Proceedings of the 19th Biennial Conference of the Palaeontological Society of Southern Africa, Stellenbosch, 5–9 July 2016

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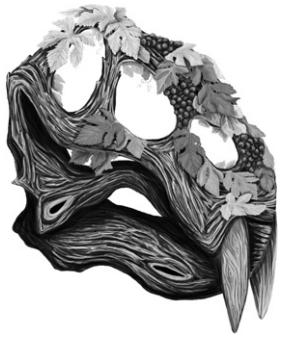

19th Biennial Conference of the Palaeontological Society of Southern Africa Stellenbosch, 5–9 July 2016

Organizers and acknowledgements

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Organizing Committee Chairs: Tucker, R.T., Choiniere, J.N., Chapelle, K.E.J., Jinnah, Z., Roberts, E.M. & Bamford, M.K.

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We also wish to thank Triggerfish Brewery, Camberley Wines, Twaalf, Nooitgedacht Wine Farms, Darling Brewery, Stellenbrau and Blitz Braais for hosting our events.

The logo of the PSSA 2016 Conference and other sketches depict the integrations of the Western Cape Winelands and the Palaeontological Society of Southern Africa. All drafts were the production of palaeoartist Dr Owen Li of Petrified Pencils, NSW, Australia.

Programme

Monday July 4

Ice Breaker & Registration
Triggerfish Brewery (Somerset West)
Begins at 5:30 pm

Tuesday, July 5

7:45 am Prestart coffee

8:15 am *Opening Remarks*: Deputy Vice Chancellor Research Prof. Eugene Cloete

Symposium: New Approaches to Biostratigraphy in the Karoo Basin

8:45 am *Plenary Talk:* Dr Roger Benson
9:15 am Rubidge, B.S.
9:30 am Day, M.O.
9:45 am Viglietti, P.A.
10:00 am Jirah, S.
10:15 am Groenewald, G.

Tea 10:30–11:00 am

11:00 am Van den Brandt, M.J.
11:15 am Butler, R.
11:30 am Hancox, P.J.
11:45 am Muir, R.

Lunch 12:00–1:00 pm

General Session

1:00 pm Iqbal, S.
1:15 pm Master, S.
1:30 pm Norton, L.A.
1:45 pm Welman, J.
2:00 pm McPhee, B.W.
2:15 pm Dinter, C.M.

Tea 2:30–3:00 pm

3:00 pm Wiersma, J.

Symposium: Virtual Palaeontology

3:15 pm *Plenary Talk:* Dr Vincent Fernandez
3:45 pm Du Plessis A.
4:00 pm Jakata, K.
4:15 pm Reid, M.
4:30 pm Araújo, R.
4:45 pm Benoit, J.
5:00 pm Dollman, K.N.
5:15 pm Staunton, C.K.
5:30 pm Chapelle, K.E.J.
5:45 pm Choiniere, J.N.

Poster Session – 6.45 pm

Bowen, D.
Canoville, A.
Duhamel, A.
Durugbo, E.U.
Engelbrecht, M.
Galimberti, M.
Gess, R.W.
Haupt, T.
Master, S.
Montoya-Sanhueza G.
Rammutla, R.T.
Singh, M.
Stynder, D.
Thackeray, J.F.
Von Der Meden, J.
Zanolli, C.

Wednesday, July 6

7:45 am Prestart coffee
8:30 am Opening

Symposium: Sedimentary Influences on the Fossil Record

8:45 am *Plenary Talk:* Dr Eric Roberts
9:15 am Rogers, R.
9:30 am Sciscio, L.
9:45 am Hilbert-Wolf, H.L.
10:00 am Smith, R.M.H.
10:15 am Bordy, E.M.

Tea 10:30–11:00 am

11:00 am Mtelela, C.
11:15 am Abrahams, M.
11:30 am Bergh, E.W.
11:45 am Penn-Clarke, C.

Lunch 12:00–1:00 pm

1:00 pm Browning, C.
1:15 pm Clayton, K.E.

Symposium: Karstic Palaeontology

1:30 pm *Plenary Talk:* Dr Paul Dirks
1:45 pm Couzens, R.A.
2:00 pm Venter, C.
2:15 pm Pickering, R.

Tea 2:30–3:00 pm

3:00 pm Kruger, A.
3:15 pm Parkinson, A.H.
3:30 pm van Dijk, E.
3:45 pm Bamford, M.K.
4:00 pm Botha-Brink, J.
4:15 pm Matiwane, A.
4:30 pm Prevec, R.
5:00 pm Anderson, H.M.
5:15 pm Master, S.
5:30 pm Mahabeer, K.
5:45 pm Barbolini, N.

Conference Keynote Address

6:45 pm Prof. Raymond Rogers

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Thursday, July 7

7:45 am Prestart coffee

8:30 am Opening

Symposium: Hominin Evolution

8:45 am *Plenary Talk:* Dr Jose Braga

9:15 am Stratford, D.

9:45 am Ngoloyi, N.

10:00 am Zipfel, B.

10:15 am Cazenave, M.

Tea 10:30–11:00 am

11:00 am Phillips, C.A.

11:15 am Lennox, S.J.

11:30 am Ritzman, T.

11:45 am Krummeck, D.W.

Lunch 12:00–1:00 pm

Symposium: Palaeosciences, Education, and Outreach

1:00 pm *Plenary Talk:* Dr Andrew Farke

1:30 pm McKay, I.J.

1:45 pm Tawane, G.M.

2:00 pm Bergh, E.W.

2:15 pm Haarhoff, P.J.

Tea 2:30–3:00 pm

3:00 pm Mudau, M.A.M.

3:15 pm Wentzel, W.A.

3:30 pm Anderson, H.M.

General Session

3:45 pm Gess, R.W.

4:00 pm Matthews, T.

4:15 pm Harrison, B.

4:30 pm Stynder, D.D.

4:45 pm Mann, N.J.

5:00 pm Govender, R.

5:15 pm Neumann, F.H.

5:30 pm Cohen, B.F.

Friday, July 8

7:45 am Prestart coffee

8:15 am Opening Centre of Excellence, Palaeosciences Program Director Dr Christine Steininger

Symposium: Vertebrate Histology & Microanatomy

8:45 am *Plenary Talk:* Dr Kristina Curry Rogers

9:15 am Canoville, A.

9:30 am Shelton, C.

9:45 am Legendre, L.J.

10:00 am Krupandan, E.

10:15 am Chinsamy, A.

Tea 10:30–11:00 am

11:00 am Groenewald, G.

11:15 am Angst, D.

11:30 am Montoya-Sanhueza, G.

11:45 am Rey, K.

Lunch 12:00–1:00 pm

General Session

1:00 pm Lavin, J.

1:15 pm Redelstorff, R.

Biennial General Meeting

1:30 pm Prof. Marion Bamford, President's address

End of Conference Awards & Dinner

Begins at 6:30 pm

Saturday, July 9

Field Trip: Langebaan Fossil Park

Begins at 7:00 am

Keynote Address

Twenty years of palaeontological adventure and discovery on the Great Red Island, Madagascar

Professor Raymond Rogers

Geology Department, Macalester College, St. Paul, Minnesota, U.S.A.

Approximately 180 million years ago, the supercontinent Gondwana began to fragment into isolated landmasses. The island of Madagascar was initally positioned in the center of Gondwana, nestled between mainland Africa and India. But by ~85 million years ago powerful geological forces had left Madagascar isolated, as it is today, in the Indian Ocean. For the past 20 years, over the course of eight eventful expeditions, I have worked as the geologist and taphonomist for the Mahajanga Basin Project (MBP), a multinational, multi-institutional team of researchers devoted to exploring the fossil and rock records of Madagascar.

Over the years, the MBP team has documented an amazing menagerie of extinct animals, including fishes, frogs, turtles, lizards, snakes, crocodyliforms, nonavian dinosaurs, birds, and mammals. In this plenary talk we will explore some of the highlights of the MBP, including (1) a meat-eating dinosaur that practiced cannibalism (the theropod *Majungasaurus*), (2) baby dinosaurs, no bigger than a Golden Retriever, that grew to immense adult size (the sauropod *Rapetosaurus*), (3) pug-nosed, plant-eating crocodiles (*Simosuchus*), and bizarre little mammals (*Vintana*). We will also investigate why ancient Cretaceous rocks of Madagascar yield so many fantastic fossils. Interestingly, the majority of the exquisitely preserved vertebrate fossils of Madagascar show evidence of dying during stressful environmental episodes, such as droughts (drought is a major killing agent in Africa to this day). When the rains returned, the dead were entombed within debris flow deposits that shielded animal remains from destructive surface processes and ushered them into the fossil record.

Funding acknowledgement: Provided by National Science Foundation (EAR-0446488, EAR-1123642), the National Geographic Society (8597-09), and Macalester College.

Plenary Talk

Tetrapod diversification and sampling in the Karoo Basin, and the world

Benson, R.[1], Day, M.O.[2], Rubidge, B.[2], Butler, R.[3], Carrano, M.[4], Alroy, J.[5]

[1]*Department of Earth Sciences, University of Oxford, U.K.*

[2]*Evolutionary Studies Institute, University of the Witwatersrand, Johannesburg, South Africa*

[3]*School of Geography, Earth and Environmental Sciences, University of Birmingham, U.K.*

[4]*Department of Paleobiology, Smithsonian Institution, Washington DC, U.S.A..*

[5]*Department of Biological Sciences, Macquarie University, Sydney, Australia*

Biostratigraphy is a core application of fossil data, with wide utility across evolutionary biology and the earth sciences. Despite its long history, biostratigraphic research remains a dynamic field of investigation. High-resolution field studies continue to yield insight on the stratigraphic column. Parallel advances in global fossil occurrence databases (https://paleobiodb.org) and quantitative analytical methods are providing significant insights into the timing and causes of faunal turnover in deep time. The Karoo Basin of South Africa has become a model system for terrestrial biostratigraphy, containing thousands of tetrapod specimens, and contributing seminal information on major events in the evolution of terrestrial ecosystems. This includes extinction and recovery around the Middle/Late Permian transition. Preservation of fossil-bearing deposits is uneven in time and space. Furthermore, the available fossil record is unevenly sampled. These factors bias inferences of ancient biodiversity, and of speciation and extinction rates at both global and regional levels. Bias is more pervasive than commonly conceived, and even those studies that attempt to correct them have typically presented continuous, 'global' time series of fossil diversity, giving an inflated impression of our knowledge of deep time diversity. Using a near-complete database of Mesozoic–Palaeocene tetrapod occurrences, we show that there is no such thing as the 'global' fossil record. Instead, the record comprises patchily distributed regional windows on diversity. This will seem obvious to some palaeontologists, and provides an important message: that statistical analyses of global databases are only useful if they explicitly analyse this patchwork of regions. When analysed as such, the inferred pattern of Mesozoic tetrapod diversity appears relatively static, with low long-term rates of increase. This differs entirely from previous notions of substantial and unbounded diversification in Mesozoic tetrapods. A key role for high-resolution regional databases should be recognized. In this context, we present analysis of 3500 occurrences of Middle Permian–early Late Permian tetrapod fossils from the Karroo Basin. Sampling-informed measures indicate high extinction rates near the top of the *Tapinocephalus* AZ. Subsequent recovery was delayed: the *Pristerognathus* AZ is a protracted interval of low diversity, with high rates of origination only in its upper part. We anticipate that further documentation and study of the Karoo succession will continue to yield substantial further insights.

Plenary Talk

Synchrotron radiation-based science

Fernandez, V.

European Synchrotron Radiation Facility, 71 avenue des Martyrs, 38000 Grenoble, France

Synchrotron has become a more and more popular tool for palaeontological investigation since the advent of the 21st century. A synchrotron is simply a ring-shaped particle accelerator generating X-rays, surrounded by experimental hutches in which a variety of studies can be conducted. Most common in palaeontological investigations are the use of X-rays for computed tomography – that is producing 3D images from X-ray slices through a fossil. Although CT methods are available in labs worldwide, the synchrotron beam has distinct advantages, primarily in its intensity. This progressively opens the gate to observing matter in the nano-world at resolutions not previously achievable. With such assets, synchrotrons are optimized for use in a broad variety of applications, whether it is to understand how a material evolves under certain pressure and temperature conditions, or to visualize protein structure at the atomic level. While the European synchrotron was built to facilitate research from scientists of member countries, there has also been a growing interest from African researchers, notably in South Africa that joined the coalition in 2013 as scientific associate. With the growing synchrotron user community from African countries, a Steering Committee was elected at the end of 2015 to initiate the process leading to the construction of the first light source in Africa. By continuing to scan rare and unique fossils, progressively replacing crucial but invasive techniques (such as virtual histology) and keeping on learning other synchrotron techniques to apply them in our domain, African palaeontologists have an important role to play in the prospect to see a synchrotron emerge on their continent.

Plenary Talk

Revisiting Jurassic–Cretaceous fossil localities in the Mana Pools Basin and Mid-Zambezi Rift, Zimbabwe: new discoveries and sedimentological and taphonomic insights

Roberts, E.M.[1], Broderick, T.[2], Munyikwa, D.[3], O'Connor, P.[4], Carrano, M.[5], Dirks, P.[1], Jinnah, Z.[6], Stevens, N.[4], Owusu Agyemang, P.[1]

[1]*James Cook University, Australia*

[2]*Harare, Zimbabwe*

[3]*National Museums and Monuments of Zimbabwe (Natural History Museum)*

[4]*Ohio University, U.S.A.*

[5]*Smithsonian Institution, U.S.A.*

[6]*University of the Witwatersrand, South Africa*

Three expeditions were conducted between 2007 and 2010 in the Zambezi Valley, which focused on revisiting historic dinosaur fossil localities in the Mana Pools and Mid-Zambezi basins, northern Zimbabwe. In Mana Pools National Park, excavation of a spectacular Early Jurassic bonebed (laterally correlative to the bonebed excavated by M. Raath in the late 1970s) containing associated to partially articulated remains of *Syntarsus rhodesiensis* was conducted, and a number of other new fossil localities were discovered, including the site of a beautifully preserved partial skeleton of a small prosauropod dinosaur. Most of the jackets containing the dinosaur material have now been prepared (nearly doubling the amount of material known for *Syntarsus rhodesiensis*), and detailed analysis of the taphonomy and palaeobiology of both sites is underway. Additional exploration was conducted in the Chewore Safari Area, including mapping of a new large sauropod trackway along the Ntumbe River and discovery of abundant partially preserved fish fossils from the Ntumbe beds. Detailed sedimentological, biostratigraphic and provenance investigation of sites from both the Mana Pools and Chewore areas have now been completed, which yield new insights into the age, depositional environments, regional tectonics and palaeofluvial drainage evolution of the Mid-Zambezi Rift System. An update and summary of these findings will be presented.

Funding acknowledgement: We acknowledge the National Geographic Society-CRE and the Jurassic Foundation for supporting this research. We also acknowledge the University of Zimbabwe for their technical support and use of equipment and vehicle rental. James Cook University provided E.M.R. with a small faculty grant to conduct U-Pb detrital zircon geochronology.

Plenary Talk

Tiny titanosaurs: primary growth and early ontogeny in a very young sauropod from Madagascar

Rogers, K.C.

Departments of Geology and Biology, Macalester College, Minnesota, U.S.A.

Sauropods began their lives as tiny animals and exhibit an ontogenetic size difference between hatchlings and adults greater than that for any other terrestrial vertebrate. The lack of data for perinatal sauropods hampers our understanding of the strategies that allowed them to achieve such astounding changes in size. Here I describe a very young specimen of *Rapetosaurus krausei* that represents one of the smallest post-hatching sauropods yet recovered. The perinatal specimen is represented by associated elements from the forelimb, hindlimb, pelvic girdle, and vertebral column. Limb element lengths indicate that this very young juvenile stood ~35 cm at the hip, and may have weighed as little as ~25 kg. In spite of its very small body size, limb elements do not exhibit significant differences from later stage juvenile and adult morphology and generally scale isometrically as documented for other sauropod taxa. Bone histological and microCT data indicate that young *Rapetosaurus* grew very quickly, but that this fast growth coincided with an early onset of bone remodelling that extends into the mid-cortex of all sampled appendicular elements. LAGs and annuli are absent, but an intracortical zonation indicates a post-hatching growth hiatus similar to hatching lines in reptiles and neonatal lines in birds. *Rapetosaurus* hatching lines provide a lower limit for body size in this titanosaur. Remodelling may be related to a phylogenetic shift in titanosaur growth strategies, to biomechanical loading, to blood calcium homeostasis, or to a combination of all three. Epiphyseal regions comprise zones of calcified cartilage perforated by tubes lined with newly formed bone tissue. These zones are thinner than in other perinatal dinosaurs and could indicate relatively slow elongation of limb bones, but is inconsistent with observed rapid appositional growth and frequency of secondary remodelling. These data combined with the taphonomy and palaeoenvironmental context of the Maevarano Formation support the hypothesis that *Rapetosaurus* were nidifugous (precocial), probably not reliant on significant postnatal parental care, and died just a few weeks after hatching as a victim of Late Cretaceous drought stress in ancient Madagascar.

Plenary Talk

Digital palaeontology for outreach and education: moving from promise to practice

Farke, A.A.

Raymond M. Alf Museum of Paleontology, Claremont, CA 91711, U.S.A.

Three-dimensional digitization of fossils has moved from a flashy novelty to a standard tool for palaeontological research. In addition to immediate research needs, digitization efforts are often promoted as beneficial for outreach and education, by allowing broader access to specimens in museum collections. Yet, it remains difficult to truly bring fossils to the masses. Despite the increasing variety of digitization methods, it can still be time-consuming and often expensive to model large numbers of specimens. Many important digitized fossils remain unavailable for broader access, variously due to researcher and museum desires to restrict distribution or technological difficulties in archiving and distributing data. Even when digital fossils are accessible, it takes effort to alert the public to their availability as well as to create meaningful educational opportunities around the specimens. Disparities in access to technology affect institutions, researchers, educators and the public alike. If digital fossils are to achieve their full potential as research and educational tools, solutions to all of these problems must be implemented. First and foremost, a culture shift within the scientific community is required to encourage and reward active sharing of digital data. Improvements in technological infrastructure, via websites such as MorphoSource, contribute positively to this. For usage in formal and informal education settings, access to technology (or creative work-arounds) is key. Furthermore, continued development of standards-based lesson plans using digital fossils is also necessary. Ongoing work by numerous parties shows considerable promise for expanding use of digital fossils in education and outreach.

Plenary Talk

The Kromdraai Research Project: new discoveries

Braga, J.[1], Thackeray, J.F.[2]

[1]*University of Toulouse, CNRS, France*

[2]*Evolutionary Studies Institute, University of the Witwatersrand*

The Plio-Pleistocene site of Kromdraai (Gauteng, South Africa) is of interest because the dentally and cranially more generalized states shown by some of its 27 hominins recovered until 2014 and not displayed by other southern African congenerics sampled thus far, may lie close to the origin of a putative *Paranthropus* monophyletic clade close to or before 2.3 Ma. However, current scenarios consider that *Paranthropus* did not occur in southern Africa prior to 2.0 Ma. Fieldwork undertaken since 2014 by the Kromdraai Research Project (KRP), as well as laboratory work on newly and previously discovered KB fossils, (i) demonstrate the much larger size of the Kromdraai site through the exposure of extensive and until then unexplored fossiliferous deposits; (ii) recovered as yet (until March 2016) more than 2000 identifiable macrovertebrate fossils, including 22 new hominins, all from the earliest part of the Kromdraai stratigraphic sequence from Member 1 to Member 3; (iii) established relative chronological relationships between Kromdraai A and B localities; (iv) initiated revised taxonomic, phylogenetic and taphonomic interpretations of the Kromdraai fossils by more precisely taking into account the context of their discovery (i.e. stratigraphic provenience or not), and by using computer-assisted 3D imaging methods and recent advances in 3D morphometry. These exciting new discoveries lead to increasing the timeline of hominins at this site, with the recognition of hominin-bearing sediments lower than Member 3 that might register a continuation from Sterkfontein Member 4 to the succeeding phases represented by Swartkrans Member 1 and Sterkfontein Member 5.

Funding acknowledgement: This work is supported by the Institut des Déserts et des Steppes, the French Ministry of Foreign Affairs, the CNRS and the NRF.

Plenary Talk

About the landscape, caves and fossils in the Cradle of Humankind; what determines their presence

Dirks, P.

Department of Geosciences, College of Science & Engineering, James Cook University, Townsville, Queensland 4811, Australia

Why do fossils end up in caves and why are they preserved? Is the chain of events that led to fossilization simply dependent on chance due to the occasional convergence of suitable circumstance, or is the process more specific, and in part systemic and predictable? The answer to these questions lies not simply in the behavioural patterns of the animals involved, and how they interacted with the landscape. There are also a range of physical processes, climate variability, landscape dynamics, and cave formation, as the most obvious ones, that influenced fossil deposition.

