

Cave Science Symposium, 2019



Creswell Gorge
Photo Andrew Chamberlain



BCRA

British Cave Research Association 30th Cave Science Symposium

**Symposium - Saturday 19th October, 2019
Fieldtrip – Sunday 20th October, 2019
British Geological Survey, Keyworth, Nottingham**

Timetable and Abstracts

Welcome from the BCRA Chairman

On behalf of the Council of the British Cave Research Association (BCRA) I am pleased to welcome members to the 30th BCRA Cave Science Symposium. The first Symposium was held at the University of Sheffield in 1984 and it was followed by annual meetings until 1987 when it became biannual (1987 and 1991). There was then a four year hiatus before the meetings resumed in 1996 since when they have been held annually. The 30 Symposia have been held at 14 individual institutions with the Universities of Bristol and Leeds tying for most popular with five meetings at each. There has been one previous meeting at the BGS, in 2013, and a new venue has been confirmed for 2020, the University of Hull.

The objective of the BCRA is “*to promote the study of caves and associated phenomena wherever they may be situated, for the benefit of the public*” and the Annual Symposium is one of the ways that this objective is fulfilled. The *associated phenomena* include karst landforms on the surface, and this aspect is reflected in the title of the Association’s scientific journal, *Cave and Karst Science*. The BCRA Cave Science policy focuses on four major themes: speleogenesis, archaeology/palaeontology, biology and technology. Speleogenesis is interpreted broadly, including those aspects of geomorphology, geology and hydrogeology that impinge on the development of conduits and ultimately caves. Studies of present cave climates and reconstruction of paleoclimates and paleoenvironments using cave sediments (speleothems and clastic deposits) are also considered under the speleogenesis heading. The programme for the 30th Symposium is dominated by the first theme but with one paper on each of the other themes and, for the first time, a presentation on cave art.

The BCRA AGM is held during the Symposium. Administrative matters are kept to a minimum, the primary objectives being to provide BCRA members with a succinct summary of Association activity during 2019 and to seek views on what should be done in 2020 and beyond. Interested non-members are welcome to attend the AGM and to contribute to the discussion.

As with all BCRA events this Symposium was made possible by the commitment of volunteers and I would particularly like to thank Dr Andrew Farrant and Dr Andrew Smith of the British Geological Survey for acting as local organisers and Dr Gina Moseley, Ingeborg Hochmair Professor at the University of Innsbruck, for acting as lecture secretary and programme organiser.

Professor John Gunn, BCRA Chairman

TIME	ORAL PRESENTATIONS – PROVISIONAL TITLES	PRESENTER
08.30	Doors open, registration, book sales, coffee	
09.15	Take seats	
09.20	Welcome and housekeeping	ANDY FARRANT
SESSION 1		ANDY FARRANT
09.30	Discovery and evaluation of a previously unknown major paleokarst within a modern cave in NE India; the Pielkhlieng Pouk-Krem Sakwa system, Meghalaya	MARK TRINGHAM
09.50	The discovery of the world's biggest cave fish; but is it a new species?	DANIEL HARRIES
10.10	A Crawl through Cave Art	DOMINIKA WROBLEWSKA
10.30	<i>Coffee, Posters and Book Sales</i>	
SESSION 2		JOHN GUNN
11.00	Exploring the speleothem pollution record	PETER WYNN
11.55	Pause	
12.00	BCRA AGM	
13.00	<i>Lunch</i>	
13.50	Return from lunch, take seats	
SESSION 3		TIM ATKINSON
14.00	Understanding Carbonate Hot Springs: a Karst approach – Chas Yonge	CHAS YONGE
14.20	Irregular flow from sumps and springs in the Castleton karst, Derbyshire	JOHN GUNN
14.40	The Morecambe Bay karst - paleoenvironmental and speleogenetic studies	PHIL MURPHY
15.00	<i>Coffee, Posters and Book Sales</i>	
SESSION 4:		ANDREW CHAMBERLAIN
15.30	The archaeology and human remains from Frank l'Th'Rocks Cave, Derbyshire: a reassessment of the evidence	CATRIN FEAR
15.50	Cave monitoring at Pooles Cavern, Buxton	JOHN GUNN
16.10	Cave stability monitoring and its significance for environmental protection	MATT ROWBERRY
16.30	U-series dating and the geomorphic evolution of caves and gorge at Creswell Crags	TIM ATKINSON
16.50	Summing up and details of Sunday fieldtrip	JOHN GUNN / ANDREW CHAMBERLAIN
17.00	Close	
18.00	Evening Meal	

**No photography of presentations or posters without permission from the presenter.
Photography of social aspects is permitted.**

The 31st Cave and Karst Science Symposium will be held on Saturday 14th November, and will be hosted by Dr. Mike Rogerson, University of Hull.

