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33rd BCRA Cave Science Symposium

hosted jointly with the Manchester Geological Association

Symposium – Saturday 08 October, 2022
[Field trip – Sunday 09 October, 2022]

Department of Earth and Environmental Science, University of Manchester, UK.

ABSTRACTS OF PAPERS

Controls on the distribution of cenote blue holes on Andros Island, North-west Great Bahama Bank

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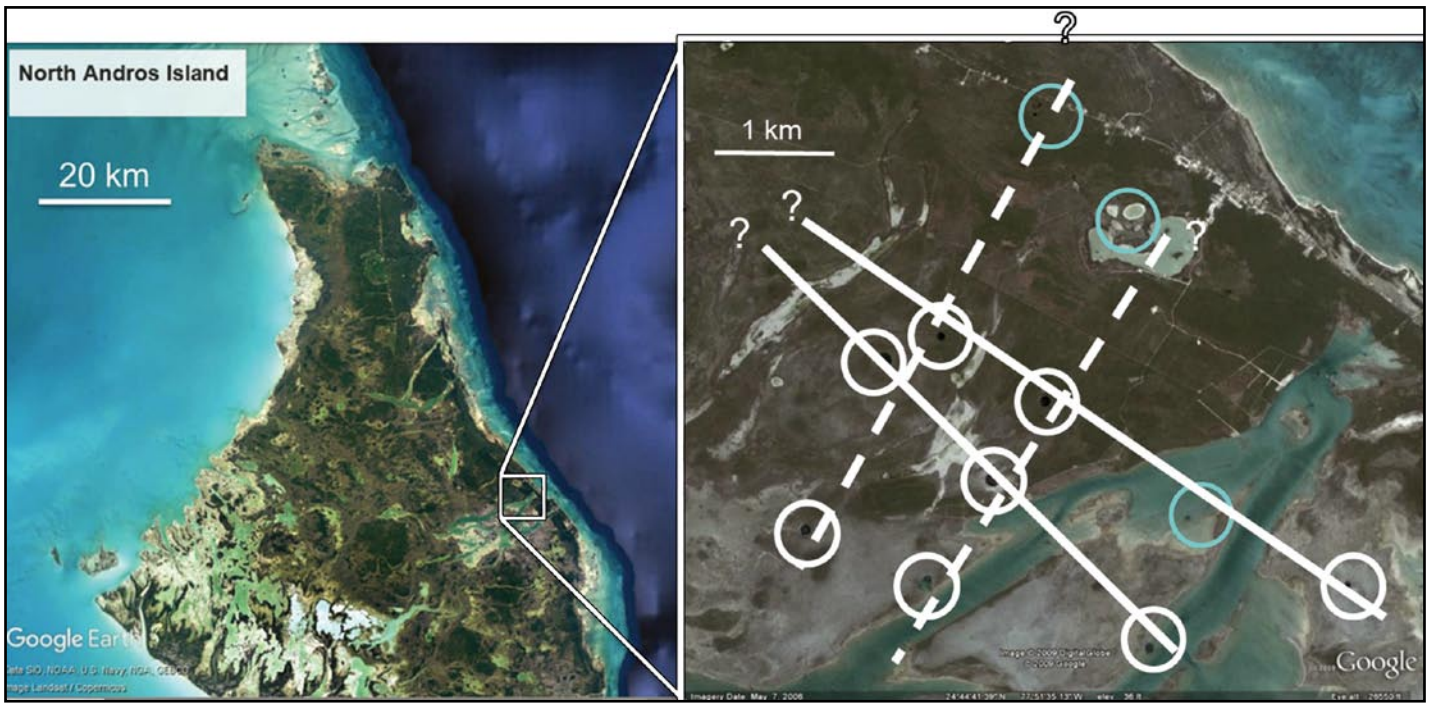
The Bahamas platform is widely recognised as the most stable continental block in the Caribbean. It is underlain by a series of normal and wrench faults, which are inherited from a late Jurassic rifting phase but presumed inactive since. These deep faults appear to control the geometry of the steep platform margins and deep-water re-entrants. At the surface and extending up 40km, major fracture systems occur parallel to the platform margins and show diagenetic alteration by circulating groundwater. Similar systems are described in ancient platform margins in the Canning Basin and Guadalupe Mountains.

Here we present a statistical analysis of the distribution of large scale karst features distributed across Andros island, which provides the first evidence for extensive fracturing up to 35km from the platform margin.

