Cymdeithas Daeareg Gogledd Cymru
North Wales Geology Association
NEWSLETTER
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Information panel describing effect of impact shocking on belemnite fossils at Nordlinger Reis meteor crater

Chairman's remarks

By Jonathan Wilkins

The restricted movement and association which is permitted under the regulations imposed by the Welsh Government to control the Covid-19 pandemic within Wales has led to a most unfortunate situation for a large number of organisations and businesses who depend upon grouped audiences and mobility in the countryside. As we have almost no fixed costs to consider, we are in a fortunate position when compared to (for example) zoos, theatres and outdoor attractions, all of whom are faced with a perilous loss of patronage and income. I do not want to imply that we are a special case in any way when I say that our Association and our activities are adversely affected by the current 'lockdown', but if the geologist is taken out of the 'field' then there is not a lot left. I am most grateful to Keith and Gary for their efforts in bringing 'virtual' field geology to those members who were able to link-in to their Skype presentations. Quite how and when our 'normal' meetings and activities will resume is unclear at present, but we look forward to that time with hope.

It is customary for me to provide in this part of your newsletter some sort of digest or commentary on matters geological that crop up as I wander through the countryside or pick-up articles from recent (or ancient) publications. There will be no surprise when I say that the amount of geology which I have encountered recently within the regulation 5 mile radius of my home is approximately zero. In fact the geological prospects of life under 'lockdown' have been so few that I have even been forced to try and locate the site of the old antimony mine which was operated intermittently a long time ago, and about which I know very little. As usual, growth of bracken made that almost impossible (I must try again after

the season ends), but I was fascinated to look at the rock in which it was developed. The tuffs of the Capel Curig Volcanic Formation have been intensely silicified, and give a curious sparkle throughout, while vesicular patches have been filled with sparry quartz carrying a black surface coating which gives a false appearance of knots of dark, metallic mineral growth. Totally misleading, and analysis shows that they are devoid of any heavy metal content apart from intriguing, elevated rare-earth elements which might simply be a feature of the tuffs. It is a disappointment that the mine was back-filled with its spoil many years ago, though maybe the National Museum of Wales could be persuaded to have a further rescue dig to investigate this curious, ancient mine. Interest here has focussed upon its rare sulphur/antimony minerals, but little work has been done upon the geochemistry of the rocks and ores.

I was delighted to read in the draft copy that was sent to me for comment, that the Ampyx trilobite was alive and well on the patch that we now call Anglesey! You might recognise the domain name that is host to our web site. Even back in 1999 when it was first registered, a meaningful, five-letter domain name was becoming difficult to find. Use of the name online goes back even further, to 1995 in fact, when CIX was just about the only dial-up Internet provider and ampyx was my username. Layers of history !

That's enough waffle from me! I hand over now to our editor who has brought together some real geological interest. I can only wish you all well at this point and look forward to a time when we can indulge our interest in geology and the fine countryside that we enjoy.

Dr Gary Eisenhauer and the Geologists' Association field trip to the *Lagerstatten* of Southern Germany. A sort of busman's holiday !

by Cathy O'Brien

Wednesday June 10th saw our second presentation on Skype, by Gary Eisenhauer. This went very well with only a few small technical issues for us, but we understood that others lost pictures at some point entirely and had to rejoin. However, Gary gave us all access to the presentation the following day to enable those who had problems to revisit the presentation and catch up on what was missed. The presentation was quite fast-paced and covered a lot of ground, so I am going to summarise the content somewhat.

The leader of this G.A. field trip was my old university colleague in Leicester Dr Dave Martill, now of University of Portsmouth. I first went to some of the sites covered in this presentation in his company when he was an undergraduate in 1981! The field trip transport was a coach and on the Germany motorways they came upon a lorry in a service station that had a geologically themed paint job operated by Joseph Schumacher, a German freight and logistics company; all his fleet have themed paint jobs. This was a good start to the field trip. Unlike the Leicester University field trip that I and Dave Martill attended in 1981 where we stayed in youth hostels, this trip was accommodated in hotels of good quality, some of which had interesting stone facings with fossils identifiable in polished cross section. The route to southern Germany is through France and Belgium and all on motorways; we are familiar with the route as we have travelled those roads many times in our journeys across Europe on our holidays.

The field trip took in a number of other sites in addition to the *Lagerstatten*. *Lagerstatten* is a German word for a fossil locality that has fossils of exceptional preservation, including preservation of soft parts. So, two meteorite craters with associated sites with rocks and fossils shocked by the compression caused by the meteorite's impact and one additional fossil site were also included.

