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The Geoscience Wales Calendar 2019

The Geology and Scenery of the Peak District

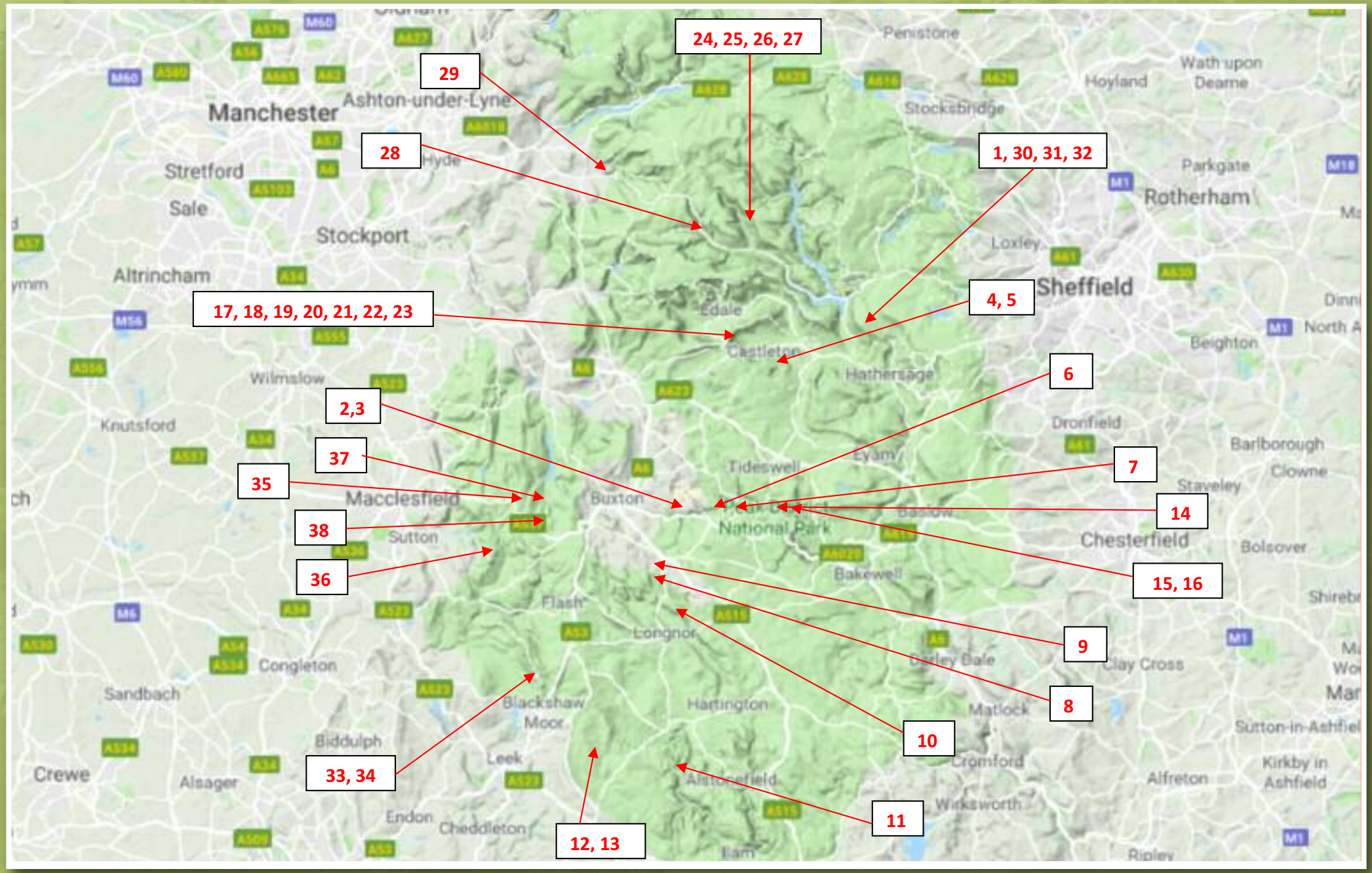
Photo 1, above. The dramatic rock structures of Bamford Edge (426m) in the foreground, give spectacular views westwards across the deep, wooded valley of the River Derwent to the steep pyramidal shape of Win Hill (462m, upper left, in the middle distance) and the broad, high plateaux of Kinder Scout (636m) and Bleaklow Hill (633m) on the skyline. The extensive and relatively resistant, coarse grained fluvio-deltaic sandstones of the Upper Carboniferous Kinderscout Grit form both the rocks of Bamford Edge, and cap the summits of all the higher hills in the distance, protecting the underlying shales and sandstones from erosion. It is the geological story of these beautiful landscapes, in the Peak District National Park area of northern England that is the focus of this year's Geoscience Wales Calendar.

