the spherule samples, I found some well-preserved fossil ripples in Mercia Mudstone, indicative of the shallow lagoonal conditions, figure 3.

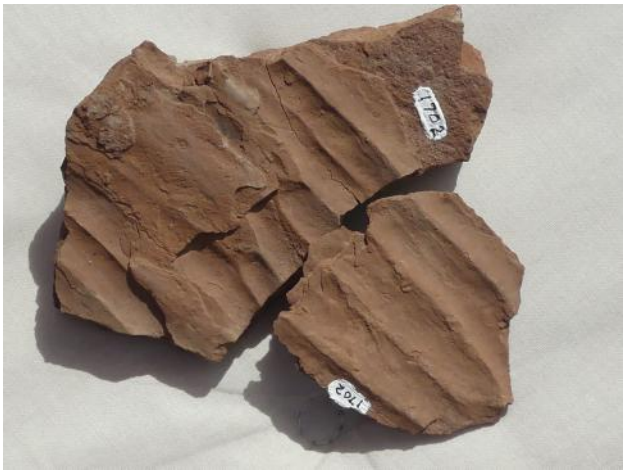

Fig. 3 Ripples in Mercia Mudstone

In 2020 the only evidence of the effect of the impact about 214 mya, 20,000 km from Wickwar, lies in various museum collections and the scientific papers written about it. Nevertheless, it is a sober reminder that these events do happen albeit rarely and that, maybe sometime in the future there will be a similar deposit of little green balls over the village of Wickwar. Now, that would be true news!

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Equatorial Rain-Forests in Bath: Fossil Coal-Measure Plants from Twerton - Radstock

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Introduction

This article discusses the Carboniferous rocks in the area of Bath – particularly the Coal Measures which were exploited in the 18th and 19th centuries in the area between Twerton and Newton St Loe. Evidence for the former coal mining activity is scant in western Bath but fragments of shale with fossil plants, as well as pieces of coal, siderite and sandstone derived from the old tips can be found. There is plenty of evidence of mining farther south / southwest in the Radstock area and coal tips are still present and accessible for collecting fossils.

Carboniferous rocks in the Bath region

One is accustomed to Jurassic sedimentary rocks in the Bath area but it is also possible to see Carboniferous rocks, and not just in the pavements of Bath either, which are of Pennant Sandstone in many places. This very hard, weather-resistant Upper Carboniferous stone was exploited at Willsbridge, just 8 km northwest of Bath, and farther afield (e.g. Hanham, Downend, and Temple Cloud). If interested, you could visit the old Pennant Sandstone quarries and exposures on your way to Longwell Green in the nature reserve of the Siston Brook valley at Willsbridge Mill (Grid Ref ST666 708) or the fine exposures along the old railway line, now a cycle track, just past Bitton towards Bristol. These outcrops are of Downend Sandstone, the lower part of the Pennant Sandstone Formation, a clean quartzitic-lithic-micaceous arenite with largescale cross-bedding and channel structures, deposited by major rivers flowing from south to north, 310-15 Ma ago. However, samples of other Upper Carboniferous coal measure facies, along with plant fossils, can be collected from old coal tips in the region. The nearest site, perhaps surprisingly, is near Twerton and a little farther afield to the south old tips can still be seen in the region of Radstock. The Radstock Museum of Somerset Coalfield Life (radstockmuseum.co.uk) has many spectacular fossil plants on display as well as artefacts from the mining activities and a reconstruction of a coal mine; it is well worth a visit.

Coal mining history and geological context

Coal has been mined in the Somerset coalfield since Roman times, but it was not until the late 1600s that is became a major industry with more than 60 pits working over the next four centuries. Peak production was in the late 19th and early 20th centuries but from then on it steadily declined until Nationalisation in 1947 when there were only 12 pits left. The last two, Kilmersdon and Lower Writhlington, near Radstock, closed in 1973. At the surface there are two small areas of Upper Carboniferous rocks in the Somerset coalfield, in the vicinity of Pensford and around Nettlebridge; otherwise they occur below the Triassic and Jurassic cover. Some

