THE CRYOPLANATION OF MOUNT WELLINGTON

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(With 1 Text Figure)

ABSTRACT

Present morphology of the Mt. Wellington summit area can be interpreted in terms of a system of cryoplanation, which operated during the Pleistocene, but has now ceased. This involved the rapid frost shattering of exposed dolerite and the removal of this and previously weathered material by mass movement over slopes as low as 3°. Periglacial processes of land reduction were probably widespread in Tasmania during the Pleistocene and particularly important in unglaciated highland areas, where their end products have been misinterpreted sometimes as evidence for glaciation.

INTRODUCTION

The main object of this contribution is to draw attention to a group of important geomorphological processes, which, locally at least, seem to have played an important part in the evolution of Tasmanian landforms and yet so far have not received proper attention. Following the nomenclature of Bryan (1946), the two most fundamental of these processes are congelifraction which involves intensive frost riving and frost shattering of rock surfaces, and congeliturbation or the mass movement of the congelifractate over very gently inclined surfaces also as a result of intense frost action. The sequence of land reduction which results from these two processes was termed cryoplanation by Bryan and is characteristic of periglacial regions where temperatures fluctuate around freezing point and rapid alternate freezing and thawing of moisture results.

Today, these processes are characteristic of subarctic and subantarctic lands, but during the glacial ages of the Pleistocene they operated much nearer to the equator and their fossil end products have now been widely recognized in North America, Europe and Northern Asia. In recent years New Zealand workers have begun to interpret landforms in terms of these processes (for example Stevens, 1957, who gives a bibliography) and Jennings (1956) has reviewed the first evidence that some landforms in south-eastern Australia may also be explained in this way. Referring to Australia, Jennings remarked that " the state of our present knowledge is well illustrated by the fact that, although about one-fifth of the area of Tasmania is thought to have been glaciated in the Pleistocene, there is scarcely a passing reference to periglacial features to be found in the published literature on that state ". The present study examines the action of cryoplanation processes on Mt. Wellington near Hobart and then suggests some of the probable implications in relation to Tasmania as a whole. Professor S. W. Carey of the University of Tasmania, Mr. J. N. Jennings of the Australian National University and Mr. K. D. Nicolls of C.S.I.R.O., Division of Soils, kindly read the manuscript and made helpful comments.

MOUNT WELLINGTON

The dolerite which caps the 4165 feet high Mt. Wellington displays strong vertical jointing and around the slopes of the mountain are great masses of dolerite boulders which have been and, in small measure, are still being derived by frost riving and frost shattering of the rock *in situ*. Some of this material lies at its angle of rest which appears to be about 25° to 30° and is probably still mobile to some extent. But much of it lies on gentler slopes, consists of residual boulders lying in a matrix of clay, and is thoroughly vegetated. It seems likely that much of this latter material is congeliturbate in origin and that a large part of the vegetated talus on the Wellington slopes dates from a time or times when congelifraction above was considerably more intense and the downward movement of talus was not restricted in the main by its normal angle of rest. On the western side of the Mt. Wellington summit this downward movement of talus at low angles has been channelled into well marked streams and these merit special mention.

Between Mt. Wellington and the Mt. Arthur ridge to the west is a broad, shallow, treeless depression, between 3200 and 3900 feet above sea level, which today is occupied by the headwaters of the North West Bay River. It is well shown in photographs presented by Martin (1940) in a study of the vegetation of Mt. Wellington. Although the depression may have originated as a stream cut valley, its present form cannot be explained in this way. Martin, who acknowledged that his geological information came from A. N. Lewis, attributed it to glacial action and described Dead Island as a nunatak. But Lewis seems to have been in two minds about the existence of glacial ice on Mt. Wellington since, although he envisaged it in some publications (Lewis, 1924, 1945), on another occasion (Lewis, 1946) he referred only to permanent snow accumulations on top of the Mt. Wellington plateau to the expressed exclusion of glacial ice. There is in fact no discernible evidence that this area has been glaciated. The broad, shallow, valley-like depressions do not head in cirques and Lewis appears to have thought in terms of a very small plateau ice cap. He compared it (Lewis, 1924) with Ben Lomond in north-

