



Cymdeithas Daeareg Gogledd Cymru

North Wales Geology Association

Inside this Issue:

Chairman's Message

Articles:

Crowd cuckoo land

Hitting the G-plate

A letter from Sedgwick (iii - continued)

Extractive Industry Scholaships

NERC funded PhD Studentships

Abstract

Book Review

Reports

New Publications

Dates for Your Diary

Web News

Committee Contacts

Call for Papers

Issue No 74

NEWSLETTER

January 2013

Chairman's Message

I shall start by wishing all our members a happy New Year, and remind you that our AGM is to take place on Saturday 26th January, with full details of the meeting and speaker enclosed in this issue. We look forward to seeing you there.

Naturally, we are all looking forward at this time of year, to longer days, better weather and geological events to come. For my part, I am excited that our annual holiday is already confirmed, and we are returning to Connemara - an area of many geological delights and a glacial landscape without peer. Let us simply hope that the Summer shows some improvement over 2012, or at least that an end to the current regular flooding comes soon. When I was out in the Conwy Valley on New Year's Eve the river between Dolgarrog and Trefriw was many times its normal width and filled the low fields as far as eye could see, while there was more water coming down the Afon Porth Lwyd overflow at Dolgarrog than I have ever seen before. This was the site of the catastrophic breach and flood that killed so many people in 1925 when the Eigiau and Coedty dams failed. I just hope that, with all the excess water in evidence, the power station was generating at its maximum capacity!

The current exceptional rainfall and unseasonal temperatures are a worrying hint that our climate may be changing (bearing in mind that weather and climate are not the same thing). We heard this year that Arctic sea-ice has

reduced to its lowest recorded level, and our cold, wet Summer was matched by record-breaking high temperatures in Greenland and Canada.

The Atlantic Ocean, which drives our weather, is a complex system and responsible for delivering a massive amount of heat to the Arctic, so research into surface temperature and flow is at fever pitch. I was interested in an article in PLANET EARTH (glossy quarterly of NERC-funded research topics) highlighting work published in NATURE on cyclic changes in Atlantic Ocean surface temperatures and the effect upon weather in western Europe. Statistical techniques were used to uncover a periodic change over about 30 years that showed as abnormally wet summers (in Britain) or drought (in the Mediterranean). The previous wet phase lasted from 1930 to 1960, with drier conditions until 1990 descending again into the present famous wetness. If you are of a certain age, then it may truly be said that summers seemed sunnier in memories of childhood than today!

References:

Planet Earth Online:
www.planetearth.nerc.ac.uk

Sutton, R.T. & Dong, B..(2012), *Atlantic Ocean influence on a shift in European climate in the 1990s*, Nature Geoscience 5, 788-792

Jonathan Wilkins

Articles:

Crowd cuckoo land

It is said that the most difficult item for any writer is a title for the work, so the fact that I came up with such an obscure/intriguing/punning/irritating title very quickly bodes ill for the rest of this short article.

Wikipedia is arguably the greatest work of reference achieved in human history, but it relies upon no paid authors and rests upon its virtual community of readers and contributors for editorial update, style, references and extension. It is a work so often drawn-upon that serious bodies such as the Geological Society of London, the World's first self-organising society for geologists, are running courses on how to become an editor so that the huge body of expertise represented by the members can be used to improve the (geological) content of the site. I confess that I became an editorial user some while ago and have contributed articles and improvements on a few (non-geological) topics, simply because I was troubled by mistakes that I encountered. Such endeavours are termed "Crowd-Sourcing" and you should score two points if you picked up the first reference in the title. "Cuckoo" because we must be mad spending so much time on an unpaid work with no tangible reward or recognition - score 4 for that one.

Other web sites on the fringe of crowd-sourcing might include Flickr, although I would not actually count it because it has an overtly commercial purpose but no tangible function. Commerce arises simply because it is a place that people are drawn to and that means that you can shove advertising in their faces and charge companies for the resulting exposure, but it has no function in so far as there is no structure or ambition. It

is just a huge gallery which often has pictures of things that interest us, but many of the pictures are terrible and humanity is no better for sharing them. There is no ambition to document the state of the World, or its inhabitants, for example, although the collection of images is now so vast that SOME conclusion could be reached...; likewise YouTube.

In 1801 the Ordnance Survey published its first map as a direct consequence of fears of invasion during the Napoleonic Wars and a desire to know distant country well enough to pursue and apprehend Jacobite renegades. As with all military endeavours, a great deal of money could be spent with complete justification and we are fortunate that we have led the World in cartographic excellence ever since. In 1835 the Geological Survey was set up as an offshoot, though it is still struggling to produce a complete and unified map series for the whole of its territory. In 1936 a committee was instituted to discuss the future of the Ordnance Survey, and that started a new triangulation based upon fixed and recognisable reference points on hilltops which replaced prominent buildings and towers as had been used previously. It also ushered in metrication and the national grid reference system. Are you getting the "Land" reference (2 points) yet? I was introduced to the NGRS at junior school, which was at TL187297, and I still have the cloth-mounted Seventh Series One-Inch Sheet 147 with its "J Wilkins, Prep 3" legend with which I was furnished for lessons. Our headmaster was a remarkable man, but that is history, not geography, and a love of maps was kindled almost instantly. So much can be learned from a map..... About the same time my Grandfather got me started with my first camera, and very slowly a synthesis started to form.

Fast-forward to 2004 and the digital, web-enabled age and a couple of geeks having a beer and pondering whether it would be

possible to build a database of images of the British Isles that would give complete coverage of EVERY SINGLE NGR 1km square? It was fairly rapidly calculated that there are 331,932 grid squares covering at least some land at low tide, and computers are good at big numbers after all. There was some initial scepticism that the task could be completed any faster than the original Ordnance Survey. Score 10 if you saw the title rushing towards you like a GPS satellite. So was born the GEOGRAPH project, and I have been a contributor for over 6 years now, with the greater part of 3000 images to my credit in a paltry 927 (as at 17th October, 2012) grid squares. Sponsorship by the Ordnance Survey was a huge commercial milestone, although that has now ceased, and respectability was gained through the recognition of the British Library who take periodic back-up copies of the database; which is an immense record of 21st century Britain (and Ireland). All submissions are moderated, in order to prevent abuse and hi-jacking for nefarious purposes and incentives, and there is a vibrant online community of 11,000 contributors (the "Crowd") who are incentivised partly by territorial objectives. My aim is to put in as many geologically-relevant images as possible, with captions that explain what is on view.

