# The Old Red Sandstone: is it Old, is it Red and is it all Sandstone?

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## Abstract

This three-day symposium focussed on the Old Red Sandstone (ORS) took place during Friday 3rd October – Sunday 5th October 2014 at the Elim Church Centre, Brecon, Powys, Wales, UK and at field locations in the close area. The conference was arranged and hosed by members of the South Wales Geologists' Association and Fforest Fawr Geopark with support and grants from the Paleontological Association and the Geologists' Association. It was advertised as being "of interest to all geologists, particularly palaeontologists, stratigraphers, sedimentologists and structural geologists comprising lectures, field excursions, poster displays and public activities in the heart of the Fforest Fawr Geopark," and universally agreed to have met these aims.

The conference and the papers which were presented on the Friday and Saturday along with the building stones walk around the town of Brecon, were the core of the event with 94 delegates attending for one or both of these days. 58 delegates then joined one or the other of the field trips arranged for the Sunday. The conference centre was also filled with exhibitions and posters from local groups and geological organisations.

Sessions were titled 1. Review of the ORS, 2. Palaeontology, and 3. Sedimentology and Lithostratigraphy. Lectures dealt with such subjects as historical figures in ORS geology, the Fforest Fawr Geopark, aerial photographic reconnaissance, fossil fish, plant evolution, soft-sediment deformation and ORS stratigraphy.

This report covers the event, abstracts are provided for the sessions not included in this thematic volume.

## Friday 3rd October 2014

The event was opened by Councillor Geraint Hopkins (Chairman of the Brecon Beacons National Park) who welcomed everyone to the area and wished the conference delegates would "enjoy all aspects of their stay in the beautiful location of the National Park". Paul Olver, who chaired the morning sessions, introduced Brian Williams who delivered the keynote address for the conference entitled **"The Lower Old Red Sandstone Continent: Wales and Beyond"** (Abstract below).

His address provided an overview and then in-depth descriptions of some of the stratigraphy, facies and complexities found in the ORS and their development though geological time. He also described where further work was needed to apply modern thinking to complex models that are in need of refinement. His presentation was informative and also provided an overview for those delegates not already familiar with some aspects of the ORS as it also covered some history of research, current theories.

[Figure1]

After a break for refreshments the morning session continued with Anthony Brook presenting on the topic of **Murchison and Miller: Contrasting founders of the Devonian or Old Red Sandstone** (Abstract below). During this he gave a historical overview of these two key contributors to not only the ORS, but to geological science overall.

He was followed by Tony Ramsay who spoke about the **Fforest Fawr Geopark - distinguished by its geological, industrial and cultural heritage** (paper in this volume) in which he described how Fforest Fawr Geopark became a member of the European and Global Geoparks Networks in 2005 and the first geopark in Wales. The geopark was established in the western area of the Brecon Beacons National Park, an area with a strong identity in terms of its geology, industrial and cultural heritage.

Finally, in the morning session, Toby Driver presented on **Old Red Sandstone landscapes in Wales: the view from the air'** (abstract below) showing a number of sites that are on (and often made from) the ORS.

The afternoon sessions were chaired by Tony Ramsay and the first paper was read out for Alain Blieck and David K. Elliott **Pteraspidomorphs (Vertebrata) and the Old Red Sandstone**. (Paper in this volume). This was followed by Bob Davidson who presented a paper on behalf of his co-authors (Michael J. Newman, Carole J. Burrow, Jan L. den Blaauwen and Roger Jones) entitled **Scottish Lower Devonian ORS: a separate realm or connected with the Anglo-Welsh Basin? The vertebrate perspective...** (Paper in this volume) this illustrated how vertebrate species are being found to co-occur in different basins, demonstrating close connection between the Midland Valley of Scotland and the Anglo-Welsh basin of the Lower ORS.

Susan Turner then presented a work by Carole Burrow, Rod Williams and her **Welsh Borderland bouillabaisse: bonebeds, age control, palaeo(bio)geography lifestyles and diversity of microvertebrates (thelodont, acanthodian, 'shark', placoderm scales)** (Paper in this volume). The range in space and time and environment of many taxa was shown to reveal interesting patterns including the observation that nearly all microvertebrate taxa have a wide geographic distribution and thus do not support a wholly freshwater provenance for the Lower ORS in this region. She ended by summarising that each fish can tell us something about biology, evolution, environment and overall biodiversity and deserve further study.

