

Collected papers of the first symposium

Modalities of the Homo-Genus appearance in southern african paleokarsts

9th-10th December 2024

Maun, Botswana



**Hominins in Botswana
Karst research project**

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Human and Karst Institute

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The modalities of the Homo Genus appearance in the African paleo-karsts

Text : Laurent Bruxelles

It has since been established that the origins of the Homo Genus is not confined only to the East African Rift Valley and South African “Cradle of Human kind”. Growing evidence now suggests that hominids evolved over a much larger geographic area. It is therefore very likely that many fossils will be discovered between these two regions of the East African Rift Valley and South Africa. The key issue will be where to look, what to expect and how to handle the context and the matrix.

After searching for potential sites in several Southern African countries, it now appears that Botswana has one of the most promising sites. The Gcwihaba-Koanaka hills area possesses the geological karsts, time scale and similar conditions that allowed for the trapped fossils elsewhere in Africa. As the program indicates, this conference presents evidence and experiences from Botswana, South Africa, Mozambique, Zambia, Zimbabwe and Sudan by researchers from Europe and the SADC region. The goal of this workshop is, therefore, to initiate the construction of a network of researchers from all disciplines who together will synergize to answer not the question of the origin of the Homo Genus, since it is Pan-African, but that of the varied modalities of its appearance.



The year is 2024, and we are in Koanaka Hills. Was this the landscape in which hominids lived 2.8 million years ago ?

Collected papers
of the first symposium

Modalities of the **Homo-Genus** appearance in southern african paleokarsts

Organizers



Laurent Bruxelles, TRACES
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Jaurès university

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Phillip Segadika, head of
archaeology, Botswana
National Museum, Gaborone

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Context

For several years now, it has been evident that the origin of the Homo genus is not confined to just two regions of Africa, the East African Rift Valley and the "Cradle of Humankind" area in South Africa. It appears that hominins, along with the fauna associated with them, evolved over a much larger geographic area, on a pan-African scale. This means that the cradle of humankind cannot be restricted to a limited area, and many African countries are likely to hold a piece of this cradle. Therefore, there are very likely many fossils to be discovered between these two regions, which could form an initial link on the scale of southern Africa.

Similar to the sites in South Africa, where we have been working for nearly 20 years (Sterkfontein, Swartkrans, Kromdraai, Makapansgat etc), we search for fossils in karstic cavities. Indeed, these constitute fossil traps par excellence, whose various aspects, such as geology, stratigraphy, dating, and past ecological-ecosystem contexts, we master. After searching for potential sites in several

southern African countries, it now appears that Botswana has the most promising sites (Gcwihaba and Koanaka hills to start). While we have not yet found hominin remains, the research we have been conducting there since 2021 is very promising due to its paleontological richness and the chronological period concerned, namely the early phases of the Pleistocene or even the Plio-Pleistocene transition.

Aim

In the framework of the joint Research Program Homini'karst, in partnership between the Botswana National Museum and the CNRS, we organized the first international conference : **Modalities of the Homo-Genus Appearance in Southern African Paleokarsts**. The idea is, with the question of inter-disciplinarity as a backdrop, to foster meetings and exchanges between African and European researchers working on karsts between South Africa and the East African Rift Valley. This quest is too important and too vast to be conducted in an isolated, fragmented manner, and especially by mobilizing only a portion of the required disci-

plines. Therefore, through this first conference, we wish to initiate the co-construction of a network of researchers from all disciplines who, together, will synergize to answer not the question of the origin of the Homo genus, since it is pan-African, but that of the modalities of its appearance. More than 50 researchers, students and officials attended the conference and to be part of the rich exchanges. We promoted interdisciplinary discussions between geomorphologist, archaeologists, paleontologists, taphonomists, paleoanthropologists, 3D and GIS specialists, dating experts...). This meeting was an opportunity to create links in various respects and provided all the keys to strengthen the current scientific network, not only with academic researchers but also by training colleagues and welcoming African students.

Beyond the scientific aspects, the organization of this symposium in Botswana has several key objectives. Firstly, it aims to integrate Botswana's researchers and staff from the Botswana National Museum into an international research network. Researchers from South Africa, Zimbabwe, Zambia, and Mozambique, were also invited and gathered in Maun to share their knowledge and build networks. The plan was to boost the scientific research in palaeosciences, a field where Botswana, following South Africa, is poised to produce top specialists and promising sites. The country's archaeological, palaeontological, and geomorphological potential, along with its international scientific programs, is making it increasingly visible on the global stage.

At the same time, we want to involve as many students as possible, as this type of conference is also aimed at them. It's important to highlight the opportunities available in these rapidly evolving scientific disciplines. Our programs already provide funding for Botswana's Master's and PhD students, and there is great potential within the country. Once trained, they will lead research projects, and through this symposium and the collaborations established, they will have gained the necessary qualifications. This confer-

ence offers an opportunity to show them that these careers are viable and that they can pursue a truly international scientific path.

And after ?

As a natural extension of the conference theme, we have organized a session dedicated to preventive archaeology, as it is crucial not only to search for traces of the past but also to protect them. The Director of International Relations at Inrap, the world's leading institute for preventive archaeology, will be attending and meeting with key figures in preventive archaeology in Botswana. Following the conference, Inrap and the University of Toulouse (France), in partnership with the Botswana National Museum, will establish comprehensive training programs in preventive archaeology, aimed at preserving Botswana's archaeological heritage as effectively as possible.

The impact of palaeoscience research on tourism will also be considered and developed. All research, training, and development activities inherently influence tourism. Our work is uncovering a previously unrecognized heritage, and our scientific publications are already putting Botswana on the map. The Gcwi-haba and Koanaka caves have significant tourist potential, which is currently under-exploited. Each discovery and new line of research enhances the tourism offerings for both archaeological and natural sites. Aside of our excavations, several current projects are developing, ranging from museology (with a French specialist on the team in collaboration with the Director of the Botswana National Museum) to site development, including writing books for the general public, one of which will focus on the caves of Botswana.

In 2027, a second conference will be organized in Gaborone to pursue this network building and expand growing cooperation with other countries of Southern Africa.

Distinguished guests

Mr Olivier Brocherin

French Ambassador to Botswana

Mr Goretetse Kekgoniegile

Member of the Parliament for Maun West

Ms Abigail Khumoyane

Deputy Permanent Secretary (Tourism), Ministry of Environment and Tourism

Mr Charles Mojalemotho

Director, DNMM

Mr Boatametse Modukanele

Permanent secretary, Ministry of Environment and tourism

Mr Thabang Wakola

District Commisionner, North West District

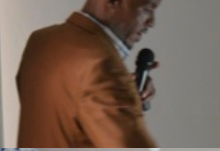
Ms Gloria Tuvare

Xaï Xaï Tlhabologo Community Trust Manager

At the end of the symposium, the participants gathered on the lawn of the Maun Lodge Hotel for a team photograph.



