PALAEONTOLOGICAL IMPACT ASSESSMENT: DESKTOP STUDY

Proposed photovoltaic power station adjacent to Welcome Wood Substation, Owendale near Postmasburg, Northern Cape Province

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1. SUMMARY

The proposed 5MW photovoltaic power plant on the Farm 457 in the Asbesberge near Danielskuil , Northern Cape Province involves the construction of a 25 ha photovoltaic array close to the existing Welcome Wood Substation. The development site is underlain by Early Proterozoic (*c.* 2.4 billion year old) banded iron formation of the Daniëlskuil Formation (Asbestos Hills Group, Ghaap Group). Rich and palaeontologically significant stromatolitic biotas (microbial mounds, columns and sheets) as well as microfossil assemblages of Late Archaean to Early Proterozoic age (2.6-2.4 Ga) have been recorded from underlying carbonate and cherty sediments of the Ghaap Group in this area, notably from the nearby Lime Acres site to the south. However, no fossils are so far known from the Daniëlskuil Formation itself, although microfossils are likely to be present within cherty sediments within this unit. The overall palaeontological sensitivity of the Precambrian bedrock as well as of the Kalahari Group cover sands in the study region is low, the development footprint is small, and extensive bedrock excavations that might intersect stromatolite-rich carbonates of the Ghaap group succession are not envisaged. Therefore further palaeontological mitigation of this project is not considered necessary. Should substantial fossil remains be exposed during construction, however, these should be safeguarded – if possible *in situ* – and SAHRA should be notified by the responsible ECO as soon as possible so that appropriate palaeontological mitigation (fossil sampling and relevant data collection) can be undertaken.

2. INTRODUCTION & BRIEF

Alt e Technologies in partnership with AMDA energia are proposing to construct six new 5MW photovoltaic power stations alongside existing Eskom substations in the Northern Cape Province. According to the BID document prepared by Van Zyl Environmental Consultants cc the footprint of the PV power station will be *c.* 25 ha, and at least two alternative sites will be considered for each substation. Associated infrastructure includes an access road in certain cases, fencing, guardrooms, toilet, shower, washbasin, security systems, lights on poles, lightning conductor poles, a hanger to store spare parts and a workshop. Around the premises a furrow will be constructed to prevent vehicles from entering the site at any other place than the main entrance.

The Welcome Wood PV power station is to be located north of the R385 between Postmasberg and Daniëlskuil, *c.* 12 southwest of the last town and just northeast of the small community of Owendale (Figs. 1, 2). The proposed construction site (Farm 457) overlies bedrock of the Precambrian Ghaap Group that is famous for its microfossils and stromatolites (microbial mounds and columns). A desktop palaeontological impact assessment for the project is therefore

necessary in accordance with the requirements of the National Heritage Resources Act, 1999. This study has accordingly been commissioned by Ms I.B. Van Zyl of Van Zyl Environmental Consultants cc, Upington.

2.1. National Heritage Monuments Act

The extent of the proposed development (over 5000 m^2) falls within the requirements for a Heritage Impact Assessment (HIA) as required by Section 38 (Heritage Resources Management) of the South African Heritage Resources Act (Act No. 25 of 1999). The various categories of heritage resources recognised as part of the National Estate in Section 3 of the 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 May 2007.

