Parkhouse Hill (top) and Chrome Hill are prominent limestone reefs in the Upper Dove Valley that will be visited on the post-Symposium Field trip (photos by John Gunn)

British Cave Research Association

32nd Cave Science Symposium

Saturday 27th November, 2021

Online on Zoom and in person at

Hulland Ward and District Millennium Village Hall, Derbyshire

For further information on how to join virtually please visit: https://bcra.org.uk/sym/

WELCOME FROM THE BCRA CHAIRMAN

On behalf of the Council and Trustees of the British Cave Research Association (BCRA) I am pleased to welcome members, and those who have not yet joined BCRA but hopefully will do so in the future, to the 32nd BCRA Cave Science Symposium. In this International Year of Caves and Karst we particularly welcome any karstologists and speleologists from outside Great Britain who may be joining us online.

The first BCRA Cave Science 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 up to and including 2019 were held at 14 individual institutions with the Universities of Bristol and Leeds tying for most popular with five meetings at each. A physical meeting was not possible in 2020 due to the global pandemic and instead a virtual meeting making use of the Zoom platform was hosted by Northumbria University and the British Geological Survey. This made it possible for us to welcome speakers and guests who would not otherwise have been able to be present and there were over 100 registered attendees from across the globe making the event our largest ever science symposium.

For 2021 BCRA Council decided that a physical meeting was desirable but as most Universities remain unwilling to host outside events due to Covid19 constraints an alternative venue was required. Thanks are due to **Jenny Potts** for securing the use of the excellent facilities at the Hulland Ward and District Millennium Village Hall, Derbyshire. Recognising the possibility that restrictions might be introduced at short notice and that some would not wish to attend in person it was decided that a combined event would be organised such that those who wish to attend in person are able to do so and those who wish to join us online, either to listen or to present, will be able to do so. BCRA thank BCA for making their Zoom platform available and the 'technical team' (**David Cooke, David Gibson, Angus Sawyer, Frank Tully and Les Williams**) for (hopefully!) ensuring this ambitious venture runs smoothly. Thanks also to the academic organisers of this 32nd Symposium, **Dr Beth Fox** and **Jo White** of the University of Huddersfield for putting together an interesting programme of lectures.

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 speleogenesis and biology themes are well represented at this meeting but this year no talks have been offered under the archaeology and technology themes. The latter part of 2021 has seen some exciting discoveries relating the cave archaeology/paleontology and BCRA Council hope that these will result in presentations (and publications) in 2022.

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 2021 and to seek views on what should be done in 2022 and beyond. Interested non-members are welcome to attend the AGM (in person or online) and to contribute to the discussion but not to vote.

Finally, and as we have many non-BCRA members attending as Guests, it is important to note that BCRA is a Charity that is run by volunteers and relies on income from membership fees and donations. If you enjoy this meeting and would like to join BCRA we would be pleased to welcome you (go to http://bcra.org.uk/detail/fees.html) and if you are willing to provide a donation to assist us then please do so via http://bcra.org.uk/donate.

Professor John Gunn, BCRA Chairman

TIME	SPEAKER	AFFILIATION	TITLE
9.30-10.00	ARRIVAL AND OPENING REMARKS		
10.00-10.30	Thomas Starnes	IUCN	Cave conservation for sites and species: Exploring the IUCN Red List of Threatened Species and Key Biodiversity Areas for caves and karst
10.30-11.00	Jo White	University of Huddersfield	Biofilms of British Caves and Mines
10.30-11.00	BREAK		
11.30-12.00	Sarah Parker	University of Reading	A global perspective of the 8,200 year BP event from speleothem oxygen isotope records
12.00-12.30	Bethany Fox	University of Huddersfield	What can magnetic speleothems tell us about past floods? A 33 kyr long record from Waitomo, New Zealand
12.30-13.30	BCRA AGM		
13.30-14.30	LUNCH		
14.30-15.00	Daniel Matthews	University of Leeds	The implications of high fluorescein-like background fluorescence for dye tracer testing in the Lea Valley, Hertfordshire
15.00-15.30	Andy Farrant	British Geological Survey	The role of inception horizons in the development of karstic conduits in the Chalk; implications for groundwater management and protection.
15.30-16.00	BREAK		
16.00-16.30	Sebastian Breitenbach	Northumbria University	Interpretations from a mid-late Holocene central Himalayan speleothem from northern India
16.30-17.00	John Gunn	University of Birmingham	Hydrological changes caused by sediment accumulation in sumps in the Peak-Speedwell cave system, Castleton, Derbyshire, UK
17.00	CLOSING REMARKS		

Cave conservation for sites and species: Exploring the IUCN Red List of Threatened Species and Key Biodiversity Areas for caves and karst

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Established in 1964, The International Union for Conservation of Nature's (IUCN) Red List of Threatened Species has evolved to become the world's most comprehensive information source on the global conservation status of animal, fungi and plant species. Currently, 1,297 species associated with caves and subterranean habitats have a conservation assessment on the Red List, but many more species remain unassessed. Of the assessed species, 358 species (27.5%) are globally threatened and 163 species (12.6%) are Data Deficient.