Introduction: The Peak District: Topography, Landscapes and Geology.

The Peak District is an area of high gritstone moorlands, escarpments and elevated limestone plateaux located in the southern part of the Pennine Hills, which form the north-south oriented upland 'spine' of northern England. Recognised both nationally and internationally as an area of outstanding natural beauty, and being situated close to the large conurbations of Manchester, Sheffield and West Yorkshire, the landscapes and scenery of the Peak District region have been appreciated by generations of travellers and tourists, and were designated as Britain's first 'National Park', in 1951. As can be readily observed in the field, and in the landscape in general, the key foundations of the Peak District's great natural beauty lie in its underlying geology, with a range of contrasting rock types forming its diverse scenery of high moorlands, steep cliffs, deeply entrenched river valleys and gorges, and numerous 'swallow holes' and caves. However, in addition to forming such a beautiful landscape on the surface, the underlying rocks also provided a wealth of natural resources to power the industries of northern England. These include limestone, basalt, dolerite, sandstone, shale, coal, cement, lead and copper, and abundant supplies of fresh water, both for drinking purposes, and for industry. It is the exploration of the beautiful landscapes and fascinating geology of this area of northern England that is the subject of this years 2019 Geoscience Wales Calendar.

Geologically, the Peak District landscape is composed of rocks laid down entirely within just one period of geological time, the Carboniferous Period, which extended from around 360 to 300 million years ago. However, their varying lithology, including limestones, dolomites, sandstones, shales and coals give rise to a great variety of scenery and were deposited in a range of different environments. The early Carboniferous Period (The Dinantian Series of rocks) was dominated by carbonate rocks (limestones and dolomites) which mainly formed on shallow marine platforms and reefs, a bit like those of the Bahamas and Great Barrier Reef of today, and deposited in a similar tropical climate. However, in late Carboniferous times (Namurian and Westphalian Series of rocks) these carbonate reefs and platforms were gradually encroached upon, and eventually buried by, clastic sediments (shales and sandstones) transported into the region by large rivers and deltas which advanced towards the south and west. The following pages tell this evolving story in photographs and maps, including Map 1 below, which shows the location of all the photos used in this year's calendar, and Map 2, on the back cover, which shows the geology and stratigraphy of the area covered in this edition.

Map 1: Showing the Locations of all the Photographs Used in this Year's Calendar.



Google Maps 2018

Map2: Simplified Geological Sketch Map of the Peak District

Google Maps 2018

Map Legend: The Rock units exposed in the Peak District, in stratigraphical order.

Westphalian age (Upper Carboniferous) Lower Coal Measures: continuing deposition of fluvio-deltaic sandstones, mudstones and delta top coals, which indicate that the marine basins were now mainly filled up with sediment to sea level.

Namurian age (Upper Carboniferous) mudstones and sandstones of the **Edale Shales, Mam Tor Beds** and **Shale Grits**, representing initial deeper water clastic sediments (Edale Shales) followed by turbidite fronted delta muds and sands, and eventually fluvio-deltaic sands and muds (**Kinderscout, Roaches/Ashover, Chatsworth Grits and Rough Rock,** respectively) transported into the basins by river systems entering mainly from the north and east.

