## Foreword

This publication supersedes the Nature Conservancy Council's Geological Trail Guide (1970) and Geological Handbook (1978) on Wren's Nest. Aimed principally at 'A' level and undergraduate students, it provides a fully illustrated comprehensive account of the West Midlands' most important and popular geological site. The trail route described here differs from that of the earlier guide, but the sites have been carefully chosen to illustrate the Reserve's most significant geological features. A Glossary is included for those unfamiliar with some of the terms used.

# WREN'S NEST NATIONAL NATURE RESERVE

## Geological Handbook and Field Guide

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## Introduction

Wren's Nest Hill was declared a National Nature Reserve in 1956 (the first in the U.K. for geology), with the Mons Hill extension being added in 1957.

The establishment of the Reserve was in recognition of the exceptional, international importance of the site as a source of Silurian (Wenlock) age fossils. Wren's Nest has yielded a great variety of both macro and micro fossils of superb preservation, the cream of which is to be found in museums throughout the world, and illustrated in many publications.

Wren's Nest is the middle of three related limestone hills (Castle Hill to the south-east and Hurst Hill to the north). They all form conspicuous steep sided features, and Castle Hill and Wren's Nest, being substantially wooded, rise "like green islands out of the dark sea" of the coal-bearing rocks of the South Staffordshire Coalfield which surround and separate them.

The folded layers of the Much Wenlock Limestone Formation (formerly the Dudley Limestone) which form the hills, have been quarried or mined for hundreds of years. Until the seventeenth century the limestone was used principally in agriculture and later in the early iron industry of South Staffordshire. At the end of the eighteenth century and throughout the nineteenth century output of limestone soared to serve the expansion of the local Black Country iron industry. Limestone extraction, however, declined before the First World War, and mining at Wren's Nest finally stopped in 1924. The nineteenth century was the most prolific period for the supply of fossils, for which there was a ready market, providing welcome, if not illicit, extra income for the miners. The size of the trade may be judged by the existence of three fossil shops in Dudley at one time.

Wren's Nest is still an abundant source of fossils, although it is unusual to find complete, perfect specimens such as those seen in Dudley Museum, most of which were collected many years ago. The Reserve, which attracts thousands of visitors a year, is universally recognised as an outdoor teaching laboratory, suitable for all ages and levels of study, which could be seriously damaged by unrestricted use. Hammers are prohibited and collecting, which is regulated, is allowed only from the abundant scree. A code of conduct for visiting parties is included on page 25 of this guide.

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## Geology of the Dudley area

The Silurian Period, which lasted from about 435- 410 million years ago, records a time when the Midlands, and indeed most of England, was covered by a relatively warm and shallow shelf sea, with the edge of the continental shelf lying to the west near present day Church Stretton in Shropshire. Rivers flowing from a continental landmass far away to the east brought mud, silt and sand, which slowly accumulated in the sea as a series of shales, mudstones, siltstones and sandstones. Sometimes the supply of this material almost ceased, enabling lime-rich deposits to form and locally, coral reefs to develop. These deposits make up the limestones seen at Wren's Nest. In total, a maximum thickness of about 550m of rocks accumulated in the Dudley area during Silurian times.

The rocks of the Silurian Period are classified into four sub-divisions; the Llandovery Series (at the base), the Wenlock Series, the Ludlow Series and the Prídolí (formerly Downtonian) Series at the top. With the exception of the latter, each of these major sub-divisions is further sub-divided and classified into smaller units. At Wren's Nest, the upper stage of the Wenlock Series (Homerian) and the lowest stage of the Ludlow Series (Gorstian) are represented.

Towards the end of the Silurian Period the area of present day Wales was subjected to a lengthy period of uplift. This caused more shallowing of the Ludlow sea and an increase in the sand content of the sediments through erosion of the uplifted areas. The process eventually led to profound changes in geography, with the transition from a marine environment to a continental one. The upper Ludlow and Prídolí Series rocks record this transition period in the form of extensive fluviatile deposits. None of these rocks are preserved at Wren's Nest, although they do occur a relatively short distance away at Gornal and at Netherton. There is no record of later Devonian and Lower Carboniferous rocks either. Consequently, rocks of the productive Coal Measures (Westphalian A & B zones of the Upper Carboniferous) rest directly on the lower Ludlow rocks surrounding Wren's Nest, Castle Hill and Hurst Hill.

Unfortunately the junction between these two rock groups cannot now be seen above ground. It is important to remember the vast time difference separating them (approaching 100 million years) and the events which took place in that interval. During the Middle and Upper Devonian the Wren's Nest area was subjected to mountain building, uplift and severe erosion. During the Lower Carboniferous much of England and Wales was subject to subsidence and a re-invasion by the sea, but it seems probable that some western parts of the Midlands, including Dudley, remained above sea level and underwent further erosion.

It is also evident that the Dudley area was subjected to earth movements which uplifted Wren's Nest and Castle Hill in relation to the immediately surrounding area, because at Sedgley, and farther south towards Netherton and Stourbridge, the Coal Measures rest on Prídolí Series rocks which at Wren's Nest have been eroded away. Although one may think of a Castle Hill to Hurst Hill ridge in the early stages of Coal Measures deposition, it was subsequently buried as this process continued.

Coal Measures is the name given to the great series of coal-bearing rocks deposited during the Upper Carboniferous, about 300 million years ago. Dudley then lay within four miles of the landward edge of a vast tropical delta swamp, criss-crossed with freshwater channels and rich in luxuriant vegetation which thrived on the raised delta flats.