The database has a simple primary key - the grid reference - which can be a single 1km square (e.g. SH3040) or wider area (e.g. SH34 for 10x10 km). Alternatively, there is a search facility which can be used for a geographical name (e.g. Nefyn) or image description (e.g. "erratic", or "raised beach") or contributor (e.g. "Ampyx"). Nefyn will return some 110 images, so you might wish to move on to refine your search with an additional search term such as "cliff". Go on, give it a try - you might find it interesting. You can also choose areas of interest by pointing at maps on different scales, but that does not lead to such focussed results at first. The Geograph Mosaics are a fascinating topological view

of the countryside tiled from the first submissions within the area and form bizarre thematic collages of mountains, towns and fields in their correct geographical position.

The colourful, friendly and helpful front page is at www.geograph.org.uk and is the portal for over 3 million images of the UK, Ireland and Man. The Channel Islands have their own web site, which is a bit in the doldrums, and is only really served by creaky extension of the NGRS, and Germany has a similar project, although it is struggling in comparison (perhaps Germans don't revere maps in the same way we do?). Give the site a look, and maybe you will get the bug - and if you want illustrations, all the images are free for re-use so long as the original contributor and source are acknowledged (just like Wikipedia).

For my own part, the objective of reaching uncharted or seldom-visited territory has taken me to places I would never have seen without that incentive, and the knowledge that I have gained of geology, landscape and geography has been thoroughly rewarding.

JW

Hitting the G-plate

I recently had the good fortune of being able to catch up with an old friend "over a couple of shandies" in Chester. Since our student days we had tread somewhat different paths, and Alastair now works in the oil industry – primarily in the Norwegian North Sea. We spoke about our mutual interests (some of which even touched upon geology!).

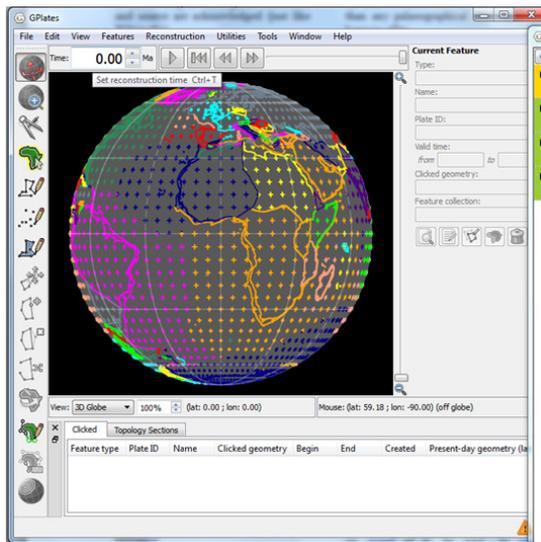
The reason for this brief article arises from his comment - "Have you come across G-Plates – great little tool...". Not putting too fine a point on it my answer was "No". Unlike Alastair I tend to get my palaeogeographic reconstructions from text books and papers, rather than from software

packages. Anyway – an e-mail or two later and I am introduced properly to:

“G-Plates – desk top software for the interactive visualisation of plate tectonics”

The tool has been put together by researchers in Australia, the USA, and Norway and offers users the opportunity to visualise plate tectonics in a far more detailed and functional manner than any palaeogeographical atlas can ever hope to offer.

The package is open access – free to all with an interest – and can be downloaded from: www.gplates.org



It is apparent that to get full use out of the software package will require a considerable investment of both time and energy – some of the computer speak is certainly obscure; to the point of intimidating; at least for the non-specialist like myself. But for those interested in plate motions and palaeogeography this tool has considerable potential.

KHN

A letter from Sedgwick (iii - continued)

This is the third extract from Sedgwick’s letter of 1853 to Murchison, his erstwhile collaborator and subsequently, his great rival. In the previous extract Sedgwick had elaborated on his belief of the existence of an unconformity bounded sequence between “his” Cambrian and “Murchison’s” Silurian. In his own straightforward manner Sedgwick continues:

“I have been writing very plainly, as I always would do to an old friend. Judging only by my own collection McCoy has long fought against any notion of an overlap ‘I see no proof of it’ he said, ‘in your collection, and I don’t believe it. If’ said he ‘the fossils of May Hill be in the same group with those of Horderley and Caer Caradoc I will give up palaeontology as long as I live’. We went last year to the localities, and you know the result. We were only five days at work this summer in the field. I could not stand the wet, and was out only two days; and was then confined to my room by English cholera. But we did some good work. The Pentamerus Limestone is at the bottom of the May Hill group, and is the true base of the unconformable series. It is a part of the unconformable series. The Olenus shales of the Malverns (Philips) are what I have called Caradoc shale, and are in the Caradoc sections, where they ought to be. But I now believe that seven or eight years since I mistook the upper bridge over the Onny for the lower bridge, and thereby carried the Caradoc shale so far down the river as to make it overlap the line where the Pentamerus beds probably pass the river. McCoy could see nothing, because of the floods of the Onny, which this year (as the last) covered the upper parts of the section. But Mr Duppa had (at my request) made excavations which set all right. McCoy and Salter both told me, years since, that I must have blundered about the one of the localities of my Caradoc shale; but I

obstinately stuck to my note-book, though it made against myself, for it would have been a formidable example of an overlap between true Cambrians and true Silurians. I mean to give a short paper on what we did, and it will, perhaps, be the last paper with which I shall ever trouble the Geological Society, which of late years has, I think, treated me rather scurvily. I must conclude...I have written very frankly as I should have wished you to write to me...Ever (whether in peace or war) your affectionate old friend,

A Sedgwick

In this letter Sedgwick confirms that on the basis of the fossils in his collection, McCoy, one of the most renowned palaeontologists of the day, had confirmed that the “Caradoc” and the “May Hill” faunas were distinct, and were unlikely therefore, to be contemporaneous. Implicitly it would be obvious that they should not have been coloured as a single formation / group on the published Survey mapping. He identified the Silurian *Pentamerus* Limestone as being the basal stratum of an unconformity bounded sequence.

In 1854 however, the John Murray press published Murchison’s magnum opus “*Siluria*”. In this Murchison expressed his regret that an “*old and cherished friend*” had “*so strenuously objected*” to the use of the term “*Lower Silurian*” but appears to draw on the fallacy of strength in numbers noting “*that the question has been determined by many competent and independent authorities*”.

Further comment by Murchison attests to his objection to Sedgwick’s apparent proposal to “*absorb my Lower Silurian into his Cambrian Rocks*” although noting that “*in general views, as in private friendship we are cordially united.*”

In a note added, seemingly, immediately prior to publication (pg86), Murchison

appears to acknowledge something of Sedgwick’s objections:

*“In a minute re-examination of the district... I learn that they have detected ...a small amount of unconformity between the uppermost of the limestones containing the *Pentamerus oblongus*...and the subjacent beds of flagstone shale and impure limestone...*

He goes on:

“I willingly admit that several of the other species of fossils in this bed are common to the Wenlock and lower deposits; a fact which strengthens my view of the unity of Silurian life”.

