Martin T. Te Punga
Wellington

ALTIPLANATION TERRACES IN SOUTHERN ENGLAND*

Abstract

Altiplanation terraces, developed by periglacial processes during the Pleistocene epoch, are described from Cox Tor, near the western margin of the Dartmoor granite batholith. The presence of stone polygons on altiplanation terraces and summits in North Devon is noted. The origin of altiplanation terraces and the significance of certain stone polygons are also briefly discussed.

INTRODUCTION

In 1916 Eakin described the remarkable altiplanation terraces which are characteristic features of the subarctic landscape of Central Alaska (*5*, pp. 78—82). „In the Yukon-Koyukuk region they are most conspicuous in the areas of altered Mesozoic rocks, on certain fine-grained granites, on the more granular greenstones and on the quartzose schists ... In size these altiplanation terraces vary within wide limits. Their surface area ranges from a few square rods to hundreds of acres. The terrace scarps range in height from a few to hundreds of feet" (*5*, p. 78).

Guilcher (*6*) was the first to recognize altiplanation terraces in the English landscape. His examples were located in the coastal district of North Devon, between Combe Martin and Trentishoe. Indurated sedimentary rocks of Devonian age, referred to as „Hangman Grits", crop out in this area. The terrace treads range up to 130 yards in width, and 220 yards in lenght; the marginal bluffs range up to 70 feet in height. It must be noted that Guilcher suggested that similar terraces might be found elsewhere in the uplands of south-west England.

While studying periglacial features in Southern England altiplanation terraces were noted on the aureole rocks peripheral to the Dartmoor granite; these are discussed below.

ALTIPLANATION TERRACES AT COX TOR

Cox Tor is a conical hill situated about 3 miles east-north-east of Tavistock in south-west Devon. The summit, which rises to a height of 1452 feet above mean sea level, is one third of a mile west of the

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western margin of the Dartmoor granite batholith. As mapped by Reid et al.[1] Cox Tor lies within the metamorphic aureole of this intrusion. It is capped by an irregularly shaped mass of diabase (greenstone) which is surrounded by a belt of calc-hornfels; the latter is bordered by metamorphosed non-calcareous Culm Measures of Carboniferous age. Passing down the slope southward from the Trig. at the summit the diabase cap crops out for about 10 chains, followed by a slightly wider outcrop of calc-hornfels; the lower part of the slope is composed of metamorphosed non-calcareous sediments. The higher terraces are cut on diabase, and the lower ones on calc-hornfels and non-calcareous Culm Measures.

The altiplanation terraces are most fully developed on the south flank, but they are also present on the west and north flanks; just to the east of the summit there is a solitary terrace (fig. 1, pl. 1). On Cox Tor the terrace treads range up to 120 yards in width, and 300 yards in length; the marginal bluffs range up to 50 feet in height. The tread of the small terrace just east of the summit is more or less horizontal (pl. 2), but the treads of the others slope down very gently from the inner to the outer margin. It should be noted that the marginal bluffs of the higher terraces are generally as steep as, and in some cases even steeper than, the bluffs of the lower terraces. The bluffs of the altiplanation terraces at Cox Tor thus stand in marked contrast to those of marine or fluviatile flights of terraces in Southern England, for with these the higher, older bluffs have been worn down to slope more gently than the lower, younger ones.

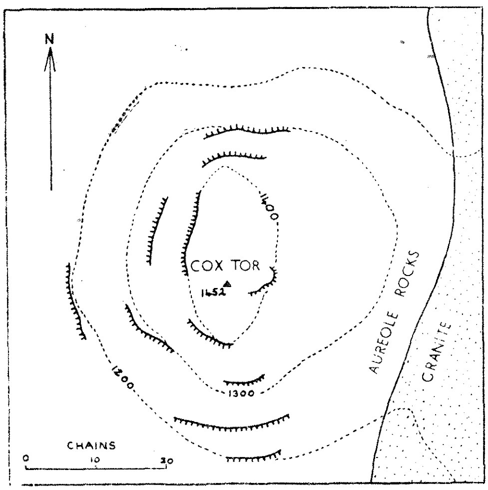

Fig. 1. Sketch map of Cox Tor, showing the outer margins of the main altiplanation terraces (toothed lines); granite of the Dartmoor batholih stippled; aureole rocks not shaded; contours (in feet) shown by broken lines

