Newsletter No. 236

April 2016

The Black Country Geological Society

Copy date for the next Newsletter is Wednesday 1 June

Contents:

Linda Tonkin, **Honorary Secretary,** 4 Heath Farm Road, Codsall, Wolverhampton, WV8 1HT. ☎ 01902 846074 secretary@bcgs.info	**Andy Harrison,** **Field Secretary,** ☎ 01384 379 320 Mob: 07973 330706 fieldsecretary@bcgs.info	**Julie Schroder,** **Newsletter Editor,** 42 Billesley Lane, Moseley, Birmingham, B13 9QS. ☎ 0121 449 2407 newsletter@bcgs.info
For enquiries about field and geoconservation meetings please contact the Field Secretary. To submit items for the Newsletter please contact the Newsletter Editor. **For all other business and enquiries please contact the Honorary Secretary.** For further information see our website: bcgs.info		

Future Programme

Indoor meetings will be held in the Abbey Room at the Dudley Archives, Tipton Road, Dudley, DY1 4SQ, 7.30 for 8.00 o'clock start unless stated otherwise.

Visitors are welcome to attend BCGS events but there will be a charge of £1.00 from January 2016.

Please let Andy Harrison know in advance if you intend to go to any of the field or geoconservation meetings. If transport is a problem for you or if you intend to drive and are willing to offer lifts, please contact Andy with at least 48 hours notice.

Monday 18 April *(Indoor meeting):* 'Microfossils of the Wren's Nest'. Speaker: James Inman.

Saturday 23 April *(Field Visit):* Churnet Valley and Cannock Chase, led by Ian Stimpson, Keele University & NSGGA. Meet at 10.30 in Froghall Wharf Car Park SK 0271 4766 just off the A52. Walking a section of the Churnet Valley Geotrail looking at Carboniferous geology (Gritstones and Coal Measures) and associated geologically related industrial history. Also the geomorphology of the Churnet Valley associated with the end of the last Ice Age. Walking ~ 6km along public footpaths (with stiles) across rolling North Staffordshire terrain. Bring a packed lunch, or food available at the Fox & Goose Pub, approximately half way round the walk.

Saturday 21 May *(Geoconservation Day):* Portway Hill, Rowley. Meet at St. Brades Close at 10.30. Directions: from Birmingham New Road (A4123) turn left on to Tower Road if coming from Birmingham, right if coming from Wolverhampton. Just after Bury Hill park, turn left into St. Brades Close. Wear old work clothes and stout footwear. Please bring gloves, spades, brushes and trowels if possible, in order to excavate and expose more of the dolerite. Also bring lunch. Finish at 14.30.

Sunday 5 June *(Geoconservation Day):* Rubery Cutting, in conjunction with the Lickey Hills Geo-Champions and directed by the Lickey Hills Rangers. Meet at 10.30 at the cutting by the junction of the slip road from A38 Bristol Road South, and Leach Green Lane, B45 9XS (SO 993 775). Parking under the flyover. Tools and equipment will be supplied by the Park Rangers. Bring your own gloves, hard hat, and high viz jacket if possible (not essential). Finish around 2.00.

Saturday 11 June *(Field meeting):* Oxford University Museum of Natural History, led by Prof. Paul Smith (Director). Meet at the Museum for 10.00. Look at mineralogy, fossil and living vertebrates and archives. Bring packed lunch or use museum cafe. Look at the two temporary exhibitions. Maximum number of places is 30. Please contact field secretary to confirm attendance.

Saturday 16 July *(Field meeting):* Visit to Cross Hands Quarry, jointly with the Warwickshire Geological Conservation Group, led by John Crossling (WGCG). Meet at 10.00, Beacon Car Park, Burton Dasset Hills, SP 394 522. View Jurassic Marlstone Rock Bed, Inferior / Great Oolite, Lias Shales – potential for fossil hunting. Lunch at 'Greedy Goose' pub (junction of A44 / A436), or packed lunch. Finish approx. 16.00.

Saturday 20 August *(Field meeting):* Wren's Nest, led by Graham Worton. Details TBC.

Saturday 10 September *(Field meeting):* Brown Clee Hill, Shropshire, jointly with the Shropshire Geological Society. Details TBC.

Monday 19 September *(Indoor meeting):* TBC.

Monday 17 October *(Indoor meeting):* Update on the Black Country Geopark. Speaker: Graham Worton.

Monday 14 November *(Indoor meeting):* Optical Mineralogy. Speaker: Frank Wells.

Monday 12 December *(Indoor meeting):* Members' Evening.

Procedures for Field Meetings

Insurance

The Society provides public liability insurance for field meetings but personal accident cover is the responsibility of the participant. Details can be obtained from the Secretary, and further helpful information can be found in the Code for Geological Field Work published by the GA and available on our website. Schools and other bodies should arrange their own insurance as a matter of course.

Health and Safety

If you are unsure about the risks involved or your ability to participate safely, you should contact the Field Secretary. Please take note of any risk assessments or safety briefing, and make sure that you have any safety equipment specified. The Society does not provide hard hats for use of members or visitors. It is your responsibility to provide your own safety equipment (eg. hard hats, hi-viz jackets, safety boots and goggles/glasses) and to use these when you feel it is necessary or when a site owner makes it a condition of entry. Hammering is not permitted unless specific permission has been sought and granted. Leaders provide their services on a purely voluntary basis and may not be professionally qualified.

Other Societies and Events

BCGS members are normally welcome to attend meetings of other societies, but should always check first with the relevant representative. Summarised information for approximately **two months** is given in our Newsletter. Further information can be found on individual Society web sites.