Towards the end of the Carboniferous Period the region was subjected to further mountain building forces, which folded the rocks at Wren's Nest Hill and its neighbours into great elongated domes. During this process the delta swamps gave way to an arid desert plain.

The events of the next 250 million years, which lead up to the present day, are beyond the scope of this guide. It is important to note, however, that the action of ice during recent glacial episodes (2.5 million - 10,000 years ago) gave the Midlands its final shaping. On Wren's Nest Hill the more resistant rocks of the Much Wenlock Limestone Formation were exposed to stand proud amidst the Coal Measures. The topographical high points have since been removed by erosion to give the outcrop seen today. The influence of mining activity is also significant, having given rise to the distinctive elongated quarries or trenches and immense caverns where limestone has been removed.

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## THE GEOLOGY OF WREN'S NEST

### Stratigraphy

The excellent exposures at Wren's Nest and distinctive differences between the major rock units found here, have made the Reserve a popular locality for teaching certain aspects of stratigraphy - the study of rock layers and their relative age.

In recent years the rocks at Wren's Nest have been placed within a sound stratigraphical framework, based on a comparison with the strata of Wenlock Edge in Shropshire, the type area for the Wenlock Series.

At Wren's Nest the lowest strata of the Wenlock Series are represented by the Coalbrookdale Formation, which occurs as light brown and grey shales in a few limited outcrops. The major exposures are of the Much Wenlock Limestone Formation, which comprises three major lithological divisions - the Lower Quarried Limestone Member, Nodular Member and Upper Quarried Limestone Member. On top of these are poorly exposed light brown shales of the Lower Elton Formation at the base of the Ludlow Series. This lithostratigraphy is summarized in the table below.

Graptolites, the biostratigraphic 'indicator' fossils used to match up certain sequences of Silurian rocks in different areas, are extremely rare in the limestones of Dudley. However, several specimens of the species *Monograptus flemingii* have been recorded. This fossil is only known from the middle of the Homerian Stage of the upper Wenlock Series. Graptolites found in the limestones at Wenlock Edge are slightly younger than this, indicating that, during Wenlock times, carbonate deposition began in the Midlands and gradually transgressed westwards towards the Welsh Borders in a diachronous manner.

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## Structure

During the Hercynian mountain building episode at the end of Carboniferous times, the Silurian rocks of Wren's Nest were folded into a north-north-west/south-south-east trending elongated dome or pericline. During deformation the structure was faulted along its axial plane and the western limb downthrown. This fault effectively reduces the outcrop of the Much Wenlock Limestone Formation on the western limb of the fold. Further evidence of the fault is given by contrasting strike patterns at the southern tip of Wren's Nest Hill. An offshoot of the main fault cuts through the centre of the pericline and appears as a small tear fault on the eastern limb. Some minor faulting also occurs.

In general, the eastern limb of the pericline is steeper, with strata dipping at up to 80 degrees. The western limb has a recorded dip as low as 24 degrees, though 50-60 degrees is the norm. As a result of folding, joint planes are developed parallel to the dip and tension cracks parallel to the strike. It is possible to see slickensides and evidence of the squeezing out and deformation of shales in some exposures.

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*Cross-section through Wren's Nest Hill showing the anticlinal structure broken along* its *axis by a fault zone. The old limestone workings and canal tunnel through which the stone was carried away are clearly shown. The line of the section runs east-west approximately 400 m south of the college buildings.*

## Petrology and Palaeoenvironments

The Much Wenlock Limestone Formation displays many interesting lithological and sedimentological features. The limestones are generally composed of the skeletal remains of crinoids, brachiopods, corals, bryozoans and algae, set in a matrix of carbonate or terrigenous (land-derived) mud or crystalline calcite cement. Fossil burrows are abundant throughout the sequence, and trails can commonly be seen. This bioturbation, the reworking of sediment by bottom-dwelling organisms, was a major factor in the production of micrite (micro-crystalline calcite), although it was also produced by the activities and accumulation of algae.

In general the majority of the limestones were deposited in shallow tropical or sub-tropical waters which were quiet or intermittently agitated, although there were periods of higher energy. At times the conditions were conducive to the development of patch reefs, with sub-tidal and lagoonal or similarly protected waters allowing reef growth just below wave-base.

The skeletal remains of crinoids commonly provided a fine sub-stratum for the growth of colonial organisms and subsequent reef development. The reefs are preserved today as lens-like masses known as bioherms. Variations in their shape reflect the influence of circulating currents and the amount of mud being washed into the sea. Extra non-carbonate sediment would give rise to a contracting reef. Indeed, bentonite clays (water-lain volcanic ashes) played a major role in the extinction of reefs during deposition of the Lower Quarried Limestone Member. In addition, some organisms may have died because of overcrowding, or changes in water temperature or chemistry.

The rocks between bioherms and in the upper part of the Lower Quarried Limestone Member indicate a micro-facies of clear, quiet waters with varying numbers of non-colonial organisms. Influxes of terrigenous mud occurred on a regular basis for short periods, giving rise to thin shales. Occasionally a semi-reef micro-facies existed, where colonial organisms were present, but not abundant enough to develop an obvious mound. These semi-reef deposits are now preserved as biostromes (stratiform fossil beds). Algal mats covered large areas of the sea floor and probably affected sediment deposition by trapping and binding fragments.

