THE ORIGIN OF THE WINNATS PASS, CASTLETON, DERBYSHIRE

by

Trevor D. Ford

Summary

An argument is presented for there having been no more than a shallow cross-reef-belt depression on the site of the Winnats Pass during the deposition of the Brigantian Beach Beds. There is some evidence to support a slight development of this during the pre-Namurian uplift and erosion phase associated with the Boulder Beds. After infilling with Namurian shale, exhumation did not take place until Pleistocene times when the Pass was greatly deepened and enlarged under periglacial run-off conditions when a hypothetical ice-margin stood close to the present watershed at Windy Knoll.

Introduction

Although the Winnats Pass presents a prominent and much visited topographic feature of the Peak District, conflicting views have been presented regarding its nature and origin and no single publication has drawn together either the various views or the evidence on which they are based. An outline of some thoughts on the matter arising out of his study of the cave systems was presented by the present author (Ford, 1986) and the present discussion expands on this.

The Winnats is barely a kilometre in length, rising from about 250 m altitude, where it debouches on to the Hope Valley floor near the Speedwell Mine, to about 400 m at the top near Winnats Road Farm. It has an average gradient of 1 in 5 and the true top of the Pass is the shallow gully, locally known as the Roman Hollow, lying north of Winnats Head Farm; the road at the top of the Pass goes through a shallow cutting in what was no more than a tributary gully. The Roman Hollow, which has been artificially modified by use as an ancient trackway, merges with the plateau surface on Treak Cliff Back, so that there is no apparent drainage system falling into the Pass. The northern part of Treak Cliff Back slopes towards Odin Sitch so that the present surface catchment of the Winnats Pass is the southern half of Treak Cliff Back stretching westwards as far as Windy Knoll some 400 metres west of Winnats Head Farm. There is no surface run-off and no stream through the Winnats as drainage is entirely underground via cave systems. Even storm run-off sinks in the floor of the Pass a few metres west of the Windy Bend. The cliffs on either side rise to heights of up to 100 m though the lower slopes are largely masked in grass-covered screes. The Pass is graded to Hope Valley floor without any obvious break.

Amongst the former opinions proposed, with little or no discussion of the evidence, are that the Winnats Pass was "cut by swift torrents of water passing down during certain pluvial phases at the end of the Ice Age" (Millward & Robinson, 1975, p. 64); the Pass was "a resurrected Lower Carboniferous sea-floor channel" (Broadhurst, in Cope, 1972, p. 28); "a submarine channel in D_1 (=Asbian) times" (Sadler, 1964, p. 369); at least partial inheritance from superimposition of a drainage system on the former shale cover (Warwick, 1964); even collapsed caverns as suggested in several general works. Whilst it will be shown below that there is an element of truth in most of these, the full story has not previously been told. The problem is this—why should there be a short, deep gorge, without a stream, cutting across the northern tip of the limestone outcrop?

From a more scientific viewpoint the hypotheses on the origin of the Winnats Pass may be summarised thus:

1. The Winnats Pass is a channel lying between the reef limestone masses of the late Dinantian which has simply been exhumed and trimmed in more recent geological times.

Mercian Geologist, vol. 10, no. 4,
1987, pp. 241–249, 2 figs.

2. The Pass is an erosional channel cut through the Dinantian reef limestones in latest Brigantian times contemporary with pre-Namurian uplift and associated Boulder Beds, and filled in with Namurian shales as the Millstone Grit deltas advanced southwards.
3. The Winnats Pass is entirely due to superimposition of a drainage network established on the former cover of Namurian sediments incising down into the limestone massif.
4. The Winnats Pass is simply a normal limestone dry valley of late Pleistocene date cut by surface run-off during one or more peri-glacial periods when the ground was sufficiently frozen to block underground drainage.
5. The Winnats Pass is a collapsed cavern system.

Assignation of the origin of the Winnats Pass to any of these on its own presents difficulties, and, as shown below, the truth is probably nearest to being a blend of hypotheses 1, 2, 3 and 4. Hypothesis No. 5 can be dismissed as no evidence has been found to support a collapsed cavern origin. The others may now be discussed in turn.

