Palaeontological Impact Assessment for the proposed SKA Antennas, Access and Powerlines
Williston Spiral, Northern Cape Province

Site Visit Report

For

Digby Wells Environmental

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Expertise of Specialist

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Qualifications: PhD (Wits Univ, 1990); FRSSAf, ASSAf

Experience: 30 years research; 22 years PIA studies

Declaration of Independence

This report has been compiled by Professor Marion Bamford, with the assistance of Alisoun House and Rick Tolchard, of the University of the Witwatersrand, sub-contracted by Digby Wells Environmental, Johannesburg, South Africa. The views expressed in this report are entirely those of the author and no other interest was displayed during the decision making process for the Project.

Specialist: Prof Marion Bamford

Signature: 

Executive Summary

To comply with the South African Heritage Resources Agency (SAHRA) in terms of Section 38(8) of the National Heritage Resources Act, 1999 (Act No. 25 of 1999) (NHRA), a site visit Palaeontological Impact Assessment (PIA) was completed for the proposed construction of antennae, power and data lines and access roads for SKA antennas southwest of Williston.

The Langbaken Road was thoroughly assessed and no fossils or potentially fossiliferous sediments were found. Permission for access to the selected highly sensitive (palaeontologically) land parcels (farms) along the Langbaken Road had not been obtained for all farms but once approached by us we gained access to four farms. Fossil plants have been seen by the landowners on three farms but we were only able to verify one record. Based on the records and our assessment of the sediments we conclude that fossils occur in the area but they are extremely rare and have a patchy distribution. Only surface surveys were done and no excavations made. There is a small chance that fossils could be affected. Ideally, a palaeontologist should be present when the roads and foundations are excavated BUT alternatively the environmental officer or responsible person can follow the Chance Find Protocol and monitor the excavations on the listed land parcels at the sites for the antennae.

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1. Background

The South African Radio Astronomy Observatory (SARAO) Square Kilometre Array (SKA) Project ("the Project") is located in the Northern Cape Province of South Africa, some 900 km, 650 km and 90 km from Johannesburg, Cape Town and Carnarvon respectively. The Project comprises two primary components, namely the 'core' (36 land parcels) and three 'spirals' (73 land parcels) covering an approximate areal extent of 211 000 hectares (ha). This land makes provision for the SKA Radio Telescope site, KAT-7 radio telescope, MeerKAT and HERA instruments.

In support of obtaining environmental exclusion in terms of Section 24(2)(e) for the Project, the Department of Environmental Affairs (DEA) commissioned the Council for Scientific and Industrial Research (CSIR) to complete a Strategic Environmental Assessment (SEA) (CSIR, 2016) in accordance with the principles of the National Environmental Management Act, 1998 (Act No. 107 of 1998) (NEMA). The SEA is interpreted as Phase 1, the first step in the development of management principles into environmental decision making processes.

The Phase 1 study area was investigated by various specialists through desktop geographic information system (GIS) analysis and site visits from November 2015 to May 2016. The SEA included a strategic level assessment of the heritage resources within the area under consideration to determine potential impacts (Almond, 2016; Bluff, et al., 2016). The results of this assessment included the identification of 105 heritage resources. These were categorised according to the recommended grading as outlined in Section 7 of the National Heritage Resources Act, 1999 (Act No. 25 of 1999) (NHRA), as well the heritage resource type as defined by Sections 27, 28, 31, 34, 35, 36 and 37. This, however, was not exhaustive.

I. Phase 2 Palaeontological Impact Assessments

John Almond completed an assessment (Almond, 2016) that covered the core area and two of the three spiral arms, namely the northwestern arm or Brandvlei arm and the northeastern arm or between Van Wyksvlei and Carnarvon. He conducted a short site visit and recommended that much of the region was potentially fossiliferous but no sites in particular were targeted. The third spiral arm, the southwestern or Williston area was not covered as extensively in the first report and because the area is considered to be highly sensitive (SAHRIS palaeosensitivity map) it was visited again and described here.

This report comprises the site visit for Williston spiral arm and Palaeontological Impact Assessment carried out on 25-28 March 2018.

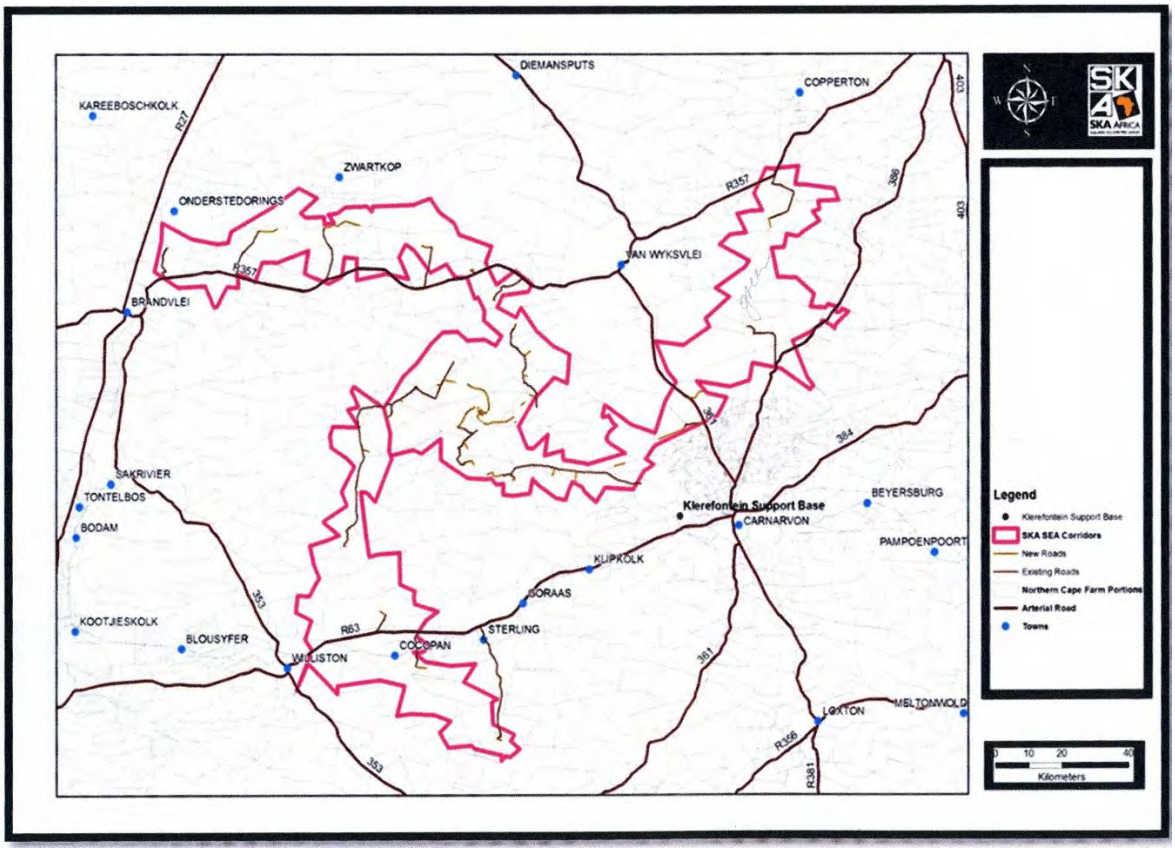

Figure 1: Map of the SKA1_MID area and three spiral arms

The southern or Williston spiral arm is the focus of this study. See Figure 4 for the Williston area

2. Terms of Reference and Methodology Statement

Based on the outcomes of the screening assessment, and based on the brief, the paleo ToR were:

The palaeontological surveys must pay particular attention to the Lower Beaufort lithological Group (Abrahamskraal Formation). Furthermore, the PIA was a requirement to comply with the Integrated Environmental Management Plan, Section 38 of the National Heritage Resources Act and the SAHRA Minimum Standards.

I. Terms of Reference

The methods employed to address the ToR included:

1. Consultation of geological maps, literature, palaeontological databases, published and unpublished records to determine the likelihood of fossils occurring in the affected

areas. Sources included records housed at the Evolutionary Studies Institute at the University of the Witwatersrand and SAHRA databases;

2. Where selected, site visits by the qualified palaeontologist were carried out in order to locate any fossils and assess their importance;
3. Where appropriate, collection of unique or rare fossils with the necessary permits for storage and curation at an appropriate facility; and
4. Determination of fossils representivity or scientific importance to decide if the fossils can be destroyed or a representative sample collected, or if further collections from the sites are necessary.

II. Selection of Sites that need to be visited

The project involves the construction of 133 antennas in the three spiral arms with associated access roads, power lines and fibre lines. Based on the outcomes of the previous assessment, the comments issued by SAHRA on 10 March 2017, the project brief (SKA PEP 6 001/2017), and the review of the PSM, the southern spiral arm was targeted for the in-field assessment. Only the land parcels in the southern part of the Williston spiral are considered here.

The site-specific study area that is underlain by geology with a high to very-high sensitivity as per the SAHRIS palaeosensitivity map were targeted for in-field verification survey. Access to these land parcels is along the Langbaken Road that runs in a southeasterly direction from the town of Williston. Proposed power and fibre lines, as well as proposed road upgrades within this route were also considered. The site-specific study area underlain by moderately sensitive geology within the targeted area were considered where possible (Table 1).

Table 1: List of Farms and Owners in the Palaeosensitive Area

SKA Sector	Farm name	Owner	Palaeosensitivity
South east arm	Weltevrede	(WFO trust) Willie Olivier	Very high and moderate
	Korfsplaas	Jean van Schalkwyk	Very high and moderate
	Uitkomst	WT van Schalkwyk	very high
	Klipdrift	Michael Hoorn	Very high and moderate
	Die Tuin/Son Tuin	R van Schalkwyk	Very high
	Die Tuin	Louwsdrift Trust	Very high
	Palmietfontein (Dampiesfontein)	JF van Wyk	Very high
	Langbaken	Langbaken Trust	Moderate
	Vlokswerven	Vlokswerve Trust	Very high and moderate
	Rooikop	JN Louw	Very high

3. Geology and Palaeontology

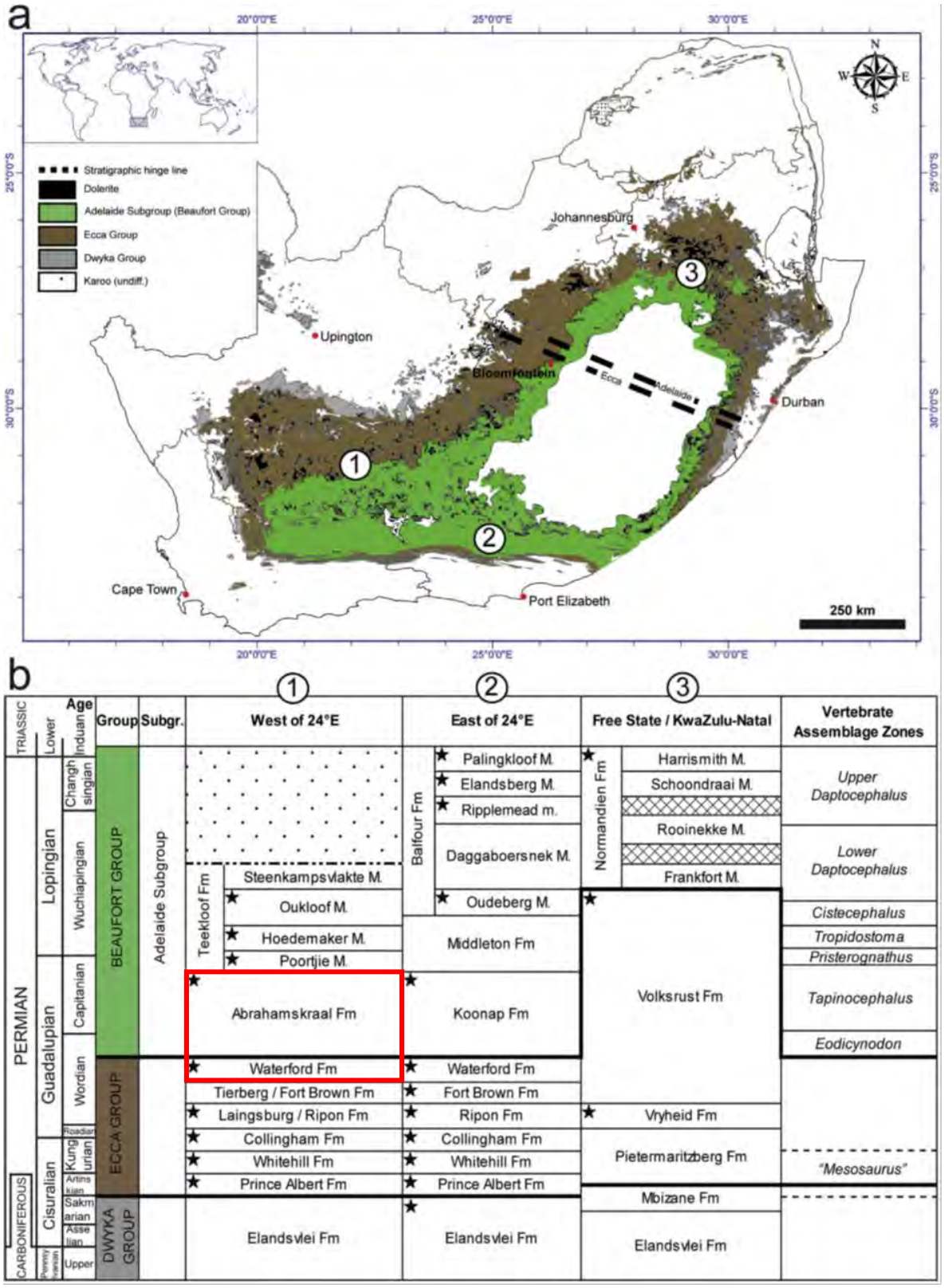

Figure 2: General Karoo Geology

a - Simplified biostratigraphy of the Karoo Basin. b – Lithostratigraphy in columns 1-3; biostratigraphy in the Vertebrate Assemblabe Zone

The red outline in Figure 2 shows the formations in the Williston/southern spiral arm as described in Barbolini et al., (2018) and based on a number of other works referenced therein. Dates are being refined as research continues by palaeontologists.