Woolhope Naturalists' Field Club - Geology Section

Friday 15 April: 'The Carboniferous under the Southern North Sea'. Speaker: Dr John Collinson. This talk will be held in the upstairs meeting room at the Hereford Leisure Centre starting at 6.45. Car park charges are £1.

Thursday 21 April: 'Participate in a Buildings Survey at Goodrich'. Organized by Sue Hay. Goodrich is one of the clusters being surveyed in detail as part of the HLF funded Thousand Years of Building with Stone. Start at 10.00. Pub (or packed) lunch. Exact meeting place will depend on numbers. If interested please contact Sue Hay (svh.gabbros@btinternet.com) for further details.

Guests are welcome with day membership of the Club: £2.00. Contact Sue Hay on 01432 357138, email: svh.gabbros@btinternet.com or visit: www.woolhopeclub.org.uk/Geology_Section/default.htm

Mid Wales Geology Club

Wednesday 20 April: 'Fossils in Art: an illustrated talk with drawings and paintings'. Guest speaker: Sue Purcell.

Sunday 24 April: Field visit to Nesscliffe & the Shropshire Triassic. Led by Tony Thorp.

Sunday 8 May: Field visit to The Fossil Forest at Brymbo, Wrexham. Led by Gary Brown, Heritage Officer.

Wednesday 18 May: 'Reflections on Geomorphology'. Guest Speaker: Jack Davies.

Further information: Tony Thorp (Ed. newsletter & Hon. Sec): Tel. 01686 624820 and 622517 tonydolfor@gmail.com Web site: http://midwalesgeology.org.uk Unless otherwise stated, meetings start at 7.15 (tea/coffee & biscuits) with talks at 7.30 at Plas Dolerw, Milford Road, Newtown.

Warwickshire Geological Conservation Group

Wednesday 20 April at 7.00: 'The Jurassic geology and the Harbury landslip.' Speaker: Luke Swain CGeol, Senior Asset Engineer (Geotechnics), Network Rail.

Wednesday 18 May at 7.00: Field trip to see and examine the Brandon Geology Wall, Brandon Marsh Nature Centre. Led by Brian Ellis and Paul Stevenson.

Doors open at 7.00 for coffee before a 7.30 start at St Francis Church Hall, Warwick Road, Kenilworth CV8 1HL. For more details visit: http://www.wgcg.co.uk/ or contact Ian Fenwick swift@ianfenwick.f2s.com or 01926 512531. There is a charge of £2.00 for non-members.

North Staffordshire Group of the Geologists' Association

Friday 13 - Sunday 15 May: Weekend Field Trip to Anglesey. Led by Dr Ian Stimpson.

Non-members pay £2 to cover temporary membership giving them insurance cover. A field fee of £2 per head is normally charged for members and non-members to cover the leader's expenses. For field trip enquiries: Steve Alcock, Longfields, Park Lane, Cheddleton, Leek, Staffs, ST13 7JS. Tel: 01538 360431 or 07711 501028. Email: steves261@aol.com Further info: www.esci.keele.ac.uk/nsgga/

East Midlands Geological Society

Saturday 9 April at 6.00: 'Ongoing research in the Peak District Lower Carboniferous. A new geochemical perspective on the South Pennine Orefield - the application of Carbonate Clumped Isotope Thermometry'. Speaker: Daniel Myhill, University of East Anglia & Leah Nolan, Leicester University.

Non-members are welcome. Meetings will be held at 6.00 in the Geography Department of Nottingham University, room A48. Further info at: www.emgs.org.uk or email: secretary@emgs.org.uk

Teme Valley Geological Society

Monday 18 April: 'Stromatoporoids'. With evidence from Martley. Speaker: Dr Stephen Kershaw.

7.30 at the Martley Memorial Hall B4197 by Sports Ground. £3 non-members. For more details visit: http://www.geo-village.eu/ or contact Janet Maxwell-Stewart, 01886 821061

Shropshire Geological Society

Saturday 23 April: (one day of a weekend meeting for the GA): **Shropshire Hills,** led by Andrew Jenkinson. Booking to reserve a place and obtain joining instructions from Andrew Jenkinson; email: andrew@scenesetters.co.uk; telephone: 01938 820 764.

Sunday 24 April: (one day of a weekend meeting for the GA): **Severn Valley looking at glacial features,** led by David Pannett. Booking to reserve a place and obtain joining instructions from David Pannett; e-mail: jessicapannett@hotmail.co.uk; telephone: 01743 850 773.

A nominal charge is levied for non-members. Further info at: www.shropshiregeology.org.uk/

Geological Society, West Midlands Regional Group

Tuesday 12 April: 'A Rock Slope Stability Case Study: Coles Quarry, Backwell Revisited'. Speaker: Richard Small (Minerals Consulting Services). Venue: Earth Imaging Lab, University of Birmingham.

Refreshments from 6.00. Meeting starts at 6.30. For further details and to register your interest in attending, please contact the Group Secretary at: geolsoc_wmrg@live.co.uk

Editorial

The demise of Dudley Museum and Art Gallery

During the discussion at the Members' evening in December, there was unanimous agreement that there should be a BCGS letter expressing support for the Museum against the threatened closure. A letter was duly sent to Dudley MBC with a copy to Ian Austin, MP for Dudley North. Our Hon. Secretary, Linda Tonkin, received an encouraging reply from Ian Austin, but in spite of our efforts and the protests of many other groups and individuals, it has been announced that our much-loved Museum and Art Gallery will close in 2017. Our main concern of course, is the geological collection, and we must now look to the future. BCGS could play a useful role in planning and executing the next step. We must help to make sure that the collection is suitably housed, maintained and promoted.

