PALAEONTOLOGICAL ASSESSMENT: DESKTOP STUDY

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

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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 86 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 by ancient Precambrian lavas of the Ventersdorp Supergroup (Allanridge Formation) of Late Archaean age (*c*. 2.7 billion years old) as well as by Early Permian mudrocks of the Ecca Group (Prince Albert Formation).

The Allanridge lavas are not palaeontologically sensitive. However, well-preserved glacial pavements incised into these ancient rocks record the movement of the Dwyka ice sheets across the area some 300 million years ago and warrant recording and protection as geo-conservation sites.

Highly fossiliferous exposures of the Prince Albert Formation are known along the Vaal River at Douglas, only 70km to the south-west of Platfontein, so further fossil occurrences from the same rock unit within the study area are quite likely.

Over large areas of Platfontein the Precambrian and Palaeozoic bedrocks are mantled by several meters of aeolian sands of the Kalahari Group (Gordonia Formation) that are of low palaeontological sensitivity, as are also the associated calcretes.

It is recommended that a qualified palaeontologist undertake a field assessment of the Platfontein Farm to determine whether or not palaeontologically significant fossil heritage occurs here and to make recommendations for appropriate conservation and mitigation measures, if any are needed. At the same time, geosites of conservation and research interest within the study area – notably any well-preserved glacial pavements - should be recorded, and any conservation or mitigation issues addressed.

Should substantial fossil remains be exposed during construction, 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 86 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.

The proposed study area (Platfontein Farm) overlies Precambrian bedrocks of the Ecca Group (Karoo Supergroup) that is reported to be highly fossiliferous in the Kimberley – Douglas region. A desktop palaeontological impact 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 desktop study

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, (3) previous palaeontological heritage assessments for alternative energy and other developments in the region (*e.g.* Almond 2010b, 2011a, 2011b).

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.

2.3. Assumptions & 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.

In the case of palaeontological desktop studies without supporting Phase 1 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.

The major limitation on this study is the lack of published work on the palaeontology of the region.