During the symposium. Photo FDU>





Laurent Bruxelles

Human Origins in Botswana Project

Laurent Bruxelles¹, Phillip Segadika²

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After nearly 15 years of archaeological and paleoanthropological research in South Africa, we have launched a new research program in Botswana in 2020 in collaboration with the Botswana National Museum.

The objective is to search for remains of ancient hominins, such as those found in South African caves, that could document the appearance of the Homo genus and sign the last traces of Australopithecines. In light of our knowledge of the South African context and considering that the "cradle of humankind" covers the entire African continent, it now appears to us that Botswana gathers all the conditions necessary to preserve new fragments of this cradle. Our fieldwork and the last resulting discoveries, reveal the full potential of Botswana's cave deposits and the paleontological collections they contain.

An interdisciplinary and international scientific collaboration has been set up and its rapid development testifies to the motivation and dynamism of all the partners. We propose here, in order to perpetuate this collaboration, an ambitious but realistic research project supported by

the CNRS and the Botswana National Museum which valorises not only our recent discoveries but also the paleontological collections kept at the Botswana National Museum. This four-year research program (2023-2027), called Homini'karst, also includes student training, a PhD bursary, partnerships with universities and museums, and the organization of two international conferences on palaeosciences in Botswana (2024 and 2027).

The aim of this interdisciplinary program is to search for ancient hominin remains but also, for the first time, define the paleoenvironmental and taphonomic framework of ancient human occupations in Botswana. □

Lapies around Gcwihaba hills. Photo VOL>



**• Cercopithecoids •
micromammalians • homo
evolution • faunal remains
• carnivores • micro faunal
...**



01



Mosarwa Babutsi

Reconstructing locomotor behaviour of southern African Plio-Pleistocene Cercopithecoids: evidence from functionally related inner structural arrangement of the trabecular bone

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Due to their abundance in African Plio-Pleistocene hominin-bearing sites and their stratigraphic association with fossil hominins, cercopithecoids represent a relevant “control group” for contextualising hominin evolution. They are often considered as ecological and biochronological indicators. This is because their ecological sensitivity is critical in reconstructing southern African hominin bearing sites’ palaeoenvironment and environmental changes. Since biomechanical loadings on trabecular bone generated throughout locomotor activities shape the structure of the skeleton, primarily at locomotor key joints, expectation is that investigation of the trabecular bone of fossil cercopithecoids key joints would provide further evidence for eloquent discreet disparity in their locomotor behaviour and reconstructing their paleohabitats.

The loads experienced during locomotor activity are relevant factors in shaping the form and structure of the skeleton, particularly the femoral head.

Accordingly, here we make the assumption that the analysis of trabecular bone structural properties from key regions of the skeleton of southern African Plio-Pleistocene cercopithecoids would provide further evidence for discussing subtle variation in their locomotor repertoire and reconstructing their paleohabitats. We focus our study on femoral and humeral heads, proximal tibiae and calcanei to assess locomotor-related functional adaptations in bony organisation.

Our sample consists in forty-one (41) fossil cercopithecoids from the southern African hominin-bearing sites of Bolt’s Farm, Makapansgat Member 3, Sterkfontein Member 2, 4 and 5, Swartkrans Member 1 and Taung, as well as forty (40) extant cercopithecoids specimens scanned using a micro-focus X-ray computed tomography (CT) scanner. A number of variables describing trabecular bone textural and structural properties (e.g., bone volume fraction, trabecular thickness, and fabric anisotropy and tra-

becular thickness) have been assessed on standardized volumes of interest

Trabecular bone textural and structural properties in fossil and extant cercopithecoids reflected variable loadings associated with terrestrial and arboreal quadrupedal locomotion. Fabric anisot-

ropy of fossil specimens is slightly higher than in extant specimens, suggesting gait forces in a specific direction during locomotion. As such, our study has the potential to document environmental shifts at a local and regional scale in southern Africa that may be concomitant with the emergence of the genus *Homo*. □



Christine Steininger

Southern Africa's Contributions to Early *Homo* Evolution: Insights into Adaptation, Dispersal, and Paleoenvironmental Contexts

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Southern Africa serves as a crucial region for understanding the evolutionary and dispersal patterns of early *Homo*. Fossil assemblages from this area have yielded extensive morphological, technological, and paleoecological data, significantly advancing our knowledge of early hominin adaptations and behaviors.

Comprehensive stratigraphic and sedimentological analyses have established robust chronologies for these fossil-bearing deposits, while taphonomic studies have detailed the formation processes and post-depositional histories of the assemblages. High-precision dating techniques, such as uranium-lead and cosmogenic nuclide dating, have refined temporal frameworks, connecting evolu-

tionary events to shifts in the paleoenvironment. Paleoecological reconstructions, informed by faunal and isotopic evidence, have shown that early *Homo* navigated dynamic and heterogeneous ecosystems, displaying remarkable adaptive versatility in response to fluctuating climatic conditions. These findings position Southern Africa as an essential region in the pan-African context of early *Homo* research, offering unique insights into the evolutionary mechanisms driving hominin dispersal and adaptation. The integration of multidisciplinary research continues to illuminate the complex interplay between early *Homo* populations and their environments, contributing to a more nuanced understanding of human evolutionary history. □



One Tshukudu

Preliminary results of microfaunal studies in Botswana: Gcwihaba Caves

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Interest in micromammal studies has been steadily increasing over most parts of the world with more focus directed towards approaches for understanding the site formation processes and past climate and environments that prevailed in the Pleistocene period. Unfortunately, that has not been the case for Botswana where more focus has been on the Archaeology of the Iron Age and Stone Age periods, focusing on remains such as pottery and stone tools. This presentation therefore will focus on an analysis of the taphonomy of a small mammal assemblage from the Gcwihaba caves in the Ngamiland District in the north-west of Botswana. Ultimately this information will be used to understand the formation history of the fossiliferous levels and for the reconstruction of the past environments that prevailed during the Plio-Pleistocene period around these caves. It could also help us understand similar situations that prevailed in southern Africa and across the continent. The Gcwihaba caves have yielded rich micromammal assemblages over time and most of these remain unstudied. The Hominins in Botswana-Karst Research Project since its inception in 2021 has been identifying new areas of high archaeo-pa-

leontological potential in karst zones (covering the Aha Hills, Koanaka Hills, and Gcwihaba Hills). Initial fieldwork in the Gcwihaba area has resulted in -in addition to the rediscovery of some previously known surface localities- the recovery of a new, rich paleontological assemblage within the Gcwihaba cave. These remains were studied to build on previous research efforts in terms of micromammal studies in the Gcwihaba area by providing the first comprehensive and initial taphonomical analysis of the assemblages recovered. The taphonomic characteristics of this assemblage were studied and analyzed based on several modifications observed on the skeletal remains such as breakage patterns, skeletal representation, and digestive corrosion on bones. The preliminary results from this analysis show birds of prey and most possibly barn owls as the mode of accumulation of this assemblage. High percentages of corrosion marks were observed on bone surfaces, which could correspond to the effect of biocorrosion rather than predator-induced digestion marks. Similar patterns in the anatomical representations and pattern of fragmentation were observed when compared to that of the barn owl neotaphonomic signature. □