Mid-Carboniferous Inter-reef channel

The concept of the Winnats Pass being a channel left by non-deposition between reefs during late Dinantian sedimentation raises serious problems. The cliffs on either side of the Pass show sections through a transition from lagoonal, "massif" or bedded, nearly horizontal limestones at the top of the Pass, a pile of lenticular "reef" masses in the centre, particularly well-developed in the Shining Tor on the south side and above the Windy Bend to around Old Tor on the north side. Indeed Wolfenden (1958) demonstrated that there were two groups of reefs unconformably separated in the middle slopes on both sides. The eastern, lower part of the Pass is cut in forereef detrital limestones, with a veneer of "Beach Beds"—rich in water-worn gigantoproductid shells. As Wolfenden and many others, e.g. Parkinson (1947, 1953), have shown, the three lithofacies, massif, reef and fore-reef, strike across the Pass in such a way that it is very unlikely that any contemporary channel could have been present. As the beds in the Pass are all of Asbian age, Sadler's assignment of her channel to that age cannot be upheld, though, as discussed below, the channel could have operated at a later date. Thus, in Asbian times, a shallow surge channel could have been present between bioherms along the present line of the Winnats Pass, though there is no evidence of this today.

To the south of the Winnats, the Cavedale Lava provides some circumstantial evidence. The frequent layers of vesicles and the columnar structure instead of pillows suggest eruption subaerially and the hyaloclastic nature of the spill-over material at the reef foot (the Speedwell "vent agglomerate") (Cheshire & Bell, 1977) supports this. Together they indicate emergence in late Asbian times, and a palaeokarst surface may well have extended across the Winnats area. However, no such surface has been demonstrated as yet, and any possible relationship to a Winnats channel must remain speculative (see Fig. 2a).

Events during the Brigantian subdivision of Dinantian times are difficult to disentangle as any former extension of Brigantian strata over the site of the Winnats Pass has very largely been removed by erosion both penecontemporary and later. The nearest outcrop of Brigantian limestones is on Hurdlow, some 400 m south of the Winnats. These may be projected over the site of the Pass and across Treak Cliff as a successor to the massif-reef-forereef lithofacies system present in the Asbian. Such beds were removed by erosion in pre-Namurian times, though their continuation is present in Pindale and the Blue Circle Quarry a kilometre or so to the east.

The "Beach Beds" strike across the lower slopes of the Winnats in such a way that they were obviously part of a continuous sheet or fan across the present site of the mouth of the Pass. The abundance of water-worn and rolled gigantoproductid shells led Barnes & Holroyd (1896, 1897, 1900) to interpret them as having been formed on a sea-beach implying a low sea level, whereas Sadler (1964) regarded them as a submarine fan at the foot of a reef-channel. Parkinson (1965) questioned whether the short distance of transport could account for the amount of damage and abrasion to the gigantoproductid valves. *Gigantoproductus* is common in the Brigantian massif facies on Bradwell Moor to the south of the Winnats and these could have been the source of the abraded shells, thereby adding another kilometre or so to the possible distance of transport. They were clearly transported while still discrete shells and not as parts of pebbles but their enclosing matrix shows no features characteristic of a beach. The probable mechanism for the formation of the "Beach Beds" is thus of derivation by tidal or wave scour from the contemporary Brigantian lagoon with transport across the reef-belt, probably through an inter-reef depression not necessarily of any great depth, to a site of deposition in moderately deep water at the foot of the fore-reef slope. The Beach Beds extend up the flanks of the Winnats to a height of 300 metres O.D., where they are truncated by erosion, so any cross-reef channel cannot have extended deeper than that.

