PALAEONTOLOGICAL HERITAGE BASIC ASSESSMENT: DESKTOP STUDY

Proposed RE Capital 3 Solar Development on the property Dyason's Klip near Upington , Northern Cape

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

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EXECUTIVE SUMMARY

It is proposed to develop a solar energy facility, known as the RE Capital 3 Solar Development, of approximately 225 MW generation capacity on the Remainder of Farm 454, Dyason's Klip. The property is situated on the north bank of the Orange River / Gariep c. 23 km WSW of Upington in the Khai Garib local Municipality, Northern Cape. The study area is in part underlain by potentially fossiliferous sedimentary rocks of Late Caenozoic age assigned to the Kalahari Group. These mainly comprise Quaternary to Recent calcretes, sandy to gravelly stream alluvium and wind-blown sands. The overall impact significance of the proposed solar energy facility is likely to be LOW, however, because:

- Much of the study area is underlain by igneous and metamorphic basement rocks (granites, gneisses *etc*) that are completely unfossiliferous;
- The overlying superficial sediments (wind-blown sands, alluvium *etc*) are generally of low palaeontological sensitivity;
- Extensive, deep excavations are unlikely to be involved in this sort of small-scale solar energy project.

Significant negative impacts on local fossil heritage are therefore unlikely to result from the proposed alternative energy development. Pending the discovery of substantial new fossil remains during construction, no further specialist palaeontological studies or mitigation for this project are considered necessary.

Should outcrop areas of potentially fossiliferous ancient Orange River alluvial gravels be identified (*e.g.* during geotechnical investigations) within the development footprint, however, these should be assessed by a professional palaeontologist before construction commences. The purposes of the field assessment study would be (a) to identify the rock units actually present, (b) to carry out judicious sampling of any fossil heritage currently exposed, together with pertinent geological and palaeontological data, (c) to determine the likely impact of the proposed development on local fossil heritage based on the new field-based information, and finally (d) to make recommendations for any no-go areas, buffer zones or further palaeontological mitigation deemed necessary for this project (*e.g.* comprehensive pre-construction sampling of near-surface surface fossil material, palaeontological monitoring of excavations). Note that further mitigation may be most useful during the construction phase of the development while fresh, potentially fossiliferous bedrock is still exposed.

In all cases, whether or not a professional palaeontologist is involved in mitigation:

- The ECO responsible for the development should be aware of the possibility of important fossils being present or unearthed on site and should monitor all substantial excavations into fresh (*i.e.* unweathered) sedimentary bedrock for fossil remains;

- In the case of any significant fossil finds (*e.g.* vertebrate teeth, bones, burrows, petrified wood, calcretised termitaria) during construction, these should be safeguarded - preferably in situ - and reported by the ECO as soon as possible to the relevant heritage management authority (South African Heritage Resources Agency. Contact details: SAHRA, 111 Harrington Street, Cape Town. PO Box 4637, Cape Town 8000, South Africa. Phone: +27 (0)21 462 4502. Fax: +27 (0)21 462 4509. Web: www.sahra.org.za) so that any appropriate mitigation by a palaeontological specialist can be considered and implemented, at the developer's expense;
- These recommendations should be incorporated into the EMP for the solar energy facility development.

The palaeontologist concerned with mitigation work will need a valid collection permit from SAHRA. All work would have to conform to international best practice for palaeontological fieldwork and the study (*e.g.* data recording fossil collection and curation, final report) should adhere to the minimum standards for Phase 2 palaeontological studies recently published by SAHRA (2013).

1. INTRODUCTION & BRIEF

It is proposed to develop a solar energy facility, known as the RE Capital 3 Solar Development, of approximately 225 MW generation capacity on the Remainder of Farm 454, Dyason's Klip. The property is situated on the north bank of the Orange River / Gariep *c*. 23 km WSW of Upington in the Khai Garib local Municipality, Northern Cape (Figs. 1 & 2). The project will be developed in three phases, each of 75 MW capacity, and the electricity generated will be fed into the national grid. The proposed development site covers an area of approximately 500 hectares and is located on a section of the farm (total area 5725.2828 ha) that is 5-10 km from the planned new Eskom MTS Substation. The EIA for the new MTS substation is being carried out independently by Eskom and the exact location of the substation is still to be publically announced.

