

Local Cave & Mine Leader Award Regional Geology



Regional Geology Overview

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Regional Geology Overview

Introduction

This document has been produced on behalf of the Qualification Management Committee (QMC) of the British Caving Association. Its purpose is to support candidates preparing for the Local Cave and Mine Leader Award.

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Contents

- Introduction
- Yorkshire Dales
- The North Pennines
- Peak District
- South Wales
- Forest of Dean
- Dorset and Portland Bill
- Mendips
- Devon
- North Wales
- Durness
- Assynt
- Applecross
- Skye
- Appin
- Schiehallion

Regional Geology Overview

The Geology of the Main Caving Areas of England, Scotland and Wales and the Effect on Cave Development.

Introduction- taken from Caves and Karst document.

The Geology of Carbonate Rocks

- Limestone is composed of calcium carbonate (CaCO_3) and comes in many different forms
- Most form in shallow warm seas, from the shells and hard parts of marine animals or from calcium rich plankton that saturate the water and precipitate out
- Some are formed by growth of coral reefs and similar bodies
- The carbonate mud may be churned over by burrowing organisms and excreted out
- Heat and pressure by burial of more deposits compacts and cements them (diagenesis) and turns them into rock (lithification)
- Dolomitised limestone (dolomite or dolostones) also forms caves in a similar way and is made up of calcium magnesium carbonate, $\text{CaMg}(\text{CO}_3)_2$

After the limestone has been formed it may be affected by various geological events which change the way the limestone fits in the area; the angle at which it sits is called the dip. Sometimes the rock may be folded, therefore the dip can vary across the region. This will affect the cave development; steep dip leads to steep caves; shallow dip leads to generally horizontal caves and flat beds may mean that the water follows the vertical joints instead of the bedding planes leading to vertical cave systems.

Limestones are those rocks composed of at least 50% calcium carbonate (CaCO_3). Limestones can come in many different forms, depending on the type of calcium carbonate grains that make up the rock, and variations on the depositional environment, sea level, climate and its subsequent geological evolution. Most carbonates form in marine environments, usually in relatively shallow tropical waters typically less than a few hundred metres depth, although they can also form in deeper water. Limestones have been deposited in the UK at several different times within geological time, Cambrian, Devonian, Carboniferous and Jurassic

The Yorkshire Dales

Age- Carboniferous 359 to 323 million years ago including the Great Scar limestone and Yoredale series.

Fossils- Crinoids, Gastropods, Nautiloids, Brachiopods, Bivalves, Corals, etc.

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Regional Geology Overview

Dip- Around the three peaks area generally flat but to the east of the region there is a slight dip

Cave Type- because of the flat beds the caves around the three peaks are of a vertical nature as the water follows the joints but in Nidderdale and other areas to the east the caves are gently dipping with some smaller pitches.

Caves- Many vertical systems such as Jingling Pot, Gaping Ghyll with several smaller horizontal systems Thistle, Runscar, Long Churns in the Three Peaks area and the Manchester Hole/Goyden system in the East

General Geology- The limestone lies unconformably on older mudstones, siltstones and sandstones. It is overlain by gritstone. The way the rocks outcrop is affected by a range of underlining features, the largest being the Askrigg Block, the Craven Fault to South and West and the Dent fault to the North and North West. The recent glacial periods, 10 to 30 thousand years ago, would have covered the region with up to a mile thick bed of ice. This has had a massive influence on the surface Karst features which the Yorkshire Dales are famous for: Limestone Pavement, Dolines, U-Shaped valleys, Malham Cove, Gordale Scar, etc.

The North Pennines

Age- Carboniferous 359 – 323 million years ago.

Fossils- Corals, crinoids, brachiopods & bivalves.

Dip- Slight dip.

Cave Type- Phreatic maze networks and horizontal stream caves.