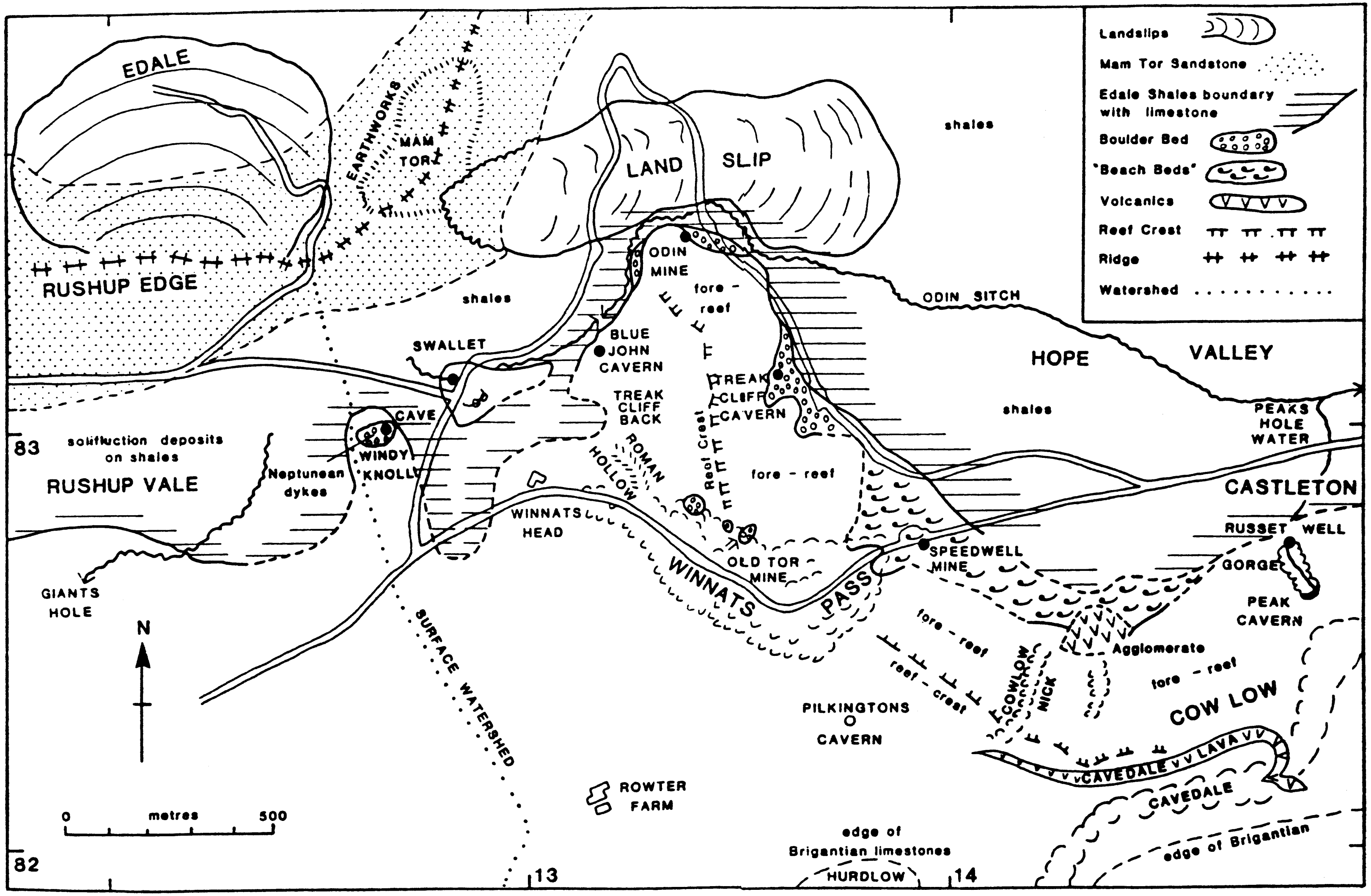


Fig. 1. Geological sketch map of the Winnats Pass and surrounding area.

Pre-Namurian Boulder Bed

The flanks of Treak Cliff are marked by outcrops of a pre-Namurian Boulder Bed (Simpson & Broadhurst, 1969). Best seen around Treak Cliff Cavern, and near Odin Mine, it is also present in the Neptunean dykes of Windy Knoll and is now regarded as including the "dykes" once described in the roof of parts of Treak Cliff Cavern (Ford, 1952, 1969). Another important occurrence is in the old opencut workings for Blue John above the Old Tor Mine high on the north side of the Winnats. Scattered outcrops with boulders extend from Old Tor towards the crags overlooking the Roman Hollow.

The relationship of the Beach Bed to the Boulder Beds is uncertain as they are nowhere seen in juxtaposition (see discussion in Simpson & Broadhurst, 1969; and Stevenson & Gaunt, 1971). In spite of this uncertainty it is here taken that the Beach Beds precede the Boulder Beds (compare Fig. 2b & c). The exact age of the Boulder Beds is uncertain, but it seems likely that they are mostly latest Brigantian, but with scattered boulders continuing to fall into the early Namurian shales.

Whilst the Boulder Beds deposition may have extended over a period from latest Dinantian to early Namurian, they signify that about the end of Brigantian times, the northern end of the limestone block was uplifted and deeply eroded. Any Brigantian massif-reef-forereef beds lying across Treak Cliff and the Winnats were eroded away, and the resultant boulders were deposited as talus slopes on the lower part of the fore-reef. The Blue John fluorspar deposits in the outer part of Treak Cliff Cavern were later formed within the voids of the Boulder Beds (Simpson and Broadhurst, 1969; Ford, 1969). Boulder Bed outcrops extend down into the floor of the Winnats near the foot of Roman Hollow, with the matrix becoming more calcareous downwards. These occurrences are critical in demonstrating the presence of an erosional channel perhaps 50 m deep in the upper parts of the present Winnats Pass.