Anticipating the negative response, there were some forward looking suggestions in our support letter (compiled by Linda with help from other committee members) and it may be useful for us to reflect on these:

"If the Council were to confirm the closure of the building it will be required to relocate the Museum's geological collection to a suitable alternative site in the Town Centre or perhaps to the developing visitor hub based around the Zoo/Living Museum sites, where it would be a 'natural fit' and enhance the overall visitor experience. The Society would be pleased to support and assist in such a development in any way that it can. In the not too distant past much was said about the development of a Wren's Nest Visitor Centre to capitalise on the unique geological inheritance of Dudley, an aspiration that never came to reality. If the Museum must close then perhaps the Council should seize the opportunity to resurrect this idea and incorporate it into the Black Country Geopark plans.

We should not want the Council to repeat the tragic occurrence of the 1970s when the Society had to rescue the geological collection from neglect, decay and ruin when it was abandoned in a Council basement, resulting in national criticism from many esteemed institutions".

There may also be a glimmer of hope in the supportive words from the MP for Dudley North:

"I have been talking to the Council about this issue and asked for assurances about their plans to display the material from the museum and other historical material and artwork that I think has been in storage for years. I want to know where they propose the material will be displayed, when this will happen and what the plans for access will be... I promise I'll keep campaigning for a better deal for Dudley and raising these issues in Parliament." *(Ian Austin, MP, to Linda Tonkin 8 March 2016.)*

These are difficult times for Dudley and the Black Country, and it is clear that our role as ambassadors for Black Country Geology has never been more important. ■

Julie Schroder

BCGS Mugs

Our anniversary mugs are now on sale for £4.00. They can be purchased at indoor meetings, or contact the Secretary.

Annual General Meeting Report

The 2016 AGM was held on Monday 14 March at 7.30 followed by a talk on the minerals of North Wales, given by Tom Cotterell from the National Museum of Wales in Cardiff. Below is a summary of the AGM reports, taken from the minutes of the AGM.

Treasurer's Report

The Treasurer circulated the audited financial statement for 2015 which showed the current account to be in a healthy state. Income had fallen slightly due to a dip in membership. Membership usually rises when new members are recruited at the Dudley Rock and Fossil Festival, but this was not held last year. There remained the same number of 'core' members. Unfortunately, it is unlikely that the RFF will be held again, so it was hoped that more members would be recruited through the updated website. The main item of regular expenditure was that of room hire. Venue costs would have been the same had the Society been able to continue using Dudley Museum and Art Gallery, but this was no longer possible due to staffing issues. It was noted that room hire was lower if meetings ended by 21.30.

The main expenditure for 2015 was for the 40th Anniversary - the buffet for the celebration event, coasters and mugs. These costs were met through accessing the Nationwide Building Society account.

Chairman's Report

The Report was circulated to the meeting and the Chairman summarised the main points. He felt that 2015 had been another exciting year for the Society particularly with its 40th Anniversary, indoor meetings, field visits and geoconservation work. The Chairman thanked the Committee for their hard work and support throughout the year and appreciated the high standard of the Society's newsletter which was the voice of the Society.

The Chairman referred to the closure of Dudley Museum and Art Gallery in March 2017 which would end the long tradition of geological displays in Dudley. The Society had been responsible for rescuing the collection from a Council basement and campaigned in 1985 for a Keeper of Geology. It was hoped that alternative options for display of the geological collections and location for the Black Country Geopark headquarters would be identified. The Society's support for these projects would be crucial.

Election of Officers

All members of the Committee had offered themselves for re-election, with the exception of the role of Meetings Secretary. It was also agreed that the serving Committee Members be re-elected as follows:
Chairman – Graham Worton
Vice Chairman – Peter Twigg
Treasurer – Alan Clewlow
Hon Secretary – Linda Tonkin
Field Meetings Secretary – Andy Harrison
Meetings Secretary – Vacancy (there were no volunteers for this role)
Committee Members – John Schroder (Website Manager), Julie Schroder (Newsletter Editor), Bob Bucki, Christopher Broughton. ■

Linda Tonkin, Julie Schroder

Norwegian Mines: Nickel, Molybdenum, Niobium, Cobalt and Silver

Most people are well aware of the wealth that Norway enjoys from the riches to be found lying beneath their sector of the North Sea. Less familiar, perhaps, is the great wealth they have enjoyed in times gone by from the varied mineral riches lying beneath their onshore boundaries. Some of these kept me entertained during a tour across south-east Norway last summer.

Evje-Iveland pegmatite district

A crystal of Beryl from the Iveland pegmatites, from the Norwegian Mining Museum at Kongsberg

My principal aim was to visit the Evje-Iveland pegmatite district north of Kristiansand, the port that offers the most convenient way of reaching Norway (by car). There is plenty of information available on the net about the pegmatites, famous for a host of rare minerals containing exotic elements such as yttrium, bismuth, scandium, uranium, and the rare-earths, which I wouldn't recognise if they stared me in the face. More accessible are the fine examples of graphic granite and the microcline variety of alkali feldspar, sometimes found as greenish amazonite. Common granite-related minerals such as biotite, muscovite, quartz and, less commonly, beryl may also be found as nice crystals. The microcline is in places particularly pure and exported to Germany, Austria and Liechtenstein for the manufacture of high grade dental porcelain. I read somewhere that Liechtenstein is a major producer of black false teeth - indeed it claims to be the world's largest producer of false teeth in general - though I'm not sure where the competition lies!