Exposures of bedrock near the summit and on the flanks of Cox Tor show quite clearly that the altiplanation terraces are „cut" in bedrock, although there is a thin veneer of waste, seldom more than

[1] Geological Survey One Inch Sheet 338, 1912.

a few feet thick, on the treads. The bluffs are commonly covered with a mantle of waste which in some places is so thin that it does not conceal the bedrock; elsewhere its thickness is not revealed. Most of Cox Tor is now covered by a thin soil which supports a dense growth of rough pasture, with small patches of bracken fern and heather; but quite large outcrops of naked bedrock are present at the summit and in several of the bluffs of the higher terraces. A few small outcrops of bedrock protrude through the turf on some of the treads. In the waste mantling the treads of terraces cut in diabase there are large blocks of diabase, from 2 to 6 feet in greatest diameter, which protrude through the turf. In a few places these large blocks are almost touching one another; elsewhere they are several or many feet apart; and in some areas there are no protruding blocks. The largest fragments produced by the weathering of the calc-hornfels and non-calcareous Culm Measures are seldom more than a few inches in diameter, so that the waste which veneers terraces cut in these rocks contains very few large blocks of the underlying parent material; but near the inner margin of terraces below the diabase outcrop there are large blocks of diabase which have travelled down from the bluffs above. Recent weathering processes, accompanied by the growth of encrusting and foliose lichens, have tended to round off the sharp edges of bedrock outcrops and blocks which protrude through the turf; but the sand, grit, fragments, and large blocks, which form the bulk of the waste on the terrace treads, are all sharply angular. There is no sign of stratification in this material.

On the higher terraces there are thousands of small subhemispherical mounds which outwardly resemble „high-centred polygons". These mounds, which measure from 2 to 5 feet in diameter and from 9 to 18 inches in height, are commonly so close together that the sunken rims between them form a polygonal pattern. Attention has been drawn to these problematical mounds, whose true nature could only be determined by thorough excavation, because polygonal structures are characteristic features of altiplanation terraces in many parts of the world.

STONE POLYGONS ON ALTIPLANATION TERRACES IN NORTH DEVON

Well preserved stone polygons were discovered while examining the altiplanation terraces described by Guilcher (*6*) in North Devon. In several places on Holdstone Down and Trentishoe Down the dense heath vegetation, which obscured the polygons at the time of Guilcher's visit, had been burned off some months before the writer's examination, so that conditions for observation were exceptionally good.

Some of the best-preserved polygons were found a few chains west-north-west of the Trig. on Holdstone Down. A typical, small example had an overall diameter of 30 inches; the soil centre measured 18 inches in diameter, and the stone rim averaged about 6 inches in width. The centre consisted mainly of dark „heather soil", with considerable amounts of fine sand and silt, and some clay; a few small angular chips of rock, similar to those in the rim, were also present. The chief constituents of the well defined rim were angular chips and fragments of rock, most of which were between $\frac{1}{4}$ inch and 4 inches in greatest dimension. Many of the larger rock fragments tended to be tabular, and a few were rod-shaped. Most of the tabular fragments were standing on edge in vertical or nearly vertical positions, and were arranged so that the elongated narrow sides which were uppermost paralleled the edges of the polygon. The rod-shaped fragments also lay with their long axes parallel to the polygon sides (pl. 3). Weathering processes had bleached the outsides of the rock fragments to a whitish or pale grey colour. Some of the smaller pieces, up to half an inch in thickness, were bleached right through, but the larger fragments had pinkish cores. In this polygon the rock fragments, which had all been derived from the underlying bedrock, were composed of quartzitic sandstone of Devonian age.

The stone polygons on Holdstone Down and Trentishoe Down vary in size from about 2 to 12 feet in overall diameter. The larger polygons generally have much larger fragments in the rim than the smaller ones. For example, one large polygon with a soil centre 6 feet in diameter had a rim, 3 feet wide, composed of large fragments and small blocks up to 9 inches or more in size. It was noted that polygons of similar size tended to be grouped together.

