PALAEONTOLOGICAL HERITAGE ASSESSMENT: DESKTOP STUDY:

Proposed PV Solar Facility on Portion 1 of the farm Hanskopfontein 40 near Kimberley, Northern Cape

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1. SUMMARY

The proposed 75 MW photovoltaic solar facility on Portion 1 of the farm Hanskopfontein 40, situated some 30 km north of Kimberley, Northern Cape, 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 Jurassic dolerite intrusions of the Karoo Dolerite Suite and Early Permian mudrocks of the Ecca Group (Prince Albert Formation). The Venterdorp lavas and Karoo dolerites do not contain fossils. Highly fossiliferous exposures of the Prince Albert Formation are known along the Vaal River at Douglas, *c*. 120 km to the south-west. However, at Hanskopfontein the Prince Albert sediments are extensively mantled and disrupted by Quaternary calcretes that are of low palaeontological sensitivity. Potentially fossiliferous, fresh (unweathered) Prince Albert rocks are therefore unlikely to be intersected by surface clearance or excavations during construction.

The overall impact significance of the proposed development for local fossil heritage is considered to be LOW and, pending the discovery of substantial new fossils during construction, specialist palaeontological mitigation for this project is not considered necessary.

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. The palaeontologist concerned would need to apply beforehand for a fossil collection permit from SAHRA.

2. INTRODUCTION & BRIEF

The company 2012/077659/07 (South Africa) (Pty) Ltd. is proposing to construct a 75 MW photovoltaic solar facility on the farm Hanskopfontein 40, Kimberley RD (Sol Plaatje Local Municipality), Northern Cape. The study site is situated on level ground on the eastern side of the Vaal River approximately 30 km north of Kimberley and 30 km east of Barkley West. The location of the proposed development is shown on the map Fig. 1 and on a satellite image of the study area is shown in Fig. 2.

The footprint of the proposed alternative energy project will be approximately 133 hectares (including supporting infrastructure). The main infrastructural components of the solar facility that are of relevance to the present fossil heritage study include:

- a photovoltaic (PV) panel array tilted at a fixed angle towards the north;
- building infrastructure including a new on-site control facility with a footprint of 400 m^2 or less;
- electrical infrastructure including an on-site 22/132 kV distribution substation (*c*. 90m x 120m) connected to the existing 132 kV overhead power line that runs *c*. 1 km to the west of the site;
- new or upgraded gravels roads (4 m wide) forming an internal site road network;
- fencing round the solar facility.

The proposed solar energy facility overlies potentially fossiliferous sediments of the Ecca Group (Karoo Supergroup) and Kalahari Group. Fossils preserved within the bedrock or superficial deposits may be disturbed, damaged or destroyed during the construction phase of the proposed project. 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 Heritage Resources Act (Act No. 25 of 1999). SAHRA has therefore requested a palaeontological heritage assessment of the proposed development (SAHRA Ref. no. 9/2/049/0001, 8 November 2012).

This desktop palaeontological study has accordingly been commissioned on behalf of the client 2012/077659/07 (South Africa) (Pty) Ltd by Mr Bennie J. Scheepers (Project Manager, Subsolar Energy (Pty) Ltd. Cell: +27 79 822 2455. Tel: +27 54 461 0293. Fax: 086 527 1258. Email: scheepers@subsolar.co.za).

The various categories of heritage resources recognised as part of the National Estate in Section 3 of the 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 2011.

