EXCURSION

Stoke-on-Trent: A Brief View of its Economic Geology

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The aim of this excursion was to gain a brief glimpse of Stoke's main geological resources, and to see something of their influence on the history of the city. Most cities based on manufacturing industry have their roots in local resources and this is especially true of Stoke-on-Trent. The city's name is synonymous with ceramics manufacture, though in the past other industries have been of major economic importance, particularly coal mining and iron and steel manufacture. Some of these resources are still in demand, and are being exploited or explored for today. Understanding of the relationship between geological resources and the development of the city is important in planning (Wilson *et al.*, 1992).

Considering the long history of mining and quarrying in the area, there is now relatively little to be seen of the formations of major economic importance. The sections visited are mostly small, though they give some idea of the character of the principal economic formations. On the excursion four localities were visited (though not in the order described below). Of these, locations 1, 2, and 4 are open to public access and are easy to reach.

1. Central Forest Park, Cobridge (SJ 886 487)

The geological structure of Stoke-on-Trent can be very well appreciated from the top of this landscaped colliery tip, which is one of several generated by the Hanley Deep Pit. A car park is situated beside the tip on Chell Street, and the top is reached by a spiralling path.

Most of Stoke-on-Trent lies on sedimentary formations of Westphalian (late Carboniferous) age, which have had a major influence on the history of the city. The Coal Measures conformably overlie the Millstone Grit Group (of Namurian age) which consists largely of sandstones and mudstones of deltaic origin. The Coal Measures of the North Staffordshire Coalfield are composed of similar lithofacies to those of other coalfields within the Pennine Basin and contain more than 60 worked seams of coal or ironstone. The most productive part of the sequence, at the top of the Upper Coal Measures, is the 'Blackband Group', which provided not only coal but clays for the pottery industry as well as abundant 'blackband' ironstones.

The Coal Measures are overlain by the Etruria Formation, which is dominated by mudstones that have been extensively worked for the manufacture of kiln furniture for the ceramics industry, as well as for bricks and tiles. This is overlain by the Newcastle and Keele formations in which clays suitable for pottery industry and coals are thin and laterally impersistent, particularly in the Keele Formation. These formations are of little economic importance.

These Westphalian rocks were folded at the end of the Carboniferous into a number of broadly SSW-NNE trending synclines and anticlines, including the Potteries Syncline, Western Anticline and Clayton Anticline (Fig. 1). Looking to the ENE from the Forest Park tip several NNW-SSE trending ridges can be seen. These represent resistant sandstones, dipping towards WSW, in an otherwise mudstone-dominated sequence. The ridges on the horizon are sandstones of the Millstone Grit, whilst those in the middle and near distance are of the Lower and Middle Coal Measures. Similarly oriented ridges can be recognized towards the WSW, which also parallel the outcrop of the formations on the eastern limb of the Potteries Syncline (Fig. 1). The most notable of these are formed by the sandstones at the base of the Etruria and Newcastle formations respectively. One of the most prominent features of the landscape of the area, seen west of Forest Park tip, is Etruria Vale, the broad belt of low ground underlain by the Etruria Formation.

The geology has had a major socio-economic impact on the area. Perhaps this is most clear when we consider the position of five of the 'six towns'. Longton, Fenton, Hanley, Burslem and Tunstall (Fig. 1) all sit in the same stratigraphical position on high ground underlain by the 'Blackband Group' and sandstones in the basal part of the Etruria Formation. Two of these towns can be easily seen from Forest Park: Hanley with many large buildings, about 1km to the south (SJ 883 477), and Burslem, on a distinct hill, about 2km to the NW (SJ 868 497).

The growth of Stoke, the sixth town, situated on low ground on the upper part of the Etruria Formation (Fig. 1), benefited less from its geological resources. Instead it was the main ecclesiastical centre and had good communications, being sited where the Derby to Newcastle-under-Lyme turnpike road crosses the Trent, and on main railways and canals (Sekers, 1981).