Some 177 circular collapses ("cenotes") were identified from satellite imagery. At the surface these features have a diameter of 105±60m, with the largest spanning 370m. Field survey shows they have a maximum depth of c.110m, with floors of collapse boulders and soft sediment suggesting active autochthonous infill. Underwater exploration of a subset of cenotes suggests they tend to increase in diameter with depth, possibly due to the effects of mixing-zone dissolution and associated collapse. Only a few of the smaller cenotes are known to connect with lateral cave passage, but this apparent absence may simply reflect dissolution, collapse, and infill of the larger features.

Perpendicular regression reveals the distribution of cenotes is significantly non-random, and identifies many lineations, defined by rows of up to 6 cenotes. The distribution suggests that cenote formation may be focussed at the intersections of lineations. Most lineations within 10km of the eastern bank margin are oriented parallel to this margin, with a subset perpendicular. However, further inland, the orientation of many lineations echoes that of the N60°W trending Sunniland (Bahamas) Fracture Zone, a long-lived transform feature related to Jurassic rifting, which extends across the Floridian Peninsula and crosses the Great Bahama Bank to the north of Andros Island. The vast majority (98%) of identified cenotes occur within 35km of the western bank margin. The absence of cenotes at greater distances from the margin may reflect increased infill by sediment generated on the shallow modern bank, or alternatively may be controlled by the location of the margin of the underlying Cretaceous Andros Bank.



Indian Summer Monsoon variability through the mid-to-late Holocene

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A stalagmite $\delta^{18}O$ record from the Syndai cave in Meghalaya in northeast India reveals high amplitude mid-to-late Holocene changes in the Indian summer monsoon (ISM) activity on a centennial timescale. Increased $\delta^{18}O$ during 4.6 to 4.1 ka BP points to a multi-centennial weak ISM activity, which is weakest at ~4.2 ka. Notably, this ~500-year-long cold and dry phase does not reveal abrupt hydroclimatic shifts. In contrast, a sharp decrease in ISM precipitation is observed at ~2.8 ka, ~2.4 ka, 2.2 ka, and 1.8 ka BP, whereas ~2.3 ka shows a period of increased ISM precipitation (decreased $\delta^{18}O$). These high magnitude changes in ISM activity are consistent with other established paleoclimatic records from the Northern Hemisphere. Consistent with the $\delta^{18}O$-inferred monsoon activity, the $\delta^{13}C$ time series reveals a sharp decline in vegetation ~2.8 ka and 2.2 ka BP and a corresponding increase at ~2.3 ka BP. The prominent climatic cycles retrieved from spectral analysis of the $\delta^{18}O$ time series reveal that the ISM variability during mid-to-late Holocene is coeval to the variations in solar insolation and/or ocean-atmosphere circulation pattern.

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Hypogenic cavern characterisation in Mississippian carbonates (UK)

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Hypogenic caverns typically comprise non-stratabound conduits (pipes) and complex maze systems that display a "morphologic suite of rising flow". They are thought to form from upward-flowing fluids, with dissolution attributable to fluid cooling, fluid mixing, changes in redox and/or pH due to injection of CO_2 or H_2S-rich water and pressure. However, despite an increasing number of studies of hypogenic caverns, they are still less well characterised than epigenic conduit systems that are formed by direct surface recharge. In part, this is because, commonly hypogenic caverns have no surface expression and hence their presence in the subsurface is often difficult to detect. Although their occurrence and distribution can significantly impact subsurface fluid-flow, prediction of this is far from straightforward.

Non-stratabound caverns of possible hypogenic origin intercepted within epigenic caverns and mines, and sometimes exhumed within outcrops, have been recognized in Mississippian carbonates on the Derbyshire Platform, northern England (UK). These caverns include: 1) open vertical and sub-vertical caverns; 2) partly mineralized and sediment-filled caverns; 3) calcite-lined caverns. Some of the calcite-lined caverns are associated with calcite veins. These often contain very coarsely crystalline calcite cement, with well-formed crystals commonly >5cm diameter, that represent the last cementation event on the platform.

This study aims to understand the relationships between cavern occurrence, morphology, size, location and geological context and the timing of cavern development to assess the degree to which hypogenic processes contributed to their formation. Fieldwork involves mapping the location, size and shape of the caverns, and their association with faults, stratal architecture, and rock type (e.g., limestone, dolomite). The geological and geochemical analysis carried out in this study, will then be used to constrain numerical models that aim better to understand processes of genesis and evolution of hypogene caverns.

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Geology and speleogenesis in the UK's longest cave formed in dolomite – Preliminary findings from new work in the Slaughter Cave System, Forest of Dean.

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Re-surveying and research has been underway in the Slaughter Cave System since late 2018. So far this has included water tracing, re-surveying of much of the 14km long Slaughter Stream Cave, geological observations, rock sampling and analysis, and photography.