More recently the World Database of Key Biodiversity Areas, established in 2016, documents sites making significant contributions to the global persistence of biodiversity. The Key Biodiversity Area Partnership, an ambitious partnership of 13 global conservation organizations, is helping to prevent the rapid loss of biodiversity by supporting nationally led efforts to identify these places on the planet that are critical for the survival of unique plants and animals, and the ecological communities they comprise.

These 'Knowledge Products' can be used to inform cave and karst conservation, as well as providing treasure troves of data for academic research. We will briefly explore these key IUCN datasets with a focus on the Red List of Threatened Species and Key Biodiversity Areas, investigating how they can inform cave conservation science and policy.

Biofilms of British Caves and Mines

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Biofilms in caves and mines exist in a wide range of forms including snottites, moon milk cave pearls and cave silver. It is likely that the morphology and community structure of these biofilms is impacted by local environment factors including mineralogy, moisture, and nutrient input. The potential for microbially influenced precipitation of minerals has biotechnological appeal since these organisms could be utilised within municipal surfaces such as roads.

To date, a range of biofilms have been examined from British caves and mines. The morphology of these biofilms has been observed, and samples have been collected. Following extraction of DNA, next generation sequencing of 16S rRNA genes has identified microbial communities within samples of snottite from Yatestoop sough. Additional samples have been utilised for the cultivation of individual strains of bacteria. These isolates have been identified through genotypic analysis of the 16S rRNA gene. The overall community structures will indicate the prevalence of these organisms within the biofilm whilst the individual isolates from the consortia will be used to determine the bio-precipitation potential.

A global perspective of the 8,200 year BP event from speleothem oxygen isotope records

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The 8,200 year BP event is one of the best examples of a large and abrupt climate change in the recent geological past. It was triggered by an influx of freshwater into Hudson Bay which resulted in a slowdown of the Atlantic Ocean circulation, with climate responses seen globally. The event provides an insight into how regional climates may respond to a freshening of the north Atlantic in the future. This makes it important to constrain the extent, timing, duration and spatial fingerprint of this event.

In this study, we examined 60 high-resolution speleothem oxygen isotope records from the SISAL (Speleothem Isotopes Synthesis and Analysis) database. We used breakpoint analysis to identify when significant shifts in oxygen isotope values occur in each record during the period between 8,400 to 7,800 years BP. We calculated the magnitude of the change in the oxygen isotope signal, and the timing and duration of the event for each of the records where there was an excursion at ~8,200 years BP.

Forty-six records had a significant signal of the 8,200 year BP event. The changes in the isotopic signal were regionally coherent: European records consistently show negative anomalies, anomalies are positive in the Asian monsoon region, and negative anomalies are widespread in South America. The duration of the event ranges from ~ 92 to 197 years, with a mean across all the records of 146 years. This is comparable with Greenland ice core records, which show an event duration of 160.5 years. The overall start and end of the event across all records is 8,206 (+34, -71) and 8,063 (+42, -97) years BP respectively, similar to the timing of ~8,250 to 8,090 years BP in Greenland ice core records (Thomas et al., 2007). Overall, our results show that north Atlantic freshening resulted in a climate response that was transmitted rapidly across the globe. Regionally coherent signals suggest that there was large-scale reorganisation of climate systems during this event.

What can magnetic speleothems tell us about past floods? A 33 kyr long record from Waitomo, New Zealand

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Speleothems (especially stalagmites and flowstones) contain a rich record of information about climatic and hydrological processes, both inside and outside the cave environment. The geochemistry of speleothems has been intensively studied for many years to extract this information. Much less attention has been paid to the physical characteristics of speleothems, and in particular the allochthonous sediment contained within them. This sediment is transported to the speleothem by flooding of cave rivers and via overlying epikarst by dripwaters, and thus can provide information about the energy of hydrological processes in the cave environment.

