellar, 1957). The McRaes Hills are part of this ridge, and the township of Bracknell stands upon it. The streams have graded courses across or along the trough between the Tiers escarpment and this ridge. The Lake River has been able to skirt the south-eastern end of the ridge, but the other streams cross it through small gorges. The more rapid cutting of one gorge than of its neighbour has led to the diversion of streams along the southern face of the ridge and the abandoning of some of the gorges. The best examples are an unnamed valley extending from Western Lagoon to Longford, and the valley of Whitemore Creek.

Western Lagoon—Longford Valley.—This has clearly been beheaded by the present Brumby Creek drainage system. Western Lagoon now drains into Brumby Creek, with a fall of 29 feet over the short distance from the south-western end of the lagoon to water level in the creek. Beyond the small gap through the dolerite at the north-eastern end of the lagoon, the valley is well defined with a clear fall towards Longford.

Western Lagoon itself occupies a hollow in the McRaes Hills ridge. The presence there of outcrops of sandstone suggests that, as commonly happens in Tasmania, the hollow has been formed by the removal of sandstone by differential erosion, leaving the harder rim of dolerite. The passage through it of the former headwaters of Brumby Creek accounts for this erosion; and swampy conditions on the divide following capture, aided by movement of windblown sands, account for the development of the lagoon.

This capture must be relatively recent—during the Canola phase. It is since the development of Brumby Terraces because a Brumby terrace is

well developed between Western Lagoon and Longford. The existence of windblown sands in the valley suggests that it may have carried a large stream in the main period of sand movement, which is subsequent to the Brumby Terrace phase. Finally, the lagoon on the divide could survive for only a limited period after the capture. Whether a large stream occupied this valley much earlier during the formation of Brickendon Terraces is uncertain. The Brickendon Terrace on the Longford-Cressy highway, three miles from Longford may be ascribed to the Lake River, and possible remnants of a Brickendon terrace between there and Western Lagoon are inconclusive.

Whitemore Creek.—Figure 2, prepared from the soil map shows the stream pattern in the neighbourhood of Bracknell. Whitemore Creek appears to be a former course of the Liffey River, and in fact in times of flood some of the water from the Liffey still goes this way. From water level at point A on the Liffey River (Figure 2) only the low river bank interrupts a continuous fall of 38 feet across the terrace to point B at the head of the Whitemore valley. Local residents have taken advantage of this to lead water into Whitemore Creek from a tributary of the Liffey.