It is in these last statements (repeated almost verbatim in a subsequent note on page 98) that we appear to see the nub of the matter between Murchison and Sedgwick, and it seems that McCoy may have been able to differentiate the respective faunas to a much greater level of detail than the Survey palaeontologists. We are perhaps therefore seeing an early dispute between “splitters” (McCoy / Sedgwick) and “lumpers” (Survey / Murchison).

Again Murchison seems to, albeit somewhat grudgingly, accept (at least some of) Sedgwick’s arguments when he records (pg 109) that:

*“Professor Sedgwick has recently attempted to show, that a sandy portion on the west flank of May Hill, which occupy this intermediate position ought not be classed with the Caradoc, as previously alluded to, as they have been by the government surveyors and myself, but should, from their fossils, be ranged with the Wenlock. If this suggestion be adopted, it will only strengthen the opinions of Professor Phillips and myself, as to the difficulty of drawing a decisive line between the **older and younger groups** of this natural system”*

My bold text above indicates an implicit acceptance on the part of Murchison, that there are, in fact two groups; one older, one younger; within the generalised Silurian (sensu Murchison) rocks.

For the reader interested in following up the original of Murchison's "Siluria" it should be noted that it can be downloaded (foc) at: <http://books.google.co.uk/books/about/Siluria.html?id=ICM-AAAaAAJ>

References:

Clark JW and Hughes TM, (1890), *The Life and Letters of the Reverend Adam Sedgwick, Volume II*. Cambridge University Press.

Murchison RI, (1854), *Siluria*, John Murray, London.

KHN

Extractive Industry Scholarships

The Extractive Industry Geology (EIG) Conference is the principal event for sharing knowledge, scientific research and good practice in the field of applied geology within the UK minerals industry.

The EIG Scholarship programme comprises funding to support research that is of relevance to the extractive industries in the UK, linked to a process of supervision, mentoring, peer review and dissemination.

EIG Scholarship Aim

To promote, and advance the understanding of, geological applications within the extractive industries in the UK; where 'extractive industries' are defined, for the purpose of EIG Scholarships, as those relating to the commercial extraction and processing of solid minerals in the UK. These include, for example, bulk aggregates, industrial

minerals, metalliferous minerals and coal, but do not include oil and gas; and 'geological application' is defined as any professional activity of relevance to these industries that is carried out by geologists, whether working for (or on behalf of) the commercial operators involved or for the relevant regulatory bodies.

These professional activities include, but are not limited to, the following disciplines; the characteristics and utilisation of mineral resources; geological investigation and modelling; geotechnical analysis, applications and solutions; extraction and restoration design; environmental geology including geodiversity; hydrology and hydrogeology.

Eligibility

Those eligible to apply for EIG Scholarships include UK undergraduates and postgraduates, studying geology or related subjects, together with those professionally engaged in any geological application (as defined above), to support studies or project work that is relevant to the EIG Scholarship Aim.

Research Topics

Applicants are encouraged to suggest their own topics but may find some suggested research topics on the EIG Website (www.eigconference.org).

Funding

A maximum value of £3,000 per scholarship is possible. The fund is designed to supplement any existing sources of funding. It is intended specifically to encourage additional work in keeping with the EIG Scholarship Aim that might not otherwise be possible.

Mentorship

Each EIG scholar will be assigned a suitable mentor from industry. The mentor will meet the scholar at least three times during the course of the Scholarship to offer guidance and support.

EIG Scholarship Award

Following peer review of the research findings, recipients may be eligible for an EIG Scholarship Award as a certificate of satisfactory completion. They will also be expected to present their findings, either orally or as a poster, at an EIG Conference, where they will receive their award.

Applications

An application form, together with additional guidance notes, can be downloaded from the EIG Website (<http://www.eigconferences.com/page18.html>). Applications should be submitted to the EIG Scholarship Officer scholarship@eigconferences.com before the 25th January.

Thanks to Alex Finlay of Chemostrat in Welshpool for drawing attention to this potential source of funding for geological research.

KHN

NERC funded PhD studentships

The School of Geography at the University of Nottingham invites applications from suitably qualified students for a NERC funded studentship. The studentship covers the costs of fees at the Home / EU rate, provides a maintenance grant for 3 years and also includes research support costs for fieldwork and conference attendance.

The engineering geology of shale gas exploitation

Contact: Professor Paul Nathanail

Other current research topics with geological content are:

Critical transitions in lake ecosystems as inferred from palaeolimnological records
Contact: Dr. Suzanne McGowan

A 'best-estimate' of the impact of climate change on global river flows
Contact: Dr. Simon Gosling

Advancing biodiversity mapping and modelling using geodiversity information.
Contact: Dr. Richard Field

Antarctic meltwater export across the Southern Ocean during the last glacial cycle
Contact: Dr. George Swann

Pliocene changes in salinity and productivity across the North Pacific Ocean and Bering Sea
Contact: Dr. George Swann

Climate variability over the last 2000 years in the circum-Caribbean: palaeolimnological perspectives on impacts and drivers of change
Contact: Professor Sarah Metcalfe

Back analysis of contaminated land human health risk assessments: Lessons from the Corby judgement
Contact: Professor Paul Nathanail

Applicants should hold a strong first degree (at least an Upper Second Class Honours or equivalent) or an MSc in a relevant subject, and must meet the NERC eligibility criteria. For the projects listed above, applicants are strongly advised to liaise with the project contacts in advance of submitting an application.

Studentships are likely to commence in September 2013.

Information on the School's research themes is available at:
<http://www.nottingham.ac.uk/geography>.

Further details, and the required application forms are available at: <https://pgapps.nottingham.ac.uk> or from Andrea Payne, Postgraduate Administrator, School of Geography, The University of Nottingham, University Park, Nottingham, NG7 2RD. Tel: 0115 951 5575. Email: Andrea-Payne@Nottingham.ac.uk.

Applicants should indicate the project for which they wish to be considered if it is one of those listed above. Applications should be clearly marked 'NERC Studentship'. Closing date: 7th February 2013. Interviews are expected to take place in late February.