After an afternoon break, Jennifer Morris presented work by her and Dianne Edwards on **Colonisation of the Old Red Sandstone Continent: recent advances in early land plant research from the Welsh Borderland** (Abstract below). This talk included examples and information from the Tredomen Quarry which many of the delegates were able to visit the next day.

The final speaker in this session was Christian Baars who spoke on **Environmental effects of early land plant evolution – atmospheric $CO_2$ during the Devonian** (Paper in this volume) he explained how plants with large rooting systems did not evolve until the mid-Devonian. The evolution of roots resulted in an increase in chemical weathering of silicate rocks. This, in turn, caused a contemporaneous drop in atmospheric $CO_2$ concentration.

## Conference Dinner

After the discussion session, 48 of the delegates retired to the Brecon Castle Hotel for the conference dinner and the after-dinner entertainment by Duncan Hawley. This was a talk and quiz regarding items that were ORS related. As part of his entertainment he showed pictures a number of very early maps of the region and strata and then further entertained the delegates by showing the originals of many of these historical maps which he had kindly brought with him.

## Saturday 4th October 2014

This session was chaired by Brian Williams and was started with a presentation by Duncan Hawley on **the Old Red Sandstone of the Black Mountains of Powys & Herefordshire: Filling the 'Black Hole'** (Abstract below). In this he explained how serious study of the ORS in the Black Mountains in the past has been sporadic and limited rather than systematic - the area to some extent formed a 'black hole' and indicated some possibilities for future study and increased understanding.

He was followed by Geraint Owen speaking about **Soft-sediment deformation structures - their nature and palaeogeographical implications** (Paper in this volume). In this paper, he showed many examples of significant levels of soft sediment deformation and discussed how trigger events such as earthquakes could be postulated from studies of these formations.

After a short break, John Davies presented on **the identification of mappable, litho-stratigraphical sub-divisions of the Brownstones across its outcrop** (Abstract below), explaining how through detailed mapping he had observed soft sediment deformation at the base of the Senni and Llyn-y-fan formations, and that these events could be used to divide the Brownstones into four divisions rather than the three divisions currently recognised.

He was followed by Kate Andrew who presented a paper on **A Thousand Years of Building with (Old Red Sand) Stone (**Paper in this volume), by herself, Beth Andrews and Elliot Carter. This focussed on their work to create an online database supported by teams of volunteers who have been recording stone built buildings and quarries in the field and undertaking archival research to investigate documented sources of stone for specific buildings.

This brought the presentation of formal papers to an end, but the symposium continued with an afternoon of events.

## Video Presentations

There were two video presentations

Allan Cuthbertson: Film: **The ORS from the air.** Alan is a member of the SWGA and shared with the group his work taken whilst flying over areas of the ORS in South Wales.

Kester & Elizabeth Webb: **The hidden edge of Exmoor, north Devon – low level aerial photographs and topographical drawings** (abstract below) The 'Hidden Edge of Exmoor' expeditions took several years, with the restrictions of weather and ten metre tides. They were recorded on colour transparency film and by means of topographical drawings of a style they termed 'geomorphic'. These drawings emphasised the strata and geological structure of the sea-cliffs, and at the same time enhanced the 'rock-experience' by leaving out the vegetation. In later years, they also took flights in old Auster aircraft, which enabled them to obtain low-level aerial photographs of the cliffs from 300 ft. (90 m) above the sea.

## Building stones walk

The building stones of Brecon town centre were examined in excursions led by Jana Horak and John Davies (Amgueddfa Cymru – National Museum Wales / Welsh Stone Forum). This included the dominant building stone of Brecon;, St. Maughan's Formation, cream, grey-green and maroon locally derived sandstones. The walks looked at a number of old and new buildings, a summary of some of the key points are given here.

There were two excursions which took different routes for reasons of expediency, but saw substantially the same localities. The description here is from the handout provided for the event.

