

The AOP/WCFP research projects

The five AOP-funded research projects aim to reconstruct the palaeoecology of various extinct animal species, as well as establish the palaeoenvironmental changes that have affected the West Coast Region over the past 5 million years. New faunal species are being identified by researchers on a regular basis, which has far-reaching implications for our understanding of the phylogeny and systematics of extant species living in the Western Cape today. Langebaanweg represents a period when many modern genera were emerging, and is the site where many taxa make their first appearance in the fossil record.

The extent of fossiliferous deposits at the Langebaanweg site, and their ages, as well as other geological formations of Plio-Pleistocene and Holocene age in the west coast region are being determined. Clarifying the chronology of the Varswater Formation and associated younger deposits will aid in establishing the depositional history of a sequence which is currently poorly understood. Besides the importance of the environmental and climatic information to be elucidated from this research, the research will also have a knock-on effect in terms of an expanded education and tourism programme at the West Coast Fossil Park.

Five projects are currently underway under the auspices of the AOP/WCFP Project.

Project No. 1 - *Surface mapping and fossil survey of the West Coast Fossil Park*

Project Collaborators: Roger Smith¹, Dave Roberts³ and Pippa Haarhoff²

Project No. 2 - *Stratigraphy, palaeogeography and age determination of Cenozoic deposits of the Cape west coast*

Project Collaborators: Dave Roberts³, John Compton⁴, Roger Smith¹

AOP Student Associates:

Claire Boulter: Postdoctoral project title: *Optically Stimulated Luminescence Dating in the Langebaanweg Environs*

Lara Scisio: Masters project title: *A biogeochemical and palynological investigation of late Cenozoic fluvial/ estuarine sediments, Western Cape, South Africa*

Other Student Associates:

Mary Hikamuah: Honours project title: *Comparing pelletal phosphorite off Namibia to Pelletal Phosphorite at Langebaanweg. Supervisors: Dr John Rogers and Dr John Compton (Both of the University of Cape Town)*

Project No. 3 - *Taphonomy and depositional history of the Early Pliocene Sivathere-dominated bone bed deposit at Langebaanweg*

Project Collaborators: R. Smith¹, P. Haarhoff²

Research Associate: Kay Behrensmeyer⁷

Project No. 4 - *An ecomorphological approach to reconstructing the Langebaanweg palaeoecology*

Project leader: D. Stynder¹

Research Associate: James Brink⁵ **Research area:** *The Langebaanweg bovids*

Research Associate: Lloyd Roussouw⁶ **Research area:** *Using phytoliths for palaeoenvironmental reconstruction at Langebaanweg*

Project No. 5 - *Reconstructing the Early Pliocene ecosystem on the Cape West Coast using fossil micromammals from Langebaanweg*

Project leader: T. Matthews¹

Assignations:

¹ Iziko South African Museum, ² West Coast Fossil Park, ³ Council for Geoscience, Cape Town Branch, ⁴ University of Cape Town,

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DESCRIPTION OF RESEARCH PROJECTS

Project No. 1 *Surface mapping and fossil survey of the WCFP*

Project Collaborators: Roger Smith, Pippa Haarhoff and Dave Roberts

The aim of this project is to produce a 1:25 000 scale surface map of rock outcrops in the West Coast Fossil Park with details of all *in situ* fossil occurrences. This will include an assessment of their research potential and susceptibility to being damaged. The results will be used to formulate a conservation strategy for future development of the Park, as well as fulfilling SAHRA (South African Heritage Resource Agency) requirements.

Project No. 2 *Stratigraphy, palaeogeography and age determination of Cenozoic deposits of the Cape west coast*

Project Collaborators: Dr Dave Roberts, Dr John Compton and Dr Roger Smith

The geological history of the fossil bearing deposits at Langebaanweg over the past 5 million years is complex, involving repeated rises and falls of sea level. This resulted in a range of sedimentary settings surrounding shifting river courses, wetlands, estuaries and marine shorelines. Comprehending and communicating this complexity coherently, and enabling informed further excavation activity in the area, necessitates the construction of a virtual spatial model reconstructing the stratigraphic and geomorphological development of the region. This project looks at the broader stratigraphic context of the Varswater Formation and associated strata making extensive use of borehole data. A clay pit at Rondeberg, north of Cape Town, exposes Late Neogene lacustrine deposits providing unique three

dimensional information on cyclical climate change in a region lacking such detailed information.