The first site was the Steinheim Impact Crater, Heidenheim County, Baden-Wurttemberg, this is of

Fig.1 View from the top of Donau-Reis church tower

Miocene age, 3.8km in diameter, exposed at the surface. Modelling indicates that the associated asteroid had a diameter of 150m. The crater was filled with a lake shortly after its formation and the lake sediments contain freshwater gastropods which demonstrate evolution. The next site is one we are familiar with as this was part of the Leicester University field trip and we have been back since. Julian really took to the instant geology of a meteorite impact site; this is the Nordlinger Reis Impact Crater in western Bavarian Donau-Reis district. This impact was also Miocene in age and is thought to be part of the same event that formed the Steinheim crater. This crater is big, 24km in diameter and would just about fit on Anglesey, for comparison. The object that made

the crater is estimated to have been 1.5 km in diameter, with an impact velocity of 45,000mph and the resulting explosion had the power of 1.8 million Hiroshima bombs. The historic walled town within the crater has a very good museum with major displays about the impact crater. Good views of the town are had from the church tower (Fig.1). Much of the town is built from *suevite* (Fig.2) which is basically the mashed up and pulverized pre-impact geology of the

Fig.2 Detail of the suevite of Nordlinger Reis crater

crater area to a great depth. It contains *coesite* (shocked quartz) and microscopic diamonds and a local quarry where this stone was excavated was visited. There is also a site nearby that has shocked belemnites which were deformed by the impact and the strata at this site were flipped over and tectonically disturbed by the impact. In the same area there are shocked ammonites too. Within the crater there are freshwater limestone deposits with stromatolites, along with snails and ostracods.

The next site is one of the *Lagerstatten*, the Hunsruck Schiefer Lower Devonian slate, in Rheinland-Pfalz. This geology includes diverse fauna, many specimens preserving soft tissue. It was situated in a marine, back-arc basin south of Laurasia. All slate mines are now closed and there are few exposures, which are over-collected. The fauna includes starfish, crinoids, echinoderms, brachiopods, corals, trilobites, cephalopods and fish, but the field trip was unable to visit any of the localities as the bus was too big for the local roads!

The next site has a similar type of geology but much younger, the disused Eocene Messel Pit bituminous shale quarry, with abundance of fossils. The site very nearly got buried by a landfill, but this was prevented by local opposition and it is now a UNESCO world heritage site. The site was mined for brown coal and oil shale but this activity ceased in 1971 and amateur collectors started to collect specimens from the site. The site is now owned by the State and because of its World Heritage designation no collecting is allowed. At the time of deposition, the area was 10 degrees south of where it is today and was a series of lakes surrounded by lush tropical forest with huge diversity of life in the lakes. These were receiving the input from surrounding rivers and streams and the lake sediments were deposited in an anoxic environment at the bottom of the lake floor. Surface layers were well oxygenated at times, but seasonal variation in oxygenation resulted in die-off of species and slow deposition in the anoxic basal layers of the lake, giving really good preservation. Also, the area around the deposits was thought to have been volcanically active at the time, with the possibility of gaseous emissions of carbon dioxide in events like the Lake Nyos (Africa) event resulting in the death of non-aquatic species such as birds and bats which are present in the fossil assemblages. The poor oxygenation of the lake waters has resulted in preservation of fur and feathers in some species. The shale is very soft and weathers rapidly so where the surface is prepared for excavation it has to be covered over with loose shale when not being used in order to preserve the material. Before collecting can be done visitors have to shovel the loose shale off the exposure! Then a large section of material is detached and taken from the face to be investigated in detail. Because the shale disintegrates easily when dry, fossils have to be carefully and rapidly conserved with epoxy resin.

Fig.3 Fossil of an aye-aye-like mammal

Fossils from the deposits are displayed at the Darmstadt Museum, including primitive primates, something like an Aye-Aye insectivore, primitive horses, tapirs, hedgehogs, pangolins, aardvarks, rodents, bats with preserved flight membranes and ears, birds with preserved feathers, frogs, reptiles and amphibians together with predators such as crocodiles, snakes, and mating pairs of turtles (Figs.3-5), fish and plant species and insects many of which had preserved colours in their wing cases.

Fig.4 Fossil of a bat with wing membranes preserved

The next area is the Early Jurassic *Posidonia* bituminous fine-grained shale with associated bituminous limestone, containing exceptionally well-preserved fossils of fish, ichthyosaurs, plesiosaurs, crocodiles, pterosaurs, ammonites and crinoids. The environment of deposition was anoxic and deep marine within an area of shallower waters. The site visited was Dotternhausen Cement works which operates with locally quarried limestone mixed with oil shale, burnt together to produce cement and producing electricity from the burning of the excess oil shale in the process, which is exported to the grid. The works also has a major community benefit providing many community facilities including a geological museum with fabulous displays of fossils including pyritized ammonites and crinoids in the walls of the facility. These took Garry back to his undergraduate studies where one of his projects was on one of the types of ammonites present at the facility. The museum displays fossil fish, and ichthyosaurs. It also has an area where children can search through a pile of quarried material for fossils. The quarry faces show almost horizontally bedded closely laminated shale which is strip mined and they were allowed to explore the quarry face over the workers' lunchtime and the group found a number of

Fig.5 Pair of fossil turtles

fossils, including a rare nautiloid. The shale contains nodules which are kept for examination by museum staff.