The excursion starts to the north of the town centre. Small exposures below the Cathedral, in the Honddu gorge provided the opportunity to examine the bedrock geology. These maroon to greyish-green sandstones are the likely source of much stone used in the town, including in the cathedral in the form of carved effigies, pillars and floor slabs. Examples of the use of the maroon sandstone were observed in buildings in Postern Street, as stepped course work in the fabric of the Old School (with dressings of Forest Pennant Sandstone), and rectangular coursed work in the Old Gaol.

Stones sourced from outside the town were also encountered in the old railway house (Ely House). Here sandstones, from the base St Maughan's Formation, form a coursework of distinct pale greenish-grey sandstone, informally referred to as 'Hay Stone', and softer greyish-green coloured Senni Beds, were used to construct the old railways bridge and station. These stones show the influence of transport enabling stone to be brought to Brecon during the building of the railway, such as the Senni Stone from Sennybridge to the west, or after the 1860s by railway. The influence of the railway is documented in the use of Bath Stone and Forest Pennant Sandstone as dressings.

From Market Street, the walls of the castle (now a hotel) were observed. The towers have rubble walls, composed of both St Maughan's Formation, maroon sandstones and pale, green-grey 'Hay' Stone. This mixture of maroon and greenish-cream sandstones is seen in most of the buildings of the town with a tendency for dressings to be dominated by 'Hay' Stone reflecting its more versatile properties. This mixture of stone is seen again in the fabric of the Market House originally built in the 1839-40.

[Figure 2]

In centre of the town there is a contrast between the pre-railway Town Hall (1850) constructed from maroon St Maughan's sandstones coursework and St Mary's church (medieval but extensively rebuilt in C19th) and the use of 'exotic' building stone brought in by the railway post 1860s, for high prestige buildings such as banks Examples include Bath Stone ground floor level frontage for the National Westminster Bank, High Street Superior (originally

the National Provincial Bank and the neo-baroque ashlar stone edifice of the HSBC building (High Street Inferior), built in 1913 from Cefn Stone from the Wrexham area. It is noteworthy that the later modifications of the Town Hall include bricks derived from the South Wales coalfield and use of a more brick-red sandstone, probably Wilderness Stone from the Forest of Dean.

[Figure 3]

Similarly St Mary's church has replacement (post-medieval) window dressings of both Bath Stone and Wilderness Stone. It is also of note that the Museum, built in the Greek-revival style in 1842 as the Brecknock Shire Hall, pre-dates the coming of the railways to Brecon and was most likely brought by canal.

[Figure 4]

On the last leg of the walk, the Town Wall was examined in Captains Walk.

[Figure 5a]

The significance of how the orientation of stone can affect its durability was viewed. Examples of face-bedded blocks, where the stone is laid with bedding parallel to the surface of the wall were seen, and effects of extensive weathering clearly seen.

[Figure 5b]

At the end of the trip the conference centre (Elim Church, Canal Road) itself provides an example of modern build faced with St Maughan's Formation maroon and greenish sandstones. These were quarried from the only working local quarry in the area, at Tredomen. This stone is recognisable by its slightly wider range in colour than the predominant stone used in Brecon. Although not comprehensive the excursion gave a flavour of the stones used in the town and identified topics for further investigation.

## Stands and stalls

The whole event was supported by a large number of organizations who had well manned stalls with displays, give away items and items to purchase.

South Wales Geologist's Association had both an information stall with displays and a selection of geological books and maps for sale. They also had at the event Dilys Harlow who was launching her book published by the South Wales Geologists' Association, The Land of the Beacons Way.

figure 6]

A list of other groups and individuals who put on displays is provided here: -

Geologists Association National Body
National Museum of Wales
Teme Valley Geological Society
Woolhope Naturalists' field club
British Geological Survey Welsh Office
Forest Fawr Geopark
OUGS Severnside Branch
SE Wales RIGS group
Geoworld Travel
Natural Resources Wales
Mid Wales geology Club
Hereford and Worcester Earth Heritage Trust
Welsh Borders Early Vertebrate Research Group
Kester and Elizabeth Webb
Colin Humphrey
Mike Featherstone
Peter Tarrant & Maggie Rowlands

## Sunday 5th October 2014

There were two optional field trips arranged for the symposium

### 1. The Old Red Sandstone of the Black Mountains Tredomen Quarry, Cockit Hill and Tremynfa Quarry

This was led by Duncan Hawley and was to explore recent work on the sedimentary, fossil and trace fossil evidence found in the St. Maughan's Formation (Freshwater Formation) and succeeding Senni Formation of the Talgarth (Back Mountains) area. The trip was an opportunity for observing and discussing facies interpretations and how these throw some light on our understanding of changing palaeo-environments in the Lower ORS along with learning about some of the fish, arthropod, ichnofauna and other finds from these exposures.