Caves- Because the limestone is relatively horizontal and bordered by the other rocks above and below, there is not much vertical development underground. Several caves have been entered by the miners and are thus accessed by a mine level (adit), e.g. Hudgill Mine Caverns, Lunehead Mine Caverns and Windegg Mine Caverns. Some of these are phreatic maze networks, for example, Cutthroat Caverns (discovered in 2018) and Knock Fell Caverns. In Hudgill Mine the natural cave is in a horizontal bedding about 10m above the mine level and has an inordinately complex set of passages contained within the space of one or two football pitches!

Other caves: Ayleburn Mine Cave, Fairy Hole, Pate Hole and Smeltnill Beck Cave are all horizontal stream caves.

General Geology- In the Carboniferous period the area was covered with shallow tropical seas, vast river deltas, and lush swampy forests. Weardale Granite underlies the Northern Pennines about 270 to 390 metres below the surface. (Proven by boreholes in 1960). The sea rose periodically, flooding the deltas and depositing limestone again. This cycle produced a repetition of rock types – layers of limestone, shale, sandstone and coal are repeated several times. These are called Cyclothem. Limestone pavements can be seen at North Stainmore, (near Brough).

Minerals-The North Pennines is well known for deposits of lead ore, zinc and other minerals. The minerals formed about 290 million yrs ago when hot mineral rich waters flowed through cracks and fissures into the Carboniferous sediments. The fluids cooled and the minerals crystallised within the rocks as vertical 'veins' and horizontal 'flats'.

Regional Geology Overview

These fluids were warmed by heat from the Weardale Granite. This mineralisation was significant for the discovery of several caves by the miners.

Peak District

Age- Carboniferous age, 359 - 323 million years ago

Fossils- Corals, crinoids, brachiopods

Dip- Broad anticlinal structure with a north- south axis. The exposed limestone in the core (The White Peak) is therefore largely horizontal or gently dipping on the flanks. Locally smaller folds exist within this larger structure.

Cave Type- Swallets follow gently dipping natural caves with vadose passage exploiting older phreatic passages (e.g. Giants). Horizontal systems following the bedding with breakdown and signs of earlier phreatic development (e.g.: Bagshawe, Streaks Pot). Very old natural systems at depth, with hypogenic development, intersected by mine shafts from surface (e.g.: Oxlow/Maskhill, JH Mine, Peak/Speedwell system)

Caves- Giants Hole, Carlswalk, P8, Oxlow, Peak/Speedwell, Bagshawe

General Geology- The limestone was deposited in shallow lagoons and reef knolls can be seen around the edges of the White Peak (e.g.: Winnats Pass, High Tor, Beeston Tor). Corals are sparse – the reefs were built by crinoids, algae and other organisms. Changes in environmental conditions and breaks in sedimentation led to the bedding planes separating the limestone beds. Occasional volcanic activity and influxes of mud left layers of ash (locally known as 'wayboards') or shale in between these. Layers of basalt (known locally as 'toadstone') are evident as lava poured over the seabed at that time. This is quarried for roadstone. These layers later formed inception horizons important in cave development.

The Hercynian or Variscan orogeny at the end of the Carboniferous led to the Derbyshire Dome structure. Faulting associated with the earth movements were exploited by deep water circulation and injected with superheated fluids. These were rich in minerals, such as galena (lead sulphide), fluorspar (calcium fluoride), barites, calcite (calcium carbonate) and sometimes copper. The result was the many mineral veins or rakes which are to be found in the limestone areas and which have been mined for lead and other minerals since at least Roman times.

South Wales

Age- Carboniferous 359 to 323 million years ago.

Fossils- Much of it is of organic origin, being the shells and skeletons of sea creatures, large and small, with much of the mass being formed by corals.

Dip- across South Wales varies between 10 degrees in the East and 25-35 degrees in the West.

Cave Types- This dip allows the water to flow gently downhill and leads to the generally horizontal development of caves in South Wales. Exceptions occur where the water has followed faults or master joints.

Regional Geology Overview

Caves- Porth yr Ogof, Ogof Ffynnon Ddu, Agen Allwedd. Vertical systems formed on faults e.g. Pwll Dwf

General Geology- A band of carboniferous limestone stretches across the Brecon Beacons National Park from Bloreng in the east, to Carreg Cennen in the west. Many of the caves of South Wales can be found in this thin belt of limestone which is 45 miles long but rarely more than one mile in width. Water pours down the southern slopes of the old red sandstone hills to the north and on meeting the limestone, disappears underground following this southward dip, but they also extend east-west across it until they emerge in one of the major valleys carved through the limestone.

