PALAEONTOLOGICAL ASSESSMENT: COMBINED DESKTOP STUDY & FIELD ASSESSMENT

Proposed !Xun & Khwe PV and CSP Solar Power Facilities on Farm Platfontein (Portion 68) near Kimberley, Northern Cape Province

John E. Almond PhD (Cantab.)
***Natura Viva* cc, PO Box 12410 Mill Street,**
Cape Town 8010, RSA
naturaviva@universe.co.za

April 2012

1. SUMMARY

Afri-Devo Energy are proposing to develop both a Photovoltaic Power (PV) and a Concentrated Solar Power (CSP) facility, of 75 MW and 100 MW generating capacity respectively, on Portion 68 of Farm Platfontein, Sol Plaatjie District Municipality, on the northwestern outskirts of the town of Kimberley in the Northern Cape Province.

The proposed !Xun and Khwe solar power facility study area is underlain at depth by ancient Precambrian lavas of the Ventersdorp Supergroup (Allanridge Formation) of Late Archaean age (*c.* 2.7 billion years old) that are not palaeontologically sensitive. Apart from a few isolated rocky surface exposures, the Precambrian bedrocks within the CSP and PV study areas are largely mantled by Kalahari sands (Gordonia Formation) that are likewise of low palaeontological sensitivity. Potentially fossiliferous Early Permian sediments of the Prince Albert Formation (Lower Ecca Group) probably do not underlie the proposed CSP and PV development sites. The Ecca Group outcrop area lies further to the west and is almost entirely mantled by calcretes, silty soils and sheetwash gravels. Direct impacts on the potentially fossiliferous Ecca Group bedrocks are therefore not anticipated. Ancient alluvial gravels of the Windsorton Formation are mapped just to the northeast of the study area but not on Platfontein itself which lies some 4 km distant from the Vaal River. Thin, widespread surface gravels on Platfontein are downwasted, dominated by basement lithologies and reworked by sheetwash. They do not appear to contain reworked petrified wood or other fossil material from the Ecca bedrocks.

It is concluded that the proposed !Xun and Khwe solar power facility is very unlikely to have a significant impact on local palaeontological heritage resources. Should substantial fossil remains be exposed during construction, however, such as well-preserved fossil fish, reptiles or petrified wood, the ECO should safeguard these, preferably *in situ*, and alert SAHRA as soon as possible so that appropriate action (*e.g.* recording, sampling or collection) can be taken by a professional palaeontologist.

2. INTRODUCTION & BRIEF

The company Afri-Devo Energy are proposing to develop both a Photovoltaic Power (PV) and a Concentrated Solar Power (CSP) facility, of 75 MW and 100 MW generating capacity respectively, on Portion 68 of Farm Platfontein, Sol Plaatjie District Municipality, on the northwestern outskirts of the town of Kimberley in the Northern Cape Province (Fig. 1). The land is owned by the !Xun and Khwe communities. The proposed projects have been named the !Xun and Khwe PV Solar Farm and the !Xun and Khwe CSP Solar Farm. The proposed activities would include the construction and operation of a Solar Energy facility and associated infrastructure.

The following main infrastructural components are envisaged for these solar energy projects:

- PV panels (up to 2.8 m high) & inverters
- CSP mirrors and power block
- On-site Substation
- Transmission Line linking the facility with Eskom
- Wiring between PV panels/CSP Mirror and on-site substation
- Internal access roads
- Security infrastructure
- Storage Area
- Temporary and permanent laydown areas (300 ha or less for each project)

The footprint of the PV project is *c*. 210 ha, and that of the CSP project is 270 ha.

Large parts of the proposed study area (Platfontein Farm) overlie Permian sedimentary bedrocks of the Ecca Group (Karoo Supergroup) that are reported to be highly fossiliferous in the Kimberley – Douglas region. A combined desktop and field-based palaeontological assessment for the project has therefore been commissioned by Enviroworks (contact details: Suite 116, Private Bag X01, Brandhof 9324; 2 Chris Botha Street, Westdene; tel 086 198 8895; e-mail elbi@enviroworks.co.za) in accordance with the requirements of the National Heritage Resources Act, 1999. This palaeontological study forms part of a comprehensive HIA to be compiled by Ms Karen van Ryneveld of ArchaeoMaps (Postnet Suite 239, Private Bag X3, Beacon Bay, 5205; e-mail kvanryneveld@gmail.com; tel 084 871 1064).

2.1. National Heritage Resources Act

The extent of the proposed development (over 5000 m^2) falls within the requirements for a Heritage Impact Assessment (HIA) as required by Section 38 (Heritage Resources Management) of the South African National Heritage Resources Act (Act No. 25 of 1999). The various categories of heritage resources recognised as part of the National Estate in Section 3 of the National Heritage Resources Act include, among others:

- geological sites of scientific or cultural importance
- palaeontological sites
- palaeontological objects and material, meteorites and rare geological specimens

Minimum standards for the palaeontological component of heritage impact assessment reports are currently being developed by SAHRA. The latest version of the SAHRA guidelines is dated August 2011.

2.2. Approach used for this palaeontological assessment

This report provides an assessment of the observed or inferred palaeontological heritage within the Platfontein study area, with recommendations for any specialist palaeontological mitigation where this is considered necessary. The report is based on (1) a review of the relevant scientific literature, (2) geological maps and accompanying sheet explanations, (3) previous palaeontological heritage assessments for alternative energy and other developments in the region (*e.g.* Almond 2010b, 2011a, 2011b), (4) the author's extensive field experience with the formations concerned and their palaeontological heritage, and (5) a one-day field assessment on 26 April 2012 carried out by the author.

In preparing a palaeontological desktop study the potentially fossiliferous rock units (groups, formations *etc*) represented within the study area are determined from geological maps. The known fossil heritage within each rock unit is inventoried from the published scientific literature, previous palaeontological impact studies in the same region, and the author's field experience (Consultation with professional colleagues as well as examination of institutional fossil collections may play a role here, or later during the compilation of the final report). This data is then used to assess the palaeontological sensitivity of each rock unit to development (Provisional tabulations of palaeontological sensitivity of all formations in the Western, Eastern and Northern Cape have already been compiled by J. Almond and colleagues; *e.g.* Almond & Pether 2008). The likely impact of the proposed development on local fossil heritage is then determined on the basis of (1) the palaeontological sensitivity of the rock units concerned and (2) the nature of the development itself, most notably the extent of fresh bedrock excavation envisaged.

When rock units of moderate to high palaeontological sensitivity are present within the development footprint, a field assessment study by a professional palaeontologist is usually warranted. Most detrimental impacts on palaeontological heritage occur during the construction phase when fossils may be disturbed, destroyed or permanently sealed-in during excavations and subsequent construction activity. Where specialist palaeontological mitigation is recommended, this may take place before construction starts or, most effectively, during the construction phase while fresh, portentially fossiliferous bedrock is still exposed for study. Mitigation usually involves the judicious sampling, collection and recording of fossils as well as of relevant contextual data concerning the surrounding sedimentary matrix. It should be emphasised that, *provided* appropriate mitigation is carried out, many developments involving bedrock excavation actually have a *positive* impact on our understanding of local palaeontological heritage. Constructive collaboration between palaeontologists and developers should therefore be the expected norm.

The focus of the field-based assessment work is *not* simply to survey the development footprint or even the development area as a whole (*e.g.* farms or other parcels of land concerned in the development). Rather, the palaeontologist seeks to assess or predict the diversity, density and distribution of fossils within and beneath the study area, as well as their heritage or scientific interest. This is primarily achieved through a careful field examination of one or more representative exposures of all the sedimentary rock units present (*N.B.* Metamorphic and igneous rocks rarely contain fossils). The best rock exposures are generally those that are easily accessible, extensive, and fresh (*i.e.* unweathered) and include a large fraction of the stratigraphic unit concerned (*e.g.* formation). These exposures may be natural or artificial and include, for example, rocky outcrops in stream or river banks, cliffs, quarries, dams, dongas, open building excavations or road and railway cuttings. Uncemented superficial deposits, such as alluvium, scree or wind-blown sands, may occasionally contain fossils and should also be included in the scoping study where they are well-represented in the study area. It is normal practice for impact palaeontologists to collect representative, well-localized (*e.g.* GPS and stratigraphic data) samples of fossil material during field assessment studies. However, fossil collection should be supported by a permit from the relevant heritage heritage authority and all fossil material collected must be properly curated within an approved repository (usually a museum or university collection).

