Quantifying Holocene relative sea-level changes and paleoclimate using the Scottish speleothem record

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Speleothems, secondary cave carbonates, are valuable archives for reconstructing paleoclimate and relative sea-level changes where the caves are in coastal locations. Unlike the typical speleothems found in carbonate caves, speleothems were recently discovered in a meta-silicate sea cave in Iona, on the west coast of Scotland. Although speleothems have previously been reported from caves in volcanic rocks, speleothems in metamorphic caves have rarely been reported. The Iona speleothems are potentially crucial because paleoclimate reconstructions spanning the Holocene are scarce in Scotland due to a lack of material, particularly speleothems, which can be dated precisely using geochemical dating methods. In this research, the U-Th and ^{14}C dating techniques will be used to constrain the precise age and growth history of the Iona speleothem. Results from pilot U-Th dating of the first speleothem sampled show it is about 1760 ~ 4780 years old (the data, however, have uncertainties up to 69.9%, due to the presence of non-authigenic Th). As for paleoclimate, oxygen isotopes indicate that the amount of precipitation was at a relatively low level between 3000 and 2000 years ago, then increased dramatically from ~2000 to 1760 years ago. These preliminary data indicate that the Iona speleothem has the potential to provide important insights into the Late Holocene relative sea-level changes and climate.

Stratigraphy, Dating and Palaeoclimatic Reconstruction of the Gondolin and Kromdraai Hominin Sites, South Africa

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University of Cape Town

Gondolin and Kromdraai are the only two Paranthropus robustus fossiliferous sites in the Cradle of Humankind that remain undated. The aim of the project is to determine a robust chronology using U-Pb dating of interbedded flowstones to build a more complete picture of their development through time, compare fossils collected in South Africa to those in eastern Africa and see how individual palaeobiogeographies were and what these effects had on the life evolution of Paranthropus in the regions.

Hydroclimate Variability of the Northern Caribbean during the Last Deglaciation: A High-Resolution Stalagmite Study

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We investigate Caribbean hydroclimate variability during the last deglaciation with a stalagmite (called OS) from western Cuba. The $\delta^{18}O$ & $\delta^{13}C$ isotope records from OS cover 14.3 to 17.6 ka BP, providing insights into hydroclimate dynamics during Heinrich 1 (H1) & the B/A interstadial. The high-resolution (1-7 yrs) OS records reveal dominant interdecadal, decadal, & multidecadal periodicities related to ENSO, NAO, and AMV. On millennial timescales, low OS growth rates during H1 are followed by a ten-fold increase at the B/A. OS $\delta^{18}O$ & $\delta^{13}C$ records likely reflect changes in past precipitation through the amount effect, & correlate well with nearby speleothem records & tropical Atlantic SSTs. We propose that SSTs are the key driver of millennial precipitation in Cuba during this interval via modulating tropical convective activity.

Stalagmite U/Th dating attempts and biocorrosion implication

Imen Arfaoui

Royal museum for central Africa / Liege University

Paleoclimate proxies recorded within speleothems, offer invaluable insights into past climate through the incorporation of various trace elements and changes in stable isotopic composition over time. These proxies reflect changes in temperature, precipitation, and other local environmental factors. Central African speleothems are poorly studied. First dating attempts on these formations have shown high contamination of detrital Thorium (Th). First observations, such as a high porosity and black traces in the studied speleothems, suggest corrosive effects of bat guano. Consequently, this research is focused on investigating this relationship in the Congo area, by observing the effects of bat guano corrosion together with the elaboration of cave climate and environment monitoring. To enhance the understanding in this area, it would be highly beneficial to initiate the process by inventorying the biocorrosion features present in the studied caves. Subsequently, coupling this inventory with geochemical analysis applied to the drip water from monitoring stations would provide valuable insights into the underlying processes. The Karst system in Kongo-Central is formed within carbonate rocks, which are part of the Neoproterozoic Schisto-calcaire subgroup. It stretches, with a distance over 1400km, from southwest Gabon to northwest Angola, traversing the Democratic Republic of the Congo (DRC) and the Republic of the Congo (RC) from NW to SE, covering nearly 500 km with a width that can reach up to 180 km. The layers of this system predominantly maintain a sub-horizontal orientation. Remarkably, the cumulative thickness of the carbonate rocks can exceed 1000 m, making it a significant and fascinating geological feature in the region. The research started with comprehensive investigation of the cave deposits and stalagmites within the caves under study. Although the dating results have not been entirely precise, the ongoing investigations are currently shedding light on the deposits, with special emphasis on the guano found in the majority of the surveyed sites. To collect crucial data, a seasonally based cave-monitoring approach is adopted, involving the collection of drip samples during both humid and dry seasons, with two to three samples per season. Additionally, continuous temperature recordings and in-situ parameter measurements are taken during each sampling time to capture a comprehensive view of environmental conditions within the caves. Nine samples collected from three stalagmites sampled, originated from both sides of Congo River in the karst area, underwent U-series dating. The obtained results proved to be unusable due to the exceedingly low Thorium (Th) content in the stalagmites. This remarkably low Th concentration contributed to increased errors in age estimation. The presence of Thorium 230 (^{230}Th) at the outset could be attributed to the influence of detrital material or an open geochemical system, possibly linked to the biocorrosion caused by bat guano within the caves and leading to the overestimation of ages. During the last field trip in the DRC, remarkable observations of cave morphology in the neighbouring regions were illustrated. The intriguing biocorrosion features caused by bat guano within the caves were illustrated, as evidenced by the following figures. Notably, Biological Cupolas, guano-holes in the ground, and bell holes in the roof, which bear striking resemblance to similar features observed in other parts of the world, such as France and Slovakia. These observed elements have sparked reflections on their significance in the late morphological evolution of caves. The presence of such biocorrosion prompts to consider their potential impact on cave development and the formation of unique cave structures. Understanding the role of bat guano in shaping the caves; morphology could shed light on the broader processes influencing cave evolution in various geographical contexts. To deepen the understanding in this field, conducting an investigation into the potential of DRC and RC speleothems as paleoclimatic archives would be immensely valuable. This would enable a detailed study of their petrographic characteristics, aiding in the identification of hiatus layers resulting from the biocorrosion process, while testing for dating possibilities

Improving bipolar ice-core chronologies around the Heinrich Stadial 2

Xiyu Dong

Xi'an Jiaotong University

We present a speleothem oxygen-isotope record from Cherrapunji cave, northeast India in the Asian monsoon domain at sub-centennial precision, covering the Heinrich stadial 2—a cold period that occurred at around 24, 000 years ago. The high-resolution and precisely-dated Cherrapunji record was used to tune Greenland and Antarctic ice-core chronologies around this interval on the basis of causal links between the AM, Greenland dust flux, and volcanic spikes, which is also supported by extant volcanic evidence and radiocarbon ages.

