REPORT

East Midlands Geological Society 60th Anniversary Conference, 12 October 2024

To celebrate our 60th anniversary, EMGS held a one-day conference on Saturday 12 October 2024 at the Conference Suite, British Geological Survey, Keyworth, Nottingham. The event included lectures and posters on some of the latest geological research either on the geology of the East Midlands itself, or being carried out by students at the region's major scientific institutions. A volume of abstracts covering the lecture programme and poster sessions was issued on the day. For the convenience of our readers and those who were unable to attend, we here reprint these abstracts.

Dr Tim Pharaoh
Honorary Research Associate
British Geological Survey

An integrated petrogenetic and petrophysical model for the crustal structure of Southern Britain: farewell to the Charnwood Terrane

The late Precambrian volcanic and sedimentary basement of Southern Britain is known from several small, widely-dispersed and tectonically-controlled outcrops. Deep boreholes sample further basement diversity. The challenge has been to map these different components and establish their relationships. Aeromagnetic data from the 1960s still provide the best hope of reaching this goal. A new inversion model provides valuable insights into the depth and structure of magnetic components of the basement. This 3D model of the crust can be sliced in any orientation, generating vertical cross-sections and horizontal depth slices and that can facilitate mapping and interpretation. Another aspect of the new work is the recognition that the present-day North Island of New Zealand provides an excellent analogue for Southern Britain 565 million years ago. The Hikurangi destructive margin incorporates a subduction trench, arc and oceanic marginal basin. Calc-alkaline volcanos of the Taupo Zone occupy an extensional wedge projecting into the juvenile NZ crust while the Taranaki volcanos occupy the back-arc region. The tremendous diversity of volcanic rocks within this small area of NZ is compared to the basement of Southern Britain, and we will see how this modern analogue can help us understand the complex geology of, and establish an internally consistent crustal model for, Southern Britain in late Precambrian time.

S. M. Clarke[1], S. T. Tisdell[1], B. J. Bowler[1], R. L. Podmore[1], A. G. Leslie[1&2], A. J. Mitten[1], O. Austin & P Morgan[3]
[1] Basin Dynamics Research Group, School of Geography, Geology & The Environment, Keele University
[2] British Geological Survey, Lyell Centre, Edinburgh
[3] Tunnel61.science, South Tyndale Railway, Alston, Cumbria

'Earth, Fire & Water': New insights into the evolution of the Carboniferous succession (Alston Formation) of northern England

Repeated successions of limestone, siltstone, sandstone and coal – Yoredale Cyclothems – are characteristic of the Carboniferous succession of northern England. Cyclothems are defined lithologically, but crudely represent shallowing-upward successions from normal regression in a marine-marginal setting. The repetitions are typically attributed to Milankovitch-style cyclicity, but the extent to which this is a factor, compared to 'on-planet' controls such as accommodation, sedimentation and auto-cyclicity, is equivocal.

We combine fieldwork, geophysical data from core, and cyclo-stratigraphical techniques, to provide new insight into the controls upon the evolution of strata of the Alston Formation. Preliminary results indicate cycles that correlate with signatures from planetary orbitals, some of which may be tentatively attributed to Milankovitch cyclicity. These include cycles that correlate to the Yoredales, but also to longer timescales that may explain unconformities, and to shorter timescales that may provide explanation for additional cyclicity observed within parts of the succession.

The work provides a framework for interpolation below seismic resolution, and within and between the sediments of coeval environments. These scales are important to the energy transition as 'reservoirs' become 'basinal' in scale and sealed by lateral facies changes with coeval systems (e.g. 'deep saline' CCS) and fluid flow questions are regional (e.g. lithium).

Dr Paul Nathanail
Land Quality Management Ltd
Nottingham

East Midlands: king coal is dead, recovering from the wake takes time

The coal mines and ancillary or secondary industries have closed. Their aftermath requires considerable geological and other professional competencies to allow land to be reused and nature to re-establish. The former Avenue Coking Works, south of Chesterfield, was a model of modern technology producing coke and other much needed products… until it wasn't. Once described as one of the most contaminated sites in Europe, its 20+ year journey from dereliction to multiple reuses required a detailed understanding of hydrogeology, heavy metal and hydrocarbon geochemistry, geotechnical properties of excavated materials and a remediation budget surpassed only by that for the London Olympic site. Starting with early efforts to fund the reclamation from opencast coal mining. Avenue's story is one of success built on innovation and sometimes reluctant collaboration. Along with hectares of repurposed land, much transferable knowledge, several research theses and many scientific publications form a lasting legacy of the wake of King Coal in our region.

