An interim Report on Wigpool Cave:  
a syncline-guided, palæo drainage cave  
in the Forest of Dean limestone basin, UK.

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Abstract: In the past the Forest of Dean limestone basin has been subjected to intensive cave forming  
processes and deposition of iron minerals. A network of caverns, infilled with generally high-grade iron  
ore, was formed in early Carboniferous limestone beds now exposed around the rim of the basin. Today  
the known ore caverns are empty following many years of mining, and they are visited by cave explorers  
and cave scientists. Recent explorations in the Wigpool Iron-ore Mine have led to the discovery of the  
Wigpool Cave, a well-developed, multi-level, cave system that evolved along the southward-plunging  
axis of the Wigpool Syncline – the northeastern culmination of the Forest of Dean Basin – and which  
drained an ancient landscape from the surface down to the contemporary water table.

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Background  
The Forest of Dean is a scenic upland lying between the River Wye and  
the estuary of the River Severn in western Gloucestershire. Currently  
it is well known for its caves, ancient iron-ore mines and former coal  
mining industry. The local basement rock, which comprises sandstones,  
siltstones and mudstones belonging to the Upper Old Red Sandstone  
of Devonian age, is overlain conformably by an early Carboniferous  
(Dinantian) limestone-dominated succession that is the host rock to  
the Forest of Dean iron ores. Younger Carboniferous (Westphalian)  
sandstones and shales with scattered coal seams are preserved overlying  
the limestones and forming the Forest of Dean Coalfield. All these strata  
(Lowe, 1989) have been folded to form a deep synclinal basin within  
which at least three component synclines – the Wigpool, Worcester and  
Lydney synclines – are recognized (Fig.1).

In the Wigpool and Lydney synclines the limestone beds plunge  
relatively gently into the Main Basin, whereas the Worcester Syncline  
displays plunges into and out of the basin on either side of a hinge  
point in the area northeast of Coleford (Fig.1). The limestones have an  
irregular outcrop encircling much of the Forest of Dean area, stretching  
approximately 17km north–south and 13km west–east. A continuation of  
the limestone outcrop extends southwards past St Briavels to Chepstow  
and beyond. In the centre of the Basin the base of the Carboniferous is  
estimated to be at about 900m below sea level.

In much earlier times when the landscape was unlike today’s,  
the entire limestone outcrop around the basin was subject to intense  
karstification, including complex cave development, and iron mineral  
deposition related to acidic iron-bearing waters running off from a high  
ridge of late Westphalian coal-bearing rocks that covered the Forest of  
Dean area at that time. This mineral-rich water was formed during a  
period characterized by torrential rainfall conditions, and was a product  
of the weathering and erosion of the coal-bearing rock sequence, which  
contained abundant pyrite (iron sulphide) and iron carbonate (ironstone)  
bands and nodules.

Because the basin was effectively enclosed and at least partially  
water filled, it was not generally possible for through drainage caves to  
develop. Instead, an extensive network of interconnecting caverns was  
formed from the surface downwards, by alternate phreatic and vadose  
processes. Development was influenced by deposition of iron minerals  
and the influx and build-up of sediment that was not washed away, but  
acted to deflect cave development towards adjacent rock surfaces, thus  
creating irregularly shaped cavities that commonly broke through into  
adjacent caverns. As the cavern network penetrated slowly through the  
limestone and the water level lowered, free drainage routes formed in  
the vadose zone, and these were also greatly affected by build up of  
sediment. Eventually the period of torrential rainfall came to an end  
and the phase of intense cave development ceased, leaving the caves  
mostly dry and in most cases infilled with clastic sediment and/or high-  
grade iron ore. By this time ore-filled caves penetrated deep into the  
limestone. In the Shakemantle Mine on the eastern side of the basin,  
where the dip of the limestone sequence is very steep, ore deposits were  
found as deep as 275m below the surface, and in areas of gentler dip on  
the western side of the basin, ore was mined down to 122m below local  
ground level (Sibly, 1927, p.10).

Figure 1: Simplified bedrock geological map of the Forest of Dean Basin and  
adjacent areas, showing features mentioned in the text.
The Forest of Dean iron-ore deposits are generally considered to have formed during the Triassic Period. There is evidence in many British limestone areas of an episode of intense cave development in the Late Triassic (Carnian) and some caves that formed adjacent to younger rock sequences containing pyritous shales have been infilled with haematite (and other iron minerals) derived at least in part from the oxidation of pyrite (Simms, 1990). Though not yet confirmed, it seems probable that the Wigpool drainage cave also evolved at some stage during this episode.