Petrographical analysis performed at University of Manchester indicates that the cave is likely all formed in dolomite, but with a widely varying silica content and porosity. Passage plans, profiles and cross-sections are strongly influenced by stratigraphy and geological structure, including shelly and more porous horizons alternating with harder dolomite-rich layers, stylolites, wrench faults, fault breccias, iron-ore veins and some local changes in structural dip.

The re-surveying has given a clearer idea on active and relict passage elevations, morphology and genesis, with three main levels of development identified. Palaeo-water flow indications from wall scallops are uncommon, but nevertheless sufficient to define the main relict epigenic drainage routes and relate them to progressive down-cutting and lateral migration of 'base level' water table and springs in the nearby Wye Valley. In some remote parts of the cave more complex speleogenetic features are present, likely related to the combined effects of early hypogenic cave formation, iron mineralisation and later epigenesis. Some faults are seen to be recently dilated with dm-scale tectonic void rift spaces that seem to post-date much of the dissolutional cave formation.

Cave sediments include large volumes of quartz sand and allogenic sandstone pebbles together with boulder breakdown and rare cryogenic calcite, all of which point to a long cave history sometimes with permafrost and flash-flooding in peri-glacial environments. Calcite spelothems are rare, likely due to lack of permeability in a shaley cap-rock that is present above most of the cave. Manganese (?) and hydrated iron minerals coat many cave walls in the active streamway and are preferentially deposited over protruding coral and brachiopod fossils.

Much future multi-disciplinary work remains to be done before arriving at a comprehensive analysis and understanding in this fascinating major cave system, which has not received much scientific attention before. The scientific results from this unusual cave environment will also help reinforce the case for improved conservation and pollution avoidance in the active streamway, which is a significant on-going concern.

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The first record of cave-dwelling Opiliones from Iran

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Study on Opiliones in Iran dates back to the 19th century when Thorrell (1876) discovered two species from the country. After that, a few studies have slightly upgraded the information on the Iranian harvestmen fauna in a long period. Snegovaya *et al*. (2018) listed all records on Iran Opiliones including 22 species from four families, along with the description of one genus and two species. Perhaps, the most remarkable work is reporting the family Biantidae for the first from Iran and Palearctic. Recently, five further species have been added to the harvestmen fauna of the country from which two are new to science. They also reported the family Trogulidae for the first time from the country. Collectively, 28 species from six families including Biantidae, Dicranolasmatidae, Nemastomatidae, Phalangiidae, Sclerosomatidae and, Trogulidae have been reported from Iran territories so far. With at least 16 discovered species, Alborz Mountain Ranges have the richest harvestman diversity in Iran followed by the west and northwest parts of the country, along Zagros Mountain Ranges. There are no reports on Opiliones from other regions of Iran except one from central and three records from southern parts. From 6650 globally described species, more than 130 use caves as permanent or temporary habitats. Cavernicolous harvestmen exit the cave at night to forage and then return to the cave before dawn for a daily rest where they may themselves be preyed by other cave inhabitants. In Iran, harvestmen have been reported from various habitats including near human settlements at high elevations, bush-covered mountains, rocky arid plains and parks. Although no detailed description has been given about their habitats. The Hyrcanian vegetation zone is an 800km-long area which is surrounded by Caspian Sea from the north, and Alborz Mountain Ranges from the south. Alborz Mountain Ranges act as a barrier to trap the evaporations arising from the Caspian Sea above the Hyrcanian region, and the consequent humidity and rainfall make it a unique and rich ecosystem in terms of habitats, fauna and flora. There is no record of the observation of harvestmen in caves of Iran so far. In this study, we reported one species of Phalangiidae family from a cave for the first time from the country.

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The Descent: Geographical Information System (GIS) Mapping as a Method of Osteoarchaeological and Taphonomic Analysis of Early Neolithic Human Remains from Cave Burials in North-Western England

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Caves have long been recognized as an important aspect of Neolithic burial practice and our understanding around such practices has been supported by taphonomic analysis and re-analysis of original excavations. Almost two decades ago Leach (2006) did a comprehensive review of 21 assemblages from subterranean sites in Yorkshire, resulting in the re-dating of several burials to the Early Neolithic. Building on her work, this research aims to assess whether Geographic Information Systems (GIS) can be used as a tool for exploring taphonomy, currently under researched in human assemblages. Through our understanding of taphonomic patterns at an element, body and stratigraphic level, site specific inferences of burial practices can be constructed and patterns across cave burials assessed.