Pierre Linchamps

A micromammalian framework for the Quaternary of southern Africa

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The study of micromammals holds a unique position in archeozoological and paleontological disciplines. Micromammals, defined as mammals weighing less than 500g, represent nearly 70% of mammalian diversity, making them an exceptionally varied group from ecological and evolutionary perspectives. Due to their small size, the collection of micromammal fossils requires labor-intensive and time-consuming sampling methods, involving fine sediment sieving and meticulous sorting of sieve residues. Moreover, the abundance of their remains within fossil assemblages from cave sites in southern Africa allows the use of robust statistical methods.

Traditionally, the study of Cenozoic micromammals, especially rodents, finds three major applications in paleontology: biochronology, taxonomy, and paleoecology. These three applications provide valuable insights into human evolutionary history during the Quaternary in southern Africa: biochronological studies serve as independent chronological tools to validate or complement numerical age estimates; taxonomic studies provide insights into the palaeobiodiversity and evolutionary history of organisms, shed-

ding light on species diversification and migration over time; paleoenvironmental studies help elucidate the role of environmental pressures in hominin speciation, extinction, and adaptation.

Today, scientific advances made in the past two decades allow researchers to overcome the methodological limitations that constrained microfaunal studies from southern African sites until recently.

Molecular phylogenies enable better understanding of rodent systematics and biogeography. Methods of shape quantification, such as geometric morphometrics and deep learning, facilitate detailed morpho-anatomical comparative analyses for taxonomic and biochronological purposes. Statistical developments, including machine learning, enhance the study of the relationship between modern and fossil faunas and their environments. These methodological advancements pave the way for a promising future in microfaunal research in southern Africa. □



Paleontology and ecology, a new insight on faunal remains from Southern Africa

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Palaeontological and palaeoanthropological research into the early phases of the African Quaternary has tended to contrast two palaeobiogeographical models that raise questions about the origin of humankind: namely the East African model and the Southern African model. These models, traditionally constructed on the basis of the palaeontological and palaeoanthropological record specific to these geographical areas, reflect the research interest in these sectors and bear witness to our palaeobiogeographical shortcomings rather than guaranteeing a palaeontological reality. Moreover, there is a degree of inconsistency even in the definition of these models. This is particularly true of the Southern African model, which is in fact based solely on the palaeontological record of the Cradle of Humankind in South Africa, a geographical area representing less than 0.05% of the total surface area of Southern Africa, including South Africa, Mozambique, Malawi, Zimbabwe, Zambia, Namibia, Botswana and Angola. However, the rich palaeontological record of the Cradle, which includes a significant diversity of bovid, carnivore and primate, among others, and has a research history stretching back almost a century, provides an initial framework for

describing these ancient ecosystems and guiding our research beyond its borders. The most recent research and the various exploration projects we have carried out across Southern Africa show a real palaeontological wealth outside the Cradle. The HON - Human origins in Namibia - project, the HOMME - Human origins in Mozambican and Malawi Environments - project and, more recently, the Hominini'Karst in Botswana project, highlight the great potential of these areas, paving the way for a more plausible model on the scale of southern Africa and extending well beyond South Africa. In Namibia, the localities in the Otavi Mountains (Jagersquelle and Harasib) have faunas that are perfectly comparable to the South African sites, where bovids mingle with carnivores and cercopithecoids in similar geological contexts. Similarly, the recognition of relict breccias in Mozambique (Buzy River and Chringoma Plateau) containing suids and hyenids suggests a strong archaeo-paleontological potential. Finally, in Botswana, a long-neglected area, our work in the Gcwihaba and Koanaka hills shows a rich palaeontological record and comparable palaeoecological contexts within which a few specific features stand out. While the preliminary results of these different approaches

highlight the strong similarity between Namibia, Mozambique, Botswana and South Africa, observable differences in the faunal components (abundance of antilopini and reduncini, rarity of bovine and cercopithecoides, and identification of new species indicating endemism specific

to Botswana, for example) thus clarify the Southern African model as currently accepted on the basis of the Cradle alone. In the light of this new field data, we are now in a position to refine this model by covering a much wider geographical area than previously considered. □



Amélie Beaudet

Hominin evolution in southern Africa: new perspectives

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One of the most challenging questions to address in human evolutionary studies is probably the following: ‘where do we come from?’. In this respect, the Plio-Pleistocene transition ca. 2.8 million years ago is considered as a key-period in human evolution. Because of the exceptional preservation of the fossil record and the high density of the remains, the southern African Plio-Pleistocene paleontological sites have played a major role in the search for human origins. Our research aims to shed new lights on the taxonomic and evolutionary context of southern African fossil hominins.

Specifically, we conducted in silico analysis on selected hominin skeletal regions, including cranial (e.g., face, bony labyrinth, brain endocast) and post-cra-

nial (e.g., vertebrae) structures. In this perspective, we developed a non-invasive approach that relies on the combined use of high-resolution imaging techniques and 3D modelling for detailed exploration of these biological structures. Our findings reveal essential patterns of morphological variation at both regional (inter-sites) and local (intra-site) scales, suggesting a more nuanced evolutionary scenario involving both gradual and sudden changes in the biology of our ancestors. In this presentation, I summarize the outcomes of over a decade of computer-based revisions of the southern African hominin record and highlight two promising avenues that would deserve specific attention in the future, that is, the exploration of temporal depth and the diversity of nonhuman primate. □



Camille Thabard

Carnivores of southern Africa, assessing trophic chain and its implication in hominins evolution