The South Wales area differs from other karst areas of Britain in having fewer limestone pavements but many more shakeholes (depressions formed where surface water washes the boulder clay that covers the limestone down into cracks or fissures in the limestone). Although such areas as Mynydd Llangynidr and Mynydd Llangatwg are gritstone plateaus, the limestone isn't far below the surface and the collapse of sections of cave within the limestone leads to craters appearing at the ground surface. Some are truly impressive at 60m across and 20m deep. There are further limestone areas in West Wales at Pembrokeshire, with numerous caves found within the limestone bands there, from Pembroke in the West to Pendine further East. Throughout the region, faults have occurred, affecting the limestone bands and hence cave and passage development. The Neath Disturbance and Swansea valley are the most notable for creating folds and faults along the trend of the disturbances.

Forest of Dean

Age- Lower Carboniferous 359 to 330 million years ago. The host rocks for most of the Forest of Dean (FOD) caves are the Lower Dolomite, Crease and Whitehead limestone Formations.

Fossils- Brachiopods, corals, shark bones and teeth. Dolomitisation has reduced much of the original fossil fabric in the Lower Dolomite and in places in the Crease Limestone.

Dip- mostly gentle, less than 10 degrees, but locally up to 45 degrees where involved in local folding or faulting. Around the east side of the Forest Of Dean Coalfield steeper dips around 75 degrees also occur and these are seen in many of the disused iron mines there, but in few, if any natural caves.

Cave Type- mostly epigenic formed by surface streams that flow off younger sandstone and Coal Measures strata and enter the carbonate formations. Underground water flow is commonly steeply down initially, 25m or more and then flows gently down-dip with fault alignment, towards local spring lines along the River Wye or other places. In some parts of some caves there is also evidence of hypogenic cave origin, perhaps linked to some of the iron mineralization.

Caves- Many small caves around Symonds Yat e.g. C10 complex, Slaughter Stream, Redhouse Swallet and Otter Hole.

General Geology- The Lower Carboniferous carbonate sequence is up to around 300m thick and sits conformably on Devonian red-bed sandstones, marls and mudstones but is overlain unconformably by Upper Coal Measures sandstones, shales and coal. Unlike in the Mendips and South Wales the Upper Carboniferous aged Millstone Grit and Lower and Middle Coal Measures are missing in Forest Of Dean due to a significant local episode

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Regional Geology Overview

of intra-Carboniferous structuring. This area was also affected by the widespread end of Carboniferous aged Hercynian deformation that is prevalent in South Wales and the Mendips, but with North-South trending fold axes developed in FOD rather than East-West as in those other caving regions.

The carbonates comprise in ascending order, the Lower Limestone Shales, Lower Dolomite, Crease Limestone, Whitehead Limestones and the Lower and Upper Drybrook Limestones. Because of the intra-Carboniferous structuring and unconformity, in some places the Coal Measures rest directly on the Lower Dolomite. This is the case for much of the Symonds Yat Cave System (comprising Wet Sink – Slaughter Stream Cave, Redhouse Lane Swallet, Big Sink and some other smaller caves). Because of their shaley nature the Lower Limestone Shales and Whitehead Limestones are mechanically weak and tend not to form many caves, even though underground drainage water does flow through them.