Flåt Nickel Mine - site of old shaft

Amidst the many pegmatite quarries lies the prominent site of the Flåt nickel mine. This opened in 1844 as a copper mine, but switched to nickel production (presumably as a demand for nickel arose with new chemical understanding and technologies), from 1872 until closure in 1946. It was, for a while, Europe's largest nickel mine, and was even under British ownership from 1884 to 1894. During its lifetime it produced 15,000 tonnes of copper and 20,000 tonnes of nickel, principally from the two sulphide minerals millerite and pentlandite.

Knaben molybdenum mine


Knaben Mine

A couple of hours circuitous drive to the west of Evje lie the remains of another of 'Europe's largest mines', this time the commodity worked being molybdenum. Situated at the head of a long valley, Kvinesdal, the mine at Knaben opened in 1885, again to serve a newly recognised variant on steel technology (molybdenum alloys make better weapons!), with its heyday during the two world wars. It finally closed in 1973 after producing around 10,000 tonnes of molybdenum metal - a fairly modest amount by ►

today's standard. The vast majority of the ore came from the common sulphide molybdenite, with some from the hydrated ferro-molybdate mineral molybdite. The mine site is a sad relic, with no pretence of any clean-up operations, but amongst blocks of the host gneiss left lying around it is still possible to find scraps and smears of molybdenite veining.

Gneiss block with molybdenite (metallic blue-grey)

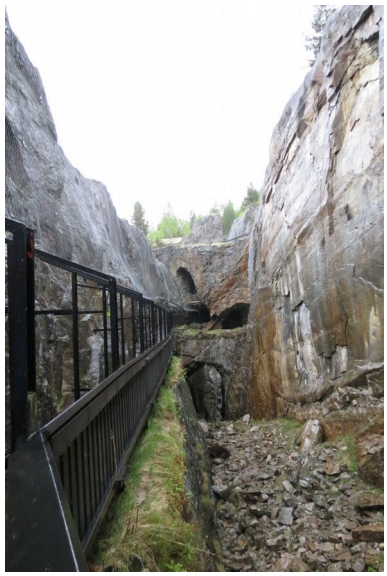
Ulefoss, Fen and limestone magma!

In the opposite direction, almost as far as the Larvik area (celebrated for the rock Larvikite and its associates), heading inland past Porsgrunn and Skien, continuing along the western shores of Norsjø lake, one finally arrives at the small town of Ulefoss. Nearby is the village of Fen, which gives its name to a rock known as fenite (or more correctly, a process known as fenitisation). This alteration process accompanies the extrusion of the extraordinary magma known as carbonatite; limestone in molten form! The existence of such magma was predicted by the Norwegian geologist Brøgger in the 1920's, but it was only recognised with certainty in 1966 after a major eruption of the volcano 'Ol Doinyo Lengai' in the East African rift valley. Surrounding rocks become infused with various carbonate-rich alterations due to the high mobility of the runny carbonatite magmas, and with this comes particular enrichment in certain rare-earth elements, notably niobium and tantalum. Niobium mines aren't thick on the ground, but Ulefoss is one location where it has been exploited. In truth there isn't very much for the casual visitor to recognise, but the local geology is well publicised, with a local museum and guided tours (in Norwegian). Information also dwells on the local former iron ore mines, similarly a product of magmatic enrichment, and the possible future exploitation of associated thorium mineralisation. *(See front page photo, caption: Main adit into Ulefoss Niobium Mine, looking back to entrance.)*

Part of the Modum Cobalt Works museum complex

Modum Cobalt Mining Museum

Beyond Fen, along the western margin of the Oslo-rift region, are two further contrasting mineral deposits of past importance. These are in addition to other lesser nickel and iron deposits. North of the town of Hokksund I chanced upon the Modum cobalt mining museum complex. This was not just Europe's biggest, but the world's biggest producer of cobalt pigments, set up in 1778 as a fully contained mining/manufacturing works, complete with its own water-power (later hydro-electric) mills and workers' village; at its height it supported over 2,000 workmen. The cobalt was mined higher up the valley near the village of Skutterud (from which the cobalt arsenide mineral skutterudite got its name), while the Royal Cobalt Works were established at Modum itself. Until 1857, these works provided some 80% of the world's cobalt pigment, and fed into the important ceramics industry, supplying famous names like Wedgewood, Meissen, Delft and Sèvres as well as the Danish Royal House. Other cobalt minerals include cobaltite, erythrite, linnaeite ►



Modum Cobalt Mine open cut workings, near Skutterud

and glaucodot, mixed with copper ores which were also extracted before the whole venture came to an end in 1898. The area is now well laid out as an 8km long museum complex describing all aspects of the industry: mining, geological, industrial, economic and social. Organised tours of the mine, largely open cut, are available; otherwise one is free to explore at leisure the reconstructed settlements, museums, shops (glassware and tableware as well as the usual souvenirs), outdoor exhibits and trails.

Kongsberg silver mines and the Norwegian Mining Museum

'Wire silver shaped into a pound sterling sign... but entirely natural'

Finally, and perhaps Norway's 'jewel in the crown', is the silver-mining district of Kongsberg, located roughly midway between Fen and Modum. Silver was first discovered in the area in 1623 and continued until 1958, after some 335 years and an estimated 300,000 'man years' of mining endeavour. The silver mines themselves extended along some 8.5 kilometres of the 'Christian VII's Adit', planned to link mines on either side of the Overberget mining area, but which was never fully completed even after 150 years of effort between 1782 and 1932. One should bear in mind that the host rock is mostly unyielding gneiss, and the fairly medieval method of fire-setting continued to be the main technique employed as late as the 1880's. A show mine, the 'King's Mine', offers a glimpse into the underground environment (not visited by your correspondent), with an associated surface visitors' area outlining the history of the mines. This site is situated at Saggrenda, about 10km from the centre of town where the more comprehensive Norwegian Mining Museum can be visited.