I. Overview of Karoo Geology

The geological history of South Africa is very long and complex, extending from some of the oldest rocks in the world in the Barberton area to very young land forms. Most of the country, however, is covered with sediments of the Main Karoo Basin which range in age from about 300 million years old to 180 million years old (Fig 2a). The Karoo sediments were deposited in a large inland basin under different climate conditions (from retreating glaciers, to lakes and deltas, to braided stream and drying out and finally capping by the Drakensberg basalts from major volcanic eruptions). As a result these deposits have different compositions and structures, i.e. different lithologies (rock types). Moreover, many fossils have been preserved in this depositional setting and palaeontologists have used the time ranges of these fossils to construct a biostratigraphic framework. These two classification approaches, the lithology and the fossil occurrences, have been correlated but differ over the shallow northeast basin and the deeper southwest basin (Fig. 2a, b) so the subdivisions of the lithological units differ across the three broad geographical zones: west of 24°E, east of 24°E and Kwazulu Natal and Free State.

II. Project Location And Geological Context

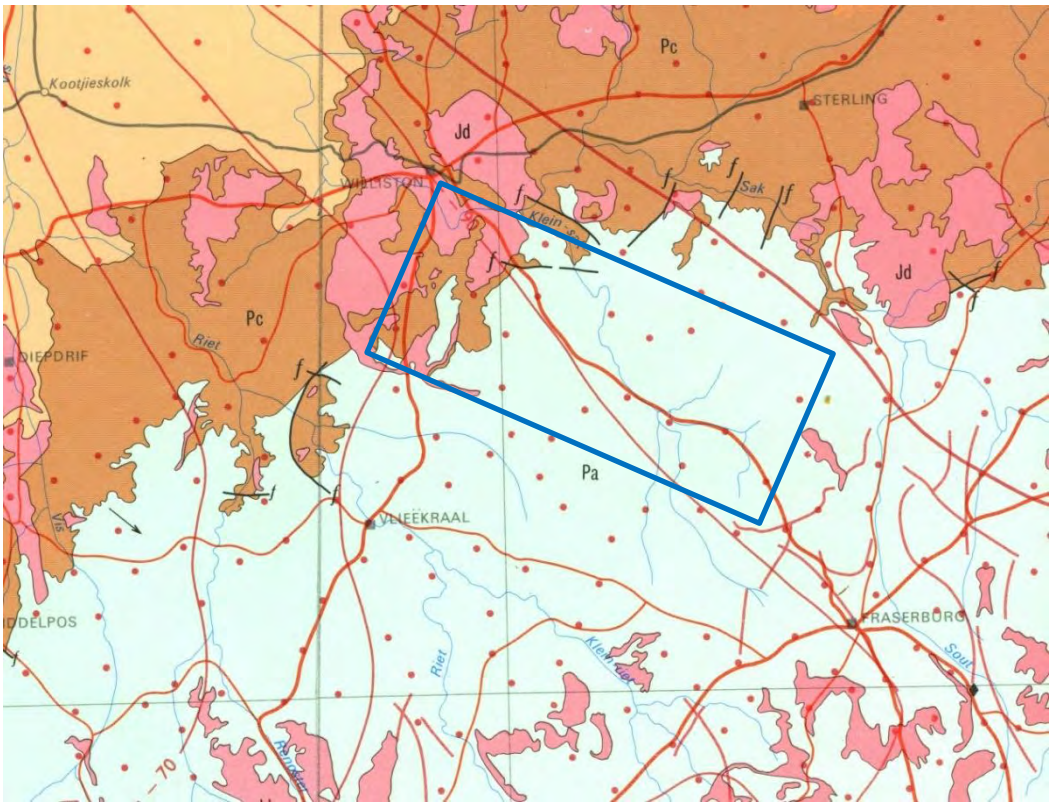

Figure 3: Geological map of the area around Williston and to the southeast

Study area in the blue rectangle. Abbreviations of the rock types are explained in Table 2. Map enlarged from the Geological Survey 1: 1 000 000 map 1984.

Table 2: Explanation of symbols for the geological map and approximate ages

Symbol	Group/Formation	Lithology	Approximate Age
Pv	Vryheid Fm	Shales, sandstone, coal	Lower Permian, Middle Ecca
C-Pd	Dwyka	Tillite, sandstone, mudstone, shale	Upper Carboniferous, Early Permian 295-290 Ma
Vlo	Loskop Fm, Middleburg Basin	Shale, sandstone, conglomerate, volcanic rocks	Ca 2000 – 1700 Ma
Vse	Selons River Fm, Rooiberg Group, Bushveld Magmatic Province	Red porphyritic rhyolite	Ca 2061 - 2052 Ma

Note Pc and Pt are now considered contemporaneous

SG = Supergroup; Fm = Formation.

(Barbolini et al., 2016; Johnson et al., 2006)
Since vegetation is low and sparse, even after good rains, exposure of the rocks is very good. The region has experienced below average rainfall for three years.

The rocks in the Williston region are predominantly of the older part of the Karoo Supergroup and lithologically are the shales and sandstones of the upper Ecca, namely the Whitehill, Tierberg, Waterberg and Prince Albert Formations. The Carnarvon Formation (Pc) is now called the Waterford Formation. This formation is dominant closer to Williston. Rocks of the Abrahamskraal Formation, farther to the south, underlie the sites at the outer edge of the Williston spiral. (Note that earlier works separated the Waterberg and Tierberg Formations temporally but new dates, summarised in Barbolini et al. (2016) have found them to be synchronous).

Most of the ridges are capped by dolorite that weathers to dark brown or black and is very fragmented, forming small and large boulders. (Or rather the more resistant dolerite does not weather as quickly as shales, sandstones, mudstones, etc., so forms ridges). Associated with Jurassic Drakensberg Basalt outpouring are extensive sills and dykes of dolerite that intruded the Karoo sediments. Quaternary sands and alluvium cover most of the areas but the Permian shale, mudstone or sandstone outcrops are easily visible at a distance as the vegetation cover is minimal.

Miocene or Plio-Pleistocene outcrops, associated pans and palaeo-rivers (de Wit, 1993; Almond and Pether, 2009; Almond, 2016) occur to the north of this section under study and were not seen.

III. Palaeontological Context

Potentially a variety of fossils could occur in this area since fossils have been recorded by Almond and Pether, 2009; Anderson and Anderson, 1985; Kitching, 1977; Rubidge et al., 1995; Smith, 1993), as listed in Table 3.

Table 3: Fossils expected to occur in the site-specific areas

Group	Examples of fossils	Formations
Fauna	dinocephalians, dicynodonts, gorgonopsians, therocephalians, cynodonts) and primitive reptiles (eg pareiasaurs),	Abrahamskraal Fm; Beaufort Group
Aquatic fauna	temnospondyl amphibians, palaeoniscoid fish, non-marine bivalves, phyllopod crustaceans	Ecca Group
Trace fossils	tetrapod trackways, burrows and coprolites. Trace fossils (arthropod trackways and burrows), “worm” burrows, fish fin trails	Ecca Group
Flora	petrified wood, rarer leaves of *Glossopteris*, horsetail stems, plant rootlet horizons, lycopods, ferns	Ecca Group

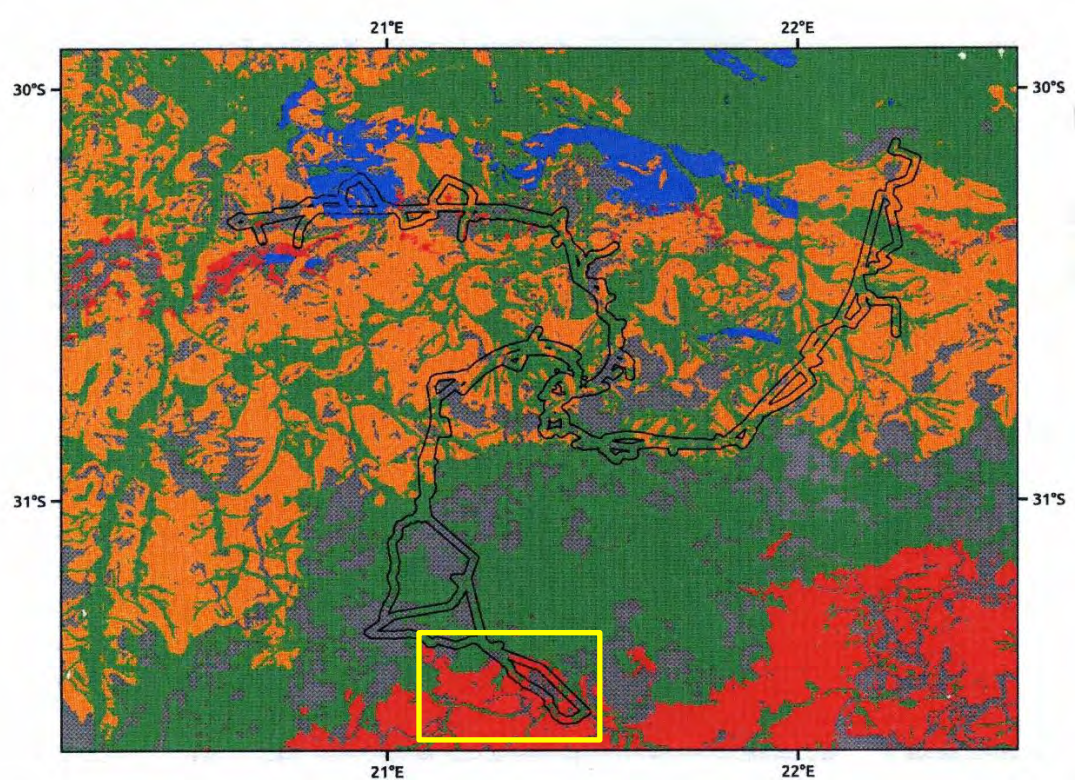

Figure 4: SAHRIS Palaeosensitivity Map for the Region

The study area is shown within the yellow rectangular outline. Colours indicate the following degrees of sensitivity: red = very highly sensitive; orange/yellow = high; green = moderate; blue = low; grey = insignificant/zero.

Although a variety of vertebrate fossils have been recorded from these formations in other parts of the Karoo basin, especially in the southern part of the Karoo, very few examples have been found here. In the Waterford Formation, which is a shallow sea to lake setting, one would expect to find impressions of fossil leaves and stems of lycopods (club mosses), sphenophytes (horsetails), ferns and possibly Glossopteris. Seldom do fossil plants and animals preserve in the same site. Sediments of this age do not have a large variety of vertebrates because they had not yet evolved (only some amphibians and fish). In the younger Abrahamskraal Formation, a more terrestrial and mud flat setting, one would expect to find the same plants or vertebrate fossils, such as dinocephalians, dicynodonts, gorgonopsians, therocephalians, cynodonts, and primitive reptiles such as pareiasaurs.

4. Description of the Scope of the Proposed Overall Activity and Results of Site Visit

Stops 1-18 are along the Langbaken Road; Stops 19-26 are on various land parcels as indicated. At each stop the GPS position was recorded, photographs of the landscape taken, soils and sediments examined and fossils looked for. If found they were photographed and identified. The information on fossils, lithology and geological features is recorded in Table 4 and the photographs have been collated into figures for each stop as listed below with the figures inserted after the table.