The present palaeontological assessment report (PIA) covers the entire extent of Dyason's Klip including the proposed 'central' development footprint option of the solar energy facility (white area labelled 'C' in Fig. 2). Associated infrastructure includes a series of solar PV arrays and inverters, internal electrical reticulation and an internal road network. An on-site substation with transformer would also need to be constructed. Auxiliary buildings, including ablution, workshops and storage areas, are planned. A transmission line would also be required to distribute the generated electricity from the site to the Eskom substation and grid.

The study area for the proposed prospecting activities overlies potentially fossiliferous sediments of the Kalahari Group (Sections 3 & 4, Fig. 3). The construction phase of the solar energy facility will entail fresh excavations into the superficial sediment cover (soils, alluvium *etc*) and perhaps also into the underlying bedrock. These notably include excavations for the solar panel foundations, buried cables (probably around 1 m deep), new gravel roads with drainage trenches, and associated building infrastructure (*e.g.* workshops storage areas). In addition, sizeable areas of bedrock may be sealed-in or sterilized by infrastructure such as the solar field, ancillary buildings as well as a new gravel road system. All these developments may adversely affect fossil heritage at or near the surface 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 solar energy facility will not involve further adverse impacts on palaeontological heritage, however.

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). A palaeontological heritage basic assessment for the proposed prospecting project has accordingly been commissioned on behalf of the developer by Dr David Morris, McGregor Museum, Kimberley (Contact details: P.O. Box 316 Kimberley 8300. Tel 082 2224777. Email dmorriskby@gmail.com).

