EXCURSION

Weekend Field Excursion to the Central Pennines

30th-31st July 1994

The valleys of the Central Pennines are incised into the Millstone Grit and Coal Measures, and the purpose of the excursion was to examine some of the sections through these ancient delta deposits. New interpretations based on the principles of sequence stratigraphy provided a recurrent theme throughout the weekend.

Saturday, 30th July

Leader: P. B. Wignall, Department of Earth Sciences, Leeds University.

The first day aimed to show the splendid late Namurian and early Westphalian sections to be seen in and around the well-developed U-shaped valley of Cliviger between Burnley and Todmorden.

1. Ratten Clough

The Yeadonian (latest Namurian) geology was examined in a steep ascent up Ratten Clough. The Gastrioceras cancellatum Marine Band is well displayed in the stream at the base of the Clough (SD 891 269) and both the Lower and Upper Haslingden Flags occur higher in the section. The Haslingden Flags prograded into the region from the west and this is one of the most distal/easterly developments of both these sand bodies. In fact siltstones dominate in Ratten Clough and the Flags are represented by only a few thin beds of sandstone. In contrast, the Rough Rock, the topmost sandstone of the Namurian, shows only minor lateral thickness variations and has a sharp (erosive) base. The sequence stratigraphical interpretation of the Rough Rock has been the subject of considerable recent debate, primarily because it refuses to be shoe-horned into any particular aspect of the sequence stratigraphy model.

There can be little doubt that the onset of Rough Rock deposition marks a significant shallowing, for the distal mouth bar facies of the Haslingden Flags is replaced by stacked low sinuosity, channel sands of the Rough Rock — a fluvial facies. Sea-level falls in the sequence stratigraphical model should be associated with incision and the development of palaeovalleys. No such erosive relief is seen beneath the Rough Rock (cf. Maynard 1992).

2. Coal Clough-Paul Clough

After lunch, further late Carboniferous sections were seen in several cloughs straddling the Yorkshire/ Lancashire border to the north of Cornholme. Coal Clough (SD 904 273) displays a well-exposed Westphalian shale section with the black paper shales of the Gastrioceras listeri Marine Band at the base. This rests on a thick coal, the Lower Mountain (Union) Mine, which in turn rests on the Ganister Rock, a thin sandstone. Like the Rough Rock, the base of the Ganister Rock is sharply erosive and abruptly overlies much finer (more distal?) sediments. In a sequence stratigraphical model this would be a candidate for a sequence boundary (unconformity) but further evidence of regional erosion at this level is required to validate this interpretation.

Paul Clough displays a long section in the Namurian including a repeat of the Yeadonian succession seen in Ratten Clough. However, the shales are better exposed here (SD 907 273) and the Gastrioceras cumbriense Marine Band can be found. Two metres below this level there is a hard, fissile black shale around 15cm thick. This is the Owd Bett's Horizon of Maynard *et al.* (1991) and is the first named example of a particular shale facies which recurs throughout the Namurian of the Pennines. It is characterised by its very high organic carbon content, high levels of radioactivity (due to its uranium content), abundant pyrite and fissile weathering. These are all features typical of true marine bands, but Owd Bett's Horizon contains no fossils. Such shales appear to form during the early stages of transgression in fully marine but intensely anoxic conditions.

Sunday, 31st July

Leader: J. I. Chisholm, British Geological Survey, Keyworth, Nottingham.

The aim of this day's excursion was to demonstrate lateral changes in the sandstones and mudstones of the Millstone Grit and Coal Measures, and to show how these can be explained by the building out of successive delta systems into the sedimentary basin.

1. Hebden Bridge: Lower Kinderscout Grit

The Lower Kinderscout cyclothem crops out extensively in the valley sides around Hebden Bridge. At Hell Hole Quarry (SD 985 277) near Heptonstall, giant cross-beds near the top of the grit are up to 10m or more high, with internal erosion surfaces showing that the river transporting the sand had a variable discharge, perhaps adding to the foresets during rare floods (McCabe, 1977). Massive or vaguely flat-bedded sandstones are visible in a quarry lower down the slope (SD 988 274). An excellent view of the surrounding valley sides here enables the lateral and vertical relationships between softer siltstones (smooth slopes) and harder sandstones (projecting crags) to be appreciated. The massive sandstones form "pods" or narrow channel-like bodies less than 0.5km wide at various levels in the background siltstone, and the giant cross-beds appear to lie in a shallower channel about 3km wide cut across the top of sandstone pods and background siltstones alike.