The Neogene Epoch (the last 24 million years) is extensively preserved onshore but less so offshore along the West Coast. However, the chronology of individual onshore units remains obscure. The poor offshore preservation is related to slight uplift of the continental margin accompanied by a eustatic sea level fall and thus an overall decline in relative sea level, such that erosion has dominated over deposition in offshore areas. The WCFP is a pocket of preservation that (due to mining operations) is well exposed and represents an extremely valuable window into the Neogene because of its rich fossil assemblage. There are certainly other 'pockets' of Neogene but they remain out of view, buried by Quaternary aeolian deposits. Drilling of boreholes provides important data on the subsurface deposits; however, the sediment recovered from these boreholes has proved difficult to date due to a general lack of fossils. The recent acquisition of a large number (over 400) of vibrocores from offshore of Cape Columbine has allowed a far more detailed stratigraphic history of the margin to emerge. The offshore sediments are rich in fossils and their ages are well established. Access to new core data from within Saldanha Bay from the NPA iron ore jetty expansion project, which began in 2008, will add more nearshore data. Both recent cores taken from the WCFP, and surrounds, contain organic material which contains fossil pollen. Study of the pollen provides information about the plants that lived in the region at various times, which in turn tracks changes in climate.

A major aim of this study will be to spatially reconstruct the palaeo-geomorphological environments by virtual geomorphological modeling of the key stratigraphic units, accounting for surface topography during fluctuating sea levels and consequent fossil deposition, and providing computerized means to communicate findings.

The onshore borehole cores will be re-examined to determine if there is anything that can be dated using ion probe i.e. fossils or authigenic minerals such as phosphorite. They will also be sampled for authigenic minerals that may be analysed using the Sr isotope technique which will then be compared with the well sampled marine record as another means of correlation. Correlations to offshore deposits will be mainly based on sedimentological evidence (texture and mineralogy of sediment lithofacies).

Over the next 3 years the focus will be on data capture. We aim to collect all the previous core data and merge this into a single data set. If funds are available we would like to continue drilling more cores down to basement through the West Coast Cenozoic deposits in and around the Langebaanweg site. Detailed sedimentological logging of the cores will aid the interpretation of the depositional sedimentary environments and palaeoclimates. Drilling of an orientated core will allow palaeomagnetic analyses which would be of great value in terms of geochronology. At the same time we will select palynological and whole rock samples for age/palaeoenvironmental determination.

Project No. 3 *Taphonomy and depositional history of the Early Pliocene Sivathere dominated bone bed deposits at Langebaanweg*

Project Collaborators: Dr Roger Smith and Pippa Haarhoff

The focus of this study is an 80 square metre exhumation of the so-called *Sivathere bone bed* at the West Coast Fossil Park. This research project combines sedimentological analysis with qualitative vertebrate taphonomy of the in situ fossils, in order to reconstruct the sequence of events that led to the accumulation of this extraordinarily rich and diverse bonebed. The larger bones are predominantly *Sivatherium*, an extinct giraffid (member of the giraffe family), and the numerous smaller bones are of a very diverse fauna that used to live in and near an ancient river estuary (possibly the former Berg river) during the Early Pliocene some 5 million years ago. Interesting and important specimens that have been

recovered from similarly dated deposits at the Park include a giant extinct bear, *Agriotherium africanum*, the first bear to be found in Africa south of the Sahara, carnivores such as sabre-toothed cats, a wolverine and the megatooth shark, as well as a fascinating diversity of herbivores such as the gomphotheres, giant pig, three-toed horses and early representatives of the wildebeest/hartebeest group. The objectives of this research are to use data from the West Coast Fossil Park excavations to (1) reconstruct the regional geography, landscape and habitats around the ancient Berg River mouth and (2) to investigate the unusual sequence of events that led to the accumulation and burial of the bone bed and, in particular, explain how species which occupy very different habitats (marine, terrestrial and fresh-water), all got buried together.