The deduction that may be drawn is that the site of the Winnats Pass was a moderately shallow channel through the reef belt, and that this may have been formed in two stages (a) during the accumulation of the Beach Beds, and (b) during the pre-Namurian uplift and erosion, both of these being during the Brigantian. The latter phase was in effect one of palaeokarst (Ford, 1984) where karstic hollows might be expected on any subaerially exposed part of the massif. The neptunean dykes at Windy Knoll fall into this category; so also may the boulder-filled hollow above Old Tor Mine, with its lenses of coarse detrital crinoidal limestone. These are both at altitudes today approaching 400 m OD. They raise the question of the position and altitude of the shore-line for the Boulder Beds around Odin Mine and at the foot of Treak Cliff could have accumulated at any water depth simply by sliding or rolling down a submarine slope. No shore-line features have yet been identified.

Thus it is possible that the pre-Namurian channel was of no great depth, and it seems unlikely that the Winnats Pass can be regarded as entirely an exhumed mid-Carboniferous palaeokarst feature (Broadhurst and Simpson, 1973). Comparison with the exhumed mid-Carboniferous landscape in upper Dovedale (Hudson, 1932; Aitkenhead *et al.*, 1985) suggests that Glutton Dale and Dowel Dale may, in effect, be smaller equivalents of the Winnats Pass, with little surviving evidence of their mid-Carboniferous history. A comparison with Cavedale, less than a kilometre to the east is easier; no writer has so far suggested that Cavedale is anything other than a dry valley, a karstic landform resulting from processes operating in the Pleistocene, but it could have been initiated as a mid-Carboniferous feature, again with no surviving evidence.

Mesozoic to Pleistocene

Once buried beneath the Namurian sediments and Coal Measures, it is likely that the site of the Winnats Pass remained a fossilized sub-surface feature until the Upper Carboniferous cover was stripped off. Whilst there is a remote possibility that Mesozoic events may have occurred of which we have no evidence, projection of the remnants of shale cover from the Brassington sand-pits (Walsh *et al.*, 1972) suggests that stripping the cover did not take place until mid to late Tertiary times. Indeed, if the early stages of cave evolution and the development of Hope Valley are taken into account (Ford, 1986) stripping the shale cover may not have occurred around Castleton until early Pleistocene times.

The mechanism of stripping the shale cover is unknown but is likely to have been a normal fluvial process like that still operating on the Millstone Grit country surrounding the present limestone outcrop. After incising through the coarse sandstones streams meandered on a shale surface until superimposed on to the limestone, with progressive underground "capture" (Ford, 1986). Warwick (1964) has suggested that much of the dry valley network is so inherited but little evidence was produced to support the hypothesis. Where superimposition took place on to limestone surface with projecting reef-knolls, rivers could become "trapped" and anomalous gorges resulted in places (Ford & Burek, 1976). Whilst such superimposition may have occurred in the Winnats Pass there is no direct evidence of it having been a significant part of the process.

Pleistocene Dry Valley

Under hypothesis 4 the Winnats Pass is a dry valley of the type occurring throughout the Derbyshire limestone outcrop. Conventionally these result simply from run-off being maintained on the surface during periglacial periods of frozen ground around the margins of the ice-sheets. Run-off may have been enhanced by snow-melt water and is thought to have been sufficiently energetic to erode the dry valleys. However, there are general problems in applying such a concept in Derbyshire, let alone to the Winnats Pass. Since the present dry valley network cuts into a plateau with a loess and, locally, till cover, were the dry valleys incised entirely since the last full glacial episode, i.e. since the Wolstonian (see Ford, 1977; 1986)? Or, were they eroded by conventional dry valley processes in earlier Pleistocene times, filled with loess and/or till, and re-excavated in late Pleistocene times? Or, as argued by Warwick (1964), is the dry valley network inherited by super-imposition from the former shale cover and only modified by Pleistocene processes? Inheritance has certainly produced "anomalous gorges" elsewhere in Derbyshire (Ford & Burek, 1976) but the circumstances of these differ somewhat from the Winnats Pass, as the incision of the anomalous gorges appears to be due to "entrapment" of superimposed drainage by upwardly projecting reef-knolls.