Most of these ancient caves are now empty, exhumed by 2000 years of mining activity. They can be entered by way of various holes around the outcrop and explored down to the water table. In general the cave morphology remains much as it was when the caves formed, apart from the iron ore being removed and some cavities backfilled with breakdown debris and sediment. Miners removed bedrock only when driving access tunnels or shafts and, locally, to enlarge pre-existing natural passages to improve access. Various stages of cave development can be recognized including scattered short remnants of drainage passage. However, exploration in the Wigpool Iron-ore Mine has led to the discovery of a well developed, multi-level, drainage cave that has formed here in response to the enhanced drainage potential within the core of the gently plunging Wigpool Syncline.

Elsewhere within the modern Forest of Dean landscape, through drainage caves have been explored in the Symonds Yat area. Here, in the northwest corner of the basin, the River Wye has cut a deep gorge through the limestone, enabling establishment of a low-level outlet for the extensive cave system behind the Slaughter Resurgence (Lowe, 1989, 1993, 2003). Overviews of various aspects of the geology and caves of the Forest of Dean are provided by Lowe (1989, 1993, 2003).

<table>
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<th>Age</th>
<th>Broad terminology</th>
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Table 1: The ages and names of rock units mentioned in the text, including traditional terms used locally in the Forest of Dean (columns 2 and 3) and modern names applicable to the whole of the South Wales, Forest of Dean, Bristol area (columns 4 and 5). The rock units that contain the cave are emboldened.

Wigpool Cave

The Wigpool Cave is part of the Wigpool Iron-ore Mine, which is situated beneath Wigpool Common 1.5km northwest of Mitcheldean, in the northeastern corner of the Forest of Dean. The mine, which straddles the Wigpool Syncline, was worked between 1861–1918. Currently the mineral rights and access are controlled by Clearwell Caves Ltd., and the mine is designated an SSSI, as are several other Forest of Dean iron-ore mines. Access to the cave is from the lowermost mine level, shown on the old mine plan as the 133-Yard Level. The level, which is at the mean elevation of the fluctuating water table, is often flooded. From the 133-Yard Level two shafts give access to the cave about 21m above the floor of the level. In 1991 members of the Royal Forest of Dean Caving Club found the northern end of the cave, having used scaffolding poles to scale the open northerly shaft. Digging by other club members in 2002 opened a way into the southern shaft and a continuation of the cave.

The cave comprises of dry linear passages on at least five levels with a vertical range of approximately 50m, draining down the plunging axis of the Wigpool Syncline towards the Main Basin. In this area the plunge of the syncline is about 5 degrees towards the south, whereas the dip of the beds on its flanks, which becomes progressively steeper southwards, is about 40 degrees in the vicinity of the cave.

A currently unexplored conduit in the upper part of the Whitehead Limestone, possibly on the boundary between the Drybrook Sandstone and the Whitehead Limestone, is conjectured as providing the highest tier, which supplied water in sequence first to the Labyrinth and, after subsequently retreating, to the Shale Chambers and Sand Chamber (Figs. 2 and 3). In the lower part of the Whitehead Limestone are Top Passage and the North Chambers. These passages might be related to the cave-guiding inception horizons within the Whitehead Limestone that were recognized by Lowe (1993, p.43). Immediately below Top Passage is Main Drain, which is probably developed on the well-known inception horizon between the base of the Whitehead Limestone and the underlying Crease Limestone (Table 1). Two lower conduits are at currently unidentified horizons within the Crease Limestone. All of the passages are interconnected vertically, exhibiting typical features of

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Figure 2: Diagrammatic vertical section oriented up/down the N–S plunging axis of the Wigpool Syncline, showing broad details of the layout of Wigpool Cave.
cave down-cutting induced by a lowering water table. However it is also possible that the precursors of the passages at all levels were imprinted prior to any drop in the water table and that they were subsequently enlarged in sequence as the water table lowered. It appears that the water that flowed through the cave was largely autogenic in origin, presumably deriving from diffuse entry around the outcrop. Whereas the cave has been thoroughly prospected by the iron-ore miners, there is little evidence of ore deposits having been present, and there are no typical ore caverns.

Several other small north–south conduits in the vicinity of the Wigpool Cave have been cut through by the meandering 133-Yard Level, but they are mostly too small to explore. Elsewhere in the mine there are a few truncated drainage passages containing traces of sediment and black nodules.

Cave passage description

Because further investigation and the taking of photographs has been prevented by persistent high water levels since 2005, this description of the cave relies upon the author’s memory of the passages and the original survey notes; figures 2 and 3 show the passage names and relationships.