Two NERC funded PhD studentships are currently available with the Palaeoenvironmental Change Research Group at The Open University. The projects are focused on understanding past environmental change in west tropical Africa and Amazonian-Andean Ecuador. Both projects will involve field work and build on on-going research within the lab. Closing date 31/01/2013

PROJECT 1

Characterization of tropical African ecosystems by their modern pollen/spore spectra

PROJECT 2

Tropical forests response to past global climate change

For further information and how to apply visit:

<http://palaeolim.wordpress.com/2013/01/09/two-studentships-available/>

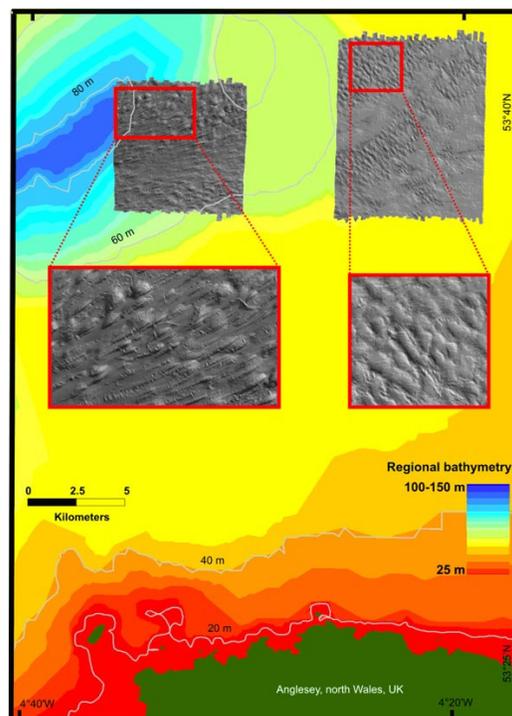
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Abstract:

Talk to be delivered following the NWGA AGM on the 26th January 2012

Enigmatic glacial and sedimentary bedforms on the Irish Sea seafloor to the north of Anglesey

To the north of Anglesey lies a seafloor that has preserved its dramatic glacial and post-glacial history remarkably well - and has helped us to understand the offshore dynamics of the entire region in the last 30,000 years. The former British-Irish Ice Sheet (BIIS) expanded to a maximum as far south as the Celtic Sea around 25,000 years ago before its rapid collapse. The Irish Sea Ice Stream (ISIS) through the Irish Sea Basin was the largest ice stream to drain the BIIS. The ISIS terminated in a marine margin and had a grounded glacier bed with adverse (up-ice) slopes and troughs, which makes its rapid retreat at several hundred metres per year a unique process analogue for sectors of the West Antarctic Ice Sheet today.



The palaeo-glaciated terrain in the Irish Sea to the north of Anglesey provides the sole evidence for a marine-terminating, grounded part of the ISIS. Exceptionally well-preserved bedforms (ribbed moraines, drumlins, flutes and eskers) generated beneath the glacier in the till that it deposited form a glacial bedform assemblage. A subsequent ice-marginal environment is represented by small moraines and many iceberg scour marks. It can thus be suggested that the ISIS retreated stepwise and rapidly, with many actively-calving icebergs dropping into a proglacial water body during times of final ice retreat in this part of the Irish Sea. Support for this hypothesis is provided by the remarkable preservation of the glacial terrain itself, implying that no transgressive surf zone could have passed this area as it would have removed the bedforms and reworked the till. Strong tidal currents since the final ice retreat have kept the submarine terrain from burial without significant erosion.

The strong tidal currents that preserved the glaciated terrain have also been responsible for transporting the sparse, mobile sediments into extremely high sediment waves - in fact the largest on record. Many of these bedforms are seen on the palaeo-glaciated terrain to the north of Anglesey, and unique heights of up to 36 m (world-record breaking) are reached in the central Irish Sea. The Irish Sea's post-glacial history, with its tills on the seafloor and strong tidal currents, has an important role to play in the formation, migration, and extreme growth of these sediment waves.

We have recently sampled these bedforms in more detail to assess the variations in sediment grain sizes, and even to investigate whether gas seepage could be involved in this enhanced growth mechanism. The observation and prediction of the development and mobility of the seabed are in high demand with rapidly expanding offshore engineering developments and the

increasing urgency to start mitigation against changing coastlines.

Katrien Van Landeghem

(School of Ocean Science, Bangor University)

Book Review:

Ichnology: Organism-substrate Interactions in space and time

Buatois L and Gabriela Mangano M
Cambridge University Press, 2011, 358pp.

This book was top of my Christmas wish list – hoping that someone would have (at last) cut through the complicated and obscure decision making processes that is trace fossil taxonomy. The authors have indeed made a valiant attempt to construct a state of the art review of ichnology which is “*an exciting and vibrant field*”. As the authors comment, the study of trace fossils is a multi-disciplinary subject, attracting specialists in fields as diverse as taxonomy, palaeo-

ecology, sedimentology, soil mechanics and stratigraphy. It was therefore perhaps a forlorn hope to expect that this document would be a panacea for all ills.

The book is beautifully illustrated, and thoughtfully constructed in three parts. The first part introduces us to the basic tools and techniques of the trade, leading the reader through chapters summarising basic concepts, taxonomy, palaeo-biology, ichnofacies and ichnofabric modelling.

The second part of the book describes spatial trends in the ichnological record in a manner that will be familiar to those with text books on their shelves on sedimentology, looking in turn at each of the main sedimentary facies, and the particular palaeo-ecology associated with them.

Finally we are introduced to temporal influences – with an introduction to concepts

of trace fossils as tools in sequence stratigraphy, biostratigraphy, evolutionary palaeo-ecology and palaeo-anthropology.

For me this book succeeds as a result of its maintaining a sensible proportion between the invertebrate ichnological record, and the tracks of “higher” animals (dinosaurs and biped trackways seem to dominate much of the literature).

One significant failing, however, is the infuriating reference system adopted. All the references made in the 358 pages are collected in a list lengthy (no less than 49 pages!) at the end of the book. Whilst these references are a valuable resource *per se*, they would have been much more usefully grouped into Chapter or Section headings, or sequentially. As it is, if you want to find out where in the book reference is made to Zylinska’s work on *Cruziana semiplicata*, you have to either skim over the possible sections, running the risk of missing it, or start at Page 1 and close read until you find it.

Similarly, the index could have been much improved – with perhaps bold type face used to illustrate a page number with a formal taxonomic description - or possibly italics to indicate a page with a photographic representation. As things stand, if you look for *Cruziana semiplicata* in the index you will find that it occurs on pages 35, 53, 130, 138, and between pages 255 to 257. If you want to find an image of this particular trace you can only start at p35 and hope that you find it before you get to p257 (you will – it’s on p138).

This book is then far from a shortcut “Idiot’s Guide to Trace Fossil Taxonomy”. It now sits on a shelf alongside Seilacher’s 2007 work “Trace Fossil Analysis”. Between them they represent the current State of the Art of the ichnological world view, but from my point of view – and to borrow from Bono – “*I still haven’t found what I’m*

looking for...”. Perhaps that reflects a deeper problem in this field of study - is it valid to apply Linnaean binomial nomenclature to what are, after all, elements of abiotic, rather than biotic nature, albeit formed by the work of animals? At a price of £50 or thereabouts this is probably out of reach of all but sad research specialists (like myself), company libraries interested in clastic sedimentology (ie hydrocarbon specialists) or academic departmental libraries. Students no doubt, and those with a general interest in the subject may be tempted by possible future paperback versions to be published, hopefully at half or even a third of this price.