Before fieldwork commenced, a preliminary screening of satellite images and 1: 50 000 maps of the Platfontein study area was conducted to identify any sites of potentially good bedrock exposure to be examined in the field. These sites might include, for example, natural exposures (*e.g.* stream beds, rocky slopes, gullies) as well as artificial exposures such as quarries, dams and cuttings along farm tracks. In the case of Platfontein, only scattered small exposures of basement rocks were identified.

Note that while fossil localities recorded during fieldwork within the study area itself are obviously highly relevant, most fossil heritage here is embedded within rocks beneath the land surface or obscured by surface deposits (soil, alluvium *etc*) and by vegetation cover. In many cases where levels of fresh (*i.e.* unweathered) bedrock exposure are low, the hidden fossil resources have to be *inferred* from palaeontological observations made from better exposures of the same formations elsewhere in the region but outside the immediate study area. Therefore a palaeontologist might reasonably spend far *more* time examining road cuts and borrow pits close to, but outside, the study area than within the study area itself. Field data from localities even further afield (*e.g.* an adjacent province) may also be adduced to build up a realistic picture of the likely fossil heritage within the study area.

On the basis of the desktop and field assessment studies, the likely impact of the proposed development on local fossil heritage and any need for specialist mitigation are then determined. Adverse palaeontological impacts normally occur during the construction rather than the operational or decommissioning phase. Mitigation by a professional palaeontologist – normally involving the recording and sampling of fossil material and associated geological information (*e.g.* sedimentological data) – is usually most effective during the construction phase when fresh fossiliferous bedrock has been exposed by excavations, although pre-construction recording of surface-exposed material may sometimes be more appropriate. To carry out mitigation, the palaeontologist involved will need to apply for a palaeontological collection permit from the relevant heritage management authority (*i.e.* SAHRA, Cape Town). It should be emphasized that, *providing appropriate mitigation is carried out*, the majority of developments involving bedrock excavation can make a *positive* contribution to our understanding of local palaeontological heritage.

GPS data for all localities mentioned in the text is provided in the Appendix.

1.5. Assumptions and limitations

The accuracy and reliability of palaeontological specialist studies as components of heritage impact assessments are generally limited by the following constraints:

1. Inadequate database for fossil heritage for much of the RSA, given the large size of the country and the small number of professional palaeontologists carrying out fieldwork here. Most development study areas have *never* been surveyed by a palaeontologist.

2. Variable accuracy of geological maps which underpin these desktop studies. For large areas of terrain these maps are largely based on aerial photographs alone, without ground-truthing. The maps generally depict only significant ("mappable") bedrock units as well as major areas of superficial "drift" deposits (alluvium, colluvium) but for most regions give little or no idea of the level of bedrock outcrop, depth of superficial cover (soil *etc*), degree of bedrock weathering or levels of small-scale tectonic deformation, such as cleavage. All of these factors may have a major influence on the impact significance of a given development on fossil heritage and can only be reliably assessed in the field.

3. Inadequate sheet explanations for geological maps, with little or no attention paid to palaeontological issues in many cases, including poor locality information.

4. The extensive relevant palaeontological "grey literature" - in the form of unpublished university theses, impact studies and other reports (*e.g*. of commercial mining companies) - that is not readily available for desktop studies.

5. Absence of a comprehensive computerized database of fossil collections in major RSA institutions which can be consulted for impact studies. A Karoo fossil vertebrate database is now accessible for impact study work, however.

In the case of palaeontological desktop studies without supporting field assessments these limitations may variously lead to either: (a) *underestimation* of the palaeontological significance of a given study area due to ignorance of significant recorded or unrecorded fossils preserved there, or (b) *overestimation* of the palaeontological sensitivity of a study area, for example when originally rich fossil assemblages inferred from geological maps have in fact been destroyed by tectonism or weathering, or are buried beneath a thick mantle of unfossiliferous "drift" (soil, alluvium *etc*).

Since most areas of the RSA have not been studied palaeontologically, a palaeontological desktop study usually entails *inferring* the presence of buried fossil heritage within the study area from relevant fossil data collected from similar or the same rock units elsewhere, sometimes at localities far away. Where substantial exposures of bedrocks or potentially fossiliferous superficial sediments are present in the study area, the reliability of a palaeontological impact assessment may be significantly enhanced through field assessment by a professional palaeontologist.

In the case of palaeontological field studies in the Platfontein study area, the main limitation is the extremely low levels of Karoo Supergroup bedrock exposure due to extensive cover by superficial deposits (surface gravels, calcretes, soil, alluvium *etc*) and vegetation, most notably summer grasses (Figs. 14, 15).

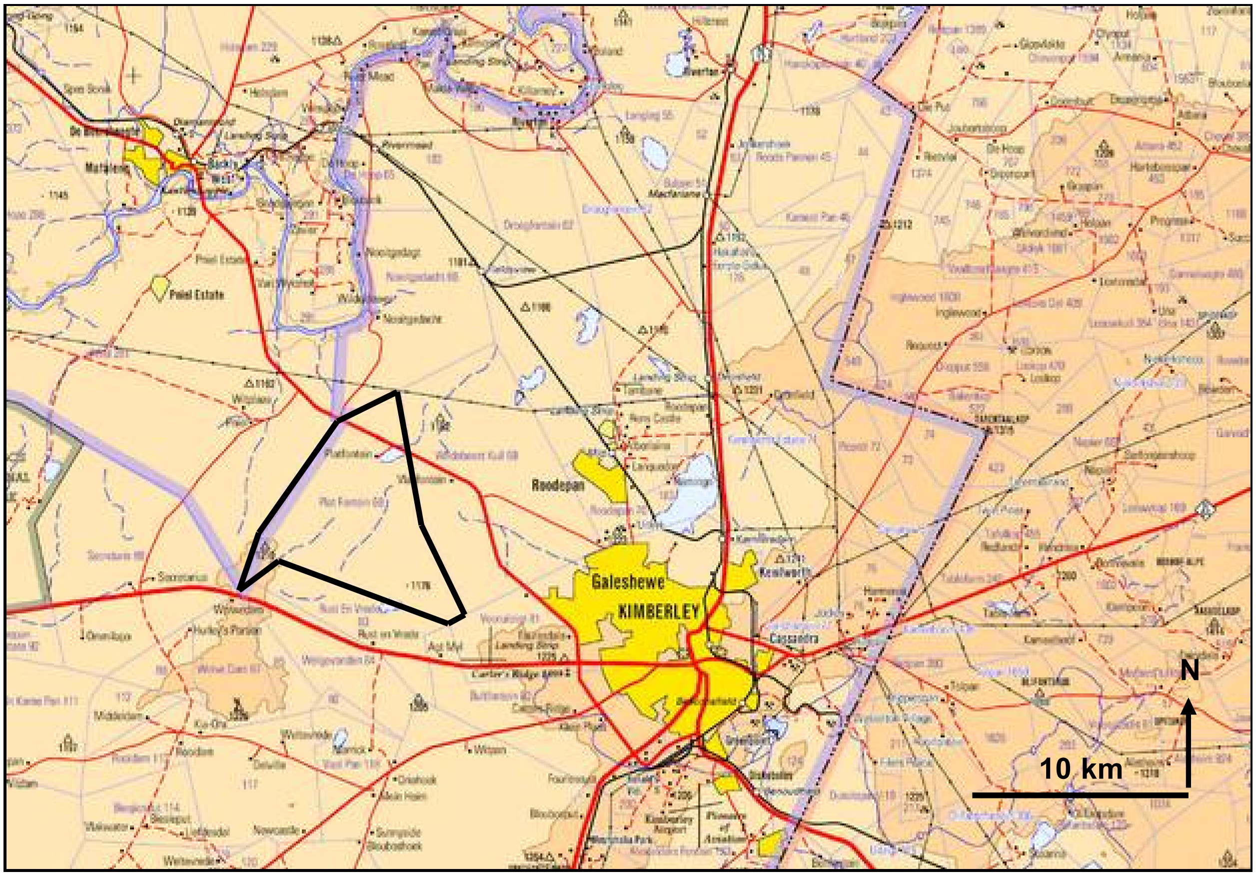

Fig. 1. Extract from 1: 250 000 topographical map 2824 Kimberley (Courtesy of the Chief Directorate of Surveys & Mapping, Mowbray) showing location of the !Xun and Khwe solar project study area on the northwestern outskirts of Kimberley, Northern Cape Province (black polygon). See also satellite image in Fig. 2.