From medieval times, the clays of the "Blackband Group" and Etruria Formation have been worked for the manufacture of tiles, kiln furniture and pottery. By the 17th century towns such as Burslem ('the mother of the Potteries') and Hanley were known as specialist pottery centres. However, in the 18th century, when the area had become known as 'the Potteries', the demand for white china had increased and local clays, which are high in iron oxides, became unpopular for pottery manufacture and clays imported from Devon and Cornwall were increasingly being used for pottery ware.

By this time the firing of kilns was becoming more dependent on local coal resources, rather than wood, though in the late 18th century almost all coal was extracted from roadside pits. Coal mining expanded greatly in the first part of the 19th century and by the 1840s coal was being mined at over 600m below the surface, most coal being used for the potteries and domestic fires (Taylor, 1967).

It was the iron and steel industry that transformed coal mining from the middle part of the 19th century. Since then economic booms, slumps and wars which have affected iron and steel production have also regulated deep coal mining, through to the general

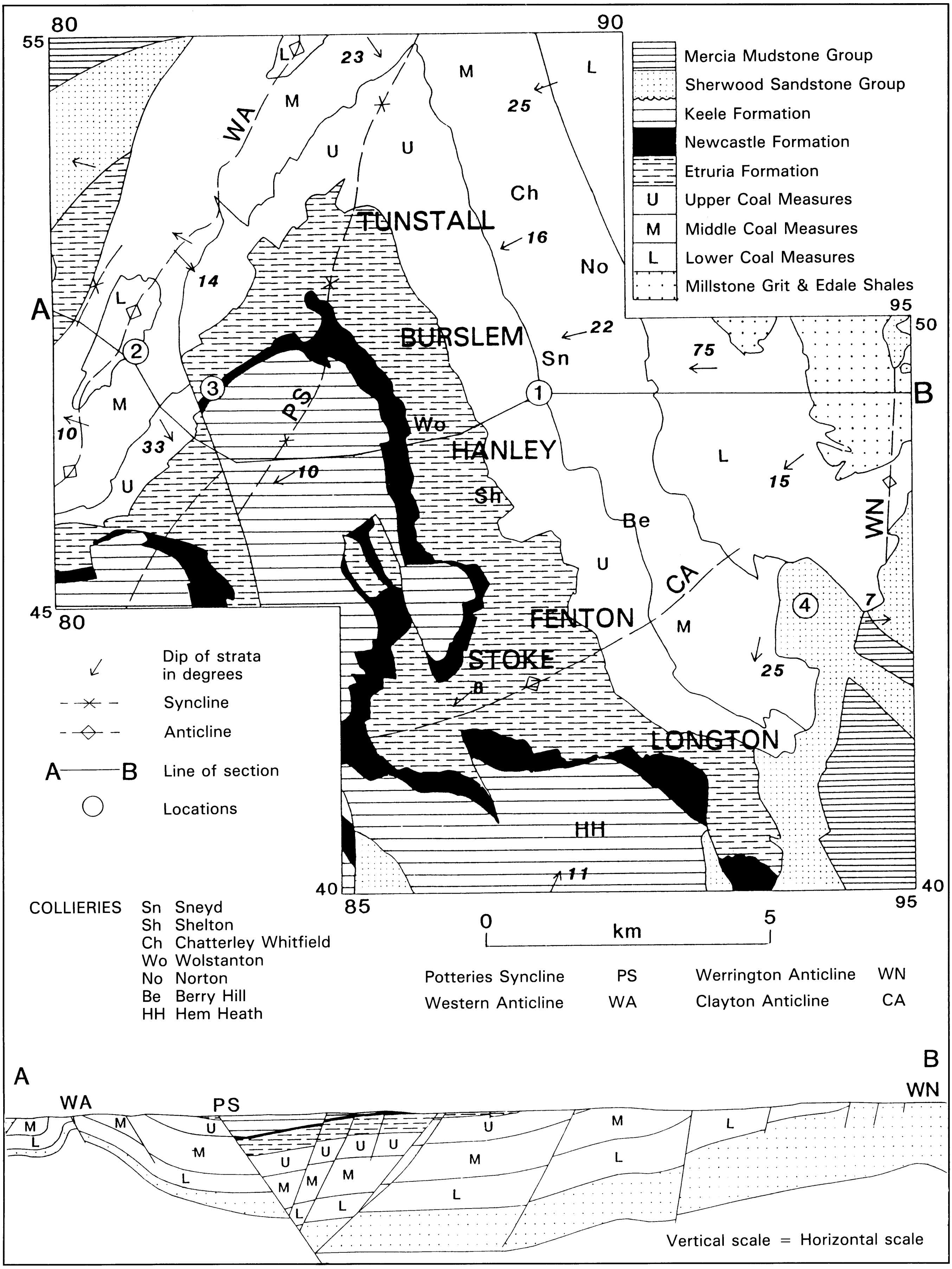

Fig. 1. Generalized geological map of the Stoke area, together with a simplified cross-section. The map shows the positions of the 'six towns', numbered locations and principal collieries mentioned in the text. (Based on Figs. 5 and 6 in Wilson *et al.*, 1992.)

decline of both industries after the last war. Although ironstones were widely mined in the Fenton and Tunstall areas from the 16th century, it was only with the growth of the railways in the 1840s that demand for iron increased. The industry picked up rapidly, and was further stimulated by the invention of the Bessemer furnace and the Siemens-Martin open hearth process in the 1850s. The latter was particularly important to the area because it enabled the blackband ironstones to be used. Later in the century the Gilchrist-Thomas process (for elimination of phosphorus from pig iron) further increased production.

The growth of the coal industry, in conjunction with the pottery, iron and steel industries, led to commercial expansion away from the centres of the five towns. Deep mining allowed working of seams away from their outcrops and collieries became dispersed over most of the Coal Measures and the lower part of the Etruria Formation. This effect can be seen from the Forest Park view-point; several coal tips, generated from collieries which have since closed down, including Chatterley Whitfield (SJ 884 529), Norton (SJ 894 505), Sneyd (SJ 882 496), Shelton (SJ 870 480) and Berry Hill (SJ 896 454), are distributed across a wide area. Although mineral workings were less concentrated on the five towns, the blackband ironstones, seatearth clays (which make good kiln furniture) and coals (particularly the Great Row seam which was popular for firing ceramics) all continued to be worked in the vicinity of the five towns until the last war.

