Contributions to Knowledge of Some Southern African Fossil Sites and Their Fossils

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Master of Science (Palaeontology) at the University of Stellenbosch

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Declaration

I, the undersigned, declare that the work contained in this thesis is my own original work and that I have not previously in its entirety or in part submitted it at any university for a degree.

Signature: ....

Date: ...September...28...2000

ABSTRACT

The fossil sites and fossils reported here range from the Archaean to the Recent. Information is presented on the circumstances of the discovery of some fossil sites in Southern Africa. A number of fossil sites, some of which can no longer be studied, are photographically recorded. Some recorded sites were relocated, while failure to locate others is noted. The assemblages at selected fossil sites are compiled, including some additions to their floras and faunas. Certain individual fossils are illustrated and discussed. Techniques which are not standard are outlined.

UITTREKSEL

Die fossiele en lokaliteite bestudeer, wissel van die Archaeozoikum tot die Resent. Inligting word verskaf oor die omstandighede waaronder vindplekke in Suider Afrika ontdek is. 'n Aantal lokaliteite, party waarvan nie meer ondersoek kan word nie, is fotografies gedokumenteer. Sekere opgetekende lokaliteite is herbesoek terwyl dié wat nie weer gevind kon word nie, as sulks aangeteken is. Die fossiele by uitgesoekte lokaliteite is saamgestel met sekere toevoegings tot hulle flora en fauna. 'n Aantal fossiele word geïllustreer en bespreek. Nie-standaard tegnieke wat gedurende die navorsing gebruik is, word uiteengesit.

ACKNOWLEDGEMENTS

Many people have been supportive to my palaeontological interests. My family, Hester and Perdita, André and Jacques, friends, colleagues and other fellow-researchers and students are thanked cordially for their contributions, often as co-participants.

Thanks, in addition to acknowledgements in publications, are given those institutions which have provided facilities or funds. Permission to photograph specimens is much appreciated.

This work was made possible by the many organisms known to me from their corporeal remains or the results of their activities.

CONTENTS

1 INTRODUCTION

Uniqueness is a property of many fossil sites and many fossils. There are therefore good arguments for recording information about them which exceeds that which publication in scientific journals usually carries, either because of the limitations imposed on publication by cost or by specialized readership. Placing information on record in a thesis can be more intensive, and more extensive for a broader, selective, readership. Illustrations of taxa can, for instance, be larger, while aspects such as the history of the discovery of a site, or its potential as an educational or tourism site, can be outlined.

While lecturer in Zoology at the University of Natal, Pietermaritzburg, from 1957 to 1987, many fossils passed through my hands, usually to the Natal Museum, and a considerable amount of information about them was published, mostly by specialists or with them. However, much information remains, while some published information can profitably be brought together, as for instance the palaeobotanical and palaeozoological aspects of a site. Some information about fossils included in this study is of vague provenance, but nevertheless of interest. The entire Phanerozoic of Southern Africa is covered and an attempt has been made to give due credit to earliest workers, as well as to indicate recent literature which can be followed back. A geological sequence is followed and a general overview of sites and fossils studied is given. Individual sites, or fossils, are dealt with in a similar sequence. A section on techniques is appended.

The division of strata outlined overleaf, follows the 1984 and 1987 Geological Maps of Southern Africa and the Geological Survey Stratigraphy Handbook 8 (Kent, compiler, 1980).

EONOTHEM	**ERATHEM**
	Caenozoicum
	Mesozoicum
	Palaeozoicum
PHANEROZOICUM	
	Namibium
	Mokolium
	Vaalium
PROTEROZOICUM	
	Randium
	Swazium
ARCHAEOZOICUM	

For economic reasons the geological literature on the older strata in Southern Africa is extensive. The discovery of organisms in the Swazian, for some time the oldest known on earth, resulted in considerable published scientific research. Organisms in the Vaalian also proved to be of scientific interest. Of the younger strata, the Upper Namibian early yielded macroscopic fossils. Other than strata of the Pongola Sequence, which bridges the Randian and Vaalian, there are few strata in Natal which can add much to what is known of the Archaeozoic and Proterozoic in Southern Africa.

In studying the literature relevant to material collected and studied, inadequacies in many references were encountered and a brief guide is thus considered to be a useful contribution on these strata.

2 DESCRIPTION *

2.1 ARCHAEOZOICUM

2.1.1 SWAZIUM

A review of Precambrian fossils by Glaessner (1962) happened to be published shortly before the discovery of fossils in the Swazian (Barghoorn & Schopf, 1966; Pflug 1966). The review thus gives a good idea of the state of knowledge at the time of the discoveries. Chemicals of presumably organic origin, including carbon, were known from strata of this considerable age, and an active search for physical remains was being conducted. Plumstead (1969) includes an account of the early discoveries, which is supplemented by recent palaeobotanical texts (e.g. Stewart & Rothwell, 1993, especially Chapter 4, pp. 32-45, including a bibliography on p. 45). Notable is Knoll & Barghoorn (1977) who reported cell division. Most of the studies were of the older Swazian, especially the Onverwacht and Figtree Groups of the Barberton Sequence.

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* Scale of Photomacrographs

In some photographs a 1 centimetre white square is used as scale.

In some photographs a white strip is used with 1 mm divisions, usually 10.

Where a block with coloured strips is used, each strip is 10 mm in length.

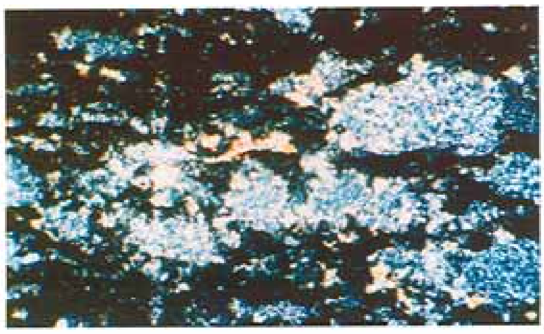
Scale of Prints of Photomicrogaphs

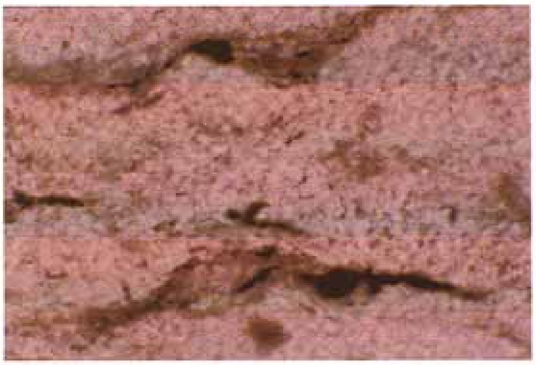
Unless otherwise stated prints are approximately 1 mm in greatest length.

Photomicrographs repeated with polarized light are to the right or below the ordinary light images.

Unless otherwise stated the Natal Museum is the repository of specimens.

Figtree





2.1.1.1 Figtree Formation

Two pieces of chert from the Figtree Formation were available for study, the provenance of neither being known; one is a block, the other a slab in the Department of Zoology, University of Stellenbosch, ex Geological Survey, Pretoria from which a portion was sampled, with the much-appreciated permission of J.A. van den Heever.

The black colouration of the chert block (top row) is produced by carbon mainly present in rounded quartzite-rich masses, as might be produced by flocculation, but there are some layers. No structures suggestive of organisms were observed.

The slab is black, but has a light portion near one end. The carbon in the dark part is similarly distributed to that in the block. In the light portion of the slab carbon appears to be present in filaments rather than in layers (middle row). The preparation was not ground down to the standard thickness so as to allow carbon concentrations to be observed through a considerable focal depth. Small particles of carbon are present on the boundaries of the quartz (chalcedony) grains, apparently representing secondary concentration during crystallization.

In the slab, structures were observed at the surface of the dark chert which projects perpendicularly into the light chert (bottom row). The material of the projections is not birefringent. Dark material, presumably carbon, is seen in cracks in the light chert, including some which is thickest near the surface of the dark chert.

2.1.1.2 NSUZE GROUP

2.1.1.2.1 Chobeni Formation

The NSUZE Group of the Pongola Sequence is at the top of the Swazian, and also contains stromatolites (Mason & von Brunn, 1977)

Stromatolites of the NSUZE Group, Chobeni Formation, were observed at a preserved site on the White Umfolozi River. Through the courtesy of V. von Brunn a polished hand specimen was made available for photographing.

Sectioned material from close to a stromatolite showed no carbon.

2.1.2 RANDIUM

The lower Randian includes banded ironstones of the Mozaan Group of the Pongola Sequence. These sediments are not fossiliferous, but are of interest because of debate about their possible relationship to biogenic atmospheric change. Ironstones of the world were the subject of studies, edited by James & Sims (1973), including Cloud (1973), devoted to palaeoecology. The dependence for diversification of early life on the acquisition of photosynthetic processes requires reassessment (e.g. Waldrop, 1990, and other articles on "extremophils"). A recent publication (Young *et al.* 1998) deals with the Mozaan in connection with glaciation, the oldest on earth which has been reported.

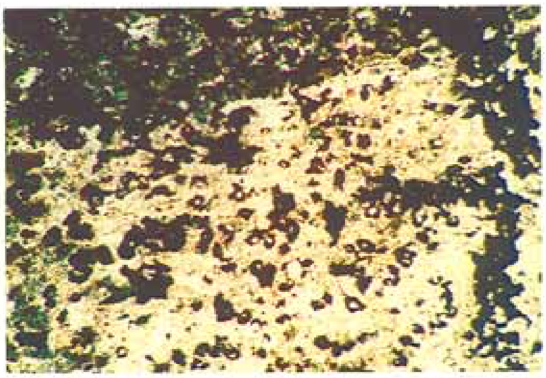
In the last decades of the nineteenth century the stratigraphic column of the obviously fossiliferous strata, the Phanerozoic, had been completed, the Ordovician having been named in 1879. It was known that the fossiliferous strata were preceded by unfossiliferous strata of greater extent, and any indications of organisms in these older strata were of interest. The discovery of radioactivity by Becquerel in 1896 was followed very quickly by the realization that radioactivity could be used to date strata, making their investigation more meaningful as they could at least be placed in sequence.

Carbon was early known to occur in gold-bearing conglomerates of the Transvaal, and Garnier (1896) and Spilsbury (1908) interpreted the carbon as evidence of organisms. Pretorius (1975) and Els (1998) give accounts of various views on the depositional environment of the Witwatersrand goldfields, and Hallbauer & van Warmelo (1974) and Hallbauer (1975) illustrate carbonaceous structures, the latter reference giving a useful brief review of previous work.

2.1.2.1 MOZAAN Group

Banded Ironstone was examined in the KwaMbizankulu-Thongwane region, in a study and teaching area of V. von Brunn.

Interference ripples indicate shallow water



The presence of iron oxide in ironstones has been taken to indicate free oxygen and hence the existence of photosynthesizing organisms in shallow water. Quartz grains are enclosed in iron oxide.

2.2 PROTEROZOICUM

2.2.1 VAALIUM

E. Kalkowsky in 1908 coined the term stromatolith for calcareous masses, of the Triassic of Germany, which he recognized as of plant origin. He refers to similar structures which he observed in older and younger strata, from the Devonian to the Miocene. Pia (1927, pp. 37-41) reviewed the literature, including references predating the term stromatolith (or stromatolite). Gürich (1922) described a stromatolitic fossil from the Transvaal; although other work of Gürich is mentioned by Pia (op.cit.), this work is not. No reference to the taxon, *Cryptozoon Dessaueri,* other than one by the author (Gürich, 1930), without pagination, could be traced. The work deserves to be resurrected.

R.B. Young, who had previously described limestone structures of early proterozoic age in South Africa without recognizing their fossil nature, referred to them as "Stromatolitic or Algal Limestones" in further work (Young, 1932), and compared such rocks of South Africa with modern algal sediments of the Bahamas (Young, 1934).

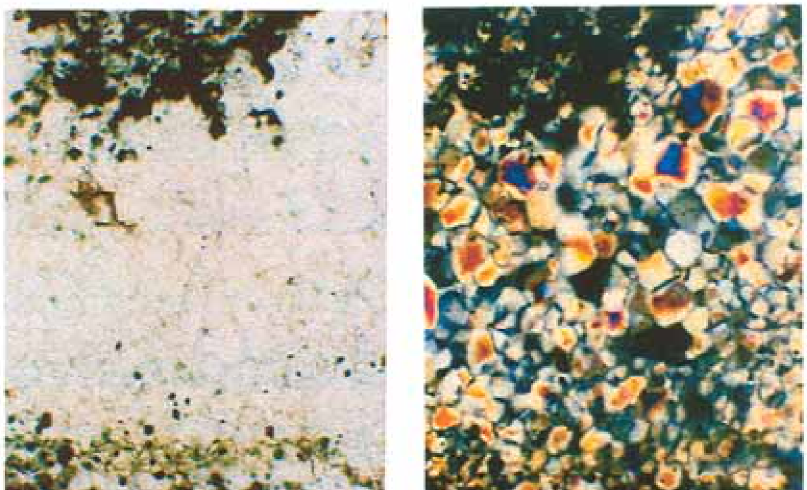
MacGregor, Truswell & Eriksson (1974) reported filamentous algae in Transvaal Dolomite, and Truswell & Erikson (1975) interpreted the palaeoenvironment.

2.2.1.1 **Malmani Subgroup** (Draper 1894 SACS 1980,p. 193)

2.2.1.1.1 **Tweefontein Formation** (Erikson & Truswell, 1974)

Specimens of stromatolites were observed near the Kromdraai Cave site. Two similar specimens which were studied, were not collected *in situ.*

On the underside of one of the specimens ooliths were observed. This suggests derivation from the Tweefontein Formation. An oolith-bearing portion of the stromatolite was sectioned to establish what objects, if any, could be found at the nuclei. Nothing of palaeontological significance was observed in the slides.



A vertical section of a stromatolite showed some zones with carbon.

2.2.1.1.2 **Hennops River Formation** (Erikson & Truswell, 1974)

The stromatolitic structures in the Hennops River Formation near the Hennops River are largely dolomitic. Some minor quartz layers are present, and such carbon as is present is mainly found in distinct concentrations mainly in association with quartz.

Dolomitization appears to have affected the fine structure of the stromatolites considerably, while relatively minor alterations have been caused by recrystallization of the quartz.

A vertical section through a stromatolite showed some zones with carbon.

2.2.2 NAMIBIUM

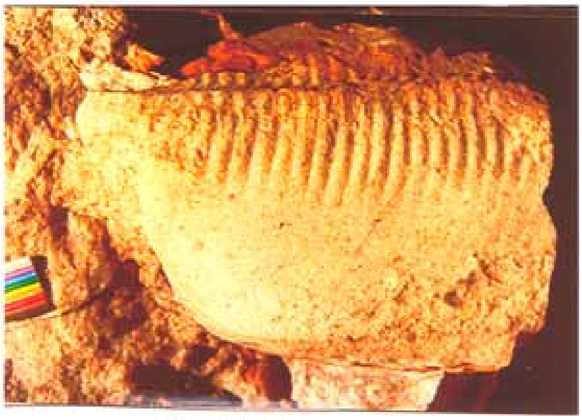
Gürich (1903) reported on structures in the Otavi limestones which were reminiscent of Archaeocyathids. Schneiderhöhn (1920) reported extensively on Otavi sediments, including references to Gürich's work. Gürich (1930a,b 1933) reported on Nama fossils. Haughton (1934) exhibited Nama fossils, interpreted as Archaeocyathids, and later discussed and illustrated them (Haughton, 1959). Similar fossils were found in erratic limestones in Dwyka tillites (Cooper & Oosthuizen, 1974; Debrenne, 1975; Oosthuizen, 1981). Bertrand-Sarfati & Eriksson (1977) reported on stromatolites. Glaessner (1962) includes some references on Nama fossils, while Nama stratigraphy and fossils were the subject of a thesis in 1972 (Germs, 1972a,b; see also Germs, 1974). Pickford (1995) gives an excellent summary of Namibian Riphean, Vendian and early Cambrian palaeontology. Cloud & Glaesssner (1982) and Grotzinger *et al.* (1995) are among many recent articles which provide references on animals in the late PreCambrian (Ediacarian). Several papers of interest were presented at the 1998 Annual Meeting of the Geological Society of America. Brain (1997); Narbonne *et al.* (1997); Dzik (1999) and Jensen *et al.* (2000) are recent articles on Namibian proterozoic animals. Brain (op.cit.) includes sediments in his scope.

A specimen of an erratic limestone from the Dwyka was examined, and similarity of the contained organisms to an archaeocyathian specimen from Australia was noted.

2.2.2.1 Schwarzrand Formation

De Aar

Specimens in the Natal Museum from De Aar in Namibia were examined, and a slide of the matrix of one of the fossils was prepared.



Pteridinium

2.3 PALAEOZOICUM

2.3.1 CAPE Supergroup

Two field guides in the past decade provide useful references and overviews of the Cape Supergroup. The first is the Geocongress 90 Cape Supergroup Excursion (PR2) guide (Theron & Thamm, 1990); the second is the post-congress Gondwana 10 Field Guide: Cape Supergroup Field Trip (Almond, Evans & Cotter, 1998). The former gives the early references, the latter refers to recent authors and the dates of their works but has no bibliography.

Cambrian System

To date no sediments of Cambrian age have been identified in Southern Africa.

2.3.1.1 TABLE MOUNTAIN Group (Rubidge1859;Wyley1859; SACS1980,p.522)

Ordovician and **Silurian** Systems.

The Geocongress 90 Cape Peninsula Excursion (M1) guide (Rogers, Thamm & Hartnady, 1990) gives references up to that date. The Table Mountain Group was the subject of studies by Rust (1967) and Thamm (1988).

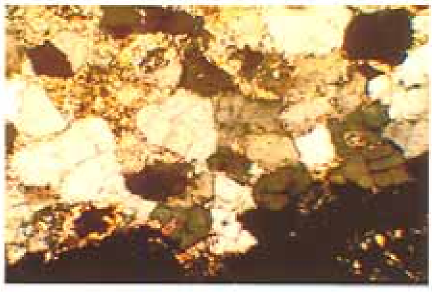
2.3.1.1.1 **Graafwater Formation** (Rust, 1967)

Helderberg

A site with trackways on the northern face of Helderberg which was discovered by R. S. Hill in 1967, was revisited with him, J. N. Theron and A. Channing in 1998. The tracks casts are under the overhang in the middle ground right.

H C T

Photographs of some scree slabs were taken, and pieces with trackway positives (natural casts) were removed from a small scree block.



A corner of one of the slabs was removed for preparation of slides. The sand from which the quartzite was derived, was not clean and probably contained material derived from the underlaying Graafwater Formation.

Devonian System.

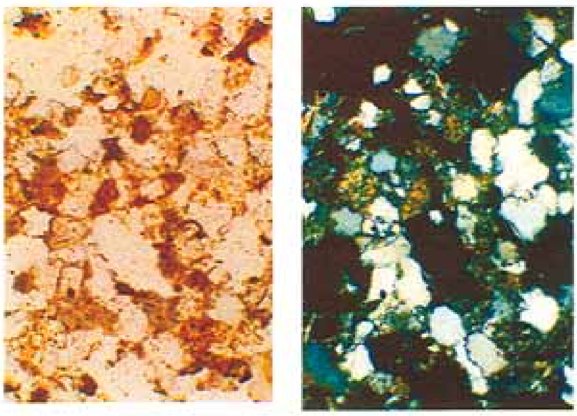
Plumstead (1969) continues her review of the South African Palaeoflora through the Devonian, and Anderson & Anderson (1985) begin theirs at this point.

2.3.1.2 **BOKKEVELD** Group (Wyley 1859 SACS 1980, p.523)

The Bokkeveld Group was reviewed by Theron (1972).

Fossil-bearing material from the neighbourhood had been collected by Mr. A de Vries of the farm Warmwatersberg, and included a block with a promising layer, which yielded a good exposure when split after drilling to establish a breaking plane.

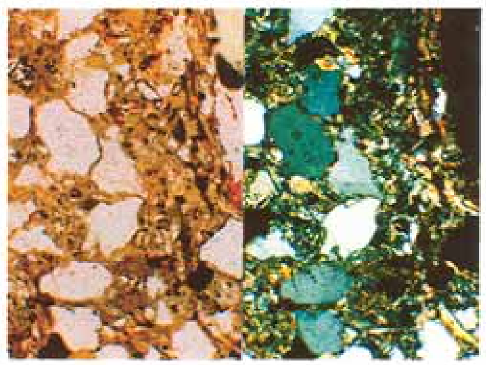
A section was made of material of the specimen, close to the fossils. The grains are well sorted, but not well rounded, suggesting limited reworking.



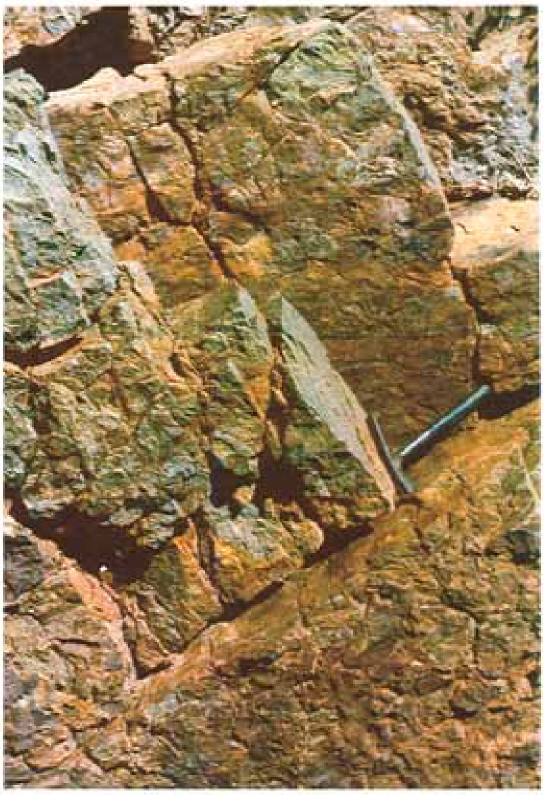
2.3.1.1. **WITTEBERG Group** (Wyley 1839; Rogers 1903; SACS 1980,p.524)

Blocks from the same farm (Warmwatersberg) as the Bokkeveld specimen above, which had also been collected in the neighbourhood, included some which differed from the Bokkeveld material. The quartzitic matrix of some suggested that they were from the Witteberg. A small block with a structure interpreted as spreiten was collected, as well as a specimen with *Zoophycos*. Sections were made of each specimen, two of them in the Geology Department, University of Natal, Pietermaritzburg. The sediment close to the spreiten consists of large, very well-rounded grains. (Height of photomicrographs 1mm)



In 1998 an area between Barrydale and Bellair Dam was visited with J.A. van den Heever where an ecotourism park was being planned and information sought regarding possible items of palaeontological interest near proposed chalets. Abundant *Zoophycos* were seen in several layers which were tilted to near vertical. Other trace fossils were observed, notably where rocks had been collected and used for walls, now disused. A few small samples were taken.



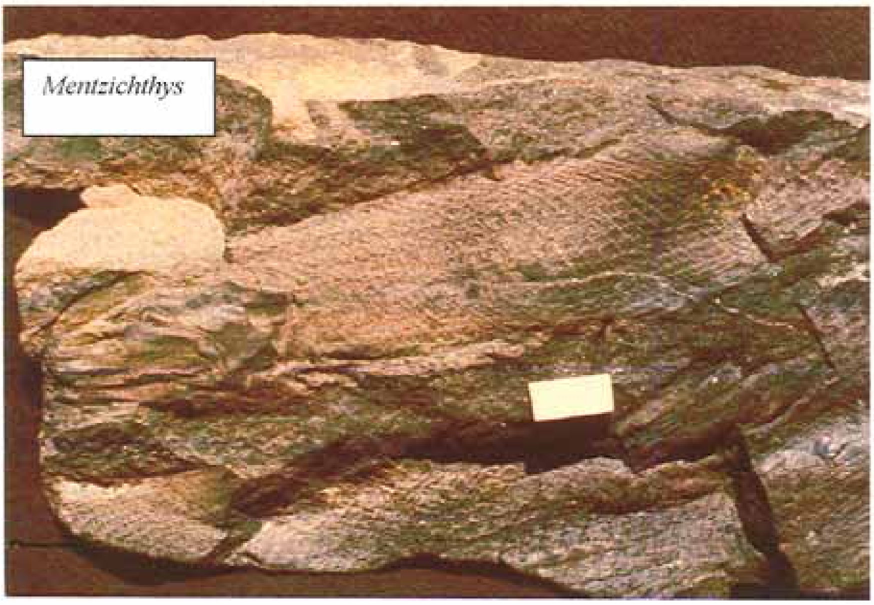
Carboniferous System and **Permian** System

2.3.1.4. **Lake Mentz** Subgroup (Loock, 1967; Loock SACS 1980,p.524)

The Upper Witteberg Lake Mentz Subgroup was reviewed by Evans, 1997. The contact between the Witteberg Group and the Dwyka Group was investigated by Loock (1967).

The Lake Mentz fish fossil locality was visited. Some useful specimens were collected among the debris from obviously intense exploitation of a productive seam.

A piece of fossiliferous material too small to yield a useful specimen when split, was sectioned. Bone and scales were found, some parts with little evidence of alteration, other parts with apparent recrystallization, and some alteration with the production of calcite (*vide infra*).



2.3.2 KAROO Supergroup

An excursion guidebook on the southwestern part of the Karoo Supergroup (Cole *et al.*, 1990) includes useful references ranging from the Carboniferous through most of the Permian. Johnson *et al.* (1996) gives an overview of the stratigraphy. Bamford (1999) investigated the fossil woods.

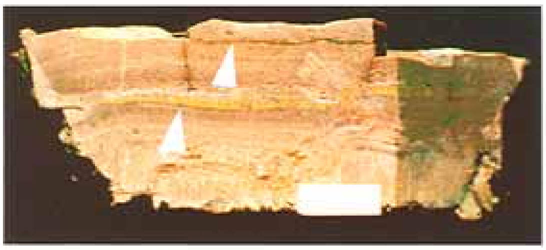
References to vertebrate trackways in the Karoo Supergroup and all other Palaeozoic and Mesozoic sites recorded in Africa have been assembled and sites mapped as far as possible. This work is being prepared for publication.

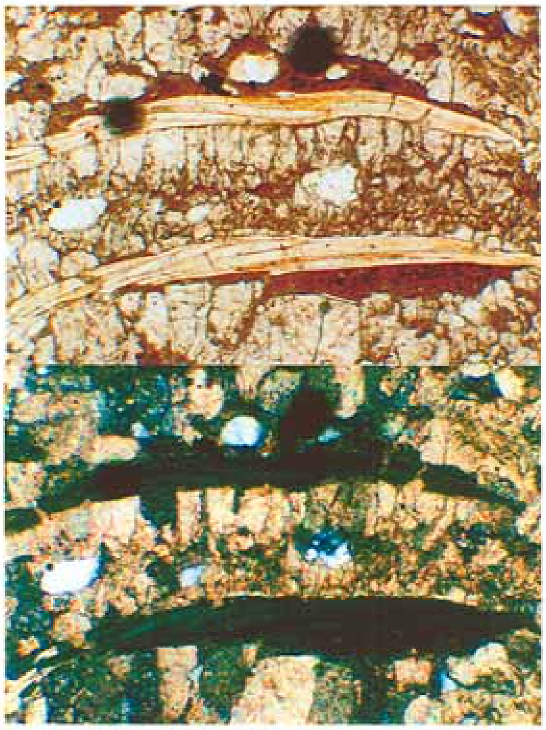
Carboniferous System and **Permian** System

2.3.2.1 DWYKA Group

The Dwyka (Dunn, 1875) has been the subject of many studies, early ones being outlined by Corstorphine (1904); because of the glacial origin of the sediments, fossils are not common and are often not mentioned. The Gondwana context is dealt with in Visser (1987) and the palaeoenvironment in Visser (1991) and Visser (1993). Visser (1989) contains a section on "Palaeontological evidence", which cites a number of works which deal with Dwyka fossils. Notable are the study of McLachlan & Anderson (1973) on the evidence for marine conditions of the Dwyka and the study of Anderson & McLachlan (1976) on plant fossils of the Dwyka and Ecca. Von Brunn (1996) in discussing the northern part of the Dwyka Group Basin, gives the setting of trackways studied by Savage (1970, 1971) and Anderson (1970, 1974, 1975, 1976, 1981) in what is now known as the Mbizane Formation. Jubb & Gardiner (1975) have illustrations of fish trails taken from specimens of V. von Brunn.

Pieces of dolomitic material of inexact provenance, brought for identification of fossils, proved to contain what are apparently Conchostraca. When a small sample was sectioned, the matrix showed angular fragments, which suggested that it was of glacial origin and the environment thus periglacial.





Fossils appear to be preserved in two forms, a thin pair of layers separated by sediment, or a solid structure with layers. Both the paired thin layers and the solid layered structure have very low birefringence and very little sign of alteration. It is possible that the layered specimens are fish scales consisting, like bone, of apatite, although scales were not seen on the surface of the specimen. Further study is in abeyance until more material, with a precise provenance, is available.

Permian System

2.3.2.2 **ECCA GROUP** (Jones 1867 SACS 1980, p.552)

2.3.2.2.1 **Mbizane Formation** (von Brunn SACS 2000)

In the late 1960s slabs of hard black shale were being sold in Natal. (The outdoor tables at the Botanic Gardens in Pietermaritzburg were made of unusually thick layers, while the floor of the Shell Garage show room in Commercial Road, Pietermaritzburg, was tiled with the shale). The origin of the material was a quarry near Swart Umfolozi on the Black Umfolozi River, (27°57'S 31°10'E cf. Anderson 1976). The owner of the quarry, wishing to obtain information which would enable him to find more of the material, made enquiries at the University of Natal, Pietermaritzburg, through a nephew (Physics Hons. student). The specimen brought to V. von Brunn of the Geology Department, exhibited fish trails (diagnosed by the quarry owner as having been made by the anus of a puffadder, demonstrating his awareness of the trace fossils). The site was visited with Vic von Brunn and selected material which could be conveyed in a station-wagon was purchased. This material, which included some very large slabs, was donated to the Natal Museum, except for small portions kept for study. The site was one of those made known at the 67th Congress of the South African Association for the Advancement of Science (Abstract: Van Dijk, Tankard, von Brunn & Gordon-Gray, 1969). The site and its shales, described as varvites, featured in an Excursion Guide (Plumstead, 1970) and papers delivered at the 1970 Gondwana Symposium (Savage, 1970; Anderson, 1970).

Some further fragments were collected after quarrying had ceased. (The dark varve fragments were best examined for trace fossils in oblique bright sunlight, but the dark surfaces made the fragments too hot to handle in the sun, limiting the useful work which could be done on site). Some useful slabs were obtained when floor tiles

Mbizane

were removed during rebuilding of the show-room of the Pietermaritzburg Shell Garage – though somewhat scratched on the exposed surface, the lower surface was often hardly affected by having been laid in cement, and could be cleaned with acid.

In 2000 the Mbizane Formation, proposed by V. von Brunn, was recognized by the Stratigraphic Commission for these deposits.

On the facing page varves are shown *in situ* and the under-surfaces of varves with the impression of a crustacean, and the fin traces of a fish, are illustrated.

Varve with dropstones and tracks (crustaceans and fish fin-traces)

Two successive varves, with crustacean tracks

Sections were made of a specimen with two layers, and two with drop-stones.

A variety of techniques have been used to produce copies (negative or positive) of some of the trace fossils.

Some impressions unlike those recorded by Savage (*op.cit.*) were noticed. There is scope for recording features of the behaviour of the animals responsible for some of the tracks, for instance changes of pace, changes of direction, response to the presence of an irregularity such as a drop-stone. Apart from the intrinsic interest, there is the possibility of usefulness for correlation. Tavener-Smith & Mason (1983) give an account of a varvite sequence near Isandlwana, Zululand.

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Richtersveld, Vioolsdrif

Trace fossils similar to those from the Mbizane of Natal were discovered by B. Lamoral while collecting scorpions along the Orange River in the Richtersveld. An excursion undertaken to attempt to locate the exposure was unsuccessful, but trace fossils in dolomite at Vioolsdrif were noted and some recorded photographically.

The early Ecca Group formations, Prince Albert Formation and Whitehill Formation were included in many studies of the Dwyka, of which they were often considered part. Anderson & McLachlan (1976) discuss stratigraphic correlations. Oelofsen (1986) includes reference to radiolaria which appear to be wide-spread in the Prince Albert Formation. Other occurrences of radiolaria which may be contemporaneous with the Prince Albert Formation or reflect similar palaeoenvironments are recorded in Strydom (1950), and Von Brunn & Gravenor (1983), while references in Bühmann, Bühmann & von Brunn (1989) may also be pertinent.

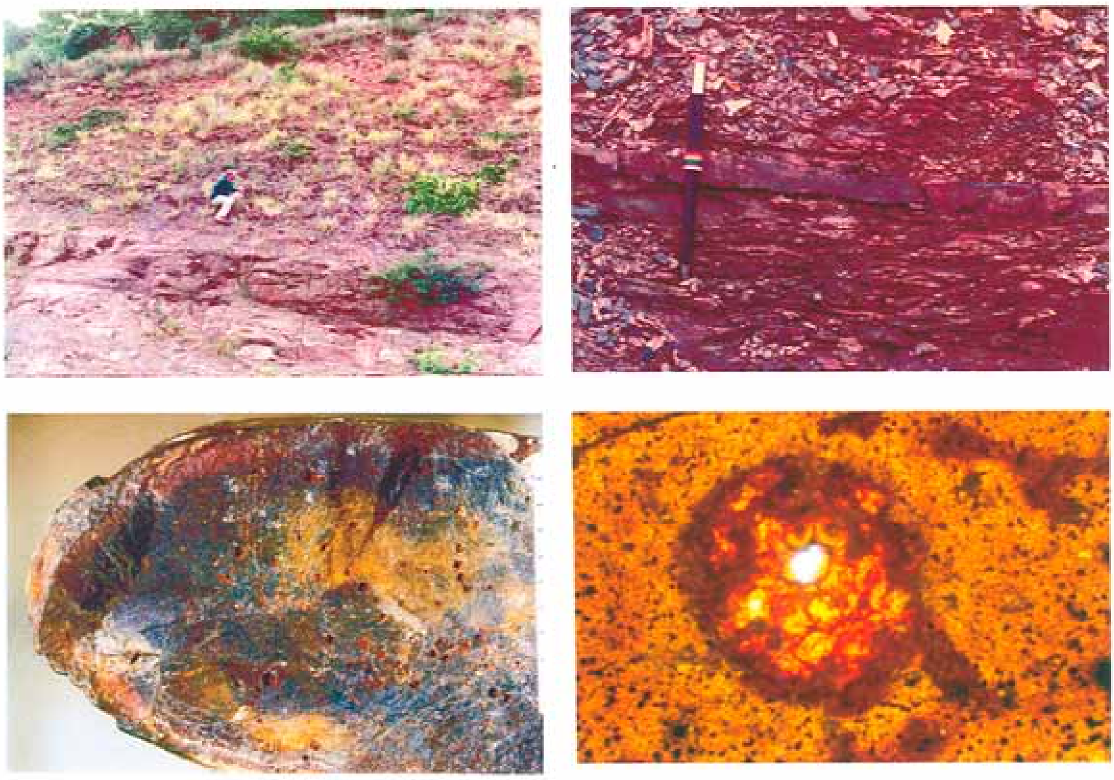
2.3.2.2.2 **Prince Albert Formation** (Botha SACS 1980, p.554)

The sediments overlying the Dwyka Group in the Cape region are referred to as the Prince Albert Formation. In 1986 B.W. Oelofsen described, from near Prince Albert, a chondrocranium of a shark which was embedded in a matrix of radiolarian skeletons. According to Oelofsen (pers. comm.), this radiolarian material is the best he encountered in the numerous sites which he visited while investigating the overlying Whitehill Formation. A piece of material probably from near Prince Albert has very fine radiolarian specimens. Illustration of this material is deferred as continuing research in this field is known to be in progress which might yield even better specimens with precise provenance.

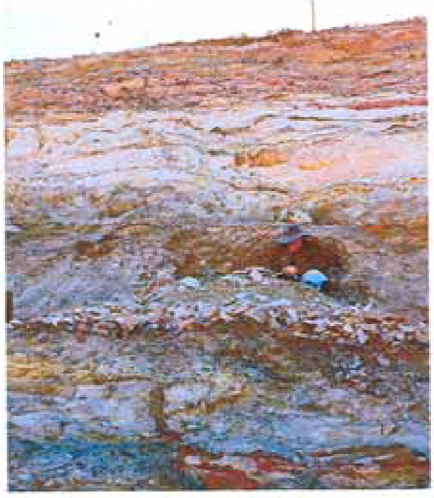
2.3.2.2.3 Pietermaritzburg Formation

The sediments in the Kwazulu-Natal region which overlie the Dwyka Group but are distinct from those of the Mbizane Formation, may, like sediments of that Formation, have dropstones near their base. Close to these dropstones small structures of about uniform size are visible to the naked eye at some sites. At one such locality, in the Umkomaas Valley, investigated by V. von Brunn as part of his work on the Dwyka/Ecca contact, there is a distinct band of harder sediment in which such structures show up as pits. They are of a similar size to the radiolaria associated with the shark chondrocranium described by Oelofsen (1986) from the Prince Albert Formation. Such structure as is visible in slides of the Umkomaas material differs from that seen in Prince Albert material. Nevertheless there is a suggestion of either stratigraphic correlation or similar palaeoenvironmental conditions.

Umkomaas Valley (R56 Road)



Whitehill



Notocaris

Mesosaurus

2.3.2.2.4 Whitehill Formation (Stratten SACS 1980, p.554)

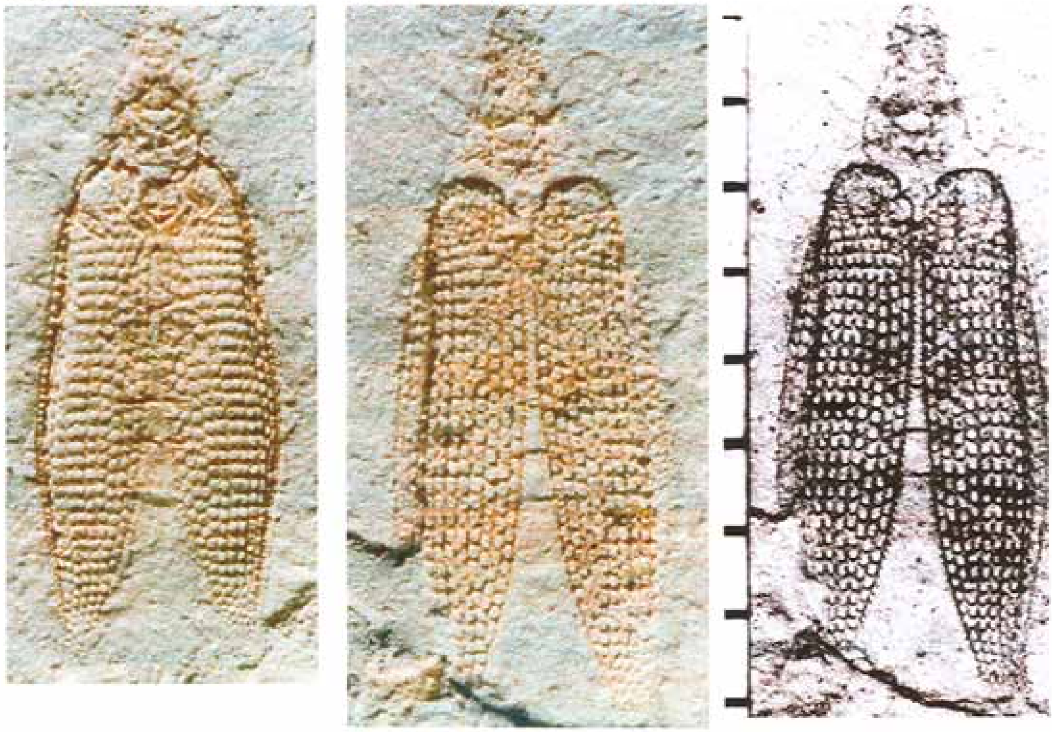
McLachlan & Anderson (1977a), Oelofsen (1981) and Visser (1992) are important references dealing specifically with the Whitehill Formation. The Whitehill Formation was studied at Loeriesfontein during a brief visit, and on several occasions at a road-side quarry at Eilandia, on the farm De Liefde (P. Naude), near Worcester. The latter was apparently first noticed when a nearby exposure was being visited in 1986 in a post-symposium excursion led by B. Oelofsen. The site has since yielded some quite good *Mesosaurus* (reptilian) material, numerous *Notocaris* (crustaceans), and subsequently also insects. A small specimen collected by Miss Lindsay Firm on the site was identified as a fossil beetle, the first insect and still the best insect specimen from the site (*Afrocupes firmae* Geertsema and Van den Heever 1996). McLachlan & Anderson (1977b), Oelofsen (1981) and Geertsema & van den Heever (1996) report on insect fossils from the Whitehill Formation. Oelofsen's specimen was from the nearby site mentioned above (also known as Eilandia), is recorded as having been identified as a coleopterid (pers comm. Van Dijk in Oelofsen *op.cit.*) and is now lost.

A *Mesosaurus* skeleton, of which the head could not found, was collected at the road-side quarry site and is now at Geosciences in Bellville.

Some of the best specimens of *Notocaris* collected were made available to Brazilian palaeontologists K. Adami-Rodrigues and I.D. Pinto, who are working on these and related crustaceans.

Afrocupes firmae was photographed in colour and high contrast black and white, and stereo pairs were also made. (Overleaf)

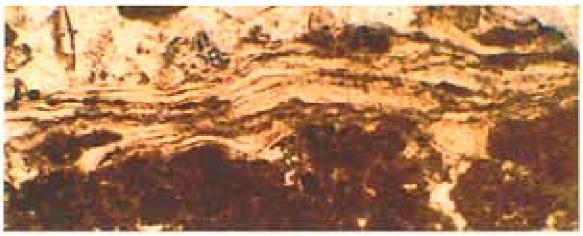
Whitehill



Afrocupes firmae

Investigation of a site to the north in the of the quarry on the same farm in the "Moordkuil"area, by J.A. van den Heever, G. van Heerden and D.E. van Dijk, with the owner, P. Naude, yielded interesting specimens of dark dolomitic layered masses resembling stromatolites.

Two stromatolite-like specimens were collected.



A section showed rounded masses of carbonaceous material, with the appearance of flocculation, and minor presence of layers. Since stromatolites have been considered characteristic of shallow, tidal waters, in the photic zone, and the Whitehill Formation has been regarded as having characteristics of deeper, still water, with anaerobic conditions, the layers could hardly be considered to be conventional stromatolites, dependent on photosynthesis. (Note the inverted commas in the title of McLachlan & Anderson, 1977a). The possibility of the layers being the product of mats of non-photosynthesizing organisms, i.e. bacteria, perhaps anaerobic sulphur- or iron- bacteria, is suggested. (cf. Cole, Smith & Wickens 1990, pp. 19-20, and Cole & McLachlan, 1991). Such mats could promote still water and anaerobic conditions even in relatively shallow water.