Monsal Dale Beds: mainly shallow water limestones thought to represent deposition in a lagoon within the eastern part of the carbonate platform, although darker, thinner limestones may represent deposition in deepening water conditions.

'Reef knoll' and marginal **'apron reef' limestones**, deposited within the central shallow water lagoon as algal mud mounds, and as fringing algal and then bioclastic reefs, respectively, which built up around the platform margins and sometimes locally in deeper water.

Igneous rocks: These are confined stratigraphically **within the Bee Low Limestones,** and mainly consist of quite extensive lavas and/or tuffs (volcanic ash) deposited both on land and in a marine environment, but the actual sites of some volcanoes have also been identified. They probably represent volcanic rocks erupted during a period of crustal extension in **Lower Carboniferous** times.

The **Bee Low Limestones:** The most extensive limestones within the Peak District, representing the continuing build-up and more widespread development of shallow water limestones on the Derbyshire Platform in **Lower Carboniferous** times.

The two main exposures at the surface of the deepest buried and oldest rocks in the Peak District, the **Woodale Limestones** and the underlying **Woodale Dolomites,** which represent the initial and early stages of development of a carbonate platform on a pre-existing topographic high in **Early Carboniferous** times.

Sketch map and geological information based on publications produced by the British Geological Survey, including 1:50,000 scale geological map sheets 99 and 111, and British Regional Geology Series Guide, 'The Pennines and Adjacent Areas', BGS, Nottingham 2002.

The Woodale Dolomite and Woodale Limestone in the Western and Central Wye Dale Gorge: The Oldest and Deepest Rock Units Exposed at the Surface in the Peak District.

Photo 2, above. The river Wye, in upper Wye Dale, looking northwest up the tributary valley of Woo Dale. The Wye's upper tributaries originate to the west of Buxton, and flow eastwards, down from the high western moors of Black Edge, Burbage Edge and Axe Edge, which have a relatively high rainfall and are mostly underlain by Upper Carboniferous age Namurian and Westphalian sandstones and shales, with the shales being impermeable. As a result, the Wye is the only river which has a year round flow sufficient to maintain its course across the whole outcrop of older, Lower Carboniferous (Dinantian) limestones and dolomites which have been exposed to the east of Buxton by erosion within the uplifted dome or platform of the central Peak District, revealing the previously buried carbonate platforms which lay beneath. In doing this, it has managed to carve a mainly east-west oriented gorge, The Wye Dale Gorge, around 16km long and up to 150m deep, from Buxton to Bakewell.

Photo 3, above. Looking back, south-eastwards, down Woo Dale towards its confluence with the river Wye (in the trees in the distance). Many of the smaller tributary valleys, like Woo Dale, are 'dry valleys' for most or all of the year (with most of their drainage being only locally sourced) and much of the water disappearing down through cracks and cave networks dissolved into the limestone beneath. The Woodale Limestones, seen here in the cliff at right, and the underlying Woodale Dolomites (probably buried here beneath the vegetated valley floor) are the oldest (and most deeply buried) rocks exposed within the Peak District. They are only revealed at the surface here, and at a few other similar locations, mainly within deeply incised river valleys and gorges, which now show the internal structure and stratigraphy of the mainly gently sloping central 'dome' uplift. Nowhere in the Peak District are any older, pre-Carboniferous rocks seen at outcrop. However, a deep borehole, drilled here in 1948, revealed the presence of pre-Carboniferous volcanic breccias and steeply tilted volcanic rocks at about 272 m depth below the surface, indicating that this area was probably dry land prior to the Early Carboniferous, when marine transgressions and tectonic subsidence started off the accumulation of Dinantian age carbonate platforms and coral reefs, perhaps quite similar to those of the Bahamas today.

January 2019

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The Bee Low Limestones: The Northern Edge of a Carbonate Platform and Fringing Apron Reefs Revealed at Winnats Pass, near Castleton.

