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THE FORMATION OF CHALK DRY VALLEYS: THE STONEHILL VALLEY, DORSET

A considerable amount of work has recently been published on Full-glacial and Late-glacial deposits in English Chalk dry valleys, and the inference could easily be drawn that many such valleys can themselves be simply explained as the results of erosion under periglacial conditions. Thus Kerney, Brown and Chandler (1964) have produced strong evidence to show that very considerable erosion of some Chalk escarpment valleys in Kent occurred in Zone III of the Late-glacial. The difficulties inherent in extending this conclusion to explain the actual origin of many other Chalk dry valleys is well illustrated by the case of the Stonehill dry valley, Dorset, in Southern England.

This valley is excavated in the Upper Chalk of the Isle of Purbeck just to the east of Creech Barrow (National Grid Reference 931 821). The Chalk dips northward here at between 75° and 90° and is exceptionally hard, probably as a result of compression during folding and faulting (Arkell, 1947). The Chalk outcrop is a narrow one in Purbeck, not 500 metres for most of its length except towards Ballard Down where it just exceeds 1000 metres, and topographically it forms a long, narrow and steep-sided ridge rising to just over 200 metres (650 feet) in places. The ridge is breached by curious twin valleys at Corfe and Ulwell, but otherwise there is nothing to compare in size with the Stonehill valley. This starts as a gentle depression just to the south of Creech Barrow and, meandering slightly, runs east-northeast neatly along the strike of the Chalk bisecting the ridge. After about 1000 metres it turns northeast to run off the Chalk onto the gravel-capped Eocene rocks of Middle Bere Heath. By the time it leaves the Chalk, the valley becomes incised to a depth of some 30 metres, with steep rectilinear slopes which are convex at the summit, but with only a slight

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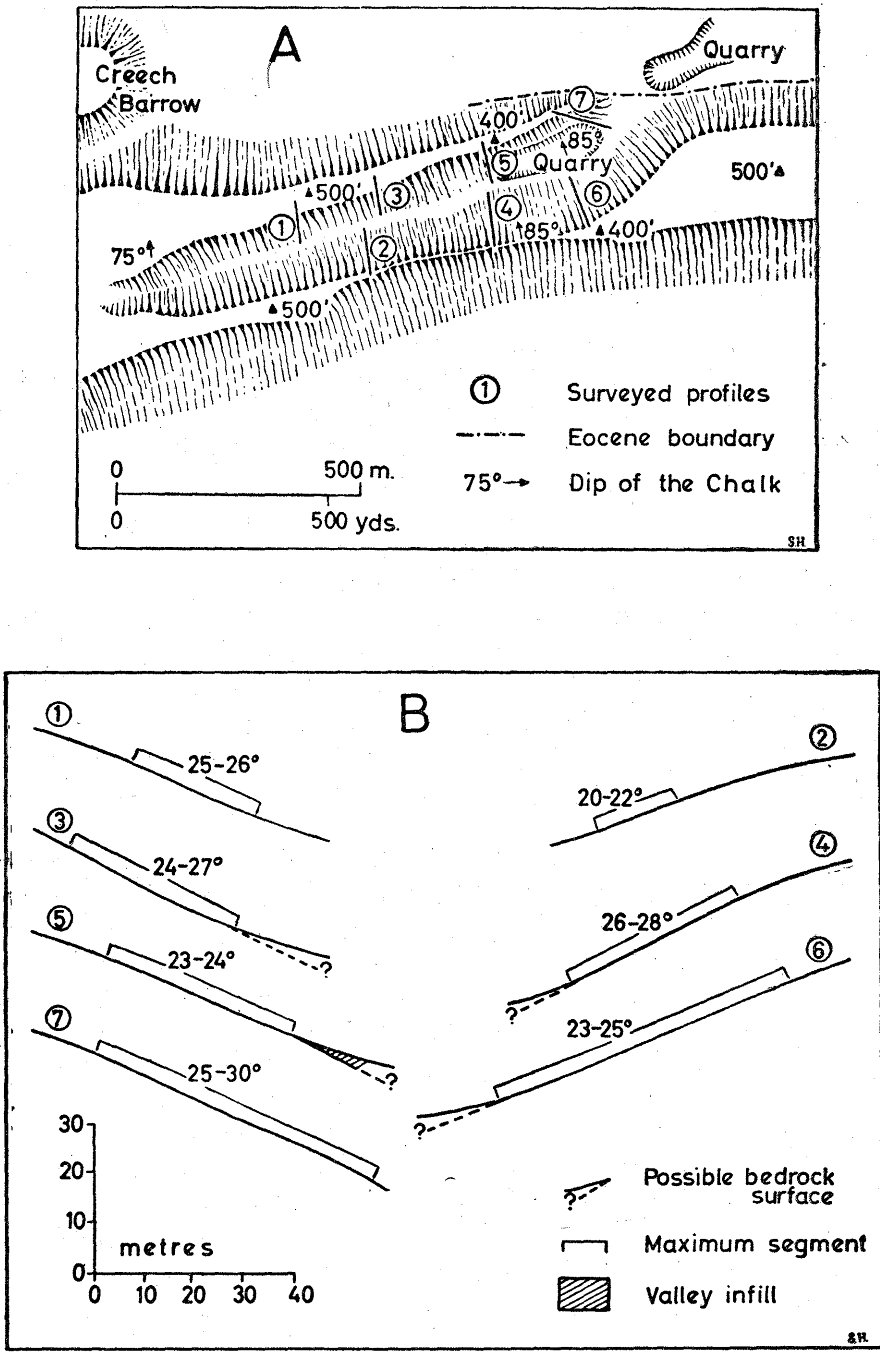