workings were at depths of many 100s of metres, down to 1000 m below the surface. The coalfield has a broad synclinal – basinal structure, with the youngest strata in the middle, but it is quite deformed with large E-W and N-S faults and two major E-W thrust systems: the Farmborough Compression Belt and the Southern Overthrust. These important structural features divide the coal basin into 3 parts, the Pensford and Radstock synclines in the north and centre of the coalfield and the Nettlebridge area to the south. The coals worked in the Pensford and Radstock areas were mainly from the Upper Coal Measures, especially the Farrington Group (Westphalian D), above the Pennant Sandstone. The deformation of the coal measures took place during the Variscan orogeny towards the end of the Carboniferous as a result of the final closure of the Rheic Ocean to the south. Uplift and erosion during the Permian were followed by further desert erosion, arid-zone rivers and lakes (playas) during the Triassic (Bunter Sandstone, Mercia Mudstone and Dolomitic Conglomerate), depositing the 'Red Ground' of William Smith (New Red Sandstone). Marine transgressions during the Rhaetic and Jurassic deposited the sedimentary rocks we are familiar with around Bath: Blue Lias and Charmouth Mudstone, Midford Sands, Inferior Oolite, Fuller's Earth and Great Oolite.

The coal mines in the Pensford sub-basin, including those around High Littleton, Mearns, Camerton and Paulton, were well known to William Smith from his survey of the coal reserves there, which first brought him to this region in 1791. However, remarkably, the stratigraphy of the coal measures in this area was actually described and illustrated in a cross-section by John Strachey in a paper published in 1721 in the Transactions of the Royal Society. Strachey's section was based on his knowledge of the coal seams and associated strata, their thicknesses and directions of dip, in many pits from Bishop Sutton to Farrington to High Littleton. It is clear from his paper that Strachey had grasped the concept of stratal continuity, dip and strike, and identifying particular beds by their contained fossils, as well as the effect of stratal displacement by faults. From 1795-98, William Smith was employed by the Somerset Coal Canal Company as a surveyor and engineer to plan the routes of the canals from Camerton and Radstock to Midford, which were then to continue as one to the Kennet & Avon canal, joining it at Dundas. It was during these years, especially surveying the Triassic and Lower to Middle Jurassic strata along the canal routes, that Smith realised the significance of sedimentary strata, their continuity, along with their specific fossils for correlation such that the new discipline of **stratigraphy** was born.

Coal mining in the Twerton - Newton St Loe area

Back in the 18th and 19th centuries there were several coal mines in this area just a few km from Bath city centre, between Twerton, Corston and Newton St Loe (Fig. 1). There is a small area of Pennant Sandstone at the surface in the Corston area (see the BGS app *iGeology*) which might have alerted early prospectors to the possibility of coal in the vicinity. Indeed, coal had been worked in open quarries to the west of Corston in the early 1700s. The first coal mines were established in the 1730s near the Globe Inn on the A4 (the Globe pits) and at Newton which lasted until 1845. Conveniently, the Globe pit, near the 17th century Globe Inn, provided coal for the coking ovens which were necessary for the brewing of beer (encouraged by the Government of the time to reduce the amount of gin being consumed by the general populace). Also, it was often better for one's health to drink beer than water in those days!

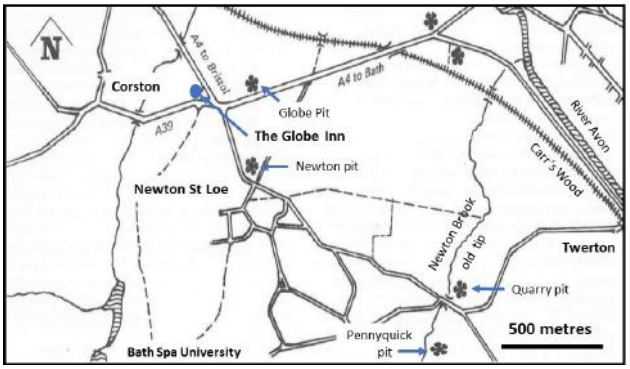

Fig. 1. Map showing the location of the coal mines in the Newton St Loe, Twerton and Corston area (modified from Davies 1977).

There were two pits in Twerton; one known as Quarry pit, started in 1834, was located at the junction of Newton and Whiteway Roads. In 1841 a new mine was opened at Pennyquick, a km to the south which lasted until 1877. Much of the coal extracted from these mines was high grade and it provided coking coals for the local industry in Bath, including brass-making at Saltford and Keynsham and, later, fuel for the cloth industries in Twerton itself, Widcombe and Lyncombe.