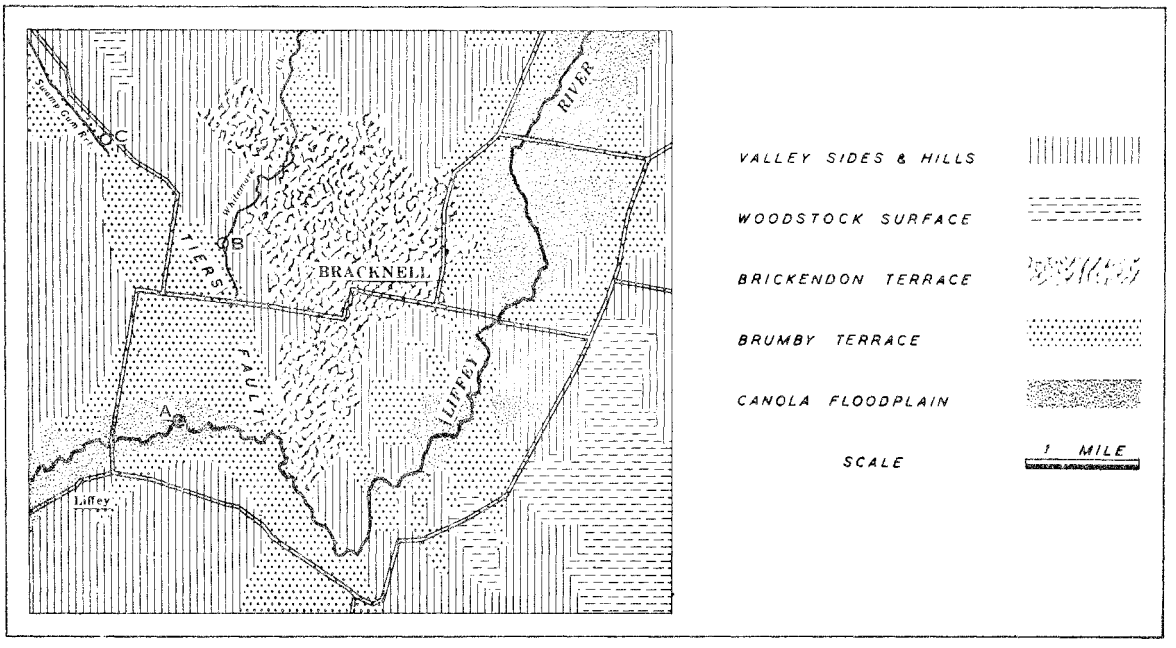

FIGURE 2.—River capture near Bracknell. Whitemore Creek and probably also Swamp Gum Rivulet are former courses of the Liffey River. "Valley sides and hills" includes dolerite, Permian sediments, basalt, and also bevelled remnants of the Woodstock Surface and of the Brickendon Terrace.

It is clear from the pattern of Brickendon Terraces shown by the soil map that during the time of their formation a large stream took the Whitemore course. At Bracknell the Brickendon terrace could be ascribed either to the Whitemore valley or to the present Liffey valley. At Carrick the Brickendon terrace belongs to the Meander River. Between Bracknell and Carrick, no remnants of a Brickendon terrace have been found along the present Liffey course, whereas along the parallel Whitemore valley, there is a prominent and almost continuous Brickendon terrace. Not only could such a large terrace hardly be ascribed to a stream of the size of the present Whitemore Creek, but also below the point B (Figure 2) there is no source of the characteristic siliceous gravels. Both the Whitemore valley and the present Liffey valley below Bracknell have well developed Brumby Terraces at the usual height (10 to 12 feet) above their Canola Floodplains (Plate 2).

The Liffey River may have changed courses several times between these alternative valleys below Bracknell. The existence of a second dolerite bar across the present course of the Liffey near Carrick, which presumably accounts for the unusually large Canola floodplain above it, might tip the balance again in favour of the Whitemore valley at some future time.

Other Captures.—The valley of Swamp Gum Rivulet is another likely former course of the Liffey River, since point C (Figure 2) on the crest of the low divide, is slightly below water level at point A on the Liffey. The stream crossing the Bass Highway near Hagley may have lost to the Swamp Gum valley its former headwaters on Cluan Tier. The flat floored valley between dolerite hills immediately to the south-east of Western Lagoon is suggestive of the former passage through it of a stream of moderate size.

DISCUSSION

1. The control of base level.

The terraces of the Tamar system appear to have graded to sea levels at former shorelines some distance down the Tamar Valley or in Bass Strait. Changing sea levels would then account for their present elevations, but until the former shorelines can be located it is not possible to estimate the magnitude of those changes. It may be assumed that since the Woodstock Surface can be traced northward from Launceston, it too graded to a former sea level.

On the other hand, the soil maps show that the terraces of the South Esk system head into the Cataract Gorge near Hadspen, where the river bed is now at an elevation of 410 feet. For these terraces to have been controlled by sea levels would require the sea at such heights that the terraces would grade to them through the head of the Gorge. In the absence of surveys of the area to the north of the Gorge this possibility must be kept in mind; however reconnaissance so far has not revealed a northward continuation of the terrace system. The much more likely alternative is that local base levels for the terraces of the South Esk system have been controlled, independently of sea level, by the dolerite at the head of the Cataract Gorge. (Plate 1 (*b*)).

A more or less regular rate of corrasion of the dolerite gorge would result in a steadily falling local base level for the basin upstream. Terraces may be formed in such conditions (Cotton, 1945, p. 244) but they are in flights, unmatched across the valley. In the Launceston Basin there are some instances of unmatched terraces, and it is possible that varying levels among the Brickendon Terraces may be accounted for in this way. However matched Brickendon Terraces also occur, and the well preserved Brumby Terraces are certainly matched in height across valleys. Relatively rapid changes of base level are required to explain these occurrences.

