Appendix D3b: Updated Palaeontological Assessment/Addendum (2017 revision)

RECOMMENDED EXEMPTION FROM FURTHER PALAEONTOLOGICAL STUDIES & MITIGATION:

PROPOSED KEREN ENERGY KEIMOES SOLAR PLANT ON ERF 666 KEIMOES, KAI GARIB MUNICIPALITY, NORTHERN CAPE

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EXECUTIVE SUMMARY

The proposed Keimoes Keren solar plant study area on Erf 666 near Keimoes is underlain by ancient Precambrian basement rocks belonging to the **Namaqua-Natal Province**. These basement rocks are approximately two to one billion years old and entirely unfossiliferous. They are mantled by Late Caenozoic sandy soils, surface gravels and possibly calcretes; fluvial gravels of the Orange River system are unlikely to be represented here.

The overall palaeontological impact significance of the proposed Keimoes Keren solar plant development is considered to be LOW because:

- Most of the study area is underlain by unfossiliferous metamorphic basement rocks (granite-gneisses *etc*) or mantled by superficial sediments of low palaeontological sensitivity;
- Extensive, deep excavations are unlikely to be involved in this sort of solar park project.

It is therefore recommended that, pending the exposure of significant new fossils during development, exemption from further specialist palaeontological studies and mitigation be granted for this solar plant development.

There are no objections on palaeontological heritage grounds to authorisation of the proposed power plant. Should any substantial fossil remains (*e.g.* vertebrate bones and teeth, shells, petrified wood, calcretised burrows) be encountered during excavation, however, these should be reported to SAHRA for possible mitigation by a professional palaeontologist (Contact details: Dr Ragna Redelstorff, SAHRA, P.O. Box 4637, Cape Town 8000. Tel: 021 202 8651. Email: rredelstorff@sahra.org.za).

In general, the anticipated impact significance on local fossil heritage of developments proposed in the Keimoes region is rated as low to very low. Potentially fossiliferous alluvial sediments along the Orange River are not an issue for the Keimoes Keren solar plant proposal and the majority of PIA studies for the region. It is concluded that cumulative impacts on the, at most very sparse, local fossil assemblages posed by the Keimoes Keren solar plant and other developments in the Keimoes region is also very low.

1. OUTLINE OF DEVELOPMENT

Keren Energy Keimoes (Pty) Ltd is proposing to construct a 5 MW photovoltaic (PV) Energy Generation Facility on Erf 666 near Keimoes, Kai Garib Municipality, in the Northern Cape (Fig. 2). Erf 666 is currently zoned for agriculture and is owned by the local authority.

The proposed activity entails the construction of about 18540 solar modules with a footprint of less than 20 ha. The PV panels will be mounted on pedestals drilled and set into the ground. Extensive bedrock excavations are not envisaged, but some vegetation will need to be cleared from the site. Associated infrastructure includes single track internal access roads, trenches for underground cables, transformer pads, a switching station, a maintenance shed, and a temporary construction camp. The electricity generated from the project will be fed directly into the national grid at the Eskom Oasis substation which is situated alongside the subject property.

The present palaeontological heritage comment has been commissioned by EnviroAfrica cc, Somerset West as part of a comprehensive Heritage Impact Assessment of the proposed development (Contact details: Mr Bernard de Witt, EnviroAfrica cc, P. O. Box 5367, Helderberg, 7135; 29 St James St, Somerset West; mobile: +27 82 4489991; tel: +27 21 851 1616; fax: 086203308).

1.1. Legislative Framework

The present palaeontological heritage assessment report contributes to the consolidated Heritage Impact Assessment for the proposed solar plant and falls under the South African Heritage Resources Act (Act No. 25 of 1999). It will also inform the Environmental Management Programme (EMPr) for this alternative energy project.

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; and
- 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 (PIAs) have been published by Heritage Western Cape, HWC (2016) and the South African Heritage Resources Agency, SAHRA (2013).

1.1. Study approach and methodology

Due to (1) the small footprint of the proposed solar plant development as well as (2) the inferred low palaeontological sensitivity of the study area based on previous desktop assessments by the author in the region (*e.g.* Almond 2014a, 2014b, 2015), only a desktop palaeontological impact assessment is submitted here.