A lengthy period of cyclic sedimentation in quiet waters existed during deposition of the Nodular Member, with terrigenous mud being continually supplied from a landmass to the east. The quantity of mud was insufficient to disrupt the abundant organic life present as the limestones were formed, but it did result in fewer organisms in the shales. Of those present, ostracods and bryozoans are the most common. Burrowing organisms such as worms considerably altered the primary fabric of the limestones, and it is possible that much of the fine sediment is the result of bioturbation. Reefs also developed under these conditions, but they were smaller than those formed when the Lower Quarried Limestone Member was being deposited.

Towards the end of deposition of the Nodular Member a significant change occurred. This is indicated by the presence of sun-cracks, ripple marks, cross-bedding and cleanly washed sediments which suggests strongly agitated water, with periods of sub-aerial exposure, associated with the littoral zone or 'sand' banks.

The transition to the Upper Quarried Limestone Member is marked by a change to moderately agitated, shallow water conditions, with fairly strong currents and minimal mud deposition. This resulted in the deposition of fairly massive limestones with cross-bedding. During quieter conditions small reefs developed. At the end of this period muddy limestones and shales were formed, indicating a return to conditions similar to those of lower units within the Formation.

Following deposition, the sediments were gradually converted into rock, a process known as lithification. Where shells were composed of aragonite, this was replaced by calcite, cavities and pores were infilled with calcite cement and the fine calcite matrix was subjected to recrystallization. The pressures associated with compaction gave rise to small scale solution in some limestones. The characteristic nodules of the Nodular Member are largely a depositional feature, but their present shape is partly the result of modification by post-depositional concentration of calcium carbonate and the effects of compaction.

The general petrology of the three members of the Much Wenlock Limestone Formation is as follows:-

**(1) Lower Quarried Limestone Member**

a) Bioherms of large size, up to 6m thick.

b) Biostromes approximately 30cm thick.

c) Bedded limestone, 8-15cm thick, but occasionally up to 30cm thick with intervening thin shales, 3cm thick. Individual beds tend to vary slightly in thickness when traced along their length.

**(2) Nodular Member**

a) Bioherms of variable size, but not as large as those of the Lower Quarried Limestone Member.

b) Alternating thin limestones and shales. The limestones vary in thickness between 1cm and 10cm. The shales tend to be thinner than the limestones.

c) Limestone nodules up to 15cm thick and 5-30cm long, surrounded by shales up to 10cm thick.

d) Occasional limestone bands up to 70cm thick.

**(3) Upper Quarried Limestone Member**

a) Bedded limestones, 5-13cm thick with intervening shales up to 5cm thick.

b) Thicker limestones, up to 30cm thick with thin shale partings.

c) Bioherms up to 1m thick.

The above units indicate the basic rock types that can be seen in the field. The limestones are further categorised by petrologists on the basis of their fossil content, fragment size and coarseness of crystalline matrix into types such as biomicrites, biosparites and biolithites (see Glossary). The recorded sequence shown at the back of this handbook gives a good indication of bed thicknesses. Other sections at Wren's Nest differ, in that bioherms are developed.

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## Palaeontology and Palaeoecology

The Much Wenlock Limestone Formation of Dudley has an extremely rich and varied fossil fauna and flora of well over 600 species, representing almost 30 major taxonomic groups. For many of these species Dudley is also the type locality - the locality from which they were first described, and the source of reference or 'type' specimens to which others are compared for identification. Fossils from Dudley have been cited and figured in hundreds of publications or scientific papers from the 18th century to the present day. Unfortunately, specimens collected and sold during the 19th century were not carefully localised, so while Wren's Nest was undoubtedly the source of many of the best Wenlock fossils, including type and figured material, this is rarely indicated on old specimen labels, or in the literature of the time.

The Dudley fauna comprises the fossil remnants of small tropical reefs and a myriad of associated reef or inter-reef dwelling organisms, reflecting a shallow-water carbonate shelf ecosystem. The reefs were constructed and bound together by calcareous 'framebuilding' and 'framebinding' organisms. The most abundant framebuilders were colonies of tabulate corals, notably *Favosites* **(a)** and *Heliolites*, and to a lesser extent *Syringopora* and the chain-coral *Halysites* **(b)**. Each colony consisted of several hundred individual polyp tubes, or 'corallae', and could be up to a metre across.

In the Nodular Member in particular, these coral colonies are preserved still in growth position, together with stromatoporoids *(Stromatopora, Actinostroma)* and bryozoans *(Hallopora* **(c)**, *Fistulipora)* to form dome or lens-like bodies of very pure limestone, up to 6 metres high and 20 metres wide, known as bioherms. These were called 'crog-balls' by the quarry workers and represent small patch reefs similar to those found behind barrier reefs in modern tropical lagoons. Compound and simple rugose corals such as *Acervularia* and *Dokophyllum* **(d)** were also common reef builders. The main organisms responsible for binding the reef into a solid structure were encrusting calcareous algae *(Girvanella, Wetheredella* and *Rothpletzella)*. Other framebinders included encrusting forms of tabulate coral such as *Alveolites* and *Thecia,* stromatoporoids *(Labechia)* and 'curtain' bryozoans like *Fenestella.*

Many non-colonial organisms, particularly shellfish, thrived within the reefs. Of these the most common were brachiopods ('lamp-shells') such as *Strophonella* (**e**), *Eospirifer, Gypidula* and *Leptaena* **(f)**. Dense communities, dominated by a single genus (notably *Atrypa* **(g)***)* are sometimes found on bedding planes, particularly in the Nodular Member. Molluscs, much less common, include gastropods such as *Acroculia* (**h**) and *Poleumita* **(i)**, bivalves *(Goniophora* **(j)**, *Pteronitella* **(k)***)* and rare predatory orthoconic nautiloids like *Dawsonoceras* **(l)**. Cricoconarids, small ribbed tapering tubes of uncertain affinity are represented locally by *Tentaculites* and *Cornulites.* Conularids, an enigmatic group with steep-sided, pyramidal shells composed of finely ribbed chitinophosphate can also be found occasionally.