Within FOD caves and disused iron mines many faults are visible and these commonly are brecciated and mineralized by haematite. The faults are in general steeply inclined and form 'damage zones' with many subordinate fault branches and altered rock. Beds are generally not offset much vertically on the faults because the displacement is lateral rather than vertical. The faults and their damage zones have formed zones of weakness where permeability is enhanced and therefore many cave passages have formed along them. The longer Forest Of Dean caves such as Wet Sink – Slaughter Stream Cave and Otters Hole are formed entirely in the Lower Dolomite Formation, while Redhouse Lane Swallet, Big Sink and Miss Graces Lane Swallet pass between the Whitehead and Crease Limestones and the Lower Dolomite. Miss Graces Lane includes some passages that are clearly hypogenic in origin, formed from ascending hydrothermal waters and terminating upwards at blind cupolas, rather than being related to present or past epigenic drainage. The profuse and very beautiful cave formations in Otters Hole have formed from surface water that has percolated down through the overlying limestone formations into the host Lower Dolomite. While in much of the Symonds Yat Cave System, because impermeable Coal Measures shales are directly overlying the Lower Dolomite, few if any formations are present.

Dorset and Portland Bill

Age- Jurassic limestones and mudstones formed approximately 140 to 150 million years ago. These rocks were deposited in an environment of swamps and deltas and coastal margins and were occasionally warm shallow seas.

Fossils- Bivalves, gastropods, ammonites

Dip- gentle to the South.

Cave Type- These are tectonic caves caused by earth movement so often rifts but with floors formed from rocks collapsed from above.

Caves- The main site used with groups is Flagpole Cave. There is really only one cave (Thrutch Cave) that is a dissolution cave. The coast has a number of small sea caves; these are "Littoral" meaning formed by the mechanical erosive force of the sea, exploiting the natural bedding plains, joints and faults found in Limestone.

General Geology- The area is known as the Jurassic Coast, a clue to the rock type. The coast has some world-famous coastal features (Lulworth Cove, Portland Bill, Durdle

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Regional Geology Overview

Door). These features were formed because the harder bands of Jurassic Limestone were breached by the sea and the Chalk behind was eroded away, at a much faster rate than the Limestone. This created enclosed bays, arches, stacks and islands.

Portland Bill is a unique feature of the Jurassic coast. It is really a large island (2km x 8km) connected to the mainland by a Tombola (narrow strip of land).

The island of Limestone is no longer supported by the rock around it. That was eroded away by the sea long ago. This island of rock is literally falling apart, cracking vertically as the cliffs lean out.

Mendips

Age- Carboniferous 359-323 million years ago

Fossils- Brachiopods, crinoids and corals

Dip- steep

Cave Type- Steep passages interrupted by short pitches

Caves- Goatchurch Cavern, Swildons, Manor Farm Swallet

General Geology- The Mendips are an area that forms a "whaleback" anticline fold caused by plate tectonics in the Variscan Orogeny which mainly affected the UK 290 million years ago. This whaleback fold means that the rocks dip steeply from the axis of the fold. There are several other rocks here as well, including a topping of Triassic Desert Scree - what we see now is the eroded relic of a desert 1km high. This area has been subjected to significant thrusting, although the covering by other rocks makes this hard to discern. There are many dry valleys on Mendip, some have been partially re-excavated (such as Burrington Combe). Cheddar Gorge is an anomaly - it is very young, perhaps 150 thousand years old, about 230 million years younger than the Dolomitic Conglomerate valleys.

Devon

Age- Devonian rocks, dating from between 415 and 360 million years ago

Fossils- Brachiopods, Corals and Crinoids. However, unlike most other caving regions of GB Devon was not covered by ice in the last ice age so cave deposits have included preserved bones of bear, wolf, mammoth, woolly rhino, horse, reindeer, giant deer and bison. E.g. Joint Mitnor Cave

Dip- gentle dip

Cave Type- Isolated caves with gently dipping passages.

Caves- Caves regularly used by groups are Bakers Pit and Pridhamsliegh Cavern.

General Geology- The uplands of Devon are dominated by the granite of Dartmoor which moved up into the folded rocks during the formation of the mountains. The limestone blocks have been subjected to much faulting and have become isolated blocks.

North Wales

Age- Carboniferous 359-323 million years ago

Fossils- corals (e.g. *Dibunophyllum*), brachiopods and crinoids

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Regional Geology Overview

Dip- 5–15° to the south or southeast,

Cave Type- Mainly gently dipping with large chambers due to the faulting and mineralisation. There are nationally important coloured speleothems.