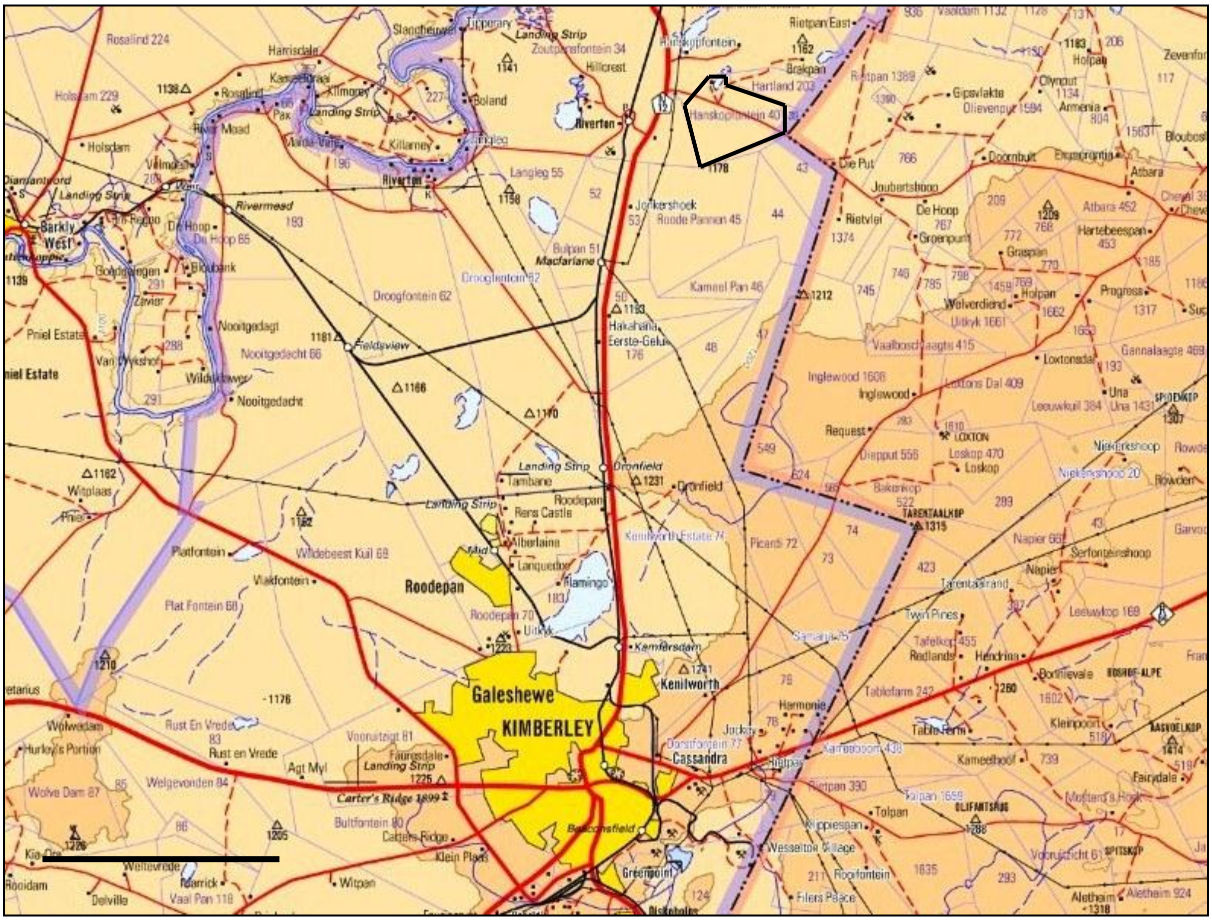

Fig. 1. Extract from 1: 250 000 topographical map 2824 Kimberley (Courtesy of the Chief Directorate of Surveys & Mapping, Mowbray) showing approximate location of the study area on farm Hanskopfontein 40 some 30 km north of Kimberley, Northern Cape Province (black polygon). Scale bar is *c*. 10 km.

Fig. 2. Google earth© satellite image of the study area on farm Hanskopfontein 40 located on the eastern side of the N12 Kimberley – Warrenton tar road some 30 km north of Kimberley. Yellow scale bar = *c*. 2 km.