Dedolomite complex in Mravljetovo brezno v Gošarjevih rupah cave, central Slovenia

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The Mravljetovo brezno v Gošarjevih rupah is a cave located in an isolated karst area in central Slovenia and was formed in Middle Triassic dolostone (Anisian), which is part of a mixed carbonate-siliclastic succession that extends from the Middle Permian to the Middle Triassic. The regional structural setting, including N–S directed faults and 30°S dipping bedding combined with multiphase speleogenetic processes, which resulted in a complex, maze-like cave morphology. In addition to common morphological wall rock features, such as ceiling channels, cupolas, solution pockets, pendants, and anastomoses, some condensation corrosion features are also present, as well as siliciclastic sediments and speleothems. Among the most distinctive cave features are the yellow and red lithologies that cover much of the cave walls and fill some cave spaces. Yellow lithologies are usually found on the floor in the center of cave rooms or forming bridges that connect opposite walls of cave channels. They appear stratified, and some of them have laminitic textures with alternating dark and light laminae. Microscopically, they are composed mainly of microsparite with a small amount of quartz and clay minerals. The red lithology is in direct contact with the cave wall rock. Microscopically, it consists of calcite crystals in the form of relatively coarse grained xenotopic to locally hypidiotopic mosaic calcite, pseudospherulitic fibrous calcite, cone-like fibrous calcite, fibrous palisade calcite and brownish micritic calcite with or without a mesh of needle-fibre crystals, etched patches, or individual crystals of coarser grained calcite mosaic. The yellow and red color derives from the presence of intercrystalline iron hydrooxides. At the contact between red lithotype and dolostone wall rock, cavities with calcite box-work and spar calcite are formed. The few outer centimeters of the dolostone wall rock has a bleached appearance that under the microscope consists of a mosaic of calcite crystals with rhombic dolomite relics. Although the exact relationship between the different lithologies and the dolostone are still unclear, it is evident that these textures were caused by dedolomitization. The source of this material and the possible causes of dedolomitization are still being investigated.

Paleotemperature Reconstruction by Fluid Inclusion Microthermometry in Speleothems - Tropical West Pacific Land Temperature Change over Termination II

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University of Bergen

Fluid inclusion microthermometry is applied to a well-dated stalagmite covering 150 to 110 ka from northern Borneo to yield paleotemperature data. The result shows a clear temperature trend from MIS 6 to MIS 5d.

Geochemical monitoring of speleothems and drips in Lapa da Onça – Peruaçu River Valley

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UFF Universidade Federal Fluminense

This study was carried out through hydrogeochemical monitoring in Lapa da Onça, located in the Cavernas do Peruaçu National Park, where five monitoring points were installed. Monitoring takes place on a monthly basis through the collection of environmental data, dripping water and measurement of the dripping rate of stalactites, and the collection of carbonate precipitation material on watch glasses, which simulate stalagmites, installed at each monitored point. The environmental parameters analyzed are temperature, humidity and carbon dioxide saturation to understand their control over isotopic fractionation and geochemical deposition of carbonate in the cave stalagmites. As a result, it was possible to observe that the hydrogeochemical data and the growth of the speleothems of Lapa da Onça are associated with the hydrological regime and evaporation conditions inside the cave.

The spatio-temporal extent of the Green Sahara during the Last Glacial Period and implication for human dispersal: New insights from NW Africa

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The Sahara Desert, one of today's most inhospitable environments, has known periods of enhanced precipitation that supported pre-historic humans. However, the Green Sahara timing and moisture sources are not well-known due to limited paleoclimate information. Here, we present a multi-proxy ($\delta^{18}O$, $\delta^{13}C$, $\Delta^{17}O$, and trace elements) speleothem-based climate record from NW Africa. Our data document two Green Sahara periods during MIS5a and the Early to Mid-Holocene. Consistency with paleoclimate records across North Africa highlights the east-west geographical extent of the Green Sahara, whereas millennial-scale North Atlantic cooling (Heinrich) events consistently resulted in drier conditions. We demonstrate that an increase in westerly-originating winter precipitation during MIS5a resulted in favorable environmental conditions. The comparison of paleoclimate data with local archaeological sequences highlights the abrupt climate deterioration and the decline in human density (Aterians) in NW Africa during the MIS5-4 transition, which suggests climate-forced dispersals of populations, with possible implications for pathways into Eurasia.

Magnetic Anisotropy for Obtaining Relative Paleointensity in Speleothems

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Speleothems have been increasingly used in studies of the geomagnetic field in the past due to their advantages when compared to other records. The project's objective is evaluate the relationship between magnetization acquisition and vs applied field. We precipitate artificial speleothems by varying the precipitation velocity, sediment content, and field intensity. The results obtained include AF demagnetization curves, anesthetic remanent magnetization (ARM), and magnetic susceptibility anisotropy (ASM).

Spatio-temporal variation of stalagmite records of Heinrich events in the East Asian monsoon region during the last glacial

Miaomiao Wang

Xi'an Jiaotong University

Stalagmite records are mostly concentrated in southwestern and central northern regions of China, and there are few records from the southeastern region during the last glacial period. This limitation hinders our comprehensive understanding of the spatiotemporal changes in monsoon rainfall and climatic abrupt events in East Asia. This study focused on analyzing a stalagmite (YXG01) from the Yindi Cave in Huangshi, Hubei province, China. The stalagmite was analyzed using high-precision U-Th dating and carbon-oxygen isotope analysis to reconstruct climatic changes during the last glacial, particularly the occurrence of Heinrich events. The results showed that YXG01 recorded H1, H2, H3, and H4 events over the period of 11.92-47.47 ka. The $\delta^{18}O$ and $\delta^{13}C$ values of the stalagmite exhibited anti-correlation during each Heinrich event. The δ18O values ranged from -7.17‰ to -2.55 ‰, with an overall amplitude of 5.38 ‰ and an average value of -5.24 ‰. The $\delta^{13}C$ values ranged from -8.81‰ to 2.47‰, with an overall amplitude of 11.28 ‰ and an average value of -1.62 ‰. Comparison of this study's results with stalagmite records from other regions in China showed similar Heinrich event patterns. Future research could incorporate more stalagmite records to further characterize the spatial distribution of Heinrich events.

A Late Holocene climatic record for the Southwestern USA based on perennial cave ice

Laura Calabrò

University of South Florida

I present the results of a paleoclimate study based on ice deposits accumulated within lava tubes in El Malpais National Monument (New Mexico). The ice cores span from 7000 to 1000 cal yr BP. The $\delta^{18}O$ values are influenced by the composition of summer and winter precipitation which can be affected by the source of precipitation (Gulf of Mexico versus Pacific). The isotopic signal transferred from the atmosphere into the cave ice enables us to trace what main climatic systems affected its accumulation. The wide oscillation of this proxy suggests that several large-scale atmospheric circulation patterns influence the region (e.g. ENSO, the Pacific/North American pattern, ITCZ location, and the North American Monsoon).

Speleothem-derived insights into hydroclimate changes over India over the past 500 years

Aniket Dhar

University of Arizona

A new stable oxygen and carbon isotope ($\delta^{18}O$ and $\delta^{13}C$) record spanning the last 500 years is generated using a flowtone speleothem from Yadiki Cave in Andhra Pradesh, India, located in the semi-arid rain shadow region of the Western Ghats. The record exhibits significantly more negative mean and modern $\delta^{18}O$ values compared to modern samples in Akkalagavi cave, located in some of the wettest parts of southern India. Despite this difference, both caves exhibit similar geochemical trends over the past 500 years, suggesting that regional hydroclimate variability over southern India was superimposed over mean $\delta^{18}O$ values that may be explained by continental rainout and moisture recycling.

