Exceptional preservation of Upper Carboniferous (lower Westphalian) fossils from Edlington, Doncaster, South Yorkshire, UK

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A new fossil-bearing, Upper Carboniferous (lower Westphalian) locality in Doncaster, South Yorkshire, UK, is reported and an account of the fossils is presented. The diverse flora and fauna consists of plants, bivalves, arthropods (primarily xiphosurans), tentaculitids (microconchids), fish scales, shark egg capsules and coprolites. Fossils are preserved in siderite nodules and shales, and display excellent preservation and detail. Previous collecting of Carboniferous fossils in the Doncaster area has been minimal. The discovery of this locality addresses this deficit and is of further importance as such localities in the UK are diminishing in number with the cessation of coal-mining and the reclamation of mine dumps, further demonstrating the importance and recognition of the Edlington site. Copyright © 2014 John Wiley & Sons, Ltd.

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1. INTRODUCTION

Fossil-rich localities that yield exceptional and complete fossil remains, often preserving fine details (including soft parts), which would not normally be found as fossils are termed Lagerstätten. Fossil Lagerstätten locations have been discovered across the world, and range from the Precambrian through to the Quaternary. Famous Carboniferous examples include Mazon Creek in Illinois, USA, Joggins Fossil Cliffs in Nova Scotia, Canada and Montceau-les-Mines in eastern France (Selden and Nudds, 2012). Some of the classic, and perhaps most famous, Upper Carboniferous Coal Measures Lagerstätten in England include Sparth Bottoms (Rochdale, Lancashire), Coseley (near Dudley, Staffordshire), Coalbrookdale (Shropshire) and Writhlington (Radstock, Somerset). Such locations have formed much of our understanding of the fauna and flora of the Upper Carboniferous Coal Measures in England (Anderson et al., 1997; Cleal and Thomas, 1994; Muir et al., 2012). Interestingly, by comparison, despite Yorkshire being famed for its coal mining industry, such reports of similar sites have been fairly poor. Although general studies of the flora and fauna of the Yorkshire Coal Measures have been recorded and documented (e.g. Kidston, 1897, 1900; Culpin, 1908a; Godwin and Calver, 1975; Scott and Chaloner, 1983; Scott, 1984), they are not as rigorous or extensive as those in Lancashire or Staffordshire. Recently, the remains of a new genus of shark were described from Todmorden, West Yorkshire, collected from an old colliery spoil dump (Martill et al., 2014). Previous reports of the flora and fauna from the Doncaster area were briefly discussed by Culpin (1908b, 1909).

As coal mining in the South Yorkshire region is now largely non-existent, with many old spoil tips grassed over, obtaining specimens is very difficult. Additionally, some of the classic British Coal Measures sites are no longer accessible or material cannot be easily collected (Anderson et al., 1997).

In this paper we report on Lagerstätte-type preservation of fossils collected at Edlington spoil tip site of the Yorkshire Main Colliery, Doncaster.

2. HISTORY AND GEOLOGICAL SETTING OF THE LOCATION

The history of scientific collecting in Doncaster really began in earnest in the 1880s with the founding of the Doncaster
The geological section of the society was undertaking active research within the borough, collecting from local quarries and coal mines (Lomax, in press). An unquantifiable number of specimens collected in the area made their way into the Doncaster museum collections which became established in 1910. A more complete account of the history of the palaeontology collection at Doncaster Museum has been submitted elsewhere.

The Yorkshire Main Colliery was one of five collieries in the vicinity of Doncaster and the South Yorkshire Coalfield. The Colliery was originally named Edlington Main, but was changed to Yorkshire Main in 1913, following the formation of the Yorkshire Main Colliery Co. The suffix ‘Main’, in South Yorkshire, denoted that the colliery worked the ‘main’ Barnsley Bed Seam, which is the principal coal seam in the South Yorkshire Coalfield. The first of two shafts was sunk in 1909. Production finally ceased in 1985.

The succession in Yorkshire Main Colliery comprises 68 m of Permian rocks, mainly dolostone and calcareous mudstone, overlying 765 m of Pennine Coal Measures Group down to the Barnsley Seam (Edwards, 1951; Engering and Barron, 2007). The local coal-bearing sediments were deposited in the Pennine Basin that covered northern England and subsided gradually throughout the Westphalian, resulting in over 2000 m of sediment in the centre of the basin around Manchester and thinning towards the basin margins. They consist of mudstone, siltstone and sandstone, with subordinated thin, laterally extensive and economically important layers of coal (Aitkenhead et al., 2002). These represent a range of facies including open marine, lacustrine, lacustrine delta, channel, overbank and crevasse splay, palaeosol and mire, the latter resulting in thick layers of peat that were compressed to form coal (Guion et al., 1995).