Photo 4, above. About 10km to the north of the Wye Dale gorge, where deeply entrenched rivers have exposed the Woo Dale dolomites and limestones near the centre of a large carbonate platform structure (the Derbyshire Dome or Platform) a similar deep, gorge like valley, Winnats Pass, has also cut down into the underlying limestones. However, these limestones are part of the overlying Bee Low Limestones, which lie on top of the Woo Dale Dolomites and Limestones (which are not exposed here, because erosion has not cut down so deeply, although they are seen slightly further west, around the small village of Peak Forest). The Bee Low Limestones are therefore slightly younger than the Woo Dale dolomites and limestones, and sit stratigraphically higher in the geological sequence (see geological map, Map 2 on back page for stratigraphical sequence of the rocks exposed in The Peak District). They form part of the continuing build up of carbonate rocks which accumulated on the northern margins of an underlying basement high, probably formed by crustal extension and rifting in the Late Devonian and Early Carboniferous periods.

Photo 5, above, shows an interesting stratigraphic sequence within the Bee Low Limestones in the Winnats Pass gorge. The upper line of cliffs along the skyline consists of almost horizontal to only slightly dipping (up to about 6-7 degrees, maximum) initially thinly bedded, then thickly bedded to massive, white limestones. Fossil and lithofacies analysis has shown that these rocks represent the accumulation of almost horizontal layers of lagoonal limestone muds within the carbonate platform's central lagoon, followed by more massive reef margin type limestones which formed around the north-eastern rim of the carbonate platform. At the left hand side of the skyline, the bedding planes within the white limestone cliffs can be seen to begin to dip down towards the left, towards the northeast. Photo 4 shows the continuing, lower section of Winnats Pass gorge, where the beds in the same cliff line can be seen to merge and dip downwards to the left. These steeply inclined (at about 18-24 degrees) more thinly bedded limestones represent a fringing margin of carbonate muds, sands and fossil debris which were washed out of the lagoonal platform area above to form a series of 'apron reefs' and talus slopes around much of the platform margin.

February 2019

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The Bee Low Limestones: The Central Carbonate Platform in the Wye Dale Valley, and the First Igneous Rocks.

Photo 6, above. In the central part of the carbonate platform, around the Wye Dale gorge to the east of Buxton, thick units of carbonate mud and sand, with their associated shallow marine lagoonal and knoll reef fossils, continued to accumulate throughout the Lower Carboniferous (Dinantian) period. These rocks are also part of the thick sequence of Bee Low Limestones, seen further north at Winnats Pass, near Castleton. Here, in the cental Wye Dale gorge, they also form spectacular limestone cliffs and pinnacles, etched out by the continuing down-cutting erosion of the river Wye. Behind the gorge, on the distant skyline can be seen the typical flat, to gently rolling uplands of the central plateau area, which is also mainly underlain by the Bee Low Limestones, as well as the overlying, slightly younger Monsal Dale and Eyam limestones, which continued to accumulate in the central and eastern lagoonal areas of the carbonate platform.