The first stop was Tredomen Quarry (NGR SO 116 304) where access was provided by the kind permission of Keith Jones of Llangorse Stone. The quarry has two working areas the West and East pits and the group visited both of these.

Excellent exposures of the lower St. Maughan's Formation allow the reconstruction of changing fluvial architecture and environments which we were able to envisage with the help of Duncan. We started with the lowest strata exposed in the West pit before exploring an area where a small fault cuts the northern part of the East pit.

[figure 7]

The next locality was Cockit Hill (NGR SO 160 278) to study the Senni Formation where exposures were examined in crags which comprise medium / coarse sandstone in upward fining channel units up to 2 m thick. The group spent some time looking at the various lithologies and then the various burrows which are found in the formations including reticulated bioturbated patches of unknown affinity known as 'pepperpot structures'.

[figure 8]

After a brief stop at Bwlch (NGR SO 148 222) to look at the Ffynnon Limestone Member we headed to the final stop of the trip which was Tremynfa Quarry (NGR SO 159 224) to examine the conglomerates and channel sandstones in the Senni Formation, about 100m stratigraphically above the Ffynnon Limestones.

### 2. Fan Fawr and Blaen Llia

This trip was led by John Davies and examined the transitional relationship between the Senni Formation and the overlying Brownstones Formation, both of Lower Devonian age and to discuss the palaeo-environmental implications of this sedimentary sequence. The morning involved a fairly stiff climb up a stream section on Fan Fawr to the south-west of Storey Arms in order to examine in outcrop the evidence for a proposed new sub-division of the Brownstones-Senni formations on the basis of the evidence presented by John in his presentation the day before.

The afternoon was spent examining exposures on Fan Llia to the south-west of Fan Fawr where soft-sediment structures within the lower part of the Brownstones Formation provide evidence of major tectonic activity contemporary with deposition.

## Acknowledgements for the event.

This conference could not have been successful without the immense amount of hard work by a lot of people. In addition to the speakers and leaders mentioned above the organizers would like especially thank the following people

Stephen Howe, Alan Bowring, Geraint Owen, Hazel Trenbirth, Janet Hiscott, Rhian Kendall, Cindy Howells, Lynfa Lewis, Brian Drew. Marnix Roels, Toby Small, Clive Williams, Judith Harvey, Ron Layton, Lynda .

Whilst noting the contribution of all the groups mentioned above, the following organizations were key to the success, South Wales Geologists Association who were the overall organizing body, Forest Fawr Geopark who provided a lot of logistics support including drivers for the field trips, British Geological Survey for delegate bags, the National Museum of Wales for exhibition materials and for running the children's colouring competition and the catering staff and members of the Elim Church In Brecon.

The Geologists Association and Palaeontological society are thanked for their support and also their funding to ensure that the event went ahead.

## Acknowledgements

This report could not have been collated without the input of the speakers and leaders who provided their abstracts and field guides for the event, and especially to Hazel Trenbirth, Janet Hiscott, Rhian Kendall, Stephen Howe, Lynda Garfield who provided information that has been used in the collation of this report. Figure 5 by Jana Horak, All other photographs by Andy Kendall

# Abstracts

Abstracts are provided of the conference papers not presented as formal papers in this volume.

## The Lower Old Red Sandstone Continent: Wales and Beyond

Professor Brian PJ Williams[1]

[1]University of Manchester

The Lower Old Red Sandstone Continent formed in Siluro-Devonian times by the amalgamation of Laurentia with Baltica and the microcontinent Avalonia. Basins containing infills of Lower ORS magnafacies developed on the margins of, and within, this continental landmass - named Laurussia. In contrast to the intramontane basins of Scotland and Norway, external basins formed south of the Caledonian mountain front and include the Anglo-Welsh, Dingle and Gaspe Basins. These basins preserve predominantly continental red-bed infills and record differing depositional architectures reflecting variations in subsidence and tectonic histories, provenance and depositional mechanisms.