The best known fossils from the limestone are trilobites. The commonest type, *Calymene* (**m**), was nicknamed the 'Dudley Locust' or 'Dudley Bug' and incorporated into the town's coat-of-arms as a symbol of the limestone mining industry. Other genera include *Dalmanites* **(n)**, *Encrinurus* and *Acaste.* Most trilobites probably had a scavenging feeding habit. They are rarely found intact, although head and tail sections are quite common. These are mainly fragments of exoskeleton discarded during periodic moulting. Complete specimens may be preserved in a defensive curled-up position known as 'enrollment'. Rare fragments of the predatory eurypterid or 'sea scorpion' *Pterygotus* **(o)** have also been recorded from the limestone.

Crinoids **(p)**, also known as 'sea-lilies', grew together in vast colonies or 'gardens' around the reefs, or in depressions in irregular reef surfaces. Despite their plant-like appearance they were, in fact, animals related to modern starfish or sea-urchins. Their descendants are still to be found in the oceans today. The broken stem sections (columnals) of dead crinoids were the most abundant debris to accumulate on the sea floor. This process of accumulation was so slow that the skeleton of each animal remained exposed for a considerable period of time, allowing it to be broken into fragments and scattered before burial.

Occasionally, however, entire colonies of crinoids were ripped from the substrate and buried under sudden influxes of terrigenous mud washed in as a result of storms or hurricanes. As death and burial were so rapid their skeletons escaped fragmentation and were perfectly preserved beneath the resulting shale bands, often aligned in the direction in which they had fallen, with their roots, or 'holdfasts', still intact. Many hundreds are reputed to have been found preserved on single bedding planes during mining of the Upper Quarried Limestone Member in the last century. Most found their way via collectors to museums, and now represent some of the most beautiful and spectacular fossils from British Silurian rocks. Over 60 species have been recognised, varying in size from 2 centimetres high *(Clematocrinus)* to well over a metre *(Periechocrinus)*. Today, complete crinoids are rarely found, but stem, and occasionally, calyx fragments, can be observed in scree material.

Museum-based studies of complete crinoids and their associated fauna (mainly branching bryozoans, small tabulate corals and short-stemmed echinoderms known as cystoids) indicate that these attached planktonic feeders formed densely stratified communities over much of the sea-floor. Where these communities continued undisturbed for many generations substrates composed mainly of crinoidal debris were formed. These are now preserved as biostromes, isolated calcareous fossil beds rarely more than 50 cm thick. More persistant biostromes, found in the Lower Quarried Limestone Member, are composed of branching and globose stromatoporoids still in life-position.

Microfossils found at Wren's Nest include ostracods, conodonts, miospores and organic-walled acritarchs and chitinozoa. Few of these creatures are visible to the naked eye, but several hundred species have been identified by micropalaeontologists.

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## The History of Mining at Wren's Nest

The Much Wenlock Limestone Formation has been worked from Wren's Nest, Castle Hill, Hurst Hill and numerous other sites within the borough for many centuries. The keep of Dudley Castle, reputedly constructed in 1300 AD, is built of local limestone. The earliest precise reference to underground workings at Wren's Nest is dated 1796, but there is no doubt that rock was being extracted before this date.

At first the limestone was worked in open quarries for building stone and for making agricultural lime and lime mortar. Towards the end of the 18th century there was a great rise in demand for limestone, particularly for use as a flux in the local iron furnaces. To meet this demand and in view of the approaching exhaustion of the quarries, extraction began underground and the limestone was raised firstly from adits, and later from pit shafts.

On the west side of the hill mining of the Lower Quarried Limestone Member was carried out using the 'pillar and stall' method, whereby as much as possible of the required rock is removed and pillars are left to hold up the roof. On the east side, where the beds dip almost vertically, the rock was worked in high, narrow caverns without pillars.

To help with the dispersal of the limestone, a private underground canal was constructed in 1805 to connect the limestone workings on the eastern flank of Wren's Nest with the Dudley Canal at Tipton Green. About a decade later the canal was extended westward through the core of the hill to connect up the underground workings then taking place on the western flank. The limestone workings at Wren's Nest were finally abandoned in 1924, although the lime kilns on the west side of the hill continued to function until at least 1935 using limestone from Much Wenlock in Shropshire. The limestone workings at Mons Hill were abandoned much earlier.

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## THE GEOLOGICAL TRAIL

The trail, which is a walk of about 3 km (1¾ miles), starts and finishes at the Reserve's main entrance on Wren's Hill Road. Parking is available on the car park of the college buildings. There are eleven localities on the trail, each marked by a numbered metal bollard. Localities 1 and 2 are on the east side of the hill, and they provide an introduction to the entire succession of rocks exposed at Wren's Nest (see fold-out section at the back of this guide).