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The large carnivores of the South African Plio-Pleistocene (felids, hyenids, canids) are undoubtedly one of the most studied groups, and have been for almost a century. While previous studies have demonstrated their biochronological potential, very little work has been done to characterise trophic chain and ecological niche through the study of carnivores, and even less to attempt to reconstruct the ecological position of ancient hominins in these complex ecosystems. However, taphonomic research has often emphasised the major (not to say unique) role played by large felids and hyenas in the bone deposition processes and in the ecological dynamics linking these predators to hominin communities, while other groups (including canids) and smaller predators (e.g. jackals, medium-sized felines) are almost excluded of such researches. The present study, based on a palaeontological reassessment of carnivore communities in the Cradle of Humankind, South Africa, aims to describe trophic chains and their evolution over the long term (from 3.5My to ca.1My) through taxonomic and ecomorphological characterisation. The study of carnivores from various localities (Kromdraai, Swartkrans, Sterkfontein, Minnaar's, Cooper's, Makapansgat) has enabled us to discuss some specific diagnoses and to recognise new species with

particular ecomorphological qualities. Putting these different palaeontological assessments into perspective opens the way to characterising ecological niches and, by extension, trophic chain. For example, the re-evaluation of the large felids (machairodonts and pantherine) will enable us to discuss the share of each within this guild. As far as canids are concerned, the identification of several species of raccoon dog *Nyctereutes* spp. and the exclusion of these species in view of the presence of the side-striped jackal *Lupulella adusta* provides a better understanding of the ecological niche of these hypocarnivores. On the other hand, the frequency and abundance of the black-backed jackal *Lupulella mesomelas* raises questions about its involvement in the bone deposition processes. Finally, the relative rarity of the spotted hyena *Crocuta* spp. compared to the abundance of the specialized hyenas *Hyaena/Parahyaena* (scavenger) and *Chasmaporthetes/Pachycrocuta* (primary hunter and ubiquitous) allows us to revisit the role of the different components of this guild. This reassessment of carnivore communities and their eco-ethological diversity has implications for the palaeo-ecological status of ancient hominins, particularly during this pivotal phase when the last australopithecines and the first representatives of the genus *Homo* co-evolved. □



1. Photo VOL.



2. Photo VOL.



4. Photo LBX.



3. Photo CBX.

1. Laurent Bruxelles collects sediments samples.
2. Guano samples at different depths in Gwcihaba cave.
3. Sieving sediment in bones cave.
4. Deep drilling in guano in Gwcihaba cave.



5. Photo CBX.



6. Photo VOL.



7. Photo LBX.



8. Photo CBX.



9. Photo VOL.



10. Photo LBX.



12 . Photo CBX.



11. Photo LBX.

5. Sediments extraction in Bones cave.

6. One Tshukudu collects owl pellets to identify the microfauna.

7. Fossil teeth in the wall 's Bones cave.

8. Sifting and sorting of bones in Bones cave.

9. Baboon carcass at the base of the Whaxhou South scree cone.

10. Recent jawbone of a herbivore, probably brought by a predator or a porcupine.

11. Sediments sampling at the bottom of the first Bones cave pit.

12. Setting up camera traps to track the underground occupation of leopards.

• Bones • old sediments •
3D mapping • conservation
• museum • reconstructing
• quartz ESR

...



02



Francis Duranthon

From the field to the display case, the journey of an object

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Exhibiting an object in a museum is just the final stage in a long process that requires a complex operating procedure with a number of key phases. The object's journey takes in different areas of museology, from the initial inclusion of the specimen in the museum's collections to its final display in the showcases, serving a scientific purpose for the education and enjoyment of a lay public.

The various stages follow one another in an established order: collection in the field, preparation and/or preliminary restoration for scientific study, integration into the collections with its associ-

ated documentation and inventory number in a collections management database, and storage in suitable reserve premises. It is only after a scientific programme has been drawn up, and then transformed into a museographic programme, that a selection process will enable the object to be chosen for display, which may require final restoration. The object will then go through a mounting phase before taking its rightful place in the display case.

It is the success of this museographic work that will generate a special emotion in visitors, making their experience of visiting the museum an unforgettable one. □



Kim Genuite

From caves to landscapes: reconstructing the story of Botswana cave systems with 3D mapping and geomorphology

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The caves that preserve ancient fossil fills are located in outcropping carbonate formations whose geological history is potentially very long. In the Cradle of Humankind and Makapansgat, the fossil caves were formed in dolomites dating from the Paleoproterozoic (-2588 Ma). These dolomites can reach 1500 m in thickness in non-eroded and non-karstified areas. In Botswana, the caves explored at Lobatse are located in dolomites that are found in the same Paleoproterozoic marine basin that measures 500 km by 300 km.

To locate other potentially karstified carbonate formations, the study of geological maps is essential. These maps are available at various scales (1/10M for Africa - CGMW BRGM 2016; 1/1M for South Africa - 2019; 1/1.5M for Botswana -1998; etc.), and in varied formats: vectorized or raster (requiring high-quality scans). We compiled these data using GIS (Geographic Information System) software (Chadelle and Bruxelles, 2022).

The main objective of my PhD is to conduct a geomorphological analysis of these formations using GIS (calculation of slopes, shading, etc.) to assess their de-

gree of karstification to determine the potential presence of caves to be explored. These analyses are based on relief measurements (DEM – Digital Elevation Model) obtained from space by Shuttle (SRTM – 90 m resolution), by satellite (Daichi – 30 m), by plane (1 m resolution) and by drone (1 cm), as we did in Gcwihaba and Koanaka, Botswana (Fourvel et al., 2024). This cartographic work, carried out in the laboratory, before the field missions, provides original maps of potentially fossiliferous karsts, allowing the location of new sites of interest for the study of ancient fossils. □



Kim Genuite

Old bones in old sediments ? Dating the fossiliferous breccia of Botswana and Southern Africa with quartz ESR

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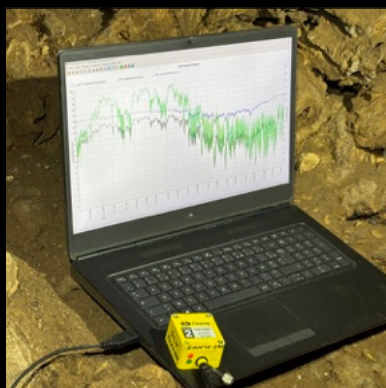
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The preservation potential of ancient hominin fossils in Southern African karst systems (caves) has allowed us to record about 4 million years of human evolution (Granger et al., 2015). Numerous discoveries of exceptionally well-preserved fossils of both hominins (*Australopithecus*, *Paranthropus*, and *Homo* genus) and fauna (including bovids, primates and carnivores among others), trapped in the sediment infills of these caves, have been made. However, dating these fossils and understanding their stratigraphic relationships remains challenging. Age estimation for these fossils is often debated, creating challenges in placing them accurately within the human. Recently, we have begun to date fossil-bearing breccias from Southern Africa using a new dating method: ESR (Electron Spin Resonance) on quartz. This method, which relies on the ability of quartz-rich sand grains to accumulate chronological information, has never been tested in Southern Africa before. It holds potential for dating the burial of quartz-rich sandy sediments over millions of years, particularly in sediments relatively close to the surface (outcrops, ancient river levels). This

approach also aims to better align the timeline of cave evolution with that of the surrounding landscapes, helping to explain why some fossils are preserved in specific valleys and not elsewhere. Analyses are underway, and we present the recent acquisition campaigns in Botswana (Bone Cave and outcrops in the Koanaka Hills) and Southern Africa (Limeworks, Makapansgat Valley), along with the dating challenges and key issues associated with each of these sites and ancient valleys. □