The expansion of mining and industry over most of the Coal Measures and Etruria Formation brought with it subsidence, pollution (particularly from the pottery stacks) and cramped accommodation. Hence from the late 19th century people moved on to higher ground of the Newcastle and Keele Formation outcrops, which lay windward of the industrial areas and were unaffected by subsidence. Ridges formed by sandstones of the Keele Formation may be seen towards the axis of the Potteries Syncline from Forest Park. This movement was initiated by the middle classes, but since the last war has included much of the working population, who have also moved east of the city.

Since the last war coal mining has continued to move away from the urban centres. As older collieries became exhausted, or sterilised resources, modern mining concentrated on deeper, virgin Coal Measures. Wolstanton Colliery was built to mine coal under the Newcastle and Keele formations towards the centre of the Potteries Syncline. The tip of the colliery (SJ 860 480) is the site of a large supermarket and can be seen to the WSW on the far side of Etruria Vale. Other mines on the southern margin of the city, such as those at Silverdale and Trentham, have concentrated on working non-urban areas south of the city. The 'A'-frame winding gear of Hem Heath Colliery (SJ 887 417), the principal colliery of the Trentham complex, can be seen directly to the south of Forest Park. Deep mining beneath Stoke has ceased, though opencast workings have grown in number. Opencasting has been beneficial to some parts of the city, which were effectively sterilised for development by the presence of shallow underground workings, as it has extracted the 'remains' of several previously worked seams. However, it is locally less popular in non-urban areas which have not been previously undermined. One such prospect at Berry Hill (SJ 898 454), seen some 3km SSE of Forest Park, has recently been contested.

Dispersal from the urban areas has also affected the pottery industry. Many potteries, needing more space (particularly for modern tunnel kilns), have moved to the margins of, or outside, the city. For instance, Wedgewood has moved from Etruria Vale to Barlaston, some 5km to the south of Stoke. These moves have resulted from the lost dependence on local resources, but the industry has remained in the area because of local expertise.