Table 4: Location Details of the Access route and Farms, Williston Spiral

Road access stop number	Farm name	Owner	Co-ordinates
Langbaken road from Williston southeast towards Fraserberg			
Stop 1	Walkraal Farm homestead	unknown	31° 19.565" S 21° 04.299" E
Site visit: along current access road. Landscape gently sloping with sheep paddocks, windmill, invasive shrub *Prosopis* sp. (mesquite) common; alluvium/soil overlying most of the area; topography - no rocky outcrops, almost flat with a covering of Kalahari sands. No fossils and no potentially fossiliferous mudstones or shales.			Figure 5
Stop 2	Uitsig Farm	Cobus and Sanette van Wyk	31° 19.743" S 21° 05.122" E

Road access stop number	Farm name	Owner	Co-ordinates
Site visit: flat landscape with open vistas. Thick covering of alluvium. No shales or potentially fossiliferous sediments were observed			Figure 6
Stop 3	Vleiwerf	O.G. van Schalkwyk	31° 20.783" S 21° 06.133" E
Site visit: flat landscape with open fields; farm dam (dry and silted up, on east side of the road and colonised by *Prosopis* sp, Eucalyptus sp. (gum trees) and *Rhigozum* sp. shrubs. No shales or potentially fossiliferous sediments were observed.			Figure 7
Stop 4	Sandtuin/ Palmietfontein entrance	Hannes Schoeman and Willem Schoemann	31° 21.114" S 21° 09.997" E
Site visit: flat landscape with open mixed dwarf shrubs and thin grass cover. Shales are predominantly alluvium but minore outcrops of mudstones and shales. No inclusions of any kind in the shales along the Langbaken Road (but see stops 19 and 20).			Figure 8
Stop 5	Sandstone outcrop	n/a	31° 20.957" S 21° 14.060" E
Site visit: surrounding landscape slightly undulating with a prominent sandstone ridge on the west side of the road, about 5m high relative to the road. Large slabs of sandstone weathering out but no fossils present. Dolerite capping far to the west along this ridge.			Figure 9
Stop 6	Dwelling, no name, corbelled house	No name (later found out it is the Farm Langbaken	31° 20.470" S 21° 14.477" E
Site visit: slightly sloping landscape dry stream in east side of road with gum trees, windmills, *Prosopis* sp and dry spiny shrubs. No shales or potentially fossiliferous sediments were observed; alluvium.			No photos
Stop 7	Turn-off (L) to Albeidersfontein	n/a	31° 21.816" S 21° 15.047" E
Land slopes down to a river/stream. No shales or potentially fossiliferous sediments were observed			No photos
Stop 8	Rus en Vrede farm		31° 22.091" S 21° 15.343" E

Road access stop number	Farm name	Owner	Co-ordinates
Site visit: landscape flat and open, minimal vegetation cover, alluvium. No shales or potentially fossiliferous sediments were observed			Figure 10
Stop 9	Windhoek	J.F. van Wyk	31° 23.887" S 21° 17.650" E
Undulating landscape with minor ridges. Promising outcrops in the distance but no shales or potentially fossiliferous sediments were observed alongside the road			Figure 11
Stop 10	Dwelling no name		31° 24.863" S 21° 18.157" E
Abandoned homestead alongside road with invasive “boxing glove cactus” *Cylindopuntia fulgida mamillata* and *Prosopis* sp. No shales or potentially fossiliferous sediments were observed except in the distance.			Figure 12
Stop 11	Die Tuin Farm	N. van Schalkwyk	31° 26.250" S 21° 19.714" E
Site visit: slightly undulating landscape with alluvium and shallow shales exposed along the roadside, laminated but thin deposit. No fossils were found.			Figure 13
Stop 12	No name (poplars and cypress)		31° 29.746" S 21° 23.684" E
Site visit: Slightly undulating landscape with sandstone ridges in the distance. Farmstead has trees of *Cypress* sp. and *Populus deltoides*. No shales or potentially fossiliferous sediments were observed.			Figure 14
Stop 13	Klipdrift Farm		31° 29.906" S 21° 23.881" E
Site visit: open undulating landscape with dolerite ridge in the distance. Thick alluvium. No shales or potentially fossiliferous sediments were observed			Figure 15
Stop 14	Korfplaas Farm	J.A. Berger	31° 31.968" S 21° 25.473" E

Road access stop number	Farm name	Owner	Co-ordinates
Site visit: land more undulating with ridges than previous farms. Dam alongside the road fully silted up and colonised by *Prosopis* sp. and *Aristida* spp. No shales or potentially fossiliferous sediments were observed.			Figure 16
Stop 15	Palaeosols about 200m from road on Left	unknown	31° 33.918" S 21° 25.447" E
No shales or potentially fossiliferous sediments were observed and no permission for access onto the farm			No photo
Stop 16	Homestead with pines and prickly pears	unknown	31° 34.697" S 21° 25.784" E
Farmstead with *Pinus* sp. and *Opuntia robusta* on large ridge with a silted up dam in the shallow valley colonised by Prosopis sp. Deep alluvium. No shales or potentially fossiliferous sediments were observed			Figure 17
Stop 17	Voerstervlei Farm buildings both sides of road		31° 35.608" S 21° 25.968" E
Buildings on both sides of the road and groves of pine and gum trees. Deep alluvium. No shales or potentially fossiliferous sediments were observed			Figure 18
Stop 18	?Weltevrede Farm		31° 37.280" S 21° 26.436" E
Site visit: sandstone outcrop with thin veneer of dolerite. Farm house a long way from the main road. No shales or potentially fossiliferous sediments were observed			Figure 19
Land parcel visits			
Stop 19	Sandtuin Farm	Hannes Schoeman 053-391-4155 083-642-9679	31° 31.968” S see GPS 21° 25.473" E
Site visit: depression behind the watertank and sheep pen, about 8km from the farmhouse – scattered pieces of shale with impressions of *Calamites* and *Paracalamites* (Sphenophyta – horsetails). Source stratum not found.			Figure 20

Road access stop number	Farm name	Owner	Co-ordinates
Stop 20	Sandtuin Farm		31° 20.470" S see GPS 21° 14.477" E
Site visit: searched the northeast facing slope for fossil wood that had been reported from here but none was found. Only small nodules with an infill or hollow centre were seen. Pieces of black, fine-grained fossil wood were shown to us at the farmhouse. Also looked through the shales here but no fossils found			No photos
Stop 21	Palmietfontein Farm Rocky outcrop	Willem and Maggie Schoeman 053-391-4136 084-514-3226	31° 24.023" S 21° 10.796" E
Site visit: sandstone outcrop along the river where the Arbeidersfontein road crossed the river. Shallow laminated shale about 2m thick and overlain by dolerite capping. Nodules found but no evidence of fossil plants or bones.			Figure 21
Stop 22	Palmietfontein Farm stream gully	ditto	31° 24.080" S 21° 11.169" E
Shale outcrop in the streambed; horizontal bedding of well-cemented mudstone and siltstone; concretions but no fossils found in either the harder overlying layers or softer weathered layers below.			Figure 21
Stop 23	Dampiesfontein Farm along Arbeidersfontein Rd	ditto	31° 21.447" S 21° 15.150" E
Shale outcrop alongside the river, horizontal bedding of mudstone and siltstone; concretions but no fossils. Exposure about 100m long and 2m thick.			Figure 22
Stop 24	Dampiesfontein Farm prominent ridge of sandstone, dropstones	ditto	31° 20.219" S 21° 16.017" E

Road access stop number	Farm name	Owner	Co-ordinates
Site visit: valley has thick alluvium; prominent ridge has top 4-5 m thick of columnar weathered fins sandstone overlying a 1m thick mudstone layer with clear horizontal laminations. Underlying these is a 5m band of coarse sandstone with no bedding planes but contains a few huge (0.5 – 1.5m diameter) dropstones. Modern dassie hyraceum in the rocks. No fossils were found.			Figure 23
Stop 25	Dampiesfontein Farm rocky outcrop at northern margin of farm	ditto	31° 18.863" S 21° 16.088" E
Site visit: Dolerite ridge with sandstone below, onionskin weathering of rocks; coarse sandstone with no bedding planes or fossils			Figure 24
Stop 26	Williston municipal land for radio tower	n/a	no GPS
Small fragments of siltstone with impressions of *Glossopteris leaves* and sphenophyte stems, not in situ; buff colour. Fossil wood has been reported from here but not found by us.			Figure 25

All photographs taken by the author and assistants.

Figure 5: Stop 1 – Walkraal Farm on Langbaken Road

A - farm entrance and general landscape showing alluvium and no fossil potential

Figure 6: Stop 2 – Uitsig Farm on Langbaken Road

a – farm entrance and sign; b –flat topography; c – flat topography and sparse vegetation typical of the region after three years of below average rainfall; d – flat topography with a hill in the far distance

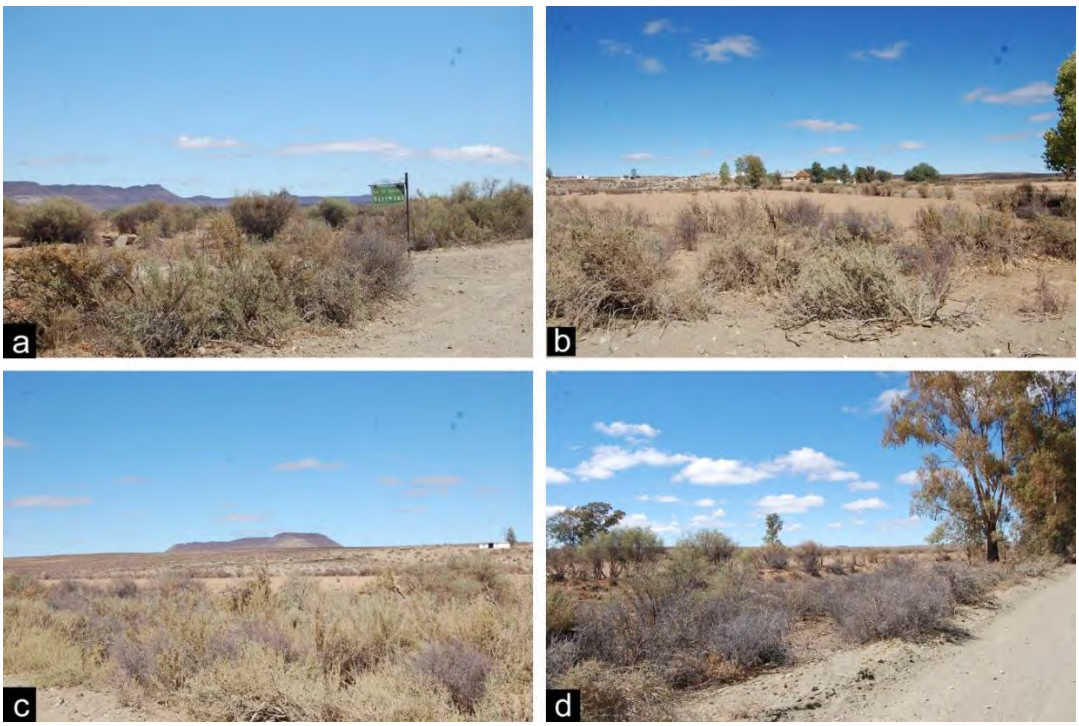

Figure 7: Stop 3 – Vleiwerf Farm

a – farm entrance; b – homestead in the distance; c – flat topography with a hill in the distance (same hill as in Figure 5d); d – silted up dam with mesquite (*Prosopis* spp.) and other shrubs, gums trees on the left.

Note presence of deep alluvium (Quaternary) and lack of any shales or rocky outcrops.

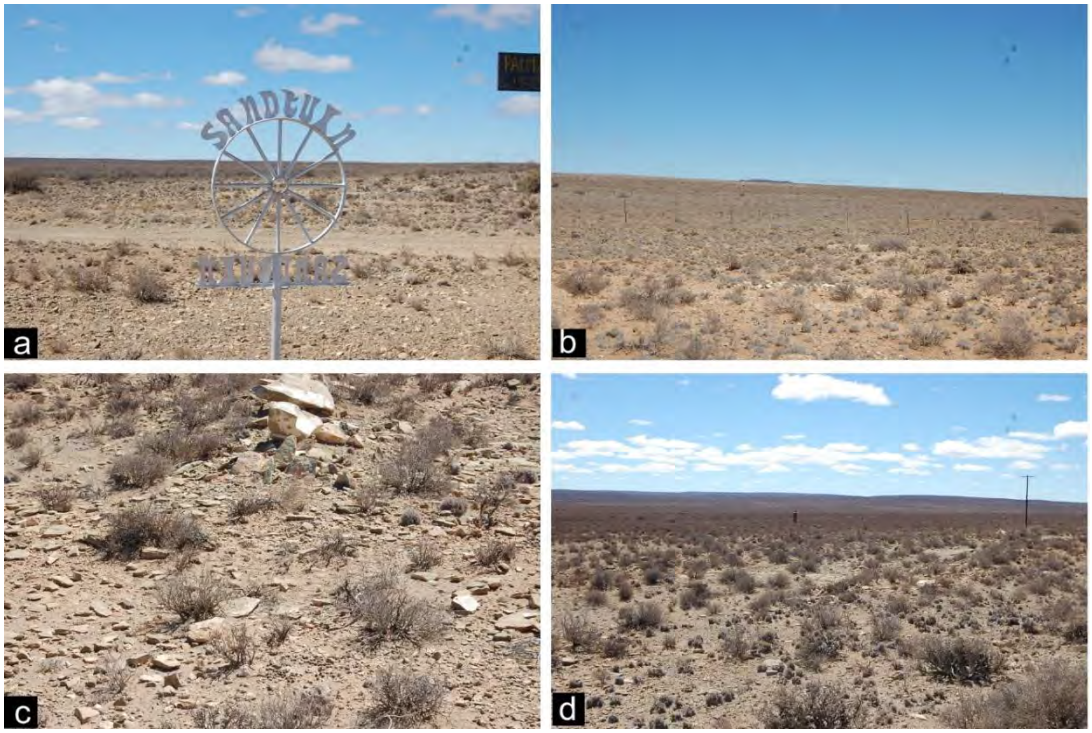

Figure 8: Stop 4 – entrance to Sandtuin and Palmietfontein Farms

a – farm sign and flat topography; b – flat topography and low, sparse vegetation; c – weathered shale on surface but no fossils present; d – flat topography with palaeontologist in the middle ground searching for fossils