Work plan

This project has been underway for 4 years and is focused on the open dig site in the West Coast Fossil Park. Research methods entail 3D spatial analysis of *in-situ* bones, studies of bone modification including scavenging and trampling damage, and detailed analysis of the distribution of bone fragments and microfauna. A valuable spin-off from this research is that after completion of the project, 80 m² of the dig site will remain open to the public as an education and tourism facility. This, along with the knowledge generated about the deposit, will continue to improve the visitor's experience at the Fossil Park.

Project No. 4 *An ecomorphological approach to reconstructing the Langebaanweg paleoecology*

Project leader: Dr Deano Stynder

The ecomorphology of a fossil species is exemplified by its overall body shape and size, skeletal and dental anatomy, dental wear patterns and stable isotopic signals. This type of information is used to deduce diet, locomotion, positional and social behaviour, foraging strategies and preferred habitat. The ecomorphological approach is a useful approach to take if one aims to reconstruct palaeoecologies. Ecomorphological data gathered from individual fossil species may be combined to recreate an entire paleoecology or parts thereof. This project uses an ecomorphological approach to reconstruct the paleoecology of the Langebaanweg large mammal component. It follows on from, and expands on, previous ecomorphological studies by employing a battery of methods (e.g. a study of morphology, isotopes, microwear and mesowear) to a particular species. It is hoped that this approach will provide precise ecological data on each of the studied species. The study will not only be limited to ungulates, as in many previous studies, but will also include other groups such as carnivores. The eventual aim of this study is to use the data from individual species to reconstruct aspects of the Langebaanweg large mammal paleoecology as accurately as possible e.g. the niche separation between the hyaenids.

Using phytoliths for palaeoenvironmental reconstruction at Langebaanweg

Research Associate: Lloyd Roussouw

Changes in the pollen composition during the Miocene-Pliocene transition at Langebaanweg suggests a shift from woody, subtropical vegetation to largely open fynbos vegetation (Coetzee and Rogers 1982; Scott *et al.* 1997), whereas a diverse range of vertebrate fossils in the Varswater Formation, also implies that grassy environments were present in the region during the early Pliocene (Hendey 1976, 1982; Franz-Odendaal 2002). In order to gather additional information regarding grassland conditions during this time, a trial investigation was initiated to assess whether the Langebaanweg sediments are conducive to the preservation of grass phytoliths. Preservational conditions for biogenic silica were found to be generally favorable in the Gravel Member and Pelletal Phosphorite Member, but not in

the Quartzose Sand Member. Coarse-grained sands common in this member most likely facilitated leaching of biogenic silica.

Preliminary identifications include diagnostic grass phytoliths, and also morphotypes found in Cape reed grasses (Restionaceae), as well as the Palm family. The positive results of this study show that fossil phytoliths are sufficiently well preserved in the Langebaanweg sediments to be used in palaeoenvironmental studies. Further research will consist of more extensive soil sampling, and a more in depth palaeoecological study of the Langebaanweg phytoliths.

Laboratory Procedures

The procedure for recovering phytoliths from sediment samples is based on published techniques (Piperno, 1988; Lentfer and Boyd, 1998, 1999; Albert and Weiner, 2001; Horrocks, 2005). Approximately 50g of each sample was used for each phytolith extraction. Essential steps included deflocculation, removal of clays by means of sedimentation and the elimination of carbonates using HCl in low concentration (10%). Phytolith extraction involved mineral separation with a heavy liquid solution of sodium polytungstate (S.D. = 2.3). Fractions were mounted on microscope slides in glycerin jelly and scanned under a Nikon 50i polarizing microscope at x500 magnification.