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 (provisional tabulations of palaeontological sensitivity of all formations in the Northern Cape have already been compiled by Almond & Pether (2008); see also the palaeosensitivity maps provided on the SAHRIS website). The likely impacts of the proposed development on local fossil heritage are 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-based assessment study by a professional palaeontologist is usually warranted to identify any palaeontological hotspots and make specific recommendations for any mitigation or monitoring required before or during the construction phase of the development.

1.3. Limitations of this study

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 present study area near Keimoes in the Northern Cape, preservation of potentially fossiliferous bedrocks is favoured by the semi-arid climate and sparse vegetation. However, bedrock exposure is constrained by extensive superficial deposits, such as surface gravels and soils, and there has been little formal palaeontological fieldwork in this area. Confidence levels for this impact assessment are nevertheless rated as *medium to high.* given the absence of older sedimentary bedrocks in the region.

2. GEOLOGICAL BACKGROUND

The proposed solar plant study area (*c.* 28 41 18 S, 20 58 51 E) is situated on flat-lying, arid, rocky terrain at 760-780m amsl on the north-eastern outskirts of the town of Keimoes, some 2 km north of the Orange River (Fig. 2). The N14 trunk road runs 400 m to the southeast.

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

According to the 1: 250 000 geology map the study area of the proposed Keimoes solar plant is largely underlain by a range of ancient Precambrian basement rocks – largely high grade metamorphic rocks (*e.g.* charnockites, metaquartzites) 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).

The Precambrian basement rock within the study area are mantled with a spectrum of other coarse to fine-grained **superficial deposits** such as rocky soils, downwasted gravels, colluvium (slope deposits), sheet wash, calcrete hardpans and alluvium of the numerous intermittently flowing streams. These deposits are generally young (Quaternary to Recent) and largely unfossiliferous. Some sectors of the study area may be covered by fine-grained aeolian (wind-blown) sands of the **Gordonia Formation (Qg)**, the youngest, Pleistocene to Recent, subunit of the **Kalahari Group** (Haddon 2000).

The study site is over 2 km away from the present course of the Orange River and elevated perhaps 30 to 50 m or more higher that this above mean sea level. According to Moen (2007) ancient river 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. However, it is considered unlikely that significant deposits of Late Tertiary **Orange River alluvial gravels** are present within this area, and none are mapped here on the 1: 250 000 Upington geology sheet.

3. PALAEONTOLOGICAL HERITAGE

The Precambrian metamorphic and igneous basement rocks in the study area are entirely unfossiliferous.

The fossil record of the **Kalahari Group** is generally sparse and low in diversity (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 2008, 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 2008). 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) but, as argued above, these are not mapped within the study area.

The palaeontological sensitivity of the Keimoes solar plant study area is assessed as LOW.

