Litton Mill Railway Cutting, Derbyshire

[SK 158 729]

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Introduction

The Litton Mill Railway Cutting, in the Wye Valley of Derbyshire, represents the Brigantian Upper Miller's Dale Lava. Here, the lava occurs within a limestone sequence and appears to have flowed across an eroded surface into a lagoonal embayment. The flow-front is well exposed and is shattered and brecciated as a consequence of contact with water. Numerous publications have referred to this section and the significance of the dramatic thinning and termination of the Upper Miller's Dale Lava (Green *et al.,* 1887; Arnold-Bemrose, 1907; Cope, 1933, 1937; Walkden, 1977).

The Upper Miller's Dale Lava, which is also present at the Calton Hill GCR site, commonly consists of several lava flows. The lavas are of Brigantian age and are younger than the Asbian Lower Miller's Dale Lava seen at the Water Swallows Quarry and Tideswell Dale GCR sites (Figure 7.3).

Description

The GCR site comprises a disused railway cutting, extending about 550 m to the west of the Litton Tunnel [SK 162 729] (Figure 7.4). The succession detailed below is a composite strati-graphical section (shown in descending order) from the former railway cutting and the cliffs below the cutting on the south bank of the River Wye. It is derived from descriptions by Cope (1937), R.A. Eden (unpublished Geological Survey field notes, 1954) and Walkden (1977).

	Thickness (m)
Monsal Dale Limestones: 'Priestcliffe Beds' of Cope (1937)	
Limestone, dark grey, thinly bedded, very fine-grained with chert nodules; a marked discontinuity is present in the lower part of the section (Figure 7.5)	17.95
Limestone, grey, dark grey towards top, fine grained, irregular bedded with rounded fragments of decomposed lava near base	1.37
Upper Miller's Dale Lava	
Basalt, brown-weathered, upper 1.52 m poorly exposed, rough flow-banding, rounded masses of harder material up to 0.61 m diameter	up to 5.18
Monsal Dale Limestones: including 'Station Quarry Beds' of Cope (1937)	
Limestone, dark grey, thinly bedded, fine grained, locally crinoidal, cherry in places especially in the upper part, 10 cm-thick K-bentonite 4 m above base; irregular base (unconformity) with pot-holes in underlying Bee Low Limestone filled with impersistent K-bentonite, up to 50 cm thick, overlying conglomerate with pale- and dark-grey limestone clasts	up to *c.* 10.00
Bee Low Limestones: Miller's Dale Beds of Cope (1937)	
Limestone, pale grey, thickly bedded, very fine-grained, but with some slightly crinoidal or shelly beds	*c.* 15.00

The Upper Miller's Dale Lava is present only in the western part of the section [SK 157 730] (Figure 7.4). Here, the lava shows a rough flow-banding which dips at 40° to the east. The irregular upper surface of the lava is obscured by a small retaining wall (Figure 7.5), but was formerly seen by Cope (1933, fig. 5) with a dip toward the east of about 25°. A thin, irregular laminated tuff occurs locally beneath the lava (Cope, 1937).

At the eastern end of the cutting, at the western portal of Litton Tunnel [SK 1617 7289], the top of the Bee Low Limestones is described by Walkden (1977) as having a karstic hollow filled with limestone breccia, overlain by an impersis-tent K-bentonite up to 50 cm thick. A further K-bentonite band, 10 cm thick, occurs 4 m above the top of the Bee Low Limestones. This bentonite displays a relict vitroclastic texture, with rock fragments and glass shards up to 0.5 mm in diameter and bioclastic debris in a calcite matrix (Walkden, 1977).

Interpretation

The Upper Miller's Dale Lava has a typical thickness of about 30 m in Miller's Dale, but decreases markedly in thickness toward the Litton Mill Railway Cutting in the east. This GCR site provides a rare example in England of such a lateral termination of a lava flow, which is both well exposed and easily accessible.

