Proceedings of the 18th Biennial Conference of the Palaeontological Society of Southern Africa Johannesburg, 11–14 July 2014

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18th Biennial Conference of the Palaeontological Society of Southern Africa

Letter of Welcome

Dear Meeting Participants,

It is with great pleasure that I welcome you to the 18th Biennial Conference of the Palaeontological Society of Southern Africa, hosted by the Evolutionary Studies Institute of the University of the Witwatersrand, Johannesburg, South Africa.

This year, we are proud to host more than 85 abstracts and participating scientists from eight countries. Our programme includes four special symposia, three focusing on the interplay between organisms and their changing environment throughout Earth's history and one focusing on the use of palaeontology in education. Please join me in thanking Drs Cindy Looy, Kaye Reed, Tony Lelliott, and Doug Erwin for delivering the plenary talks at these symposia, and in thanking our keynote speaker Dr Kevin Hand, who will tell us how studying Earth's past and present is the key to understanding life on other planets. This conference would not have been possible without the assistance of our sponsors. The organizing committee wish to express their sincere gratitude to: The Palaeontological Scientific Trust, who provided major funding; the Department of Science and Technology/National Research Foundation Centre of Excellence for Palaeosciences; the University of the Witwatersrand; and the National Research Foundation's Knowledge Interchange and Collaboration Programme.

This volume contains our meeting schedule and programme of conference abstracts in alphabetical order. Contained within your welcome packet please find a tee shirt, campus map, venue overview, and information about: the University of the Witwatersrand, the Evolutionary Studies Institute, the School of Geosciences, and Johannesburg attractions. All the best to you in 2014, and on behalf of the organizing committee, I hope you enjoy the conference!

Sincerely,

Dr Jonah Nathaniel Choiniere
Senior Researcher, ESI
Conference Chair

Programme

Thursday, July 10

Registration

4.30 pm – 8.30 pm — Palaeosciences Building

Friday, July 11

8.30 am *Opening Remarks*: Deputy Vice Chancellor Prof. Zeblon Vilakazi

Symposium: Earliest Life and their Environs

8.45 am *Plenary Talk*: Dr Doug Erwin
9.15 am Siahi, M.
9.30 am Master, S. (seafoam)
10.00 am Penn-Clarke, C.R.
10.15 am Gess, R.W.

Tea 10.30–11.00

11.00 am Bamford, M.K. (microbial)

General session

11.15 am Kruger, A.
11.30 am Prevec, R.
11.45 am Tucker, R.T.
12.00 pm Smith, R.M.H.
12.15 pm Matthews, T.

Lunch 12.30–02.00

2.00 pm Anderson, H.
2.15 pm Cohen, B.F.
2.30 pm Butler, E.
2.45 pm Muir, R.
3.00 pm Parkinson, A.H.
3.15 pm Moodley, A.

Tea 3.30–4.00

Lightning Talks

4.00 pm Mocke, H.B. / Fernandez, V. (burrows)
4.15 pm de Carvalho, A.R. / Day, M.O.
4.30 pm Mavuso, S.S. / du Plessis, A.
4.45 pm Jasinoski, S.C. / Bunge, A.
5.00 pm Choiniere, J.N. / van Gend, J.
5.15 pm Durugbo, E.U. (Nsukka) / Master, S. (Magalies)

Grand Opening

6.00 pm Prof. Bruce Rubidge
6.05 pm Vice Chancellor Prof. Adam Habib
6.10 pm Minister of Science and Technology Hon. Minister Naledi Pandor
6.25 pm Dr Jonah Choiniere
6.30 pm Dr Kevin Hand
7.30 pm Origins Centre reception

Saturday, July 12

Symposium: Environmental Change Across the Permo-Triassic boundary

8.30 am *Plenary Talk*: Dr Cindy Looy
9.00 am Barbolini, N.
9.15 am Rubidge, B.S.
9.30 am Day, M.O. (biozones)
10.00 am Viglietti, P.A.
10.15 am Smith, R.M.H. (mass extinctions)

Tea 10.30–11.00

11.00 am Fröbisch, J.
11.15 am Paiva, F.
11.30 am Mzobe, T.
11.45 am Hancox, P.J.
12.00 pm Sciscio, L.
12.15 pm Neveling, J.

Lunch 12.30–02.00

Symposium: Palaeontology and Education: Problems and Solutions

2.15 pm *Plenary Talk*: Dr Tony Lelliott
2.30 pm McKay, I.J.
2.45 pm Kyriacou, X.
3.00 pm Lavin, J.
3.15 pm Jones, A.

Tea 3.30–4.00

4.00 pm Anderson, J.M.
4.15 pm Spelman, S.
4.30 pm Fernandez, V. (CT)
4.45 pm Viglietti, P.A. (documentary)

General Session

5.00 pm Durugbo, E.U.
5.15 pm McPhee, B.W.
5.30 pm Krupandan, E.D.

Poster Session – 6.30 pm

Berti, M.R.
Bowen, D.
Chapelle, K.E.J.
Cohen, B.F. (dog)
Dabee, V.P.
Dollman, K.N.
Dutra, T.L.
Iqbal, S.
Mabotha M.E.
Mancuso, A.
Manegold, A.
Montoya, G.
Penn-Clarke, C.R.
Phillips, C.A.
Reid, M.
Staunton, C.K.

Sunday, July 13

Symposium: Hominin Evolution and Environmental Context in the Cenozoic

8.30 am *Plenary Talk*: Dr Kaye Reed
9.00 am Faith, J.T.
9.15 am Val, A.
9.30 am Steininger, C.M.
10.00 am Zipfel, B.
10.15 am Su, A. (presented by Carlson, K.J.)
10.30 am Trower, G.E.

Tea 10.45–11.00

11.00 am Jashashvili, T.
11.15 am Lennox, S.J.
11.30 am Thackeray, J.F.
11.45 am Wurz, S.
12.00 pm Backwell, L.R.

General Session

12.15 pm Chukwuma, K. (presented by Bordy, E.)

Lunch 12.30–02.00

2.00 pm Neumann, F.H.
2.15 pm Welman, J.
2.30 pm Krummeck, W.
2.45 pm Abdala, F.
3.00 pm Bamford, M.K. (Kirkwood)
3.15 pm Labandeira, C.C.

Tea 3.45–4.00

General Meeting

4.00 pm Dr Bernhard Zipfel, President's address

Awards Banquet

6.30 pm Prof. Marion Bamford, incoming President's speech
8.00 pm Dr Bernhard Zipfel, Awards

Monday, July 14

Field Trip — 8.00 am – 5.15 pm

Keynote Address

Bringing Two Worlds Together: How Earth's Past and Present Help Us Search for Life on Other Planets

Kevin Peter Hand

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At least five moons in the outer solar system may harbour liquid water oceans. These oceans have likely persisted for much of the history of the solar system and as a result they are highly compelling targets in our search for life beyond Earth. I explain the science behind why we think we know these oceans exist and what we know about the physical and chemical conditions that likely persist on these worlds. I will focus on the surface chemistry of Jupiter's moon Europa and connect laboratory spectroscopic measurements to ground and space-based observations of Europa's surface. I will also show how the study of several extreme environments on Earth, as well as the palaeontological record of early life, are helping to inform our search for habitable environments on distant worlds, while simultaneously providing new insights into Earth's complex ecosystems.

Plenary Talk

Major Evolutionary Transitions in Early Life: A Public Goods Approach

Douglas H. Erwin

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In 1995 Maynard Smith and Szathmary identified eight Major Evolutionary Transitions (MET) in the history of life, from the origin of chromosomes and DNA to eukaryotes, cellular differentiation and the evolution of societies. Each of their transitions involves changes in the packaging and transmission of information (as in the origin of eukaryotes). But absent from their work was any discussion of the role of changes in either ecological relationships or in the physical and geochemical environment. Knoll and Bambach offered a more ecologically based analysis of a similar (although not identical) suite of evolutionary 'megatrajectories', each characterized by increasing ecological complexity. Unresolved, however, are the mechanisms that generate such increased complexity. A third approach, favoured by many geologists, invokes planetary drivers including changes in oceanic and atmospheric redox, tectonics and climate as the primary factors responsible for METs.

Many evolutionary innovations, including some of the METs, exhibit macroevolutionary lags – a decoupling between the origin of a clade as defined by a major novelty and the time the clade becomes ecologically significant. Such lags emphasize the critical distinction between a successful *evolutionary invention* (the origin of the clade) and successful *evolutionary innovation*. As in technological innovation, many viable inventions never become innovations. I have previously argued that a characteristic of innovation during the basal Cambrian diversification of bilaterian metazoans was ecological feedback generated by ecosystem engineering/niche construction. Here I extend these earlier arguments to suggest that major contributor to the evolutionary success of METs was innovations which generated *public goods*. Public goods are those goods where the use of the good does not exclude use by others (non-excludability) and the inability to prevent others from using the good (non-rivalry). Economic examples radio, knowledge, and national defense; biological examples include oxygen and redox gradients. Many, and perhaps all, METs involve a significant component of generation of public goods. Some examples relevant for this meeting are: 1) gene sequences can be considered public goods subject to varying degrees of vertical and horizontal gene transfer. Many microbes essentially share gene sequences (non-excludability and non-rivalry) as needed. 2) The origin of many metabolic processes involved the generation of public goods (methane, oxygen, etc.) as a byproduct with considerable impact on ocean and atmospheric redox. 3) The symbiotic origin of mitochondria and chloroplasts.

Plenary Talk

A Survey of Visitors' Experiences of Human Origins at the Cradle of Humankind, South Africa

Anthony D. Lelliott

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Relatively little is known about the general public's views of evolution, particularly with respect to humans. The study provides valuable information on why people visit the Cradle of Humankind (a World Heritage Site in Gauteng Province, South Africa), how they view the concept of human origins, and what features of the visitor centres may influence visitors' views. Maropeng Visitor Centre (MVC) based in the Cradle of Humankind aims to provide visitors with positive experiences of science-related activities.

The principal method of data collection was a survey of the general public visiting MVC, along the lines of previous studies in similar contexts. Visitors who exited the Visitor Centre were invited to complete a survey questionnaire eliciting information about their visit. 437 'general public' visitors were surveyed between May and July 2013.

Analysis is on-going, but the results analysed so far show that people's reasons for visiting the area are varied, but relate principally to a 'day out' for pleasure, and to a lesser extent, learning. Approximately 80% have not visited the centre before, and a similar number consider that their visit made an impression on them. While very few visitors have heard of the newly discovered australopithecine (*Au. sediba*), the great majority (85%) have heard of 'Mrs. Ples' (the australopithecine discovered in the area in 1947). Around 60% of respondents do not consider that anywhere else could be called the 'cradle of humankind' – their more detailed responses are still being analysed. The participants were also asked about their acceptance of evolution of humans from an ape-like ancestor. A majority (58%) do accept the concept of human evolution, and refer to anatomical, genetic, fossil, and behavioural facts in support of their opinion. Those who do not accept the idea of human evolution mostly invoke religious reasons (e.g. God as a Creator; the bible as the source of authority) for their views. This suggests very different ways of thinking between the two groups. These findings will be compared with the relatively few other international studies in the area of human origins, and their implications for the field.

Funding acknowledgement: This presentation is based on research supported by the Palaeontological Scientific Trust.

Plenary Talk

The End-Permian Biotic Crisis: Why Plants Matter

Cindy Looy
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The end-Permian crisis is long known for its profound reorganization of marine ecosystems. A process of progressive elimination of marine species is punctuated by a final extinction pulse. This pulse is generally correlated with a conspicuous negative shift in $^{13}C/^{12}C$ isotope ratios of marine carbonates, reflecting a dramatic disturbance in the global carbon cycle. Through the years there has been an animated discussion on the ultimate cause of the end-Permian crisis. The concepts differ with respect to source (extraterrestrial or terrestrial) and rate (catastrophic to relatively rapid). Besides paleobiological information, sedimentological and biogeochemical evidence are taken into account. The latter includes evidence for anoxia, increased weathering rates and temperatures, and acid rain. At present, many of the proposed scenarios emphasize the role of the Siberian Trap volcanism.

Models linking the patterns of extinction, survival and recovery were until recently mainly constrained by generalizations of temporal distribution of marine invertebrate lineages. The greater part of the biomass on Earth is, however, sequestered as terrestrial vegetation. In this lecture I will contribute to a botanical perspective of the end-Permian ecologic crisis and its aftermath by describing the sequence of events is described based on paleobotanical and palynological records. Despite the discontinuous and qualitative nature of the plant-megafossil record, it provides information of which plant groups occupied the basinal environments consecutively. These records are complemented by successive pollen and spore assemblages, which provide the sample size and stratigraphic spacing needed to resolve the temporal pathway of vegetation responses to changing environmental conditions. Comprising the tropic base of ecosystems, floral changes must have affected the terrestrial fauna. Although incomplete and perhaps ill-suited for general analysis of extinction and origination rates, the fossil record of land plants, does provide important insight in the dynamics of extinction-recovery sequences, and can contribute to refining conceptual models.

Understanding the patterns and processes of past ecologic crises and biodiversity decline such as the end-Permian biotic crisis are no longer a matter of purely academic interest. Studies of biotic and biogeochemical change related to major extinction events may substantially contribute to a prediction of the long-term consequences of the current, human-induced 'Sixth Extinction' and the future of ecosystem services on which humankind depends.

Plenary Talk

Hominin Evolution and Habitat: The Importance of Analytical Scale

Kaye Reed

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Climate changes and alterations of landscape vegetation structure have long been cited as drivers of human evolution – changes in climate caused vegetation modifications, and in turn vegetation and the ability to utilize resources contributed to evolution. The reconstruction of hominin habitats and resource use has been the focus of over 40 years of palaeoecological research. Recently, however, attention has shifted from classifying the reconstructed environments of hominins as savannas – a word that is overused and merely identifies most African closed woodland to open grassland habitats – to an understanding that many past African habitats associated with hominins are better described as 'mosaic' habitats. Most landscapes in Africa are multifaceted mosaics of many types of habitats, with the possible exceptions of tropical rainforests and the Sahara. But does this make 'mosaic' just another word that describes a variety of savanna habitats?

Using 'mosaic' implies that at certain spatial scales, a variety of habitats exist. This raises questions regarding not only the spatial scale used to reconstruct hominin environments, but also the temporal scales used in analyses – for example, is the vegetation reconstructed based on a single locality, perhaps 50 m^2, or on a hyaena-collected cave deposit averaging 40 km^2 of foraging area, or on a stratigraphic member of a site that perhaps covers 150 km^2? How do the scales that are selected influence both hominin habitat reconstructions and their relationships to climate proxies? The recognition of the primary importance of spatial and temporal scale raises the question: as spatial area decreases and temporal precision increases, does vegetation structure become more homogenous?

To address this question, data on mammalian communities from modern savanna game reserves and national parks in eastern and southern Africa were collected, as well as environmental data for each of the sites, and the relationship between the large mammals, the overall area of the reserves, and the spatial extent of each habitat type was analysed. To apply this to the hominin fossil record, ancient habitats were reconstructed using large mammal fauna from large and small collection areas in tephra-constrained stratigraphic units in Ethiopia, and at a South African cave site.

Results for extant habitats suggest that non-mosaic habitats can be reconstructed at smaller spatial scales, often at 4–8 km^2. Habitat heterogeneity increases proportionally as the area sampled increases. Using smaller spatial scales for the fossil localities provides a better representation of the habitat from which the mammals derived, but there are (of course) other problems that need to be considered. It is often difficult to collect large enough sample sizes at smaller spatial scales in fossil sites, and the nature of depositional environments – such as fluvial, lacustrine, and cave deposits – also influences the mammals recovered, and thus habitat reconstruction.

Funding acknowledgement: This study was funded in part by NSF BCS 1157351.

Conference Abstracts

Transitional fossils at hand: evolution of the manus of Synapsida

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[4]*Instituto de Herpetología, Universidad Nacional de Tucumán, Argentina*

Synapids document a fairly complete morphological sequence from Carboniferous basal 'pelycosaurs' to the only living representative, mammals. We report results of a morphological study of the manus of synapsids. For this research we assembled a data matrix of 39 characters of the manus and 72 taxa, representing 'pelycosaurs', biarmosuchids, dinocephalians, anomodonts, gorgonopsians, therocephalians, non-mammaliaform cynodonts and basal representatives of mammaliaforms and crown mammals. We used these data to map characters in a synapsid tree produced by integrating recent phylogenies of the different lineages. The pattern of the manus is differentiated in the two main clades of 'pelycosaurs', with Caseidae presenting digits III and IV equally long, whereas in non-therapsid eupelycosaurs digit IV is the dominant. In therapsids, ectaxony (metacarpal IV larger) is dominant, but lateral paraxony (metacarpals III and IV larger) is present in advanced dicynodonts of large body size. Mammaliaformes have a wide variation in metapodial axony, with at least four different patterns. The phylogenetically more basal record of mammalian manual digital formula is in tapinocephalid dinocephalians. Absence of the mammalian digital formula in therapsids is correlated with the presence of disc-like reduced phalanges in digits III and IV. These type of phalanges are represented in a biarmosuchian, an anteosaurid dinocephalian, a basal anomodont, gorgonopsians and three non-mammaliaform cynodonts. The record of the manus in three specimens of the Early Triassic cynodont *Thrinaxodon* shows that these phalanges are constrained in number and location, having one in digit III and one in digit IV. In the contemporaneous cynodont *Galesaurus*, the constraint is relaxed, as one specimen lacks disc-like phalanges whereas the other has one element in digit IV.

Funding acknowledgement: Department of Science and Technology/National Research Foundation Centre of Excellence for Palaeosciences, South Africa; CONICET, Argentina.

Giant horsetails in the Molteno Triassic Flora of Gondwana

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Is it possible that giant horsetails grew in Triassic times? From the Gondwana Molteno Flora of southern Africa we have strong evidence that this was the case. Sphenophytes and allied plants have been recorded from the Molteno Formation since the earliest records were made and included well known genera such as *Schizoneura*, *Neocalamites* and *Equisetites*. We are reviewing of the Molteno sphenophytes based on our own collections and describe eight genera and 23 species from sterile material and 5 genera and 8 species based on unattached strobili. Sphenophytes form an important component and are third after *Dicroidium* and the conifer *Heidiphyllum*, as the most abundant vegetative forms. They are often the dominant element and occur at 59 of the 100 Molteno assemblages included in our study. They are recognized as forming one of the seven primary habitats in the Molteno Biome. The final stage of our study has been to reconstruct the Molteno sphenophytes and to estimate the height to which these ancient plants may have grown. Giant equisetums from the Triassic of Germany grew to 5 metres tall but our best models for the Molteno sphenophytes are the extant species in the genus *Equisetum* with range in height from 15 cm to 8 m. Most species fall in the range of 30 cm to 1.5 m in height. The general diameter-to-height ratio of the stems of extant species is in the range 1:100–200. From biomechanical studies a plant with a stem diameter of 1.4 cm had a critical self-supporting height of 2.8 m (i.e. a ratio of 1:200) and for the plant to grow higher than this it needed the support of other stems or plants. They also devised a formula for predicting the free standing height of such stems based on a specific diameter. Another analogy can be made with bamboos as their features are comparable with sphenophytes. The stem diameter-to-height ratio of the largest species of bamboo is 1:150–200. Using the ratio of 1: 200 for our Molteno sphenophytes we estimate heights up to 2 m for the thinner-stemmed species and up to 22 m for stems with diameters of 11 cm. Furthermore as these mostly grew in clumps they could well have been even taller.

We suggest there were indeed giant horsetails growing in the Molteno and probably elsewhere in Triassic times.

'*Africa Alive Corridors*' (AAC) – Autobiography of the continent told along 20 corridors

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Africa is the colossus amongst the continents. It is the cradle of our primate ancestors and of our hominin ancestors. It is the womb of our species *Homo sapiens*; of our humanity, our culture, our art and our language. It is the heartland of the former Gondwana supercontinent, and the centre of Earth's geo-biodiversity – embracing Earth's geodiversity and biodiversity hotspots. Yet Africa is the continent of greatest human suffering; from poverty and illiteracy, to war and disease.

This story of extremes and contradictions is told through a selection of 20 heritage corridors. These are winding strips of territory averaging some 1–3000 km in length and 50 km wide. Each tells a chapter in the 4-billion-year story of Africa better than anywhere else. Each corridor includes 20 heritage nodes which provide discrete chapters in the story of that particular 'Corridor'.

We are currently well into the preparation of the first two volumes of the AAC series. These include *Africa Alive Corridors*, the introductory volume to the full series; and *Homo sapiens Corridor*, which tells our 200 000-year epic tale of human cultural evolution along the southern Cape coast. These are muliti-contributor volumes, each involving over 50 leading scientists and others in diverse fields who are pushing current research and thinking.

The ultimate aim in telling the holistic geological-biological-cultural history of the Mother Continent is to bring everyone together – all 1-billion of us living here as co-custodians of Africa's unmatched irreplaceable heritage. How better to address the dilemma of inequality and other extremes? This initiative is done in the context of the Anthropocene, in which we humans appear to be fashioning our own demise through the Sixth Extinction and runaway global warming.