The sequence is thinner than in the well-known sections around the Kinderscout Plateau in Derbyshire and differs in one important way — there is no equivalent here of the turbidite fan sandstones that form a prominent unit (the Shale Grit) near the bottom of the cyclothem in Derbyshire. An earlier belief (Ramsbottom, 1969, fig. 5) that the Todmorden Grit of Hebden Bridge is equivalent to the Shale Grit has proved mistaken (Ramsbottom, 1977, p.276). There are one or two marine bands of R_{1c} aspect above the Todmorden Grit (Lloyd and Stephens, 1931), dating it as late R_{1b} or earliest R_{1c}, whereas the Shale Grit appears to be entirely in R_{1c}, so is likely to be younger. A sandstone probably belonging to the Todmorden Grit is exposed in a small quarry

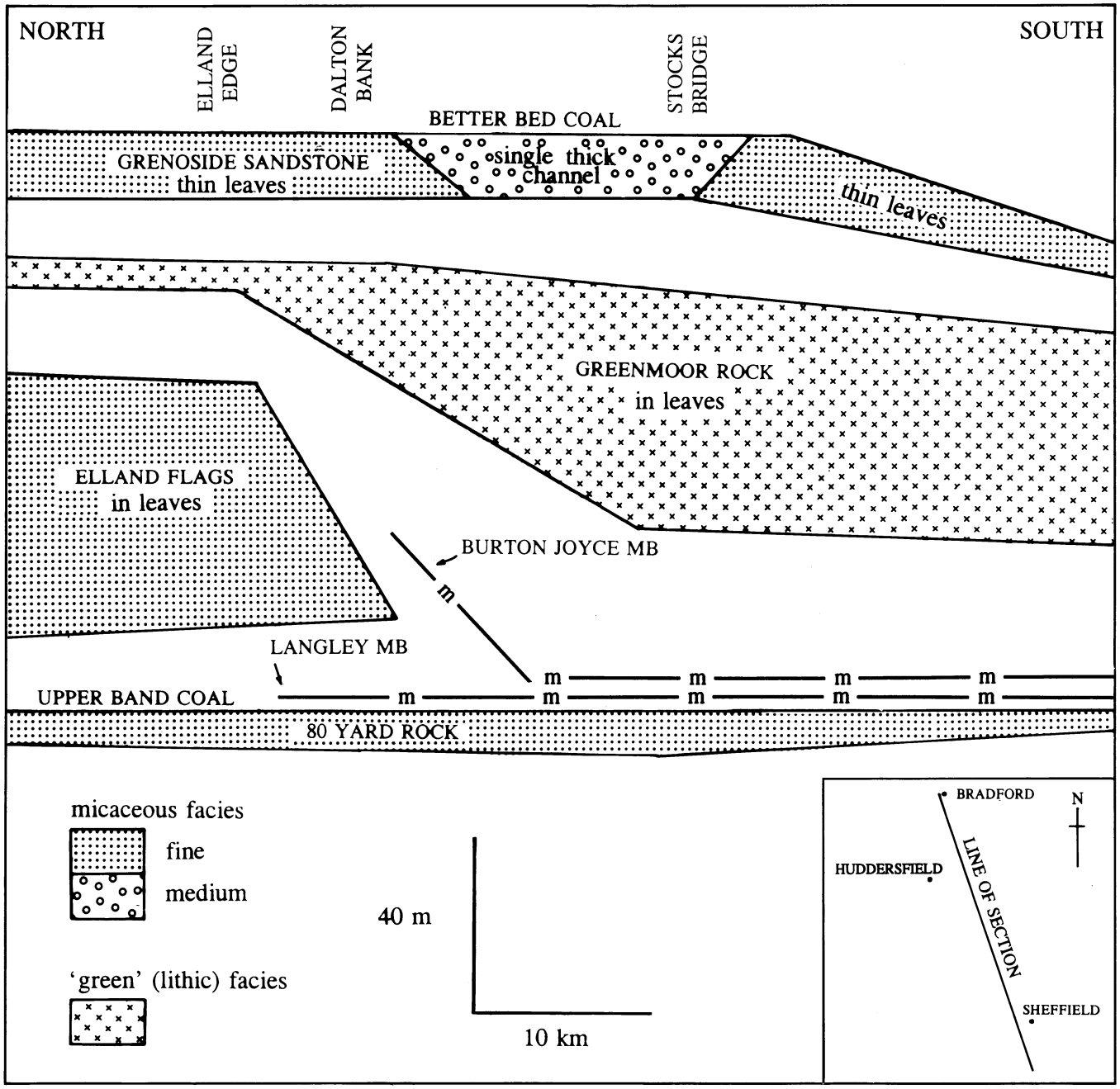

Fig. 1. Schematic diagram illustrating the stratigraphical relationships of sandstones in the Lower Coal Measures of the Cental Pennines.