The coal mines provided employment for around 100 men and boys judging by the returns on the 1841 census, with most living in Corston and Newton. Although a dangerous and tough environment working in cramped spaces with the danger of rock-falls and explosions, as well as floodings, the coal miners were generally better paid than agricultural workers. In the early 1800s a hewer in the mine working a 6-day week would be earning up to 18 shillings whereas a farm labourer in Somerset would be receiving around 7 shillings.

The coal measures in the Twerton-Newton area are on the very eastern edge of the Bristol & Somerset Coalfield and on the northeast side of the Pensford Syncline and they occur unconformably below the Triassic-Jurassic strata (Fig. 2). The coal beds belong to the Upper Coal Measures, i.e. the Westphalian C (Bolsovian sub-stage), and are within the Downend Member of the Pennant Sandstone Formation. The rocks appear to be quite faulted and locally folded, as recorded in the mine records, and the general dip is towards the NW at quite high angles (Fig. 3). Figure 3 is a delightful sketch cross-section by M. Harvey, Manager, of the mine workings at Newton St Loe dating from 1844, showing the surface buildings, the dipping coal seams named and the pattern of tunnels, along with notes on the particular use of the coal from each seam. Many of the shale fragments that can be collected from the vicinity of the Twerton pits are shiny and sheared, the result of the strong deformation of the strata. The coal seams in these pits are relatively thin, mostly 40-70 cm, but they are at quite shallow depths. In the Pennyquick mine 13 coal seams were encountered, but

many of these were less than 40 cm so that only 3 were worked at depths of 110, 120 and 210 m, with thicknesses of 0.7, 0.6 and 1.5 m, the last being known as the Great Seam (!).

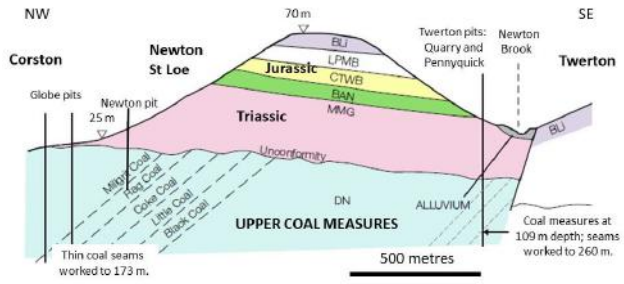

Fig. 2. Cross-section from Twerton to Corston showing the geology and the location of the coal mines. BLi = Blue Lias, LPMB+CTWB+BAN = Rhaetic, MMG = Mercia Mudstone, DN = Downend Formation (modified from B&NES 2010).

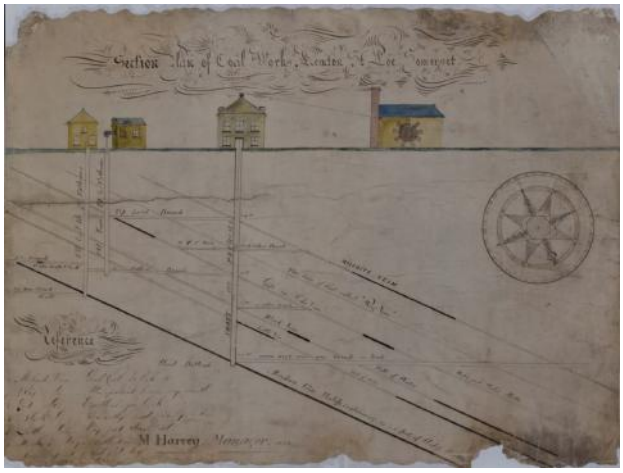

Fig. 3. Cross-section of the coal workings at Newton St Loe showing the steep dip of the beds and access tunnels. From the Bath Record Office.

Between 1808 and 1813, on the other side of Bath a trial shaft was dug at Batheaston (ST782 675) in the hope of reaching coal, with the now-famous Father of English Geology, William Smith, involved as a consultant. However, this venture was not successful; the coal measures are absent, having been eroded away during Permian uplift, and beneath the Triassic 'Red Ground' occurs the Lower Carboniferous Cromhall Sandstone and then limestone. In addition, the shaft flooded several times during the digging and this affected the flow of water at the Roman Baths to everyone's consternation (Kellaway, 1991).