The Urwelt Museum Hauff in Holzmaden holds the fossils from the *Posidonia* shale and has displays of fossil preparation techniques. It also has specimens of belemnites (with preserved soft parts including tentacles with hooks Fig.6), crustacea, fish, pterosaurs, crocodiles, plesiosaurs, ichthyosaurs including embryos in the body (Fig.7), and crinoids including a 18m long log covered in over 300 individual crinoids (Fig.8) the presentation included a film of this section along with Dave Martill talking about the museum they were in.

The next site is the late Jurassic Solnhofen Limestone in Bavaria between Nuremberg and Munich. This limestone has rare assemblages of fossils including soft bodied organisms, with over 600 species including many examples of pterosaurs and the early bird *Archaeopteryx*. This fine-grained limestone was deposited in a placid lagoon environment with limited access to the open ocean and as a result the environment had high salinity and the deeper water lacked oxygen. So as a result, anything that died or was washed into the area would be buried in the soft fine calcareous mud. This material is quarried for roof tiles, flagstone and flooring stone. It is a fine, even grained stone and was also used for lithographic plates. There are many quarries in the area, and the trip went to the Langenaltheim quarry, the site of the first *Archaeopteryx* find in 1861. The quarry does not provide access but there is a small public quarry nearby for public access. There is a public facility Besuchersteinbruch Muhlheim bei Mornsheim where

Fig.6 Belemnite fossil with preserved soft parts

fossil hunting and tourism meet, run by an enterprising person who allows people to pay for access and provides facilities to enable fossil hunting, with a bar and snacks for sale (Fig.9). You pay for the time you want and you keep what you find.

Another quarry that is accessible is the

Fig.7 Ichthyosaur with embryos

Schernfeld Sportzplats Quarry, where the face can be explored and shows a 2.5m thick layer of folded and slumped sediment between horizontal bedded layers. This limestone frequently contains fossils of free-swimming crinoids (Fig.10). Garry, thanks for telling me what a fossil I found in 1981 is, indeed I found one of these, *Saccoma tenella* and the group found a slab with a lot of them. The limestone also commonly has dendritic manganese and iron oxides across the bedding planes from fluids that travelled along joints in the limestone. The limestone contains lovely detailed fossils of fish, shrimps, pterodactyls and coelacanths.

In the area there are a number of museums displaying the fossils found; the Solnhofen Museum has three *Archaeopteryx* specimens, pterodactyl, juvenile feathered dinosaur, ichthyosaur, rhizostome jellyfish, squid, horseshoe crab with trail of footprints, fish, starfish, free swimming crinoids, dogfish, sea urchin with spines and undigested remains of sea urchin in the gut of pycnodontiform fish, ammonites,

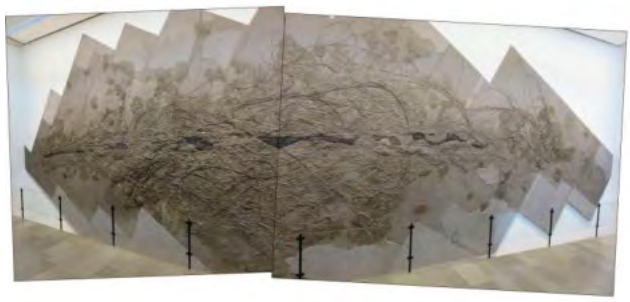

Fig.8 Fossil log with many attached crinoids

insects and leaves. The Jura Museum in Eichstatt has a number of *Archaeopteryx* specimens, pterosaurs including one with a preserved wing membrane (Figs.11,12), a non-avian therapod, sea turtles, jellyfish, free swimming crinoids, crustacea, and crustacea with tracks, plants and insects, guitar-fish and coelacanths. This museum also has displays of palaeoecology, biostratinomy and trace fossils as well as displays of fossils alongside modern birds and fish (Figs.13,14). Some of the trace fossils are enigmatic, such as the track left by a rolling ammonite, a fish death trail and a spectacularly preserved fish which was Gary's favourite.