David Boon

Senior Engineering and Geothermal Geologist
British Geological Survey, Keyworth

A new Ground Source Heat Pump and geothermal observatory at BGS Keyworth

The Natural Environment Research Council (NERC) has a target to decarbonise its heating by 2030 and achieve Net Zero by 2040. The space heating of two existing office buildings on the British Geological Survey (BGS) Keyworth Campus, Nottinghamshire, have been decarbonised by employing electrically-driven ground source heat pumps coupled to 28 closed-loop borehole heat exchangers installed to 225 m. The project includes a 'Living Lab', featuring an advanced monitoring system that tracks the thermal changes in the ground array using downhole fibre optical cables and electrical resistivity tomography (ERT). The project included a new research borehole cored at 4-inch diameter (102 mm) to 238.5 m with good core recovery. Downhole geophysical logging, core scanning, thermo-physical property testing, and groundwater and microbiological analysis were conducted. The succession encountered was *c.*215 m of red, variably gypsiferous, Mercia Mudstone Group with Sherwood Sandstone to TD. The Arden and Cotgrave sandstones were encountered at *c.*48 and *c.*89 m respectively.

Briony Bowler

MPhil student, Keele University

Sedimentology and the evolution of arid terminal fluvial fans: implications for reservoir heterogeneity

Spatial and temporal variations in the sedimentology of continental basins are preserved at facies and stratigraphic scale, with the relationships between architectural elements and facies reflecting the evolution of the depositional system. Coeval aeolian and fluvial environments interact in such basins, forming heterogenous, complex sedimentary successions. However, comparatively little research has been conducted into the implications of aeolian-fluvial interactions upon the preserved sedimentology, system evolution, and the resultant reservoir potential. Sedimentary logs and magnetic susceptibility data of the Middle Jurassic Carmel Formation across southern Utah have been combined to produce three-dimensional facies models of aeolian-fluvial depositional systems. Changes within the palaeoenvironment, caused by changes in the dominance and relative balance of autogenic and allogenic processes, are reflected by preserved architectures. Heterogeneity impacts reservoir quality, which can be evaluated using generalised models applicable to sub-surface, sub-seismic scale analogues.

Dr Mike Spence

UK Geoenergy Observatory Cheshire, Science and Operations Lead, British Geological Survey, Keyworth

The UK Geoenergy Observatories: New research facilities to de-risk investment in shallow geothermal energy

New initiatives to systematically map UK geothermal potential are paving the way for widespread development of aquifer and mine water geothermal energy resources. A key factor in realising this potential is understanding the influence of geology on thermal and environmental performance and to address this need, the British Geological Survey has recently completed the construction of two high tech, borehole-based shallow geothermal research facilities called the UK Geoenergy Observatories. The Observatories, which are located in the Cheshire Sherwood Sandstone and Scottish Coal Measures, are designed to provide the data and scientific understanding needed to maximise geothermal performance, avoid interference between adjacent schemes and minimise any environmental effects. The Geoenergy Observatories incorporate advanced electrical, fibre optic and groundwater monitoring capabilities that can map thermal plumes in 3D and close to real time. This allows the effect of geological variation and groundwater flow in the rock matrix, fractures or mine voids to be assessed, together with the effects of thermal perturbation on groundwater chemistry and aquifer properties. More generally, the Observatories will provide important insight into how geological volumes can be effectively monitored for other geoenergy technologies, such as CO2 and hydrogen storage.

Aerial view of the UK Geoenergy Observatory, Thornton Science Park, Cheshire.

Professor Paul Wignall

Professor of Palaeoenvironments
University of Leeds

The end-Triassic mass extinction: the view from eastern England

The end-Triassic mass extinction, a little over 200 million years ago, is one of the 'big five' crises of the fossil record. Victims include many groups of molluscs, such as the bivalves and ammonites, and on land many groups also disappeared, paving the way for a world dominated by dinosaurs. Like all extinction crises,

the end-Triassic one coincides with the eruption of gigantic volumes of lava from a mantle plume, with the gases released being widely held to be responsible for devastating climatic consequences. In this case the volcanism was centred to the south west of the British Isles in the centre of the Pangea supercontinent, and we know it as the Central Atlantic Magmatic Province.