References:

Buatois L and Gabriela Mangano M, (2011), *Ichnology: Organism-substrate Interactions in space and time*, Cambridge University Press.

Seilacher A (2007), *Trace Fossil Analysis*, Springer

KHN

Reports:

NWGA

University of Chester: 22nd October

The Big Chill... Life, death, and destruction, a story from the end of the Ordovician.

This lecture was the first joint meeting of the North West Regional group of the Geological Society of London and the North Wales Geologist Association. The event was hosted by the University of Chester which proved to be both a great venue and host. This event was attended by both geological groups, as well as students and lecturers of both Chester and Edge Hill Universities.

Keith Nicholls (University of Chester and Geotechnics Ltd) gave a talk on his current

PhD project regarding the environmental changes associated with the Hirnantian Stage (youngest Ordovician) and the evolution of fauna across this period, drawing on evidence from Cwm Hirnant and the surrounding areas of North Wales, as well as the western Brittany coast line and south west Scotland.

Keith ran through the background to the period including the global spatial positions of the local sites (Wales, Scotland and Brittany) He also discussed the importance of understanding fossil taphonomy and preservation potentials, and important diversity mass extinction concepts

Keith used the fossils and associated strata to present an evidence line regarding the environmental conditions prevalent at the time of the Hirnantian extinction event. He described evidence based on significant trace , graptolites as well as brachiopods at the type Hirnantian locality near Bala.

This period of time was associated with the 2nd most significant mass extinction event in accordance with generic, familial and species extinctions. Sea level was noted to vary significantly with reductions of up to 100m conjectured associated with a significant period of glaciations.

The macro- fauna associated with this age were noted to be potentially unreliable for global stratigraphic correlation as they have been considered to be cold adapted. This meant that the fauna moved to suit the environmental conditions with the onset of the glaciations and the subsequent regression (*habitat tracking*).

With the onset of the glaciations, benthic fauna associated with the abyssal zone and continental slope, as well as pelagic fauna were relatively unaffected by the environmental conditions. Benthic fauna adapted for life on the continental shelf were significantly impacted due no doubt in part

to the significant regression associated with the advancement of the ice sheets. An important line of Keith's research relates to ichnology. There has been much conjecture on the source of the trace fossils, many of which relate to burrowing organisms. However as many of these creatures are likely to have been soft bodied, little remains of their presence other than the tracks they left. Some trace fossils have been attributed to organisms such as trilobites, with Frankenstein conjectures based upon the form of traces noted. It should be noted that many Frankenstein soft bodied creatures have been realised in locations such as the Burgess Shales!

The geological record was discussed from off shore (turbiditic) evidence (Llangrannog, Ceredigion) as well as on shore facies (around the type Hirnantian area of Bala). The quarry at Cwm Hirnant (from where this stage takes its name) is a SSSI and contains the Hirnant Limestone Member with brachiopod fossils. The shelf strata were noted to contain coarse clasts as well as possible evidence of algal blooms.

The presence of the limestone in temperate latitudes during a period of significant glaciation does not conform with the typical environments associated with the accretion of carbonate sediments. The source of the carbonate is currently unknown with many conjectured hypotheses

Keith's concluding assessment of this period was that the onset of glaciations caused the first phase of extinction, causing a significant regression in sea level, resulting in shelf destruction. The onset of the transgression caused the second extinction event with significant reworking of shelf sediments. Vacant ecological niches were exploited by microfauna, and deep water or benthic fauna were not significantly impacted. Soft body predators are likely to have removed much of the evidence of death assemblages on continental shelves, and

evolved to become specialist for this time period. The cause of the glaciations event is still a moot point and is one Keith is looking currently researching.

There is clearly plenty to explore stratigraphically, paleontologically and climatically in the Hirnantian. We look forward to having Keith discussing his progression with his PhD in the coming years.

Following discussions with Chester University and Jonathan Wilkins, we are in strong agreement that this event should be continued into 2013, hopefully becoming a regular slot in the annual cycle of both groups as well as the University. It has also been agreed that this talk will be an academic lecture and be preferably associated with new research which is of general geological interest.

Nik Reynolds

NWGA

Treborth: Wednesday 7th November

Plants through the ages

The November meeting was hosted by Bangor University Treborth Botanic Garden. Nigel Brown, the curator of this facility, gave us a detailed examination of plants through the geologic record, drawing on evidence from fossils and their relationships with modern plant species. This paleobotanic excursion started with the beginnings of life in the Pre-Cambrian seas in the form of algae, where many modern phyla of algae have their origins. The most well known Pre-Cambrian fossil *Charnia* is may be related to plants – perhaps not -, but plants as we know them appear as fossils in the early Silurian in the fossil record. The late Silurian – early Devonian period shows the first plants occupying shore environments, where plants were like the

shoreline plants we know today as seaweeds, kelp, wracks and algae. plants that both photosynthesise, and can also survive both within the water column and drying on land, but these plants could only reproduce through spores and required water to reproduce. Some of the smaller sized species were *Chlorophyta*, these were bright green and were the precursors of all land plants today, evolving mechanisms that enabled them to support themselves, and having internal vascular “plumbing” to enable the distribution of water and nutrients.

Liverworts, mosses and bryophytes evolved which have some degree of internal strengthening enabling them to stand upright, many of these can also withstand high levels of desiccation down to 5% water content and revive with the addition of water. The best preserved early plant forms are those of *Rhynia* from the early Devonian found in Rhynie in Aberdeenshire. These plants were fossilised in a hot spring environment where their remains were silicified and therefore extremely well preserved. This exceptional preservation enables us to see both the stems showing thickened cells providing the support for upright growth, and also stomata, providing direct evidence that these plants photosynthesised. There is also evidence of rhizomes and fungi in the root zones indicating a symbiotic relationship where the fungi assisted the plants to get nutrients from soils that were poor in organic content. Nigel provided a modern living example of a similar plant to *Rhynia*, however this is not an ancient relict survivor but an evolutionary throwback.