Project No. 5 *Reconstructing the Early Pliocene ecosystem on the Cape West Coast using fossil microfauna from Langebaanweg*

Project leader: Dr Thalassa Matthews

A Geometric morphometric study of the Langebaanweg micromammals is currently underway to investigate the differences between certain groups of specimens where it is unclear if different species or sub-species are represented, or alternately, if observed differences are attributable to sexual dimorphism. These analyses will aid in clarifying the morphological and phylogenetic relationships of the extinct micromammal species found at Langebaanweg.

Traditionally the habitats utilized by, and habits of, extant micromammal species are used to extrapolate those of extinct animals. This can be very problematic as many modern southern African micromammal species may utilize very different habitats in areas which have different rainfall patterns. For example, several micromammal species are associated on the south coast with moist environments, but on the west coast are found in relatively arid habitats. The problem of using modern genera and species to work out the habitat or habits of extinct species is compounded by the fact that in some genera which contain multiple species the different species utilise very different habitats or have different diets, despite the fact that their teeth morphology is very similar. In the second phase of this project this problem will be addressed by using the microwear patterns on murid teeth to link wear patterns with diet, using modern murids as analogues for the Langebaanweg species. This information is vital for ascertaining the different niches and habitats utilised by the Langebaanweg micromammals, and will provide very interesting palaeoenvironmental information.

During mining operations, sediments recovered from a variety of different depositional environments at Langebaanweg were boxed and have remained unsorted to date. Under the auspices of this project a field assistant is being employed to sort through the boxes and remove all micromammal material. This micromammal material will aid in the identification of several genera and species which are to date represented by only one or two teeth.

The accurate identification of new murid species is essential if the micromammal population at Langebaanweg is to be used to recreate the paleoenvironment at the site, and also provides essential information for the understanding of the evolution of southern African micromammals. This research aims at increasing the number of specimens, so that these new species may be formally named and described. This work will allow for a complete assessment of the micromammal populations from the LQSM and MPPM members of the Varswater Formation, which in turn can be used for palaeoenvironmental reconstruction.

References

Albert, R.M., Weiner, S., 2001. Study of phytoliths in prehistoric ash layers using a quantitative approach. In: Meunier, J.D., Coline, F. (Eds.), *Phytoliths: Applications in Earth Sciences and Human History*. A.A. Balkema Publishers, Lisse, pp. 251–266.

Coetzee, J.A. and Rogers, R. 1982. Palynological and lithological evidence for the miocene palaeoenvironment in the Saldanha region (South Africa). *Palaeogeography, Palaeoclimatology, Palaeoecology* 39: 71 – 85.

Franz-Odenaal, T. 2002. New evidence for the lack of C4 grassland expansions during the early Pliocene at Langebaanweg, South Africa. *Paleobiology* 28(3): 378 – 388.

Hendey, Q. B. 1976. The Pliocene fossil occurrences in 'E' Quarry, Langebaanweg, South Africa. *Annals of the South African Museum, Cape Town* 69: 215 – 247.

Hendey, Q. B. 1981. Palaeoecology of the late Tertiary fossil occurrences in 'E' Quarry, Langebaanweg, South Africa, and a reinterpretation of their geological context. *Annals of the South African Museum, Cape Town* 84: 1 – 104.

Horrocks, M., 2005. A combined procedure for recovering phytoliths and starch residues from soils, sedimentary deposits and similar materials. *Journal of Archaeological Science* 32, 1169-1175.

Lentfer, C.J., Boyd, W.E., 1998. A comparison of three methods for the extraction of phytoliths from sediments. *Journal of Archaeological Science* 25, 1152 – 1183.

Lentfer, C.J., Boyd, W.E., 1999. An assessment of techniques for the deflocculation and removal of clays from sediments used in phytolith analysis. *Journal of Archaeological Science* 26, 31 - 44.

Piperno, D. R., 1988. *Phytolith analysis: an archaeological and geological perspective*. Academic Press, London.

Scott, L., Anderson, H.M. and Anderson, J.M. 1997. *Vegetation History*. In: R.M. Cowling, D.M. Richardson and S.M. Pierce (Eds.) *Vegetation of Southern Africa*. Cambridge University Press, Cambridge, pp 62 – 90.