**LOCALITY 1. Quarry trench, Mons Hill.**

From the Reserve's main entrance, proceed eastwards along Wren's Hill Road and over the brow of the hill. After a further 100 metres, turn left at the end of the fence and continue down the steps into the quarry trench, until you reach the bollard. Turn to face the southern face of the quarry.

This man-made trench was excavated in the 18th century for the 'pure' limestone of the Upper Quarried Limestone Member. Three distinct lithological units can be seen here. The oldest of these is the Nodular Member, the top of which forms the large bedding plane to your right. The nodular limestone, which has an irregular surface, was too impure for use as a flux in iron-smelting and thus was not quarried.

This unit passes up, eastwards, into the Upper Quarried Limestone Member (in total 8.6 metres thick) which comprises a sequence of alternating flaggy limestones and thin shales, overlain by a massive 4.2 metre thick bed of coarse grained blue-grey limestone. This is the rock in which the quarrymen were most interested. Above this is a 1.2 metre thick bed of nodular limestone with shale partings. Complete fossils are not common, but those present include the brachiopods *Atrypa* and *Strophonella,* colonies of the coral *Acervularia* and numerous trilobite fragments. Colonies of stromatoporoids occur on a prominent bed near the top of the limestone.

Continuing eastwards, the sequence passes up through silty shales with thin nodular limestone bands (formerly called the Passage Beds) into pale grey shales of the Lower Elton Formation. The latter has two bands of green bentonite clay (formed from water-lain volcanic ash) several metres above the base. Brachiopods are common at some horizons, notably strophomenids *(Amphistrophia, Strophonella),* together with *Atrypa, Leptaena, Eospirifer* and *Meristina.* The entire sequence dips eastwards at an angle of about 60 degrees. Limestone was extracted along the strike of the beds, hence the linear shape of the workings.

**LOCALITY 2. N.C.C. cutting.**

Return to the road and cross to the narrow path beyond. This runs along the line of the old Upper Quarried Limestone Member trench, which has been largely filled in. Almost immediately on the right is a narrow cutting, about 35 metres long, which was excavated by the Nature Conservancy Council in 1977 to provide a dip section through the Nodular Member.

The eastern end of this cutting corresponds with the top of the Member. It passes through a sequence of progressively older beds, comprising nodules and lenses of limestone, separated by silty shales and mudstones. Near the entrance of the cutting, the limestone nodules are of a coarse grained nature. These become more argillaceous and laterally persistent down-sequence and shales become thicker and more dominant. Two thin greenish bentonite bands occur 10 and 15 metres respectively along the section, and a small bioherm composed of large compound corals in a crystalline calcite matrix is exposed on the southern face, 20 metres from the entrance. Towards the end of the section limestone bands once again become dominant.

At its western end the cutting joins a trench formed by quarrying of the Lower Quarried Limestone Member, a section of which can be examined in the north face of the workings. It is considerably thicker (16.2 metres) than the Upper Quarried Limestone Member, and comprises thickly bedded blue-grey limestone with shale partings, notably near the top and bottom. At the top is a 26 cm bed of limestone which was usually left to form the roof of underground workings. Colonies of stromatoporoids and corals *(Coenites, Favosites)* are preserved in position of growth towards the top of the Member.

The lowest, and therefore the oldest beds, are exposed in the north-western corner of the trench. Formerly known as the Basement Beds, they consist of greenish grey mudstones with limestone nodules and lenses. Below these, friable shales of the Coalbrookdale Formation (formerly Wenlock Shale) are just visible beside the steps.

**LOCALITY 3. Nodular Member bedding plane.**

Mount the steps and bear right, following the path beside the college fence back to Wren's Hill Road. Head back towards the Reserve's main entrance and turn left up the path 50 metres beyond 'The Caves' public house.

After 100 metres a major bedding plane is exposed. This is the top of the Nodular Member, which forms a prominent north/south trending ridge on this side of the hill. In contrast to the previous localities the strata here are dipping westwards and at an angle of about 50 degrees. The anticlinal structure of the hill should now be apparent. Calcite filled tension cracks run approximately parallel to the strike, and joints can be seen at right angles to these. The ground to the west, which is now grass covered and landscaped, was originally a trench produced during working of the Upper Quarried Limestone Member.

**LOCALITY 4. The Quarry.**

Proceed southwards for 100 metres until a gap in the ridge is reached. This is the entrance to a disused quarry in the Lower Quarried Limestone Member. It is an excellent area for study, but care should be taken and hard hats worn. Do not stand beneath overhanging rocks.

The rocks to the south of the gap provide a dip section, starting with an alternating thin limestone/shale sequence within the Nodular Member. These beds are similar to those seen at Locality 2. The rocks on this face contrast strongly with those to the north of the gap, where bioherms have been weathered proud and the junction with bedded inter-reef sediments can be studied. The reef-masses contain 'in-situ' reef-builders, particularly tabulate corals, stromatoporoids and compound rugose corals, many still in life position. Non-colonial organisms, mainly brachiopods, bivalves, gastropods and trilobites, together with abundant crinoid fragments, are common in the interstitial clayey cement.