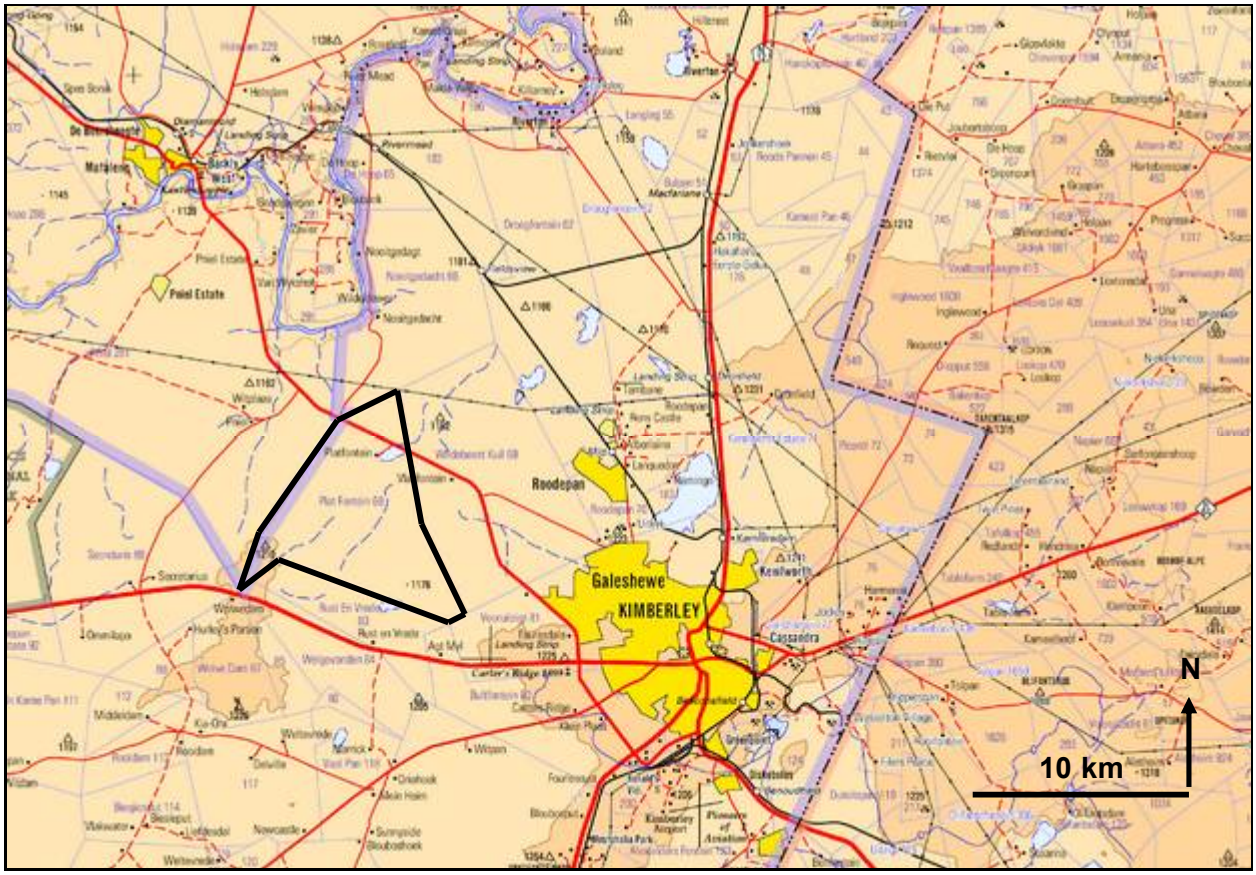

Fig. 1. Extract from 1: 250 000 topographical map 2824 Kimberley (Courtesy of the Chief Directorate of Surveys & Mapping, Mowbray) showing location of the !Xun and Khwe solar project study area on the northwestern outskirts of Kimberley, Northern Cape Province (black polygon). See also satellite image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

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 Patfontein several small inliers of basement rocks are mapped as the **Allanridge Formation** (**Ra**) at the top of the **Venterdorp Supergroup**. This Late Archaean succession is almost entirely composed of resistant-weathering, dark 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). Since these ancient basement rocks are not known to be fossiliferous, however, they will not be considered further here. Conical stromatolites are recorded from the underlying Bothaville Formation of the Platberg Group (Schopf 2006) which is not mapped within the study area, however.

A number of **glacial pavements** - glacially-striated and eroded bedrocks - of Dwyka age (*i.e.* Permo-Carboniferous, *c.* 300 Ma) are indicated 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.

The central portion of Platfontein is largely underlain by laminated 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 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.

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).

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 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.

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).

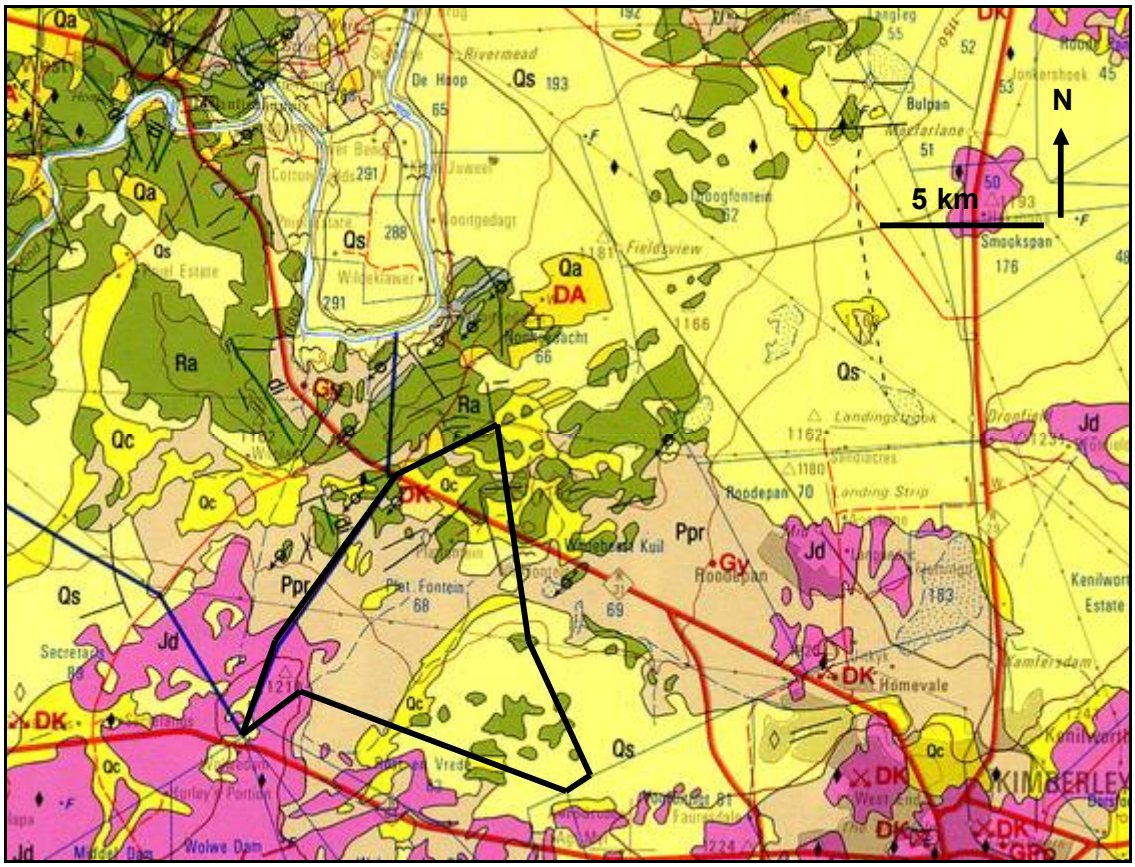

Fig. 3. Extract from the 1: 250 000 geological map 2824 Kimberley (Council for Geoscience, Pretoria) showing the location of Farm Platfontein to the NW of Kimberley (black polygon).