Specifically, the three coal seams that were extracted at the Yorkshire Main Colliery (the Barnsley Main, Dunsil and Swallow Wood) are all in the lower part of the Duckmantian (Westphalian B) Substage (Waters et al., 2011). Therefore we can expect that most of the material in the spoil tips will relate to this specific substage. The possible exception is the last and lowest development at the mine, extending workings down to the Parkgate Seam in the upper Langsettian (Westphalian A) where engineering work may have resulted in material from this lower level being found in the spoil at the surface. Of particular note is the possibility that some fossil material found in the spoil (see below) comes from the Vanderbeckei Marine Band (Duckmantian) (Edwards and Stubblefield, 1948; Calver, 1968).

The fossil remains are found in siderite nodules and shales. Unfortunately, as the remains derive from a spoil tip, they are unstratified and out of context. Although unstratified, the siderite concretions are routinely found in roof shales above coal seams at other Carboniferous Lagerstätten. There are no surface exposures in the vicinity of the area and the fossil-bearing strata cannot be examined in situ and thus we cannot state exactly which coal seam (or seams) the material derives from. Nevertheless, the age of the fauna is considered to be early Westphalian (late Langsettian or early Duckmantian) and the preserved flora probably comes from the Lonchopteris rugosa Zone.

3. MATERIALS AND METHODS

The fossils described here represent a new collection based on fossil collecting between 2012 and 2014, all of which were subsequently donated to Doncaster Museum and Art Gallery (DONMG). However, it should be noted that a few specimens collected and donated pre-2012, whilst the mine was working, are recorded in the museum’s collection. Specimens from Edlington Tip were collected by authors D. R. L. and P. R., along with Brian Williams, a local collector, who has so far discovered the highest percentage of the fossils found.

The nodules and shales were discovered across the entire spoil tip, although at least two specific locations at the site are highly productive for the recovery of specimens in shale. It should be noted that several additional specimens have been collected (and temporarily retained) but, due to their rather fragmentary nature and lack of readily identifiable features, cannot be referred to a specific group and are not discussed further.

At present the abundance of plant to animal ratio is similar to that suggested by Anderson et al. (1997) who noted an estimated strike rate of 100 nodules containing plant material for each one containing animal remains, though Edlington has a slightly lower strike rate with regards to animal remains.

Measurements of specimens were taken with digital callipers for features smaller than 15 cm, and recorded to the nearest 0.1 mm (Fig. 1).

4. FLORA AND FAUNA

4.1. Plants

Remains of plants found within the nodules and shales are extremely abundant (Fig. 2). A certain number of species have been identified, displaying several variants. The plants include: Alethopteris decurrens (Artis) Zeiller, Alethopteris urophylla (Brongniart) Presl, Neuropteris obliqua (Brongniart) Zeiller, Laveineopteris loshii (Brongniart) Cleal et al., Cyclopteris sp., Paripeteris pseudogigantea (Potonié) Gothan, ?Linopteris sp., Mariopteris muricata (Brongniart) Zeiller, Eusphenopteris sauveurii (Crépin) Simson-Scharold, Palmatopteris sp., Pecopteris plumosa (Artis) Brongniart,
Sphenophyllum majus (Bronn) Bronn, Annularia radiata Brongniart, Annularia gallioides (Lindley and Hutton) Kidston, Asterophyllites equisetiformis Brongniart, Asterophyllites charaeformis (Sternberg) Unger, Calamites sp., Cordaites sp., Pinnularia sp., Lepidodendron cf. ophiurus Brongniart, Ulodendron landsburgii (Kidston) Thomas, Sigillaria sp., Lepidostrobus sp., Lepidostrobophyllum sp., Cyperites bicarinatus Lindley and Hutton, Asolanus camptotaea Wood, as well as seeds (including Cordaicarpus) and cf. Whittlesey (pollen organ), and other fragments including cf. Potoniea and numerous indeterminate cone, lycopsid and general leafy twig/shoot fragments. Of these remains, A. decurrens, N. obliqua and L. loshii are the most abundant at the site. Interestingly, there are a few rarities, including the lycopsid A. camptotaea and the abundance of at least three or four types of sphenophyte foliage (Asterophyllites and Annularia). The majority of the collected plants are preserved as black, carbonaceous compressions within a light grey to dark grey shale matrix. A few of the specimens are partially pyritised. A substantial amount of the collected material, more specifically the cones and lycopsid shoots, are heavily mineralised, and are sometimes preserved three-dimensionally.