2.3.2.2.5 **Tierberg Formation** (Nel SACS 1980, p.554)

Haughton (1919) noted trackways in the "Ecca Beds of the west" of Zak River Estates, now included in the Tierberg Formation. Anderson (1974) refers *inter alia* to Tierberg trackways, including specimens collected by Haughton.

A.E. Channing, visiting the Huguenot Memorial Monument at Franschhoek, with overseas friends, observed that the paving stones of the pathways exhibited trace fossils. Subsequent investigation of the paving-stones under suitable low angle (early morning) lighting, revealed numerous trackways, later (with J.A. van den Heever) found to include vertebrate footprints. According to the Curator of the Museum, Mrs J.E. Malherbe (February 1997) the monument and its paths were built in 1942/1943, and the paving-stones came from the Karoo. The Town Clerk, P. Smit, was able to add that the paving came from Downes, near Calvinia. The slab with the vertebrate tracks was donated by the Museum to the University of Stellenbosch. During a two day visit to Calvinia (Channing and Van Dijk) the original quarry on the farm De Puts, north of Downes, was visited, and trace fossils were observed along the road northwards from west of Downes where streams, notably the Hantamsrivier, produced flat exposures. In July 1999 vertebrate footprints of smaller size were observed on two other slabs at the monument at Franschhoek. Material at the South African Museum collected in the second decade of the 1900's by Haughton at Zakriver Estates was studied. The taxon was named *Quadrispinichina parvia* by Anderson (1974). Kuhn (1958).had, however, already named it *Broomichnium permianum* from a photograph by Abel (1935) of the same specimen as was chosen as holotype by Anderson (*op.cit.*). A paving slab with a few footprints was made available for study by J. Jarvis (via A Channing).

Moulds, casts and replicas of the available material have been made by various techniques, including a rubber mould (J.A. van den Heever and Van Dijk) of the main slab, from which Plaster of Paris replicas have been made.

Fore- and hind- prints cannot be distinguished, nor are there distinct series. This has been observed in other specimens. An interpretation which comes to mind is that an animal of almost neutral bouyancy has thrust against the substrate, rather than that an animal has walked over the substrate. Notable is that the proximal parts of the inner two digits leave concave impressions, while the distal parts leave convex ones, such as might result from pressure between the middle two digits and one either side of them, perhaps by a web.

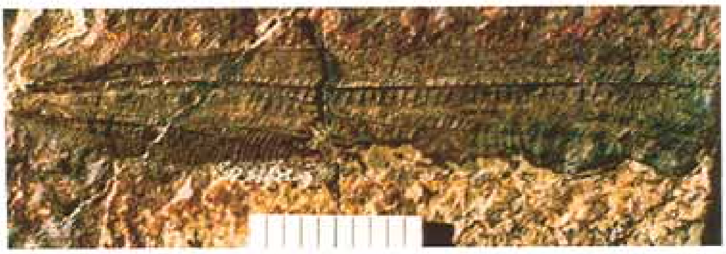
A paper on *Broomichnium* has been submitted (Van Dijk, Channing & Van den Heever).

Broomichnium permianum Kuhn 1958 ex De Puts, near Calvinia.

2.3.2.2.6 **Laingsburg Formation** (Theron 1967)

A site 2 km west of Laingsburg, by the national road, was visited on several occasions and specimens of trace fossils were collected.

In 1998 an insect specimen in the possession of Roy Oosthuizen, now deceased, of Prince Albert, collected at the Laingsburg site by B.J. Oelofsen, was borrowed and described (Geertsema & Van Dijk, 1999) as *Afroedischia oosthuizeni*. It is one of the very few insects known from the Ecca (*op.cit.*).



Afroedischia oosthuizeni

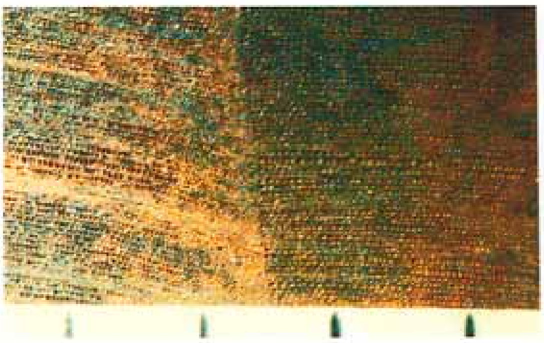
2.3.2.2.7 **Vryheid Formation** (Ryan SACS 1980, p.554)

The Vryheid Formation palaeoenvironments and ichnology were investigated by Hobday and associates in the Muden area (Hobday & Tavener-Smith, 1975). Some trace-fossils were observed in cuttings in the Muden area, but not recorded.

2.3.2.2.7.1 **Dayeni**

A small slab was collected at the roadside within sight of the Dayeni school, near Ulundi. It contained lycopod stems and (detached) leaves, provisionally identified as *Cyclodendon*, part of a glossopterid leaf, and burrows. This is apparently the only known occurrence of lycopsids in Kwa-Zulu Natal.

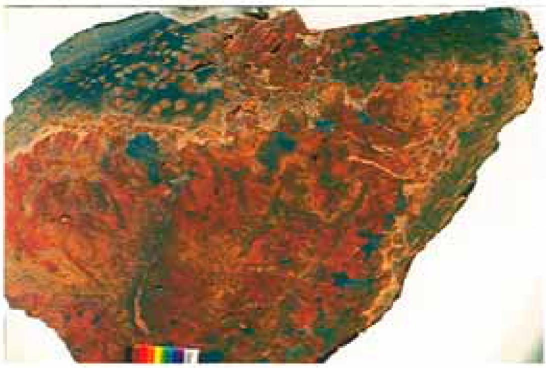
Pieces of fossil wood identified as having been collected in Zululand, presumably from the Vryheid Formation, were studied, and showed that good preservation of detail does occur, although arrangement of pits in the tracheids could not be reliably determined.

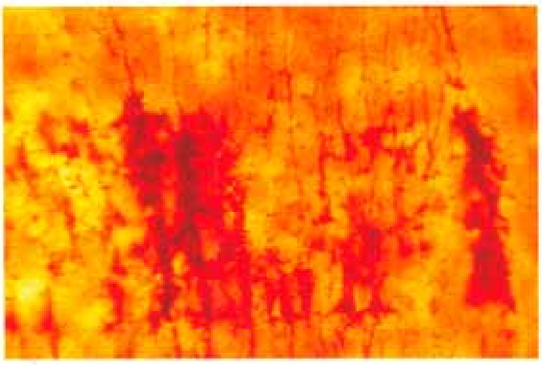


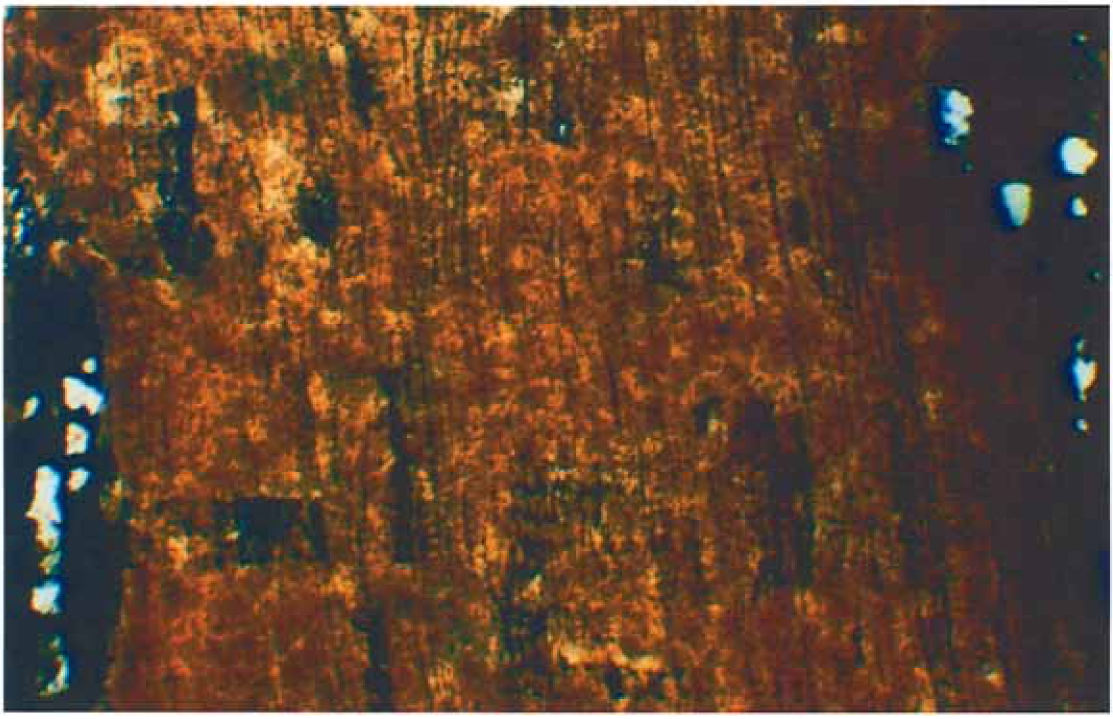
2.3.2.2.7.2 Pondwane-Ngwibi

A specimen of wood from the Pondwana-Ngwibi area, near the origin of the Swart Umfolozi in Northern Natal, is the only example exhibiting ferruginization available with a collection locality. Since well-ferruginized wood is more resistant to weathering than associated shales, other specimens collected may have been remote from the sites of origin. The Pondwana specimen shows patches of ferruginization, and indications that the process of ferruginization was interrupted.

Scanning Electron Microscopy and Micro-Probe Analysis showed Calcium and Phosphorus predominant in the zones not replaced by Iron.







2.3.2.2.7.3 Ermelo

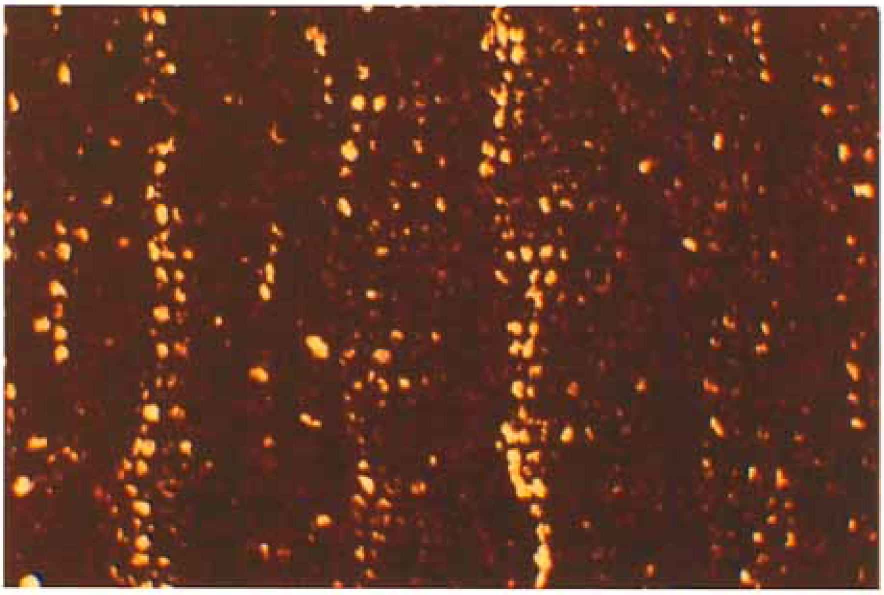
A site near Ermelo, known for some time to the Geological Survey, was visited with H.M. Anderson and C. MacRae. When a Brunton compass was used to measure slope of the surface, it was noticed that the sediments are strongly magnetic. The shadow of a plumb line at 12 noon was used to obtain a North reference, and some sediments were marked for possible palaeomagnetic studies. No results of any studies are known to me.

The following are recorded fossils (identifications from Anderson & Anderson,1985):

Lycopsida
Cyclodendron leslii (Seward) Kräusel 1928
Glossopteridales
Ottokaria cf. obovata (Carr 1869) comb.nov. And.&And.1985 p.112
Scutum ermeloensis sp.nov. And.&And.1985 p.117
Scutum ermeloensis megasporophyll
Hirsutum leslii leaf (Thomas 1921) Smithies comb.nov.
Cordiatales
Noeggerathiopsis hislopii (Bunbury 1861) Feistmantel 1889

Pieces of ferruginized wood are present. They appear to be twigs lying flat among the fossilized leaves. Fossilization probably occurred in a bog which contained iron bacteria, for the fine detail preserved, together with the large amount, suggests that the iron oxide is not of secondary origin.

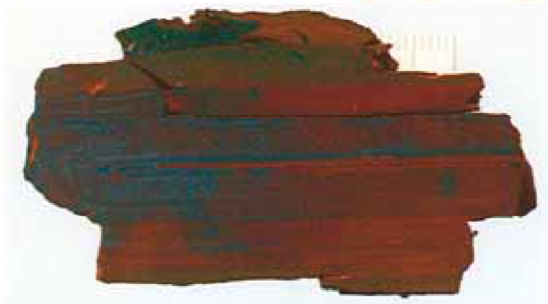
A twig approximately 12mm wide had more than 30 growth rings, visible in a cut surface, and in sections, such as is illustrated at higher magnification (length of portion photographed approx. 1mm).



2.3.2.2.7.4 Roodekrans (near Ventersdorp)

Iron-rich rock mined here by Rand London Manganese Mine contains similar glossopterid and cordiatalian leaves to the site at Ermelo. No Karoo sediments are shown in the vicinity on the 1: 1 000 000 Geological Map. A contact address of some years ago was 104 von Brandis St, Krugersdorp. The name of the student who brought the sample to Pietermaritzburg is unfortunately no longer legible on the label which accompanied the specimens.






Layers in a vertical slice of the ironstone can be seen where there are impressions of leaves. The lower illustration is of a layer from a vertical slice.

2.3.2.2.7.5 Van Dyk Mine

A core from Van Dyk Mine in the Transvaal Coalfields showed burrows. (Compare Estcourt Formation, Spioenkopdam).

2.3.2.2.8 **Volksrust Formation** (Johnson SACS 1980, p.554)

2.3.2.2.8.1 **Ladysmith**

Nodules with fragmentary fishes were collected from a road-side donga south of Ladysmith (cf. Hatch 1910, Woodward, 1910, Jubb & Gardiner, 1975).

2.3.2.2.8.2 **Weenen**

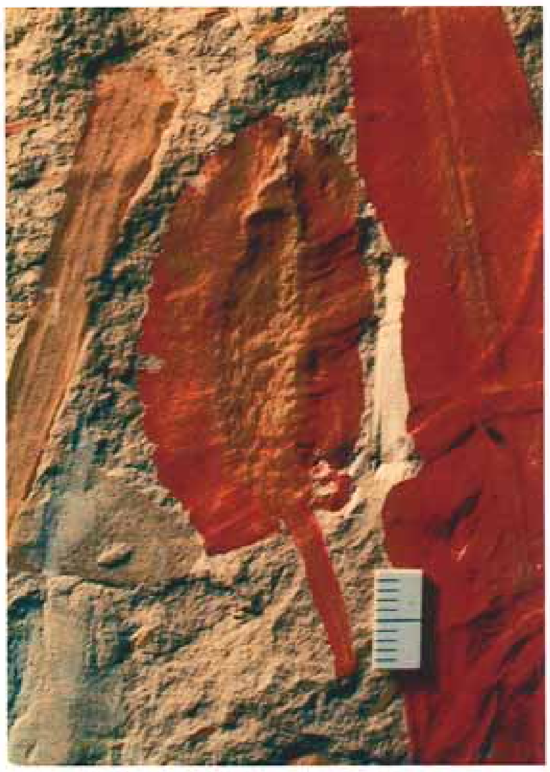
A small slab from Weenen has impressions of conchostracan shells and fish scales on it. The conchostracan shells (upper photograph) are considerably larger than the fish scales (both scales 10 mm wide).

Sites at Cedara and Hilton probably belong in the Volksrust Formation.

2.3.2.2.8.3. **Maidstone, Cedara**

A site with a glossopterid flora with large leaves and seeds was discovered by A.J. Tankard at St. Joseph's Scholasticate, Cedara, and on the farm Maidstone. The site was one of those reported at a 67th Congress of the South African Association for the Advancement of Science, held in Pietermaritzburg in 1969. The site was visited and collecting done by a number of palaeobotanists, including E.P. Plumstead and students of the Bernard Price Institute for Palaeontology, Johannesburg, E. Kovács-Endrödy of the Geological Survey, Pretoria, and H.M. Anderson and J.M. Anderson of the above Bernard Price Institute, and later the National Botanical Research Institute, Pretoria. This is one of the sites at which no insects have been found among the large number of plant fossils. Not uncommon are *Ottokaria*-like fructifications, including NM 2546, included in the paradigm of *Hirsutum acaderense* sp.nov. Anderson & Anderson, 1985.

▲
Perdita, André and Jacques van Dijk and Éva Kovács-Endrödy



Detached fructification NM 2546; and leaf base showing abcission zone ▶

Umgeni Valley

The farm Maidstone is at the top of a cliff above the Umgeni valley, above a dolerite sill which is prominently exposed at the Howick Falls, to the northwest. A search for other exposures of fossil-bearing shales revealed an inferior one in the Umgeni Valley Game Ranch educational conservation area, accessible from the Karkloof road from Howick.

Hilton College

Creighton

At Hilton College, to the north-northeast, burrows were found in similar light-coloured shales. Burrows were also seen in a stream to the south of the college.

Several specimens of a trace fossil were observed in the shale alongside the Umzimkulu River near Creighton.

Estcourt to Weenen

2.3.2.3 **BEAUFORT Group**

Rubidge *et al.* (1955) reviewed the biostratigraphy of the Beaufort Group.

Permian System, Upper

2..3.2.3.1 **Estcourt Formation** (Linstrom, 1973 SACS 1980, p.552)

The Estcourt Formation has an rich flora and fauna, especially if a site at Lidgetton is included within its lower limits, and another in Bulwer within its upper limits. These inclusions are indicated by similar conditions for preservation of plant and animal fossils as occur at a site such as Mooi River. Lacey, Van Dijk & Gordon-Gray (1974; 1975) discuss the plant fossils of the Mooi River site, and Riek (1973; 1974a; 1976) and Van Dijk & Geertsema (1999) the insect fossils. The discussion of Bay Facies in Van Dijk, Hobday & Tankard (1978) is applicable to the palaeoenvironment of most Estcourt Formation sites. Green (1998) is devoted to Estcourt palaeoenvironments, especially in regard to a site in Estcourt. Van Dijk (1981) deals with the Lidgetton site, Anderson & Anderson (1985) include many plant fossils from the Estcourt formation, and Van Dijk (1997, Erratum 1998) deals with the insects at different sites in the Estcourt formation. The Estcourt Formation has been extensively collected and continuing research is in progress.

2.3.2.3.1.1 **Estcourt to Weenen**

Specimens of the glossopterid rhizome *Vertebraria* and a bivalve (identified by Rilett, 1975, as "*Palaeomutela subparallela* Amalitsky, previously known from the Lower to Upper Permian of Russia and the Permian of Tanzania...") were collected in shales at road-works between Estcourt and Weenen, apparently in the Estcourt Formation.

2.3.2.3.1.2 Spioenkop Dam

Near Spioenkop Dam a slab was collected which had numerous largely vertical burrows. Similar burrows were seen in a core from Van Dyk Mine in the Transvaal coalfields (Volksrust Formation). Dark mud from the surface is trailed into the burrows. The appearance in horizontal section is similar to that observed incidentally on some modern-day beaches (e.g. Sardinia Bay near Port Elizabeth).

Lidgetton

The circumstances of the discovery by A.O.D. Mogg of a small fossiliferous exposure on the farm Bellavista, Lidgetton, KwaZulu-Natal have been placed on record (Van Dijk, 1981), with a summary of knowledge of the fossils up to the date of that publication.

In addition to fragments of insects observed in Hydrofluoric Acid digests, the survival of the substance of a wing was proved by a peel of an unimportant fragment.

The small original exposure and subsequent exposures were in a streambed, now covered by a dam. Further work upstream or outwards might be possible. An insect fragment (1mm broad) from an HF digest is illustrated.

References: Thomas, H.H. (1958); Van Dijk, Gordon-Gray & Lacey (1975); Gordon-Gray, van Dijk & Lacey (1976); Riek (1976); Van Dijk, Hobday & Tankard (1978); Van Dijk (1981); Van Dijk (1998); Van Dijk & Geertsema (1999).

A brief summary of the fossils follows.

Bryophyta

Buthelezia mooiensis Lacey *et al.* 1975

Sphenopsida

cf. *Neocalamites*

(*Phyllotheca australis* of And. & And. 1985)

Pteropsida

Sphenopteris fragments

Glossopteridales

Leaves of 3 glossopterid species; scale leaves

(*Lidgettonia africana* of And.& And.1985)

(*Glossopteris symmetrifolia* of And.&And.1985)

Lidgettonia africana Thomas 1958 Type locality

Plumsteadia megasporangium

(?Ottocariaceae fruit of And.&And.1985)

seeds (*Arberiella*); microsporangia (*Eretmonia*); rhizomes (*Vertebraria*)

Cordiatales

Wood (pyritized)

Spores

Invertebrate Ichnia, including crustacean

Crustacea

Conchostraca

2 types (one of which cf. *Leaia*)

Insecta

A possible machilid apterygote, inadequate for description

Perlaria

Euxenoperla oliveri Riek 1976 NM 923a,b Holotype

(p.769; p.759 Fig.9; Plate 2 Fig.5 on p. 768)

Nymphs

Protorthoptera

Mioloptera stuckenbergi Riek 1973

Mioloptoides andrei Riek 1976

Homoptera

Beaufortiscus dixi Riek 1976 NM 950a,b Holotype, NM 928a,b Paratype

(p.779; p.767 Fig. 15; Plate 5 Fig. on p. 783)

hind-wing NM 958a,b (vD&G pp.144-145; Figs 17&18 on pp. 158-159)

Permocicada thompsoni Van Dijk & Geertsema 1999 NM 982 Holotype

(p.145; Figs 23&24 on pp. 160-161)

Undescribed specimens, including a whole insect and body parts

Blattaria

Aleuronympha bibulla Riek 1974

Specimens related to *Aleuronympha bibulla*

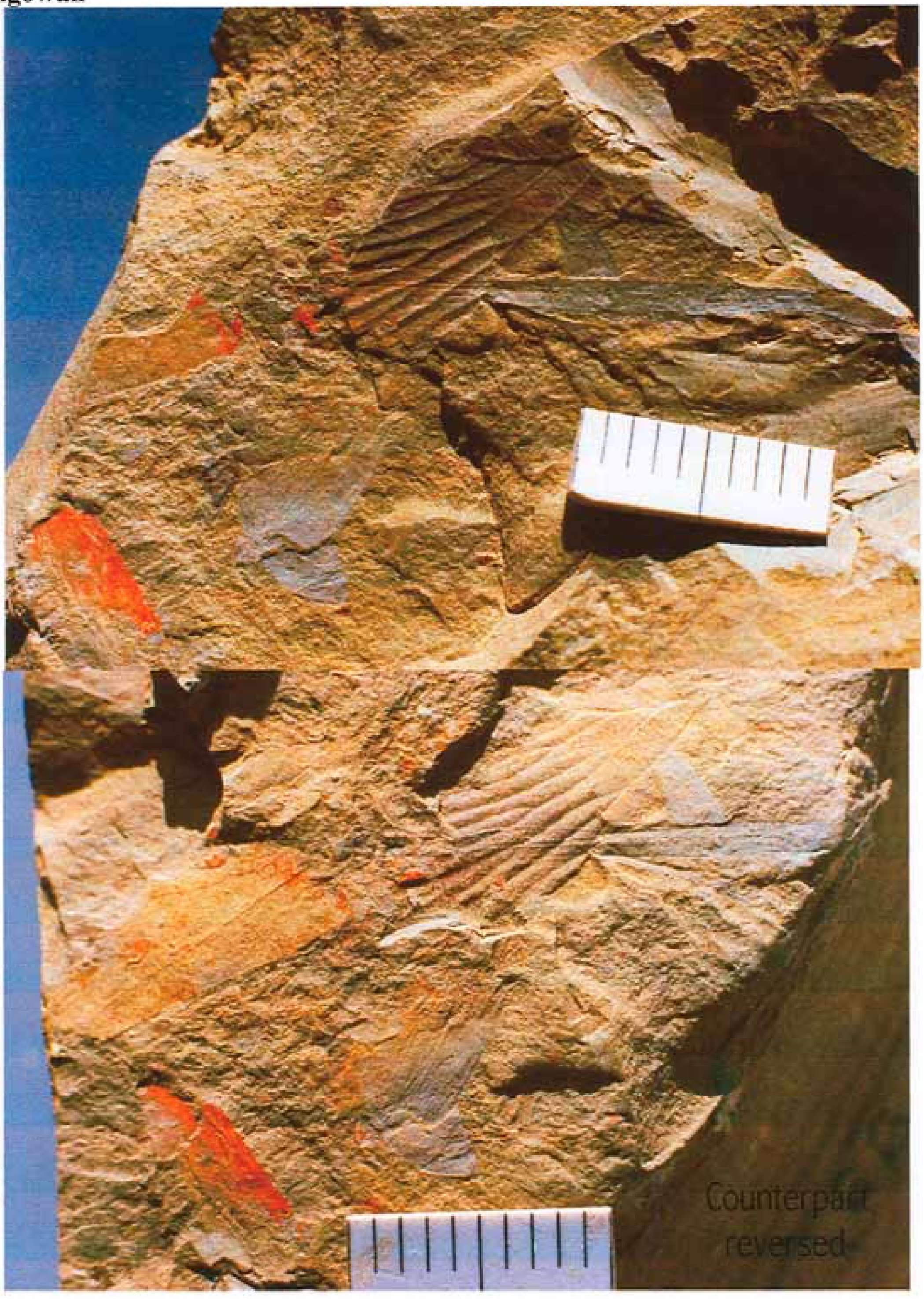
Coleoptera

Undescribed specimen

Teleostei

Fish scales

Balgowan



Fragmentary specimens of the following are present: Homopteran (top centre); Odonatan (transverse above centre); small wing near vertical between these; Mecopteran? (top left in counterpart); Orthopteran (centre left); conchostracan (bottom centre); ? folded wing (bottom left)

2.3.2.3.1.4 Balgowan

In August 1976 while travelling from the N2 Highway to Balgowan a stop was made at a cutting on the East side of the road 3km short of Balgowan. At first only trace fossils in somewhat silty layers were noticed, but Miss Perdita van Dijk drew attention to a corner slightly lower down with finer sediments. Subsequent visits yielded many fossil insects and remarkably few plant fossils. The presence of concentrations of insect fossils suggested a sorting process, presumably at the surface of small eddies. Areas of red pigmentation on several wings suggested that they were floating until fine sediment encroaching on them made them sink. The amount of concentration is well illustrated by a group of overlapping wings.

A brief summary of the fossils is the following:

Glossopteridales

Leaves of 2 or 3 glossopterid species

(*Glossopteris symmetrifolia* of And.& And.1985)

Lidgettonia

Invertebrate trace fossils

Crustacea

Conchostraca

1 species

Insecta

Odonata

Permolestidae? 2 specimens

(VanDijk&Geertsema1999 pp.141-142, Figs 3&4 on pp.152-153)

Homoptera

Ignotala ?mirifica Riek 1973

Megoniella multinerva Riek 1973

cf. *Beaufortiscus* fore-wing and hind-wing (NM 2527a,b and NM 2536)

(VanDijk&Geertsema1999 p.142, Figs 19&20 and 21&22 on pp.158-159)

Permocicada 3 species (NM 2542a,b; NM 2543a,b; NM2545a,b)

(VanDijk&Geertsema1999 pp.145-146,Figs25&26,27&28and 29&30 on pp.160-161)

parts of the third species including head, thorax and wings (NM2546a,ab)

Stenotegmocicada triclades vD&G1999 NM2553Holotype;NM2554a,bPara (hind)

(p.146; Figs 31&32 and 33&34 on pp.162-163)

Undescribed specimen ?*Orthoscytina*

Coleoptera

2 undescribed specimens (different species)

Miomoptera

2 isolated wings, fore- and hind-, close to *Permonka bifida* Riek 1973

? *Palaeomantis* wing NM 2528a,b

(VanDijk&Geertsema1999 p.147, Figs 37&38 on pp. 164-165)

Neuroptera

cf. Permithone NM 2568a,b

(VanDijk&Geertsema1999 p.147; Figs 39&40 on pp. 166-167)

? *Permopsychops* wing NM 2570

(VanDijk&Geertsema1999 p.147; Figs 41&42 on pp. 168-169)

Mecoptera

? Permochoristidae fore-wing NM 2561

(VanDijk&Geertsema1999 p.148; Figs 49&50 on pp.168-169)

Prochoristella balgowanensis VanDijk&Geertsema 1999 NM 2564a,b Holotype

(p.149; Figs 51&52 on pp.170-171)

Since the insect fossils include a number represented by single good specimens, and many were observed which were inadequate for description, the site could be expected to yield much useful material if further studied. This would present little difficulty if the cooperation of the owner of the farm to the East of the site could be obtained.

References:

Van Dijk (1981); Van Dijk & Geertsema (1999).

Rosetta

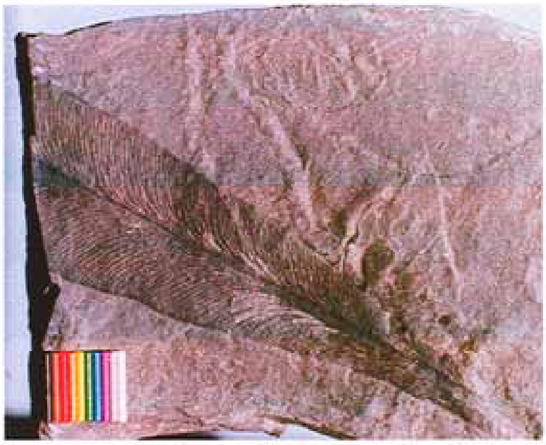
Crevasse seen cutting through upward-fining sediments capped by sandstone

Opposite side of road (W) showing nodules in fine sediments of levee

Schizoneura

Raniganjia

Sphenopteris frond from below nodule



Glossopteris leaf and trace fossils

2.3.2.3.1.5 Rosetta

The road between Rosetta and Mooi River has deep flanks where it passes under a railway line. Fossils were probably observed there for many years before very good fossils were noted in a thin seam The site was brought to the attention of sedimentologist D.K. Hobday, who was able to throw light on the sedimentary environment of the fossils and also detail the associated crevasse splay (cf. Van Dijk, Hobday & Tankard, 1978).

The exposure is an upward-fining sequence with a row of carbonate concretions near the top, followed by a sandstone. The lower parts of the sequence has impressions of sphenopsid stems and glossopterid leaves, while the best fossils occur in a thin highly carbonaceous layer immediately below the series of concretions. The upper part of the sequence represents a levee, where evaporation resulted in the concentration of carbonates, which later formed the concretions. A crevasse broaching the levee can be seen on either side of the road near the Rosetta end of the exposure.

The fossils are as follows:

Sphenopsida

Schizoneura (not recorded in Anderson & Anderson 1985)

? *Raniganjia*) (not recorded in Anderson & Anderson 1985

sphenopsid stem impressions (not recorded in Anderson & Anderson 1985)

Pteropsida

Sphenopteris fronds with and without sori

(*Sphenopteris lobifolia* in And.&And.1985 Plate 49 Fig. 9)

Glossopteridales

At least 3 types of glossopterid leaves

(And.& And.record 3 taxa: *Lidgettonia africana; L. lidgettonioides; Glossopteris symmetrifolia*)

Invertebrate trace fossils

Mooi River

Construction of the National Road near Mooi River exposed a large fossiliferous area. The material had to be collected rapidly, as muddy water quickly soaked down through cracks and into bedding planes, as seen on the right and bottom of the slab. The specimens were plentiful without too much overlap.

The first *Lidgettonia* with a seed in a cupule (enlargement) is on the left of the slab.

2.3.2.3.1.6 Mooi River

Brian Schaller, engineer of Estcourt, in 1971 or 1972 drew attention to an access road from Estcourt to Mooi River along the road-works for the National Road, which had been completed, allowing examination of the exposed surface. Such an examination, beginning at the Estcourt end, was undertaken (V. von Brunn of the Geology Department, University of Natal, D. E. van Dijk & Brian Schaller) revealed a few exposures with fossil leaves. Just short of Grantleigh Spruit, north of Mooi River, a massive exposure of fossil plants in the road-works was encountered, and subsequently extensive collecting was undertaken.

The palaeobotanists Heidi and John Anderson were alerted to the exposure and also collected specimens, for the Bernard Price Institute for Palaeontological Research of the University of Witwatersrand. Within a few days of the exposure being discovered, fossils insects were observed. The first collected became the type of *Mioloptera stuckenbergi* Riek 1973. At that stage only four palaeozoic insects were known from Africa. The Mooi River site was one of those mentioned at the 67th Congress of the South African Association for the Advancement of Science (Van Dijk, Tankard, von Brunn & Gordon-Gray, 1969).

One thousand five hundred hand specimens were prepared of fossil plants and housed in the Natal Museum (NM 1001 to NM 2500). W. S. Lacey from Wales, who had experience of the Wankie (Zimbabwe) plant fossils, was invited to study the material with Kathleen Gordon-Gray of the Botany Department, University of Natal. Several papers followed from 1974, the most comprehensive being Lacey, Van Dijk & Gordon-Gray (1975).

Edgar Riek, who had extensive knowledge of the Australian fossil insect fauna, was invited to study the fossil insects at Mooi River (Riek, 1973, 1974a, 1976).

The following is a list of plant taxa, with indications of the different interpretations of Anderson & Anderson 1985 added in parenthesis and smaller font. It must be emphasized that interpretations based on coexistence of entities in a sample, and even several samples, are subject to revision.

Bryophyta

Buthelezia mooiensis gen. et sp.nov. Lacey *et al.* 1975 pp.411-413
NM1880a,b;1871a,b;1872a,b; 1875
(p.95; Plate 17 Figs 1-4 on p. 192 And &And 1985)

Sphenopsida

Phyllotheca australis Brongniart Lacey *et al.* 1975 pp.354-355
(p.102; Plate 40 Figs 11-12, 14-15 on p. 215 And. & And. 1985)
cf. etheridgei Aber Lacey *et al.* 1975 pp. 354-355
(*P. australis* vide supra Fig. 13)
cf. *Raniganjia bengalensis* (Feistmantel) Rigby Lacey *et al.* 1975 pp.355-357
(pp.100-101 *Raniganjia kilburnensis* And. & And. 1985)
Sphenophyllum speciosum (Royle) McClelland Lacey *et al.* 1975 pp.357-358
(p.99; Plate 32 Figs 7-10 And. & And. 1985)

Pteropsida

Filicales

Sphenopteris alata (Brongniart) Brongniart Lacey *et al.* 1975 pp.357-359
(*S. lobifolia* Morris 1845; p.105, Plate 49 Figs 1-8 on p.224 And. & And. 1985)

Gymnospermopsida

Glossopteridales

Glossopteris browniana Brongniart Lacey *et al.* 1975 p.361, pp.362-363, p.364
(*Lidgettonia mooiriverensis* pp.132-134, Plates 117&118 on pp.292-293 A&A 1985)
indica Schimper Lacey *et al.* 1975 p.361, pp.362-363, pp.366-367
(*Lidgettonia africana*; *L. mooiriverensis*; *Glossopteris symmetrifolia* A&A1985)
angustifolia Brongniart Lacey *et al.* 1975 p.361, pp.362-363, p.368
(*Lidgettonia elegans* in And.&And. 1985, vide infra *Rusangea*)
cf. leptoneura Bunbury Lacey *et al.* 1975 p.361, pp. 362-363, p.369
feistmantelii Rigby Lacey *et al.* 1975 pp.361-362, pp.362-363, p.370
(*Estcourtia vandijki* And.&And. 1983, vide infra *Scutum conspicuum*)
conspicua Feistmantel(*Scutum conspicuum*)Lacey *et al.* 1975pp.362-363,365,370
(*Estcourtia vandijki* And.&And. 1983, vide infra *Scutum conspicuum*)
cf. ampla Dana Lacey *et al.* 1975 pp.362-363, p.365, p.371
(*G. symmetrifolia* And.&And. 1985, p.139; Plate 138 on p. 313)
elongata Dana 1849 Lacey *et al.* 1975 pp.362-363, p.365, p.372
(*Rigbya arberioides* Lacey *et al.* 1975, vide infra, in And.&And.1985)
Belemnopteris elongata sp.nov. Lacey *et al.* 1975 pp.362-363, 373, 374-375
NM1772;1751;1741
(*Rigbya arberioides* Lacey *et al.* 1975; p.127 Plate 101 on p.276 And.&And.1985)
NM 1743; 1750 vide supra
(*Estcourtia vandijki* p.126, Plate 96 on p. 271 And.&And. 1985)

Glossopterid scale leaves
(allocated to various species in And.&And.1985)
Eretmonia natalensis Du Toit Lacey *et al.* 1975 pp.378-384
(*Lidgettonia africana; L. mooiriverensis; L. inhluzanensis* in And.&And.1985)
Arberiella sp. (detached microsporangia) Lacey *et al.* 1975 p.384, p.383
Lidgettonia africana Thomas 1958 Lacey *et al.* 1975 pp. 384-389
(*L. africana* pp.133-134, Pl. 113 on p.288; *L. mooiriverensis* Pl. 115 on p.290 A&A)
Mooia lidgettonoides gen. et sp. Lacey *et al.* 1975 pp.389-392
NM 1476a,b; 1479a,b; 1471a,b; 1533; 1539; 1576a,b;1579; 1474
(*Lidgettonia lidgettonoides* p.133, p.136 Plate 125 on p.300 And.&And. 1985)
Rusangea elegans gen. et. sp. Lacey *et al.* 1975 pp.392-394
NM1362a,b; 1363a,b; 1361a,b; 1384a,b
(*Lidgettonia elegans* comb.nov. p.133, p.136, Plate 131 Figs 1-4, 7 And.&And.1985)
Scutum conspicuum comb.nov. Lacey *et al.* 1975 pp.394-395
NM1276a,b
(*Estcourtia vandijkii* And. & And. 1983; pp.125-126, Plate 96 on p.271 A&A1985)
Plumsteadia natalensis sp. Lacey *et al.* 1975 pp. 396-399
NM 1260; 1243a,b; 1265; 1274a,b; 1257
(p.124; Plate 92 on p. 267 And.&And.1985)
Rigbya arberioides gen.et.sp. Lacey *et al.* 1975 pp. 409-411
NM1644a,b;1646a,b;1669a,b;1650,1656
(p.127 Plate 101 Figs 1, 3, 6 on p.276 And.&And.1985)
Seeds Lacey *et al.* 1975 399-407
(assigned to various taxa in And.& And.1985)

Coniferopsida

Cordiathales

Noeggerathiopsis hislopii (Bunbury) Feistmantel Lacey *et al.* 1975 pp. 407-408
(*N. spathulata*)
Axes with leaf cushions - ? *Noeggerathiopsis*

?Undescribed taxa:

The following is a list of animal fossils:

Crustacea

Conchostraca

1 species

Insecta

Megasecoptera

Karoohymen delicatulus Riek 1976 NM 850 Holotype; NM 847, 846a,b Paratypes
(pp.757-758; p.759; p.760 Plate 1 Fig.1)

minutus Van Dijk & Geertsema 1999 NM 885a,b Holotype
(p.144; Figs 1&2 on pp.152-153)

Perlaria

Euxenoperla simplex Riek 1973 NM 845a,b Holotype; NM 851 Paratype
(pp.521-522; p.519; Plate I on p. 517; Riek 1976 p.769, p.768 Plate 2 Fig.3)
(*Euxenoperla similis* Riek 1973 cf. Riek 1976 pp.766-767, probably synonym of *E.simplex*)

Euxenoperla oliveri Riek 1976 NM 861 Paratype
(p.769)

spp. Riek 1976 (pp.769-780; p.759; p768 Plate 2 Fig.4)

Euxenoperlella jacquesi Riek 1976 NM 922 Holotype
(p.770; p.759; p.771 Plate 3 Fig.1)

Protorthoptera

Mioloptera stuckenbergi Riek 1973 NM 850 Holotype; NM 847, 846a,b Paratypes
(p.515; p.516; p.517 Plate1; Riek1976pp.758-761 Figs 2&3 Pl.1Figs2&3)

Liomoptoides similis Riek 1973
(pp.515&518; p. 516; Riek 1976 no comments)

Liomopterina clara Riek 1973 NM 854a,b Holotype Probably synonym of above
(p.518; p.516; Plate 1 on p.517; Riek 1976 p.761, p.760 Plate 1 Fig.6)

Mioloptoides andrei Riek 1976 NM 852a,b Holotype
(p.761;p.759 Fig.4; p.760 Plate 1Fig.5)

Paolekia perditae Riek 1976 NM 940a,b Holotype
(pp.763-764; p.759; p.760 Plate 1 Fig.8)

Protelytroptera

Phyllelytron acuminatum Riek 1976 BPI N-MN 52 Holotype;
BPI N-MN 71, NM 867 Paratypes
(pp.773-774; p.771 Plate 3 Fig.5)

Orthoptera

Protettavus exilis Riek 1976 NM 924a,b Holotype
(pp.764-765; p.759; p.768 Plate 2 Fig.1)

Eolocustopsis primitiva Riek 1976 NM 855 Holotype
(pp.765-766; p.759; p.768 Plate 2 Fig.2)

Homoptera

/overleaf

Homoptera

Ignotala mirifica Reik 1973 BPI N-MN 3a,b; NM 868 Paratype
(pp.522-523; p.524; p.525 Plate 2 Figs 1,2,5; Riek 1976 pp.774-775)

Megoniella multinerva Riek 1973 NM 849 Holotype; NM 871 Paratype
(p.526; p.524; p.525 Pl.2 Fig.3; Riek 1976 p.775, p.767Fg13, p.776Pl.4Fg1)

Neurobole ramosa Riek 1976 BPI N-MN 32 Holotype
(pp.779-780; p. 767; p.776 Plate 4 Fig.4)

Austroprosboloides vandijki Riek 1973 NM 844a,b Holotype; BPI N-MN 4 Paratype
(p.527; p.524; p.525 Pl. 2 Fig.4; Riek1976 p.780,p.767Fg.18, p.776Pl.4Fg5)

Orthoscytina dubitata Riek 1976 NM 873a,b Holotype
(pp.777-778; p.767; p.776 Plate 4 Fig.3)

Perissovena heidiae Riek 1976 BPI N-MN 50 Holotype
(pp. 775-776; p.767; p.776 Plate 4 Fig.2)

Redactineura acuminata Riek 1973 NM 849 Holotype
(pp. 529; p. 529; p.525 Plate 2 Fig.9; Riek 1976 no comments)

Protopsyllidium lynae Riek 1976 NM 874a,b Holotype
(pp.781-782; p.767; p.783 Plate 5 Fig.4)

Blattaria

Aleuronympha bibulla Riek 1974 NM 875a,b Holotype
(pp.271-274; Fig. 1 on p. 273; Riek 1976 p.782)

Miomoptera

Permonka bifida Reik 1973 NM 843a,b Holotype
(p.520; p.519; p.517 Pl. 1 Fig.8; Riek 1976 pp.772-773,p.771Pl. 3 Figs 2,4)

Neuroptera

Sismerobius pusillus Riek 1976 NM 938 Holotype
(pp.787-788; p.785; p.786 Plate 6 Fig.8)

cf. Archeosmylidae Riek 1976 NM 937a,b
(p.788; p.785; p.786 Plate 6 Fig.6)

Trichoptera?

cf. Cladistochorista Van Dijk & Geertsema 1999 NM 2700a,b
(p.148; pp.164-165 Figs 45&46)

Mecoptera

Agetochorista similis Riek 1973 BPI N-MN 2a,b Holotype
(pp.530-531; p.529; p.525 Plate 2 Fig.7; Riek 1976 no comments)

Mesochorista aff. *australica* Riek 1976 NM 930a,b; 878a,b
(p.784; p.785; p.786 Plate 6 Figs.1,2)

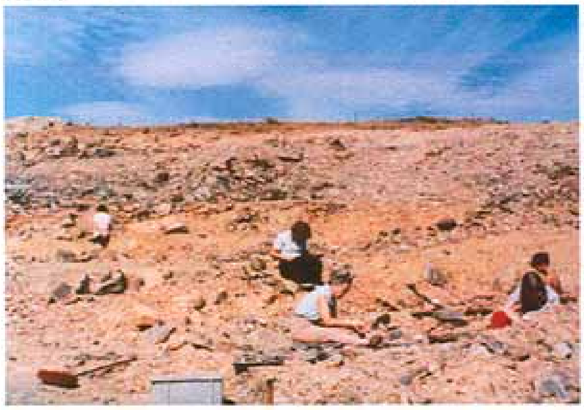
Mesochorista channingi Riek 1976 NM 877a,b Holotype
(p.784; p.785; p.786 Plate 6 Fig. 3)

Prochoristella hartmani Riek 1976 NM 900a,b Holotype; BPl N-MN 23a,b Paratype
(pp.785-786; p.785; p.786 Plate 6 Figs 4,5,7)

Prochoristella sp. indet. Riek 1976 NM 932a,b
(p.786)

cf. Nannochoristidae? Riek 1976 NM 934a,b
(p.786)

FarEnd



Specimens are usually very crowded, with much overlapping (cf. reticulate glossopterid leaf top right and *Sphenophyllum* mid left). A *Sphenopteris* frond, an unusual glossopterid leaf, a cone-like group of scales and a *Plumsteadia* are figured.