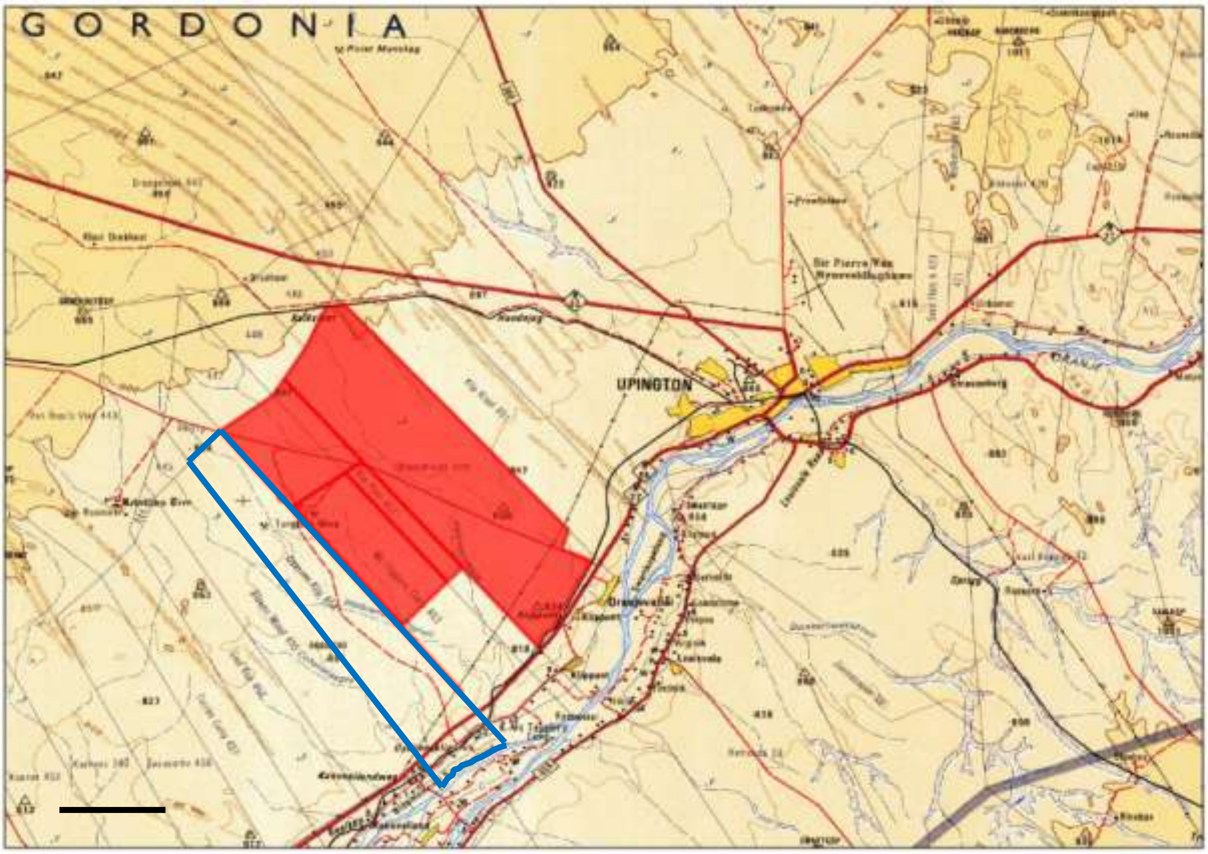

Fig. 1. Extract from 1: 250 000 topographical map 2820 Upington showing location of the study area on farm Dyason's Klip, situated *c*. 23 km WSW of Upington, Northern Cape (blue polygon). The adjacent Rooipunt Solar Power Plant study area (red polygon) to the east was the subject of a separate palaeontological assessment by Almond (2011) from which this image has been abstracted and modified. Scale bar = *c*. 5 km.