The Lower ORS facies of these three basins reveal a transitional contact with the underlying marine Silurian – mainly Ludlovian – sediments of estuarine, barrier / shoreface or deltaic origin. These Lower ORS basins contain broadly punctuated, upward-coarsening sequences varying between 2.8 and 4.5 kms in thickness. The UC character of their fills is in response to the onset of Acadian deformation which climaxed in the Emsian (Wales and Ireland) or Middle Devonian times (Quebec). The infills are dominated by fluvial sediments with some influences from lacustrine, aeolian and shallow marine processes. The fluvial deposits are of varying styles and provenances, both ephemeral and perennial in nature, and show both axial and lateral inputs into the basins.

The Lower ORS has long been of interest due to the presence of early vascular plants and vertebrate faunas, but modern sedimentological research has generated more ideas over the last four decades on lithostratigraphic facies analysis of continental basin fills than any other comparable red-bed sequences. Although relatively poor in biostratigraphic controls, many advances have been made in recent years by integrating palaeobotanical/palynological, microinvertebrate and ichnofacies studies with the sedimentology. Additionally, during the last ten years a chronometric time scale, based on radiometric dating of airfall tuffs, has been developed across Lower ORS basins from E. North America, through SW Ireland to the Anglo-Welsh Basin.

A template for this integrated analysis has been the Lower ORS of Wales, in particular that exposed in the magnificent coastal outcrops of SW Wales. From this area the major magnafacies belts can be traced over 20,000 sq. kms. to the Borderlands. The Pridolian facies belt is mudrock-dominated throughout this extensive area whereas the Lockhovian to early Emsian sees a progressive increase in fluvial sandstones to conglomerates, punctuated locally by alluvial fan incursions. This is true of both the Welsh and Irish Lower ORS successions but in Quebec the whole sequence is sandstone to sandstone/conglomerate – dominated.

Many enigmatic sedimentary phenomena are preserved within the basin infill magnafacies. The thick mudrock sequences and their origin are only now being analysed and understood; the ubiquitous pedogenic and non-pedogenic calcrete (so abundant in Wales but poorly preserved in SW Ireland and E. Canada) are hugely important in understanding the climatic and tectonic controls on basin evolution; the source, deposition and dating of the airfall tuff complexes in Wales and Ireland are key to unravelling correlation of the Lower ORS particularly when taken in tandem with palynological analysis. Also, receiving much attention in recent years has been the variations in fluvial style within these basins and the causes of ephemeral fluvial systems in the Pridolian – Lockhovian to the very large perennial rivers of the Emsian – Mid Devonian. The Lower ORS drainage networks of this southern and southwestern margin of the Continent are complex and old models are in need of refinement, as does the connectivity of systems and their relationship to the growth of Acadian deformation.

## Murchison and Miller: Contrasting Founders of the Devonian/Old Red Sandstone

Anthony Brook[1]

[1]West Sussex Geological Society/HOGG

The 60 million years of the Devonian Period (419-359 Mya) left its mark in 3 areas of the U.K.: 3 Basins in Scotland, from the Orkneys to the Borders; in the extensive Anglo-Welsh Basin, from the Welsh Borders to Pembroke; and in Devon, where the marine equivalents of the Old Red Sandstone enabled this geological time period to be first established by Roderick Murchison and Adam Sedgwick in 1839, giving rise to what is known as 'The Great Devonian Controversy'.

Roderick Murchison (1792-1871) and Hugh Miller (1802-1856) were two geologists of this so-called Heroic Age of Geology who made significant contributions in presenting the strata and fossils of this Late Palaeozoic era in the scientific literature and in the popular imagination. However, there could hardly be a greater contrast in their lives and lifestyles: they were poles apart. Both were born and brought up in the Scottish Highlands, had strong-willed wives, and a life-long obsession with rocks and fossils; otherwise, they were completely different personalities, living in completely different social worlds, and only slightly acquainted. Indeed, Miller, the overworked and overwrought newspaper editor, shot himself, aged only 54, whilst Murchison lived on, as a greatly-honoured scientist, into his late 70s and died a natural death. Miller published his marvellous work The Old Red Sandstone in 1842 for the general readership; Murchison published his mighty volumes for science and posterity---to give just a few examples.