2.3.2.3.1.7 Far End

While the surface exposed by the excavations for the National Road near Mooi River was being studied, quarrying began above the road on the farm Far End, within a few metres of the road. The material in the quarry was different, suggesting a different palaeoenvironment. There was also alteration caused by the presence of dolerite intrusions nearby. The matrix is very friable. The palaeoflora and –fauna is much more restricted, nevertheless some new taxa have come from the site.

A considerable amount of material was collected, some still being studied.

Sphenopsida
Sphenophyllum speciosum
Phyllotheca australis
Pteropsida
Filicales
Sphenopteris alata (*S. lobofolia* in And.&And.1985)
Glossopteridales
Plumsteadia natalensis megasporophyll
Plumsteadia gibbosa Benecke 1976 megasporophyll
Rigbya arberioides megasporophyll
Lidgettonia africana megasporophyll (*L.inhluzanensis* in And.&And.1985)
4 or more types of leaf
(*Plumsteadia gibbosa;Rigbya arberioides;Ligettonia inhluzanensis;L. lidgettonoides* of A&A)
Cone
Coniferales
Pagiophyllum vandijkii And.&And1985

Insecta
Odonata
? Permaeschnidae – a fragment of a wing
(Van Dijk & Geertsema 1999 p. 142; pp.152-153 Figs 5&6)
Protorthoptera
Mioloptera stuckenbergi Riek 1973
(Van Dijk & Geertsema 1999 p.142; pp.154-155 Figs. 7&8)
Miolopterina tenuipennis Riek 1976 NM 909a,b Holotype
(p.762; p.759 Fig.5; p.760 Plate 1 Fig.4)
Blattaria
Aleuronympha Riek 1974

Estcourt

The overlapping leaves have little of scientific interest, but the thick, solid, slab is ideal as a demonstration specimen.

The opposite side of the slab has sparse leaves, including (top, right of centre) a specimen of the uncommon sphenopsid *Raniganjia* (whorl of fused leaves and a piece of stem. The slab is strong enough to be sawn between the two surfaces.

2.3.2.3.1.8 Estcourt Weir

The Bushman's River passes eastward through Estcourt and there is a weir on the river on the eastern side of the town. Upstream of the weir there is a small hill to the North and a park to the South. There are fossils in shales below a sandstone layer which is prominent both north and south of the hill. These shales are dark-coloured and soft near the level of the river, and lighter coloured and harder nearer the sandstone. There is an abundance of fossil leaves, mainly coated with manganese oxide, and the site has been known to pupils of a nearby school for many decades. Among the glossopterid leaves there are other fossil plant taxa in small numbers, but no insects have so far been found. The site is referred to as Sheba's breasts in Anderson & Anderson 1985.

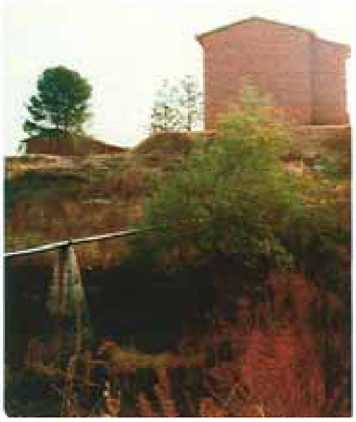
The following are the plant fossils:

Sphenopsida
Sphenophyllum speciosum
Raniganjia (*Raniganjia kilburnensis* And.&And.1985)
Phyllotheca australis
Schizoneura gondwanensis
Pteropsida
Filicales
Sphenopteris (*S. lobifolia* in And.&And.1985)
Glossopteridales
3 types glossopterid leaves
(*Estcourtia vandijkii; Lidgettonia lidgettonoides; Glossopteris symmetrifolia* in A&A)
Incerta sedis
Taeniopteris escourtiana And&And.1985 sp.nov.

The fossil-bearing layers at this site are unusually hard and weather-resistant, and consideration might be given to the construction of a site-museum by excavation of an alcove under the sandstone.

2.3.2.3..1.9 Estcourt Indian School

The fossil site at the weir in Estcourt is about 2 metres above the level of the water, and this suggested that similar exposures might be found nearer to river level upstream. This proved to be the case, for an exposure was found just to the west of the main road to the north on the north bank. This is just below the Indian School. The fossils are similar to those at the weir, but pyritization is more common, as well as carbonized twigs surrounded by a calcareous layer.



The fossils observed are as follows.

Sphenopsida

Raniganjia (*Raniganjia*)
Phyllotheca australis
Schizoneura gondwanensis

Pteropsida

Filicales

Sphenopteris (*S. lobifolia* in And.&And.1985)

Glossopteridales

2 types glossopterid leaves
(*Lidgettonia lidgettonioides; Glossopteris symmetrifolia* in And.& And. 1985)

Incertae sedis

?Benlightfootia mooiensis (in And.&And.1985)

2.3.2.3.1.10 Mount West

School children noticed fossil leaves in shale in a ploughed field to the west of Mount West. The sister of one of the children, Miss Clare Reid (Mrs. C. Archer), was a geology student at the University of Natal, Pietermaritzburg, and made the site known. There is a small exposure in a gully, and this yielded a number of interesting fossils. The shale is rather uniform and lacking in bedding planes. On the neighbouring farm, to the south, fossil wood was found.

The fossils recorded are as follows.

Sphenopsida
Sphenophyllum speciosum
Phyllotheca australis
P. lawleyensis (in And.&And. 1985)
Phyllotheca westensis Anderson & Anderson 1985 NM 2523 Holotype
(p.102; Plate 41 Figs 10-14 on p. 216)
Schizoneura gondwanensis

Glossopteridales
3 types of glossopterid leaves
(*Rigbya arberioides; Lidgettonia inhluzanensis; Lidgettonia lidgettonioides* in A&A)
Fructification Ottocariaceae (fruit) sp. in And.&And. 1985

Insecta

Protorthoptera
Mioloptera NM 2522a,b
(Van Dijk & Geertsema Figs 9&10 on pp. 154-155)

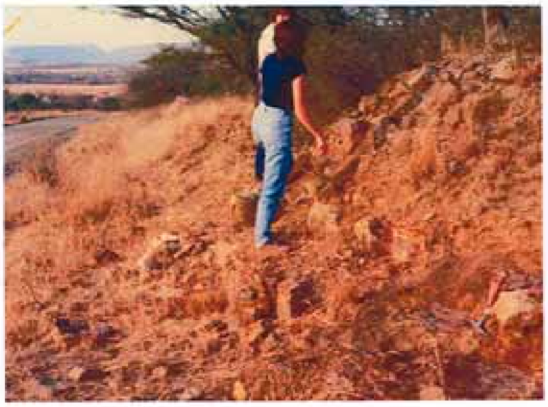
Homoptera
Afrostenovicia reidae vD&G1999 NM 2556 Holotype
(p.147; Figs 35&36 on pp. 162-163)

Mecoptera
? *Prochoristella* NM 2566
(Van Dijk & Geertsema Figs 55&56 on pp.170-171)

?nymphs

2.3.2.3. 1.11 Rondedraai

In May 1968 Dr Edna Plumstead and a group of students were shown some of the plant fossil sites which were investigated in the Natal Midlands. The group was accompanied a short distance east of Estcourt on their way to the varvite trackway site near Vryheid when Edna Plumstead suggested a stop to look at a small cutting on the south side of the road. It proved to have fossil plants and to be near the entrance to the farm Rondedraai. Subsequent studies were made at nearby exposures, one of which yielded to H.M. Anderson and J.M. Anderson a fossil insect. The exposures are not extensive, do not have many plant taxa, but some of the fossils are found on calcareous nodules near the original site, and could be investigated microscopically.



The insect fossil is the following:

Dysmorphoscartella lobata Riek 1973 BPI N-E Rd 1a,b Holotype

(pp.527-528; p.529 Fig.13; p.525 Plate 2 Fig. 8)

Wagondrift

Sphenophyllum and glossopterid leaf

2.3.2.3.1.12 Wagondrift

A quarry at the turnoff towards the Wagondrift Dam Resort was probably known for some time before a single insect specimen was collected there by H.M. Anderson and J.M. Anderson. On the first visit to the site by a party from Pietermaritzburg, Miss Perdita van Dijk found a concretion with skin of a large *Atherstonia*-like fish. Although the number and variety of fossils was not large, the site proved to be of great interest because of the variety of sediments and the palaeoenvironmental interpretations of D.K. Hobday. (Van Dijk, Hobday & Tankard, 1978, pp. 230-232). The profile in the photograph has bay margin ripples (above the large shadow); contorted beds representing subaqueous levees about 20 cm (one pole unit) above the ranging pole tip; concretions in bank pools (two units from tip of pole to the right) including a fish skin (a scale of which is also illustrated – it is little altered); and top of bank sediments with *Glossopteris* leaves and trace fossils.

The fossils are as follows:

Sphenopsida
Phyllotheca australis
Sphenophyllum speciosum (not in And.&And.1985)
Glossopteridales
1 type glossopterid leaf
(*Lidgettonia lidgettoniodes* in And.&And.1985)

Insecta
Perlaria
Euxenoperla similis Riek 1973 BPI N-EW 22 (Probably a synonym of *E. simplex*)
(p.522; p.519 Fig.8; p.517 Plate 1 Fig.7)

Osteichthyes
Atherstonia
Sigmoid tracks made by paired fins of fishes

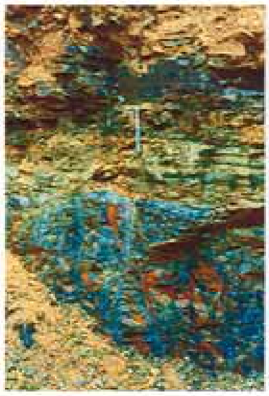
Trace fossils of invertebrates

2.3.2.3.1.13 **Bulwer** (Permian System near Triassic boundary)

In 1959-1960 children observed fossils in the town of Bulwer in a quarry adjacent to the house and consulting rooms of the District Surgeon, Dr. Grantham, at the North end of the town (pers. comm. Geoffrey Grantham). In 1966 Derek and Anne Wyatt-Goodall, teachers at Ixopo High School, attended a teachers' refresher course at the University of Natal, Pietermaritzburg, where they became acquainted with fossils of the Natal Midlands. Mention of fossils by them at the school resulted in the Bulwer site becoming known to the Wyatt-Goodalls, with whom the site was then visited. A few slabs of shale were collected and split in a search for plant fossils. A whorl of leaves of *Sphenophyllum speciosum* in addition to glossopterid leaves indicated prospects of a good variety of plant fossils. Subsequent to the discovery of fossil insects at Mooi River, Bulwer material already in Pietermaritzburg was further split to expose bedding planes which had not been found to be productive of plant fossils. Within less than an hour the tip of a homopteran wing was found.

By 1966 the Bulwer quarry had been excavated to a steep cliff to the west, and was being worked mainly northwards to the eastern side. This exposed productive beds which were subsequently visited by palaeoentomologists Edgar Riek, from Australia, and Jarmila Kukalová-Peck, from Canada. In 1998, when the site was visited with Henk Geertsema, quarrying had destroyed the exposure illustrated and was being done by machines working from below the level of the productive layers (at the level of the head of the hammer in the face illustrated) to reach the silty layers needed for road making. The fossiliferous layers were needlessly being destroyed, as quarrying operations could be performed above these layers by approaching from the north-east at a higher level, visible beside a small road skirting the quarry to the east.

The quarry is the dark area between the bend in the road to Impendhle at the top and the road from the East turning South.



The Bulwer site is of particular interest because it is close to the Permian/Triassic boundary (Van Dijk, 1998) and has yielded several new insects (summarized in Van Dijk & Geertsema (1999).

A list of fossils follows:

Sphenopsida

Sphenophyllum speciosum
Phyllotheca australis
Raniganjia (*Raniganjia kilburnensis* in And.&And.1985)

Pteropsida

Filicales

Sphenopteris (not in Anderson & Anderson 1985)

Glossopteridales

Scutum (not in Anderson & Anderson 1985)
Rigbya arberioides megasporophyll
5 types of leaf (probably includes leaves named by Anderson & Anderson 1985 *R. arberioides; Lidgettonia lidgettonioides; L. inhluzanensis;* but not their *L. mooiriverensis*)

Cordiatales

?Noeggerathiopsis

Insecta

Perlaria (Plecoptera)

Euxenoperla similis NM 895 (Probably a synonym of *E.simplex*)
awaiting description NM 2733a,b

Protorthoptera

Mioloptera Riek 1973 NM 2730a,b
(Van Dijk & Geertsema 1999: p.142; Figs 11&12 on pp. 154-155)
Miolopterina tenuipennis Riek 1976 NM 897 Paratype
(p.762; p.759 Fig. 5; p.760 Plate 1 Fig.4)
Liomoptoides Riek 1973 NM 2526
(Van Dijk & Geertsema 1999: p.142; Figs. 13-14 on pp. 156-157)

Protelytroptera

Phyllelytron acuminatum Riek 1976 NM 2533; NM 2534a,b; NM 2535a,b

Miomoptera

Permonka bifida Riek 1973 NM 925
(Riek, 1976: pp.772-773)

Psocoptera/Hemiptera?

NM 2731a,b

Homoptera

Austroprosboloides vandijki Riek 1973 NM 889a,b
(Riek 1976: p.780; p.767 Fig.18; p.776 Plate 4 Fig.5)
Dysmorphoscartella lobata Riek 1976 NM 893 Holotype
(p.781; p.767 Fig.16; p.783 Plate 5 Fig.2)
cf. Beaufortiscus vD&G 1999 NM 2581
(p.142; Figs 15&16 on pp. 156-157)
cf. Eoscarterella NM 890a,b (Riek 1976, p.781)

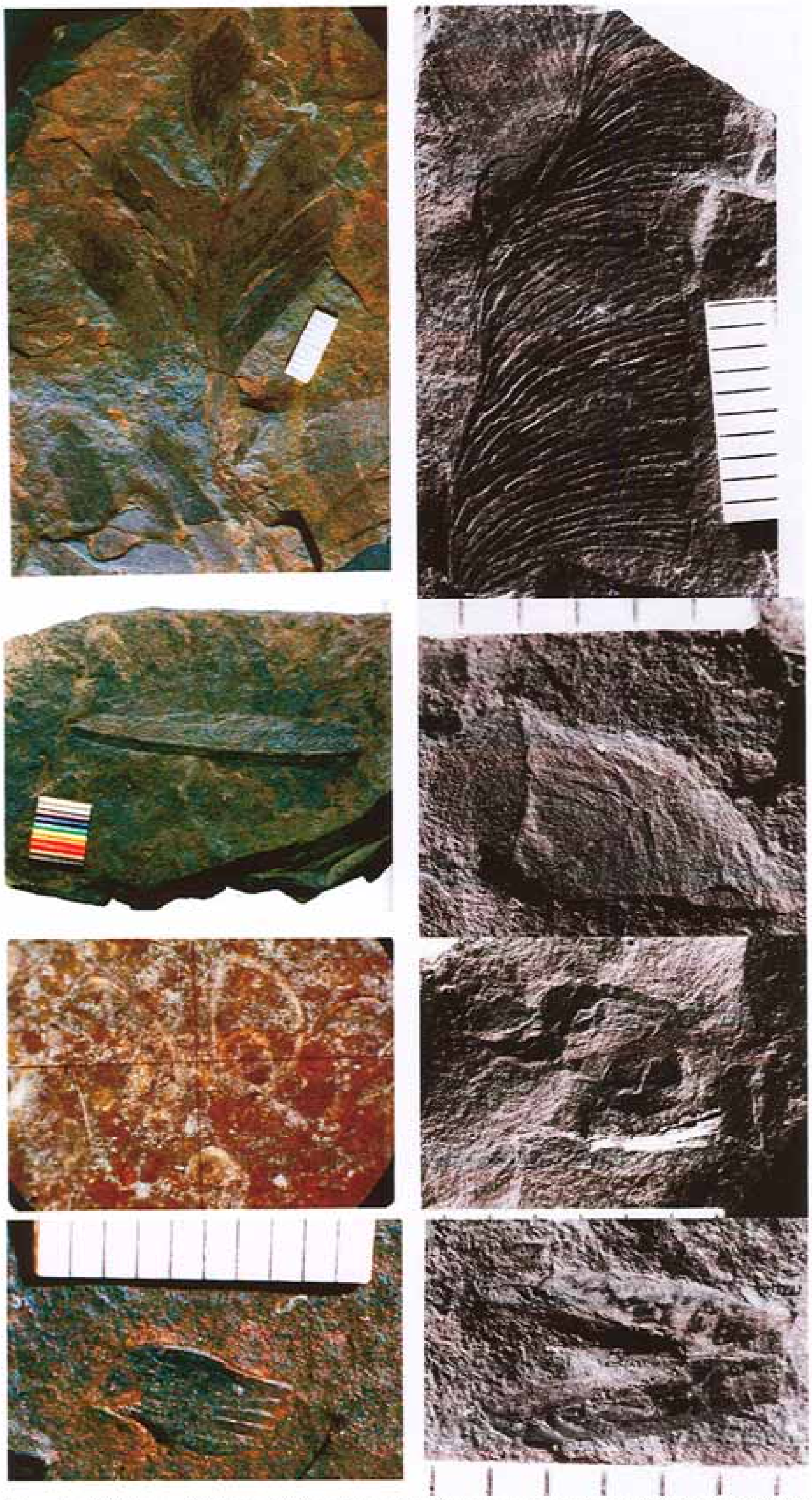
Neuroptera

cf. Archeosmylus vD&G 1999 NM 2569a,b
(p.148; Figs 43&44 on pp. 166-167)
awaiting description NM2732a,b

Mecoptera

Callietheira granthami vD&G 1999 NM2558a,b Holotype; NM2559a,b Paratype
(p.148; Figs 47&48 on pp. 168-169)
Prochoristella bulwerensis vD&G 1999 NM 2565a,b Holotype
(p.149; Figs 53&54 on pp. 170-171)
Neochoristella goodalli vD&G 1999 NM 2567a,b Holotype
(p.150; Figs. 57&58 on pp. 168-169)

Kilburn



Left Top to Bottom: Close-Veined Leaf; *Dictyopteridium*; Ostracods; Scale.

Right Top to Bottom: Leaf; Conchostracan; Insect Wing Fragment; Enigma.

2.3.2.3.1.13 Kilburn Dam

When the Drakensberg Pumped Storage Dam was planned, Mr and Mrs Rein-Weston, owners of the farm Admiralty Estates, comprising the farms Kilburn and Newcastle, at the future site, asked people in various disciplines to study the area. On the first visit, collecting on Kilburn on the south side of the dam, fossil plants were found, including the rare fructification known at the time as *Dictyopteridium*, and Hester van Dijk found the fragment of an insect wing.

Small structures in a calcareous nodule *in situ* were found on sectioning to be ostracoda.

The following are the fossils found:

Sphenopsida
stem
Glossopteridales
2 types of glossopterid leaf
(*Lidgettonia lidgettonioides* p.136;pp.301-302Pls126-7 in And.&And.1985)
megasporophyll *Lidgettonia*
(*Lidgettonia inhluzanensis* p.135;p.297 Plate122 Figs1-9 in And.&And.1985)
microsporophyll cf. *Dictyopteridium*
(*Plumsteadia gibbosa* p. 125; p. 169 Plate 94 Figs11-14 in And.&And.1985)
seeds and scale leaves
Crustacea
Ostracoda
Conchostraca
Insecta
wing fragment
Osteichthyes
fish scales

Insertae sedis
2 scale-like structures

2.3.2.3.1.17 Loskop

An exposure of sediments south of the road west of Loskop yielded many plant fossils and an insect to other collectors. A piece of fossil wood was collected and sectioned. The site has been regarded as belonging to the Estcourt Formation. *Lystrosaurus* has been found close to the site, indicating the proximity to the Triassic boundary.

Insecta
? Eoscartarellidae Riek 1973 (BPI N-Lk 505a,b)
(p.528; p.525 Plate 2 Fig.6; Riek 1976, pp. 780-781)

2.3.2.3.2 Emakwezini Formation

Two samples of fossils from west of Empangeni were brought to the University of Natal in Pietermaritzburg. A party consisting of the Van Dijk family and V. von Brunn was unsuccessful in an attempt at locating the two sites. The fossils represented are as follows:

2.3.2.3.2.1 Emakwezini Station

Insecta
Protorthoptera
Neoliomopterum picturatum Riek 1976 NM 910 Holotype
(pp.762-763; p.760 Plate 1 fig.7)

2.3.2.3.2.2 Mevamhlope

Sphenopsida
Phyllotheca australis
Glossopteridales
2 types of leaves
(*Rigbya arberioides; Glossopteris sp.* in And.&And.1985)

Permian/Triassic Systems

2.3 PALAEOZOICUM/2.4 MESOZOICUM

2.3.2.3.4 **Adelaide** Subgroup (Johnson & Keyser SACS 1980,p.552)

2.4.1 **Tarkastad** Subgroup (Johnson & Keyser SACS 1980,p.554)

Stear (1978, 1980), Smith (1980) and De Beer (1986) give accounts of flood-plain deposits near Beaufort West in the Upper Permian Adelaide Subgroup of the Beaufort Group which include references pertinent to sites bearing vertebrate fossils in KwaZulu-Natal. The discussion of Fluvio-Lacustrine Offlap Facies in Van Dijk, Hobday & Tankard (1978) is applicable to the palaeoenvironments of the Beaufort. Lawes (1983) did a study (Honours Project, unpublished) on a site in KwaZulu-Natal underlying a sandstone interpreted by D.K. Hobday (pers.comm.) as the northern wedge of the Katberg Sandstone Formation, and hence below the Tarkastad Subgroup (Johnson & Keyser SACS *vide supra*), i.e. top of Estcourt formation in the *Lystrosaurus* Zone. Smith & Macloed (1998) discuss the changes in sedimentology across the Permian/Triassic boundary.

Literature on vertebrate tracks in the Adelaide and Estcourt Formations since Holub (1881) is included in the compilation mentioned above (cf. poster: Van Dijk, 2000).

***Lystrosaurus* Zone**

Several sites in the *Lystrosaurus* Zone in KwaZulu-Natal were studied, that at De Hoek (see Lawes, above) being visited frequently.

Several De Hoek specimens have been studied, or are being studied, others have been referred to specialists in the Pisces, Amphibia and Synapsida.

2.3/4.1 ***Lystrosaurus* Zone**

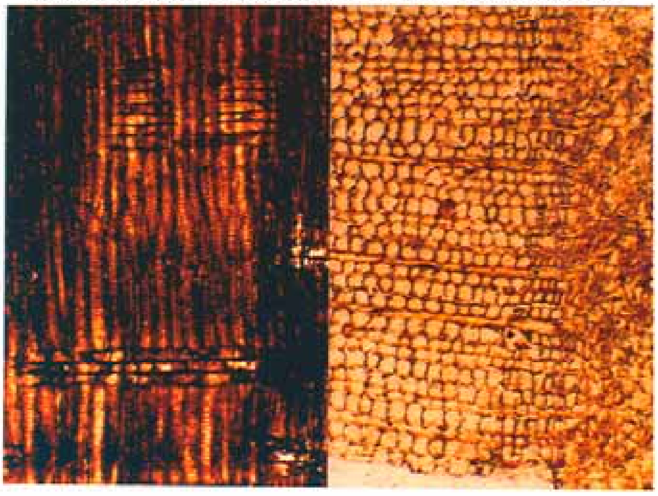
2.3/4.1.1 Winstone Hill

While travelling between Estcourt and Loskop, an exposure along a stream which the road crossed at Winston Hill (Winstone according to maps). The site was studied on one of the visits by sedimentologist D.K. Hobday, who constructed a profile (Van Dijk, Hobday & Tankard, 1978, p. 229). A *Lystrosaurus* skull and a fragment of an amphibian skull and fragments of fossil wood were among the isolated fossils observed. Coprolites with fish bones and scales were observed on exposed surfaces. Invertebrate tracks and the trails made by the fins of fishes were recorded.

Rippled surface with invertebrate tracks

Surface with fish bones and scales

Fossil Wood in Radial and Transverse Section



2.3/4.1.2 **De Hoek (Draycott)**

The name Draycott appears as locality in a number of publications on vertebrate fossils. When driving from the main Estcourt-Loskop road towards Draycott station, erosion below the sandstone of a hill to the south can be seen from some distance. This appears to be the main exposure named Draycott, and ranges from the *Dicynodon* Zone through the *Lystrosaurus* Zone to immediately below the northern extremity of the Katberg sandstones. Numerous visits were made to the site.

Fossils include the following:

Osteichthyes
Teleostei
A small fish skull, presently being studied by a fish specialist.
Amphibia
Skulls in calcareous nodules, similar to *Lydekkerina,* presently being studied by an amphibian specialist.
Reptilia
Therapsida
Lystrosaurus skulls, skeletal parts, including a near complete skeleton
Thrinaxodon skeleton
Oliveria skull, prepared by J.A.van den Heever and in the University of Stellenbosch collection.

Invertebrate burrows, including some around a *Lystrosaurus* skull, suggesting feeding on sediments containing nutrients derived from the decaying animal.

Concretions present appear to be coprolites, probably of a vegetarian.

Channel sediments included some with the characteristic zones of clay pellets and bones of "bone beds".

The sedimentology of the site was studied by D.K. Hobday, and a B.Sc Zoology Honours Project on the site by M. Lawes was devoted especially to taphonomy (Lawes, 1983).

2.3/4.1.3 Umtata Mouth

Following the report via students of good *Lystrosaurus* material near the Umtata River Mouth an excursion to the site revealed fossils in a very hard matrix. Some nearly complete skeletons were seen. One, near the limit of the wave action, was nearly complete and was considered for later removal in its entirety. A second visit found the skull removed, however, with no regard for the damage to the rest of the skeleton. The site is excellent as a field fossil exhibit.

A loose boulder containing much of a skull was collected.

2.4.1.4 Oliviershoek

A small boulder which was collected by the road near the top of the Oliviershoek Pass, illustrates well the bottom of a river channel, with areas where the muddy bottom is lifted, and higher up a layer of clay pellets derived from such a muddy bottom, together with bone fragments.

MESOZOICUM

Triassic/Jurassic

Haughton (1924) reviews the fauna and stratigraphy of the Stormberg, including a list of plants provided by Du Toit, later the subject of a publication by (Du Toit, 1927). F. Ellenberger and P. Ellenberger and associates discuss stratigraphy in relation to vertebrate trackways, especially in F. Ellenberger *et al.* (1964) and P. Ellenberger (1970).

Triassic

2.4.2 **Molteno Formation** (Green, 1883)

Turner (1984) gives an account of the sedimentology of the Molteno Formation. Anderson & Anderson (1984) review the fossils this formation. Raath, Kitching, Shone & Rossouw (1990) discuss the age of the Molteno and succeeding formations, and report on dinosaur trackways. Anderson & Anderson (1985 especially; 1983, 1989) review the palaeoflora, Riek (1974b; 1976) the insects, and Raath (1996) vertebrates of the formation.

In view of the intensive work done by the Andersons, few specimens were collected.

Sites visited were Duart Castle and Vergelegen (both with H.M. and J.M. Anderson), Matatiele, Mount Fletcher and the lower end of Sani Pass (Van Dijk and Wyatt-Goodall families).

2.4.2.1 and **2.4.2.2** **Matatiele** and **Mount Fletcher**

From Matatiele and Mount Fletcher specimens were collected to illustrate the fluvial sediments with which plant fossils were associated –sand and channel deposits respectively.

2.4.2.3 **Bushman's Nek**

A piece of wood was brought to Pietermaritzburg from the Police Post at Bushman's Nek. It may from come from the Molteno or Elliot Formations. It is still under investigation.

Upper Triassic/Jurassic

Olsen & Galton (1984) review the fossils of the Elliot and Clarens Formations, and discuss the age. Kitching & Raath (1984) review the tetrapods and a suggested biozonation, and Raath *et al.* (1990), as mentioned above, also discuss the Elliot Formation.

2.4.3 **Elliot Formation** (Botha, 1968)

2.4.3.1 Cathedral Peak

A piece of Elliot-like reddish-coloured rock containing the bones of a foot, described as being from Cathedral Peak was brought to Pietermaritzburg. It was reported as having been collected in the gorge upstream of the Cathedral Peak Hotel. A section of the specimen block was prepared.

2.4.3.2 Rhodes

The vicinity of Rhodes, south of Lesotho, was visited (Van Dijk and Stuckenberg families) in an unsuccessful attempt at finding the locality from which Haughton (1924) obtained insects and crustaceans. A fish trackway was observed.

Note upward curving marks on either side of the pale area in the middle.

Jurassic System

2.4.4 Clarens Formation (Beukes SACS 1980, p.552)

Dornan (1905,1908) reported vertebrate trackways in Basutoland (Lesotho). F. Ellenberger and P. Ellenberger and associates published on the region, with most attention given to trackways (*vide supra*). Raath (1972) recorded dinosaur footprints in Rhodesia (Zimbabwe), which was followed by several other publications from the region. Van Eeden & Keyser (1972) reported tracks from near the Limpopo and Gow & Latimer (1999) from Qwa Qwa. Beukes (1970) reviewed the stratigraphy and sedimentology of the Clarens Formation (as CaveSandstone Stage). The discussion of Playa Lake Facies in Van Dijk, Hobday & Tankard (1978) is relevant to the palaeoenvironment. Van Dijk (1978) reported on trackways from Giants Castle. Olsen & Olsen (1984), mentioned above, review the fauna. Most references to vertebrate tracks in Africa are to Jurassic sites. (A bibliography is near completion and was included in posters at Geocongress 2000 and the Palaeontological Society Congress in 2000. *cf.* Appendix A).

Sites at Quthing and Leribe in Lesotho; Giants Castle, Kamberg and near Underberg in South Africa; and Otjihaenamaparero near Omaruru in Namibia and Waterberg Plateau Park (Etjo Formation: Reuning 1923), were visited. At Giants Castle many examples of sedimentary structures and trackways were studied and some collected for further study.

2.4.4.1 Quthing

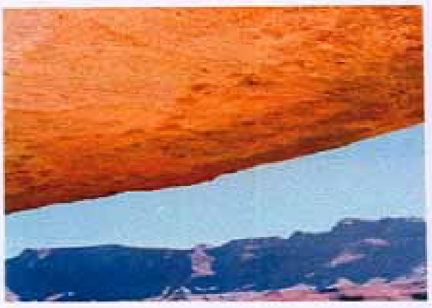
A trip was made in 1966 to Lesotho (Van Dijk and Wyatt-Goodall families) to see trackways. We were directed by the curator of the Museum at Maseru to Quthing, where we visited Reverend Paul Ellenberger, who showed us the remarkable trackway site in this area. This trip was useful as preparation for the subsequent discoveries at Giants Castle and other sites in the Natal Drakensberg. Some of the more accessible trackway sites are shown on tourist maps, such as that of the Automobile Association, but several others can be visited fairly readily and could, should, be included in any Southern African ecotourism/geoconservation initiative. Good photographs of the sites are rarely seen.

2.4.4.2 Giants Castle

In 1966 K.L. Tinley discovered tracks under an overhang in layered sediments near the bottom of the Clarens Formation a short distance north of the entrance to the Giants Castle Resort. A visit with him a week later revealed a number of different types of tracks. Photographs were sent to Rev. P. Ellenberger at Quthing. He gave names to taxa on the basis, apparently, of these photographs. Of particular interest is a species which he named *Molapopentapodiscus supersaltator*, with another species in Lesotho. These, and perhaps another genus from Lesotho, are the only described fossil hopping tetrapods.

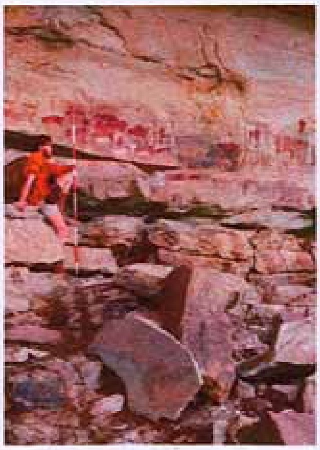
The palaeoenvironment is a playa lake (Van Dijk, Hobday & Tankard,1978, pp. 235-238).

The site has good potential as a ecotourism site, being close to an established tourist camp with nearby rock paintings. Monitoring of access is easy, as the site is visible from the road, but takes time to reach and leave.



2.4.4.3 Kamberg

Teachers and Teachers' College lecturers were made aware of the Giants Castle site during a Natal Educational Activities Association visit in 1968. One of the participants, Barry Beck, subsequently reported the presence of a slab with footprints at Kamberg, which was confirmed during an Archaeological Society Excursion with O. Davies. Subsequent visits were made with sedimentologists. The site palaeoenvironment is interpreted as a playa lake, of which there is less of the periphery and hence the places with the highest likelihood of preserved trackways. The presence of rock paintings at the site illustrates the potential for adding features of palaeontological interest to known sites.



Fallen slab *in situ*

Footprints turn left at margin of the water

2.4.4.4 Little Bamboo Mountain?

A small outlier of the Clarens Formation of the Natal Drakensberg was reported to have an overhang with dinosaur trackway casts, and was visited. Attempts at getting positive identification of the name of the outlier have so far been unsuccessful. Little Bamboo Mountain has been suggested and is in roughly the area visited.

This type of site has good potential for incorporation in ecotourism in the area, there being no danger of damage by visitors. About a dozen outliers seem to be candidates for examination for similar trackways.

Cretaceous

Kraus (1843) reported Cretaceous fossils from the East coast of South Africa. A further publication by him in 1850 was followed by numerous others by other authors. Kennedy & Klinger (1975) reviewed the more northernly faunas. Anderson & Anderson (1985) reviewed the plant fossils as far as the Lower Cretaceous. Reviews of the literature on fossil Lissamphibia of Africa (Van Dijk, 1995) and fossil Anura (Salientia) of Southern Africa (Van Dijk, 1996) commence in the Cretaceous (and extend to the Holocene).

2.4.5 ZULULAND Group (Kennedy & Klinger, 1975)

Specimens of marine and terrestrial origin were collected from sites in the Mkuze area. Whether they can be attributed to a single formation is not clear. Calcified wood was collected from the Mzinene Formation. Some specimens were obtained from a bore-hole in Durban.

Mkuze

When a visit to the Mkuze Reserve was made for the first time in 1957 the roads were being made with fossil-bearing Cretaceous material. The source or sources could not be established, but pieces along the sides of the road were collected. Other, better, specimens likewise without known provenance were later obtained.

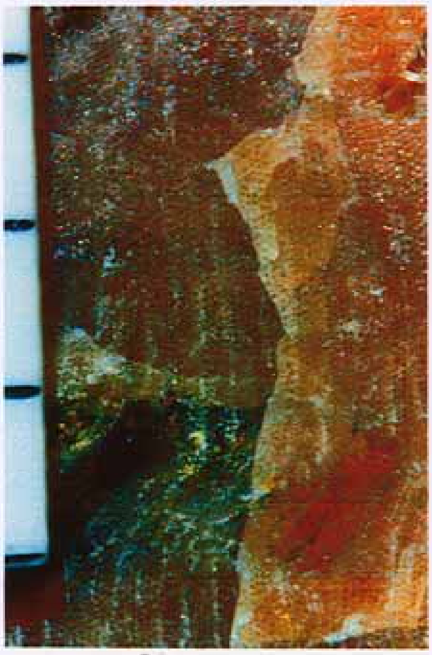
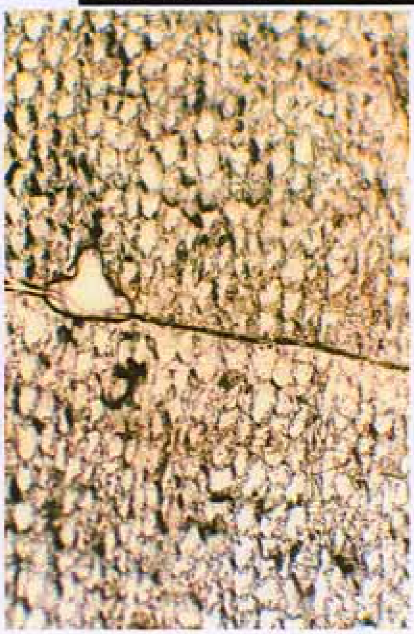
The shells of ammonites collected often show evidence of a period during which they acquired an epifauna, e.g. oysters, and a period during which they formed a boulder nucleus. Calcareous and siliceous casts of chambers are not uncommon.

Pieces of wood were found with mollusc shells on the surface and burrows containing the shells of boring molluscs (*Teredo*?) in their deepest parts. The wood had largely lost its cellular structure and the shells showed recrystallization. The sediments in the burrows included angular fragments and some feldspar grains, suggesting a terrestrial source and limited reworking. Wood floating out to sea was probably water-logged, when some molluscs attached to the surface and other molluscs burrowed. The wood must have come to rest close inshore, possibly in a lagoon, where the sediments had not been subject to much reworking.

2.4.5.1 Mzinene Formation
Mkuze

On a later visit to Mkuze Reserve, a site not far from the entrance complex was pointed out where there are calcified tree trunks. Superficially unpromising, the wood proved to have been well preserved, despite the presence of large calcite crystals. Cell structure could be revealed by etching and peeling. When a small piece is hammered or sawn a characteristic odour is discernible, somewhat like rotten sea-weed. Preliminary Gas Mass Spectrography suggested a four carbon compound. The possibility of post-exposure ingrowth of organisms cannot be excluded.



Mkuze

Terrestrial plants, mainly cycad leaves were found in a gully close to the fire-watch tower.

2.4.5.2 Mzamba Formation. (Du Toit, 1920; Kennedy & Klinger, 1975)

Specimens of fossil wood were collected at a site being cleared for the making of a casino. Various forms of replacement and some apparently little-altered fibres are of interest. An epifauna, large superficial, and small radial burrows are present.

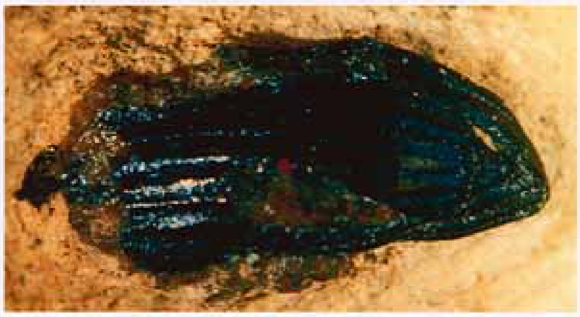
2.4.6 CRATER LAKES (Cretaceous Intrusions)

2.4.6.1 Banke (Namaqualand)

The Banke sediments were investigated by Reuning (1931, 1934), the plant fossils by Adamson (1931), Rennie (1931), Kirchenheimer (1934) and Scholtz (1985), and frogs by Haughton (1931) and Estes (1977). Description of a beetle is in press (Geertsema & Van den Heever).

A fragment (approx. ½mm) of an insect was found in a slide provided by A. Scholtz to illustrate pollen from the Arnot Pipe at Banke. This suggests the need for scanning of all the permanent palynological preparations.

A fossil recorded as an insect in the Banke collection was examined and identified as a plant fossil. A *circa* 4mm beetle SAM PK K7567 from the collection (Geertsema & Van den Heever, in press) was photographed.

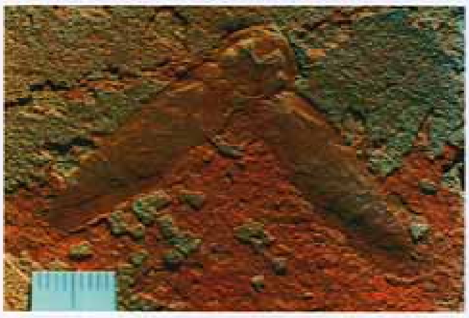


Isolated vertebrae of *Eoxenopoides* were examined to determine the form of the zygapophyses, which are characteristic in some Pipidae, but no useful information could be obtained.

2.4.6.2 Orapa (Botswana)

The Orapa Diamond Mine site was visited at the request of the resident geologist and a confidential report was prepared. Since that time other palaeontologists have been permitted to study the site and publish their findings. Rayner *et al.* (1997) gives results and reference to other research. The published fossils are quite likely to have come from a different horizon to those first studied, since there are considerable differences in the preservation.

A leaf, ?*Trimeria*, a cockroach and a cicada nymph are illustrated.