The panorama seen from Forest Park tip today is very different from what would have been seen from the same site before the last war. It is very much cleaner, though still bears some scars of old activities. Most mineral workings have been filled in, so to see rocks of the type that underlie the city we now have to travel further afield.

2. Miry Wood, Apedale (SJ 812 494)

This location is accessible via an old railway track extending from the sawmill in Apedale (SJ 820 490). This dale is one of several channels which transported meltwaters from the Irish Sea icesheet on the Cheshire Plain southeastwards across the higher ground of the coalfield. The high ground west of Apedale is located on the Western Anticline (Fig. 1), which is the site of one of the earliest oil boreholes, Apedale No. 2 (1920-1921). This did not hit oil, but proved a thin Namurian succession overlying a thick sequence of lithic tuffs derived from a probable Dinantian volcano.

The large hill which dominates the skyline south of the sawmills is the tip from one of the largest opencast sites in the area, at High Lane. In times past the Aegiranum (Gin Mine) and Clayton marine faunal bands of the Coal Measures have been well exposed along the track, but unfortunately they have since been covered. The main feature of interest along the track is the site of one of the first blast furnaces in the area, on the eastern side of Apedale (SJ 821 491). It was active at about the turn of the 19th century.

The Miry Wood opencast was excavated to remove the Banbury Coal, which underlies the Banbury Rock, one of the major sandstones of the Lower Coal Measures (Fig. 2). This has since been mostly backfilled, though the exposure we see today has been preserved, largely through the efforts of the North Staffordshire group of the Geologists' Association.

The section contains typical Coal Measure lithologies. The sandstones exposed here, including the Banbury Rock, represent channels of rivers which transported sediment southwards into the central part of the Pennine Basin (Guion and Fielding, 1988). The mudstones mostly represent fluvial overbank, or inter-distributory lacustrine, deposits. Some mudstones contain beds or nodules of clayband ironstone (Fig. 2). These are thinner than the extensively worked blackband ironstones of the Upper Coal Measures. They do not