Wonderkrater peat mound: Middle Stone Age site amid a multiproxy record of climate change

Backwell, L.R.[1]; Wadley, L.[1]; McCarthy, T.S.[2]; Chase, B.M.[3]; Scott, L.[4]

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Few Upper Pleistocene terrestrial sequences of climate change exist, and when available, they are difficult to correlate with early human settlement patterns. In this regard, the site of Wonderkrater represents an exception, preserving layers rich in modern and ancient organic material that alternates with sand layers, which record human use of the site. Extracted sediment cores yielded a number of Middle Stone Age (MSA) artefacts, prompting exploratory excavation of the sediments in the peat mound. Our aim was to understand better the geomorphology of the site and chronology of the deposits, document environmental changes recorded in the sequence, characterize human use of the area through an analysis of the cultural remains, and combine the results to produce a multiproxy record. Here we present the results of test excavations in different areas of the site over three field seasons from 2005–2007. Excavations yielded three MSA lithic assemblages with age estimates of 30 ka, >45 ka and 138 ka, diverse Florisian fauna, and vegetation in the form of fruiting structures, pollen, phytoliths and charcoal preserved in deposits aged ~1 –>45 ka. Below the upper peat layers, a 1 m-thick layer of white sand yielded two MSA lithic assemblages in association with faunal remains dated to between 30.8 ± 0.7 ka and >45 ka (cal yr BP). Clay underlying the sand has an OSL age of 63.1 ± 5.8 ka, and sandy peat below it has an Infrared Stimulated Luminescence (IRSL) age of 70 ± 10 ka. Faunal remains in the sand layer indicate a substantial grassland component in the landscape >45 ka, while phytolith and pollen data show a change from moderately warm and dry savanna grassland to cooler and wetter savanna woodland by 30 ka. The conditions that resulted in the deposition of the sand also attracted people to the site, but whether it served as an oasis, or was visited during wet phases, is unclear. The composition of the lithic assemblages, which include many tools suitable for cutting, suggests that the peat mound may have been used as a place to harvest and process plant materials, and butcher animals that were either deliberately or accidentally trapped in mud or peat.

Funding acknowledgement: Department of Science and Technology/National Research Foundation Centre of Excellence for Palaeosciences.

A possible 29 MA colony of extremophiles in the hypatia stone, Libyan Desert Glass Area, SW Egypt

Bamford, M.K.[1]; Andreoli, M.A.G.[2,3]; Straker, C.[4]; Kramers, J.[5]; Belyanin, G.[5]; Pischedda, V.[6]; Przybylowicz, W.J.[7]; Mesjasz-Przybylowicz, J.[7]; Di Martino, M.[8]

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Scanning electron microscope (SEM) and micro X-Ray tomographic investigations of the diamondiferous, carbonaceous stone hypatia, found in the Libyan Desert Glass (LDG) area of southwest Egypt reveal the presence of fracture-hosted, unusual carbonaceous filaments and hollow membranes ±20 μm thick that form a complex network or reticulum suggestive of fossilized plants. This interpretation is supported by mass spectrometry measurements on fragments of Hypatia, yielding a number of organic molecules, and by SEM EDS analyses of the structures. Such analyses show that C, O, N and S are in abundance as found in fossilized plant remains. Some filaments resemble plant hypocotyledons; others looked like fractured stems with frayed ends and others are more globular. Their surface is sometimes decorated with longitudinal ridges, small beads and what appear as small black holes. The minor element data and the close spatial association between filaments and metallic (Ag, Ce, La) inclusions are, however, more difficult to interpret. Also difficult to explain is the presence of sub-micron Ti-rich particles as scattered dusting on otherwise uncontaminated filaments. PIXE and micro-biochemical analyses are planned to identify the full organic-inorganic chemical constituents of the filaments. Given that Hypatia is the fragment of a comet that exploded in the atmosphere above SW Egypt at 29 Ma, causing the flash melting (T >1700°C) of the silica-rich desert sands over an area of ~6000 km^2, the filaments may represent remnants of extremophiles that re-colonized the area after the cooling of the LDG. We tentatively interpret the filaments as the first ever known example of extremophiles colonizing a landscape virtually sterilized by an exploding comet 29 Ma ago. In the Phanerozoic aeon this is indeed a rare environment, yet it must have been comparatively common during the Hadean and Palaeoarchean aeons. If our interpretations are correct, the study of these Egyptian extremophiles may shed light on the way early life on Earth recovered during the environmental crises induced by the Late Heavy Bombardment of meteorites and comets between ~4.1 and ~3.8 Ga.

Funding acknowledgement: Department of Science and Technology/National Research Foundation Centre of Excellence for Palaeosciences; iThemba LABS; NECSA.

Charcoal analysis provides new insights into the plant diversity of the Lower Cretaceous Kirkwood Formation

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The Kirkwood Formation of the Algoa Basin of South Africa, well known for its dinosaur fossil record, also provides us with a rare opportunity to study the poorly understood Early Cretaceous floras of Gondwana. Previous collections of impression fossils, sparse cuticle fragments and palynological studies revealed a pre-angiospermous, gymnosperm-dominated flora comprising cycads, bennettitaleans, conifers, ferns and bryophytes. Ironically, although the Kirkwood Formation has in the past been referred to as 'The Wood Beds', acknowledging the profusion of fossil logs found in this formation, these are predominantly preserved as casts, with no apparent preservation of internal cellular structure, and therefore providing no means of identification. Only a single permineralized specimen of wood (*Brachyoxylon*) has been described in the literature to date.

Exposures of the Kirkwood Formation in the Algoa Basin are highly restricted, both in their geological distribution and in terms of the dense vegetation present in these areas, and although a number of productive plant localities near the town of Kirkwood have been intensively collected in the past, most of these sites have subsequently been mined out, overgrown or washed away, and recent surveys have failed to yield new localities of similar productivity.

However, recent international interest in the prevalence and effects of wildfires during the Cretaceous

Period, a time of particularly elevated oxygen levels in the atmosphere, has awakened new interest in an aspect of the Kirkwood Formation that has been long recognized but never studied – an abundance of fossil charcoal.

Two localities have been recently identified that have produced diagnostic charcoal fragments, and preliminary analyses have resulted in the identification of *Podocarpoxylon*, *Brachyoxylon* and *Agathoxylon* wood. This new approach could substantially increase our knowledge of the diversity of woody plants present during this prelude to the domination of the angiosperms, and could contribute significantly to our understanding of the role of intense and regular wildfires in Early Cretaceous ecosystems.

Palynofloras of the Karoo vertebrate biozones and their contribution towards reconstructing Permo-Triassic extinction events

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The vertebrate biozones of the Main Karoo Basin have international importance for the correlation of terrestrial Permian to Jurassic rocks, owing to their status as the most complete fossil tetrapod-bearing record of this age. The Karoo Supergroup also preserves a record of two of the 'Big Five' mass extinctions, namely the end-Permian and end-Triassic events. Because of its excellent preservation, the Karoo is ideal for studying faunal diversity changes through time, but there is significant debate over whether extinction events affected continental floras in the same ways, and to the same extent, as the marine and vertebrate realms. Palynological records have the potential to be especially useful in reconstructing these extinctions, because of their elevated propensity for fossilization in a wide range of environments. Moreover, disappearances of plant taxa are likely to reflect real-world extinctions rather than temporary faunal emigrations in response to disturbed habitats.

In order to investigate the palynological record of the Main Karoo Basin, 275 samples were collected from outcrops from the western region (west of the 24° E meridian), southern region (east of the 24° E meridian) and the northeast distal facies of the Main Karoo Basin. Samples were processed using standard palynological methods, predominantly omitting oxidation treatment, and a total of 65 productive samples were obtained. Palynomorphs in all the stratigraphic horizons were identified and those taxa useful for biostratigraphic correlation were recognized.

Every formally recognized vertebrate biozone of the Beaufort Group, except for the *Eodicynodon* Assemblage Zone was found to be palynologically productive in this study. The *Dicynodon*, *Lystrosaurus* and *Massospondylus* assemblage zones can be well defined on the basis of their palynoflora, while the *Tapinocephalus*, *Pristerognathus* and *Cynognathus* assemblage zones can be tentatively defined on the basis of their palynoflora. Palynological records also corroborate previously proposed vertebrate extinction events in the Karoo Basin, with significant microfloral turnovers being observed in the upper *Tapinocephalus* and upper *Dicynodon* assemblage zones. In particular, the dramatic loss of species within the Palingkloof Member is concurrent with a sudden and catastrophic event among Permian floras at the Permo-Triassic boundary.

This and previous studies of the Karoo Basin microfloras demonstrate that the palynological signatures of the various Karoo formations are consistent, and that it is possible to correlate microfloras from indeterminate localities in the Main Karoo Basin to microfloras with known stratigraphic provenance. As a result, palynology can significantly assist in stratigraphic refinement of the Karoo vertebrate biozones.

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Microbial mounds as food sources in subglacial and postglacial Carboniferous-Permian marine systems, Karasburg Basin, Namibia

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Palaeozoic syn-sedimentary carbonate nodules in the Dwyka and Ecca groups of the Karasburg Basin, southern Namibia occur at discrete stratigraphic intervals and contain richer ichnofossil assemblages than their host rocks. These nodules are preserved in marine shales and occur as discrete bodies at specific stratigraphic horizons, or as a series of amalgamated nodules that form a stratiform carbonate layer. The isolated nodules occur as lenticular bodies and are typically ellipsoidal, oblate or spherical in shape and vary in size from 0.2 to 3 m. Amalgamated nodule layers are more continuous, up to tens of metres and

aligned along sedimentary bedding planes. Many nodules preserve ichnofossils and sedimentary structures, indicating that they precipitated pre-burial; however, not all nodule-bearing stratigraphic horizons preserve ichnofossils, and ichnofossil diversity varies through the stratigraphy. Associated body fossils are uncommon, but in the Whitehill Formation, nodule horizons overlap with richly fossiliferous Mesosaurus sites in the proximal reaches of the basin. In the Amibberg Formation some carbonate nodules also preserve fragmented fish scales. The majority of ichnofossils are attributed to feeding, movement and farming activities.

We consider two possible explanations for the rich ichnofossil assemblages found in carbonate nodules: firstly a preservational bias in which nodules preserve ichnofossils better than the host shales. This is considered unlikely because the host shales do contain sparse ichnofossil assemblages. A second possible explanation is ecological: the microbial communities that stimulated carbonate precipitation also acted as important food sources in subglacial and postglacial seas, and attracted and supported a diverse invertebrate community.

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Sedimentary facies analysis and non-marine sequence stratigraphy of Upper Mesozoic strata in the onshore rift basins, Western and Eastern Cape, South Africa

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The southern African continental margin contains several fault-controlled sedimentary basins that extend on- and offshore, and are associated with the break-up of the Gondwana in the Late Mesozoic. The earliest sedimentary fill of these basins, a ~150 to 130 million years old non-marine rock succession, records the climatic, tectonic and ecological events that occurred during the separation of the African and South American plates. However, the geological history of the smaller and shallower onshore sections of these echelon sub-basins is very poorly known, especially in comparison with the offshore rift sections that contain exploitable hydrocarbon reserves and have carbon sequestration potential. To-date, no modern sedimentary facies analytical or sequence stratigraphic work has been undertaken to explain the generation and evolution of the onshore half-graben system and ecosystems that existed within them. Understanding the geology of the onshore rift basins is important because such systems, firstly, record of the early stages of (super)continental breakup, but are usually buried under the seaward thickening prisms of marine post-rift and other passive margin sediments, and secondly, may also have hydrocarbon or carbon sequestration potential.

The focus of this study will be the reconstruction of the sequence stratigraphic evolution of the Middle Jurassic to Lower Cretaceous sedimentary half-graben fills in the four major regions in the Western and Eastern Capes: the Algoa, Outshoorn-Gamtoos, Worcester-Pletmos and Bredasdorp Basins. The basins are filled by the fossiliferous Uitenhage Group which is a succession of poorly-sorted conglomerates interbedded with subordinate sandstones and mudstones with rare, low diversity and often fragmentary plant remains as well as vertebrate (especially dinosaur) bones and teeth.

Micro- and macroscopic examination of the Uitenhage Group in terms of their sedimentary structures, palaeoflow, sediment provenance and 3D sedimentary architecture will be carried out. Furthermore, geochemical analysis of tuffaceous units will also be attempted. Integration of these observations through high-resolution digital mapping will enable the spatial quantification of vertical and lateral abundance and variation the sedimentary facies associations. These facies maps will be augmented by potential palaeo-botanical (e.g. the locally abundant charcoal remains), taphonomic and other palaeontological observations to better contain the stratigraphic framework.

This study is expected to generate insights into the tectono-sedimentary dynamics of the rift systems associated with the breakup of southern Gondwana, particularly, the role of regional tectonics versus local climate on the ancient rift sedimentation rates as well as on the distribution and evolution of ancient organisms that lived in these rifts.

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The Cedarberg Formation: review and new research possibilites

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The Hirnantian-aged Cedarberg Formation forms part of the Table Mountain Group within the Cape

Supergroup, South Africa. It overlies the glacial deposits of the Pakhuis Formation and consists of two members; the Soom and Disa. The former is composed mostly of black shales and finely laminated siltstones and the latter is coarser grained comprising fine to medium-grained micaceous sand- and siltstones. These members form an upward coarsening transgressive cycle of sedimentation in a glaciolacustrine to shallow marine setting and are overlain by the dominantly fluvial sandstones of the Goudini Formation. The Soom Shale is particularly significant as it represents the only Ordovician Gondwanan Konservat-Lagerstätte as well as rarely preserved high-latitude faunas. Historically, studies were focused largely on the taphonomy and palaeontology of the Soom Member with key localities, such as Keurbos Farm in the Clanwilliam area, yielding exceptionally well preserved (soft-bodied) fossils most notably including conodonts as well as orthoconic cephalopods, naraoiid trilobites, euypterids, brachiopods, chitinozoa and a few enigmatic taxa. Detailed sedimentology of the Soom Member in recent years has revealed uncharacteristically coarse sand laminae (associated with plankton-derived organics) within the dark mudrocks. These laminae have been interpreted as glacially derived loess having been blown either across seasonal sea ice or directly into the sea. A 40 m stratigraphic borehole through the Cedarberg and Pakhuis Formations was recently drilled at the farm Holfontein ~25 km south of Clanwilliam to extract material for detailed systematic analysis. The main aim is to use grain-size analysis to determine if wind-blown dust fertilized the growth of algae. The complex interplay between wind speed and fetch, dust input and nutrient-enhanced primary productivity has a profound control on either maintaining or ameliorating glacial conditions but this is not well understood, and until now has not been directly tested in deep-time. The Soom Shale can potential provide significant insights into the precise course of climate change as major ice-sheets retreat – and a greatly improved understanding of the climate dynamics of Early Palaeozoic icehouse climates. Drilling at a number of localities including Clanwilliam, Somerset West and Oudtshoorn recently means additional fresh diamond drill core intersecting the Cedarberg and underlying Pakhuis Formations is now available for study. A proposal to utilize these new data in a detailed sedimentology and basin evolution study is also being investigated.

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High-resolution sedimentary and ichno-facies analysis of the upper Elliot Formation (Early Jurassic) at Nova Barletta Farm, Free State, main Karoo Basin, South Africa

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Sedimentological and ichnological studies of the Elliot Formation (Stormberg Group, Karoo Supergroup) have proved to be fundamental in understanding the final stages of basin development in the main Karoo, and the palaeo-ecological evolution following the mass extinction event at the Triassic–Jurassic boundary.

A high resolution (centimetre-scale) sedimentological and ichnological study is designed on a well-exposed outcrop in the upper Elliot Formation (UEF) that contains most of the key features of the highly heterogeneous UEF including: fossiliferous floodplain with palaeosols, ephemeral stream and lake deposits. The multi-scale heterogeneities, from hundreds of metres (even km) down to millimetres scale, in fluvial depositional systems not only complicate the regional bio- and lithostratigraphic correlations of such successions, but also create a major challenge in the modelling of subsurface fluid flow behaviour (i.e. permeability patterns), which is crucial in estimating natural resource distribution (e.g. groundwater, hydrocarbon) in geological units.

This exceptionally well-exposed, large-scale and structurally undisturbed outcrop at Nova Barletta Farm (Free State) contains a wealth of quantifiable information on the spatial and temporal distribution patterns of the facies in the UEF. The objectives of this study are (a) to gather centimetre-scale sedimentological and ichnological data on the facies geometries and distribution trends from the outcrop surface; (b) to use photogrammetry to document the aforementioned features in a high-resolution, grid-referenced, digital map; and (c) to refine the resolution of palaeo-ecological reconstruction of the UEF, in particular the fine-scale dynamics of sedimentation in the Early Jurassic rivers, lakes, floodplains and palaeosols.

Such high-resolution digital documentations on the abundance and variation in sedimentary and ichnofacies, if conducted on regional-scale, may be scaled up to reservoir model size and used to refine the predictive geological framework in stratigraphic correlation as well as natural resource exploration or carbon sequestration studies. High-resolution studies thus may potentially improve the geostatistical modelling of facies architecture (e.g., continuity, geometry) in fluvial reservoirs and the estimating of the permeability distribution patterns in fluvial depositional systems.

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

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The gorgonopsian therapsids are only known from Permian deposits in Africa, Russia, India and China. By the middle Late Permian these animals had become the dominant terrestrial predators of Gondwana, but they succumbed to the end Permian mass extinction some 252 million years ago. Here we describe the skull of a new species of gorgonopsian consisting of two well-preserved specimens. The specimens are the largest known gorgonopsians in South Africa. They are characterized by the absence of palatal teeth, a small frontal-orbital contact, the presence of a pineal boss, well-developed interparietal and supra-occipital, short robust jugal not reaching the anterior part of the a quadrangular lacrimal and small temporal fenestra. The latter characteristic is similar to the more basal, geologically older gorgonopsians from the *Eodicynodon* and *Tapinocephalus* AZ of South Africa as well as to the similar-aged Russian Inostranceviidae. These specimens were found approximately 4 m and 23 m below the Permo-Triassic boundary in the Karoo Basin, making this new species the geologically youngest gorgonopsians in South Africa.

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The first detailed cranial description of *Massospondylus carinatus* using a CT scan and 3D digital representation

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Massospondylus carinatus is a basal sauropodomorph dinosaur from Lower Jurassic deposits in South Africa and Zimbabwe. Although *Massospondylus carinatus* is an important taxon for understanding early sauropodomorph evolution, anatomical descriptions of its abundant cranial material were lacking until relatively recently. Additionally, focused descriptions of its braincase and internal cranial morphologies have been relatively topical because adhering matrix in key specimens obscures anatomical details. There is limited fossil braincase material across basal Sauropodomorpha, and hence a scarce number of braincase characters used for phylogenetic analyses in basal sauropodomorph dinosaurs. To perform a detailed investigation of skull anatomy in *Massospondylus carinatus*, we used CT scans and 3D digital representations to reconstruct the bones of the braincase of a complete, undistorted specimen (BPI/1/5341). These methods revealed details that are not visible in external examination and allowed for the determination of its internal osseous anatomy as well as other endocranial structures such as the inner ear. These data were then used to establish a detailed cranial and braincase descriptions of the genus. Our study yielded information about *Massospondylus carinatus* that was previously missing or unclear, notably with regard to the orbitosphenoid, prootic and palate bones. We compared the skull of *Massospondylus carinatus* to relevant sauropodomorph taxa, such as *Plateosaurus*, and were able to identify previously unknown cranial autapomorphies for it as well as increase the cranial character dataset. Our research forms a strong basis for future studies of the growth and development of this important dinosaur taxon.

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New tuff deposits from the Elliot Formation and their implications for absolute dating of the Triassic–Jurassic terrestrial boundary

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The Elliot Formation of South Africa preserves a rich fossil record of terrestrial life during the early Mesozoic, including dinosaurs, crocodylomorphs, therapsids, and turtles. Current hypotheses for the age of the Elliot Formation are based on loose fossil vertebrate correlations (often footprints) with similar deposits in South America, China, and North America. These suggest that the Elliot Formation straddles the Triassic-Jurassic boundary, and thus indicate that it offers a crucial means of testing hypotheses for faunal turnover during the Triassic-Jurassic extinction event. However, no absolute dating has been done

to evaluate these biochronological age estimates, in part because suitable volcanoclastic layers have not been found within the Elliot stratigraphic section. We report here on the discovery of a regionally extensive series of ash layers within the Elliot Formation in the Lady Grey area, Eastern Cape. Preliminary stratigraphic work on these tuffs shows that they are the result of at least three separate eruptive events, with minimal to extensive reworking of sediments in between them. The overall thickness of the tuffaceous horizon is over 3 m, suggesting a substantial amount of ash was laid down during deposition of the layers. The tuffaceous horizons extend laterally over our entire focus area (one large farm), and we are currently doing more regional work to determine their overall extent. Our current understanding of the placement of these tuffs is that they are close to the lower Elliot/upper Elliot boundary, and thus possibly can provide an idea of where the end-Triassic may sit within the Stormberg sequence. Microscopic examinations of thin sections cut from the tuffs shows a cryptocrystalline groundmass, consistent with interpretation as devitrified volcaniclastic material. Reworked sedimentary layers between the tuffs have coarser grains of subangular detrital quartz within a very fine-grained matrix. We have recently sent samples for zircon separation; results suggest that datable zircon populations are present. Our efforts are currently focused on increasing our stratigraphic resolution of the tuffaceous layers, obtaining radioisotopic dates from them, and sampling the fauna above and below them.

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The role of biostratigraphy in mapping the organic matter in the Whitehill Formation

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Organic matter (OM) is assumed to be a mappable entity within the Early Permian Whitehill Formation, which is a richly fossiliferous mudstone-dominated unit in the lower part of the Ecca Group (Karoo Supergroup) with total organic carbon (TOC) value of up to ~4.5 wt %. To date, a reliable OM map of the Whitehill Formation based on methodically measured values is lacking, and the nature of interactions among the factors that govern and alter these values through time and space is poorly understood.