Fig. 2. Google earth© satellite image of the Platfontein Farm study area on the northwestern outskirts of Kimberley (black polygon).

3. GEOLOGICAL BACKGROUND

The study area on Farm Platfontein near Kimberley spans the R31 tar road between Kimberley and Barkly West, and lies less than 4 km south of the Vaal River. The semi-arid terrain here lies between 1100 and 1200 m amsl, with low dolerite hills in the south-western corner. The area is drained by several shallow, ephemeral water courses that do not appear to link up with the Vaal River and that drain into large shallow pans in the northern portion of the farm. Relief is general low to very low, especially overlying the Ecca Group outcrop area (Fig. 8), and levels of bedrock exposure are generally minimal, due to almost ubiquitous cover by soils and vegetation (summer grasses, low *bossies*, taller shrubs and thorn trees).

The geology of the study area north of Kimberley is shown on the 1: 250 000 geology map 2824 Kimberley (Council for Geoscience, Pretoria; Fig. 3 herein). An explanation for the Kimberley geological map has been published by Bosch (1993).

On the northern and south-eastern corners of Platfontein the terrain comprises low rocky hills where several small inliers of basement rocks are mapped as the **Allanridge Formation** (**Ra**) at the top of the **Ventersdorp Supergroup**. This Late Archaean succession is almost entirely composed of resistant-weathering, dark grey-green lavas and associated pyroclastic rocks that are dated to 2.7 Ga (Bosch 1993, Van der Westhuizen & De Bruiyn 2006 and refs. therein). Thin lenses of cross-bedded quartzite and conglomerate are recorded just above the base of the succession by Bosch (1993). Conical stromatolites are recorded from the underlying Bothaville Formation of the Platberg Group (Schopf 2006) which is not mapped within the study area, however.

Small rocky exposures of tough-weathering Allanridge Formation lavas occur in several parts of Platfontein (Figs. 5, 6). Scattered boulders and low, well-jointed exposures of Allanridge lavas occur in the southeastern portion of Platfontein where the proposed CSP and PV developments will take place. Most of the Ventersdorp Group bedrocks here are mantled in orange-hued Kalahari sands (Gordonia Formation), from which occasional boulders emerge (Figs. 14, 15). A range of lava facies are seen, both as bedrock exposures and float blocks. At Loc. 491 the vesicular (bubbly) tops of lava flows are seen (Fig. 6), while elsewhere the lavas appear massive to locally vuggy (with cavities). Sometimes the vesicles have been secondarily infilled with diagenetic minerals (*e.g.* microcrystalline quartz / calcite / zeolites) to form lenticular amygdales up to 17 mm in maximum diameter (Fig. 7). A rusty-brown to metallic (desert varnish) surface weathering patina has developed on many boulders; this patina has been exploited locally by Later Stone Age rock engravers (*e.g.* Wildebeest Kuil rock art centre).

A number of **glacial pavements** - glacially-striated and eroded bedrocks - of Dwyka age (*i.e.* Permo-Carboniferous, *c*. 300 Ma) are mapped within the Allanridge Formation outcrop area both on Platfontein as well as to the west, north and east (circle with arrow symbol in Fig. 3). These features, which here indicate consistent ice transport directions to the southwest, are of geological conservation significance. A search made for glacially striated Allanridge bedrock in the northwestern portion of the study area was unsuccessful, probably due to thick grassy vegetation cover in April.

According to the geological map (Fig. 3) the central portion of Platfontein is largely underlain by basinal mudrocks of the **Prince Albert Formation** (Ecca Group)(**Ppr**). This unit of Early Permian (Asselian / Artinskian) age was previously known as “Upper Dwyka Shales” and reaches a thickness of 90m in the Kimberley area (Bosch 1993). Useful recent geological accounts of the Ecca Group are given by Johnson *et al.* (2006) and Johnson (2009). Key reviews of the Prince Albert Formation are given by Visser (1992) and Cole (2005). The Prince Albert Formation in the Kimberley - Britstown area consists predominantly of dark, well-laminated basinal mudrocks (shales, siltstones) that are sometimes carbonaceous or pyritic and typically contain a variety of diagenetic concretions enriched in iron and carbonate minerals (McLachlan & Anderson 1973, Visser *et al.* 1977-78, Zawada 1992, Bosch 1993). Some of these carbonate concretions are richly fossilferous (See Section 4.1 below). Much of the Ecca shale outcrop in the Kimberley sheet area has been modified by surface calcretization (Zawada 1992). Palaeontologically important exposures in incised river banks near Douglas, to the west of Kimberley, are described by McLachlan and Anderson (1973). The Ecca beds near Douglas are mantled with a thin Quaternary calcrete and reddish Kalahari sands (= Gordonia Formation). They mainly comprise shales with a band of ferruginous carbonate as well as a 6m-thick zone of fossiliferous calcareous concretions that lies 9m above the base of the formation.

During field assessment almost no exposure of Prince Albert Formation sediments were seen within the extensive area in the western portion of Platfontein assigned to this rock unit on the geological map (Fig. 3). Very small exposures of ferruginous mudrocks and pale cherty layers (possible volcanic tuffs) that may belong to the Prince Albert Formation were seen near the margins of the large pan in the northern part of the farm (Fig. 10). Shallow stream courses are mantled by silty and gravelly alluvium, with apparently no Ecca Group exposure.

Large portions of the Platfontein study area, especially in the southeast and north, are mantled by superficial deposits of Quaternary to Recent age, especially Pleistocene **calcretes** (**Qc**) and aeolian (wind-blown) sands of the **Gordonia Formation** (**Kalahari Group**) (**Qs**). The geology of the Late Cretaceous to Recent Kalahari Group is reviewed by Thomas (1981), Dingle *et al.* (1983), Thomas & Shaw 1991, Haddon (2000) and Partridge *et al.* (2006). The Gordonia dune sands are considered to range in age from the Late Pliocene / Early Pleistocene to Recent, dated in part from enclosed Middle to Later Stone Age stone tools (Dingle *et al*., 1983, p. 291). Note that the recent extension of the Pliocene - Pleistocene boundary from 1.8Ma back to 2.588 Ma would place the Gordonia Formation almost entirely within the Pleistocene Epoch. At the latitude of the Kimberley study site (28° 40"S) Gordonia Formation sands less than 30m thick are likely to be the main or perhaps the only Kalahari sediments present (*cf* isopach map of the Kalahari Group, fig. 6 *in* Partridge *et al*., 2006). These unconsolidated sands *might* be locally underlain by thin surface gravels equivalent to the **Obobogorop Formation**, as well as by pebbly calcretes of Plio-Pleistocene age or younger (**Mokalanen Formation**; Fig. 4).

Orange-hued Kalahari sands mantle the Precambrian bedrocks in the south-eastern part of the study area, including the regions assigned to the CSP and PV developments (Figs. 14 and 15). The depth of the sands here is difficult to gauge, and is probably very variable depending on the relief of the underlying Allanridge bedrock. Pale brown silty to gravelly soils, locally with domical termitaria, overlie most of the areas outside the Kalahari sand-covered area (Fig. 8).