As has been noted above, there is at least some stratigraphic evidence for the present of a shallow inter-reef channel at high level along the present line of the Winnats Pass. This was probably filled with shale in early Namurian times so that any development of a dry valley could have had the advantage of re-excavating the relatively soft shale to initiate incision. However, there is more to it than such a simple explanation. Firstly, the Winnats Pass has a very small catchment area for energetic run-off to gather and erode the Pass floor. From the top of the Roman Hollow head of the Winnats to the watershed at Windy Knoll is only 400 m of relatively flat ground; even if the southern flank of Mam Tor is included (now "captured" and draining via Odin Sitch) the likely catchment is probably no more than 1 km^2, certainly not enough for run-off to incise the Pass as we see it today.

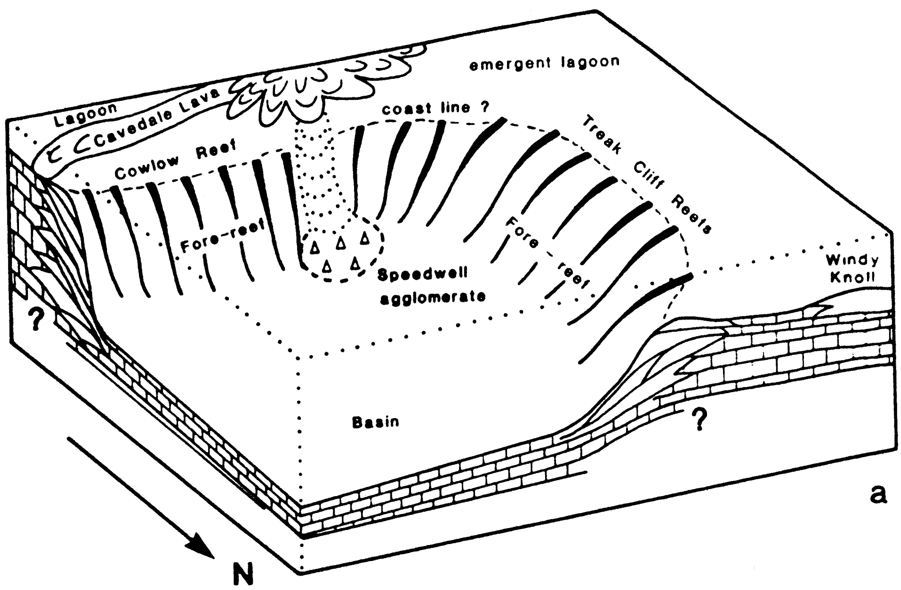
There is no known till in the Castleton area and only relics of loess occur on the plateau, not in the Pass, though derived loessic sediments occur in the cave systems. A solifluction sheet covers the floor and northern flank of the Rushup Vale. Both loess and solifluction are probably largely of Devensian age, so that they throw little light on the earlier Pleistocene history of the area around the Winnats. However, if it is postulated that ice advanced into Rushup Vale in at least one pre-Devensian phase of the Pleistocene and that the ice margin stood somewhere in the vicinity of Windy Knoll, both a very much larger catchment and more energetic run-off could have been available. In this case the Winnats Pass may be regarded as partly dry valley and partly spillway channel, though the lack of an outwash fan at the foot of the Winnats suggests that the spillway effect was minimal. However, it must be emphasized that at present there is no direct evidence for the ice margin concept but inferences drawn herein and from the cave systems support the possibility.

On the basis of the argument in the preceding paragraph the Winnats could have been developed as a short, steep run-off periglacial water-course fed by melt-water from an ice-margin near Windy Knoll in Wolstonian times. Advantage would have been gained in the early stages by the removal of the less resistant Namurian shales from a shallow mid-Carboniferous channel. Some modification by periglacial run-off in the Devensian may have occurred but there is no evidence for an ice lobe at this time. A chronological constraint for Wolstonian incision is provided for by the fact that the Hope Valley must have been incised to somewhere approaching its present depth to give a local base level to which the Winnats is graded.