Club-mosses also appear in the fossil record in the late Silurian providing a picture of lawns of vegetation starting to occur on land and by the Carboniferous period these club-mosses had evolved into 30 m high trees. These had branched roots, diamond shaped leaf scars, and 30 cm long leaves. The trunks

of these trees would have been photosynthesising, seen through evidence of stomata, and green in colour, and their fossilised trunks demonstrate the internal plumbing and the presence of stomata on the roots demonstrate that the roots were on the soil rather than in the soil. Minor forms of club-moss in the Carboniferous were the ancestors of all flowering plants, but the club-mosses themselves had cones and spores and therefore still required water for reproduction. Horsetails were also common in Carboniferous forests growing to 25-30 m high, there are only 25 species of horsetails on the earth currently but back in the Carboniferous there were hundreds of different species. Ferns also appeared in the early Devonian as well as early seed ferns that evolved into cycads.

The Mesozoic Period brought significant evolutionary changes, the development of conifers which frequently had broad leaves like monkey puzzle trees as opposed to the narrower leaves now typical of the conifers of today. Early flowering plants appeared in China 135 million years ago when early relatives of Magnolias and water lilies appeared. By 80 million years ago the

division within the plant world had occurred between monocots, plants which germinate with a single narrow leaf and have flowers with a threefold symmetry, and dicots, plants which germinate with two rounded leaves and have four or five fold symmetry. There was an explosion in the variety of flowering plants which occurred between 130 and 80 million years ago indicating co-evolution with insects to assist the process of fertilisation of the flowers to produce seeds and the development of plants indicative of open habitats such as *Ranunculaceae* (buttercups).

Nigel also provided thin sections of many of the plant fossils obtained from collections made by earlier academics at Bangor University enabling viewing of the structure of these fossil plants in the same way one

might examine a living plant of today and illustrated his talk with living and fossil specimens from the University collections. Nigel covered the spectrum of the evolution of plants within the fossil record with a distribution of time within his talk correlated to the passage of geological time which meant that the more recent plant evolution appeared somewhat rushed, or maybe I ran out of ability to take notes at the speed the subject matter was being covered in this epic lecture. But it seemed to be the right way to deliver this subject where the early forms of plants were given a full explanation showing how early in the history of life on earth plants started to appear and how slow the changes were at that point and how the more rapid burgeoning of plant forms in the more recent geologic record owe their origins to deep time. Nigel also offered a further meeting in the University museum where there are a range of other fossil specimens that might be enjoyed.

CO'B

Conwy: 15th November Geoscience Wales – Cluster Meeting

Nuclear Waste and where to stick it...

Professor Richard Pattrick of the University of Manchester

I have always thought that nuclear energy was the way to go for the human race if we want to sensibly (ie forget about the wind turbines et al) combat the global warming of our carbon footprints while maintaining our current (very high energy consumption) life styles. If only we could keep the politicians and incompetent site managers out of the mix and learn to rely on the expertise of our scientists... Then perhaps, nuclear power would be a safe and very long lasting source of energy. Not quite perhaps the dawn of a new era..

'..electricity so cheap; bills will be a thing of the past',

..but at least a safe and constant source of energy.

We are all familiar with the spoil tips which are the above ground visible indications of mining (coal, lead, zinc, copper, etc.) having taken place in an area. Eventually nature returns and these sites become overgrown with natural vegetation. Yes, even Parys Mountain has vegetation encroaching onto the site! The ash from coal fired power stations is now used to make thermal insulating bricks, so the only real problem with the coal fired power stations is the unfortunate amount of carbon dioxide (CO₂) they produce and its impact on our ecosystem.

But as for nuclear power;- there is no CO₂ - yippee! We are saved... except for the disposal of all its waste. Waste, what waste? Doesn't THORP reprocess all of the waste into new fuel rods?

It was therefore with much interest that I made a point of attending this GWL cluster meeting talk in Conwy on the 15th November.

What a sobering experience the talk was.

Professor Patrick started his talk by reminding us that the nuclear power industry is not the only user of the fission process; the nuclear weapons industry also produces its share of nuclear waste.

Here in the UK, we have been producing nuclear waste from one or both of these industries since the 1940s. These nuclear industries rely on Uranium. Uranium is a very heavy metal. The Uranium is found in naturally occurring Uranium Ore and is

made up of different isotopes;- ²³⁸U (99.28%), and ²³⁵U (about 0.72%), which is the radioactive one suitable for the fission processes required for bombs and nuclear reactors. For typical economic extraction the

ore grades are usually between about 0.3% and 0.7% Uranium.

Oh dear - quite appreciable spoil tips therefore at the mine itself... Not that we have mines in the UK. We get our uranium from either Canada or Australia. Phew!

The refining of the uranium from the basic rock is a complicated process involving crushing the rock and treating it with various chemicals to isolate the uranium into a product called yellowcake (U₃O₈). In which form it is then exported to customers like us here in the UK. To then refine the tiny percentage of ²³⁵U from the yellowcake is a devilishly difficult process which involves further chemical treatment of the yellowcake to produce the gas Uranium hexafluoride (UF₆) and then because the ²³⁵U is only marginally lighter than ²³⁸U putting that gas through centrifuges, repeatedly through centrifuges! Banks, and banks, of hundreds of centrifuges... are required, to remove some of the unwanted, slightly heavier ²³⁸U. Eventually, the ²³⁵U of the required purity (3.5%) is obtained. An unfortunate by product of this process is the rest of the uranium. This is called Depleted Uranium as it is now "depleted" of the ²³⁵U and is higher

in ²³⁸U. This depleted uranium is precipitated from the UF₆ and is stored.^[1]

Our attention was then directed to the reactor inside a nuclear power station. These are fed with fuel rods about 2 - 3cms in diameter containing uranium oxide with 3.5% ²³⁵U. When the controlled fission reaction of the ²³⁵U takes place within the nuclear reactor, its atoms split into a wide range of elements (fission products). Each such fission of a ²³⁵U atom releases energy as heat, which is conducted away to the boilers, to produce the high pressure steam, to drive the turbines, to turn the generators,

to produce our electricity. (The heat is used in the same way as in a coal fired power

station, but without all of that dreadful CO₂ from the burning of coal in air!)

These fission products however, are themselves radioactive; and are predominantly the radioactive isotopes of Iodine, Caesium, Strontium, Barium, and having a range of half-lives from minutes to years. In the fuel rods themselves some of the uranium ²³⁸U is also converted to unstable radioactive elements neptunium, plutonium (²³⁹Pu) and americium.

Another unforeseen effect of having a nuclear reprocessing plant, or nuclear reactor working away inside a building for thirty odd years, is that the building itself becomes contaminated. As also happens in Atomic Warfare Research Establishments and of course nuclear powered submarines. This leads to further radioactive wastes when finally decommissioning/demolishing such a site.