Two main sites were selected for analysis, Cave Ha 3 (Yorkshire) and Heaning Wood (Ulverston). Two further sites, Lesser Kelco and Sewell's Cave (Yorkshire), were brought in as supporting assemblages. Bone fragments were assessed for twelve taphonomic characteristics, split into 42 subcategories. The taphonomy was mapped onto anterior and posterior templates of bones in QGIS, creating visual representations of changes. Additionally, archive material was examined for spatial information relating to find locations. Cave Ha 3 offered the most comprehensive data and the taphonomy data was geographically referenced in QGIS. This provided stratigraphic distribution of changes. Tertiary excavations were conducted at Cave Ha 3 during July 2022, further improving mapping. Spatial data for Heaning Wood is less detailed and mapping is currently in progress.

Initial results suggest that QGIS can provide excellent visualisation of taphonomic modifications, regardless of whether a site has spatial legacy data. It has allowed analysis of intra and inter-body taphonomic changes. For sites that do have context data, QGIS provides a more traditional use, mapping where these modifications have occurred within the cave. This has implications for understanding original deposition, geological processes and the relationship between the buried bodies and cave.

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Stoned in Stonelands and Washed up in Wharfedale: Palaeoclimate and archaeological studies in the caves of Littondale and Wharfedale.

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The caves in the eastern valleys of the Yorkshire Dales karst have been subject to relatively little archaeological and scientific study in recent years. Such work, like cave exploration in the area, has been undertaken by a few dedicated individuals. Stonelands Cave, situated beneath the north eastern flank of Littondale, appears an obvious site for human use but no previous reference to any archaeological evidence from the site was known. Materials recovered from sedimentary deposits in the large entrance chamber produced evidence of Roman occupation. A study of speleothem deposits in the cave suggest the possible presence of an ice body within the cave during Late Pleistocene times.

Stonelands Cave, Littondale, entrance chamber. (Photo: D Hodgson.)

Archaeological materials recovered and preserved by the local caving community during the 1960s have been accessed as part of this study and radiometric dating of such materials has provided further supporting evidence of a breeding population of bears in the area during lateglacial times and evidence of flooding in now dry surface features during the Roman occupation.

This study shows that the area is a potential treasure trove for future cave archaeological and palaeoclimate studies and illustrates the importance of cultivating relationships with the caving community. The work was undertaken in partnership with David Hodgson, a leading figure in karst science in the area and a true Dalesman, who sadly passed away during 2021. The project was funded by a grant from the BCRA Cave Science and Technology Research Initiative.

Related reading

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Derbyshire Mine Biofilms – Snottites, Slime and Oozes

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Jelly-like pendulous ‘snottites’, gelatinous oozes and mucoidal slimes, while sounding like something from a low-budget alien horror film, are descriptions of some of the biofilms found in Derbyshire mine environments.

We have studied three soughs that drain former lead mines in Derbyshire, through collection of samples of the biofilms present. Within the project we have analysed the bacterial composition of these samples using metagenomic analyses and 16S rDNA sequencing coupled with analysis of the water chemistry to understand the relationship between the environment and biofilms present. Cultivation techniques have also been employed to try to isolate individual organisms to study their role within the environment. The results obtained to date provide an insight into the metabolic pathways and processes occurring in these biofilms, including sulphur cycling and iron oxidation.

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Spatial variability of limestone permeability in the Dow Low area, Buxton, Derbyshire

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As part of hydrogeological investigations at Dowlow Quarry, Buxton, Derbyshire, groundwater tracing experiments using sodium fluorescein dye were undertaken from three locations: Borehole H2 in the quarry and two dolines, DOL1 to the north and DOL6 to the northeast. There were two injections into H2, one using 3.68kg and a second using 24kg. In both experiments dye was flushed in using a bowser. Springs and soughs (lead mine drainage levels) at distances ranging from 0.9km to 25.35km from the site were monitored for 215 days but no tracer was recovered. Spot samples collected from H2 over a period of 1163 days following tracer injection all contained dye demonstrating a low rock permeability. In contrast, dye injected into DOL1 was detected at four spatially separated sites demonstrating divergent flow. Based on the first dye emergence at the closest monitored spring the velocity was >2600 m/d and the velocity towards the most distant recovery point was 550–1250 m/d. Two tracer tests were undertaken at DOL6, one under low groundwater elevations and a second at higher elevations. During the first experiment there was a slight increase in dye concentrations in borehole H2 (velocity 90m/d) and poor dye recovery from a single spring, the tracer having moved at a velocity of 60–80m/d. In contrast, the second experiment demonstrated that there is divergent flow and that DOL6 is in the groundwater catchments of two rivers. The velocity towards the spring where tracer emerged under low groundwater conditions was 165m/d and the velocity towards a spring in a different drainage basin was 490m/d. Dye was also recovered from a monitoring borehole in the quarry (velocity 190m/d) and from a more distant spring (velocity 75–90m/d). These results demonstrate the marked heterogeneity of limestone permeability and the importance of repeated groundwater tracing experiments under different groundwater elevations.

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