Dual pathways of aragonite-to-calcite transformation in stalagmites: implications for paleoclimate reconstructions

Rui Zhang

Xi'an Jiaotong University

Multiple geochemical proxies in speleothem are crucial for reconstructing paleoclimate, but the impact of diagenesis on these proxies, including ^{230}Th ages, trace element ratios, δ^{18}O and δ^{13}C, is not well-established. In this study, in order to analyze the aragonite to calcite transformation and its effects on ^{230}Th ages and geochemical proxies, we investigate the petrography and geochemical composition of six aragonite-calcite stalagmites from Shennong Cave in southeastern China. We find two different types of secondary calcite (mosaic and columnar calcite) with various changes in geochemical proxies and ^{230}Th ages comparing with the primary aragonite. The stable isotope compositions (δ^{18}O and δ^{13}C) and trace element ratios (Mg/Ca, Sr/Ca and Ba/Ca) in mosaic secondary calcite have been investigated in Zhang et al. (2014) and He et al. (2021), here we further study these proxies in secondary columnar calcite and U concentration and ^{230}Th age in both mosaic and columnar calcite. We found that different from little change in δ^{13}C, U concentration and trace elements in mosaic secondary calcite there are significant changes in δ^{13}C and δ^{18}O, trace element ratios and U content in secondary columnar calcite. However, the ^{230}Th age of secondary mosaic calcite significantly changes, the ^{230}Th age of secondary columnar calcite is similar to that of primary aragonite, and the ages of secondary calcite in the same layer are repeatable. We suggest that degassing and flow state of the solution involved in transformation may affect the geochemical proxies and ^{230}Th age of secondary calcite. Flowing solution can reduce the contents of Sr, Ba, and U in calcite while Mg in the solution is absorbed by calcite. Moreover, insufficiently degassed solutions can chemically dissolve calcite more thoroughly, resulting in significant carbon isotope fractionation. However, reduced flow and sufficient degassing alter transformation results significantly. Different changes in U concentration of mosaic and columnar calcite are related to two different diagenetic pathways, resulting in different changes in ^{230}Th ages. The ^{230}Th ages of secondary columnar calcite suggest that the transformation to secondary calcite may occur soon after crystallization of primary aragonite. Our study provides crucial insights into the impact of diagenesis on speleothem geochemical proxies, emphasizing the significance of distinguishing between mosaic and columnar calcite for precise paleoclimate reconstructions.

Indian summer monsoon variability in the core Indian monsoon zone and its teleconnection with the solar activity during mid-Holocene.

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We have generated a high resolution (sub-decadal) ^{230}Th absolute dated record of a stalagmite from Mahadev cave, capturing the Indian summer monsoon (ISM) variability during ~ 7894 to 4728 yr BP, encompassing the mid-Holocene period. Mahadev cave is a part of the karsts system in the Jagdalpur region of Chhattisgarh in Central India, which falls under the core monsoon zone (CMZ). The δ^{18}O record from a 36 cm long stalagmite sample (sub-sampled at 0.5mm) documents sub-decadal to decadal and even centennial-scale variability in ISM. We compared the δ^{18}O records of Mahadev cave stalagmite with published δ^{18}O data of stalagmites of other caves from the ISM and East Asian monsoon (EAM) region. All records show a steady decile in rainfall intensity from ~8000 yr BP to 4700 yr BP associated with sub-decadal to centennial-scale high amplitude variations. The spectral analysis of the δ^{18}O time series data from Mahadev cave reveals several cyclicities of decadal (~10.5 to 12 years, ~18 to 20 years, ~30 to 40 years), centennial (~107 to 118 years) and millennial (~ 1580 years) scale. The decadal and centennial-scale oscillations are interpreted as different sunspots or solar cycles, and the millennial-scale cycle is depicted as a Bond cycle. The cyclicity at around 10.5 to 12 years is indicated

as Schwabe solar cycle (~ 11 years); the cyclicity at around 18 to 20 years is indicated as the Hale solar cycle (~ 22 years); the cyclicity at around 30 to 40 years is demarcated as Brucker solar cycle (~ 35 years) and the cyclicity at around 110 years is interpreted as Gleissberg solar cycle (~ 100 years). The solar influence on the rainfall pattern in the CMZ is also confirmed by the excellent correlation between the $\delta^{18}O$ time series data from Mahadev cave and data depicting solar activity (e.g., sunspot number, radiocarbon production rate in the atmosphere) during the mid-Holocene. The $\delta^{18}O$ data of stalagmite from Mahadev cave covers two bond events (Bond 4 and Bond 5), which are cold and dry events during the Holocene. Our data, as well as all the other speleothem records from the South Asian monsoon system, mark a significant change in rainfall pattern, which becomes lesser during the Bond 4 events. However, during the Bond 5 events, there is no imprint of the weakening of ISM and EAM documented by the given records. We will be refining our results and try to find out the complex driving mechanisms.

Understanding kinetic fractionation of cave carbonates in North-East India

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Clumped-isotope (Δ47) values are sensitive recorders of kinetic or disequilibrium effects[1], making it an ideal proxy to understand the dynamics of carbonate precipitation in cave settings. In this study, we analyse Δ47 from fresh carbonate precipitates from caves of Meghalaya situated in North-East India. The state of Meghalaya is endowed with a vast repository of karst formations, with more than 1500 caves. Abundant records of speleothem have been reported from this area to understand past climate, especially that of the Indian Summer Monsoon (ISM), its rainfall is derived from the moisture transported from the Bay of Bengal branch. Numerous records of speleothems from this area have been used to report past ISM variability[2,3,4,5]. Active speleothem from 4 caves- Mawsmai, Arwah, Mawmluh and Syndai were analysed, which yielded a range of Δ47 values from 0.611 ‰ – 0.745 ‰. The large variation in Δ47 values particularly relates to the distance of the site of speleothem collection from the entrance of the cave. The average $\delta^{18}O$ of carbonate from each cave is -5.084 ‰, -5.761 ‰, -6.599 ‰ and -7.059 ‰ respectively. The $\delta^{18}O$ of carbonate within the samples of the same cave does not vary much but differences in $\delta^{13}C$ values within the same cave are observed. This study hints at the importance of indulging in the factors responsible for kinetic isotopic fractionation affecting the Δ47 and hence of using this proxy while interpreting speleothem records.

Exploring a new Central European site of paleoclimate reconstruction: First results from Erdmannshöhle (Southern Germany)

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We present cave monitoring and speleothem results from Erdmannshöhle, Southern Germany. Monitoring of cave air and drip water is ongoing and started in August 2022. Drip water is collected bi-monthly from three chambers. Cave air and humidity are constant throughout the year with a strong seasonal CO_2 ventilation pattern favouring speleothem growth during winter. Moreover, we present precise 230Th/U ages, petrography, and proxy data from several speleothems. In sum, Erdmannshöhle has excellent preconditions for the continuous reconstruction of past Central European climate.