Green *et al.* (1887) were first to recognize the lateral thinning and dying out of the lava flow. Arnold-Bemrose (1907) suggested that the absence of the flow along part of the railway cutting resulted from the presence of a fault with a downthrow of some 60 m to the east. However, in a detailed description of the cutting and adjacent area, Cope (1933, 1937) discounted the fault model and proposed that the lava died out as a flow-front about 550 m to the west of the Litton Tunnel. Walkden (1977) confirmed the presence of a flow-front and identified bentonites present laterally to the east of the lava. He also identified an intra-Brigantian unconformity beneath the flow and provided an interpretation of the environment of formation of the lava and of the events necessary to produce the succession seen at this site. This is summarized as follows:

1. Regional uplift at the end of Asbian time produced a karstic surface at the top of the Bee Low Limestones. Alternatively, this could have been caused by a sea-level fall (Aitkenhead *et al.,* 1985).
2. Resumed sedimentation with deposition of the Station Quarry Beds, of early Brigantian age.
3. Folding and development of a broad, low-amplitude anticline with a WNW-trending axis, referred to as the Taddington Anticline by Cope (1937), located to the south of the GCR site. The folding is associated with uplift and erosion, with localized removal of the Station Quarry Beds in the hinge of the anticline, re-exposure of the karstic surface on the top of the Bee Low Limestones and filling of potholes with limestone breccia, as seen at the Litton Tunnel portal (Figure 7.4). The broad syncline described by Walkden (1977) in the Bee Low Limestones beneath the railway cutting is a product of this folding event.
4. Eruption of earlier flows of the Upper Miller's Dale Lava to the west, with these flows not reaching the area of the Litton Mill Railway Cutting. Along the cutting this event is found as pyroclastic debris, evident as the lower K-bentonite present only in karstic hollows, such as at the portal of the Litton Tunnel.
5. Dormant phase associated with local subsidence and deposition of carbonates of the Monsal Dale Limestones, possibly in an embayment between inactive lava flows.
6. Resumption of extrusive activity with the earlier flows over-ridden by a lava that extends eastwards as far as the western end of the Litton Mill Railway Cutting. The tapered margin of this lava seen in the cutting is interpreted as an eastward-facing flow-front developed in a flooded embayment. The lava front displays a blocky and brecciated texture, interpreted by Walkden (1977) as a flow-foot breccia formed as a result of lava entering water and shattering. Palagonitization of the basalt is evident in places, in which devitrification of basaltic glass may have formed by rapid chill and hydration of lavas on entering water. The rapid chilling was sufficient to halt the flow of the lava and cause the development of a steep flow-front. Separate inclined sheets of lava rubble would have developed under water, giving the rough flow-banding described by Cope (1937) and Aitkenhead *et al.* (1985). The upper 10 cm-thick K-bentonite present at the Litton Tunnel portal may represent a hyaloclastitic carpet of fine-grained volcanic detritus, which accumulated in the lagoon in front of and was over-ridden by, the advancing lava (Walkden, 1977). The irregularly bedded limestones marginal to and overlapping the lava were interpreted by Cope (1937) as having being deposited at the time of the lava flow, and the angular discordance between two steeply dipping packages of

limestone beds were interpreted as a foreset by Walkden (1977).