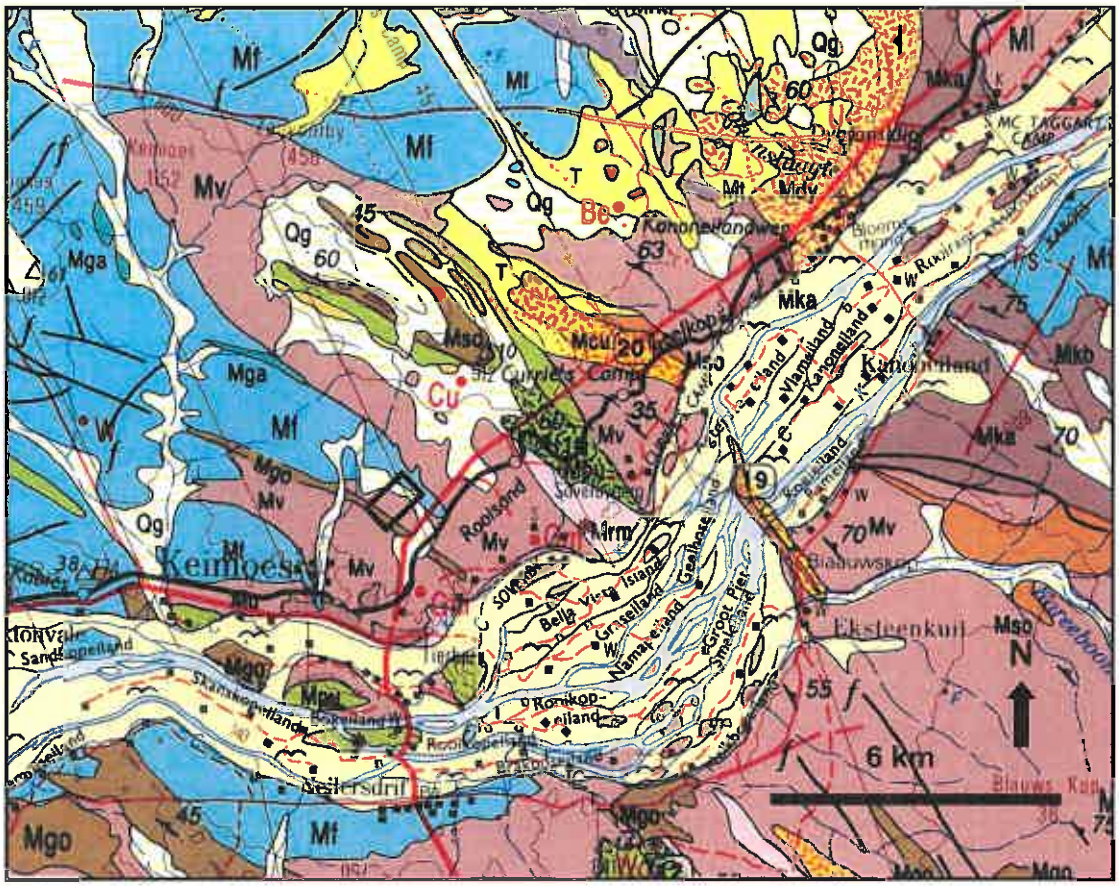

Fig. 1. Extract from 1: 250 000 geological map 2820 Upington (Council for Geoscience, Pretoria) showing approximate location of proposed Keimoes Solar Plant study area on the north-eastern outskirts of Keimoes, Northern Cape Province (small black rectangle). Major rock units mapped within the study area include:

Qg (white with yellow stripes) = red aeolian (wind-blown) sand of the Gordonia Formation (Kalahari Group)

The remaining area is underlain by a range of unfossiliferous Precambrian (Middle Proterozoic / Mokolian) basement rocks of the Namaqua-Natal Metamorphic Province, including various highly metamorphosed sediments and intrusive igneous rocks (*e.g.* Mv Vaalputs Granite, Mgo Goedehoop Formation metaquartzites, Mf Friersdale Charnockite).

Fig. 2. Google earth© satellite image showing the study area for the Keren Keimoes solar farm on Erf 666 on the north-eastern outskirts of Keimoes and NW of the N14 trunk road, Northern Cape (yellow polygon).

3.1. Cumulative impacts on palaeontological heritage

In order to assess cumulative impacts on palaeontological heritage, previous palaeontological impact assessment reports (PIAs) for alternative energy and other developments in the Keimoes region were accessed using the SAHRIS website as well as the author's own database. It is noted that for the great majority of development proposals in the region a PIA report has not been submitted, reflecting its low palaeontological sensitivity (Several PIA Letters of Exemption for local projects (*e.g.* Rubidge, 2011, for the Sonnenberg PV plant) are not available on the SAHRIS database). Proposals documented are for agricultural and housing developments, mine prospecting and powerlines as well as for a number of solar energy power plants on the northern bank of the Orange River between Keimoes and Upington. These last include projects on the farms Dtyason's Klip and Bloemsmond (Almond 2014a, 2014b, 2015). In practice, the only strictly relevant studies are those that deal with comparable fossil heritage assemblages from the same sedimentary rock units that are represented in the Keimoes Keren solar plant itself, in particular Late Caenozoic superficial sediments broadly associated with the Kalahari Group (*i.e.* calcretes, alluvium, surface gravels).

In general, the anticipated impact significance on local fossil heritage of developments proposed in the Keimoes region is rated as low to very low. Potentially fossiliferous alluvial sediments along the Orange River are not an issue for the Keimoes Keren solar plant proposal and the majority of PIA studies for the region. It is concluded that cumulative impacts on the, at most very sparse, local fossil assemblages posed by the Keimoes Keren solar plant and other developments in the Keimoes region is also very low.