In general, the distribution of the OM in geological units is controlled by the intricate combination of the physical, chemical, and biological processes both at the time of deposition and during the subsequent geological history of the host rock. Syn-sedimentary processes can impact on the biological production of the organic remains (e.g. amount of nutrients) as well as on their preservation potential (e.g. amount of free oxygen) in the depositional environment. Post-depositional processes (e.g. igneous intrusions, rapid burial/exposure) may also alter the quantity and quality of the OM. Accurate modelling of the thermal effect of such post-depositional events requires a realistic premise on the original distribution of the OM in the basin.

In this study, field-based sedimentological and detailed geochemical analyses will be utilized to (a) map out the OM distribution in the Whitehill Formation and (b) evaluate the criteria that controlled the distribution of OM during and after deposition. Assuming that the biological productivity at microscopic and macroscopic levels occurred under similar physico-chemical conditions, the sedimentary facies, sequence stratigraphic and biostratigraphic frameworks of the Whitehill Formation will be combined into a proxy for mapping out the distribution of OM at the time of deposition.

The potential significance of an OM map of the Whitehill Formation is twofold as such map could be used not only as a prospective tool in hydrocarbon exploration (e.g. to assess whether the TOC values are spatially systematic), but also as a predictive tool for estimating the vertical and horizontal distribution of fossil remains in the subsurface. Finally, the determination of the 3D distribution of the OM in the Whitehill Formation may also assist in reconstructing a realistic burial history in the main Karoo Basin and in simulating the thermal maturation of the OM in the Ecca Group.

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Hair of the dog that bit; the evolution of man and his dog

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One has only to step inside a pet shop and peruse the large selection of Dolce and Gabanna pet outfits to know how important dogs are to man (or perhaps woman). However many of us are unaware that dogs

were the first species to be domesticated and few people understand how wolves (the ancestors of modern dogs), a large and dangerous carnivore, came to be domesticated. The story of dog domestication is an excellent example of a field in which divergent scientific disciplines like archaeology, genetics and even ethnography can provide fascinating insights that together tell a greater story than any single discipline. For example, recent archaeological evidence from Siberia and the Czech Republic have identified the remains of early dogs from 30 000 to 35 000 years ago. Genetic research from a number of researchers has shown that modern dogs originated from the Eurasian Wolf. Experimental genetics with a large controlled breeding population of silver foxes in Russia has over the last 40 years produced successive fox generations showing progressively more phenotypic and behavioural characteristics typical of dogs. This experiment has not only provided us with a possible mechanism for canine domestication but it also means that you can have your very own pet fox that will chase its tail and fetch a ball just as well as any Labrador.

Dog domestication is also an excellent example of the process of artificial selection and its importance to evolutionary sciences. Dogs present the widest range of phenotypic variation of a single species with more than 400 different breeds. All this variation does not indicate a mixed ancestry with multiple canids, but rather reflects intense artificial selection by humans for forms related to different purposes. In this presentation we review literature on dog domestication and evolution to investigate the usefulness of the dog domestication story as a tool for teaching evolutionary biology. We also investigate how the domestication and development of dogs have affected our evolutionary history as a species and how dogs have evolved capabilities indirectly through contact with humans. For example dogs have been shown to be better at understanding human communications like point signals than our own closest relatives.

In conclusion, the story of dog domestication provides an excellent model for understanding artificial selection, multidisciplinary scientific research and the development of modern human behaviour and society.

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Is Langebaanweg an estuarine deposit? A taphonomic perspective

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The objective of this study is to undertake a taphonomic investigation of the fossil site Langebaanweg. Langebaanweg is the only Mio-Pliocene fossil locality in South Africa. Phosphate mining and small excavations in the latter half of the 20th century resulted in the recovery of a vast number of faunal remains. Indeed, Langebaanweg has one of the most abundant and diverse faunal accumulations of the Early Pliocene. A great deal of research on Langebaanweg was published in the 1970s and 1980s. During this period the depositional environment at Langebaanweg was interpreted as an estuary with floodplains, backswamp and aeolian localities within it. These interpretations, as well as more recent work, have focussed on sedimentology, although a stratigraphic column was only produced for the site in 2012. The accumulation of vast numbers of well-preserved remains is one of the most striking characteristics of Langebaanweg. Brief mention is made of the presence of rolled bones and of burnt bones but no taphonomic analysis has been conducted at Langebaanweg. In order to undertake a taphonomic analysis new test pit excavations will be dug in each bed of the formation so that all taphonomic factors including context specific characteristics like orientation can be measured. Taphonomic criteria to be utilized in this investigation will include, orientation, articulation, and surface markings like toothmarks or burning. Some faunal remains from the older collections will also be assessed for comparative purposes. The taphonomic patterns identified in this study will provide evidence to support or dispute previous palaeoecological reconstructions. In this presentation we will present preliminary data from the first test pit excavations.

Funding acknowledgement: Department of Science and Technology/National Research Foundation Centre of Excellence for Palaeosciences; University of the Witwatersrand.

Periosteal bone histology and depositional rates in the extant archosaur, *Crocodylus niloticus*

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According to Amprino (1947) there is a direct relationship between the type of bone microstructure and the rate at which bone is deposited. In recent years there have been several studies that have examined

Amprino's rule, but these have focused mainly on birds. Among extant reptiles, although there has been research on the nature and texture of the microscopic structure of bones of chelonians and squamates, not much has been done on crocodilian periosteal bone growth rates.

Here, our preliminary findings on the long bone microanatomy and histology of the Nile crocodile (*Crocodylus niloticus*) are presented. The study material comprised four juvenile crocodiles (two males and two females) that were injected intraperitoneally with three fluorochrome stains (two Engemycin and one Alizarin Red solutions) at regular intervals. The aim of the research is to examine the bone depositional rates within different bones of each individual, as well as among the different individuals. The crocodiles were sacrificed after two years. A total of 80 bones (including both sagittal planes of skeletal elements) were dissected out of the carcasses and will be analysed in this study. Using the fluorescent labelling, we will test Amprino's rule by examining the nature of the bone histology and the rate of bone deposition in the forelimb bones (humerus, radius, ulna, 1st metacarpal), the hind limb bones (femur, tibia, fibula, 1st metatarsal) and thoracic ribs (4th and last thoracic ribs).

Preliminary histological findings show that the bone histology of *Crocodylus niloticus* comprises a lamellar-zonal type of bone. During the favourable growing season, the bone tissue comprises a more parallel-fibred bone with many simple vascular channels, whereas during the unfavourable season, a more lamellar type of bone tissue with hardly any vascular channels occurs. This results in a zonal compacta resulting in distinctive growth rings that can be counted (skeletochronology).

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The application of vertebrate assemblage zones to deciphering the evolution of the Karoo Basin in the Middle Permian

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The vertebrate fauna of the Karoo has long been subdivided into assemblage zones. The diversity of fossil taxa from the Beaufort Group in particular has meant that the Karoo assemblage zones form the reference for vertebrate faunas from the Middle Permian to the Early Triassic. While the use of vertebrate biostratigraphy in biochronology and evolutionary studies is well established, their potential contribution to the debate surrounding the evolution of the Karoo Basin has been less explored.

By representing a means of relative dating, biostratigraphy has already allowed the recognition that the lower contact of the fluvial Beaufort Group with the marine/lacustrine Ecca Group is diachronous. By exploring the fauna that is present above the contact of the Ecca and Beaufort groups around the basin it is possible to chart the regression of the Ecca Sea during the Middle–Late Permian. Furthermore, the change in stratigraphic thickness of each assemblage zone throughout the basin provides data on the distribution of accommodation space through this period. This has been achieved for the Middle Permian by comparing lithostratigraphic sections from the southern and western Karoo Basin and the thickness of vertebrate assemblage zones therein.

The lower three Beaufort assemblage zones were considered in this research: the *Eodicynodon*, *Tapinocephalus* and *Pristerognathus* assemblage zones. A reappraisal of their respective thicknesses suggests that the younger zones are each thinner than their predecessor. At the same time, the younger zones are each more widespread than their predecessor. This suggests that the distribution of accommodation space within the basin changed during the late Middle Permian in a more distal direction, resulting in the progradation of the shoreline to the northeast.

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First thoughts on the aftermath of the end-Guadalupian extinction in tetrapods and the fate of the *Pristerognathus* AZ

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The *Pristerognathus* Assemblage Zone (AZ) of the Beaufort Group is one of the least studied biozones in the Karoo sequence. This zone is described as consisting of an impoverished remnant of the underlying *Tapinocephalus* AZ, characterized by low diversity and the prolific occurrence of a very few genera. The *Pristerognathus* AZ does, however, record the aftermath of an extinction that witnessed the disappearance of dinocephalian therapsids and of a large proportion of genera. The age of this biozone falls within the latest Middle Permian (Capitanian epoch of the Guadalupian stage) and may be linked to diversity crises recorded in the marine realm of China. In view of its position within a continuously exposed depositional

sequence, the *Pristerognathus* AZ is therefore of particular significance in exploring the aftermath of the dinocephalian extinction.

Stratigraphic fossil collecting in and immediately adjacent to the Poortjie Member of the Teekloof Formation in the southwestern Karoo basin is providing high resolution data on the occurrence of fossil vertebrate taxa in the *Pristerognathus* Assemblage Zone. Together with fossil data from existing collections and the Beaufort Fossil Vertebrate Database, this is revealing that the *Pristerognathus* AZ may be more complex than currently understood and may potentially be subdivided. Perhaps more importantly, the first signs of recovery in the wake of the dinocephalian extinction are evident within the *Pristerognathus* AZ.

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Locating the boundary of the Katberg and Burgersdorp formations in the main Karoo Basin

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Currently, the position of the lithostratigraphic boundary between the Triassic Katberg and Burgersdorp formations (Tarkastad Subgroup, Beaufort Group, Karoo Supergroup) is poorly defined and remains largely unmapped, except for northwestern part of the Eastern Cape in South Africa. These formations belong to the world-famous, Triassic non-marine succession of South Africa that is richly fossiliferous and was deposited during a period of recovery of life after the largest mass extinction event in the Earth's history at the end of the Permian.

Preliminary stratigraphic investigation suggests that the contact between the formations is either sharp or gradational, comprising of a transitional unit between the Early Triassic Katberg Formation and the conformably overlying, Early to Mid-Triassic Burgersdorp Formation. Furthermore, it is assumed that the boundary of the vertebrate biozones within the Tarkastad Subgroup (i.e. the contact of the *Lystrosaurus* and *Cynognathus* biozones) coincides with the lithostratigraphic contact of the Katberg and Burgersdorp formations in the Eastern Cape.

The sedimentary sequences of the upper Katberg and lower Burgersdorp formations are also assumed to be different enough at outcrop scale. For instance, the Katberg Formation is predominantly composed of thick, laterally extensive, light olive-grey, coarse grained sandstones, predominantly composed of transverse and longitudinal macroforms with horizontal and trough cross-stratification. Minor, thin sequences of red olive to yellow mudstones are sometime preserved. In contrast to this, the Burgersdorp Formation consists of predominantly thick, fining-upward units of laterally non-extensive, olive-grey, fine to medium grained sandstones overlain by red-maroon coloured siltstones and mudstones. Based on these lithological differences, it has been suggested that the Katberg Formation was deposited in a braided, whereas as the Burgersdorp Formation was laid down in a meandering fluvial system.

The primary scope of this detailed sedimentological study is to evaluate these assumptions and to define the position of the actual lithostratigraphic boundary. Mapping out the macro and micro facies differences across the contact between the Katberg and Burgersdorp Formation will involve remote sensing techniques, field observations, sedimentary logging and petrographic techniques. The results are expected to refine the 1:1 000 000 scale geological map of South Africa and to contribute to the understanding of the environmental conditions experienced by organisms during the Early Triassic.

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The first detailed description of *Protosuchus haughtoni* cranial pneumatic regions using a CT scan and 3D digital representation

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Protosuchus haughtoni is a basal crocodyliform from the Early Jurassic beds of the Stormberg group of South Africa. Basal crocodyliforms are known to have pneumatic skulls, but to date there has been little research to quantify and describe their cranial pneumaticity. We scanned the cranium of *Protosuchus haughtoni* using the Wits microfocus CT scanner to investigate its pneumaticity. By using 3D reconstruction techniques, we are able to for the first time visualize and describe the interior bones of the skull of *P.haughtoni*. Our results show that considerably more pneumatic structures are present than were previously known, particularly in the basisphenoid, prootic, and laterosphenoid. Quantification of pneumaticity in archosaurs has previously been focused on postcrania, and a current metric for this is the Pneumaticity Index (PI). By adjusting this index to evaluate cranial elements, this study has determined that there is a noticeable reduction of pneumatic intrusion from the ancestral state of *P. haughtoni* to

modern taxa like *Alligator*. This study provides an important point of comparison when evaluating the evolutionary development of pneumaticity between both the avian and crocodilian lineages.

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CT scanning and 3D laser fossil preparation applied to a selection of South African fossils

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A prior proof of concept study demonstrated that a combination of CT scanning and 3D laser processing can successfully remove breccia from around a fossil, accurately and at a high removal rate. This proof of concept study was on a 25 mm diameter sample, cut and mounted in a metallurgical mount, and of a very specific sample of unique breccia type. This was not yet representative enough to demonstrate the wider applicability of the method. In the study reported here, larger samples of selected different fossil sites in South Africa were used, with minimal sample preparation. Raw samples were glued to plastic mounting cubes for reference axes, microCT scanned followed by segmentation of the data. This process requires isolating the fossil from the rock in the 3D images, followed by surface fitting of the rock data, extracting the rock data surface file in a CAD format, and programming this into the laser processing workstation. Loading the fossil in the laser workstation in the correct angle is crucial, followed by selecting laser processing parameters and starting the laser processing, which is only attempted from one direction for safety of the fossils. Promising results are presented and future challenges for semi-automated laser processing / preparation of fossils are discussed.

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Palynological age dating and palaeoenvironments of the Middle Miocene Niger Delta

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The palynological study of ditch cuttings of well M1 between 6060–8850 feet from the Western Niger delta, Nigeria, yielded a well-preserved assemblages of palynomorphs dominated by the mangrove pollen *Zonocostites ramonae*, in association with common *Monoporites annulatus, Sapotaceoidaepollenites* spp., *Psilatricolporites crassus, Gemmamonoporites* spp., *Racemonocolpites hians, Acrostichum aureum, Verrucatosporites* spp., *Laevigatosporites* spp., *Polypodiaceoisporites* spp., the freshwater algae *Botryococcus braunii* and *Pediastrum* sp., and records of dinoflagellate cysts especially *Spiniferites ramosus, Lingulodinium machaerophorum, Nematosphseropsis labyrinthus, Impagidinium* sp., *Selenopemphix* spp., *Sumatradinium* sp., and *Spiniferites* sp. The well is dated Middle Miocene due to the preponderance of typical Niger Delta Middle Miocene diagnostic palynomorphs *Verrutricolporites rotundiporus, V. microporus, Belskipollis elegans*, *Crassoretitriletes vanraadshooveni,* and *Proteacidites cooksonni*. Furthermore, the palaeoclimatic deduction revealed a more definitely humid environment in the Middle Miocene of the studied area as the pollen records revealed the dominance of the mangrove pollen in association with freshwater swamp, brackish water swamp species and common algae in association with dinoflagellate cysts. The palaeoenvironment fluctuated between nearshore to deep marine inferred from the spotty records of *Nematosphaeropsis labyrinthus*, and *Impagidinium* sp., at some intervals.

Palynostratigraphy, palynofacies and thermal maturation of the Nsukka Formation from an excavation site in Okigwe, southeastern Nigeria

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There is a dire need to assess the petroleum generating potentials of the Nigerian inland basins. The palynological study of the Nsukka Formation from an excavation site in Okigwe, southeastern Nigeria, revealed abundant records of pollen, spores and dinoflagellate cysts. Palm pollen, *Longapertites*

marginatus, *L. vaneendenburgi*, *L. microfoveolatus*, *Spinizonocolpites echinatus*, *S. baculatus*, *Psilamonocolpites medius*, *Foveomonocolpites bauchiensis* and *Retimonocolpites nigeriensis*, dominated the microfloral assemblage with common dinoflagellate cysts, especially *Ifecysta* spp., *Cordosphaeridium* spp., *Fibrocysta* spp., *Senegalinium* spp., *Phelodinium* spp., *Spiniferites* spp., *Hafniasphaera* spp., and *Kallosphaeridium* spp., *Glaphyrocysta* sp. and *Distatodinium* sp., indicating alternating shallow to marginal marine depositional environments. The already published ranges of the palynostratigraphically important taxa such as *Buttinia andreevi, Monocolpopollenites sphaeroidites, Rugulatisporites caperatus, Cingulatisporites ornatus, Damassadinium californicum* and *Carpatella cornuta* enabled the delineation of the age as Late Maastrichtian-Middle Paleocene. This preponderance of palm pollen supports the Cretaceous – Early Tertiary palm province which traversed the whole of the southern hemisphere. The studied Nsukka sequences consists of alternating successions of fine-grained sandstones, well-bedded dark and sandy shales. The samples were dominated by terrestrial organic components especially structured phytoclasts, black debris and degraded wood elements indicating deposition in predominantly nearshore settings. However, the basal samples were characterized by common amorphous organic matter co-occurring with dinoflagellate cysts suggesting periods of marked transgressions. Using *Deltoidospora adriennis* as an index, the spore colouration index (SCI), ranged from 4 (golden yellow) – 4.5 (deep yellow) which correlates to vitrinite reflectance of 0.4 – < 0.5, indicating sediments with immature oil and gas-generating potentials.

First occurrence of *Hamshawvia* Anderson & Anderson and *Stachyopitys* Schenk in the Triassic of Rio Grande Do Sul (South Brazil)

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The scarce and exclusive exposures of the *Dicroidium* Flora in South Brazil remained inaccessible to geological and palaeontological research for a long time. New excavations made recently allow the rediscovery of the fossil levels in lacustrine deposits included in the main fluvial system assigned to the basal unit of Santa Maria Formation, the Passo das Tropas Member. On the two-metre-thick laminated mudstones *Dicroidium* and other related Umkomasiales dominated, exhibiting a homogenous distribution along the profile and well-preserved forms. This follow in importance by ginkgophytes, represented by reproductive structures and leaf impressions of *Baiera* and *Sphenobaiera*. Three distinct forms of *Hamshawvia* and one of *Stachiopitys* are present. The female oviluferous structures show elongated, slender, single-branching axes, with a pair of nearly rounded megasporophylls that characterize the forms of *Hamshawia* Anderson & Anderson. First identified in the Carnian Molteno Formation in South Africa, it was later also recorded in Australia and Argentina (*Hamshawia* (*Umkomasia*) *cacheutensis* Anderson & Anderson). The forms described here are the first record for Brazil and one of them shows close relations with *H. longipedunculata* Anderson & Anderson in its well-preserved round, fleshy, dorsoventrally compressed megasporophyll, inserted in a long axis. The more rare male structure *Stachiopitys* Schenk (a condition shared with other Triassic areas of Gondwana) show numerous pendant microsporangia arranged in rosettes around the axis, similar to that found both in *S. mazarinus* Anderson & Anderson and *S. lacrisporangia* Anderson & Anderson from the Molteno Formation. The common occurrence of reproductive organs and leaves (including *Sphenobaiera shenkii sensu* Anderson & Anderson) in Santa Maria Formation, yet without organic connections, attest to a common composition with other taphofloras from Gondwanaland, especially with those from Argentina and South Africa, and strengthen the affinity of those forms with the Ginkgoales. Their presence in the plant assemblage of the basal member of Santa Maria Formation also contributes to extend the age of those levels to the Carnian.

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Rusingoryx atopocranion (Artiodactyla: Bovidae) and the non-analogue ecosystems of modern human origins in East Africa

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Previous research on late Quaternary fossil assemblages from East Africa indicated that – with a few minor exceptions – an essentially modern faunal community was in place by ~400 000 years ago.

However, a growing body of evidence, stemming largely from our investigation of the Late Pleistocene (126 000 to 12 000 years ago) fossil and archaeological record of the Lake Victoria Basin in Kenya, indicates that these communities included numerous extinct grassland specialists, implying greater taxonomic and ecological breadth than today. The Lake Victoria Basin documents the survival of several lineages thought to have disappeared in East Africa during the Middle Pleistocene, including the giant wildebeest *Megalotragus* and the bushpig *Kolpochoerus*. Also present are several large-bodied or exceptionally hypsodont bovids, including the long-horn buffalo *Syncerus antiquus*, an unnamed impala *Aepyceros* sp. nov., an extinct blesbok *Damaliscus* hypsodon, and the wildebeest-like *Rusingoryx atopocranion*. Of these, *R. atopocranion* provides an exceptional testament to the discrepancy between the Late Pleistocene and modern faunal communities of East Africa. Cranial material recovered from a mass death assemblage of *R. atopocranion* on Rusinga Island reveals the presence of an ossified nasal crest unseen in vertebrates outside of Late Cretaceous lambeosaurine hadrosaurs (Ornithischia, Hadrosauridae). Associated features of its palatal morphology and tortuous nasal tract, revealed using X-ray computed tomography, are likewise unknown within Mammalia. As has been demonstrated for some hadrosaurs, multiple lines of evidence indicate that the nasal dome of *R. atopocranion* was likely used to produce loud, low-frequency vocalization across long distances. The presence of an associated Middle Stone Age (MSA) lithic assemblage and butchery marks on *Rusingoryx* postcrania indicate that early modern humans not only interacted with this trumpeting antelope, but inhabited ecosystems that included faunas dramatically unlike those of the present. *Rusingoryx atopocranion* and the associated Late Pleistocene fauna of the Lake Victoria Basin clearly demonstrate that neither Holocene ecosystems nor the foragers that inhabit them are suitable analogs for understanding the context of human evolution in East Africa.