A mass of wire silver... and not a Brillo pad! From the 'Silver Room' at Kongsberg Mining Museum

The Norwegian Mining Museum incorporates displays on technology and weaponry as well as the national sport of ski-jumping, but of more interest to the geologically minded are the mineral galleries, model mine and mining history displays. The mineral gallery includes fine exhibits from beyond the Kongsberg, and indeed beyond Norway's boundaries. It also features a scale geological model of the Overberget silver-bearing area: the silver is carried in hydrothermal calcite veins associated with the Permian magmatism of the Oslo rift (noted for the afore-mentioned larvikite intrusions and their volcanic counterparts, the celebrated and rare rhomb-porphyries). There is another gallery dedicated to the history of the Norwegian Royal Mint, but the main attraction is the separate chamber in which the display of native silver is housed. Admittance is carefully controlled and presents a breathtaking series of exhibits of 'wire-silver' and rare crystalline silver second to none in the world.

Norway isn't everyone's first thought when it comes to geo-touring. The relatively long journey overland doesn't encourage visitors (perhaps a fly-drive option would suit some people better), but it certainly doesn't disappoint the determined traveller. ■

Mike Allen

The Palaeobiology of the Placoderms

1. Introduction

The Placoderms are a group of fish that became extinct during the Fammenian stage at the end of the Devonian period. The oldest known fossils are from the Silurian of China. Six of the 14 late Frasnian families were lost during the Frasnian-Fammenian mass extinction (c.374.5Ma), the remaining families lasting until a second extinction event at the end Fammenian (c.359.2Ma). They form part of the Gnathostomata (jawed vertebrates) and within the clade (group derived from a common ancestor) comprising the jawed fishes are their sister groups (Fig. 1), the Chondrichthyes (early sharks), Acanthodii (spiny skins) and the Osteichthyes (bony fishes).

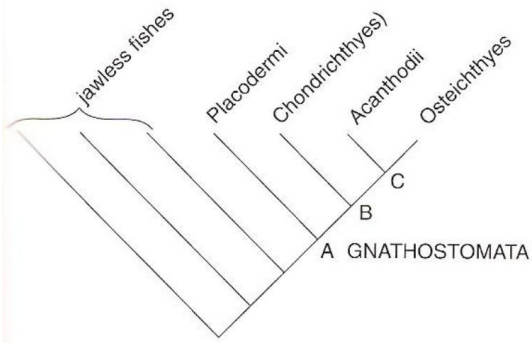
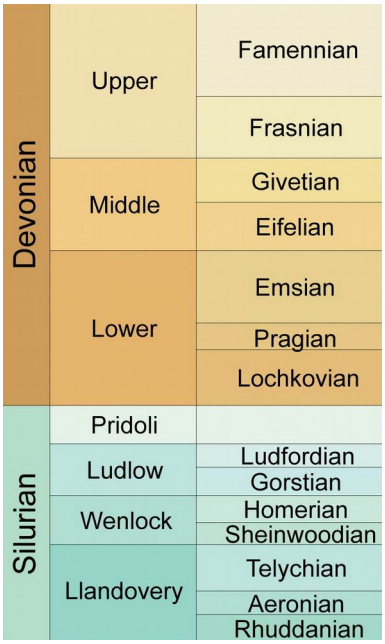


Fig. 1. Cladogram of jawed fishes (from Benton, 2005)



Benton (2005) considers the distinguishing evolutionary characteristics (synapomorphies) that define the base of the clade to be the acquisition of jaws composed of a primary upper (palatoquadrate) and lower (Meckel's cartilage) component. Other features that also appear at this nodal point are separate endoskeletal and pelvic girdles and fin skeletons, basals and radials supporting dorsal and anal fins, and a horizontal semi circular canal.

Placoderms differ from the other groups of armoured fish in that they possess bony carapaces that have a special neck joint, the Nuchal Joint (Fig. 2), that allows flexibility between the head and the trunk as well as being the first fish to possess paired pelvic fins.

Placoderms

The placoderms (the name means 'plate skin'), are considered to be the basal gnathostomes and the group can, depending upon different authors, comprise either six sister groups (Benton, 2005) or ten groups (Carr et al., 2009). Within the placoderm clade there are around 200 known genera with new taxa still being found. Over half of them are from the order Arthrodires. The most primitive (plesiomorphic) taxa are the Acanthoraci and the most derived are the Arthrodires. ►

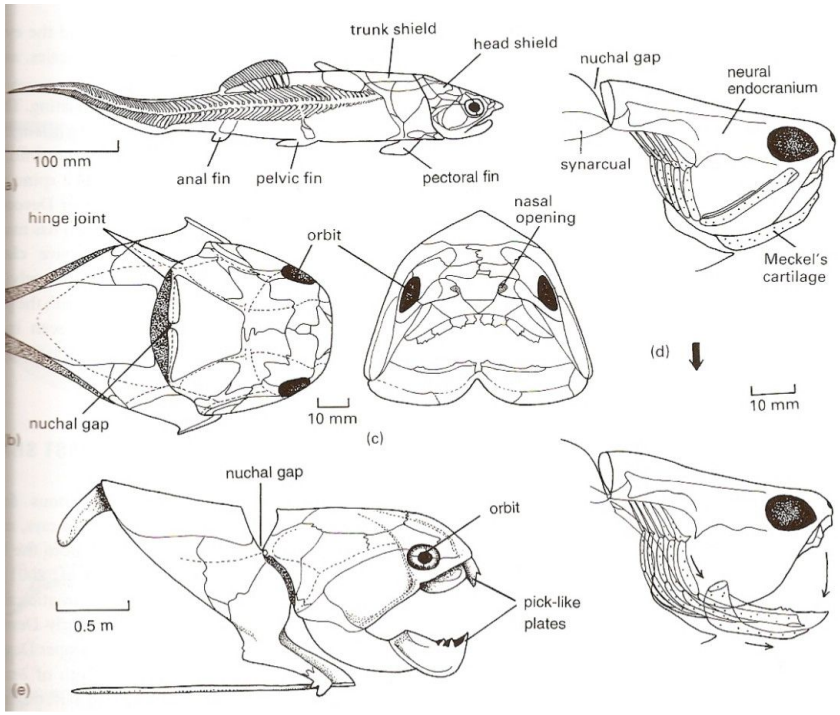


Fig. 2. Nuchal gap position in the placoderms (from Benton, 2005)