Caves- The Minera system, comprising Ogof Llyn Parc, Ogof Llyn Du, and Ogof Dydd Byraf, represents the most extensive integrated karst drainage network currently known in North Wales. The Elwy Valley hosts several significant archaeological caves, including Pontnewydd, Cefn, and Plas Heaton. These sites have yielded rich faunal assemblages and, in the case of Pontnewydd, important hominin remains dated to the Middle Pleistocene (~230,000 years BP). The Alun valley has 3 important caves Ogof Hesp Alyn, Poachers Cave, both of which are active phreatic stream caves and Ogof Nadolig which is a dry phreatic system. In the Ceiriog Valley Ceiriog Cave is a similar dry phreatic system up above the river

General Geology- Lower Brown Limestone, Loggerheads Limestone, Cefn Mawr Limestone, White Limestone, and Upper Grey Limestone beds are later affected by faults and mineralisation.

Scotland

There are six main areas of limestone caves within Scotland: broadly north to south, these are Durness, Assynt, Applecross, Skye, Appin and Schiehallion.

Durness

Age- Cambro-Ordovician carbonates – mostly dolostones – of the Durness Group, 530-500 million years old.

Fossils- Only trace fossils and stromatolites in the lowest two units, but the top four units contain thrombolites, cephalopods and conodonts, with some limited trilobites and brachiopods.

Dip- Due to the heavily-faulted terrain, strata dip varies but is most often towards the SE or SSE.

Main Caves- Smoo Cave and the Ach a' Chorrain caves (mostly rather small)

General Geology- The full sequence of the Durness Group is exposed here, separated into seven units with a full thickness of 920m. The two lowermost units are the same as in the Assynt region (below), the dark-grey Grudaidh Formation and the pale-grey Eilean Dubh Formation. These give way to the darker, coarser Saimhor Formation with characteristic dark leopard-spot patterning and paler grey, sandy dolostones of the Sangomore Formation. Lighter bands occur throughout both these units. The overlying Balnakiel and Croisaphuill Formations are similar in appearance, being mid to dark grey dolostones and limestones with distinct black and maroon chert nodules. Distinctive burrow-mottling in the Croisaphuill Formation weathers unevenly and produces razor-sharp surfaces that are unwelcome on the knees in smaller cave passages! The uppermost Durine Formation of pale-grey dolostones appears not to contain caves. The whole sequence appears not to have been caught up in the Moine Thrust Belt, unlike in the Assynt region farther south. Rather, the rocks here exhibit faulting at the edge of a graben (rift valley), with faults trending NW-SE to WSW-ESE.

Regional Geology Overview

Assynt

Age- Cambrian dolostones of the lower part of the Durness Group, 530-520 million years old.

Fossils- Few actual discernible fossils – mainly mottling due to traces of burrowing organisms and some algal stromatolites.

Dip- Depends on position within Moine Thrust belt, but many dip towards the east and south-east.

Main Caves- Area contains most of Scotland's larger cave systems: Uamh an Claonaite/Rana Hole, Allt nan Uamh Stream Cave, the Cnoc nan Uamh system. Other significant caves include Lower Traligill Cave, the short Creag nan Uamh 'Bone Caves', Uamh an Tartair/Uamh Mhor, Uamh Poll Eoghainn.

General Geology- The two lowest members of the Durness Group are present: the dark-grey Grudaidh Formation, overlain by the pale-grey or buff-coloured, laminated dolostones of the Eilean Dubh Formation. Although stratigraphically only about 200m deep in total, these were caught up in the Moine Thrust belt due to the Caledonian Orogeny (400 million years ago) and forced up and over each other in what is called a 'duplex' due to earth pressures from the south-east as continents collided. This thickening of the carbonate rocks, with angled thrust faults creating lines of weakness, enabled karst drainage and the formation of cave systems. The carbonate rocks are cut by numerous igneous dykes which have influenced karst drainage patterns. Deposits in the Creag nan Uamh caves have yielded an impressive fauna dominated by reindeer and brown bear with feral horse, wolf, arctic fox, lynx, etc., dated to either side of the last Scottish ice sheet.