The presence of stone polygons on the altiplanation terraces in North Devon emphasizes the close similarity of these to the terraces described by Eakin in Alaska. Prior to the discovery of stone polygons in Devon Guilcher (*6*) had already drawn attention to this resemblance.

ORIGIN OF ALTIPLANATION TERRACES

Theories concerning the origin of altiplanation terraces have been summarized by Guilcher (*6*) who notes that „all authors think they are cryoturbation features". There can be little doubt that altiplanation terraces are initiated by nivation processes similar to those described in Iceland by Lewis (*8*, pp. 153—156 and pl. 1, 2). On the flanks of a Late Glacial basaltic volcano Lewis noted that „transverse snow-patches, whose major axes lie transverse to the lines of drainage... varied in length from 100 yards to a mile or more, and in width from 20 to several hundred yards". Snow-patch erosion had formed minor terraces on a hillside and „this terracing ... though seen here in what is clearly an initial stage, might assume considerable physiographical importance if it were carried many stages further". It seems reasonable to regard Lewis's „nivation hollows developed by transverse snow-patches" as youthful altiplanation terraces.

It is probable that increase in size of an altiplanation terrace is mainly due to downwearing of the tread by progressive robbing of the bedrock floor by shattering and comminution due to frost action, together with the removal of the fine material so produced by melt water, assisted perhaps by deflation. The conditions under which such downwearing takes place favour the development of stone polygons; and wherever lithological conditions are suitable for their formation stone polygons seem to be typical features of altiplanation terraces.

Eakin (*5*, p. 81) considered that many blocks of rock, brought to the surface by frost-heaving, would be moved very slowly down the gentle slope towards the outer margin of the terrace and travel over the rim, thus adding to the talus on the scarp and tending to build the terrace-front forward. Such transport may be limited to special cases, for the perfect shape of the polygons described and figured by Eakin could scarcely be maintained if there were significant downslope movement. Moreover, at Cox Tor the bedrock crops out in several of the terrace bluffs, and there are some indications that a certain amount of backwearing has taken place. Indeed, it seems likely that in many cases backwearing of the bluff might be expected to accompany downwearing of the tread. It is clear, however, that most, if not all, investigators envisage downwearing of the bedrock as being fundamental in altiplanation terracing; and, depending on local circumstances, the terrace-front might be built forward or worn back.

Eakin (*5*) also considered it probable „that one terrace might overtake and engulf a lower one, and that in the course of time the number of terraces has been reduced while their individual areas have been greatly increased". Where backwearing accompanied downwearing there would also be some increase at the expense of a higher terrace.

It is known that in Iceland and Alaska, where altiplanation is now actively in progress, the ground is perennially frozen (*8*, *5*); and there can be little doubt that the formation of altiplanation terraces in Southern England was also associated with perennially frozen ground developed during Pleistocene periglacial episodes. It seems that altiplanation terraces could be formed in any situations which favoured the development of perennial transverse snow-patches, provided that the lithological type of the bedrock were suitable for the maintenance, under periglacial conditions, of the relatively sharp shoulders at the outer margins of the terraces. Variation in hardness of more or less horizontal stratified rocks would favour the development of altiplanation terraces (*8*, p. 156 and p. 161); but the terraces are by no means restricted to these conditions, for they commonly bevel steeply inclined strata, and may also be cut in massive homogeneous bedrock.

REMARKS

It is probable that altiplanation terraces are not uncommon in the relict periglacial landscape of Southern England. In the districts listed below features that may prove to be altiplanation terraces have been noted but not examined in detail: a) on the northern flank of Cawsand Hill, about 3 miles east-south-east of Okehampton, near the northern margin of the Dartmoor granite, Devon; b) on the western flank of the prominent hill whose summit lies about one mile south-west of Lynton, North Devon coast; c) on the north-western side of Kipscombe Hill, about one mile south-east of Foreland Point, North Devon coast; d) on the northern flank of Culbone Hill, about 3 miles westward of Porlock, West Somerset; e) between Beacon Batch Trig. and Burrington Coombe, on the northern flank of Black Down, about 3 miles north-north-east of Cheddar, Mendip Hills, Somerset.

It appears that altiplanation features are best preserved in areas which were affected by several periglacial episodes without ever being glaciated. Nevertheless, as each retreat of the Pleistocene ice sheets must have been accompanied by migration of the periglacial zone across previously glaciated country, altiplanation features may also be sought in these areas. Study of photographs suggests that such features are preserved in the uplands of Wales and Scotland.