In this talk I would like to inspect the relationship between hominid fossil deposits and the caves and landscapes in the Cradle of Humankind (CoH) in which they occur, to determine to what degree the physical environment facilitated fossil formation, preservation and variations therein.Caves in the CoH occur in dolomite, and their formation and exposure is the result of erosion and tectonics. Cosmogenic isotope dating in the CoH indicate erosion rates of 2–3 m/Ma, and suggests that the caves are younger than 4 Ma. In combination with other dating techniques and knowledge of cave geometries it appears that most caves formed sometime between 2–3 Ma and, as the climate changed, may have been relatively inactive (except as fossil depositories) after that. Caves with macrofossils are not randomly distributed, but relate to a range of topographic and geological controls such as terrain roughness, slope direction, faulting and proximity to water sources, which allows for the construction of fossil prospectivity maps. Fossil deposits also appear to vary depending on their position on the landscape (e.g. breccia-dominated deposits away from river courses; mud-dominated deposits near river courses). New species like *A. sediba* and *H. naledi* come from non-traditional deposits and suggest a high degree of localized niche behaviour by hominins. Whilst fossil distribution can be linked to landscape-scale processes; fossil preservation is a function of the cave environment itself. Within individual caves, it can be observed that fossil deposits occur intermittently separated by depositional non-conformities commonly decorated with flowstone. Of particular interest is evidence of event horizons in the sedimentary sequence that link to fossil deposits and reflect sudden and dramatic changes to the cave environment. These changes could be externally driven (e.g. a climate event) or internal to the cave (e.g. chamber collapse). Of note are the association of fossil deposits with geological anomalies such as quartz veins or palaeomagnetic reversals.

Conference Abstracts

Tridactyl dinosaur trackways in the Lower Jurassic upper Elliot Formation near Lephoto village (Roma, Maseru District, Lesotho)

Abrahams, M.[1], Bordy, E.M.[1], Sciscio, L.[1], Knoll, F.[2,3]

[1]*Department of Geological Sciences, University of Cape Town, 7701 South Africa*

[2]*School of Earth, Atmospheric and Environmental Sciences, University of Manchester, Manchester, U.K.*

[3]*School of Earth Sciences, University of Bristol, Bristol, U.K.*

Footprint morphology (outline, shape, impression depth) is a principal feature used to interpret vertebrate tracks. The upper Elliot Formation is well known for the wealth of Early Jurassic footprint sites and their different morphologies. Recent fieldwork on previously reported but unstudied footprint localities within the Lower Jurassic upper Elliot Formation at Roma (Maseru District, Lesotho) has revealed approximately 40 footprints on a single 4 m^2 slab near Lephoto village. These tracks vary in size and make up thee distinct track-ways. Morphologically the footprints are tridactyl, with divergent curvature of the digits and pointy tips with some prints preserving digital pad impressions and claw marks. The tridactyl prints can be subdivided by size due to low morphological variation. These split the tracks into two groups, smaller (6 cm length) footprints and larger (16 cm length) footprints. Trackways illustrate three individuals walking in E–W and W–E directions. Although preservation of the slab and the associated sedimentological structures (e.g. ripple marks and dessication cracks) is good, it is unclear as to whether or not the footprints are true-tracks or under-tracks. The footprints can be attributed to theropod track-makers based on the following criteria: a) the absence of manus impressions which is suggestive of bipeds, b) the impressions are long rather than broad and c) the digits are asymmetrical, long and slender.

Funding acknowledgement: The financial support of the DST-NRF Centre of Excellence in Palaeosciences (CoE in Palaeosciences) and NRF Competitive Programme for Rated Researchers to E.M.B. towards this research is hereby acknowledged.

Generic and specific concepts in Molteno and Gondwana palaeobotany

Anderson, H.M.

Honorary Research Associate, Evolutionary Studies Institute, University of the Witwatersrand, Johannesburg

An historical perspective is provided of the development of the 'Palaeodeme' concept and its application to the study of fossil plants from the Molteno Formation as undertaken by John Anderson and myself. The palaeodeme was the subject of a presentation at the first PSSA meeting in the early 1970s. Now 45 years on we still have the same problems in palaeobotany and a novice researcher could well be asking the same question I once asked. How does one define the variable leaves of the genus *Dicroidium* – as one or as six genera and decide on a multitude of specific names? How does one communicate with researchers from the various Gondwana continents if the same definitions are not used? One may ask 'Is it of concern?' In solving problems of distribution, phylogeny, palaeoecology it is of great importance to use uniform taxonomy and nomenclature. According to present literature, *Umkomasia*, the female fruit of *Dicroidium* first appears in the Upper Permian of India (Chandra *et al.* 2008) and the last record is from the Lower Cretaceous of Mongolia (Shi *et al.* 1916). In my opinion these fruits have been incorrectly classified and are not *Umkomasia*. Therefore, even a simple question 'What is the first and last appearance of a genus?' can lead to very different answers. At present *Umkomasia*, originally based on a good collection of fossils with the affiliated male organs (*Pteruchus*) and the leaves (*Dicroidium*) is becoming a basket genus for any female fruit with somewhat similar cupule morphology found anywhere in the world.

Biodiversity and extinction

Anderson, J.M.[1,2]

[1]*Honorary Research Associate, Evolutionary Studies Institute, University of the Witwatersrand, Johannesburg*

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We are running a 12-part series on '*Biodiversity & Extinction*' in the school-kid magazine Supernova. Each part covers a major group of plants or animals on a two-page spread. And each aims to include the most recently published Timetree for the relevant group, along with sketches of typical members of the orders (or classes) covered. The focus, then, is on the known (and still unknown) global diversity of the group and on our ongoing human impact on that richness of life. The interdependent nature of all life, climate change and drifting continents is emphasized. The seven parts published to date are: Part 1, *Introduction*, 'from the printing press to biodiversity'; Part 2, *Flowering Plants*, that appeared at around 135 Ma in the

Early Cretaceous; Part 3, *Birds*, that appeared at around 150 Ma, in the Late Jurassic; Part 4, *Mammals*, that appeared at around 200 Ma, in the Late Triassic; Part 5, *Insects*, that appeared around 425 Ma, in the Late Silurian; Part 6, *Molluscs*, that appeared at around 540 Ma, near the Ediacaran–Cambrian boundary; and Part 7, *Hominins*, including the gorillas, chimpanzees and humans going back to around 10 Ma. From Parts 2 to 6, the roots of the Timetrees reach progressively further back in time from the Early Cretaceous to the Late Ediacaran. The idea is to end the series with Part 12, *Homo sapiens*, who appeared in the last wink of a geological eye (some 200 000 years ago) – and have had a devastating impact on the rest of life, setting alight the Sixth Extinction. For each part, we coauthor with two specialist scientists from the universities and research organizations around South Africa – thus involving a spreading authoritative network. Supernova is a South African magazine, based in Pretoria, that appears every 2 months. They target school kids between the ages of 9 and 14. Their mission is to 'make children aware of issues which affect them, their community, and their environment, by giving them tools and inspiration to become active and responsible world citizens.' Their aim is to filter into the school curriculum and to be used by 'educators as a classroom resource'. This meets our aims exactly in producing the series – and the further it spreads across Africa and beyond, the more those aims will be met.

Life history insights of the dodo from bone histology

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Raphus cucullatus, the dodo, is a large extinct flightless bird endemic to the Indian Ocean island of Mauritius, that was first described at the end of the 16th century when sailors arrived on the island. By the end of the 17th century it was extinct due to human activities. Although this bird was contemporaneous with humans for several decades, we know hardly anything about its ecology. Since it is well recognized that the microscopic structure of fossil bones retains signals pertaining to various aspects of their biology, we conducted a histological analysis of various long bones of the dodo. Twenty-two bones (four femora, one humerus, twelve tibiotarsi and two tarsometatarsi) were obtained from the swamp, La Mare aux Songes in the southeastern part of Mauritius, while four tibiotarsi were obtained from various cave sites on the island. Our results were quite striking in that the histological structure of the bones from the swamp were well preserved, but the bones from the cave environments showed severe degradation of the histology. The majority of the bones presented a histological structure showing three distinctive layers: the outer circumferential layer and inner circumferential layer (i.e. the OCL, and ICL) composed of lamellar bone, which enclose a central layer of fibrolamellar bone. Three of our samples showed an incipient OCL, suggesting that they had just attained sexual maturity, while one of them was clearly still a juvenile. In some of our samples, lines of arrested growth were observed in the OCL, showing periodic arrests in growth, and in one thin section at least 6–7 growth marks were evident. Interestingly among our samples there are indications of medullary bone (and hence female birds), and histological features that are attributable to moulting. The bone histology of the dodo has given us unprecedented insight into various aspects of the life history of this recently extinct bird.

The neuroanatomy, braincase and occiput in Gorgonopsia revealed by synchrotron microtomography

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The internal structures of the braincase and occipital region in gorgonopsians so far obtained from serial grinding techniques are currently incompletely known. Gorgonopsians are key synapsid taxa for the understanding of the early steps of pre-mammalian evolution. A specimen of *Aloposaurus gracilis* (GPIT/RE/7124) collected from the upper Permian of South Africa was subjected to propagation phase-contrast X-ray synchrotron microtomography. The gorgonopsian braincase is particularly complex, especially in older individuals where extensive co-ossification and fusion occurred. Notably though, GPIT/RE/7124 is a juvenile specimen in which the sutures are clearly visible. The tomographies revealed the complex anatomy of braincase and occiput elements, but also of the osseous labyrinth, cranial nerves

and vasculature and brain endocast. The cerebellum is broader than the forebrain, resembling the condition of other non-mammalian therapsids. The floccular complex lobes are solely delimited by the supraoccipital, yet there is an embayment on the dorsal portion of the prootics forming a lateral inflation of the cerebellum. The hypophysis is divided ventrally into two laterally-positioned pituitary lobes that communicate with the single median internal carotid foramen anteriorly. The paths of some cranial nerves and vasculature could be discerned from the tomographies. The trigeminal nerve and the vena capitis medialis exit the brain endocast from between the pila antotica and the anterodorsal process. The vidian canal runs along the laterodorsal side of the parabasisphenoid. The internal carotids pierce the parabasisphenoid laterally and join in the median plan of the skull to exit anterior to the sella turcica. The osseous labyrinth is well preserved; however, the horizontal semicircular canal is not delimited by bone. The anterior and posterior semicircular canals are housed in the prootic, supraoccipital and opsithotic. The anterior semicircular canal is significantly larger than the posterior semicircular canal. The gorgonopsian brain endocast retains many 'reptilian' features, demonstrating its conservative anatomy in non-mammalian therapsids.

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The diversity of conifer woods from the Early Cretaceous Kirkwood Formation and palaeoenvironmental implications

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The Kirkwood Formation, Uitenhage Group, outcrops in the Algoa and Gamtoos basins, Eastern Cape Province, and has been known since 1845. Discoveries of theropod, ornithopod and sauropod dinosaurs, a variety of invertebrate fossils and plants have been made over the years. The plants comprise ferns, cycads, cycadeoids and conifers. The large trunks exposed along the Bezuidenhouts river, among other sites, are poorly preserved but the charcoal fragments, represented in a 1m thick stratified parabreccia, are much better preserved. Silicified charcoal from Shamwari game reserve is also well preserved. Three genera are known from this formation but have not been described: *Agathoxylon*, *Brachyoxylon* and *Protocircoporoxylon*. A representative of the genus *Taxaceoxylon* is now added to the list. Based on these woods from a number of other sites worldwide it is possible to reconstruct the past environment for the Kirkwood Formation. *Agathoxylon* is the most common wood in Gondwana and occurred in all climate zones. *Brachyoxylon* ranges from the Early Jurassic to Early Cretaceous but is more common in summer wet environments, as is *Protocircoporoxylon* but its time range is limited to the Early Cretaceous. *Podocarpoxylon* has a long time range but did not occur in summer wet regions. *Taxaceoxylon* was restricted to warm temperate and winter wet environments. These woods imply a diversity of microhabitats rather than a long time range and rapidly fluctuating climate.

Glacial barriers to floral migration in the Permo-Carboniferous of Gondwana

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The late Palaeozoic Ice Age (LPIA) is known to have had a drastic impact on biological, chemical and physical systems across Gondwana for up to 100 million years. Contemporary glaciation models now propose a more dynamic interplay of alternating glacial and interglacial cycles lasting between 1–8 million years, with ice centres waxing and waning diachronously across Gondwana. In the late Carboniferous and early Permian, southern Africa was largely enveloped by a multitude of ice sheets, ice caps, and alpine glaciers that extended to parts of South America and Antarctica. First appearance datums of many stratigraphically significant palynomorphs in the main Karoo Basin are delayed relative to other parts of Gondwana. The wide-ranging index taxon *Pseudoreticulatispora* (*Converrucosisporites*) *confluens* is present in deglaciation successions of Australia, Antarctica, South America, India, Oman and Saudi Arabia, but has never been recorded from South African deposits. However, *C. confluens* is present in the neighbouring Kalahari (Aranos) Basin of southern Namibia. The large glacial centre over the Cargonian Highlands separated the Kalahari from the Karoo Basin, and posed a significant geographic and climatic barrier that prevented successful dispersal and establishment of the parent plants of *C. confluens*, and possibly other plant taxa, in South Africa. This spatio-temporal variation of floras hinders global biostratigraphic correlations. Radiometric dating is useful for calibrating Permo-Carboniferous palynozones because

diachronous fluctuations in ice volume and palaeoclimate had a strong influence on plant migrations and extinctions. This resulted in differing stratigraphic ranges of continental floras across Gondwana.

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Early hominin brain evolution: extracting palaeoneurological evidence from the fossil record

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Tracking the early appearance of the derived *Homo*-like neuroanatomical features in the hominin fossil record should contribute the assessment of (i) the inter-taxic evolutionary relationships within the human lineage and (ii) the tempo and mode of the most critical endocranial changes (i.e. size increase, cortical reorganization). Indeed, based on the investigation of East and South African early hominin endocasts, Falk and colleagues (JHE, 2000) have suggested that the palaeoneuroanatomical features of *Australopithecus* are consistent with a potential ancestral condition to *Homo* as compared to the more ape-like *Paranthropus* pattern. Based on recent development of 3D imaging and modelling methods, we revised the endocranial morphoarchitectural pattern of three Pliocene *Australopithecus africanus* (STS 5, STS 60, Taung) and one Early Pleistocene *Paranthropus boisei* (OH 5) representatives with respect to the extant human ($n = 10$), chimpanzee ($n = 10$), and bonobo ($n = 10$) conditions. We combined a semi-automatic technique for extracting the sulcal pattern together with a landmark-free registration method based on deformations. Both local and global information provided by our morphometric approach are used to perform statistical classification and topological analysis of inter- and intra-specific variation. In association with a morphology of the frontal lobes that substantially differs from the non-hominin condition, the fossil hominin endocasts combine a global neural condition closer to *Pan* than to *Homo*. The *Australopithecus sulcal* pattern preserves both *Homo*- (i.e. the middle and superior frontal sulci organization) and *Pan*-like (i.e. the fronto-orbital sulcus) features. Additionally, our analyses support a relatively closer affinity between *Australopithecus/Homo* than between *Paranthropus/Homo*.

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A reappraisal of the capacity to envenom the bite in *Euchambersia* (Therocephalia, Therapsida) using *μ*CT scanning

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Euchambersia mirabilis is an iconic species of Permo-Triassic therapsid because of its unusually large external maxillary fossa associated with a ridged canine. This anatomy led to the commonly accepted conclusion that the large fossa accommodated a venom gland. Because *Euchambersia* is considered the earliest and most robustly supported case of a venomous terrestrial vertebrate, it usually serves as a model for the inference of envenoming capacity in other fossil species. However, a review of the literature demonstrates

inconsistencies in the interpretation of the morphology of the canine, which sheds some doubt about the hypothesis that *Euchambersia* was venomous. As such, we conducted a μCT scan-assisted reappraisal of the envenoming capacity of *Euchambersia*, with a special focus on the anatomy of the maxillary fossa and canine. This study included both known specimens of *Euchambersia*. It shows that the fossa, presumably for the venom-producing gland, is directly linked to the maxillary canal, which carries the trigeminal nerve (responsible for the sensitivity of the face). The peculiar anatomy of the maxillary canal suggests important modifications in the somatosensory system of the face. In addition, we describe for the first time the complete crown morphology of the incisiform teeth of *Euchambersia*; a replacement maxillary incisor, and an isolated incisor, possibly of mandibular origin. The upper incisor has a concave labial surface, whereas the isolated tooth is strongly recurved and bears lateral ridges. Together, these data support that the maxillary fossa could have housed a venom-producing gland, a specialized sensory organ, or both.

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Stratigraphy and depositional environment of Namibian continental shelf sediments as indicated by fossil foraminifera

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The Pleistocene-aged sediments on the Namibian continental shelf are rich in pelletal phosphorite containing a wide variety of biogenic grains including foraminifera. Vibracores from the central Namibian continental shelf to south of the Kunene River mouth were studied to determine the depositional history and palaeoenvironment of the area. Foraminiferal index species *Globoquadrina dehiscens* and *Globigerinoides bisphericus*, and Sr-age dating on foraminiferal tests from the northern shelf revealed a Middle Miocene age for foraminifera in olive-green mud units underlying pelletal phosphorite units. The contact between the olive-green mud units and overlying pelletal phosphorite units is sharp and erosional. Components above the contact were found to be reworked Late Miocene to Pleistocene in age. The final deposition of the pelletal phosphorite sand units took place in the Pleistocene confirmed by index species such as *Globorotalia inflata* and *Globorotalia truncatulinoides*. The water depth for the Miocene-aged foraminifera was greater than today and Pleistocene-aged foraminifera indicated shallower depths for that time period. Planktonic foraminifera and trace abundances of the ostracods *Henryhowella* and *Bairdoppilata* indicate subtropical warmer surface waters during the Miocene cooling slightly during the Quaternary.

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The role of museums in palaeontological education

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Museums are constantly redefining and questioning their role in society. These institutions are more than just a space to display strange, unusual and interesting objects. Museums such as the Iziko South African Museum have the benefit of extensive collections, public exhibitions and specialist scientists. The Museum's Education and Public Programmes and Natural History Departments work together to present fossil and evolution workshops to schools and tertiary institutions. The content of these workshops is aligned with the Curriculum Assessment Policy Statements (CAPS) at primary school and secondary school (grades 10 and 12) level. Workshops are also adapted for tertiary-level life sciences, environmental management and education students. The fossil and evolution workshops are presented by palaeontology curators and focus on fossil basics, the evolutionary record, continental drift and other geological topics. Tours within the Museum's fossil exhibitions are led by museum curators and educators to supplement the presentations. The workshops have shown that there is an important role for museums to assist

teachers and lecturers in educating students. The need for geology and basic palaeontology programmes may be greater at schools from disadvantaged backgrounds. A pre-workshop evaluation of one of the fossil workshops showed that less than 15% of learners had any idea of what a fossil was. This percentage increased by nearly 40% post-workshop. Other indicators recorded improvements on different scales for the various topics that were assessed. The success of these workshops in assisting learners to understand basic concepts are enhanced through interactive, hands-on activities that utilize museum specimens.

A new theropod dinosaur footprint site in the Lower Jurassic Elliot Formation (Mafube, eastern Free State, South Africa): footprint preservation in a semi-arid fluvio-lacustrine setting

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Bipedal saurischian dinosaur tracks have been recently discovered in the Lower Jurassic Elliot Formation at Mafube Mountain Retreat (eastern Free State, South Africa). We studied over 80 tridactyl tracks on the bedding surface of a single sandstone bed that shows evidence for footprint preservation in an abandoned, high energy ephemeral stream, which is typical in semi-arid climates. The tracks show large shape variability over the length of the bed; however, these morphological differences are considered here to be mainly due to variations in the substrate rheology (e.g. moisture content) as opposed to differences in the trackmaker's foot anatomy, foot kinematics or recent, footprint modifying weathering processes on the exposed bedding surface. Desiccation cracks, invertebrate burrows, ripple marks, etc., preserved in association with and within some of the Mafube tracks suggest that the imprints are essentially contemporaneous and are true tracks rather than undertracks or erosional remnants. The best preserved footprints are therefore valuable not only for the interpretation of the palaeoenvironment (i.e. seasonally dry river channels) but also for taxonomic assessments, because some of them closely resemble the original anatomy of the trackmaker's foot. The Mafube ichnotaxa are assigned to *Eubrontes* and potentially *Grallator* ichnogenera and are linked to large and small tridactyl theropod trackmakers, possibly to *Dracovenator* and *Coelophysis* based on the following criteria: a) lack of manus impressions indicative of obligate bipeds; (b) long, slender digits, asymmetrical, tapering, (c) often ending in a claw impression or point, and (d) the prints being longer than broad.