2.4.6.3 Stompoor (Marydale)

Geoffrey Grantham, while a geology student, worked for a prospector near Marydale, and reported the presence of frog fossils in a diamond exploration pit. The prospector was hired to dig another pit and several frog specimens were obtained. A photograph of a good specimen obtained during the first excavation, in the possession of the prospector, was also photographed. The find was published (Van Dijk, 1985), and some material was sent to R. Estes for study. The study was not completed because of the death of Richard Estes. By the time the preliminary publication was being prepared, boreholes had been made by a diamond exploration group, who supplied a portion of the cores to the South African Museum. Smith (1986) reported on bore-holes from the site. The South African Museum now has a number of specimens, which have been made available to overseas researchers.

The material from Stompoor is generally not very good, since the bones are usually shattered, apparently by crystallization of minerals within the marrow cavities. A specimen in the possession of the prospector is illustrated.

2.5 CAENOZOICUM

Tertiary System

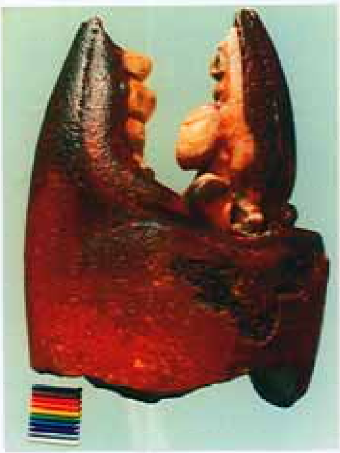
Miocene/Pliocene

2.5.1 **Uloa Formation** (King, 1954: according to SACS1980, p.625)

Described by King (1953).

The Uloa Formation site was visited and specimens were also obtained which were derived from excavations for the Richards Bay harbour and other dredgings and beachings. Nothing of note was obtained.

The excavations for the Richards Bay harbour seem to have provided an enormous amount of material suitable if not for study, at least for distribution to educational institutions. Other material from dredgings also is worth preservation even if not new or remarkable. A Crab claw and a Sea Urchin test are illustrated.



Miocene

2.5.2 **Arriesdrift Formation** (Corvinus & Hendey, 1978 SACS 1980,p.624)

Frog fossils are know to have been found during investigations at fossiliferous sites at Arriesdrift. There is apparently a considerable amount of material.

Pliocene

2.5.3 Varswater Formation (Hendey,1974; Tankard,1975: according to SACS1980)

2.5.3.1 Langebaanweg

Singer & Hooijer (1956) first reported on the site. Tankard (1974) described the Varswater Formation of the Langebaanweg-Saldanha area. Hendey (1982) records the circumstances of the discovery of the fossils of the Langebaanweg site.

At a Symposium of the African Amphibian Interest Group at Giants Castle a short note on the fossil frogs of Stompoor (see above – Cretaceous) was presented Van Dijk, (1985). This initial involvement with fossil frogs was a stimulus to extract from a comprehensive bibliography of the Anura of Africa and its surrounds which was being compiled, a list of the fossil frogs of African interest (Van Dijk, 1995). This was followed by a survey of the fossil frogs of Southern Africa, presented to the African Amphibian Interest Group Symposium at the Waterberg Plateau Park in Namibia (Van Dijk, 1996).

It was noted that frog bones were not uncommon at Langebaanweg according to Hendey (1970). During a visit to the South African Museum with A. Channing, the material was located and it was immediately obvious that there was more than the single taxon, related to *Xenopus laevis*, which Hendey had mentioned. Proper examination of the material, however, required an extensive survey of the limited literature on the osteology of African frogs. Numerous preparations were required as well. Mention must be made of the excellent work done by volunteers, notably Nick Holliday, who set the anuran material aside during sorting. The publication of a survey of the fossil frogs of the world (Sanchiz, 1998) made it possible to recognize the Langebaanweg fauna as one of the richest in the world, with at least four families (Pipidae, Bufonidae, Brevicipitidae and Ranidae), probably five (Hyperoliidae). A variety of ranoid sacra suggested at least an additional two or three genera. Eight genera are only known at two sites in the world, and seven at four sites. Thus Langebaanweg can conservatively be placed with the six richest sites in the world.

A poster made as a paste-up for the opening of the Langebaanweg Research Station on 22nd September 1998 was designed to be as far as possible understandable without verbiage. A subsequent version incorporated X-rays of members of the four families certainly, and the one probably, present, to permit individual elements of the fossil fauna to be compared with the same elements in extant anurans.

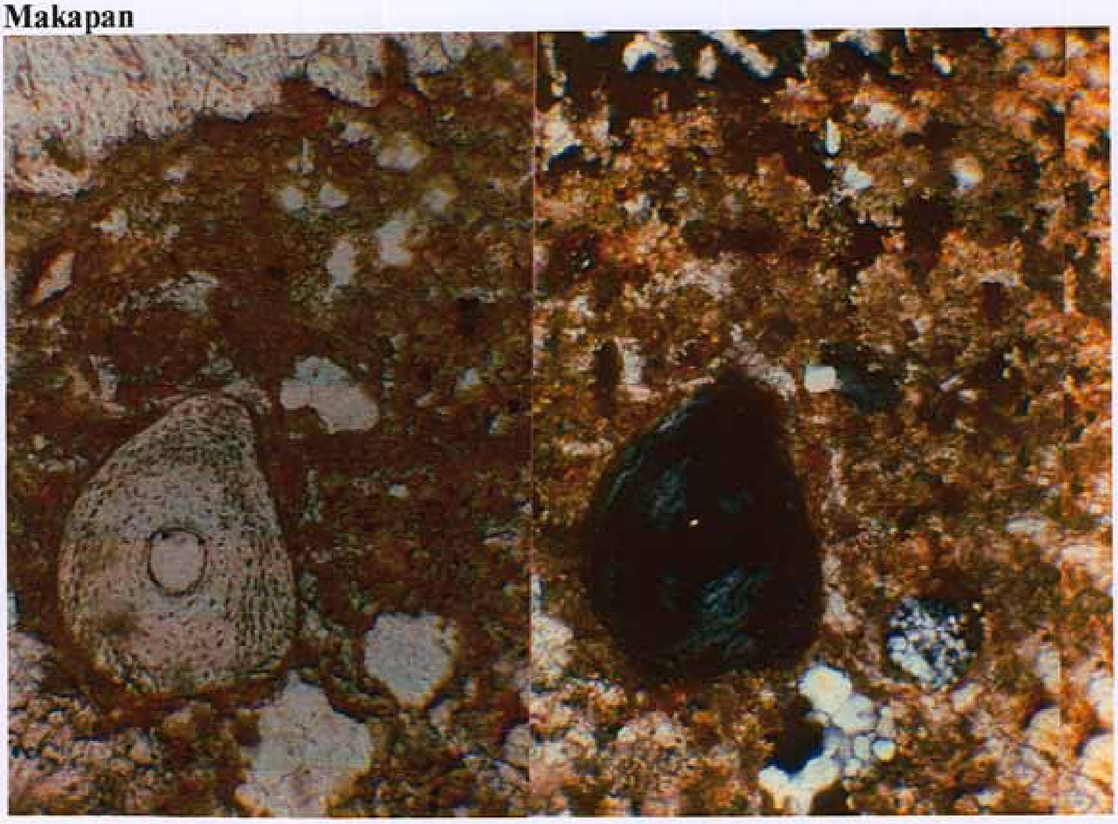
A notable feature of the fossil fauna and its modern counterparts, is that the families represent differences in main locomotory modes: Pipidae – swimming; Bufonidae –hopping/walking; Brevicipitidae - burrowing/walking; Ranidae – leaping; Hyperoliidae – climbing/leaping. The later version of the poster is on display at Langebaanweg and was presented at the Geocongress 2000 at Stellenbosch.

Field Station

Excavation

Excavation is continuing, the frog bones being found among larger bones.

Makapan



Bone is present across the top of the images and, in cross section, at the bottom left. There are three sand grains which can be seen to be derived from a quartzite, especially in the crossed-Nicol image on the right. Both the calcareous material of the cave, and its sand grains, are apparently derived from Vaalian stromatolites.

The layered nature of the bone accounts for the slight birefringence, and its absence parallel to the planes of polarization.

Tertiary/Quaternary

Pliocene/Pleistocene

2.5.4 Makapansgat Formation (Brain, 1958: according to SACS; Brock *et al.*1977)

Partridge (1979) investigated the lithostratigraphy of the formation. Tobias (1997) gives a history of the site.

2.5.5 Swartkrans Formation (Brain 1958: according to SACS; Butzer, 1976)

Butzer (1976) investigated the lithostratigraphy of the formation.

2.5.6 Kromdraai Formation (Brain 1975, SACS 1980, p.625)

Samples from lime works debris at Makapan were collected during a visit in 1947 (with Kitching brothers and B. Maguire). A few specimens from Swartkrans were received from C. Juta and a small piece of Kromdraai material was collected near the cave site. Among material accumulated over decades, a box of unlabelled samples came to light during clearing of the basement of the Natal Museum. The matrix resembles the sample of Kromdraai material collected.

Nothing of value was observed in any of the samples, but sections did reveal a feature of interest, namely that sand grains showed their derivation from Transvaal stromatolites.

Quaternary

Tyson (1999) reviewed the Late-Quaternary and Holocene palaeoclimates of South Africa.

Pleistocene

2.5.7 Klasies River (Singer & Wymer, 1982)

Deacon & Deacon (1999) is a recent reference.

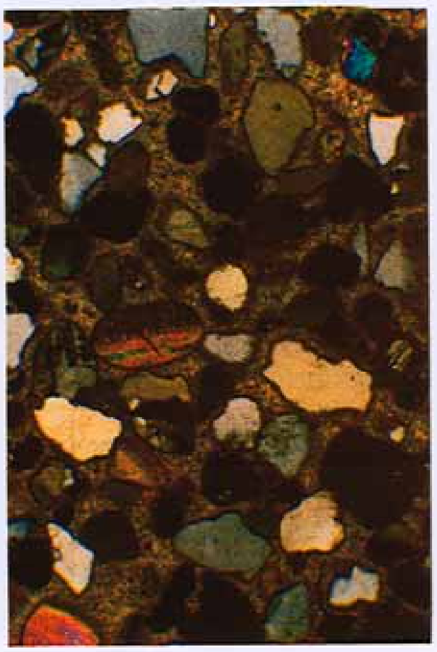
Awareness of interest in fossil Anura of Langebaanweg led Kate Henderson to mention that frog bones been observed at the archaeological site at Klasies River, during investigation by the Archaeology Department of the University of Stellenbosch. Sieved material from which most of the mammalian and reptilian bones had been removed, was examined in March 1999. Within two hours four anuran families could be identified. For two man-hours to produce so much was very encouraging. In response to a request by Juri van den Heever for suggestions of Honours projects for two students of the Zoology Department, University of Stellenbosch, Kate Bell and Aliza le Roux, a follow-up of the initial observations was suggested, under my supervision. The results were presented at the Tenth Symposium of the African Amphibian interest group in Stellenbosch in July 1999 by the these students.

The material has been reworked to a single unit, and a poster, including the students as co-authors, was presented at the Palaeontological Society Symposium in Pretoria in September 2000.

2.5.8 Quaternary ?Holocene

Reunion (near Durban)

In 1966/1967 botanist C.J. Ward was demonstrating coastal vegetation to students at Reunion, near Durban, when he observed material extending below high tide level which he interpreted as a slumped dune. Investigation without causing damage was difficult, as was photography of some specimens on the sea-cut rock-face. A large fragment of bone was identified as part of an artiodactyl jaw. There were loose specimens of Cape Hare and mouse jaws, and some snail shells which could be recognized as terrestrial and similar to those on the present dunes. Pieces of reddish sandstone embedded in the matrix appeared to be man-made flakes.



Quaternary ?Holocene

2.5.9 Reunion

In addition to the dune material, portions of large stems in a calcareous matrix were observed nearby, where they had been left by wave action. The texture of surfaces which represented transverse sections, was of stems with large spaces, as occur in the palmiet. Sections were made and showed very good detail. Illustrations of the cellular structure of palmiet stems have not yet been located.

Quaternary

2.5.10 **Ulco**

A sample of limestone from limeworks at Ulco, west of Kimberley, has impressions of leaves, but no other remains of plants and fossils were detected. Another limestone specimen without details of provenance has leaf impressions which are close to being good enough to yield details of the cuticle.

Holocene

2.5.11 **De Hoek**

The triassic sediments at De Hoek yield a maroon mud below the site. This is sometimes calcified. A specimen collected by a student during an excursion shows what are clearly mammalian herbivore teeth. These are interpreted as goat, and modern.

3 DISCUSSION AND CONCLUSION

Stratigraphy

Some of the concepts of stratigraphy, and their application to Southern Africa, were involved in deciding on the sequence in which sites and fossils were dealt with in this thesis. Besides the SACS Handbook 8 (Kent, 1980), Holland (1964), Van Eysinga (1970) and Johnson (1996) were consulted.

In the SACS Handbook (Kent, compiler, 1980) there is, under Main Karoo Basin, a paragraph headed Dwyka (tillite) Formation, in which it is stated: 'There are no sound reasons for grouping this formation with some of the overlying shale units in a "Dwyka Group", since the requirement of significant unifying lithologic features is not satisfied.' (p. 536). Visser (1986) refers to this paragraph and to the definition for the Dwyka Formation as applying mainly "to the northern (valley) facies ...", and outlines alternative nomenclatures which include that of raising the status of the Dwyka Formation to that of a Group. He refers to recognition by V. von Brunn of a Mbizane Formation and Mfolozi Formation and refers to Von Brunn (1981). The Dwyka Group was formally recognized in Visser *et al.* (1990), and that a Mbizane Formation (and underlying Elandsvlei Formation) had been proposed was noted. The Mbizane Formation was mentioned in Johnson *et al.* (1996) and Johnson *et al.* (1997). It was formally accepted in 2000 (Johnson, pers. comm.).

The above references serve also for the Ecca Group. Visser (1990) deals with the age of Dwyka and Ecca sediments.

The presence of what appear to be stromatolite-like carbonaceous mats in the Whitehill Formation is has previously been noted. Sections show evidence of filaments, as well as masses which could have been produced by flocculation. That these mats are comparable to stromatolites on a solid substrate in shallow water, is doubtful. Dome-like structure was not observed in the specimens at Eilandia, and such structure is associated with water flow, as occurs on tidal flats.

The Volksrust Formation was studied by Tavener-Smith *et al.* (1988) in an area remote from the sites referred to the formation in this thesis.

Most of the sites and fossils studied here have been allocated to the Beaufort Group, notably the Estcourt Formation. There is no Estcourt Formation in the 1997 Geological Map of the Republic of South Africa and the Kingdoms of Lesotho and Swaziland. In the Preface of a SACS publication entitled "Biostratigraphy of the Beaufort Group (Karoo Supergroup)" (Rubidge ed., 1995) it is stated: "This volume resulted from that meeting and is a synthesis of available information pertaining to the amniote biostratigraphy of the Beaufort Group". No mention is made of the Estcourt Formation. The section on "Biostratigraphy of the *Dicynodon* Assemblage Zone " (J.W. Kitching), lists publications on Insects by Riek (with 1976a instead of 1974) which were referred to what was known at the time as the *Daptocephalus* zone. Under plant fossils the list is: "*Dadoxylon Glossopteris Schizoneura*". Under Lithostratigraphic position it is noted: "In the northern and northeastern Orange Free State rocks belonging to the *Dicynodon* Assemblage Zone are assigned to the Normadien Formation (Groenewald, 1984, 1990)." Under Geographic distribution it is noted: "In Natal the strata are attenuated and at times they are difficult to separate from the underlying Ecca rocks." The basis for identifying the underlying rocks as Ecca is not given. It has been argued (Cooper, 1974) that: 'Deposition of the *Cistecephalus* Zone in the Cape probably occurred simultaneously with "Upper Ecca" strata in Natal.' In Johnson *et al.* (1997) it is stated under Adelaide Subgroup: "In the northeastern region the Estcourt and Normandien Formations are laterally equivalent units in the subgroup (Figs. 2, 4), although the Estcourt Formation will probably in future be incorporated in the Normandien Formation." The floras (Anderson & Anderson 1985) and insect faunas (Van Dijk 1997 [1998]) of Lidgetton and Bulwer have much in common with those of Mooi River and other sites mapped as Estcourt Formation (or Adelaide Subgroup), although Lidgetton is mapped as Ecca and Bulwer as Tarkastad Subgroup. The megasporophyll *Lidgettonia* ranges from Lidgetton to Bulwer in KwaZulu-Natal. It is also found at Lawley, mapped as Ecca in the Transvaal. The Upper Ecca and Lower Beaufort Formations in the northern and eastern parts of the Karoo Basin are in need of re-assessment, and this with respect to biostratigraphy based on a wider spectrum of organisms than just vertebrates.

The Triassic De Hoek locality is of special interest because it includes the transition from *Dicynodon* zone to *Lystrosaurus* zone and the area is capped by a sandstone identified by D. Hobday as Katberg sandstone near its southern extremity (Van Dijk, Hobday & Tankard, 1978). Since the *Dicynodon* zone is Permian, and the Katberg Triassic, this represents an area where the Permian/Triassic boundary could be studied remote from the sections studied by Ward *et al.* (2000).

The lack of common lithological features in the Molteno, Elliot and Clarens Formations has been offered as reason for abandoning the term Stormberg. In compiling a bibliography of the Palaeozoic and Mesozoic vertebrate trackways of Africa, a number of instances were noted where there was doubt as to whether a particular location was Molteno or Elliot, or Elliot or Clarens. This suggests some sort of commonality which might profitably be accorded a name.

Literature

An attempt was made to trace early references, often found to have been neglected, and also some of the most recent references which would help others to get into specific literature expeditiously. With present information technology it is possible for organizations and persons to compile the results of literature searches, or of examination of specimens, so that they are reasonably easily accessible to interested parties. Compilations of references to African and Southern African fossil frogs have been made and published (Van Dijk, 1995; 1996) and one on Palaeozic and Mesozoic Vertebrate Trackways of Africa is nearly ready for publication (included in a poster, cf. Tierberg, pp. 11-12, presented at two meetings – Van Dijk, 2000). A list of compilations on an African palaeontological website would be most useful.

One example of an interesting taxon which has been almost entirely overlooked is *Cryptozoon Dessaueri* Gürich 1922 from the Transvaal.

Discovery of Sites

Sites which are of palaeontological importance have often been discovered by non-palaeontologists, or through their interest in fossils. Thus the engineer Brain Schaller was instrumental in the timeous discovery of the Mooi River site, with which, in the Southern Hemisphere, only one or two Australian sites can compare with the 25 plant taxa (7 holotypes) and 33 animal taxa (23 holotypes).

Children discovered the Bulwer and Mount West sites.

Recording of Sites

Many specimens were brought to the University of Natal or the Natal Museum by non-palaeontologists. Attempts at tracing the site from which a specimen came were often unsuccessful. This was sometimes because the donor was not the collector, but the problem was often the inability to record sufficiently accurately. Usually these specimens were then not found in situ in the matrix, but were picked up loose. In the case of hard specimens, such as silicified wood, they might have been transported naturally for some distance. (A tooth from a river bed in Namibia, thought to be a lion's tooth by the collector, was in fact an dicynodont tooth from Karoo beds tens of kilometres away).

The fossils on the Mooi River National Road excavation surface could not have escaped the notice of workers, and certainly not that of a geologist. Fossils must have been visible in some of the numerous cores taken. Similarly fossils on the Kilburn Dam site were not reported by the resident geologist. There is clearly a case to be made for mandatory reporting of fossils during such operations as road- and dam building, particularly by resident geologists.

Discovery and Recording

Collection of loose fossils should not be prohibited; rather accurate recording, proper care before seen by some-one knowledgable, availability for study if a specimen is valuable, designation of an educational institution as ultimate recipient, and proper labelling and care until it is permanently housed, should be obligatory.

Properties of Sites

Sites vary in the taxa they contain and their matrix or matrices. The site at Mooi River has extraordinary value not only for the variety of the fossils it contains, but also the relatively sparse distribution of the specimens. Individual specimens can often be isolated on quite small, manageable, blocks which show no signs of deterioration after several decades in a museum collection. Collection at the site was prompt, limiting the amount of deterioration, especially invasion of muddy water on bedding planes, before collecting. Steps need to be taken to ensure that in future such exposures are reported promptly, and that there are facilities for rapid temporary or permanent storage.

At Far End the specimens are crowded on planes separated only by millimetres of rather friable matrix. Complete leaves can rarely be isolated. Valuable specimens are rather rare, and usually only found after destroying many overlying ones. The material deteriorates before collecting very rapidly, but once collected and carefully housed specimens survive well. Material has been stored, but steps need to taken to distribute the large number of scraps that result from attempts at finding valuable fossils.

At Estcourt Weir the material is both suitable for display in an *in situ* field museum, and for distribution as small robust blocks with only one or two leaf taxa, after inspection for anything valuable.

Bulwer is a site with great potential in what has been left after decades of destruction by quarrying for road gravel. Potential non-palaeontologist collectors are at hand and ample storage is available nearby for fossiliferous layers. Supervised collecting or collecting after instruction is urgently needed if this site is to be used as well as it deserves.

Education

There is ample fossil plant material in numerous operating quarries to provide a few specimens for every school in Southern Africa. There are also many places in the Karoo where isolated scraps of bone can be collected in dongas and stream beds, and once collected they could help to stimulate children to keep their eyes, and minds, open.

At the moment there is discussion of the introduction of evolution into school syllabuses. It is much more to the point to show children fossils, and explain the circumstances of their fossilization and the evidence which they can themselves experience (not necessarily see, for fossils, and sedimentary features, are ideal for the sight impaired).

4 REFERENCES

Abel, O. 1935. *Vorzeitliche Lebensspuren.* Jena, Gustav Fischer, xv 644pp.

Adamson, R.S. 1931. Note on Some Petrified Wood From Banke, Namaqualand. *Trans.roy.Soc.S.Afr.* **19:** 255-258, Pl. XXV.

Almond, J., Evans, F. & Cotter, E. 1998. *Cape Supergroup Field Trip Gondwana 10.* Cape Town, University of Cape Town, (vi) 64pp. 2 Tables Maps A-E.

Anderson, A. 1970. An Analysis of Supposed Fish Trails From Interglacial Sediments in the Dwyka Series, Near Vryheid, Natal. *Proc.2nd IUGS Gondwana Symposium 1970*: 637-647.

Anderson, A.M. 1974. *Arthropod Trackways and Other Trace Fossils From the Early Permian Lower Karroo Beds of South Africa.* Ph.D. Thesis, University of Witwatersrand, xiv 190pp. (ii) xix 76pp. + publication (Unpublished)

Anderson, A.M. 1975. Turbidites and Arthropod Trackways in Dwyka Glacial deposits (early Permian) of southern Africa. *Trans.geol.Soc.S.Afr.* **78:** 265-273.

Anderson, A.M. 1976. Fish Trails From the Early Permian of South Africa. *Palaeontology* **19:** 397-409, pl. 54.

Anderson, A.M. 1981. The *Umfolozia* arthropod trackways in the Permian Dwyka and Ecca Series of South Africa. *J.Paleontol.* **55:** 84-108.

Anderson, A.M. & McLachlan, I.R. 1976. The Plant Record in the Dwyka and Ecca Series (Permian) of the South-Western Half of the Great Karroo Basin, South Africa. *Palaeont.afr.* **19:** 31-42.

Anderson, J.M. & Anderson, H.M. 1983. *Palaeoflora of Southern Africa Molteno Formation (Triassic).* Volume 1 Part 1. Introduction / Part 2. Dicroidium. Rotterdam, A.A. Balkema, (vii) 227pp.

Anderson, J.M. & Anderson, H.M. 1984. The Fossil Content of the Upper Triassic Molteno Formation, South Africa. *Palaeont.afr.* **25:** 39-59.

Anderson, J.M. & Anderson, H.M. 1985. *Palaeoflora of Southern Africa Prodromus of South African Megafloras Devonian to Lower Cretaceous.* Rotterdam, A.A. Balkema, 423pp.

Anderson, J.M. & Anderson, H.M. 1989. *Palaeoflora of Southern Africa Molteno Formation (Triassic)* Volume 2 Gymnosperms (excluding Dicroidium). Rotterdam, A.A. Balkema, 567pp.

Anderson, W. 1907. On the Discovery in Zululand of Marine Fossiliferous Rocks of Tertiary Age, Containing Mammalian Remains. *Rep.geol.Surv.Natal Zululand* **3:** 119-127.

Baily, W.H. 1855. Description of some Cretaceous Fossils from South Africa; collected by Capt. Garden, of the 4th Regiment. *Quart.J.geol.Soc.Lond.* **11:** 454-463, Pls. XI-XIII.

Bamford, M. 1999. Permo-Triassic Fossil Woods From the South African Karoo Basin. *Palaeont.afr.* **35:** 25-40.

Barghoorn, E.S. & Schopf, J.W. 1966. Microorganisms Three Billion Years Old from the Precambrian of South Africa. *Science* **152:** 758-763.

Bertrand-Sarfati, J. & Eriksson, K.A. 1977. Columnar Stromatolites From the Early Proterozoic Schmidtsdrift Formation, Northern Cape Province, South Africa - Part I: Systematic and Diagnostic Features. *Palaeont.afr.* **20:** 1-26.

Beukes, N.J. 1970 (1969). *Die sedimentologie van die Étage Holkranssandsteen, Sisteem Karoo.* M.Sc. Tesis, Univ.Oranje Vrystaat (Ongepubliseerd)

Brain, C.K. 1958. The Transvaal Ape-Man-Bearing Cave Deposits. *Transvaal Museum Memoir* No. 11: (ix) 131pp.

Brain, C.K. 1997. The Importance of Nama Group Sediments and Fossils to the Debate About Animal Origins. *Palaeont.afr.* **34:** 1-13.

Brock, A., McFadden, PL. & Partridge, T.C. 1977. Preliminary palaeomagnetic results from Makapansgat and Swartkrans. *Nature Lond.* **266:** 249-250.

Bühmann, D., Bühmann, C. & von Brunn, V. 1989. Glaciogenic Banded Phosphorites from Permian Sedimentary Rocks. *Econ.Geol.* **84:** 741-750.

Butzer, K.W. 1976. Lithostratigraphy of the Swartkrans Formation. *S.Afr.J.Sci.* **72:** 136-141.

Casamiquela, R.M. 1961. Sobre la Prescencia de un Mamifero en el Primer Elenco (Icnologico) de Vertebrados del Jurasico de la Patagonia. *Physis* **22:** 225-233.

Cloud, P. 1973. Paleoecological Significance of the Banded Iron-Formation. *Econ.Geol.* **68:** 1135-1143.

Cloud, P. & Glaessner, M.F. 1982. The Ediacarian Period and System: Metazoa Inherit the Earth. *Science* **217**: 783-792.

Cole, D.I. & McLachlan, I.R. 1991. Oil Potential of the Permian Whitehill Shale Formation in the Main Karoo Basin, South Africa. *Proc.Pap.7th Internat.Gondwana Symposium Sao Paulo 1988*: 379-390.

Cole, D.I. Smith, R.M.H. & Wickens, H. de V. 1990. Basin-plain to fluvo-lacustrine deposits in the Permian Ecca and Lower Beaufort Groups of the Karoo Sequence. *Guidebook Geocongress '90 Geological Society of South Africa,* PO2: 1-83.

Cooper, M.R. 1974. The Correlation of the Subdivisions of the Karroo System by O.R. Van Eeden Discussion. *Trans.geol.Soc.S.Afr.* 77: 377-379.

Cooper, M.R. & Oosthuizen, R. 1974. Archaeocyathid-bearing Erratics from Dwyka Subgroup (Permo-Carboniferous) of South Africa, and their Importance to Continental Drift. *Nature Lond.* **247:** 396-398.

Corstorphine, G. S. 1904. Section B. Presidents Address. The History of Stratigraphical Investigation in South Africa. *Rep.S.Afr.Assoc.Advanc.Science* **1904**: 145-181 + Appendix(folding table).

Crimes, T.P. & Harper, J.C. (Editors) 1970. *Trace Fossils.* Liverpool, Liverpool Geological Society, v 547pp.

Deacon, H.J. & Deacon, J. 1999. *Human Beginnings in South Africa Uncovering the Secrets of the Stone Age.* Claremont, David Philip Publishers, (ix) 214pp.

De Beer, C.H. 1986. Surface Markings, Reptilian Footprints and Trace Fossils on a Palaeosurface in the Beaufort Group Near Fraserburg, C.P.. *Ann.geol.Surv.S.Afr.* **20:** 129-140.

Debrenne, F. 1975. Archaeocyatha Provenant de Blocs Erratiques de Tillites de Dwyka (Afrique du Sud). *Ann.S.Afr.Mus.* **67:** 331-361.

Dornan, S.S. 1905. On the Geology of Basutoland. *Rep.75th Meeting Brit.Assoc.Adv.Science*: 404-405.

Dornan, S.S. 1908. Notes on the Geology of Basutoland. *Geol.Mag.* **5:** 57-63, 112-118.

Du Toit, A.L. 1927. The Fossil Flora of the Upper Karroo Beds. *Ann.S.Afr.Mus.* **22:** 289-420 Plates XVI-XXXII.

Dunn, E.J. 1875. *Geological Sketch Map of South Africa. 2nd Ed.* Stanford.

Dzik, J. 1999. Organic membranous skeleton of the Precambrian metazoans from Namibia. *Geology* **27:** 519-522.

Els, B.G. 1998. The question of alluvial fans in the auriferous Archaean and Proterozoic successions of South Africa. *S.Afr.J.Geol.* **101:** 17-25.

Ellenberger, F.; Ellenberger, P.; Fabre, J.; Ginsburg, L. & Mendrez, C. 1964. The Stormberg Series of Basutoland (South Africa). *Proc.Internat.geol.Congress XX Section IX*: 320-330.

Ellenberger, P. 1970. Les Niveaux Paléontologiques de Première Apparition des Mammiferes Primordiaux en Afrique du Sud et Leur Ichnologie Établissement de Zones Stratigraphiques Détaillees dans le Stormberg du Lesotho (Afrique du Sud) (Trias Supérieur a Jurassique). *Proc.2nd Gondwana Symposium IUGS*: 343-370.

Eriksson, K.A. & Truswell, J.F. 1974. Stratotypes From the Malmani Subgroup North-West of Johannesburg, South Africa. *Trans.geol.Soc.S.Afr.* **77:** 211-222.

Estes, R. 1977. Relationships of the South African Fossil Frog *Eoxenopoides reuningi* (Anura, Pipidae). *Ann.S.Afr.Mus.* **73:** 49-80.

Evans, F.J. 1997. *Palaeobiology of Early Carboniferous Fishes and Contemporary Lacustrine Biota of the Waaipoort Formation (Witteberg Group), South Africa.* M.Sc. Thesis, University of Stellenbosch, xii 214pp 88pls i-lviii.

Faure, K. & Cole, D. 1998. Stable isotope evidence for a freshwater algal bloom in the Permian Karoo and Paraná Basins of southwestern Gondwana. *J.Afr.Earth Sciences* **27(1A):** 70-71.

Garnier, J. (translated C. de Savigny) 1896. Gold and Diamonds in the Transvaal and the Cape. *Trans.geol.Soc.S.Afr.* **2:** 91-103 Plate (Figs. 1-13); 109-120, Plate (Figs. 14-15) & Map According to David Draper.

Geertsema, H. & van den Heever, J.A. 1996. A new beetle, *Afrocupes firmae* gen. et sp. nov. (Permocupedidae), from the Late Palaeozoic Whitehill Formation of South Africa. *S.Afr.J.Sci.* **92:** 497-499.

Geertsema, H. & van Dijk, D.E. 1999. The earliest known Palaeozoic ensiferan insect from Africa, *Afroedischia oosthuizeni* gen. et sp. nov. (Orthoptera: Oedischiidae). *S.Afr.J.Sci.* **95:** 229-230.

Germs, G.J.B. 1972a. New Shelly Fossils From Nama Group, South West Africa. *Amer.J.Sci.* **272:** 752-761.

Germs, G.J.B. 1972b. The Stratigraphy and Paleontology of the Lower Nama Group, South West Africa. *UCT Chamber of Mines Precambrian Research Unit Bulletin* 12: (viii) 250pp.

Germs, G.J.B. 1974. The Nama Group in South West Africa and Its Relationship to the Pan-African Geosyncline. *J.Geol.* **82:** 301-317.

Glaessner, M.F. 1962. Pre-Cambrian Fossils. *Biol.Rev.* **37:** 467-494 Plate I.

Gordon-Gray, K.D., van Dijk, D.E. & Lacey, W.S. 1976. Preliminary Report on Equisetalean Plants From Lidgetton, Natal. *Palaeont.afr.* **19:** 43-57.

Gow, C.E. & Latimer, E.M. 1999. Preliminary Report of Dinosaur Trackways in Qwa Qwa, South Africa. *Palaeont.afr.* **35:** 41-43.

Green, D. 1998. *Palaeoenvironments of the Estcourt Formation (Beaufort Group), Kwazulu-Natal.* M.Sc. Thesis, University of Natal Durban, (i) 188pp. (Unpublished)

Groenewald, G.H. 1984. *Stratigrafie en sedimentologie van die Groep Beaufort in die Noordoos-Vrystaat.* M.Sc. Tesis, Randse Afrikaanse Universiteit, 174pp. (Ongepubliseerd)

Groenewald, G.H. 1990. Gebruik van Paleontologie in Litostratografiese Korrelasie in die Beaufort Groep, Karoo Opeenvolging van Suid-Afrika. *Palaeont.afr.* **27:** 21-30.

Grotzinger, J.P., Bowring, S.A., Saylor, B.Z. & Kaufman, Alan J. 1995. Biostratographic and Geochronologic Constraints on Early Animal Evolution. *Science* **270:** 598-604.

Gürich, G. 1903. Cambrium (?) in Deutsch-Südwestafrika. *Centralbl.Mineral.Geol.Paläont.* 1902: 65-69.

Gürich, G. 1922. *Cryptozoon Dessaueri* aus den Dolomit-Schichten des Transvaal-Systems in Südafrika. *Palaeont.Zeitschr.* **4:** 129-131.

Gürich, G. 1926. Über Saurier-Fährten aus dem Etjo-Sandstein von Südwestafrika. *Palaeont.Zeitschr.* **8:** 112-120, Taf.2.

Gürich, G. 1929. Die ältesten Fossilien Afrikas. *Zeitschr.prakt.Geol.* **37:** 85.

Gürich, G. 1930a. Die bislang ältesten Spuren von Organismen in Südafrika. *Proc. 15th Int.geol.Congress* : 670-680, Figs. 1-5.

Gürich, G. 1930b. Über den Kuibis-Quarzit in Südwestafrika. *Zeitschr.deut.geol.Ges.* **82:** 637

Gürich, G. 1933. Die Kuibis-Fossilien der Nama-Formation von Südwestafrika. *Palaeont.Zeitschr.* **15:** 137-154.

Hallbauer, D.K. 1975. The Plant Origin of the Witwatersrand "Carbon". *Minerals Sci.Engin.* **7:** 111-131.

Hallbauer, D.K. & van Warmelo K.T. 1974. Fossilized Plants in Thucholite From Precambrian Rocks of the Witwatersrand, South Africa. *Precambrian Res.* **1:** 199-212.

Hatch, F.H. 1910. The Discovery of Fish-Remains in the Ecca Shales, near Ladysmith. *Ann.Natal Mus.* **2:** 227-228.

Haughton, S.H. 1919. A Review of the Reptilian Fauna of the Karroo System of South Africa. *Trans.geol.Soc.S.Afr.* **22:** 1-25.

Haughton, S.H. 1924. The fauna and Stratigraphy of the Stormberg Series. *Ann.S.Afr.Mus.* **12:** 323-495.

Haughton, S.H. 1931. On a Collection of Fossil Frogs from the Clays at Banke. *Trans.roy.Soc.S.Afr.* **19:** 233-249, Pls. XXIII-XXIV.

Haughton, S.H. 1934. Exhibition of Fossils from the Nama System of South-West Africa. *Trans.roy.Soc.S.Afr.* **22**(3)**:** vii-viii.

Haughton, S.H. 1959. An Archaeocyathid from the Nama System. *Trans.roy.Soc.S.Afr.* **36:** 57-59 Plates III-V.

Hendey, Q.B. 1982. *Langebaanweg A Record of Past Life.* Cape Town, South African Museum, (vi) 71pp.

Hendey, Q.B. 1970. A Review of the Geology and Palaeontology of the Plio/Pleistocene Deposits at Langebaanweg, Cape Province. *Ann.S.Afr.Mus.* **56:** 75-113, Pls. 1-4.

Hill, R.S. 1967. *An Investigation of the Northern Flank of Helderberg.* B.Sc. Project, University of Stellenbosch (unpublished) (Not available for checking of pagination)

Hobday, D.K. & Tavener-Smith, R. 1975. Trace Fossils in the Ecca of Northern Natal and Their Palaeoenvironmental Significance. *Palaeont.afr.* **18:** 47-52.

Holland, C.H. 1964. Stratigraphical classification. *Science Progr.* **52:** 439-451.

Holub, E. 1881. *Sieben Jahre in Südafrika Ergebnisse, Forschungen und Jagden auf meinen Reisen von den Diamantfelden zum Zambesi (1872-1879)* Zweiter Band. Wien, Alfred Hölder, ix (+ i Errata) 532pp. 4 Tafeln.

Ishigaki, S. & Fujisaki, T. 1989. In: *Dinosaur Tracks and Traces.* (eds. Gillette, D.D. & Lockley, M.G. 48 Three Dimensional Representation of *Eubrontes* by the Method of Moiré Topography. Cambridge, Cambridge University Press, xvii 454pp.

James & Sims 1973, see Cloud 1973.

Jensen, S., Saylor, B.Z., Gehling, J.G. & Germs, G.J.B. 2000. Complex trace fossils from the terminal Proterozoic of Namibia. Geology **28:** 143-146.

Johnson, M.R. (Edit./Red.) 1996. South African Code of Stratigraphic Terminology and Nomenclature. *S.Afr.Comm.Stratigr.* **ii:** 8 pp. ; 8pp.

Johnson, M.R., Van Vuuren, C.J., Hegenberger, W.F., Key, R. & Shoko, U. 1996. Stratigraphy of the Karoo Supergroup in southern Africa: an overview. *J.Afr.Earth Science* **23:** 3-15.

Johnson, M.R., Van Vuuren, C.J., Visser, J.N.J., Cole, D.I., Wickens, H. deV., Christie, A.D.M. & Roberts, D.L. 1997. *Sedimentary Basins of the World* 3 (Series Editor: K.J. Hsü) African Basins (Editor: R.C. Selley) Chapter 12 The Foreland Karoo Basin, South Africa. pp. 269-317. Amsterdam, Elsevier.

Jubb, R.A. & Gardiner, B.G. 1975. A Preliminary Catalogue of Identifiable Fossil Fish Material From Southern Africa. *Ann.S.Afr.Mus.* **67:** 381-440.

Kalkowsky, E. 1908. Oolith und Stromatolith im norddeutschen Bundsandstein. Zeitschr.deut.geol.Ges. **60:** 68-125.

Kennedy, W.J. & Klinger, H.C. 1975. Cretaceous Faunas From Zululand and Natal, South Africa Introduction, Stratigraphy. *Bull.Brit.Mus.nat.Hist.(Geol.)* **25:** 265-315, Plate.

Kent, L.E. (compiler) 1980. *Stratigraphy of South Africa* Handbook 8 Part 1: Lithostratigraphy of the Republic of South Africa, South West Africa/Namibia and the Republics of Bophuthatswana, Transkei and Venda. Pretoria, Government Printer, xix 690pp. Text Figures and Folding Figures.

King, L.C. 1953. A Miocene Marine Fauna from Zululand. *Trans.geol.Soc.S.Afr.* **56:** 59-91, Plates VIII-XII.

Kirchheimer, F. 1934. On Pollen from the Upper Cretaceous Dysodil of Banke, Namaqualand (South Africa). *Trans.roy.Soc.S.Afr.* **21:** 41-50, Pls. V&VI

Kitching, J.W. & Raath, M.A. 1984. Fossils from the Elliot and Clarens Formations (Karoo Sequence) of the Northeastern Cape, Orange Free State and Lesotho, and a Suggested Biozonation Based on Tetrapods. *Palaeont.afr.* **25:** 111-125.

Knoll, A.H. & Barghoorn, E.S. 1977. Archaean Microfossils Showing Cell Division from the Swaziland System of South Africa. *Science* **198:** 396-398.

Kraus (F.) 1843. Über die geologischen Verhältnisse der östlichen Küste des Kaplandes, mit besonderer Berücksichtigung der in der Algoabay vorkommenden Kreideformation und deren Petrefacten eröffnet. *Amtl.BerVersamml.Ges.deut.Naturf.Aertze zu Mainz* **20** (1842):126-131.

Kuhn, O. 1958. *Die Fährten der vorzeitlichen Amphibien und Reptilien.* Bamberg, Meisenbach KG, 64pp.

Lacey, W.S., Van Dijk, D.E. & Gordon-Gray, K.D. 1974. New Permian *Glossopteris* Flora from Natal. *S.Afr.J.Sci.* **70:** 154-156.

Lacey, W.S., Van Dijk, D.E. & Gordon-Gray, K.D. 1975. Fossil plants from the Upper Permian in the Mooi River district of Natal, South Africa. *Ann.Natal Mus.* **22:** 349-420.

Lawes, M. 1983. *A Study of the Lithology, Sedimentology and Taphonomy of Upper Estcourt Formation Deposits, Beaufort Group, at the De Hoek Fossil Site, Draycott, Natal.* B.Sc. Honours Project (Zoology), University of Natal Pietermaritzburg, (iv) 68pp. (Unpublished).

Loock, J.C. 1967. *The stratigraphy of the Witteberg-Dwyka Contact Beds.* M.Sc.Thesis, University of Stellenbosch, (ii) vi 139pp. 2Pls. 15Tables 19Figs.. (Unpublished)

MacGregor, I.M., Truswell, J.F. & Eriksson, K.A. 1974. Filamentous algae from the 2,300 m.y. old Transvaal Dolomite. *Nature Lond.* **247:** 538-540.

MacRae, C. 1999. Fossils of South Africa. Cramerview, Geological Society of South Africa, (xix) 305pp.

Marais, J.A.H. 1963. Fossil Fish from the Upper Witteberg Beds near Lake Mentz, Jansenville District, Cape Province. *Ann.geol.Surv.S.Afr.* **2:** 191-202 (Pls. I-IV).

Mason, T.R. & von Brunn, V. 1977. 3-Gyr-old stromatolites from South Africa. *Nature Lond.* **266:** 47-49.

McLachlan, I.R. & Anderson, A. 1973. A Review of the Evidence for Marine Conditions in Southern Africa During Dwyka Times. *Palaeont.afr.* **15:** 37-64.

McLachlan, I.R. & Anderson, A.M. 1975. The Age and Stratigraphic Relationship of the Glacial Sediments in Southern Africa. *Proc.3rd Gondwana Symposium* 415-422.

McLachlan, I.R. & Anderson, A.M. 1977a. Carbonates, "Stromatolites" and Tuffs in the Lower Permian White Band Formation. *S.Afr.J.Sci.* **73:** 92-94.