Turning to the south, the Nodular Member gives way down sequence to the Lower Quarried Limestone Member. This massively bedded sequence of limestones with thin intervening shales has largely been removed, although it can be observed in the rock face above. It is best studied in the large fallen blocks on the quarry floor. These mainly comprise bioherm material composed of crinoid debris, stromatoporoids, bryozoans and small tabulate corals. (N.B. Some of these blocks are from the Nodular Member). PLEASE DO NOT ATTEMPT TO REMOVE FOSSILS FROM THESE BOULDERS OR FROM THE ROCK FACES. A look back to the north from here confirms the linear shape of the quarry.

At the foot of the south-eastern face of the quarry is a small exposure of transitional rocks at the bottom of the Lower Quarried Limestone Member, together with underlying shales of the Coalbrookdale Formation. These can also be seen adjacent to the flight of steps nearby.

**LOCALITY 5. The Fossil Trench.**

Return to the footpath to the west and proceed 60 metres southwards to the viewing platform.

From here, extensive bedding planes can be observed. These mark the upper part of the Nodular Member, just below the transition to the Upper Quarried Limestone Member. The latter has been removed leaving the trench below you. The bedding planes contain excellent examples of sinuous crested and bifurcating symmetrical megaripples and smaller symmetrical ripple marks. Such features can be seen today in the littoral zone (on sandy beaches and in river estuaries) and indicate wave or current action in shallow water. A well developed groove pattern is also exhibited on some surfaces. This may be due to wave scour of suncracks formed during brief periods of emergence.

Walk down the steps to the base of the bedding plane. The scree here is a particularly rich source of fossils, including brachiopods such as *Atrypa*, *Leptaena* and *Strophonella*, small simple and compound corals, bryozoans, bivalves, gastropods and trilobite fragments, notably those of *Calymene, Dalmanites, Acaste, Warburgella* and *Balizoma.* Samples from this scree have proved useful in the study of faunal assemblages and also provide examples of graded and cross bedding, sun cracks and bioturbation.

**LOCALITY 6. Section close to Meadow Road.**

Continue southwards along the footpath for 200 metres until you reach some old lime kilns on the left. Limestone was burnt here to produce agricultural lime until 1935. From here bear left along the gravel path for a further 200 metres and down a flight of steps. 30 metres further on is a small exposure of the topmost beds of the Upper Quarried Limestone Member.

The thickly bedded limestone sequence to the right of the outcrop contains some small, fairly coarse grained cross-bedded units and channels. At the western side of the exposure a reverse fault has downthrown shales of the Lower Elton Formation against the Upper Quarried Limestone Member. The whole sequence can be seen dipping west-south-west, but at a lower angle than the exposures previously encountered, (approximately 25 degrees). Note the change in lithology up the sequence from thickly bedded limestones, through alternating shales and nodular limestones into shales.

**LOCALITY 7. Exposure close to Cedar Road.**

Proceed southwards past the 'Cherry Hole', a 'crown-hole' formed as a result of the underground workings collapsing. Note the difference between the true dip of the beds, and their 'apparent' dip, the illusion resulting from a curved rock face. Follow the steps down into the trench of the Upper Quarried Limestone Member and continue on the path for another 200 metres until you reach Bollard 7.

Here, at the southern tip of the pericline, a change in dip orientation to the south can be seen by observing the exposure of Nodular Member rocks north of the bollard. The ground on which you are standing is the infilled trench of the Upper Quarried Limestone Member, but a few metres to the east, across the fold axis, it is met at right angles by the trench of the Lower Quarried Limestone Member. This abrupt change in bed orientation and the downthrow of the western fold limb, is due to disruption of the pericline by the axial fault. To the east of the trench is a small cutting within the Nodular Member of the eastern fold limb, where the nodular structure is particularly well developed. The red colour of the rock here, together with the presence of coal and ash fragments, is evidence of lime burning.

**LOCALITY 8. Southern end of Pericline.**

Walk northwards for 75 metres along the trench of the Lower Quarried Limestone Member to the 'ninety-nine' steps. Climb to the top of the cliff and turn right to reach the viewpoint.

From here can be seen, to the east, a flat plain underlain by the Carboniferous Coal Measures, and to the south-east, Castle Hill, similar in structure and stratigraphy to Wren's Nest Hill and formerly mined in the same way. Beyond Castle Hill is Turner's Hill, the highest of the Rowley Hills, which are made up of late Carboniferous dolerite intrusions. To the south lie the Clent Hills, composed of breccias and sandstones of early Permian age.

**LOCALITY 9. The Seven Sisters.**

Follow the path northwards for 300 metres until you reach the viewing platform at the Seven Sisters caverns, so called because originally seven pillars supported the roof of the old workings at this point. Only five pillars now remain. The 'pillar and stall' method of mining can be clearly seen.

The rock forming the pillars represents the best exposure of the Lower Quarried Limestone Member on the Reserve. It consists mainly of well bedded limestones with thin intervening shales, together with a well developed bioherm which can be seen in the two pillars directly in front of the platform. Its isolated character indicates that, although patch reefs were well developed locally, they covered fairly small areas of the sea floor, and did not persist throughout the period of limestone deposition.

The clay and silt content of the limestone is as high as 40%, indicating a continuous supply of muddy material to the sea, even during deposition of this relatively 'pure' carbonate unit. Bands of bentonite clay can be seen in the middle of some of the pillars. Although these layers are several centimetres thick, their deposition was not sufficient to kill off life in the reefs permanently. The bentonites are affecting the stability of the pillars by acting as lubricated planes, along which their central portions are gradually slipping and breaking up. The cavern roof is also insecure; large blocks of remaining Lower Quarried Limestone Member material have fallen, exposing unstable rubbly limestones of the overlying Nodular Member. In time, roof-fall will become more rapid and a 'crown-hole' could appear on the surface above.