Relict patches of elevated Late Tertiary to Quaternary **alluvial gravels** ("High Level Gravels") are mapped along both the Vaal and Orange Rivers in the Windsorton – Kimberley – Douglas - Prieska area, where they have been associated with diamond mining (De Wit *et al*., 2000, their table 4.1 and fig. 4.1). These gravels are *not* mapped within the Platfontein study area on geology sheet 2824 Kimberley which lies 4 km or more from the Vaal River. However, diamondiferous "Older Gravels" do occur on farm Nooigedacht 66 just to the northeast of Platfontein (Qa / DA in Fig. 3; Engelbrecht 1963, Bosch 1993 p. 37) and later occurrences ("Youngest Gravels" of Bosch 1993, p. 38) may be present along the banks of the Vaal River. These possible younger gravels will not be directly impacted by the proposed !Xun & Khwe solar park development, however. In the Windsorton area to the north of Kimberley heavily calcretized "Older Gravels" have been grouped into the **Windsorton Formation** and are suspected to be Miocene-Pliocene in age (Partridge & Brink 1967, De Wit *et a*l., 2000, Partridge *et al.* 2006). The "Younger Gravels" (**Rietputs Formation**) of the Vaal River system, at lower elevations, are associated with Acheulian stone tools and are therefore considered to be Early to Middle Pleistocene (Cornelian) in age (Klein 1984, Table 2, Butzer *et al*., 1973, Partridge *et al*., 2006). Recent cosmogenic nuclide dating of coarse gravels and sands in the Rietputs Formation gave an age of *c*. 1.57 Ma (Gibbon *et al.,* 2009).

Small patches of **calcretes** (pedogenic limestones) (**Qc**) are mapped in various parts of the Platfontein study area. In many cases they appear to be associated with Karoo sediments of the Prince Albert Formation but towards the north they may alternatively represent calcretized wind-blown sands blown out from several small to large pans in this region (Bosch 1993). Extensive calcretes overlying the Karoo Supergroup and older basement rocks in the Douglas area to the WSW of Kimberley, forming a broad band either side of the Orange River, may be, at least in part, stratigraphically equivalent to the **Mokalanen Formation** of the Kalahari Group (Fig. 4). According to Zawada (1992) calcretes are especially well developed overlying the Ecca Group outcrop in the Koffiefontein sheet area to the east of Douglas. The commonest type in this region are the so-called Second Intermediate Calcretes that contain Middle Stone Age tools dated between *c*. 300 000 and 50 000 years, indicating a Pleistocene age (Note that Partridge *et al*., 2006, suggest an older, Late Pliocene, age for the Mokalanen Formation proper). Older calcretes are associated with calcified alluvial gravels (see below), and younger ones form hard pans adjacent to extant pans (Potgieter 1974, Partridge & Scott 2000). The thickness of these surface calcretes is not specified, but is unlikely to exceed a few meters in most areas.

Sheet-like creamy calcretes overlying Ecca Group bedrocks are exposed in farm tracks across the south-central portion of Platfontein (Fig. 11), for example in proximity to the dolerite intrusions. Surface blocks show brecciation and reworking of earlier calcrete phases, as well as embedded angular gravel clasts. Reworked calcrete fragments are a major component of surface gravels in many areas. The widely occurring **surface gravels** probably owe their origin primarily to downwasting, but reworking of finer gravels by sheetwash processes is often evident (Figs. 12 & 13). It is notable that most of the gravel clasts consist of resistant-weathering basement lithologies (*e.g.* cherts, porphyritic, amygdaloidal and fine-grained lavas, quartzite, well-cemented coarse grits, banded iron formation) with almost no rock types that can be confidently ascribed to the Karoo Supergroup. Probable exceptions include dark hornfels (baked mudrock) that may be eroded from Lower Ecca mudrocks within the thermal aureole of the dolerite intrusions to the southwest as well as pale greenish-grey, oblate diagenetic nodules showing cone-in-cone structures that may well have weathered out of the Prince Albert Formation (Fig. 9). High levels of anthropogenic flaking are seen on finer-grained surface gravel clasts. Unflaked clasts are mostly angular, but occasional water-worn, well-rounded pebbles and cobbles are also seen. No mature fluvial gravels were observed on Platfontein, with the possible exception of a small patch of subrounded coarser-grained gravels at Loc. 492.

Early Jurassic (183 Ma) **Karoo dolerite intrusions** (Jd) are mapped within the south-western corner of the Platfontein study area. The adjacent Ecca rocks here have probably been thermally and chemically modified by nearby intrusions.

Kimberlite pipes and **fissures** dated to 77-120 Ma are mapped just outside and to the west of the study area as well as further north where they intrude the Ventersdorp Supergroup lavas (black diamond symbols in Fig. 3; Bosch 1993 Table 8.1, Skinner & Truswell 2006). These Early Jurassic to Early Cretaceous igneous rocks do not contain fossils. However, where the associated crater-lake sediments are preserved beneath cover sands they sometimes prove to be highly fossiliferous, as seen in examples from Bushmanland (*e.g.* Scholtz 1985, Smith 1986a, 1986b, 1988, 1995).

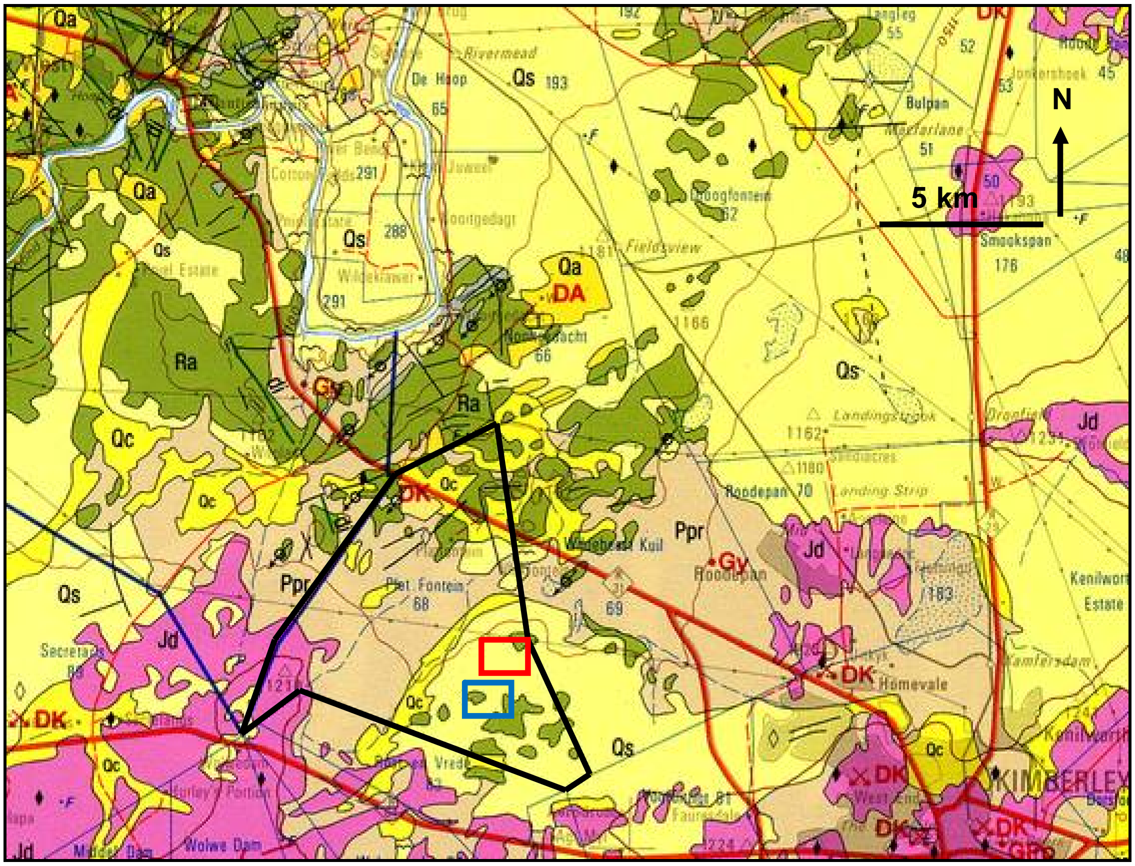

Fig. 3. Extract from the 1: 250 000 geological map 2824 Kimberley (Council for Geoscience, Pretoria) showing the location of Farm Platfontein to the NW of Kimberley (black polygon). Proposed sites for the CSP Solar Field (red rectangle) and PV Solar Field (blue rectangle) are also shown. Both sites are underlain by Precambrian lavas of the Allanridge Formation (green) mantled by orange Kalahari Group sands (yellow).