All of these events are recorded in the British Isles in the Penarth Group: a fascinating succession of rocks that record the transition from the desert conditions of the latest Triassic to marine flooding and offshore deposition in the earliest Jurassic. It is within this succession of rapidly changing environmental conditions that the mass extinction is recorded. In eastern England, the first phase of the mass extinction coincides with a change from marine siltstones to curious pale mudstones that probably formed in non-marine conditions, while the second phase coincides with the onset of anoxic deposition.

Latest Triassic strata exposed in Bantycock gypsum mine, near Newark, Nottinghamshire.

Professor David Bridgland

Professor of Physical Geography
Durham University

Quaternary evolution of the Trent: knowns and unknowns about its complex drainage evolution

Britain's third river, the Trent, straddles the boundary between the area glaciated and unglaciated during the Late Pleistocene, although much of its catchment is inherited from a system entirely obliterated by our most extensive glaciation nearly half a million years ago: the 'Anglian'. A geo-archaeological project has firmed up our understanding of the complex evolution of drainage hereabouts, with glacial effects strangely bringing about repeated northward diversion within Lincolnshire. The first diversion coincided with the obliteration of the pre-Trent system, named 'Bytham' (after Castle Bytham), which had drained from the West Midlands across East Anglia. The first Trent emerged from beneath the Anglian ice, re-using parts of the Bytham system, and was essentially a Soar–Derwent. We know little about any upper catchment in the West Midlands and are uncertain about its lower course, although it probably used the Lincoln (Witham) Gap. It seems that the Middle Trent alignment was first established by a later, poorly understood glaciation around 250 000 years ago. The location of Lincoln was on the Trent course until the very end of the Pleistocene, when deglaciation and drainage of the ice-dammed 'Lake Humber' resulted in the modern Trent course via Gainsborough to join the Yorkshire Ouse.

Daniel Adegbosin (poster presentation)

University of Derby

Optimising geothermal energy extraction in Wessex Basin, UK: integrating fluid flow dynamics for sustainable resource utilization (poster presentation)

This study aims to enhance geothermal energy extraction in the Wessex Basin, UK, by integrating geological and dynamic fluid flow modelling of potential geothermal reservoirs. Focusing on the HURN 1 well, we investigate the Sherwood Sandstone Formation, found at 1843.5 m depth with a temperature of 69°C. Seven formations were identified through seismic interpretation, which, combined with well data, facilitated the creation of high-accuracy geological models. Utilizing the Matlab Reservoir Simulation Toolbox (MRST), numerical models of a low-enthalpy geothermal doublet system were developed to simulate fluid extraction. Parameters including pressure, production rate, and temperature, were tested to optimize energy production for a district heating scheme. This research contributes to the development of sustainable geothermal energy solutions for the UK by providing insights into reservoir behaviour and optimisation of energy extraction in the Wessex Basin.

Oluseyi Adeleke (poster presentation)

University of Derby

Assessing low enthalpy geothermal potential in the Cheshire basin: insights from geological and numerical fluid flow modelling using Petrel and MRST

To attain net-zero carbon emissions by 2050, the UK must now decarbonise heat production, potentially facilitated by deep geothermal energy. This project assesses geothermal energy potential beneath the Blacon area of the Cheshire Basin. Seismic interpretation identifies four distinct potential reservoirs: Lower Mottled Sandstone, Westphalian, Namurian, and Carboniferous limestone, with the last being the deepest and warmest. The feasibility, recoverability, and sustainability of energy resources from deep-marine limestone reservoirs is modelled to understand how the potential for geothermal energy varies across the basin. As the deepest identified reservoir in the Cheshire Basin, at a depth of 2.2 km and a potential temperature of ~60 °C, the Carboniferous limestone could support a combined power plant, or be increased using heat pumps to produce water of ~90 °C.