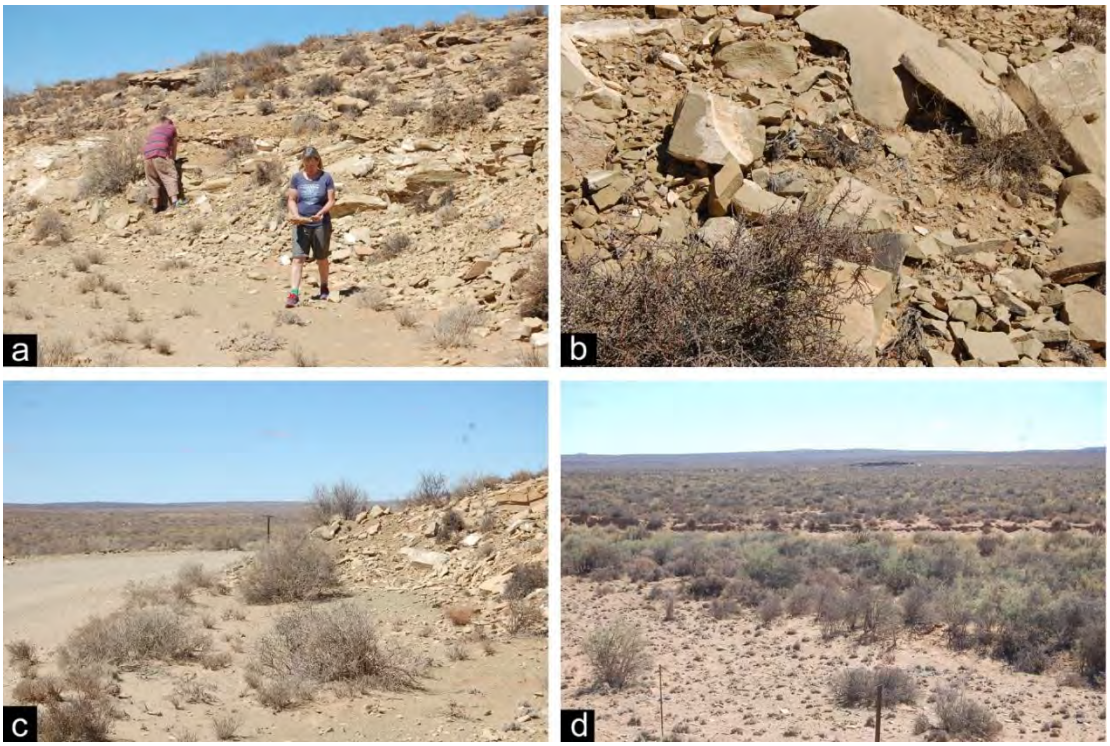

Figure 9: Stop 5 – sandstone outcrop along road,

a – outcrop with large slaps of mudstone breaking up; b – close up of mudstone slabs and lack of fossils; another view of the outcrop; d – view northeast from outcrop showing cutbank of dry stream (middle ground) in deep alluvium

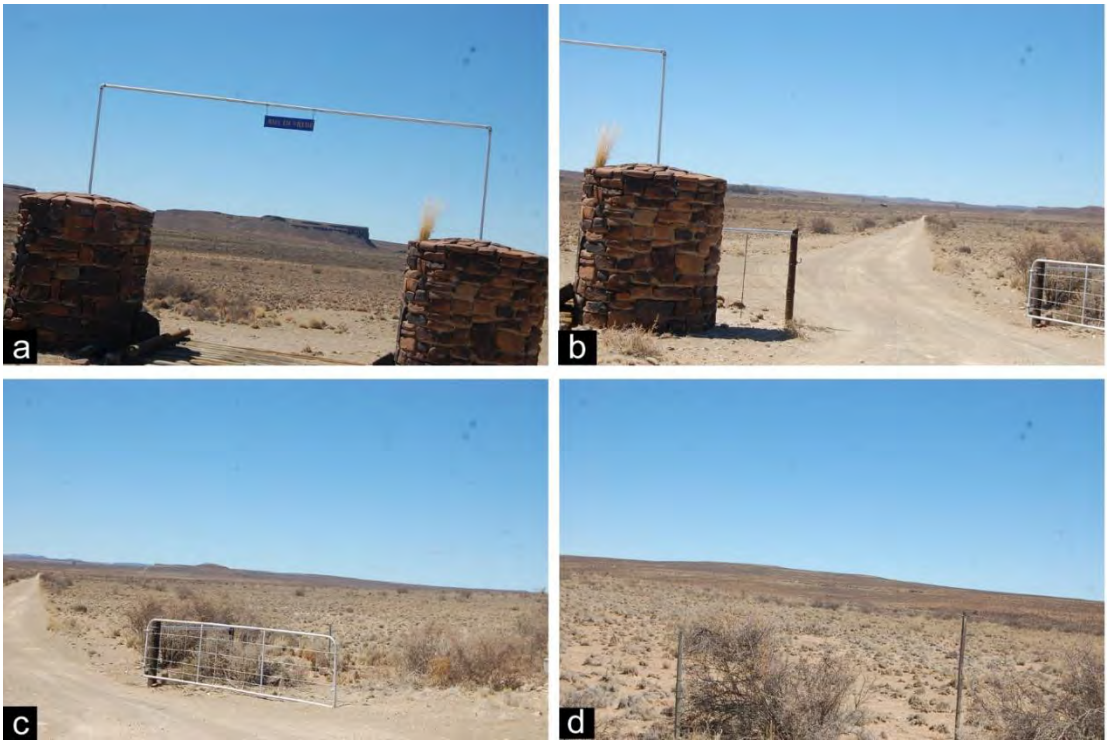

Figure 10: Stop 8 – Rus en Vrede Farm

a – entrance to farm; b – view to the north with slight undulating topography; c – view to the northeast; d – view to the south with the same vegetation and alluvium (no outcrops)

Figure 11: Stop 9 – Windhoek Farm

a - entrance with gum trees and wind pumps; b – alluvium with a scattering of mudstone; c – view to the west with a rocky outcrop in the distance; d – alluvium and shrubs on a slight rise

Figure 12: Stop 10 – abandoned homestead

a – farmstead with poplar trees and plantings of the invasive cactus *Cylindopuntia fulgide mamillata* (boxing glove cactus); b – view to the south with flat topography and bushes; c – farm dam made of sand and soil with mesquite tree; alluvium in the foreground and a rocky outcrop in the distance

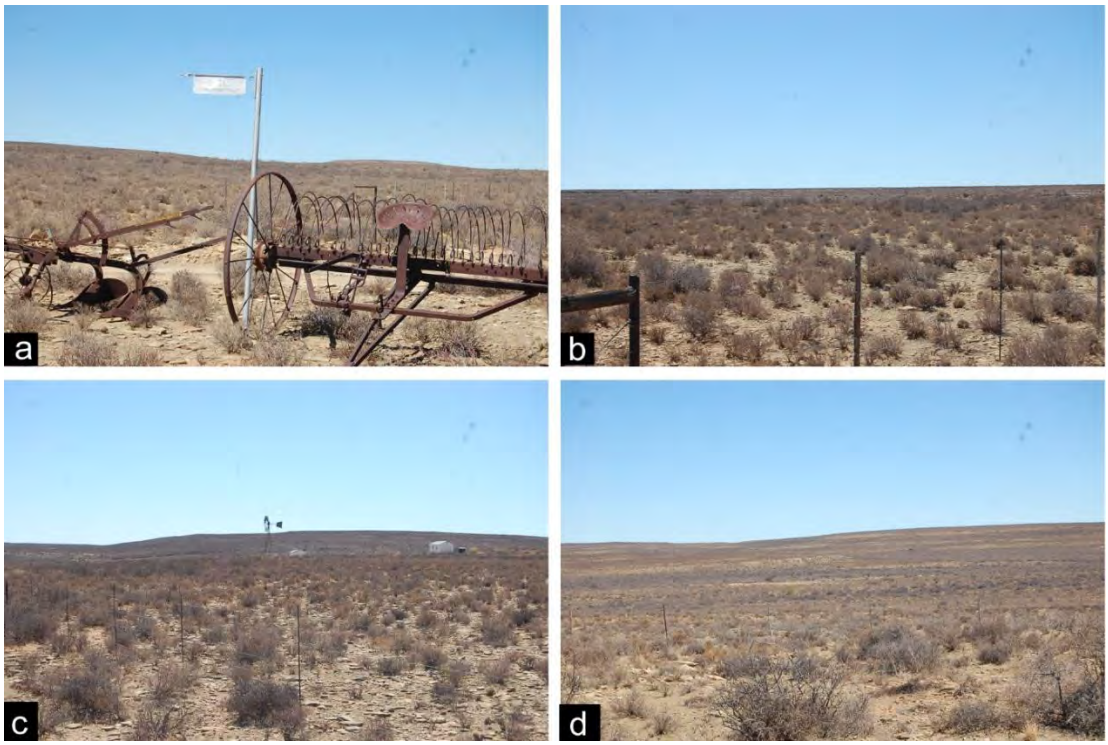

Figure 13: Stop 11 – Die Tuin Farm

a – entrance with old machinery; b – almost flat landscape with sandy soil and pebbles; c – buildings in the background and small slabs of mudstone in the foreground; d - view to the south

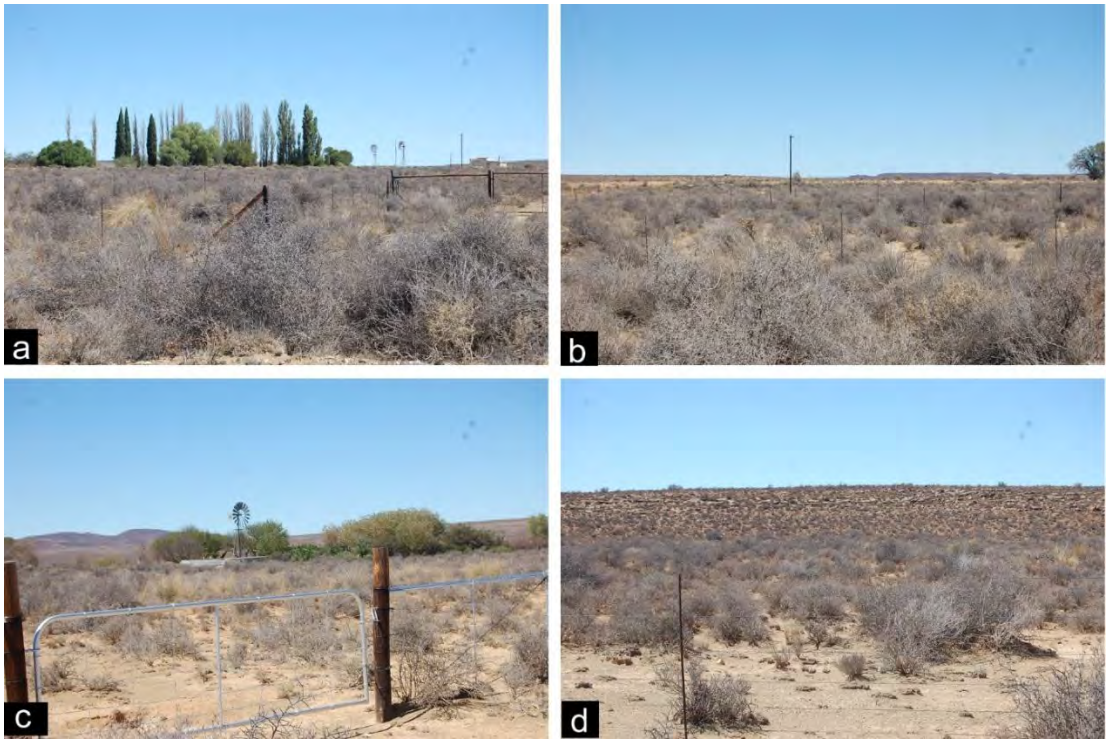

Figure 14: Stop 12 – unnamed farm

a – farmstead with poplars and cypress trees; b – almost flat landscape with small hill in the far distance; c – alluvium and water pump with reservoir; d – view to the south east with alluvium and minor shale or sandstone ridge in the background

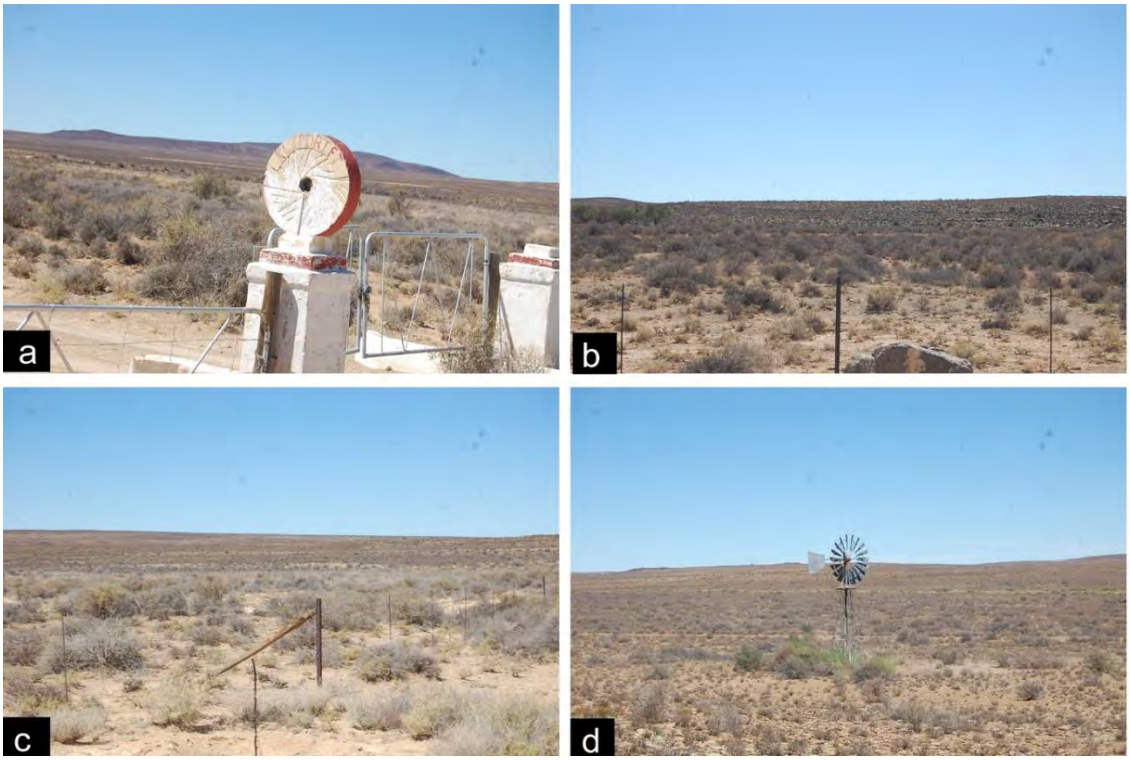

Figure 15: Stop 13 – Klipdrift Farm

a – farm entrance with hill in the background; b – view west; c – view of the almost flat topography and alluvium in the foreground; d – wind pump