4. CONCLUSIONS & RECOMMENDATIONS

The overall palaeontological impact significance of the proposed Keimoes solar plant development is considered to be LOW because:

- Most of the study area is underlain by unfossiliferous igneous and metamorphic basement rocks (granites, gneisses *etc*) or mantled by superficial sediments of low palaeontological sensitivity;
- Extensive, deep excavations are unlikely to be involved in this sort of solar park project.

It is therefore recommended that, pending the exposure of significant new fossils during development, exemption from further specialist palaeontological studies and mitigation be granted for this solar plant development.

There are no objections on palaeontological heritage grounds to authorisation of the proposed power plant. Should any substantial fossil remains (*e.g.* vertebrate bones and teeth, shells, calcretised burrows) be encountered during excavation, however, these should be reported to SAHRA for possible mitigation by a professional palaeontologist (Contact details: Dr Ragna Redelstorff, SAHRA, P.O. Box 4637, Cape Town 8000. Tel: 021 202 8651. Email: rredelstorff@sahra.org.za).

The Environmental Control Officer (ECO) responsible for the solar plant development should be made aware of the potential occurrence of scientifically-important fossil remains such as stromatolites within the development footprint. During the construction phase all major clearance operations (*e.g.* for new access roads) and deeper (> 1 m) excavations (*e.g.* for solar panel footings) should be monitored for fossil remains on an on-going basis by the ECO. Should substantial fossil remains - such as stromatolites, vertebrate bones and teeth - be encountered at surface or exposed during construction, the ECO should safeguard these, preferably *in situ*. They should then alert the relevant provincial heritage management authority as soon as possible - *i.e.* SAHRA for the Northern Cape (Contact details: Dr Ragna Redelstorff, SAHRA, P.O. Box 4637, Cape Town 8000. Tel: 021 202 8651. Email: rredelstorff@sahra.org.za). This is to ensure that

appropriate action - *i.e.* recording, sampling or collection of fossils, recording of relevant geological data - can be taken by a professional palaeontologist at the developer's expense.

These mitigation recommendations should be incorporated into the Environmental Management Programme (EMPr) for the solar plant project.

Please note that:

- All South African fossil heritage is protected by law (South African Heritage Resources Act, 1999) and fossils cannot be collected, damaged or disturbed without a permit from SAHRA or the relevant Provincial Heritage Resources Agency (in this case Heritage Western Cape);

- The palaeontologist concerned with potential mitigation work will need a valid fossil collection permit from SAHRA (N. Cape) and any material collected would have to be curated in an approved depository (*e.g.* museum or university collection);

- All palaeontological specialist work should conform to international best practice for palaeontological fieldwork and the study (*e.g.* data recording fossil collection and curation, final report) should adhere as far as possible to the minimum standards for Phase 2 palaeontological studies developed by HWC (2016) and SAHRA (2013).

5. REFERENCES

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

ALMOND, J.E. 2009. Contributions to the palaeontology and stratigraphy of the Alexander Bay sheet area (1: 250 000 geological sheet 2816), 117 pp. Unpublished report for the Council for Geoscience. Natura Viva cc, Cape Town.

ALMOND, J.E. 2014a. Proposed RE Capital 3 Solar Development on the property Dyason's Klip near Upington , Northern Cape. Palaeontological heritage basic assessment: desktop study, 13 pp. Natura Viva cc, Cape Town.

ALMOND, J.E. 2014b. Proposed construction of RE Capital 11 photovoltaic solar facility on the remainder of the Farm Dyasonsklip 454, Upington, Northern Cape. Recommended exemption from further palaeontological studies, 6 pp. Natura Viva cc, Cape Town.

ALMOND, J.E. 2015. Proposed AEP Bloemsmond Solar 1 & Solar 2 PV facilities on the Farm Bloemsmond 455 near Upington, Siyanda District Municipality, Northern Cape. Recommended exemption from further palaeontological studies, 6 pp. Natura Viva cc, Cape Town.

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

CORNELL, D.H. *et al.* 2006. The Namaqua-Natal Province. In: Johnson, M.R., Anhaeusser, C.R. & Thomas, R.J. (Eds.) The geology of South Africa, pp 325-379. Geological Society of South Africa, Johannesburg & Council for Geoscience, Pretoria.