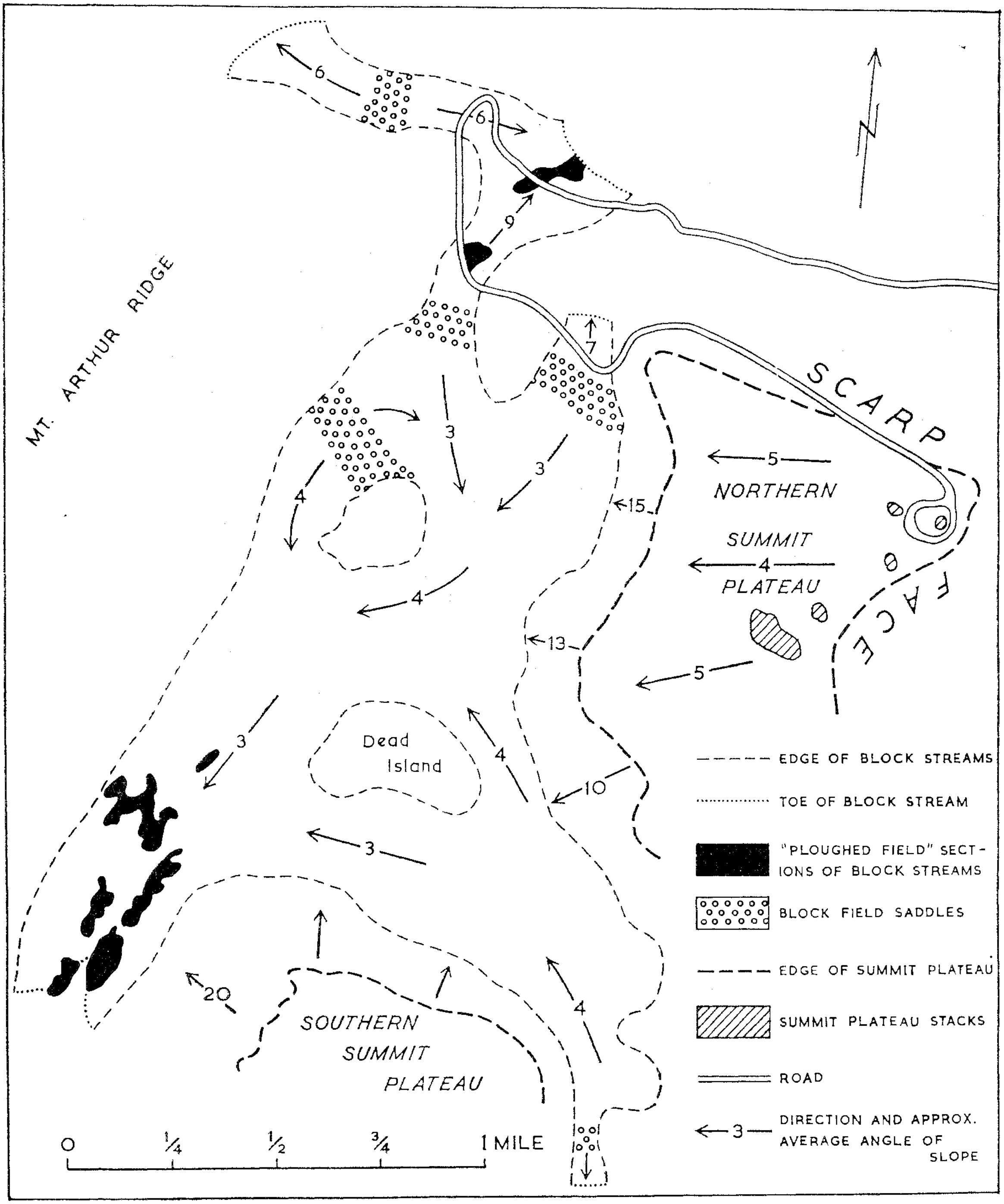

FIG. 1.—The Summit area of Mt. Wellington.

eastern Tasmania, which certainly seems to have supported such a glacier, and suggested that the two were contemporaneous. But an examination of aerial photographs suggests that the glaciated surface of Ben Lomond is freshly ice scoured and relatively unweathered, whereas the summit plateaux of Mt. Wellington are much weathered and exhibit tor-like features which could not have survived glaciation. Lewis's evidence of glaciation seems to have comprised " accumulations of rocks resembling moraines and almost certainly ice borne. At least many of them could not have rolled into their present position and it is clear that they reached their present position before the present vegetation grew up " (Lewis, 1924). Such a description would apply admirably to the congeliturbate material described earlier. Soil scientists have started to interpret the soils of Mt. Wellington in terms of periglacial processes and Loveday (1955) mapped the dominant soils above about 2000 feet as " yellow-brown soils on solifluction deposits ".