Returning to the reactor itself however; as the ²³⁵U decays into these fission products (daughter elements) the useful percentage of ²³⁵U in the fuel rods gradually falls from the initial 3.5%. When it reaches 2% the rods are no longer considered to be energy efficient and are replaced. These spent fuel rods are now 1 million times more

radioactive than when they went in and are full of fission products – their casings are also very radioactive. Consequently although these rods still contain about 2% ²³⁵U when they are sent for reprocessing into new fuel rods, they also now contain some really horrible stuff including Plutonium ²³⁹Pu which is radioactive, fiendishly toxic, extremely dangerous to handle, and very difficult to store. It also has an inconveniently long half-life of about 24,000 years.

Currently there are about one hundred tonnes of the stuff at Sellafield stored as oxides, with various other quantities of

similar size scattered around the globe, as we all try to work out how we are going to keep this ghastly stuff safe for the next one million years, when it is felt that only then, will its radioactivity have reduced to a safe level. (Against this problem the disposal of merely intermediate and low level radioactive waste nearly fades into insignificance).

This plutonium could be used in new reactors because it is itself a fissionable material. It is felt however, that due to financial and political constraints, this is possibly not the most favoured option. It would also need a special type of power station to be built in the UK using a new design with, perhaps, liquid sodium to take the heat from the reactor to the boilers.

There are two main problems with which the government/nuclear industry are now faced;-

- 1) decommissioning of used sites, and
- 2) how to safely store all of the highly radioactive waste from the reprocessing of the used fuel rods, all the other contaminated materials, and of course, all of the ²³⁹Pu.

Extensive work is now going on to see how stable glass, concrete, stainless steel, etc might be over such a long time if used as the

initial storage medium. Current thinking is to vitrify the waste and put it into stainless steel drums, surrounded by concrete and buried in a hole deep underground...

But where underground? It is felt that clay may be a suitable medium in which to construct a special storage facility as there are indications of past spontaneous fission reactions taking place in the Earth's crust and being contained within the surrounding clay.

But we can all guess at the howls of protest that would greet any suggestion for having the depository here, or there...

"NOT IN MY BACK YARD..."

So the authorities are now going through a volunteering process looking for a site. The area around Sellafield (West Cumbria,) where there is good deal of relevant skills and expertise among the resident population, is currently being examined as a possible site. But no decisions have yet been made as talks with the local communities appear to have stalled, at step three of a six step process.

There was a suggestion made from the floor that perhaps we could get rockets to shoot it into the sun. This seemed like a really admirable idea, until it was pointed out that not all rockets actually succeed in making it out of the Earth's atmosphere, or even indeed; very far off the launch pad...

All in all this was a very interesting, educational and thought provoking talk.

[1]*Brief Discursion:

Efforts have been made to find a use for this very hard, very heavy, metal. The military (of course!) have found a really good use for it;- special armour piercing rounds, in which it has proved extremely effective. Unfortunately however, it burns furiously on, and during impact with, the enemy vehicle; releasing the uranium into the

immediate area. This promptly contaminates everything on which it settles (the destroyed tank, the surrounding soil, sand, dust, and any vegetation). This makes life difficult and/or hazardous for any persons entering the area afterwards, ie civilian scrap metal merchants, children, goat herders (and their goats), et al. It is also being used to make armour plate but I have found no details of its efficiency in this area.

Happily though, gentler minds have turned their attention to this material and have found other uses:

-

- in medicine - as shielding for scanners
- in the aviation industry where it is used in relatively small quantities as ballast to perfect the design balance of an aircraft.

Frank Buxton

Joint Meeting GSoL (NW) and LGS

Thursday 22nd November

"Earthquakes, volcanoes & God"

Considering the foul weather and the nearby alternative attraction (Old Boys of Berne) at Anfield, the turnout of 40 plus dedicated souls at JMU must have been pleasing to the organisers. The Reverend David Chester (now retired, but formally a Reader in Geology at the University of Liverpool) gave an intriguing talk looking at the link between scripture (of the Judaeo-Christian ilk) and society's attitude towards suffering wrought by natural disasters.

In contemplating the role of Christian Doctrine some authors had written persuasively that prior to the start of the enlightenment in Europe, the Church had been reactionary, displacing early attempts to impose rational thought and reason, with superstition and fear. It was noted that in some ways this attitude continues today, with our willingness to dismiss flood, plague and pestilence as "Acts of God", rather than looking closely at our decision making, in the light of informed choice; in where we chose to build and live, knowing what we know, of the workings of the Earth. In making this latter point the Reverend Chester twice quoted Imperial College's Engineering Seismologist Nick Ambrayseys – *"Today's Acts of God, are tomorrow's Acts of Criminal Negligence"*.

KHN

RECENT PUBLICATIONS RELATING TO THE GEOLOGY OF WALES AND THE BORDERS

Cullum AA and Loydell DK (2011), "*The Rhuddanian / Aeronian transition in the Rheidol Gorge, mid Wales*", Proc Yorkshire Geol Soc, Vol 58, Part 4, November 2011.

Zalasiewicz J et al (2011), "*The systematic relationship of the monograptid species acinaces Tornquist 1899 and rheidolensis Jones 1909*", also in Proc Yorkshire Geol Soc, Vol 58, Part 4, November 2011.

Ross KLA (2012), "*Diatoms in the Dyfi Estuary, West Wales: developing a tool for the reconstruction of Holocene sea-level change.*" Quaternary Newsletter, Vol.128, October, 2012, Quaternary Research Association.

Dates for your Diary:

NWGA

Saturday 26th January
Annual General Meeting

Followed by:

Katrien Van Landeghem (School of Ocean Science, Bangor University).

"Enigmatic glacial and sedimentary bedforms on the Irish Sea seafloor to the north of Anglesey"

Canolfan Yr Hen Felin, Abergwyngregyn
AGM at 10:00AM followed by refreshments, Lecture to commence at 11:30AM

Formal notice of the AGM and an agenda was published in the previous Newsletter.

OTHER ORGANISATIONS' EVENTS

GeoMon

Geomon's web e-contact details are available at:

<http://www.geomon.co.uk/#/contact/4533286691>

Alternatively you can write to The Old Watch House, Porth Amlwch, Anglesey or telephone 01248 810287.

GSoL (North West region)
Wednesday 13th February 2013

"Forensic Geology"

Laurence Donnelly

Swan Hotel, Winwick

Details from Nik Reynolds (Secretary) or the GSoL website

<http://www.geolsoc.org.uk/~link.aspx?id=4089760AC8324918AA855E0525DDE0CD&z=z>

Liverpool Geological Society

Tuesday 26th February 2013 *"Diamonds"*

Jeff Harris

Theatre 137 at Byrom Street Campus, Liverpool, L3 3AF. Please meet at 6:45 pm for Tea/Coffee and biscuits in the Tower Cafe

University of Liverpool

Herdman Symposium

Saturday 16th February 2013

"Geoscience Frontiers 4"

Speakers and further details registration etc from Helen Kokelaar at:

herdman@liverpool.ac.uk

Manchester Geology Association

Wednesday 13th February 2013 at

7PM - AGM followed by Presidential Address

"The Middle Jurassic of Ketton, Rutland"

Peter del Strother MBE.