Multi-paleothermometer reconstruction on a northern California speleothem using fluid inclusions and dual clumped isotopes.

Kesego P. Letshele, Yuval Burstyn, Cameroon B. de Wet, Isabel P. Montanez

Department of Earth and Planetary Sciences, University of California Davis

Investigating high-resolution palaeoclimate variability in South Central Europe by using speleothem record from Nova Grgosova cave, Croatia

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Croatian Geological Survey

Global climate models accentuate the Mediterranean region as a climate change hotspot, warming faster than the global average. Due to the need for more accurate predictions on climate change and atmospheric circulation, a comprehensive database of palaeoclimate records is necessary. High-resolution, well dated records from climate change sensitive regions are of particular importance. In this study we investigate the link between geochemical properties of speleothems from Nova Grgosova cave in Croatia and the North Atlantic Oscillation (NAO), a major mode of internal climate variability in the wider North Atlantic region. Preliminary research showed that the speleothems at this cave site are relatively fast-growing and the laminas are likely of seasonal to annual origin. The main goal of this study is to develop high-resolution stable isotope speleothem record aiming to provide more accurate information on atmospheric processes and circulation patterns related to internal modes of climate variability in the late Holocene. Here we present preliminary results of stable isotope analysis performed on a stalagmite sample NG2, micromilled on a 100 µm resolution covering the last ~150 years. Considering that the speleothem isotopic composition is responsive to different processes acting in the atmosphere, soil, epikarst and within the cave itself, we aim to further investigate major drivers of the oxygen isotopic composition in speleothems at our study site. For this purpose, a long-term cave monitoring program was established in 2022 and here we will present some preliminary results.

Hydrogeological Characterization of a High-Discharge Coastal Freshwater Karst Spring System

Maria Jhonnie Villareal

University of Guam

Studies of coastal discharge provide hydrogeologists with important clues and insights into the internal plumbing of aquifers. This study employed remote sensing techniques, field survey and cave mapping to characterize - Ayuyu Cave (65-m-long x 3486 -m3-volume) – a coastal cave discharging the singularly highest-volume concentrated spring flow on the northwest coast of Guam and its relationship to prominent geologic (e.g., Pugua Fault) and geomorphic features of the interior area containing its catchment. Presented here are new insights into the structural characteristics of the Pugua Fault Zone, as interpreted from LiDAR data, which have significant implications to the surface hydrology of the study area. Pugua fault was originally interpreted as a classic normal fault, but analyses of LiDAR show feature diagnostic of strike-slip fault. Brecciated zones observed in the cave are consistent with the regional structural deformation that is characteristic of strike-slip displacement. The complex morphology of Ayuyu Cave is a testament to its complex history which reflects the many cycles of Pleistocene eustatic sea-level fluctuation, contemporaneous with episodes of tectonic uplift and subsidence of unknown timing and magnitude. Features characteristic of vadose, phreatic, breakdown, and flank margin caves are overprinted such that the sequence and timing of events cannot be discerned.

Sedimentary deposits in Karstic cave (Cova Dets Ases, Mallorca, W-Mediterranean): Mineralogical and sedimentological characterization of the Clay-rich fraction

Ana Entrena, University of the Balearic Islands

The Ases cave is part of a large group of coastal caves developed in the Miocene materials of the island of Mallorca. Most of these caves present a good development of speleothems in their interior that have been studied for decades. However, the sedimentary deposits inside of these caves have not yet been examined in depth. Therefore, this work focuses on the characterization of these deposits in order to determine their origin. For this purpose, representative samples were taken and analyzed from almost the entire cavity. The samples were analyzed for grain size and mineralogy, including X-ray diffraction (XRD) in whole sample and XRD and scanning electron microscopy (SEM) in the clay fraction. The general mineralogy consists of calcite, quartz and clay minerals, with minor proportions of dolomite, albite, orthoclase, hematite and goethite. The mineralogy of the clay fraction comprises illitic phases, kaolinite, smectite and chlorite. The information extracted from the grain size and SEM indicate the presence of three general processes (bedrock degradation, creep or saltation and suspension) and two origins for these deposits (authigenic and detrital). This differentiation has made possible to separate between: (1) Autochthonous deposits: principally related to bedrock degradation and located on the floor of chambers and corridors in subaqueous zones; (2) Allochthonous deposits: related to creep or saltation and suspension processes and filling voids on the walls and the ceiling in the terrestrial zone of the cave. The first group reflects the stability over the time of the mixing zone of the pool waters inside of the cave and, therefore, the stability of the sea level. The second group evidences the material backfilling and subsequent emptying the cavity in presence of water (wet periods). This work evidences the importance of studying this type of sedimentary deposits inside the caves, since they may provide paleoenvironmental information and contribute to a more complete understanding of the evolution of the caves.

Atlantic ITCZ variability during the Holocene based on high-resolution speleothem isotope records from northern Venezuela

Melissa M. Medina, Universidade de São Paulo

Few high-resolution paleoclimate proxy records exist in the region located under the direct influence of the Intertropical Convergence Zone (ITCZ) in South America and most of them were retrieved from the Cariaco Basin off the coast of Venezuela. Here we present new $\delta^{18}O$ and $\delta^{13}C$ records of Venezuelan speleothems collected in caves adjacent to Cariaco, covering the mid- and late-Holocene. We document previously undetected secular-to multidecadal-scale climate variability in the core region of the ITCZ, which is compared to other high-resolution records from the North Atlantic, Caribbean, and tropical South America. Over the mid-Holocene our record exhibits broad swings between periods of reduced (8.3-8.0, 6.5-5.0, 4.1-3.6 ka BP) and increased (8.5, 8.0-6.5, 4.9-4.2 ka BP) rainfall. In particular, between 5.5 and 5.0 ka BP, increases in polar and subpolar North Atlantic ice rafted debris and a reduction in North Atlantic Deep Water (NADW) formation might have contributed to the southward displacement of the North Atlantic Subtropical High (NASH) and the ITCZ, which led to severe dry conditions in north central Venezuela and an enhancement of the South American Monsoon System (SAMS). During the late-Holocene, contrary to data from Cariaco reported in previous studies, our results point to drier conditions during the Medieval Climate Anomaly (MCA, 900-1100 CE), which were further amplified during positive Atlantic Multidecadal Oscillation (AMO) phases. Wet conditions, however, prevailed during the first part of the Little Ice Age (LIA, 1400- 1500 CE). No speleothem deposition occurred during the main LIA period, which might be related to drier conditions in response to a southward displacement of the ITCZ that led to major moisture convergence over the SASM domain. Our new records from Venezuela provide a reliable proxy for ITCZ behavior over the Atlantic - South America domain and document past dynamics in relation to other climate systems (NASH and SAMS), while providing new evidence of ITCZ-North Atlantic teleconnections during the Holocene.