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Studies in palaeontology using synchrotron radiation

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In May 2013, South Africa signed a medium-term arrangement with the European Synchrotron Radiation Facility (ESRF), becoming the 20th member country of the consortium. While synchrotron light sources were mostly viewed as research tools in material sciences and macromolecular crystallography, their use in palaeontology is becoming more common since the first experiment of this kind carried out at the ESRF at the beginning of the 21st century. The characteristics of the synchrotron radiation have generated several new opportunities to study many kind of fossils in a non-destructive way, for a wide range of sizes and resolutions. Notably, synchrotron phase contrast based tomography has proven to be the best imaging technique in palaeontology, generating images with great contrast and accuracy. Applications include, among others, imaging of fossils hidden in matrix (insect in opaque amber, vertebrate embryos in ovo, skeletal remains in burrows), virtual histology (dental and bones microstructure) and studies of endocranial cavities. Through the results of several studies, I will present the variety of applications available on the different beamlines of the ESRF. Notably, by comparing results obtained using laboratory and synchrotron microtomographs on various fossils, I aim to present the benefits offered by synchrotron radiation but also its limitations. Finally I also want to take the opportunity to explain what this partnership means to South African researchers and how you can benefit from it.

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Large helical burrow casts from the Late Permian of South Africa

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We report here very large helical burrows of vertebrate origin at a new locality from the *Cistecephalus* Assemblage Zone. These burrows are larger than previously reported helical burrows from the Late Permian *Pristerognatus* and *Tropidostoma* assemblage zones, attributed to the small-sized dicynodont *Diictodon*, and hence must have been dug by another, larger taxon. About 25 burrows have been reported from the locality, most of them been partially preserved and are distributed within two stratigraphic horizons. All burrows within a stratigraphic horizon show a similar sedimentary infill, indicating that

these casts were produced during single flooding even. Burrows from the upper horizon present generally a good preservation and are filled with a greenish calcareous sandy matrix with clay pebbles. Other burrows from the lower horizons are mostly known from badly preserved terminal filled by a maroon calcareous sandy matrix. From the size of the terminal chambers and observed descending tunnels, only one morphotype can be identified. The reconstructed geometry form best preserved casts consist of a helical tube loosely coiling around a central vertical axis. We counted up to two whorls, with no preferred sense of coiling (either senestral or dextral). The descending tube, about 15 to 20 cm in diameter, presents a declination (ramp angle) ranging from 10° to 35° and a height of 50-60 cm. The single terminal chamber extends outside the axis of coiling and is about 60–65 cm long, 30–35 cm in width, with a maximal thickness of 12–17 cm.

No skeletal remains were identified yet within burrow casts. The only identified skeletal remain found in close association with these burrows consist of a partial mandible attributed to the dicynodont *Oudenodon*. While further investigation is required to assess the identity of the animal that dug these burrows, *Oudenodon* represent a suitable candidate in term of size. Together with other helical burrows from the Late Permian it would indicate proclivity of dicynodonts for this unusual architecture.

Anomodonts (Tetrapoda: Therapsida) as model group to study the end-Permian mass extinction and its aftermath

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Anomodont synapsids are an ideal case study to investigate the impact and subsequent recovery of the end-Permian mass extinction (EPME) on land. This most speciose and morphologically diverse clade of Permian-Triassic tetrapods dominated as herbivores the terrestrial vertebrate ecosystems in numbers of individuals and occupation of ecological guilds. They ranged in body size from small (10–15 cm) to large (2–3 m) and included fully terrestrial, semi-aquatic, fossorial and arboreal ecomorphs. Anomodonts had a global distribution and represent one of only few survivors of the EPME and the only tetrapod clade that experienced a true bottleneck at this event with radiations before and after. For the purpose of this study, taxic (TDEs) and phylogenetic (PDEs) diversity estimates were calculated at the global scale and residual diversity estimates (RDEs) at the regional scale of the South African Karoo Basin (using number of specimens, number of farms, and outcrop area as sampling proxies). Anomodont diversity increased throughout the Permian with varying support for a minor mid-Permian (end-Guadalupian) extinction, collapsed in the earliest Triassic and reached a second peak in the Middle Triassic before their final decline in the Late Triassic. In addition, disparity was measured as sums of ranges and variances obtained from a comprehensive phylogenetic dataset of anomodonts converted to generalized pairwise Euclidean distances and subsequently subjected to principal coordinates analysis. Comparison of diversity and disparity measures indicates that diversity is clearly decoupled from morphological disparity in anomodont history, with a macroevolutionary bottleneck in one (taxic diversity) apparently not affecting long-term trends in the other (disparity). Finally, a character Completeness Metric (CCM2) was calculated for each taxon and consecutive time intervals at the global scale and in South Africa. These metrics indicate that the quality of the anomodont fossil record is exceptionally good, but it remains unclear whether this pattern is a result of the unrivalled fossil record in the South African Karoo Basin or genuine and unique to the clade. Correlation tests indicate a strong and statistically significant positive correlation of the different sampling proxies with TDEs at the regional scale of South Africa. Moreover, they show a statistically significant strong positive correlation between the RDEs (based on outcrop area and number of farms) and the global PDE, indicating that the two divergent methods for correction (residual diversity estimates and phylogenetic diversity estimates) of the biased raw diversity converge on the same potentially biological diversity signal for anomodonts.

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New specimens of *Africanaspis*, an arthrodire placoderm genus from the Devonian, Famennian, Witpoort Formation Waterloo Farm lagerstätte allow for the definition and full reconstruction of two species

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A monospecific genus *Africanaspis* was erected in 1997 for unusual arthrodire placoderm trunk armour

plates, characterized by a conspicuously high medium dorsal plate, and associated anterior dorsolateral and posterior dorsolateral plates.

Subsequent excavation of shale from the type locality, the Waterloo Farm deposit, has made available a far larger set of specimens, allowing for identification of two distinct species. Both are now known from almost complete sets of trunk armour plates and one taxon is also represented by a complete dermal head shield.

Reconstruction of head and trunk armour from dissociated and flattened plates was achieved by rescaling them and modelling them in paper. Cut out paper models were then assembled onto a three-dimensional plasticene core.

In two cases impressions of the soft tissue post armoured portion of the body is preserved, allowing for reconstruction of near complete organisms. This is extremely unusual in the fossil record of placoderms which are most commonly known from their bony plates. Exceptional soft tissue preservation resulted from anaerobic conditions that at times occurred within the fine lagoonal muds that were the source of the black shale.

Reanalysis of *Africanaspis* indicates that it is closely related to two other genera of high median dorsal bearing arthrodires, *Tiaraspis* from Europe and *Turiaspis* from north America, which may be a junior synonym of *Africanaspis*. This adds to growing evidence from Waterloo Farm of faunal exchange between south western Gondwana and Laurasia by the end of the Devonian.

New developments from the lower Burgersdorp Formation (*Cynognathus* Assemblage Zone), Free State, South Africa

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The lower Burgersdorp Formation (Beaufort Group) in the Free State of South Africa records a diverse and rich fauna that is referred biostratigraphically to the *Cynognathus* Assemblage Zone. Although known since the 1920s it was only in the early 1990s that the fauna was recognized for what it is. Recent collecting efforts in this part of the Burgersdorp Formation have resulted in this sequence becoming one of the best documented non-marine Early Triassic sites worldwide.

The stratigraphic succession of the lower Burgersdorp Formation may be broadly subdivided into three units, which have different sedimentological, palaeontological and taphonomic histories. The Burgersdorp Formation is unconformably overlain by the Late Triassic Molteno Formation, marking one of the largest temporal unconformities within the main Karoo Basin.

The fauna from the lower Burgersdorp Formation is dominated by aquatic or semi-aquatic taxa including the temnospondyl amphibians *Kestrosaurus*, *Parotosuchus*, *Trematosuchus*, *Bathignathus*. Fish fossils include material attributable to the actinopterygian *Saurichthys*, chondricthyans *Lissodus* and *Polyacrodus* and the sarcopterygian *Ptychoceratodus*.

The terrestrial component of the fauna includes the procolophonid *Thelegnathus*, the bauriid *Bauria*, the enigmatic diapsid reptile *Palacrodon*, and a number of as of yet undescribed macro- and microvertebrate remains. Rare therapsid remains also occur, with teeth assignable to the trirachodontid *Langbergia* and the cynodont *Cynognathus* as well as therapsid postcanines with haramiyid-like crowns, which represent a new taxon. Most recently a new species of the erythrosuchid taxon *Garjainia* has been described. The discovery of a diverse microvertebrate fauna is particularly important, as previously only the Czatkowice quarry in Poland and the Arcadia Formation in Australia have produced Early Triassic microvertebrate remains.

Thousands of vertebrate coprolites of various morphologies have also been collected, a number of which contain fish scales and vertebrate bone. Work on this material has also shown them to preserve rare organisms such as various invertebrates.

The presence of *Cynognathus* places the fauna biostratigraphically within the *Cynognathus* Assemblage Zone; however, it shares few other genus or species level ties with the typical *Cynognathus* Assemblage Zone fauna, and this new assemblage is designated as the type fauna for the lowermost subdivision of the *Cynognathus* Assemblage Zone. Correlation with faunas from Russian, Chinese and Australia strongly suggests a late Early Triassic (Upper Olenekian) age for this fauna. Gaining a better understanding of this fauna is important as it is at this time that the radiation of life following the end Permian mass extinction begins.

Comparative study of the forelimb of the Early Triassic cynodont *Thrinaxodon liorhinus*: exploring burrowing anatomy

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Therapsids were severely affected by the Permo-Triassic mass extinction and only a few lineages were

able to survive. Burrowing is usually considered as one of the main behavioural responses that most likely aided therapsid survival across the extinction event. Several fossilized skeletons of the therapsid cynodont, *Thrinaxodon* have been found in curled up positions, presumably indicating that they died in enclosed spaces (e.g. a burrow). This circumstantial evidence has led to the idea that this taxon was perhaps a digger. To date, limb functional morphology of *Thrinaxodon* has not been systematically compared to that of extant burrowers. Irrespective of potential digging adaptations, the limbs of *Thrinaxodon* also have been described as exhibiting a transitional phase between classic sprawled limb postures of reptiles and mammalian parasagittal postures. The present study attempts to address both of these issues by quantitatively comparing forelimb structure (humerus, radius and ulna) of *Thrinaxodon* liorhinus with forelimb structure of a parasagittal cursorial marsupial (*Thylacinus cynocephalus*), parasagittal digging marsupials (*Vombatus ursinus* and *Lasiorhinus kefftti*), and sprawled limb reptile form (*Varanus niloticus*). A geometric morphometric approach featuring a landmark-based analysis was completed in order to quantify the extent of similarity and difference between *Thrinaxodon* forelimb structure and forelimb structure in comparative groups. This series of nested comparisons permitted interpretation of the functional morphology of the fossil *Thrinaxodon* as having mixed functional inputs. Humeral morphology was observed to be structurally closest to that of fossorial marsupials (*Vombatus* and *Lasiorhinus*); however, radial morphology was closest to that of the sprawled reptile (*Varanus*). These results advance present understanding of *Thrinaxodon* limb structure, mobility, palaeobiology, and cynodonts in general.

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The digital virtual reality of the fossilized fruit endocarp from Malapa

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In close proximity to other hominin fossil cave sites of the South African 'Cradle of Humankind' (i.e. Sterkfontein, Swartkrans, Kromdraai, Drimolen, and Coopers) ranging in time between 2.6–1.3 Ma, Malapa is one such cave containing hominin fossil remains around 1.977 Ma. Since its first discovery in 2008, the flowstone deposit of Facies D of Malapa, has yielded a large number of hominin and faunal remains. We know that *Australopithecus sediba* has a mosaic of anatomical characteristics traits with more derived lower limbs and more primitive upper limbs, which allowed these hominins to have comfortable access to the ground and the trees. In this regard it is most helpful to have well-approximated pictures of the local ecosystem in order to define functional traits of *A. sediba's* skeletal morphology. The first works on faunal and botanical remains from coprolites gave evidence of relatively closed habitats with nearby open grasslands, and moister forest vegetation.

Using X-ray images, sixteen endocarps of fruits with similar morphology were registered from four of the blocks (breccia) collected at the Malapa site. These blocks mostly contain upper limb and axial skeletal elements. To date, no fossilized seed/endocarp remains are known from South African hominin sites. The botanical macro-remains mostly were not recognized because of the hard nature of breccia, in which the fossils are encapsulated. Using the usual mechanical preparation techniques small extraneous objects up to 5 mm diameters are destroyed but are visible when scanned. Every fossil botanical macro-remain provides some valuable information on the ecology of the hominin habitat. The following objectives are considered during the study of the fossilized fruit endocarps. First, to reveal the benefit of the digital preparation of the small sized fossil materials (e.g. seeds, endocarps, insects). Second, to study recent southern African endocarp material, which will help to identify the fossil endocarp and fruits. Third, to reconstruct the local habitat based on the taxonomic identity of the fossil endocarp. Lastly, to investigate the taphonomic process of carbonate and biogenic silica replacement.

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Cranial ontogeny of basal non-mammaliaform cynodonts from the Karoo Basin, South Africa

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Thrinaxodon liorhinus was a basal cynodont from the Early Triassic of Gondwana. Specimens of

Thrinaxodon are common and tend to be well preserved, allowing a comprehensive examination of cranial variation within the species. Previous studies that surveyed a small sample of individuals proposed only a few cranial features that could separate immature and mature specimens of *Thrinaxodon*. Here we re-evaluate these proposed ontogenetic features using both qualitative and quantitative analyses based on a larger sample of individuals ranging in skull length from approximately 30–96 mm. Seven specimens were also analysed using micro-computed tomography (micro-CT), allowing the internal structure of the skull to be thoroughly investigated.

Preliminary results of our comprehensive survey corroborated some of the previously proposed ontogenetic features, but our study also indicated that two features in the skull roof posterior to the pineal foramen start to manifest during the early juvenile stage: 1) the development of the sagittal crest; and 2) the progressive fusion of the parietal-parietal suture. The latter feature was not recognized in previous ontogenetic studies and was documented here for the first time using micro-CT. In addition, our bivariate analysis indicated that the length of the temporal region and height of the occipital plate shows positive allometry. This is consistent with our qualitative observations and suggests that during ontogeny the size of the sagittal crest increased at a faster rate than the rest of the skull.

In order to determine the functional significance of these ontogenetic differences, our observations must be placed within a broader phylogenetic context. For this, we propose comparing our results of the ontogenetic study of *Thrinaxodon* with two other basal cynodonts, *Galesaurus* and *Procynosuchus*. This forthcoming contribution will document the differences in skull morphology between these taxa using micro-CT, and in conjunction with other lines of evidence such as dental morphology, will determine if the differences indicate changes in skull function and diet.

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Guidelines for rehabilitating archaeological and palaeontological sites

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There is a lack of information available to researchers on how to rehabilitate a fossil site once excavations are complete. Reasons for this general lack of rehabilitation guidelines can be attributed to the scarcity of publications, limited documented case-studies, undefined clauses in existing legislation and the lack of information being disseminated. South African Heritage Resource Agency's guidelines do reference *best practice* with regard to site rehabilitation; however, the definition of *best practice* is not specified. The consequence is a shortage of information that has resulted in the lack of knowledge pertaining to the rehabilitation of archaeological and palaeontological sites. To address this disparity, case-studies of archaeological and palaeontological closures were assessed and compiled; existing legislation was discerned, and interviews were conducted with a cross-section of professions in the fields of archaeology and palaeontology. This research highlights the importance of formulating guidelines to assist researchers in developing best practice for the rehabilitation of their site. This study identifies: (1) best practice standards that all heritage specialists should observe, (2) a ten-step guideline, *MICRO-ORDER* was developed geared towards guiding the heritage professional through a structured process of developing a successful and site-specific rehabilitation design programme, and (3) techniques that could be applied to the rehabilitation of all archaeological and palaeontological sites. Discussions and workshops are needed to determine minimum standards for the rehabilitation of our precious heritage, which are long overdue and crucial if we are to fulfill our obligation and responsibility in terms of the World Heritage Convention Act (Act No. 49 of 1999).

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Ontogeny and cranial morphology of the basal carnivorous dinocephalian, *Anteosaurus magnificus* from the *Tapinocephalus* Assemblage Zone of the South African Karoo

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Anteosaurs (Therapsida: Dinocephalia: Anteosauria) were the dominant terrestrial predators during the late Middle Permian period and became extinct at the close of the *Tapinocephalus* Assemblage Zone. Only two genera of anteosaurs, *Australosyodon* and *Anteosaurus*, are recognized from the Karoo rocks of

South Africa. A newly discovered small anteosaurid skull from the Abrahamskraal Formation is fully described. Because of its relatively large orbits, the unfused nature of its sutures, and the lack of replacement teeth in the dental alveoli, the specimen is considered to be a juvenile *Anteosaurus magnificus*. A full computer-aided 3-D reconstruction of the skull enabled cranial measurements to be taken for an allometric analysis which included 23 measurements and 11 specimens. Positive allometry was found for four of the measurements suggesting fast growing in the temporal region, and a significant difference in the development of the postorbital bar and suborbital bar between juveniles and adults. Phylogenetic research shows that the Russian anteosaurids are forerunners to *Anteosaurus*, and because the juvenile *Anteosaurus* manifests many features of both *Syodon* and *Titanophoneus*, it is suggested that ontogenetic growth of *Anteosaurus* follows Haeckel's Law.

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A new digital classification system of trace fossils

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Ichnotaxonomy is the science of naming and classifying trace fossils according to the guidelines of the International Commission on Zoological Nomenclature (ICZN). As with palaeontology, holotypes are required for naming new trace fossil taxa in the form of samples, casts or photographs (previously sketches). Under the ICZN, morphological criteria are now regarded as the primary means of identifying existing or erecting new trace fossil taxa.

In biological classification, higher taxonomic ranks at family or order level tend to group together taxa that have similar defining physical, physiological, ecological, behavioural, molecular, etc. characteristics, and thus an identifiable organism can be efficiently compared to many taxa. However, ichnotaxonomic hierarchy is generally limited to genus and species levels, with family level assignments being made very rarely. When attempting to identify a trace fossil, one has to sift through lists of ichnotaxa and their descriptions, searching for those that match the morphology of the unknown specimen. To date, some of the most comprehensive works on ichnofossil identification are still without a key, contain unclear illustrations, and the entries are organized alphabetically, and not by morphological criteria. It is therefore not surprising that most newly discovered South African trace fossils are assigned to informal groupings and that many field-based geologists consider the formal and systematic description of newly found trace fossils a daunting, but more alarmingly, pointless task.

We propose an informal digital trace fossils classification system that is based on the morphological grouping of ichnofossils. The purpose of this user-friendly classification system is to facilitate, simplify and systematize the process of trace fossil identification. This type of classification system, especially if linked to a robust, digital, open-source, richly and three-dimentionally illustrated trace fossil database, could encourage the use of trace fossils in sedimentary facies analysis and palaeo-environmental reconstructions in a sensible and functional way even by non-ichnologists.

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Phylogenetic and histological analysis of Late Triassic sauropodomorph material from the Lower Elliot Formation of Lesotho

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One of the richest known Late Triassic–Early Jurassic sauropodomorph faunal assemblages is the Elliot Formation of South Africa. It is dominated by sauropodomorph dinosaur remains consisting of *Antetonitrus ingenipes, Blikanasaurus cromptoni, Melanorosaurus readi, Massospondylus carinatus, Plateosaurus cullingworthi, Eucnemesaurus fortis* and *Aardonyx celestae*. In the current study, we assessed the remains of undescribed sauropodomorph material that was excavated during the 1950s from the Late Triassic, Lower Elliot Formation in Lesotho. NMQR 1705 is composed of the postcrania of at least five individuals of varying ontogenetic sizes, totalling more than 250 postcranial elements. Previous researchers suggested that the material belonged to either a 'prosauropod' similar to either *Plateosaurus* or Melanosaurus, or to *Euskelosaurus* browni (*nomen dubium*).

We evaluated the taxonomic identity of this material by comparing it to other Late Triassic-Early Jurassic sauropodomorphs, performed a character analysis to assess the phylogenetic placement of this taxon and

conducted histological studies of long bones to deduce aspects of its biology and growth dynamics.

Our taxonomic assessment identified the material as belonging to *Antetonitrus ingenipes* based on the sharing of four out of five autapomorphies and morphological similarity of elements present in both the holotype (BPI/1/4952) and this material. Elements present in NMQR 1705 but not BPI/1/4952 include a sacrum, ilia, ischia, astragali, coracoids and a complete pes.

The cladistic analysis of a re-scored *Antetonitrus* incorporating data from NMQR 1705 resolved it as the sister-taxon to *Blikanasaurus cromptoni*, yet more derived than *Lessemsaurus sauropoides*. Long bone histology indicates highly vascularized FLB without regular growth marks throughout the compacta suggesting similar growth dynamics to more derived sauropods, rather than basal sauropodomorphs such as *Massospondylus carinatus*. The lack of a true outer-circumferential layer in the femora indicates that these individuals were still growing.

In conjunction with the shared autapomorphies, the presence of a 4-vertebrae sacrum with incipient sacro-costal yoke indicates sauropod affinity – firmly establishing that this material is not referable to any of the LEF basal sauropodomorphs. In terms of phylogeny, *Lessemsaurus* + (*Antetonitrus* + *Blikanasaurus*) represent the basal-most sauropod clade. The bone histology of NMQR 1705 indicates that the earliest sauropods had already begun to exhibit growth dynamics markedly different from basal sauropodomorphs.