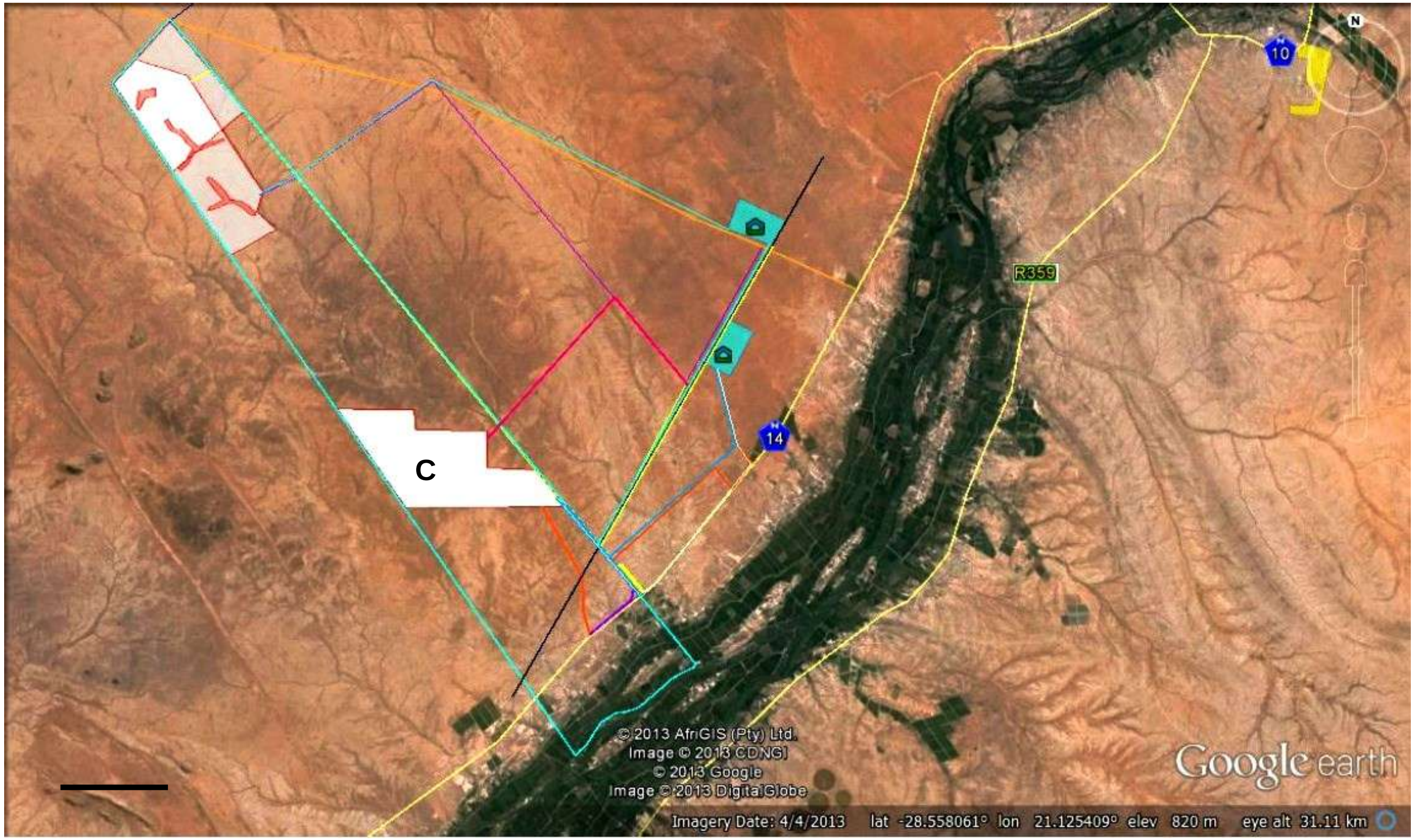

Fig. 2. Google earth© satellite image of the Dyason's Klip study area on the north bank of the Orange River / Gariep *c.* 23 km to the west of Upington (green polygon). The proposed 'central' development footprint option of the solar energy facility is indicated in white and labled 'C'. Scale bar = *c*. 3 km.

1.1. Legislative context of this palaeontological study

The various categories of heritage resources recognised as part of the National Estate in Section 3 of the National Heritage Resources Act (1999) include, among others:

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

According to Section 35 of the National Heritage Resources Act, dealing with archaeology, palaeontology and meteorites:
(1) The protection of archaeological and palaeontological sites and material and meteorites is the responsibility of a provincial heritage resources authority.
(2) All archaeological objects, palaeontological material and meteorites are the property of the State.
(3) Any person who discovers archaeological or palaeontological objects or material or a meteorite in the course of development or agricultural activity must immediately report the find to the responsible heritage resources authority, or to the nearest local authority offices or museum, which must immediately notify such heritage resources authority.
(4) No person may, without a permit issued by the responsible heritage resources authority—
(a) destroy, damage, excavate, alter, deface or otherwise disturb any archaeological or palaeontological site or any meteorite;
(b) destroy, damage, excavate, remove from its original position, collect or own any archaeological or palaeontological material or object or any meteorite;
(c) trade in, sell for private gain, export or attempt to export from the Republic any category of archaeological or palaeontological material or object, or any meteorite; or
(d) bring onto or use at an archaeological or palaeontological site any excavation equipment or any equipment which assist in the detection or recovery of metals or archaeological and palaeontological material or objects, or use such equipment for the recovery of meteorites.
(5) When the responsible heritage resources authority has reasonable cause to believe that any activity or development which will destroy, damage or alter any archaeological or palaeontological site is under way, and where no application for a permit has been submitted and no heritage resources management procedure in terms of section 38 has been followed, it may—
(a) serve on the owner or occupier of the site or on the person undertaking such development an order for the development to cease immediately for such period as is specified in the order;
(b) carry out an investigation for the purpose of obtaining information on whether or not an archaeological or palaeontological site exists and whether mitigation is necessary;
(c) if mitigation is deemed by the heritage resources authority to be necessary, assist the person on whom the order has been served under paragraph *(a)* to apply for a permit as required in subsection (4); and
(d) recover the costs of such investigation from the owner or occupier of the land on which it is believed an archaeological or palaeontological site is located or from the person proposing to undertake the development if no application for a permit is received within two weeks of the order being served.

Minimum standards for the palaeontological component of heritage impact assessment reports have been developed by SAHRA (2013).