In several places in the Exmoor district, West Somerset, vertical sections of stone polygons were clearly exposed in temporary cuttings in areas where the dense moorland vegetation obscured the surface expression. For example, on Porlock Common, after noting the vertical sections typical of stone polygons, it was found that the surface markings of the polygons could be traced on the ground just behind the top of the cutting. On Porlock Common there is a flattish summit area with stone polygons, and there can be no doubt that altiplanation was active here during periglacial episodes. This summit is similar to the summits flattened by altiplanation in Alaska (*5*, p. 78) [2]. Indeed, stone polygons are so common on altiplanation terraces and summits that it may be desirable to regard all areas covered by stone polygons, formed in material derived by periglacial robbing of the underlying bedrock, as altiplanation features. Wherever such polygons are found the surface on which they lie must have been lowered to a level below that of the initial surface which has been modified. This lowering may be considerable, for the heights of the terrace scarps bordering the polygon-covered treads in Alaska show that the bedrock has been lowered hundreds of feet by downwearing associated with altiplanation (*5*, p. 78).

In Southern England altiplanation terraces and summits are now known at numerous levels between 750 and 1450 feet above sea-level; and they are likely to be present at higher and lower levels. Such features must be taken into account in any theories concerning the origin and history of the much discussed „high level surfaces" (or „upland plains" or „benches") in this district. In previous theories, which have been ably summarized by Wooldridge (*9*, *10*), the part played by altiplanation, solifluxion, and other periglacial processes leading to cryoplanation (*2*, p. 103) have not received adequate attention; but it must be noted that Cotton (*3*, pp. 114—5) has already suggested that „most, or even all" of the upland benches above the „430 ft" marine platform in Devon and Cornwall may be „of the kind recognized by Guilcher... in N. Devon as cryoplanation or altiplanation terraces". Although the altiplanation features so far known in Southern England are rather small some of them approach the size of isolated remnants that have been mapped by certain workers as relics of pre-Pleistocene marine surfaces. Moreover, it must be borne in mind that periglacial downwearing and backwearing can produce landscape features which resemble remnants of coastal plains backed by marine cliffs; and the same processes could modify ancient marine or fluviatile terraces to such an extent that the topographic reconstruction of the pre-Pleistocene landscape could never be precise.

Finally, it may be noted that the comparison of the periglacial landscape of south-west England with that of Alaska is facilitated by the fact that many lithological types are common to both areas. In Alaska Eakin (*5*, p. 78) noted that altiplanation terraces were not developed on the „coarser granites, which disintegrate readily and produce relatively large amounts of fine material"; nor were they

[2] The flattish summit of Holdstone Down, with stone polygons on its surface is also regarded as an altiplanation summit.

developed on other rocks which „produce fine, uniform detritus". In south-west England, likewise, altiplanation terraces seem to be absent on the coarser granites; on Bodmin Moor and Dartmoor periglacial processes produced solifluxion slopes, commonly leading up to prominent naked tors, which are strikingly similar to those found in areas of coarse granite in Alaska (*5*, Pl. 8 A, p. 77, Pl. 3 B, p. 12)[3].

Geology Department, Victoria University College
Wellington, New Zealand

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[3] As only a small amount of the relevant Russian literature was available to the writer, reference to altiplanation in Russia has been omitted in the above account. It is clear, however, that many, if not all, of the Russian *goletz terraces* are altiplanation features (*4*, *7*).

After this manuscript was prepared your Editor kindly drew my attention to a paper concerning altiplanation in the Northern Urals (*1*). It may be noted that these authors regard periglacial backwearing as an important process in the formation of altiplanation terraces.

photo by Te Punga, 1955

Pl. 1. Cox Tor, from the south-south-east, showing altiplanation terraces

photo by Te Punga, 1955

Pl. 2. The almost horizontal tread of the small altiplanation terrace east of Cox Tor Trig. (sky-line, centre background)

photo by Te Punga, 1955

Pl. 3. Stone polygon on an altiplanation terrace at Holdstone Down, North Devon
(The pencil marking the centre is 6 inches long)