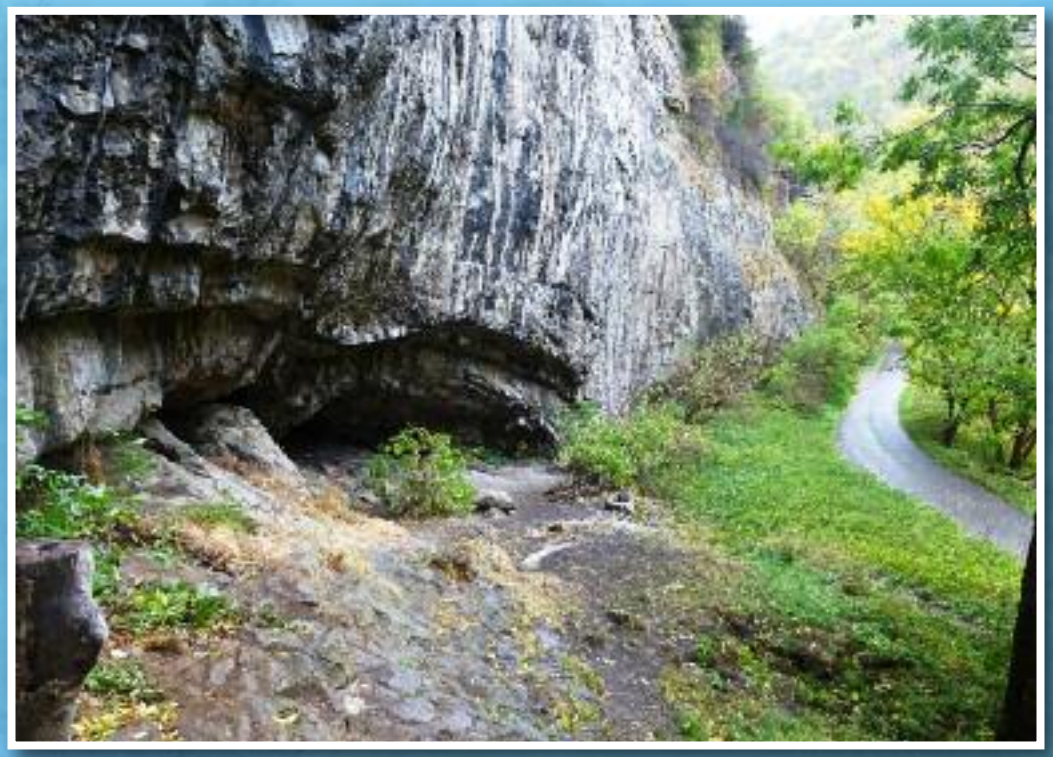

Photo 7, above. Slightly further east, down the Wye Dale gorge, near Ravenstor and the small village of Miller's Dale, the base of the massive to thick bedded Bee Low Limestones is exposed in a roadside cave. Here, the River Wye has eroded the basal contact between the Bee Low Limestones above, and the Lower Miller's Dale lava below (darker, slightly greenish rocks in the foreground). These basaltic lavas were erupted out of volcanoes which were situated in the surrounding area of the carbonate platform in the central Peak District, with two possible agglomerate filled vents being identified just to the northwest of here in the tributary gorge of Monk's Dale. Several of these lavas occur at different levels within the limestones, along with some volcanic ash layers (known as 'tuffs'). These igneous rocks only occur within the Lower Carboniferous limestone sequence, and were thought to be partly sub-aerial and partly submarine. They are probably associated with early Carboniferous crustal extension, block faulting and tilting, and later subsidence, which occurred in this area of northern England.

March 2019

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The Bee Low Limestones around Earl Sterndale and Hartington: The South-Western Margins of the Carbonate Platform Revealed by Erosion.

Photo 8, above left. About 10km to the southwest of the Wye Dale gorge the small hamlet of Harley Grange lies in a picturesque green valley with the high ridge line of hills on the left skyline, above the village of Earl Sterndale. On the right skyline, in the distance is the steep, conical hill of High Wheeldon (422m). The limestone beds in the hills at the left, and in the left-hand slope of High Wheeldon, can be clearly seen to lie almost horizontally. These are the shallow water platform and lagoonal limestones of the Bee Low Limestones. However, the right-hand slopes of High Wheeldon are composed of, steeply dipping limestone mud and rubble, which slope down steeply to the right, into a deeper water marginal basin (the Widmerpool Gulf) that lay to the southwest of the main Derbyshire Platform structure. **Photo 9, above right.** Buxton quarry, just to the north, has been excavated deeply into the Bee Low Limestones (and possibly part of the overlying Monsal Dale Limestones) and clearly shows the sub-horizontal, thickly bedded, white limestones which accumulated within the shallow water platform area and its central and eastern lagoons. **Photo 10, below left.** Just to the south of the village of Earl Sterndale, the steep slopes of Hitter Hill give excellent views north-westwards to the steeply sloping apron reef limestones of Park House Hill and Chrome Hill, which formed the south-western margins of the Derbyshire Carbonate Platform in Dinantian times.