The main geological units represented in the study region include:

Ra (green) = Allanridge Formation (Platberg Group, Ventersdorp Supergroup)
Round symbol with arrow = glacial pavements of Dwyka age
Ppr (buff) = Prince Albert Formation (Ecca Group)
Jd (pink) = Karoo Dolerite Suite

Qs (pale yellow) = aeolian dune sands (Gordonia Formation, Kalahari Group)
Qc (medium yellow) = surface calcrete, calcified pan dunes
Qa (dark yellow) = ancient alluvial gravels ("High Level Gravels") (DA = diamonds)

Open and solid diamond symbols = kimberlite fissures and pipes respectively

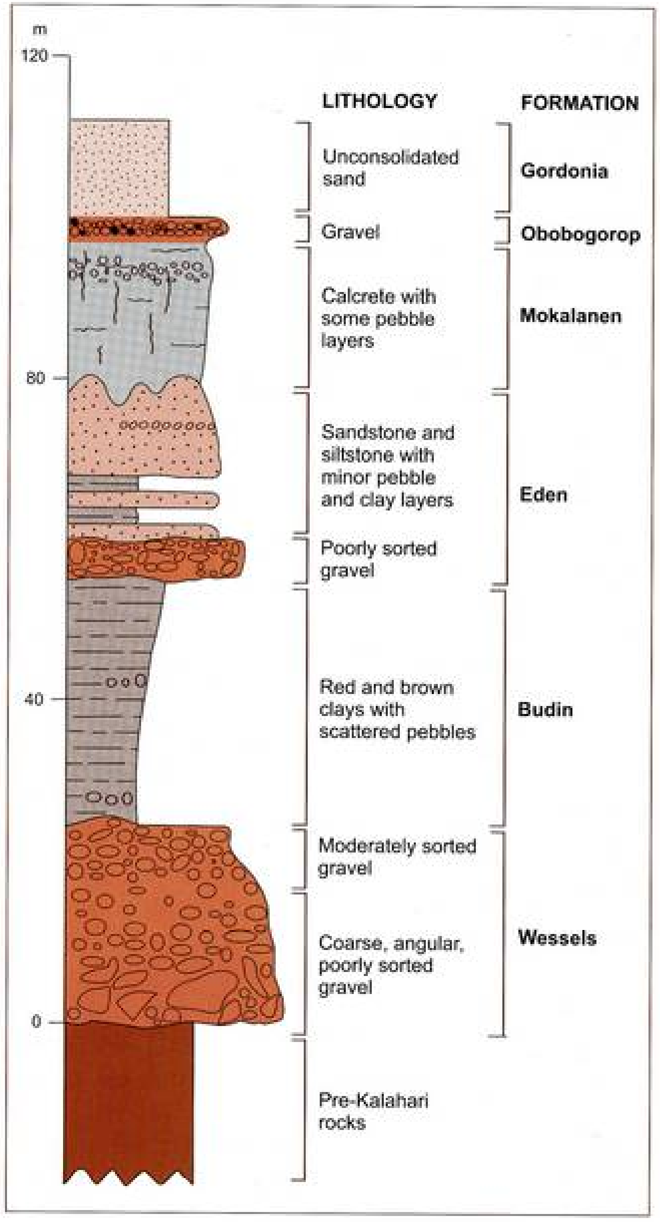

Fig. 4. Stratigraphy of the Kalahari Group (From Partridge *et al.,* 2006). Aeolian sands of the Gordonia Formation as well as calcretes *possibly* equivalent to the Mokalanen Formation are represented in the study area.

Fig. 5. Low rocky exposure of well-jointed, greyish-brown Allanridge Formation lavas on the northern part of Platfontein (Loc. 487) (Hammer = 27 cm).

Fig. 6. Vesicular top of lava flow, Allanridge Formation, northern Platfontein (Loc. 491) (Hammer = 27 cm).

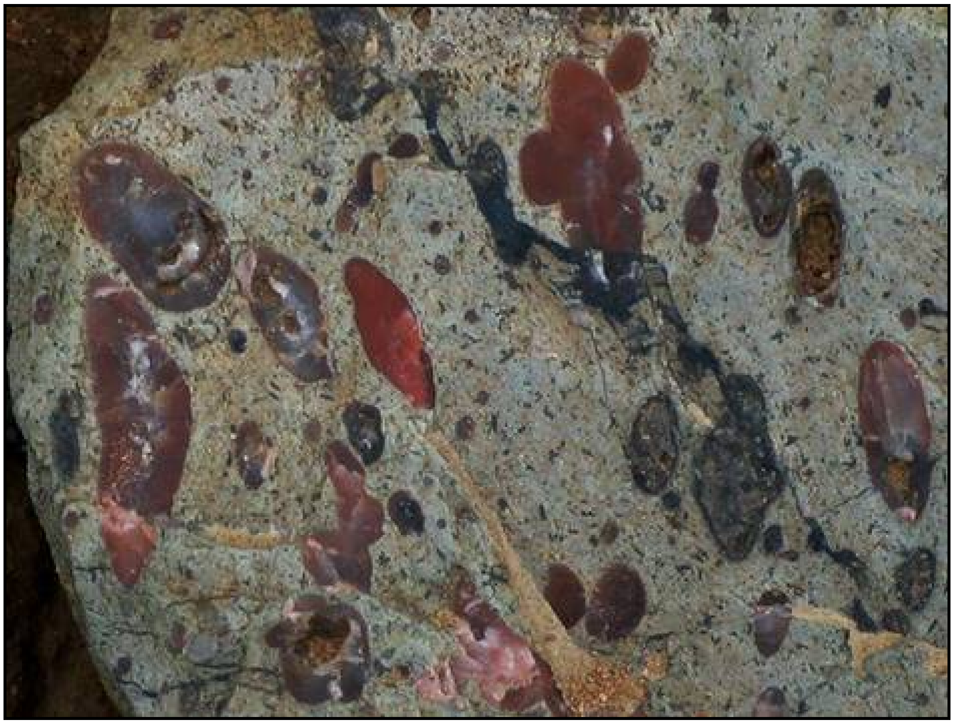

Fig. 7. Detail of float block of amydaloidal Allanridge lava (Loc. 492). The original vesicles (gas bubbles) have been infilled with pinkish secondary minerals, forming amygdales. The largest bubble infills seen here are *c*. 17 mm long.

Fig. 8. View eastwards across the very flat outcrop area of the Ecca Group (Prince Albert Formation) on the southern part of Platfontein. Note complete cover of Ecca rocks by soils and vegetation here.

Fig. 9. Locally common fragments of oblate carbonate nodules containing fossil-like cone-in-cone structures (Loc. 488) (Scale in cm). These are probably diagenetic nodules that have weathered out of the underlying Ecca Group bedrocks. True fossils (*e.g.* plant material, fish remains) were not observed within them.

Fig. 10. Sparse, small exposures of ferruginised mudrocks on the northern part of Platfontein (Loc. 492) (Hammer = 27 cm). These rocks may well belong to the Prince Albert Formation.

Fig. 11. Rubbly exposure of near-surface calcretes on the southern part of Platfontein (Loc. 489). The calcretes here probably overlie Prince Albert Formation bedrocks.

Fig. 12. Extensive fine- to medium-grained polymict surface gravels on the northern part of Platfontein (Loc. 492). Most of the clasts are angular and composed of basement lithologies (cherts, lavas *etc*). Many are also flaked. Reworked petrified Ecca wood or other Karoo Supergroup fossils were not observed among the gravel assemblages.

Fig. 13. Brown silty soils overlying Ecca Group outcrop area with surface scatter of fine sheetwash gravels (here mainly chert and hornfels). Many of the largr clasts are flaked (Scale in cm).

Fig. 14. General view of terrain in CSP study area, Platfontein, with occasional emergent boulders of Allanridge Formation lavas embedded in orange-hued Kalahari sands.

Fig. 15. Flat terrain in the PV study area, Platfontein. The bedrock here (Ventersdorp Subgroup lavas) is largely obscured by Kalahari sands.

4. PALAEONTOLOGICAL HERITAGE

The fossil heritage recorded within each of the main sedimentary rock successions represented within the Platfontein study region northwest of Kimberley is outlined here (See also the summary of fossil heritage provided in Table 1 below). Igneous rocks such as the Allanridge lavas, Karoo dolerites and kimberlite pipes are not considered further here since they do not contain fossils.