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

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

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March 2012

1. OUTLINE OF DEVELOPMENT

Keren Energy Keimoes (Pty) Ltd is proposing to construct a 10 MW Concentrating Photovoltaic (CPV) Energy Generation Facility on Erf 666 near Keimoes, Kai Garib Municipality, in the Northern Cape (Fig. 2). Erf 666 is currently zoned for agriculture and is owned by the local authority.

The proposed activity entails the construction of about 140 CPV solar panels with a footprint of about 20 ha. The CPV panels will be mounted on pedestals drilled and set into the ground. Extensive bedrock excavations are not envisaged, but some vegetation will need to be cleared from the site. Associated infrastructure includes single track internal access roads, trenches for underground cables, transformer pads, a switching station, a maintenance shed, and a temporary construction camp. The electricity generated from the project will be fed directly into the national grid at the Eskom Oasis substation which is situated alongside the subject property.

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2. GEOLOGICAL BACKGROUND

The proposed solar plant study area is situated on flat-lying, arid, rocky terrain at 760-780m amsl on the north-eastern outskirts of the town of Keimoes, some 2 km north of the Orange River (Fig. 2). The N14 trunk road runs 400m to the southeast.

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

According to the 1: 250 000 geology map the study area of the proposed Keimoes solar plant is largely underlain by a range of ancient Precambrian basement rocks – largely high grade metamorphic rocks (*e.g.* charnockites, metaquartzites) 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).

The Precambrian basement rock within the study area are mantled with a spectrum of other coarse to fine-grained **superficial deposits** such as rocky soils, downwasted gravels, colluvium (slope deposits), sheet wash, calcrete hardpans and alluvium of the numerous intermittently flowing streams. These deposits are generally young (Quaternary to Recent) and largely unfossiliferous. Some sectors of the study area may be covered by fine-grained aeolian (wind-blown) sands of the **Gordonia Formation (Qg)**, the youngest, Pleistocene to Recent, subunit of the **Kalahari Group** (Haddon 2000).

The study site is over 2 km away from the present course of the Orange River and elevated perhaps 30 to 50m or more higher that this above mean sea level. According to Moen (2007) ancient river terrace gravels occur "all along the river" within 2km of the present banks and at elevations of up to 45 m (rarely as high as 85m) above the present flood plain. However, it is considered unlikely that significant deposits of Late Tertiary **Orange River alluvial gravels** are present within this area, and none are mapped here on the 1: 250 000 Upington geology sheet.