The caverns (now largely infilled) slope down for almost 100 metres, following the dip of the strata. At the bottom is a canal basin. From here limestone was transported to iron-smelting furnaces elsewhere in the Black Country.

**LOCALITY 10. Quarry viewpoint.**

Proceed northwards on the footpath for 300 metres to view Locality 4 from the top of the cliff. The bioherms of the Nodular Member are particularly prominent from here. Immediately below the viewpoint, and just north of the steps, coal and ash debris marks the site of an early kiln or 'lime-pie'.

Beyond the Reserve boundary the housing estates are sited on the surrounding rocks of the Coal Measures. On the horizon to the north-west is Sedgley Beacon, another Silurian inlier, which is composed of rocks of the Ludlow series, notably the Aymestry Limestone Member within the Bringewood Formation. A view to the east and south-east across Wren's Nest illustrates how the crest of the pericline has been worn away by erosion to leave the hill flat-topped. The shales of the Coalbrookdale Formation form the core of the hill, while the trees in the distance mark the limestone workings of the Lower Quarried Limestone Member on the eastern limb of the fold.

**LOCALITY 11. Viewpoint close to 'The Caves' public house.**

Continue northwards along the path for 200 metres and bear left at the fork. After a further 20 metres a viewpoint is reached.

To the south is the heavily vegetated man-made trench within the Lower Quarried Limestone Member. The trench ends immediately in front of the viewpoint. Here the axial fault has cut off the outcrop of the Lower Quarried Limestone Member by throwing up shales of the Coalbrookdale Formation.

Return to the main path, turn left, and continue 60 metres to the Reserve entrance.

*PO, CR*

## Wren's Nest National Nature Reserve Policy Statement on Fossil Collecting

The Wardens of this internationally important fossil site have reassessed the rate of removal of fossil specimens, and have found that it greatly exceeds the natural rate of weathering of the rock faces containing them. It has therefore been necessary to establish clear guidelines on collecting for all visiting parties and the general public, in order to ensure the continued survival of the very features of interest which visitors have come to see.

Please observe the following code of conduct when on the Reserve:-

1. Leaders of organised parties (whether school children, students, geologists or palaeontologists) wishing to collect fossils at Wren's Nest must consult the Warden on duty prior to their visit. Reserve office tel. Sedgley (0902) 662934.

2. No geological hammer to be brought onto the Reserve without prior consultation.

3. The use of hammers on rock faces or fossil beds is not allowed under any circumstances.

4. Group leaders should not allow individuals to make large collections.
By arrangement with the Warden representative samples of fossils may be collected. These can easily be found amongst the weathered material in the loose scree at the foot of the largest face on the western side of the Reserve.

Students of palaeontology should attempt to record, as accurately as possible, the original location of fossil specimens, and the range of associated fossil species. This should help in the understanding of faunal assemblages and their related environments.

Any enquiries about the code of conduct should be addressed to the Senior Warden. The Nature Conservancy Council has endorsed these guidelines.

Senior Warden,
**Wren's Nest National Nature Reserve,**
Dudley Metropolitan Borough Council,
5 Ednam Road, Dudley, West Midlands
Tel. (0384) 456000

*June, 1990*

## Further Information

The following publications and resources should prove particularly useful when undertaking geological fieldwork at Wren's Nest.

### Maps

*Ordnance Survey*

Sheet 139 - Birmingham (1: 50,000).
Sheet SO 99SW (1: 10,000).
Sheet SO 9391 (1: 25,000).
Sheet SO 9392 (1: 25,000).

*Geological Survey*

Sheet 167 - Dudley (1: 50,000).
Sheet SO 99SW (BGS overprint 1981)
DoE Support, Copyright NERC (1: 10,000).

### Books and other publications

*British Palaeozoic Fossils*. 1975, London. British Museum (Natural History).

BASSETT, M. G.
1974 Review of the stratigraphy of the Wenlock Series of the Welsh Borderland and South Wales. *Palaeontology*, **17**, 745-777.

BASSETT, M.G., LANE, P.D., and EDWARDS, D. (eds.)
1990 The Murchison Symposium : Proceedings of an International Conference on the Silurian System. *Spec. Pap. Palaeont.*, **44**.

BUTLER, A. J.
1939 The stratigraphy of the Wenlock Limestone of Dudley. *Q. Jl geol. Soc. Lond.*, **95**, 37-74.

COCKS, L.R.M., HOLLAND, C.H., RICKARDS, R.B. and STRACHAN. I.
1971 A correlation of Silurian rocks in the British Isles. *Jl geol. Soc. Lond.*, **127**, 103-136.

HARLEY, M.J.
1988 *Wenlock Edge geology teaching trail*. Nature Conservancy Council.

HAMBLIN, R. J. O., WARWICK, G.T. and WHITE, D. E.
1978 *Geological Handbook for the Wren's Nest National Nature Reserve*. Nature Conservancy Council.

HOLLAND, C.H. and BASSETT, M.G. (eds.)
1989 *A global standard for the Silurian System*. Nat. Mus. of Wales.

OLIVER, P.G.
1971 *The petrology of the Wenlock Limestone of Wren's Nest*. Ph. D. thesis, Univ. of Birmingham (unpublished).