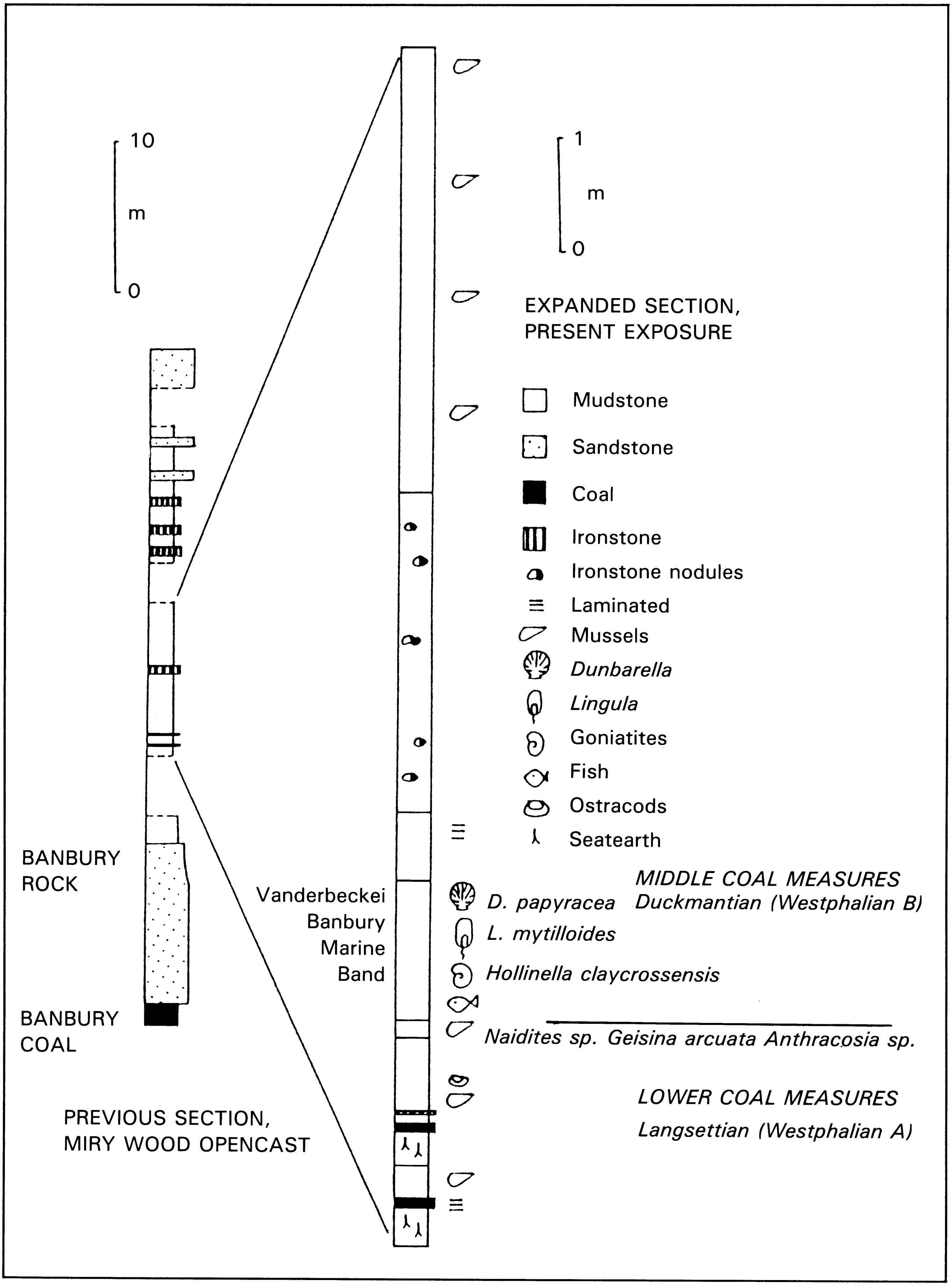

Fig. 2. Log of section exposed at Miry Wood.

have the carbonaceous content or the distinctive banding of the latter, though they are compositionally similar sideritic mudstones (Boardman, 1989). The section only exposes thin coals, though during recent re-mapping of the area, Wilson (1990) noted 0.6m of the underlying Banbury seam exposed along the railway track. Both coals in the section have distinctive seatearths of structureless pale grey mudstone that represent the soils in which the coal-producing forests were established (Fig. 2). Clays such as these were much prized by potteries, particularly in the 'Blackband Group' where they are considerably thicker. The refractory qualities of these clays make them suitable for the production of kiln furniture, such as saggars, which are used to hold pottery during firing (Sekers, 1981).

These rocks were deposited on a delta plain in fresh or brackish water environments as the fauna of bivalves and ostracods in the mudstones indicates. Conditions on the plain did not remain static, and the occurrence of a marine fauna, including goniatites, *Lingula* and *Dunbarella*, in a 1.2m thick mudstone (Fig. 2) indicates where the delta suffered one of several marine inundations. This is the Vanderbeckei Marine Band, which marks the base of the Middle Coal Measures and of the Duckmantian (Westphalian B), and is traceable over most of northwestern Europe.

3. Apedale South Quarry, Apedale (SJ 828 488)

The first section exposes part of the Etruria Formation, which is much prized in the Potteries by numerous companies including Redland Bricks Ltd. who kindly gave us permission to visit the quarry.

The section is dominated by red mudstones, typical of the middle and upper parts of the formation, with subordinate grey, ochre and dark mudstones, sandstones and siltstones marking the bases of fining upwards cycles. In this section the sandstone (Fig. 3a), which broadly fines upwards from an erosional pebbly base, represents a channel, and the siltstones probably represent a crevasse splay. The red mudstones are ferruginous palaeosols (Besly and Fielding, 1989) which represent well-drained soils that owe their colour and lack of plant debris to oxidation. The greenish grey mudstones represent partially waterlogged gley soils. In places these include dark grey, black and purple-grey horizons which contain organic remains. Some mudstones are variegated, such as that above the sandstone, suggesting partial oxidation of waterlogged soils. In this case the development of the soil profile has been influenced by root systems, indicated by the marked vertical zonation.