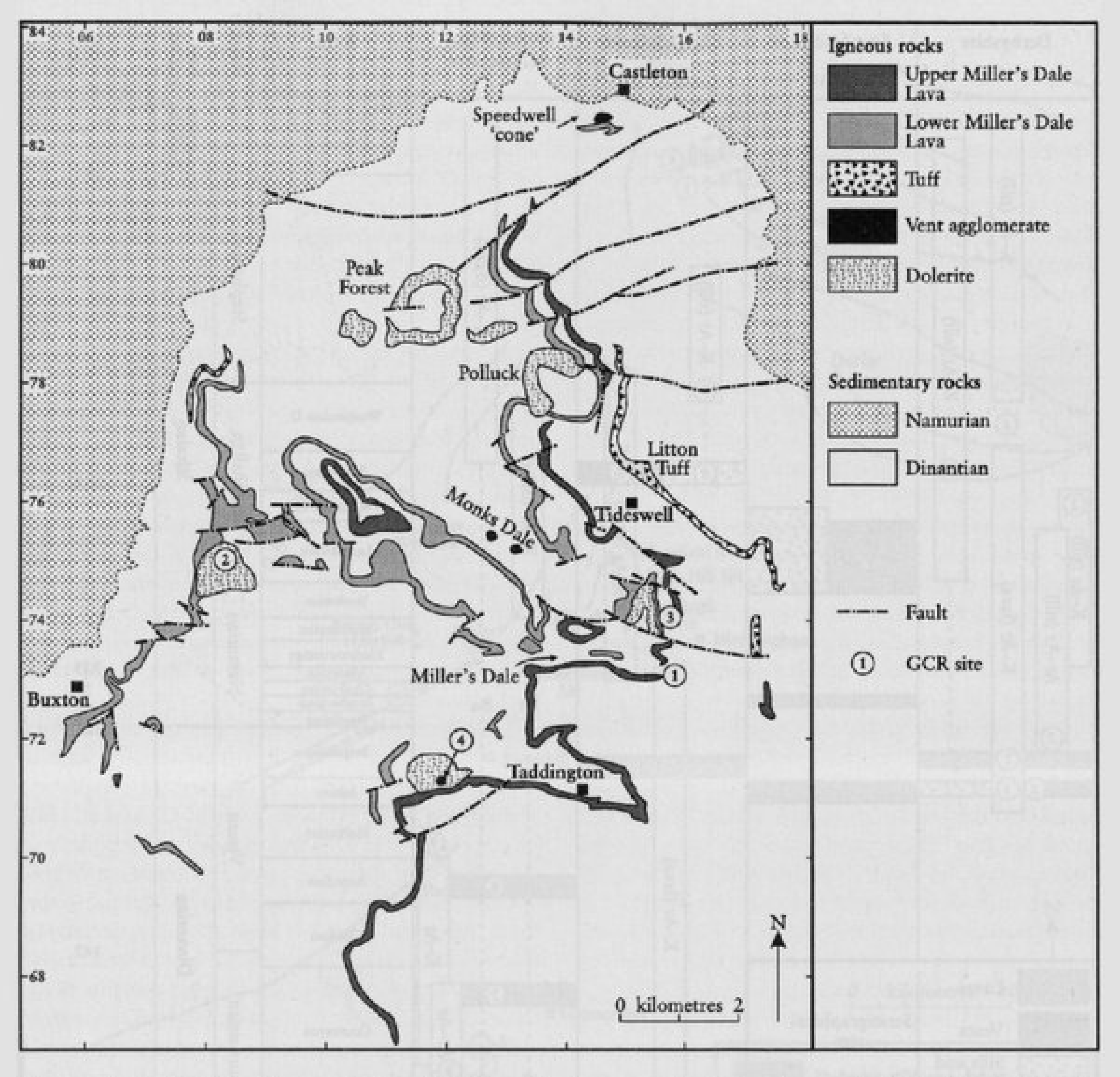
Evidence for two distinct extrusive events is present at Lime Works Quarry [SK 140 730] in which a *c.* 30 m-thick, non-vesicular, holocrystalline basalt is underlain by 5.2 m of tuffs with a thin amygdaloidal basalt (Walters and meson, 1981). The lava front observed at Litton Mill Railway Cutting is thought to equate to the thick upper flow.

Cope (1937) noted that the nearby Calton Hill Vent occurs in the core of the Taddington Anticline, with the inference that there may be a link between localized uplift and volcanic activity and that the Upper Miller's Dale Lava may have been sourced from the vent. However, the Calton Hill intrusion appears to be younger than the Upper Miller's Dale Lava and is of a different composition (see Calton Hill GCR site report).