DISCOVERY AND EVALUATION OF A PREVIOUSLY UNKNOWN MAJOR PALEOKARST WITHIN A MODERN CAVE IN NE INDIA; THE PIELKHLENG POUK-KREM SAKWA SYSTEM, MEGHALAYA.

Mark Tringham¹

¹University of Bristol Spelaeological Society, Gloucester Speleological Society, Grampian Speleological Group

Correspondence to: Mark Tringham (mtringham@btinternet.com)

The Late Paleocene to Middle Eocene sedimentary sequence in Meghalaya comprises interlayered coaly sandstones and limestones hitherto considered as conformable. Major caves totalling over 500Km mostly occur in the Lakadong and Prang Limestone Members in the Jaintia and Khasi Hills. One such cave in the Lakadong Limestone is the 20Km long PP-KS system. Exploration and study over the last decade or more have exposed a wide variety of paleokarst features through many parts of this cave. These include a pinnacle epikarst on the top surface of the limestone with up to around 15m relief seen in the walls and roof of the cave with sandstone and coals infilling around the pinnacle towers and buttresses. Additionally within the same limestone interval large tube and ball shaped sandstone bodies occur which are interpreted as pit and cavern infills. This paper will describe the nature of these features and their significance in the stratigraphy of the region introducing for the first time an interpreted Late Paleocene unconformity with exposure and erosion of the Lakadong Limestone prior to Lakadong Sandstone deposition. It additionally will explain why this horizon was likely overlooked during surface studies by previous workers. The speleogenesis of the PP-KS system across this unconformity is very unusual and raises interesting questions concerning cave inception and drainage. Overall the cave system permits observation and study of a world-class exposure of a paleokarst infilled by sandstone likely unmatched in any surface outcrops anywhere else on earth.

THE DISCOVERY OF THE WORLD'S BIGGEST CAVE FISH; BUT IS IT A NEW SPECIES?

Daniel Harries¹

¹Grampian Speleological Group

Correspondence to: Daniel Harries (d.b.harries@hw.ac.uk)

In February 2019 a newly explored cave in the Jaintia Hills of Meghalaya in north-eastern India was found to contain a substantial population of large blind depigmented carp. One of the larger individuals was captured and photographed before being released alive. Photographs of this individual indicate it was in excess of 40 cm in length. Subsequent investigations have shown that these fish are by far the world's largest known troglomorphic fish. In terms of body weight it is likely to be an order of magnitude bulkier than the largest previously known species. An examination of detailed images of the new fish indicates they are a close anatomical match to the common surface species known as the Golden Mahseer (*Tor putitora*). Continued investigations will seek to establish if this finding is indeed a new species or if it might be regarded as an extreme and formerly unknown variant of the Golden Mahseer.

A CRAWL THROUGH CAVE ART

Dominika Wroblewska¹

¹Manchester Metropolitan University

Correspondence to: Dominika Wroblewska (domeeart@gmail.com)

Did you know? There are people underground and there are many of them. This is a culmination of a 2 year long research into caves through reportage illustration. Since the summer of 2018, I've been following UK's caving community, recording any cave-related activities with drawing. Sketching on-site (over-ground and underground) here becomes a main tool to learning about the community, which simultaneously leads to learning about caves. I output the gathered knowledge into a fully illustrated book, which explores questions such as: 'what is a cave?' 'why are some of us drawn to caves?' Through poetry and interactivity, it looks at the science of caves and brings attention to our human presence underground. Its main objective is to intrigue those who don't know much about caves, as well as invite those who do to take a look at them from a different point of view.

'The Cave Starter Pack' book will be available to view during coffee breaks.