Top Passage
This undulating passage joining the south Breakdown Chamber and the two Shale Chambers displays a generally roughly square cross-section, with a few smooth roof pockets and tubes. It appears to be of phreatic origin, though much modified by breakdown and now entirely floored with rock debris. Water entered from a currently unknown higher conduit feeding through the Labyrinth and the roof of the Shale Chambers. At two points holes in the floor drop to the Main Drain below. The 18m x 24m Breakdown Chamber has formed as a result of collapse into the Main Drain. It has a spectacular domed roof in thinly bedded rock that is typical of the Whitehead Limestone. Such thinly bedded rock will not normally support wide roof spans but, in this case, the beds, some as thin as 7cm, have broken in short steps, which now form a strong natural corbeling. At the highest point of the chamber a short passage and climb lead to a vestibule that has three entrances leading into the Labyrinth.

The Labyrinth
This is not yet surveyed. A three-dimensional phreatic network of small interconnecting passages and chambers, almost a maze cave, extends well above the roof of the adjacent chamber. It was partly infilled with sediment and breakdown debris until cleared by the miners, who created through routes and left some backfilled passages.

Shale Chambers
Top Passage terminates to the north at the two Shale Chambers. The larger of these is a tapering aven-like chamber 9m high, exposing colourful shale bands. Both chambers are part of a vertical drainage route that captured the flow from the conjectured high-level conduit, initially to feed into Top Passage and, after further downward development, to feed into Main Drain. The upper parts of the two chambers are now choked with green shale and there are large mounds of fallen shale on the floor below. There is also a small vertical conduit inlet, choked with green shale, in the passage below the Shale Chambers.

Main Drain
This is a vadose conduit of rectangular cross-section beneath a gently arched, fissured roof that is cut by closely spaced, smooth tapered blind fissures parallel with the passage. The deepest fissures penetrate about 0.5m and appear to be guided by joints. Some of the fissures contain tightly packed sandy clay. Such roof features are commonly related to the action of flood waters (Palmer, 2007, p.202). Most of the Main Drain is now obscured by collapse material, but three short sections remain accessible.

The lower section is 2.1m high x 3.6m wide whereas the upper section is filled to the roof with sandy clay sediment and limestone blocks. What little rock debris originally littered the floor has been moved to the sides by the miners. The central section is wider and its floor holds the inclined shaft that descends to the 133-Yard Level. From its large, funnel-shaped top, its twisting shape and variable size, it is clear that this is a natural drainage shaft that was modified by the miners. Halfway down the shaft there is a connection to the next lower drainage level. It is not known how far the Main Drain extended beyond the known cave, but there is a strong indication, in the adjacent 133-Yard Level, that it continued southwards. Investigation northwards within the mine and on the surface, where the limestone crops out at Bailey Point, has failed to find any further evidence.
North Chambers
The north end of the cave consists of two large chambers connected by a short passage. Holes in the passage floor descend through unstable boulders into a short section of the Main Drain, which here shows only sporadic phreatic roof features. The Breakdown Chamber has formed as a result of collapse into the Main Drain, leaving a floor of rock debris and a high, domed ceiling in thinly-bedded limestone, similar to that exposed in the chamber at the south end of the cave. In the east wall of the chamber is the entrance to a short passage that leads up to Sand Chamber, which is filled to the roof with bands of pale-coloured sand and some thin bands of green shale. The passage once carried water from the high-level conduit down to the Main Drain, until it was abandoned and left infilled with boulders and finer sediment. Miners eventually dug open the passage, dumping the spoil in the main chamber to the side of the passage entrance. However, with no hint of iron-ore discovered, the excavation was unfortunately abandoned. There are also several shallow prospecting excavations in the floor of the chamber.

The low 12m x 21m final chamber is unmoved by mining activity, with its shallow arched roof only 1.5 to 2.0m above a floor covered in thick brown mud deposits. Desiccation cracks reveal underlying boulders, and small handprints in the mud indicate the juvenile age of some of the miners. A sunken miners’ walkway walled with boulders crosses the chamber and seems also to be the route followed by the last stream to flow through the chamber. A final short passage terminates abruptly against a wall of disturbed slabs and boulders, which might be the infill of another collapsed chamber.

Lower conduits (not surveyed)
Beneath the Main Drain and offset slightly towards the east are two smaller conduits. Both display well-developed phreatic roof features above vadose passages that contain remnants of a sediment infill and sporadic black nodules. In some places the conduits have widened sufficiently to allow emplacement of minor iron-ore and ochre deposits. Up-dip both passages end fairly abruptly where small-diameter feeders enter from various directions. The higher of the two conduits has a connection to the inclined shaft and at its lower end a bypass drainage route that has developed in the conduit floor has been enlarged by miners to connect to the 133-Yard Level. Although the conduit continues beyond the bypass it is choked with sediment after a short distance.