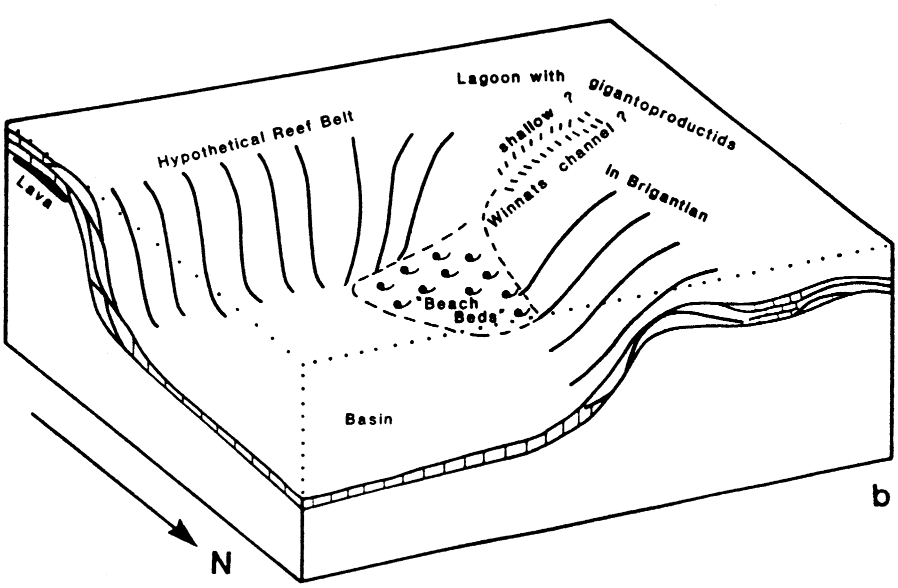
Important evidence is provided by the cave systems. Apart from the absolute dates on speleothems (which give a minimum date for drainage of the cave) (see Ford, Gascoyne & Beck, 1983) the cave passages themselves yield evidence of a series of morphological phases (Ford, 1986). Vadose incision of the inner part of Speedwell Cavern, lying some 500 m south of the Winnats and over 150 m below the surface, was active by Wolstonian times draining streams which sank in swallets in Rushup Vale and resurged at Castleton close to Hope Valley floor level. Whilst such a crossing beneath the surface watershed could have taken place whether the Winnats Pass was there or not, an important tributary to the Speedwell stream was Pilkington's Cavern. The streamway in this section had a limited period of vadose incision; it has a few sandstone pebbles on the floor, and was fed by water going underground via sink-holes adjacent to Faucet Rake, only some 200 m south of the cliffs on the south side of the Winnats. Such a stream must have had a catchment and it is difficult to see how there could have been one with the Winnats so close. However, if it is argued that the Winnats still had a shale fill the catchment could have extended towards Windy Knoll. Relative dating is important here—Pilkington's Cavern could only have been an active swallet before the Winnats had been cleared of its shale, before it had been incised as a dry valley and before it was graded to Hope Valley. Whilst the dating of glacial and inter-glacial episodes is still controversial the timing of the events relating to Pilkington's Cavern must remain uncertain, but at least it seems that the vadose stream-cutting therein may have been pre-Wolstonian.

The deduction is that the Winnats Pass originated in a series of stages; commencing with a possible inter-reef depositional hollow, developed as a scour channel across a high level of the Dinantian reef complex which produced the Beach Beds fan at the Winnats foot; a mid-Carboniferous phase of uplift yielded the Boulder Beds with a moderately deep erosional channel across the reef complex; burial by the pro-deltaic Edale shales meant that the site of the Winnats was concealed and inactive until exhumed as the Namurian cover was stripped off in late Tertiary or Pleistocene times. In mid-Pleistocene times a stream meandered across the shale fill and sank into Pilkington's Cavern; later, when an ice margin stood around Windy Knoll, melt-water run-off scoured out the remaining shale fill and deepened the Pass as a classic dry valley partially inherited from the pre-Namurian topography. The late Pleistocene has seen the final incision and trimming of the Pass and the abandonment of drainage through Pilkington's Cavern. This blend of hypotheses 1, 2, 3 and 4 offers the most likely explanation of the origin and development of the Winnats Pass as a mid-Carboniferous channel deepened and enlarged by a Pleistocene dry valley mechanism.