2.2. General approach used for palaeontological desktop studies

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 exposed within the development footprint, a Phase 1 field-based 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, potentially 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. The palaeontologist concerned would need to apply beforehand for a collection permit from SAHRA. 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

3. GEOLOGICAL BACKGROUND

The Hanskopfontein study area is occupied by very flat-lying terrain at 1140-1170 m amsl (sloping gently northwards) situated some 8 to 9 km east of the Vaal River and less than one kilometer east of the N12 Kimberley to Warrenton tar road (Fig. 1). Bedrock exposure is very limited given the low relief. The northern portion of the area features a number of interconnected shallow pans (see satellite image in Fig. 2) that are in turn related to the west-flowing Leeurivier to the north, a east bank tributary of the Vaal River. 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).

A small area of basement rocks mapped as the **Allanridge Formation** (**Ra**) of the **Venterdorp Supergroup** is located in the SE corner of the study area and these rocks probably underlie some of the calcrete cover rocks elsewhere. The Late Archaean Allanridge 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.

Small inliers of laminated basinal mudrocks of the **Prince Albert Formation** (Ecca Group, Karoo Supergroup) (**Ppr**) are mapped in the southern and north-western portions of the study area. This unit of Early Permian (Asselian / Artinskian) age was previously known as "Upper Dwyka Shales" and reaches a thickness of 90 m 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 there are mantled with a thin veneer (*c*. 3m) of intrusive dolerite, Quaternary calcrete and reddish Kalahari sands (= Gordonia Formation). They mainly comprise shales with a band of ferruginous carbonate as well as a 6 m-thick zone of fossiliferous calcareous concretions that lies 9 m above the base of the formation.

The lower Ecca Group sediments in the southwestern and western portions of the study area are intruded by dolerite rocks of the **Karoo Dolerite Suite** (**Jd**). This suite comprises an extensive network of basic igneous bodies (dykes, sills) that were intruded into sediments of the Main Karoo Basin in the Early Jurassic Period, about 183 million years ago (Duncan & Marsh 2006). The dolerites form part of the Karoo Igneous Province of Southern Africa that developed in response to crustal doming and stretching preceding the break-up of Gondwana. Hard cappings of blocky, reddish-brown to rusty-weathering dolerite are a very typical feature of the flat-topped *koppies* in the Great Karoo region. The country rocks adjacent to the intrusions have often been extensively baked or thermally metamorphosed. Mudrocks are altered to flinty hornfels ("lydianite" of some authors), while sandstones are metamorphosed to resistant-weathering, siliceous quartzites. The Karoo rocks within the thermal aureole of the dolerite intrusions are also often chemically altered; they tend to be silicified, more brittle and contain numerous irregular *vugs* (cavities) lined or infilled with secondary minerals.

WSW to ENE trending **Kimberlite fissure intrusions** dated to 77-120 Ma are mapped in the study area where they intrude the Precambrian to Mesozoic bedrocks (open diamond symbols in Fig. 3; Bosch 1993 Table 8.1, Skinner & Truswell 2006). Weathered Kimberlite fissure fills appear at surface as a yellowish-green micaceous material and may enclose xenoliths of country rocks (Bosch 1993). These Early Cretaceous igneous rocks do not contain fossils. However, where crater-lake sediments associated with Kimberlite pipes 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).

The central and northern portions of the Hanskopfontein study area are mantled by superficial deposits of Quaternary to Recent age, especially **calcretes** of probable Quaternary age (**Qc**) that are included by some geologists within the Kalahari Group. The calcretes in the Kimberley sheet area are often associated with the Ecca Group outcrop area but may also represent calcretized wind-blown sands blown southeastwards out from numerous 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, 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. Pleistocene aeolian (wind-blown) sands of the **Gordonia Formation** (**Qs**) are mapped just to the west of the Hanskopfontein study area but not within the area itself. Small patches of Gondonia dune sands maybe expected here, however. The site is situated too far from the Vaal River for potentially fossiliferous Tertiary alluvial gravels (Qa) to be preserved here.