Precise determination of the timing and duration of Dansgaard-Oeschger events in Central Europe

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The last glacial period and especially Marine Isotope stage 3 (MIS 3, 57 – 27 ka) was characterized by various climate oscillations (i.e., rapid increases in temperature, followed by a gradual cooling, the Dansgaard-Oeschger (D/O) events). Although their causes are still not fully understood, clear evidence for their supra-regional character was found in various climate records around the globe. However, European speleothem samples, which grew during MIS 3, are limited and mainly restricted to alpine regions and to south/south-western parts of Europe characterised by a generally warmer climate. This led to the opinion that it was too cold and/or too dry in Central Europe to enable speleothem growth and the precise timing and extend of D/O events in Central Europe remained more or less unclear. Here we present three speleothems from Bleßberg Cave, Germany, which grew during MIS 3. By using a combination of various sampling approaches (handheld drilling, MicroMill drilling and Laser ablation) for the U/Th dating method we were able to precisely determine various D/O events for Central Europe.

Hyperspectral Imaging of Stalagmite - A case study of Anjokipoty Cave, NW Madagascar

Ali Raza

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Stalagmites contain a significant record of paleoclimate information because of numerous proxies preserved in their chemistry and their precise chronologies. They complement information from regions, where other climate archives, such as ice cores and deep-sea sediment cores, are rare or absent. Many studies have used mineralogy, laminations, and petrography of stalagmites to understand long-term climate change. In this research, we used hyperspectral imaging (HSI) that is a non-destructive technique to identify mineralogical composition, organic matter content, and laminations. HSI analyses of a stalagmite collected from Anjokipoty Cave, NW Madagascar, is the first high-resolution spectral analysis study using Visible-Near infrared (VNIR) and Short-wave Infrared wavelengths (SWIR) (400-2500 nm). Different false color composites using red-green-blue combinations have been used to better visualize laminations. We then used these variations to assess the stalagmite's chemical composition and mineralogy. Results were confirmed by point spectral reflectance data obtained by Analytical Spectral Devices (ASD) Spectroradiometer. Preliminary results reveal that the spectral profile response along the growth axis of the studied stalagmite exhibits a similar spectral profile as that of calcite and aragonite at diagnostic absorption wavelengths of carbonate minerals. These wavelengths fall within the (SWIR), approximately at 2300 nm with some additional absorption features around 1800–2000 nm. This HSI method additionally allowed us to identify clay minerals, especially illite. Distinct spectral profile responses have also been observed between white and dark laminas around the wavelength of 400 to 550 nm. These changes could reflect changes in environmental conditions during $CaCO_3$ precipitation that may favor preservation of organic matter in the lattice of the carbonate minerals. A petrographic analysis will be performed to better understand the texture and the type of laminae, which aids in chronology building. This hyperspectral imaging offers a non-destructive and highly informative technique for studying mineral distributions within stalagmites. We plan on running X-Ray Diffraction on the selected lamina to determine the mineralogy for a robust paleoclimate interpretation. The current approach will help develop a high-resolution non-destructive dataset for paleoclimate reconstruction and insights for future studies of stalagmite using hyperspectral imaging.

Modeling of the response of cave and lake systems in the northern Iberian Peninsula to regional climate change and human activity

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This PhD project focuses on modeling several cave and lake systems in northern Spain targeted within a broader paleoclimate project, with the aim of assessing their responses to current climate change and to generate projections for both past and future climatic scenarios. Significant changes in mean annual temperatures, precipitation and seasonal patterns have been observed in the region during the last decades, confirming their sensibility to climate change and great variability in both space and time. A first goal of this project is to collect, standardize and analyze existing and team-generated paleoclimatic data, as well as meteorological and climatic datasets. An array of monitoring techniques, hydroclimatic modeling and analysis of sedimentary records and speleothems will be used. In addition, the response of natural systems to future climate scenarios will be evaluated and the possible impacts of human activities will be analyzed. Under this scope, our aim is to advance in the understanding of how the North Atlantic Oscillation (NAO) impacts on the spatial-temporal distribution of precipitation in the Iberian Peninsula. We have started by analyzing the available historical series on the NAO to identify and isolate events that reflect exceptional conditions of the system (very positive or very negative NAO indexes). Subsequently, we have selected stations belonging to the IAEA Global Network of Isotopes in Precipitation within the Iberian Peninsula to obtain their precipitation $\delta^{18}O$ isotopy records, focusing on the extreme NAO events described above. Once the discrete data from the stations were obtained, using kriging techniques in Python, we proceeded to the parameterization of $\delta^{18}O$ for a single event, obtaining as a result $\delta^{18}O$ distribution as a function of latitude, longitude, altitude and a NAO constant, this being the mean for the months of November to March. The next steps to follow will be the parameterization of the distribution of $\delta^{18}O$ as a function of the NAO as a variable, by means of machine learning techniques, which will allow us to obtain a discrete value of $\delta^{18}O$, and therefore of precipitation, for any point of the Iberian Peninsula, given a specific NAO value. Subsequently, we want to correlate the values obtained from the model with the isotopy data obtained from speleothems and lakes for the recent past, in order to improve its predictions and allow us to calculate NAO values for past climatic situations.

Microthermometry on fluid inclusions in stalagmites: what does the retrograde homogenisation tell us?

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Nucleation-assisted microthermometry allows to measure the liquid-vapor homogenization (T_h) in stalagmite fluid inclusions for studying their formation temperature. These fluid inclusions also show a retrograde homogenization (T_{hr}) upon cooling. Here we present some preliminary T_h-T_{hr} data from stalagmite fluid inclusions that show significant scatter around the modelled T_h-T_{hr} relationships. We hypothesize that it may be due to cracks on the inclusion walls and discuss how this can affect the T_h values in stalagmite fluid inclusions.

Reconstruction of the variability of Indian Summer Monsoon Rainfall using high-resolution multi-proxy records from speleothems of Meghalaya, north-east India

Dildi, Johannes Gutenberg University

Indian Summer Monsoon Rainfall (ISMR) is part of the Asian Summer Monsoon Rainfall (ASMR) system contributing to about 80% of annual rainfall (June through September in India) with its variability widely been investigated. A small discrepancy or delay in the ISMR could cause significant impact on the environment, agriculture, socioeconomic and cultural advancement across South Asia. The understanding of the strength, seasonality, the driving mechanisms and the timing of the onset and retreat of the ISMR remains comparatively poorly understood; it is not clear whether observed changes are due to natural variability (internal and external forces) or anthropogenically induced warming. Long-term high resolution and precisely dated records of past variability of ISRM are required to obtain a better understanding of the temporal dynamics of the ISMR. We sampled five stalagmites from Krem Mawmluh growing under active drip sites. These samples have high uranium concentrations enabling precise age control. Three of the stalagmites have been preliminarily dated by precise ^{230}Th/U-dating. The ages show that the aragonitic sections grew between 21 ± 0.3 and 64.5 ± 0.5 yrs. while the calcitic sections grew from 828.1 ± 439.7 to 6547.7 ± 57.2 yrs. Hence, the speleothems cover a wide age range between recent growth and 6547.7 ± 57.2 yrs., which offers great potential for the reconstruction of the ISMR on various time scales (interannual to millennial and even orbital). In addition, all stalagmites show this transition from calcite to aragonite close to the top, which is clear evidence for a big change in the cave system, which may have been induced anthropologically. Additional stalagmite samples from Krem Lymput (Nongjri village, East Khasi Hills) will also be analysed. Three main objectives of the present study are: i) To generate high-resolution multi-proxy records of climate and ISMR variability from Krem Mawmluh and Krem Lymput, Meghalaya, north-east India; ii) Understanding the mechanisms influencing past ISMR variability and its association to the EASM; iii) Understanding the relationship between high-resolution proxy data (geochemical and isotopic signatures) with mineralogical fabrics of the stalagmite samples. The project intends to achieve these objectives through an interdisciplinary approach including the state-of-the-art ^{230}Th/U-dating and analysis of several established and novel climate proxies, such as stable isotopes (™D, δ^{18}O and δ^{13}C) of speleothem calcite and fluid inclusion-hosted H_2O, trace-elements (Mg, Sr, etc.) as well as non-traditional stable isotopes (δ^{44}Ca).