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1981 Lithological groups within the Wenlock Limestone (Silurian) at Wren's Nest, Dudley.
*The Black Country Geologist*, **1**, 39-53.

RATCLIFFE, K.T.
1987 *Sedimentology, palaeontology and diagenesis of the Much Wenlock Limestone Formation*.
Ph. D. thesis, Univ. of Aston (unpublished).

RATCLIFFE, K.T.
1988 Oncoids as environmental indicators in the Much Wenlock Limestone Formation of the English Midlands. *Q. Jl geol. Soc. Lond.*, **145**, 117-124.

RATCLIFFE, K.T.
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WATKINS, R. and HURST, J. M.
1977 Community relations of Silurian crinoids at Dudley, England. *Paleobiology*, **3**, 207-217.

WHITEHEAD, T.H. and POCOCK, R.W.
1947. *Dudley and Bridgnorth (Explanation of 1: 50,000 Geological Sheet 167).*
(Reprinted 1962), HMSO, London.

## Safety

Rock exposures are often unsafe and visitors must bear this in mind. They should not leave the established footpaths, which provide good access to all the main features. The area within the safety fence is strictly out of bounds. Visitors who enter the Reserve to study geology do so entirely at their own risk. Neither Dudley Metropolitan Borough Council nor the Nature Conservancy Council can accept any liability or responsibility for loss, damage, or injury to property, or, in the absence of negligence, to persons.

## Wardens

The Reserve now has a permanent team of wardens to look after the site's geological and biological interest. They will be happy to provide information to visitors, and to arrange guided walks or illustrated talks. Reserve office tel. Sedgley (0902) 662934.

## Dudley Museum and Art Gallery

Dudley Museum houses one of the most important collections of local Wenlock fossils in the country. Many of these were collected in the early part of the 19th century when quarrying was at its peak. The Museum's Geology Gallery has fine displays of material from Wren's Nest and the local Coal Measures.

Staff are on hand during weekdays to offer general advice on geology. Group visits are also catered for and material from the reserve collection can be viewed by appointment. Books and other items, including replicas of the main fossil types to be found at Wren's Nest, can be purchased at the Museum Reception.
ADMISSION FREE.

**Dudley Museum and Art Gallery**
St. James's Road, Dudley, West Midlands DY1 1HU

Contact: The Keeper of Geology, Tel. Dudley (0384) 453574.

## Geological Societies

The Black Country Geological Society comprises both professional and amateur geologists. Meetings are held at the Saracen's Head public house in Dudley and the Society arranges talks and field trips. For more information contact: The Secretary, Tel. (021) 459 3603.

## Nature Conservancy Council

The Nature Conservancy Council is the body responsible for advising Government on nature conservation in Great Britaain. Its work includes the selection, establishment and management of

National Nature Reserves; the selection and management of Marine Nature Reserves; the identification and notification of Sites of Special Scientific Interest; the provision of advice and dissemination of knowledge about nature conservation; and the support and conduct of research relevant to these functions.

N.C.C. Headquarters, Northminster House, Peterborough PE1 1UA. Tel: (0733) 40345

N.C.C. West Midlands Region, Attingham Park, Shrewsbury, Shropshire SY4 4TW.

## Glossary

| | |
|---|---|
| Argillaceous | Term applied to a rock containing a notable proportion of clay. |
| Bentonite | Clay formed from weathering of pyroclastic rocks, notably volcanic ash. |
| Bioherm | Organic reef built by sedentary organisms which are normally preserved in their position of growth. |
| Biolithite | Limestone composed entirely of the skeletons of reef-building organisms. |
| Biomicrite | Limestone composed dominantly of skeletal fossil grains in a matrix of microcrystalline calcite. |
| Biosparite | Limestone composed dominantly of skeletal fossil grains in a coarse calcite cement. |
| Biostratigraphy | Description and correlation of strata based on fossil assemblages. |
| Biostrome | Sheet-like deposit, largely of organic origin, such as shell beds, crinoid beds and coral beds. |
| Bioturbation | Disturbance and reworking of sediment by organisms, on or just below the depositional surface. |
| Clastic | Term applied to a rock composed of fragments of pre-existing rocks. |
| Diachronous | Term applied to a rock unit which has developed at different places at different times, i.e. it has transgressed the absolute time divisions. |
| Limestone | Sedimentary rock composed chiefly of calcium carbonate. |
| Lithification | Processes by which loose sediments become consolidated into rock. |
| Lithostratigraphy | Description and correlation of strata based on rock types. |
| Micrite | Microcrystalline calcite having a crystal size of less than 20 microns (0.02mm), or a rock so composed. |
| Recrystallization | Process of conversion of a mineral species to a different crystal shape. |
| Reef | Structure formed by framework-building or sediment-binding organisms and usually forming a topographic feature on the sea floor. |
| Shale | Argillaceous rock showing well-marked bedding or fissility. |
| Skeletal | Debris derived from the remains of organic hard parts. |
| Solution | The change of matter from the solid or gaseous into the liquid state, by its combination with a liquid. |

| | |
|---|---|
| Sparite | A calcite cement consisting of an interlocking mosaic of clear crystals with well defined edges; (crystal size greater than 20 microns, or 0.02 mm). |
| Stratigraphy | Study of rock units, especially their sequence in time and correlation in different localities. |
| Sub-aerial | Relating to exposure to the atmosphere. |


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