4.1. Fossils within the Prince Albert Formation

The fossil biota of the post-Dwyka mudrocks of the Prince Albert Formation is summarized by Cole (2005) and Almond (2008a, b; see also previous palaeontological assessments by the author in the Kimberley – Douglas region, Almond 2010b, 2011a, 2011b). Epichnial (bedding plane) trace fossil assemblages of the non-marine *Mermia* Ichnofacies, dominated by the ichnogenera *Umfolozia* (arthropod trackways) and *Undichna* (fish swimming trails), are commonly found in basinal mudrock facies of the Prince Albert Formation throughout the Ecca Basin. These assemblages have been described by Anderson (1974, 1975, 1976,1981) and briefly reviewed by Almond (2008a, b). A small range of simple, horizontal to oblique endichnial burrows forming dense monospecific ichnoassemblages have been recorded from the Ceres Karoo, especially from those parts of the Prince Albert succession containing thin volcanic tuffs (Almond 2010a). The presence of more diverse, but incompletely recorded, benthic invertebrate fauna in the Early Permian Ecca Sea is suggested by the recent discovery of complex arthropod trails with paired drag marks in the Prince Albert Formation near Matjiesfontein in the southern Great Karoo.These trackways might have been generated by small eurypterids (water scorpions), but this requires further confirmation. Pooly-defined invertebrate burrows are recorded from the Prince Albert Formation in the Kimberley sheet area by Bosch (1993).

Diagenetic nodules containing the remains of palaeoniscoids (primitive bony fish), sharks, spiral bromalites (coprolites, spiral gut infills *etc* attributable to sharks or temnospondyl amphibians) and petrified wood have been found in the Ceres Karoo (Almond 2008b and refs. therein). Rare shark remains (*Dwykaselachus*) are recorded near Prince Albert on the southern margin of the Great

Karoo (Oelofsen 1986). Microfossil remains in this formation include sponge spicules, foraminiferal and radiolarian protozoans, acritarchs and miospores.

The most diverse, as well as biostratigraphically, palaeobiogeographically and palaeoecologically interesting, fossil biota from the Prince Albert Formation is that described from calcareous concretions exposed along the Vaal River in the Douglas area to the west of Kimberley (McLachlan and Anderson 1973, Visser *et al.,* 1977-78). The important Douglas biota contains petrified wood (including large tree trunks), palynomorphs (miospores), orthocone nautiloids, nuculid bivalves, articulate brachiopods, spiral and other "coprolites" (probably of fish, possibly including sharks) and fairly abundant, well-articulated remains of palaeoniscoid fish. Most of the fish have been assigned to the palaeoniscoid genus *Namaichthys* but additional taxa, including a possible acrolepid, may also be present here (Evans 2005). The invertebrates are mainly preserved as moulds.

The most important known fossil sites from the Prince Albert Formation are located close to the confluence of the Vaal and Riet Rivers near Douglas, only some 70km to the southwest of the Platfontein study area. The possibility of palaeontologically important fossils also occurring within this rock unit near Kimberley is therefore significant. This could not be tested during fieldwork, however, since the Prince Albert Formation is hardly exposed at all on Platfontein. Float fragments of diagenetic carbonate nodules that have probably weathered out from the Ecca Group (Fig. 9) show fossil-like cone-in-cone structures (stromatolite-like pseudofossils) but no true fossils such as plant or fish remains were seen within them.

4.3. Fossils within the superficial deposits

The fossil record of the **Kalahari Group** is generally sparse and low in diversity. The **Gordonia Formation** dune sands were mainly active during cold, drier intervals of the Pleistocene Epoch that were inimical to most forms of life, apart from hardy, desert-adapted species. Porous dune sands are not generally conducive to fossil preservation. However, mummification of soft tissues may play a role here and migrating lime-rich groundwaters derived from the underlying bedrocks (including, for example, dolerite) may lead to the rapid calcretisation of organic structures such as burrows and root casts. Occasional terrestrial fossil remains that might be expected within this unit include calcretized rhizoliths (root casts) and termitaria (*e.g. Hodotermes*, the harvester termite), ostrich egg shells (*Struthio*) and shells of land snails (*e.g. Trigonephrus*) (Almond 2008a, Almond & Pether 2008). Other fossil groups such as freshwater bivalves and gastropods (*e.g. Corbula, Unio*) and snails, ostracods (seed shrimps), charophytes (stonewort algae), diatoms (microscopic algae within siliceous shells) and stromatolites (laminated microbial limestones) are associated with local watercourses and pans. Microfossils such as diatoms may be blown by wind into nearby dune sands (Du Toit 1954, Dingle *et al*., 1983). These Kalahari fossils (or subfossils) can be expected to occur sporadically but widely, and the overall palaeontological sensitivity of the Gordonia Formation is therefore considered to be low. Underlying calcretes might also contain trace fossils such as rhizoliths, termite and other insect burrows, or even mammalian trackways. Mammalian bones, teeth and horn cores (also tortoise remains, and fish, amphibian or even crocodiles in wetter depositional settings such as pans) may be expected occasionally expected within Kalahari Group sediments and calcretes, notably those associated with ancient alluvial gravels.

The "Older" Vaal River Gravels (**Windsorton Formation**) of possible Miocene-Pliocene age have not yet yielded well-dated fossil biotas (Partridge *et al.,* 2006). A "sparse, poorly provenanced vertebrate fauna from diamond diggings" is noted herein by De Wit *et al.* (2000) who favour a Pliocene age (4.5-3.5 Ma). In contrast, a wide range of Pleistocene mammal remains (bones, teeth) as well as Acheulian stone tools are recorded from the "Younger" Vaal River Gravels or **Rietputs Formation** (Cooke 1949, Wells 1964, Partridge & Brink 1967, Butzer et al. 1973, Helgren 1977, Klein 1984, Bosch 1993). These are assigned to the Mid Pleistocene Cornelian Mammal Age and include various equids and artiodactyls as well as African elephant and hippopotamus (See MacRae 1990, De Wit 2008 for brief reviews, and Gibbon *et al.* 2009 for recent dating of the matrix).

Equivalents of the Vaal River Gravels are not seen on Platfontein. No fossils were recorded within the superficial sediments here. Buried fossils or subfossils may be associated with the pan sediments in the northern part of the farm, but were not observed at surface. Multi-layered, partialy reworked surface calcretes were carefully examined for embedded fossil snail shells, which may be abundant in similar settings near the coast, without success.

5. CONCLUSIONS & RECOMMENDATIONS

Impacts on fossil heritage are normally confined to the construction phase of a solar power development. This phase development will normally entail shallow excavations into the superficial sediment cover (soils, alluvial gravels *etc*) and perhaps also into the underlying potentially fossiliferous bedrock. These notably include excavations for the PV panel support structures, buried cables, access roads, any new power line pylons and foundations for associated infrastructure. All these developments may adversely affect potential fossil heritage within the study area by destroying, disturbing or permanently sealing-in fossils that are then no longer available for scientific research or other public good. Once constructed, the operational and decommissioning phases of the PV power station will not involve further adverse impacts on palaeontological heritage, however.

The proposed !Xun and Khwe solar power facility study area is underlain at depth by ancient Precambrian lavas of the Ventersdorp Supergroup (Allanridge Formation) of Late Archaean age (*c.* 2.7 billion years old) that are not palaeontologically sensitive. In the proposed PV and CSP development sites the Precambrian bedrocks are mantled by Kalahari sands that are likewise of low palaeontological sensitivity. Potentially fossiliferous Early Permian sediments of the Prince Albert Formation (Lower Ecca Group) probably do not underlie the proposed CSP and PV development sites. The Ecca Group outcrop area lies further to the west and is almost entirely mantled by calcretes, silty soils and sheetwash gravels. Direct impacts on the potentially fossiliferous Ecca Group bedrocks are therefore not anticipated. Ancient alluvial gravels of the Windsorton Formation are mapped just to the northeast of the study area but not on Platfontein itself which lies some 4 km distant from the Vaal River. Thin, widespread surface gravels on Platfontein are downwasted, dominated by basement lithologies and reworked by sheetwash. They do not appear to contain reworked petrified wood or other fossil material from the Ecca bedrocks.

It is concluded that the proposed !Xun and Khwe solar power facility is unlikely to have a significant impact on local palaeontological heritage resources. Should substantial fossil remains be exposed during construction, however, such as well-preserved fossil fish, reptiles or petrified wood, the ECO should safeguard these, preferably *in situ*, and alert SAHRA as soon as possible so that appropriate action (*e.g.* recording, sampling or collection) can be taken by a professional palaeontologist.