The map shows the general plan of the valley-like depressions and also the direction and degree of the slopes involved. Their surface is covered by a more or less dense mat of alpine vegetation including a variety of small shrubs. From this surface rise dolerite boulders which sometimes, as to the south of Dead Island, are clearly *in situ*, but more often, judging by their lack of joint orientation, are not. Between the latter is the normal clay matrix which is covered in part by peaty swamps. But here and there the clay matrix has been washed away to reveal the true nature of the surface of much of this depression, for, where the matrix has been removed, are masses of weathered dolerite boulders forming what locally are called " ploughed fields ". The location of these patches is shown on the map and two of them are traversed by the road ascending Mt. Wellington. Because of the removal of the matrix, some degree of subsidence has taken place so that the surface is concave and generally lower than that of the undisturbed and still vegetated, contiguous areas, but there is every reason to suppose that both vegetated and unvegetated areas are essentially similar in nature and origin. Most convincing of all in this respect are the boulder accumulations in the extreme south-west where the North West Bay River enters a comparatively narrow valley. Here is to be seen the toe of the congeliturbate standing in a steep cliff about 20 or 30 feet high and cut into by the river.

The depressions are fringed almost entirely to the west by partly vegetated dolerite talus descending at a steeper angle from the Mt. Arthur ridge. To the east and south they abut on the summit plateaux of Mt. Wellington along a line of slopes of between about 10° and 20° where the dolerite has been considerably shattered and large blocks appear to be in various stages of falling to the edge of the depression below.

This combination of circumstances, which is difficult, if not impossible, to explain by other means, can readily be interpreted in terms of the arrested cryoplanation of the Mt. Wellington plateau. The broad depressions at the head of the North West Bay River represent a system of fossil block streams which under past periglacial conditions were fed by rapid congelifraction of the dolerite on the Mt. Arthur ridge and along the edges of the Mt. Wellington summit plateau. Also at the various saddles or divides it appears that there were small block fields or Felsenmeere where the dolerite was being shattered on the surface of the depression and removed in either direction as congeliturbate.

The apparent direction and approximate average gradient of these block streams is thus indicated on the map. It will be seen that gradients vary between 3° and 9° and are therefore far outside any possible angle of slope of dolerite talus under normal conditions.

Although such block streams are well known from other parts of the world and their connection with periglacial conditions is well established (compare, for example, descriptions and photographs in Smith, 1949), the exact mechanisms by which flow takes place are not yet properly elucidated. Two such mechanisms are most widely suggested. In the first it is assumed that the frequent periodic melting of snow and ice lubricates the surface of the shattered blocks and also the finer weathered material between them. It is probable that the blocks actually moved in a matrix of finer material, in which case the existing clay matrix may be of periglacial origin or, more probably, older. The second mechanism is provided by the equally well known process of frost heave where the surface of saturated material is alternately pushed up and lowered by successive freezing and thawing. Such a heaving process would give rise to a resultant movement downhill along very slight slopes of larger material lying on the surface.

On the northern summit plateau of Mt. Wellington are several stacks of dolerite *in situ*, standing up to about 20 feet above the plateau surface and well weathered along the joint planes after the fashion of tors. Some of them support perched boulders. Whether they come fully within the genetic definition of tors as suggested by Linton (1955) is difficult to say. They undoubtedly represent residuals resulting from the removal of the weathered surrounding rock westward as congeliturbate over the plateau surface and eastward to the scarp face, but it seems likely that this was part of a single cycle of cryoplanation. Today, the northern summit plateau slopes gradually westward with slopes varying between 3° and 8° and its surface is covered with weathered dolerite boulders lying without preferred orientation of jointing in a matrix of clay and matted alpine vegetation. Along occasional snow runnels, the matrix has been removed to reveal loose, weathered boulders.