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Essentialism, teleology, racism and other findings from a South African evolution education short learning programme

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With evolutionary biology relatively recently introduced into the South African school curriculum, the need arose to explore practicing teachers' knowledge of the subject, with a view to improving short learning programmes offered by the University of Johannesburg.

A baseline questionnaire was administered to 57 participants at the start of the first learning programme, and was followed up with interviews at the end of the programme. Questions were open ended and designed to probe the understanding and beliefs of teachers on evolution.

The course participants were not selected, but comprised teachers undergoing professional development in evolution education. The sample was relatively large and did include a wide range of teachers from different educational and cultural backgrounds, and who taught at a range of schools from more affluent suburban to less-affluent township and rural schools. Most of the teachers held Christian or traditional African beliefs.

Responses to the baseline questionnaire were analysed according to pre-determined categories. Responses were coded with one or more of the category codes if they suggested certain types of reasoning. Apart from the pre-determined categories, a number of emerging categories were also identified and coded as the analysis proceeded. The coded categories were grouped into themes. The themes were arrived at inductively.

The results of the analysis of the baseline questionnaire revealed that the teachers involved in this study held strong essentialist ideas and gave teleological and creationist responses to questions about origins and biodiversity. The results also revealed a number of other naive explanations and poor content knowledge, as well as a perceived racist agenda to the teaching of evolutionary biology.

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The Early Eocene food web of Messel, Germany

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After the end-Cretaceous ecological crisis, continental ecosystems were dramatically affected, with effects lasting throughout the Palaeocene and into the Early Eocene. The effects of these major environmental perturbations were variable, but the intensity and duration of trophic change and ecosystem remodelling into the Eocene remains unknown. For this reason we compiled an extensively documented,

highly resolved dataset of feeding interactions from the 48-million-year-old Messel Formation in central Germany. Messel is a small fossil lake 0.7 km^2 in area and representing 0.6 Myr of time from a maar-lake depression. The spatiotemporally confined deposit represents considerable environmental stability, judged from the pollen and sediment records. The oil-shale sediments preserve delicate biological structures such insect colour patterns, identifiable foliage and seed details, gut contents, and vertebrate body outlines of scalation, feathering and pelage.

We compiled data from 700 taxa from lacustrine sediments and a broad swath of surrounding paratropical forest. Taxonomic resolution of the data included 54 % of taxa resolved to the genus or species level and 82 % to the family. The dataset for the terrestrial Messel web was highly representative; consisting of 44 microorganisms, 187 plants, 326 invertebrates and 143 vertebrates. Trophic links were assigned from 10 sources of observations: 1) taxonomic uniformitarianism, 2) functional morphology, 3) gut contents, 4) plant damage patterns, 5) stratigraphic co-occurrence, 6) body size, 7) coprolites, 8) host relationship, 9) chemical and isotopic signatures, and 10) ichnological evidence. These lines of evidence were used to establish three certainty levels to provide degrees of confidence regarding the data.

The food web network structure of the Messel Lake and forest foodwebs were compared to relevant extant webs using analyses that accounted for scale dependence of web structure with diversity and complexity. The much smaller lake web, with 94 taxa and 517 links and a connectance of 0.059 showed similar trophic structure to extant webs. By contrast, the Messel forest web, with 630 taxa, 5534 links and a connectance of 0.014 exhibited differences with modern webs. This discordance is attributable to the elevated diversity of the forest web and detailed resolution of plant–insect interactions, explained by an effect of web scale dependence rather than fundamental difference in trophic structure. These data indicate that the Messel biota exhibited modern trophic structure, following an 18-million-year interval of post-extinction change. This study also provides a critical assessment of how modern webs are assembled, constructed and modelled.

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Special note: This presentation is a result of the 'Paleofoodweb Construction and Evolution of Ecosystem Structure' workshop at the Santa Fe Institute during 2002 and 2003, organized by J.A.D. and D.H. Erwin.

Using GIS and the SAHRIS database to better manage the impact of development on palaeontological heritage

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The fossil sensitivity map is an important step forward in the proactive management of palaeontological and geological heritage resources. The map will guide and assist developers, heritage officers and practitioners in screening palaeontologically sensitive areas at the earliest stages of the development cycle.

The successful development of SAHRIS in 2012 opened up a range of possibilities to automate access to and dissemination of the valuable information contained in the palaeontological reports. Furthermore, a number of provinces had only been partially assessed (or not at all). The extraction of the technical information onto a Geographical Information System (GIS) provided a means to eliminate gaps in the sensitivity maps where geological formations overlapped provincial boundaries.

SAHRA approached the Council for GeoScience (CGS) in order to access their 1:250 000 geological shapefile data. The CGS were happy to collaborate and on 19 September 2013, SAHRA and the CGS signed a license agreement for the use of their data. SAHRA has combined the Palaeotechnical Report information with the shapefile data on SAHRIS and has developed a Fossil Sensitivity Map for South Africa.

The map can be used in conjunction with the inventory of Fossil Heritage Layers on SAHRIS. These data has been taken from the Palaeontological reports compiled by Dr Almond, Dr Pether and Dr Groenewald and provide information on the kinds of fossil heritage known from geological formations in South Africa as well as the approximate age of the formations and the fossil sensitivity of the formations. The palaeotechnical project is continuing and as more information is provided, the Fossil Heritage Layers will be updated with new information.

It is SAHRA's hope that this information will assist in the proactive management of South Africa's palaeontological heritage and provide new insight into South Africa's unique heritage. This map can be utilized by the South African public, learners and researchers alike. Most importantly, this map can be used by developers as an early-warning system for potential impacts to significant palaeontological heritage.

Wild camphor smoke from hearths at Sibudu; finding '*Tarchonanthus camphoratus*' charcoal from the MSA

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The wood anatomy of aromatic *Tarchonanthus camphoratus* (wild camphor bush) was characterized, enabling its recognition archaeologically. This evergreen shrub or small tree is found in various habitats, from woodland and thicket to river banks and termite mounds. It tolerates frost, drought and sea breezes. The hard, heavy wood is insect resistant and burns even when green. The essential oil of *Tarchonanthus camphoratus* has antimicrobial and insecticidal properties. There are reports of the use of camphor smoke in folk medicine and of leaves in bedding by the Masaai, Kenya. Charcoal from two occupational layers with hearths at Sibudu rockshelter, KwaZulu-Natal, were studied to identify woody taxa from approximately 58 to 49 000 years ago. Layers dated 77 000 years ago previously yielded fossilized leaves of aromatic insecticidal *Cryptocarya woodii* on bedding of *Cladium mariscus*, *Scleria natalensis* and *Scleria melanomphala* sedge culms. Other layers contained charcoal from poisonous *Spirostachys africana*. To distinguish between woody Asteraceae, *Tarchonanthus camphoratus*, *Brachylaena huilensis*, *Brachyalaena discolor*, *Brachyalaena uniflora* and *Artemisia afra* modern wood reference charcoal was examined. A detailed anatomical study of the warp and weft of the wood was required in order to discover similarities and differences between these taxa. Xylem vessel pits and perforation plates, ray and fibre dimensions, presence or absence of pith and growth rings, varied subtly between the woods. Woody taxa were recognized according to a suite of IAWA list characters (International Association of Wood Anatomists). Charcoal was studied by means of a stereo-microscope, examined more closely by means of a reflective light microscope and digitally photographed using Olympus Stream Essentials® image analysis software with Extended Focal Image (EFI) capability. *Brachylaena* spp. (previously reported at Sibudu) and *Tarchonanthus camphoratus* were identified in archaeological charcoal from approximately 58 000 years ago. Burning *Tarchonanthus camphoratus* coincidentally burns smoking aromatic oils. Distinguishing between the woody Asteraceae is important as the presence of *Tarchonanthus camphoratus* in hearths at Sibudu implies the use of aromatic, insecticidal smoke in addition to tinder.

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A new skeleton of a scaloposaurian therocephalian (Therapsida, Eutheriodontia) from the Late Permian of the Karoo Basin

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Therocephalians are a diverse group of extinct mammal-like therapsids that were abundant in the Karoo of South Africa from the Middle Permian to the Middle Triassic. This group has several representatives in the Late Permian *Dicynodon* Assemblage Zone. It is difficult to give a precise number of therocephalian taxa represented in this assemblage zone because seven of the 13 therocephalians are member of the Scaloposauria, a group in need of a taxonomical revision. A new specimen representing an almost complete skeleton of a medium-sized therocephalian was collected from the farm Biscuitfontein in the Karoo, at levels corresponding to the top of the *Dicynodon* Assemblage Zone. The new specimen is member of the Scaloposauria and bears a resemblance to *Ictidosuchus longiceps* and *Lycideops longiceps*, both representatives from the *Dicynodon* Assemblage Zone. These taxa are represented by one to two specimens without any knowledge of their postcranium. The objective of this contribution is the determination of the taxonomic identity of the new therocephalian specimen. In addition, we also will explore quantitative differences in the limb bones (stylopodium *vs* zeugopodium) of therocephalians of different sizes and of basal non-mammaliaform cynodonts.

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Vertebrate taphonomy: first articulated large non-mammalian therapsid from the Triassic Chañares Formation

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The Chañares record is worldwide known by the well-representation of Ladinian tetrapod fauna with

small and medium-sized archosauriforms and synapsids. The Chañares tetrapod assemblages document two accumulation modes: (1) attritional mortality assemblage characterized by disarticulated skeletons of the different Chañares groups in similar proportion with dispersion pattern produced by low-energy flowing water; and (2) mass-mortality assemblage dominated by small and medium-sized elements of the fauna in a singular layer with a large quantity of complete or partially articulated skeletons, and rapid burial. The large dicynodonts are poorly represented with skulls and very few isolated postcranial elements. The first nearly complete articulated large non-mammalian therapsid in the Chañares attritional assemblage is reported here. The bearing level is characterized by structureless light olive-grey clay-siltstone deposited in the floodplain environment. The material is an individual comprising fragmentary skull, tusk, cervical and dorsal vertebrates, two fragmentary scapulas, clavicle, interclavicles, ribs and abundant fragmentary indeterminate bones. The skeleton is articulated, although the appendicular bones are missing. The individual displays a ventral-up attitude with the vertebral column forming a sharp curve. The skull is also in ventral-up attitude with a slight rotation and with loss of some ventral cranial bones and mandibles. Scapulas are fragmented and displaced, clavicle and interclavicle are only slightly displaced and the ribs are articulated in life-position. The bones show cracking without loss of superficial tissue suggesting a stage 1 of weathering and transverse fractures without movement that are associated to post-mineralization. The bone modifications are stronger in the bones located in the upper part of the assemblage. The taphonomic history of the specimen starts with a natural death in the ecosystem as there is no evidence of catastrophic death. The well-preservation of the bones observed suggest that the individual died in the exhumed site or in a very close area in the floodplain environment. The carcass was entombed during a short time with a constant sedimentation evidenced by the structureless deposit. The skeleton attitude suggests that the animal could had suffered predation/scavenging and/or high decay processes in the abdominal area that produce the ventral-up exposition although tooth marks are not observed in the preserved bones. The stronger bone modification and the absence of appendicular bones are favoured by the carcass position that exposed portion of the body to taphonomic processes for more time during pre-burial and were the first to be exhumed.

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Early Pliocene vultures (Aegypiinae) and owls (Strigiformes, Aves) from Langebaanweg, South Africa, and their significance for palaeoenvironmental reconstructions

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The Early Pliocene Upper Varswater Formation (Langebaanweg, South Africa) is one of the most important pre-Pleistocene fossil localities in Africa. Most recently, a new species of an aegypiine vulture as well as five species of owls (Strigiformes) were identified. The new vulture species represents the earliest, unequivocal and most substantial evidence for crown-group Aegypiinae in the world. Evidence for an *Aegypius* vulture at Langebaanweg indicates that open woodlands were an important component of the early Pliocene palaeoenvironments at this particular site. Owls are represented by a new species of *Tyto* (Tytonidae) as well as representatives of the strigid genera *Asio* and *Bubo*, which form the earliest records for these taxa in Africa. Especially remarkable is the first evidence for a species of *Athene* south of the Sahara, which is also the earliest record for an Athene owl worldwide. Modern representatives of all these owl taxa can be found in a great variety of habitats, but the composition of the owl assemblage at Langebaanweg might be congruent with latest hypotheses on local palaeoenvironments based on other taxa.

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Surface markings and sedimentary structures produced by stranded organic seafoam rafts derived from kelp mucilage and phytoplankton exudates: implications for recognizing early life on Earth and Mars

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On rocky coastlines of the cold Atlantic seaboard near Cape Town, South Africa, kelp (*Ecklonia maxima*)

forests are buffeted by waves driven by strong winds, and damaged blades release mucilage which, together with particulate organic matter and the exudates from several species of phytoplankton, forms organic polymers on the sea surface, which are worked by waves into seafoam. The seafoam, varying from low-density fluffy, frothy, white foam, which can float into the air from breakers in the surf zone, to greenish-yellow malodorous scum, bound strongly by capillary forces, may form large rafts (hundreds of metres long) which can persist for days, before being stranded, or dissipated. Elsewhere in South Africa, similar structures have been observed from stranded foam rafts at Smitswinkel Bay on the western shore of False Bay, and at Illovo Beach, KwaZulu-Natal (in subtropical waters with phytoplankton blooms but lacking kelp beds).

The stranded seafoam rafts produce sedimentary structures on the siliciclastic beach sand substrate. These include foam impressions, circular and elliptical craters with raised sandy rims formed around persistent bubbles, and stretched bubble marks which may be in a variety of irregular shapes with rounded edges. The rafts tend to be broken up into numerous small islands with a few to dozens of bubbles, elongated in the direction of the retreating ebb currents. These kinds of markings are quite different from those produced by normal surf-generated foam, because they are the products of bubbles in organic films with much greater surface tension (produced by surfactant polymers) than can be generated in ordinary seawater. Normal seawater, from which organic kelp-mucilage or phytoplankton-derived exudates have been filtered out, does not produce foam through agitation.

Foam and bubble impressions in the geological record, e.g. from the Devonian and Permian of Germany, the Upper Pennsylvanian of Kansas, and the Neoproterozoic (Upper Brachina Subgroup, Adelaide Supergroup), of South Australia, are reinterpreted as the exclusive markings of organic seafoams, which, because of their greater stability, have a much higher preservation potential than normal surf. They are thus regarded as physical biomarkers, or varieties of ichnofossils! Organic seafoams derived from phytoplankton would have been quite common in early Precambrian seas on earth (and Noachian seas on Mars?), and since they contain proteins, lipids and carbohydrates (bacterial nutrients), when stranded they could have provided a crucial trophic foothold for the colonization of shorelines by microbial mats.

A sequentially disrupted microbial mat in the Magaliesberg Quartzite, Pretoria Group: a 2.1 Ga geobiological jigsaw puzzle

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The Magaliesberg Quartzite Formation of the Pretoria Group (Transvaal Supergroup) is a *c.* 2.1 Ga quartzite unit inferred to have been deposited in a tidally-influenced braid delta epeiric marine coastline environment. The occurrence of petee ridges, reticulate sand crack networks, elephant skin textures, wrinkle structures and *Manchuriophycus*-like cracks, as well as sinuous cracks on ripple crest ridges, has been interpreted to be evidence for microbially-induced sedimentary structures (MISS) formed on the siliciclastic sediment substrate.

Here I document the first occurrence of an actual preserved partly disrupted microbial mat, in the Magaliesberg Quartzite, at Mountain Sanctuary Park, situated in the Magaliesberg Range, at 25°50′10″S, 27°28′33″E, some 50 to 80 km west of the previously reported occurrences of MISS.

The quartzite at Mountain Sanctuary Park shows many of the MISS previously recorded, including sand cracks, sinuous cracks, and *Manchuriophycus*-like cracks. In addition, there are raindrop impressions, and evaporite molds, resembling gypsum casts. A very spectacular outcrop was found of a bedding plane on which the inferred disrupted microbial mat occurs. On a small portion of the outcrop, there are near-symmetrical ripples, having a wavelength = 4.5 cm, amplitude = 2 mm, giving a ripple index of 27.5, typical of aeolian ripples. The rippled section is grey and much finer grained (made of muscovite and quartz) than the quartzite on which rests. The rest of the outcrop consists of 'exploded' and rotated disrupted segments of the rippled layer, scattered in small clusters over the rest of the outcrop over an area of 0.8 m^2.

The fact that the layer is disrupted into discrete coherent flakes, with sharp, angular edges, attests to a cohesion not found in muddy layers, but is characteristic of microbial mats, which are held together with networks of filaments. The are nine clusters of individual fragments which are related to the breaking up of larger segments broken away from the original microbial mat, like pieces of a geobiological jigsaw puzzle. In most of the clusters, invidual fragments can be matched with nearby flakes in terms of shape, and sometimes in terms of ripple crests that are still visible on them. Desiccation of the microbial mat led to its breaking into large fragments. Immersion in very shallow water raised up some of the detached

microbial mat fragments, and floated them away for short distances, where they underwent further disruption.

An osteohistological examination of fossil *Xenopus* (family Pipidae) from the early Pliocene site of Langebaanweg, West Coast, South Africa

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The phenomenally fossiliferous Early Pliocene site of Langebaanweg includes a diverse and rich anuran fauna. The abundance and the diversity of the frog community at Langebaanweg makes it one of the richest collections of fossil frogs in Africa, and a significant contributor to understanding frog systematics and anuran evolution worldwide. Research to date has identified approximately eight families, including Hyperoliidae, Brevicipitidae, Phrynobatrachidae, Pxyicephalidae, Arthroleptidae, Heleophrynidae, Bufonidae and Pipidae, and some 21 species have been distinguished. One of the most abundant taxa found in the Muishondfontein Pelletal Phosphate Member (MPPM), which forms part of the Varswater Formation at Langebaanweg and dates to approximately 5.1 Ma., belongs to the genus *Xenopus* (family Pipidae). There are currently two sympatric pipid species found in the Western Cape, namely *X. laevis* and *X. gilli*. The pipid *X. leavis* is endemic to sub-Saharan Africa, and *X. gilli* to the southwestern Cape. The latter is considered endangered due to habitat destruction, the fact that it occupies a narrow/specific niche, and also because it may inter-breed with, or be displaced by, *X. laevis*. *Xenopus laevis* is a particularly adaptable and hardy species, occupying a wide variety of freshwater bodies. Both species are aquatic but may disperse over land. At Langebaanweg two pipid species may be distinguished, based upon the size of the femur and humerus, which roughly corresponds to the size difference observed between the two extant species – *X. gilli* being the smaller of the two. The larger fossil pipid was scarce, but the smaller pipid was found in abundance throughout the MPPM. An osteohistological examination was conducted in order to examine growth and demographic patterns of the fossil *Xenopus*, and to investigate evidence of seasonality at Langebaanweg.

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A bio- and litho-stratigraphic study of the Ecca-Beaufort contact in the Northern Karoo Basin

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The Karoo Supergroup stratigraphic succession provides a time extensive and largely unbroken depositional history from the Carboniferous to the Jurassic, and records a climatic transition from glacial marine through fluvial to aeolian desert conditions. Although a lithostratigraphic scheme exists for the Beaufort Group the paucity of geographically extensive marker beds make lithostratigraphic correlation difficult. Because of the wealth of fossil tetrapods in the Beaufort Group, biostratigraphy is currently the most reliable method of stratigraphic correlation, and which reflects a younging of the Ecca-Beaufort contact in a northerly direction within the main Karoo Basin. In the southwestern part of the basin the *Eodicynodon* Assemblage Zone (AZ) is present immediately above the contact, whereas in the north the *Dicynodon* AZ is present at this lithostratigraphic transition. In the past there has been a great deal of debate about the lithological nature of this contact, largely because individual researchers worked independently at different localities around the basin.

Despite this, there is consensus that this shoreline contact reflects a change in depositional environment from subaqueous to subaerial fluvial deposition. Because of extensive research on this stratigraphic interval (Waterford to Abrahamskraal formations) in the south, this transition has been well documented for this part of the basin. More recently, the same lithofacies changes have also been recorded for the Ecca-Beaufort contact in the Free-State and KwaZulu-Natal provinces, suggesting that the contact can be defined by the same criteria over most of the basin. However, in the northern part of the basin this contact has been less intensively studied. To address this shortcoming, this project has undertaken field-based research in the vicinity of Virginia in the central Free State Province and accurately documents the lithofacies present across the contact between the Volksrust and Normandien formations in this part of the basin.

The results of this research will enhance understanding of Karoo Basin development in the Late Permian.

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Investigation into University of the Witwatersrand student opinions and knowledge of science and technology issues: beliefs about evolution and palaeontology icons like Mrs Ples

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As the global human population exceeds seven billion, technology becomes more sophisticated and invasive, and global issues like climate change and biodiversity loss loom, it is becoming more and more important that citizens become scientifically literate so that they can contribute to discussions about the best policies to ameliorate these crucial global issues. This study used the University of the Witwatersrand National Science Week 2013 activities as an opportunity to survey students of the University of the Witwatersrand about scientific literacy, via the online programme Survey Monkey. We asked whether they were optimistic about science and technology as tools for solving future problems, and inquired into their beliefs about evolution and knowledge of palaeontology icons like Mrs Ples. While the results are still being analysed, we report our preliminary findings. Six hundred forty-one responses were received, fairly evenly distributed across all faculties, and from various proportions of first through fourth year students and postgraduates. University of the Witwatersrand students performed similarly or even better than their counterparts in similar surveys in the U.S.A. and were for the most part optimistic about the role that science and technology have played in human progress in the past and will play in the future. The majority had heard of Mrs Ples, and between 20 and 30% correctly identified *A. sediba*. Between 70 and 90% agreed that humans evolved from earlier species of animals, approximately 60% felt that understanding human evolution is an important scientific goal, yet 40% to 60% felt that creationism should be taught alongside evolution in schools. Interestingly, results did not appear to vary much from faculty to faculty, or even year by year suggesting that science literacy is more influenced by basic school education than by what happens at university. This is supported by the fact that most students indicated that they learned about Mrs Ples while at school.