Fig. 1. The Stonehill dry valley, Dorset (930 820)

basal concavity (Fig. 1). The long profile of the valley is smoothly concave with no sharp breaks, no springs or flowing water on the Chalk, and no gradient steeper than 8°.

A quarry excavated into the floor and side of the valley allows both the valley infill and the weathered bedrock to be examined. The solid Chalk on the valley side is broken up to a depth of about 2 metres, with deeper fissures also opened out. The valley slopes are masked by an uneven layers of platy, angular chips of Chalk, sometimes roughly bedded, and in part in a sandy matrix. The floor of the valley contains over 6 metres of this unsorted coarse debris, which has an openwork structure (Pl. 1). There can be no doubt that this is the product of frost weathering. The deposit is an unusual one for southern England, with a closer resemblance to deposits in the Yorkshire Wolds. This unusual nature can be attributed to the comparatively hard nature of the Chalk here and in Yorkshire rather than to any local differences in processes. Variations in Chalk lithology may have led to varied resistance to erosion under periglacial conditions just as much as under temperate conditions.

The deposits at the Stonehill valley have three additional points of interest.

(1) There has been more than one period of frost-weathering and removal, as is shown by an exposure at the western end of the quarry within the valley. Beneath an horizon of loam containing flints about 25 centimetres deep, is a layer of Chalk fragments 80 centimetres in thickness. This is stained a reddish yellow (Munsell colour 7.5 YR 7/6; moist) by contained sand. The latter is to be found on slopes as well as in the floor of the valley, and was clearly derived from the narrow interfluves which now contain few traces of it. However, it has been found extensively elsewhere on interfluves nearby and is probably to be associated with the early-Tertiary Creechbarrow Beds (Arkell, 1947). Until stripped off under periglacial conditions, it must have been even more widespread. The topmost layer of Chalk fragments at the eastern end of the quarry contains no sand and must have been deposited after the sand had locally been removed.

Below the stained Chalk layer is one dark brown in colour (7.5 YR 3/2) and some 25 centimetres thick. This may be interpreted as a fossil soil which correlates with similar "marker horizons" elsewhere on the Chalk which are assigned to Zone II (Allerød) of the Late-glacial (K e r n e y, 1963). However, no mollusca or charcoal have been discovered which might have afforded more definite confirmation. Below the fossil soil is a further zone of stained Chalk fragments extending to an unknown depth beneath the valley.

(2) The very fortunate existence of a quarry pit in Eocene rocks right in the mouth of the valley shows that none of the frost-weathered debris has moved out of the valley. This evidence, together with the considerable depth of valley infill, shows that recent periglacial processes have tended to fill up the valley rather than excavate it in depth.