1. Photo CBX.



2. Photo VOL.



3. Photo VOL.



4. Photo VOL.

1. In Bones cave, tools were lowered to install radiation sensors in the rock.

2. Analysis of humidity and temperature sensors in Gwcihaba cave.

3. Installing the sensors is sometimes acrobatic.

4. The location of the sensors is noted on a map.



5. Photo CBX.



6. Photo VOL.



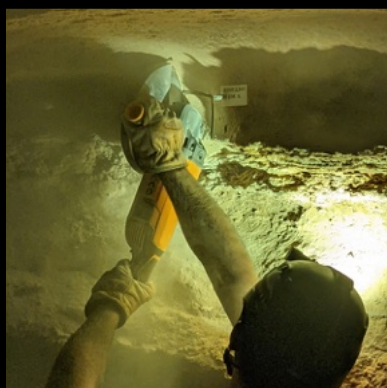
7. Photo CBX.



8. Photo CBX.



9. Photo CBX.



10. Photo CBX.



12 . Photo CBX.



11. Photo CBX.

5. 3D mapping in progress. The spheres are being moved gradually and used as reference points.

6. An ancient stalagmite now exposed in a cave whose ceiling collapsed thousands of years ago.

7. Kim Genuite explains the operation of the device.

8. Kim genuit et gregory Dandurand with 3D scann.

9. Drilling of the wall for installing radioactivity sensors.

10. Limestone sampling for ESR quartz dating.

11. 3D Scanner outdoor Bones cave.

12. Investment sphere mapping.

- **Taphonomy • Rescue**
 - **Salvage • sorting**
- **preventive archaeology**
 - **Stone Age**

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03



Kaï Salas Rossenbach

Concept and general framework of preventive archaeology in France

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This presentation outlines the emergence, legal framework, and current practices of preventive archaeology in France. Born from the limitations of rescue archaeology in the 1970s and 1980s, preventive archaeology integrates archaeological research into development planning, ensuring heritage protection while enabling modern infrastructure growth. The French law of 2001 established the “polluter pays” principle, leading to the creation of Inrap in 2002 as the public institute in charge of diagnostics, excavations, research, and dissemination.

The preventive archaeology process involves multiple stakeholders: the Ministry of Culture (decision-making and oversight), Inrap and local authority departments (diagnostics, excavations, research, public outreach), private companies (excavations and reporting), and developers (financing). The diagnostic (or evaluation, Phase 1) — defined as the rapid assessment of the presence, importance, preservation and dating of archaeological remains on a site prior to construction, in order to determine the potential need for excavation — is a public monopoly, whereas excavations (Phase 2) — full-scale investigations aimed at un-

covering, recording and analysing archaeological data before their destruction by development — are open to market competition. Funding mechanisms include a preventive archaeology tax for diagnostics and direct contracts for excavations. Overall, the annual cost of preventive archaeology represents only about 0.25% of the turnover of new construction in France.

Inrap today employs nearly 2,000 professionals, has carried out more than 45,000 evaluations (diagnostics) and 5,000 excavations since 2002, and publishes over 900 scientific articles annually. Its work spans all chronological periods and themes, from prehistory to the Great War, and includes major urban, territorial, and industrial archaeology projects. Beyond France, Inrap engages in international cooperation, training, and European projects, contributing to global knowledge and skills transfer.

The institute’s mission combines heritage preservation, scientific research, and public engagement, making it one of the leading producers of archaeological knowledge in Europe. □



Decio Muianga

Stone Age archaeology in Southern Mozambique

Decio Muianga^{1,2}

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The Mozambican Stone Age remain poorly explored. Their archaeological heritage is still largely explained in better-known sequences of other southern African countries. Southern Mozambique has a large collection of sites with archaeological evidence related to hunter-gatherers' presence. The lithic assemblages and faunal remains from DAI I and DAIM II rock shelters in Maputo Province have become, apart from the rock art, one of the few sources of explanation for the use of rock shelters in the area. Lithic analysis, environmental reconstitution and different dating methods show that formal and informal tools were produced or used in the area, as part of the hunting and gathering way of life. To build an understanding of the transition between the SA sequence of the region, this research project considers the sequence of the occupation of

the sites based on the typological and chronological features recognized on the lithic and other artefacts. Diagnostic cultural material from the SA at DAIM I and DAIM II strongly suggests a continuity of the hunter-gatherer presence through the Holocene and maintenance of the LSA way of life in the Lebombo Mountain range and surrounding areas. On the other hand, the different technocomplexes identified at the excavations of both rock shelters allow us to infer that MSA and LSA transition was a complex/dynamic process and we should not exclude the possibility of the existence of elements of regional variability in the lithic assemblage. □



Raphaël Hanon

From taphonomy to behaviours: zooarchaeology of the first meat-eaters in Southern Africa

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Diet and its role within our evolutionary lineage, as well as the behaviours associated with it, have always had an important place in the scientific landscape. Hunting and meat consumption have been proposed as major drivers of the encephalization process and the emergence of complex social systems (e.g. food sharing, group hierarchization). However, there is currently no consensus regarding the identification of the oldest traces of butchery or their interpretation in terms of carcass acquisition methods.

Despite an obvious scarcity of the fossil record, the universal image of “Man the hunter” has gradually and deeply anchored itself in the collective imagination. This model was developed around the idea that subsistence behaviours evolved in stages, starting with the first taxa of the Miocene, mainly exploiting the plant

environment, then the hominins of the Early Pliocene prior to the genus *Homo*, very rarely and opportunistically exploiting animal resources, to finally “end” with the emergence of the genus *Homo*, the first true meat eater. As a result, this paradigm accepted today by consensus is built on a linear vision of the evolution of hominin subsistence behaviours, going against the taxonomic “bushiness” observed in the fossil record. New data and research conducted in Southern Africa help testing these hypotheses. □

Rescue/salvage archaeology in Botswana



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Salvage or rescue archaeology is the practice of protecting archaeological sites and objects through non-invasive or minimal excavations. The principle of Salvage Archaeology is to document and recover as much information as possible about archaeological sites that are threatened by development or other activities. This paper examines the origins and current state of salvage archaeology, focusing on methodologies used to conduct excavations methods and legal frameworks governing Salvage Archaeology in Botswana.