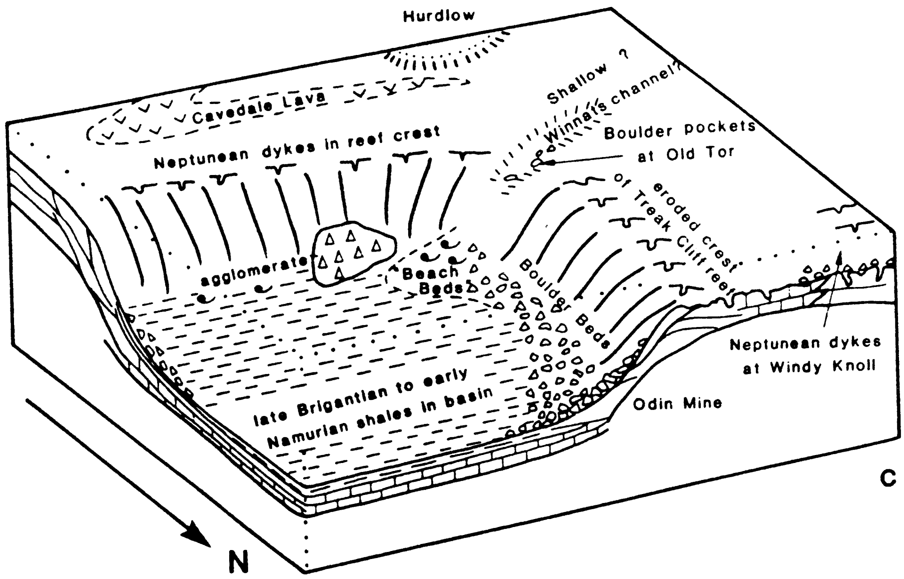
Fig. 2. Block diagrams to illustrate the origin and development of the Winnats Pass.



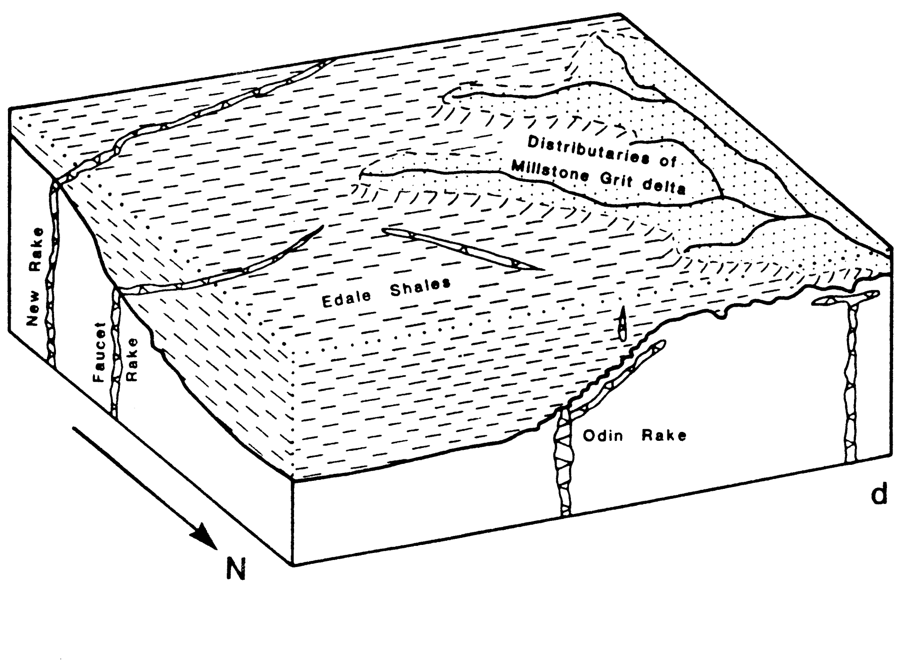
(*a*) The massif-reef-basin relationship in Asbian times at the time of sub-aerial eruption of the Cavedale lava, showing it spilling over into the sea to accumulate as the Speedwell agglomerate.



(*b*) The relationship in Brigantian times—only the Brigantian beds are shown on the sections. A shallow depression across the reef-belt provides a means of transporting water-worn and broken *Gigantoproductus* towards the basin to form the Beach Beds.



(*c*) The relationship in latest Brigantian-early Namurian times. Uplift and erosion has led to removal of most Brigantian beds, with an outlier on Hurdlow, south of the Winnats. Neptunean dykes and other palaeokarst features are developed on the subaerially exposed top of the Asbian reef complex. Boulder Beds accumulate around Windy Knoll, Odin Mine and along the foot of Treak Cliff. Earliest Namurian shales start to fill the basin and bury the Boulder Beds. The Winnats Pass is a shallow channel across the reef-belt.



(*d*) Burial by tongues of Namurian deltaic sands and pro-deltaic muds blankets the mid-Carboniferous palaeokarst. Mineral vein fissures start to open in the buried limestone.

Acknowledgments

Thanks are due to Fred Broadhurst for constructive criticism of various stages of the preparation of this paper, and for his useful suggestions regarding several points which still remain unproven. Mrs Sue Button drew the diagrams.