The mudstones of the Etruria Formation are broadly similar to the seatearths of the Coal Measures. They have been widely utilized for similar purposes, such as the manufacture of kiln furniture, and for brick and tile manufacture. Several quarries are currently working the formation, and companies such as Steetley are actively looking for new resources.

A second section in the quarry displays part of the sequence overlying the Etruria Formation. The excavated section is approached to the south of the copse opposite the lower gate to the site and displays rocks of the lower part of the Newcastle Formation. The junction with the Etruria Formation is very poorly exposed, though it can be traced in the ditch to the north-west of the excavation.

The section (Fig. 3b) is dominated by siltstones, mudstones and thin coals. One of the basal sandstones of the Newcastle Formation occurs at the bottom of the section. Limestones, which commonly occur towards the base of the Newcastle Formation, are not present at this locality, though they have been found in the uppermost part of the Etruria Formation. The rocks of the Newcastle Formation were deposited in very similar conditions to those of the Coal Measures; coals, seatearths, channel sandstones and overbank siltstones and mudstones are well developed. The latter here contain an exceptionally well-preserved flora of pteridosperm fragments including whole fronds, best preserved in the platy beds.

4. Hulme Quarries, Weston Coyney (SJ 936 446)

Although rocks of Westphalian age gave Stoke-on-Trent much of its past prosperity, during the 20th century, and particularly since the last war, Triassic rocks have become commercially important. Particularly in demand are the sandstones and conglomerates of the Sherwood Sandstone Group. These are unconformable on the Carboniferous rocks, and form a broken rim around the southern and western margins of the North Staffordshire Coalfield and Stoke-on-Trent. The rocks are generally friable and easily quarried and are a valuable source of sand and gravel. Such is the current demand for these products that the planning permission for new prospects at Moddershall and Beech, both within 5km of Stoke-on-Trent, have recently been hotly contested by mineral companies.

The Hulme quarries display clearly the lithologies commonly seen in the Sherwood Sandstone. The best section is that in the central north quarry, described in detail by Steel and Thompson (1983). Two sections are seen, east and west of a normal fault exposed at the end of the quarry. The east wall displays a long section, approximately parallel to the current direction during deposition of the sandstones and conglomerates.

Following an initial lithofacies classification (Thompson, 1970; Buist and Thompson, 1982), Steel and Thompson (1983) divided the local Triassic strata into lithofacies related to depositional environment. These can be readily identified in Hulme central north quarry:

(A) Horizontally stratified conglomerates, ranging from simple disorganized clast- or matrix-supported conglomerates to complexly organized rhythmically graded types, in which imbrication is common. These represent longitudinal or diagonal river bars.

(B) Planar or trough cross-stratified conglomerates with bimodal grain-size distributions, often showing rhythmically developed textures and structures on the foresets, which represent the downstream avalanche surfaces of such bars or the migration of transverse gravel bars.

(C) Planar or trough cross-stratified, pebbly, medium- to coarse-grained sandstones, in which intraformational