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New data on the Permo-Triassic Boundary from the Karoo Basin of South Africa

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The South African Karoo Basin preserves a detailed record of environmental and evolutionary changes associated with the Permo-Triassic Mass Extinction (PTME) that has been the focus of considerable research for decades. Currently, the Permo-Triassic boundary (PTB) is defined biostratigraphically by the last appearance of *Daptocephalus leoniceps* and *Lystrosaurus maccaigi*. Recently there has been much debate regarding this placement within the South African Karoo Supergroup. Recent research has resulted in claims that the vertebrate-defined PTME in South Africa is not synchronous with the extinction in the marine realm. This assertion has important implications for correctly interpreting and understanding the PTME in South Africa. Our ongoing fieldwork at PTB sites in the Free State, particularly on the farm Nooitgedacht 68, has yielded new information on the placing of this event. We present an updated lithostratigraphic log of the PTB at Nooitgedacht 68 that includes new *in situ* records of archosauromorphs and therapsids. For the first time, plants and an insect wing are recorded at the site, including lidgettonioid *Glossopteris* leaves and fragments of a fern species previously unknown from the Late Permian of South Africa. Isotope stratigraphy shows a negative excursion at the PTB, which is supported by preliminary data from therapsid enamel. A preliminary U-Pb date from detrital zircons using thermal

ionization mass spectrometry (TIMS) places a maximum age on the boundary fauna. We compare these data with coeval sites and use them to address the claim that the vertebrate-defined PTME in South Africa does not coincide with the marine PTME.

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Palaeoenvironment, stratigraphy and evolution of Mesozoic rift basins, onshore Outeniqua Basin, Western and Eastern Cape, South Africa

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The Mesozoic rift basins of the Western and Eastern Cape demonstrate a dichotomy in extant research. The Uitenhage Group sedimentary rocks and their palaeontological heritage in the Algoa Basin are well-researched, in contrast to poorly documented onshore compartments of the Oudtshoorn, Heidelberg, Gamtoos and Pletmos basins. This presents a problem in that current assumptions made about these rift compartments lack the stratigraphic context to accurately compare them with the Algoa Basin, which has a seemingly more fossiliferous sedimentary fill. Furthermore, without comprehensive synthesis of stratigraphic data from all these Mesozoic basins, the context of any palaeontological findings and their palaeoenvironments would be geographically and temporally limited. This research aims to provide that stratigraphic context by conducting ongoing sedimentological, geochronological, and palaeontological studies in these four lesser-studied Mesozoic basins. Detailed lithofacies and architectural element analyses have enabled the reconstruction of fluvial, lacustrine and coastal regimes in these rift compartments. Palaeontological findings have been noted, and together with sedimentological data, a rift sequence stratigraphic framework of these four basins is being compiled to better document their development. U-Pb dating of zircons from several tuffaceous beds would allow the refinement of the temporal relationships within these basins and their correlation to the Algoa Basin.

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A record of sedimentation of the Late Ordovician Soom Shale Member (Cedarberg Formation) from new borehole data in the Cedarberg region of South Africa

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The Late Ordovician glaciation–deglaciation is recorded in the South African Table Mountain Group (Cape Supergroup) by the Pakhuis and Cedarberg formations, respectively. The Cedarberg Formation, consisting of Soom Shale and Disa Siltstone Members, forms an upward coarsening cycle of sedimentation in a shallow marine setting and is overlain by the dominantly fluvial sandstones of the Goudini Formation. The Soom Shale Member is particularly significant as it represents the only Ordovician Konservat-Lagerstätte in southwestern Gondwana. A preliminary investigation of the sedimentary rocks revealed an unusual facies comprising coarse quartz grains that occur in clusters and aggregates within organic matter and intercalated within distal, laminated turbidites. This microfabric was tentatively linked to glacially derived loess which was either blown across seasonal sea ice or directly into the sea. To obtain new data on this unique facies, we drilled a 40 m stratigraphic core through the lower Cedarberg and upper Pakhuis formations on Holfontein farm (~25 km south of Clanwilliam). A detailed (mm-scale) sedimentological log, petrographic thin sections and Scanning Electron Microscope analysis were employed to quantify and interpret the sedimentary facies. Our preliminary results show that the unique laminated facies is well-developed throughout the Soom Shale and persists, albeit less prolifically, into the Disa Siltstone Member. To explain the origin of this unique facies, in this study we explore hypotheses, including: 1) loess-derived quartz fertilizing marine algal blooms and 2) an algal mat-bound seafloor trapping quartz grains.

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A new gorgonopsian from the uppermost *Daptocephalus* Assemblage Zone, Karoo Basin of South Africa

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The gorgonopsian therapsids are well known in the Permian deposits of Africa, Russia, India and China. By the middle Late Permian these gorgonopsians become the dominant terrestrial predators of Gondwana and by the end of the Permian they were geographically widespread in southern Africa with a high taxonomic diversity. However, they did not survive the Permo-Triassic mass extinction some 252 million years ago. Here we describe the skulls and postcranial elements of a new species from South Africa. Although these specimens are the geologically youngest gorgonopsians known, they exhibit several basal characteristics, similar to the geologically older specimens from the *Eodicynodon* and *Tapinocephalus* Assemblage Zones. A comparison with Russian taxa reveals that the new species is similar to the gorgonopsian *Inostrancevia*, which is only known from Russia. The presence of palatal tuberosities and absence of palatal teeth compared to the Russian species suggests that, although closely related, the new material does not belong to the Russian genus. This new gorgonopsian has several implications for South African biostratigraphy and taxonomy, as well the global distribution of gorgonopsians during the Late Permian.

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Palaeobiological implications of the bone microstructure of pareiasaurs (Parareptilia) from the Karoo Basin, South Africa

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Numerous morphological studies have been carried out on pareiasaurs; yet their taxonomy and biology remain incompletely understood. Earlier works have suggested that these herbivorous parareptiles had a short juvenile period as compared to the duration of adulthood. Several studies further suggested an aquatic lifestyle for these animals, but more recent investigations have proposed a fully terrestrial habitat. Bone palaeohistology is regarded as a powerful tool to assess aspects of tetrapod palaeobiology. Although this method has been extensively applied to the non-mammalian therapsids of the Karoo Basin of southern Africa, few studies have been conducted on pareiasaurs, which were abundant in the Middle and Late Permian continental ecosystems. The present study assesses intra and inter-specific histovariability of pareiasaurs and provides fresh insight into their palaeobiology, thereby permitting a re-evaluation of earlier hypotheses. Our sample comprises various skeletal elements and several specimens covering most of the taxonomic and stratigraphic spectrum of South African pareiasaurs, including large and basal forms from the Middle Permian, as well as small and more derived forms from the Late Permian. Our results suggest that the species diversity of the pareiasaurs of the *Tapinocephalus* Assemblage Zone may have been underestimated. Bone histology also confirms that these animals experienced a relatively rapid growth early in ontogeny. The growth later slowed down during adulthood, which appears to have been extended. Pareiasaur bone microanatomy is unusual for continental tetrapods, in having extremely spongious stylopod diaphyses. Rigorous palaeoecological interpretations are thus limited since no real modern analogue exists for these enigmatic animals.

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Microanatomical diversity of amniote ribs

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Numerous studies have documented long bone microanatomical diversity in tetrapods. Yet, the majority of previous works has focused on the appendicular skeleton. A relationship between limbbone microanatomy and lifestyle (e.g. aquatic, amphibious, terrestrial) has been uncovered and used for palaeoecological reconstructions. Relatively fewer comparative studies have focused on the microanatomy of the axial skeleton and its ecological signal. Here, we propose an extensive quantitative

study of the microanatomy of amniote ribs. Our sample comprises 155 species of extant amniotes and encompasses the taxonomic, ecological, and body size diversity of this group. We standardized our sampling location to the midshaft of mid-dorsal ribs. Transverse sections were obtained from classical petrographic methods, as well as from X-ray microtomography. Our analyses reveal that most of the microanatomical and size parameters of the ribs display a phylogenetic signal, an expected result also observed in amniote limb bones and vertebrae. We found a significant relationship between rib cortical thickness, global compactness and lifestyle. As for the vertebrae, the development of the spongiosa in the medullary region seems to be strongly correlated with size. This study is complementary to previous work conducted on long bones and vertebrae because it further documents bone inner architectural diversity and offers a better understanding of the general adaptation of the skeleton to environmental and biomechanical constraints.

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Cancellous network patterning and cortical bone distribution at the proximal femoral end in *Paranthropus robustus*

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Compared with the extant human condition, some characteristics of the paranthropine proximal femur provide evidence for a gait-related adaptation resulting in relatively increased superoinferior bending loads at the femoro-pelvic complex. As also body shape in this extinct hominin differs in some way from the human bauplan, we expect the biomechanically-related cortico-trabecular signature imprinted at the coxo-femoral joint somehow reflects such differences in terms of site-specific structural arrangement. By means of X-ray microtomography the cancellous network properties and cortical bone topographic variation in four adult upper femoral ends from Swartkrans *P. robustus* samples: SK 82 and SK 97, likely males, and SK 3121 and SKW 19, likely females, were investigated. While relatively and absolutely denser, and also locally more contrasted, especially along the mediolateral axis, the cancellous network of *P. robustus* globally traces the human pattern. Interestingly, for their proportion of thinner struts, the likely sex-related differences expressed by the fossil specimens exceed the range measured in our comparative modern sample ($n = 9$). Similarly to the CT-based results provided by Ruff and Higgins (AJPA, 2013), we found superoinferior cortical bone asymmetry in the neck of SK 82 and SK 97 (S/I thickness ratio <1.0), and also confirm the finding that asymmetry in *P. robustus* is expressed at a lower degree than in extant humans. However, because of the higher resolution of our record, present estimates allowed for a subtler assessment of cross-sectional changes along the neck. Accordingly, they reveal that, at the midneck, *P. robustus* had more human-like proportions than previously observed.

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Three-dimensional morphometric analysis of the cranial ontogeny of *Massospondylus carinatus* based on CT reconstructions

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Understanding ontogenetic variation in dinosaurs is necessary because it informs taxonomic hypotheses, elucidates larger macroevolutionary patterns, and allows for the inference of behavioural traits such as parental care, feeding and locomotion. *Massospondylus carinatus* Owen 1854 is an emblematic South African basal sauropodomorph dinosaur and it presents an ideal study system for dinosaurian cranial

ontogeny because it has a range of referred specimens aged from hatchling to adult. This study reconstructs individual skull bones of a size series of *M. carinatus* using CT scans and qualitatively and quantitatively assesses the ontogenetic variation between these bones. The results show clear differences in the development between facial bones and braincase bones (both in the amount of growth and in the correlation between size and shape). Several morphological differences are also identified between juveniles and adults. There is a possibility that several species are represented in the *M. carinatus* sample, based on both the qualitative and quantitative assessments.

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Vascularized, endosteal bone tissue in saltasaurine titanosaurs from Argentina

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Well-vascularized, endosteal bone in the medullary region of long bones of non-avian dinosaurs has been invoked as being homologous to avian medullary bone, a specialized tissue formed during ovulation. However, similar bone tissues are known to form in response to pathologies in modern birds and in non-avian dinosaurs, and have also been reported in an immature non-avian dinosaur. In the current study we describe the occurrence of well-vascularized endosteal bone tissue in three skeletal elements of saltasaurine titanosaurs from the Upper Cretaceous of Argentina: i) within the medullary cavity of a metatarsal, ii) inside a pneumatic cavity of a posterior caudal vertebra, iii) in intra-trabecular spaces in an osteoderm. Our results show that considering the criteria of location, origin (or development), and histology, these endosteally-derived tissues in these armoured sauropods could be described as either medullary bone or pathological bone. Additionally, we show that similar endosteally-formed well-vascularized bone tissue is quite widely distributed among non-dinosaurian archosauriforms, and is not restricted only to long bones, but can occur in the axial, and dermal skeleton. We propose that independent evidence is required to verify whether vascularized endosteal bone tissues in extinct archosaurs are pathological or reproductive in nature.

CT-based reconstruction of the skull of the basal maniraptoran *Ornitholestes hermanni* Osborn 1903

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More than 100 years after its discovery, the phylogenetic relationships of the theropod taxon Ornitholestes hermanni remain enigmatic. General consensus holds that *Ornitholestes* is important for understanding the early evolution of *Maniraptora*, the theropod group that includes birds and their agile, generally small bodied relatives. Confusion about this taxon's relationships is in part due to the crushed preservation of the holotype skull, AMNH 619. The crushing of the specimen obscures details such as the morphology of the braincase bones, which contain important character data. To better understand its anatomy, we CT-scanned the cranium of *Ornitholestes* and made 3D digital reconstructions using VG Studio Max. We present more complete descriptions of braincase bones, including the prootic and laterosphenoid, as well as previously unknown aspects of other skull bones, including the quadrate. These observations allow us to refine the phylogenetic position of *Ornitholestes* and to provide more precise diagnostic criteria for the species. Finally, we present a more accurate 3D model for what *Ornitholestes*' skull would have looked like.

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Trace and Body Fossils of the Triassic–Jurassic Elliot and Clarens formations in the Lebombo–Tshipise Basin, South Africa

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The Triassic–Jurassic aged rocks of the Karoo Supergroup are perhaps best known for assemblages of amphibian, crocodylomorph, dinosaurian and therapsid (cynodontid and mammaliamorph) fossils, in addition to an assortment of vertebrate and invertebrate ichnofossils. Recent re-evaluation of the palaeoenvironments of this succession in the Lebombo–Tshipise Basin has yielded both sauropodomorph dinosaur fossils from the Elliot Formation and invertebrate ichnofossils from the Elliot and Clarens formations. Previously discovered sauropodomorph dinosaur fossils from the Lebombo–Tshipise Basin were assigned to the now invalid '*Euskelousaurus browni*' in 2001. Preliminary comparative work on newly recovered manual elements suggests that this find either represents a new species of sauropodomorph, or informative, but currently unknown, elements from a known species. We present further comparisons of additional material and suggest taxonomic affinities for this material. Additionally presented are ichnofossils from a fine-grained sandstone unit at the Red Rocks locality, recently posited as Elliot Formation, but formerly considered as a member of the Clarens Formation. These ichnofossils appear to be networks within the casting medium, interpreted to be formed by burrowing communal arthropods. The overlying Early Jurassic Clarens Formation preserves *Arenicolites isp., Planolites isp., Entradichnus isp.,* in addition to dubious *Lockeia isp.* in medium-grained planar and low-angle cross bedded sandstones interpreted to be fluvial and aeolian dune foresets. These ichnofossils often occur together in pervasively bioturbated-and-soft-sediment-deformed horizons. These data suggest a perennially wet interdune environment; however, this ichnocoenosis contains elements of both *Scoyenia* and *Octopodichnus-Entradichus* ichnofacies, but differs from each in a paucity of arthropod trackways.

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Archaeological methods and practice: a multidisciplinary approach

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The disciplines of archaeology and palaeontology cover a diverse array of fields from Stone Age lithic analysis to palaeoanthropology to dinosaur and therapsid research. Excavations and field collection of specimens is an essential component of fossil research – indeed it is one of the main draw cards of these disciplines. There are, however, many pitfalls to conducting field work and excavations. Each individual site is idiosyncratic and can present many unexpected obstacles and while there are numerous fundamental field processes or laboratory techniques common across the discipline as a whole, there are numerous specialized protocols inherent to particular localities. For example, the methodologies outlined by Shannon McPherron are highly effective in unconsolidated archaeological deposits, but are ineffective in for example, consolidated dinosaur beds where rock saws and jackhammers are the preferred excavation tools. All students of the palaeo-disciplines are exposed to and/or taught field methodologies, but their experiences are usually limited to local methodologies and they may be unaware of other equally relevant techniques. This work will investigate a variety of excavation methods and pitfalls with the aim of identifying ways in which excavations techniques and information may be improved across the discipline. Such methods may include improvements in field recording, publication of excavation information in the form of site reports, as well as the increased use of volunteers, amateurs and general outreach programmes. Other disciplines like geology, zoology and even oceanography utilize field methodologies and laboratory analyses that could greatly benefit our discipline. Thus an emphasis on increased multidisciplinary research is advised.

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Spatial modelling, formation and transformation of the Oldowan lithic artefact assemblages from Sterkfontein caves, South Africa

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The research project detailed here focuses on the formation of the underground artefact-bearing depos-

its of Member 5 (M5) at Sterkfontein Cave. Since the discovery of the first adult *Australopithecus* by Robert Broom in 1936, Sterkfontein has played an integral role in the palaeoanthropological sciences. *P. robustus* teeth have been excavated from M5 as well as the most complete and oldest Oldowan assemblage in southern Africa. Much research has been done at Sterkfontein over the last 80 years to clarify the complexity of karst stratigraphy and its relationship with the artefacts and fossils. In M5 there has been only a traditional, basic approach to lithic analysis. My examination seeks to assess the site wholly and more accurately than ever before. The aim of this study is to determine how the lithic and geological elements of M5 relate to one another using a high-resolution 3-D, GIS approach. Powerful Micro CT scanning was used to quantify lithic abrasion using a 3-D technique; a Geographic Information System (GIS) was subsequently used to place artefacts within a 3-D representation of M5. Quantifying lithic abrasion and, thus, exploring the extent of sediment reworking in M5 will better explain how the site came to be defined as a secondary depositional environment. Currently very little literature exists for the study of lithics at a microscopic level; here I present some of my preliminary methods and findings. My methodology is easy to replicate *en masse* and should prove beneficial in future lithic studies.

A new burnetiamorph therapsid from the *Pristerognathus* AZ of South Africa and a proposed solution to their stratigraphic incongruence

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Burnetiamorphs are a group of Permian basal therapsids that are currently best known from the main Karoo Basin of South Africa but with representatives from European Russia, Zambia and Tanzania. Within the Permian of South Africa, burnetiamorphs have been reported from all biozones except the Guadalupian-aged *Eodicynodon* and *Pristerognathus* Assemblage Zones (AZs) and discoveries over the past decade have increased the number of known genera to 10. While this has provided additional data for determining relationships, a problem remains: the continued recovery of the oldest burnetiamorph genera within the family Burnetiidae, the most distal and derived subclades of the Burnetiamorpha. In 2011 the snout of a burnetiamorph was discovered in the Poortjie Member of the Teekloof Formation north of Merweville, within strata assigned to the *Pristerognathus* AZ. This prompted a review of burnetiamorph phylogeny involving the assembly of most known specimens and a critical revision of morphological characters. The results suggest that the *Pristerognathus* AZ specimen is a new taxon, which is most closely related to the Russian *Niuksenitia sukhonensis*. Our phylogeny also suggests that the oldest burnetiamorphs, *Bullacephalus* and *Pachydectes*, are not burnetiids but basal burnetiamorphs. Similarities in palatal structure also link *Bullacephalus* and *Pachydectes* with *Hipposaurus*, a contemporaneous non-burnetiamorph from the *Tapinocephalus* AZ. This change makes the newly proposed burnetiamorph tree significantly more congruent with the stratigraphic appearance of its constituent taxa and allows for diversification of the clade after the Wordian.

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New associated basal sauropodomorph material from the Late Triassic lower Elliot Formation, Karoo Basin, Eastern Cape

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South Africa's Late Triassic–Early Jurassic Elliot Formation is well known for its fossils of basal sauropodomorph dinosaurs in its upper strata. Despite more than a century of study, however, sauropodomorphs from the lower parts of the formation remain poorly known due to fossil scarcity or are represented by material of uncertain provenance and association. We present a new, associated sauropodomorph specimen from the middle of the lower Elliot Formation. The material represents a single animal, and includes axial and appendicular bones. We present a preliminary description of the new specimen, and analyse its phylogenetic relationships by incorporating it into a data matrix of basal sauropodomorph dinosaurs. Our preliminary results show that the specimen is not *Blikanasaurus* or *Plateosauravus*, two of the better known lower Elliot sauropodomorph taxa. It possibly represents a previ-

ously unknown species of *Melanorosaurus*. The discovery of an articulated lower Elliot sauropodomorph with precise provenance data helps us to refine our biostratigraphic interpretations for the Late Triassic.

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A study on the cranial anatomy of Lower Jurassic crocodylomorphs *Protosuchus haughtoni* and *Litargosuchus leptorhynchus* using 3D digital models

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Crocodiles, alligators and gharials are all members of a much larger and more ecologically diverse clade Crocodylomorpha, which originated in the Late Triassic. The cranial anatomy of early crocodylomorphs, particularly their braincase and palate, remains enigmatic even after nearly a century of anatomical investigation. These structures have significant implications for phylogeny, biological functionality, and homology of a variety of features within the larger crocodylomorph tree. We Micro-CT scanned and developed 3D digital models of the skulls of the basal crocodylomorphs *Protosuchus haughtoni* (Protosuchidae), and *Litargosuchus leptorhynchus*(Sphenosuchia) from the upper Elliot Formation in South Africa. 3D digital modelling allowed for the most complete and detailed anatomical descriptions of these skulls to date. This study highlights the usage of digital modelling as an investigatory tool in anatomical studies. We amended the cranial characters of basal crocodylomorphs in a large phylogenetic dataset. We analysed this dataset and provided a revised evolutionary hypothesis for the earliest members of the group.