April 2019

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Carbonate Knoll and Reef Mound Facies in the Widmerpool Gulf: The Hopedale and Milldale Limestones of the Manifold and Dovedale Valleys, and thinner bedded Ecton Limestones of the Mixon-Morridge Anticline.

Photos 11, 12 and 13. As the Woo Dale Dolomites and Limestones, and succeeding Bee Low Limestones were accumulating on the pre-existing 'structural high' of the Derbyshire Platform, they gradually built up an extensive, mainly shallow water carbonate platform, with fringing coral reefs, steeply outward sloping 'apron' reefs (which shed calcareous debris into the surrounding deeper water basins) and a central, shallow water lagoonal system. However, to the south-west of the Earl Sterndale area, in the present day Dovedale and Manifold valleys, a deeper water submarine basin or ramp like bathymetry existed, which became deeper and broader towards the south-east. This basinal area was called the Widmerpool Gulf, whilst further to the south-west a second carbonate platform had developed, called the Staffordshire Platform (see Geological map on back page). In these deeper water areas carbonate algal mud mounds also managed to build up locally, sometimes able to keep pace with sea level rise, and/or basin subsidence, to develop into steep, massive 'knoll' shaped reefs **(Photo 11, above left)** mainly within the Hopedale and Milldale Limestones. In the surrounding, deeper water parts of the gulf, darker, more thinly bedded, locally cherty, lime muds **(Photo 12, upper right)**, and fossil debris rich carbonate sands, known as the Ecton Limestones **(Photo 13, lower right)** accumulated, sometimes as interbedded turbidite facies.

May 2019

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The Monsal Dale Limestones and Dark Limestone Facies: Eastward Tilting in the Lower Part of the Wye Dale and Monsal Dale Valleys

Photo 14, above left. To the east of Ravenstor, near the small village of Cressbrook, the River Wye continues to cut a beautiful, tree lined gorge through the thick, Lower Carboniferous limestone sequences. However, here, the thickly bedded to massive, pale grey to white Bee Low Limestones gradually begin to disappear beneath the thinner, and locally darker, beds of the Monsal Dale Limestones, a transition possibly shown by the lower and upper parts, respectively of the steep cliff and overlying slopes seen here. **Photo 15, above right**. The popular walking and cycling route of the Monsal Trail, which follows the course of the old Buxton to Bakewell railway line, slices several long, and geologically revealing cross-sections through the Woo Dale, Bee Low and Monsal Dale limestones, which succeed each other upwards in the ancient carbonate reef and lagoonal facies of the Derbyshire Platform, (see geological map on back page). Here, the distinctly thinner bedded, and often darker lagoonal facies of the Monsal Dale limestones can be seen to dip gradually eastwards, away from the central crest of the anticlinal dome like structure, seen earlier at Woo Dale. **Photo 16, lower right.** Close up view of the thinner Monsal Dale Limestones, with softer, intervening, darker lagoonal mudstones.

June 2019

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Deeper Water Sediments in the Surrounding Basins: The Namurian (Upper Carboniferous) Edale Shales.