In the area occupied by the summit stacks are numerous monoliths, formed by individual joint blocks *in situ*. These are absent from the plateau surface generally, but re-appear on the convex slope immediately above the free face separating the summit plateau from the block streams. This distribution is what would be expected from a two level cryoplanation of the summit area . Along the convex slope too, are great masses of weathered dolerite boulders which can only have been derived from the plateau surface itself and have been stranded there after having moved westward as congeliturbate.

There were thus two "free faces" supplying congelifractate to the block streams from the east: one represented by the westward faces of the summit stacks and the other represented at a lower level by the steep slope between the summit plateau and the block streams themselves. Although some amount of frost shattering is still going on, block streams and congeliturbate slopes are now completely fossil.

CRYOPLANATION AND THE EVIDENCE FOR GLACIATION

Weathered block streams and other congeliturbate material may be extremely difficult to distinguish from glacial till and in the field this is often impossible, especially in Tasmania, where so many highland areas are uniformly capped with dolerite. Congeliturbate deposits will consist of unsorted materials which have moved from their point of origin and in which a large proportion of the bigger constituents have their major axes aligned parallel to the direction of movement so that when subjected to detailed examination they may simulate the fabric of till. Because they may move a long way along very gentle slopes, congeliturbate boulders may give the appearance of being glacial erratics.

The actual angle of slope over which congeliturbate material may have moved will be determined by local circumstances. In particular perhaps it will vary with the wetness or dryness of the local type of periglacial climate (Troll, 1944; Tricart, 1950) and consequently it will be difficult to make a general rule. It may be argued from the Mount Wellington example however that slopes at least as shallow as 3° carried congeliturbate in comparable Tasmanian conditions.

It follows from these considerations that, in those parts of highland Tasmania where glaciation has been inferred only from deposits which were assumed to be till, the evidence needs particularly careful appraisal. The most important case in point is probably the eastern part of the Central Plateau where there seems to be a complete lack of erosional evidence and glaciation has been assumed in the past (for example, Lewis, 1933) on the basis of superficial deposits which were not explicable in terms of normal erosion and therefore were thought to be glacial moraines. Many of these "morainic" deposits could easily be congeliturbate and the problem needs re-examination in this light.

ONE CYCLE OR TWO

Up to now it has been more or less assumed here that congeliturbate material originated as congelifractate but this was certainly not always so, for it is probable that among the congeliturbate would be material derived by chemical weathering in pre-glacial times. Linton (1955) has suggested that tors in unglaciated Britain are the result first of deep chemical weathering in warmer Pliocene climates and second of movement of much of this material downslope by periglacial solifluction during the Pleistocene. Earlier, Costin (1952) had invoked a similar two cycle theory to explain the tors of the Monaro Plateau in New South Wales. Deductive reasoning would suggest that this idea may be applicable in some Tasmanian instances. Certainly it must be assumed that a more or less deep mantle of weathered material overlay the Tasmanian highlands at the end of the Tertiary and that, under ensuing periglacial conditions, this material would be available for translation into congeliturbate. At this stage frost shattering could only take place on steep scarps and cliffs and it would require the removal of the Tertiary regolith for the full system of cryoplanation to be initiated.

To what extent these deductions may be read into the Tasmanian landscape cannot yet be assessed, but they must clearly be borne in mind.

CRYOPLANATION AND SCARP RETREAT

Along the high, dolerite capped scarps of Tasmania, frost shattering has been most active. Here there is no protecting waste mantle and the strongly jointed dolerite provides an admirable target for the freeze-thaw processes. The rate of frost shattering would have been greatly accelerated during the Pleistocene and the resulting great increase in the rate of scarp retreat would have been assisted by congeliturbate processes. At the base of the Western Tiers scarp in central Tasmania, below the zone of active scree, are fields of weathered and vegetated talus lying at angles well below the normal angle of rest of dolerite boulders. Even more significant perhaps are the "rivers" of talus which extend for more than a mile in places to the foot of the scarp (see Map square 4885 in McKellar, 1957). These appear to be true periglacial block streams for they lie at angles as low as 5° and if this is so, it is particularly interesting that they extend down to 1000 feet above sea level.

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