The alternation of periods of stillstand and terrace formation, with periods of rapid change of local base level might be explained by:—

(*a*) Climatic fluctuations varying the volume of water and the load of sediment carried by rivers.
(*b*) Variations in the resistance of the dolerite bar to corrasion, associated with joint systems in the dolerite.
(*c*) Intermittent movements of a fault system.

Consideration of these possible causes involves the further question of the extent to which the terraces are built by deposition, or are cut in earlier sediments. Unfortunately the few deep sections exposed in the area, and such records of deep borings as are available do not resolve this question. All the terraces are depositional in the surface few feet, since even a cut terrace (strath) has a surface skin of transported material. Borings for the examination of soil profiles, and shallow cuttings reveal stratification, with lenses of river gravels to depths of eight feet or sometimes more on each terrace. As discussed above the Brickendon Terraces are depositional between Evandale and Longford, where sandy clays and siliceous gravels have buried basalt to depths of at least 30 feet. This deposition in the vicinity of the basalt blockage, does not necessarily preclude the Brickendon Terraces being cut in earlier sediments further upstream, and such appears to be the case with the bluff on the Lake River near Cressy. The sediments exposed on its face are considered to be pre-Brickendon. However this is an isolated section, and may or may not be typical of the terrace in its locality. If, as seems likely, the Brickendon Terraces consist mostly of gravelly deposits resting disconformably upon non-gravelly earlier sediments, the depth of the former will naturally vary with the pre-Brickendon topography, and in places only a skin of the later transported material will cover the older sediments. The sharp banks between Canola and Brumby, between Brumby and Brickendon, and occasionally between Canola and Brickendon, are strongly suggestive of river planation (Figure 1; Plate 2). Such sharp banks occur rarely if at all between different levels of the Brickendon, or between Brickendon and Woodstock. This however might be accounted for by their removal by erosion, in the much longer intervals available.

Climatic fluctuations such as those of the Pleistocene, could result either in depositional or in cut terraces through changes in the volume and load of rivers entering the Basin and consequent changes in gradient of their courses across it. The gravelly nature of the Brickendon deposits, in contrast to the finer sediments of the Woodstock Surface, indicates markedly differing conditions of deposition. However, it is conceivable that the Brickendon surfaces might have arisen by planation in climatic conditions differing from those which permitted the original accumulation of the gravels. If the climatic hypothesis is accepted, similar climatic conditions during the shaping of each terrace must be envisaged, since the gradients of successive terraces appear to differ little if at all.

Joints and faults through the dolerite in the Cataract Gorge might be responsible for irregular variations in its resistance to corrasion, and this might be accentuated by variations in the load carried by the river. This mechanism would apply to intermittent rapid fall of base level after a period of stillstand and would result in terraces cut in earlier sediments.

The South Esk River crosses a horst in its course through the Cataract Gorge (Carey, 1946; Blake, 1959). If the faults have been active in comparatively recent times, they could be responsible for intermittent lifting of the river bed at the head of the Gorge, with consequent sedimentation upstream and later river planation of the new sediments as the dolerite bar was again cut down. Intermittent lowering of base level by faulting, resulting in cut terraces upstream, is also conceivable, though unlikely because it would involve a reversal of the direction of former movement at these faults. Carey (1946) considered that blockage of the valley at Evandale by basalt was the direct cause of the accumulation of the siliceous gravels of which the Brickendon Terraces between Evandale and Longford are built. On the other hand, if the formation of terraces is in fact due to renewed movements of the fault system, it is likely that this mechanism, and not the extrusion of basalt, would account also for the deposition of

the gravels. If so, the gravel deposits might be much younger than the basalt, which would be in line with the possibility of a pre-Woodstock age for the basalt discussed above. Banks (1958, p. 235) states " ..... it would appear that faulting has occurred in Tasmania throughout the Cainozoic ". However, renewed faulting as the cause of terrace formation in the Launceston Basin must remain hypothetical, since no positive evidence to support it has been found. The gradients of the terraces do not appear to have been affected by warping of the basin floor, nor have youthful fault scarps been observed. Scarps relating to the formation of the comparatively young Brumby Terraces might be expected to be still recognisable.