The lowermost conduit can only be reached from the 133-Yard Level, close to its intersection with the inclined shaft, from where it can be followed up or down dip. Most of this conduit lies within the zone of alternating phreatic / vadose conditions caused by the fluctuating water table, and phreatic features become more pronounced towards its lower end. Also down-dip the conduit branches on both sides into smaller parallel passages and a few small chambers containing traces of iron-ore and ochre. The conduit continues down-dip below water level. Up-dip there is evidence of mining activity, and a hole in the side wall of the conduit gives access to a series of ore caverns.

Observations on the cave deposits
Because the cave was thoroughly explored by miners, much sedimentary infill was disturbed and/or removed, either in their search for iron-ore or simply to provide access. However, a variety of deposits remains.

Green shale
Deposits of reworked green shale occur in the cave, seen for example as infill in the two Shale Chambers and in a small nearby conduit and as shale partings between the bedded sand deposits in Sand Chamber. It appears that this shaley material was derived from in situ green shale beds that occur within the Whitehead Limestone rather than from an external source, and was a result of underground erosion with subsequent re-deposition by water flowing through the inferred high-level conduit. Such deposits are not confined to the cave. Elsewhere in the mine there are several examples of small diameter conduits infilled with green shale, visible in the roofs of the now empty ore caverns, or where exposed in mined tunnels.

Black nodules
Black nodules or concretions are present sporadically in the Main Drain, in ground that has been disturbed by miners, and in the two lower conduits. Elsewhere in the mine black nodules have been found in some of the truncated remnants of other drainage passages. The nodules are smooth and rounded, ranging in size from 25mm to 150mm and they have a black, powdery coating. Their presence and nature, together with their black coating, possibly indicate formation under turbulent flow conditions. The intense black staining property of the coating is indicative of high manganese oxide content.

Iron ore
Fast-flowing drainage conditions in the cave have generally inhibited the precipitation of iron minerals. However, ponding of water in the two large chambers on the Main Drain appears to have allowed some mineral deposition to take place and the access shafts and adjacent railway lines leading into the base of the chambers suggest that iron-ore was found here in workable quantities. These small workings are now collapsed, preventing further investigation. Elsewhere in the cave there are several small worked-out ore pockets, showing fragments of iron-ore and ochre. Much ore might have been lost by the iron-bearing water being flushed through the cave system. Although iron-ore deposits probably formed lower down, in the saturated zone, these might have been beyond the reach of the miners. This situation might also account for a low output of ore from the mine. Ore production records started in the early 1800s and whereas they show that the mines on the eastern side of the basin were the most productive in the Forest of Dean area, Wigpool Mine had by far the lowest output among them.

Quartz conglomerate
It appears that the Main Drain continued farther southwards beyond the currently known cave, and that its extension was cut through by miners driving the 133-Yard Level. This intersection of passages resulted in an area of poorly supported roof, and the Level was strengthened with masonry walls and a timber roof. Subsequently these have partially collapsed and reveal in places deposits of consolidated quartz conglomerate. A similar occurrence of quartz conglomerate in limestone was observed in 1921 during the construction of the Bailey Level. This mine level is independent of the Wigpool Mine and was driven through the west flank of the Wigpool Syncline by miners prospecting for iron-ore. The following details are based on an account by Sibby (1927).

When the Bailey Level reached the Crease Limestone headings were driven out along the strike. In one of these it was found that the limestone was cut out by a disturbance having a superficial resemblance to a fault. Black shales and conglomerate resembling the Coal Measures were proved for 12 yards [c.11m] and the heading was abandoned. It is clear that the shale and conglomerate could not have reached their position as a result of faulting. An explanation probably lies in the phenomenon of dissolitional cavern formation. The subsequent infilling was effected by underground water carrying sediment derived from the Coal Measures above.

Speleothems
No calcite speleothems are present in the cave, but in other parts of the mine, closer to the surface, there are a few well-decorated grottoes.

Acknowledgements
The Wigpool Cave and many other interesting features of the Wigpool Iron Mine were found as a result of the extensive exploration carried out in the mine, over many years, by Les Twissell and the late Terry Browning, accompanied in later years by Chris Bowen. Thanks to Clearwell Caves Ltd for allowing access to the Wigpool Iron Mine, and to Dr D J Lowe for reading the first manuscript and suggesting improvements to the text.

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