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New burnetiid specimens add to understanding of biarmosuchian taxonomy and ontogeny

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The Biarmosuchia (Sigogneau-Russell, 1989) is a poorly known group of Middle to Late Permian therapsids (Broom, 1905). Currently the taxon comprises 16 genera from different regions of Pangea (South Africa, Malawi, Zambia, Tanzania, Zimbabwe and Russia) which are classified into four families : Biarmosuchidae (Olson, 1962), Hipposauridae (Watson and Romer,1956), Ictidorhinidae (Broom, 1932) and Burnetiidae (Broom, 1923). Although there are sixteen genera, most of them are represented by only one specimen, with the result that we have no understanding of ontogenic development. Even though Biarmosuchia are currently considered to be a monophyletic group, the phylogenetic position and the ontogeny of the individual genera is not yet well understood. New cranial material of *Lemurosaurus* (Broom, 1949), including a juvenile, increases the sample size of the genus to four individuals, making this the best represented burnetiid and offers new possibilities to understand biarmosuchid taxonomy and ontogenetic development. Evolution of the proportions of *Lemurosaurus* throughout its ontogenetic development and implications for burnetiid systematics will be discussed.

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X-ray CT scanning at Stellenbosch University: palaeontological applications

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X-ray computed tomography (CT) scanning is a well-known technique embraced by the palaeontological community worldwide, and encompasses synchrotron CT, laboratory macro, micro and nanoCT

devices and the associated advanced 3D image processing software and procedures. In this talk we outline the capabilities of the open access Stellenbosch University CT Scan Facility (www.sun.ac.za/ct-scanner), focusing on palaeontological examples. We specifically highlight the advantages of multiscale CT investigations, the potential of nanoCT and challenges in data analysis. Some unique methods for improving image quality of fossil scans embedded in rock are briefly discussed, for the very special case of Karoo fossils.

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Biostratigraphic and sequence analysis of Well H1, from the central Niger Delta, Nigeria

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The sequence analysis of well H1(4100–12898 ft) dated Middle Eocene to Middle Oligocene from the Central Niger Delta have broadened our knowledge of the prevailing palaeoenvironments and vegetation around the Niger Delta in the early Tertiary. The logs indicated the presence of two lithostratigraphic units: the continental Benin Formation (4100–7820 ft) and the Upper Agbada Formation (7820–12898 ft) composed of alternating sand and shale intervals. The Benin Formation was barren of foraminifera and nannofossils, the palynological data revealed moderate counts of pollen and spores especially typical diagnostic Nigerian Eocene and Oligocene taxa. Four 3rd Order Maximum Flooding Surfaces characterized by marker shales, high faunal abundances and diversities were delineated and dated 35.9, 36.8, 38.0 and 39.45 Ma. The increased occurrence of *Retibrevitricolporites ibadanensis* and Base continuous occurrence of *Arecipites exilimuratus* at 5500 and 7160 ft defined the Early/Middle Oligocene and Late Eocene/Early Oligocene boundaries. Furthermore, the FDO *Nonion oyae* (*Nonion* sp. 8) at 7860 ft; FDO *Brizalina ihuoensis* at 7880 ft, HO: *Coccolithus formosus* at 8160 ft coupled with the FDO: *Doualaidites laevigatus* at 9160 ft, HO: *Helicosphaera lophata* at 9640 ft all indicated the penetration of Late Eocene. The FDO *Uvigerina hourqi* (*Uvigerina* cf. *topilensis*) delineated the Middle /Late Eocene boundary at 10 240 ft. The Middle Eocene is confirmed by the FDO *Chiloguembelina martini* at (12 780 ft), Acme *Uvigeriella-sparsicostata* at (11 580 ft) and the common presence of *Doualaidites laevigatus*. The palaeoenvironments fluctuated between Coastal Deltaic to Middle Neritic based on pollen and foraminiferal data.

Taxonomic and taphonomic analyses of fossil fauna from a new deposit in Gondolin

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The Plio-Pleistocene palaeocave site of Gondolin is located on the edge of the Cradle of Humankind near Hartebeestpoort Dam, 4 km SW of the town of Broederstroom. Gondolin is one of several early hominin fossil-bearing cave sites in South Africa. Historically, only three short excavations were conducted by Vrba in 1979, Menter in 1999 and Adams in 2006 respectively. In June of 2015, a fourth phase of excavation was initiated by Dr Job Kibii. This poster outlines the methods that will be used to study the bone assemblage recovered from a fourth excavation, into a deposit that consists of decalcified, *in situ* sediments, which lie in close proximity to Vrba's excavations. Given the proximity of the newly excavated deposit to Vrba's excavation (GD2), we hypothesize that the faunal assemblage recovered from itis similar (taxonomically and taphonomically) to the one from GD2. The main aims of this research are to conduct a taxonomic and taphonomic analysis of the 3000 macrovertebrate fossil fauna specimens excavated in June 2015. A taxonomic list of the macrofauna from this deposit will be compiled, together with a thorough taphonomic analysis of the assemblage, in order to identify possible bone modifiers and accumulators. Atentative age estimate will be made based on faunal correlations. The results will be compared and contrasted to the previously studied faunal assemblages from Gondolin 1 and 2, as well as to other Plio-Pleistocene assemblages within the Cradle of Humankind

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A reflection on the use of palaeosensitivity maps in heritage resources management

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Cedar Tower Services (CTS) developed a new heritage management product called the 'Heritage Screener' in 2014. It is a fast and convenient tool that maps and summarizes heritage resources surveyed within proposed development areas and makes proactive recommendations to guide developers to minimize or avoid creating negative impacts on heritage resources. Palaeontological heritage features prominently in the range of resources taken into account for Heritage Screeners. The development and release of the national palaeosensitivity maps on the South African Heritage Resources Information System (SAHRIS) has significantly improved the ability of heritage practitioners to predict the impact of developments on fossils. These maps are publicly accessible on the web and they have raised the awareness of fossil heritage in a very short time. CTS has interpreted the fossil sensitivities for a number of development applications based on the SAHRIS palaeosensitivity maps. By working with the data on a daily basis we noted a number of issues which, if addressed in a coordinated fashion, will improve the quality and value of the tool. These issues are discussed along with suggestions for action. While the community of palaeontologists working in Cultural Resources Management in South Africa is small, the discipline is increasingly gaining recognition. The maintenance, debate and update of the SAHRIS palaeosensitivity maps is an important forum which brings heritage managers, impact assessors and researchers into the same space to share their findings. We therefore hope this is taken even further with bolder approaches to protecting palaeontological heritage by meaningfully integrating data derived from research institutions and palaeontological impact assessments.

Estuarine fish breeding grounds: a tale of two times

Gess, R.W.
Albany Museum, Grahamstown, an associate of Rhodes University, and partner in the South African NRF DST Centre of Excellence in Palaeontology

Estuarine systems comprise partially enclosed coastal water bodies which are either permanently or periodically open to the sea and within which there is variable salinity due to mixture of marine and fresh water, typically supplied by rivers. Commonly estuaries exhibit exceptionally high levels of primary and secondary production, though abrupt fluctuations in salinity, water temperature, dissolved oxygen and turbidity, which make them challenging environments. Relatively inaccessible regions of estuaries provide attractive nursery areas for those taxa that can tolerate environmental fluctuations. Although many species spend their entire lifecycles in estuaries approximately 40% of fish species in modern southern African estuaries are marine species that enter as early juveniles and return to the sea when mature. Estuaries are therefore vital for many marine fish lifecycles. Carbonaceous metashales of the ±360 mya (latest Devonian) Witpoort Formation (Witteberg Group, Cape Supergroup) Waterloo Farm lagerstätten are interpreted as having been deposited in a quiet embayment of a back-barrier lagoonal estuary. More than 500 vertebrate derived specimens, systematically collected over several decades, represent both complete and incomplete growth series, providing evidence for variable use of estuaries as fish nurseries. As in recent estuaries, certain taxa (including both arthrodire and antiarch placoderms) spent their entire life cycle within the estuarine environment whereas others (including the coelacanth, *Serenichthys*) only inhabited the estuary as juveniles and subadults. Additional taxa (including gyracanthid acanthodians), only represented by remains of large adults, may have entered the estuary to feed on juvenile fish or may have been washed in postmortem from adjacent environments.

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Environmental and depositional setting of a low diversity lingulid brachiopod assemblage from the Witpoort Formation (Witteberg Group, Cape Supergroup) east of Grahamstown

Gess, R.W., Harris, C.
Albany Museum, Grahamstown

Lingulid brachiopod impressions have been recovered from three widely spaced localities along a laterally extensive, fine grained carbonaceous metashale horizon within the lower Witpoort Formation (Witteberg Group, Cape Supergroup). At two of these localities they are extremely abundant, occurring as virtually monospecific invertebrate assemblages. A possible second species of lingulid is the only other species represented. Occasional terrestrial plant stems are preserved on the same bedding planes. Poor

sorting of shells, their large size range and their lack of damage suggests minimal transport before deposition on bedding surfaces, perhaps during erosive episodes. Some specimens that occur in near vertical orientation are interpreted as having been preserved in their infaunal life position. Lingulids have previously been reported from taxonomically more diverse marine invertebrate communities of the underlying Weltevrede Formation (Witteberg Group) and the Bokkeveld Group. The presence of entirely lingulid brachiopod constituted communities is conventionally considered indicative of a shallow marine environment with sufficient fresh water input to exclude taxa less tolerant of variable salinity. The above reported occurrence is interpreted as evidence for a fauna associated with mud flats formed from organic-rich fine-grained sediment discharged from an adjacent open river mouth. It represents the stratigraphically youngest record of brachiopods in the Cape Supergroup.

Funding acknowledgement: This project has been funded by SANRAL which has enabled the collection and study of fossil material exposed during mitigation of the N2 in 2015/'16.

Marine and terrestrial carnivore damage on Mio-Pliocene marine mammals from the west coast of South Africa

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Marine mammal fossils, including seals and cetaceans, from the West Coast span the Late Miocene to Early Pliocene (7–5 Ma). During the taxonomic analysis of seal and cetacean skeletal remains, we identified a variety of bite marks that could be attributed to marine and terrestrial predators/scavengers. Thus far, the marine carnivores have been identified as sharks with and without serrated teeth. The results show that white and mako sharks were feeding on carcasses at sea, but whether or not the sharks were scavenging or actively hunting cetaceans and seals was not possible to determine. Skeletal damage by large and small terrestrial carnivores is linked to bears, hyaenas, wolverines, canids, felids and viverrids. The evidence lends support to the proposition that carcasses of cetaceans and seals were beached along the shorelines of the Early Pliocene lagoon/estuary, where they became accessible to terrestrial scavengers.

Funding acknowledgement: The Langebaanweg Cetacean Project was initially funded by the Claude Leon Foundation Postdoctoral Fellowship through R.G. from January 2010 to August 2011. The terrestrial carnivore damage analysis is funded by NRF/AOP through R.G.'s current project: Mio-Pliocene marine mammal palaeoecology and palaeoenvironment reconstruction.

Palaeontological Impact Assessments – Opportunities for exploring new fossil sites

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Palaeontological Impact Assessments (PIAs) have been requested more regularly since the increase in formal recognition of this important part of the geological history of southern Africa.The request for PIAs are based on the Palaeontological Sensitivity Map of South Africa that is available on the website of the South African Heritage Resources Authority (SAHRA) and developers are compelled to ask for at least desktop surveys in all areas where fossils might be present in the rock sequence on sites of new developments. In this relatively short presentation the focus will be on the valuable information gathered through these PIA studies and how discoveries of previously unknown fossil localities are the direct result of these requests for Palaeontological Investigation in areas that would otherwise not have been thought of as important in terms of Palaeontological Heritage. The sites that are of particular interest include, for example The Ingula Pumped Storage Scheme of Eskom Holdings (Pty) Ltd, the Amatola Water Reticulation Scheme; the Water Recultation Scheme at Tsomo in the Eastern Cape; the Sendawo Photo-Voltaic Development near Vryburg. Case studies will be presented as part of the very short discussion on the value of these finds for future studies of the palaeontology of South Africa.

Preliminary findings: Litho- and biostratigraphic analysis of the Lower Beaufort Group, Karoo Supergroup, in the central Free State Province, South Africa, and implications for the depositional history of a distal bulge

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The Ecca–Beaufort contact has been the subject of ongoing research, and stratigraphic collecting in the

lower Beaufort has revealed a northward younging of this boundary and associated faunal changes. Few extensive lithological markers are present for basin-wide stratigraphic correlation in the Beaufort Group and stratigraphic correlation of Beaufort Group strata around the basin has largely relied upon the eight SACS approved vertebrate biozones. The *Daptocephalus* (formerly *Dicynodon)* Assemblage Zone (AZ) is the only Permian biozone present north of the town Philippolis in the southern Free State. Recent fieldwork in the Jagersfontein district resulted in the recovery of faunal elements of the *Pristerognathus* AZ. Fossils probably assignable to *Daptocephalus* AZ taxa have been recovered in lower Beaufort Strata only 40 km to the east and no fossils of the *Tropidostoma* and *Cistecephalus* AZs have been found in the area to date, suggesting that in this part of the basin middle Permian rocks of the *Pristerognathus* AZ are directly overlain by the Late Permian deposits of the *Daptocephalus* AZ. Based on recently published dates of the Permian Beaufort biozones, this indicates a possible depositional hiatus of Late Permian Beaufort deposition lasting four million years or that a later period of erosion was experienced by this part of the basin. Both of these possibilities lend support to the reciprocal stratigraphic depositional model for the Karoo Basin. Fossil specimens collected during field work were prepared and identified in order to determine the presence and extent of the *Tropidostoma* and *Cistecephalus* AZs in the study area.

Funding acknowledgement: The financial assistance of the National Research Foundation (NRF) towards this research is hereby acknowledged. Opinions expressed and conclusions arrived at, are those of the authors and are not necessarily to be attributed to the NRF. The authors also acknowledge the financial support of the Palaeontological Scientific Trust (PAST), Johannesburg, South Africa.

West Coast Fossil Park – Past, present and future

Haarhoff, P.J.

West Coast Fossil Park

In the 1950s, the Chemfos mining company started mining phosphate at Langebaanweg and in 1958 the first fossil remains were discovered. Expansion of the mining activities in the 1960s revealed huge deposits of fossils and the South African Museum, under the leadership of Dr Brett Hendey, started an intensive research project on these deposits. With the halt in mining operations in 1993, it was decided not to follow the normal closure procedure that would have rehabilitated the mine for agricultural use, but rather to implement a programme that would ensure the preservation of the fossils of the area. Thus in 1996 the West Coast Fossil Park (WCFP) project commenced in a joint venture between the mining company Samancor (the holding company for Chemfos) and the South African Museum (now part of Iziko Museums of South Africa) and in 2005 the WCFP Trust was formed. The present challenge is to ensure that the WCFP is sustained and preserved in perpetuity as a fossil site and to take advantage of the unique opportunities that it provides for research, tourism, environmental education and other activities. The WCFP has an important role in stimulating economic and social upliftment on the West Coast and is currently engaged in a major facilities upgrade project funded by the NLC. This presentation will provide an overview of the development of the Park and will include a summary of the research programme.

Funding acknowledgement: Primary funders of the WCFP are: NLC, Bhp Billiton.

The vertebrate fauna from the lower Burgersdorp Formation (*Cynognathus* Assemblage Zone – *Langbergia* subzone) of South Africa

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The lower Burgersdorp Formation (Beaufort Group) records a rich and diverse Lower Triassic (Upper Olenekian) aged fauna that is referred biostratigraphically to the Langbergia subzone of the *Cynognathus* Assemblage Zone. The macrofauna of the *Langbergia* subzone comprises a relatively high diversity of temnospondyl amphibians, which are also the most abundant fossils, found. Taxa include the mastodonsaurids *Kestrosaurus dreyeri* and *K. kitchingi*, *Parotosuchus haughtoni*, the trematosuchid *Trematosuchus sobeyi* and the brachyopid *Bathignathus poikilops*. The associated amniote fauna includes the erythrosuchid archosauriform *Garjainia madiba*, eucynodont teeth, the cynodonts *Cynognathus craternotus* and *Langbergia modisei*, the therocephalian *Microgomphodon oligocynus*, the enigmatic diapsid *Palacrodon browni*, and as of yet undescribed procolophonoids. Despite extensive collecting no dicynodonts are documented from this subzone. Evidence of a diverse actinopterygian, sarcopterygian and chondrichthyan fish fauna exists in the form of thousands of isolated cranial bones, teeth and scales. At present, however, only the actinopterygian *Saurichthyes*, the dipnoan *Ptychoceratodus* and the chondrichthyan *Lissodus* are

documented in the literature. Thousands of vertebrate coprolites of various morphologies have also been collected, which contain fish scales and vertebrate bone. The remaining microvertebrate fauna remains undescribed; however, the discovery of this diverse microvertebrate fauna is important, as previously only the Czatkowice quarry in Poland and the Arcadia Formation in Australia have produced Early Triassic microvertebrate remains. Gaining a better understanding of this recovery fauna is important, as it is at this time that the radiation of life following the end Permian mass extinction begins.

Investigating the Ediacaran–Cambrian boundary in the Vanrhynsdorp Group, South Africa, and the Vestertana Group of Finnmark, northern Norway

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The Vanrhynsdorp Group of South Africa is a thick fluvio-marine siliciclastic succession with minor carbonates that contains the Precambrian–Cambrian boundary. The age of the Vanrhynsdorp Group is poorly constrained and the stratigraphic position of the boundary within the succession remains unresolved. New detrital zircon dating in one of the middle units (lowermost Besonderheid Formation) yielded a maximum depositional age of 524 to 528 Ma. Additionally, trace fossil evidence suggests that the lowermost units are Upper Ediacaran while the bulk of the upper units are Lower Cambrian. The Group correlates with the world-famous Nama Group of southern Namibia as well as the Vestertana Group of Finnmark, northern Norway, both of which feature diverse Ediacaran–Cambrian fossils. This project focuses on the lithostratigraphy, sedimentology, micropalaeontology and chronostratigraphy of the lower Vanrhynsdorp Group that is believed to encompass the critical Precambrian–Cambrian boundary. Micropalaeontological correlation studies may help resolve stratigraphic problems regarding the position of the Precambrian–Cambrian boundary in South Africa and northern Norway. Our aims are to: 1) determine the stratigraphic location and nature of the Ediacaran–Cambrian boundary, 2) refine the sedimentological interpretation of the units by undertaking sedimentary facies analysis, 3) characterize the micropalaeontology in comparison to the Vestertana Group, and 4) separate detrital zircons from the coarse-grained siliciclastics and tuffaceous layers for dating purposes using Laser Ablation ICPMS.

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Sedimentological, geochemical and palaeontological assessments across the upper Elliot and lowermost Clarens formations, South Africa

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The upper Elliot and Clarens formations encapsulate the Early Jurassic geological history in the main Karoo Basin of southern Africa. The transition from the upper Elliot Formation into the overlying Clarens Formation has been known for its steadily increasing aridity from semi-arid to desert-like conditions. In an attempt to reconstruct the palaeoenvironment and understand the broader geological and climatic changes over this critical interval, sedimentological logs were constructed and samples for geochemical analyses were taken both from the upper Elliot lake deposits, known to be anoxic and often containing conchostraca, as well as the transition between the upper Elliot and Clarens formations. This study reports on the provisional results of the investigations at farms Belmont, Rhodes and Westerford in the Ladybrand and Clocolan districts of South Africa in order to provide quantitative data for palaeoclimatic changes over this critical interval in the Early Jurassic. Major and trace elements of the samples were analysed using X-ray fluorescence and induction-coupled plasma emission spectrometry. Results calculated using the chemical index of alteration (CIA) method show a restricted but linear spread with low range of CIA values indicating semi-arid conditions. In addition, X-ray diffraction (XRD) analysis of clay minerals has been conducted in order to determine the rock provenance and further elucidate the palaeoclimatic conditions. Integration of field- and lab-based techniques offers potential for new knowledge on the Early Jurassic history of the Earth, which has been known for an overall humidification trend in several studies outside southern Africa.

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Geochronological and stratigraphic correlations of new late Oligocene and late Miocene–Pliocene vertebrate-bearing successions in the Rukwa Rift Basin

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Nearly a decade of palaeontological and geological investigations of the Rukwa Rift Basin in southwest Tanzania have led to the discovery of richly fossiliferous Cretaceous and late Oligocene vertebrate-bearing strata. Here we report the discovery of the first confirmed late Miocene–Pliocene vertebrate-bearing deposits in the Rukwa Rift, as well as a series of newly identified late Oligocene deposits to the east of the well-known Nsungwe Formation type area in the Songwe Valley. The discovery of a new late Miocene–Pliocene unit in the rift, which we assign to the base of the Lake Beds Sequence, is significant because it represents the only known fossil-bearing deposit of this age exposed in the western branch of the East African Rift System between lakes Edward and Malawi. Preliminary investigation has resulted in the discovery of numerous fossiliferous horizons, with faunal remains consisting of abundant fish, some turtle and crocodilian elements, as well as rare mammalian remains, including those of hippopotami and large ungulates. We have dated two volcanic tuffs within the sequence via LA-ICPMS U-Pb zircon geochronology, constraining the major vertebrate fossil localities. The Rukwa Rift Basin has been affected by recent tectonic inversion along the basin margins, and the isolated and varied sedimentary exposures and difficult-to-recognize alkaline volcanics make dating and correlation challenging. However, careful geological mapping, in combination with applying multiple dating methods and Sm-Nd isotopic fingerprinting of tuffs is proving to be a powerful approach for deciphering the complex stratigraphy and correlating isolated exposures and fossil localities across the basin.