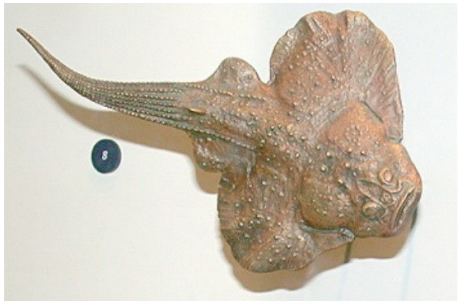


Fig 3. Gemuendina stuertzi

Acanthoraci are the basal placoderms and possess head armour that is similar to the later more derived arthrodires. The plates are separate in the juveniles but fuse in the adults (Benton, 2005).

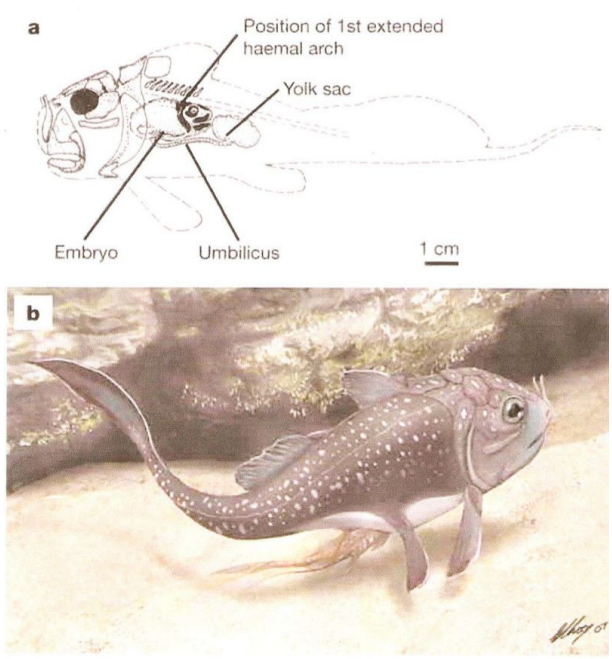
Rhenanida have a body covering of small tessarae instead of large plates and some appear ray-like, as in *Gemuendina stuertzi* (Fig. 3), but with large bone plates along the mid line, around the eyes, nostrils and mouth and the sides of the head. The large plates are separated by a mosaic of smaller plates that extend onto the trunk and pectoral fins (Benton, 2005).

Antiarchi are a diverse group that ranged from the mid to late Devonian and retained a heavy armour covering. They are thought to have been bottom dwellers that specialised in sifting mud for its organic content (Benton, 2005). A high domed form, *Pterichthyodes*, had pectoral fins that were completely encased in bone (Fig. 4), but were moveable against the trunk. A second joint part way along the fin has been suggested as having a use as a shovel to dig into the sediment and pile it up over its back, in order to bury itself in the sediment.

Fig. 4. Pterichthyodes

The thoracic armour comprised two median dorsal plates, the head armour containing a single opening for the eyes, olfactory and pineal organs. During the Devonian the diversity of antiarchs was not high but they were abundant. It has been suggested that they lived mainly in freshwater or deltaic environments but this was not exclusive as Bothriolepis (a widespread genus of antiarch placoderms), is present in the Australian Gogo Fauna that is known to be a marine reef environment.

Ptyctodontida were a group comprised of smaller forms usually less than 200 mm in length and with much reduced armour. Other morphological features included in some taxa are long whip like tails, a long posterior dorsal fin and a high anterior dorsal fin supported by a spine on the trunk shield. Some ptyctodonts have claspers associated with the pelvic fins. Claspers are a reproductive adaptation involved with internal fertilisation and hence the live bearing of offspring.



Figs. 5a & 5b. Materpiscis attenboroughi from Long et al., Nature 453)

The small aspinothoracid ptyctodontid '*Materpiscis attenboroughi*' from the early Frasnian Gogo Formation of Western Australia (Long et al., 2008) is the earliest gnathostome fossil that has phosphatised preserved muscle tissue and nerve fibres. This specimen was unique in that it also contained within the body cavity a partially ossified juvenile skeleton of the same species that was placed in the position against the spine where the uterus would be located (Figs. 5a & 5b). The position of the skeleton within an adult female and the lack of breakage or erosion by stomach acids indicated that this was an embryo and was not ingested prey. ►

Young et al., (2008) also cite evidence within this specimen of filamentous processes branching off the umbilical cord, equivalent to the appendiculae in extant sharks. They therefore consider that Ptyctodonts evolved beyond the first live bearing stage of oviviparity, (where the eggs are retained within the body cavity and fed by a yolk sac), to full matrotrophy (where the embryo is supplied with additional nutrition from the mother). The artist's impression in Fig. 5b is based on the birthing process observed in some extant viviparous sharks that deliver the offspring tail first.