2. APPROACH TO THE PALAEONTOLOGICAL HERITAGE ASSESSMENT

The information used in this desktop study was based on the following:

1. A short project outline and maps abstracted from the Archaeological Impact Assessment for the project by Morris (2013);

2. A review of the relevant scientific literature, including published geological maps, satellite images, and several previous desktop and field-based fossil heritage assessments in the area, notably the previous study for the adjacent Rooipunt Solar Power Park by Almond (2011);

3. The author's database on the formations concerned and their palaeontological heritage.

In preparing a palaeontological desktop study the potentially fossiliferous rock units (groups, formations *etc*) represented within the study area are determined from geological maps and satellite images. 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 following field assessment during the compilation of the final report). This data is then used to assess the palaeontological sensitivity of each rock unit to development. The potential 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 and scale of the development itself, most significantly the extent of fresh bedrock excavation envisaged. When rock units of moderate to high palaeontological sensitivity are present within the development footprint, a Phase 1 field assessment study by a professional palaeontologist is usually warranted to identify any palaeontological hotspots and make specific recommendations for any mitigation required before or during the construction phase of the development.

On the basis of the desktop and Phase 1 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. Phase 2 mitigation by a professional palaeontologist – normally involving the recording and sampling of fossil material and associated geological information (*e.g.* sedimentological data) may be required (a) in the pre-construction phase where important fossils are already exposed at or near the land surface and / or (b) during the construction phase when fresh fossiliferous bedrock has been exposed by excavations. 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 for the Northern Cape (Contact details: Mrs Colette Scheermeyer, P.O. Box 4637, Cape Town 8000. Tel: 021 462 4502. Email: cscheermeyer@sahra.org.za). 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.

2.1. 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.

In the case of the development projects in the Upington region the major limitation for fossil heritage assessments is the paucity of previous specialist palaeontological field studies in this region of the Northern Cape as well as the frequently low levels of sedimentary bedrock exposure. The relevant geological explanation for 1: 250 000 sheet 2820 by Moen (2007) includes almost no palaeontological data.

3. GEOLOGICAL BACKGROUND

3.1. Location and brief description of study area

The Dyason's Klip study area for the proposed RE Capital 3 Solar Development is situated in arid, sparsely-vegetated terrain at about 880 to 770 m amsl on the northern side of the Orange River some 20-25 km west of the town of Upington (Fig. 1. See also Morris, 2013). The N14 tar road and railway between Upington and Keimoes run close to the south-eastern boundary of the area, near the northern banks of the Orange River, while the N10 tar road and railway to Karasburg run to the north of the area. Most of the study area is sandy and of low relief, with a few isolated areas of basement rocks projecting up through the sandy plains (See satellite image, Fig. 2). The latter slope gently south-eastwards down to the Orange River and are dissected by shallow dendritic drainage systems of intermittently flowing streams, notably the Helbrandkloofspruit. Linear sand dunes with NW-SE trending crests are clearly visible on satellite images of the area to the west of the study area.

3.2. Geology of the study area

The geology of the study area near Upington is shown on the 1: 250 000 geology map 2820 Upington (Council for Geoscience, Pretoria; Fig. 3 herein). A comprehensive sheet explanation for this map has been published by Moen (2007).

According to the 1: 250 000 geology map (Fig. 3) the study area of the proposed Rooipunt solar park is underlain at depth by a range of ancient Precambrian basement rocks – largely high grade metamorphic rocks (*e.g.* gneisses, metapelites) and intrusive granitoids – that belong to the **Namaqua-Natal Province** of Mid Proterozoic (Mokolian) age (Cornell *et al.* 2006, Moen 2007). These basement rocks are approximately two to one billion years old and entirely unfossiliferous (Almond & Pether 2008). They only crop out as small, isolated patches of basement rocks or low *Inselberge* and will probably not be directly impacted by the proposed solar energy facility development. The main basement rock units are listed in the legend to Fig. 3 will not be described any further here.

The greater part of the Rooipunt study area is mantled by superficial sediments of Late Caenozoic (*i.e.* Late Tertiary or Neogene to Recent) age. Small patches of Late Tertiary to Quaternary **calcretes** (T, darker yellow in Fig. 3) or pedogenic limestones occur in the south-central sector. Some of these may be correlated with the Pleistocene or Late Pliocene **Mokalanen Formation** of the Kalahari Group, while others may be of younger age (Partridge *et al.* 2006, Moen 2007). They include horizons of layered to structureless or nodular calcretes overlying basement rocks that are usually less than 3 m thick and often partially covered by wind-blown sands.