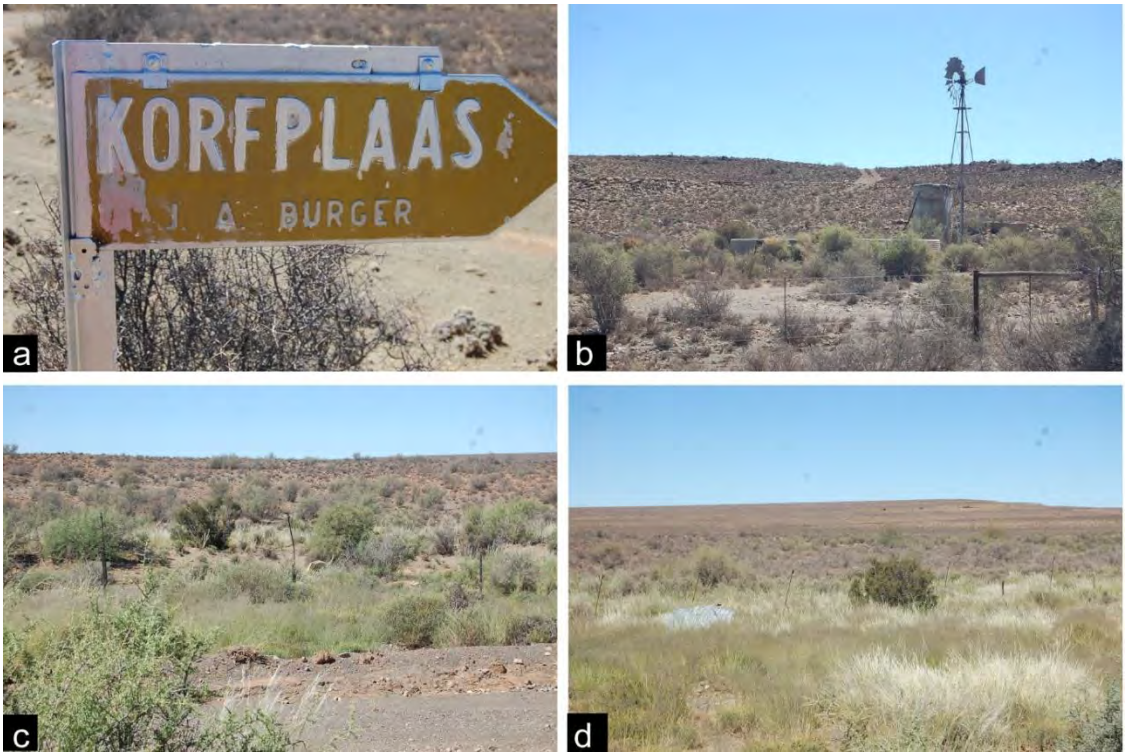

Figure 16: Stop 14 – Korfplaas

a – farm sign at the entrance; b – alluvium, wind pump and rocky ridge in the background; c – alluvium and shrubs on the slight rise; d – silted up dam filled with Mesquite shrubs and *Aristida* spp. Grasses

Figure 17: Stop 16 – unnamed farm with prickly pears (*Opuntia robusta*) and pine trees

a - left of entrance; b – right of entrance, seems abandoned; c – alluvium and planted invasives in the distance; d – alluvium and mesquite

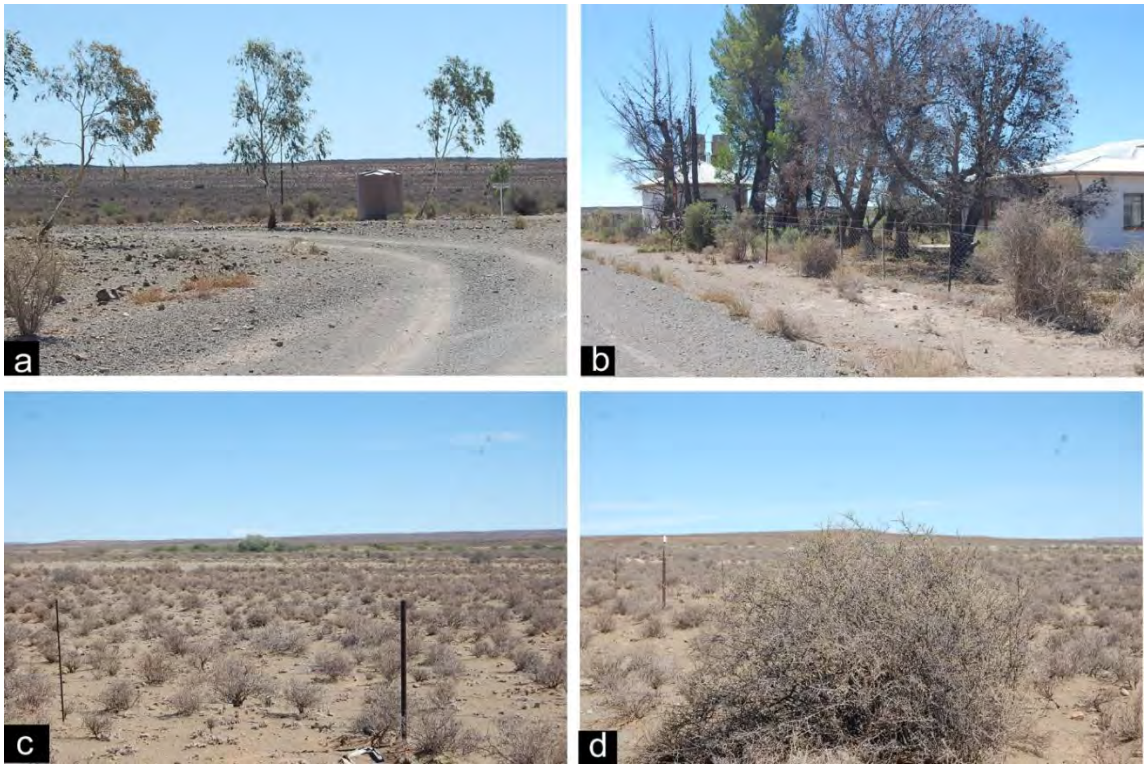

Figure 18: Stop 17 – Farm Voerstervlei

a – entrance with *Eucalyptus camaldulensis* (red river gum tree); b – pine trees and abandoned farmstead; c – alluvium and dry stream in the distance with mesquite; d – almost flat landscape

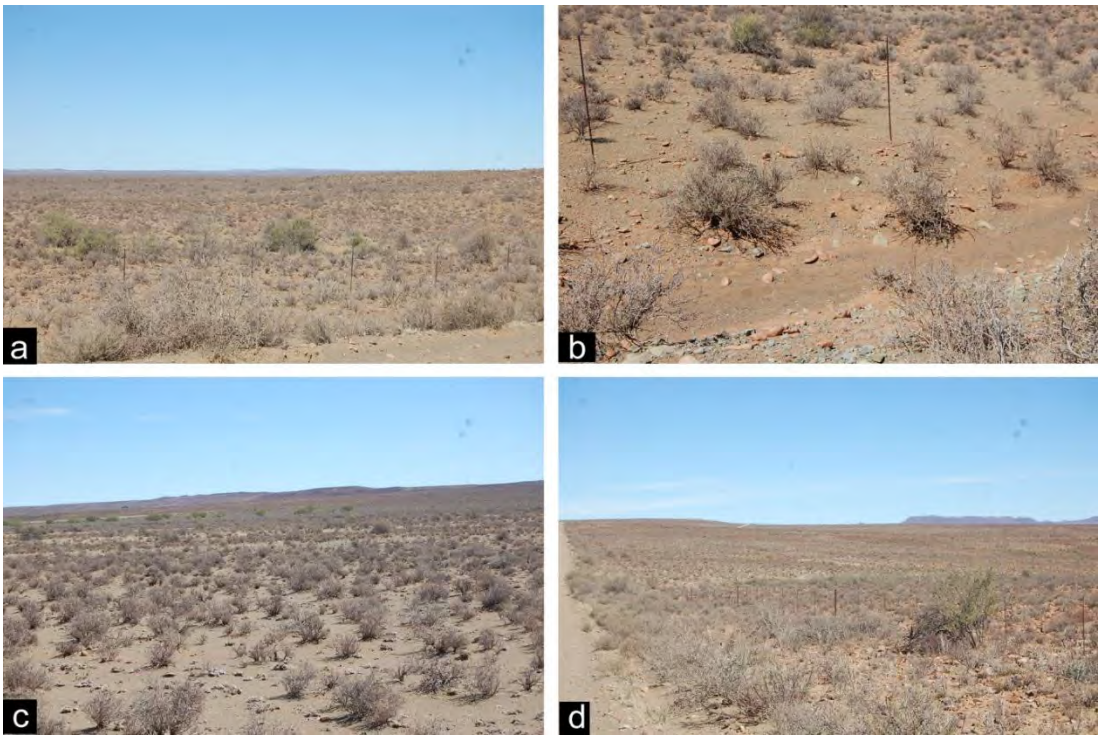

Figure 19: Stop 18 – Farm Weltevred

a – almost flat topography; b – dry stream showing mostly alluvium and a few small rocks; c – minor hill in the background; d – view to the north.

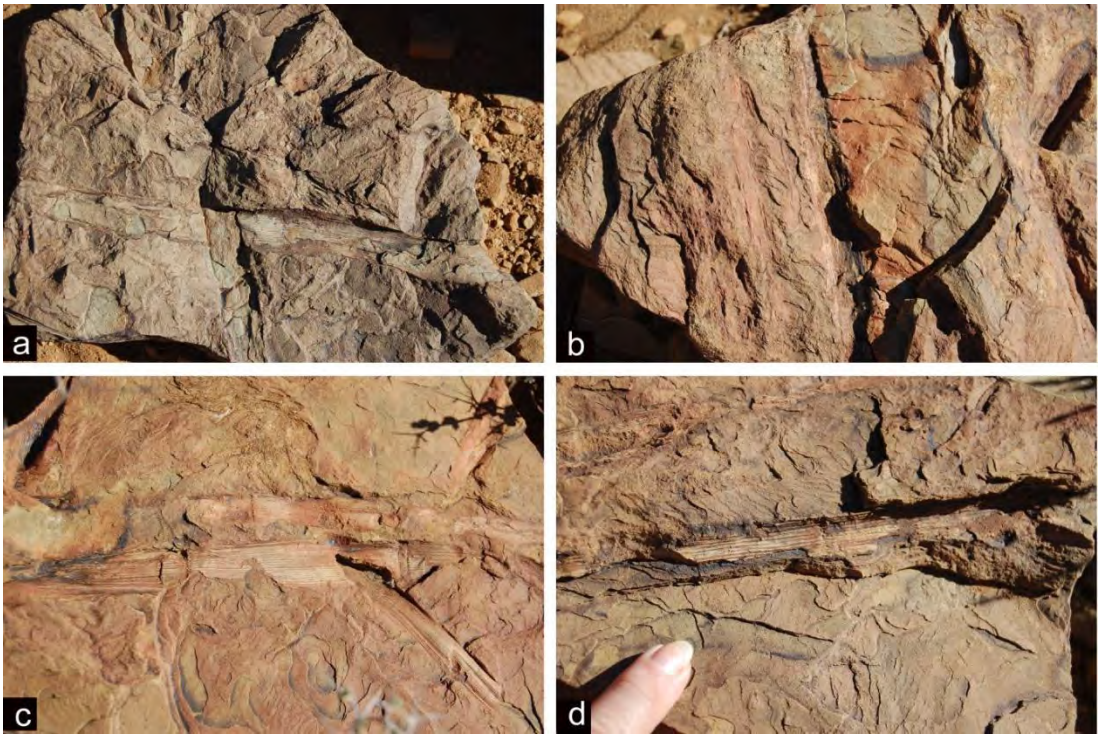

Figure 20: Stop 19 fossils on Farm Sandtuin

a – impressions of plant culms of *Calamites* sp.; b – several parallel culms *of Paracalamites*; c – *Calamites* stem (horizontal) with clear longitudinal striations and a node to the left and side branch to the right; stem diameter 15mm; d – another *Calamites* culm