Funding acknowledgement: We acknowledge Heritage Rukwa Tanzania Limited for funding geochronology analytical work and for logistical assistance, and the Tanzanian Petroleum Development Corporation for making samples available. We thank the Tanzanian Commission for Science and Technology and the Tanzanian Antiquities Unit for logistical support in the field. Fieldwork was supported by the National Science Foundation (BCS_1127164; EAR_1349825) and the National Geographic Society (Committee for Research and Exploration). This project was also funded by the AAPG Suzanne Takken Memorial Grant, and we are grateful to the AAPG Grants-in-Aid Program for this support.

The functional morphology of the Early Triassic non-mammaliaform cynodont *Thrinaxodon* liorhinus forelimb

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The non-mammaliaform cynodont, *Thrinaxodon liorhinus*, is one of the best known fossils in the transition to mammals, and has been a key taxon in understanding the evolution of therapsids. The species is abundant in the South African Karoo Basin and is one of the best represented taxa immediately after the Permian–Triassic mass extinction event. One of the key adaptive behaviours that may have aided in their survival of the extinction was fossorialism. Usually, evidence for this comes in the form of numerous fossils of *Thrinaxodon* having been found in burrows or in a curled-up position. Direct evidence for burrowing capability; however, can come from the functional morphology of *Thrinaxodon* limbs. The present study investigates the internal and external structure of the *Thrinaxodon* forelimb by quantitatively comparing it to forelimb structure of a variety of reptiles characterized by different behavioural patterns, to a fossorial mammal, and to other cynodonts. The study employs geometric morphometric analyses, forelimb metric indices, torsion and cortical thickness of humeri in order to determine the extent to which, the *Thrinaxodon* forelimb functionally and structurally resembles that of a fossorial mammal versus a reptile. Results of the study tease apart the extent to which the *Thrinaxodon* forelimb illustrates structural modifications and prove that the morphology is close to that of fossorial mammals with minimal similarities to digging reptiles. This study provides direct anatomical evidence that the limb configuration of *Thrinaxodon* indicates the non-mammalian forelimb form had begun to show similarities to the mammalian form.

Funding acknowledgement: The Palaeontological Scientific Trust (PAST), National Research Foundation (NRF).

CT scanning of fossils at the Evolutionary Studies Institute

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Computed tomography has become one of the main methods used in palaeoscience to study fossil materials. The technique uses X-rays to allow researchers to acquire a three-dimensional image of the specimen, observe the internal structure non-destructively and to take measurements. However, some of the fossils have inclusions with relatively higher density compared to other elements in the matrix or bone material. This has the effect of reducing contrast between the matrix and the bone whilst introducing bright regions in the acquired images. We will be discussing the scanning of such specimens and other CT artefacts such as noise, and movement.

Funding acknowledgement: Centre for Excellence in PalaeoSciences, Evolutionary Studies Institute, University of the Witwatersrand.

Middle Permian diversity of large herbivores: taxonomic revision of the Titanosuchidae (Therapsida, Dinocephalia) of the Karoo Basin, South Africa

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Dinocephalians are a group of therapsids that constitute a significant part of the Middle Permian tetrapod biodiversity. They comprise six families, four of them, anteosauridae, titanosuchidae, tapinocephalidae and styracocephalidae, occur in South Africa. Three of these families (anteosauridae, styracocephalidae and tapinocephalidae) have recently undergone taxonomic revisions by various researchers except for the family titanosuchidae, which has been neglected and the current taxonomy has not changed since 1969. Currently the family titanosuchidae comprises two genera and nine species (*Titanosuchus ferox*, *Jonkeria boonstrai*, *J. haughtoni, J. ingens, J. koupensis, J. parva, J. rossouwi, J. truculenta* and *J. vanderbyli*). This project is an enquiry into the validity of these species and involves first hand examination of the majority of the known (well preserved) specimens of the group to evaluate the morphological features proposed to characterize the different members of the titanosuchidae. In addition, aspects relating to ontogenetic development and sexual dimorphism would also be a target of this study. Together with the recent taxonomic work on anteosaurids, styracocephalids and tapinocephalids, this research project will give a comprehensive picture of dinocephalian diversity in the Middle Permian of South Africa. Taxonomic clarification of groups represented in the fauna is a basic prerequisite for any project aiming to explorethe diversity changes and extinctions of terrestrial faunas from the Middle Permian.

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Tree growth rings as a palaeoclimate proxy for the Karoo Basin

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Very few dendroclimatology studies have been done on the *Agathoxylon* wood specimens found in the Permian to Jurassic Beaufort Group and overlying Molteno and Elliot formations of the Karoo Supergroup in the main Karoo Basin of South Africa. Preliminary analyses of these gymnosperm wood specimens reflect a variable palaeoclimate that may be the result of palaeoenvironmental conditions in the immediate area or the area's distance from the coast. The study will look at five anatomical features of 60 Karoo fossil wood specimens from outcrops in the Free State to reconstruct the palaeoclimate of this area over 60 million years from Mid-Permian to Early Jurassic times. The anatomical features include: the presence/absence of tree growth rings, width of the growth rings, annual width variations of adjacent growth rings, presence/absence of false and traumatic rings and the portions of early wood and late wood in each growth ring. The features will be used as an indicator of the seasonality of the palaeoclimate, favourability of growing conditions, regularity of the length of the growing season/environmental stresses and the occurrence of extreme climatic conditions. Fossil wood specimens at/near the P-Tr boundary will also be studied and compared to woods from other parts of the Karoo Basin to see whether their tree growth rings reflect extreme climatic conditions that can be associated with the P-Tr mass extinction event. Finally, intra-ring growth analysis will be used to determine whether the trees had evergreen or deciduous habits.

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Spatial taphonomic reconstruction of the Dinaledi Chamber, Rising Star Cave, by the use of high-resolution three-dimensional data collection

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The Dinaledi Chamber in the Rising Star Cave (Cradle of Humankind, South Africa) has yielded approximately 1550 specimens of hominin remains to date, representing a minimum of 15 individuals. The excavation environment within the cave represented an exceptionally difficult and dangerous recovery challenge where conventional methods of high-resolution spatial data retrieval would have been exceptionally cumbersome. Through the innovative use of white-light photogrammetry and laser scanning at scales ranging from landscape level down to the level of individual bone fragments, data collected with these methods push boundaries of both technology and image reconstruction as applied to the analysis of taphonomy, palaeoenvironment and skeletal morphology. Here we review the use of these technological solutions in the Dinaledi excavation, and show applications that help us to understand the spatial distribution of remains, possible disarticulation or disaggregation processes in the site, and the association of taphonomic signatures with spatial position of hominin elements. The findings from the spatial data are an important input parameter in understanding how the bodies entered the Dinaledi Chamber. These high-resolution data integration methods create a foundation for further work on understanding site formation processes for the Dinaledi Chamber and other parts of the Rising Star cave system.

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Update on the digital library of ichnofossils in the Karoo Supergroup, South Africa

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The Karoo Supergroup in southern Africa boasts a stratigraphic record that: a) contains evidence for the end-Permian and end-Triassic mass extinction events, ~252 and ~200 Ma ago, respectively; and b) is rich in trace and osteological fossil assemblages. Ichnofossils are important in capturing the biotic changes associated with these events and can provide unique insights into the interactions among organisms and their sustaining ecosystems. To date, no consolidated South African ichnotaxa database exists, and thus the spatiotemporal distribution and abundance of the Karoo ichnites are unknown. We are creating a Karoo ichno-database using primarily the digital reappraisal of various museum collections in South Africa. Photogrammetry has been a sustainable technique, because it requires simple tools (camera) and skills (photography, basic computer literacy) that form part of the general ichnological and geological practice. Photogrammetry has been relatively efficient in the digital 3D modelling of larger trace fossils (e.g. vertebrate burrows). However, smaller inchnofossils require more specialised photographic equipment such as macro lenses and photostacking rigs, making the technique less practical for producing digital 3D models. Laser scanning is effective for converting small ichnites into digital 3D models; however, it requires specialized, less affordable equipment. We propose that, for small trackways and traces, the data collection should focus on capturing the variations in these highly repetitive structures with the aid of techniques that involve semi-automated, statistical descriptions. Our ultimate aim is to utilize the data in the ichnological applications of deep learning algorithms, especially those that are equipped with graphical user interfaces.

Funding acknowledgement: The financial support of the NRF African Origins Platform and CPRR to E.M.B. towards this research is hereby acknowledged.

The long bone histology of *Antetonitrus ingenipes*: basal sauropoda and the evolution of the sauropod-type growth strategy

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Analysis of the long bone microstructure of *Antetonitrus ingenipes* fills a crucial gap in our understanding of the growth dynamics of sauropodomorph dinosaurs. Basal Sauropodomorpha are largely characterized by zonal bone tissue; in contrast, more derived sauropod taxa show a shift towards continuous, uninterrupted growth, characterized by fibrolamellar bone with lines of growth either absent or only present

in the outer circumferential layer. While *Mussaurus patagonicus* shows an increase in growth relative to more basal sauropodomorphs, *Antetonitrus* shows us that the histology of the first true sauropods exhibits an increase in growth rate coupled with intermittent growth lines. Growth lines are not restricted to the outer margin of the compacta (i.e. late ontogeny), indicating that the fully uninterrupted growth seen in more derived sauropods, such as the Nam Phong sauropod, had not yet developed – even in larger sampled individuals. Growth patterns in the youngest individuals exhibit uninterrupted fibrolamellar bone, similar to that of the older individuals, bar the lack of growth marks. Occurrence of growth marks are decoupled from bone size, indicating a level of developmental plasticity in this taxon. Modulations in the pattern of vascular channel arrangements throughout the cortex may indicate periods of resource strain, but the lack of consistency in these modulations indicate this is not likely due to seasonal fluctuations in resource availability. Bands of radial fibrolamellar bone in two samples are interpreted as evidence of disease. While exhibiting highly vascularized, azonal fibrolamellar bone throughout the cortex, as in more derived sauropods, *Antetonitrus* lacks the restriction of growth marks to the outer cortical margin considered diagnostic of Sauropoda.

Funding acknowledgement: NRF/DST Innovation Grant, Palaeontological Scientific Trust (PAST), Harry Crossley Foundation Doctoral Research Grant.

Proposed new Palaeontological Guidelines for the Western Cape

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Heritage Western Cape, South Africa

Following a meeting between key stakeholders in the palaeontological community, as well as representatives of the various national and provincial heritage authorities in July 2014, various issues were raised regarding the requirements of Palaeontological permitting under the National Heritage Resources Act (NHRA 25 of 1999). These issues arose from a conflict between requirements under the act, as well as expectations and relevant needs from research palaeontologists in the field. Following the 2014 meeting, the various needs and requirements have been incorporated into a set of guidelines that address many of the issues raised. Heritage Western Cape is in the process of adopting these guidelines in an effort to better facilitate palaeontological research in the Western Cape. The guidelines are intended to help interpret the NHRA in a way that better suites the research approach of a field palaeontologist, and in a legal sense, to move the field of Palaeontology into a position where legal requirements better mirror the needs of palaeontological methodology.

Funding acknowledgement: Western Cape Government, Department of Cultural Affairs and Sport.

Palaeohistological Evidence for ancestral high metabolic rate in archosaurs

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Archosaurs are a clade of vertebrates that includes birds, crocodiles, and numerous fossil groups. This clade has long been a matter of debate among palaeontologists concerning the evolution of its thermometabolism. The classical hypothesis considers that only modern birds are truly endotherms (i.e. able to produce their own body heat), whereas all other archosaurs are ectotherms (i.e. relying on the external environment to maintain their body at a high temperature). Bone histology allows the study of several traits linked to thermometabolism, otherwise impossible to estimate on fossil specimens. However, no quantitative estimation of metabolic rate has ever been performed on fossils using bone histological features. Here we performed statistical predictive modelling in a phylogenetic context using a sample of vertebrates and a set of bone histological features to estimate metabolic rates of fossil archosauromorphs. We used the recently published method called Phylogenetic Eigenvector Maps (PEM) to express phylogenetic relationships between species as independent variables in our models. Our results show that Mesozoic theropod dinosaurs exhibit metabolic rates close to those of modern birds, and that most fossil archosaurs share an ancestral metabolic rate higher than that of extant ectotherms. This derived metabolic rate was acquired at a more inclusive level of the phylogenetic tree, among non-archosaurian archosauromorphs. These preliminary results also highlight the difficulties of assigning a given heat production strategy (i.e. endothermy, ectothermy) to an estimated metabolic rate value,

and confirm findings of previous studies that the definition of the endotherm/ectotherm dichotomy may be ambiguous.

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Charcoal analysis from 58 and 49 000-year-old hearths at Sibudu: implications for wood uses and the KwaZulu-Natal environment during the Middle Stone Age

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Sibudu cave was occupied by hunter gatherer groups of modern humans. The site includes technological industries from approximately 77 ka to 35 ka, distinguished by specific stone tool types. The environmental conditions have previously been elucidated from studies of well-preserved botanical remains. Archaeological charcoal specimens, from hearths on three of the occupation floors, were analysed for information about wood selection and use. Charcoal was identified by means of reflected light. Taxa identified, such as *Afrocarpus/Podocarpus* spp., confirmed that the coldest, driest phase of occupation was at approximately 58 ka. Bushveld woods, including five *Acacia* types, have been identified in charcoal from MOD layer. The vegetation mosaic was different from today's coastal forest and savanna near Sibudu. The vegetation succession since ~58 ka and ~49 ka represents an increase in savanna at the expense of forest. Charcoal from poisonous *Spirostachys africana* occurs in one hearth in each of the three layers and suggests that the wood was selected deliberately and burnt for insecticidal smoke or other medicinal purposes. This is supported by the occurrence in one hearth, in one layer, of *Tarchonanthus parvicapitulatus* charcoal.

Funding acknowledgement: The support of the NRF and the Palaeontological Scientific Trust (PAST) and its Scatterlings of Africa Programmes towards this research is acknowledged.

Palynology of the Permian Mucanha-Vuzi Coal Basin (Ecca Group, Karoo Supergroup), Tete Province, Mozambique

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A significant amount of palynological work has been carried out on southern African coals but very few studies have focused on coal seams in Mozambique. This study investigated the palynology of the Mucanha-Vuzi Basin in the Tete Province, Mozambique. A total of 32 samples were examined from three boreholes. Standard acid preparation was carried out and 15 samples were productive. The palynomorphs were mostly fragmented and darkly coloured but 36 species were positively identified. Biostratigraphic correlation, age determination, thermal maturity and palaeoenvironmental reconstruction were the objectives of the study. An abundance of saccate pollen allowed a strong correlation to be made between the Mucanha-Vuzi samples and those from the Witbank/Highveld coalfields of South Africa. Correlation with the Waterberg and Pafuri coal-bearing basins (MacRae, 1988) was also possible due to the same dominant species being present. Based on these correlations, the Mucanha-Vuzi Basin samples were determined to be Lopingian (late Permian). The thermal maturity of the palynomorphs was determined to be 4–6 according to the Thermal Alteration Scale of Batten (1980). The palaeoenvironment was reconstructed based on parent floras of the palynomorphs, and this indicated a fluctuating climate with warm wet cycles dominating in the late Permian. Palynology is a powerful tool for analysing past ecosystem changes, and accordingly more research should be undertaken in areas such as Mozambique, where macrofloral and -faunal remains are extremely rare.

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What is happening in palaeosciences outreach and education in South Africa in 2016?

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It is relatively easy for those involved in palaeontological research in South Africa to tell you who else is

doing research in their particular field, where they are working, what their qualifications are and what there outputs are in terms of number of publications and citations. The situation, however, is not so easy with regard to Palaeoscience education and outreach. This paper presents the results of a mainly internet based survey – using Survey Monkey, follow up e-mails and telephone calls to summarize the state of palaeosciences outreach and education in South Africa in 2016. All the NRF funded Palaeoscience Centre of Excellence (CoE) institutions are being surveyed as well as a number of non-CoE organizations also doing palaeosciences outreach including the McGregor Museum, the Cradle of Humankind and the Durban Museum of Natural History. The survey intends to find out what programmes are being offered, what audience and what size audience they are reaching, how successful the presenters of the programmes rate them and what the biggest obstacles that they face when presenting programmes. The survey will also find out what education resources are being using when presenting their programmes, such as posters and casts, and what resources they need. Also, what are the qualifications of the presenters and what remuneration are they receiving. The purpose of this survey is to establish a baseline for palaeosciences outreach and education in South Africa with the goal of identifying joint projects that can be used to develop it sustainably in the future.

Using phytolith evidence to reconstruct the Middle Pleistocene vegetation community along the southwest coast of South Africa

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The southwest coast of South Africa is home to a unique fynbos-dominated plant community that is characterized by a mix of low-growing shrub, succulent and geophyte species. Unlike plant communities in the rest of southern Africa, grasses (comprising primarily C3 taxa) and indigenous trees in this region are conspicuously rare. Low primary productivity with respect to grasses in particular has resulted in very low levels of ungulate biomass and diversity. Vegetative conditions may have been significantly different in the past however. While today the indigenous ungulate community is typified by small-bodied browsing and mixed feeding bovid species, a diversity of large-bodied ungulates dominated the region's faunal community during the Pleistocene. It has been proposed that the presence of these large ungulates, indicates a significantly grassier past for this region. To investigate this hypothesis further, we analysed grass silica short-cell phytoliths extracted from Middle Pleistocene fossil soil horizons in the archaeological excavations at Elandsfontein. Our results suggest that grasses (C3 and to a lesser extent C4 taxa) were indeed more abundant than they are in the contemporary environment. This notwithstanding, grass does not appear to have dominated the environment as some have suggested, since non-grass plant taxa were equally well represented. Overall, these results support the existence of a rich mosaic C3-dominated plant community and confirm previous findings that the Elandsfontein Middle Pleistocene environment was highly productive.

Funding acknowledgement: NRF.

Alexander Logie du Toit's drawings of Alfred 'Gogga' Brown's collection of Stormberg plant fossils, and notes on the localities of several important vertebrate fossil holotypes from the Eastern Cape

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Alfred Gogga Brown (born England, 1834), an amateur fossil collector and naturalist, settled in Aliwal North (Eastern Cape) in 1859, living there until his death in 1920 (Drennan, M.R., n.d., *Gogga Brown*). He is best known for his vertebrate fossil discoveries from the Stormberg mountains where he had made six journeys by 1868, traversing >650 km in total. Twelve fossil reptiles, three fossil fishes, and a temnospondyl amphibian were named after him. Brown is less well known for his fossil plant collection, which was, nevertheless, one of the best and most beautiful in the country (Drennan). Vertebrate palaeontologist T.H. Huxley, upon receiving a box of 350 mostly plant fossils, was unimpressed, referring to them as vegetable remains (letter to R.I. Murchison, 2.10.1866). However, one of Brown's plant specimens was described by palaeobotanist A.C. Seward, and named *Odontopteris browni*. Alexander Logie du Toit (1878–1948), pioneering advocate of continental drift, and widely regarded as South Africa's greatest geologist, was also a good palaeobotanist. Among his papers (UCT, BC722.D), there is an undated sketchbook, containing sketches by du Toit of plant fossils, collected by Brown, occurring in soft yellow sandstones (Molteno Formation) near Aliwal North, and Herschel. Among the plants illustrated are:

Callipteridium stormbergense; Danaeopsis(?), *Pterophyllum, Ginkgo* (or *Baiera*?), *Noeggerathiopsis*(?). Du Toit sketched these fossils during a visit to Brown in Aliwal North, and he also made notes on the detailed localities of holotype fossils collected by Brown, of *Euskelosaurus browni* Huxley 1867, *Batrachosuchus browni* Broom 1903, and *Karoomys browni* Broom 1903.

Funding acknowledgments: S.M. is grateful to the School of Geosciences, University of the Witwatersrand, for funding his attendance at the PSSA 2016 conference.

New historical information on the first vertebrate fossil discoveries from Lesotho in 1867, including the type locality of the cynodont therapsid *Tritylodon longaevus*

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In the 1870s, Richard Owen of the British Museum received vertebrate fossils from Basutoland (Lesotho), sent to him by medical doctor Hugh Exton from Bloemfontein, Orange Free State, and he published an illustrative catalogue of these in 1876. In 1884, he described from this collection a Triassic mammal – *Tritylodon longaevus* (an important cynodont therapsid or mammal-like reptile). New information has been found concerning the discovery, locality, stratigraphic position, and discoverers of the Basutoland vertebrate fossils, in two letters sent to Dr Alexander Logie du Toit by the 80-year-old David Draper in 1929. Draper revealed in these letters that the fossils were found during a raiding party by horse commandos from the Orange Free State during the Basuto War of 1867. The then 18-year-old Draper assisted Dr Exton with collecting vertebrate fossils from the Upper Red Beds (i.e. upper Elliot Formation, Karoo Supergroup, of Lower Jurassic age) not far below their contact with overlying Cave Sandstones (Clarens Formation), at a site whose location he pointed out on a map (present day Thaba Tso'eu). The incidents regarding the Basutoland fossil discovery had not been recorded before in the biographies of Hugh Exton and David Draper, who both later became illustrious geologists. The discovery of fossils by Exton and Draper in 1867 was the first find of any fossils in Basutoland, and predated discoveries of plant fossils associated with coal seams, described by Richard Bright in 1873 and 1874, which were previously thought to have been the first fossils found there.