The Monuments and Relics Act of 2001 requires pre-development archaeological impact assessments (AIAs) to protect cultural sites and ensure their preservation. Salvage Archaeology involves a collaboration between Archaeologists, developers and government departments to ensure that development projects are carried out responsibly. The paper also highlights the role of archaeological Consultants in Rescue archaeology, the importance of local communities as ethical

considerations, and adaptive management to address the challenges/ limitations such as limited resources. This paper will clearly articulate the process of Archaeological Impact Assessment reporting for Botswana and compare it with that of France to share the best practices. This paper will also describe the techniques used in Salvage Archaeology such as surface salvage and manual excavation. It will conclude by proposing for the necessary actions/ recommendations to mitigate or remedy the situation because Salvage Archaeology is crucial for preserving and understanding our cultural heritage. □

The journey of Gcwihaba caves landscape as a potential 3rd World heritage site for Botswana



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The Gcwihaba Caves landscape conservation area consist of a distributed number of dolomitic hill outcrops, hosting cave systems that are topographically located in the Ngamiland District of Botswana. Even though there are several distinct caves in the landscape, these will be referred collectively as the Gcwihaba Caves landscape for the purpose of the UNESCO potential nomination process. Geologically the landscape area is composed of underlying limestone, marble and dolomite rock formations dating back to the Precambrian era, which are soluble and presents essential conditions for the development of large-scale cavities with potential for trapping fossil remains (e.g. bones, stone tools, e.t.c.).

These caves present several features of 'Outstanding Universal Value' in terms of rare, beautiful with associated secondary cave formations (Stalactites, Stalagmites, Helictites, Soda straws and cave pearls), as well as preserved fossilized carbonate platform systems. Since the discovery of the Main Gcwihaba cave in 1934, there has been discovery of extra new cave systems -through exploration projects- and revelation of new scientific information in the region.

Despite Botswana's rich natural and cultural heritage, since its accession to

the World Heritage Convention in 1998 Convention, Botswana has successfully inscribed only two sites on the World Heritage List: Tsodilo, known as the "Louvre of the Desert," in 2001, and the Okavango Delta, as the 1000th World Heritage site inscribed in 2014.

The Botswana Government have since taken advantage of a UNESCO project aimed at "Supporting Southern African Member States in Increasing the Number of Inscriptions on the World Heritage List." The initiative aims to assist Botswana to focus on building a sustainable, multidisciplinary team capable of independently preparing and managing World Heritage nominations. Botswana has since completed and submitted a Preliminary Assessment Form for Gcwihaba Caves landscape to the World Heritage Centre in September 2024. The State Party of Botswana was further encouraged when Preliminary report received positive response from International Union for Conservation of Nature (IUCN), and with the final verdict expected in October 2025. The country awaits with bated breath for the final verdict to roll out a final nomination dossier for its 3rd World Heritage site in the prestigious World Heritage list. □

The archaeological context of early prehistoric remains in Botswana : Insights from the Makgadikgadi, Kalahari and Tsodilo Landscapes



Philipp Segadika

Philipp Segadika*¹

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Botswana's early prehistoric record has emerged as a key contributor to our understanding of human evolution and adaptive strategies in arid landscapes. This paper synthesizes multidisciplinary archaeological work conducted across three critical regions: the Makgadikgadi basin, the Kalahari interior, and the Tsodilo Hills. Drawing from my published research with Macfarlane in Botswana Notes and Records, which explored artefact-rich surfaces and paleo-lake interactions in the Makgadikgadi, the study integrates findings from a team led by Sheila Coulson and David Thomas highlighting early human behavioral signatures along ancient shorelines. Their use of Chaine Operatoire method and dating of shorelines as well as observations of site occurrences will affect how we determine clearances of permits for developments where we used to think landscapes were barren of sites.

More recent geoarchaeological investigations by the Kiel University team led by Michaela Ecker in the Kalahari deepen the narrative, revealing ephemeral occupation sites and basin-edge activity areas that speak to mobility, resource use, and landscape familiarity in challenging Pleistocene environments. Furthermore, Coulson's ongoing work at Tsodilo contributes symbolic, technological, and stratigraphic data that hints at ritual and possibly spiritual cognition emerging in the Middle and Later Stone Ages in cave deposits. Together, these sites form a mosaic of early lifeways, underscoring the region's archaeological potential to inform continental debates on early Homo sapiens dispersals, desert adaptations, and the emergence of symbolic behavior. The paper calls for integrative frameworks that unite archaeology, paleoecology, geomorphology and intensive public engagement to safeguard these fragile records. □

In search of trans-african technological behaviour patterns in the Pleistocene - archaeological research on the early and middle Stone Age in the eastern desert, Sudan and Okwa valley, Botswana



Grzegorz Michalec

Grzegorz Michalec^{*1}, Cynthia Mooketsi², Phillip Segadika³, Stansilau Shytsik⁴, Thabo Kgosietsile⁵, Read Mapeo⁵, Mirosław Masojć¹

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In 2016-2019, an International research team led by archaeologists from the University of Wrocław conducted a research project (EDAR project) in the Eastern desert of Sudan. The research area is located 70 kilometres to the East of Atbara City, where modern mining activity destroyed the desert landscape. Apart from a few eroded and exposed sites on the surface, most of the Early and Middle Stone Age sites were discovered within mining shafts in a stratigraphical position. The main aim of this project was to determine the chronological framework for human occupation in this area during periods of favourable climatic conditions in the Pleistocene. Furthermore, the research aimed to identify the impact of climatic and environmental changes on the subsistence strategies of hunter-gatherer groups in the Pleistocene, determine the site formation process, and investigate technological behaviours in the Early and Middle Stone Age. In order to check whether climate changes had a similar impact on human activity and occupation in the Pleistocene in another part of the African continent, we decided to start a project in Botswana based on our experience and using similar research methods.

Due to the scarcity of archaeological record so far in the Okwa Valley, we decided to select this area as a potential research area. For this area, the only previously known traces of human activity from the Pleistocene were recorded by Don Aldiss (1987), who during his geological fieldworks, noted the presence of three hand axes discovered near Tswanee Borehol (located near the main road between Ghanzi and Kang).