In summary, several mechanisms may be postulated as responsible for the existence of the terraces of the South Esk system, but none has been proved. The Brickendon Terraces are built of post-basalt gravelly sediments near Evandale and Longford, but further upstream they may be largely cut in pre-basalt sediments though with a veneer of transported gravels. The Brumby Terraces and the Canoia Floodplains may represent relatively young deposits partially filling old valleys within the Brickendon. Alternatively they may represent surfaces with a thin veneer of young transported material, but essentially cut by river planation in the post-basalt Brickendon deposits or in the pre-basalt sediments. Further field observations are needed, north of the Gorge to determine whether there is any continuation of these terraces there, and southward to determine the sediments of which each terrace is composed. Deep drilling at chosen sites may be required.

2. Ages of the Surfaces, and Summary of Late Cainozoic History.

Nye and Blake (1938) assigned a Lower Pliocene age to the pre-basalt sediments and Carey (1946) considered them to be Miocene and the basalts Pliocene. Gill and Banks (1956) on fossil evidence placed the sediments, or at least their lower members, as Eocene or Lower Oligocene; they considered the basalts near Launceston to be between the limits Lower Oligocene and Middle Pleistocene.

The present work introduces the Woodstock Surface as a possible time marker. The basalts at Deloraine-Westbury, and at Campbell Town are pre-Woodstock, but at Evandale the evidence is slender and the basalt may be either pre or post Woodstock. Owen (1954, p. 191) regarded the bauxite at Myalla, north-western Tasmania, as " younger than Miocene " and the other Tasmanian instances as " much older—probably Eocene ". While this may be true of some Tasmanian bauxites, those belonging to the Woodstock Surface, for example at Campbell Town, can hardly be older than Pliocene in view of the considerable degree of preservation of the surface. The age of the Woodstock Surface may well be the same as that of the bauxite at Myalla. Wells (1957) regarded as Quaternary the laterite capping basalt hills near Deloraine and Exton, here considered to be part of the Woodstock Surface.

The Brickendon Terraces are younger than the Evandale basalt, though how much younger is not clear. Though Carey (1946) considered the accumulation of siliceous gravels to follow immediately upon the basalt, there is an alternative possibility of a considerably younger age for the Brickendon Terraces if the hypothesis of renewed faulting discussed above is accepted. Like the Woodstock Surface, the Brickendon Terraces have lateritic soils. In several places, for example on the Midland Highway five miles north-west of Powranna, there are substantial outcrops of laterite. These outcrops are studded with the siliceous gravels, indicating that the laterite was formed in the Brickendon materials themselves, and not on earlier remnants of the Woodstock Surface buried by the terrace. Several writers have considered that climates of the Tertiary Period are necessary to account for lateritization. For instance, Owen (loc cit p. 191) states " The writer does not know of any locality in Australia where lateritization has proceeded to completion during the Quaternary Period ". On the other hand Edwards (1955, p. 26) discussing the same occurrences of laterite, suggests that those developed upon basalt may relate to an interglacial phase of the Pleistocene. Blake (1959) shows the Brickendon Terraces as Pleistocene, though his map does not disclose the evidence for this. Stephens et al (1942) regarded them as " Pleistocene moraine remnants ". They have not the form of moraines, though they may well be Pleistocene.

If the Brickendon Terraces are relegated to the Tertiary on account of the laterite upon them, the conclusion from this area must be that only the Brumby and Canola surfaces, and the windblown sands, are Quaternary. On this view, the climatic fluctuations of the Pleistocene, despite the glacial and periglacial conditions known to have existed in the catchments of rivers traversing the basin, have left very little imprint upon the basin itself. It seems far more reasonable to assign the Brickendon Terraces to the early Pleistocene, and their lateritization to one or more of the interglacial phases. The basalt at Evandale may then be as late as Pleistocene, as Gill and Banks (loc cit) suggest.