Although Murchison and Miller are such 'Contrasting Founders' of the Devonian/O.R.S., both Scotsman, in their own separate ways, have earned an honoured place in the pantheon of those who helped to establish the science of Geology.

## Old Red Sandstone Landscapes in Wales: The View from the Air

Dr Toby Driver[1]

[1]Aerial Investigator –Team Leader Reconnaissance, Royal Commission on the Ancient and Historical Monuments of Wales

The Royal Commission, based in Aberystwyth, has been carrying out its own pan-Wales programme of archaeological aerial reconnaissance since 1986. Its remit is to record sites illustrative of the people, landscape and history of Wales, as well as specifically recording 600 Scheduled Ancient Monuments a year for Cadw for management purposes, and carrying out exploratory reconnaissance for new archaeological sites at the extremes of light and season. The Royal Commission also innovates, working with airborne laser scanning or LiDAR to better understand and document the archaeology of Wales.

Today commercial aerial photography is commonplace. The Welsh Government commissions regular pan-Wales vertical sorties taken in summer light with maximum vegetation to inform a range of work. Unmanned Aerial Systems (UAS) or drones are also more common and cheaper to use, providing low and medium level imagery and video and 3D landscape modelling for a range of users.

However, the archaeological aerial reconnaissance programme retains a unique role to discover and record the landscape and archaeology of Wales, frequently at times of year and in conditions when no other operators are flying. Flights are often carried out at the extreme of light and seasons, and in optimum conditions for documenting archaeological sites. During extreme summer droughts when parching and variable crop growth can show long-hidden plough-levelled archaeology, conditions for archaeological visibility can change in a few days. A site visible in one week can be erased by a summer rain shower; a blank field can change in a few days with the arrival of hot, drying winds. In winter, drifting snow or differential melt-marks in snow and frost can show known sites with incredible clarity or allow the discovery of new sites. After heavy snowfall the landscape of Wales can be transformed, and the Royal Commission aerial archaeologist may be the only person airborne.

This presentation provides an overview of Old Red Sandstone landscapes in Wales from the year-round perspective of an aerial archaeologist. High summer sunshine, low evening and winter light, rain and flood, geological cropmarks, heavy snow and melting frost will all serve to show the shape, character and changing personality of the ORS landscapes from Pembrokeshire to the Black Mountains.

## Colonisation of the Old Red Sandstone Continent: recent advances in early land plant research from the Welsh Borderland.

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The Lower Old Red Sandstone sequences of the Anglo-Welsh Basin and Welsh Borderland have been vital to the study of early land plants. Since Lang's seminal paper in 1937, new records, along with the development of imaging techniques (e.g. scanning electron microscopy), has led to the detailed description of several megafossil plant assemblages, spanning Ludfordian to Pragian in age. More recent discoveries from Tredomen Quarry, near Brecon (lowermost Lochkovian) and Craswall, Herefordshire (middle to upper Lochkovian), augment the observation of progressive diversification through this time period, albeit still of simple organisation when compared to elsewhere in the world. The main changes observed are increases in overall size, complexity of branching and improved spore dispersal efficiency. These changes are interpreted as responses to increased competition for light and space in these early terrestrial ecosystems.

However, the effects of plant taphonomy on diversity and disparity patterns cannot be overlooked. This is exemplified by rare, middle Lochkovian mesofossils of exceptional preservation via charcoalification. These fossils provide an insight into a component of early land plants of very small stature (a few millimetres in height) that are often missing from megafossil assemblages. Work on this group has led to several new taxa and the reconciliation of some dispersed spore taxa with their parent plants. Of particular interest are a group of cryptospore-bearing plants, named cryptophytes, some of which may be stem group embryophytes or tracheophytes, while others are more closely related to bryophytes.