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A new fossil termite nest from the uppermost Clarens Formation at Pafuri River camp, Venda, Limpopo Province, South Africa – Comparison with other occurrences in southern Africa

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A new ichnofossil locality, interpreted to contain fossil termite nests, has been discovered in the Lower Jurassic Clarens Formation of the Karoo Supergroup, at Pafuri River camp, NE Venda (S22°25.34′; E21°02.17′), Limpopo Province, South Africa. The ichnofossils are found stratigraphically in the uppermost Clarens Formation, directly below the contact with the ~183 Ma Karoo basalts (Lebombo Group). The ichnofossils are positively-weathering structures, which stand out in sharp contrast to the uniform cream-coloured, well-sorted, medium-grained aeolian sandstones which form the host rocks. They consist of a tangled mass of intertwined tubules, and tube-like cavities, 0.5–1 cm in diameter. These traces are confined to irregular elliptical sandstone structures (L: 48 cm; W: 25 cm) that are better cemented and less susceptible to erosion than the surrounding sandstone, which is more friable. Another elliptical structure (L: 16 cm; W: 10 cm) is connected to a tube that is 2.5–3 cm wide and 28 cm long. Other isolated, similar-sized tubes are present in the outcrop. The interiors of the tubes and elliptical structures are oxidized and pink in colour, while their peripheries are bleached paler than the host sandstones, indicating strong diagenetic reduction around these structures. Overall, the structures resemble fossil termite nests and associated structures described previously from other parts of the Clarens Formation in southern Africa (Bordy *et al.* 2004 – *Palaios* 19: 68–78; Bordy *et al.* 2009 – *SAJS* 105: 356–362).

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Investigations of a *Glossopteris* flora near Sutherland: a new approach embracing morphometric and ecological aspects

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Glossopteris leaves are one of the most common and easily recognized fossils in the Permian of the Karoo Basin, but they are morphologically conservative and taxonomic approaches to species differentiation have been varied, relying on visual estimations of relatively plastic characteristics such as shape, length etc. Species identification has therefore proven to be subjective, inconsistent and extremely challenging. Here, we consider new approaches involving morphometric and ecological techniques with the aim of establishing a standardized methodology for the leaf taxonomy of this group. A new flora from the Ouberg Pass (near Sutherland), has been selected as the subject for this study, and will contribute towards the greater goal of establishing a reliable biostratigraphic framework for *Glossopteris* floras of the Permian of the Karoo Basin. The middle Permian is particularly poorly understood in terms of palaeofloras in South Africa. Previous records have been allochthonous fragments, or floras lacking conclusive stratigraphic and temporal constraints. The Ouberg Pass lies in the southern Karoo Basin, rich in fossil records of terrestrial vertebrates of the *Tapinocephalus* Assemblage Zone, and these together with multiple ash dates in the immediate area provide excellent context for this study of a well-preserved, middle Permian parautochthonous flora.

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Palaeoclimatic implications of frog taxa from South African fossil sites

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Frogs are useful palaeoclimatic indicators as they are sensitive to climate change and, in particular, to shifts in variables such as temperature and moisture due to their semi-permeable skins, unshelled eggs, biphasic lifestyles, and the fact that the timing of breeding is driven by environmental cues. Fossil frog assemblages may potentially provide information on rainfall, seasonality, the types of water bodies available, and also the terrestrial environment (vegetation and substrate) as a number of frog species are independent of water during various periods of their lifecycles. The results from an analysis of fossil frog assemblages from the archaeological west coast Holocene site of Dunefield Midden (DFM) and the much older 5.1 Mya palaeontological site of Langebaanweg (LBW) are presented. DFM provides information on some of the agents/agencies which led to the accumulation of microfauna at the site, while the LBW frog fauna provides evidence for substantial rainfall at 5.1 Mya at the southwestern tip of Africa, and also provides new and compelling evidence for a summer rainfall regime, or of at least significant summer rainfall during the Early Pliocene. Preliminary taxonomic and palaeoenvironmental results from the frog fauna from Coopers Cave (1.9–1.6 Ma), situated approximately 45 km northwest of Johannesburg in the Cradle of Humankind, are presented.

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The largest dinosaur in the Karoo: what the Highland Giant is and is not

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In 1994 Prof. James Kitching discovered an assemblage of massive dinosaur bones while prospecting in the Elliot Formation near Clarens at one of the key sites for the Lesotho Highlands Water Project. Almost two decades later, *in situ* material from the same assemblage was relocated on Beginsel farm (Free State) by a team from Wits University. In addition to the vertebrae, ulna and pedal ungual originally collected by Kitching, we have recovered a partial sacrum and femur, as well as additional dorsal and caudal vertebral

material. This assemblage (informally known as the Highland Giant) represents a sauropodomorph dinosaur of appreciably larger size than any previously known specimen from deposits close to the global Triassic–Jurassic boundary. Despite the 20 years since its initial discovery, the taxonomic affinities and stratigraphic provenance of the Highland Giant remain enigmatic. Originally thought to be a giant biped from Late Triassic beds of the lower Elliot Formation, our recent investigations securely place it within the upper Elliot Formation and suggests a close relationship with the large-bodied supposedly quadrupedal lower Elliot genus *Antetonitrus*. In-depth analyses of the stratigraphic and phylogenetic relationships of the Highland Giant and a quantitative estimate of its body mass and general proportions are presented. This allows for guided speculation about the locomotory habits of this intriguing animal. These concerns also have bearing on the way in which ecological partitioning of the increasingly arid upper Elliot palaeoenvironment encouraged the taxonomically and morphologically diverse assemblage of large-bodied herbivores now recognized.

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Bone microstructure of two highly specialized subterranean rodents: *Bathyergus suillus* and *Heterocephalus glaber* (Bathyergidae)

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African molerats are a large group of strictly subterranean rodents endemic to the sub-Saharan region, and occurring in a wide range of habitats. An important ecofunctional difference among bathyergids is the way they dig underground; *Cryptomys*, *Fukomys*, *Georychus*, *Heliophobius* and *Heterocephalus* are chisel-tooth diggers, so they use mostly their incisors during digging, while *Bathyergus* is a scratch digger, being the only one showing long digging claws in fore- and hindlimbs. Majority of the studies on the fossorial adaptations of mammals have focused on macrostructural features of the musculoskeletal system, whilst little attention has been given to their bone microstructure. In the current study, we compared the adult femoral and humeral (midshaft) histology of the smallest bathyergids (weighing ~35 g), *Heterocephalus glaber*, with that of the largest, *Bathyergus suillus* (>2 kg). Both species have thick cortical walls, and have similar humeral microanatomy, although in *H. glaber* is more ellipsoidal. The femoral microanatomy differs, being more elliptical in *B. suillus*, likely due to differences in the extension of third trochanter along the midshaft. The histodiversity is higher in *B. suillus*, showing a stratified cortex with distinct layers of endosteal and periosteal bone, e.g. lamellar, parallel-fibred, woven, compact course cancellous and fibrolamellar bone. The cortex of *H. glaber* is mostly composed of parallel-fibred bone. Vascularization is more developed in *B. suillus*. These histological differences are likely due to size, shape and mechanical function. Further quantitative research of the bathyergid skeleton is needed to understand interrelationships between bone microstructure and bone shape.

Hindlimb histology of the specialized climber, *Procavia capensis* (Hyracoidea; Paenungulata)

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Bone development in mammals is mostly known for domestic cursorial animals, but, there is a gap in our understanding of how other lifestyles affect bone growth. Hyracoids are small ungulates adapted for rock and tree climbing; they have feet with elastic and rubbery pads on the soles, which constitute a particular locomotor adaptation in mammals. Their crouched and high-fulcrum posture typical of small mammals involves specific mechanical loads (e.g. stress and momentum) in the musculoskeletal system. Thus, microstructural differences are expected when compared to similar-sized organisms with extended limbs. In this preliminary study we explore the mid-diaphyseal hindlimb histology of three individuals of *Procavia capensis* (Procaviidae) representing a relative ontogenetic series. The femur and tibia show a modelling pattern established by a fibrolamellar scaffold followed by symmetrical periosteal apposition of parallel-fibred and lamellar bone tissues. As in other terrestrial mammals, the medullary cavity expands as a result of considerable endosteal resorption as the animal grows. The femoral microanatomy changes slightly from an elliptical cross-sectional shape to a more circular shape, while the tibia changes more

drastically from circular to highly ellipsoidal. All bones analysed were well vascularized and remodelling was present from early stages of ontogeny. Dense Haversian tissue was observed in the tibia of the adult. Such changes in bone geometry and histology may be correlated with shifts in locomotor patterns during ontogeny. This pilot study represents the first histological assessment of the long bone growth in Hyracoidea and highlights areas for future research.

Stratigraphy, palaeontology and continental ichnology of the late Cenozoic Lake Beds Successions, Rukwa Rift Basin, Tanzania

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We present the first detailed sedimentological investigation and palaeontological survey of the late Cenozoic Lake Beds succession of the Rukwa Rift Basin, Tanzania. Work over four field seasons revealed a complex unconformity bounded, stratigraphic succession with isolated fossiliferous exposures of highly variable ages, between late Miocene and late Quaternary. Our work provides the basis for subdividing the poorly understood Lake Beds into a three-fold stratigraphy, which includes: (1) a basal, richly fossiliferous upper Miocene–Pliocene lower unit; (2) a lithologically complex, and as yet poorly understood, lower to middle Pleistocene (?) middle unit; (2) and an extensive, well exposed upper unit. Biostratigraphy, geochronology and establishment of a formal stratigraphic nomenclature is currently underway in all three units. The lower Lake Beds have two distinct members: a poorly fossiliferous lacustrine lower member; and a richly fossiliferous, fluvial-floodplain dominated upper member. The middle Lake Beds are characterized by a series of isolated exposures, many fault bounded, throughout the southern end of the rift. As of yet, these deposits have only yielded plant macrofossils and trace fossils. The middle unit is characterized by localized lacustrine (including carbonate), volcaniclastic alluvial fan, and fluvial-floodplain facies. Overlying the middle Lake Beds, is a thick succession of late Pleistocene–Holocene volcanic-rich, locally fossiliferous alluvial to deep-water lacustrine strata. The upper Lake Beds record a spectacular continental ichnofauna, as well as abundant isolated fish remains, and isolated larger vertebrate macrofossils. Detailed analysis reveals six discrete depositional sequences that record climate-driven lake cyclicity (±70 m fluctuations) over the last 50 Ka.

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Producing a glossary to explain palaeontological terms in indigenous South African languages for palaeoscientists, outreach officers, teachers and learners

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Traditionally, palaeosciences outreach has been conducted in English and Afrikaans which has resulted in calls to translate outreach materials into more official languages. Here we describe a new project creating a basic glossary of palaeontological terms used in school education in some of South Africa's indigenous African official languages. The terms and definitions chosen for translation have been taken from evolution and palaeontology sections of popular South African Natural Science and Life Science textbooks and are therefore currently very much in use in our education system, and are also more likely to be at the appropriate level for South African learners. In the beginning we are focussing on the languages of IsiZulu, Tshivenda, and Sesotho and are hoping to find partners who will translate IsiXhosa for us. We hope that this glossary will be used as a resource by school teachers, palaeoscientists and outreach officers. We foresee that it will be most useful for nursery school teachers and primary school teachers whose learners may not understand English at all, as well as for high school English second language learners who struggle to understand biological terms but will still need to write their exams in English. A major problem we have encountered is that most palaeontological terms such as 'fossils' simply do not exist in indigenous African languages, and the words required in definitions like 'Marambo a khale are tomboni' in Tshivenda are ambiguous. Ultimately we also would like to produce a simple pamphlet on South African palaeontology, in our four chosen languages.

Stratigraphic framework of the Kirkwood Formation in the southern Cape region, South Africa: invertebrate-based biostratigraphy and zircon geochronology

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The Jurassic–Cretaceous Kirkwood Formation, which forms part of the fluvio-lacustrine sedimentary fill of the rift basins along the southern continental margin of Africa, consists of mudstone, sandstone, sporadic conglomerate and tuffaceous layers. It also contains a diverse non-marine biota comprising fossil flora, charophytes, invertebrates, reptiles and mammalians. Despite the rich fossil heritage preserved, none of the terrestrial fossils are sufficiently age diagnostic to accurately date the Kirkwood Formation. A Valanginian age is commonly accepted; however, this is entirely based on the foraminifera found in the overlying Sundays River Formation and poorly understood Colchester Member of the Kirkwood Formation. This age may not be accurate because the contact between the Kirkwood and Sundays River formations has not been fully resolved. Additionally, the known age of the thin Colchester Member cannot be extrapolated through the entire Formation. In order to improve the chronostratigraphic framework of the Kirkwood Formation, this study aims to both refine the palaeoenvironmental conditions during its deposition and establish the age of the tuffaceous layers using U-Pb LA-ICPMS and CA-TIMS dating methods on detrital zircons. Preliminary U-Pb LA-ICPMS zircon ages from primary tuffaceous layers range from 172 ± 3 Ma to 130 ± 3 Ma confirming the suspected diachronous nature of the Kirkwood Formation. The integration of these, and additional dates, with biostratigraphic work will provide information about both the geological evolution of the rift system and biological evolution of life during the Jurassic–Cretaceous transition.

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Palaeoenvironmental fluctuations during a terminal Oligocene–early Miocene transgression at the southwestern tip of Africa

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A multi-proxy study from an offshore core in Saldanha Bay spans the Palaeogene–Neogene transition. It consists of fluvio-paludal sediments that provide perspectives on fluvial deposition, ecosystems, and sea-level history. Offshore seismic data illuminate the control of bedrock topography on Cenozoic stratigraphy and provide evidence of relative sea level as low as –100 m during the early Oligocene. A 3D landscape reconstruction reveals hills, plains and ananastomosing river. A Chattian to early Miocene age for these diments is suggested by dinoflagellate taxa. Pollen indicates subtropical vegetation including mangroves, lianas and vines, evergreen arboreal elements, palms and ferns. The forested environment implies high precipitation, probably reduced seasonal drought and a stronger contribution of summer rainfall. From the topography, sedimentology and palynology we hypothesize Podocarpaceae-dominated forests, proto fynbos, swamp/riparian forests with palms and other angiosperms along the water courses. Subtropical woodland-thicket with Combretaceae and *Brachystegia* developed possibly on the coastal plains. Mangroves with Rhizophoraceae and associated ferns were restricted to estuaries. Typical Gondwanan elements, which became extinct during the Neogene in South Africa, e.g. Araucariaceae, prevailed. Fungal elements were recovered with charred particles suggesting fires. The marine microfossils (dinoflagellate cysts, microforaminiferal linings), pollen and spores, together with various organic and inorganic geochemical proxy data suggest a gradual glacio-eustatic sea-level rise which

began during a late Oligocene warming phase, keeping pace with wetland sedimentation. The sequence sheds light on southern hemisphere biogeography and regional climate during the Palaeogene–Neogene transition, enabling comparison and correlation with marine and terrestrial records on other Gondwanan continents.

The use of GIS and multi-scalar analysis tools to reconstruct the geomorphology of the fossil hominin sites and, to facilitate the understanding and interpretation of fossil hominin taphonomy in Kromdraai and the Cradle of Humankind

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The application of Geographic Information System (GIS) tools in archaeology has become an increasingly valuable approach for the visualization and interpretation of fossil hominin sites, as well as for the study of their geomorphological contexts at a more regional scale. This research explores the use of multi-dimensional efforts to create a 3D representation and, to generate a complete digital record of the Kromdraai B (KB) site and the 'Cradle of Humankind'. The main objective of the study is to demonstrate the series of geological changes at different scales, the geometry of the fossiliferous deposits at KB and the taphonomy of fossilized Plio-Pleistocene hominins, ultimately providing an archive documenting the palaeoenvironments of Kromdraai. With the application of modern, innovative methods such as multi-image photogrammetry from land and drone imagery, remote sensing, terrestrial and close range laser scanning and micro-computed tomography (microCT); a multi-scalar analysis of various aspects of the study site is provided. An accessible web interface comprising a database incorporating the findings of the study, the progression of the excavation and relevant metadata will be created for the benefit of both academics and the general public. This presentation will discuss the usefulness of adopting a four-tiered approach (3D modelling, image processing and the use of GIS and remote sensing) towards the understanding of fossil taphonomy in different study sites and, the importance of disseminating information through a virtual environment. Preliminary results showing the integration of 3D point cloud data and photogrammetry documenting the changes in the Kromdraai excavation operation from 2014 to 2016 will also be presented.

Funding acknowledgement: Erasmus Mundus Programme (European Commission), Evolutionary Studies Institute (University of the Witwatersrand, South Africa), Centre National de la Recherché Scientifique (CNRS-France), French Ministry of Foreign Affairs.

Comparison of tooth replacement patterns of the Permo-Triassic epicynodonts *Cynosaurus* and *Galesaurus*

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Cynosaurus suppostus and *Galesaurus planiceps* were small non-mammaliaform cynodonts from the late Permian and Early Triassic of South Africa. Eight specimens of *Galesaurus* and five of *Cynosaurus* were scanned using micro-computed tomography. This was undertaken in order to establish the size, number and positions of unerupted teeth relative to functional teeth, in order to determine the patterns and rates of tooth replacement in the two taxa. Results showed that in both genera the incisor and postcanine teeth were replaced in an alternating pattern. Replacement maxillary canines erupt anterior to the functional canine, whereas mandibular replacement canines erupt posterior to the functional one. For *Galesaurus*, replacement of the maxillary canines took place at an earlier stage than replacement of the mandibular canines. In both genera, the largest specimens showed no signs of replacement activity associated with

the canines. This suggests a finite number of replacement generations associated with the canine teeth. Furthermore, the canine teeth of the largest specimens of *Galesaurus* remain open-rooted. Both genera showed an increase in the number of teeth in the postcanine series through ontogeny, with the possible retention of the first postcanine tooth. For *Cynosaurus* the maxillary series showed an increase from 7 to 10 postcanines and the mandibular from 9 to 10; whereas in *Galesaurus* the maxillary and mandibular postcanine series showed an increase from 9 to 12 and 11 to 15, respectively. Despite the difference in morphology and number of postcanine teeth, the manner in which the series was replaced is very similar between *Cynosaurus* and *Galesaurus*.

Funding acknowledgement: This research was made possible by an NRF PDP bursary awarded to L.A.N. Thanks to K. Carlson, T. Jashashvili, and K. Jakata (Wits MicroCT facility) for performing the scans of the fossil material.

New ichnotaxa from Cooper's D, Cradle of Humankind, South Africa

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This presentation will detail the first comprehensive description and analysis of trace fossils produced by insects on bone from a faunal assemblage in the Cradle of Humankind, South Africa. A total of 9500 bone fragments from Cooper's D were visually inspected for evidence of insect trace fossils. Fifty-three specimens with insect traces were identified and analysed using optical microscopy at low magnifications. Analysis revealed frass and coprolites preserved on some bones, and nine morphologically distinctive traces. Circular boreholes associated with a crescent-shaped excavation are attributed to a new ichnotaxa. Ellipsoidal surface borings (pupation chambers) are assigned to a new ichnospecies of Cubiculum. Evidence suggests that traces were produced by more than one agent at different stages during the taphonomic process. Modification either took place whilst bones were sub-aerially exposed, at the point of final deposition, or post-burial of the remains. These two new ichnotaxa represent the first ichnotaxa described in bone from the Cenozoic of Africa.

Funding acknowledgement: DST/NRF Centre of excellence in Palaeosciences, Evolutionary Studies Institute, University of the Witwatersrand, South Africa.