Stalagmite record of Vietnam over the Dansgaard–Oeschger events and their paleoclimate implications

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On millennial to orbital time periods, previous paleoclimatic investigations using Asian cave records have demonstrated a strong correlation between the variability of the Asian summer monsoons and local summer insolation, the temperature of the North Atlantic, and the Greenland stadial-interstadial cycles. On short durations, whether a similar consensus exists is still up for debate. Using ^{230}Th data that have an accuracy of ± 62 years, a decadal resolved δ^{18}O record is presented from from a stalagmite in northwestern Vietnam that serves as a proxy record of the Asian summer monsoon (ASM). I also intend to use stable isotopes of oxygen and carbon to deduce past environmental changes in the study region. The time and geographical variation of D-O onset and structure will be noted. With ENSO having a major influence on the region, the generated records will help entangle the role of El Niño-like and La Niña-like conditions on seasonality vis-à-vis decadal to centennial-scale climate variability. We will also investigate primary cause of precipitation change in northern Vietnam speleothem site during the last glacial period, particularly during the millennials-scale like D-O and it's linked with the North Atlantic abrupt events.

The subglacial speleothem archive

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The Alpine speleothem dataset, which benefits from numerous samples and excellent age control, provides an ideal opportunity to study past glacial climate. At a European scale, only few radiometrically dated and continuous record exists for the Last Glacial Maximum. Alpine speleothems procure a high signal-to-noise ratio of the stable isotope data as well as the high temperature sensitivity. In the framework of our study, we will try to determine more precisely how speleothems develop and evolve in mountain caves despite cold climate conditions. While many caves lack speleothem deposition during glacial periods, some even in high elevation caves in the Alps have provided evidence of the presence of water above the freezing point in these climate periods, leading to (uninterrupted) speleothem deposition albeit at slow rates. The leading hypothesis to sustain karst dissolution in the karst and subsequent calcite precipitation in caves involves two components: the presence of a temperate glacier above the karst and the presence of pyrite in the host rock. The first scientific objective is to understand the system of speleothem deposition in subglacial conditions. The growth process will be studied to reveal how does the glacier melt water composition influence growth rate compared to soil cover catchment. Other key variables are temperature, network fissure density and porosity, which impact the water transit through the karst. Secondly, in terms of records, the principle is like other speleothem dating, the slower deposition will bring to closer dating on the sample. Different methods such as ^{230}Th-^{234}U dating, stable isotope analyses and CAS, fluid inclusion analyses and trace element analyses will be used. This new record will complement the existing subglacial speleothem dataset and will allow an improvement for the Quaternary paleoclimatic dataset. The existent subglacial speleothem records has a ranged from MIS 2 to MIS 7. The aim is to extend this record beyond MIS 7 and as far back as possible. Ideally, if we can extend the records from MIS 7 to MIS 12/13 (243 to 524 ka) would be a success. However, many risks are link to this approach. The main points are the presence of discontinuities in the record, diagenetic alteration, site-specific effects and delayed climate signals. Then, we will investigate the physico-chemical processes leading to deposition of carbonate in subglacial setting, specifically for speleothems. We will also study how those specific conditions affect the paleoclimate proxies from speleothems. If the dating and the study of the different speleothems proxies prove to be relevant, they will finally shed light on several Quaternary glacial cycles (MIS 8/10/12) that until now have been little or not even referenced in the literature.

$\delta^{13}C$ and $\delta^{18}O$ enamel isotope insights into the paleoecology of MSA foragers from Gotera, southern Ethiopia

Seminew Asrat Mogesie,

La Sapienza University of Rome

Ecological and climatic changes thought to have driven cultural and cognitive developments including dispersal and vicariance, adaptation and resilience, symbolism and ornamentation, and technological complexity of modern humans within and beyond Africa during the late Pleistocene. Over the past few decades, global cooling and humid climatic episodes associated with behavioral and biological changes between 70-30 ka have sought scholarly attention in Africa. However, despite the recent advances, more refined studies on the regional and local paleoenvironmental and paleoclimatic context of late Pleistocene MSA foragers associated with behavioral modernity and the transition from Middle Stone Age (MSA) to Later Stone Age (LSA) technologies hampered by site-based research lacunas. Carbon ($\delta^{13}C$) and oxygen ($\delta^{18}O$) stable isotope analysis of mammalian tooth enamel has become a well-established proxy for the understanding of the paleoecology and environmental contexts of hominins in eastern and southern Africa. In order to address this critical issue, here, we report our carbon ($\delta^{13}C$) and oxygen ($\delta^{18}O$) stable isotope analysis of mammalian tooth enamels from the Gotera MSA site dating to the MIS3.

Integrated study and modelling of Don Juan Cave (SE Spain)

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University Complutense of Madrid

The aim of this project is to provide an integrated study of Don Juan Cave. It is being based on speleothem characterization and mapping, together with cave environmental and hydrochemical monitoring. The cave is in eastern Spain, characterized by a Mediterranean climate. It is a touristic site that, however, shows low anthropogenic disturbance. It is hosted by a Neogene carbonate breccia unit. The cave shows a main dome-shaped room that accumulates large fallen blocks covered by speleothems and whose origin can be linked to collapse structures, carbonate dissolution and piping, around this room we find some smaller galleries. Cave speleothems are mostly related to dripping points and fractures in the ceiling. However, we find other speleothems such as coralloids and helictites that suggest cave ventilation with other parts of the cave. Interestingly, the highest gallery of the cave shows corrosion signs that affects all speleothems but mostly to those in located in the ceiling. Monitoring data have enabled us to distinguish different microclimatic and hydrochemical areas in the cave: an area with high external influence and seasonal dripping, a dry area that shows small but significant climatic variability, and an isolated area that shows a nearly constant temperature of 14.5 ºC and that has permanent dripping. Based on these studies, we are now working on developing models for the karst system dynamics. These will be used to generate projections of the cave functioning under different hypothetical climatic scenarios applicable to the past (focused on paleoclimate) and the future (focused on cave management).