In the biostratigraphical scheme of Wagner (1984) and Cleal and Thomas (1994), the species in this flora range through the upper Lyginopteris hoeninghausii and Paripetris linguaeolia zones. However, as there are no species restricted to the L. hoeninghausii Zone (e.g. Neuralethopteris spp., Lyginopteris spp., Karinopteris acuta (Brongniart) Boersma) we are inclined to refer it to the Lonchopteris rugosa Zone. This would tend to indicate an early Duckmantian (Westphalian B) age, but a late Langsettian (Westphalian A) age cannot be ruled out.

4.2. Bivalves

The remains of non-marine bivalves appear to be rather uncommon with only a few examples so far recorded. They have been found within both shales and nodules. In the shales, several blocks of poorly preserved and crushed bivalves have been found, they are probably referable to Carbonicola and Anthraconaia. One such large block (DONMG: 2014.1.31), consisting of four pieces, comprises an assemblage of many complete and fragmented bivalves, identified as Anthraconaia sp. Only very few examples have been found within the nodules themselves, one of which (DONMG: 2014.1.22) includes both valves and displays the part and counterpart, tentatively identified as ?Acharax radiata (Meek and Worthen) Bailey (Fig. 3). Two other isolated specimens, found within nodules, are identified as Myalinella sp. Some of the other remains are poorly preserved and remain indeterminate.

4.3. Arthropods

4.3.1. Xiphosurans

So far, only one xiphosuran taxon (Chelicerata: Xiphosura) has been recorded, Euproops rotundatus (Prestwich). One
complete individual has been collected and allows for positive referral to this taxon (Fig. 4). However, a handful of specimens, that represent isolated fragments to near-complete individuals, have been collected and probably also belong to this taxon. All of the xiphosuran material has been discovered inside nodules, rather than shales.

DONMG: 2014.1.1 represents the first (and only) complete xiphosuran collected. The specimen is exceptionally well-preserved, comprising a complete prosoma with both genital spines. The surface of the prosoma is punctate and well detailed, with both the ophthalmic ridge and ophthalmic spines present. The opisthosoma is nearly complete, but damaged and somewhat poorly preserved. The dorsolateral portion of the left side is damaged, with some of the opisthosomal spines missing. In general, the opisthosomal spines are well preserved and diamond-shaped. The telson is thin, elongate and appears to be complete, perhaps missing the very distal end. The total length of the specimen,
measured from the tip of the prosoma to the end of the telson, is 5.48 cm; the width of the prosoma (measured from both genal spines) is 5.69 cm, and the width of the opisthosoma (abdomen) is 3.91 cm.

4.3.2. Insects
It has been suggested that the remains of insect wings are often the most abundant fossil arthropod remains at many Coal Measures sites (Anderson et al., 1997). However, so far, the remains of insects are poorly represented at the spoil tip, if present at all. Only a few fragmentary specimens, perhaps representing isolated segments, have been tentatively recorded. Identifying insect wing cases can be difficult, as they are very similar to detached plant leaves (pinnules) (Jarzembowski, 1989).

4.3.3. Arachnids
A single fragment of an arachnid, perhaps a scorpion (based upon the morphology of what may be a portion of the abdomen), has been tentatively identified (Personal Communication, Botting J, 2013). It is impossible to assign this fragment to a particular species.

4.4. Tentaculitids
Only microconchids have been identified. Two specimens have been discovered within the Edlington material (DONMG: 2014.1.167). Both are preserved on the leaf pinnule of a specimen identified as Neuropteris obliqua. The specimens are morphologically similar and represent small individuals. Their identification remains indeterminate. For a long time, many microconchids were considered to represent the polychaete annelid Spirorbis (Taylor and Vinn, 2006). Their classification within the phylum Annelida is readily debated (Taylor and Vinn, 2006; Załocki et al., 2012).

4.5. Vertebrates
Vertebrates are represented by a few specimens. DONMG: 2014.1.9 represents an isolated, large circular scale found inside a nodule. The scale is somewhat oblong-shaped at the anterior, but the posterior is rounded. A well-defined circular structure is present throughout the scale, though the centre is completely smooth. A preliminary identification of the scale suggests it may be attributed to Ctenodus.
sp. DONMG: 2014.1.9 measures 2.28 cm in length and 1.3 cm at its widest point. Other possible vertebrate remains have been found but consist of very small, poorly preserved bone fragments.