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A second species of *Eucnemesaurus* (Dinosauria: Sauropodomorpha): new information on the diversity and evolution of the sauropodomorph fauna of South Africa's Lower Elliot Formation (latest Triassic)

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Although our anatomical and systematic knowledge of the basal sauropodomorphs of the Late Triassic lower Elliot formation (LEF) has increased dramatically since the late 20th century, many LEF genera currently recognized as valid remain very poorly understood. Of these, the most enigmatic is undoubtedly *Eucnemesaurus*. With the only previously recognized species – *E.fortis* – known from sparse, incomplete material, the continuing lack of morphological information on the genus not only obscures an in-depth understanding of its own taxonomic relationships, but of the interrelationships of LEF Sauropodomorpha generally. The discovery of a largely complete pelvis, hindlimb (including pes), and partial vertebral column of a *Eucnemesaurus*-like sauropodomorph (BP/1/6234) from the LEF of the Aliwal North district of the Eastern Cape therefore provides an opportunity to advance our understanding of this rare and poorly defined taxon.

A comprehensive investigation of the anatomical and phylogenetic relationships of this new specimen suggests that it is best considered as a new species of *Eucnemesaurus*. A cladistic analysis confirms the monophyly of *Eucnemesaurus* spp., as well as its continued inclusion within the low-diversity 'Riojasauridae'. Nonetheless, this result highlights continued uncertainties regarding the validity of the *Riojasaurus* hypodigm. The new information on *Eucnemesaurus* reinforces the observed, outwardly progressive shift from relatively basal through to more derived forms within the LEF. However, whether this transition can be couched in terms of either graded (= anagenetic) or divergent (= cladogenetic) morphological change remains an open-ended question, with more material and improved anatomical resolution required before attempting to typify the character complex of LEF Sauropodomorpha as either a continuous or reticulate distribution. The difficulty of this task is also underpinned by the absence of

good stratigraphic and temporal control, with considerably more biostratigraphic work required in order to more fully elucidate the durations and variability of lineages during this important period of sauropodomorph evolution.

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The anatomy of *Chiniquodon* (Therapsida: Cynodontia) from the Middle Triassic, Upper Omingonde Formation of Namibia

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The recent discovery of the chiniquodontid cynodont, *Chiniquodon*, a rauisuchian archosaur and the dicynodont *Stahleckeria* in the top levels of the Upper Omingonde Formation of Central Namibia were interpreted as indicative of a putative Ladinian age and thus younger than remaining Middle Triassic faunas from continental Africa. The record of *Chiniquodon* is the first documented for Middle Triassic faunas of mainland Africa. This taxon is member of the family Chiniquodontidae, represented by advanced carnivorous cynodonts also known from Brazil, Argentina and Madagascar. There is a general lack of research on the postcranial skeletons of cynodonts and it is not common to find postcranial material preserved associated with the skull, especially in medium-to-large body sized specimens. The Namibian *Chiniquodon* has the complete skull and mandible and large part of the postcranial associated. The specimen shows a size roughly comparable with that inferred for the largest specimens of the Chañares Formation of Argentina (represented by the snout), but smaller than those from the Santa Maria Formation in Brazil. Cranial characters are indicative that the Namibian specimen represents a new species of *Chiniquodon*. The Namibian *Chiniquodon* is one of the few cynodonts in which the pelvis from both sides is preserved almost in their natural placement. One remarkable feature of the specimen is the femur characterized by a short diaphysis and a strong head directed dorso-medially. Different from the Argentinean specimens, the scapula show a broad lamina with both anterior and posterior margins curved laterally and a distinctive acromion process at the base of the lamina. The new specimen, in the process of being studied, will improve our understanding of the postcranium of chiniquodontids whose knowledge is mostly based on an almost complete skeleton but which is extremely deformed and poorly preserved.

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Life history traits of a subterranean rodent *Bathyergus suillus* using bone microstructure

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The Cape dune molerat *B. suillus* is a sexually dimorphic, seasonal breeder, and the largest member of Bathyergidae. *Bathyergus* spp. have an abundant palaeontological and archaeological record (from Pliocene until Middle Pleistocene), where co-occur with early *Homo sapiens* of southern South Africa. The high frequency of *B. suillus* in archaeological sites suggests that they were collected by early humans, likely as a food resource. Hence, the palaeoautoecology of this species could provide insight into the foraging behaviour of early humans. Histomorphometry and bone histology of midshafts of long bones (i.e. femur, humerus, tibia-fibula, ulna and radius) are used to identify ecological and demographic aspects of a modern sample collected in Cape Town (n = 41), including males and females of different ages. Bone microanatomy is typical of subterranean/fossorial organisms, with thick walls and a relatively small medullary cavity area in femur and humerus. Woven, parallel-fibred and lamellar bone tissues were the most common types. In general, all the bones followed a similar growth pattern; a woven matrix in juveniles, which becomes thick and relatively longitudinally vascularized in older individuals, due to subsequent deposition of parallel-fibred mainly and lamellar bone. Some areas contain dense formation of Sharpey's fibres. Females showed a higher number of resorption cavities (femur) compared to males. Some long bones (i.e. tibia, ulna, radio) do not undergo extensive remodelling, preserving a complete growth sequence and enabling skeletochronology. Cross-sectional parameters account for thickening of the bone walls in *B. suillus* during ontogeny, without an extensive resorption of the endosteal layers in both males and females, although a greater variation of some of these parameters (e.g. total cortical area resorbed) in females indicates different dynamics related to mineral requirements. Most of the individuals without resorptive cavities are juvenile or intermediate individuals. This indicates that imbalances in

mineral metabolism occur during subadult stages of ontogeny, possibly associated with attainment of sexual maturity and the start of reproduction. Consequently, bone microstructure evidences useful demographic features such as age and sex trends in *B. suillus*, hence the results obtained can be extrapolated to fossil specimens.

Sedimentary petrology of carbonate nodules in the Late Triassic – Early Jurassic Elliot Formation (Karoo Supergroup, South Africa and Lesotho)

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Globally, the Triassic and Jurassic boundary marks one of Earth's largest mass extinction events. In southern Africa, the transition from the Triassic to the Jurassic is contained within the fossiliferous Elliot Formation (Stormberg Group, Karoo Supergroup). Fossils, especially remains of *Tritylodon* sp., a taxon from one of the advanced cynodont therapsids, as well as dinosaurs, are often associated with genetically poorly-constrained carbonate nodules in the upper part of the Elliot Formation (Early Jurassic). The origin of carbonate nodules, i.e. pedogenic versus diagenetic, is important as pedogenic nodules may be used as palaeoclimate indicators of seasonally wet, semi-arid to arid areas where the high rates of evaporation of the soil water can cause *in situ* carbonate precipitation within the uppermost superficial sediments (i.e. soils). On the other hand, diagenetic carbonate nodules carry limited palaeoclimatic information on the depositional setting, because they are usually associated with secondary accumulations of carbonate minerals in the subsurface, and form in the zone of groundwater saturation (phreatic zone) after or during sediment burial.

This research aims to characterize the carbonate nodules of the Elliot Formation macroscopically, petrographically and geochemically in order to establish a diagnostic set of criteria to enable the differentiation between pedogenic and diagenetic nodules. The research techniques employed in this study range from a) macroscopic field observations of the stratigraphic relationships between the nodules and sedimentary features of the host rocks; b) sedimentary petrography of the textural features; c) X-ray diffraction for the assessment of the bulk rock composition, and d) geochemical analysis of stable isotope (carbon and oxygen) compositions. It is expected that, if the degree of diagenesis (overprint) can be accounted for, the carbonate nodules of the Elliot Formation could be used as proxies for the palaeoclimatic conditions in southern Africa at the Triassic-Jurassic boundary. Furthermore, the potential reconstruction of the palaeo-relief (i.e. relative position of the soils from the groundwater table) and the diversity of soil-dwelling organisms may potentially provide a better view of the dynamics of the ecological controlling factors during the post-extinction, recovery period in the Early Jurassic.

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Sedimentology and Palaeobotany of an Early Cretaceous locality in the Kirkwood Formation, Algoa Basin, Eastern Cape

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The Algoa Basin is an onshore rift basin filled by an Upper Mesozoic non-marine and shallow marine sedimentary sequence. The middle unit of this clastic succession is assigned to the Lower Cretaceous Kirkwood Formation, known to host fossil reptiles (e.g. theropod, sauropod and ornithopod dinosaurs, turtles), mammals, freshwater bivalves, crustaceans, trace fossils, as well as fossil bryophytes, ferns, bennettitaleans, cycads, conifers, fossil wood logs, and poorly documented lignites, amber and charcoal clasts. This project is motivated by the growing interest in the impact of wildfires on palaeo-ecosystems during the Cretaceous greenhouse world. It is hypothesized that the more frequent and severe Cretaceous wildfires triggered large-scale non-marine denudation events, altering the sedimentation dynamics as well as influencing the evolution of ecosystems. In order to investigate this problem, charcoal-bearing sedimentary rocks and plant fossil assemblages of the Kirkwood Formation (Swartkops Sandstone Member) have been described in detail from two outcrops ~10 km SE of Kirkwood, a town NNW of Port Elizabeth (Eastern Cape).

The two studied outcrops are orientated semi-parallel and perpendicular to the palaeo-current directions, which are determined from clast imbrication, cross-bedding and fossil wood log orientations. These suggest unidirectional, high strength currents that were flowing from NW to SE, and are consistent with the previously reported regional palaeocurrent directions.

Detailed observations of the sedimentary facies in the outcrops, including lithology, sedimentary struc-

tures, geometry and fossil content suggest that deposition occurred in a meandering fluvial environment. Well-developed palaeosols with *in situ* plant fossil roots are present in the floodplain deposits, while charcoal-rich debris flow deposits are found in the channel fills. The depositional trends (i.e. decrease in sediment grain size vertically, and in charcoal clasts size laterally) indicate diminishing energy conditions of the fluvial system through time and in a down-current direction. Overall, the characteristics of the sedimentary facies point to a sandy meandering fluvial system with laterally migrating river channels on mature, vegetated floodplains in this part of the Kirkwood Formation.

Initial results, based on the sedimentary characteristics of the charcoal rich layers, suggest an interplay between wildfires and subsequent rapid denudation events. Further research during this study will attempt to establish the in-depth relationship between locally abundant *in situ* plant fossils, charcoal rich layers as well as the impact of ancient wildfires on the Early Cretaceous ecosystem in the Algoa Basin.

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Can a diagenetic study resolve the preservation enigma of the Late Triassic Molteno Formation?

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The coal-bearing Late Triassic Molteno Formation (Stormberg Group, Karoo Supergroup) contains one of the richest Carnian plant assemblages of Gondwana, and yielded various insects (e.g. beetles, bugs, dragonflies, cockroaches), bivalves, conchostracans, spiders, possible gastropod or bivalve trails and a large variety of insect feeding traces on plants. This fossil abundance is in contrast with the impoverished record of vertebrates in the Molteno Formation, which to date, only encompasses one fish fossil taxon (*Semionotus* sp.), putative vertebrate tail dragging traces and the tridactyl footprints of an unknown bipedal dinosaurs, which are currently the oldest dinosaur trackways and the earliest evidence for dinosaurs in South Africa. This preservational contrast is commonly assumed to be due to diagenetic obliteration of vertebrate bones under acidic, poor drained and virtually anoxic burial conditions, which on the other hand would favour the excellent preservation of macroflora. The virtual absence of fossil tetrapod fauna is fascinating; however, the simultaneous lack of trackways, burrows, coprolites is even more intriguing; considering that ichnofossils are biogenic sedimentary structures (traces) made by organisms in sediments, trace fossil preservation is not controlled by the same taphonomic processes that govern the fossilization of animal body parts. This preservation enigma has been noted by several previous authors; however, systematic diagenetic and geochemical studies attempting to address this taphonomic anomaly have not been undertaken to date. This study will focus on the petrographic analysis of the medium- to coarse-grained, feldspathic sandstones that are characterized by a glittering appearance due to the secondary quartz that precipitated in the voids between the sediment grains during digenesis. Often, such pore-filling secondary quartz contains fossil fluid (and/or gas) inclusions that become entrapped during burial. The microscopic analysis of the textural relationships in the sandstones as well as that of the fluid inclusions may provide answers regarding the pressure and temperature conditions at the time of inclusion entrapment, and indirectly could provide clues on the physical and chemical conditions during sedimentation and fossilization. This study is part of a larger, interdisciplinary research that involves several research methods ranging from lithostratigraphy, sedimentology, mineralogy, to geochemistry. Specifically, petrographic microscopy aid diagenetic and provenance studies of sandstones, whereas XRD and XRF spectroscopy allow the geochemical and mineralogical analyses of mudstones. The results are expected to assist in achieving a better understanding of the taphonomic processes that occurred during diagenetic history of the Molteno Formation.

Funding acknowledgement: National Research Foundation.

A multi proxy study of Miocene fluvio-palludal sediments in offshore cores from Saldanha Bay, Western Cape: implications for Neogene evolution and fluctuations of oceanography, climate, vegetation and fluvial depositional style

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The few palaeoecological studies of the Neogene in the southwestern Cape of South Africa show that important climatic changes took place; notably an aridification trend and a shift to a winter rainfall climate during the Pliocene, which was triggered by the establishment of the cold Benguela upwelling regime and global tectonic events. These long-term trends in climate and oceanography also mediated the evolution of the current biomes at the southwestern tip of Africa, among them the unique and enigmatic Fynbos biome. During the Miocene rainfall was seemingly higher at the Cape than present and probably less seasonal, as suggested by a recent study of the Elandsfontein Formation at Langebaanweg, which combined palynological, sedimentological and biogeochemical proxies. Marine ingressions at the top of the Langebaanweg sequence were inferred from isolated silicoflagellates, foram linings and an increased abundance of dinoflagellates. It is advantageous to compare these rare terrestrial Neogene records to marine archives where dating may be more precise using marine microfossils, especially foraminifera.

Geotechnical cores drilled offshore of the Saldanha Bay Ore Terminal, 115 km north of Cape Town, penetrated Cenozoic sediments that included the Miocene fluvio-palludal organic sediments of the Elandsfontyn Formation. This provided an opportunity to compare the sedimentology, geochemistry and biology of a more distal segment of the palaeo-Berg River with the previously studied cores in more proximal reaches of the ancient river, especially at Langebaanweg. Here we apply palynology, the analysis of diatoms, phytoliths, foraminifera, charcoal fragments, biomarkers, sedimentology, stable isotopes and silicates to reconstruct the regional palaeo-landscape and to constrain the stratigraphy of the deposits. The expanded thickness of the organic sediments in the distal offshore cores (up to 10 m) relative to their proximal counterparts (~4 m) provides a higher resolution record of palaeo-environments and their variability through time, and a more pronounced marine influence is hypothesized. From these new data we seek to address in more detail questions concerning proximal–distal variations in vegetation patterns and fluvial style, the influence of Miocene oceanographic climate drivers and the role of orbital forcing on ecosystem. Initial pollen results from the Saldanha Bay core, which can be compared to the recently published pollen record at Langebaanweg, show similar subtropical, humid vegetation types. Podocarps, palms, Sapotaceae and other trees are abundant, while characteristic fynbos (e.g. Restionaceae), wetland and probably mangrove elements are also recorded. Foram linings are more numerous than at Langebaanweg, and along with dinoflagellates suggest a greater marine influence.

Early Triassic *Glossopteris*: an examination of stratigraphic evidence

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The continental stratigraphic record in the Beaufort Group (Karoo Basin, South Africa) plays an important role in our understanding of the response of terrestrial ecosystems to the End-Permian mass extinction. Current models envisage environmental change to be the catalyst of a catastrophic plant die-off which resulted in a phased extinction of vertebrate faunas, and a change in fluvial regime. To a large extent, palaeoenvironmental models for the Beaufort Group have been constructed in the absence of palaeobotanical data, because the record for the latter is extremely depauperate for the southern and central parts of the basin.

Our research group previously reported a plant-fossil assemblage from a horizon about 70 m below the vertebrate-defined Permian–Triassic boundary at Wapadsberg Pass. Here we report the occurrence of *Glossopteris* macrofossils from a section that spans the latest Permian to earliest Triassic, at Old Lootsberg Pass (South Africa), along with permineralized wood, palynological and vertebrate data. These fossils were recovered from an interval that displays significant lateral and vertical variation. To document and understand this variation we measured eleven stratigraphic sections over a lateral distance of ~1.5 km and correlated strata across the area by walking the bounding surfaces of fluvial complexes

The sections are dominated by olive grey, light olive grey and greyish red siltstones which are organized into stacked fining up sequences in which thin, lenticular or planar, very fine wacke sandstones are overlain by coarse-to-fine siltstone. *Glossopteris* was recovered from these olive-grey siltstones below, and

laterally equivalent to, multistoried sandstone channels wherein metre-scale bedforms are well developed and lenses of pebble nodular conglomerate lags often drape erosional boundaries at the base. Our placement of *Glossopteris* in the Triassic is largely based on sedimentological data, and it contradicts the clade's reported extinction at the boundary, instead supporting previous reports of a more gradual decline of this clade into the Triassic.

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Architectural and provenance study of the upper Abrahamskraal and lower Teekloof formations of the Lower Beaufort Group in the SW main Karoo Basin

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The fluvial deposits of the Lower Beaufort Group preserve information about the subsidence *versus* uplift history as well as climatic evolution of the main Karoo Basin in the Middle Permian. The changes in the environmental (allogenic) forcing factors (i.e. tectonics and climate) are the ultimate controls on sedimentation dynamics, hence, on the spatial and temporal distributions of the preserved sediments (i.e. facies architecture). The sharp or gradational nature of the stratigraphic boundaries, which are commonly used in subdividing rock successions, is also a reflection of these coupled environmental changes. In the Lower Beaufort Group, the stratigraphic boundaries are often gradual and spatially irregular, which led to a proliferation of informal (often discordant) lithostratigraphic subdivisions. Biostratigraphy, which records climatic changes via biological filters, uses well-established reptilian biozonation and is currently the primary tool for subdividing the Lower Beaufort Group.

The main objective of this study are (a) to refine the lithostratigrapic subdivision of the Lower Beaufort Group by evaluating the vertical and lateral abundances of the facies associations, and (b) to attempt the decoupling of the preserved tectonic and climatic signals in the upper Abrahamskraal Formation and the overlying Poortjie Member of the Teekloof Formation.

The applied methodology in study will be the high resolution digital mapping of outcrops to assess the architectural information such as temporal and spatial changes in bed shape, nature of erosional surfaces, width/depth/orientation of channel-bodies, etc. Furthermore, various analytical investigations such as petrographic microscopy and geochemical studies will be used to establish compositional and textural properties of the facies associations. The results of micro-scale investigations will be integrated with palaeocurrent measurements to assess the provenance of the sediments.

The results of this ongoing study may aid palaeontological investigations by (a) providing a lithostratigraphic framework for regional correlations, and (b) suggesting environmental reasons for the changes in major biodiversity patterns (through determining the relative contributions of allogenic controls on the depositional environment). Furthermore, this study, which is part of a larger interdisciplinary research to reconstruct the subsidence history and heat flow in the SW main Karoo Basin, could also offer insights into the diagenetic processes that may have affected the taphonomy of vertebrate fossils in the Lower Beaufort Group.

The limitations of Neoichnological criteria of insect–bone interactions in identifying and differentiating causal agents in the fossil record

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Peer reviewed publications relating to insect–bone interactions have been on the increase and have resulted in an increase in the number of neoichnological experimental trials being conducted. The aims of such studies are primarily to establish modification criteria in order to facilitate identification and differentiation of potential causal agents. To date a number of causal agents have been investigated (termites, dermestids, tenebrionids) and their associated modification criteria are well documented. However, neoichnological investigations are best suited to establish a total taphonomic signature of a particular agent but at this stage many of the established criteria contribute little to the identification or differentiation of these agents within the fossil record. The reasons for this include equifinality and that criteria do not have distinctive morphologies which can be readily associated to a particular agent and used as a basis for differentiation. Additionally, metrological data from experimental trials show that modifications such

as pits, bore holes and striae are also limited in their application due to a high degree of intra-species variation and inter-species mimicking/overlap. Many of these limitations are well recognized by neo- and palaeo-ichnologists alike resulting in cautionary interpretations of such modifications by these researchers. However, the yet unpublished nature of these limitations appear to pose a problem to non-ichnological researchers who endeavour to interpret insect–bone interactions. Such efforts often culminate in the over simplification of facts, misidentification of causal agent and over-interpretation of the associated taphonomic deductions of such results. It is therefore proposed that a new standard be established which classifies the usefulness of particular modification criteria in the identification and differentiation of the associated causal agent based on neoichnological data. This proposed 'usefulness in identification and differentiation index – UID index' would aim to provide a cautionary note to none specialist researchers and limit the misinterpretation of insect–bone interactions. Three classifications should be established; UID 1 – infers criteria which has the highest potential for identification and differentiation, UID 2 – infers that criteria can assist with identification when found in association with UID 1 criteria, UID 3 – has little application in the identification and differentiation of a causal agent due to a current lack in available data. This system was applied to established termites and dermestids criteria and indicates that out of a total of 13 criteria, four are classified UID 1, five UID 2 and four as a UID 3 criterion. The results will be discussed.