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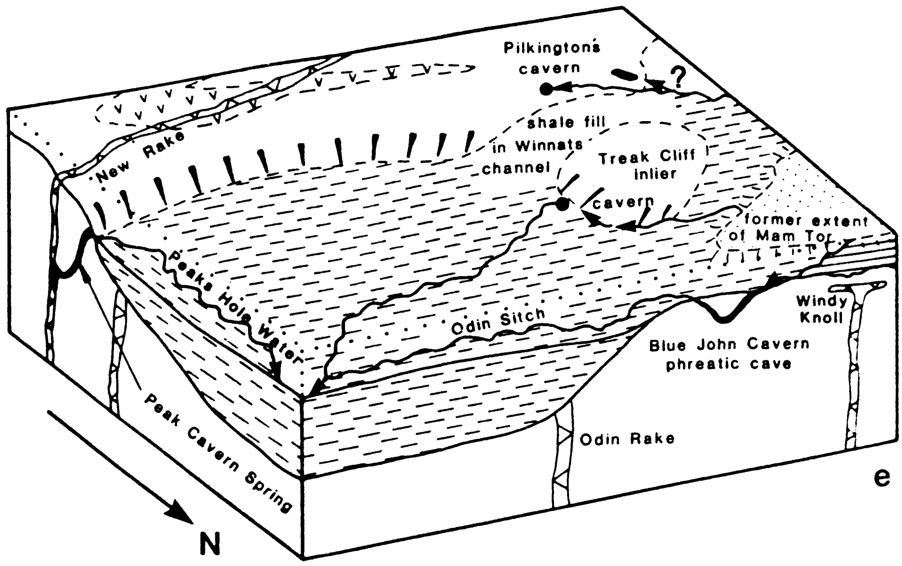
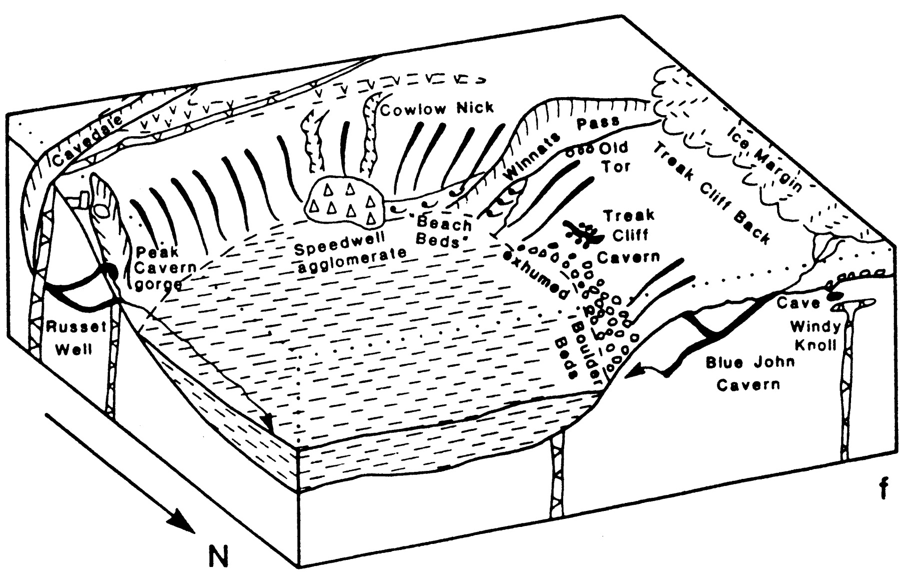
T.D. Ford
Geology Department
University of Leicester
Leicester LE1 7RH.



(*e*) An early Pleistocene exhumation stage—Treak Cliff is partly uncovered as an isolated limestone mass surrounded by shales; an early stream goes through part of it to form Treak Cliff Cavern; to the north (right-hand corner of diagram) a stream drains via a phreatic system now seen as the Blue John Cavern. The shallow valley of the Winnats is still full of shale and a stream meanders across it to sink into Pilkington's Cavern. Part of the main Castleton Caves drainage rises from mineral vein cavities in New Rake to resurge at a vauclusian spring at the site of the present Peak Cavern gorge, debouching onto a Hope Valley floor much higher than at present.



(*f*) As Hope Valley floor is cut down, probably in Anglian-Wolstonian times, the vauclusian spring's lip is cut away, partly draining Peak Cavern and picking up the Speedwell cave stream at Russet Well. Dry valleys are incised, particularly Cavedale. Potentially dry valleys loose their catchments underground and are left as the short steep gullies of Middle Bank gully and Cowlow Nick; The Winnats Pass is deeply incised by melt-water run-off from the margin of an ice tongue near Windy Knoll. Treak Cliff Cavern is left high and dry; the Blue John Cavern drainage is incised and then largely abandoned.