REPORT

Visean coal seam in Crich Quarry

Limestone quarrying in late 2004 at the northern end of the Crich anticline (beyond the Tramway Museum), on the eastern margin of the Derbyshire Dome, revealed a coal seam within the Visean succession of the Carboniferous Limestone (Fig. 1). This report places the coal on record before its loss by quarrying. It also raises some questions of palaeo-environmental significance that are briefly discussed below.

Description

The coal is variable in thickness, up to 300 mm at maximum, and is exposed over a distance of around 100 m (Fig. 2). It is crumbly with streaks of mudstone, and rests on a clay wayboard that is also of variable thickness, averaging about a metre. This in turn lies on an undulating, "potholed" surface of the underlying limestone. The coal is capped by higher limestones, some 10 m thick, with a sharp but undulating base.

Previous research

While thin coals, up to 50 mm thick, have been recorded on wayboards elsewhere in Derbyshire over the last century and a half (Worley & Dorning, 1977), this exposure of Visean coal at Crich is exceptional. It is a new record, as it was not mentioned either in the Geological Survey Memoir (Frost & Smart, 1979) or in Bridges' study of cyclic sedimentation in the Carboniferous Limestone of Crich (Bridges, 1982). A brief note by Sargent (1912) referred only to a former exposure of coal at an unspecified locality "near Matlock".

Stratigraphy

The stratigraphical position of the Crich coal seam appears to be close to the boundary of the Monsal Dale Limestones (formerly Matlock Limestones) and Eyam Limestones (formerly Cawdor Limestones), both of upper Visean (Brigantian) age. The underlying wayboard appears to be that recorded as Clay Horizon D in Bridges' (1982) study of cyclic sedimentation in the limestones, though he did not mention any coal being present; nor did he offer any stratigraphic correlations between the areas around Matlock and Wirksworth.

Discussion

The cyclic sedimentation within the limestone sequence (Bridges, 1982) signifies transgression-regression cycles, and it is in these that coal represents maximum regression with emergence to form land areas. Equivalent cyclic shallowing has also been recognized in the nearby Wirksworth area (Oakman & Walkden, 1982), though few traces of coal were noted. The carbonate cycles there mostly end with some evidence of emergence above sea level, marked by palaeosol textures in the limestone representing caliche and rhizoliths as evidence of soil-forming processes in the topmost carbonate sediments. These carbonate palaeosols are capped by clay wayboards representing air-fall dust tuffs, which Walkden (1972) demonstrated to be degraded volcanic ash layers, also known as K-bentonites. The dust tuffs may well have been palaeosols but do not show evidence of soil textures. The tuffs rest on "potholed" palaeokarstic surfaces (Walkden, 1974; Vanstone, 1998), which are widespread within the Carboniferous Limestone of Britain (e.g. Davies, 1991). Outside the Peak District the potholed surfaces are commonly covered by mudstone seat-earths as they are in areas without obvious volcanic associations. Davies (1991) noted that clays in Anglesey also contained K-bentonites, possibly contributed by wind-blown dust from distant eruptions, and were apparently bound by rootlets.

The sharp but undulating base to the limestone that caps the coal suggests a period of erosion, before a sharp rise in sea-level led to submergence in the transgressive phase. The succeeding limestones are coarse-grained indicating the deeper part of a shallowing-upwards cycle. As no coal was recorded either in the Geological Survey Memoir (Frost & Smart, 1979) or by Bridges (1982) it could be that the

Figure 1. *The coal at Crich (with 200mm bands on staff).*

***Figure 2**. The quarry outcrop of the coal seam within the Carboniferous Limestone at Crich; the coal lies over the pale shale that forms the lower part of the face in the foreground.*

coal seam was not exposed at Crich during their research or is only present over a limited area due to Carboniferous erosion.

The Crich "coal" is in reality a crumbly and highly pyritic carbonaceous mudstone. The crumbly nature suggests a predominance of fusian, derived from comminuted vegetable matter. Pyrite is common in such coals, and often occurs in the limestones adjacent to waybords and lavas elsewhere in the Peak District.

None of the thin Dinantian coals associated with wayboards elsewhere in the Peak District has been described in detail as to its content of clarain (fossil wood), durain (comminuted vegetable matter such as twigs, leaves, spores etc) or fusain (partly oxidised leaf detritus), but some accounts note the "sooty" nature of the coals, suggesting fusain. From this, it may be inferred that the coals were largely comminuted vegetable matter that drifted in from surrounding areas such as emergent islands covered with low scrubby vegetation instead of trees. Transported vegetable material would explain the lack of root structures. However, Dorning (in Worley & Dorning, 1977) recorded spores of lycopod trees in a thin coal at Tearsall, west of Matlock, indicating the presence of at least a few trees on what must have been islands somewhere on the carbonate platform. The new exposure at Crich has little sign of clarian, denoting either few trees or drifted trunks.