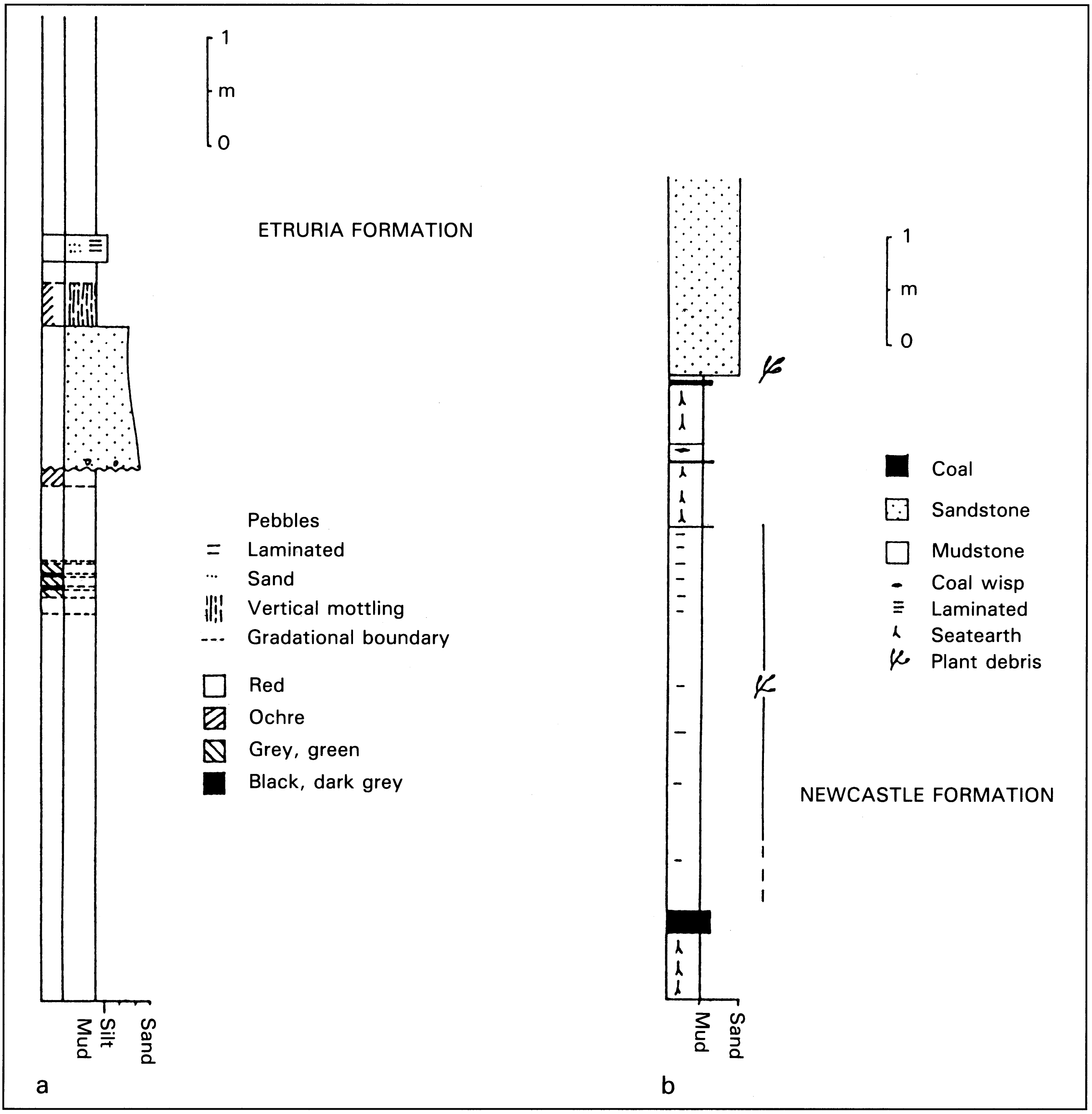

Fig. 3. Logs of sections in (a) the Etruria Formation and (b) the Newcastle Formation in Steetley's quarry, Apedale.

pebbles, cobbles and blocks lie above erosion surfaces, and reactivation surfaces are common. These represent the migration of dunes, sandwaves, megaripples and transverse bars in a sandy river.

(D) Argillaceous, medium and fine-grained cross-bedded sandstones containing soft-sediment deformation structures. Intraformational pebbles are common but only rarely form lenses and stringers. These sandstones represent sandwave deposits and sheet-sands.

(E) Interbedded, horizontally stratified, parallel-bedded, fine-grained argillaceous sandstones, siltstones and mudstones, which represent finer sediments deposited during periods of lower river discharge or in abandoned parts of the river system.

The rocks are dominated by flat-based sheet-like gravelly and pebbly sandstones which do not correlate laterally with fine sandstones and argillaceous rocks. They are derived from the south, being composed of detritus from the Hercynides and its margins, including the Midlands, Cornwall, Devon, the English Channel and Brittany. This sediment was transported via grabens, including the Worcester Graben, in a gross north-northwesterly direction towards a major depocentre in the Cheshire Basin, to the north-west of Stoke. This is borne out very clearly by the palaeocurrents measured in these quarries.

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