Terrestrial sediment often contains magnetic iron-bearing minerals which can be detected, characterised, and quantified using sensitive magnetometers. Magnetic first-order reversal curves (FORCs) provide detailed information about the grain size distribution, mineralogy and concentration of even very small populations of nanometre- to micrometre-scale magnetic minerals. The magnetic properties of speleothems can thus be used as a proxy for terrestrial sediment (and therefore hydrological processes) with no need to extract the sediment itself.

We present a 33 kyr long record of magnetic properties from a flowstone from Waipuna Cave, Waitomo District, New Zealand, a key region for understand Pacific climate and El Niño—Southern Oscillation dynamics. The overlying soil is rich in magnetic mineral grains of volcanic origin, leading to an unusually high concentration of magnetic minerals in parts of the speleothem. There are two main magnetic populations: a population of nanoscale magnetite grains and a population of micron- to millimetre-scale magnetite grains. The latter are clearly visible on X-ray computed tomography scans, and, given their high density, their presence indicates very high energy hydrological processes, most likely floods. Our record indicates a period of increased hydrological activity from 33-16 ka BP, with flooding particularly prevalent around 20-25 ka BP, which coincides with the Last Glacial Maximum. This is followed by a period of reduced hydrological activity from 16-10 ka BP. Hydrological activity increases again from 10 ka BP to the present, and this period is characterised by numerous flood layers. This preliminary study is of relatively coarse temporal resolution (500-1,500 yr/sample), but future work will enable us to produce a high-resolution well-dated record of hydrological dynamics in this key region.

The implications of high fluorescein-like background fluorescence for dye tracer testing in the

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Fluorescein-like background fluorescence has been comprehensively characterised at three public water supply (PWS) abstractions and three surface water sites in the Lea Valley in preparation for a catchment-scale tracer test from a sinking stream near Essendon, south Hertfordshire. High levels of fluorescein-like background fluorescence (up to 3.22 ppb) across the catchment present a challenge to effective dye tracing in the catchment due to the significant reduction in measurement sensitivity. This challenge is compounded by the requirement to employ the precautionary principle when conducting dye tracer tests to PWS abstractions. This presentation will discuss the implications of high background fluorescence for dye tracer testing in the Lea Valley and present a testing methodology that should allow for safe dye tracing to PWS abstractions despite these constraints. It will also provide an overview of my PhD project investigating the influence of karst on PWS abstractions in the Chalk.

The role of inception horizons in the development of karstic conduits in the Chalk; implications for groundwater management and protection

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The Upper Cretaceous Chalk is the UK's largest and most important aquifer. Recent work in southern England, and in particular from boreholes and coastal sections along the south coast have highlighted the importance of karst in facilitating groundwater flow in the Chalk. This talk will discuss the development and extent of karst and in particular the role of inception horizons in the formation of dissolution conduits in the chalk. The implications for groundwater management and protection will be discussed.

Interpretations from a mid-late Holocene central Himalayan speleothem from northern India

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Seasonally resolved paleoclimatic reconstructions are particularly useful from regions of the world that have bi-modal rainfall patterns, such as NW South Asia where the Indian Summer Monsoon (ISM) and Indian Winter Monsoon (IWM) overlap. Such reconstructions are critical for time periods like the mid-late Holocene transition around 4.2 ka BP, when major human developments occurred during the growth and decline of the Indus Civilization (c. 5.0-3.6 ka BP). A new central Himalayan stalagmite record (DHAR-1) was analyzed at intra-annual resolution over 4.2-3.6 ka BP, with an age model precision of ± 18 years (2σ error). Samples were milled at 50 µm resolution for oxygen and carbon stable isotope analysis, and a multi-trace element record was generated along the same growth axis using LA-ICP-MS at 25 µm resolution (sub-annual resolution).

Oxygen, carbon, and calcium stable isotope trends, as well as trace element data, show a distinct 230-year-long period of increased drought frequency at c. 4.2 ka BP, with $\delta^{18}O$ over this interval suggesting a weakened ISM. The arid interval features 3 distinct 30-90-year-long extreme drought intervals, which is important when considering human decision-making time scales. The Indus Civilization had reached its urban apex with evidence of diverse communal cropping strategies, just as the duration of summer monsoon shortened and the amount of precipitation decreased in both rainy seasons.