## The Old Red Sandstone of the Black Mountains of Powys & Herefordshire: Filling the 'Black Hole'.

Duncan Hawley

The Black Mountains form a dissected upland plateau comprising both Lower Old Red Sandstone and Upper Old Red Sandstone rocks, roughly delimited by the Wye Valley to the north and the Usk Valley to the south. They occupy a central position within the Anglo-Welsh Basin nestled between the traditionally better studied areas of ORS to the

west (Brecon Beacons and west Wales) and to the east (Shropshire and the Marches and the Forest of Dean). The lithologies comprise a broadly coarsening-upward sequence of mudstones and silty mudstones, tuffs, sandstones (red, green and grey), gravels and calcretes that occur in varying relations and proportions, enabling litho-stratigraphical divisions to be recognised. However, serious study of the ORS in the Black Mountains in the past has been sporadic and limited rather than systematic - the area to some extent formed a 'black hole'. This presentation will review the development of past and recent advances in the lithostratigraphy, sedimentary geology and palaeo-environmental interpretations of the ORS in the Black Mountains and indicate some possibilities for future study and understanding.

## The identification of mappable litho-stratigraphical sub-divisions of the Brownstones across its outcrop

John Davies[1]

[1]Fforest Fawr Geopark

The currently accepted divisions of the Lower Devonian comprising the St Maughan's, Senni and Brownstones formations are reviewed. This sedimentary sequence is dominated by three major regressions, the earliest - St Maughan's regression – occurred at the base of the sequence, followed by a second event at the base of the Senni Formation and a third, previously undescribed regression in the middle of the Brownstones. The latter has been termed the, Llyn-y-fan Regression.

Intensive mapping of the outcrop suggests that at least two of these events, at the base of the Senni Formation and the Llyn-y-fan involve soft-sediment deformation. The Llyn-y-fan event also records the influx of course-grained exotic materials into the area of deposition and is associated with chaotic sedimentary depositional structures. It is thus suggested that the present Brownstones Formation could be sub-divided into four – Lower Brownstones arenites, and then argillites below the Llyn-y-fan sedimentary event, the event itself, and the normal Upper Brownstones above. Suitable litho-stratigraphical terms might be - Craig-y-fro Arenites – Bryn Melyn Argillites - Caeras Rudites and Fan Fawr Arenites.

It would appear that each of these regressions form part of a coarsening upward sequence of sedimentary events associated with soft sediment deformation suggesting increasing tectonic activity reflecting the imprint of the Arcadian Orogeny.

## The Old Red Sandstone of The Hidden Edge Of Exmoor

Kester and Elizabeth Webb

Exmoor's high moorland, with its north-facing coast, is the southernmost tip of the Old Red Sandstones of Wales. The bedding planes dip inland and disappear underneath the overlying Ilfracombe Beds to the south and to the west; while the western part of the Exmoor shore has miles of vertical sea-cliffs with north-facing scarps, similar to the inland cliffs of the Brecon Beacons. Several of the vertical cliffs rise to 500ft (164 m). The highest of these is where the Great Hangman Hill meets the sea, boasting the highest marine cliff in England 750ft (228 m). It is this highest cliff that gives rise to the formal name 'Hangman Sandstone Formation' for the Exmoor equivalent of Old Red Sandstone.

By contrast, the eastern hills of Exmoor dip north towards the sea, making a slabby land-slipping shore with few solid cliff-faces. The exploration of this shore, beneath the 'hogsback' cliffs was suggested by the palaeobotanist E.A. Newell Arber in 1911, p26 in The Coast Scenery of North Devon*: "It would indeed be a proud accomplishment to have traversed the whole of the shore-line from Porlock…. Whoever manages to accomplish this feat in the future will have seen wonders in the way of cliff scenery and can also boast of a remarkable record"*. The scale of preparation necessary he regarded as being similar to that required in tackling some untrodden Alpine peak. In response to Newell Arber's challenge, exploring Exmoor's shoreline, fifty years later, involved walking for many miles on sandstone boulders along low-water reefs and wave-cut platforms; it also involved serious rock-climbing where vertical cliffs rise up out of the sea, even at low water.