This project is a result of my MA in Illustration at the Manchester Metropolitan University.

EXPLORING THE SPELEOTHEM POLLUTION RECORD

Peter Wynn¹, Ian Fairchild², Andy Baker³, James Baldini⁴, Christoph Spotl⁵, Silvia Frisia⁶, Andrea Borsato⁶, Adam Hartland⁷, Jonathan Lageard⁸, Peter Thomas⁹, Dave Matthey¹⁰, Phil Barker¹, Andy Stott¹¹, Andi Smith¹², Ben Surridge¹, Imke Grefe¹, Poppy Ambler¹,

¹Lancaster University; ²University of Birmingham; ³NSW Australia; ⁴University of Durham;

⁵University of Innsbruck, Austria; ⁶Newcastle, Australia; ⁷University of Waikato, New Zealand;

⁸Manchester Metropolitan University; ⁹University of Keele; ¹⁰RHUL, UK; ¹¹Life Sciences Mass Spectrometry Facility; ¹²NERC Isotope Geosciences laboratory;

Correspondence to: Peter Wynn (p.wynn@lancaster.ac.uk)

Pollution of the atmosphere and earth surface has been a major defining feature of the twentieth century. Emissions from industry and agriculture have altered the biogeochemical cycling of key nutrients beyond all recognition. However, proxy records show little acknowledgement of these changes at the regional scale. Indeed, the speleothem record of biogeochemical changes in the major affected nutrients has received limited attention. Here, we explore the use of speleothems as archives of pollution. We specifically address the use of stalagmites as recorders of sulphur, nitrogen and phosphate dynamics. Speleothems have become well established archives of regional atmospheric Sulphur pollution, with many records depicting peak emissions in the late twentieth century and a subsequent decline following the introduction of regulatory legislation. We trace the source of sulphur using stable isotopes and examine its presence in speleothem calcite from the centennial to annual scale using a variety of techniques. The speleothem sulphur archive is seen to be far more than just a record of anthropogenic sulphur pollution, encompassing also volcanic activity and changing climatic conditions. We will also present some of the first data documenting the transfer of nitrate into the speleothem record. Modern calcite from several cave sites around the world is used to demonstrate the effectiveness of speleothem nitrate as an indicator of atmospheric pollution, fertilizer use, and biogeochemical cycling. Phosphate is an element which has attracted a lot of interest in the speleothem record, not least because of its association with vegetation dynamics, pollution and possible within-cave microbial processing. However, the use of phosphate-oxygen isotopes as an indicator of phosphate source and biogeochemical cycling has so far eluded researchers due to the low concentrations available and methodological problems of extraction. Here, we present some very preliminary data for the first phosphate-oxygen isotope values from speleothem calcite and discuss the potential of this new speleothem proxy. These three indicators of pollution within the speleothem record form part of an ongoing research program and will be presented within the context of the Anthropocene.

UNDERSTANDING CARBONATE HOT SPRINGS: A KARST APPROACH

Chas Yonge¹

¹Yonge Cave and Karst Consulting Inc. and Alberta Speleological Society, Canada

Correspondence to: Chas Yonge (chas-karst@telus.net)

There are many studies of hot springs worldwide, but little attention has been paid to carbonate hot springs as a distinct class (Goldscheider et al, 2010). It appears that treating carbonate hot springs as a karst system may lead to a number of insights regarding their hydrogeology. The Banff Hot Springs has been fairly extensively researched since the 1950s (e.g. Yonge and Lowe, 2017; Yonge, 2019), but some of the conclusions regarding their systematics are at best vague or unsatisfying. This presentation, applying a karst perspective, allows a number of these conclusions to be clarified. While it is generally agreed that the hottest components of the groundwater (67°C) rise from more than 3 km depth, that their origin is snowmelt from high elevations (>2,000 m) and that extensive thrust faulting is involved, little attention has been paid to the role of dissolution in the circulation process. Here therefore I hope to address the following questions: (i) How distant could the recharge locations be (currently thought to be local, ~3 km); (ii) how old is the groundwater (currently thought to be seasonal); (iii) why is the hottest spring at the highest elevation; (iv) why did the secondary tufa deposits stop growing some 3 ka ago; (v) Are there conduits dissolved out along the fault thrust and beddings, and (vi) what agents of dissolution are at work?