Fig.9 The public fossil hunting site, with bar etc

Fig.10 Free-swimming crinoids slab

Fig.11 Photos of *archaeopteryx*

Fig.12 Pterodactyl with preserved wing membrane

Fig.13 A remarkable 'exploded' fossil fish

Fig.14 A perfectly preserved fossil fish

Follow the evidence: rediscovering a forgotten outcrop

by Dr Richard Birch

A geologist colleague - sadly no longer with us - once rounded on me with some emotion when I admitted I had been collecting fossils, citing the damage done to important sites. Collectors were '*scum of the earth, hanging was too good for them*, etc, etc'. It is true that collecting has gotten a bad name thanks to the systematic plundering of sensitive sites such as Birk Knowes in Lanarkshire, which was worked out for commercial gain by collectors using industrial rock saws. Wales has not been immune either: a renowned site near Corwen has been systematically plundered in much the same way.

I confess I was too taken aback by the strength of feeling to point out that the majority of palaeontological discoveries are made by amateurs (including the discovery of the Wales dinosaur *Dracoraptor hanigani*, named after the amateur collectors who found it weathering out of the rocks at Penarth). That site is well-known and ruthlessly collected, but it yields its specimens slowly over time and discovery is dependent on constant attention by collectors. Obviously there is a balance to be struck, but the trend to denigrate what was, in my youth, encouraged as a hobby to get youngsters outdoors, is counter-productive.

I would suggest that the most significant discoveries of late have been made from locations with little interest to collectors (although good discoveries from such sites can soon elevate their status). An example would be a small exposure of Ordovician mudstone at Tandinas quarry, Carreg Onnen on Anglesey's north-east coast.

The Ordovician outlier was first described by Edward Greenly[1] as part of his historic work on the geology of Anglesey, so it is not a new discovery. However, the quarry itself - a limestone quarry, designated as a SSSI for its Carboniferous exposure - was abandoned sometime in the 1960s and is now much overgrown. It is, in fact, far more notable for its existing flora, which includes many rare species of plant. The early Palaeozoic rocks are exposed on the western end of the beach but the bulk of the section is now buried beneath scrub woodland.

Greenly's work is not all openly available to peruse online. My thanks to Keith Nicholls and Terry Williams for making it available. This indicates that in

[1] Greenly E. *The Geology of Anglesey*. HM Stationery Office, printed under the authority of HM Stationery Office, by J. Truscott and son, Limited; 1919.

1896 the section was more visible than it is today but examples of each rock type Greenly describes can be located from the beach section, including the sharply dipping slates, which he suggests are older than Ordovician. I could find no organic evidence in them either and they are probably unrelated to the mudstones further up the section, from which the fossils in Fig.1 were collected.

There is a reference to the site in the out-of-print Directory of British Fossiliferous Localities'[2] which states [sic]: '*Beach E. of Careg-Onen, nr. limestone quarries. Ordovician (?Caradoc) grey shales underlying red-stained shales*.' There is also a reference in the Geological Survey 'Anglesey Special', but I can find no publication under that name. Evidently it was detailed enough to confirm that the graptolites point to the *Nemagraptus gracilis* zone (appropriating to the middle Ordovician, or late Llanvirn - early Caradocian. See Error! Reference source not found.). There is a general reference to the middle Ordovician sequence in *Fossil Collecting: an illustrated guide*[3] which was a birthday present when I was 11. It gets a mention under the broader entries for Ordovician Anglesey as being an exposure that outcrops at '*a few places near Beaumaris and Menai Bridge*.' Nowhere could I find a specific name for it.

Despite having 3 Sites of Special Scientific Interest (SSSIs) designated for their Ordovician biostratigraphy, all of which are to the mid-west of the island, Anglesey has very poor non-coastal Ordovician exposures that can be stratigraphically verified from their fossils. Most have succumbed to the requirements of modern agriculture; serving as reclaimed land, rubbish tips or eutrophic ponds. But torrential rain in the winter of 2019-2020 scoured the Tandinas access track clear of the usual covering of cow ordure and provided a brief opportunity to collect a representative fauna (Fig.1 j).

And it has proven to be very interesting ! Sites which contain both trilobites and graptolites are rare, as the conditions in which both lived were very different: graptolites were oceanic, trilobites benthic. However there must have occasionally been some overlap, as it is certainly not unique. We're dealing in fragments here though: these are weathered greenish-brown shales, strongly cleaved and very brittle. Indeed, a hammer is barely necessary, as it is possible to break the rock apart with one's hands. Keeping the specimens whole is much more of an issue.

From the limited exposure available – just a few places along the track to Tandinas quarry, it was possible to collect several individual trilobites, fragmentary graptolites and a few other fossils, which are enough to add a few observations to the existing canon of knowledge concerning this exposure.