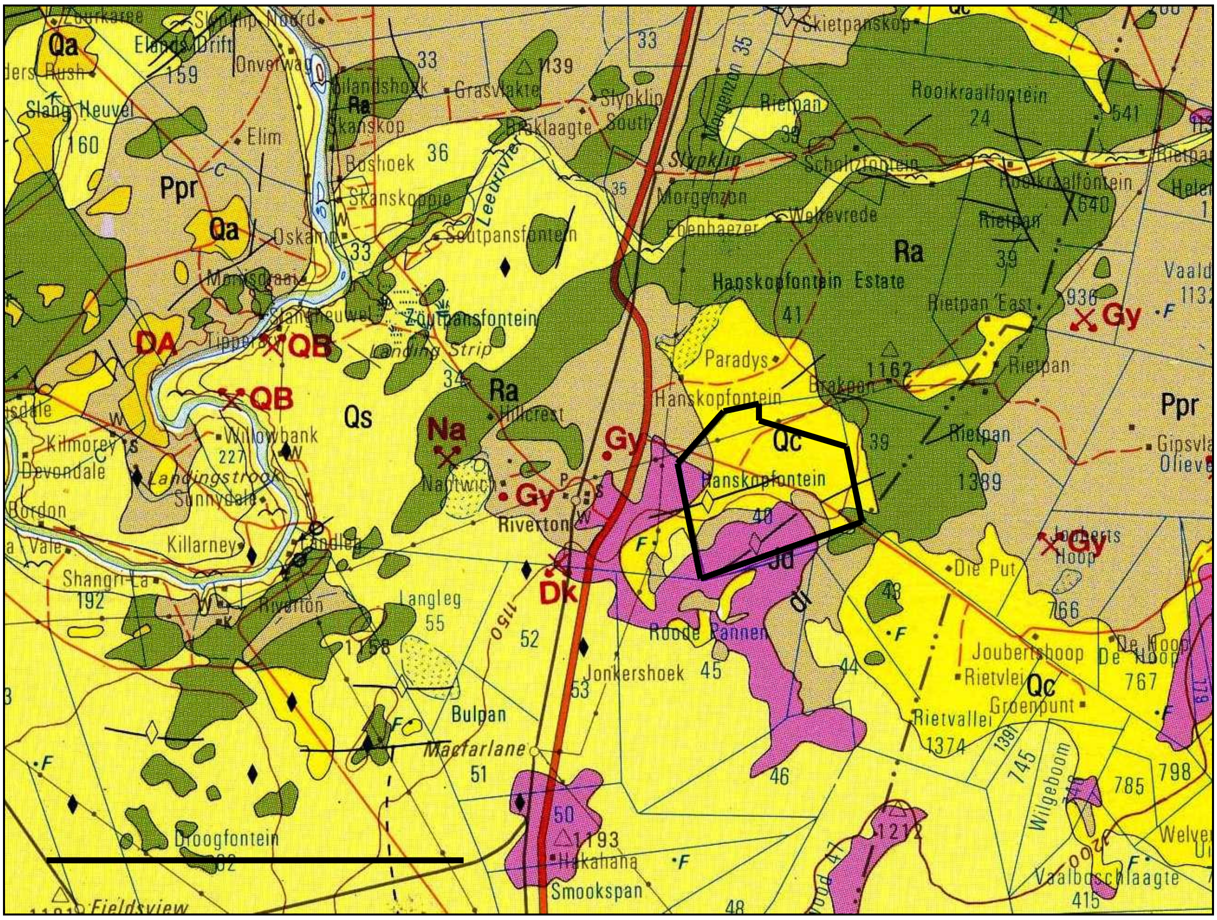

Fig. 3. Extract from the 1: 250 000 geological map 2824 Kimberley (Council for Geoscience, Pretoria) showing approximate location of study area on the farm Hanskopfontein 40 some 30 km north of Kimberley (black polygon). Scale bar = *c*. 10 km. The main geological units represented within the broader study region include:

Ra (dark green) = Allanridge Formation (Platberg Group, Ventersdorp Supergroup)
Ppr (buff) = Prince Albert Formation (Ecca Group, Karoo Supergroup)
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")**

Open and solid diamond symbols = kimberlite fissures and pipes respectively

*** These two units are not mapped within the boundaries of Hanskopfontein 40.**

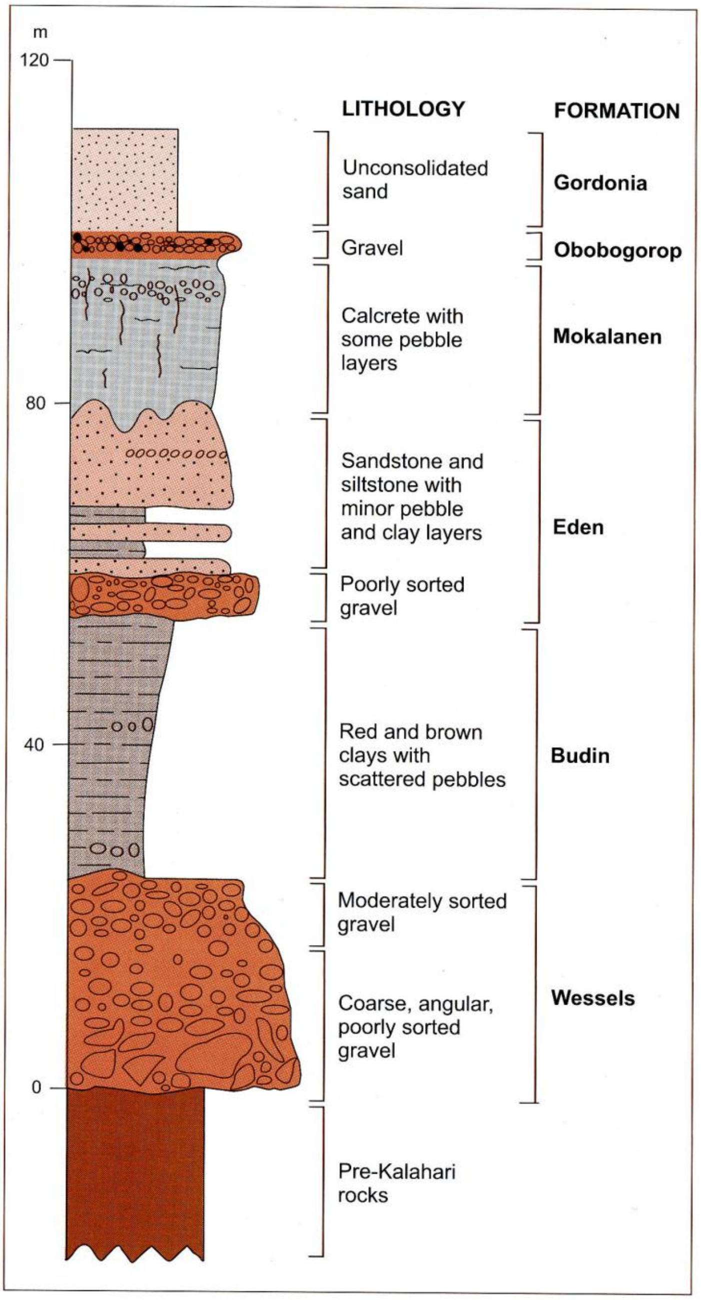

Fig. 4. Stratigraphy of the Kalahari Group (From Partridge *et al.,* 2006). Aeolian sands of the Gordonia Formation as well as calcretes *possibly* equivalent to the Mokalanen Formation are represented in the broader study region, but only the former are mapped on Hanskopfontein 40.

4. PALAEONTOLOGICAL HERITAGE

The fossil heritage recorded within each of the main sedimentary rock successions represented within the Hanskopfontein study region north of Kimberley is outlined here. See also the summary of fossil heritage provided in Table 1 below, which also covers the igneous rock units (*e.g.* Venterdorp Supergroup, Karoo Dolerite Suite, Kimberlite intrusions).