The Brumby Terraces and windblown sands are certainly Quaternary. It has been suggested (Nicolls, 1958*b*) that the windblown sands relate to the concluding phases of the last glaciation. The Canola Floodplains belong to the present day.

The late Cainozoic history of the Launceston Basin may then be reconstructed as follows:—

(1) Probably during the Pliocene, the Woodstock erosion surface was formed across early Tertiary sediments and across basalt and dolerite. It graded to sea level via the Tamar Valley. Heavy cappings of laterite developed on the basalt and dolerite, and lateritic soils with smaller occurrences of laterite, on the Tertiary sediments.

(2) The basalt at Evandale may have been already present at this time; if so, the Woodstock Surface presumably developed across it, but its soils have been almost completely stripped away since. Alternatively, the valley filled by the Evandale basalt had already been cut deeply into the Woodstock Surface.

(3) Either as an immediate consequence of the basalt eruption, or by later capture, the South Esk River was diverted by the basalt at Evandale, into the valley that later became the Cataract Gorge. By this time the present valley system had become well established through the Woodstock Surface, except for some later captures.

(4) Either together with the diversion of the river, or later as a result of renewed faulting, sediments largely consisting of siliceous gravels were deposited in the valley between Evandale and Longford, burying part of the basalt sheet. How far they extended upstream is not known.

(5) The Brickendon Terraces formed at successive levels in these gravelly sediments and further upstream either in the gravelly sediments or in the earlier Tertiary sediments. These terraces, and later ones of the South Esk system, graded to the dolerite bar in the Cataract Gorge. Lateritic soils developed upon the Brickendon Terraces and continued to develop on what remained of the Woodstock Surface.

(6) Excavation of the Tertiary sediments from the Tamar Valley had commenced before the eruption of the Evandale basalt and continued afterwards. The 300-330 foot terraces of the Tamar Valley developed at about the time of formation of the Brickendon Terraces, and similar lateritic soils formed upon them.

(7) The Brumby Terraces developed at a lower level than the lowest Brickendon Terraces. An appreciable time interval is indicated by the presence of lateritic soils on the lowest Brickendon Terraces and their absence from the Brumby.

(8) At stages subsequent to (5) and (6), but of unknown relationship to (7) the 100-140 foot Tamar terraces were formed and drowning of the Tamar Valley took place.

(9) Bevelling of parts of the Woodstock Surface and of the Brickendon Terraces at some time or times since (5) gave rise to the Cressy and Newham Associations of soils.

(10 Base level fell more than 10 feet below the level of the Brumby Terraces. In the resulting shallow valleys between remnants of the Brumby Terraces, braided streams supplied sands which were blown by prevailing winds onto the eastern valley sides. This event may date towards the close of periglacial conditions in the mountain catchments. The lunettes of Stephens et al (1942) may also belong here, or may be younger. On the Brumby remnants soil formation has continued with very little modification of the original groundsurface

(11) The present Canola Floodplains developed, partially burying dunes of sand.

(12) River captures have occurred from time to time since (5). The capture of the South Esk River at Evandale is an almost certain event for the future.