- The following trilobite genera have been identified: *Ampyx* (cf. *lindleyensis*) and *Toxochasmops* (cf *extensus*) (Fig.1 a-e) Other species are fragmentary and currently unidentified, although Greenly cites *Calymene brevicapitata* and *Asaphus powsii* of which the former is an extant name kown from specimens collected in Ireland.
- It is unusual that *Ampyx* is the most common trilobite, and the only one to be found in an articulated state (3 specimens). The long rostrum and genal spines (Fig.1 f) are thought to be protection from predators, but there were no fish in the Ordovician seas, and they would not provide much protection from another arthropod. It has been suggested that they prevented *Ampyx* from sinking into soft mud in the same way as snowshoes do.
- These suggest that it is an *in situ* fauna from fairly deep, muddy water - conditions which must have persisted hereabouts for much of the Ordovician.
- The lithology is very similar to the Crugan mudstones on the Llŷn Peninsula, Gwynedd, which has a confirmed 26 species of trilobite including those indicative of the late Ordovician (Ashgill). These were described in detail by Price (1981).[4] From the specimens collected at Carreg Onnen so far, there is no overlap in species.
- The Anglesey sequence is probably earlier, based on the trilobite identification, which ranges from Llanvirn to early Caradocian (Table 1). A fragmentary brachiopod is a candidate *Dalmanella* sp.
- The graptolites are all very fragmentary and include a monoserial form, with the individual *theca* on both sides of the stipe (Fig.1 g), suggestive of an *Climacograptus*. Another fragment has *thecae* offset and resembles a *Pleurograptus*, (Fig.1 g, inset) both of which are middle-late Ordovician forms.
- An interesting find is a near-complete echinoderm resembling a blastoid (Fig.1 i). These are a group of stem echinoderms that emerged in the

[2] Palaeontographical Society (Great Britain). *Directory of British fossiliferous localities*. Palaeontographical Society; 1954.

[3] Casanova, R. *Fossil Collecting: an illustrated guide'* Faber & Faber Ltd. 1960.

[4] Price D. *Ashgill trilobite faunas from the Llŷn Peninsula, North Wales, UK*. Geological Journal. 1981; 16(3):201-16.