McLachlan, I.R. & Anderson, A.M. 1977b. Fossil Insect Wings From the Early Permian White Band Formation, South Africa. *Palaeont.afr.* **20:** 83-86.

Narbonne, G.M., Saylor, B.Z. & Grotzinger, J.P. 1997. The Youngest Ediacaran Fossils from South Africa. *J.Paleont.* **71:** 953-967.

Oelofsen, B.W. 1981. The Biostratigraphy and Fossils of the Whitehill and Irati Shale Formations of the Karoo and Paraná Basins. Proc.6th Gondwana Symposium. *Geophys.Monogr.Amer.Geophys.Union* 41: 131-138.

Oelofsen, B.W. 1981. *An Anatomical and Systematic Study of the Family Mesosauridae (Reptilia: Proganosauria) With Special Reference to Its Associated Fauna and Paleoecological Environment in the White-Hill Sea.* Ph.D. Thesis, University of Stellenbosch, (viii) 164pp. (+87pp.). (Unpublished)

Oelofsen, B.W. 1986. A Fossil Shark Neurocranium from the Permo-Carboniferous (Lowermost Ecca Formation) of South Africa. *Proc. 2nd Internat.Conf. Indo-Pacific Fishes*: 107-124.

Olsen, P.E. & Galton, P.M. 1984. A Review of the Reptile and Amphibian Assemblages from the Stormberg of Southern Africa, With Special Emphasis on the Footprints and the Age of the Stormberg. *Palaeont.afr.* **25:** 87-110.

Oosthuizen, R.D.F. 1981. An Attempt to Determine the Provenance of the Southern Dwyka from Paleontological Evidence. *Palaeont.afr.* **24:** 27-29.

Partridge, T.C. 1979. Re-appraisal of lithostratigraphy of Makapansgat Limeworks hominid site. *Nature Lond.* **279:** 484-488.

Pflug, H.D. 1966. Structured Organic Remains from the Fig Tree Series of the Barberton Mountain Land. *Econ.Geol.Res.Unit Information Circular* 28: (v) 14pp. 4 plates.

Pia, J. 1927. In: *Handbuch der Paläobotanik* (Max Hirmer) Band I: Thallophyta Bryophyta Pteridophyta 1. Abteilung: Thallophyta (pp. 31-112). München, R. Oldenburg, xvi 708pp.

Pickford, M.H.L. 1995. Review of the Riphean, Vendian and early Cambrian Palaeontology of the Otavi and Nama Groups, Namibia. *Communs geol.Surv.Namibia* **10:** 57-81.

Plumstead, E.P. 1969. Three Thousand Million Years of Plant Life in Africa. Alex L. du Toit Memorial Lectures No. 11. *Trans.geol.Soc.S.Afr.* Annexure to **72:** Frontispiece (vii) 72pp. Plates I-XXV.

Plumstead, E.P. 1970. *Post Symposium Excursion. Guide Book No.4* Part A –Text The Transvaal and Natal Coal Measures. pp. 9-37 Part B – Maps Geological Sketch Map of Routes A & C. IUGS Comm.Gondwana Stratigr.Palaeont. **2nd** Symposium 1970. Pretoria, C.S.I.R.

Pretorius, D.A. 1975. The Depositional Environment of the Witwatersrand Goldfields: A Chronological Review of Speculations and Observations. *Minerals Sci.Engin.* **7:** 18-47.

Raath, M. 1972. First Record of Dinosaur Footprint from Rhodesia. *Arnoldia (Rhodesia)* **5** (27): 1-5.

Raath, M. 1996. Earliest Evidence of Dinosaurs From Central Gondwana. *Mem.Queensland Mus.* **39:** 703-709.

Raath, M.A., Kitching, J.W., Shone, R.W. & Rossouw, G.J. 1990. Dinosaur Tracks in Triassic Molteno Sediments: The Earliest Evidence of Dinosaurs in South Africa? *Palaeont.afr.* **27:** 89-95.

Rayner, R.J., Bamford, M.K., Brothers, D.J., Dippenaar-Schoeman, A.S., McKay, I.J., Oberprieler, R.G. & Waters, S.B. 1997. Cretaceous Fossils from the Orapa Diamond Mine. *Palaeont.afr.* **33:** 55-65.

Rennie, J.V.L. 1931. Note on Fossil Leaves from the Banke Clays. *Trans.roy.Soc.S.Afr.* **19:** 251-253.

Reuning, E. 1931. A Contribution to the Geology and Palaeontology of the Western Edge of the Bushmanland Plateau. *Trans.roy.Soc.S.Afr.* **19:** 215-232, Pls XX XXII.

Reuning, E. 1934. The Composition of the Deeper Sediments of the Pipe at Banke, Namaqualand, and Their Relation to Kimberlite. *Trans.roy.Soc.S.Afr.* **21:** 33-39.

Riek, E. F. 1973. Fossil insects from the Upper Permian of Natal, South Africa. *Ann. Natal Mus.* **21:** 513-532.

Riek, E. F. 1974a. An unusual immature insect from the Upper Permian of Natal. *Ann. Natal Mus.* **22:** 271-274.

Riek, E.F. 1974b. Upper Triassic Insects from the Molteno 'Formation', South Africa. *Palaeont.afr.* **17:** 19-31.

Riek, E. F. 1976a. New Upper Permian insects from Natal, South Africa. *Ann. Natal Mus.* **22:** 755-789.

Riek, E.F. 1976b. A new collection of insects from the Upper Triassic of South Africa. *Ann.Natal Mus.* **22:** 791-820.

Rilett, M.H.P. 1975. A fossil Lamellibranch from the Permian Lower Beaufort beds near Estcourt, Natal. *Ann.Natal Mus.* **22:** 677-679.

Rogers, A.W. 1903. Report of the Acting Geologist for the Year 1902. *Ann.Report geol.Commission Cape Good Hope* (1902):3-10.

Rogers, J., Thamm, A.G. & Hartnady, C.J.H. 1990. Scenery and Geology of the Cape Peninsula. *Guidebook Geocongress '90 Geological Society South Africa,* M1: 67pp.

Rossouw, P.J. 1953. Results of an Investigation Into the Possible Presence of Oil in Karroo Rocks in Parts of the Union of South Africa. (Haughton, S.H., Blignaut, J.J.G., Rossouw, P.J., Spies, J.J., Zagt, S.). II. -General Geology A. The Southern Karroo (pp. 14-36, Folder 3). *Geol.Surv.S.Afr.Mem.* 45: viii 130pp. 8 folders.

Rubidge, B.S. (editor) 1995. Biostratigraphy of the Beaufort Group (Karoo Supergroup). *S.Afr.Committee Strat. Biostratigraphic Series* No. 1: v 45pp.

Rust, I.C. 1967. *On the Sedimentation of the Table Mountain Group in the Western Cape Province.* D.Sc. Thesis, University of Stellenbosch, Title i-iii 110pp. 21 Pls. 123 Figs. (Unpublished)

SACS see Kent, 1980.

Savage, N.M. 1970. A Preliminary Note on Arthropod Trace Fossils From the Dwyka Series in Natal. *Proc. 2nd IUGS Gondwana Symposium 1970*: 627-635.

Savage, N.M. 1971. A varvite ichnocoenosis from the Dwyka series of Natal. *Lethaia* **4:** 217-233.

Sanchiz, B. 1998. *Handbuch der Paläoherpetologie Teil 4 Salientia.* München, Friedrich Pfeil, xii 275pp.

Schneiderhöhn, H. 1920. Beiträge zur Kenntnis der Erzlagerstätten und der geologischen Verhältnisse des Otaviberglandes, Deutsch-Südwestafrika. *Abh.Senck.nat.Ges.* **37:** 221-318, Tafn. 18-29, Karte.

Scholtz, A. 1985. The Palynology of the Upper Lacustrine Sediments of the Arnot Pipe, Banke, Namaqualand. *Ann.S.Afr.Mus.* **95:** 1-109.

Seeley, H.G. 1904. Footprints of small Fossil Reptiles from the Karroo Rocks of Cape Colony. *Ann.Mag.nat.Hist.* (7) **14:** 287-289.

Singer, R. & Hooijer, D.A. 1956. A Stegolophodon from South Africa. *Nature Lond.* **182:** 101-102.

Singer, R. & Wymer, J.J. 1982. *The Middle Stone Age at Klasies River Mouth in South Africa.* With contributions by K.W. Butzer, N.J. Schackleton, and E. Voigt. Chicago, University of Chicago Press, Frontispiece vi 234pp. 72Pls.

Smith, R.M.H. 1978. The Sedimentology and Taphonomy of Flood-Plain Deposits of the Lower Beaufort (Adelaide Subgroup) Strata near Beaufort West,Cape Province. *Ann.geol.Surv.S.Afr.* 1977-78 **12:** 37-68.

Smith, R.M.H. 1980. The Lithology, Sedimentology and Taphonomy of Flood-Plain Deposits of the Lower Beaufort (Adelaide Subgroup) Strata near Beaufort West. *Trans.geol.Soc.S.Afr.* **83:** 390-413.

Smith, R.M.H. 1986. Sedimentation and palaeoenvironments of Late Cretaceous crater lake deposits in Bushmanland, South Africa. *Sedimentology* **33:** 369-386.

Smith, R.M.H. & Macloed, K.G. 1998. Sedimentology and carbon isotope stratigraphy across the Permian-Triassic boundary in the Karoo Basin, South Africa. *J.Afr.Earth Sciences* **27(1A):** 185-186.

Spilsbury, E.G. 1908. Gregory J.W.: The Origin of the Gold in the Rand Banket - Contributed Remarks. *Trans.Institution Mining Metallurgy* **17:** 66-69.

Stear, W.M. 1978. Sedimentary Structures Related to Fluctuating Hydrodynamic Conditions in Flood Plain Deposits of the Beaufort Group near Beaufort West, Cape. *Trans.geol.Soc.S.Afr.* **81:** 393-399.

Stear, W.M. 1980. *The Sedimentary Environment of the Beaufort Group Uranium Province in the Vicinity of Beaufort West, South Africa.* Ph.D. Thesis, Univ. Port Elizabeth, front. (xi) 188pp. (Unpublished)

Stewart, W.N. & Rothwell, G.W. 1993. *Paleobotany and the Evolution of Plants.* 2nd Ed. Cambridge, Cambridge University Press, xii 521pp.

Strydom, H.C. 1950. The Geology and Chemistry of the Laingsburg Phosphorites. *Ann.Univ.Stellenb.* **26A:** 267-285.

Tankard, A.J. Varswater Formation of the Langebaanweg-Saldanha Area, Cape Province. *Trans.geol.Soc.S.Afr.* **77:** 265-283.

Tavener-Smith, R.; Cooper, J.A.G. & Rayner, R.J. 1988 Depositional environments in the Volksrust Formation (Permian) in the Mhlatuze River, Zululand. *S.Afr.J.Geol.* **91:** 198-206.

Thamm, A.G. 1988. *Contributions to the Geology of the Table Mountain Group.* M.Sc.Thesis, University of Cape Town, (v) 103pp +1 +publications. (Unpublished)

Tavener-Smith, R. & Mason, T.R. 1983. A Late Dwyka (Early Permian) Varvite Sequence Near Isandhlwana, Zululand, South Africa. *Palaeogr.Palaeoclim.Palaeoecol.* **41:** 233-249.

Theron, J.N. 1972. *The Stratigraphy and Sedimentation of the Bokkeveld Group.* D.Sc. Thesis, University of Stellenbosch, (v) 175pp. 17 pls. 66 figures. (Unpublished)

Theron, J.N.and Thamm, A.G. 1990. Stratigraphy and sedimentology of the Cape Supergroup in the Western Cape. *Guidebook Geocongress '90 Excursion Geological Society of South Africa*, PR2: 1-64.

Thomas, H.H. 1958. *Lidgettonia*, a new type of fertile *Glossopteris.* Bull.Brit.Mus.(Nat.Hist.) Geol. **3:** 179-190, Pls. 22-23.

Tobias, P.V. 1997. Some Little Known Chapters in the Early History of the Makapansgat Fossil Hominid Site. (Unintended italics omitted) *Palaeont.afr.* **33:** 67-79

Truswell, J.F. & Eriksson, K.A. 1975. A Palaeoenvironmental Interpretation of the Early Proterozoic Malmani Dolomite from Zwartkops. South Africa. *Precambrian Res.* **2:** 277-303.

Turner, Brian R. 1984. Palaeogeographic Implications of Braid Bar Deposition in the Triassic Molteno Formation of the Eastern Karoo Basin, South Africa. *Palaeont.afr.* **25:** 29-38.

Tyson, P.D. 1999. Late-Quaternary and Holocene palaeoclimates of southern Africa: A synthesis. *S.Afr.J.Geol.* **102:** 335-349/

Van Dijk, D.E. 1978. Trackways in the Stormberg. *Palaeont.afr.* **21:** 113-120.

Van Dijk, D.E. 1981. A Study of the Type Locality of *Lidgettonia africana* Thomas1958. *Palaeont.afr.* **24:** 43-61.

Van Dijk, D.E. 1985. An addition to the fossil Anura of Southern Africa. *S.Afr.J.Sci.* **81:** 207-208.

Van Dijk, D.E. 1995. African Fossil Lissamphibia. *Palaeont.afr.* **32:** 39-43.

Van Dijk, D.E. 1996 (1995). Fossil Anura of Southern Africa. *Madoqua* **19:** 57-60.

Van Dijk, D.E. 1998. Insect Faunas of South Africa From the Upper Permian and the Permian/Triassic Boundary. *Palaeont.afr.* **34:** 34-48.

Van Dijk, D.E., Channing, A.E. & Van den Heever, J.A. Permian Trace Fossils Attributed to Tetrapods (Tierberg Formation, South Africa). (Submitted for publication)

Van Dijk, D.E. & Geertsema, H. 1999. Permian Insects from the Beaufort Group of Natal, South Africa. *Ann.Natal Mus.* **40:** 137-171.

Van Dijk, D.E.; Gordon-Gray, K.D. & Lacey, W.S. 1975. Fine Structure of Fossils From Lidgetton, Natal, South Africa (Lower Beaufort, Upper Permian). *Electron Micro.Soc.S.Afr.Proc.* **5:** 89-90.

Van Dijk, D.E., Hobday, D.K. & Tankard, A.J. 1978. Permo-Triassic lacustrine deposits in the Eastern Karoo Basin, Natal, South Africa. *Spec.Publs.int.Ass.Sediment.* **2**: 225-239.

Van Dijk, D.E.; Le Roux, A. & Bell, K. 2000. Fossil Anura From Klasies River Mouth Hominid Site, Tsitsikama, South Africa. Poster. *11thBiennial Conference Palaeont.Soc.Southern Afr. Abstract.*

Van Dijk, D.E., Tankard, A., von Brunn, V. & Gordon-Gray, K.D. 1969. Fossiliferous Areas in the Natal Region. *S.Afr.Assoc.Advanc.Science 67th Congr. Abstract*: V.

Van Eeden, O.R. & Keyser, A.W. 1972. Fossielspore in die Holkranssandsteen op Pont Drift, Distrik Soutpansberg, Transvaal. *Ann.geol.Opname S.Afr.* **9:** 135-137 8pl. kaart (oopvou)

Van Eysinga, F.W.B. 1970. Stratigraphic Terminology and Nomenclature; A Guide For Editors and Authors. *Earth. Science Rev.* **6:** 267-288.

Visser, J.N.J. 1986. Lateral Lithofacies Relationships in the Glacigene Dwyka Formation in the Western and Central Parts of the Karoo Basin. *Trans.geol.Soc.S.Afr.* **89:** 373-383.

Visser, J.N.J. 1987. The Palaeogeography of Part of Southwestern Gondwana During the Permo-Carboniferous Glaciation. *Palaeogeogr.Palaeoclimat.Palaeoecol.* **61:** 205-219.

Visser, J.N.J. 1989. The Permo-Carboniferous Dwyka Formation of Southern Africa: Deposition by a Predominantly Subpolar Marine Ice Sheet. *Palaeogeogr.Palaeoclimat.Palaeoecol.* **70:** 377-391.

Visser, J.N.J. 1990. The age of the late Palaeozoic glacigene deposits in southern Africa. *S.Afr.J.Geol.* **93:** 366-375.

Visser, J.N.J. 1991. Self-destructive collapse of the Permo-Carboniferous marine ice sheet in the Karoo Basin: evidence from the southern Karoo. *S.Afr.J.Geol.* **94:** 255-262.

Visser, J.N.J. 1992. Deposition of the Early to Late Permian Whitehill Formation during a sea-level highstand in a juvenile foreland basin. *S.Afr.J.Geol.* **95:** 181-193.

Visser, J.N.J. 1993. Sea-level changes in a backarc-foreland transition: the late Carboniferous-Permian Basin of South Africa. *Sed.Geol.* **83:** 115-131.

Visser, J.N.J. & Loock, J.C. 1978. Water Depth in the Main Karoo Basin, South Africa, During Ecca (Permian) Sedimentation. *Trans.geol.Soc.S.Afr.* **81:** 185-191.

Visser, J.N.J.; Von Brunn, V. & Johnson, M.R. 1990. *Catalogue of South African Lithostratigraphic Units* (Editor: M.R. Johnson).*[Carboniferous-Permian]* [Karoo Sequence] DWYKA GROUP. *S.Afr.Comm.Stratigr.* **2:** 2-15 – 2-16.

Von Brunn, V. 1981. Sedimentary facies related to Late Paleozoic (Dwyka) Deglaciation in the eastern Karroo Basin, South Africa. *Proc.5th Internat.Gondwana Symposium 1980*: 117-123.

Von Brunn, V. 1996. The Dwyka Group in the northern part of Kwazulu-Natal, South Africa: sedimentation during late Palaeozoic deglaciation. *Palaeogr.Palaeoclim.Palaeoecol.* **125:** 141-163.

Von Brunn, V. 2000. (Published, but not yet, Nov. 2000, available for purchase)

Von Brunn, V. & Gravenor, C.P. 1983. A Model for Late Dwyka Glaciomarine Sedimentation in the Eastern Karoo Basin. *Trans.geol.Soc.S.Afr.* **86:** 199-209.

Von Brunn, V. & Mason, T.R. 1977. Siliciclastic-Carbonate Tidal Deposits From the 3000 M.Y. Pongola Supergroup, South Africa. *Sed.Petrol.* **18:** 245-255.

Waldrop, M.M. 1990. Goodbye to the Warm Little Pond? *Science* **250:** 1078-1080.

Ward, P.D.; Montgomery, D.R. & Smith, R. 2000. Altered River Morphology in South Africa Related to the Permian/Triassic Extinction. *Science* **289:** 1740-1743.

Woodward, A. Smith 1910. Note on Palaeoniscid Fish-scales from the Ecca Shales, near Ladysmith. *Ann.Natal Mus.* **2:** 229-231 Pl. IX.

Young, G.M., Von Brunn, V, Gold, D.J.C. & Minter, W.E.L. 1998 Earth's Oldest Reported Glaciation: Physical and Chemical Evidence from the Archean Mozaan Group (~ 29 Ga) of South Africa. *J.Geol.* **106:** 523-538.

Young, R.B. 1932. The Occurrence of Stromatolitic or Algal Limestones in the Campbell Rand Series, Griqualand West. *Trans.geol.Soc.S.Afr.* **35:** 29-36 Pls. IV-VI.

Young, R.B. 1934. A Comparison of Certain Stromatolitic Rocks in the Dolomitic Series of South Africa, with Modern Algal Sediments in the Bahamas. *Trans.geol.Soc.S.Afr.* **37:** 153-162 Pls. III-V.

5 Techniques (and Equipment)

Exposure of Fossil-Bearing Planes

Many plant fossils studied (cf. especially Upper Permian, Lacey *et al.* etc.) and insect fossils (cf. especially Upper Permian, Van Dijk & Geertsema 1999) were exposed on bedding planes in shaly material. Initial splitting was done using a brick bolster (10cm) or electrician's chisel (5cm), and fine splitting with a putty-knife with a suitably strong handle which permitted hammering with a tack-hammer (or 25mm wooden mallet with dowel handle). Material which could not easily be further split was not discarded, but put out to weather, which often allowed further division – e.g. the type specimen of the insect *Aleuronympha bibulla* Riek 1974 was obtained from weathered piece of shale no bigger than the last phalanx of a thumb.

To initiate splitting in difficult material, such as shale with few fossil leaves on a bedding plane or Bokkeveld sandstone with a zone of fossils but little change in lithology, holes were drilled at about the level of desired plane before splitting (c.f. Bokkeveld specimen from near Barrydale). Drill bits between 3mm and 6mm were used. For field use a 12V drill was equipped with a hammer-drill attachment (Black & Decker) between the drill and the chuck.

Trimming of Shaly Blocks

Removing unwanted portions of a shaly block before storage presented the difficulty that wet cutting produced mud and dry cutting dust, and mud or dust getting on to the retained portion tended to adhere to the surface. Wrapping a block in transparent plastic before wet-cutting was tried. More effective was dry-cutting with continuous or continual blowing or brushing away of dust. A hacksaw was sometimes used. More suitable was a fretsaw (Bosch) mounted with the blade upwards and equipped with a blade intended for use with ceramics, particularly because a clear view of the cut was possible, as well as easy access for removal of dust. The shale block could be fed to the saw with one hand, while the other hand was free for brushing or directing a bellows or air stream (e.g. from a hair-dryer) for removing dust.

Cutting with a Water-Cooled Blade

Commercially available rock-cutting apparatus for hand specimens has the limitation for palaeontological work that slabs cannot be cut. A saw-table was therefore constructed after a design for an apparatus made to cut fire-bricks and glass tubing (Chris Morewood, Faculty of Science Workshop, University of Natal, Pietermaritzburg). The blade is 200mm, with a diamond-studded edge, and projects 65mm through the table, which is thus the maximum cut. A cowling which is lowered over the top of the blade provides water as coolant. The motor is ¼ Ampere, running at 1425 r.p.m, driving the blade by pulley (tensioned by the motor mass) at approximately 4 times the motor speed. The saw is used to cut slabs, to trim hand specimens, to provide surfaces for polishing, to cut small slices for mounting on slides, and to trim away excess from such slices to leave a layer suitable for preparation of ground sections. Some specimens were embedded in polyester resin to prevent disintegration during cutting (e.g. shale specimens).

Cutting with an Oil-Cooled Diamond Saw

Specimens up to 130mm could be cut on a Diamond Saw with geared feed. (cf. Triassic, "Bone Beds" from De Hoek and Oliviershoek).

Preparation of Polished Surfaces and Ground Sections

A scrap washing-machine was modified to take a lapping wheel (255mm, rotating approximately 4x per second) for fine grinding and polishing. Final grinding was done using 600 corundum grit, sometimes preceded by 400 corundum grit, occasionally coarser grades.

Mounting of Ground Sections

A reliable mountant for mounting ground specimens on the fine-ground surface of microscope slides was found to be Araldite Epoxy. This epoxy is relatively slow-setting, and can be warmed to reduce viscosity for sufficiently long to permit most air-bubbles introduced during mixing to escape before mounting the specimen. Further warming ensures hardening within 24 hours or less, when ground sections can be prepared.

Peel Preparations

Some peel preparations were made using Cellulose Acetate or Cellulose Acetate/Butyrate. A surface of the specimen was moistened with acetone and the Acetate film was applied; the acetone dissolved the surface of the film which was then pressed against the specimen and allowed to dry partially. While still having increased flexibility the film was peeled away and then allowed to dry while being kept more or less flat. Some films were mounted on microscope slides in Canada

Balsam in Xylene under a coverglass, (cf. Permian, Estcourt Formation: Lidgetton, the moss *Buthelezia* and a fragment of insect wing). Some other films were mounted in photographic slide (diapositive) holders. (cf. Cretaceous, Mkuze Formation: Mkuze, calcified wood). Overhead projector sheets were the source of Cellulose Acetate film, but projector sheets are now made of polythene, which is resistant to most organic solvents. Reversal ("Positive") photographic film, which is colourless after treatment with developer and transparent after treatment with fixer, has been successively used (for Mkuze calcified wood). Acrylate ("Perspex") can be used for peels when moistened with chloroform, but thin sheets (1mm) are not readily available. Perspex can be bent when placed in water at about 60°. Perspex peels (1mm thick) can be cut to the size of microscope slides or diapositives.

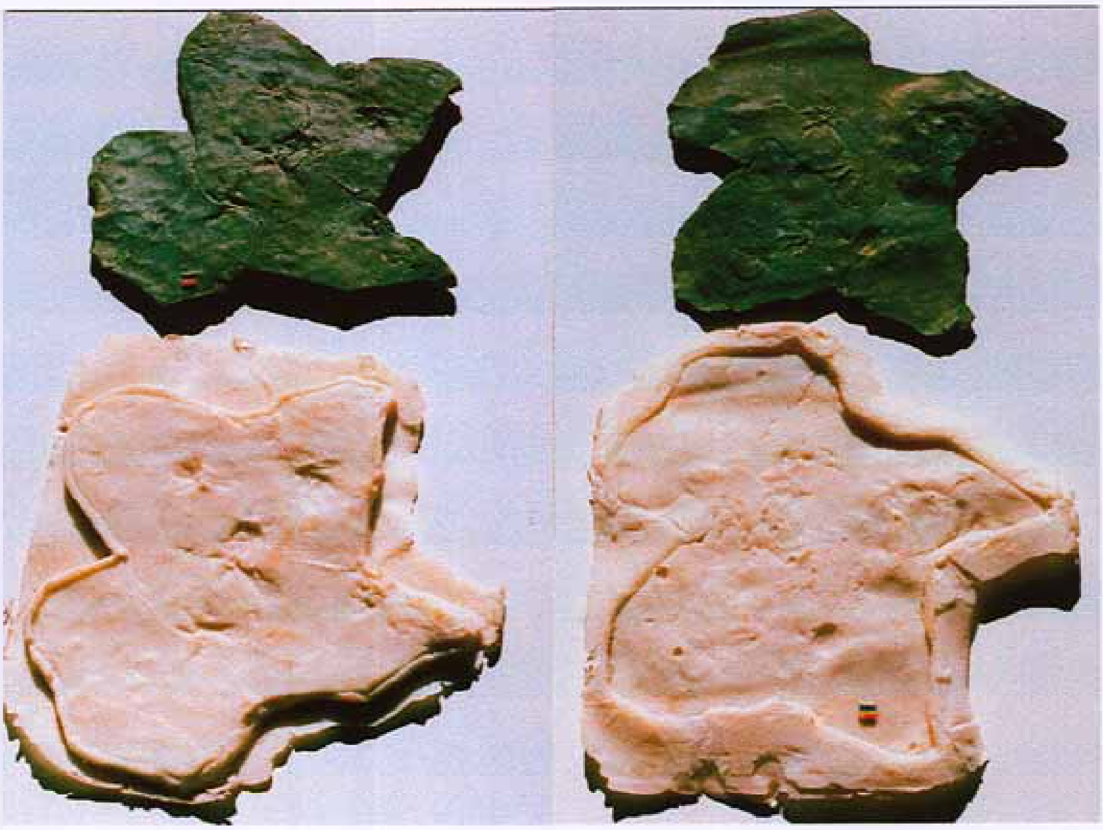
Shear Preparations

Preparations similar to peels may result from mounting a specimen which has suitable cleavage planes, e.g. tangential and radial planes of wood, on a slide and then shearing it off. (cf. Permian, Estcourt Formation: Mount West, silicified wood).

Moulds, Casts & Replicas

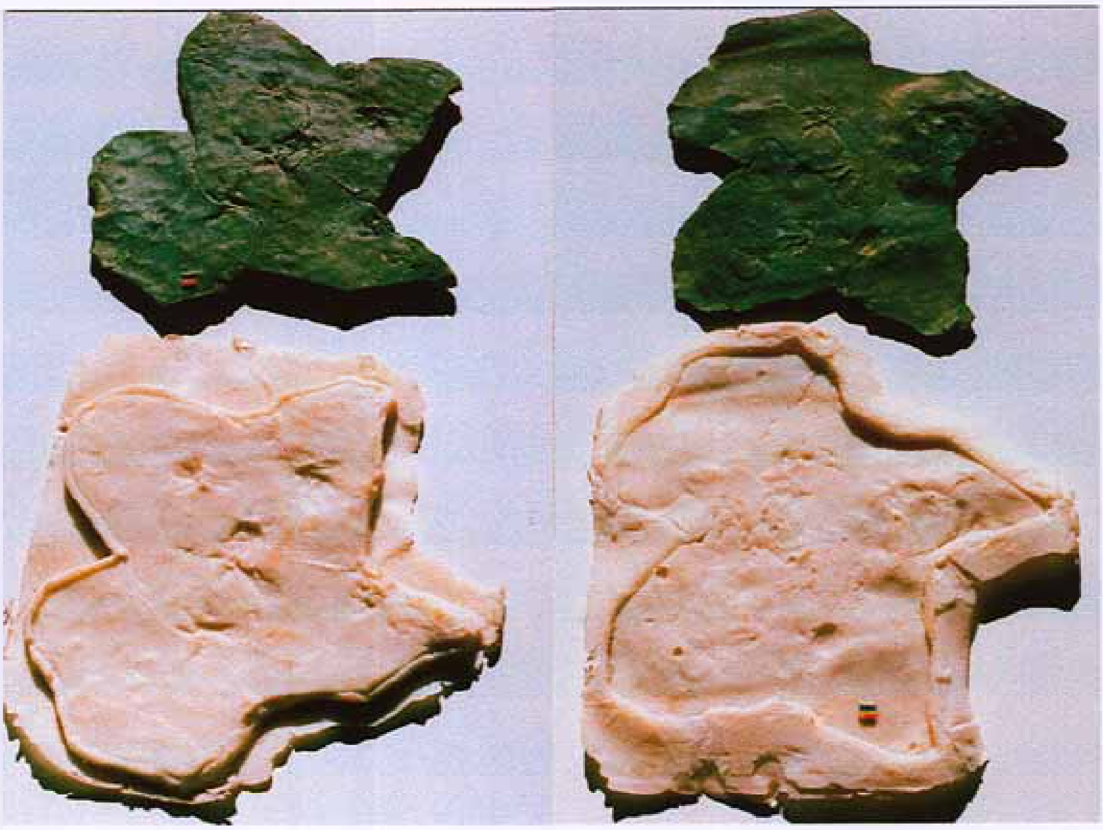
Release Agent, Containment & Backing

In preparation for making a mould, a cast or a replica, the surface of the specimen was covered with a thin film of release agent, usually a liquid soap suspension or a silicone spray (Release Agent or Waterproofing Agent). The boundary of the preparation was usually formed by the walls of a container, by a fence of lead strip, or by plastic material such as putty, modelling clay or reusable flexible glue. If the applied material was rigid (e.g. Plaster of Paris) when set, it



A rubber replica of a slab was made between Plaster of Paris moulds of the two surfaces of the slab. Each surface of the rubber mould can be used for casting while it is backed with the appropriate original Plaster of Paris mould.

The surface of the rubber mould seen on the right, has some air bubbles, which are fortunately not close to areas with footprints.



A rubber replica of a slab was made between Plaster of Paris moulds of the two surfaces of the slab. Each surface of the rubber mould can be used for casting while it is backed with the appropriate original Plaster of Paris mould.

The surface of the rubber mould seen on the right, has some air bubbles, which are fortunately not close to areas with footprints.

Plaster of Paris replica of footprints by casting on the underside of slab (natural cast). The replica on the right has been coloured with chrome pigment powder.

Portion of a polyester replica made on the underside of a slab (natural cast). Strips of Masonite where taped around the part with tracks (fish trails) to make a shallow well for the resin. The resin had black pigment added, and 600 Corundum grit to simulate the texture (settling of the grit during setting was not a problem).

Plaster of Paris Casts/Replicas

Plaster of Paris was cast on the (inverted) lower surfaces of slabs, giving in each case a replica of the surface which had been below the slab. (cf. Permian: Mzimbe, Swart Umfolosi, various trace fossils; Permian: Tierberg Formation, foot-prints of *Broomichnium*, some with fish trails; Jurassic: Clarens, reptile foot-prints). Replicas were also produced by casting on Rubber Moulds. The replicas were usually strengthened by inclusion of cloth mesh during pouring of the plaster. The plaster was usually coloured by means of suspensions of pigment powder to approximate the colour of the surface replicated. Black, White, Chrome Green, Yellow Ochre, Red Ochre and Prussian Blue powders (HardWare quality) were available to produce the chosen colour. A suspension of the pigment in water was brushed onto the plaster.

Polyester Resin Casts/Replicas

Polyester resin was used for casting in a Plaster of Paris mould (see above).

Use of polyester for embedding before sectioning has been mentioned.

Replicas of surfaces were made in polyester a few millimetres thick, without backing, or very thin (lmm or less) backed by Plaster of Paris, thin cardboard or paper. Enquiry at the Polymer Unit at the University of Stellenbosch produced the recommendation of a polyester surface with a polyurethane backing. The use of canned polyurethane foam has been tried, but not production of the foam *de novo*.

Acrylic Replicas

Aqueous emulsions of a flexible Acrylic, designed for waterproofing in conjunction with a polyester membrane, were used to produce replicas of low-relief trace fossils from their counterpart layers or occasionally from polyester or plaster

Replica of fish, and crustacean, trails made by painting acrylic paint onto the underside of a varvite slab. The thickness is about 0,4 mm. The replica has remained flexible for two years. A similar replica was glued to a sheet of Masonite pressed board.

moulds. Cost and convenience were important advantages over latex and rubber. Others were: ready availability (from hard-ware stores); good shelf-life; easy application with brush or roller, which can be cleaned in water; quick-drying (about an hour for a thin coat); availability in white, black, and several colours, besides the ease with which dry- or water-soluble pigments could be added (occasionally material such as fine corundum grit was added to the first layer to match the texture of the specimen); long-lasting; retention of original dimensions with and without suitable reinforcing while offering the advantages of considerable flexibility. Release agents used on specimens were thin detergent layers, silicone release agent, or talcum powder. Adhesion was seldom a problem.

The usual procedure was to paint a thin layer onto the specimen and allow it to dry thoroughly. This was then followed by a thicker second layer, as uniform as possible, and this was allowed to dry thoroughly, overnight if this was convenient. A third layer was the added and reinforcing, preferably fine-textured organdy, was laid on this. Finally a fourth layer was added to embed the reinforcing material. Thorough drying of the first layers and use of fine-textured reinforcing prevented the penetration of texturing onto the specimen-contacting surface.

Other Surface-contact Materials

Some experimentation was done with cement, potter's clay, and modelling clay (Das Pronto).

Photography

Sites

Most sites where collecting was done have been photographically recorded as diapositives or colour prints, occasionally only as black and white prints. Limited use has been made of a 16mm ciné camera and a video-camera. Some deterioration of colour prints more than 20 years old has occurred, as well as some deterioration of the colour negatives from which they were printed. Satisfactory black and white prints can be made from colour negatives which cannot easily be used to produce good colour prints. Photographs from the air have been made of three sites (Helderberg, Mooi River and De Hoek).

Specimens

Standard Photography

Specimens greater than about A4 size or excessively heavy have usually been placed on a uniform background, such as black melton cloth, and photographed in sunlight. For the past 5 years Agfa Ultra50 colour negative film has been used. It is fine-grained and has good colour saturation. Exposures in sunlight have usually been 125^{th} of a second at f11, which is about the exposure indicated for ASA50 to ASA100 film. (Many of the earlier films used were Ektachrome or Agfa Professional, which could be self-processed. With films being made for processing at higher temperatures, requiring continuous temperature control and more precise timing of the first development, self-processing was discontinued).

Photomacrography with Extension Ring/s

Photographing specimens smaller than A4 requires extension rings or bellows if a standard lens is used, e.g. 50mm lens on a standard 35mm camera. The specimens are usually not too heavy to be supported on glass, which permits a setup which allows shadows to be cast beyond the background against which the specimen if photographed. A table with a glass top has been used for most hand specimens (those that did not require magnified negatives, i.e. which did not require extensions exceeding about 50mm). Alternatively use was made of a sheet of glass attached horizontally to the central post of a Velbon tripod; this permitted adjustment of lighting by tilting of the central post, and focussing of the camera by racking the central post up or down.

The use of extension rings uncouples the Auto mechanism of some camera/lens combinations, e.g. the slight extension afforded by the Nikon K1 ring, which was often used. With the Nikon E2 extension the lens may be treated as a preset lens by focussing with the plunger pressed in.

A slide-copying apparatus was used for low-power photography of microscope slides (approx. 1:1 on the negative or diapositive). A groove was cut into a slide (diapositive) holder to accommodate a microscope slide (cf. slide of Tweefontein Formation ooliths). Polarizing material was mounted in two diapositive holders which could be placed on either side of the slide to be examined to act as polarizer and analyzer; but the slide to be examined could not be rotated in relation the two polarization planes.

Photomacrography with Bellows Attachment

Mounting

A light bellows attachment was occasionally used on a tripod, as above. A copying stand was modified to support a robust, versatile, bellows attachment, the Nikon PB-4. A hole was made in the base of the stand to accommodate a rod extending from the front of the bellows, making great rigidity possible. The specimen was initially carried on a small laboratory jack, which permitted focussing by movement of the specimen. In early 2000 an acrylic plastic support was made which could be slid up and down on the rod which anchored the bellows to the base.

Lighting

Sunlight at about 45° was usually used. Specimens were usually placed on a 50x75mm microscope slide sufficiently high above the stand base to permit shadows to fall beyond the field of view. The background was usually a light grey, lit by the same source. Flash has also been used. The background was sometimes made lighter by reflection of the light source by means of a mirror. (Care has to be taken when mirrors are used, as light falling on the upper edge of a mirror may pass between the surface of the glass and the mirror layer and produce highlights which fall in the field of view). Matt aluminium or aluminized paper provided reflecting material which was used for modelling, i.e. reduction of shadows. A 6 volt microscope lamp with a blue filter, run at 6 amps during photographing, was also used, sometimes with a second such lamp used to light the background.

Sunlight was found to have one drawback. With shaly specimens at higher magnifications highlights of various colours appeared, which were not experienced with artificial light. The cause is unknown, but could result from response of the emulsions to Ultraviolet light of wave-lengths not absorbed by the usual UV filters.

Image/Object Ratio approximately 1 : 1

The bellows when closed gives an extension which yields a negative or diapositive which varies from about 1x (lens set on infinity) to about 3½x (lens set at closest). The coupling of lens and camera is lost, and the iris diaphragm of an Nikkor Auto lens has to be opened and closed manually. As focussing is best done with the lens wide open, it is necessary to remember to stop down to give maximum depth of field. Exposure is best measured with the lens wide open and then doubled for each stop during stopping down. With a given film and a standard lighting arrangement, such as sunlight, exposure needs only to be measured occasionally. For Agfa Ultra50 1/8th second at f16 was adopted as standard. The working distance (lens to object distance) is about 72mm with bellows closed to 25mm when extended. This may make lighting the specimen from a high angle or with a lamp difficult.

An E2 extension between bellows and lens facilitates focussing Nikkor lenses at full aperture, as widest aperture is obtained by pressing a plunger, and the preset aperture is restored on releasing the plunger.

Photomacrography with Nikon PB-4 Bellows and reversed 50mm lens with E2 ring (plunger to the right). Lighting with Leitz Monlar lamp for both specimen and background; later a separate lamp was used to illuminate the background. Matte foil was used as a reflector for modelling. Focussing was done with a laboratory jack

Image/Object Ration >1 (Magnification)

Nikon recommends reversal of lenses for magnification. For this purpose a reversing ring (Nikon BR2) is used on the PB-4 bellows. Since this has a thread designed to fit onto the lens in the place of a filter, any lens can be used, provided that it has the appropriate diameter thread (52mm) or a step-up or step-down ring is used. A great advantage of reversed lenses is that working distance is increased (in the case of a Nikkor f2 50mm lens from 25mm to 48mm with fully extended bellows). The slight deterioration at the corners of the image when the lens is closed down beyond f8 which is referred to in Nikon booklets on the PB-4 Bellows and on Close-up Equipment, was not found to be a problem, and f16 was usually used to give maximum depth of focus.

An E2 ring can be mounted on the lens to facilitate focussing at full aperture.

The reversed Nikkor 50mm lens gives a slighter greater magnification than when in the normal position, without requiring any substantial increase in exposure. Very many photographs, e.g. of fossil insect wings and fossil frog bones, were taken with a reversed Nikkor 50mm lens on a closed PB-4 bellows and set on infinity. Standard processing of Colour Print film and printing of standard size prints ("Jumbo" – 101mm x 151mm) gave an enlargement of 7,4x.

For high magnifications a reversed Asahi Super-Takumar 35mm f2,8 was used. Like other Pentax lenses this lens has a Manual/Auto option, which enables it to be used like a preset lens. That is, when the tab is moved to the Auto position, the iris is wide open, permitting focussing with the least depth of field, and movement to the Manual position selects the set lens opening. (The lens used was obtained very cheaply because the grease in the iris mechanism had become very viscous, making the closing of the iris diaphragm too slow for normal use. Many such lenses are probably available. Pre-set lenses are also often very much cheaper than Auto lenses, and perfectly suited to Photomacrography). Very limited use was made of a reversed Vivitar Wide-Angle 28mm lens, which gives higher magnification.

Photomicrography

Microscope lenses are designed to give a bright image, with high resolution. Accordingly they are designed to operate at maximum aperture and images deteriorate dramatically if they are stopped down, which is necessary if depth of field is important. (Zeiss Luminar lenses are designed for low-power microscopy, and have iris diaphragms for increasing depth of field, but the deterioration in image quality with stopping down is very easily visible). Camera lenses can be stopped down very considerably without excessive loss of image sharpness. Photomicrography was used were camera lenses were not convenient, especially for microscope slides.