Kristian Blyth (poster presentation)

University of Derby

Ultra-low enthalpy geothermal systems beneath Derby: Potential for decarbonising domestic and industrial heating

Ultra-low enthalpy geothermal fluids present a widespread and abundant heat resource, available across the UK without the need for ultra-deep drilling or reservoir permeability enhancement. They present a promising option for decarbonising heat resources on a small to medium scale where higher enthalpy resources are not accessible. In Derby, existing borehole and seismic reflection data indicate potential for permeable reservoirs at approximately 1 km depth within the Widmerpool Formation and in potentially deeper formations. Using Petrel, we interpret subsurface data to create a geological reservoir model, utilised to run numerical fluid flow simulations using MATLAB Reservoir Simulation Toolbox (MRST) to simulate fluid extraction rates, subsurface pressures, and geothermal energy potential. As an industrial city with a population of over 250 000, decarbonisation of Derby's key heating requirements could represent a significant step towards meeting UK carbon emission targets.

Jeneeva Fish (poster presentation)

University of Derby

The effects of ocean acidification on temperate sediments

We investigate the effects of ocean acidification on temperate marine sediment retention under a range of projected future ocean acidification scenarios. This pilot study employed seven sediment samples, collected from beaches throughout the UK, each of which was placed in five different simulated marine waters maintained at a range of pH values. The pH range of the five fluids was selected to span ocean pH from prior to the Industrial Revolution (pH 8.2) to slightly above the most distal predictions of future ocean acidification (pH 6.5). Unsurprisingly, under all acidification scenarios, a strong relationship was observed between the carbonate content of the sediments and the amount of sediment retained during the experiment. Increased acidity corroded carbonate grain surfaces, increasing the surface area and weakening the grains. Our findings have implications for coastal erosion and sediment retention pathways under rising acidification scenarios.

Luke Longley (poster presentation)

University of Derby

Using geodynamic numerical models to understand the role of plate motion changes and inherited structures on oceanic mega-transform fault development (Poster presentation)

Transform faults are a type of plate boundary demonstrating horizontal motion and displacement. Typically, oceanic transform faults demonstrate offsets of 100 to 200 km, with a minority defined as mega-transforms having offsets of >200 km. Consequently, these mega-transforms represent a relatively understudied feature of plate tectonics, with our understanding of their formation and development currently incomplete. In this study, we use the numerical modelling software ASPECT to create high resolution 3D simulations of mega-transform development resulting from oblique changes in plate motion. Specifically, we determined that transpression leads to the formation of a new, longer transform margin, while transtension causes rifting across the old transform system. These results are also compared to real world examples such as the Davis Strait and West Somali Basin, where better understanding these ancient transform margins could open development opportunities for geothermal, CCS, and conventional hydrocarbon resources, essential for the energy transition.

Cyril Mbachu

University of Derby

Enhanced weathering strategy in atmospheric carbon dioxide sequestration in regenerative land management (Poster presentation)

Increased levels of atmospheric carbon, caused by emissions of carbon dioxide (CO2) from anthropogenic activities, is directly responsible for climate change. Combatting this situation within a limited timeframe will involve the deployment of a number of CO2 removal strategies, one of which is enhanced weathering. Enhanced weathering is a nature-based strategy involving the application of crushed silicate rocks (such as quarry wastes) to agricultural lands where they undergo natural weathering and, in the process, sequester atmospheric CO2 and enrich the soil. This study undertakes a quantitative evaluation of the CO2 sequestration potential of enhanced weathering, highlighting its co-benefits, in a regenerative agricultural land setting in Derbyshire. The monitoring of 30 application quadrats and 25 control quadrats is characterising the weathering of the feedstock, assessing soil health, and determining the scalability of this strategy, in a regenerative agricultural setting.

Nell Mineyko

University of Derby

Understanding and managing anthropogenic ocean acidification (Poster presentation)

During this study we aimed to examine the impact of Ocean Acidification on tropical carbonate environments and consider the wider global impacts. We also sought to offer potential mitigation and adaptation strategies to meet the societal impacts of Ocean Acidification. We did this by combining a desk study of the literature with a laboratory experiment looking at the dissolution of carbonates in seawater of five pH's in a simulated shallow marine environment. The findings of this experiment have serious implications for the future of the sediment budget of Earth's oceans and, potentially, significant impacts to humans via the erosion of coastlines around the world. This research helps to

bridge the gap between the geological sciences and their practical implications. The study aims to inspire future research and develop mitigation strategies for Ocean Acidification as a product of anthropogenic climate change.