Most of the remainder of the study area is covered by fine-grained aeolian (wind-blown) sands of the **Gordonia Formation** (**Qg**, pale yellow in Fig. 3), the youngest, Pleistocene to Recent, subunit of the **Kalahari Group**. Prominent NW-SE trending linear dunes of orange-hued sands are clearly visible on satellite images of the region to the west of the study area. 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.

Much of the arid terrain within the study area is doubtless mantled with a spectrum of other coarse to fine-grained **surface deposits** such as rocky to gravelly soils, downwasted gravels, colluvium (slope deposits, *e.g.* around margins of basement rock patches), sheet wash, sandy vlei deposits and alluvium of the numerous intermittently flowing streams (*e.g.* the Helbrandkloofspruit). Since these deposits are generally young and largely unfossiliferous, they will not be treated further here.

The south-eastern edge of the study site lies along the present course of the Orange River. It is considered unlikely that significant outcrops of ancient (Late Tertiary) **Orange River alluvial gravels** (*terrasgruis*) are present within this area, and none are mapped here on the 1: 250 000 Upington geology sheet. It is noted, however, that according to Moen (2007) terrace gravels occur “all along the river” within 2 km of the present banks and at elevations of up to 45 m (rarely as high as 85 m) above the present flood plain. It is possible that some of the pale grey – rather than orange - areas seen in or around the south-eastern study area on satellite images may represent silty or coarser alluvial deposits. Any remaining uncertainty on this palaeontologically relevant point can only be resolved by fieldwork.