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

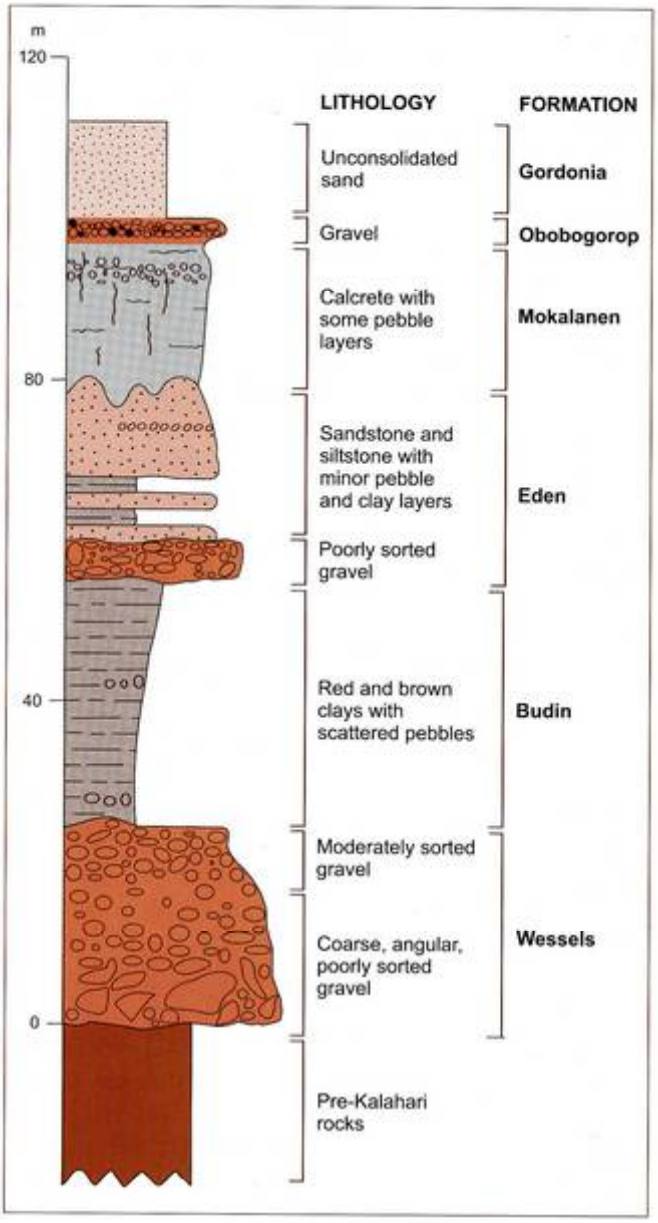

Fig. 4. Stratigraphy of the Kalahari Group (From Partridge *et al.*, 2006). Aeolian sands of the Gordonia Formation as well as calcretes *possibly* equivalent to the Mokalanen Formation are represented in the study area.

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.

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 2010). 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 high.

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).

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) as well as by Early Permian mudrocks of the Ecca Group (Prince Albert Formation). The Allanridge lavas are not palaeontologically sensitive. However, well-preserved glacial pavements incised into these ancient rocks record the movement of the Dwyka ice sheets across the area some 300 million years ago and warrant recording and protection as geo-conservation sites. Highly fossiliferous exposures of the Prince Albert Formation are known along the Vaal River at Douglas, only 70km to the south-west of Platfontein, so further fossil occurrences from the same rock unit within the study area are quite likely.

Over large areas of Platfontein the Precambrian and Palaeozoic bedrocks are mantled by several meters of aeolian sands of the Kalahari Group (Gordonia Formation) that are of low palaeontological sensitivity, as are also the associated calcretes. 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.

It is recommended that a qualified palaeontologist undertake a field assessment of the Platfontein Farm to determine whether or not palaeontologically significant fossil heritage occurs here and to make recommendations for appropriate conservation and mitigation measures, if any are needed. At the same time, geosites of conservation and research interest within the study area – notably any well-preserved glacial pavements - should be recorded, and any conservation or mitigation issues addressed.

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.

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

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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.

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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.

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