During our fieldwork, which spanned a few days, we identified a total of 14 sites. These sites, ranging from the Early to Late Stone Age, are scattered across a section approximately 20-30 kilometres east and west of the A2 highway crossing the Okwa Valley. The lower density of vegetation and the impact of erosion processes in this area facilitated the exposure of the sites on the surface of the terrain. Some of the sites were discovered on eroded slopes of the valley, while the rest were found on flattened ridges. The diverse raw material structure of the discovered stone artefacts, including silcrete, sandstone, mudstone, and quartz, suggests the use of different types of rocks depending on the availability of their outcrops in different periods. □



1. Photo CBX.



2. Photo CBX.



3. Photo VOL.



4. Photo VOL.

1. Bones sorting session at Gcwihaba campus.
2. The excavators use dental tools to sort.
3. The sieves each weigh several kilograms, to which must be added the weight of the sediments.
4. meticulous work to separate the fossils from the sediments.



5. Photo VOL.



6. Photo VOL.



7. Photo VOL.



8. Photo VOL.



9. Photo CBX.



10. Photo CBX.



12 . Photo CBX.



11. Photo CBX.

5. The residents of Xaï Xaï came to lend a hand at Koanaka hills.

6. Pierre Linchamps in bones sorting session.

7. Being a specialist in microfauna requires having good eyesight.

8. Francis Duranthon at the sediment reception area at the bottom of Bones cave.

9. Francis Duranthon and One Tshukudu during a sorting session.

10. A tedious but necessary task.

11. A bush acid lab was set up to extract bones from the limestone.

12. Jean-Baptiste Fourvel extracts the jawbone of a small carnivore in the corridor of Gcwihaba cave.

**• Geomorphology •
dolomite • ghost-rock •
karstic breccia
• fossiliferous caves**

...



04



Manoah Muchanga

Geomorphology of Zambia, potential for fossiliferous caves: challenges and opportunities

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Zambia's Geomorphology is characterized by a complex interplay of tectonic, climatic, and erosional processes that have shaped its landscape over millions to thousands of years during the Plio-Pleistocene-Holocene Periods. The country features diverse geological formations, including ancient Precambrian rocks, sedimentary basins, and karst landscapes, which provide significant insight into its geomorphological evolution. Key geomorphological features include plateaus, river valleys, and prominent escarpments, notably the East African Rift System in the north and the Zambezi River Basin in the south. The region's karst topography, particularly in areas such as the Barotse Floodplain and parts of the Kafue Basin, presents potential for the development of fossiliferous caves. These caves are likely to preserve a wealth of paleontological and archaeological material due to the region's stable climatic conditions and ongoing geomorphological processes that favour cave formation. Given the geological diversity and the presence of limestone formations prone to dissolution, Zambia's karst landscapes exhibit considerable potential for undiscovered

fossil sites. Notwithstanding the enormous distribution of caves across the country and potential for scientific studies in caves, there still remains an imposing geomorphic knowledge gap around caves, which in most cases are just treated as foreign tourists' sites in Zambian context.

This paper explores Zambia's geomorphological context and assesses the prospects for fossiliferous cave systems within the country, emphasizing the implications for paleontological research and the preservation of fossil records with the aid of three snapshot case studies from Leopard's Hill, Chipongwe and Kapongo Caves in Lusaka. □



Bastien Chadelle

Dolomite outcrops, mapping and potential survey

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The caves that preserve ancient fossil fills are located in outcropping carbonate formations whose geological history is potentially very long. In the Cradle of Humankind and Makapansgat, the fossil caves were formed in dolomites dating from the Paleoproterozoic (-2588 Ma). These dolomites can reach 1500 m in thickness in non-eroded and non-karstified areas. In Botswana, the caves explored at Lobatse are located in dolomites that are found in the same Paleoproterozoic marine basin that measures 500 km by 300 km.

To locate other potentially karstified carbonate formations, the study of geological maps is essential. These maps are available at various scales (1/10M for Africa - CGMW BRGM 2016; 1/1M for South Africa - 2019; 1/1.5M for Botswana -1998; etc.), and in varied formats: vectorized or raster (requiring high-quality scans). We compiled these data using GIS (Geographic Information System) software (Chadelle and Bruxelles, 2022).

The main objective of my PhD is to conduct a geomorphological analysis of these formations using GIS (calculation of slopes, shading, etc.) to assess their de-

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Gregory Dandurand

Ghost-rocks in Southern Africa First evidence of ghost-rock in Botswana

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The search for ancient hominin fossils, covering the period between -4 and -1 million years ago, in the Ngamiland region of north-western Botswana, led us to prospect several groups of low karstic hills, the Aha Hills, the Gcwihaba Hills and the Koanaka Hills, which form a series of marble and dolomite patches in the Kalahari landscape. Long before they were partially covered by eolian red sands during the Quaternary period, these carbonate outcrops were intensely karstified. And it's precisely in the core of these karst hills that huge networks of interconnected underground galleries and chambers develop at depths of around 30-40 m. Over the last few years, a better understanding of the formation and evolution of these caves has become one of the keys to understanding how these karstic traps function in the long term.

The exploration of numerous caves has enabled us to understand that they have a very ancient origin. Although they are all located on karstic hills, they do not all have the same appearance. To sum up, there are two types of cave: those that open onto the surface and can be accessed via a natural entrance of varying

size, from a narrow shaft to a porch several dozen meters wide; and then there are caves that have no connection with the surface. They are totally confined. They're like blind caves. In these particular caves, we identified some of the most spectacular examples of ghost-rock type speleogenesis. This geological phenomenon was previously unknown in this part of the world. For the very first time, following the example of studies previously carried out in South Africa, we were able to demonstrate the role of ghost-rock in the formation of Botswana's caves.

The dolomitic marbles of the Precambrian (800-600 Ma) are made up of over 6,000 metres of limestone and dolomitic strata (Damara formation), interrupted by limestone beds. Folding caused by the Pan-African orogeny, which developed over a very long period between 800-900 Ma and 460 Ma, affected the carbonate beds with a dense network of fractures and diclases. These fractures and diclases enabled a very slow circulation of groundwater, which in turn favored chemical alteration of the bedrock. The carbonate mass is literally immersed in water. We're in the phreatic zone. The product of this alteration of ge-

ological strata at different depths is a black, decayed, decarbonated rock that is extremely porous, powdery and crumbly. This is what we call “ghost-rock”. In all the confined caves we've explored, gigantic volumes of ghost-rock are recognizable, still in place and crossed by beds of limestone also in situ and in continuation with the healthy rock.