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). 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. Poorly-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.

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 and the **Quaternary calcretes** 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, Dorcasia, Achatina*) (Almond 2008a, Almond & Pether 2008). Other fossil groups such as freshwater bivalves (*e.g. Corbula, Unio*) and gastropods (*e.g. Planorbis, Viviparus*), 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 sponge spicules, diatoms, pollens and phytoliths may be preserved within calcretes or blown by wind into nearby dune sands (Du Toit 1954, Netterberg 1978, Dingle *et al*., 1983). 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. These Kalahari Group fossils (or subfossils) can be expected to occur sporadically but widely, and the overall palaeontological sensitivity of the Quaternary calcretes and Gordonia Formation is considered to be low.

TABLE 1: SUMMARY OF FOSSIL HERITAGE IN THE KIMBERLEY AREA				
GEOLOGICAL UNIT	ROCK TYPES & AGE	FOSSIL HERITAGE	PALAEONTOLOGICAL SENSITIVITY	RECOMMENDED MITIGATION
Gordonia Formation (Qs), calcretes (Qc) *etc* KALAHARI GROUP	unconsolidated to semi-consolidated aeolian sands, locally calcretized at depth, pan sediments QUATERNARY TO RECENT (± last 2.5 Ma)	calcretised rhizoliths & termitaria, ostrich egg shells, land snail shells, rare mammalian and reptile (*e.g.* tortoise) bones, teeth freshwater units associated with diatoms, freshwater molluscs, stromatolites *etc*	LOW (local concentrations of mammalian remains of high significance, however)	none recommended any substantial fossil finds (*e.g.* vertebrate fossils) to be reported by ECO to SAHRA
KIMBERLITE INTRUSIONS (diamond symbols)	Kimberlite / olivine melilitite / carbonatite volcanic pipes and related intrusions (fissure fills), sometime diamondiferous. JURASSIC, CRETACEOUS TO PALAEOCENE (*c*. 120 - 77 Ma)	rare fossiliferous xenoliths of country rocks (*e.g.* Beaufort Group sediments with fossil fish). Bryophytes, vascular plants (leaves, wood, fruit), fish, pipid frogs (adults, tadpoles), reptiles (tortoises, lizards), rare dinosaurs, birds (ratites), insects, ostracods, palynomorphs (bryophytes, ferns, gymnosperms, angiosperms) within crater lake sediments	LOW	none
KAROO DOLERITE SUITE (Jd)	intrusive dolerites (dykes, sills), associated diatremes EARLY JURASSIC (182-183 Ma)	no fossils recorded or expected	INSENSITIVE (intrusions also cause baking of adjacent fossiliferous sediments)	none
Prince Albert Formation (Ppr) 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	LOW IN THIS AREA	none recommended any substantial fossil finds to be reported by ECO to SAHRA
Allanridge Formation (Platberg Group) (Ra) VENTERSDORP SUPERGROUP	lavas and pyroclastics with minor siliciclastic lenses LATE ARCHAEAN (c. 2.7 Ga)	No fossils recorded	INSENSITIVE	none recommended stromatolites recorded from sediments of underlying Bothaville Formation

5. SIGNIFICANCE OF IMPACTS ON PALAEONTOLOGICAL HERITAGE

A brief assessment of the impact significance of the proposed Hanskopfontein photovoltaic solar facility development on local fossil heritage resources is presented here.

- **Nature of the impact**

Bedrock excavations and site clearance for the proposed PV panels, control building, any buried cables, the electrical substation as well as the internal site roads and powerline infrastructure may adversely affect potential fossil heritage within the study area by damaging, destroying, disturbing or permanently sealing-in fossils that are then no longer available for scientific research or other public good.