Jessica Mackie

BGS/Manchester

Microbiology of the BGS Keyworth shallow geothermal cored borehole relevant to UK geological waste disposal (Poster presentation)

The UK subsurface is being explored for suitable nuclear waste disposal locations. The BGS Keyworth shallow geothermal borehole was cored to 238.5 m through the Mercia Mudstone and Sherwood Sandstone groups. Such lower strength sedimentary rocks are being considered as host rocks for nuclear waste. It is therefore important to characterise microbial groups present within these materials to better understand the potential for microbial activity in geological disposal settings. Fresh core subsamples were obtained using sterile sampling techniques and preserved anaerobically for no longer than eight days before initiating culture-based analyses. Results indicated that sediment-associated heterotrophs (with a higher presence of anaerobes than aerobes), sulphate-reducing prokaryotes and iron-reducing bacteria were present in low numbers. These early-stage results demonstrate the presence of key microbial groups which could potentially impact safe nuclear waste disposal within UK strata.

Alessandro Ranise

University of Derby

Repurposing the near-end-of-life Whisby Oilfield in the East Midland Province for geothermal use (Poster presentation)

This study focuses on the feasibility of repurposing nearly exhausted oilfield wells for geothermal energy production utilising formation waters. The project investigates the East Midland Province of the UK, particularly the Whisby Oilfield, for its potential to supply a geothermal district heating system for the nearby city of Lincoln. The report provides a comprehensive analysis of the region's geological setting, stratigraphy, and tectonic history, with emphasis on the formation's porosity, permeability, geothermal gradient, and heat flow. The Carboniferous Limestone is the primary unit of interest for this research as it has an above-average geothermal gradient and areas with good porosity and permeability, albeit its subsurface extent is quite unpredictable. Repurposing near-end-of-life oilfields reduces geothermal drilling costs and provides clean energy, thereby extending the oilfield's economic life.

Nadir Samuel

University of Derby

Unlocking the Earth's warmth: exploring the potential of low-enthalpy geothermal heating at the Kedleston Road campus of the University of Derby

The UK aims for net-zero gas emissions by 2050. Ground-source heating geothermal systems are emerging as key components of the UK's future energy mix, offering a sustainable solution. Britain's universities can lead the way by decarbonising their campuses. This forward-thinking approach aligns with global efforts to combat climate change and appeals to environmentally conscious students. This project quantifies the shallow geothermal resources beneath the Kedleston Road campus to ascertain the potential for implementing geothermal heating. The study employs a combination of borehole and seismic data to analyse the potential reservoir. Initial findings suggest that the campus has a promising target, the Carboniferous Limestone, approximately at 150 m depth. This project exemplifies how educational institutions can lead the fight against climate change, setting a precedent for others to adopt. (Poster presentation)

Tom Slatter

University of Loughborough

Finger-rock interactions in rock climbing and the effect of friction modifiers (Poster presentation)

The application of chalk (magnesium carbonate) in rock climbing is common practice as climbers attempt to improve their grip by removing moisture from their hands with the aim of increasing friction at the finger pad-rock interface. We investigated the effectiveness of chalk as a friction modifier on sandstone, granite, dark limestone, and light limestone, all typically found in areas of the UK where the sport of climbing is undertaken. The results of this study, and the explanation of friction mechanisms involved, provides guidance for the use of chalk with consideration of the type of rock which is being climbed.

Thi Mai Khanh Tranova

University of Derby

Lithospheric controls on plate tectonic motions and microcontinent formation. Part 1: Mapping global transpression (Poster presentation)

Many potential green energy resources are undiscovered on our planet, hidden within crustal structures such as microcontinents, the formation of which is not well-understood. Recent work by Whittaker et al. (2016) suggests formation of microcontinents from plate tectonic reorganisation, where transpression along transform plates causing ridge jumps into rifted continental margins. To test this hypothesis, we aim to globally map transpressive and transtensional oceanic fracture zones. These structures with specific spectral gravity wavelength signatures will be identified using machine learning approaches and Generic Mapping Tools (GMT). In later work, we will kinematically model the onset and development of these transpressional and transtensional structures to understand their relative timing to kinematic change and decipher the role of lithospheric structures in microcontinent cleaving and the global plate tectonic system.