Tuesday 12th March 2013 at 6:30PM -

Joint Meeting with the Geographical Association

"Now that the dust has settled... The Impacts of Icelandic Volcanic Eruptions"

Professor Fiona Tweed, Staffordshire University

Most MGA Meetings are held in the Williamson Building, Oxford Road, opposite The Manchester Museum.

Further information about any indoor meetings:

email_lectures@mangeolassoc.org.uk

Shropshire Geological Society

Wednesday 13 February 2013

"Seeing inside the stones"

viewing fossils in rock courtesy of the latest scanning technology and red-green 3D glasses (supplied)

Dr Imran Rahman

Shire Hall, Shrewsbury, commencing at 7.15pm for 7.30pm.

A nominal charge is levied for attendance by non-Members

St Asaph Archaeological Society

**Wednesday 6th February 2013,
7:30PM**

"The Picts"

Philip Holdsworth, Cricket Club Pavilion St Asaph

Wednesday 6th March 2013, 7:30PM

"Ffynnon Beuno Cave Dig – Neanderthal Period Finds"

Rob Dinnis, Cricket Club Pavilion St Asaph

Wednesday 1st May 2013, 7:30PM

"Archaeology of Liverpool Docks"

Sarah Pevely, Cricket Club Pavilion St Asaph

Saturday 4th May 2013, 9:00AM

Field Visit

"Industrial Archaeology at Gwydyr Forest"

Contact Secretary – Maria Blagojevic, 07767705100;

maria@stasapharchaeologysociety.org.uk or Mblag@gotadsl.co.uk

National Association of Mining History Organisations

(NAMHO)

28 June to 1 July 2013

Conference: Mining Legacies - the environmental, physical and cultural impact of mining

Venue: University of Aberystwyth

Ironbridge Gorge Museum Trust

10th to 14th July 2013

Rust, Regeneration and Romance:

Iron and Steel Landscapes and Cultures

venue: Ironbridge Gorge World Heritage Site
see Call for Papers at rear of this Newsletter)

Web News:

1. A new website on Antarctic Glaciers has been created by Dr Bethan Davies to document glacial response to climate change. The site is available at www.AntarcticGlaciers.org and has been designed to appeal to students from A-Level upwards and aims to deliver peer-reviewed science to the general public. Many commonly misunderstood concepts have been explained, and the site provides many photographs, maps and images that of Antarctica. It covers

lots of topics from the A-Level geography curriculum, and also much of the exciting research currently being done in Antarctica. There is a section on careers in geography and geosciences, projects and essay questions targeted at A-Level students.

2. The Earth is a dynamic planet, and understanding its history and how the Earth, oceans and atmospheres work today has never been more important. In 2008, the Geologists Association (our mother body) have developed an educational programme (Your Planet Earth www.earth4567.com) to coincide with the UNESCO Year of the Earth and the Association's own 150th anniversary.

The core of YPE is a set of Powerpoint talks that may be used by anyone in speaking to school groups. Each talk carries a full commentary or script in the associated panels. A selection of the subjects covered are listed below:

- Volcanoes
- Dinosaurs

- Natural Hazards
- Plate Tectonics
- Climate Change
- The Ice Age
- Evolution.

Under the expert guidance of Professor Mike Benton (former GA President), the talks have been conceived and designed by geoscientists Dr Jess Trofimovs at the University of Bristol (UK) and Dr Howard Falcon-Lang at Royal Holloway, University of London (UK), with extensive involvement from many colleagues. Aimed at the 14-15-years age group, they introduce key earth sciences subjects with a focus on current debate and basic science concepts.

The GA encourages free and extensive use of these materials. Every effort has been made to confirm copyright of all images, and the talks are made available freely for educational use. This initiative has been made possible through the backing of the GA, the Geological Society of London, and the Earth Science Educational Unit (ESEU), and funding from Shell.

3. A little earlier in the year we reported on a GeoScience Wales meeting in which Simon Price of the BGS described the Σ igma mapping tool used by the BGS during their work in Oman. The BGS have now made the third revision of this tool freely available to the geological community. It can be downloaded (FoC) at:

<http://www.bgs.ac.uk/research/sigma/home.html>

4. The NWGA Facebook page is slowly attracting a select band of followers. Please take a little time to visit and "join" at:

<http://www.facebook.com/groups/northwalesga/>

Finally a reminder of the NWGA Web site itself at: www.ampyx.org.uk

The web site has been updated recently with all except the very recent editions of the Newsletter now available for direct download.

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Front cover image:

Oxford Museum of Natural History,
specimen of the Ordovician (Llanvirn to
Caradoc) Asaphid trilobite *Ogygiocarella*
augustissima (Salter) collected in Powys.

Call for Papers

Ironbridge International Institute for Cultural Heritage

University of Birmingham and The Ironbridge Gorge Museum Trust

Rust, Regeneration and Romance: Iron and Steel Landscapes and Cultures

10-14 July 2013, Ironbridge, UK

This conference seeks to engage in an open multi-disciplinary analysis of iron and steel landscapes and cultures, from the ancient to the modern. It looks toward the legacies of both production and consumption and how these metals have influenced all aspects of social life. We wish to explore the relationships that communities, regions, nations share with iron and steel through its functional use, creative and artistic use and its symbolic use.

The conference welcomes academics from the widest range of disciplines and wishes to act as a forum for exchange between the sciences, social sciences and the humanities. The conference will draw from anthropology, archaeology, art history, architecture, engineering, ethnology, heritage studies, history, geography, landscape studies, linguistics, metallurgy, museum studies, sociology, tourism studies etc. The conference will take place at the Ironbridge Gorge World Heritage Site.

Indicative themes of interest to the conference include:

- Understanding iron and steel landscapes – historic and contemporary perspectives
- Human – technology relationships
- Challenges in the presentation and interpretation of iron and steel heritage
- Touring and tourism in iron and steel landscapes
- Histories and ethnographies of iron and steel communities – labour relations and working environments
- Architectural tropes surrounding mining and fabrication
- Representations of iron and steel cultures in the ‘popular’ media
- The ‘cultural industries’ (arts, sport, tourism, etc.) in the regeneration of iron and steel communities
- Languages of steel cities – dialects and territories
- Symbolic economies of iron and steel – iconography, art and design

Abstracts of 300 words with a clear title should be sent as soon as possible but no later than January 31st 2013 to ironbridge@contacts.bham.ac.uk