The rise and fall of the Malvinokaffric Realm in South Africa: insights from palaeoenvironmental, biostratigraphic and sequence stratigraphic data

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The Malvinokaffric Realm is a Silurian to Middle Devonian (Eifelian) high latitude polar-to-subpolar palaeobiogeographic realm of southwestern Gondwana characterized by a low-diversity fauna comprising several genera and species of endemic brachiopods and molluscs, in addition to certain phacopid trilobites, of which calmonids are unique. Conularids, tentaculitids and hyolthids are abundant, whilst bryozoans and corals are rare. Rhynchonellid brachiopods, stromatoporoids, conodonts, ammonoids and graptolites are absent making correlation of Malvinokaffric Realm successions tenuous. Closure of the Realm is recognized by admixture with warm-water Old World Realm fauna. The appearance of trans-Atlantic brachiopods, *Tropidoleptus* sp. and *Rhipidothyris* sp., typically mark this event. Their appearance in South America is coincident with a global warming trend and transgression possibly related to the global Kačák Event transgression and extinction at the end of the Eifelian. In South Africa, the Malvinokaffric Realm is restricted to the Rietvlei-Baviaanskloof formations (Table Mountain Group) and the Bokkeveld Group (Gydo to Waboomberg formations). *Riphidothyris* sp. and *Tropidoleptus* sp. are present in the Karoopoort and Wagendrift formations (Witteberg Group), implying a Givetian age for the Bidouw and Weltevrede Subgroup. Palaeoenvironmental, biostratigraphic and sequence stratigraphic research on the Bokkeveld Group suggests that the Malvinokaffric Realm is contained within two second-order transgressions with maximum flooding surfaces in the Gydo and Waboomberg formations. Closure of the Realm and the Eifelian–Givetian boundary coincides with a regressive surface of marine erosion or paraconformity near the Waboomberg–Wupperthal contact, suggesting a protracted regressive phase prior to transgression of the Klipbokkop Formation and admixture with Old World Realm Fauna.

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The palaeoenvironment (*c.* 1.6 Ma) of FxJj20 complex, Koobi Fora, Kenya, using phytoliths

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Phytoliths are opal silica shapes of plant cells formed during a plant's lifetime. They can survive millions of years of deposition and be taxonomically distinctive to plant type. Their presence can be used to determine how vegetation changes over time and as such are a valuable tool in the reconstruction of palaeoenvironments. We analysed samples collected from palaeosols within FxJj20 East site at Koobi Fora in northwest Kenya (dated 1.6 Ma). Globular echinate phytoliths, associated with palm trees, were the most dominant morphotype encountered which corroborate findings of fossilized palm tree trunks in this region. Other phytolith morphotypes detected are found in parts of tropical dicotyledonous trees and shrubs, and grasses. Although grass phytoliths found occur in both C3 and C4 grasses, as a combination (rondels, saddles and trapeziforms), they are more associated with C4 grasses in drier, lowland areas. Aridification occurred in this region 2.5–1.8 Ma which resulted in an expansion of C4 grasses. How dominant each plant type was in this palaeoenvironment 1.6 Ma, remains unknown, as this is not reflected by relative abundances of phytolith morphotypes detected in palaeosols. This preliminary work is the first systematic examination of phytoliths at this site and indicates that hominins would have encountered and utilized both open areas and those with more shrubs/trees forming a mosaic across the landscape.

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Frequency and duration of U-Pb dated flowstone growth intervals in South African early hominin caves reflect Early Pleistocene climate variability

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The Cradle of Humankind (CoH) in South Africa is home to a rich collection of early human (hominin) fossils, preserved in dolomite caves. Flowstones, horizontally bedded layers of calcium carbonate, are ubiquitous features at all sites and serve the dual utility of providing ages for the fossilferous sediments sandwiched between them (via U-Pb dating) and as indicators of past climate regimes by their presence alone, being associated with increased effective precipitation. We present a dataset of 28 U-Pb dated flowstones from 8 caves across the CoH, 14 new ages and 14 published ages, a number of which have been re-calculated, yielding greater precision. To solve the problem of necessarily large uncertainties on individual ages, we use a kernel density estimate to sum together the U-Pb age data into a single record of flowstone growth intervals (FGIs). This record spans from 3.2–1.3 Ma, with four major FGIs identified and interpreted as wet phases. The time periods interceding the FGIs are interpreted as drier phases. It is during these phases that the fossiliferous sediments accumulate in the caves, suggesting that these deposits in fact have a 'dry phase' bias and that the South African hominin and faunal record is only sampling these drier intervals.

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Rigbya revisited: a large new collection from KwaZulu-Natal confirms glossopterid affinities and associated *Glossopteris* leaf morphotype

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Rigbya arberioides, a typical seed-bearing fructification of the Upper Permian floras of South Africa, is a widespread taxon that has been found in *Glossopteris*-dominated floras of Australia and Antarctica. The distinctive fan-shaped, dichotomizing fertile branch system of *Rigbya* is in contrast to the more typical, capitate fructifications of the Dictyopteridiaceae that have been found in direct, organic attachment to midrib of *Glossopteris* leaves. Additionally, the long, slender pedicels and axillary attachment of *Rigbya*

fructifications have apparently precluded the preservation of fructifications in organic connection to stems and leaves. For these reasons, the botanical affiliations of *Rigbya* have been a source of debate. However, careful examination of well-preserved material housed in South African collections demonstrates a clear morphological link between fructifications of the Arberiaceae, Dictyopteridiaceae, Lidgettoniaceae and Rigbyaceae, suggesting that these organs are all glossopterid, and represent modified branching axes, rather than the traditionally-held view that they are leaf homologues. A fossil locality in KwaZulu-Natal has produced an exceptionally well-preserved, large and informative Upper Permian fossil plant collection, containing over 100 specimens of *Rigbya*, along with a comprehensive representation of the associated glossopterid foliage. This provides further evidence of the glossopterid affinities of this taxon, and confirms a leaf association first proposed by Anderson and Anderson (1985).

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Lithology and Palaeontology of the Ecca–Beaufort contact in the northern Karoo Basin

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The position and lithological nature of the contact between the Ecca and Beaufort groups of the Karoo Basin has been a subject of dispute for some time. More recently there is consensus that the lithological position of the contact is signified by a palaeoenvironmental change from subaqueous delta plain conditions in the case of the Ecca to a continental fluvial environment for the Beaufort. The contact is currently mapped at the top of the Waterford Formation of the Ecca Group in the southern, western, central and extreme northeastern parts of the basin while the lithological nature of the contact in the northern part of the basin is still uncertain, largely because of the lack of good outcrops. This study documents the lithology and palaeontological occurrences of the Ecca–Beaufort contact in the northern Karoo Basin between the towns of Frankfort and Newcastle. Localities for lithological study were selected based on a Google Earth analysis of outcrops that fall within the area. The main goal of the project is to establish the absence or presence of lithofacies which characterize the Waterford Formation in the study area, as these facies are known to be present in the central Free State and also in the Estcourt area of KwaZulu-Natal, as well as to determine palaeontological occurrences. We report on the lithofacies present in the study area and assess the significance of our findings for Karoo Basin development modelling.

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New 'Guidelines for Palaeontological Permitting Policy' by SAHRA: what are the improvements?

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The South African Heritage Resources Agency (SAHRA) is a statutory body that was created to implement the National Heritage Resources Act (NHRA) No. 25 of 1999 and it is responsible for the coordination of the identification and management of the National Estate. The implementation of the provisions of the NHRA relating to permitting has been biased towards archaeological standards and techniques, in particular with regard to excavation and collection practices. This has resulted in it being applied only with difficulty to palaeontological research and excavation/collection methods. The previous 'Policy and Guidelines for the Management of Archaeological and Palaeontological Heritage Resources, and Meteorites', implemented in September 2006, is in the process of being reviewed and divided into three different policies to address issues and methods specific to each field. The new 'Guidelines for Palaeontological Permitting Policy' addresses permits with regard to research and development-led applications. Research permits are needed for excavation and collection, destructive analysis/sampling as well as temporary and permanent export for analytical, exhibition or educational purposes. SAHRA, as the national body, coordinates permits for all provinces except those three that are declared functional, i.e. Amafa (KwaZulu-Natal), ECPHRA (Eastern Cape) and HWC (Western Cape), as well as export permits for material from the entire country (including EC, KZN and WC provinces). In an effort to work more closely with

the functional PHRAs and to address the needs of palaeontological research, the main new improvement is that a Formation/Group Collection Permit was approved. This and other improvements within the new Policy Guidelines will be presented.

Exploring an ophiuroid–stylophoran assemblage from the Devonian Voorstehoek Formation, Bokkeveld Group, Western Cape: taphonomy, palaeoecology and taxonomy

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The Emsian Voorstehoek Formation (Ceres Subgroup, Bokkeveld Group, Cape Supergroup) is richly fossiliferous and contains typical cool to cold-water benthic biota (e.g. brachiopods, trilobites, crinoids) from the Malvinokaffric Realm of SW Gondwana. Palaeontological and sedimentological features of the Voorstehoek Formation suggest that deposition took place in a shallow marine environment within a storm-influenced, proximal offshore transition zone in the Early Devonian. We excavated a 5 cm thick layer at a study site in the Western Cape, and through the use of micro-CT scans, found complete ophiuroids associated with rare stylophorans. Taphonomic analyses of this ophiuroid–stylophoran assemblage suggest a marine obrution deposit, which formed due to the rapid burial that smothered both autochthonous and allochthonous taxa of the benthic community during high-energy storms. This uniquely preserved, mixed assemblage provides a taphonomic window into the marine ecosystems of the Early Devonian, including the structure of a benthic community within the Malvinokaffric Realm of SW Gondwana. The current project aims to extend the micro-CT scanning for a much large portion of the fossil-rich obrution bed to generate a computerized 3D model that would allow a more detailed taphonomic analysis of the bed. This includes the determination of the degree of fossil articulation, fossil orientation and faunal counts without damaging the delicate echinoderm fossils and primary sedimentary features. Furthermore, the ability to digitally dissect the fossil-rich bed can reveal organisms that would have otherwise been missed or destroyed using traditional, mechanical fossil preparation techniques.

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Oxygen isotopes suggest elevated thermometabolism within multiple Permo-Triassic therapsid clades

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Nowadays, birds and mammals are the only true endothermic homeothermic animals. They produce and regulate their internal temperature quite independently from ambient environmental temperatures. Whereas birds likely inherited their thermophysiology from their dinosaur ancestors, the oldest definitive evidence of mammal endothermy dates back to the Middle Jurassic. However, anatomical clues suggest an older origin, during the Triassic or the Permian. We analysed apatite stable oxygen isotope compositions of a representative sample of Permo-Triassic therapsids to investigate the origin and timing of mammal thermoregulation. All main clades of Eutherapsida were sampled (Dinocephalia, Anomodontia, Gorgonopsia, Therocephalia and Cynodontia). By comparing the $\delta^{18}O_p$ values of therapsid bone and tooth apatites with those of coexisting tetrapods of various ecologies and physiologies (terrestrial and semi-aquatic parareptiles, semi-aquatic stereospondyl and terrestrial archosauriforms), thermoregulatory strategies estimated from body temperature differences are proposed. Our results indicate that

amongst the Dicynodontia, Induan Lystrosauridae and Anisian and Camian Kannemeyeriiformes may have acquired elevated thermometabolism. A similar result has been obtained in the Cynodontia clade within Anisian Cynognathia and Rhaetian Mammaliaformes. Our results indicate that mammalian thermoregulation possibly originated from the Epicynodontia group during the middle late Permian. It appears that the timing of acquisition of elevated thermometabolism in amniotes coincides with major global climatic and environmental fluctuations that may have acted as a selective pressure during the origin of mammal endothermy.

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Seasonal exploitation of coastal resources in the Middle and Later Stone Age of southern Africa from comparative Cape fur seal (*Arctocephalus pusillus*) assemblages

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Modern human behaviour – marked by increases in cognitive ability, including symbol use, complex technologies, and advanced subsistence strategies – appear as early as 160 ka, but become more widespread after 100 ka. Arguments about seasonal exploitation of resources have been central to the debate about how, when, and in what context this behaviour emerged. For example, comparisons of Cape fur seal (*Arctocephalus pusillus*) remains from coastal sites in South Africa have been used to suggest that Later Stone Age (LSA) foragers, unlike those living in the preceding Middle Stone Age (MSA) period, strategically-targeted coastal sites during seasons when seals were more abundant. Although methods for establishing seasonality from archaeological seal mandibles have been evaluated by previous researchers, specific predictions for differences in MSA and LSA seal assemblages have not been rigorously tested. To investigate these unresolved issues, this study addresses two questions: (1) Are comparative samples of seal remains adequate to address the question of seasonality? and (2) Do comparisons of archaeological and comparative samples demonstrate the predicted differences between LSA and MSA suggested by prior research? These questions are evaluated using resampling techniques and mortality assemblage simulation modelling. The results indicate that the comparative samples may be useful for assessing seasonality, but do not support the contention that differences existed between the seasonal strategies of LSA and MSA peoples. The findings are discussed in terms of the appearance of behavioural modernity in southern Africa, particularly in relation to the evolution of seasonal variation in foraging.

Isotaphonomy in concept and practice: an exploration of vertebrate microfossil bonebeds in the Upper Cretaceous (Campanian) Judith River Formation, north-central Montana

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Vertebrate microfossil bonebeds (VMBs) are commonly studied to recover otherwise rarely found small-bodied taxa, and to document relative abundance and species richness in ancient vertebrate communities. Taphonomic analyses of size and shape data from VMBs have generally found them to be non-isotaphonomic, and outcomes of 'strict' statistical tests of isotaphonomy suggest that potential for palaeoecological reconstruction in a broad comparative sense is limited. Given the general lack of clarity with regard to the definition of 'strict' isotaphonomic comparability, and the likelihood of significant variability within taphonomic systems, it is not surprising that sensitive statistical tests highlight variations among VMBs. Six VMB localities representing two distinct palaeoenvironments of the Upper Cretaceous Judith River Formation were rigorously sampled and compared to evaluate potential biases. The significant distinctions in size and shape reported in most previous comparative studies of VMBs are not developed in the Judith River VMB data set. Few defining distinctions are evident in comparisons of bioclast size and shape in surface collections, and site-to-site similarities are compelling among sieved subsamples. With one diagenetic outlier culled from the comparative sample, seven of ten potential comparisons yield indistinguishable or marginal results for size, and all are statistically indistinguishable from a shape frequency

perspective ($P \leq 0.01$). The case for isotaphonomy among Judith River VMBs is strong, whether based on graphical comparisons or evaluated in the 'strict' statistical sense. This bodes well for studies of palaeoecology, particularly in relation to investigations of faunal membership and community structure in Late Cretaceous wetland ecosystems.

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The Middle Abrahamskraal Formation and the mystery of the *Eodicynodon–Tapinocephalus* Assemblage Zone transition

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The Abrahamskraal Formation, which reaches a maximum thickness of 2500 m, is the lowermost formation of the Beaufort Group and has been subdivided into several lithostratigraphic members, which have not yet received SACS recognition. The rich diversity of Middle Permian tetrapods has resulted in the official recognition of two vertebrate biozones, the *Eodicynodon* and *Tapinocephalus* Assemblage Zones (AZ). The *Eodicynodon* AZ comprises at least the lower 700 m of the formation and *Tapinocephalus* AZ makes up the rest, but the contact between the two is unsure . Fossil assemblages from the Abrahamskraal Formation primarily comprise a diverse number of dinocephalians, pareiasaurs and small dicynodonts. Recent research indicates that 80% of species have their Last Appearance Datum near the top of the Abrahamskraal Formation, which represents the transition from the *Tapinocephalus* AZ to the succeeding *Pristerognathus* AZ. This interval has been dated to the late Capitanian and represents the recovery from the Guadalupian extinction and the rise of the Lopingian fauna. While the stratigraphic distribution of the Upper Abrahamskraal Formation tetrapod taxa is now relatively well understood, the upper limit of the *Eodicynodon* Assemblage Zone is still not defined and biostratigraphic resolution of the middle portion of the Formation has not yet been achieved, largely because of the paucity of fossils. Recent fieldwork reveals that dinocephalians and pareiasaurs are more abundant than dicynodonts in the upper Leeuvlei and lower Koornplaats members, whereas in the lower Combrinkskraal Member (the lowermost member of the Abrahamskraal Formation) dicynodonts are more abundant and there are no pareiasaurs.

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The first vertebrate burrow from the upper Elliot Formation (Early Jurassic), main Karoo Basin

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A semi-elliptical burrow cast was found on the farm Edelweiss 698 (Free State, South Africa) in the Lower Jurassic upper Elliot Formation (Stromberg Group, Karoo Supergroup) of the main Karoo Basin. The horizontal and vertical diameters of the burrow cast are ~18.4 and 6.5 cm, respectively. This semi-horizontal, straight to slightly sinuous tunnel is ~50 cm long with a ramp angle of <5°. The tunnel lacks branching, terminal chamber, or associated fossil bones. The massive burrow cast consists of medium sandstone that shows faint horizontal lamination in one of the burrow cast segments. The burrow cast is hosted in maroon, fine-grained pedogenically altered crevasse splay sandstone that is 10–20 cm thick and is under- and overlain by a massive, red, bioturbated floodplain mudstone unit with large scale (>20 cm) desiccation cracks, invertebrate trace fossils, calcareous rhizocretions, and spherical to elongated carbonate nodules. These and other associated sedimentary features provide evidence for a semi-arid fluvio-lacustrine palaeoenvironment during the burrowing activity. Based on comparisons to fossil and modern burrows, this burrow cast is tentatively interpreted as a vertebrate burrow, and appears to be the first report of vertebrate burrowing activity within the Elliot Formation in southern Africa. The ancient burrow architect has yet to be identified. However, given the size of the burrow and the occurrence of similar-sized fossil cynodont therapsids that inhabited the main Karoo Basin in the earliest Jurassic, the potential burrow maker may be tentatively linked to the Cynodontia (e.g. *Pachygenelus* – an advanced tritheledontid).

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Histovariability revealed in anteosaurid (Therapsida: Dinocephalia) limb bones

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Anteosauridae (Therapsida: Dinocephalia) is a family of carnivorous basal synapsids that flourished as the dominant terrestrial predators during the Guadalupian, (Middle Permian: *Tapinocephalus* Assemblage Zone) between 270 and 260 million years ago. The current study focuses on the microstructure of nine anteosaurid elements from three individuals (three ulnae, two radii, two femora, and two fibulae). Until now, the most recent study to be published on anteosaurid bone histology comes from 1973 in which Armand de Ricqlès analysed a large distal humerus, and found the cortex consisted of a moderately vascularized (circumferential) lamellar zonal bone. The results from the femur of our largest individual somewhat correspond to these earlier findings with the exception that fibrolamellar bone (FLB) occurs in localized regions. The material from the medium-sized individual consists of longitudinal FLB and has the best record of growth. The third individual consists of a proximal ulna, and histological analysis suggests that it is from a much older individual that has reached skeletal maturity. Furthermore, its histology is similar to both the large and medium-sized individual. Histovariability is evident in the nine sampled bones, and it appears the femur contains the best record of life history data.

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Preliminary report on the palynology of the Permian Mid-Zambezi Basin of Zambia

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Palynology is the study of pollen and spores and is most useful for stratigraphic correlations, coal and oil explorations, and the reconstruction of palaeoenvironments. This is achieved by studying the palynomorphs and identifying all the taxa of a particular study area. The aim of this particular study is to analyse pollen from the mid-Zambezi Basin in Lusitu, Zambia and correlate the identified taxa with other microfloral assemblages in the main Karoo Basin of south-central Africa. The prediction is that the palynology of Lusitu is likely to correlate with assemblages of the Karoo supergroup which are of Permian age based on macrofauna and flora as well as the microfloral studies that were undertaken by John Utting during the 1970s. The extraction techniques for palynomorphs are adapted from Phipps and Playford (1984). Slides were studied under an Olympus bx51 microscope and identification and counting of the palynomorphs is in progress. The flora will be compared with floras from the main Karoo Basin, Brazil and Argentina.

Funding acknowledgement: NRF AOP programme.

Taphonomy and sedimentary environments of mid-Triassic vertebrate accumulations, Lifua Member (Manda beds), Ruhuhu Basin, Tanzania

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Four recent expeditions to southwestern Tanzania investigated strata of the Ruhuhu Basin as part of a project aimed at understanding the biogeographic structure of vertebrate communities across southern Pangea during the Permian and Triassic. New data relating to the climate, sedimentary environments and burial history of tetrapod fossils in the mid-Triassic Lifua Member of the Manda beds are reported here. Two bone-bearing intervals have been defined – one in the lowermost Lifua containing rare multitaxa bonebed-type occurrences, and the second midway through the succession containing multiple skeletons of the same taxon. Both bone-bearing levels are in overbank redbed facies deposited on the flanks of low-sinuosity rivers that flowed from the Ruhuhu rift scarps into a series of subsiding basins under warm, seasonally-wet climate. The lower bonebed-type occurrence, only discovered in 2014, contains a large

dicynodont (*Dolichuranus*), large cynodonts (*Cynognathus*), and a number of small archosauromorhs. It is associated with massive pedogenically-mottled sandy siltstone overlying a 2 m-thick medium-grained, trough-cross bedded channel sandstone. At the top of this interval a chaotic melange of semi-articulated, disarticulated and reworked bones occurs at the base of a laminated sandstone interpreted as a distal crevasse splay. Similar floodplain-hosted multitaxa bonebeds have been reported from age-equivalent *Cynognathus* AZ (subzone B) strata in the South African Karoo Basin. Most vertebrate collections from Manda beds derive from mid-Lifua bone accumulations associated with floodplain scour troughs and deflation hollows that, at times, held standing water. Outcropping as isolated patches of calcified overbank mudrocks, they contain multiple articulated and semi-articulated archosauromorph (*Asilisaurus*) and herbivorous cynodont (*Scalenodon*) skeletons. We propose that increased mean annual rainfall raised the water tables resulting in vegetated semi-permanent water bodies in all the floodplain depressions and the preferred habitat for herbivorous dicynodont, cynodont and archosauromorph populations. The distinctive change in faunal assemblage and taphonomic style between lower and mid Lifua strata suggests increasingly wetter climatic conditions in this part of Pangea from early to mid-Triassic similar to the *Cynognathus* AZ of the main Karoo Basin of South Africa.