## Geographical Description - East to West

### *West Somerset*

At Minehead, the Hangman Sandstones rise up dramatically out of the Bristol Channel to form North Hill, one of the eastern foothills of Exmoor. To the south, Dunkery Beacon, the highest point of Exmoor, is formed from these same sandstones. Behind North Hill, the seaward-dipping Hangman Sandstones make long coastal slopes rising to 800 ft (244 m), with only a few rocky bluffs down on the boulder beaches. Two miles to the west the strata steepen, buttressing Selworthy Beacon at the western end of North Hill. Cliffs formed of steeply dipping overlapping slabs continue toward Hurlstone Point. The seaward tip of this headland is an anticlinal curve forming a graceful arch completely penetrated by a narrow cave known as the Gull Hole at its core. The cliffs now end abruptly where they are faulted against the younger rocks of the Vale of Porlock. From here a shingle ridge of sandstone pebbles stretches almost three miles westwards across the Vale as far as Gore Point. Beyond Porlock Weir, the hills rise again and the seaward-dipping Hangman Sandstones form long coastal slopes above a straight shoreline of boulder beaches.

### *North Devon*

At the Somerset-Devon Border the massive Foreland Point dominates the scene for miles around. At the point itself the Hangman Sandstones are still dipping north. They continue as north-west facing cliffs into Lynmouth Bay, where the strata become contorted with two huge gullies reaching up to the 600ft (183 m) contour. At the back of the bay, the Hangman Sandstones are faulted against the softer strata of the underlying Lynton Formation. The sea-cliffs from now on are in these less resistant strata which form the famous Valley of Rocks. In contrast to the continuous vertical wall of the Hangman Sandstone cliffs to the east, marine erosion here has caused the cliffs to become more indented, with stubby bluffs separated by deep gullies, or ‘guts’ as the locals call them. The Hangman Sandstones reappear, high up in Woody Bay, with their characteristic flat scarp-faces above a straight east-west shoreline, scoured by 10 metre tides. The Lynton Formation continues to crop out and form the foreshore for several miles westwards; the last traces of these beds disappearing beneath the foreshore below Trentishoe Down.

As the coastal hills of Exmoor rise steadily westwards and the Hangman Sandstones become coarser, the beach boulders appear more pink than grey, with occasional clusters of fossilised gastropods (Naticopsis) from some of the higher beds. These are the rocks Newell Arber knew by their traditional name of ‘Hangman Grits’. The masons of Combe Martin quarried these ‘grits’, known locally as ‘rawns’; regarding them as ‘the best stone in North Devon’ and using them in constructing fine churches and country houses. Interestingly this gritty rock is also the best for rock-climbers on Exmoor. While the Hangman Sandstones of Exmoor are generally devoid of minerals, late 19th century miners found manganese and drove adits into the vertical cliff faces beneath the Great Hangman.

We have seen that the Old Red Sandstones of Exmoor make a dramatic entry at North Hill, above Minehead, in the east. They make an equally dramatic exit, twenty-five miles (40 km) to the west, at Little Hangman. Here the Hangman Sandstones dip southwards beneath the Ilfracombe Beds inland from the Little Hangman Point, but their sea-cliffs face northwards across the Bristol Channel towards the Old Red Sandstones of the Brecon Beacons.

Figure 1 Brian Williams presenting his keynote address in the Elim Centre

Figure 2 Market House walls showing maroon sandstones and pale, green-grey 'Hay' Stone, both from the St Maughan's Fomation

Figure 3 Market House walls showing maroon sandstones and pale, green-grey 'Hay' Stone, both from the St Maughan's Fomation

Figure 4 St Mary's Church, Brecon showing 2 distinct phases of buildings. The windows in the tower (and the main part of the church) have been replaced during C19th restoration work

Figure 5 John Davies explaining the use of the Old Red sandstone facies sandstones as a building stones, and the importance of bedding orientation to avoid excessive weathering of the faces

A. The Wall south of the Museum and Art Gallery

B. Example of weathering in face-bedded sandstone

Figure 6 Teme valley Geological Society, one of the many displays of ORS related materials

Figure 7 Duncan Hawley demonstrating palaeocurrent directions in the St. Maughan's Formation in Tredomen Quarry

Figure 8 Exposures of Conglomerates and channel sandstones in the Senni Formation Tremynfa Quarry

Figure 1

Figure 2

Figure 3

Figure 4 A

Figure 4 B

Figure 5

Figure 6


Figure 7

Figure 8