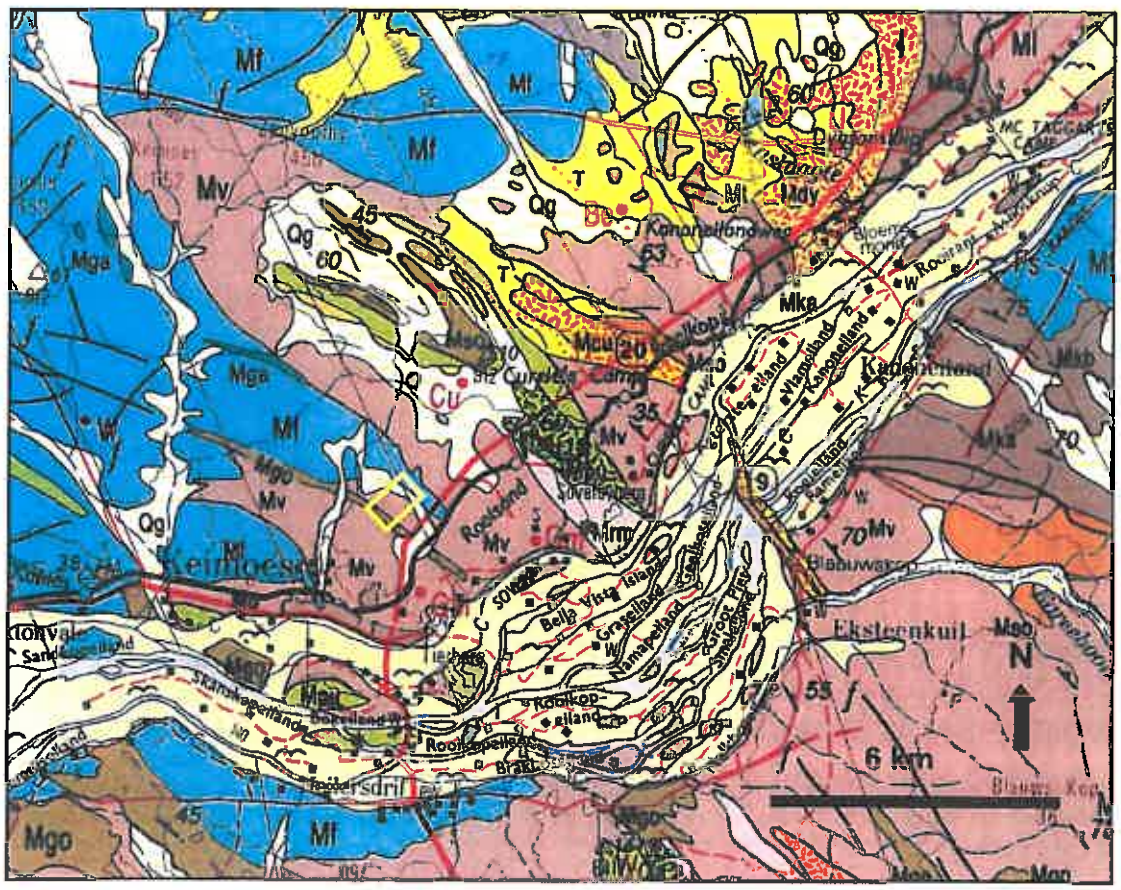

Fig. 1. Extract from 1: 250 000 geological map 2820 Upington (Council for Geoscience, Pretoria) showing approximate location of proposed Keimoes Solar Plant study area on the north-eastern outskirts of Keimoes, Northern Cape Province (small yellow rectangle). Major rock units mapped within the study area include:

Qg (white with yellow stripes) = red aeolian (wind-blown) sand of the Gordonia Formation (Kalahari Group)

The remaining area is underlain by a range of unfossiliferous Precambrian (Middle Proterozoic / Mokolian) basement rocks of the Namaqua-Natal Metamorphic Province, including various highly metamorphosed sediments and intrusive igneous rocks (*e.g.* Mv Vaalputs Granite, Mgo Goedehoop Formation metaquartzites, Mf Friersdale Charnockite).