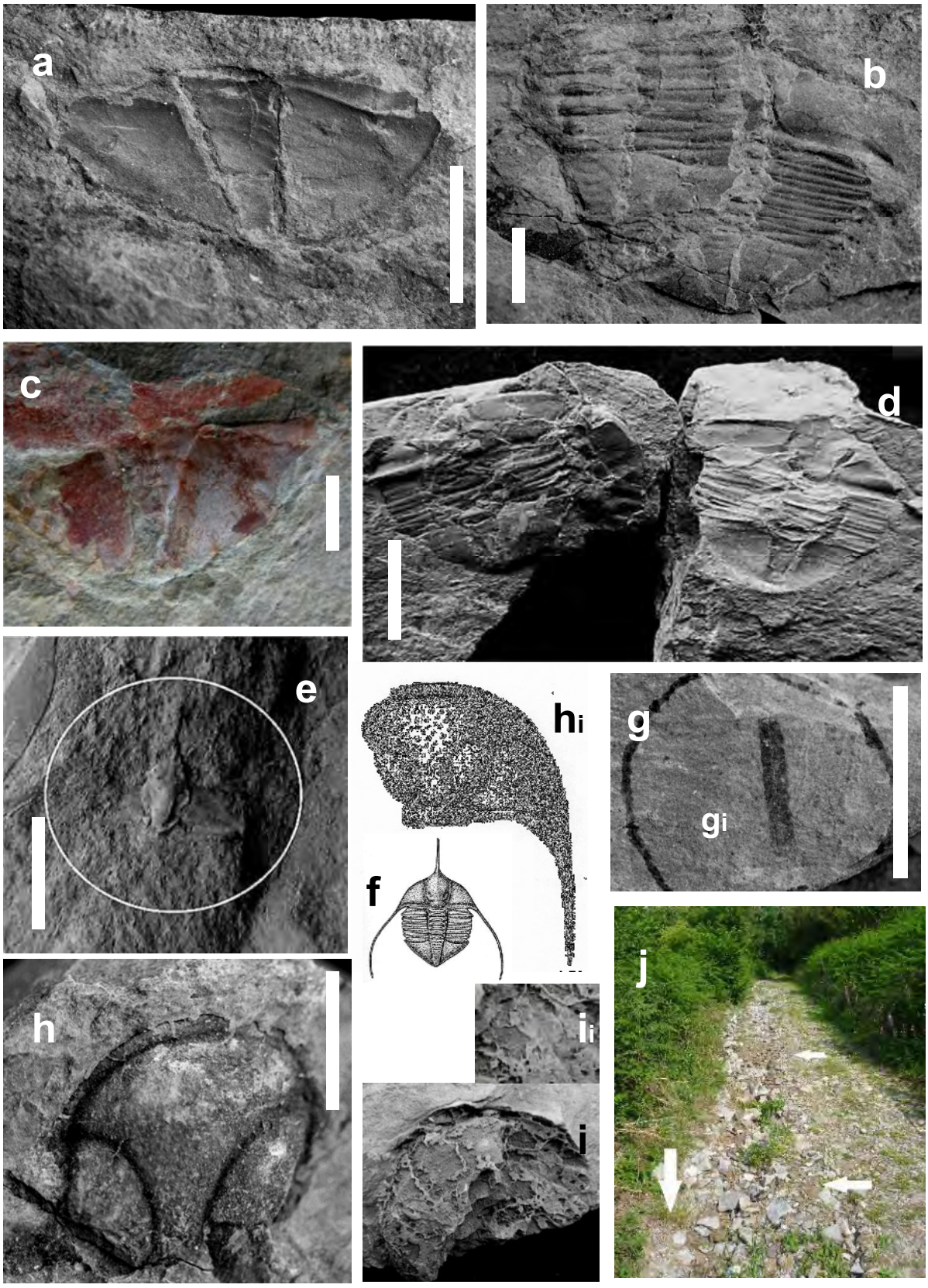

Fig.1 Ordovician Fossil assemblage from Carreg Onnen, Anglesey

- Ordovician and became extinct in the Carboniferous. The specimen is near-complete and articulated, subsequent disarticulation having occurred post-fossilisation. This is rare: echinoderms are frequently disarticulated after death. Together with trace fossils, this suggests an in-situ fauna rather than a derived one.

The fauna, as described here, spans a stratigraphical range from the Llanvirn up to the Hirnantian, (mid to late Ordovician) but suggests early Caradocian (late middle Ordovician), although were further collecting possible, greater stratigraphical accuracy could be achieved.

And so, the necessary arrangements for further work have been agreed with the landowner. This will include excavation of trial pits in order to expose any boundaries between the weathered 'green' shale and the fractured shales at beach level (Precambrian?) and perhaps even the unconformable boundary with the overlying Carboniferous limestone. I am grateful to Sir Richard Bulkeley for granting permission. The location is outside the SSSI boundary for the limestone coast between Penmon and Carreg Onnen, and the Ordovician sequence is not included in the citation; nevertheless I am also indebted to Ray Roberts and Sally Ellis for facilitating communication and access.

This may not be straightforward. Overgrowth of the vegetation makes excavation difficult, and the activities associated with quarrying will have confused the matter: the track has been reinforced with limestone, and it is already difficult to determine whether the green shale is in situ or is in itself a track foundation. Nevertheless, a fossiliferous zone can be identified, and even with just a spade, it should be possible to make a reference collection.

I have no fear that this will open up a 'gold rush' of collectors. The delicate and much-distorted specimens featured in Fig.1 will not interest the commercial collector. But they are of inestimable value to those who wish to document the palaeoecology of Wales throughout the early Palaeozoic, and to map a complex sequence of rock types on the west side of the quarry, extending into Red Wharf Bay.

Figure 1 key

a) Large pygidium with raised front margin, indicative of *Ampyx*.

b) Thorax with 6 articulating segments and part of both pygidium and cephalon present. Characteristics indicate *Ampyx*, but if so, a very large specimen. This appears to be an unsuccessful moult, or two exuviae on top of each other.

c) Large undet. pygidium with 7 axial segments, but smooth pygidial cheeks. The red colouration is typical of Greenly's description.

d) *Ampyx* [cf.] *lindleyensis* in part and counterpart (the base of the rostrum is visible in the counterpart, but the genal spines are broken off).

e) Small cranidium of *Ampyx* [cf.] *lindleyensis* with visible rostrum.

f) Reconstruction of *Ampyx lindleyensis* (reproduced from *British Palaeozoic Fossils* 4th edition 1975).

g) Fragment of monoserial graptolite resembling a *Climacograptus* sp. (gi = fragment resembling *Pleurograptus*, with offset thecaea).

h) One of 2 glabella resembling *Toxochasmops* sp. hi) Reconstruction of *Toxochasmops* (modified from *British Palaeozoic Fossils* 4th edition 1975).

i) Large 3-dimensional echinoderm (Blastoid) with (*inset* ii) details of hexagonal plates.

j) Exposure in track to Tandinas quarry, consolidated with limestone from the quarry itself. Scale bar = 10mm.