The karst approach gives insightful answers to these questions, briefly that; (i) distal recharge may be up to ~100 km away; (ii) the highest thermal components of the groundwater may be >15 ka; (iii) the hot groundwater may be diluted by post-glacial, local, cool seasonal groundwater (snowmelt) at progressively lower elevation, which also (iv) prevents precipitation of the tufa; (iv) Rats Nest Cave, a local relict cave formed on the thrust fault, has large conduits that may indicate inception horizons along both fault and bedding partings for the hot springs. (v) Sustained dissolution along distal flow paths is triggered by diverse mineral (and biological) interactions and temperature/pressure regimes along its underground path.

Further examination of hot springs in the carbonate terrain of the Canadian Rockies and elsewhere suggests that the karst approach is valid, and that it may be applicable worldwide.

Goldscheider, N., Mádl-Szönyi, Eröss & Schill, E. 2010. Review : Thermal Waters in carbonate rock aquifers. *Hydrogeology Journal* 18 : 1303–1318

Yonge, C J and Lowe D J, 2017. Banff Hot Springs hydrogeology: a karst perspective. *Cave and Karst Science* 44(2), 82 – 93, 2017.

Yonge, C, J., Understanding the Banff Hot Springs through Karst Hydrogeology. *1st Edition*, ISBN 978-0-9879369-3-6, 104pp.

IRREGULAR FLOW FROM SUMPS AND SPRINGS IN THE CASTLETON KARST, DERBYSHIRE

John Gunn¹, Chris Bradley¹ & Ryan Davies¹

¹School of Geography, Earth & Environmental Sciences, University of Birmingham, Birmingham, B15 2TT, England

Correspondence to: John Gunn (J.Gunn.1@bham.ac.uk)

The Castleton karst (Derbyshire, UK) is at first sight typical of many karst systems worldwide. There are inputs of allogenic water from streams that sink at 15 points and inputs of autogenic water fed by rain and snow falling onto the soil-covered limestone outcrop which is pitted by dolines. Water output occurs from three springs that feed a surface stream: the Peakshole Water. Between the sinks and springs there are 45 caves with a total surveyed length >38km. The longest is the Peak-Speedwell system which is upstream of the springs and has ~50 inlet streams of which 20 flow from permanently water-filled ‘sumps’. Cave divers have explored >1000m of these sumps one of which descends to a depth of at least

76m below dive-base. Over 50 water-tracing experiments have revealed the broad outline of the sub-surface hydrology but a great deal of internal complexity is yet to be fully understood. Water depth and temperature were logged at 1-minute or 2-minute resolution from July 2012 to April 2015 in the two main inlet sumps in Speedwell Cavern (Main Rising and Whirlpool Rising), at the three springs (Russet Well, Slop Moll and Peak Cavern Rising), and in the Peakshole Water. The data reveal a level of flow complexity that is greater than is found anywhere else in the world that we are aware of. The sumps, several hundred metres apart and at different elevations, exhibit flow switching (the majority of the flow from the allogenic sinks enters via one sump for a period of time and then switches to the other); chaotic nonlinearity (rapid changes of depth and temperature but with no consistent periodicity) and intervals when the behaviour is periodic. Depth changes during the chaotic events can be as rapid as +20cm and -18cm per minute. Vadose streams from the inlet sumps, combine and flow to a downstream sump in Speedwell Cavern that connects with the springs. Some of the complexity is retained in the spring output response (depth changes of up to +8cm and -8cm per minute) and in the stream-discharge downstream of the springs. For example, in one event the discharge fell from 1429L/s to 822L/s over a 54 minute period and then rose back up to 1429L/s over the following 142 minutes.

In this paper we first seek to characterise the 'average' behaviour of the inlet sumps, springs and Peakshole Water over the period 18/12/2013 - 18/2/2014 using autocorrelation and crosscorrelation analysis of rainfall and stage (water depth) data. The data set was then divided into a 22 separate 'events' where an individual event commenced with an increase in depth up to a peak and then a recession, the end of the event being the point where no further decrease in depth was observed. The events were then grouped based upon duration (median length as threshold) and degree of variability in stage yielding 12 categories, 9 of which were used in event categorisation. Autocorrelation and crosscorrelation analysis were then applied to the individual events demonstrating significant event-scale variability that differs not only from the 'average' behaviour, but also differs between events (inter-event variability) and between sites (intra-event variability).