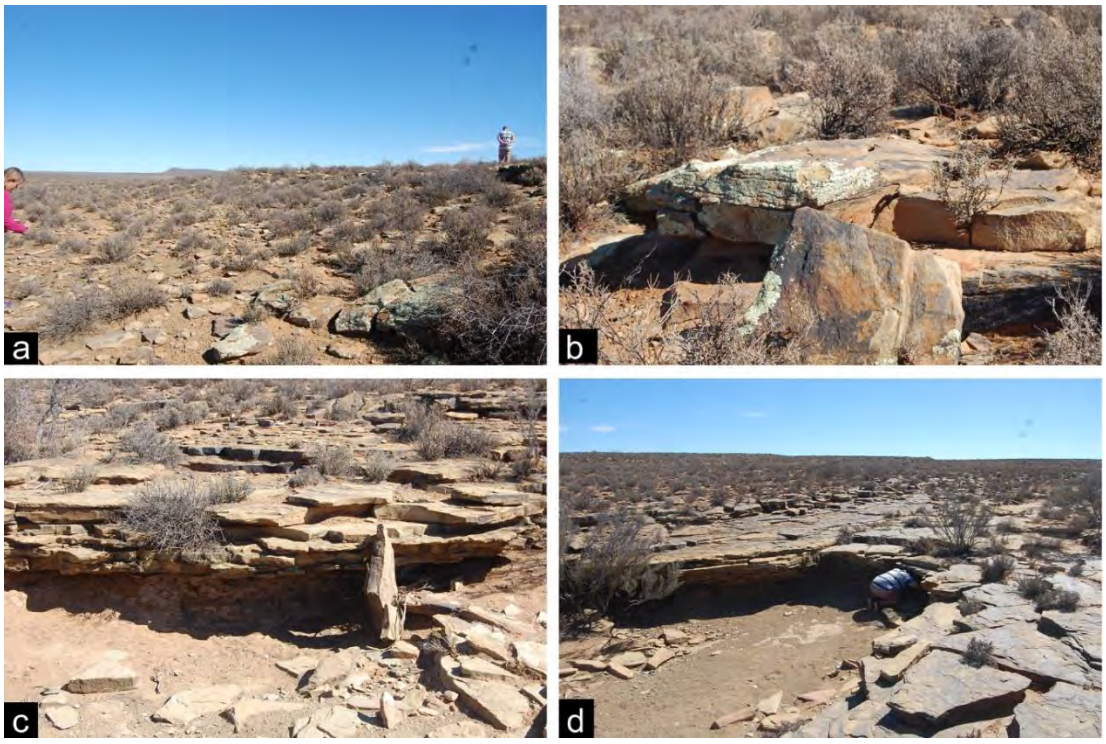

Figure 21: Stops 21 and 22 – Palmietfonein Farm

a,b – stop 21 sandstone ridge with large blocks of coarse sediments; c,d – stop 22 in the stream bed with the harder shale overlying the softer and undercut mudstone

Figure 22: Stop 23 – Farm Dampiesfontein

a – shale outcrop alongside the Albeidersfontein Road (branches northeast from the Langbaken Road); b – shale outcrop but no fossils; d – streambed that cut into the shales and Langbaken homestead in the background; d – view south of the stream bed and deep alluvium

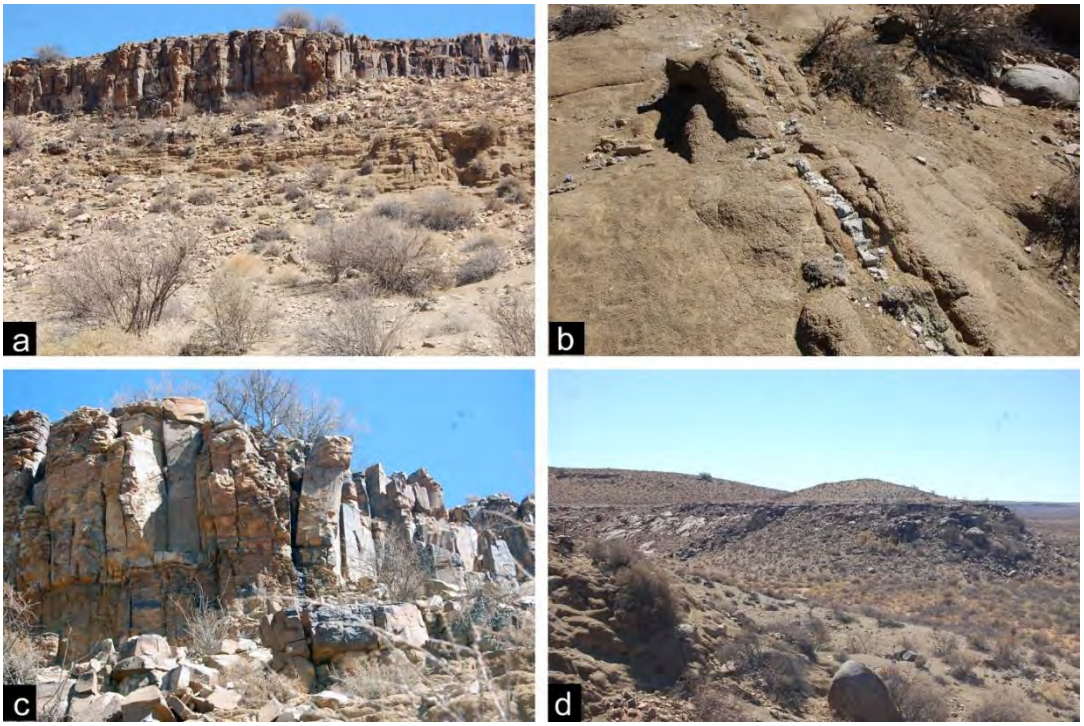

Figure 23: Stop 24 – Farm Dampiesfontein, high ridge

a – view of the ridge from the valley below; b – vein of quartz in the coarse sandstone and dropstone on the far right; c - uppermost sandstone unit with hyraceum (dassie (*Hyrax*) dung and urine midden) in the central crack and finer-grained sandstone unit slightly recessed and only about 1m thick; d – view to the north with another ridge

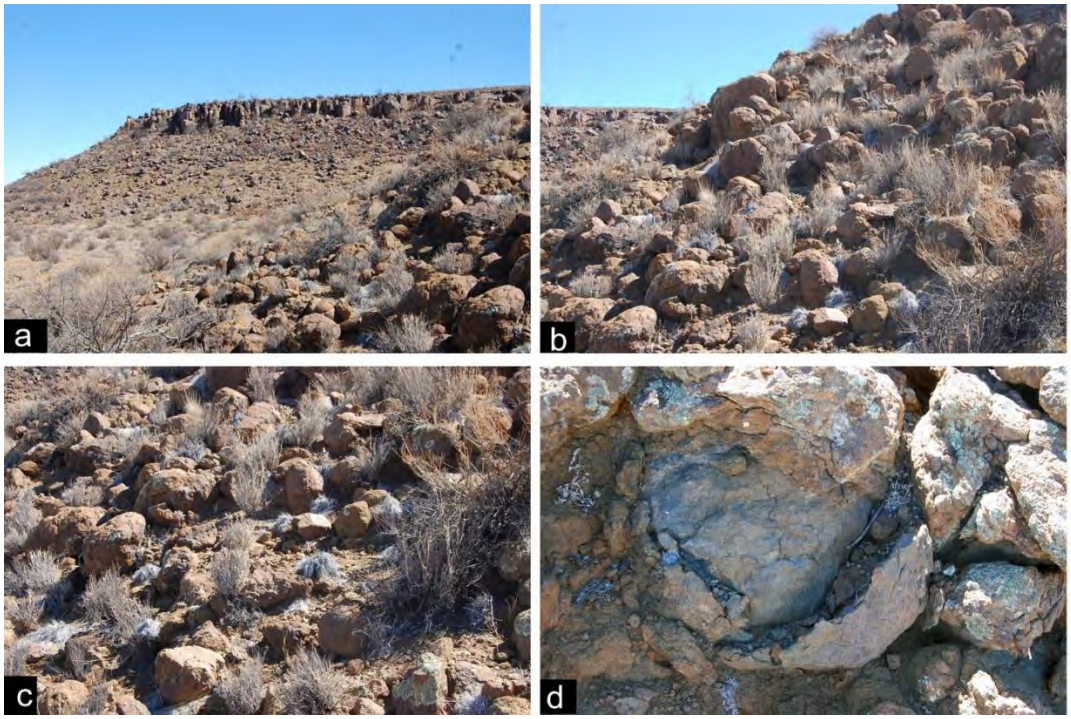

Figure 24: Stop 25 – Farm Dampiesfontein low ridge

a - dolerite capped lower ridge; b - boulders on the ridge slope; c – boulders and coarse sandstone matrix; d – onion-skin weathering of boulder

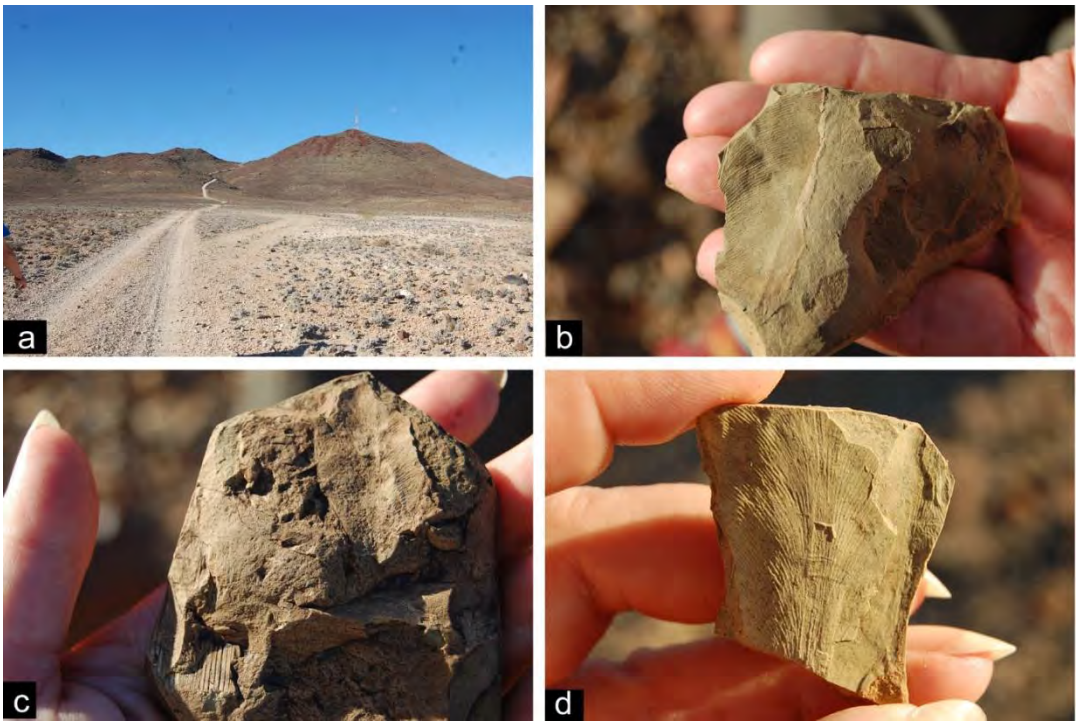

Figure 25: Stop 26 – Municipal Grounds for the radio tower to the southwest of Williston

a – view of the road to the radio mast. Fossil site is on the right of the right kink in the road; foreground shows the typical small shale slabs throughout this area but only those at the site (about 200m^2) have fossil imprints; b – impression of a *Glossopteris* leaf with prominent midvein; c – *Equisetum* stem on the bottom left and *Glossopteris* leaf partial top right; d – *Glossopteris* leaf impression with broad, poorly defined midvein

5. Impact Assessment

An assessment of the potential impacts to possible palaeontological resources considers the criteria encapsulated in Table 5.

Table 5: Potential Impacts Assessment

<table>
<tr><th colspan="5">IMPACT DESCRIPTION: Direct Impacts - Road upgrades and new roads</th></tr>
<tr><th>Dimension</th><th>Rating</th><th colspan="3">Motivation</th></tr>
<tr><td colspan="5">PRE-MITIGATION</td></tr>
<tr><td>Duration</td><td>Permanent (7)</td><td>Earth moving activities through fossiliferous lithostratigraphic units will result in permanent destruction of the resource.</td><td rowspan="3">Consequence: Moderately detrimental (-13)</td><td rowspan="4">Significance: Negligible - negative (-26)</td></tr>
<tr><td>Extent</td><td>Province/ Region (5)</td><td>Permanent destruction of fossils will affect the fossil record for the region as these resources are sparse, i.e. restricted in their distribution</td></tr>
<tr><td>Intensity x type of impact</td><td>Very low - negative (-1)</td><td>The impact and extent will result in a minor change to the palaeontological record</td></tr>
<tr><td>Probability</td><td>Improbable (2)</td><td colspan="2">It is improbable that the impact will occur as the road servitudes are already established, and no fossils were identified during the field assessment in the development footprint of the roads.</td></tr>
<tr><td colspan="5">MITIGATION:</td></tr>
<tr><td colspan="5">SARAO must develop a Fossil Finds Procedure for inclusion into the IEMP, and implement it during construction and operational activities.
Development footprint areas underlain by high palaeontologically sensitive lithology’s must be monitored during earth moving activities by:
1. A palaeontologist; or
2. The Environmental Control Officer (after appropriate training)</td></tr>
<tr><td colspan="5">POST-MITIGATION</td></tr>
<tr><td>Duration</td><td>Permanent (7)</td><td>Any destruction of the fossil record through earth moving activities will be permanent</td><td rowspan="3">Consequence: Moderately beneficial (10)</td><td rowspan="4">Significance: Negligible - positive (20)</td></tr>
<tr><td>Extent</td><td>Limited (2)</td><td>Limited to the road upgrade and new roads development footprint</td></tr>
<tr><td>Intensity x type of impact</td><td>Very low - positive (1)</td><td>Implementation and collection of the exposed fossils will contribute to the fossil record and scientific community</td></tr>
<tr><td>Probability</td><td>Improbable (2)</td><td colspan="2">Previous activities associated with the establishment of the existing roads would have destroyed any existing fossils within the impact footprint. Considering the results of the field assessment, it is improbable that any new fossils will be identified during the establishment of the new access roads.</td></tr>
</table>