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New insights into the palaeo-environmental history of the Bokkeveld Group (Cape Supergroup) in the Clanwilliam sub-basin, South Africa

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The Early to Middle Devonian Bokkeveld Group of South Africa is a clastic sedimentary rock succession of the Cape Supergroup composed of five to six conformable and alternate upward coarsening successions, each thought to represent sedimentation as a series of prograding storm and wave dominated deltaic complexes during eustatic lows. These upward coarsening successions are noteworthy in that their constituent lithologies are laterally continuous along tectonic strike. This led to the assumption by earlier workers that the Cape Fold Belt mimicked the Early Palaeozoic and that of the present day shoreline of South Africa and that lateral continuity of lithologies, notably sandstone bodies, were due to alongshore drift reworking and amalgamation of deltaic complexes by storm and wave activity. Another noticeable enigma of the Bokkeveld Group remarked upon by earlier workers is the apparent lack of 'delta-plain/top set' environments at the upper terminus of coarsening upward successions, reasoned to have been removed with transgressive erosion. A re-analysis of the sedimentology and palaeontology of the Bokkeveld Group in the Cederberg, Western Cape, South Africa is currently being undertaken. From comparison with the Cretaceous Western Interior Seaway, applied and theoretical bedform modelling and palaeontological data, a new facies model, as well as a reinterpretation of the palaeo-environments of the Bokkeveld Group has emerged. Here, a shallow marine seaway model is envisioned. Preliminary results suggest that each coarsening upward succession is unique in its expressed palaeo-environments. Several palaeo-environments spanning from deep water offshore environments to shallow water storm/wave dominated shorefaces, beaches, estuaries, barriers, washovers and tidal flats within the Bokkeveld Group at time of sedimentation, have been recognized. New shoreline constraints from palaeocurrent vector distributions, sandstone geometries and published detrital zircon populations suggest a northerly source area and a southward progradational sense for outcrop of the Bokkeveld Group in the Clanwilliam Sub-basin.

Funding acknowledgement: Department of Science and Technology/National Research Foundation Centre of Excellence for Palaeosciences; Palaeontological Scientific Trust.

Two centuries of discovery: the palaeontological and geological heritage of the Bokkeveld Group (Cape Supergroup) of South Africa, a review

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The Bokkeveld Group of South Africa is best known for its rich southwestern Gondwana endemic

Malvinokaffric Realm invertebrates, gnathostome fish and among the earliest terrestrial plant fossils known from Africa in addition to its characteristic hogsback topography of alternate sandstone and mudstone lithologies within the Cape Fold Belt. Scientific inquest of the Bokkeveld Group began as far back as the early 19th century initially in the form of fossil curiosities held either as mementos of trekboers, or adorning the homesteads of voortrekkers, European merchants and missionaries of the Cape Colony. In the later 19th century, word of the fossiliferous nature of the Bokkeveld Group spread beyond the borders of the Colony, enticing the interest of foreign natural scientists and that of early road builders active in the expanding Cape Colony. By the end of the 19th century, and within a span of just under a hundred years, the marine origin, Devonian age and first geological maps of what was then known as the Bokkeveld Beds were determined. These ideas were refined during the 20th century. The Bokkeveld Beds were initially formally ascribed as the Bokkeveld Series and later as the Bokkeveld Group. The palaeontology of the Bokkeveld Group, most notably of its abundant invertebrate fauna, was intensively studied in the first half of the 20th century. In the process, the invertebrate fauna (and later, the vertebrate fauna) of the Bokkeveld Group was recognized to be akin to that of similar aged successions in Antarctica, Argentina, Bolivia, Brazil, the Falkland Islands and Ghana and were all part of a large high latitude provincial biogeographic realm, the Malvinokaffric Realm. Stratigraphic subdivision, aided by an increased understanding of sedimentology, of the Bokkeveld Group was impressed upon further by intensive geological inquests in the 1950s–1970s, to the system in use today of three subgroups, namely the Ceres, Bidouw and Traka Subgroups comprising 14 formations. The characteristic sedimentology of the Bokkeveld Group, delineated by several alternate and laterally continuous upward coarsening successions of lower mudstones and upper sandstones is thought to represent a series of storm and wave dominated deltaic complexes. Palaeontological and geological research in the Bokkeveld Group of South Africa, decreased towards the end of the 20th century, but has continued in its Gondwanan correlatives, with the result that earlier understanding of the sedimentology, palaeontology and basin development of the Bokkeveld Group requires revision.

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How low can you go? Homogenization effects on faecal $\delta^{13}C$ and $\delta^{15}N$ values to interpret great ape diet

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Stable isotope values, in particular, $\delta^{13}C$ and $\delta^{15}N$, in animal tissues and excreta have revealed valuable insights in the dietary intake of extinct and extant primates. For analysis, a homogenous sample is desirable to ensure accurate results. A common protocol for homogenization of faeces is to pass dried matter through a sieve of known mesh-size; thereby, analysing the sieved matter content only. We analysed faecal samples ($n = 71$) collected from 10 adults of the Kanyawara chimpanzee community in Kibale National Park, Uganda to determine faecal $\delta^{13}C$ and $\delta^{15}N$ stable isotope values and investigate if different homogenization techniques affect isotope values produced. We prepared two sub-samples from each faecal sample: the first was ground in a pestle and mortar to achieve homogenization (non-sieved); the second was passed through a 45 m mesh-sized sieve (sieved). It was predicted that the sieved faecal matter would have a higher concentration of leaf and pith fragments, as visible fruit parts could not pass through the sieve mesh; therefore, would be more representative of pulverized and fully-digested food items in each faecal sample. Median faecal $\delta^{13}C$ value in sieved faeces was significantly lower ($P < 0.001$, $n = 71$), and $\delta^{15}N$ was significantly more positive ($P < 0.05$, $n = 65$) than found in the non-sieved faecal counterparts. The higher $\delta^{13}C$ values found in non-sieved faeces, which contained the visible fruit skin and seeds, is possibly due to fruits containing more non-fibrous carbohydrates than leaves. Of foods known to be included in the diet of this ape community, ingested pith and leaf parts have been found to have either similar, or more positive $\delta^{15}N$ values than fruit pulp; therefore, the more positive faecal δ^{15} values in the sieved faecal matter may reflect higher pith or leaf content. This study highlights that sieving of faecal matter can affect stable isotope values obtained for dietary reconstruction, as certain food parts are excluded from analysed matter, and should be considered during analysis and interpretation of findings.

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The coal floras of South Africa: to PIA or not to PIA?

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South Africa is internationally recognized for its coal-associated floras, particularly for the huge contribution they have made to studies of *Glossopteris* reproductive biology and diversity. We have the World's largest and most intensively studied collections of fertile organs from this enigmatic group and Prof. Edna Plumstead placed us firmly in the palaeobotanical limelight during the 1960s and 1970s for her work on these fossils. Yet, if we consider that all South African Permian coal-related macrofloral palaeontological research has focused on only six localities, we can begin to realize the extent to which this aspect of our fossil heritage has been neglected.

Our vast coal mining industry is a double-edged sword that provides palaeontologists with fantastic access to coal-associated plant fossils, while simultaneously resulting in the destruction of important National palaeontological heritage. The current Palaeontological Impact Assessment process presents us with an opportunity to identify, access and possibly salvage significant palaeontological specimens from the mines, both conserving our heritage, and providing long-term research opportunities. However, the scale of monitoring these developments appears to have daunted our palaeontological community to the extent where there is a sense of general reluctance on the part of PIA practitioners to perform Phase 1 and Phase 2 surveys of coal mining developments. This is perhaps coupled with a general lack of appreciation for the value of the fossil resources at stake, and the legislative procedures that serve to protect them.

Previously, some palaeontological impact practitioners have suggested that coal mining developments be exempt from Phase 1 PIAs, or even from the entire PIA process. Here, we challenge these perceptions and recommendations, within the context of our current heritage legislation. We also seek to clarify the potential impacts of various mining activities and provide guidelines as to what is expected of both the PIA practitioners and the consultants commissioning these studies. We also seek input from the palaeontological community at large as to how we can best attenuate our human resources challenges and implement effective onsite monitoring of coal mining activities.

We also point out potential advantages of the PIA process to the mining companies involved, as these studies represent a gateway for beneficial onsite research. Additionally, supporting research and understanding of coal-associated palaeontology could be framed as positive publicity for an industry increasingly struggling with its public image in light of the heavy environmental impacts of coal mining.

Invertebrate taphonomy and sedimentology of the Devonian Voorstehoek Formation (Ceres Subgroup, Bokkeveld Group, Cape Supergroup), Western Cape

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The Lower Devonian Voorstehoek Formation forms a unit within the Ceres Subgroup and comprises essentially mudstones and siltstones that were deposited in a shallow marine, probably offshore shelf or prodelta slope environment. It is relatively fossiliferous and consists of the typical Malvinokaffric faunas (e.g. brachiopods, trilobites, crinoids) of Gondwana. To date, the fossil preservation or taphonomy of the invertebrates within the Voorstehoek Formation is grossly understudied.

This field based study aims to describe and record detailed taphonomic and sedimentologic features of two large-scale and structurally undisturbed outcrops in the southern part of the Clanwilliam sub-basin. The objective of this investigation is to quantify the preservation of the invertebrate fossils of the Voorstehoek Formation in order to reconstruct the biostratonomic (syndepositional) and diagenetic processes (i.e. physical, chemical and biological interactions) that acted on fossil preservation. In addtion to lithologic observations, taphonomic information such as degree of fossil articulation, fragmentation, orientation, alignement, pedicle/brachial and faunal counts will be recorded at 10 cm increments at each outcrop. Small comparative collections will be made from highly fossiliferous horizons for further study in the laboratory. Of special focus will be the recognition of 'obrution' or rapid burial assemblages that may preserve taxa in life position. Obrution assemblages have been previously collected from several horizons within the Bokkeveld Group, including the Voorstehoek Formation, and provide unique taphonomic windows into benthic community structure.

Furthermore, the outcomes will also lead to the detailed facies reconstruction of the vertical and lateral changes of the sedimentary architecture in these outcrops. By integrating the taphonomic and sedimentologic findings, a detailed reconstruction of the palaeo-environment of the Voorstehoek Formation at the study sites as well as a more accurate understanding of the Devonian Bokkeveld marine communities will emerge.

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Pristerognathus Assemblage Zone fauna from the Central Free State Province – Support for reciprocal stratigraphy in Karoo Basin Development

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The Middle Permian to mid-Triassic rocks of the Beaufort Group were deposited in a variety of fluvial depositional environments. Because of the channelized nature of fluvial deposits, there are relatively few extensive lithological markers which can be used for basin-wide stratigraphic correlation in the Beaufort Group. As a result stratigraphic correlation of strata of the Beaufort Group around the basin has relied largely on the six Permian and two Triassic SACS approved vertebrate biozones. Fossil collecting programmes to targeted stratigraphic horizons of the Beaufort Group over the past two decades have resulted in several proposals for the subdivision of some of the existing biozones. These biostratigraphic refinements have enhanced Pangean-wide correlation of tetrapod-bearing continental successions, and improved models of Karoo basin development. Stratigraphic collecting along the Ecca-Beaufort shoreline contact around the basin has revealed a northward change in the fauna above this contact. North of the town of Phillopolis in the southern Free State Province, the only Permian biozone is the *Dicynodon* Assemblage Zone (AZ). Recent fossil collecting in the Jagersfontein district of the central Free State resulted in the discovery of faunal elements of the *Pristerognathus* AZ, a biozone characterized by the presence of scylacosaurid and lycosuchid therocephalians and the absence of dinocephalians.

Our collecting in the Jagersfontein district has revealed basal therocephalians and no dinocephalians. The most northerly occurrence of a dinocephalian in the Karoo is from the Victoria West district. The only fossils recovered above the basal therocephalians are of *Dicynodon*, only a few metres higher in the succession. This fact, coupled with the fact that no fossils of the *Tropidostoma* and *Cistecephalus* AZs have been found so far north in the basin, indicates that in this part of the basin rocks of the Middle Permian *Pristerognathus* AZ are directly overlain by the Late Permian *Dicynodon* AZ. Recently published dates of the Permian Beaufort biozones consider the lower *Tropidostoma* AZ to be 259.291 ma, and the uppermost *Cistecephalus* AZ at 255.24 ma. This implies that the early part of the Late Permian depositional succession, present in the southern part of the Beaufort Basin, is absent in the central Free State Province. There was thus a depositional hiatus of Late Permian Beaufort deposition lasting at least four million years – or perhaps a later period of erosion – in this part of the Basin, which lends support to the reciprocal stratigraphic depositional model for the Karoo Basin.

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Palaeomagnetic analysis of the Lower Elliot – Upper Elliot Formation transition (Triassic–Jurassic boundary) in South Africa and Lesotho: an overview

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The Elliot Formation, encompassing the Triassic-Jurassic boundary (TJB) within the Karoo Basin, can provide insight into one of the five main Phanerozoic mass extinction events. Dating of the formation and the exact position of the TJB is still tentative. Dinosaur-based biostratigraphic framework suggests a Norian lower Elliot (LEF) and Toarcian upper Elliot Formation (UEF). The first formal magnetostratigraphic column for the Elliot Formation was generated by De Kock in 2003, and produced a composite magnetic zonation pattern splitting the Elliot Formation into four polarity pairs (EF1, EF2, EF3 and EF4), with the TJB falling into a period of normal polarity at the junction of *Euskelosaurus* Range Zone (LEF) and the *Massospondylus* Range Zone (UEF).

The null hypothesis of the current study is that the TJB is marked by geomorphological feature, which based on previous studies, coincides with the biostratigraphic and sedimentological change between the

mainly perennial meandering fluvial system deposits of the lower Elliot, and the semi-arid ephemeral stream and floodplain deposits of the upper Elliot formations. Several sites in South Africa and Lesotho (Barkly Pass, Damplaats, Golden Gate National Park, Maseru, Quthing, Likhoele) were drilled at ≤1 m scale over this divide between the LEF and UEF. Two northern sites (Damplaats and Golden Gate National Park) encompass the entirety of the Elliot Formation, with the type section of the formation, in the Barkly Pass, making up almost a complete magnetostratigraphic section of the formation in the southern part of the basin. An additional outcome of the magnetostratigraphic investigations is the attempt to constrain the age of the *Trityldon* Acme Zone in the upper Elliot Formation. To date, the preliminary results demonstrate the stability of the palaeomagnetic samples in the consistency and similarity of polarity patterns between geographically widely separated study sites.

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Diverse stromatolite morphologies in the 3 Ga Nsuze Group, Pongola Supergroup, South Africa

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Sedimentary carbonates are extremely rare in the Palaeo- to Mesoarchaean geological record. They were typically deposited in shallow-water settings as relatively thin sedimentary successions in between episodes of volcanism. Replacement by chert frequently took place. Mesoarchaean stromatolitic carbonates from the *c.* 3.0 Ga Nsuze Group of the Pongola Supergroup in South Africa are amongst the oldest known marine carbonates, and have the potential to record important information on ocean chemistry and the habitat of life on the early Earth. Detailed sedimentological and microfacies analyses of three different stratigraphic sections of carbonates 2–25 m thick exposed in the White-Umfolozi Inlier of KwaZulu-Natal was undertaken to delineate depositional environments of carbonates. The carbonates are intercalated with shallow-marine siliciclastic and volcaniclastic deposits. They consist essentially of dolomite, with minor calcite and ankerite. Siliciclastic detritus is common and suggests trapping and binding by microbial mats. Carbonaceous matter is preserved locally, but does not delineate microbial structures due to dolomitization and recrystallization, the latter associated with greenschist facies metamorphism. Sedimentological investigations revealed different, in part cyclically-stacked sedimentary facies that were deposited in tide-dominated, deep subtidal to supratidal shallow marine environments. Different types of organo-sedimentary structures with a variety of morphologies and sizes are present. Stratiform, small-scale domical and digitate stromatolites formed in supratidal to upper-intertidal settings. Columnar and domical stromatolites, oncoids and domical thrombolite-like features formed in lower intertidal to upper subtidal environments and finally, conical stromatolites and composite bioherms with colloform texture formed in the permanently submerged part of a deeper subtidal environment. Distinctive stromatolite/thrombolite morphology suggests the presence of a distinctive assemblage of microorganisms and their response to the different physicochemical conditions of the environment.

Anatomy of a mass extinction: sedimentological and taphonomic evidence for drought-induced die-offs at the Permo-Triassic boundary in the main Karoo Basin, South Africa

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The southern part of the Karoo Basin of South Africa contains a near complete stratigraphic record of the Permo-Triassic boundary (PTB). Isotope- and magneto-stratigraphy confirm that these predominantly fluvial strata are approximately the same age as zircon-dated marine PTB sections (252 Mya). By August 2013, our team had found 580 *in situ* vertebrate fossils, mostly of the clade Therapsida, in PTB exposures at three widely separated locations in the southern Karoo Basin. Biostratigraphic ranges of the various taxa found in each of the sections reveal three separate phases of die-off within the same roughly 75 metre-thick stratigraphic interval displaying the same sequence of sedimentary facies interpreted as indicative of climatic drying, increased seasonality and the onset of an unpredictable monsoon-type rainfall regime. The three phases of an inferred ecologically-stepped mass extinction are: Phase 1 (45 mB30 m below PTB datum) brought on by lowered watertables, which led to loss of shallow rooting groundcover

in the more elevated proximal floodplain areas and the disappearance of the smaller groundcover-grazing herbivorous dicynodonts and their attendant small carnivores. Phase 2 (20B0 m below PTB datum), is the main extinction that occurs in massive maroon/grey mudrock culminating in an event bed of laminated reddish-brown siltstone/ mudstone couplets. This facies reflects progressively unreliable rainfall leading to vegetation loss in proximal and distal floodplain areas. The larger tree-browsing herbivores and their attendant carnivores are confined to watercourses before finally disappearing. Phase 3 (25–30 m above PTB datum) occurs in massive maroon siltstone facies with evidence of climatic aridity including the accumulation of mummified carcasses buried by windblown dust. All of the surviving Permian taxa disappear within 30 m of the PTB. Temporal resolution based on accretion rates and pedogenic maturity of each stratigraphic section reveals that Phase 1 and Phase 2 die-offs lasted 21 000 and 33 000 years separated by a short period of 7000 years where no disappearances are recorded and this was followed by 50 000 years of stasis for the final extinction phase, lasting only 8000 years, that removed all the Permian survivor taxa. We propose that the recorded disappearances are real (rather than preferential preservation failure) and that they represent drought-induced die-offs moving progressively up the food chain as the terrestrial ecosystem collapsed; the latter mostly likely caused by volcanogenic greenhouse gas emissions and rapid global warming.

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Breeding behaviour of Early Jurassic sub-polar sauropodomorphs in Patagonia

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The Late Triassic/Early Jurassic Laguna Colorada Formation of Patagonia contains a unique sub-polar fossil assemblage dominated by the basal sauropodomorph *Mussaurus patagonicus*. This taxon was originally described from several well-preserved post-hatchling specimens associated with egg remains found at the Laguna Colorada type section. Our recent expeditions to this locality have yielded 25 new specimens of this taxon, comprising skeletons of six different ontogenetic stages along with several complete 'nests' of unhatched eggs. We have obtained good zircon dates for the egg-bearing interval at ±192.57 Ma which makes them contemporaneous with the recently described *Massospondylus* egg sites in South Africa. Detailed sedimentological investigation shows the skeletal remains and eggs occur in three distinct horizons within a 3 m-thick bed of mottled light reddish-brown/olive-grey massive siltstone. The bones are encrusted in brown weathering calcareous siltstone similar to the numerous spherical calcareous nodules that occur in the same horizons. The latter are interpreted as palustrine carbonate precipitated in loessic parent material around a floodplain pond or lake under a seasonally dry climate. The first *Mussaurus* hatchlings described from this site comprise eight closely-associated and notably small individuals (femoral length 3 cm). Their proximity to unbroken eggs and eggshell fragments clearly suggests an aggregation of nestlings rather than unhatched embryos, as their body size largely exceeds that of all the associated eggs, and the lack of size variation among them suggests they are from the same brood. A new aggregation of at least 11 articulated juvenile skeletons (femoral length 12 cm) was found in the vicinity of the type hatchlings. These specimens are all the same size and histological data indicate that these individuals died together before reaching the first year of life. Our latest field studies located several clusters of up to 24–27 unhatched dinosaur eggs close to the *Mussaurus* juvenile and nestling aggregations, in the same horizons. The eggs clusters lie in two layers within elongate depressions or tunnels that appear to have been deliberately excavated in the loess. We propose that the fertilized but unhatched eggs (at least one with an ossified embryo) were all laid at the same time, possibly by more than one female *Mussarus*, and left half exposed to incubate. The unhatched clutches appear to have been asphyxiated by rapid deposition of a thick layer of aeolian silt loaded with volcanic ash.

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The geo-library of the main Karoo Basin: a preliminary 3-D geological model

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The Karoo Supergroup preserves a wide spectrum of palaeontological and geological events in the

history of the southern Africa in the main Karoo Basin. The large size and architectural complexities of the sedimentary basin fill confine the analysis and understanding of the key evolutionary events that occurred within the basin from the Late Carboniferous to Early Jurassic. Effective 3D visualization via digital modelling of the subsurface Karoo stratigraphy would, however, assist in this regard.

Thus the main objectives of this study are to a) produce a preliminary 3D geological model of the main Karoo Basin which will capture the geo-dynamic history, structural and architectural properties of the stratigraphic units; and b) produce a validated digital database of the available vintage geological data.