Hydrological changes caused by sediment accumulation in sumps in the Peak-Speedwell cave system, Castleton, Derbyshire, UK

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One of the many remarkable aspects of the Peak-Speedwell cave system is the number of sumps, over 50 of which have been explored by cave divers. Many are static but the active sumps exert an important influence on the manner in which the cave system responds to storm events and hence on the discharge of the Castleton springs. In Peak Cavern there are periods when the input of water to the Halfway House Sump exceeds the capacity of the sump to transmit water and as a consequence water accumulates in the upstream Five Arches passage. During the largest events the whole of the Five Arches passage (c. 150m) fills to the roof and water rises up, and eventually overtops, the Devil's Staircase and cascades down through the tourist cave. Limited evidence from water depth loggers suggests that the frequency of these events has increased since the 1980s, possibly because sediment from upstream digs has accumulated in the Halfway House sump. In Speedwell Cavern, the Downstream Sump is similarly restricted and during flood events the sump extends upstream from its normal position by around 300m. As water backs up from the Downstream Sump it flows through the normally static Treasury Sump the surface of which is thought to rise by over 16m allowing water to enter Treasury Chamber in Peak Cavern. At the upstream ends of the Speedwell Cavern streamway all of the allogenic recharge from the Rushup Edge swallets, together with some autogenic recharge, enters Speedwell Cavern via two sumps, Main Rising and Whirlpool Rising, both of which have been explored by cave divers. The risings are 235m apart (all distances quoted are straight line, horizontal) and the elevation of Whirlpool Rising is about 10m higher than Main Rising. The phreatic conduits behind the risings extend upstream for over 1000m to Giants Hole, although only around 150m of this distance has been explored by divers. During 2021 there was a marked reduction in flow from Main Rising and a commensurate increase in flow from Whirlpool Rising which began to operate with a different periodicity. Pressure transducers to record water depth were deployed at both risings and in the Giant's Hole sump. The water depth at Main Rising was virtually constant but periods of pulsing were recorded at Whirlpool Rising that appear to be a function of depth increases at the Giant's Hole sump and are not related to outside weather conditions. It is hypothesised that this behaviour will only occur when the Main Rising sump is partially blocked by sediment.

POSTER PRESENTATION

Monitoring a Scottish cave for its sensitivity to North Atlantic Oscillation dynamics

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Boreal winter (December – March) climate variability in north- and southwestern Europe is strongly affected by the North Atlantic Oscillation (NAO). The atmospheric pressure systems over the Azores (Azores High) and Iceland (Iceland Low) are key drivers in NAO variability. A pronounced pressure difference between the Azores High and the Iceland Low brings warm air from the west and is referred to as positive NAO (Hurrell, 1995). This setting promotes mild, stormy, and wet winter conditions in Northern Europe and at the East Coast of the U.S., while northern Canada, Greenland, and southern Europe experience cold and dry winters. Negative NAO conditions yield the opposite, with northern Europe and the eastern U.S. experiencing cold and dry winters, while northern Canada and Greenland and southern Europe experience mild and wet winters. Understanding and predicting the NAO can help forecast extreme weather conditions in Europe and the US to prevent humanitarian and environmental crises.

Previous studies found that NAO variability is recorded in Scottish (Baker et al., 2015; Fuller et al., 2008; Roberts et al., 1998) and Moroccan speleothems (Wassenburg et al., 2013), Moroccan tree rings (Esper et al., 2007) and West Greenland ice core records (Olsen et al., 2012). These studies suggest that low growth rates, in both speleothems and tree rings, reflect positive NAO states and vice versa.

Here we present high resolution monitoring data comprising daily driprates, cave air temperature, cave air CO_2 and rainfall amount from Uamh an Tartair, a cave in northwestern Scotland. Two sets of dripwater samples have been analysed for stable isotope ratios (oxygen, carbon, and hydrogen) and are compared to previous studies from Baker et al. (2015), Fuller et al. (2008), and Proctor et al. (2000). Uamh an Tartair dripwater chemistry (mainly pCO_2), which controls limestone dissolution and calcite precipitation, is sensitive to the water level in the overlying peat (Baker et al., 2015). The speleothems from Uamh an Tartair reflect precipitation variability above the cave, with increased growth representing drier and negative NAO conditions and vice versa. The speleothem SU-96/7 used for comparison with our monitoring data reaches back 1000 years, with no apparent hiatus, and contains annual laminae that record NAO climate variability annually.

The scope of ongoing work is the implementation of a novel proxy to reconstruct palaeo-driprates, which will allow us to approximate past precipitation amount above the cave. We use a LA-ICP-MS based trace element record for the past 1000 years to calculate palaeo-driprates following Hartland & Zitoun (2018). These authors suggest that divalent transition metals like Ni^{2+}, Co^{2+}, Cu^{2+}, Zn^{2+}, which bind to organic ligands, can be used as a proxy for the residence time of dripwater (1/driprate), which in turn could yield palaeo-driprates.

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