6. ACKNOWLEDGEMENTS

Ms Karen van Ryneveld of ArchaeoMaps, Beacon Bay, and Ms Elbi Bredenkamp of Enviroworks, Bloemfontein, are both thanked for commissioning this study and for kindly providing all the necessary background information. I am grateful to Madelon Tusenius for assisting with GPS data handling.

TABLE 1: SUMMARY OF FOSSIL HERITAGE IN THE KIMBERLEY AREA				
GEOLOGICAL UNIT	**ROCK TYPES & AGE**	**FOSSIL HERITAGE**	**PALAEONT-OLOGICAL SENSITIVITY**	**RECOMMENDED MITIGATION**
Gordonia Formation *etc* KALAHARI GROUP	**unconsolidated to semi-consolidated aeolian sands, locally calcretized at depth, calcrete hardpans QUATERNARY**	**Calcretised rhizoliths & termitaria, ostrich egg shells, land snail shells, rare mammalian and reptile (*e.g.* tortoise) bones, teeth Freshwater units associated with diatoms, molluscs, stromatolites *etc***	**LOW**	**Any substantial fossil finds to be reported by ECO to SAHRA**
KAROO DOLERITE SUITE	**Dolerite intrusions (sills, dykes) Early Jurassic (*c.* 183 Ma)**	**None**	**ZERO**	**None recommended**
Prince Albert Formation ECCA GROUP	**basinal mudrocks with carbonate & phosphatic concretions, minor tuffs EARLY PERMIAN**	**Marine invertebrates (esp. molluscs, brachiopods), coprolites, palaeoniscoid fish & sharks, trace fossils, various microfossils, petrified wood**	**POSSIBLY HIGH IN THIS AREA**	**Field assessment by qualified palaeontologist Any substantial fossil finds to be reported by ECO to SAHRA**
Allanridge Formation VENTERSDORP SUPERGROUP	**lavas and pyroclastics with minor siliciclastic lenses LATE ARCHAEAN (c. 2.7 Ga)**	**None (Stromatolites recorded from sediments of underlying Bothaville Formation)**	**INSENSITIVE**	**None recommended**

7. REFERENCES

ALMOND, J.E. 2008a. Fossil record of the Loeriesfontein sheet area (1: 250 000 geological sheet 3018). Unpublished report for the Council for Geoscience, Pretoria, 32 pp.

ALMOND, J.E. 2008b. Palaeozoic fossil record of the Clanwilliam sheet area (1: 250 000 geological sheet 3218). Unpublished report for the Council for Geoscience, Pretoria, 49 pp. (To be published by the Council in 2009).

ALMOND, J.E. 2010a. Eskom Gamma-Omega 765kV transmission line: Phase 2 palaeontological impact assessment. Sector 1: Tanqua Karoo to Omega Substation (Western and Northern Cape Provinces), 95 pp. Natura Viva cc, Cape Town.

ALMOND, J.E. 2010b. Proposed photovoltaic power station adjacent to Herbert Substation near Douglas, Northern Cape Province. palaeontological impact assessment: field scoping study, 21 pp. Natura Viva cc, Cape Town.

ALMOND, J.E. 2011a. Proposed Droogfontein Solar Power Project on the farm Droogfontein 62 near Kimberley, Northern Cape Province, 17 pp. Natura Viva cc, Cape Town.

ALMOND, J.E. 2011b. Proposed Mainstream solar park near Douglas, Northern Cape Province. palaeontological specialist study: preliminary desktop screening assessment, 27 pp. Natura Viva cc, Cape Town.

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

ANDERSON, A.M. 1974. Arthropod trackways and other trace fossils from the Early Permian lower Karoo Beds of South Africa. Unpublished PhD thesis, University of Witwatersrand, Johannesburg, 172 pp.

ANDERSON, A.M. 1975. Turbidites and arthropod trackways in the Dwyka glacial deposits (Early Permian) of southern Africa. Transactions of the Geological Society of South Africa 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 Groups of South Africa. Journal of Paleontology 55: 84-108, pls. 1-4.

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 Karoo Basin, South Africa. Palaeontologia africana 19: 31-42.

ANDERSON, J.M. 1977. The biostratigraphy of the Permian and the Triassic. Part 3: A review of Gondwana Permian palynology with particular reference to the northern Karoo Basin, South Africa. Memoirs of the Botanical Survey of South Africa 45, 14-36.

ANDERSON, J.M. & ANDERSON, H.M. 1985. Palaeoflora of southern Africa. Prodromus of South African megafloras, Devonian to Lower Cretaceous, 423 pp, 226 pls. Botanical Research Institute, Pretoria & Balkema, Rotterdam.

BAMFORD, M.K. 2000. Fossil woods of Karoo age deposits in South Africa and Namibia as an aid to biostratigraphical correlation. Journal of African Earth Sciences 31, 119-132.

BAMFORD, M.K. 2004. Diversity of woody vegetation of Gondwanan South Africa. Gondwana Research 7, 153-164.

BOSCH, P.J.A. 1993. Die geologie van die gebied Kimberley. Explanation to 1: 250 000 geology Sheet 2824 Kimberley, 60 pp. Council for Geoscience, Pretoria.

BUTZER, K.W., HELGREN, D.M., FOCK, G. & STUCKENRATH, R. 1973. Alluvial terraces of the Lower Vaal River, South Africa: a re-appraisal and re-investigation. Journal of geololgy 81, 341-362.

COLE, D.I. 2005. Prince Albert Formation. SA Committee for Stratigraphy, Catalogue of South African Lithostratigraphic Units 8: 33-36.

COOKE, H.B.S. 1949. Fossil mammals of the Vaal River deposits. Memoirs of the geological Survey of South Africa 35, 1-117.

DE WIT, M.C.J. 2008. Canteen Koppie at Barkly West: South Africa's first diamond mine. South African Journal of Geology 111, 53-66.

DE WIT, M.C.J., MARSHALL, T.R. & PARTRIDGE, T.C. 2000. Fluvial deposits and drainage evolution. In: Partridge, T.C. & Maud, R.R. (Eds.) The Cenozoic of southern Africa, pp.55-72. Oxford University Press, Oxford.

DINGLE, R.V., SIESSER, W.G. & NEWTON, A.R. 1983. Mesozoic and Tertiary geology of southern Africa. viii + 375 pp. Balkema, Rotterdam.

DU TOIT, A. 1954. The geology of South Africa. xii + 611pp, 41 pls. Oliver & Boyd, Edinburgh.

ENGELBRECHT, L.N.J. 1973. Die geologie van die gebied tussen Kimberley en Barkley-Wes, Kaapprovinsie. Unpublished MSc thesis, University of the OFS, 105 pp.

EVANS, F.J.E. 2005. Taxonomy, palaeoecology and palaeobiogeography of some Palaeozoic fish of southern Gondwana. Unpublished PhD thesis, University of Stellenbosch, 628 pp.

GIBBON, R.J., GRANGER, D.E., KUMAN, K. PARTRIDGE, T.C. 2009. Early Acheulean technology in the Rietputs Formation, South Africa, dated with cosmogenic nuclides. Journal of Human Evolution 56, 152-160.

HADDON, I.G. 2000. Kalahari Group sediments. In: Partridge, T.C. & Maud, R.R. (Eds.) The Cenozoic of southern Africa, pp. 173-181. Oxford University Press, Oxford.

HELGREN, D.M. 1977. Geological context of the Vaal River faunas. South African Journal of Science 73, 303-307.

JOHNSON, M.R. 2009. Ecca Group. SA Committee for Stratigraphy Catalogue of South African lithostratigraphic units 10, 5-7. Council for Geoscience, Pretoria.

JOHNSON, M.R., VAN VUUREN, C.J., VISSER, J.N.J., COLE, D.I., De V. WICKENS, H., CHRISTIE, A.D.M., ROBERTS, D.L. & BRANDL, G. 2006. Sedimentary rocks of the Karoo Supergroup. In: Johnson, M.R., Anhaeusser, C.R. & Thomas, R.J. (Eds.) The geology of South Africa, pp. 461-499. Geological Society of South Africa, Marshalltown.