Implications of the South Atlantic Convergence Zone activity since the Last Glacial Maximum for biodiversity in southeastern Bahia based on isotopic speleothems records

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Despite the great contribution of paleoclimate studies based on isotopic speleothem records to understanding the patterns of precipitation changes associated with the South American Monsoon System (SMAS), little is known about how these changes influenced the vegetation distribution in one of the most known endemism area, the Atlantic Forest zone in the southeastern of Bahia state (Brazil). This project aims to provide a new scenario about how climatic events that occurred from the Last Glacial Maximum to present have impacted the distribution of precipitation in the South Atlantic Convergence Zone (SACZ) domain region. The results are essential for the discussion about refuge theory and the formation of humidity corridors that would have contributed to the dispersion of species between the Atlantic Forest and the Amazon Forest, through areas now covered by Cerrado or Caatinga.

Constraints on late-Pleistocene sea-level change from submerged Bahamian speleothems

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University of Minnesota

We present new U-series ages for speleothems collected from coastal caves (blue holes) in the Bahamas, which are presently submerged at ~15-20 m below present sea level but grew subaerially when the caverns were exposed during past sea-level lowstands. Dating the timing of speleothem growth/cessation allows us to determine when a cavern was inundated by rising sea level. Our preliminary data show that this record extends back >400 kyr, constraining local sea-level change over four glacial cycles.

Linking holocene regional hydroclimate and paleo-fire using a central-California speleothem record

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California is a special area of interest for paleoclimatic studies due to the region's variable hydroclimate, sensitivity to climate change, and proliferation of wildfires (1,2). The paleoclimate record has the potential to provide regional and temporal context and critical insight into intervals of intensified hydroclimate and wildfire activity in California's past for comparison with modern variability under anthropogenic influence. I will apply a multi-proxy approach to two speleothems (WMC1 and WMC5) from White Moon Cave (WMC) in order to build robust reconstructions of hydroclimate in coastal California during the Holocene and understand the region's past precipitation and paleo-fire dynamics. WMC is located in the Santa Cruz Mountains, along the central California coast. WMC1 grew from ~8,600 to ~239 cal years BP 1950, and WMC5 was active from ~6,200 to 7,900 cal years BP 1950. Previous studies on a portion of WMC1 have presented Holocene stalagmite records that capture evidence of repeated intervals of precipitation extremes and suggest complex hydroclimate patterns in coastal California (3,4). WMC1 records have been particularly useful in advancing our understanding of "climate whiplash" during periods of the Holocene such as the 8.2 kyr event– a distinctive isotope excursion in the Holocene paleoclimate record that represents an abrupt cooling event– and precursor events (3,4). Based on these findings, there is ample opportunity to advance efforts in paleo-hydroclimate reconstruction by maximizing the potential of WMC speleothem archives and employing a new suite of proxies. This project will involve developing new records from WMC1 and WMC5 of traditional hydroclimate proxies including trace element to calcium rations (e.g. Mg/Ca, P/Ca, and Sr/Ca) and stable isotopes ($\delta^{18}O$, $\delta^{13}C$); more quantitative, novel hydroclimate proxies such as calcium isotope ($\delta^{44}/^{40}Ca$) and fluid inclusion proxies (δ^{18}OFI and δ HFI); and novel paleo-fire proxies such as biomarkers (levoglucosan and PAHs). Using WMC stalagmites, I will develop a high-resolution record of regional hydroclimate that can be temporally related to regional fire activity. Fire-sensitive biomarkers such as levoglucosan and polycyclic aromatic hydrocarbons (PAHs) are organic molecules that are produced during the combustion of vegetation during wildfires, transported from the critical zone, and incorporated in speleothem carbonate (5). Despite pre-existing speleothem data from California, hydroclimate records have not yet been integrated with paleo-fire data, and California speleothems have great potential to shed light on the relationship between climate state, hydroclimate, and paleo-fire activity. A recent study has demonstrated that levoglucosan, an anhydrosugar that originates from the combustion of cellulose, in WMC1 varied with hydroclimate during the Holocene and 8.2 kyr event (6). This link between precipitation volatility and wildfire activity will be further analyzed using paleo-fire biomarker data from WMC5 and the topmost portion of WMC1.

Cyclic subaerial and subaquatic speleothem deposition as paleowater table fluctuation in the Catão cave system, Central west Bahia state, Brazil

Gabriela Duarte

University of Sao Paulo

Magnetically Enhanced Laminae in Speleothems as a Proxy for Extreme Hydrological Events

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Extreme precipitation events and associated flooding represent a major hazard to societies worldwide. The concentration of ferrimagnetic iron oxide particles in speleothem laminae has been recognized as a potential paleoflood proxy that can be used alongside existing techniques such as ICP-MS and XRF scanning. However, it can be difficult to distinguish magnetically enriched flood layers from other detrital layers, such as hiatuses.To isolate the effect of flooding on speleothem magnetic enhancement, we examine speleothem MFZ-N1 from Malfazido cave in Paraná, southern Brazil. MFZ-N1 was collected from ~100 meters inside the cave in a section subject to repeated flood events. U-Th ages obtained from the sample span 1100-2007 CE over a length of 200 mm, implying an average growth rate of 0.22 mm/y. We impart a saturation magnetization to the speleothem, then use the Quantum Diamond Microscope (QDM) to produce micrometer resolution magnetic maps of ferrimagnetic particles in the MFZ-N1 central column. We then integrate the magnetic field intensity along each lamina to construct a time series that can be compared to local rainfall and streamflow records.The magnetic particles are sparsely spatially distributed, with the exception of isolated laminae that contain high concentrations of these particles. We hypothesize that these enriched laminae are the results of flooding events while the sparsely distributed background particles were introduced via a distinct mechanism. To test this hypothesis, we conduct a demagnetization of the saturation magnetization to extract the coercivity spectra of the ferrimagnetic grain populations. These spectra will then be compared to those from grain populations identified in previous environmental magnetism studies to fingerprint the source of the grains. Additionally, the coercivity spectra and time series will be compared to data from a replicate stalagmite sample and flood-related mud samples from elsewhere in the cave. These comparisons, applied to a statistically representative set of enrichment horizons, may be able to identify rock magnetic properties unique to flood deposit layers, making high-resolution magnetic study a means of identifying such events in speleothems beyond the historic period.

Reconstruction of Continental Surface Temperature based on Isotopic Analysis of Fluid Inclusion in speleothems from central eastern Brazil

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Paleoclimate reconstructions in South America heavily rely on the interpretation of $\delta^{18}O$ and $\delta^{13}C$ from carbonate ($\delta^{18}OC$, $\delta^{13}CC$) in speleothems. However, these records are often influenced by complex processes along atmospheric transport pathways and within the cave system, which hinders straightforward interpretations. Specifically, temperature variations within the cave environment and the exchange time between dripping water and cave atmosphere can impact the $\delta^{18}OC$ composition of the precipitating carbonate. Significant temperature fluctuations, such as those occurring from the Last Glacial Maximum (LGM) to the Holocene, can be crucial for speleothem $\delta^{18}OC$. Nonetheless, there is a scarcity of continental surface temperature reconstructions in South America, which precludes a comprehensive understanding of environmental changes during glacial phases and their effects on Neotropical biomes. The main objective of this research is to assess and produce new paleoclimate reconstructions from the LGM to the Holocene based on traditional $\delta^{18}OC$ and $\delta^{13}CC$ analyses of stalagmites. This ongoing study aims to provide new continuous surface temperature reconstructions for South America, spanning the LGM to the Holocene, using fluid inclusion analyses on speleothems. The research focuses on speleothems from Rei do Mato and Lapa Sem Fim caves, situated in central eastern Brazil, a region heavily impacted by rising temperatures associated with current climate change. Additionally, the area is influenced by the South American Monsoon System (SAMS), which is known to have varied in the past on multi-decadal to millennial timescales, leading to significant consequences for the local hydrological balance. Generating new paleoclimatic records is crucial for understanding climate evolution and improving future projections in this densely populated region.