Transmitted Light

Microscope Field Coordinates

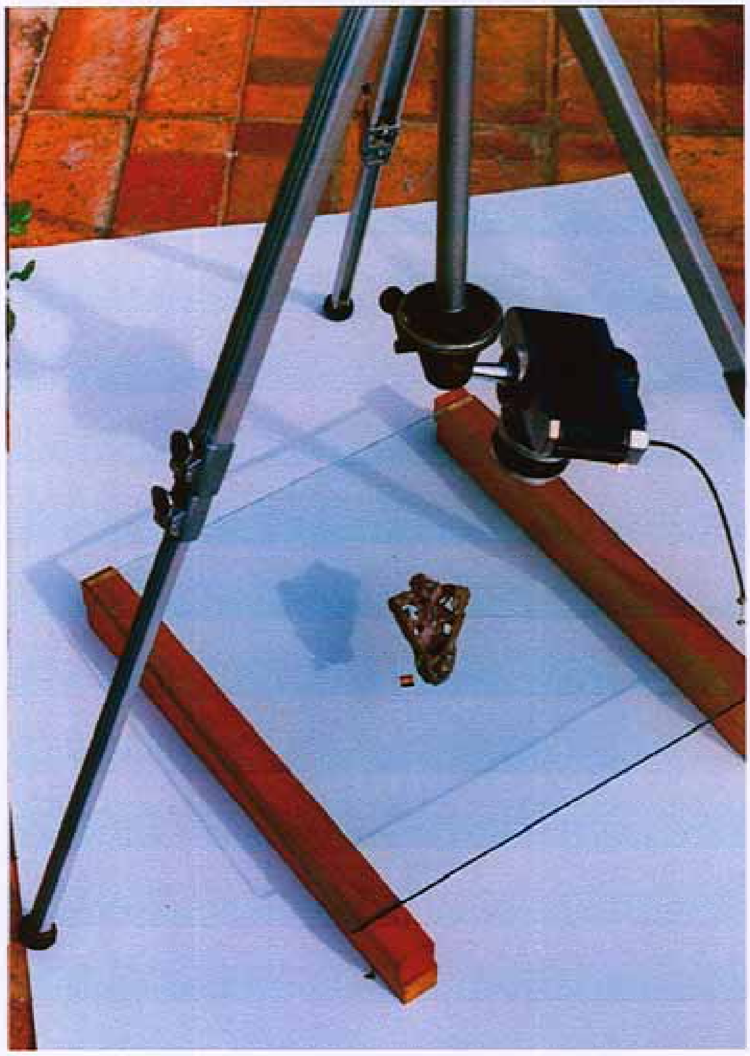
In order to make areas of slides photographed easily identifiable, coordinates were recorded on one microscope, a Leitz microscope with built-in lamp-housing and focussing stage. A ordinary microscope slide, 75mm by 25mm, was marked at its centre and the coordinates read on the stage verniers. The readings were approximately 24,0 and 103,0. By marking a slide similarly, the coordinates of any other microscope can be roughly calibrated, a field of a photographed slide found, and necessary adjustments then made to make the calibrations transferable.

Normal Light

The built-in 6V light source of the Leitz microscope provided consistent lighting, photographs being taken at 5 amp, with a blue filter. Because focussing was done by movement of the stage, the weight of a camera did not put the microscope out of focus, a problem experienced with other microscopes used. The inclined binocular head was removed and replaced for photomicrography by an inclined monocular viewing head which is retractable to allow light to pass up a vertical tube to a camera attachment. Camera attachments used for the Leitz microscope were usually ones made for the Nikkormat camera, incorporating an auxiliary lens which substituted for the lens of the eye and brought an image focussed for the eye into focus on the film plane. If necessary focus adjustments could be made by observation through the view-finder of the camera at the same time as framing. The most frequently used combination of lenses was 10x Objective and 8x Periplan Ocular, yielding standard colour prints at 153x magnification.

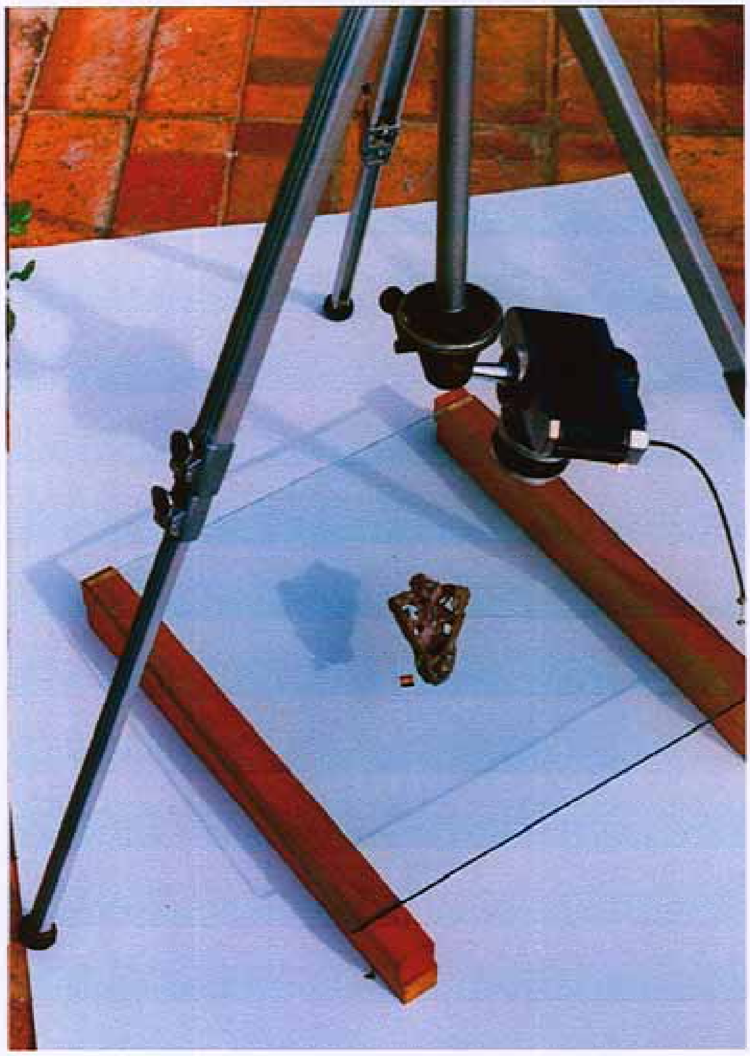
Polarized Light

A Leitz Petrographic Microscope was used for some work involving polarized light, since it had the advantage of rotating stage, in addition to polarizer and analyzer filters. The Petrographic Microscope used is a tiltable monocular type. Various light sources were used, including one with a matt 60W Tungsten bulb and a water-filled flask as condensor (Leitz), and Leitz Monla or Schott Belani 6V 6A microscope lamps. Where only "crossed Nicols" were required, and not slide rotation, the Leitz microscope used for Normal Light was provided with a polarizer below the substage condensor and an analyzer above the ocular.



Stereophotography using 180° rotation of a rotatable tripod universal joint. The left image of the stereo-pair is being photographed (snout end of skull at the top). The specimen is placed on a sheet of glass to allow the shadow to fall outside the frame of the photograph.

Photomacrography with Nikon PB-4 Bellows and reversed 50mm lens with E2 ring (plunger to the right). Lighting with Leitz Monlar lamp for both specimen and background; later a separate lamp was used to illuminate the background. Matte foil was used as a reflector for modelling. Focussing was done with a laboratory jack



Stereophotography using 180° rotation of a rotatable tripod universal joint. The left image of the stereo-pair is being photographed (snout end of skull at the top). The specimen is placed on a sheet of glass to allow the shadow to fall outside the frame of the photograph.

Stereophotography using 180° rotation of a tripod pan head. The convergence angle can be altered by choosing an appropriate thread in the L-piece in which to insert the camera-holding screw.

Stereo Photography

Large Specimens

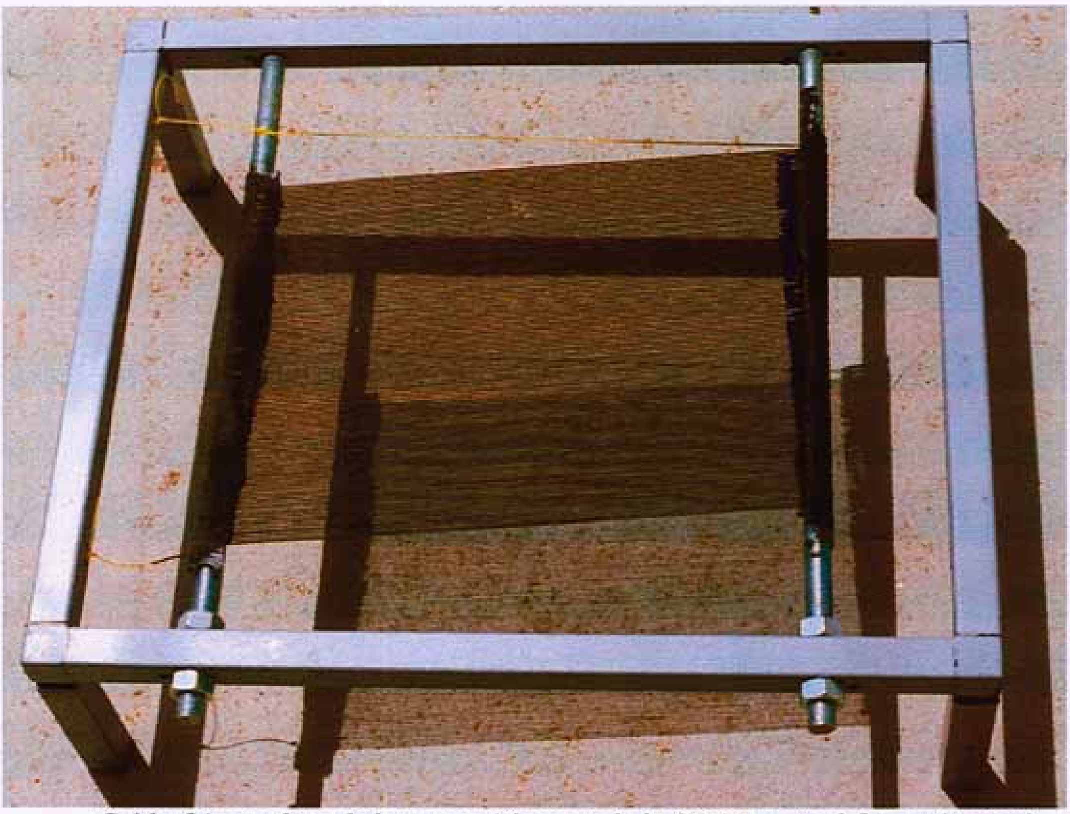
For large specimens stereo pairs were obtained by rotating a camera through 180° while suspended from the central post of a tripod either on a rotatable tripod ball and socket attachment, or on a tripod pan head. The ball and socket attachment had to be levelled with a spirit level, and it was difficult to change the convergence angle of the head. With the panoramic head tilting to a suitable convergence angle was easy; however a right-angle attachment was required for attachment to the central post of the tripod. Use could be made of the existing slot on the pan head, or a series of holes in the attachment L-plate to adjust the radius of the turn.

Stereophotomacrography

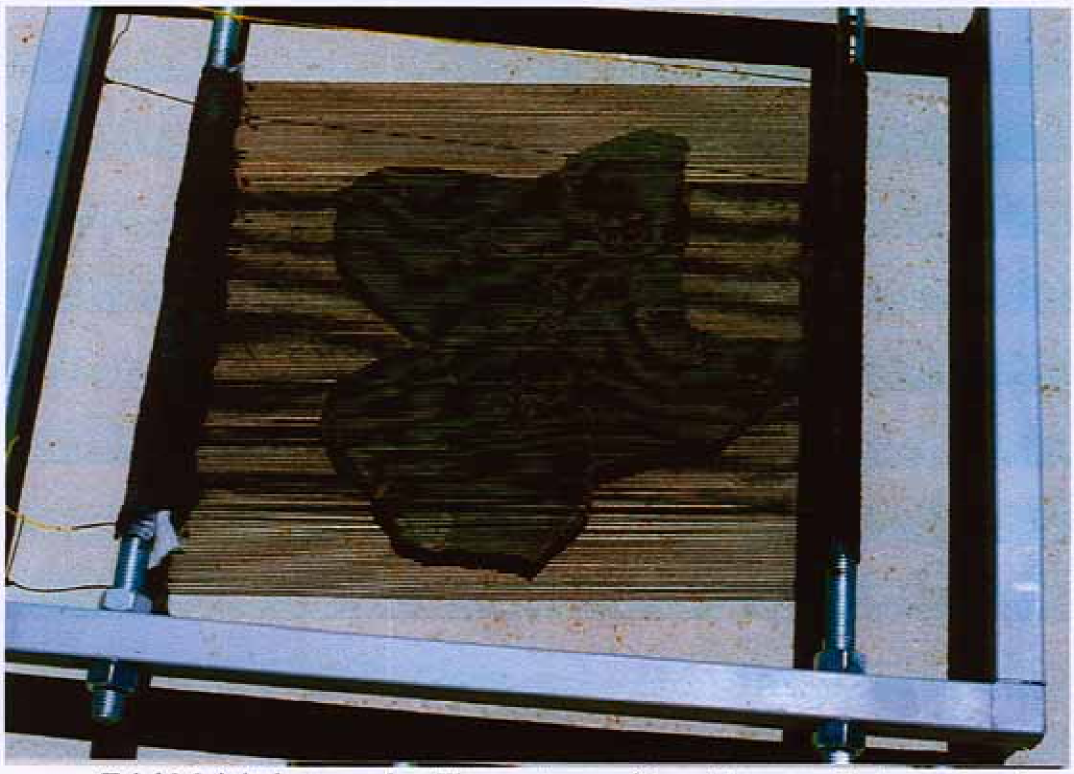
Use was made of the tilting-, or occasionally the sliding-, facility on the Nikon PB-4 bellows. Tilting of the specimen was also used, e.g. for radiolaria on a slide, where the slide was supported alternately by a slide placed under on end of the specimen slide and the other end.

Moiré Topography

Topography of an object can be visualized, and/or digitized for computer analysis by lighting the object through a grid at an angle and photographing it through the same grid at another angle, e.g. the reciprocal angle, producing a Moiré pattern. The technique is especially suitable for footprints (Ishigaki & Fujisaki, 1989). There are no indications of how the grid illustrated by these authors was made, but drilling 1mm holes at 1mm intervals is a major undertaking.



Grid of 1mm threads between 16mm rods in 25,4mm steel frame (Apton).



Trial Moiré photograph. The contours of the slab are well shown, but the grid is too coarse to show the footprints well.

In order to make such a grid two 16mm threaded rods were mounted parallel between lengths of 25mm steel tubing (Apton). Since 16mm threaded rods (available at hard-ware stores) have a 2mm thread, 1mm nylon wound around the pair of rods gave two grids with 1mm spacing, one above and one below the rods. The nylon was sufficiently strong when pulled taut to bend the rods in the middle, and after completing the winding, slack had to be taken up to produce approximately uniform tension. Acrylic roof paint was then used to stick the nylon in the threads of the rod. A layer of polyester matting was then painted onto the top, outside, and bottom of each rod. The lower grid was then cut away. The grid could be tensioned or slackened by turning one rod, or (in reverse directions) both rods, locking the two rods in position by means of nuts inside and outside the tubing. The grid could be tensioned for use, slackened for storage. Matt black spray paint was used to blacken the nylon.

The 1mm grid proved to be rather coarse for the small footprints available, therefore a 0,5mm grid was made by using 6mm threaded rods, which have 1mm threads. Angle aluminium extrusion (25mm, 3mm thick) was used for the ends of the grid. It was found necessary, to prevent bending of the rods, to mount a strip of aluminium flat (25mm, 3mm thick) on the inside of each rod, and these strips were placed at the bottom of the rods. This meant that each turn of nylon passed across the aluminium strip in contact with it, giving an area for adhesive additional to the top, side, and bottom of each rod. Additional strips of aluminium had adhesive applied to them and were then bolted near their ends to the first two strips, adding to the adhesive surface. After painting over the rods and adding polysester mat, the lower grid was cut away. Slackness of any part of the grid could be corrected by insertion of spacers (pieces of toothpick) near the rod. Spray painting proved difficult, there being a tendency for drops to bridge adjacent lines, but a satisfactory grid could be made.

Scanning Electron Microscopy

Some use was made of SEM to study ultrastructure, mainly of plant fossils. Whole small fossils (insects, conchostracans), fractured structures (plant leaves) and surfaces, as exposed (leaves) or polished, with or without etching (stems, wood) have been studied.

Radiography

The use of X-rays for studying some thin specimens was tried. The X-ray unit used was a Siemens Heliodont modified to 25Kv (from 75Kv). X-rays yield images which give an idea of the specimen in the round. Some stereo images were also prepared.

6 APPENDICES

A

Literature on African Palaeozoic and Mesozoic Vertebrate Tracks

List to December 2000

and

Stratigraphically Arranged Table (Arial 8pt)

Ichnolit

African Palaeozoic and Mesozoic Vertebrate Trackways

Underline indicates Not seen. C J T P indicates Creta Jura Trias Perm

Abel, O. 1912. Grundzüge der Paläobiologie der Wirbeltiere.
Stuttgart, Enke. ?(ref. Gürich 1926 as "Paläobiologie")

P Abel, O. 1935. Vorzeitliche Lebensspuren.
Jena, Gustav Fischer, xv 644pp.

C Alessandrello, A. & Teruzzi, G. 1989. New outcrops with dinosaurs trackways in the Cretaceous of the Agadez region (eastern Niger).
Atti Soc.Ital.Sci.nat.Mus.Civ.Stor.nat.Milano **130(2):** 177-188.

C Ambroggi, R. & Lapparent, A.F. de 1954. Découverte d'empreintes de pas de reptiles dans le maestrichtien d'Agadir (Maroc).
C.R.somm.Soc.géol.France **1954 (3):** 50-52.

C Ambroggi, R. & Lapparent, A.F. de 1954. Les Empreintes de Pas Fossiles du Maestrichtien d'Agadir.
Notes Serv.géol.Maroc **10:** 43-57 pls I-III.

P Anderson, A.M. 1970. An Analysis of Supposed Fish Trails From Interglacial Sediments in the Dwyka Series, near Vryheid, Natal.
Gondwana Symposium 2: 637-647.

P Anderson, A.M. 1974. Arthropod Trackways and Other Trace Fossils From the Early Permian Lower Karroo Beds of South Africa.
Ph.D. Thesis, University of Witwatersrand, xiv 190pp. (ii) xix 76pp.
\+ publication.

P Anderson, A.M. 1976. Fish Trails From the Early Permian of South Africa.
Palaeontology 19: 397-409 pl. 54.

J Bassoullet, J-P. 1971. Découverte d'empreintes de pas de reptiles dans l'Infralias de la région d'Aïn-Sefra (Atlas saharien-Algérie).
C.R.somm.Soc.géol.France **1971:** 358-359.

P Beer, C.H.de 1986. Surface Markings, Reptilian Footprints and Trace Fossils on a Palaeosurface in the Beaufort Group Near Fraserburg, C.P..
Ann.geol.Surv.S.Afr. **20:** 129-140.

C Bellair, P. & Lapparent, A.F. de 1949. Le Crétacé et les empreintes de pas de Dinosauriens d'Amoura (Algérie).
Bull.Soc.Hist.nat.Afr.Nord **39:** 168-175 Pls.I-V.

C Biron, P.E. & Dutuit, J-M. 1981 (1982). Figurations sédimentaires et traces d'activité au sol dans le Trias de la formation d'Argana et de l'Ourika (Maroc).
Bull.Mus.natn.Hist.nat. Paris (4e sér.) **3(section C):** 399-427.

J Bourcart, J., Lapparent, A.F. de & Termier, H. 1942. Un nouveau gisement de Dinosauriens jurassiques au Maroc.
C.R.Acad.Sci. **214:** 120-122.

J Broderick, T.J. 1984. A Record of Dinosaur Footprints From the Chewore Safari Area West of Mana-Angwa.
Harare, Report of Geol.Survey unpubl., 5pp. 7 figs. (1 folding).

J Broderick, T.J. 1985. Zambezi Valley Notes.
Annals Zimb.geol.Surv. **10:** 48-63. 3 figs. (1 folding).

J Channing, A. 1998. Fossil Footprints Revealing An Ancient Landscape in the Modern Karoo.
Africa – Environment & Wildlife **6 (5):** 76-79.

J Choubert, G., Faure-Muret, A. & Levèque, P. 1956. Au sujet des grès de Guettioua et des empreintes de Dinosauriens de la région de l'Oued Rhzef (Atlas marocain).
C.R.Acad.Sci.Paris **243:** 1639-1642.

Chure, D.J. & McIntosh, J.S. 1989. A Bibliography of the Dinosauria (Exclusive of the Aves) 1677-1986.
Grand Junction, Museum of Western Colorado, 260pp. Out of Print

C Congleton, J.D. 1988. Early Cretaceous vertebrate fossils from the Koum Basin, northern Cameroon.
Jour.Vert.Paleont. **8 (Suppl.):** 12A.

T Damane, M. 1969. Dinosaur footprints and fossils at Matsieng.
Proc.Lesotho Mus.Board **1969**: 2pp. ref. Ellenberger 1970

P Davidow, A. (illus. Marx, G.) 1999. Nature Notes Footprints from the Past.
Getaway **1999 February:** 31-32. see also Klerk, B. de

P Day, B. 1999. Reconstructing the gait of Late Permian therapsids from their footprints.
B.Sc.Hons.ZoologyProject, Univ.CapeTown, 50pp.Appendices(4pp. 1 folded).

C Dejax, J., Michard, J-G., Brunet, M. & Hell, J. 1989. Empreintes de pas de dinosauriens du Cretace inférieur dans le Bassin de Babouri-Figuil (Fossé de la Bénoué, Cameroun).
Neues Jahrb.Geol.Paläont.Abh. **178:** 85-108.

T.Demathieu, G. & Haubold, H. 1974. Evolution und Lebensgemeinschaft Terrestrischer Tetrapoden nach ihren Fährten in der Trias.
Freiberger Forschungshefte **C298:** 51-72.
Reprinted 1983 in: Terrestrial Trace Fossils. (ed. Sarjeant, W.A.S.)
Benchmark Papers in Geology **(7):**178-199. cf.

J Dijk, D.E. van 1966. The animals responsible for tracks of Cave-Sandstone Age.
Abstr.S.Afr.Assoc.Adv.Sci.64th Congress.

J Dijk, D.E. van 1978. Trackways in the Stormberg.
Palaeont.afr. **21:** 113-120.

P Dijk, D.E. van, Channing, A.E. & Heever, J.A. van 2000. Permian Trace Fossils Attributed to Tetrapods (Tierberg Formation, South Africa).
Abstr.Pal.Soc.sthn Afr. 11th Biennial Conf. **2000:** unpaginated

J Dijk, D.E.van, Hobday, D.K. & Tankard, A.J. 1978. Permo-Triassic lacustrine deposits in the Eastern Karoo Basin, Natal, South Africa.
Spec.Publs.int.Ass.Sediment. **2:** 225-239.

P Dijk, D.E. van & Klerk, W.J. de 2000. Footprints by the Moiré Technique for Contours and a Way of Constructing a Grid (Poster).
Abstr.Pal.Soc.sthn Afr. 11th Biennial Conf. **2000:** unpaginated

JT Dornan, S.S. 1905. On the Geology of Basutoland.
Rep.Brit.Assoc.Adv.Sci.75: 404-405.

JT Dornan, S.S. 1908. Note on the Geology of Basutoland.
Geol.Mag. **5:** 57-63; 112-118.

P Durand, F. 1999. Dit is wat ek dink.
Archimedes **41 (4):** 38-40.

J Dutuit, J-M. & Ouazzou, A. 1980 Découverte d'une piste de Dinosaure sauropode
sur le site d'empreintes de Demnat (Haut-Atlas marocain).
Mém.Soc.géol.France (N.S.) n° **139:** 95-102 (2pls).
J Eeden, O.R. van & Keyser, A.W. 1972. Fossielspore in die Holkranssandsteen op
Pont Drift, Distrik Soutpansberg, Transvaal.
Ann.geol.Opname S.Afr. **9:** 135-137 8 ple 1 kaart (oopvou).
JT Ellenberger, F. 1962. New Dinosaur tracks in Basutoland.
Basutoland news, Maseru. ref. Ellenberger 1970
JT Ellenberger, F. & Ellenberger, P. 1956. Quelques précisions sur la série du
Stormberg au Basutoland (Afrique du Sud).
C.R.Acad.Sci.Paris **241:** 799-801.
JT Ellenberger, F. & Ellenberger, P. 1958. Principaux types de pistes de Vertébrés dans
les couches du Stormberg au Basutoland (Afrique du Sud) (Note préliminaire).
C.R.Bull.Soc.géol.France **4:** 65-67.
T Ellenberger, F & Ellenberger, P. 1960. Sur une nouvelle dalle à pistes de Vertébrés
découverte au Basutoland (Afrique du Sud).
C.R.somm.Soc.géol.France **1960:** 236-238.
JT Ellenberger, F. & Ellenberger, P. 1962. New Dinosaur tracks in Basutoland.
Basutoland news, Maseru. ref Ellenberger 1970
JT Ellenberger, F., Ellenberger, P., Fabre, J., Ginsburg, L. & Mendrez, C. 1964. The
Stormberg Series of Basutoland (South Africa).
Proc.Internat.geol.Congress **XX Section IX**: 320-330.
JT Ellenberger, F., Ellenberger, P., Fabre, J. & Mendrez, C. 1964. Deux nouvelles
dalles à Pistes de Vertébrés fossiles découvertes au Basutoland (Afrique du
Sud).
C.R.somm.Soc.géol.France **1964:** 315-316.
JT Ellenberger, F., Ellenberger, P. & Ginsburg, L. 1967. The Appearance and
Evolution of Dinosaurs in the Trias and Lias: A Comparison Between South
African Upper Karoo and Western Europe Based on Vertebrate Footprints.
Gondwana stratigraphy IUGS Symposium, Buenos Aires: 333-354.
JT Ellenberger, F., Ellenberger, P. & Ginsburg, L. 1970. Les Dinosaures du Trias et du
Lias en France et en Afrique du Sud, d'après les pistes qu'ils ont laissées.
Bull.Soc.géol.France (7) **12:** 151-159.
JT Ellenberger, F. & Ginsburg, L. 1966. Le gisement de Dinosauriens triasiques de
Maphutseng (Basutoland) et l'origine des Sauropodes.
C.R.Acad.Sci.France **262D:** 444-447.
JT Ellenberger, P. 1955. Note préliminaire sur les pistes et restes osseux de Vertébrés
du Basutoland (Afrique du Sud).
C.R.Acad.Sci. **240:** 889-891.
JT Ellenberger, P. 1961. Basutoland National Museum Morija.
Leselinyana Morija **1961:** 2-3. ref Ellenberger 1970
JT Ellenberger, P. 1970. Les Niveaux Paléontologiques de Première Apparition des
Mammiferes Primordiaux en Afrique du Sud et Leur Ichnologie
Établissement de Zones Stratigraphiques Détaillees dans le Stormberg du
Lesotho (Afrique du Sud) (Trias Supérieur a Jurassique).
Gondwana Symposium IUGS **2:** 343-370. (Typography of Title Corrected)

JTEllenberger, P.1972. Contribution à la classification des pistes de vertébrés du Trias: Les types du Stormberg d'Afrique du Sud (I).
Paleovertebrata, Memoire Extraordinaire Montpellier, 152pp. (30pls, 2 folding)

JTEllenberger, P.1974. Contribution a la classification des pistes de vertebres du Trias: Les types du Stormberg d'Afrique du Sud (IIème Partie: Le Stormberg Superieur - I. Le biome de la zone B/1 ou niveau de Moyeni: ses biocénoses).
Paleovertebrata, Memoire Extraordinaire Montpellier, 147pp..pls. A-R &1-31 (one folding).

PTEllenberger, P. 1975. L'Explosion Démographique des Petits Quadrupèdes a Allure de Mammifères dans le Stormberg Supérieur (Trias) d'Afrique du Sud Aperçu sur Leur Origine au Permien (France et Karroo).
Coll.internat.Cent.natn.Rech.sci. **No. 218**: 409-432 pls I-IV.

J Ennouchi, E. 1953. A Propos des Empreintes de Dinosauriens de Demnat (Est de Marrakech).
Bull.Soc.Sci.nat.phys.Maroc **32:** 11-16 pls III-IV.

P Estes, R. & Reig, O.A. 1973. In: Evolutionary Biology of the Anurans Contemporary Research on Major Problems (ed. Vial, J.L.).
1 The Early Fossil Record of Frogs A Review of the Evidence (pp. 11-63).
Columbia, University of Missouri Press, xii 470pp.

C Flynn, L.J., Brillanceau,A., Brunet, M., Coppens, Y, Dejax, J., Duperon-Laudoueneix, M., Ekodeck, G., Flanagan, K.M., Heintz, E., Hell, J., Jacobs, L.L., Pilbeam, D.R., Sen, S. & Djallo, S. 1987. Vertebrate fossils from Cameroon, West Africa.
Jour.Vert.Paleont. **7:** 469-471,

P Fountain, A.J. 1985. Notes on the Occurrence of Synapsid Footprints in the Adelaide Subgroup of the Lower Beaufort Group in the Richmond Area, Cape Province.
Ann.geol.Surv.S.Afr. **18:** 67-69.

C.Gaudry, A. 1890. Les enchaînements du Monde Animal dans les Temps Géologiques. Fossiles Secondaires.
Paris, F. Savy (pp.269-271) Thulborn 1990

Gillette, D.D. & Lockley, M.G. eds. 1989. Dinosaur Tracks and Traces.
Cambridge, Cambridge University Press, xvii 454pp. .

C Ginsburg, L., Lapparent, A.F. de, Loiret, B. & Taquet, P. 1966. Empreintes de pas de Vertébrés tétrapodes dans les séries continentales à l'Ouest d'Agadès (République du Niger).
C.R.Acad.Sci.Paris **263D:** 28-32.

T Ginsburg, L., Lapparent, A.F. de & Taquet, P. 1968. Piste de Chirotherium dans le Trias du Niger.
C.R.Acad.Sci.Paris **266D:** 2056-2058.

T Gow, C.E. & Latimer, E.M. 1999. Preliminary Report of Dinosaur Tracks in Qwa Qwa, South Africa.
Palaeont.afr. **35:** 41-43.

P Green, D. 1998. Palaeoenvironments of the Estcourt Formation (Beaufort Group), Kwazulu-Natal.
M.Sc. Thesis, University of Natal Durban, (i) 188pp.

P Griffiths, I. 1963. The Phylogeny of the Salientia.
Biol.Rev. **38:** 241-292 Pl. I.

J Gürich, G. 1926. Über Saurier-Fährten aus dem Etjo-Sandstein von Südwestafrika.
Paläont.Z. **8:** 112-120 Taf.II. (Taf. II missing)
Haubold, H. 1971. Handbuch der Paläoherpetologie (Herausg. Oskar Kuhn) Teil 18
Ichnia Amphibiorum et Reptiliorum fossilium.
Stuttgart, Gustav Fischer Verlag, viii 124pp. .
Haubold, H. 1974. Die fossilen Saurierfährten.
Wittenberg Lutherstadt, Ziemsen, 168pp. .
Haubold, H. 1984. Saurierfährten.
Wittenberg Lutherstadt, Ziemsen, 231pp. 135figs. 19 tabs.
JT Haubold, H. 1986. The Beginning of the Age of Dinosaurs Faunal change across
the Triassic-Jurassic boundary (Ed. Padian, K.).
15 Archosaur footprints at the terrestrial Triassic-Jurassic transition
(pp.189-201).
Cambridge, Cambridge University Press, xii 378pp. .
P Haughton, S.H. 1919. A Review of the Reptilian Fauna of the Karroo System of
South Africa.
Trans.geol.Soc.S.Afr. **22:** 1-25.
P Haughton, S.H. 1925. Exhibit:- Tracks of Animals preserved in the Ecca Shales of
the Cape Province.
Trans.roy.Soc.S.Afr. **13:** xxviii-xxix.
P Haughton, S.H. 1928. The Geology of the Country Between Grahamstown and Port
Elizabeth. An Explanation of Cape Sheet No. 9 (Port Elizabeth).
Union of South Africa Geological Survey, 7-45.
J Heinz, R. 1932. Die Saurierfährten bei Otjiaenamaparero im Hereroland und das
Alter des Etjo-Sandsteins in Deutsch-Südwestafrika.
Zeitschr.Deutschen geol.Ges. **84:** 569-570.
P Hoffmann, H.J. (Photographs Blair, J.) 2000. The Rise of Life on Earth When Life
Nearly Came to an End The Permian Extinction.
National Geographic September 2000: 100-113.
P Holub, E. 1881. Sieben Jahre in Südafrika
Ergebnisse, Forschungen und Jagden auf meinen Reisen von den
Diamantenfeldern zum Zambesi (1872-1879).
Wien, Alfred Hölder, ix (+ i Errata) 532pp. 4 Taf. .
Huene, F. von 1925. Die südafrikanische Karroo-Formation als geologisches und
faunistisches Lebensbild.
Fortschr.Geol.Paläont. **12:** (iii) 124pp. 1 Karte.
J Huene, F. von 1925. Ausgedehnte Karroo-Komplexe mit Fossilführung im
nordöstliche Südwestafrika.
Zentralbl.Min.Geol.Pal. Ser.B. **1925:** 151-156.
Huene, F. von 1932. Die fossile Reptil-Ordnung Saurischia, ihre Entwicklung und
Geschichte.
Monogr.Geol.Paläont. **4:** 361pp. . Ellenberger I p.5
J Ishigaki, S. 1985. (Dinosaur footprints of the Atlas Mountains).
Nature Study **31(10):** 113-116 (In Japanese).
J Ishigaki, S. 1985. (Dinosaur footprints of the Atlas Mountains).
Nature Study **31(12):** 136-139 (In Japanese)
J Ishigaki, S. 1986. (The Dinosaurs of Morocco).
Tokyo, Tsukiji Shokan (In Japanese) ref. Thulborn

J Ishigaki S. 1988. Les empreintes de Dinosaures du Jurasique inférieur du
Haut Atlas central marocain.
Notes Serv.géol. Maroc **44 (334):** 79-86.

J Ishigaki, S. 1989. Dinosaur Tracks and Traces (eds Gillette, D.D. & Lockley, M.G.).
9 Footprints of Swimming sauropods from Morocco (pp. 83-86).
Cambridge, Cambridge University Press, xvii 454pp. .

J Ishigaki, S. & Haubold, H. 1986. First International Symposium on Dinosaur Tracks and Traces, Albuquerque, 1986, Abstracts with Program (ed. D.D. Gillette).
Lower Jurassic dinosaur footprints from the central High Atlas, Morocco (p.16).
Albuquerque, New Mexico Museum of Natural History,

C Jacobs, L.L., Flanagan, K.M., Brunet, M., Flynn, L.J., Dejax, J. & Hell, J.V. 1989.
Dinosaur Tracks and Traces (eds. Gillette, D.D. & Lockley, M.G.).
38 Dinosaur Footprints from the Lower Cretaceous of Cameroon, West Africa. (pp. 349-351).
Cambridge, Cambridge University Press, xvii 454pp. .

J Jenny, J., Jossen, J-A. 1982. Découverte d'empreintes de pas de Dinosauriens dans le Jurassique inférieur (Pliensbachien) du Haut-Atlas central (Maroc).
C.R.Acad.Sci. (Série II) **294:** 223-226.

J Jenny, J., le Marrec, A. & Monbaron, M. 1981. Les couches rouges du Jurassique moyen du Haut Atlas central (Maroc): correlations lithostratigraphiques, éléments de datations et cadre tectono-sédimentaire.
Bull.Soc.géol.France (7) **23(6):** 627-639. Ishigaki 1989

J Jenny, J., le Marrec, A. & Monbaron, M. 1981. Les Empreintes de Pas de Dinosauriens dans le Jurassique Moyen de Haut Atlas Central (Maroc): Nouveaux Gisements et Precisions Stratigraphiques.
Geobios Lyon **14:** 427-431.

P Klerk, W.J. de 1998. A New Dicynodont Trackway Exposed on a Palaeosurface in the Cistecephalus Assemblage Zone of the Beaufort Group, East of Graaff-Reinet.
Abstr.Pal.Soc.S.Afr.Conf. **1998:** 9.

P Klerk, W.J. de 1999. (See Davidow, A. 1999.)
Getaway **February 1999:** 31-32.

P Klerk, W.J. de 2000. A Dicynodont Trackway in the Cistecephalus Assemblage Zone of the Beaufort Group Easy of Graaf-Reinet (Sante Sana).
Abstr.Pal.Soc.sthn Afr. 11th Biennial Conf. **2000:** unpaginated

P Klerk, W.J. de, Fourie, F. & Bangay, S. 2000. Computer Enhancement of Selected Manual and Pedal Dicynodont Footprints From the SanteSana Trackway in the Cistecephalus Assemblage Zone of the Beaufort Group East of Graaff-Reinet.
Abstr.Pal.Soc.sthn Afr, 11th Biennial Conf. **2000:** unpaginated

Kuhn, O. 1958. Die Fährten der vorzeitlichen Amphibien und Reptilien.
Bamberg, Meisenbach KG, 64pp.

Kuhn, O. 1963. Ichnia tetrapodorum. Fossilium Catalogus I. Animalia pars 101.
Gravenhage, Junk, 176pp. 12 pls.

Lapparent, A.F. de 1942. Dinosauriens de Maroc.
C.R.somm.Soc.géol.France **1942:** 28. (Ishigaki 1989) : 38 (deLapparent1945)

J Lapparent, A.F. de 1945. Empreintes de Pas de Dinosauriens du Maroc exposées dans la Galerie de Paléontologie.
Bull.Mus.natn.Hist.nat.Paris (2) **17:** 268-271.

Lapparent, A.F. de & Lavocat, R. 1955. Traité de Paléontologie (ed. Piveteau, J.). Tome V Amphibiens Reptiles Oiseaux Reptiles Dinosauriens (pp. 785-962). Paris, Masson et C[ie].

Leonardi, G. ed. 1987. Glossary and Manual of Tetrapod Footprint Palaeoichnology. Brasília, Rep.Fed.Bras.Min.Minas Energia Dep.nac.Prod.Min., xi 75pp.plsXX.

Lessertisseur, J. 1955. Traces Fossiles d'Activité Animale et Leur Signification Paléobiologique.
Mém.Soc.géol.France (N.S.) **34:** 150pp. pls.I-XI.

J Lingham-Soliar, T. & Broderick, T. 2000. An Enigmatic Early Mesozoic Dinosaur Trackway From Zimbabwe.
Ichnos **7:** 135-148.

P MacRae, C.S. 1990. Fossil Vertebrate Tracks Near Murraysburg, Cape Province.
Palaeont.afr. **27:** 83-88.

MacRae, C.S. 1999. Life Etched in Stone Fossils of South Africa.
Linden, Geological Society of South Africa, (xviii) 305pp. .

C Mesle, (G.) le & Péron, (P.-A.) 1881. Sur des empreintes de pas d'oiseaux Observées par M. le Mesle dans le sud de l'Algérie.
C.R. Assoc.française Avanc.Sci. **9:** 528-533.

Molnar, R.E. 1985. The Beginnings of Birds (eds. M.K. Hecht, J.H. Ostrom, G. Viohl & P. Wellnhofer). Proceedings of the International Archaeopteryx Conference Eichstätt 1984.
Alternatives to *Archaeopteryx*: A Survey of Proposed Early or Ancestral Birds (pp. 209-217).
Willibaldsburg Eichstätt, Freunde des Jura-Museums, frontis 382pp. .

Monbaron, M. 1983. Dinosauriens du Haut Atlas Central (Maroc).
Actes de la Société Jurassienne d'Émulation **1983:** 203-234.

J Monbaron, M., Dejax, J. & Demathieu, G. 1985. Longues pistes de Dinosaures bipèdes à Adrar-n-Ouglagal (Maroc) et repartition des faunes de grands Reptiles dans le domaine atlasique au course du Mésozoïque.
Bull.Mus.natn.Hist.nat.Paris (4[e] sér) **7** section A: 229-242.

JT Mossman, D.J. 1990. Book Review Dinosaur Tracks and Traces.
Ichnos **1:** 151-153.

J Munyikwa, D. 1996. Description of the first dinosaur trackway found in Zimbabwe.
Arnoldia Zimbabwe **10(6):** 36-45.

Nopcsa, F. 1923. Die Familien der Reptilien.
Fortschr.Geol.Paläont. **12:** 210pp. Taf. 1-6. JU

JT Olsen, P.E. & Galton, P.M. 1977. Triassic-Jurassic Tetrapod Extinctions: Are They Real?
Sci. **197:** 983-986.

JT Olsen, P.E. & Galton, P.M. 1984. A Review of the Reptile and Amphibian Assemblages From the Stormberg of Southern Africa, With Special Emphasis on the Footprints and the Age of the Stormberg.
Palaeont.afr. **25:** 87-110.

J Plateau, H, Giboulet, G. & Roch, E. 1937. Sur le présence d'empreintes de Dinosauriens dans la région de Demnat (Maroc). C.R.somm.Soc.géol.Fr. **1937**:241-242.

P Plumstead, E. 1970. I.U.G.S. sub Commission on Gondwana Stratigraphy and Palaeontology 2nd Symposium, South Africa Post Symposium Excursion Guide Book No. **4** Part A – Text E. Transvaal, Natal and Drakensberg Section A (pp. 5-37).The Transvaal and Natal Coal Measures (pp. 9-37); Fourth Day (pp. 30-37). Part B – Maps (Figs. 1-7, cf. Fig. 1&7). C.S.I.R. Pretoria.

J Raath, M.A. 1972. First record of dinosaur footprints from Rhodesia. Arnoldia (Rhodesia) **5 (27):** 5pp..

J Raath, M.A. 1996. Earliest Evidence of Dinosaurs From Central Gondwana. Mem.Queensland Mus. **39:** 703-709.

T Raath, M.A., Kitching, J.W., Shone, R.W. & Rossouw, G.I. 1990. Dinosaur Tracks in Triassic Molteno Sediments: The Earliest Evidence of Dinosaurs in South Africa? Palaeont.afr. 27: 89-95.

Sarjeant, W.A.S. ed. 1983. Terrestrial trace-fossils. Benchmark Papers in Geology / 76. Stroudsburg, Hutchinson Ross, xiii 415pp.

Sarjeant, W.A.S. 1987. Glossary and Manual of Tetrapod Footprint Palaeoichnology (ed. Leonardi, G.). The Study of Fossil Vertebrate Footprints A Short History and Selective Bibliography (pp.1-19). cf. Leonardi, G. 1987.

P Seeley, H.G. 1904. Footprints of small Fossil Reptiles from the Karroo Rocks of Cape Colony. Ann.Mag.nat.Hist. (7) 14: 287-289.

P Smith, R.M.H. 1980. The lithology, sedimentology and taphonomy of flood-plain deposits of the lower Beaufort (Adelaide Subgroup) strata near Beaufort West. Trans.geol.Soc.S.Afr. **83:** 399-413.

P Smith, R.M.H. 1986. Trace Fossils of the Ancient Karoo. Sagittarius **1 (3):** 4-9.

P (Smith, R.) 1986. 220-Million-Year-Old "Trackways" Found in Karoo report from The South African Museum. The Naturalist **30 (1):** 43-44.

P Smith, R.M.H. 1990. A review of stratigraphy amd sedimentary environments of the Karoo Basin of South Africa. Jour.Afr.Earth Sci. **10:** 117-137.

P Smith, R.M.H. 1993. Sedimentology and ichnology of floodplain palaeosurfaces in the Beaufort Group (Late Permian), Karoo Sequence, South Africa. Palaios **8:** 339-357.

PT Smith, R.M.H. 1998. Sedimentology and ichnology of a crevasse splay Palaeosurface in the Beaufort Group (Late Permian), Karoo Supergroup, South Africa. Jour.Afr.Earth Sci. **27(1A):** 184-185.

P Smith, R.M.H., Hanse, C. & Hunter, C. 1995. Footprints from the dawn of time. YOU No **422:** 96-97.

P Smith, R.M.H., Eriksson, P.G. & Botha, W.J. 1993. A review of the stratigraphy and sedimentary environments of the Karoo-aged basins of Southern Africa. Jour.Afr.Earth Sci. **16:** 143-169.