KLEIN, R.G. 1984. The large mammals of southern Africa: Late Pliocene to Recent. In: Klein, R.G. (Ed.) Southern African prehistory and paleoenvironments, pp 107-146. Balkema, Rotterdam.

MACRAE , C. 1999. Life etched in stone. Fossils of South Africa. 305 pp. The Geological Society of South Africa, Johannesburg.

McLACHLAN, I.R. & ANDERSON, A. 1973. A review of the evidence for marine conditions in southern Africa during Dwyka times. Palaeontologia africana 15: 37-64.

OELOFSEN, B.W. 1986. A fossil shark neurocranium from the Permo-Carboniferous (lowermost Ecca Formation) of South Africa. In: Uyeno, T, Arai, R., Taniuchi, T & Matsuura, K. (Eds.) Indo-Pacific fish biology. Proceedings of the Second International Conference on Indo-Pacific Fishes. Ichthyological Society of Japan, Tokyo, pp 107-124.

PARTRIDGE, T.C. & BRINK, A.B.A. 1967. Gravels and terraces of the lower Vaal River basin. South African Geographical Journal 49, 21-38.

PARTRIDGE, T.C. & SCOTT, L. 2000. Lakes and Pans. In: Partridge, T.C. & Maud, R.R. (Eds.) The Cenozoic of southern Africa, pp.145-161. Oxford University Press, Oxford.

PARTRIDGE, T.C., BOTHA, G.A. & HADDON, I.G. 2006. Cenozoic deposits of the interior. In: Johnson, M.R., Anhaeusser, C.R. & Thomas, R.J. (Eds.) The geology of South Africa, pp. 585-604. Geological Society of South Africa, Marshalltown.

POTGIETER, G.J.A. 1974. The geology of an area south of Kimberley, 91 pp. Unpublished MSc Thesis, University of the Orange Free State.

SCHOLTZ, A. 1985. The palynology of the upper lacustrine sediments of the Arnot Pipe, Banke, Namaqualand. Annals of the South African Museum 95: 1-109.

SCHOPF, J.W. 2006. Fossil evidence of Archaean life. Philosophical Transactions of the Royal Society of London B 361, 869-885.

SKINNER, E.M.W. & TRUSWELL, J.F. 2006. Kimberlites. In: Johnson, M.R., Anhaeusser, C.R. & Thomas, R.J. (Eds.) The geology of South Africa, pp. 651-659. Geological Society of South Africa, Marshalltown.

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

SMITH, R.M.H. 1986b. Crater lakes in the age of dinosaurs. Sagittarius 1: 10-15.

SMITH, R.M.H. 1988. Palaeoenvironmental reconstruction of a Cretaceous crater-lake deposit in Bushmanland, South Africa. Palaeoecology of Africa and the surrounding islands 19: 27-41, pls. 1-8.

SMITH, R.M.H. 1995. Life in a prehistoric crater lake. The Phoenix. Magazine of the Albany Museum 8: 4-6.

THERON, J.N., WICKENS, H. DE V. & GRESSE, P.G. 1991. Die geologie van die gebied Ladismith. Explanation to 1: 250 000 geology sheet 3320, 99 pp. Council for Geoscience, Pretoria.

THOMAS, D.S.G. & SHAW, P.A. 1991. The Kalahari environment, 284pp. Cambridge University Press.

THOMAS, M.J. 1981. The geology of the Kalahari in the Northern Cape Province (Areas 2620 and 2720). Unpublished MSc thesis, University of the Orange Free State, Bloemfontein, 138 pp.

THOMAS, R.J., THOMAS, M.A. & MALHERBE, S.J. 1988. The geology of the Nossob and Twee Rivieren areas. Explanation for 1: 250 000 geology sheets 2520-2620. 17pp. Council for Geoscience, Pretoria.

VAN DER WESTHUIZEN, W.A. & DE BRUIYN, H. 2006. The Ventersdorp Supergroup. In: Johnson, M.R., Anhaeusser, C.R. & Thomas, R.J. (Eds.) The geology of South Africa, pp. 187-208. Geological Society of South Africa, Marshalltown.

VISSER, J.N.J. 1992. Deposition of the Early to Late Permian Whitehill Formation during a sea-level highstand in a juvenile foreland basin. South African Journal of Geology 95: 181-193.

VISSER, J.N.J. 1994. A Permian argillaceous syn- to post-glacial foreland sequence in the Karoo Basin, South Africa. In Deynoux, M., Miller, J.M.G., Domack, E.W., Eyles, N. & Young, G.M. (Eds.) Earth's Glacial Record. International Geological Correlation Project Volume 260, pp. 193-203. Cambridge University Press, Cambridge.

VISSER, J.N.J., LOOCK, J.C., VAN DER MERWE, J., JOUBERT, C.W., POTGIETER, C.D., MCLAREN, C.H., POTGIETER, G.J.A., VAN DER WESTHUIZEN, W.A., NEL, L. & LEMER, W.M. 1977-78. The Dwyka Formation and Ecca Group, Karoo Sequence, in the northern Karoo Basin, Kimberley-Britstown area. Annals of the Geological Survey of South Africa 12, 143-176.

WELLS, L.H. 1964. The Vaal River 'Younger Gravels" faunal assemblage: a revised list. South African Journal of Science 60, 92-94.

ZAWADA, P.K. 1992. The geology of the Koffiefontein area. Explanation of 1: 250 000 geology sheet 2924 Koffiefontein, 30 pp. Council for Geoscience, Pretoria.

Appendix: GPS LOCALITY DATA

All GPS readings were taken in the field using a hand-held Garmin GPSmap 60CSx instrument. The datum used is WGS 84.

Locality number	**South**	**East**	**Comments**
486	S28 42 19.9	E24 38 05.1	Allanridge Fm boulders mantled in Kalahari sands, CSP site area
487	S28 39 56.4	E24 36 28.5	Low rocky exposure of Allanridge lavas
488	S28 40 23.8	E24 35 40.4	Oblate diagenetic carbonate nodules as float blocks; probably weathered out of Prince Albert Fm
489	S28 40 39.8	E24 35 12.6	Surface calcretes
490	S28 40 03.3	E24 36 21.7	Downwasted gravels reworked by sheetwash
491	S28 39 54.0	E24 36 35.0	Allanridge Fm exposure showing vesicular tops of lava flows
492	S28 39 54.3	E24 36 41.5	Surface gravels, some coarse. Ferruginous mudrocks, probably Prince Albert Formation

QUALIFICATIONS & EXPERIENCE OF THE AUTHOR

Dr John Almond has an Honours Degree in Natural Sciences (Zoology) as well as a PhD in Palaeontology from the University of Cambridge, UK. He has been awarded post-doctoral research fellowships at Cambridge University and in Germany, and has carried out palaeontological research in Europe, North America, the Middle East as well as North and South Africa. For eight years he was a scientific officer (palaeontologist) for the Geological Survey / Council for Geoscience in the RSA. His current palaeontological research focuses on fossil record of the Precambrian - Cambrian boundary and the Cape Supergroup of South Africa. He has recently written palaeontological reviews for several 1: 250 000 geological maps published by the Council for Geoscience and has contributed educational material on fossils and evolution for new school textbooks in the RSA.

Since 2002 Dr Almond has also carried out palaeontological impact assessments for developments and conservation areas in the Western, Eastern and Northern Cape under the aegis of his Cape Town-based company *Natura Viva* cc. He is a long-standing member of the Archaeology, Palaeontology and Meteorites Committee for Heritage Western Cape (HWC) and an advisor on palaeontological conservation and management issues for the Palaeontological Society of South Africa (PSSA), HWC and SAHRA. He is currently compiling technical reports on the provincial palaeontological heritage of Western, Northern and Eastern Cape, Limpopo, Gauteng and Free State for SAHRA and HWC. Dr Almond is an accredited member of PSSA and APHP (Association of Professional Heritage Assessment Practitioners – Western Cape).

Declaration of Independence

I, John E. Almond, declare that I am an independent consultant and have no business, financial, personal or other interest in the proposed development project, application or appeal in respect of which I was appointed other than fair remuneration for work performed in connection with the activity, application or appeal. There are no circumstances that compromise the objectivity of my performing such work.

Dr John E. Almond
Palaeontologist
***Natura Viva* cc**