Applecross

Age- Early Jurassic, *ca.* 200 million years old

Fossils- Shelly fossils are abundant, comprising mainly bivalves, ammonites and belemnites.

Dip- Mainly 15-25° to the WNW, towards the Applecross Fault.

Main Caves- Cave of the Liar, Cave of True Wonders, Ashery Pot, Liar's Sink

General Geology- Grey oolitic limestones and shaley limestones deposited in a down-faulted basin in a broadly asymmetric synclinal fold whose dip increases near to the Applecross Fault, approaching 55°. The local limestone has produced some spectacular speleothem displays in certain caves, which is unusual for Scotland. (Note: a small patch of Cambrian dolostone at Kishorn, just to the south of Applecross, has some karstic drainage, but caves are very short and rarely visited.)

Skye

Age- Carbonate rocks of two different ages occur on Skye. Cambro-Ordovician dolostones occur in an outcrop arcing southwards from Broadford then turning west to the head of Loch Slapin. Parallel to this outcrop, younger Lower Jurassic limestones crop out to the south and east of the Cambrian strata.

Fossils- The Cambro-Ordovician dolostones contain fossils in the upper units present (see the Durness region description, above). The Lower Jurassic limestones are generally 'shelly', containing bivalves and gastropods.

Regional Geology Overview

Dip- The carbonate rocks of Skye are heavily faulted by tectonic forces and disrupted by igneous intrusions. Rock dip is very variable across the region.

Main Caves- Uamh Cinn Ghlinn, Camas Malag caves, High Pasture Cave, Valley Head Cave, Uamh Beinn an Dubhaich.

General Geology- The two main carbonate outcrops contain rocks described previously in the descriptions of the Durness and Applecross regions (see above). The Cambro-Ordovician outcrops contain rocks from the Grudaigh up to the Sailmhor Formations. In confined cave passages, the presence of cherty bands produces protruding layers which can be unwelcome! The presence of major igneous intrusions (e.g. granites) and associated igneous dykes in various areas complicates cave passage layouts, which are often multi-layered and with complicated plans. This is particularly noticeable in the caves of the Coille Gaireallach woodland area.

Appin

Age- Dalradian/Neoproterozoic – probably deposited 700-600? million years ago. No accurate dating has been done on these rocks.

Fossils- None known.

Dip- Very variable due to intense tectonism.

Main Caves- Uamh nan Claig-ionn, Uamh Steall na Burich, Draught Caledonian, Allt Coire Sheileach Cave, Owl Hole, Chamber Pot.

General Geology- Glenstockdale is a structural synclinal basin with the Appin Limestone member deposited low in the sequence as thin beds of possibly lagoonal muds. The subsequent deformation of the area by the Caledonian orogenic movements from the SW turned the original syncline into a complex of faulted isoclinal folds with steep dips in various directions. The often-banded limestones are usually dolomitic and sandy. Caves are usually short and complex.

Schiehallion

Age- Dalradian/Neoproterozoic – probably deposited *ca.* 650-600 million years ago.

Fossils- None known.

Dip- Very variable due to intense tectonism.

Main Caves- Foss caves, Lassintullich caves.

General Geology- The geology in this area is very complex due to intense tectonism during the Caledonian orogenic movements, mainly from the SW, and information is limited. The local carbonate rocks of the Blair Atholl Subgroup comprise two distinct marmorised (metamorphosed to marble) groupings: an older dark-grey rock interbedded with pelitic schists and a younger pale limestone interbedded with distinctive banded schists. The whole has been caught up in a massive overfold ('nappe'), of which it forms part of the core. Caves are fairly short, wet and the rocks sharp with protruding chert layers, although often attractive due to the banding of the rocks through which they have been cut. The various Foss caves are short intersections of one single line of drainage.

Regional Geology Overview

References and Bibliography

This document should be read in conjunction with the Caves and Karst document

Other useful references

Caves and Karst of the Yorkshire Dales Volume 1 pub by BCRA ISBN 9 780900265464

Caves and Karst of the Yorkshire Dales Volume 2 pub by BCRA ISBN 9 780900265488