Photo 17, above left. The dramatic cliffs of Mam Tor (517m) and its continuing eastern ridge to Lose Hill (476m) rise to the west and north of the present day, deep Castleton-Hope valley, which formed part of a larger Alport/Edale Basin, to the north of the carbonate reef build ups of the Derbyshire Plafform, in Early Carboniferous times (see geological map back page). The bluish grey hillside at the left of the photo is composed of very soft, easily eroded, thinly bedded shales, the Edale Shales, which accumulated in this deeper marine basin from at least Early Namurian times onwards. They represent the steady fall out of very fine grained mud, locally with calcareous, cherty and iron oxide stained layers and nodules, called 'bullions' **(Photo 18, above right)** which are much harder and stand out as thicker, more resistant layers locally. However, the shales are structurally very weak, and often collapse under the weight of the overlying interbedded layers of shales and thick sandstones, as has occurred here at Mam Tor, producing the huge landslip scar which forms the cliffs behind. In the foreground, the thick, multiple layers of tarmac of the old Castleton to Manchester main road also show the effects of this ongoing process; continual landslips over the last century eventually resulted in the enforced abandonment of this road, which has now almost totally disintegrated in places. **Photo 19, lower left.** The deeper marine environments of the basinal areas surrounding the carbonate platforms often contain goniatites and other deeper water fossils. The rapidly evolving, and geographically widespread goniatites, in particular, have been extremely useful in dating and defining the Namurian stratigraphy in this and other areas, helping to identify the stratigraphic sequence.

July 2019

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The Mam Tor Beds: 'Distal' Turbidite Fronted Delta Sediments Encroach from the North, Begin to Fill in the Deeper Marine Basins, and Smother the Carbonate Reefs.

Photo 20, Upper left. The 130m high east face of Mam Tor exposes the multiple, stacked strata of interbedded darker shales and pale cream to brown sandstones of the Mam Tor Beds.

Photo 21, top right, shows a closer view of the distinctive, darker coloured shales and lighter coloured sandstones near the base of the cliff. The Mam Tor Beds represent the accumulation of hundreds of metres of submarine turbidites which avalanched off the front of large river deltas entering the Alport/Edale basin from the north and east, and sweeping down into the deeper marine basins which surrounded the carbonate platforms to the south. The thick sandstones often show graded bedding **(Photo 22, lower left)** and elongated, erosive scour structures at their bases **(Photo 23, above right).**

August 2019

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The Shale Grit at Alport Castles: More 'Proximal' 'Turbidite Fronted Delta' Sediments Become Thicker and Coarser Grained Towards the North.

Photo 24, above left, shows another spectacular cliff face, this time in Alport Dale, about 9km north of Castleton, which shows an excellent cross-section through the regional stratigraphy. In this case, these are the so called 'Shale Grit' These rocks lie stratigraphically above the thinner, more shale dominated Mam Tor Beds, seen further south, around Mam Tor itself, and are much more proximal, sand dominated turbidites, this time containing only relatively thin, subordinate, intervening shales.. Like the Mam Tor cliffs, these cliffs were formed by collapsing of the underlying shales, creating the back scar cliffs seen here, and the rubble filled valley in **Photo 25, above right.**

Photo 26, above. The Shale Grit gets its name from the frequent inclusions of shale mud clasts, probably incorporated into the sandstones by fast flowing submarine turbidite currents which eroded the underlying muds.

Photo 27, above. This photograph clearly illustrates the much thicker sandstone turbidite beds of the Shale Grit, which are coarser grained, and often erode down into the much thinner mud/shale layers beneath (darker, recessed layers in lower part of cliff section).

September 2019

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The Kinderscout Grit: The Marine Basins Begin to Fill Up With Sediment, and River Mouthbar, Fluvial Channel and 'Fan Delta' Top Sediments Become More Widespread and Coarser Grained.

Photo 28, above, taken in the Woodlands Valley, just south of Alport Castles. The lower hill slopes are formed from the Mam Tor Beds and Shale Grit, seen earlier at Mam Tor and Alport Dale, respectively. However, the crest line of the hills behind (Kinder Scout, 636m) is formed from thick bedded to massive, coarser grained, pebbly sandstones of the Kinderscout Grit. This formation probably represents the spread of more proximal, shallower water and laterally more extensive mouthbar, 'fan delta' top and fluvial channel sandstones (as seen in **Photo 30, below**) into the marine basins from the north and east. Locally, thin coal seams, representing delta top vegetation, can also be found, showing that by this time the basins were filling with sediment right up to sea level.