COLLOQUIAL DIVISIONS	INTERNATIONAL DIVISIONS	BRITISH EPOCH	BRITISH STAGE DIVISIONS
Late Ordovician	Hirnantian	Ashgill	Hirnantian
	Katian		Rawtheyan
			Cautleyian
			Pusgillian
		Caradoc	Strefordian
			Cheneyian
	Sandbian		Burrellian
			Aurelucian
Middle Ordovician	Darriwilian	Llanvirn	Llandeilo
			Abbereidian
	Dapingian	Arenig	Fennian
			Whitlandian
Early Ordovician	Floian		Moridunian
	Tremadocian	Tremadoc	Migneintian
			Cressagian

Table 1

Welsh amateur geology and photo-microscopy ... an appeal and an opportunity

by Drs. Joe Botting and Lucy Muir
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The world of the natural sciences is changing. For most of the past century, field-based research in palaeontology (and entomology, and geology...) has been dominated by academics. Jobs were plentiful, and time was sufficient to indulge in exploration. No more. Today, the academic research world is heavily biased towards analytical and laboratory work and fieldwork is focused on high-profile sites, usually in exotic locations. Taxonomic descriptions and exploratory fieldwork are fitted in as an afterthought ... and the field is slowly being left to the amateurs.

What do I mean by 'amateur' in this context? In short, someone who does it for the love of the subject,

At the *Sign of the Trilobite* in Llandrindod Wells

rather than because of payment. There is a long tradition of highly skilled, and highly knowledgeable amateur palaeontologists (and many other -ists!) in the UK, and much of the pioneering work in the 19th Century was also performed by them. Some become so skilled in their specialism that they are the de facto authorities in their fields ... despite never being paid to do their research. This tradition has never gone away, but what is critical is that now we are largely *dependent* on amateurs for new geological discoveries in this country. This is not an empty statement, either; most of the important palaeontological finds in North Wales in recent decades have come from them (we're looking at you, Richard Birch and Tom Unite!).

Being an amateur has its drawbacks, though, as we understand all too well. We're both academics by training, but are only paid to do palaeontology while on short-term contracts in China. When we're there, we have all the facilities we need; when we're back home, we have only what we own, or can use when we visit the National Museum in Cardiff. We've spent quite a bit of our meagre funds on microscopes, computers, a library (and a house big enough to accommodate all the rocks and equipment!) ... but we've been forever tied to the 'hobbyist' level of equipment, with all the limitations that involves (and yes, papers have been rejected because of it). Now ... we need to move to the next level in one key area, and in the process provide a resource that can be used by any amateur natural scientists that need it.

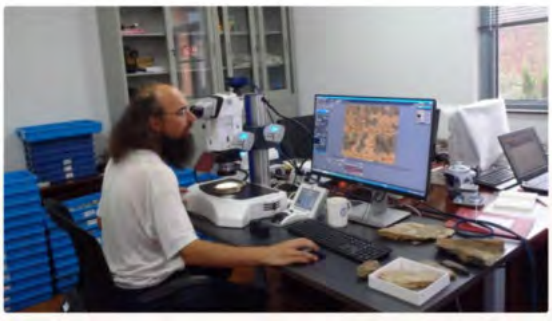
Who are we?

First, let us assuage that nagging fear that we're going to do a bunk with the money, or hoard the microscope just for ourselves... We are both academic palaeontologists, and met as undergraduates in the geology lectures at Cambridge. Between us, we've held fellowships and jobs in Cambridge University, the Natural History Museum (London), Leeds Museum, and the Nanjing Institute of Geology and Palaeontology. After a two-year stint at the latter, we moved to Llandrindod while looking for permanent jobs ... and never left. We just fell in love with the place, and the lifestyle, and we now work freelance as an scientific language editor (Lucy) and as a tutor, musician and entomological surveyor (Joe) ... with, still, semi-regular three-month stints in China on short-term fellowships.

In Llandrindod, we've now become part of the scenery, and probably wouldn't be allowed to leave even if we wanted to. Among other things, we run a local amateur palaeontology group that's been going for six years, and use our old shop window (now our study and teaching space) to house natural history displays to amuse passers-by. You can find us at the Sign of the Trilobite. We can't run away.

The microscope

In short, we want to crowd-fund a state-of-the-art, research-grade photomicroscope which we will host and look after, but make accessible to all who need it. We're aiming for the best we can get (although there are other, less spectacular options if we fall short). This monster of technological wonder is the Leica M205C. This machine is a stereo-zoom microscope designed for reflected light (rather than slides), with dual eyepieces (adjustable to suit all eyes), a wide magnification range, and the best optics you can buy (unless you work for NASA). Unlike the microscopes familiar to most amateur scientists, a high-powered PC (we're providing that ourselves) is a required accompaniment, because of the high-resolution imaging capabilities that are built into the system. The microscope itself is modular: there are a range of components (lenses, etc.) available, and the machine is built to the user's specifications. We want it to be as flexible as we can get, but include the following:



Joe using a similar model in Nanjing, China

- a very wide magnification range, ideally from around 7x to over 200x. You'll see little USB microscopes advertising those sorts of magnifications, or even higher... but they don't *really* give you that. It all depends how you measure it... and how good your lenses are. And these are *seriously* good.