- **Extent and duration of the impact**

Significant impacts on fossil heritage are limited to the construction phase when excavations into fresh, potentially fossiliferous bedrock may take place. No further significant impacts are anticipated during the operational phase of the solar facility.

- **Probability of the impact occurring**

Given that the potentially fossiliferous Ecca Group bedrocks within the study area are (a) extensively mantled in fossil-poor superficial deposits (*e.g.* Quaternary calcrete, soils, possible aeolian sands), (b) often highly weathered and (c) baked by dolerite intrusions, while large scale bedrock excavations are not envisaged for this project, significant impacts on palaeontological heritage are considered unlikely.

- **Degree to which the impact can be reversed**

Impacts on fossil heritage are generally irreversible. Well-documented new records of any fossils revealed during construction would represent a positive impact from a scientific viewpoint.

- **Degree to which the impact may cause irreplaceable loss of resources**

Well-preserved and locally abundant fossils from the Prince Albert Formation, which is present beneath a substantial part of the Hanskopfontein study area, are already well-known from good rock exposures along the Vaal River in the neighbourhood of Douglas *c*. 120 km to the southwest. In contrast, the Prince Albert bedrocks at Hanskopfontein are mostly mantled by very sparsely fossiliferous Quaternary calcrete and other superficial deposits, have been baked by dolerite intrusion and are probably deeply weathered near-surface. The proposed development therefore does not pose a serious threat to local or regional fossil heritage and its impact is therefore rated as of LOW significance in palaeontological terms.

- **Degree to which the impact can be mitigated**

Pending the discovery of significant new fossil heritage during construction, specialist palaeontological mitigation is *not* regarded as warranted for this project. Should substantial fossil remains (*e.g.* petrified wood, fish, invertebrates) be exposed during the construction phase of the development, these should be safeguarded, preferably *in situ*, by the ECO and reported to SAHRA so that appropriate mitigation measures can be considered.

- **Cumulative impacts**

Previous desktop and field-based studies by the author for solar facility projects on the farms Platfontein and Droogfontein to the north of Kimberley (Almond 2011, 2012) concluded that impacts on local fossil heritage would probably be of low significance in both cases. A 19.5 MW solar plant has been proposed for a site on Portion 24 of the farm Zoutpansfontein 34 situated a few km west of Hanskopfontein while a 11.7 MW solar plant has been proposed on the north-western portion of the farm Hanskopfontein 40. In both cases, given the similar geological and geographic setting, the impacts on fossil heritage are likely to be low. Cumulative impacts on fossil heritage resulting from these various solar facility projects north of Kimberley are assessed as LOW.

6. CONCLUSIONS & RECOMMENDATIONS

The proposed Hanskopfontein photovoltaic solar facility 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 Jurassic dolerite intrusions of the Karoo Dolerite Suite and Early Permian mudrocks of the Ecca Group (Prince Albert Formation). The Venterdorp lavas and Karoo dolerites do not contain fossils. Highly fossiliferous exposures of the Prince Albert Formation are known along the Vaal River at Douglas, *c*. 120 km to the south-west. However, at Hanskopfontein the Prince Albert sediments are extensively mantled and disrupted by Quaternary calcretes that are of low palaeontological sensitivity. Potentially fossiliferous, fresh (unweathered) Prince Albert rocks are therefore unlikely to be intersected by surface clearance or excavations during construction. The overall impact significance of the proposed development for local fossil heritage is considered to be LOW and, pending the discovery of substantial new fossils during construction, specialist palaeontological mitigation for this project is not considered necessary.

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. The palaeontologist concerned would need to apply beforehand for a fossil collection permit from SAHRA.

7. ACKNOWLEDGEMENTS

Mr Bennie J Scheepers (Project Manager, Subsolar Energy (Pty) Ltd.) is thanked for commissioning this study and for kindly providing all the necessary background information

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9. 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 for SAHRA and HWC. Dr Almond is an accredited member of PSSA and APHAP (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.

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