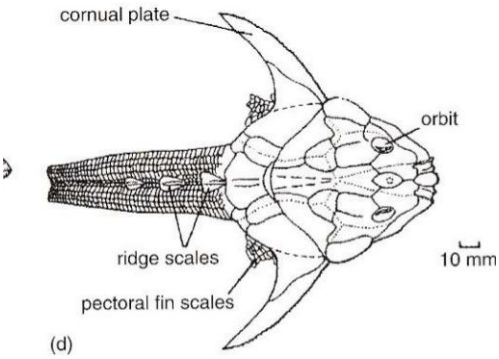


Fig 6. Lunapsid (from Benton, 2009)

Petalicthyids are described as a small group of bottom dwelling fish from the Lower Devonian of Europe (Benton, 2005). An example of this group is *Lunapsis*, that is dorso-ventrally flattened, with a short trunk shield and long corneal plates (Fig. 6). The remainder of the long trunk and the area around the eyes and nostrils is covered with numerous very small scales.

Arthrodires were the most abundant and diverse of the placoderms as well as being the most derived. There are three major groups, the Actinolepida (including the phyllolepids), the Phlyactaenida and the Brachythoraci. The phyllolepid arthrodires, (the name is derived from 'leaf scale') are dorso-ventrally flattened and have a single large Nuchal plate that covers much of the head and upper body. Late Devonian forms include the largest of the vertebrate predators that evolved at that time. *Dunkleosteus* (from the Cleveland Shale of the United States) attained lengths up to 6-7m (Fig. 7), and an even larger form, *Titanicthys*, reached in excess of 7m in length.

The lower jaw plates wear against a series of eight small plates in the upper jaw forming a beak like structure rather than teeth. Head and trunk shields are separated by the Nuchal gap, that allows the head to flex upwards and the lower jaw to drop open (Benton, 2009). The Nuchal joint is hinged at the lateral margins on a form of ball and socket joint arrangement and it is the width of this Nuchal gap between the head and trunk armour that controlled the maximum gape of the jaws.


Fig. 7. Dunkleosteus

Phylogenetic Development

The Gnathostomata are defined as 'jawed fishes' and Placoderms lie within the clade, but as stem group gnathastomes that use the jaws as a feeding mechanism, they are more derived than the 'late pre-gnathostomes' that developed jaws to aid forced ventilation (Mallat, 1996). All of the early gnathostomes possess the 'new mouth' (the post mandibular pharynx that enables a suction effect to be created), but the placoderms also have additional derived characters; a strong bite and mandibular plates to enable prey to be held and sliced. Mallat considers the major radiation of the gnathostomes in the Silurian period to be a product of the ability to use this pharyngeal suction to capture larger, more mobile prey from the water column, particularly with the later gnathostomes. This does not appear to be the case for most of the placoderm clade and may in part be the reason that they go extinct at the end of the Devonian, whereas the pre-Osteichthyans (bony fish) do not. ■

Bob Bucki

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Mike's Musings No.2 - The Age of the Earth?

I seem to recall at the Christmas meeting that the subject of the age of the Earth, and how it was first investigated, cropped up in discussion, without time to fully explore the question. It therefore seems opportune to pontificate further on the subject in this column.

Time, in geology, may be relative or absolute. Relative time puts events in the correct order of occurrence, but says nothing about the age of any event. Such order is deduced by logical reasoning as, for instance, concluding that an igneous intrusion displaced by a fault was older than the fault itself, but younger than the strata it intrudes. Similar reasoning is used in the application of the 'Law of Superposition', whereby the oldest stratum lies at the base of a series of undisturbed beds. This has been extended, with the help of the methodology of correlation by fossil content, to build up a whole stratigraphic sequence of sedimentary rocks which is how our familiar 'Stratigraphic Column', from Pre-Cambrian to Holocene, has been established.

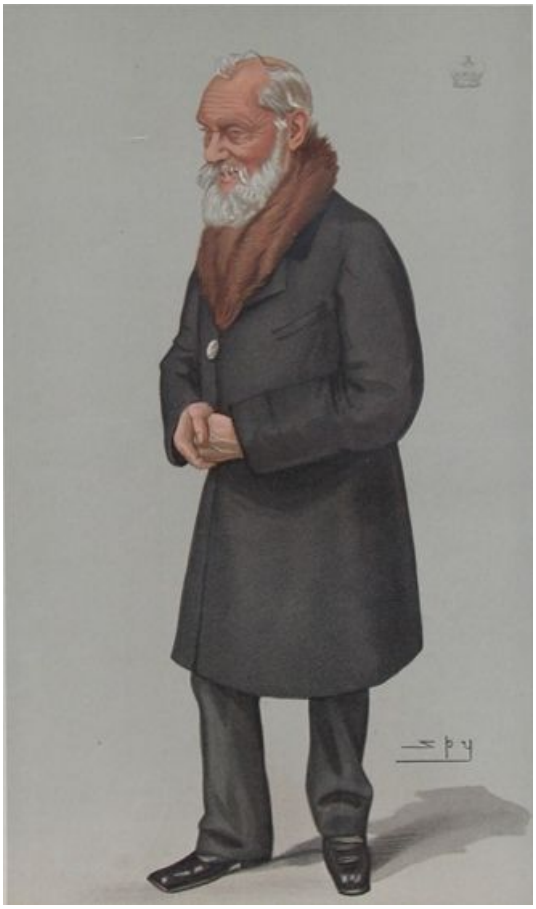
James Ussher portrait by Cornelis Janssens van Ceulen. From Wikimedia Commons.