The methodology will involve the collection of vintage data, such as borehole logs, cross-sections, outcrop descriptions as well as geophysical data. Most of these data are in hardcopy format, therefore extensive validation and digitization procedures will be required to produce the digital database. These data will then be integrated into specialized geo-modelling software – Petrel® Interpretation Software by Schlumberger – to build an accurate and realistic 3D geo-model of the main Karoo Basin. This phase is iterative and the model will continue to improve with the capturing of future and better quality data. The 3D model will be accompanied by an uncertainty projection to account for the interpretative data as well as the predictive nature of the algorithms used.

The importance of this 3D model of the Karoo Basin is multifold as it would allow data management (organization, extraction, visualization) and analysis that can lead to identifying data deficiencies and testing of outcrop-based geological concepts and interpretations. More specifically, the model could serve as a resource for the visualization of the 3D spatial distribution of the thickness, facies variation, boundary locations of the different stratigraphic units in time and space (e.g. palaeogeographic maps), the topography of the pre-Karoo basement, structural deformations, all of which would collectively contribute towards the more accurate visualization and reconstruction of the basin evolution (e.g. history of the thermal subsidence). Furthermore, the model would act as a data repository providing effective access to diverse and large amounts of geoscientific information applicable not only in the academic research programmes, but also in hydrogeological and hydrocarbon exploration, subsurface storage projects, etc.

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Forelimb osteology of *Massospondylus carinatus*

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Massospondylus carinatus is a prosauropod dinosaur from the Early Jurassic. Few studies have been done on the forelimb anatomy of this dinosaur despite the debate about the posture that it had in life. This study used the proposed neotype specimen from the BPI collections to create a detailed record of the osteology of the forelimb. This was done by creating detailed drawings of the bones of the forelimb. This study provides an up to date record of the anatomy of the forelimb of *Massospondylus carinatus* and a record of the forelimb of the proposed neotype specimen.

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Foraging strategies and niche partitioning among large-bodied primates from the Cooper D assemblage

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There are four large-bodied primates in the Cooper D assemblage (1.5–1.4 Ma). Although the hominins identified from the assemblage belong to *Paranthropus robustus,* their remains are relatively rare, where papionins are more common. Craniodental and postcranial remains currently indicate the presence of three large-bodied papionin genera recently retrieved from Cooper's D: *Gorgopithecus*, *Theropithecus*, and *Papio*. Unlike other fossil localities in southern Africa, most of the new fossil craniodental remains belong to *Theropithecus oswaldi*, an extinct graminivorous baboon related to the living gelada found only in Ethiopia. In addition, a rare and large-bodied extinct baboon, *Gorgopithecus,* has recently been identified. Also present in the new sample are teeth from *Papio*, related to the modern savanna baboon. The abundance of the extinct gelada fossils at Cooper's D suggests that *Papio* was not the most common papionin in South Africa over the past two million years as previously thought. The skeleton from adult papionin remains suggests that the body mass ranged between 30 to 60 kg, whereas *Paranthropus robustus* body mass ranged from 28 to 54 kg. The similar body masses raises the question of how did these mostly terrestrial

large-bodied primates that sympatrically utilized the landscape partitioned their feeding niche. To address this question, I applied stable light isotope and microwear techniques to the dental remains of Cooper's D primates to determine subsistence patterns and niche partitioning. The results were then compared to primates from other South Africa and East African deposits of similar age. Data from the isotope and microwear analyses reveal the herbivorous diet of *Gorgopithecus* for the first time. While *Theropithecus* from Cooper's D demonstrates that they had a more flexible diet. The initial results suggest that the large-bodied primates at Cooper's D may have been in direct competition for limited resources.

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Trabecular structure and foot function in South African hominins

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Bones within the postcranium typically consist of cortical bone surrounding internal cavities (e.g. medullary spaces) and networks of trabecular struts. Within long bones, these struts are usually concentrated underneath joint surfaces. Struts are arranged so as to provide rigidity under loading conditions (usually compressive) of the overlying surfaces, but their presence also must be balanced by the high physiological costs associated with maintaining bone. The process by which trabecular bone is retained according to these mechanical demands and physiological limitations is called bone functional adaptation. In some anatomical locations (e.g. the ankle), the 3D distribution and orientation of trabecular struts has been shown to be consistent with theoretical loading conditions. Thus, trabecular properties can be quantified to provide information on 3D joint postures, and more broadly speaking, activity patterns. This is particularly useful for extinct taxa where behaviour patterns are no longer observable. In order to reconstruct (ankle) joint postures of South African hominins, and comment more broadly on reconstructions of their activity patterns, we quantify 3D trabecular properties beneath the trochlea of several hominin tali. We compare hominin 3D trabecular arrangements to those from several extant hominoid tali, including tali from modern humans. In at least some volumes of interest (VOIs), structural properties of the trabecular network beneath the hominin talar trochlea (e.g. directionality) resemble structural properties in modern human tali. Importantly, however, structural properties in other VOIs differ between hominins and extant hominoids. We use these comparisons to comment on ankle kinematics in South African hominins, and more broadly-speaking on reconstructions of their activity patterns.

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Homo habilis, *Australopithecus africanus* and the concept of a chronospecies

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On the occasion of the 50th anniversary of the announcement of *Homo habilis*, a morphometric approach is applied to certain specimens attributed to this species and to other fossils attributed to *Australopithecus africanus*. This study serves to present results obtained from pairwise regression analyses of crania of selected well-preserved specimens attributed to *A. africanus* and *H. habilis,* and to assess the probability that they are conspecific. It is suggested that South African specimens Sts 71 and Sts 5 (considered to represent *A. africanus*, dated between about 2.6 and 2 million years) and East African specimens OH 24 and KNM-ER 1813 (considered to represent *H. habilis*, dated between about 1.8 and 1.6 million years) represent the same species, changing through time with a tendency for cranial capacity to increase in the process of evolution as a chronospecies. At least some specimens attributed to *H. habilis* could be considered to represent East African examples of *A. africanus*.

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An archaic human femur from the Venterspruit, NE Free State: understanding the morphology of this specimen in context of the archaeological and palaeontological sites from the valley

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Several drainages in the central interior contain good Quaternary fossil preservation, as well as abundance of ESA, MSA and LSA sites, but large sections of these donga exposures remain unexplored. During a survey of the Venterspruit, NE Free Sate in 2010, several new palaeontological and archaeological sites were located. Amongst these was an important palaeoanthropological discovery in the form of a partial archaic human femur. This specimen was associated with pre-Holocene fauna, including *Megalotragus priscus* and *Antidorcas bondi*, as well MSA artefacts in the form of points and stone balls. Furthermore, the extreme cortical thickness of the bone reflects an individual that falls outside of the range of Khoi-San populations, suggesting that the specimen is likely Middle to Late Pleistocene in age. However, dates from the associated stratigraphy do not match the fossil and archaeological material. The specimen does not appear to be redeposited, so further dating using multiple luminescence chronometers, specifically optically stimulated luminescence (OSL), post-infrared infrared stimulated luminescence (pIRIR) and violet stimulated luminescence (VSL), will be carried out in an attempt to resolve this discrepancy. Archaic postcranial human material from this time period is rare in South Africa and this specimen may contribute to a better understanding of the morphology and biomechanics of humans living during this time period.

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Re-evaluation of the mid-Cretaceous Winton Formation, Australia via U-Pb LA-ICPMS detrital zircon geochronology; implications for regional tectonics, sedimentary provenance and vertebrate palaeontology

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Currently, U-Pb detrital zircon geochronology is a popular tool in resolving temporal complexities in the geological history and stratigraphic context of sedimentary successions; however, this approach is still vastly underutilized in palaeontology. This northeastern Australian study utilizes detrital zircon geochronology not only to constrain the depositional age, tectonic setting, basin history, but also to refine the ages and evolutionary changes of terrestrial floras and faunas in the poorly understood mid-Cretaceous Winton Formation. This formation is vital to our understanding of Late Mesozoic terrestrial biota in Asutralia, which includes, among others, dinosaurs, crocodyliforms, aquatic squamates, turtles, lungfish, teleosts, and a flora that has been considered to include some of the world's earliest flowering plants. The Winton Formation is ideal for the application of detrital zircon geochronology for refining the maximum depositional age, because of its relative proximity to suggested coeval volcanic and plutonic source rocks along the east to northeastern coast of Australia. Dated detrital zircon samples (n = 12 samples (~1000 grains)) from key fossil localities across the succession indicate that most of the vertebrate fossils in the Winton Formation are no older than earliest Turonian to latest Cenomanian (92–94 Ma). The most abundant detrital zircon population clusters between 92–115 Ma, indicating that the volcanic-rich sediment was syndepositionally eroded from an active continental volcanic arc system located along the eastern margin of Australia (presumably the Whitsunday Volcanic Province). The results also suggest that sedimentation commenced no earlier than the latest Albian (~103.0–100.5 Ma), and that deposition of the upper vertebrate-rich portion of the stratigraphy began no earlier than the Cenomanian-Turonian boundary (~94.0–92.5 Ma). The utilization of these methodologies has also facilitated stratigraphic correlation between key fossil localities. Specifically, distinct changes in the maximum depositional age of nearby fossil localities from similar stratigraphic positions led to the identification a previously unrecognized normal fault system between the sites. Hence, the detrital zircon data were also critical to identifying cryptic structural complexities in the field and recognizing temporally distinct faunal assemblages in the Winton Formation. These results provide a significant advancement in understanding the age of the flora and fauna of the Winton Formation, and emphasize the utility of detrital zircon geochronology for better constraining other terrestrial biotas.

Primate taphonomy in the Plio-Pleistocene cave deposits from the Cradle of Humankind

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Around two million years ago, five species of early hominin, namely *Australopithecus africanus*, *Au*. 'second species', *Au. sediba*, *Paranthropus robustus*, and early *Homo* inhabited the Cradle of Humankind, together with various papionins, including the extinct giant gelada, (*Theropithecus oswaldi*), extinct large baboons (*Papio/Dinopithecus ingens*, *Papio izodi, Papio angusticeps* and *Gorgopithecus major*), baboons (*Papio (hamadryas) robinsoni*) and *Parapapio* (i.e. *Parapapio jonesi, Parapapio broomi,* and *Parapapio whitei)*.

To explain the concentration of primate remains inside cave deposits, Brain proposed the 'carnivore-collecting hypothesis', whereby a predator (leopard or hyaena), specialized in preying upon primates and occupying caves or areas near cave entrances, would have been responsible for the presence of primate remains in cave deposits. Recent studies have readdressed the 'carnivore-collecting hypothesis' in light of new taphonomic analyses and have confirmed the prominent role played by large carnivores in the accumulation of hominin and non-hominin primate bones within cave deposits.

However, this scenario does not always apply and fails to explain cases such as Cooper's D or Malapa where the ratios between hominin and non-hominin primates inside the fossil assemblages are completely disproportioned. Here, we propose to explore alternative hypotheses to explain the presence of primate remains within fossil assemblages.

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Reevaluation of vertebrate tracks in the Elliot and Clarens formations (Karoo Supergroup), Lesotho – implications for the macrovertebrate biostratigraphic framework and early Mesozoic faunal turnover

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To date, macrovertebrate tracks as biostratigraphic markers have been underutilized, among others, due to the immaturity of the ichnotaxonomic classification schemes and morphological variation of ichnotaxa resulting from abiotic and biotic phenomena. Furthermore, only a handful of places in the world preserve fossiliferous track-bearing successions that can be utilized as reliable temporal markers in the stratigraphic record and subjected to marcro-evolutionary studies. Thus, this study seeks to utilize the richly-diverse vertebrate track assemblages within the Late Triassic to Early Jurassic Elliot and Clarens formations of Lesotho. Early investigations of the Lesotho track sites identified ~170 ichnospecies, from 58 sites throughout the succession; however, subsequent ichnotaxonomic work greatly reduced the number of morphotypes. In the initial stages, this study will seek to address and resolve these ichnotaxonomic discrepancies, and will construct a robust ichnostratigraphic framework based on key ichnological assemblages, which have broad stratigraphic ranges and occur in discrete stratigraphic units. Along with this, a reevaluation of the local taphofacies will also be conducted to accurately account for the valid morphological variation in the ichnotaxa (i.e. eliminating undertracks from true tracks). Once consolidated, this information will be compared with recent sedimentological, stratigraphic and palaeontological studies of the Elliot and Clarens formations. Furthermore, this information will also be coupled with radiometric dating of detrital minerals potentially to be collected at key ichnological localities in order to provide critical temporal constraints on the ichnofauna as well as on the depositional setting of the localities. This work will not only provide a more reliable biostratigraphic context for the ichnofauna of the Elliot and Clarens formations, but also may elucidate rates of faunal turnover during the initial stages of dinosaurian radiation within South Africa in the Mesozoic.

Southern African Palaeosciences Documentary Initiative: 3.5 Ga of Life history and origins, the responsibility to showcase it

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The rocks of southern Africa provide a near continuous and unparalleled story of the Earth and origins of Life over the last 4.5 Ga. A few examples of important fossil finds which give insight into early (Archaean – Palaeoproterozoic) conditions and environmental change on Earth include: some of the oldest unicellular organisms and stromatolites from the Barberton and Pongola Supergroups, photosynthetic cyanobacteria from the Transvaal Supergroup are evidence for Earth's shift to an oxygen rich surface geochemistry, Neoproterozoic to Cambrian successions of the Gariep, Nama, Vanrhynsdorp and Cango Caves Group's metazoan fossils on Earth, and those of the enigmatic ediacaran/naman biota. The Early Palaeozoic Cape Supergroup contains some of the earliest known plant spores and macro plant fossils, fossil shark, lamprey, terrestrial arthropod, and the largest known conodont from Gondwana. They are all associated with an array of highly endemic and poorly understood vertebrate and invertebrate fossils. The overlying Late Palaeozoic-Early Mesozoic Karoo Supergroup's Beaufort Group is most famous for fossils of an unusual and now extinct reptile group known as the Therapsids. Nowhere else on Earth better preserves their evolutionary transition from reptiles into mammals. Footprints and body fossils of some of the World's earliest dinosaurs come from the Stormberg Group's Molteno, Elliot and Clarens formations. However, this amazing fossil heritage is virtually unknown to the public which is unacceptable, and southern African earth scientists only have themselves to blame. These exciting finds have only recently been revealed to the public in a locally popular science book *The Story of Earth and Life*. Nevertheless, what is required to truly showcase this unparalleled heritage is an exciting documentary series. Inspired by this book, the documentary would take the audience on a journey, bringing this amazing story of the Earth and our origins from a southern African perspective back to life. In doing so it is hoped that this initiative will educate the public, and enthuse the next generation of southern African palaeoscientists. The documentary series would be beneficial to the Centre of Excellence in Palaeosciences as it could directly generate a source of income with the broadcast of the series, and indirectly by promoting geoheritage. The latter would encourage the public and scientists from abroad to visit various local museums, tourist attractions and repositories. As custodians of this exceptional heritage, it is our responsibility as southern African earth scientists to promote our research to the public, and the World.

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Stratigraphy and sedimentary environments of the Late Permian *Dicynodon* Assemblage Zone (Karoo Supergroup, South Africa) and implications for basin development

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The Permian portion of the Beaufort Group (Karoo Supergroup) stratigraphic succession has been divided into five biozones, of which the geographic distribution of the lower four biozones is restricted to the southern part of the Karoo Basin. By the Late Permian, rocks of the *Dicynodon* Assemblage Zone (Balfour Formation and its equivalents) occupied the entirety of the Karoo Basin, as the final remnants of the Ecca Sea gave way to vast fluvial floodplains. Sediments deposited in this environment are preserved as the dominantly argillaceous Daggaboersnek and Elandsberg members of the Beaufort group, apart from a pulse of amalgamated sandstone packages nestled between the two. This arenaceous interval was first identified as Johnson's (1976) Zone 3 sandstone. Later Tordiffe (1978) separated it from the Elandsberg Member, naming this sandy interval the Barberskrans Member. By 1980, the Barberskrans Member was officially approved by SACS. Characterized generally as a 50–60 m thick unit of paired, laterally accreted sandstone packages, this member is most apparent in the vicinity of Nieu Bethesda, Cradock, and along the N1 in the vicinity of the Gariep Dam. Recent field work in the Free State (Bloemfontein, Jagersfontein) and Western Cape (Beaufort West) has expanded the geographic extent of this this arenacous marker and identified the occurrence of the Barberskrans Member in the northwestern and southwestern extent of the *Dicynodon* Assemblage Zone's range. If this is verified, the Barberskrans Member could represent a basin-wide event related to basin tectonics, climate, or both. Fossil collection and referral to the collections database has revealed a possible faunal difference below and above the Barberskrans Member. *Dicynodon* Assemblage Zone defining fossil fauna (*Dicynodon lacerticeps* and *Theriognathus microps*) appear to decrease in relative abundance above the Barberskrans sandstones after the appearance of *Lystrosaurus maccaigi*, *Moschorhinus kitchingi* and the now revived taxon, *Daptocephalus*

leoniceps. Independent proxies such as fossils are of great importance to characterize stratigraphic marker horizons, such as the Barberskrans Member, and in this way play an important role in refining basin development models.

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Phylogenetic analysis based on the braincases of early archosauromorphs, birds and maniraptorans

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We (i) review the brain case anatomy of *Euparkeria*, *Archeopteryx*, *Marasuchus*, *Struthio* and maniraptorans, (ii) present a model of how the reptile to bird transition of the structures of the otic region may have happened, (iii) conduct a braincase-based phylogenetic analysis of the earliest birds, early archosaurs and a range of possible archosaromorph ancestors of birds, and (iv) discuss if brain case data support the BMT hypothesis (maniraptorans are the sistergruop of birds) and whether some maniraptorans may be derived birds.

In addition to comparative anatomical evidence, embryological information can be integrated with direct evidence from fossils to test the homologies of structures of birds and reptiles. This integrative approach suggests that, the otic wing in dinosaurs (and crocodylomorphs) consists of the pterotic, basioccipital and the exoccipital, whereas the metotic process of birds consists of the opisthotic and the ventral process of the opisthotic (prevagial commisura). If these structures are not homologous and the rest of the brain case structures are also not homologous, it apppears that birds may not have descended from theropods. If birds have not descended from theropods, where do they come from?

In dinosaurs 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 it is shown here, 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.

A connection of the perilymphatic system passed between the basioccipital and basiparasphenoid segments of the brain case to the throat and formed a median Eustachian system in *Proterosuchus* as a pressure balancing mechanism between the perilymph and the surrounding aquatic medium. Subsequently, the median Eustachian system became highly modified in various ways to accommodate secondary functions such as thermoregulation. The homologies of the cavities in the basicrania of birds, early theropods and maniraptorans are investigated.

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Renewed investigation of the human remains from Klasies River main site, southern Cape

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The Klasies River main site, situated on the southern Cape Tsitsikamma coast, contains extensive Late Pleistocene deposits dating to between *c.* 120 000 and 55 000 years ago. This 20-metre thick archaeological occurrence consists mostly of characteristic shell middens, and its shell, fauna and stone artefacts have been described in a significant number of publications. A much discussed assemblage of more than forty hominin fossils, most of them fragmentary, has been recovered by the Wymer in the late 1960s. The Deacon excavation (1984–1999) added twelve more specimens to this collection. Two left maxillae from the Light Brown Sand Member represent the oldest (*c.* 115 000) hominin presence at the site, but the vast majority of the fossils come from the lower part of the Sand and Shell Member, dating to MIS 5c. Three teeth, one from the Howiesons Poort level, and two from the post Howiesons Poort show that juveniles were present at main site during MIS 4/3. A number of issues will be discussed: the contribution of this group of fossils, displaying a mixture of modern and more archaic traits, to interpretations of modern human evolution; the possibility that the MIS 5c remains relate to episodic cannibalism; and renewed efforts at contextualizing and dating these fossils.

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The hyperpronating foot of *Australopithecus sediba* – so what is the big deal?

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A humanlike arch and a stable midfoot region of the hominin foot are thought to be essential for habitual bipedalism. However, extreme medial weight transfer (hyperpronation) of the feet in modern humans is common and may result in a number of pathological conditions. The origins of this 'dysfunction' in humans is a point of debate. The discovery of a relatively complete *Australopithecus sediba* adult female skeleton may shed some light on a number of biomechanical factors that play a role in causing hyperpronation. A detailed locomotor analysis of *Au. sediba*, in which joint systems can be integrated to form a comprehensive picture of gait kinematics in this late australopith, suggests that this species walked with an inverted foot during the swing phase of bipedal walking. Initial contact of the lateral foot with the ground resulted in a large pronatory torque around the joints of the foot that caused hyperpronation into the toe-off phase of the gait cycle (late pronation). A well-preserved and articulated partial foot and ankle including an associated complete adult distal tibia, talus, and calcaneus, in direct association with the female paratype Malapa Hominin 2 (Zipfel *et al*. 2011; DeSilva *et al*. 2013), may offer an hypothesis as to the origins of anomilies such as calcaneo varus and pre-clinical clubfoot in modern humans. The fossil calcaneus has a very laterally located Lateral Plantar Process (LPP), in which the LPP has 'migrated' up the lateral side of the calcaneus. This would place the plantar surface of the calcaneus in an inverted position in relationship to the ground, reminiscent of what is clinically known as 'rearfoot-varus'; possibly an atavistic feature in modern humans. This is also similar to the analogue in chimpanzees. The initial (Zipfel *et al*. 2011) interpretation of this trait, using chimpanzees as a model, was that the position of the LPP assisted in tree climbing with the foot in an inverted position, even though there is no doubt that this hominin was a habitual biped. Even though this is not surprising in an early hominin, considering that many living humans hyperpronate, these bipedal mechanics appear to be different from those often reconstructed for other australopiths.

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