Photo 29, above. The Kinderscout Grits, seen further west, at Shire Hill Quarry, near Glossop. Here they occur at a much lower elevation (around 300m) due to gentle folding and downward dip to the west, into the tighter north-south oriented folds found along the western margin of the Derbyshire Dome structure.

Photos 31, above left, and 32, above right. These photos clearly show the coarse grained, often more poorly sorted, pebbly sandstones of the Kinderscout Grit. The sample in Photo 31 is quite feldspar rich, much of which has weathered to pale cream clays, making it weak and crumbly; the sample in Photo 32 is much more quartzitic, and more strongly silica cemented.

October 2019

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The Roaches and Ashover Grits: Continuing Deposition of Fan Delta and Fluvio-deltaic Sediments, Sea Level Fluctuations, Folding and Fracturing the Rocks.

Photos 33, above, and 34, left. Following on from deposition of the Kinderscout Grit, which seems to be the first major, laterally more extensive, 'fan delta top' type sandstone (at least in its upper unit) several other, similar, coarse grained, often cross-bedded, fluvio-deltaic sandstone were also deposited across the Peak District area in Namurian (Upper Carboniferous) times. Most of these sands were transported into the area by large river systems and deltas, which prograded towards the south and south-west, filling in the Alport and Widmerpool Basins and spreading across, and terminating development of, the Early Carboniferous carbonate platforms. They are thought to have been sourced from the eroding Caledonian mountains, which were located in the present day Greenland/Scandinavia/Scottish Highlands region, far to the north and east. However, fluctuating sea levels (associated with alternate ice cap formation and melting in the southern hemisphere) and probably also delta lobe subsidence and channel switching, led to frequent re-flooding of the delta tops and the deposition of intervening mudstone/shale units deposited in either fresh water lakes, brackish bays and lagoons, or more extensive transgressive marine flooding events. These later sandstones include the well known Roaches/Ashover Grits, and the Chatsworth Grit. Along the western edge of the Peak District Dome structure, many of these thick rock units were uplifted and folded, probably in the Late Carboniferous/Early Permian Hercynian Orogeny, and now form rugged gritstone 'edges' and escarpments, such as those of the Roaches and Hen Cloud rocks seen here **(Photos 33 and 34, respectively)**.

November 2019

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The Chatsworth Grit and Rough Rock, and the Westphalian Coal Measures: Delta Top Sandstones, Tropical Forests and Fuel for the Industrial Revolution.

Photo 35, above. The Chatsworth Grit now forms many of the steep 'edges' or escarpments along the western edge of the Peak District, between Macclesfield and Buxton. Here, at Shining Tor (559m) it can be seen to be tilted to the left (east) to form the western limb of the north-south oriented Goyt Trough, an extensive synclinal fold structure probably developed by east-west compression and uplift in the Hercynian Orogeny.

Photo 36, above. The striking, sharp peaked summit of Shutlingsloe (506m) is formed by a small capping remnant, or outlier, of the relatively hard and resistant Chatsworth Grit. However, the rest of this and other rock units (both underlying and overlying) have clearly been eroded away in the surrounding area by extensive uplift and subsequent river erosion.

Photo 37, above. The Rough Rock is the highest, fluvio-deltaic, fan-delta type sandstone or 'grit' deposited in the Namurian Series of the Upper Carboniferous Period. It is also one of the most extensive, covering much of northern England. This outcrop is in the Goyt Valley, on the western edge of the Peak District.

Photo 38, right. This spectacular outcrop occurs in the upper Goyt Valley, close to the famous Cat and Fiddle Inn. A small tributary stream has eroded into the relatively soft shales. These overlie a harder, flat bedded sandstone in the stream bed. This sandstone is the Woodhead Hill Rock. It is the first sandstone in the Westphalian Series of rocks, commonly known as the 'Coal Measures' which overlie the Dinantian Limestones and Namurian sandstones and shales. Indeed, a thin, dark grey coal can be seen at the base of this outcrop. It was the occurrence of many, much thicker delta top coals like this which provided the fuel for the Industrial Revolution.

December 2019

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