BENEATH THE LAND OF KNOLLS AND MOSSES - KARST STUDIES IN THE ARNSIDE AND SILVERDALE AONB.

Phil Murphy¹

¹School of Earth and Environment, University of Leeds, Leeds LS2 9JT
Correspondence to: Phil Murphy (P.J.Murphy@leeds.ac.uk)

The low lying karst lands on the south eastern side of Morecambe Bay, North West England, consist of a series of fault bounded limestone blocks separated by glacially over-deepened valleys. The area is famous for its limestone pavements and the valleys contain ecologically important wetlands but other aspects of the geology and geomorphology, including cave development, have received little attention in recent years. Speleological, archaeological and mining history research work was undertaken in the late 1960s and early 1970s by the short lived Lancaster Cave and Mine Research Society (Murphy 2019). Since then very little cave research has been undertaken with the exception of studies by Professor Stephen Gale in the 1980s (e.g. Gale 1981 & 1984). The publication of a series of excursion guides to the area by Peter Standing (1) has increased interest in the geology and geomorphology of the area and highlighted the need for further research. A review of cave occurrence and development in the area will be presented along with results of recent speleothem dating and cave sediment studies.

Gale, S. J. 1981. The geomorphology of the Morecambe Bay karst and its implications for landscape chronology. Zeitschrift fur Geomorphologie 25. 457-469.

Gale S J 1984. Quaternary hydrological development in the Morecambe Bay Karst, northwest England. Norsk Geografisk Tidsskrift 38 pp 185-192.

Murphy P J (ed.) 2019. The karst and caves of Morecambe Bay – a tribute to the works of Peter Ashmead. British Cave Research Association, Buxton.

THE ARCHAEOLOGY AND HUMAN REMAINS FROM FRANK I' TH' ROCKS CAVE, DERBYSHIRE: A REASSESSMENT OF THE EVIDENCE

Catrin Fear¹ and Hannah O'Regan¹

¹Department of Classics and Archaeology, Humanities, University Park, Nottingham, NG7 2RD, UK
Correspondence to: Catrin Fear (Catrin.Fear@nottingham.ac.uk)

In 1925, Dr Palmer excavated Frank i' th' Rocks Cave, Derbyshire. However, the excavation and the subsequent publication left many questions unanswered. With a focus on gaining an understanding of how the site linked to Quaternary glaciations, the excavators provided a detailed report on the artefacts and fauna but failed to give details of the human remains or to relate the finds to one another. This has left a gap in the understanding of the site, compounded by the later loss of many of the artefacts that were excavated.

In 2017, the surviving assemblage was re-analysed, comparing the results with the details in the excavation report and in later catalogues. This re-analysis suggests that Frank i' th' Rocks Cave had multi-period usage from the Upper Palaeolithic to the Georgian period. However, most of the evidence, including the human remains, relates to the mid-late Romano-British period. This re-analysis highlights the importance of re-examining archival material as well as conducting new excavations when studying cave archaeology is stressed.

Collection and support from Buxton Museum and Art Gallery. Funding and support from The National Trust.

CAVE MONITORING AT POOLES CAVERN, BUXTON

Andrew Smith¹ and John Gunn²

¹British Geological Survey, Keyworth, Nottingham NG12 5GG, United Kingdom

²School of Geography, Earth & Environmental Sciences, University of Birmingham, Birmingham, UK
Correspondence to: Andrew C. Smith (andrew.c.smith@bgs.ac.uk)