Evidence of coal mining at Twerton

The coal mines around Twerton, as elsewhere, naturally produced a lot of waste material but unfortunately (for fossil hunters that is!), and as is the case in many places in the UK, these tips have been removed or flattened and grassed over. In fact, in the 18-19th centuries it was a requirement that land disturbed by coal mining be returned to its original state when the mining activity ceased. Hence, in the Twerton-Corston-Newton area there is little evidence of the pits and opencast sites. With material from the pits near the A4 and the Globe Inn it is thought that some of this was used to construct the embankment of the GWR railway line across the Avon floodplain towards Saltford, built by Brunel in the late 1830s. The waste rock from the Quarry pit at Twerton was landscaped to form Pennyquick Park, adjacent to Newton Road, towards Whiteway Road.

Fig. 4. Coal measures mudstone with abundant plant fragments, including a leaf (pinnule) of a pteridosperm (seed ferns). Twerton.

In spite of most evidence from the coal mining industry being lost in this western area of Bath it is possible to find pieces of coal measures rock hereabouts. One location is along the footpath in a wooded area that runs south from the A4 to Whiteway Road, following the line of the Newton Brook on the eastern side; look along the footpath itself and in the adjacent bank, above Newton Brook, opposite Bath Mill. This path can be accessed through Carr's Wood, which runs alongside the main GWR railway line (itself parallel to the A4) with two fine neo-gothic Bath-stone tunnel entrance arches built by Brunel in the late 1830s. Here can be found pieces of coal, black mudrock with coaly streaks (referred to as 'scares' by miners) and carbonaceous shale, which may contain plant fragments (Fig. 4) or show shiny polished surfaces. Round to egg-shaped nodules of siderite are present (Fig. 5); these consist of very fine crystals of iron carbonate ($FeCO_3$), they weather orangey brown on the outside but have a steely grey colour when fresh.

Fig. 5. Siderite nodule, distinguished by a brown colour and feeling heavy in the hand, formed within muddy anoxic sediment during very shallow burial. Twerton.

There are also pieces of sideritic mudstone with rootlets and some nodules contain fossil insects. Siderite is a common mineral in coal measures strata and forms in an anoxic freshwater environment, such as marshes and waterlogged soils. There are fragments of sandstone, fine-grained, thin-bedded samples with cross laminae and generally larger pieces of more massive coarser sandstone derived from a thicker bed. Sandstone was likely deposited in streams, on floodplains, in deltaic channels and in shallow bays.

Coal measures fossil plants

Of the common fossil plants there are many fragments of seed ferns (pteridosperms) to be found on old coal tips, including conspicuous delicate leaves (pinnules) of *Neuropteris* (Fig. 6) and *Alethopteris* (Fig. 7).

Fig. 6. Leaf of a seed fern, probably Neuropteris. Twerton.

Fig. 7. A large piece of the seed-fern Alethopteris (pteridosperm). Radstock Museum.

These actually look like modern ferns but in fact they are not (they produce spores rather than seeds) and they became extinct in the Jurassic. One of the most common fossil plants seen in mudrocks is *Calamites* (Fig. 8), a pteridophyte, i.e. a spore-bearing vascular plant, rising to 25 m in height. *Calamites* is the term for the stem, which has transverse markings of leaf nodes and longitudinal furrows and ridges. Its leaves, *Annularia*, are small, lance-shaped and arranged into rosette-like whorls (Fig. 9). This is a relative of the present-day horsetail, *Equisetum*, which can be found in many damp places near streams and in woods, indeed commonly where the coal tips are! Another common pteridophyte is the tree-like *Lepidodendron*, which grew to a height of 40 metres in the swamps and had a horizontal, forked root-system, referred to as *Stigmaria,* off which extended numerous thin rootlets (Fig. 10). The stem is recognised by its rhomboid-shaped leaf-scars (Fig. 11) contrasting with another common pteridophyte *Sigillaria*, with its squarish leaf scars.

Fig. 8. A stem fragment of Calamites (pteridophyte), a relative of the modern horsetail. Kilmersdon tip.

Fig. 9. Leaves of the horsetail, Annularia, with a distinctive radiating pattern. Radstock Museum.

Fig. 10. The root system (Stigmaria) with thin rootlets of a lepidodendron tree. Radstock Museum.