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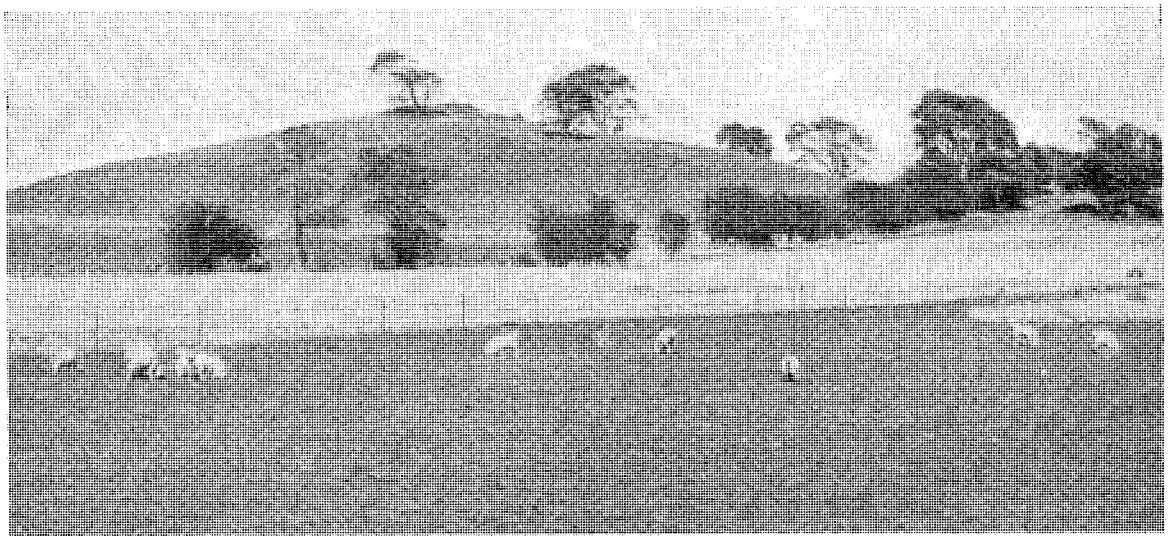

PLATE 1 (*a*).—Small basalt hill one mile south-east of Exton. Its capping of laterite (on skyline) 920 feet above sea level is considered to be a remnant of the Woodstock Surface.

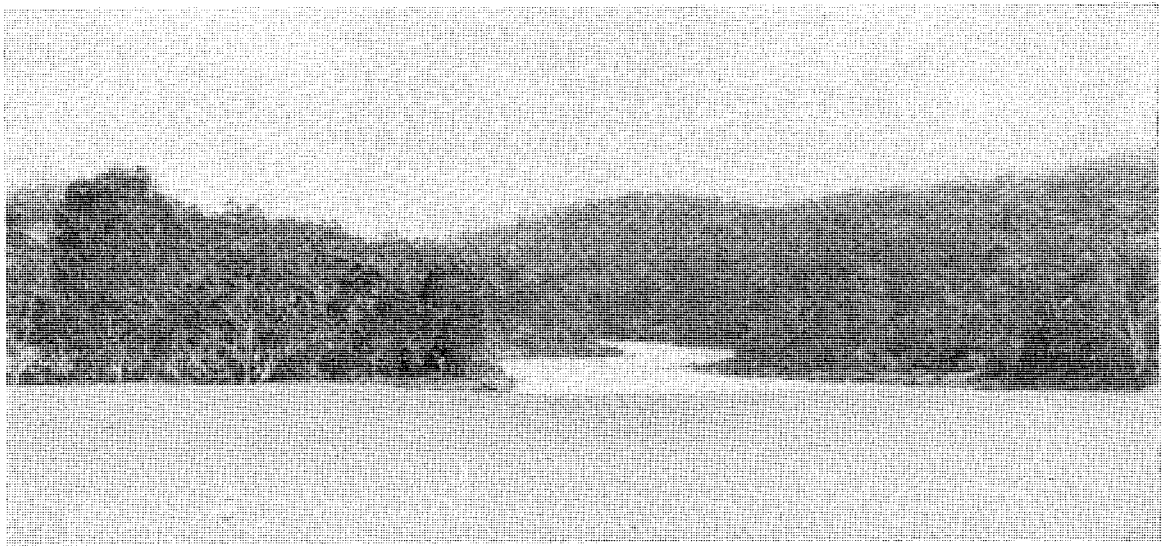

PLATE 1 (*b*).—The head of the Cataract Gorge near Hadspen, control point for terraces of the South Esk system. Dolerite hills on either side of the river, bevelled Brickendon terrace in the foreground. Water level here (415 feet above sea level) has been raised slightly by the Trevallyn dam.

PLATE 2.—Brumby Terrace (left) standing 12 feet above Canola Floodplain (right), with typical sharp bank between. Abandoned channel characteristic of floodplain in foreground. Locality, one and a half miles south-west of Bishopsbourne.