4.6. Shark egg capsule

A single egg case has been recorded, identified as *Palaeoxyris* sp. The specimen was discovered within a shale block, as a part and counterpart (Fig. 5). A few plant fragments, including a single pinnule of *Neuropteris*, are preserved within the same block. DONMG: 2014.1.8 is unfortunately rather fragmentary; a thin film overlies the egg capsule itself. A coating of Paraloid B72 consolidant was applied to the egg case, which has, in turn, preserved the original film. The films’ colouration is a pale to slightly dark orange-yellow. Sections of the anterior and posteriormost portions of the egg case are missing, although both are preserved on the negative. There are a total of six segments preserved in the body. The morphology of the body is similar to many *Palaeoxyris* specimens, including the Triassic form *Palaeoxyris friessi* (Böttcher, 2010), but not nearly as long, measuring 3.71 cm (of what is visible) in length. The negative is slightly longer at 3.82 cm, though part of this is missing. The specimen measures 0.97 cm at its widest point. A fragment of the beak is preserved, but the majority is missing. As opposed to the rest of the capsule, the beak displays a strong, brownish-orange colouration. It is possible that the majority, if not the entire, pedicle is preserved, but is rather short. There is the prospect that the posterior of the pedicle could be present, but overlain by matrix.

4.7. Coprolites

A large variety of coprolite types have been reported from the Carboniferous (e.g. Scott, 1977; Taylor and Scott, 1983; Sumner, 1993). Within the studied material, a fairly diverse amount has been found, all within nodules (Fig. 6).
There are several forms present: spiral-like, elongate blobs, smaller non-spiral blobs and larger spherical blobs. Most of these coprolites were likely produced by fish, although the latter may have been produced by tetrapods, perhaps amphibians. If identifiable, the coprolites comprise arthropod fragments, bone fragments and possibly plant debris. Interestingly, one particular specimen (DONMG: 2014.1.21) includes the remains of a partial xiphosuran prosoma, possibly belonging to *Euproops*, preserved within. This occurrence is fairly important, as the first remains of a xiphosuran found within a coprolite was mentioned by Anderson et al. (1997), which suggest this occurrence may be unusual, or rare. As discussed in Anderson et al. (1997), the occurrence of a horseshoe crab preserved within a coprolite allowed for the confirmation in which Coal Measures xiphosurans were preyed upon by large predatory fish.

5. REVIEW AND COMPARISON

The preservation of fossils from the Edlington Tip is similar to remains collected from many of the British Coal Measures Lagerstätten, along with the famous Mazon Creek locality in Illinois, USA (Wittry, 2006, 2012). Although the collection
of material so far suggests the biota at Edlington is not nearly as abundant, or diverse, and soft-part preservation is minimal (aside from the egg capsule), nevertheless, it is hoped, as a result of sustained collection over many years that the site may yield an extensive number of specimens (as in Mazon Creek). There have been very few British localities which have been subjected to the same level of scrutiny (Anderson et al., 1997). This may depend largely on the longevity of, and access to, individual collecting sites, or sites which are accessible for only short periods of time. Such recovered locations allow for the potential discovery of specimens that are no longer readily collected elsewhere, or poorly represented in museum collections. This allows for the collection of new, comparative material to be recorded and documented, along with new investigation techniques applied.

Two comparable studies were undertaken by Anderson et al. (1997, 1999) who described exceptionally preserved fossils from coal mine tips at Bickershaw and Westhaughton in the West Lancashire Coalfield (Mid to Late Westphalian A). The representative flora and fauna at both the Bickershaw locality (Anderson et al., 1997) and the Whirlington Nature Reserve (Jarzemowski, 1989, 2004) is similar to that collected at Edlington Tip. However, a higher number of specimens and a broader range in diversity of both aquatic and terrestrial fauna, are better recorded at Bickershaw and Whirlington, than Edlington. This reflects a rather low amount of collecting time from this location, especially when compared to the Bickershaw locality; which represents approximately 2 years of sustained collection (Anderson et al., 1997).

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Figure 6. A selection of coprolites (all part and counterpart nodule specimens) collected from Edlington Tip. A. Spherical blob with fragments of bone and other material within (DONMG: 2014.1.191). B. Large, elongate coprolite with ‘shell-like’ material within (DONMG: 2014.1.17). C. Elongate coprolite, likely produced by a fish (DONMG: 2014.1.13). D. Rounded, spherical blob coprolite, possibly produced by an amphibian (DONMG: 2014.1.11). Scale bar = 5 cm.
understanding would be far less. Additionally, we thank members of the Doncaster Naturalist’s Society for accompanying DRL and PR on a collecting trip to the site. Thank you to Reece Davies for creating the image used in Figure 1. Finally, this project was partially funded by the Esmée Fairbairn Foundation (CIRCA project), as part of a grant awarded to the Museums and Heritage Strand to Doncaster Museum Service, and this valuable financial assistance is gratefully acknowledged. This included the preparation costs of the horseshoe crab, which was skillfully prepared by Chris Moore of Charmouth.

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