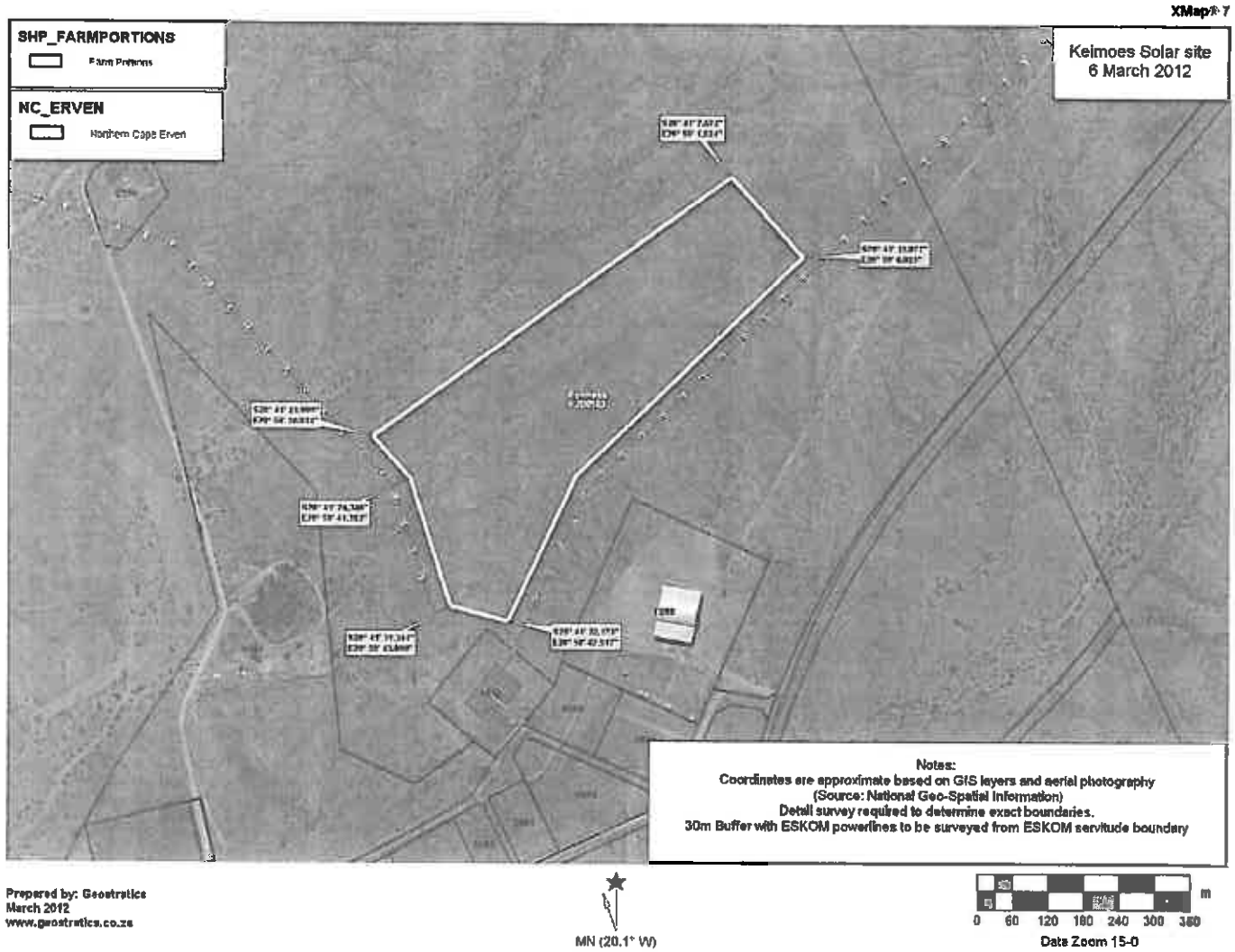

Fig. 2. Satellite image showing the study area for the Keren Keimoes solar farm on Erf 666 on the north-eastern outskirts of Keimoes, Northern Cape (Image prepared by Geostratics 2012). The N14 trunk road runs across the right hand side of the image.

3. PALAEONTOLOGICAL HERITAGE

The Precambrian metamorphic and igneous basement rocks in the study area are entirely unfossiliferous.

The fossil record of the **Kalahari Group** is generally sparse and low in diversity (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 2008, 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 2008). 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) but, as argued above, these are not mapped within the study area.

The palaeontological sensitivity of the Keimoes solar plant study area is assessed as LOW.

4. CONCLUSIONS & RECOMMENDATIONS

The overall impact significance of the proposed Keimoes solar plant development is considered to be LOW because:

- Most of the study area is underlain by unfossiliferous igneous and metamorphic basement rocks (granites, gneisses *etc*) or mantled by superficial sediments of low palaeontological sensitivity;
- Extensive, deep excavations are unlikely to be involved in this sort of solar park project.

It is therefore recommended that exemption from further specialist palaeontological studies and mitigation be granted for this solar plant development.

Should any substantial fossil remains (*e.g.* vertebrate bones and teeth) be encountered during excavation, however, these should be reported to SAHRA for possible mitigation by a professional palaeontologist.

5. REFERENCES

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

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

ALMOND, J.E. 2009. Contributions to the palaeontology and stratigraphy of the Alexander Bay sheet area (1: 250 000 geological sheet 2816), 117 pp. Unpublished report for the Council for Geoscience. Natura Viva cc, Cape Town.

CORNELL, D.H. *et al.* 2006. The Namaqua-Natal Province. In: Johnson, M.R., Anhaeusser, C.R. & Thomas, R.J. (Eds.) The geology of South Africa, pp 325-379. Geological Society of South Africa, Johannesburg & Council for Geoscience, Pretoria.

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

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

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

HENDEY, Q.B. 1984. Southern African late Tertiary vertebrates. In: Klein, R.G. (Ed.) Southern African prehistory and paleoenvironments, pp 81-106. Balkema, Rotterdam.

MOEN, H.F.G. 2007. The geology of the Upington area. Explanation to 1: 250 000 geology Sheet 2820 Upington, 160 pp. Council for Geoscience, Pretoria.

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

SCHNEIDER, G. & MARAIS, C. 2004. Passage through time – the fossils of Namibia. 159 pp. Gamsberg MacMillan, Windhoek.

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

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

6. 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 as well as Limpopo, Free State and Gauteng 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 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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