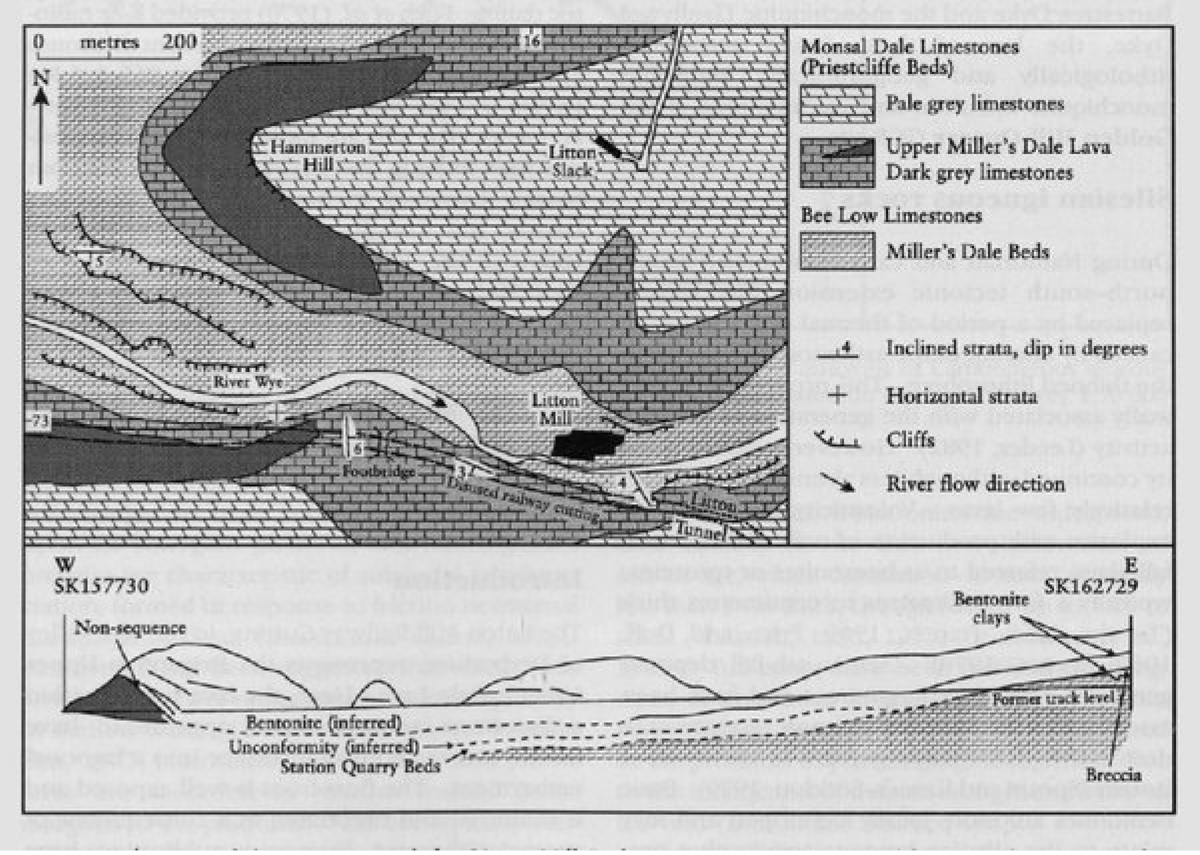
Conclusions

The Litton Mill Railway Cutting GCR site shows a dominantly carbonate succession of Early Carboniferous age (*c.* 330–340 Ma), with evidence for a phase of broad folding, uplift and erosion interrupting deposition of the carbonate sediments. This folding event immediately predated the extrusion of several lavas, collectively known as the Upper Miller's Dale Lava, which crop out over a large area to the north-east of Buxton. The GCR site is representative of the upper part of this volcanic unit and is of great significance as it provides a rare opportunity in the Carboniferous rocks of England and Wales to study the lateral termination of a lava flow. This lava is interpreted as having flowed into a lagoonal embayment, becoming shattered and brecciated as it came into contact with the water. Explosive activity associated with rapid quenching of the lava may have produced a thin bed of fine volcanic detritus, which accumulated in the lagoon immediately in front of the lava flow and was subsequently partly over-ridden by the lava front.