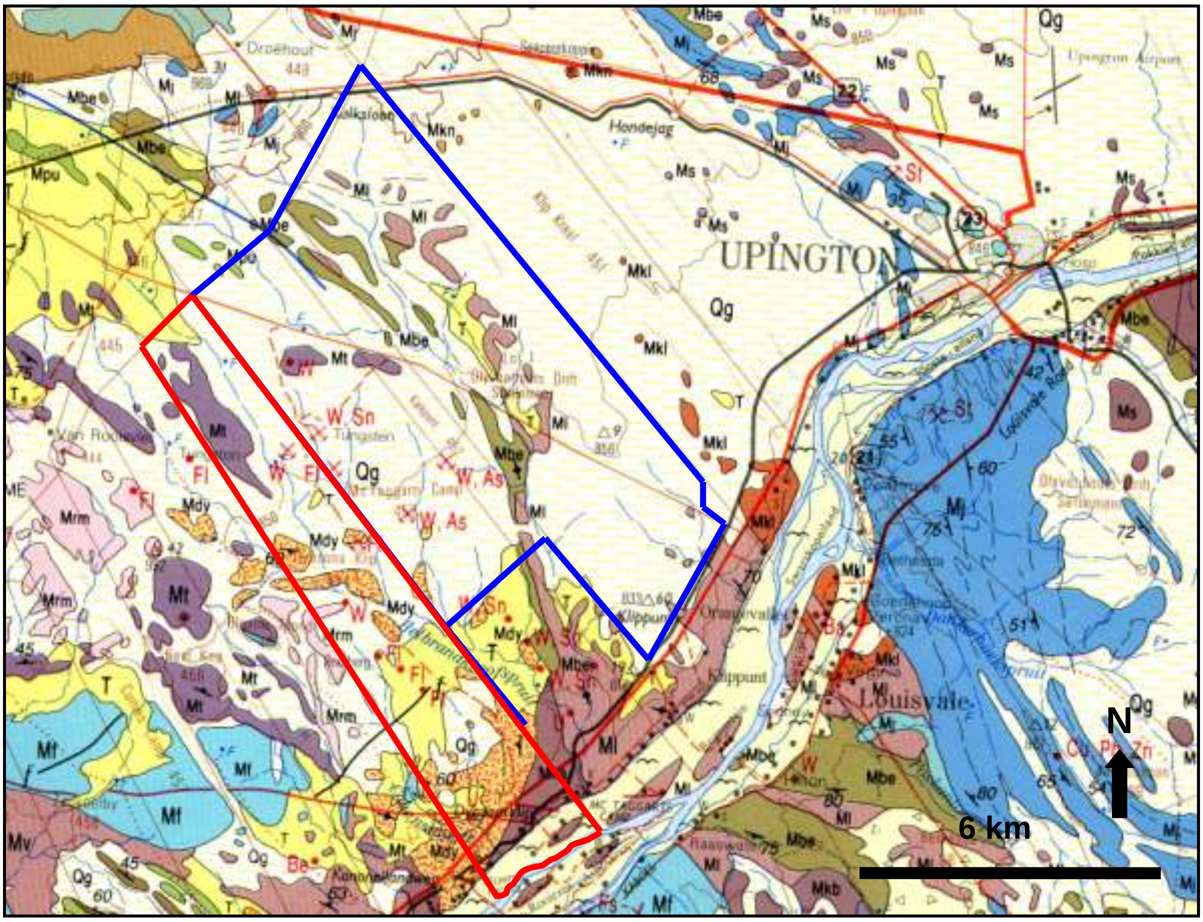

Fig. 3. Extract from 1: 250 000 geological map 2820 Upington (Council for Geoscience, Pretoria) showing the location of Dyason’s Klip study area (red polygon), as well as the adjacent Rooipunt Solar Power Plant study area (blue polygon), *c*. 20-25 km WSW of Upington, Northern Cape Province (blue polygon). Potentially fossiliferous sedimentary rock units mapped within the study area include: Qg (white with yellow stripes) = red aeolian (wind-blown) sand of Gordonia Formation (Kalahari Group); T (yellow) = Late Caenozoic calcretes (Kalahari Group). The remaining area is underlain by small inliers of unfossiliferous Precambrian (Middle Proterozoic / Mokolian) basement rocks of the Namaqua-Natal Metamorphic Province, including a range of highly metamorphosed sediments and intrusive igneous rocks (*e.g.* Mdy – Dyason’s Klip Gneiss, Ml – granites of Keimoes Suite, Mka – Kanoneiland Granite, Mt – Korannaland Sequence, Mrm – Riemvasmaak Gneiss). The overall palaeontological sensitivity of the entire study area is LOW.

4. PALAEONTOLOGICAL HERITAGE

The Precambrian basement rocks (granites, gneisses *etc*) underlying the Dyason's Klip study area are entirely unfossiliferous.

The fossil record of the overlying Late Caenozoic **Kalahari Group** sediments is generally sparse and low in diversity (Almond 2008a, Almond & Pether 2008). 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 rocks 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.

Late Caenozoic calcretes may 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) may be expected occasionally expected within Kalahari Group sediments and calcretes, notably those associated with ancient alluvial gravels and pans (*cf* Almond 2008a). However, these fossil assemblages are generally sparse, low in diversity, and occur over a wide geographic area, so the palaeontological sensitivity of the calcretes within the study area is rated as low. This applies equally to the thin veneer of other surface deposits (rocky scree, stream alluvium *etc*) within this highly arid region.

Alluvial gravels of the Orange River of Miocene and younger age are locally highly fossiliferous (*e.g.* Hendy 1984, Schneider & Marias 2004, Almond 2009 and extensive references therein). As argued above, these are not mapped within the study area are probably not present there. However, the possibility of fossiliferous Orange River alluvial deposits on the south-eastern margins of the study area should be borne in mind (See following section).

5. CONCLUSIONS & RECOMMENDATIONS

The study area is in part underlain by potentially fossiliferous sedimentary rocks of Late Caenozoic age assigned to the Kalahari Group. These mainly comprise Quaternary to Recent calcretes, sandy to gravelly stream alluvium and wind-blown sands. The overall impact significance of the proposed solar energy facility is likely to be LOW, however, because:

- Much of the study area is underlain by igneous and metamorphic basement rocks (granites, gneisses *etc*) that are completely unfossiliferous;
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7. ACKNOWLEDGEMENTS

Dr David Morris of the McGregor Museum, Kimberley, is thanked for commissioning this study and for kindly providing the necessary background information as well as his archaeological assessment report for this project.

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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 APHP (Association of Professional Heritage 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**