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The evolution of forelimb architecture in early sauropodomorphs

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The evolutionary history of Sauropodomorpha is currently hypothesized to record a change from small-bodied, bipedal animals to large-bodied quadrupedal animals. Such major changes in locomotory strategy must necessitate shifts in morphology. We investigated the shape changes that occur in the humerus bone of various sauropodomorphs at key muscle insertion points, as a proxy for understanding the changing role of the forelimb in locomotion. To do this, we made 3D models of a variety of sauropodomorph humeri using photogrammetry and analysed the shift in positions of landmarks using geometric morphometric techniques. We find distinct changes in the morphology of the humerus from more basal to more derived sauropdomorpha. These changes likely result from a shift in gait from bipedal in the more basal animals to quadrupedal in the more derived animals as well as the limb architecture being constrained due to an increase in the size of these animals overtime.

Funding acknowledgement: Centre of Excellence – Palaeosciences, Palaeontological Scientific Trust (PAST), University of the Witwatersrand.

Increasing stratigraphic resolution within the *Australopithecus*-bearing Member 4 deposit, Sterkfontein

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Member 4 at Sterkfontein is currently the world's richest repository of *Australopithecus* fossils. The ancient cave infill accumulated into a large underground chamber within the Sterkfontein karst system between about 2.6 and 2.0 million years ago, and documents an important window of environmental and hominid evolution. De-roofed by lime-miners in the early 20th century, the fossil-rich sediments were exposed to the landscape surface and excavated by Alun Hughes under the direction of Philip Tobias. Despite recognition of four beds within the Member 4 deposit by Tim Partridge, the sediments were excavated as a single unit with no recording of stratigraphic features. As such, interpretations of site formation, taxonomic diversity, taphonomy and palaeoenvironments have been varied, and generally limited to low-resolution inter-member comparisons. This paper presents results from a renewed effort to increase stratigraphic resolution to the Member 4 deposit and focusses on the formation history of the infill. Previous studies have proposed Member 4 accumulated from a single entrance throughout its formation history, developing in a single massive talus. Careful mapping of clast fabric has revealed a more complex formation history. Despite extensive post-depositional modification through erosion, collapse and subsidence, the residual fabric patterns indicate distinct depositional phases with multiple openings accumulating sediments from different directions through the formation of Member 4. Situating the fossil assemblages within the new stratigraphic model will enable taphonomic, hominid and palaeoenvironmental data to be associated for the first time within a relative chronostratigraphic framework.

An analysis of gross dental wear and dental breakage patterns to determine the dietary ecology of large-bodied carnivores from Langebaanweg 'E' Quarry

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Gross dental wear/breakage patterns may serve as proxies for establishing the dietary behaviours of carnivores. Analysed across a fossil carnivore guild, this type of data can inform on aspects of guild structure, particularly niche separation and inter-specific competition. I analysed the gross dental wear/breakage patterns of carnivore teeth from the South African early Pliocene locality of Langebaanweg (LBW). The early Pliocene is an important period in the evolutionary history of Africa's carnivores, as it was at this time that the continent's carnivore guild began to develop its modern structure. As one of the few African localities to preserve a relatively complete early Pliocene carnivore fossil record, LBW provides a window into this critical period. For this study, dental wear was characterized as (1) light; (2) light–moderate; (3) moderate; (4) moderate–heavy; or (5) heavy. Pre-mortem breakage was also recorded. Analysis indicates similar patterns of dental wear across all carnivore families, with light to light–moderately worn teeth being most prevalent. This suggests that irrespective of family, LBW carnivores died mostly in their prime and that competition levels were low. Moderate–heavy to heavily worn teeth, as well as teeth exhibiting pre-mortem breakage, are almost exclusively those of hyaenids. The incidence of heavily worn teeth, however, is much lower amongst LBW hyaenids than extant bone-cracking hyaenids. This supports the hypothesis that Mio-Pliocene hyaenids were not bone specialists. Preliminary results suggest that patterns of gross dental wear/breakage patterns can provide ecological information about the LBW carnivore guild, justifying a more comprehensive study.

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Dental microwear texture analysis of the early Pliocene African bear *Agriotherium africanum*

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Agriotherium africanum, which was originally discovered in 1965 at the South African early Pliocene site of Langebaanweg (LBW), represents the first pre-Pleistocene ursid to be identified in sub-Saharan Africa. Ever since its discovery, it has generated scientific interest due to its relatively unusual morphology. While resembling extant ursids in overall form, it displays certain adaptations, particularly those related to feeding ecology, that are absent or rare in extant ursids. With regard to its skull, the muzzle is relatively short and broad, the zygomatic arches are particularly wide, and the neurocranium features a high sagittal crest. The P4 and maxillary molars possess pointed, high crowned buccal cusps that are coupled with reductions of the lingual cusps, forming what could be regarded as a shearing complex that functioned as a 'second carnassial'. These morphological features have long been considered indicative of a hypercarnivorous lifestyle. Recently, a study of tooth root morphology of *A. africanum* has challenged its characterization as a hypercarnivore. In particular, questions were raised about its ability to consume large bones on a regular basis. Here we report on microwear texture analysis of *A. africanum* M1s and M2s. In contrast to morphological evidence, dental microwear textures (DMT) can inform directly on the mechanical properties of foods eaten. Results show that *A. africanum* consumed significantly more hard foods – most likely bone – than extant omnivorous ursids. The hypothesis of hypercarnivory can therefore not be ruled out just yet, for this early Pliocene African bear.

Use of media platforms as tools to initiate community engagement

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Homo naledi was discovered by explorers at the Cradle of Humankind in the Rising Star cave in 2013. Working together with a team of scientists, the species was announced in September 2015. The discovery and the announcement experienced a huge amount of media coverage. Media avenues ranging from television, radio, press, and online platforms were utilized to cover the announcement. The coverage

lasted for weeks to follow, with news trending across the entire media platform. This guaranteed momentum, as one article in the media is usually not enough to spread the intended communication. The success of the launch of the *Homo naledi* announcement was a result of all parties working together, from scientists and media houses. This strong interaction between scientists and the media resulted in an announcement that positively spilled over as a community engagement exercise. In addition to sharing the announcement via media house, the original fossils were placed on display and made accessible to the public. This garnered visitor numbers in excess of 250 000 and has proven very successful as an outreach avenue. The ripple effect saw the general public enquiring more about heritage sites and being interested in learning more about their heritage, and their origins.

Hominin evolution: sigma taxonomy in relation to palaeoanthropology and the lack of clear boundaries between species

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Hublin (2014) has highlighted a problem relating to 'the limits of a paleontological species'. This problem may be approached using a morphometric method of the kind developed by Thackeray, recognizing that boundaries between species such as *Australopithecus* and *Homo* are not necessarily clear. The method has been applied to cranial measurements obtained initially from modern conspecific vertebrate species, using least squares linear regression to quantify the degree of scatter around a regression line associated with the general equation $y = mx + c$, where m is the slope and c is the intercept. Thackeray *et al.* (1997) reported central tendency of the log-transformed standard error of the m-coefficient, known as 'log se_m', based initially on pairwise comparisons of conspecific specimens in museum collections of extant taxa. Central tendency has been confirmed with larger samples, associated with a mean log se_m value of –1.61 (Thackeray, 2007; Thackeray and Dykes, 2015). This log se_m value has been hypothesized to be an approximation for a biological species constant (T), expressed through geographical space and evolutionary time, associated with a statistical (probabilistic) definition of a species that could be applied to fossils, including specimens attributed to *Australopithecus* and early *Homo* (Thackeray, 2007). Log se_m values have potential for assessing probabilities of conspecificity, and can be used in the context of 'sigma taxonomy', without assuming clear boundaries between species. 'Sigma' relates to 'S' in the context of a spectrum of variation between taxa in the context of evolutionary time and geographical space.

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Cranial morphology of *Embrithosaurus schwarzi* (Parareptilia, Pareiasauria), and a taxonomic and stratigraphic reassessment of the South Africa Middle Permian pareiasaurs

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Pareiasaurs were abundant large, herbivorous parareptiles of the Middle and Late Permian with a global distribution. During the Middle Permian, they comprised 25% of the terrestrial tetrapod fauna, second to dicynodonts and dinocephalians which each make up 30 % of the fauna. The most basal pareiasaurs are found only in the Middle Permian of South Africa, suggesting that this important taxon had a Gondwanan origin. Despite their relative abundance, most pareiasaurs are poorly known, including the large Middle Permian South African taxa that went extinct at the end of the *Tapinocephalus* Assemblage Zone. Historically, unabated naming of new species created taxonomic confusion until Lee (1995, 1997) conducted a much needed alpha-taxonomic reorganization of all pareiasaurs, reducing the Middle Permian South African group from 11 to 4 species (*Bradysaurus baini*, *B. seeleyi*, *Embrithosaurus schwarzi* and *Nochelesaurus alexanderi*). However, this revision of Lee's did not include detailed anatomical descriptions of the *Tapinocephalus* Assemblage Zone forms. We present the first detailed cranial description and interpretive figures of *Embrithosaurus schwarzi*, including a taxonomic reassessment of all Middle Permian pareiasaurs and updated diagnoses for each valid species. These updated diagnoses have been used to re-identify all identifiable specimens of pareiasaurs from the *Tapinocephalus* Assemblage Zone, stored in South Africa, as well as a few holotypes in London. The re-identification allowed for accurate biostratigraphic and geographic range determination for the Middle Permian species.

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Biogeography antecedes plate tectonics

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Thomas Henry Huxley in 1870 in his Presidential Address to the Geological Society of London compared the Miocene mammals of Europe and North America and concluded that there had been a dry-land connection between the two regions because nowhere else had there been ancestrally similar fossils discovered. Slides are presented which illustrate chronologically, stages in the concept of the Origin of Continents and Oceans based on the finding of similar organisms in regions now separated.

Palaeoenvironmental analysis of Plio-Pleistocene cave deposits from the Cradle of Humankind using stable light isotope analysis of speleothems

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During the Plio-Pleistocene, the Earth experienced a period of gradual cooling, leading to a decrease in atmospheric temperature and increased seasonality. This resulted in the aridification of large parts of Africa, and this is believed to have encouraged human evolution and innovation. Palaeoenvironmental analyses using sediment deposits in the Cradle of Humankind have been used to understand the timing and intensity of this aridification by determining how changes in environmental conditions and seasonal cycles (including temperature and precipitation) affected the South African landscape and human evolution. These changes are recorded within the carbon and oxygen isotopic signatures of speleothems, which have precipitated within the Sterkfontein Caves system. The aim of this study is to understand the degree to which modern speleothems represent the modern climate and environment. Samples of modern speleothems from different areas of the Sterkfontein Caves were used to obtain modern temperature, precipitation and vegetation data from stable light carbon and oxygen isotope analyses. Some preliminary results will be presented here. This data was then compared to modern climatic and environmental records. The stable light isotope analysis should reveal patterns in the oxygen and carbon isotopes present in the speleothem samples, which can be related to changes in local climate during the precipitation of these modern speleothems from drip water sources. This would provide evidence of the reliability of speleothems as palaeoclimate proxies, which is influenced by climaticchanges regarding precipitation, atmospheric temperatures and variations in the overlying vegetation.

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A new litho- and biostratigraphic framework for the latest Permian (Balfour and Teekloof formations) Karoo Basin of South Africa: implications for basin development

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A revised stratigraphic framework is proposed for the latest Permian *Dicynodon* Assemblage Zone (DiAZ). Within this new framework the Balfour Formation's Barberskrans Member (BM) correlates with the Oudeberg Member. A new unit, informally named the Upper Balfour sandstones (UB) replaces the BM. The uppermost Teekloof Formation's Javanerskop Member is also documented as a mappable arenaceous unit. The Musgrave Grit was also documented but only near Bloemfontein. These locally persistent sandstone horizons do not correlate temporally across the Karoo Basin and northward thinning is also documented in the UB. Moreover, three index fossils that currently define the DiAZ (*Dicynodon lacerticeps*, *Theriognathus microps*, and *Procynosuchus delaharpeae*) appear below its lower boundary and disappear below the PTB, and coevally with the appearance of *Lystrosaurus maccaigi*. Thus the base of the DiAZ is redefined, and the revived *Daptocephalus leonice*ps is re-established as the index fossil for the newly proposed *Daptocephalus* Assemblage Zone (DaAZ). A Lower and Upper DaAZ subdivision satisfies the

appearance of *L. maccaigi*. Wetter floodplain conditions prevailed in the Lower DaAZ than in the Upper DaAZ, and the faunal changes documented at this transition may reflect early onset of the climatic changes associated with the end-Permian mass extinction event. Northward thinning of strata suggests the end-Permian extinction event is not fully represented throughout the basin. Orogenic loading/unloading events are identified by two fining-upward cycles in DaAZ strata, and separated by a single diachronous third-order subaerial unconformity (SU). Flexural tectonics meant that sediment progradation northwards was out of phase with the south, preserving an incomplete northern stratigraphic record.

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The micromorphology and U-Pb dating of Elandsfontein carbonates: implications for the mid-Pleistocene hominin occupation and the palaeoenvironment

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The Elandsfontein dune fields, situated on the West Coast of South Africa, have preserved unique geological features, as well as an abundance of fossils and artefacts, from the mid-Pleistocene (Braun *et al.* 2013). The fossils, which include those of large grazers such as hippopotamus, elephant and buffalo, indicate that during this period the climate and vegetation was different to present-day conditions and conducive to hominin occupation. The Quaternary sediments mainly comprise aeolian sand deposits and a carbonate-rich/calcrete layer. These calcretes, outcropping as laterally discontinuous pedestals scattered across the dune field, consist of concentric layers of hard, resistant micrite, and less-resistant layers of quartz-rich sand. Flow marks, desiccation cracks and fossilized spring eyes, suggest palaeo spring activity and a supply of fresh groundwater to the area. Current research is focused on the micromorphology of these calcretes together with stable isotope analysis and U-series dating, aiming to contribute to the further understanding of the palaeoenvironments of the area, as well as relating the dated carbonate pedestals to the archaeological excavation sites.

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Phylogenetic analysis based on braincases of early theropods, coelurosaurs, birds and maniraptorans

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In this paper we (i) discuss some variation in the theropod braincase; (ii) review the published phylogenetic analyses of theropod dinosaurs; (iii) conduct a braincase-based phylogenetic analysis of the earliest birds, early archosauromorphs and a range of theropods. In addition to comparative anatomical evidence, embryological information can be integrated with direct evidence from fossils to test homologies. This integrative approach confirms that the pharyngo tympanic system in early theropods has been derived from the pouch of Rathke. Such a derived system is present in *Syntarsus* (*Megnaposaurus*) and *Allosaurus*. In *Compsognathus* and *Alioramuson* the other hand, the pharyngo tympanic system is present in the plesiomorphic form, closely resembling the pouch of Rathke in *Euparkeria* and *Proterosuchus*. In early theropods a fenestra pseudorotunda is present that is situated posterior to the ossified posterior basicapsular commisura that forms a crista interfenstralis that separates it from the fenestra ovalis. In birds, the function of dampening soundwaves in the perilymph is done by a neomorph avian fenestra rotunda separated from a neomorph fenestra ovalis by the promontorium which represents the ossified anterior basicapsular commisura. The condition of the middle ear of *Tyrannosaurusis* unclear.

Bringing fossils back to life at the Fossil Park through our education programmes

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The aim of our Education Programme is to stimulate interest in fossils by investigating aspects of the palaeo environment 5 million years ago, and relating it to the present environment. Subject matter is linked to the school curriculum and covers a variety of components, including Environmental Education,

Biodiversity, Citizen Science and Conservation. Carefully planned hands-on activities have been developed to stimulate curiosity and to create awareness of our present environment, while opening a window to the past by relating these activities to the past environment of the West Coast Fossil Park.This presentation will demonstrate how Basic Science method is introduced informally to the learners by teaching them to record their observations, labelling of the samples, evaluating the samples and drawing conclusions from the activity which has been done.

Funding acknowledgement: Bhp Billiton, NLC – main sponsors of the WCFP.

The biogeography of Late Cretaceous ankylosaurid dinosaurs: implications for ankylosaurid diversity in Western North America

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Global and regional fluctuations in sea level and climate during the Late Cretaceous strongly influenced the biogeographic distribution of non-marine faunas from Asia to western North America (Laramidia), including ankylosaurid dinosaurs. These dispersal events may have been triggered by short-lived regressions, producing an ephemeral Beringian land bridge that allowed for intercontinental dispersal to take place. Episodic transgressions repeatedly inundated this Beringian land bridge and prevented continuous faunal dispersal. Fossil evidence from the Early Cretaceous of Asia yields some of the earliest ankylosaurid dinosaurs (e.g. *Shamosaurus*), suggesting an Asian origin for the clade Ankylosauridae, with one or more dispersal events to North America. Currently, two distinct clades of Late Cretaceous ankylosaurid dinosaurs are known from Laramidia. The oldest occurrence of northern Laramidian ankylosaurids (*Scolosaurus, Dyoplosaurus*) are recorded from the middle Campanian stage (~77 Ma) of the Dinosaur Park Formation of Canada, whereas the younger, southern Laramidian clade, first appears at ~76 Ma in the upper Campanian Kaiparowits Formation of Utah. To investigate how the biogeography of these clades relates to sea level change during the Late Cretaceous, we utilized temporal calibrated phylogenies in combination with biogeographic modelling, and the most recent eustatic sea level data, to reconstruct dispersal, extinction, and vicariance events for the clade Ankylosauridae. These data suggest at least two intercontinental, three intracontinental, and a single vicariance event during Santonian and Campanian times (~86–77 Ma). These results support the hypothesis of distinct northern and southern biogeographic provinces for ankylosaurid dinosaurs during the upper Campanian in Laramidia.

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Australopith- or *Homo*-like? Investigating the taxonomic status of SK 27 (Swartkrans, South Africa) through its inner tooth structural signature

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SK 27 represents a partially crushed juvenile cranium that was found in 1949, in the Hanging Remnant of the Member 1 of Swartkrans. Biochronology and U-Pb isotopic dating of its provenance stratigraphic unit coincide to an age of *c.* 1.8 Ma. The specimen preserves the LI2, Ldm2, LM1, and RM1, the unerupted LP4 and LM2, small crown and root fragments representing the I1s, the RC and the Rdm2, as well as the isolated LC and LP3. Formerly attributed to *Paranthropus robustus*, SK 27 is now considered as more likely representing early *Homo*, usually classified as *H. habilis*, but recently attributed to a possibly distinct southern African endemic taxon, *H. gautengensis*. In order to noninvasively extract from this problematic specimen additional morphostructural information suitable for clarifying its taxonomic status and phylogenetic relationships, the specimen SK 27 was imaged by X-ray microtomography and compared with similar evidence from Indonesian *H. erectus*, North African *H. heidelbergensis*, as well as with *Au. africanus* and *P. robustus* representatives from the South African hypodigm. Besides the virtual exploration and GM analysis of the premolar and molar enamel–dentine junction, we primarily focused on molar crown tissue proportions and enamel thickness distribution pattern. Our 3D analyses of the

internal tooth crown structural organization of SK 27 substantially differs from the average *P. robustus* condition, but show a combination of primitive (australopithecine-like) and derived (*Homo*-like) features. The taxonomic status of this controversial specimen remains contentious, pointing to the need for complementary analyses extended to additional taxa, including *Au. sediba*.

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Fossil hominin collections of the University of the Witwatersrand: composition, curation and access

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The Phillip V. Tobias hominin collections of the University of the Witwatersrand began with the discovery of the Taung skull in 1924, holotype of *Australopithecus africanus*, followed by numerous discoveries primarily from Sterkfontein and Makapansgat. Other hominin discoveries followed from Border Cave, Drimolen, Gladysvale, Cooper's Cave and others. With the discovery of 'Little Foot' in 1998, the first complete australopithecine skeleton from South Africa, and subsequent substantial discoveries from Malapa (2008) and Dinaledi (2013), the nature of the collections changed. The number of specimens rose from 900 in 2007 to almost 3000 in 2016; a substantial number in terms of hominins. These collections now include a number of almost complete skeletons and several holotypes, unprecedented in South African palaeoanthropology. With this rapid growth, the existing repository had become too small; a new, state of the art hominin laboratory and vault was established at the university's Evolutionary Studies Institute. This new facility now houses the largest hominin collection in the world, containing a substantial record of human evolution. In order to maximize these resources, individual access to students and scientists is encouraged, innovative international workshops are held and scientific teams established to ensure efficient and timely publication in high impact journals. These projects provide a strong case on how primary source materials can be curated, catalogued and studied within the spirit of open access and scientific best practices.

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