IMPACT DESCRIPTION: Direct impact to fossils on the Farm Son Tuin (Die Tuin)				
Dimension	**Rating**	**Motivation**		
PRE-MITIGATION				
Duration	Permanent (7)	Earth moving activities through fossiliferous lithostratigraphic units will result in permanent destruction of the resource.	Consequence: Highly detrimental (-15)	Significance: Minor - negative (-45)
Extent	Province/ Region (5)	Permanent destruction of fossils will affect the fossil record for the region as these resources are sparse, i.e. restricted in their distribution		
Intensity x type of impact	Moderate - negative (-3)	Unmitigated change will result in moderate intensity impact to the fossils with medium - high CS		
Probability	Unlikely (3)	Considering the restricted distribution of fossils in this region, it is unlikely that the identified impacts will manifest		
MITIGATION:				
Impressions of *Calamites* and *Paracalamites* (Sphenophyta – horsetails) were identified within the site-specific study area, but not the development footprint. To this effect, SARAO must develop a Fossil Finds Procedure for inclusion into the IEMP, and implement it during construction and operational activities. Development footprint areas underlain by high palaeontologically sensitive lithology's must be monitored during earth moving activities by: 1. A palaeontologist; or 2. The Environmental Control Officer (after appropriate training)				
POST-MITIGATION				
Duration	Permanent (7)	Any destruction of the fossil record through earth moving activities will be permanent	Consequence: Moderately beneficial (11)	Significance: Negligible - positive (33)
Extent	Limited (2)	Limited to the development footprint area		
Intensity x type of impact	Low - positive (2)	Implementation and collection of the exposed fossils will contribute to the fossil record and scientific community		
Probability	Unlikely (3)	Considering the restricted distribution of fossils in this region, it is unlikely that the identified impacts will manifest		

IMPACT DESCRIPTION: Potential direct impacts to palaeontological resources - good integrity				
Dimension	**Rating**	**Motivation**		
PRE-MITIGATION				
Duration	Permanent (7)	Earth moving activities through fossiliferous lithostratigraphic units will result in permanent destruction of the resource.	Consequence: Extremely detrimental (-18)	Significance: Minor - negative (-72)
Extent	Province/ Region (5)	Permanent destruction of fossils will affect the fossil record for the region as these resources are sparse, i.e. restricted in their distribution		
Intensity x type of impact	Very high - negative (-6)	Unmitigated change will result in a moderate change to fossils heritage with high CS		

IMPACT DESCRIPTION: Potential direct impacts to palaeontological resources - good integrity				
Dimension	**Rating**	**Motivation**		
PRE-MITIGATION				
Probability	Probable (4)	The restricted distribution of fossils noted, it still remains probable that fossil heritage may be impacted upon considering the nature and extent of the Project		
MITIGATION:				
SARAO must develop a Fossil Finds Procedure for inclusion into the IEMP, and implement it during construction and operational activities. Development footprint areas underlain by high palaeontologically sensitive lithology's must be monitored during earth moving activities by: 1. A palaeontologist; or 2. The Environmental Control Officer (after appropriate training)				
POST-MITIGATION				
Duration	Permanent (7)	Earth moving activities through fossiliferous lithostratigraphic units will result in permanent destruction of the resource.	Consequence: Highly beneficial (15)	Significance: Minor - positive (60)
Extent	Limited (2)	Limited to the development footprint area		
Intensity x type of impact	Very high - positive (6)	Implementation of the proposed mitigation measures will result in a moderate positive change to the regional fossil record		
Probability	Probable (4)	The restricted distribution of fossils noted, it still remains probable that fossil heritage may be impacted upon considering the nature and extent of the Project		

IMPACT DESCRIPTION: Potential direct impacts to palaeontological resources - poor integrity				
Dimension	**Rating**	**Motivation**		
PRE-MITIGATION				
Duration	Permanent (7)	Earth moving activities through fossiliferous lithostratigraphic units will result in permanent destruction of the resource.	Consequence: Moderately detrimental (-13)	Significance: Minor - negative (-52)
Extent	Province/ Region (5)	Permanent destruction of fossils will affect the fossil record for the region as these resources are sparse, i.e. restricted in their distribution		
Intensity x type of impact	Very low - negative (-1)	Unmitigated change will result in a change to the fossil record assigned with a negligible CS		
Probability	Probable (4)	The restricted distribution of fossils noted, it still remains probable that fossil heritage may be impacted upon considering the nature and extent of the Project		
MITIGATION:				
SARAO must develop a Fossil Finds Procedure for inclusion into the IEMP, and implement it during construction and operational activities. Development footprint areas underlain by high palaeontologically sensitive lithology's must be monitored during earth moving activities by: 1. A palaeontologist; or 2. The Environmental Control Officer (after appropriate training)				
POST-MITIGATION				

IMPACT DESCRIPTION: Potential direct impacts to palaeontological resources - poor integrity				
Dimension	**Rating**	**Motivation**		
Duration	Permanent (7)	Earth moving activities through fossiliferous lithostratigraphic units will result in permanent destruction of the resource.	Consequence: Moderately beneficial (10)	Significance: Minor - positive (40)
Extent	Limited (2)	Limited to the development footprint area		
Intensity x type of impact	Very low - positive (1)	Implementation of the proposed mitigation measures will result in a low positive change to the regional fossil record		
Probability	Probable (4)	The restricted distribution of fossils noted, it still remains probable that fossil heritage may be impacted upon considering the nature and extent of the Project		

Based on the nature of the project, ONLY surface activities and to a depth of a few metres are planned for the construction of access roads, foundations for power lines and antennae, and fibre lines. The final positions of all the antennae and the infrastructure were not accessible because most farmers had not given permission to access their land, so the region was surveyed and a general impression of the variety and distribution of the fossils was gained. Based on the fieldwork to survey the area in as much detail as time and permission allowed it can be concluded that:

1. General:

   A – Fossil leaves and plants occur in the area but only in mudstones and siltstones, not in the sandstones or dolerites

   B – No fossils occur in the dolerites

   C – Fossils are extremely rare and no vertebrates or invertebrates were seen by us (but they have been reported from near Fraserberg and Carnarvon)

2. Specifics:

   D – fossil leaf impressions and silicified wood occur on the farm (land parcel) Sand Tuin (Die Tuin).

   E – fossils do not occur along the Langbaken Road between Williston and the farm Weltevrede.

   F – fossils of moderate importance could occur on the land parcels indicated as highly sensitive on the SAHRIS palaeosensitivity map but they are not abundant.

   G – the potential presence of fossils below the earth surface are completely unknown

6. Assumptions and Uncertainties

Based on the geology of the area and the palaeontological record as we know it, it can be assumed that the formation and layout of the dolerites, mudstones, shales, sandstones and alluvium are typical for the country and the fine-grained material does potentially contain fossil plant, insect, invertebrate and vertebrate material. Their occurrence is extremely rare as was confirmed by a site visit by the palaeontology team on 24-26 March 2018.

Based on the nature of palaeontological resources, it is possible that unidentified fossil remains exist within the proposed development footprints.

7. Recommendation

Based on the first general report (Almond, 2016) on the Brandvlei, Vanwyksvlei and Carnarvon regions, and on the site visit reported on here, there is a small chance of finding fossil leaf impressions, silicified wood, trace fossils and vertebrates (dinocephalians, dicynodonts, gorgonopsians, therocephalians, cynodonts and pareiasaurs). A fossil find protocol is included for when excavations commence. It is the opinion of the palaeontologist that this project may proceed but ideally a palaeontologist should be present when excavations commence. Alternatively the contractor and environmental officer or responsible person after suitable training should follow the chance find protocol.

8. References

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Almond, J.E., Pether, J. 2008. Palaeontological heritage of the Northern Cape. Interim SAHRA technical report, 124 pp. Natura Viva cc., Cape Town.

Anderson, J.M., Anderson, H.M., 1985. Palaeoflora of Southern Africa: Prodromus of South African megafloras, Devonian to Lower Cretaceous. A.A. Balkema, Rotterdam. 423 pp.
Bamford, M.K. 2004. Diversity of woody vegetation of Gondwanan southern Africa. Gondwana Research 7, 153-164.

Barbolini, N., Bamford, M.K., Rubidge, B., 2016. Radiometric dating demonstrates that Permian spore-pollen zones of Australia and South Africa are diachronous. Gondwana Research 37, 241-251.

De Wit, M.C.J. 1993. Cainozoic evolution of drainage systems in the north-western Cape. Unpublished PhD thesis, University of Cape Town, Cape Town, 371 pp.

Johnson, M.R., van Vuuren, C.J., Visser, J.N.J., Cole, D.I., Wickens, H.deV., Christie, A.D.M., Roberts, D.L., Brandl, G., 2006. Sedimentary rocks of the Karoo Supergroup. In: Johnson, M.R., Anhaeusser, C.R. and Thomas, R.J., (Eds). The Geology of South Africa. Geological Society of South Africa, Johannesburg / Council for Geoscience, Pretoria. Pp 461 – 499.

Kitching, J.W. 1977. The distribution of the Karroo vertebrate fauna, with special reference to certain genera and the bearing of this distribution on the zoning of the Beaufort beds. Memoirs of the Bernard Price Institute for Palaeontological Research, University of the Witwatersrand, No. 1, 133 pp (incl. 15 pls).

Plumstead, E.P., 1969. Three thousand million years of plant life in Africa. Geological Society of southern Africa, Annexure to Volume LXXII. 72pp + 25 plates.

Rubidge, B.S. (Ed), 1995. Biostratigraphy of the Beaufort Group (Karoo Supergroup).. Biostratigraphy Series 1, South African Commission for Stratigraphy. Council for Geoscience, 46 pp.

Smith, R.M.H. 1993. Vertebrate taphonomy of Late Permian floodplain deposits in the southwestern Karoo Basin, South Africa. PALAIOS 8(1): 45-67.

Chance Find Protocol

Monitoring Programme for Palaeontology – To Commence once the Excavations Begin

1. The following procedure is only required in areas where the development footprint is underlain by very-high sensitive geology as per the PSM.
2. When excavations begin the rocks must be given a cursory inspection by the palaeontologist or environmental officer or designated person. Any fossiliferous material (plants, insects, bone, trace fossils) should be put aside in a suitably protected place. This way the construction activities will not be interrupted.
3. Photographs of similar fossil plants must be provided to assist in recognizing the fossil plants in the shales and mudstones (for example see Figure 26 in Appendix 1). This information will be built into the consequent Conservation Management Plan (CMP)
4. Photographs of the putative fossils must be sent to the palaeontologist for a preliminary assessment.
5. There should be mandatory on-site monitoring in very-highly sensitive areas, and then cursory monitoring of moderate sensitivity areas by the contracted palaeontologist.
6. Fossil plants or vertebrates that are considered to be of good quality or scientific interest by the palaeontologist must be removed, catalogued and housed in a suitable institution where they can be made available for further study. A SAHRA permit must be obtained before the site visit, fossils will be deposited in the Evolutionary Studies Institute, University of the Witwatersrand and a full report sent to SAHRA (NHRA regulation GNR584; section 10).
7. If no good fossil material is recovered then the site inspections by the palaeontologist will not be necessary. A report by the palaeontologist must be sent to SAHRA after onsite inspections and within one month of the inspection.
8. Monitoring will no longer be required after the groundworks of the construction phase have been completed.

List of Fossil Groups and Genera

List of fossil groups and genera from the Abrahamskraal Formation from around South Africa. From Rubidge (Ed), 1995 and Bamford (2004) and references therein.

Abrahamskraal, Koonap and Volksrust Fms / Tapinocephalus AZ		
Group	**Fish/Vertebrate Genera**	**Plant Genera (# species)**
Pisces	*Namaicthys* *Atherstonia*	Mosses: *Buthelezia* (1) Sphenophytes: *Sphenophyllum, Raniganjia, Phyllotheca, Schizoneura* (6) *Sphenopteris* (1) *Glossopteris*: minimum: 11 leaf types, 6 fructifications Cordaitales: *Noeggerathiopsis* (1) Conifers?: *Taeniopteris*, *Pagiophyllum*, *Benlightfootia* (3) *Australoxylon* (1) *Prototaxoxylon* (1)
Amphibia	*Rhinesuchus*	
Captorhinida	*Eunotosaurus* *Bradysaurus* *Embrithosaurus*	
Pelycosauria	*Elliotsmithia*	
Dinocephalia	*Anteosaurus* *Paranteosaurus* *Titanosuchus* *Jonkeria* *Struthiocephalus* *Struthiocephaloides* *Taurocephalus* *Avenantia* *Criocephalus* *Delphinognathus* *Moschops* *Riebeeckosaurus* *Keratocephalus* *Mormosaurus* *Phocosaurus* *Tapinocephalus* *Styracocephalus*	
Dicynodontia	*Pristerodon* *Diictodon*	
Biarmosuchia	*Hipposaurus*	
Gorgonopsia	*Galesuchus* *Scylacognathus*	

Abrahamskraal, Koonap and Volksrust Fms / Tapinocephalus AZ		
Group	**Fish/Vertebrate Genera**	**Plant Genera (# species)**
	Broomisaurus *Eoarctops* *Aelurosaurus*	
Therocephalia	*Glanosuchus* *Alopecodon* *Scylacosaurus* *Lycosuchus* *Blattoidealestes* *Icticephalus* *Pristerognathus*	