Sample SC-06-01 from The Askhaira Cave: A Window into the Paleoclimate of Libya.

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University of Tobruk

This poster will introduce Sample SC-06-01, a 93 cm stalagmite sample, which is considered the largest sample speleothem collected for the fluid inclusion dataset for the country and the adjacent countries to this date. Acquisitted in 2009 from Susah cave also known Askhaira Cave, which is a shelter cave with almost a close entrance, it has been reported in two published papers.

The cave is located in Aljabel Alakhdar, Cyrenaica northeast Libya, The region is counted as a karstic region with a maximum elevation of 830 meters and an average rainfall of 600 mm per year, The cave is situated at 32° 53.4190' N, 21° 52.4850' E on the nearby shoreline with a 200-meter elevation and a rainfall rate of 200 mm per year.

Speleothem fluid inclusions from the latest Marine Isotope Stage (MIS) 4 and throughout MIS 3 (67 to 30 kyr BP) The fluid inclusions from SC-06-01 show that rainfall compositions in the southeastern Mediterranean region during MIS 3 were comparable to modern rainfall compositions recorded in regional GNIP datasets.

Forcings and Teleconnections of the Indian Summer Monsoon: A Multi-Archival Investigation

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The growing population of Southeast Asia faces severe climate stress, characterized by irregular monsoon precipitation, sea level rise, flooding, agricultural pressure, vegetation loss, insect outbreaks, and wildfires. Understanding the controls and long-term consequences of this climate stress is paramount, considering its projected increase. In this study, we adopt a multi-archival approach to investigate the Indian Summer Monsoon (ISM) and its long-term variations. By combining climate model simulations, speleothem, marine, and lake records, we aim to explore the teleconnections between insolation, greenhouse gases (GHG), methane feedback, and the roles of the Atlantic Meridional Overturning Circulation (AMOC), Indian Ocean Dipole (IOD), and El Niño-Southern Oscillation (ENSO) on the ISM. Preliminary data from Loktak Lake and established data from the Bay of Bengal and Bittoo and Mawmluh Caves provide some insights into these connections. We hypothesize that the ISM's seasonal forcing was more pronounced during periods of higher (lower) Northern Hemisphere summer (winter) insolation between approximately 36-29 ka and 15-6 ka. At multi-centennial scales, the ISM exhibits greater sensitivity to changes in ENSO and IOD mean-state compared to the East Asian Summer Monsoon, owing to Indian Ocean teleconnections with the Pacific. During Heinrich stadials and the Younger Dryas, several links are observed with the Inter-Tropical Convergence Zone (ITCZ), AMOC, and Hadley cell circulation, leading to a weakening of the ISM and possibly acting as a positive feedback that further suppresses precipitation and enhances evaporation. The marine record suggests that the ISM may be more responsive to GHG forcings than insolation. Additionally, the strengthening of the ISM is believed to contribute to increased global methane concentrations through the expansion of Northern Hemisphere wetlands. Lower GHG concentrations coincide with a weaker ISM and stronger East Asian Winter Monsoon. To further investigate these teleconnections, we propose an in-depth analysis of four speleothem records by the addition of established data from the Dongge and Hulu Caves, to reconstruct precipitation from the ISM and EASM. Furthermore, we plan to extend the Loktak Lake record to 50 ka, enabling the reconstruction of past changes in the precipitation-evaporation balance, lake level, and vegetation dynamics using various climate proxies, including sedimentology, geochemistry, stable isotopes, palynology, diatoms, and biomarkers.

Multi-paleothermometer reconstruction on a northern California speleothem using fluid inclusions and dual clumped isotopes.

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Paleothermometry utilizing inorganic calcite, specifically in cave deposits, is not without its challenges and limitations. In recent years, several novel paleo temperature approaches have been put forward, each with its advantages and handicaps. For example, speleothem Fluid Inclusion (FI) $\delta^{18}O$ is used to calculate the temperature at entrapment. However, there are post-entrapment processes that can alter isotopic composition such as exchange with calcite, this can be constrained by using δD of fluid inclusion. As δD is not modified by exchange with calcite it be used as a thermometer using the H/Temperature equation calculated from the regional T-dependence of δD of modern datasets and a sub-recent fluid-inclusion as benchmark “anchor”. Applying this thermometer together with $\delta^{18}O$ can provide insights into the drip-water history and elucidate the paleo- physicochemical processes at the time of lamiae formation. Dual clumped isotopes (Δ47/ Δ48) are another thermometer that can also provide us with information about potential disequilibrium during precipitation. An integrated paleo-temperature analysis using multiple paleothermometers has the potential to account for kinetic-dependent processes outside and inside the cave. In this study, we attempt to resolve thermometer-specific uncertainty by applying multiple approaches to approximate coeval temperature measurements. For this purpose, we use a deglaciation temperature time series in a stalagmite growing between 19.1 and 11.5 ka from a cave in the Sierra Nevada, California, USA. Fluid inclusion isotope data derived from the stalagmite indicate that $\delta^{18}O$ and δD fall on an apparent evaporation slope when plotted against the modern local meteoric water line (LMWL) (Wortham et al., 2021). This deviation from the LMWL may be the result of changes in moisture source, evaporation, and/or post-entrapment calcite-water interactions that altered the fluid inclusion isotopic composition. Dual-clumped isotope analysis suggests the original calcite was deposited in isotopic equilibrium with drip water, and provides an estimated temperature range between 11.6-19.9 °C. Under the assumption of equilibrium precipitation, if post-depositional water-rock interactions did occur, then the offset from the LMWL could be corrected. When we compare additional temperature calculations; this indeed seems the case for most of the fluid inclusion dataset. FI paleothermometers include H/T-temperature and fluid inclusion $\delta^{18}O$ corrected using the modern LMWL. FI ^{18}O temperatures were calculated using equations from Kim and O’Neil.,1997 (fast deposition), Tremaine et al., 2011 (speleothem global average), and Daeron et al., 2019 (very slow deposition). These methods indicated mean paleotemperature for the first and third quartiles set in the following order as mentioned above;(13.08,17.46) °C, (15.11,19.19) °C, (9.63,11.36) °C and lastly (8.26,12.04) °C. Our preliminary data suggests an overlap of temperatures from the different approaches, with the general agreement between the dual clumped, H/T and Kim and O’Neil.,1997. Modern temperatures from nearby cave shows annual temperature of 13°C. The integration of the different approaches has the potential to quantify uncertainties of individual paleothermometers allowing for more robust temperature reconstructions and providing constraints on other climate variables by resolving depositional biases.