- *camera lucida*. A drawing tube is an old-fashioned but invaluable device for extracting information that cannot be obtained from any one photograph. It allows you to trace what you see down the microscope, as you adjust the light sources, filters, etc., and combine all the information into one image. They're critical pieces of equipment in some specialisms (such as Lucy's graptolites), but are very rarely seen. We don't have access to one even in the National Museum of Wales.
- Dual lighting options, including LED ring light, and flexible fibre-optics. These allow all manner of manipulation, which is critical to observing and getting perfect images. The flexibility of these also allows us to use coloured filters or polarisers, highlighting details that are otherwise invisible.
- Purpose-built 5MP coaxial camera and Leica image processing software. This is the key thing; for anyone who has struggled with attaching cameras to a trinocular microscope, or rigging up your own system, you know it's usually frustrating and ultimately not very successful. We've used this system in China, and it really does work. If it's set up perfectly, then what you see down the eyepieces is almost exactly what you capture. It's hard to get across just how important this is.

In short, Leica produce some of the best (if not *the* best) lab-grade microscopes in the world, and we're looking at getting their flagship model, with a lot of the trimmings.

Our proposal

The full kaboodle will cost around £30,000 (including VAT). We simply can't afford this, or anything like it, but can contribute a significant chunk. However, we own in Llandrindod an accessible palaeontological lab space (we've recently bought a large [but "in need of improvement"] old Edwardian building that includes an old shop) and part of our dream is to make this as accessible as we can to other enthusiasts in the natural sciences. We already have a decent working stereomicroscope (for preparing and general study), a petrological microscope (donated from old university stock), an extensive library, reference collections of palaeontology, geology and natural history items, and more. For those travelling from afar and who'd rather not stay in a hotel, we can also offer spare beds and simple home comforts. With the addition of a high-end photomicroscope, we would be able to offer virtually all that is necessary to study and image material up to publication-standard photographs (well, except an electron microscope; that's for some time down the line !).

Support this bid, and you're effectively helping to purchase an accessible high-end research and imaging facility. But that's not all ...

Why now?

You may be wondering why we've suddenly found a need for a microscope we've done well enough without for many years. Partly it's that we have been almost-but-not-quite hamstrung for a long time ... but partly it's because we've found a new site with exceptionally preserved fossils that absolutely *demand* this type of equipment!

A 2.5-mm-long tube with the tentacles of the inhabitant preserved

I'll tell you more about this new fauna in future, but suffice to say that we have a diverse assemblage of animals (worms, arthropods, cnidarians, sponges) with soft tissue preservation and exquisite detail... but the entire animals are often around millimetre scale. In some cases (such as 0.1-mm-long worms) we *think* we can assign them a phylum (for example, as a *kinorhynch*), but don't have the resolution or imaging capacity to prove it. Even in larger animals like sponges, there are details preserved that are beyond the limit of our resolution.

This fauna is in the very early stages of research, but already appears to be far richer and more important than other Welsh Konservat-Lagerstätten, such as Afon Gam, Llanfawr or Llanfallteg. It has some similarity, in its preservation, palaeoecology and sedimentology, to the Chengjiang Biota. Just ... a bit smaller!

As part of the crowdfunding bid, and as a mark of gratitude, we are committing to releasing regular news bulletins about what we are finding, using images from the photomicroscope... as far as we can without scuppering publication, at any rate! Even if you don't have a use for the microscope yourself, your contribution would earn you a front-row seat for the exploration of a new Konservat-Lagerstätte.

Benefits

It's hard to come up with an exhaustive list of the benefits for you and for Welsh geology, but here are some that we can think of ...

A 2-mm-wide fossil starfish.

- For those actively publishing, you can get research-level imaging in a relatively handy location in the centre of Wales.
- The ability to make spectacular images for presentations, popular publications, workshop handouts, and even artwork.
- Equally useful for palaeontology, sedimentology, mineralogy, botany, marine biology, entomology, archaeology and more.
- A step towards independence of the amateur science community from major museums and universities.
- Will generate diverse publications on Welsh material, reinforcing the importance of Wales in global palaeontology
- Facilitation of work on a new Ordovician Konservat-Lagerstätte, as we aim to encourage a new paradigm of openness during the research process.
- Helps to cement and inter-connect a network of amateur scientists across Wales.

We have no doubt that more benefits will appear that we haven't even thought of ... but hopefully that is more than enough to be worth supporting.

All donations to this cause will directly affect the future of Welsh amateur natural science, and we thank you profoundly for your support... and look forward to sharing the rewards with you. To contribute to this project, please visit: https://www.gofundme.com/f/a-microscope-for-amateur-science-in-wales. **Please also share this link as widely as you dare**.

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