(SD 985 274) by Mytholm Church. It is massive, with a strongly fluted base eroded into dark siltstone.

The accepted "turbidite-fronted delta" model of Collinson (1988, fig. 9.4) for the Kinderscout cyclothem can be applied here on the assumption that the Shale Grit turbidite fan was only deposited in the deepest parts of the basin, well to the south of Hebden Bridge. The sandstone pods are interpreted in the model as feeder channels leading down the delta slope and into the turbidite fan, and the giant cross-bedded sandstones are seen as the deposits of a river channel that advanced across the earlier deposits of its own delta, cutting down into these as it went. Only minor changes of sea level are envisaged in the Collinson model.

The more recent ideas of sequence stratigraphy suggest that there may have been larger and more frequent sea level changes than previously thought, and lead to alternative interpretations of the relationships seen in the Hebden valley sides. The older model can easily be taken apart on this basis, but if we want to put another one in its place we need to know how many times the sea rose and fell, and by what amounts, during the Kinderscout cyclothem. This knowledge is not yet available, but some suggestions can be made. The sandstone pods might be shallow-water channels that pushed through the delta front deposits during floods, and were sealed up immediately after. The giant cross-beds could be resting in channels incised during a drop of sea level, and filled during a subsequent rise. Hampson (1994) has suggested that incision and backfilling could have happened several times in the Kinderscout Grit, as sea level rose and fell.

2. Elland to Stocksbridge: Elland Flags, Greenmoor Rock and Grenoside Sandstone

The relationship between these sandstones in the Lower Coal Measures has recently been clarified (Chisholm, 1990). The Elland Flags of West Yorkshire were previously thought to pass laterally southwards into the Greenmoor Rock of South Yorkshire (Bromehead *et al.*, 1933; Davies, 1967) but it is now clear that the Elland Flags die out southwards near Huddersfield, and that the Greenmoor Rock thins northwards over the top of them. The Grenoside Sandstone of South Yorkshire is now known to lie below the Better Bed Coal, not above it. These stratigraphical relationships are shown in Figure 1. The same regional study shows that the Elland Flags deltas entered the Pennine Basin from the north but did not get very far, the Greenmoor Rock deltas advanced across the whole basin from the west, and the Grenoside Sandstone came in from the east. The westerly-derived Greenmoor Rock sediments have a different character from the other two units — they are less micaceous, and have a greenish look when weathered. They obviously came from a different source terrain, but the location of this is still a puzzle. Thin sections of sandstones show a high proportion of lithic grains of fine mica and chlorite, perhaps pointing to a source land of Lower Palaeozoic greywackes and slates.

At Elland Lower Edge (SE 128 218) the top of the Elland Flags is exposed. The characteristic micaceous nature of these deposits is well seen here. Cross-bedded and ripple-laminated mouthbar sandstones pass up into siltstones of inter-distributary bay facies, overlain by wave-reworked sands showing hummocky cross-stratification. The wave reworking can be related to the extent of the open water that lay to the south of the delta front at that time — this bay stretched at least as far as the Midland Barrier at Charnwood, a distance of 90km. Elland Edge provides an excellent viewpoint, from which can be seen the Elland Flags escarpments running north and south from the Calder Valley, brickpits dug into the Lower Coal Measures mudstones below the scarp, and the Rough Rock dip slope below the mudstones.

At Dalton Bank another excellent viewpoint is located on the escarpment of the Greenmoor Rock. A quarry on the face of the bank (SE 174 187) shows a good example of the lithology — it is ripple-laminated, but is much less micaceous than the Elland Flags and has a greenish tinge. The greenish colour is most obvious in interbedded siltstones and mudstones. On the skyline to the west is a saddle-shaped outlier of Rough Rock. Nearer to hand, to the south-west, Grenoside Sandstone forms tree-covered dip slopes shelving eastwards into the Yorkshire Coalfield, and the same bed caps an outlier of Greenmoor Rock at Castle Hill. At Dalton Bank the Grenoside Sandstone only forms an inconspicuous ridge on the hillside above the Greenmoor Rock dip slope — the different expression in the landscape is due to lateral variation in the sandstone. The prominent dip slopes to the south are developed where the Grenoside Sandstone forms a single thick leaf of medium-grained cross-bedded sandstone, probably a river channel deposit.

At Stocksbridge a new road cutting (SK 299 988) exposes this channel facies in vertical cliffs. The Greenmoor Rock is also well exposed in old rail cuttings at a lower level (SK 297 987), showing its characteristic greenish look.

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