P Stear, W.M. 1980. The Sedimentary Environment of the Beaufort Group Uranium Province in the Vicinity of Beaufort West, South Africa. Ph.D. Thesis, University of Port Elizabeth, (xii) 188pp. frontis. .

JTStockley, G.M. 1947. A Report on the Geology of Basutoland. Maseru, Basutoland Government, vii 114pp. 40 photographs 3 plates 1 map (colour, folding).

Taquet, P. 1972. A la recherche des dinosaures du Niger. Cour.Centre natn.Rech.sci.Paris **1972:** 33-36 and rear cover.

Taquet, P. 1976. Géology et Paléontologie du gisement de Gadoufaoua (Aptien du Niger). Cahiers de Paléontologie, Cent.natn.Rech.sci.Paris **1976:** 1-191.

JTTaquet, P. 1977. Les découvertes récentes de Dinosaures du Jurassique et du Crétacé en Afrique, au Proche et Moyen-Orient et en Inde. Mém.Soc.géol.France **8:** 325-330.

JTTaquet, P. 1977. Dinosaurs of Niger. Nigerian Field **42:** 2-10.

J Termier, H. 1942. Données nouvelles sur le Jurassique rouge à Dinosauriens du Grand et du Moyen Atlas (Maroc). C.R.somm.Bull.Soc.géol.France (5) **12:** 199-207.

P Theron, A.C. 1967. The Sedimentology of the Koup Subgroup Near Laingsburg. M.Sc. Univ.Stellenbosch (iv) 25pp. 22figs. 15pls. 5 tabs.

Thulborn,T. 1990. Dinosaur Tracks. London, Chapman & Hall, xvii 410pp.

Toit, A.L. du 1954. Geology of South Africa, 3rd Edition. Edinburgh, Oliver & Boyd, xiv 611pp. map.

P Watson, D.M.S. 1960. The anomodont skeleton. Trans.zool.Soc.Lond. **29(3):** 131-208 Plate 1.

Era/Systema		Taxon/Taxa	Locus/Loci	Patria	Auctor
Mesozoicum			Domaine atlasique	Maroc	Monbaron Dejax & Demathieu 1985
CRETA					
Supérieur	Maestrichtian	oiseaux	Amoura	Algérie	le Mesle & Peron 1881
			Amoura	Algérie	Gaudry 1890
		Groupes A-C Thér carn Coelurosauria	Amoura (±50km NE Messaâd)	Algérie	Bellair & deLapparent 1949
		TypesA-E Thér;dino;*Agadirichnus*;?;?	Agadir (±15,5km E) Mesguina	Maroc	Ambroggi & deLapparent 1954, 1955
		cf. *Elaphrosaurus*; cf. *Eubrontes*	Agadez	ENiger	Alessandro & Terruzi 1990
Inferior	Aptian	tridactyl (Iguanodont or theropod ?)	Mayo Rey (Koum) Basin	Cameroon	Flynn et al. 1987, Jacobs et al 1989
		Dinosaur	Koum Basin, several localities	Cameroon	Congleton, 1988
		A-K Théropodes; Iguanodontidès	Babouri-Figuil Basin	Cameroun	Dejax Michard Brunet & Hell 1989
		dinosaurs; herbivorous sauropod	Agades; Ouest de Agades	Niger	Taquet 1977
CRETA/JURA		Amphibiens;Théropodes;Sauropode	Ouest de Agadès	Niger	Ginsburg deLapparent Loiret Taquet 1966
			Ouest de Agadè =Irhazer	Niger	Taquet 1977 (Gins deLappLiorTaquet 1966)
JURA					
Dogger				Niger	Taquet 1971, 1966
		cf.Mégalosaures voisins *Plateosaurus*	Demnat - Aït Blal, Aït Kelelch	Maroc	Plateau Giboulet & Roch 1937
Lias supérieur		stratigraphie (Plateau et al 1937)	Demnat	Maroc	Bourcart deLapparent & Termier 1942
		Reptiles	Aït Ouaridéne and 20km NE	Maroc	Termier 1942
		Théropodes carnivores cf.*Eubrontes*	Règion de Demnat	Maroc	de Lapparent 1945
		thérop carnivor voisin Mégalosauridés	12km Est de Demnat	Maroc	Ennouchi 1953
		stratigraphie	Région de l'Oued Rhezef	Maroc	Choubert Faure-Muret & Levèque 1956
			Agades; Ouest de Agades	Niger	Taquet 1967,1972,1976,1977a,b
		Breviparopus nov.sp.	Demnat	Maroc	Dutuit & Ouazzou 1980
	Bathonien	Sauropodes, Théropodes;stratigraphie	10 gisements Demnat région	Maroc	Jenny Marrec & Monbaron 1981
Lias	Pliensbachien	Coelosaur,Carnosaur,Sauropod,bipèd	Lakhdar, Aït Bou Guemez	Maroc	Jenny & Jesson 1982
			Atlas =?	Maroc	Monbaron 1983
		Dinosauriens bipèdes	Adrar-n-Ouglagal	Maroc	Monbaron Dejax & Demathieu 1985
		(quadrupeds);(bipeds)		(Morocco)	Ishigaki 1985, 1985
	Pliensbachien	5groupes:Coeluro-,Carno-,Sauropod	20 gisements Sud d'Azilal	Maroc	Ishigaki 1988
		Breviparopus+	4 sites E of Demnat	Morocco	Ishigaki 1989
				Morocco	Ishigaki & Haubold 1986
Lias		Saurischer	Otjihaenamaparera	Namibia	vonHuene 1925
		Saurichnium 4spp. *Tetrapodium* 1sp.	Otjihaenamaparera	Namibia	Gürich 1926(1927); Heinz 1932
		Saurischia indet.	Otjihaenamaparera	Namibia	Haubold 1971
		dinosaur	(Waterberg Plateau Park)	Namibia	Channing 1998
		cf. Théropodes carnivores	région de Demnat	Maroc	Lapparent 1945
	?Hettangienne	cf. *Grallator*	12km Est d'Aïn-Sefra	Algérie	Bassoullet 1971; Taquet 1977
		cf. *Tetrasauropus*, *Syntarsus*, +	Pontdrif naby Limpopo	Suid Afrika	vanEeden & Keyser 1972
		land vertebrates, incl. hopping biped	Giants Castle	Sth Africa	vanDijk 1966

		Molapopentapodiscus , hopper, dino+	Giants Castle		Sth Africa	vanDijk 1978
		palaeoecology- quadruped & biped	Giants Castle		Sth Africa	vanDijk, Hobday & Tankard 1978
		small tridactyl dinosaur	Ntumbe River Chewore Area		Zimbabwe	Lingham-Soliar & Broderick 2000
					Lesotho	Taquet 1977 (Ellenberger Ell Ginsurg 1970)
	basal Elliot	ornithopod theropod (*?Syntarsus*)	Tweedegeluk,QwaQWa distr.		Sth Africa	Gow & Latimer 1999
JURA/TRIAS						
		1 type; 2 types	Qalo, Morija		Lesotho	Dornan 1905
		several types, 3-toed (+gregarious?)	+Tsikuane,Teyateyaneng		Lesotho	Dornan 1908
		Euskelosaurus ?				vonHuene 1932
		dinosaurs ornithopod			Lesotho	Stockley 1947
		dino plantigrade bipéd quatre doigts	Leribe-Jonathane	(Tr c)	Lesotho	Ellenberger & Ellenberger 1956
		dinos bipéd tridactyle (&+1)	Libataolong	(Tr m)		"
		biped tridactyl cf. *Brontozoum* +	Qalo Tsikoane Morija	(Tr c)	Lesotho	Ellenberger & Ellenberger 1958
		pistes aviformes cf. *Anoemopus*	Thejane >Maphutseng	(Tr e)		"
		cf. *Cheirotherium,Erythrosuchus*	Seobeng Qeme Seaka	(Tr m)		"
		(tridactyle)	Hermon	(Tr t)		"
		stratigraphy Cave Sandstone	Morija Tsikoane	(Tr c)	Lesotho	Ellenberger Ell FabreGinsburg&Mendrez1964
		Red Beds transition	Jonathane Cana	(Tr e)		"
		Red Beds Tritylodon	Moyeni Thejane	(Tr e)		"
		Red Beds lower	Maphutseng	(Tr e)		"
		Molteno	Seaka Phuthiajsana Seobeng Qeme	(Tr m)		"
		stratigraphy: footprints A-M then N-T	Upper Karroo & WEurope TrJu		Lesotho	Ellenberger Ellenberger & Ginsburg 1967
		Grypo;? Plateo;?*Aeto;Anomo* ;?Masso	Cave Sandstone et Red Beds		Lesotho	Ellenberger Ellenberger & Ginsburg 1970
		Euskelosaurus;Otozoum ;?Mélanoros	Lower Red Beds et Molteno			"
		faunas, floras	localités>44 Trt Trm Tre Trc Ju		Lesotho	P Ellenberger 1970, 1972, 1974, 1975
		stratigraphy	Upper Karoo (Stormberg)		+Sth Africa	Olsen & Galton 1977
		stratigraphy, faunal correlation	Upper Karoo (Stormberg)		Sth Africa+	Olsen & Galton 1984
		faunal change	Karoo		+ Afrika	Haubold 1986
TRIASSIC						
Supérieur		*Chirotherium*	AnouMakarèneN125kmAgades		Niger	Ginsburg deLapparent & Taquet 1968
Upper		5 nov gensp;7 nov sp;1 cf.sp; 1=sp	Argana, Ourika		Maroc	Biron & Dutuit 1981(1982)
		cf. *Syntarsus*	Nyamandhlovu		Zimbabwe	Raath 1972; Munyikwa 1996
			Nyamandhlovu		Zimbabwe	Broderick 1984,1985; Lingham-Soliar&B 2000
		dinosaur	Matsieng		Lesotho	Damane 1969
	Elliot	A-H cf.*Kannemeyeria, Cheirotherium+*	Maphutseng	(Tr e)	Lesotho	Ellenberger & Ellenberger 1960
		sauropod	Maphutseng		Lesotho	Ellenberger & Ellenberger 1966
	basal Elliot	?*Syntarsus*	Tweedegeluk,QwaQWa distr.		NEFreeStat	Gow & Latimer 1999
	Elliot/Molteno	biped dinosaur; cf. *Otozoum*	Moyeni; Phuthiatsana		Lesotho	Ellenberger Ellenber Fabre & Mendrez 1964
	Molteno	cf.*Cheirotherium;* 3-dactyle; 5-dactyle	Seobeng		Lesotho	P Ellenberger 1955

		cf. *Grallator*	Maclear	Sth Africa	Raath et al 1990
		cf. *Grallator*	Maclear	Sth Africa	Raath 1996
PERMIAN					
	Estcourt	cf. therapsids	Estcourt	Sth Africa	Green 1998
	Adelaide				
		Dicynodon ?	MiddelburgCP Kuilsfontein	Sth Africa	Holub 1881
		Procolophon ?	"	Sth Africa	Seeley 1904
		Procolophonichnium	"	Sth Africa	Nopcsa 1923
		Procolophonichnium	"	Sth Africa	vonHuene 1925; Gürich 1927
		anomodont (cf. *Dicynodon*)	Middelburg CP	Sth Africa	Watson 1960
		reptile, fish	Beaufort West Putfontein	Sth Africa	Stear 1980
		rhinesuchid?	NW Beaufort West	Sth Africa	Smith 1980, 1995
		Diictodon	Oukloof Pass	Sth Africa	Smith 1986,1986; Day 1999
		therapsids, ?dinocephalian	AbrahamskraalFm TeekloofFm	Sth Africa	Smith 1990
		reptile ?dinocephalian	Gansfontien	Sth Africa	deBeer 1986
		5 types:cf. dinoceph, *Bradys* , *Diicto*	Fraserburg, Gansfontein +	Sth Africa	Smith 1993; 1998
		? synapsid cf. *Aulacephalodon*	Richmond CP Klipplaat	Sth Africa	Fountain 1985
		cf. *Aulacocephalodon*	Murraysburg vTondersKraal	Sth Africa	MacRae 1990
		Dicyn. cf.*Aulacephalodon*+?*Diictodon*	40Km East of Graaff-Reinet	Sth Africa	deKlerk 1998,1999(in Davidow 1999),2000a,b
	Laingsburg/	fish, vertebrate	Ecca Pass	Sth Africa	Haughton 1925
	Fort Brown	fish, tetrapod	W of Laingsburg on N2	Sth Africa	Theron 1967
		fish, vertebrate	Laingsburg, Ecca Pass	Sth Africa	Anderson 1974
		fish	Laingsburg, Askop	Sth Africa	Anderson 1976
	Tierberg	vertebrate	Zak River Estates	Sth Africa	Haughton 1919
		"amphibian"; cf. *Acanthodes*	Zak R. Calvinia;Ecca Pass	Sth Africa	Haughton 1925
		reptile	Zak R. Calvinia;Ecca Pass	Sth Africa	vonHuene 1925
		vertebrate; *Acanthodes* cf.	Ecca Pass Brak River	Sth Africa	Haughton 1928
		vertebrate cf. Haughton 1928	Ecca Pass Brak River	Sth Africa	vonHeune
		vertebrate	Zak River Estates	Sth Africa	Abel 1935
		Broomichnium	Zak River	Sth Africa	Kuhn 1958
		amphibian (Protoanuran)	Zak River	Sth Africa	Griffith 1963
		amphibian (not Protoanuran)	Zak River	Sth Africa	Estes & Reig 1973
		fish	near Vryheid	Sth Africa	Anderson 1970
		Undichna ; *"Quadrispinichna"*	Swart Umfolosi+; Zak River+	Sth Africa	Anderson 1974
		Undichna	Zak River + 5 sites	Sth Africa	Anderson 1976
	Mbizane	fish	near Vryheid; Swart Umfolosi	Sth Africa	Plumstead 1970; Anderson 1970,1974,1976

B

Conference Abstracts and Posters

10th Conference of the Palaeontological Society of Southern Africa
September 1998

Paper presented by Dr. J.A. van den Heever

Fossil Anura at Langebaanweg

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c/o Department of Zoology, University of Stellenbosch, Stellenbosch 7600

In 1970 the Pliocene/Pleistocene fossil site at Langebaanweg was recorded as having, in 'E' Quarry: "At least one anuran species". Comparison was made with *Xenopus laevis*, the extant Common Platanna, a frog of the family Pipidae. Examination in 1997 of material in the collection of the South African Museum from Langebaanweg, which consisted of isolated bones sorted as amphibian, revealed material identifiable as belonging to four groups of anurans – the families Pipidae, Bufonidae, and Brevicipitidae; and the Ranoidea, probably of the family Ranidae. This makes the site the richest anuran fossil site in Africa so far investigated. Some ilia have been found to differ from those of all extant South African frogs investigated.
An outline is given of diagnostic features of isolated anuran bones from Langebaanweg. Some potentially valuable skeletal parts are illustrated from extant material.

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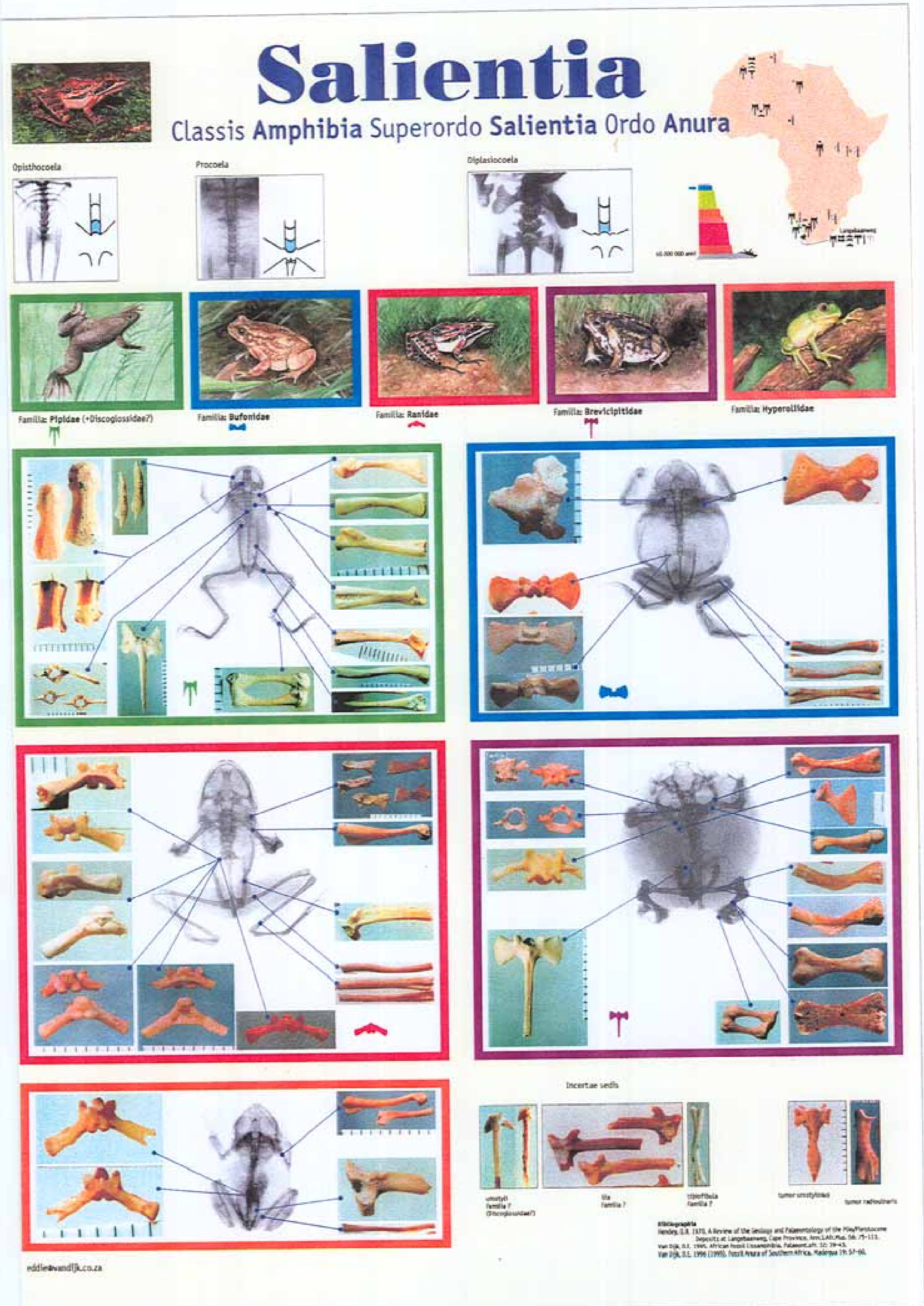
A poster covering the fossil anuran material of Langebaanweg was assembled for the opening of the research laboratory at Langebaanweg in September 1998.
A permanent poster was subsequently prepared, one copy of which is on display at Langebaanweg.
A copy of the poster was presented at Geocongress 2000, July 2000, and at the 11th Conference of the Palaeontological Society of Southern Africa, September 2000.



Salientia
Classis Amphibia Superordo Salientia Ordo Anura
Opisthocoela
Procoela
Diplasiocoela
Langebaanweg
Familia: Pipidae (+Discoglossidae?)
Familia: Bufonidae
Familia: Ranidae
Familia: Brevicipitidae
Familia: Hyperoliidae
Incertae sedis
urostyli
familia ?
(Discoglossidae?)
ilia
familia ?
tibiofibula
familia ?
tumor urostylosus
tumor radioulnaris
Bibliographia
Hendey, Q.B. 1970. A Review of the Geology and Palaeontology of the Plio/Pleistocene Deposits at Langebaanweg, Cape Province. Ann.S.Afr.Mus. 56: 75-115.
Van Dijk, D.E. 1995. African fossil Lissamphibia. Palaeont.afr. 32: 39-43.
Van Dijk, D.E. 1998 (1999). Fossil Anura of Southern Africa. Madoqua 19: 57-60.
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Langebaanweg Salientia (Amphibia)

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'n Opname van verwysings na paddafossiele van suidelike Afrika (Amphibia: Salientia:Anura) is onlangs gemaak (Van Dijk, 1996). Daaruit blyk dit dat dié fossiele bekend geword het óf omdat hulle tydens prospektering vir diamante gevind word, óf by verslae oor soogdierfossielevondse genoem word, sonder dat hulle besondere aandag geniet. Langebaanweg (Pliocene) is bekend veral vir sy soogdier- en voël-fossiele, maar het ook 'n verskeidenheid paddafossiele. Die Anura fossiele van Langebaanweg is los beentjies, wat saam met die bekende groot soogdier- bene in die sedimente van die Berg-Rivier en sy monding versamel het.

Vier verskillende soorte sacra (kruisbene of kruiswerwels) dui op minstens vier families: Die familie Pipidae (platannas) - sacrum met urostylus (stertbeen) versmelt, en met groot parallele rande. Die Bufonidae (skurwepaddas) - sacrum hol aan voorkant, en met effens ronde afgeplatte rande. Die Ranidae (gewone springpaddas) - sacrum halfbolvomig aan voorkant, en los van die urostylus. Die Brevicipitidae ("reenpaddas", "blaasoppe") – sacrum met urostylus versmelt, en met ronde afgeplatte rande. Daar is enkele bene, 'n ilium (heupbeen), humerus (bo-arm) en femur (dybeen), wat waarskynlik 'n vyfde familie verteenwoordig – die Hyperoliidae (rietpaddas en boompaddas), met 'n rana-agtige sacrum.

Die verskillende sacrum-urostylus-ilia vorms van die families verteenwoordig verskillende bewegingstyle: By die swemmende Pipidae skuif die ilia, en dus die pelvis (bekken) as geheel, reguit vorentoe en agtertoe aan die rande van die sacrum. By die hoppende en lopende Bufonidae, en die grawende en lopende Brevicipitidae, draai die pelvis effens van die een kant na die ander tydens loop- en graaf-bewegings, soos die een ilium vorentoe skuif en die ander agtertoe. By die springende Ranidae roteer die pelvis voor 'n sprong op (wat die voet-, knie-, en dy-bekken -gewrigte in lyn met die werwelkolom bring), en voor landing af (wat die agterbene onder die dier laat val, gerem deur spiere tussen die urostylus en die ilia – wat elk 'n rif bekend as 'n crista op sy borand het). By die klimmende en springende Hyperoliidae roteer die ilia soos by Ranidae, maar minder, en kan ook effens draai soos by Bufonidae (bewegings van voor- en agterbene is veelsydiger as by Ranidae).

Die volgende bene is opgeteken:

Pipidae: cranium dak- en vloer-, en bo-kaak (maxilla); vertebrae; sacrum+urostylus; scapula+clavicula; coracoid; humerus; radioulna; ilium; femur; tibiofibula; astragalus+calcaneum

Bufonidae: cranium (posterior); sacrum; scapula; femur; tibiofibula

Ranidae: sacrum; scapula; humerus; ilium; femur; tibiofibula

Brevicipitidae: vertebrae I+II; vertebra III; scapula; coracoid; humerus; femur; tibiofibula; astragalus+calcaneum

Hyperoliidae: sacrum?; humerus; ilium; femur

Familie onbekend: ilia met kenmerkende uitsteeksel (ook by Klasiesrivier waargeneem); urostyli met dwarsuitsteeksels; 'n versmelte vertebrae I+II

Uit omtrent 1200 paddafossiel-lokaliteite wêreldwyd kom 6 genera of meer net by 20 voor, waarby Langebaanweg nou gevoeg moet word, waarskynlik selfs by die sewe met meer as 6genera (7 genera by 5, 8 genera by 2). In Afrika is die tweede meeste genera (5) by Beni-Mellal in Marokko bekend.

Verwysing:

Van Dijk, D.E. 1996(1995). Fossil Anura of Southern Africa. Madoqua **19:** 57-60.

Ichnia Africae (Vertebrata)

Palaeozoicum; Mesozoicum

Spore van Afrika (Vertebrata) Tracks of Africa (Vertebrata)

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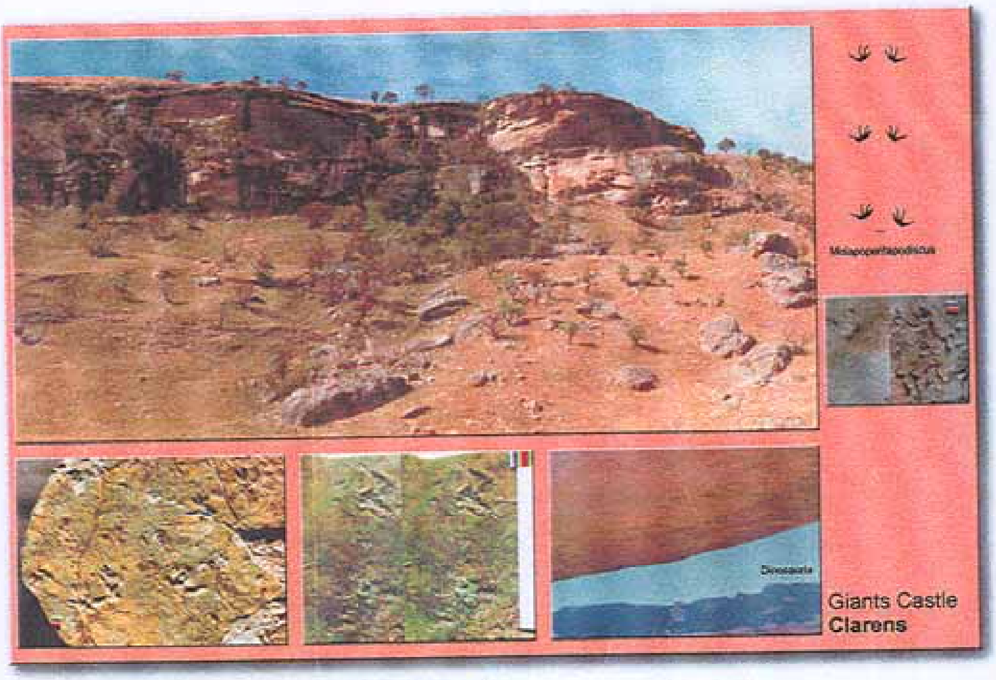

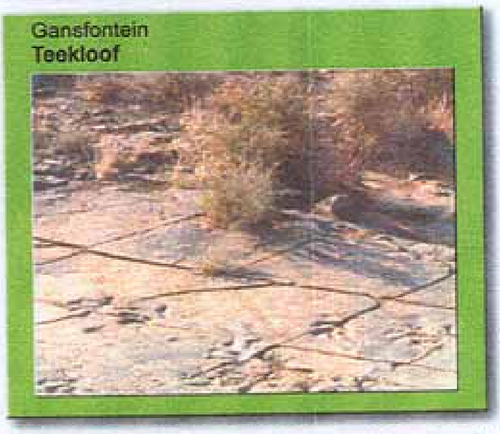

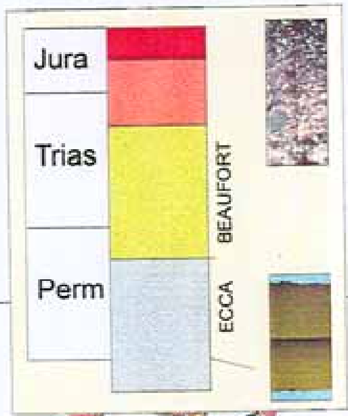

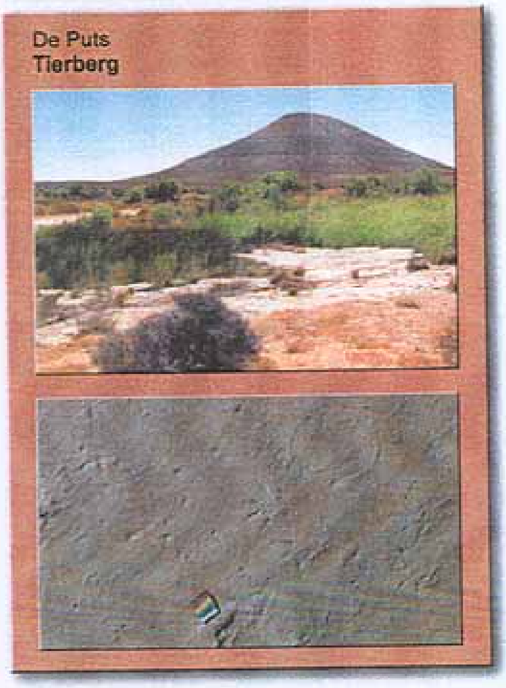

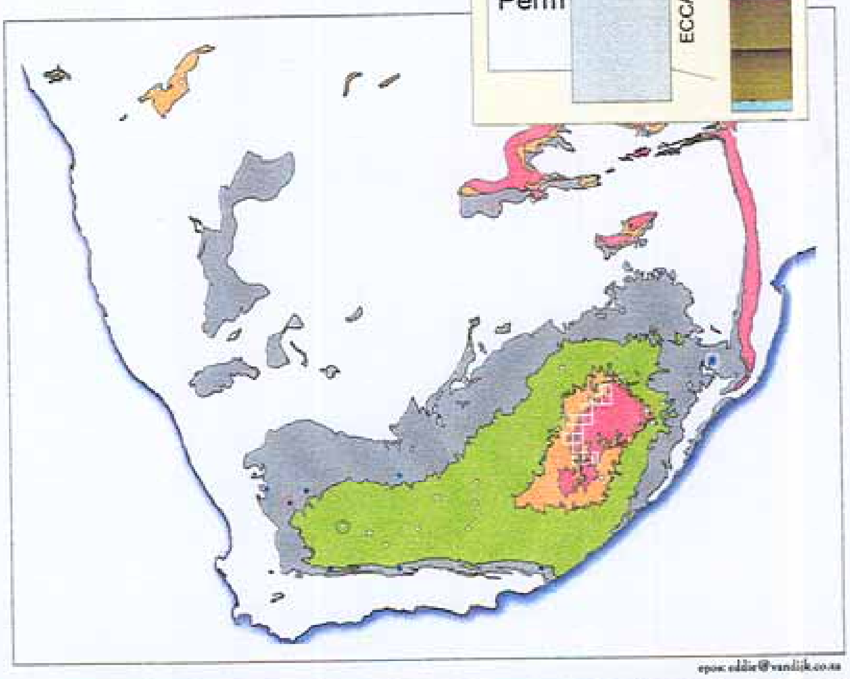

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Poster: Geocongress of Geological Society of South Africa July 2000
& 11th Conference of Palaeontological Society of Southern Africa Sept.2000

Vertebrate Trackways of Africa

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Bibliographies of footprints and trackways of vertebrates of Europe, North America, South America and Australia are available, but not of Africa. A compilation of literature for Africa is near completion, the scope being Permian to Cretaceous, i.e. caenozoic prints (e.g. of hominids), are excluded. There are about 120 references, including preliminary reports, and derivative items. In addition to a bibliography, the data have also been arranged as far as possible geochronologically in the form of an extensive table, with columns for taxa, sites, countries, and authors, with some cross-referencing to indicate derivative or additional information. An attempt has been made to map sites as accurately as the data permit, which is sometimes no better than ¼° latitude and longitude.

A map of vertebrate ichnology sites in Southern Africa illustrates a striking phenomenon – the paucity of tracks in the Adelaide Subgroup of the Beaufort Group in contrast to its richness in body-fossils, and the concentration of tracks in the relatively fossil-poor Clarens Formation. [The first discovery of prints in the Beaufort, near Middelburg Cape (Holub, 1881), was followed nearly 80 years later by a second discovery in the same area (Watson, 1960), and further discoveries only followed from 1980]. For vertebrate tracks to be recorded it is necessary that they are made on the surface of suitable sediment, that the sediment is not disturbed before preservation, that it is preserved, and that the sediment is later exposed and the tracks observed. In the Mbizane Formation (Ecca Group) the tracks of fishes are preserved on varves, the sediment of which is derived from glaciers and hence has little organic matter and therefore is not burrowed by animals, i.e. there is no bioturbation. In the Tierberg Formation (Ecca Group) prints of the feet of tetrapod vertebrates are made on sediment in water at depths not too great for the animals to surface to breathe nor too close inshore for there to be bioturbation, which is limited offshore. In the Adelaide Subgroup, where most of the Karoo vertebrate fossils are found, the tracks are found in the sediments of distal floodplains, presumably because there is no resident burrowing fauna in a situation where submergence is infrequent and/or of short duration. In the Clarens Formation there are, among the aeolian sediments, lenses of sediments deposited in playa lakes, and covered by later influxes. Periodic desiccation would have been inimical to sediment-burrowing animals, while the lake would have attracted animals to its shores and shallows.

Mention may be made of trackways as a means by which geology may be brought to the attention of the public.

Callietheira (Insecta: Mecoptera)

Perm: Kuznetsk; Karoo

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Kaltan, Kuznetsk

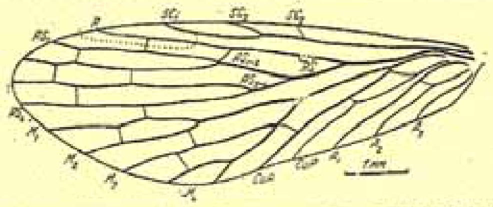


Рис. 484. *Callietheira khalfini* O. Mart. Переднее крыло. Колл. ПИН № 600/212. Калтан

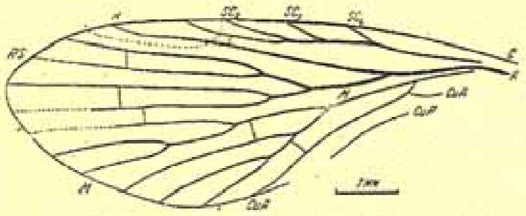


Рис. 485. *Callietheira bimembris* O. Mart. Переднее крыло. Колл. ПИН № 600/161. Калтан

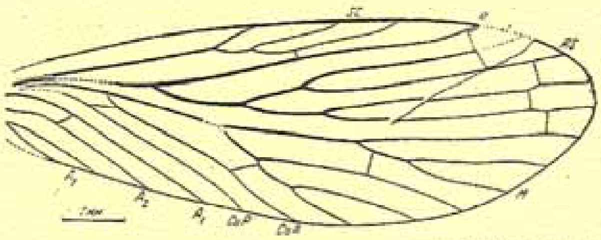


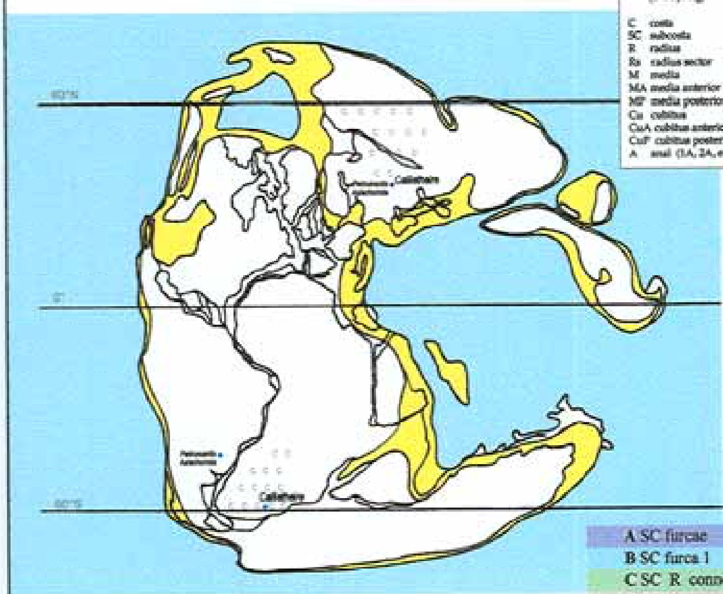
Рис. 486. *Callietheira major* O. Mart. Переднее крыло. Колл. ПИН № 598/87. Сарбала II

Bulwer, Karoo (Beaufort)

holotypus

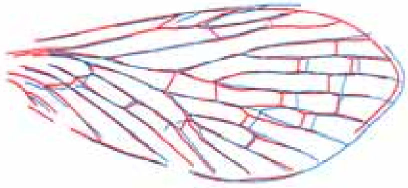
Callietheira granthami

paratypus

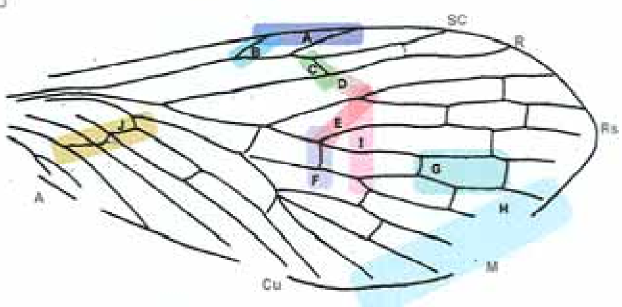


Clavus

- C costa +
- SC subcosta -
- R radius +
- Rs radius sector -
- M media -
- MA media anterior +
- MP media posterior -
- Cu cubitus -
- CuA cubitus anterior +
- CuP cubitus posterior -
- A anal (1A, 2A, etc.) +



holotypus
paratypus



	C.khalfini	*C.bimembris*	*C.major*	*C.granthami*
A SC furcae	2	3	2	2
B SC furca 1	>60°	<45°	<45°	<45°
C SC R connexus	**0**	1	1	1 (2)
D R Rs connexus	**1**	0	0	0 (?1)
E Rs furcae 1+2 & 3+4	1+2 distal	1+2 distal	**3+4 distal**	1+2 distal
F Rs4 M1+2 connexus	0	0	0	**1**
G Rs4 M1 connexus	1	1	1	**2**
H MA + MP furcae	**2+3**	3+3	3+3	**2+3**
I MA1+2 & Rs1+2 furcae	MA distal	MA distal	MA distal	**≈aequus**
J CuA-CuP-A connexus	CuA-CuP	CuA-CuP	CuA-CuP	**CuA-CuP-A**

Bibliographia

Rohdendorf, B.B., Becker-Migdisova, E.Eh., Martynova, O.M. & Sharov, A.G. 1961. Paleozojskie nasekomye kuznetskogo bassejna. *Trudy paleontologicheskogo instituta akademii nauk SSSR* 85: 705pp. 40 Tb.
Van Dijk, D.E. & Geertsema, H. 1999. Permian Insects from the Beaufort Group of Natal, South Africa. *Ann.Natal Museum* 40: 137-171.

Poster: Geocongress 2000 of Geological Society of South Africa July 2000
& 11th Conference of Palaeontological Society of Southern Africa Sept.2000

Callietheira (Insecta: Mecoptera) Martynova 1958 (Perm: Europa) *C. granthami* Van Dijk & Geertsema 1999 (Perm: Africa)

D.E. van Dijk[1] & H. Geertsema[2], Universiteit van Stellenbosch
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English Summary: The mecopteran insect genus *Callietheira* was described, with three species, from the Kuznetsk Basin of European Russia, by O.M. Martynova in 1958. A new species was described from Bulwer, KwaZulu-Natal, by Van Dijk & Geertsema in 1999. The Kuznetsk Basin also shares mecopterans *Petromantis* and *Asiachorista* with Brazil (Pinto, 1972). A poster is presented which is intended to be readily understandable also in Russia and Brazil.

Die insekgenus *Callietheira* (Mecoptera) is deur O.M. Martynova in 1958 beskryf (Rohdendorf *et al.*, 1961), met spesies *C. khalfini*, *C. bimembris*, en *C. grandis*, almal van die Perm Kuznetsk Kom in suidelike europese Rusland. By Bulwer, KwaZulu-Natal, in die Beaufort, is twee insek-vlerke wat tot hierdie genus behoort gekry. 'n Nuwe spesies, *Callietheira granthami* is vir hulle in 1999 geskep. Die verskil tussen die twee Suid-Afrikaanse eksemplare, beide voorvlerke, is min. Hulle is apart gevind, en behoort nie aan dieselfde individu nie. Die drie Russiese spesies is elkeen op een voorvlerk, en die een Suid-Afrikaanse spesies op twee voorvlerke, gebaseer. 'n Ontleding wys dat *C. granthami* van die ander verskil tot ongeveer dieselfde mate as wat hulle onder mekaar verskil. Hierdie waarneming ondersteun die oprigting van meer as een spesies vir die Russiese *Callietheira*. (Daar moet in gedagte gehou word dat die vlerke van 'n Mecoptera spesies geslagsverskille mag toon).

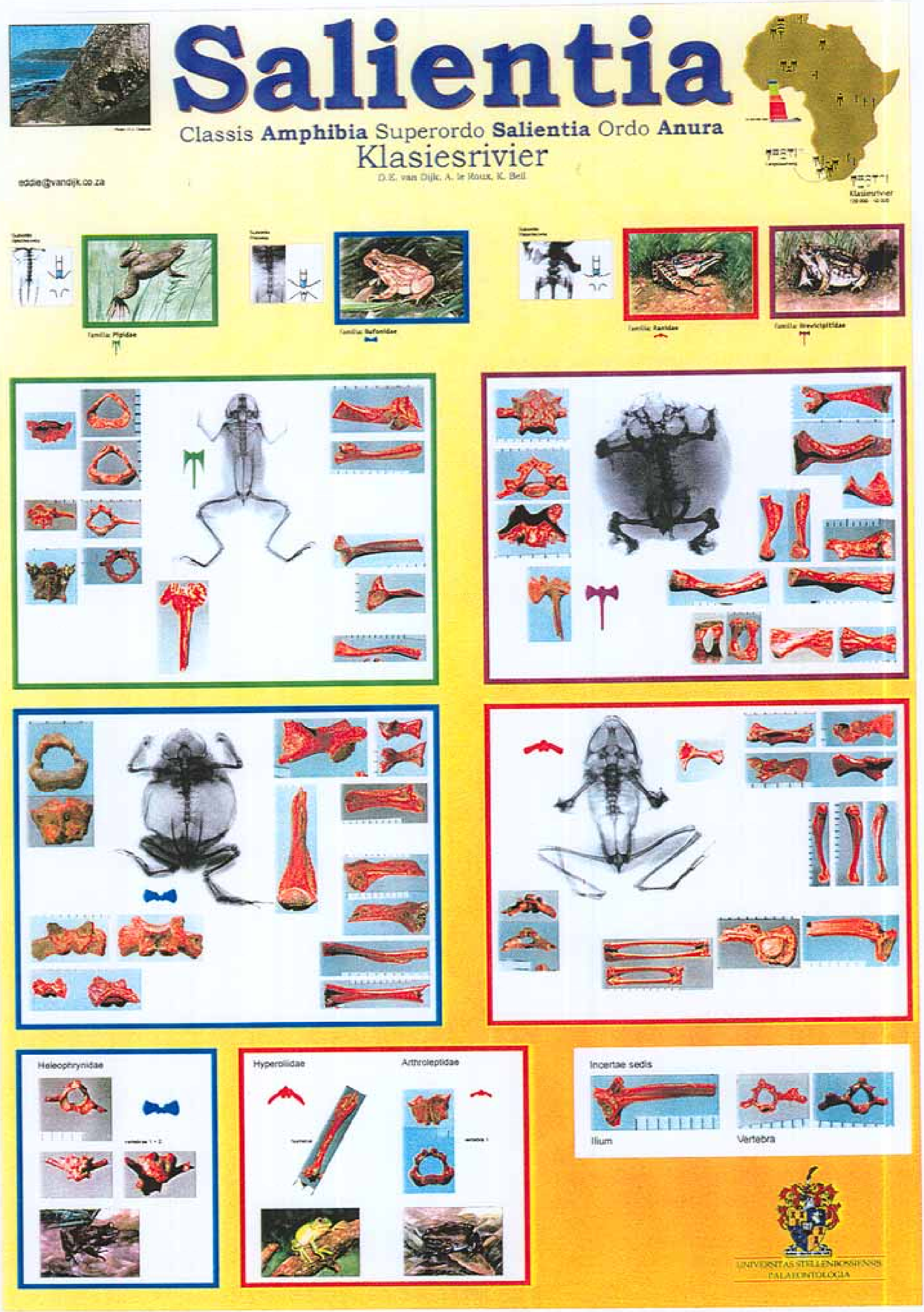
Die Mecoptera genera, *Petromantis* Handlirsch 1904, en *Asiachorista* Martynova 1958, wat in die Kuznetsk Kom voorkom (Martynova in Rohdendorf, op.cit.), kom ook in Brasilië voor (Pinto, 1972). Pinto het van oorkomste tussen Russiese- en Brasiliaanse fossiele tot die slotsom gekom dat suidelike Rusland en Brasilië naby mekaar moes gelê het. Dat Brasilië en Wes-Afrika na aan mekaar was, word algemeen aanvaar. Die Kuznetsk Kom en die Karoo by Bulwer is beide in Perm steenkoolvormende gebiede, al was die Kuznetsk Kom verder van die ewenaar af. Dit is moontlik dat ooreenkomste tussen die palaeoflora en -fauna van suidelike Rusland en suider Afrika ook in verband staan met soortgelyke klimate noord en suid van die ewenaar.