(3) Whether the valley is strictly a periglacial feature will be considered shortly, but for the moment it can at least be suggested that valley slopes have been modified under cold conditions and their form at least to some extent is the result of frost-weathering. Profiles have been measured with tape and abney level, and the results are presented in Figure 1 B. These consist essentially of a central straight segment at an inclination of between 23° and 30°, a slight basal concavity developed in the deposits, and a summital convexity. On these slopes, sandy Chalk debris is overlain in places by a layer of clean open-textured Chalk blocks and chips, sometimes in channels like block streams.

These deposits resemble the grèzes litées found more commonly on the continent but occasionally in Britain. They are thought to result from the transport of frost-weathered fragments for short distances in considerable volumes of water. High precipitation is also likely to aid frost shattering, so that the evidence of the Stonehill Valley favours the former existence of wet periglacial conditions.

But interesting though these deposits are, the fact that they are relatively small in volume and confined within the valley suggest that the valley was in existence prior to their formation. The question then remains, could the valley have been originally formed by meltwater in some previous and unrecorded periglacial episode? This seems doubtful for several reasons. In the first place the valley has a negligeable catchment area, whilst any surface meltwater would surely have caused channeling down the steep sides of the Chalk ridge and certainly not along the crest. Such a course, not at all in accordance with the fall of the land, must have been effected by headward erosion, along what is in all pro-

Pl. 1. Frost-weathered Chalk deposits
The scale is in inches

bability a continuation of the Ballard Down fault found further east (Arkell, 1947). Again, the influence of this structure would hardly have been felt by meltwater flowing over permafrost. There is really little concrete evidence that the existence of permafrost should lead to deep linear erosion in otherwise permeable strata, and the fact that dry valleys are so frequently occupied by periglacial deposits may show as much that the valleys were previously in existence and acted as gutters into which and along which such deposits were carried.

However, one way in which permafrost may have affected the erosion of the valleys is as follows. It is usual to emphasise the break-up and disturbance of ground in the seasonally-active layer, but it is also the case that ice segregation at depth may cause considerable rock disintegration. Obviously, one factor that will aid such break-up is a supply of water. Disintegration of Chalk at depths well below the level of seasonal freezing and thawing may be seen in a number of localised situations on the Chalk; one example is well illustrated by Kerney (1965, plate 7), while deep disintegration may be seen just where Chalk dry valleys reach the sea along the coast to the east of Brighton in Sussex and on Flamborough Head in Yorkshire. In both these cases comminution of the Chalk has enabled the sea to erode a channel through the Chalk on the shore so that obvious discontinuities in the wave-cut platforms occur at valley mouths which are even visible on 1 : 25,000 maps. The reason why disintegration was so localised would seem to be that only in places was water available; the line between sound and disintegrated Chalk in the cliffs is often sharp. Thus under conditions of permafrost, pulverization of the Chalk has occurred along the major joint lines through which groundwater is generally assumed to move and a subsequent period of surface erosion would easily remove this pre-weathered material. To this extent both periglacial weathering and the later erosion of Chalk dry valleys may have been influenced by the structure and hydrology of the Chalk. It should, however, be emphasised that the pattern and distribution of these valleys in England, which can so often be related to hydrogeological conditions (Small, 1964), does not support the hypothesis that such valleys originated in some simple way with the existence of meltwater streams flowing over frozen ground.

CONCLUSIONS

(1) Although there is clear evidence of periglacial activity in the Stonehill valley probably dating from the Late-glacial, the volume of the deposits is fairly small, so that while valley slopes have been modified to some extent during this period, the valley itself is of an earlier date.

(2) There are good reasons for disbelieving that such a valley would have been excavated by surface meltwater streams flowing over permafrost.

(3) Headward erosion of the valley must have occurred, although there is now no evidence of precisely how the process operated. A way in which such headward erosion may have facilitated by the prior existence of permafrost has been suggested, and it is clearly insufficient to consider either periglacial or interglacial conditions in isolation when explaining the form of the valley.

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