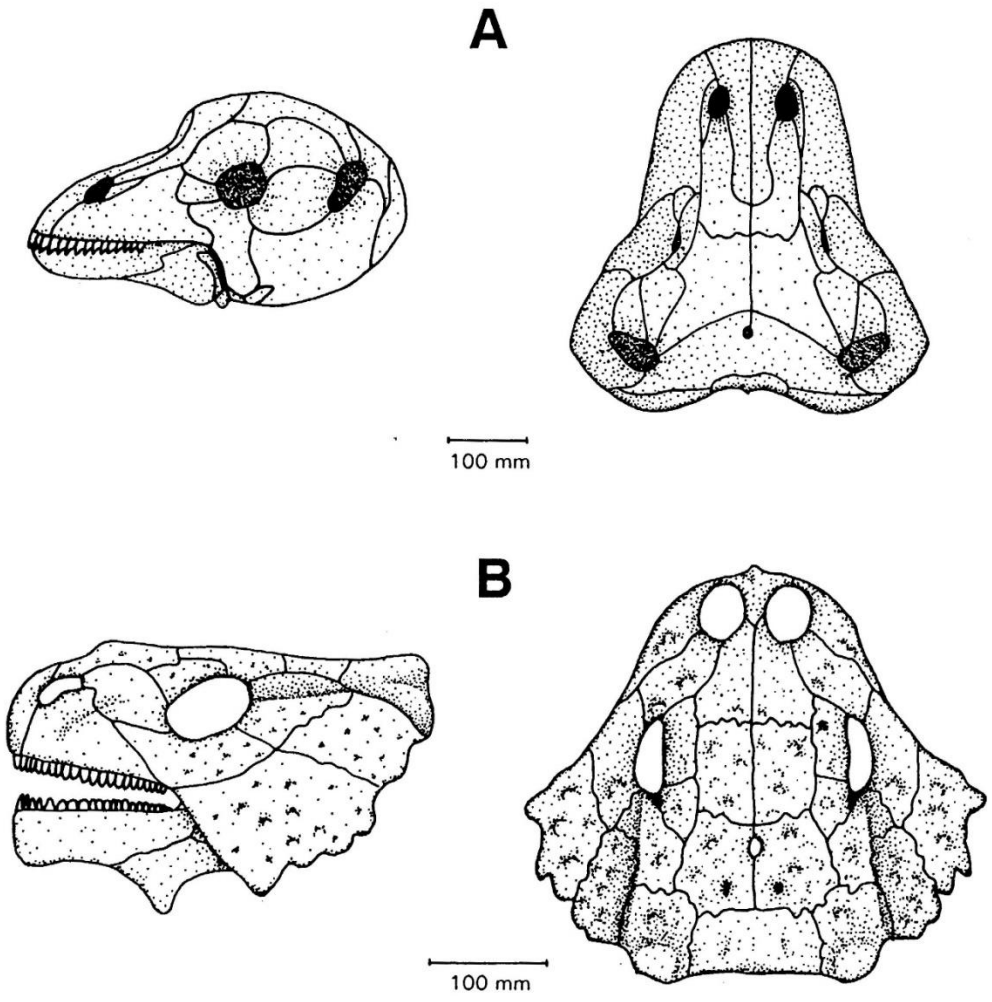

Figure 26: Examples of fossil vertebrates from the Abrahamskraal Formation

A –lateral and dorsal views of a skull of *Tapinocephalus* sp. B – lateral and dorsal views of a skull of *Bradysaurus* sp. (From Rubidge et al., 1995)

Curriculum Vitae (Short) - Marion Bamford PhD

April 2018

I) Personal Details

Surname	:	**Bamford**
First names	:	**Marion Kathleen**
Present employment	:	Professor;
		Director of the Evolutionary Studies Institute.

Member Management Committee of the NRF/DST Centre of Excellence Palaeosciences, University of the Witwatersrand, Johannesburg, South Africa-

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Fax	:	+27 11 717 6694
Cell	:	082 555 6937
E-mail	:	marion.bamford@wits.ac.za;
		marionbamford12@gmail.com

II) Academic Qualifications

Tertiary Education: All at the University of the Witwatersrand:

1980-1982: BSc, majors in Botany and Microbiology. Graduated April 1983.

1983: BSc Honours, Botany and Palaeobotany. Graduated April 1984.

1984-1986: MSc in Palaeobotany. Graduated with Distinction, November 1986.

1986-1989: PhD in Palaeobotany. Graduated in June 1990.

III) Professional Qualifications

Wood Anatomy Training (overseas as nothing was available in South Africa):

1994 - Service d'Anatomie des Bois, Musée Royal de l'Afrique Centrale, Tervuren, Belgium, by Roger Dechamps

1997 - Université Pierre et Marie Curie, Paris, France, by Dr Jean-Claude Koeniguer

1997 - Université Claude Bernard, Lyon, France by Prof Georges Barale, Dr Jean-Pierre Gros, and Dr Marc Philippe

IV) Membership of Professional Bodies/Associations

Palaeontological Society of Southern Africa

Royal Society of Southern Africa - Fellow: 2006 onwards

Academy of Sciences of South Africa - Member: Oct 2014 onwards

International Association of Wood Anatomists - First enrolled: January 1991
International Organization of Palaeobotany – 1993+
Botanical Society of South Africa
South African Committee on Stratigraphy – Biostratigraphy - 1997 - 2016
SASQUA (South African Society for Quaternary Research) – 1997+
PAGES - 2008 –onwards: South African representative
ROCEEH / WAVE – 2008+
INQUA – PALCOMM – 2011+onwards

V) Supervision of Higher Degrees

All at Wits University

Degree	Graduated/completed	Current
Honours	5	2
Masters	8	1
PhD	10	2
Postdoctoral fellows	9	3

VI) Undergraduate Teaching

Geology II – Palaeobotany GEOL2008 – average 65 students per year
Biology III – Palaeobotany APES3029 – average 25 students per year
Honours – Evolution of Terrestrial Ecosystems; African Plio-Pleistocene Palaeoecology; Micropalaeontology – average 2-8 students per year.

VII) Editing and Reviewing

Editor: Palaeontologia africana: 2003 to 2013; 2014 – present Assistant editor
Guest Editor: Quaternary International: 2005 volume
Member of Board of Review: Review of Palaeobotany and Palynology: 2010 – present
Cretaceous Research: 2014 - present

Review of manuscripts for ISI-listed journals: 25 local and international journals

VIII) Palaeontological Impact Assessments

Selected – list not complete:

- Thukela Biosphere Conservancy 1996; 2002 for DWAF
- Vioolsdrift 2007 for Xibula Exploration
- Rietfontein 2009 for Zitholele Consulting
- Bloeddrift-Baken 2010 for TransHex
- New Kleinfontein Gold Mine 2012 for Prime Resources (Pty) Ltd.
- Thabazimbi Iron Cave 2012 for Professional Grave Solutions (Pty) Ltd
- Delmas 2013 for Jones and Wagener
- Klipfontein 2013 for Jones and Wagener
- Platinum mine 2013 for Lonmin
- Syferfontein 2014 for Digby Wells
- Canyon Springs 2014 for Prime Resources
- Kimberley Eskom 2014 for Landscape Dynamics
- Yzermyne 2014 for Digby Wells
- Matimba 2015 for Royal HaskoningDV
- Commissiekraal 2015 for SLR
- Harmony PV 2015 for Savannah Environmental
- Glencore-Tweefontein 2015 for Digby Wells
- Umkomazi 2015 for JLB Consulting
- Ixia coal 2016 for Digby Wells
- Lambda Eskom for Digby Wells
- Alexander Scoping for SLR
- Perseus-Kronos-Aries Eskom 2016 for NGT
- Mala Mala 2017 for Henwood
- Modimolle 2017 for Green Vision
- Klipoortjie and Finaalspan 2017 for Delta BEC
- Isondlo and Kwasobabili 2018 for GCS
- Kanakies Gypsum 2018 for Cabanga
- Nababeep Coper mine 2018
- Glencore-Mbali pipeline 2018 for Digby Wells

IX) Research Output

Publications by M K Bamford up to January 2018 peer-reviewed journals or scholarly books:

over 120 articles published; 5 submitted/in press; 8 book chapters.

Scopus h index = 24; Google scholar h index = 26;

Conferences: numerous presentations at local and international conferences.

X) NRF Rating

NRF Rating: B-2 (2016-2020)

NRF Rating: B-3 (2010-2015)

NRF Rating: B-3 (2005-2009)

NRF Rating: C-2 (1999-2004)

Curriculum Vitae (Short) - Alison House PhD

April 2018

I) Personal Details

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Telephone	:	+27 11 327 0023
Cell	:	084 5870023
E-mail	:	alisoun@worldonline.co.za

II) Key Skills And Attributes

- The stamina and ability to work effectively under pressure.
- Highly developed social and interpersonal skills.
- Good communication skills, both oral and written.
- The ability to be creative and innovative and to find workable strategies to achieve stated aims.
- Excellent organisational skills.
- The ability to analyse situations, behaviour and thinking and respond with patience and understanding.
- Research and scientific writing.

III) Work History

Sessional position – School of Animal, Plant and Environmental Sciences

March 2016 – November 2016

Academic support for postgraduate students

Short term internshnip – University of the Witwatersrand

August – November 2015

Assistant to Editor for 'Flora of the Witwatersrand' – University of the Witwatersrand

September 2008 – February 2010

Assisted in editing and preparing the Flora for publication.

Tutor at the College of Science – University of the Witwatersrand

Academic years 2000 – 2003

Responsibilities included teaching general biology to first and second year students in the College of Science; as well as marking essays and assignments.

P.A. to Director/Manager of Cowling Davies (Small Advertising/Design Studio)

April 1992 – December 1992

Responsibilities included reception work; office administration; preparation of quotations; booking media advertisements and general assistance.

Herbarium Technician - University of the Witwatersrand

October 1991 – March 1992

Responsibilities included identification, pressing and mounting of plant specimens; capturing and maintaining data in the Herbarium computer system; maintaining the collection; filing; acting as librarian for the reference book collection and assisting students with research.

IV) Education

Doctor of Philosophy (PhD) University of the Witwatersrand (2015)

Title: Systematic Applications of Pollen Grain Morphology and Development in the Acanthaceae

Supervisor: Professor Kevin Balkwill

Master of Science (M.Sc) University of the Witwatersrand (1991)

Title: A developmental study of Nephroselmis viridis (Inouye, Suda et Pienaar) Prasinophyceae

Supervisor: Professor Richard Pienaar

Degree awarded with Distinction.

Awarded the Florence D. Hancock prize for a Dissertation in Phycology (1998).

Bachelor of Science with Honours (B.Sc. Hon.) University of the Witwatersrand (1987)

Higher Diploma in Education (Postgraduate) for Secondary Education University of the Witwatersrand (1985)

Teaching subjects: Biology and Science

Bachelor of Science (B.Sc.) University of Witwatersrand (1984)

Major: Botany

Sub-majors: Microbiology and Zoology

Matriculation Certificate Hyde Park High School (1979)

Subjects passed: English, Afrikaans, Biology, Mathematics, Geography, Home Economics

V) Publications

Young A.V. and Pienaar R.N. 1989. The ultra structure of a new species of Nephroselmis (Prasinophyceae). Proceedings of the Electron Microscopy Society of Southern Africa. 19:113–114.

House A. and Balkwill K. 2013. FIB-SEM: An Additional Technique for Investigating Internal Structure of Pollen Walls. Microscopy & Microanalysis 19: 1535–1541.

House A. and Balkwill K. 2014. FIB-SEM: A new technique for investigating pollen walls. Microscopy: advances in scientific research and education (A. Méndez-Vilas, Ed.) 1: 54–58. © FORMATEX.

House A. and Balkwill K. 2016. Labyrinths, columns and cavities: new internal features of pollen grain walls in the Acanthaceae detected by FIB-SEM. Journal of Plant Research 129: 225–240.

House A. and Balkwill K. Taxonomic significance of the internal pollen wall structure in Justicia (Acanthaceae). (Under Review).

House A. and Balkwill K. Development of the pollen wall (exine) in Barleria obtusa Nees (Acanthaceae). (In preparation).

Curriculum Vitae (Short) - Rick Tolchard

April 2018

VI) Personal Details

Surname	:	**Tolchard**
First names	:	**Frederick**
Address	:	210 Chelverton Avenue, Mondeor, Johannesburg, 2110
Cell	:	082 620 8292
E-mail	:	681459@students.wits.ac.za

I) Education

- Current – MSc in Palaeontology – project title: Full title of project: Identification of archosauriform material from Namibia and its implications for Gondwanan biostratigraphy
- Bachelor of Science with Honours in the field of Palaeontology. University of the Witwatersrand. Date: February 2017 to Nov 2017 – completed and graduated 22 March 2018.
- Science Occasional Studies. University of the Witwatersrand. February 2016 to November 2016. Successfully completed.
- Bachelor of Arts. University of the Witwatersrand. Majors: Political Studies, International Relations. February 2012 to November 2015. Graduated.
- Matriculated: 2011. Mondeor High School.

II) Activities

- Centre of Excellence in PalaeoSciences workshop. 10th September 2017 to 12th September 2017.
- IMGRAD Conference. 14th September 2017. Poster presentation.
- Rand Easter Show 2017. 14th April to 17th April 2017. Outreach assistant.
- JP Morgan Family Day at Maropeng: September 16th 2017. Guide.
- Geology II and Palaeontology III (APES) 2017: Teaching assistant.

Plan 9

SKA Project

PIA Stops and Geological Context

Legend

Project Area

- SKA Phase 1 Spiral Arms
- PIA Stops
- Other Town
- Settlement
- Main Road
- Railway Line
- River
- Dam

Geology

- Adelaide Subgroup, Beaufort Group
- Karoo Dolerite Suite
- Waterford Formation, Ecca Group

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Projection: Transverse Mercator	Ref #: ajm.NRF4874.201808.037
Datum: WGS 1984	Revision Number: 1
Central Meridian: 21°E	Date: 21/08/2018

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