Verwysings:

Pinto, I.D. 1972. Permian Insects from the Parana Basin, South Brazil *I. Mecoptera.* Revista Brasileira de Geociências **2:** 105-116 (Pls II-III).

Rohdendorf, B.B.; Becker-Migdisova, E.Eh.; O.M. Martynova & Sharov, A.G. 1961. Paleozojskie nasekomye kuznetskogo bassejna. Trudy palaeontologicheskogo instituta akademii nauk SSSR **85:** 705pp. 40Tb.

Van Dijk, D.E. & Geertsema, H. 1999. Permian Insects from the Beaufort Group of Natal, South Africa. Annals Natal Museum **40:** 137-171.



Salientia
Classis Amphibia Superordo Salientia Ordo Anura
Klasiesrivier
D.E. van Dijk, A. le Roux, K. Bell
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Klasiesrivier
Familia: Pipidae
Familia: Bufonidae
Familia: Ranidae
Familia: Brevicipitidae
Heleophrynidae
Hyperoliidae
Arthroleptidae
Incertae sedis
Ilium
Vertebra
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Poster 11th Conference of the Palaeontological Society of Southern Africa 2000

Fossil Anura from the Klasies River Mouth Hominid Site, Tsitsikama, South Africa

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Department of Zoology, University of Stellenbosch

A report that frog bones were seen during sifting operations at the hominid site at Klasies River Mouth, led to the collection, at the Archaeology Department of the University of Stellenbosch, being examined by one of us (EvD). Within two hours four families of frogs were found to be present: Pipidae; Bufonidae; Ranidae; Brevicipitidae. Further extraction and recording of frog material was done with A. le Roux concentrating on the Opisthocoela and Procoela and K. Bell on the Diplasiocoela.

The Klasies River anuran material comes from caves dating from about 120 000 to 60 000 years BP. The source is probably almost exclusively owl pellets, and consists almost entirely of isolated bones, although instances were the astragalus and calcaneum were still attached to one another, and one of a more or less complete acetablular region of a pelvis, were observed. The present anuran fauna of the area includes the genera *Xenopus* (Opisthocoela: Pipidae); *Heleophryne* (Procoela: Heleophrynidae); *Bufo* (Procoela: Bufonidae); *Afrana* and *Strongylopus*(Diplasiocoela: Ranidae); *Breviceps* (Diplasiocoela: Brevicipitidae); *Hyperolius* and *Semnodactylus* (Diplasiocoela: Hyperoliidae). As a result of need for comparative skeletal extant material having been experienced when anuran material from Langebaanweg was investigated, comparative material was available for all of these genera, and most other Southern- and East-African Anura, if not as skeletal preparations, then as X-rays. Bones from Klasies River could be allocated to the genera *Xenopus*; *Bufo*; *Strongylopus* and *Breviceps*. In addition there were a number of ilia which could not be allocated to any genus, but which were similar to ilia from Langebaanweg. Some ranioid bones, especially a humerus, were suggestive of a hyperoliid, most probably *Semnodactylus*. In addition there was a fused atlas and second vertebra which differed from the same fused bones in *Breviceps* by wide separation of the cotyles for attachment to the occipital condyles of the skull, and so must be considered to belong to *Heleophryne*, a genus not previously found fossil. An atlas vertebra which is ranoid in there being a gap in the neural arch such as seen in *Afrana* and *Strongylopus*, has widely spaced cotyles, unlike those of ranids such as these two genera, and the bone must be considered to belong most probably to *Arthroleptis* (Arthroleptidae), of which the species *A. wahlbergi* is known from the Pondoland coastal region.

If the bones at Klasies River all come from owl pellets, it is not surprising that the bones of the reed-frog *Hyperolius* should be uncommon, for owls would not be expected to hunt in a noisy reed-bed. The capture of aquatic frogs of the genus *Xenopus* in fair numbers is unexpected. The absence of bones which could be assigned to the riparian genus *Afrana* may be atttributable to a tendency towards diurnal activity, but some *Afrana* bones may be present among the those merely diagnosed as ranid, because confusion with bones of *Strongylopus grayii* was possible.

Abstract of Paper 11th Conference of the Palaeontological Society of Southern Africa
September 2000, Presented by Dr J.A. van den Heever

PERMIAN TRACE FOSSILS ATTRIBUTED TO TETRAPODS (TIERBERG FORMATION, SOUTH AFRICA)

by

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ABSTRACT

The Ecca Group of the Karoo Supergroup has yielded few tetrapod species, represented by few specimens, in contrast to the younger Beaufort Group. Neither Ecca nor Beaufort has yielded many vertebrate fossils, and only one taxon has been recognized in the Ecca. The Ecca traces have not been accepted by all who have examined them as undisputably vertebrate. The groups of traces found cannot be attributed to fore- and hind-feet, and trackway sequences have not been described. Only two photographs have been published, one in Abel's "Vorzeitliche Lebenspuren", a classic work illustrating traces of past life, and one in a review of Salientia (frog) phylogeny. Other illustrations are in theses, one geological, one on Southern African trace fossils. New finds are presented and the literature reviewed.

KEYWORDS: ***Vertebrate trace fossils; ichnology; Ecca; Broomichnium***

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FOOTPRINTS BY THE MOIRé TECHNIQUE FOR CONTOURS AND A WAY OF CONSTRUCTING A GRID

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Fossil footprints are often recorded as photographs or as replicas in fibreglass or plaster-of-paris. Replicas are, in some cases, difficult to make where they occur on dipping strata or if they are present as natural casts under a rock overhang. In addition replicas, unlike photographs, are not easily reproducible in a form that can be widely distributed (such as for publication). Photographs, if taken with judiciously chosen lighting, can give some idea of depth and in paired stereo combination often produce the best result. Stereo-photographs also present their own difficulties, such as restriction to approximately twice the interocular distance unless special apparatus is used for viewing. Moreover, stereo-photographs do not present an accurate image of contours which lack features, as is commonly the case with the deeper parts of a footprint. Where a footprint, or a replica, can be horizontally positioned, contours can be recorded by progressive submergence in an opaque fluid - such as a suspension of Magnesium Carbonate. A succession of photographs is then taken from which a contour reconstruction can be traced to produce a single unit.

A technique for recording footprints using Moiré topography has been described by Ishigaki and Fujisaki (1989) which has the advantages of producing a single image that directly reveals details of even subtle contours, and of being suitable for computer analysis. The technique depends on lighting the object obliquely through a finely spaced one-direction grid and photographing it through the same grid from an angle opposite to the incident light. A point source of light, or light from a distance source (such as sunlight) can be used.

The technique described by Ishigaki and Fujisaki appears to present only one problem – the construction of a suitable grid. They show a parallel grid mounted on a frame with 1mm holes spaced 1mm apart on two sides of a supporting frame. The wire or nylon material of the grid is threaded through the holes. Technically this is quite difficult to produce.

We show a simple method of producing regularly spaced grid lines by using two 16mm diameter mild steel threaded bolts (with a thread spacing of 1mm) mounted parallel to each other in a four-sided metal frame. The bolt thread produces a regular 1mm spacing for the grid lines. Dark coloured 1mm diameter fishing line (c.35kg breaking strain) is then wound progressively from one bolt to the next producing a double set of parallel lines – in this way two grids are produced - one above, and the other below the bolts. The fishing line is then firmly glued onto the bolts using acrylic roof paint and "membrane" as a support. Once set, the lower grid is cut away and the nylon thread is sprayed with matt-black paint . When not in use the securing lock-nuts supporting the threaded bolts can be loosened and then rotated to release the tension in the grid.

The configuration of the frame and size of the parallel grid can be modified to suite the size of the fossil and degree of detail required of the moiré contours.

Reference

Ishigaki, S. and Fujisaki, T. 1989. Three Dimensional Representation of *Eubrontes* by the Method of Moiré Topography. **In:** *Dinosaur Tracks and Traces.* Gillette, D.D. & Lockley, M.G. eds. pp. 421-425. Cambridge, Cambridge University Press, xvii 454pp.

C

Articles Accepted or Submitted

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Jurassic Bipeds That Could Hop? Perch? Pounce? Fly??

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Description of the ichnogenus *Molapopentapodiscus* Ellenberger 1970 includes the presumption that progression was by bounding with feet together. That this genus, and other genera based on footprints or trackways, were hoppers, has been disputed. Material from KwaZulu-Natal, South Africa, suggests that more than one Lower Jurassic biped was a hopper, but with feet adapted also to other functions.

The Ranoid Burrowing African Anurans *Breviceps* and *Hemisus*

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To facilitate classification of isolated fossil bones, one genus of each of ten anuran African families was chosen, and criteria were sought (with two or more character states) which could be used to indicate the presence of a genus or group of genera, and the family or families it or they represent. Some of these criteria were used to compare the burrowing genera *Breviceps* and *Hemisus*. The two genera are found to have more differences than similarities. It is concluded that these two genera must represent early divergent lines from ranoid stock. It is suggested that the Brevicipitinae should be accorded family status similar to that accorded the Hemisotidae.

Key words: Anura, Ranoidea, *Hemisus*, *Breviceps*, osteology, burrowing.

D

Publications Authored or Co-Authored

during M.Sc. Research

Palaeont. afr., **34**, 43-48 (1997)

INSECT FAUNAS OF SOUTH AFRICA FROM THE UPPER PERMIAN AND THE PERMIAN/TRIASSIC BOUNDARY

by

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ABSTRACT

Those sites in South Africa where more than one insect fossil specimen has been found have been interpreted as younger than Middle Triassic or as Late Permian. One site which has yielded a number of specimens and is apparently near the Permian/Triassic boundary is a quarry in the town of Bulwer KwaZulu-Natal. There are six sites with more than one insect specimen which are stratigraphically lower than Bulwer, namely Escourt (a new site), Far End, Mooi River (National Road), Mount West, Balgowan and Lidgetton. According to the 1984 1:1 000 000 Geological Map of Southern Africa Bulwer is situated in the Tarkastad Subgroup of the Beaufort Group near its lower boundary; the Tarkastad has been considered as Triassic. The remaining sites, except Balgowan and Lidgetton, fall in the Estcourt Formation of the Beaufort Group, as do all the sites with single Late Permian specimens except for one similarly aged specimen from the more easterly Emakwezeni Formation. The stratigraphically lowest sites are Lidgetton and slightly younger Balgowan; both are mapped as Volksrust Formation of the Ecca Group. An analysis is made of vertical distribution of taxa, with those of Lidgetton and Balgowan grouped together as a lower unit, of Bulwer as upper unit, and of the Estcourt Formation sites and Emakwezini site as a middle unit. No obvious break between the three units has been noted.

KEYWORDS: Insects, Upper Permian; Permian/Triassic Boundary; Estcourt Formation; Volksrust Formation; Tarkastad Subgroup.

INTRODUCTION

Thirty years ago there were only two described African (Zaïre and Zimbabwe) fossil insect specimens and another two South African specimens awaiting study. Since then the number of specimens of insects of Palaeozoic and possibly Lower Triassic age in Africa has grown to hundreds, most of which have come from an area about 90km from north to south and 50km from west to east in Kwazulu-Natal (Figure 1). This area includes the sites of all but one of the Upper Permian and possibly Lower Triassic specimens (the exception being from Emakwezini, further east) and all the Palaeozoic sites which have so far yielded more than one specimen. Most of the specimens from this area are in the Natal Museum, with a few, including some types, in the collections of the Bernard Price Institute for Palaeontological Research (BPI), University of the Witwatersrand, Johannesburg. These two collections include all the described material. A photographic record of types, and other important specimens, including undescribed taxa, is being compiled. Sufficient information is available to permit an analysis of the stratigraphic distribution of taxa.

MATERIALS AND METHODS

All the material in the Natal Museum has been studied and many types and other important specimens were photographed either previously, or recently. The types from the Bernard Price Institute were photographed in September 1996. Two insect fossils from a new site in Estcourt are represented by photographs supplied by Mr. D. Green. A small number of specimens has been discovered recently during a further splitting of material collected several years ago. Of these, one significant specimen which has not yet been accessioned has been included in the analysis of distributions. Photographs which included a millimetre scale and were enlarged similarly, greatly aided comparisons of specimens within a site and between sites. Specimens in which the radial vein appeared negative, i.e. as a trough instead of a ridge, were often also photographed with posterior lighting, which reversed the relief. By scanning photographs into a computer manipulations such as adjustments in size and reversals of wings to a standard apex-right view were made simple.

The specimens were grouped as members of three units, corresponding to divisions on the 1984 1:1000 000 Geological Map of Southern Africa: an upper unit for Bulwer specimens (Tarkastad Subgroup of the Beaufort Group), a lower unit for specimens from Lidgetton and Balgowan (Volkrust Formation of the Ecca Group), and middle unit for all the other Palaeozoic Kwazulu-Natal sites (Estcourt or Emakwezini Formations). It should be noted that Triassic fossils occur quite low in the Tarkastad Subgroup.

For the stratigraphic distribution of the insect groups, reference was made to Riek (1970) and Kukalová-Peck (1991). The sequence of insect groups in the latter was followed. The stratigraphic range of the Trichoptera is shown in the Triassic in Kukalová-Peck (1991), but in the Permian in Riek (1970), who unlike Kukalová, includes the stem-

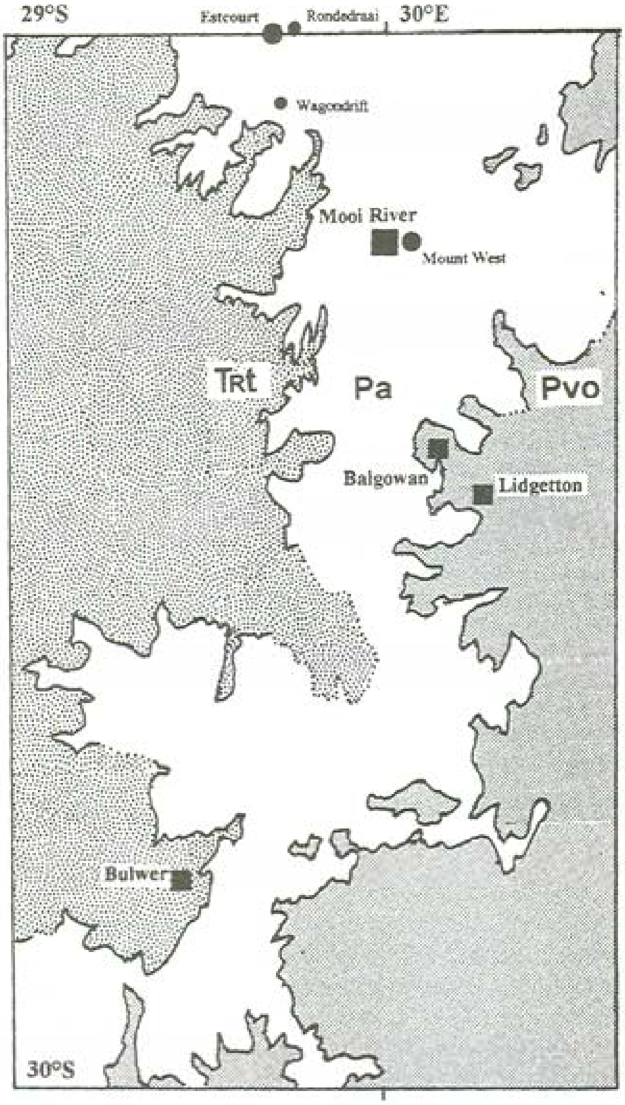

Figure 1. Map showing the study area, and the three units, the lowest being in the East, the highest in the West. TRt = Tarkastad Subgroup of the Beaufort Group; Pa = Estcourt Formation of the Beaufort Group; Pvo = Volksrust Formation of the Ecca Group. Boundaries are represented by dotted lines when they are obscured by dolerite intrusions.

group Amphiesmenoptera (Permian to Triassic) in the Trichoptera. The stratigraphic units form the upper two-thirds of the Carboniferous to the lower two-thirds of the Cretaceous were rescaled to a million years per millimetre, to represent the geological periods in proportion (Figure 2). The lengths of the three units under study have been arbitrarily made the same length, and together shown as considerably more of the Permian than they really represent. Species are represented as narrow lines, monospecific genera as broad lines.

RESULTS

The orders Paraplecoptera; Plecoptera; Orthoptera; Protelytroptera; Hemiptera; Mecoptera; and Neuroptera are apparently represented by the same taxon (genera and sometimes species) in more than one of the units (Table 1). In the case of Orthoptera, the taxon *Eolocustopsis* Riek 1976, is represented by a wing in one unit (middle one – Mooi River) and by specimens which include a thorax with wingbase only, at the other (lower – Lidgetton) unit. Protelytroptera, represented by *Phyllelytron acuminatum* Riek 1976, and Neuroptera, represented by *Archeosmylus*, have been found only in the upper two units.

The stratigraphic occurrence of the Protelytroptera shown in Riek (1970) ends in the Permian, but they are shown as extending into the early Cretaceous in Kukalová-Peck (1991). The remaining four orders each have one genus which possibly extends from the lower to the upper unit. They are: Paraplecoptera, *Mioloptera* Riek 1973 (Figure 3); Plecoptera, *Euxenoperla* Riek 1973; Hemiptera, *Beauforticus* Riek 1976 – in lower and upper units only (Figure 4, note caption); and Mecoptera, *Prochoristella* Riek 1953 (Figure 5), the first record of the genus in South Africa being the species *P. hartmani* Riek 1976.

The taxa reported as shared between the lower and middle units, are the following. Paraplecoptera: *Mioloptoides* Riek 1976; Hemiptera: an undescribed stenovicid (see Van Dijk 1978: p.57, figures 70, 71); *Orthoscytina* Tillyard 1926, with some doubt about the specimen from the lower unit; *Aleuronympha* Riek 1974; and two species of a new permaleurid nymph (Riek 1974 figure 74). The new taxa reported as shared between the middle and upper units are the following. Paraplecoptera: *Miolopterina* Riek 1976

TABLE 1.

Stratigraphic distribution of Taxa known from more than one level, the three levels being represented by the sites listed.

<table>
<tr><td>Lidgetton
Balgowan</td><td>Mooi River
Far End Wagondrift
Mt. West Rondedraai
Estcourt Emakwezini</td><td>Bulwer</td></tr>
<tr><td colspan="3">Paraplecoptera: Mioloptera</td></tr>
<tr><td colspan="3">Plecoptera: Euxenoperla</td></tr>
<tr><td colspan="3">Hemiptera: Beaufortiscus</td></tr>
<tr><td colspan="3">Mecoptera: Prochoristella</td></tr>
<tr><td colspan="2">Paraplecoptera: Mioloptoides</td><td></td></tr>
<tr><td colspan="2">Hemiptera: Stenovicid</td><td></td></tr>
<tr><td colspan="2">Hemiptera: Orthoscytina</td><td></td></tr>
<tr><td colspan="2">Hemiptera: Aleuronympha</td><td></td></tr>
<tr><td colspan="2">Hemiptera: Permaleurid</td><td></td></tr>
<tr><td></td><td colspan="2">Paraplecoptera: Miolopterina</td></tr>
<tr><td></td><td colspan="2">Paraplecoptera: Liomopteroides</td></tr>
<tr><td></td><td colspan="2">Protelytroptera: Phyllelytron</td></tr>
<tr><td></td><td colspan="2">Hemiptera: Austroprosboloides</td></tr>
<tr><td></td><td colspan="2">Hemiptera: Dysmorphoscartella</td></tr>
<tr><td></td><td colspan="2">Neuroptera: Archeosmylus</td></tr>
</table>

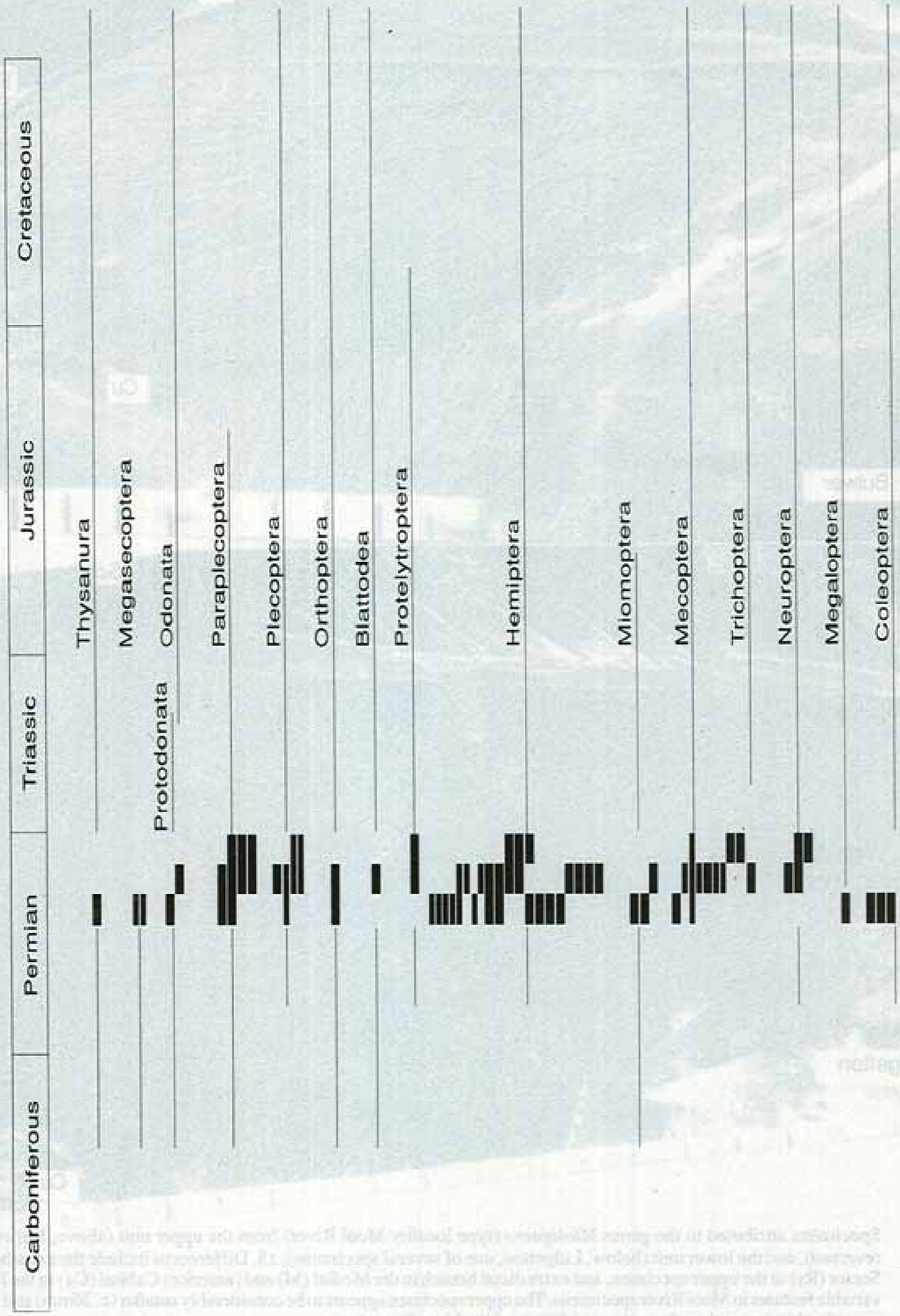

Figure 2. Fossil insect taxa reported from Kwazulu-Natal, South Africa, and the stratigraphic ranges of the groups after Kukalová-Peck (1991). (0.81 mm = 1 million years)

and *Liomopteroides* Riek 1973 (synonym *Liompterina*, according to Riek 1976); Protelytroptera: *Phyllelytron* Kukalová 1966; Hemiptera: *Austroprosboloides* Riek 1973 and *Dysmorphoscartella* Riek 1973; Neuroptera: *Archeosmylus*.

Overall 30 recognisable genera are found in only one of the three units, 13 are found in two units, and three in all three units.

DISCUSSION AND CONCLUSIONS

There is no obvious discontinuity either between the lowest and middle unit or between the middle and

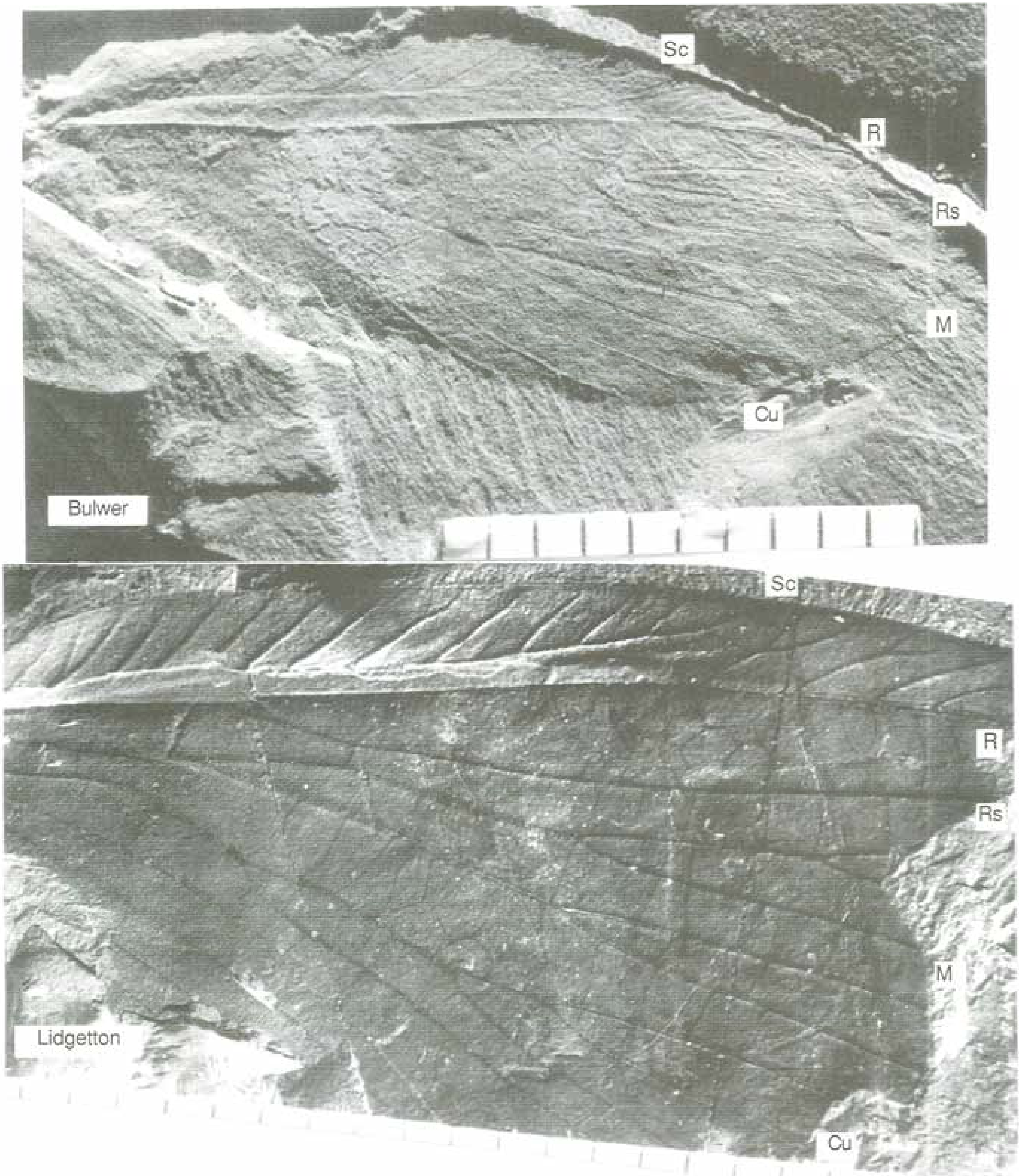

Figure 3. Specimens attributed to the genus *Mioloptera* (type locality Mooi River) from the upper unit (above, Bulwer; only specimen; reversed), and the lower unit (below, Lidgetton, one of several specimens); x8. Differences include the extra branch of the Radial Sector (Rs) in the upper specimen, and extra distal branch in the Medial (M) and (anterior) Cubital (Cu) in the lower specimen, all variable features in Mooi River specimens. The upper specimen appears to be considerably smaller (c. 20mm) and the lower specimen considerably larger than the estimated 26mm of the Mooi River type.

highest unit. The flora, rather poorly represented in the lower unit (Lidgetton and Balgowan), is similar in the three units. Anderson & Anderson (1985) treat all the sites as Permian. Bulwer is shown as in the Estcourt Formation in their Map 2.8 (Anderson & Anderson 1985 p.34). The map is based on Map 1 of Anderson (1977), derived from a palynological study. Among the assemblages selected for the study by Anderson & Anderson there were none in the *Lystrosaurus* Assemblage Zone and two in the *Dicynodon* Assemblage Zone (which corresponds to the Estcourt Formation). Carbonaceous material does occur at Bulwer, and has been sampled by A.J. Tankard, but no palynological results of a study of this material are known which might provide information indicating a Permian or Triassic age of

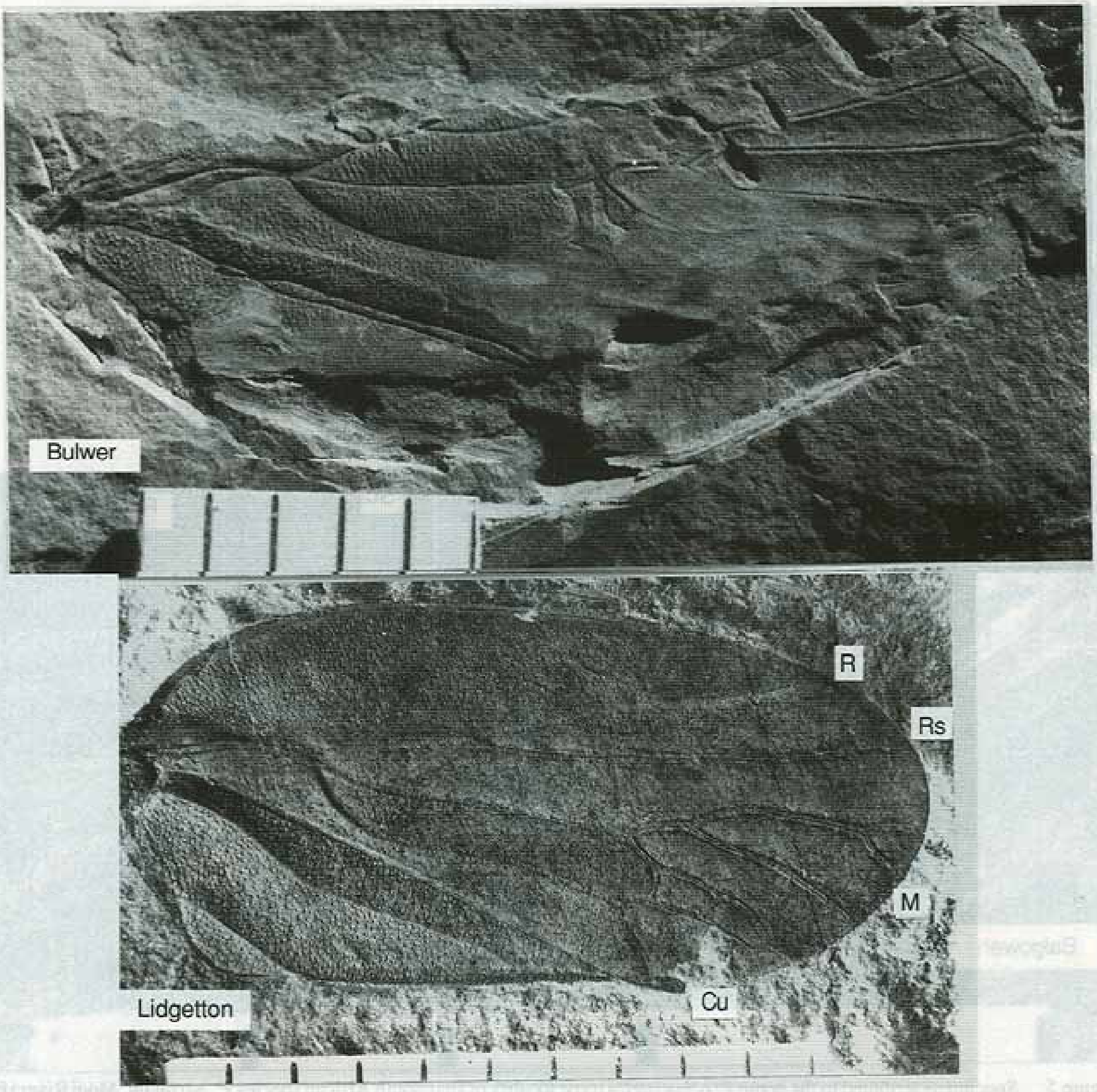

Figure 4. Specimen attributed to the genus *Beaufortiscus* (above, Bulwer, only specimen; reversed) and the type specimen of the genus from Lidgetton (below); x 8,8. The upper specimen shows a number of differences from the type. These include the lesser curvature of the Medial and Cubital veins at their common origin with the Radial, the more proximal branching of the Medial, and straighter marginal branches. These are at least specific differences, and may be generic ones.

the site. The inclusion of the Bulwer area in the Tarkastad Subgroup during mapping was presumably based on local lithology independent of biostratigraphic relationship to the Estcourt Formation. There are three chrono-stratigraphic alternatives for the Bulwer site, namely Permian, at the Permian/Triassic boundary, or Triassic. The transition from *Glossopteris*-dominated to *Dicroidium*-dominated floras seems to have occurred during the Early or Middle Triassic, a period for which the fossil record of the floras and the associated insect faunas in South Africa is poor. As with the flora, the insect fauna of the Bulwer site shows affinities with the older sites.

Further work at the Mooi River site is not feasible, as the site is covered by a broad highway, the N3 National Road. A test excavation made during the road-making into the road cutting yielded plants of inferior quality and no insects. A quarry just above the road cutting, on the farm Far End, yielded a small number of insects. The productive layers are probably exhausted. Some material from Far End was collected and stored, and has yet to be studied. The Balgowan site is a small road cutting which probably could be further studied. Some Lidgetton material is being studied at present. Further study of the Bulwer site has been planned. In the town of Bulwer, this site is a disused quarry with great potential for further continued study provided steps are taken to stop the invasion of the site by wattle trees. As this is the productive site closest to the Permian/Triassic boundary, intensive study may be well rewarded.

ACKNOWLEDGEMENTS

The information in the catalogue of the Natal Museum used is largely dependent on the researches of Dr Edgar Riek, who is accordingly warmly acknowledged. Any errors in the present work must be attributed to me. Mrs Bianca Lawrence is acknowledged for

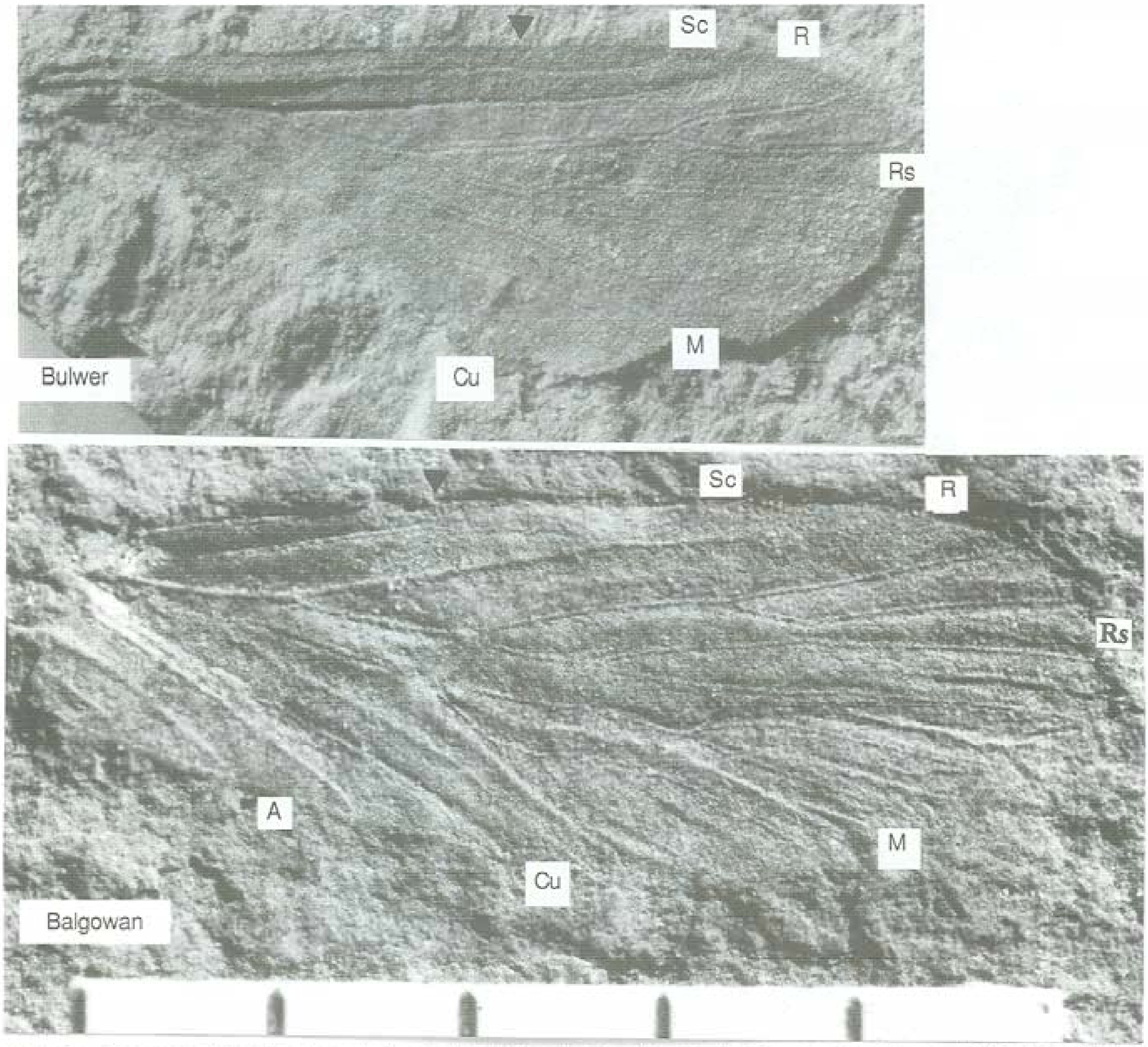

Figure 5. Specimens atributed to the genus *Prochoristella* (type locality of first South African species, *P. hartmani*, Mooi River) from the upper unit (above, Bulwer, only specimen) and the lower unit (below, Balgowan, only specimen; reversed); x27. Note that the upper specimen has the opposite (uncorrected) relief to the lower specimen. Note also that the lower specimen has folds (mainly raised) between some of the veins. In the upper specimen the Radial is parallel to the front edge of the wing for some distance, unlike the Radial of the lower specimen. The Subcosta (Sc) of the upper specimen has a branch and a kink well beyond the level of the first forking of the Radial Sector, whereas the branching and kink in the Subcosta of the lower specimen is proximal to this fork. These differences at about the specific level. The upper specimen is smaller than the lower one.

making it possible for me to work on the Natal Museum material at a distance, not only by loan of specimens, but also by painstakingly matching photographs with specimens. Dr Mike Raath is acknowledged for making it possible for me to photograph the BPI types during the September 1996 Palaeontological Society Symposium. Dr Henk Geertsema is acknowledged for making valuable comments on the original manuscript and on a final version with minor changes, which version also benefited from scrutiny by Dr Juri van den Heever.

REFERENCES

ANDERSON, J. 1977. The biostratigraphy of the Permian and Triassic. Part 3. A review of Gondwana Permian palynology with particular reference to the northern Karoo Basin, South Africa. *Mem. Bot. Surv. S. Afr.*, **41**, 1-65.

-------- & ANDERSON, H.M. 1985. *Palaeoflora of Southern Africa Prodromus of South African Megafloras Devonian to Lower Cretaceous*. Rotterdam, A. A. Balkema (for Botanical Research Institute). 423pp.

KUKALOVÁ, J. 1966. Protelytroptera from the Upper Permian of Australia, with a discussion of the Protocoleoptera and Paracoleoptera. *Psyche Camb.*, **73**, 89-111.

KUKALOVÁ-PECK, J. 1991. Fossil History and the Evolution of Hexapod Structures, Chapter 6 pp. 141-179 **In:** Naumann, I.D. Ed. *The Insects of Australia* 2nd Edition. Volume 1 Carlton. Melbourne University Press.

RIEK, E.F. 1953. Fossil Mecopteroid Insects From the Upper Permian of New South Wales. *Rec. Austr. Mus.*, **23**, 54-87 pls. 5-6.

-------- 1970. Fossil History, Chapter 8 pp. 168-186 **In:** Mackerras, I.M. Ed. *The Insects of Australia* Carlton. Melbourne University Press.

-------- 1973. Fossil insects from the Upper Permian of Natal, South Africa. *Ann. Natal Mus.*, **21**, 513-532.

-------- 1974. An unusual immature insect from the Upper Permian of Natal. *Ann. Natal Mus.*, **22**, 271-274.

-------- 1976. New Upper Permian insects from Natal, South Africa. *Ann. Natal Mus.*, **22**, 755-789.

VAN DIJK, D.E. 1978. A Study of the Type Locality of *Lidgettonia africana* Thomas 1958. *Palaeont. afr.*, **24**, 43-61.