The cave science research centre at Pooles Cavern, Buxton UK is now up and running, with high resolution data being collected from the cave since autumn 2018. The research centre is currently focussing on collecting and maintaining data sets for the most regularly monitored cave climate variables, including air temperature, humidity, speleothem drip rates, atmospheric pressure, rainfall and CO₂ concentrations. Over the next year we are intending to improve the network of loggers at the site to include a soil monitoring station and improved drip water monitoring regime. Much of the data produced at the cave site is being "live" streamed onto the BCRA server for instant access by users of the site, facilitating the ease of use of the site and its data sets. Over the past year we have had a good number of student science projects within the cave including one focussed on tourist interactions with the cave atmosphere and speleothem chemistry, another addressing the chemistry of drip waters and partitioning of trace elements in to hyper-alkaline calcite and another interested in testing CO₂ measurement devices. All of these projects have finished their data collection phases and we look forward to their results. In addition, we have a number of instrument tests being undertaken by new manufacturers and we have been working closely with Matt Rowberry and his team to facilitate their project on cave stability monitoring. There is still much work to be done at the site, both physical hands on work but also behind the scenes work to help quality check, process and archive data sets and develop a good web platform for the site. We are always looking for volunteers to help in these endeavours.... Hopefully 2020 will build on the success of this year and we will continue to expand the levels of cave research being undertaken within the UK.

CAVE STABILITY MONITORING AND ITS SIGNIFICANCE FOR ENVIRONMENTAL PROTECTION

Matt Rowberry¹, Xavi Martí², Carlos Frontera³, Ivo Baroň¹

¹ Department of Engineering Geology, Institute of Rock Structure & Mechanics, Czech Academy of Sciences, V Holešovičkách 41, 182 09 Prague 8, Czech Republic; ² Department of Spintronics & Nanoelectronics, Institute of Physics, Czech Academy of Sciences, Cukrovarnická 10, 162 00 Prague 6, Czech Republic; ³ Department of Magnetic Materials & Functional Oxides, Institut de Ciència de Materials de Barcelona, ICMA-B-CSIC, Campus UAB, E-08193 Bellaterra, Barcelona, Spain.

Correspondence to: Matt Rowberry (rowberry@irms.cas.cz)

Monitoring the vital signs of a cave is important for protecting the cave as a whole well as its cultural, biological, and geological resources. Cave stability monitoring provides important information about the preparatory factors that trigger cave breakdown as well as insights into the kinematic behaviour of active tectonic structures and deep seated slope deformations. Such monitoring helps to recognise potential dangers to human safety and has significant implications - both positive and negative - for the environmental protection of caves. This presentation focuses on the installation of a Spinterference contactless positioning system for 3D fracture displacement monitoring in the recently established British Cave Monitoring Centre at Poole's Cavern in Buxton, Derbyshire. The contactless positioning system takes advantage of the effect of anisotropic magnetoresistance to record changes in an artificially generated electromagnetic magnetic field. In Poole's Cavern, mains electricity supplies power to a control unit and electromagnet while the magnetic field data pass along more than 150 m of recently installed Ethernet cable before being transmitted to a computing cluster hosted by the Institute of Physics of the Czech Academy of Sciences. Fast execution algorithms transform the electromagnetic field data into a Cartesian coordinate system for three dimensional space in which the x component represents contraction and expansion across the fracture, the y component represents sinistral or dextral strike slip along the fracture, and the z component represents normal or reverse dip slip along the fracture. These data - both the electromagnetic field data and the three dimensional displacement data - are plotted online in real time and are available for download. Initial results from the site suggest that the monitored fracture is generally stable although some displacement was recorded during a large storm on 24 July 2019. The final part of the presentation illustrates how integration of the disparate climatic and geophysical time series generated in the British Cave Monitoring Centre at Poole's Cavern enables the use of big data and deep learning in order to prototype early warning systems for caves and other potentially hazardous environments.

U-SERIES DATING AND THE GEOMORPHIC EVOLUTION OF CAVES AND GORGE AT CRESWELL CRAGS

Peter Rowe¹ and Tim Atkinson^{1,2}

¹School of Environmental Sciences, University of East Anglia, Norwich NR4 7TJ, UK.

²Departments of Earth Sciences and Geography, University College London, London WC1E 6BT, UK.

Correspondence to: Tim Atkinson (t.atkinson@ucl.ac.uk)

The caves of the Creswell Crags gorge were studied in the 1980s with the aim of using U-series dating of speleothems to provide a time-scale for their formation, for the down-cutting of the gorge, and for the cave sediments and the archaeological and faunal remains they contain. The results have been published. This very short introduction will provide a pointer to the published literature as a background for the field visit to Creswell Crags on the following day.