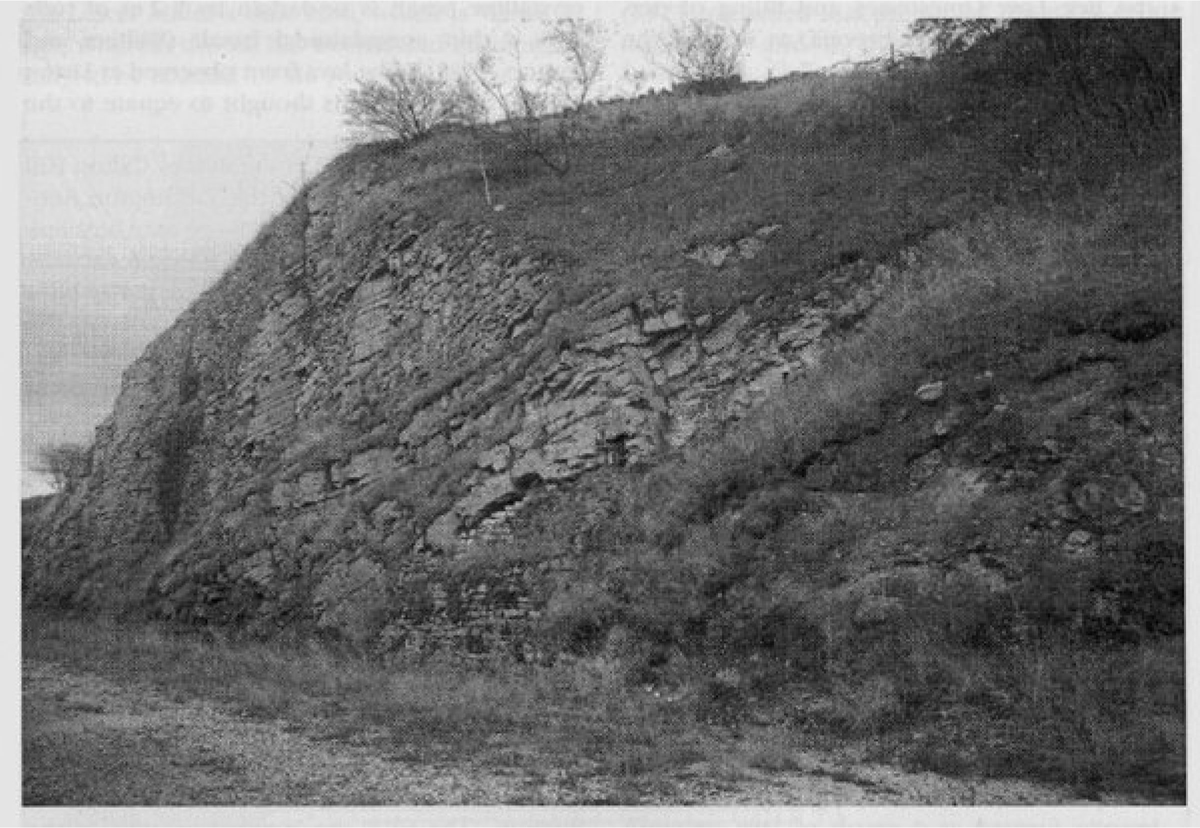
References



(Figure 7.3) Map of the Buxton-Tideswell area, Derbyshire, showing the outcrops of Carboniferous igneous rocks and the positions of the GCR sites (numbered as in (Figure 7.1)). Based on Geological Survey 1:50 000 sheets 99, Chapel en le Frith (1975); and 111, Buxton (1978).



(Figure 7.4) Map of the area around the Litton Mill Railway Cutting GCR site and horizontal section. After Walkden (1977).



(Figure 7.5) Litton Mill Railway Cutting viewed towards the south-east and showing the Upper Miller's Dale Lava (bottom right), overlain by well-bedded limestones of the Monsal Dale Limestones (above the inclined grassy ledge and reinforcing wall). The cutting is here about 18 m deep; see hammer, bottom right. A sketch of this view, with annotation, was presented by Cope (1933, fig. 5). (Photo: British Geological Survey, No. L2270, reproduced with the permission of the Director, British Geological Survey, © NERC.)