This phenomenon can be compared to a real preparation for the formation of karstic voids. When the water table is lowered, these altered zones are preferentially and rapidly removed by runoff or vacuum. Very fragile, this black alterite is still being drained in the lower parts of the networks. But evidence of it can also be found in caves connected to the surface, notably in dead-end galleries, both at the ceiling and along the walls. It therefore appears that most of the volume of the underground networks was initially composed of ghost-rock, and that a significant part of the initial voids were formed by the settling and/or removal of the alterite, which may have been substituted by Kalahari red sands.

This removal process took place as the hydrographic network slowly deepened, and the omiramba, the dry valleys that incise the plateaus over variable lengths, are today's only morphological witnesses. This incision has shaped the evolution of the landscape for several million years. Then, as the slopes retreated and the karstic surface lowered, these underground voids were successively cut through, allowing the caves to open up and connect directly with the surface. From this point, the caves could be used as traps for fauna living close to the entrance. Vegetation debris, animal falls and the intrusion of sediments and collapsed blocks from the walls and ceiling gradually accumulated and fossilized the bone remains. Thus, wherever breccias are observed, whether ossiferous or not, we systematically find the remains of the in situ ghost-rock. This type of geological feature is therefore a very good marker of karst that has functioned over the long term and could potentially have trapped ancient hominins. □



Oaitse Ledimo

Gcwihaba Caves Exploration Project : Subterranean Discoveries and Research Potential

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This abstract details the findings from the Gcwihaba Caves Exploration Project (GCEP), a multifaceted initiative aimed at discovering new cave passages and enhancing access to unseen before cave systems for exploration, research understanding and tourism potential. The Gcwihaba caves is located in the North Western part of Botswana, within the Ngamiland District. The Department of National Museum as custodians of culture and natural heritage have since demarcated 4 areas of conservation of cave resources for management, research and sustainable developmental projects to benefit local communities.

The Gcwihaba Caves exploration project (2005 to 2018) was aimed at exploring for new caverns at both the Gcwihaba and Koanaka hills catchment areas. The initial phase of the project involved the manual excavation of Kalahari sands, with a human chain removing sediment from an existing cavity to the surface. This labor-intensive tunneling method was implemented to follow potential connecting tunnels between known sections of the cave system. Following this initial stage, a

gravimetric survey was conducted to identify larger, undiscovered subterranean voids. The survey results guided the next phase, which involved targeted drilling to gain access to these anomalies. Small-diameter test drills were first used to confirm the presence of open cavities, followed by the drilling of three larger, 100 mm circumference boreholes. These boreholes successfully accessed three distinct cave anomalies.

Subsequent exploration of these new chambers was conducted by a team of cavers trained in specialized techniques, including rope work, caving rescue, and safety protocols. Significant challenges faced during the exploration included low air quality due to high carbon dioxide concentrations, confined spaces in narrow passages, the presence of snakes, and unstable ground conditions.

The project successfully exposed three hundred meters of new tunnel through manual excavation at Gcwihaba and provided access to three separate, large cave anomalies via boreholes at Gcwihaba and Koanaka. The successful exploration of these newly discovered

caves has led to the development of a Master Plan (NG4 integrated management plan) to advice on implementation of future cave developments. Gcwihaba Caves national monument landscape has been inscribed in to the Botswana's UNESCO Tentative World Heritage list since 2010 and the NG4 Integrated Management Plan of 2001 was designed to consider all factors (including GCEP) to enable listing of the Gcwihaba caves landscape into the UNESCO world heritage site. Recommendations from the management plan included the implementa-

tion of interdisciplinary researches to gather more comprehensive data, which is essential for prioritizing areas for either scientific study or tourism development.

The Botswana Karst research project (2019 - Current) has since filled the research gap by providing valuable research information which will be useful in preparation of the nomination dossier for the Gcwihaba caves landscape after the successful submission for UNESCO Preliminary Assessment form in September 2024. 



Seke Katsamudanga

Karstic breccia research in Zimbabwe: the state of affairs

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The exploration of Karstic landscapes in Zimbabwe for the purposes of recovering evidence that contributes to the story of human evolution has been patchy. While there is palaeontological and archaeological evidence in the two regions of East African Rift Valley and the Cradle of Humankind in South Africa, Zimbabwe presents a glaring gap that should connect these regions. We present here the state of karstic and palaeosciences research in Zimbabwe and results of recent efforts to find evidence of Plio-Pleistocene and Pleistocene hominins in the country. A collaborative interdisciplinary research project involving the University of Witwatersrand, CNRS, and the University of Zimbabwe and bringing together Stone Age archaeology, zooarchaeology, geology, and geography has demonstrated the potential to recover hominin evidence from the karstic caves in Zimbabwe. There are numerous karstic caves in dolomitic areas, particularly in Mashonaland West province the northwestern parts of the

country, that had remained understudied. Highlighting the importance of data from deep caves could provide insights not only into human evolution but also into broader issues such as climate change, agriculture, health sciences and ecotourism. Looking into the future, there is an urgent need to enhance palaeosciences research in Zimbabwe through collaborations with both local and international institutions. Accelerated research in this area is essential, particularly as some of the potential sites are threatened by guano extraction. Training researchers in speleology and adopting innovative technologies and methodologies can significantly contribute to filling the gaps in our understanding of hominins. By prioritizing this area of research, Zimbabwe will enrich the global narrative of human evolution and address the existing knowledge voids in that story. □



1. Photo LBX.



2. Photo LBX.



4. Photo LBX.



3. Photo LBX.

1. In Diviners Cave, a closed-cycle condensation-evaporation phenomenon is observed.

2. Blue cave was formed by ghosting.

3. Exploration of North Whaxhou, which remains incomplete due to lack of rope.

4. Gregory Dandurand in Fossil cave.



5. Photo LBX.



6. Photo LBX.



7. Photo LBX.



8. Photo LBX.



9. Photo VOL.



10. Photo LBX.



12 . Photo LBX.



11. Photo CBX.

5. Biocorrosion is at work in Gcwihaba cave.

6. In the Diviners cave network.

7. Bastien Chadelle documents the geomorphological formation of Fossil Cave.

8. Stratification by period in Bones cave.

9. Ascent of the fossil cave pipe, 45m deep. The rope progression depending on the speleologist.

10. Depart from the Diviners cave pipe.

11. In Gecko Chamber.

12. On the scree cone of southern Wax-hou, natural light can be seen at the ceiling.

The organizing Committee of this 1st International Paleontology Conference would like to extend its gratitude to all the Sponsors and delegates of this event.



Editions Human and Karst Institute

ISBN : 979-10-987260-0-2