Fig. 11. Piece of a lepidodendron tree with leaf scars. Radstock Museum.

Fossil plant sites in the Somerset coalfield near Radstock

There were numerous old coal tips (locally called batches) in the Somerset coalfield but many have been removed or reclaimed and some are now covered with trees and bushes; nevertheless, there are still a few places left to seek out fossil plants. The old tip for the Kilmersdon pit is just west of Haydon (Grid ref ST682 536) and the tip for the Lower Writhlington pit (ST703 553), 1.5 km ENE of Radstock, are both still accessible. There is also the spectacular batch at Midsomer Norton (ST654 553) which from a distance looks just like a volcano (Fig. 12).

Fig. 12. The impressive batch, old coal tip, at Midsomer Norton.

The Writhlington and Kilmersdon tips mostly consist of debris coming from the roof shales above the No. 10 coal seam (also called the Big, Brights or 21-inch seam) in the Farrington Group of the Upper Coal Measures, which was exploited by the pits in the last 20 years of their operation. Numerous fossil plants have been recorded from these tips and a list is given in Allen (1977). However, perhaps the most exciting fossils to look out for here are the insects, much sought after by Victorian collectors. Dragonflies are particularly special with one found with a total wing-span of around 50 cm; it was discovered on a slab of shale from the Tyning tip and named as *Boltonensis radstocki*, after the palaeontologist who first described it and its location. In addition, cockroaches, grasshoppers and spiders have been found in the shale of these tips near Radstock, showing that the coal measures environment was not very different from tropical swamps today. It can be difficult to distinguish insect wings from fern pinnules, however, a case of clever camouflage!

For the Kilmersdon tip, take a footpath west from Haydon opposite the post-office or there is a public footpath out of Radstock south along the Wellow Brook (1.5 km) which crosses the SW side of the tip and there are good exposure for searching out fossils. Much of the material there is black shale and coaly shale, which commonly have compressed plant fossils. In addition, siderite nodules are present, and these may contain fossils too. Pieces of *Calamites* are common, as well as a variety of seed ferns.

The Lower Writhlington tip is accessible from the south side of the old Radstock to Wellow to Midford railway line which is now a cycle path. Coming from Upper Writhlington, off the A362, take the minor road north to Lower Writhlington, pass St Mary's Church and cross the bridge over the Wellow Brook to get to the old railway line. The tip is a conspicuous discrete steep hill with many pieces of coal measures rock lying around near the base. Coal was recovered from this tip in the mid-1980s. Also look out for the WWII pill-boxes. From the summit of this tip there is a good view to the NW and the Tyning tip, on the north side of the old railway track, where there are also exposures and plant fossils.

The Midsomer Norton Batch is very accessible, but much of the shale has disintegrated into very small pieces. Large slabs of thin sandstone and sideritic mudstone can be picked up with plant fossils. Climbing to the top though is an effort and risky!

Concluding remarks

It is always interesting to find fossils and think about how things were millions of years ago, but it is almost even more exciting to find fossils lying about which are from rocks not exposed at the surface but coming from 100s of metres below ground. The pieces of Upper Carboniferous mudstone with fossil plants shown in the Twerton area and tips near Radstock are the evidence of hot and steamy equatorial forests and swamps that existed 300 million years ago with a quite different flora from that of today, and also testament to the hard work of a long-gone generation of coal miners, who worked in terrible, unpleasant, confined and dangerous conditions.

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Acknowledgements

I am grateful to Radstock Museum for permission to photograph their fossil plants. Figure 3 was purchased from the Bath Record Office.

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Bath Geological Society 50th Anniversary 1970-2020

By Graham Hickman

2020 is an important year for the Bath Geological Society as it represents our 50th anniversary since the inaugural meeting on 25th September 1970 at Bath University. The Society is indebted to the officers and committee members who have enabled the programme of monthly lectures and fieldtrips over the years. When circumstances allow the Society plans to hold a special event to celebrate.

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Vicki Griffths	2006-2007
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John Parkins	1998-2001
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Joy Coppin	1987
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Edna Parmenter	1980-1981
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The Purpose of the Journal is to record the activities of the Bath Geological Society. It may include, but is not limited to the following; Chairman's report for the year, record of the meetings held, list of members including committee, officers of the Society and obituaries. Illustrated articles of geological interest written by members.

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