While this was being worked out by the early stratigraphers from William Smith onwards, some minds had been considering the question of how long all this 'relative time' actually represented. Put simply, they were asking: “How old is the Earth?”. We are all familiar with the story (much distorted) about Archbishop Ussher, and his method of calculating the age of the Earth from the Scriptures, arriving at the conclusion that Earth was formed in 4004 BC. In point of fact a similar estimate had been made by others, including Bede, Kepler and Newton; it is only the vagaries of history that have brought the unfortunate Ussher centre stage over this much ridiculed and vexed issue.

One alternative, and completely contrasting, view of the age of the Earth comes from another religious perspective: the Vedic calendar of the Hindus. One version equates the year AD 2000 with an Earth precisely 1,972,949,101 years old. Their vision goes on to predict that the Earth will come to an end after 4.32 billion years, so that it is just less than half way through its expected lifetime. ►

Leaving religious approaches aside, and turning to the scientific method to investigate this question, there have been a number of innovative geologically minded approaches. Perhaps the first was that of the French naturalist, Count Buffon (or George-Louis Leclerc, Comte de Buffon, to give him his full title). Believing that the Earth had cooled from a ball of molten matter, he reasoned, through a famous experiment conducted in 1750, that observing the cooling rate of two large iron spheres of known volume heated to red-heat, he could extrapolate and thereby calculate the time it took Earth to cool, regarding this as a good approximation for its age. His conclusion was that the Earth was at least 74,832 years old.

About a century later, in 1862, William Thompson, better known as Lord Kelvin, used a similar, but more sophisticated and theoretical, 'cooling' approach and arrived at the rather wide-ranging conclusion that the Earth was between 20 and 400 million years old, though apparently favouring the lower end of the estimate. This figure pleased nobody - too small to satisfy the evolutionists and uniformitarians, but far too large for those of a religious bent. His result was flawed (on the low side) because it took no account of radioactive heat within the Earth, which, of course, was yet to be discovered.



Lord Kelvin caricatured by Spy for Vanity Fair, 1897. Wikimedia Commons.

Another Irish scholar, one Samuel Haughton, took a completely different, and purely geological approach to the problem. He reasoned that geological time could be estimated from sedimentation rates. 'All' that was necessary was to calculate the total thickness of strata that had been laid down through geological time and apply a suitable average rate of deposition. It doesn't need me to point out the practical difficulties of such an approach, but the result he came up with, in 1878, was a minimum value of 200 million years.

A not un-related method was adopted by Haughton's countryman and contemporary, John Joly, in 1899. His approach was to determine how long it had taken for the Earth's oceans to attain the degree of salinity they have today, on the assumption that the early oceans were fresh. This novel idea gave a result of somewhere between 80-100 million years for the age of the oceans, and thereby a minimum age for the Earth.

All these approaches, needless to say, were not without considerable practical problems, so it was a happy day for geology when the physicist discovered the property of radioactivity. This provides us, after much refinement of method over many decades of the 20th century, with today's most reliable method of numerically measuring 'geological time'. Our present estimate of the Earth's age is suspiciously convenient - 4,567 million years. But one shouldn't get too carried away: radiometric dating is not without its difficulties, ambiguities, limitations or contradictions. ■

Mike Allen

Members' Forum

Birds, Diaphragms and Dinosaurs

Hi everyone. A question from a new member:

I believe it is generally accepted that the present day bird families are descended from the dinosaurs with the help of Archaeopteryx and its kin. However, I have a bit of difficulty with one small part of that concept since, as far as I can determine, birds do not have diaphragms in the way that we mammals do: you know, that sheet of muscular tissue dividing the thoracic and abdominal cavities which pulses ceaselessly through life to expand and contract our lungs. However, looking at dinosaur skeletons, it seems very likely to me that they must have had a diaphragm since:

- Their bony anatomy is so similar to ours with ribs and spinal column forming a thoracic cavity.
- Surely animals as large as these must have required some mechanical help to aid their breathing?

So I'm just wondering what happened to that sheet of tissue on the way from dinosaurs into birds.
It seems to me there might be 4 possibilities:

- Did the early birds (those which immediately followed the dinosaurs), inherit diaphragms from their dinosaur ancestors which then slowly disappeared as the various species and families of birds evolved?
- Did the dinosaurs not have diaphragms in the first place?
- Is there some alternative to a diaphragm that was, maybe, used by the dinosaurs and can still be found in lizards today?
- Do we not know because of poor or absent fossil record?

Although I should imagine this small matter must have some relevance to the story of evolution, and must surely have been debated more than once in the last 100 years or so, I have never come across any reference to it in any of the books or articles I have ever read. Any comments anyone? ■

Paul Truelove

I hope someone can help with this interesting problem. Please send your comments to the Newsletter Editor.

More historic photos from the Lapworth Museum

Bernard Duggan has been working on photo collections at the Lapworth Museum, and has recently sent three more of particular local interest. They are reproduced from old slides, and the descriptions are as written on the slides. They have been added to the Society's web photo archive and can be seen here: http://bcgs.info/pub/bcgs-photo-archive/lapworth/ ■

Cairngorm Gems exhibition at Braemar Castle - short video of launch event now on Facebook

You may remember that BCGS member Roy Starkey's book: 'Crystal Mountains' was published just over a year ago, and promoted in the pages of our Newsletter. Roy has curated the Braemar Castle Gems Exhibition, so if you're on holiday in the Braemar area, be sure to go and have a look. Ed.

In case it is of interest – have a look at this:
https://www.facebook.com/Braemar-Castle-112116528804705/

Click on the white arrow when you get to the page. If you are an active Facebook user, please feel free to give the Castle Team a plug – they will be very grateful for any support and publicity you can generate. ■

Roy Starkey