The duration of coal formation is uncertain though Walkden (1974) argued that the accumulation of dust-tuffs could have taken anywhere from 30,000 to 100,000 years. A comparable period would be necessary for the growth of vegetation and accumulation of enough peat to form 300 mm of coal.

The much better known coals in the later Coal Measures normally rest on seat-earths (fireclays or ganisters) with ample evidence of tree roots, either as carbonised rootlets normal to bedding or as the much larger structures commonly known as Stigmarian roots. None of the wayboards in the White Peak has been reported to carry either rootlets or *Stigmaria*. The new exposure of coal at Crich also appears to be without roots or rootlets in the underlying clay wayboard. Their absence also indicates that the coals were transported vegetable matter.

In both Anglesey (Davies, 1991) and northwest England (Vanstone, 1998), it was argued that the potholes, up to a metre deep in the undulating limestone surfaces beneath wayboards (and seat-earths elsewhere), could be due to acid rainwater draining down from the bases of tree trunks through the clays to attack the limestones beneath. However, no fossil root structures that could have led such waters downwards have been recorded in Derbyshire wayboards. While the wayboards may well have provided acidic soil conditions with potentially corrosive effects on the underlying limestones, the problem of potholed surfaces beneath wayboards remains incompletely explained.

Conclusion

The phenomena of cyclic sedimentation and clay wayboards with occasional coals clearly indicate intermittent emergence above sea-level through much of late Visean time in the Crich and Matlock areas. This appears to have created temporary islands that supported terrestrial vegetation. The coals, wayboards and the pot-holed surfaces are worthy of further research both in the Peak District and elsewhere in the British Carboniferous Limestone.

Acknowledgments

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Appendix

The coal is possibly best described as a highly carbonaceous mudstone. Several grams were prepared for palynology using standard fuming nitric acid and Schulze's Solution maceration, followed by heavy liquid separation to remove the remaining silicate minerals. The organic residue is dominated by heavily degraded, broken and sub-rounded humic material with lesser amounts of angular vitrinite. The humic material is deformed by intergrowths of pyrite. Spores are very scarce and poorly preserved with only questionably identified specimens of *Calamospora* sp., *Cyclogranisporites* sp., *Lycospora pusilla* and *L. orbicula* recorded. These provide little biostratigraphical information other than to indicate a post-Tournaisian, Carboniferous age for the material. They also provide little evidence to allow reconstruction of the coal mire vegetation other than to suggest that it included sphenophylls, ferns and aborescent lycopsids, as would be expected of a British Carboniferous coal.

As unusual feature of the coal residue is the common presence of tubular organic remains that are broadly similar in form to *Reduviasporites* Wilson 1962 emend. Foster *et al*. 2002. This is either of algal origin (Foster *et al.* 2002) or fungal origin (Elsik, 1999) depending on which interpretation is believed. The palaeo-ecological significance of the common occurrence of *Reduviasporites* in the coal at Crich cannot be understood until the biological relationships of this form are resolved.

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LECTURE

Anhydrite to zinc - a pictorial survey of working mines in the British Isles

Summary of the lecture given to the Society on Saturday 10th December 2005 by Paul Deakin of the Royal Photographic Society.

For many years, Paul Deakin has been photographing the mines of Britain, both working and disused. His presentation to the Society was more of a visual experience than a lecture. Consequently, in place of a summary text, a small selection of Paul's photographs from mines in the East Midlands appears on both front and back covers of this issue of *Mercian Geologist*. Though these mines were working when Paul photographed them, they are now all closed, except for the tiny Treak Cliff operation.

The hydrothermal veins within the limestone of the Derbyshire Peak District are only economic if worked on a large scale, though now only in Sallet Hole. Trackless transport is used, as in the Mill Dam Mine on the western end of the Hucklow Edge Vein. Large stopes are created and generally remain stable in the strong limestone; unusually, the big vertical stope in the Long Rake Mine, near Youlgreave, was worked for its pure calcite. Lead ore is now just a by-product from mines that target fluorspar. The Ladywash Mine, near Eyam, was an older and smaller mine that was worked for lead, and it still has veins rich in galena that survive in remnant pillars of ore.

Treak Cliff Mine, at Castleton, is only worked by hand on a very small scale for selective extraction of Blue John fluorspar for the jewellery trade. It is also in the limestone, but the ore is found only within pockets in the structurally complex reef beds.

North Nottinghamshire still has a handful of deep coal mines, all using the longwall method of total extraction. Though Bolsover Mine is now closed, its face was typical, with the coal shearer moving along the long wall cut into the seam, while the roof was temporarily supported by a line of moveable hydraulic props. Roadways within the pillars that were left between extracted longwall panels are subjected to huge pressures; the roof of the roadway in the Clipstone Mine, also now closed, was supported by colliery arches, but the need for its continual maintenance was a big factor in the mine economics.