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

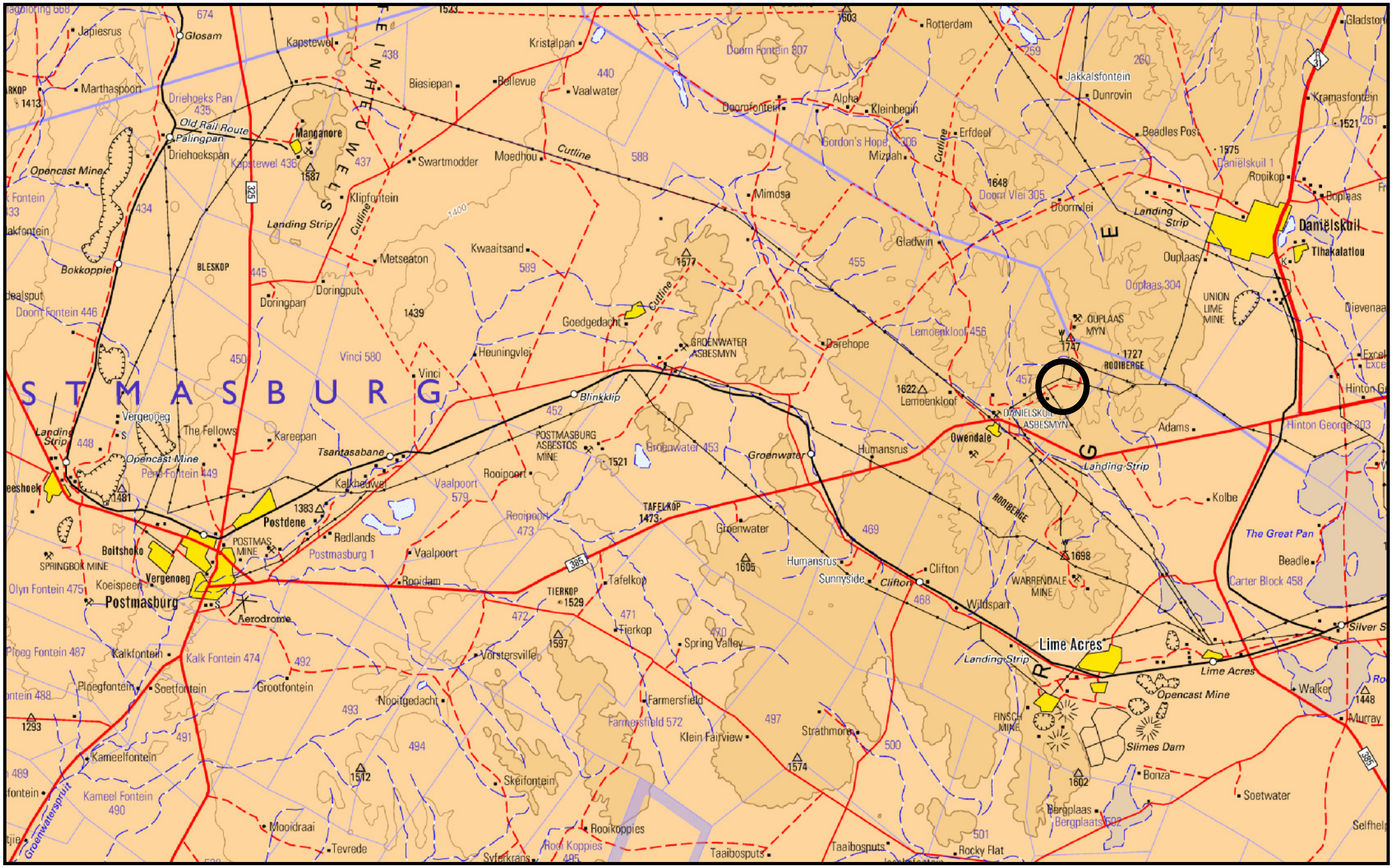

Fig. 1. Extract from 1: 250 000 topographical sheet 2822 Postmasburg showing location of the proposed Welcome Wood PV power station to the northeast of Owendale, *c.* 12km southwest of Daniëlskuil, Northern Cape Province (Map courtesy of the Chief Directorate of Surveys & Mapping, Mowbray).

Fig. 2. *Google Earth*® satellite image showing (middle right) the location of the proposed photovoltaic power station at Welcome Wood, near Owendale, *c.* 12km southwest of Daniëlskuil, Northern Cape Province (Image provided by Van Zyl Environmental Consultants cc).

3. GEOLOGICAL BACKGROUND

The geology of the study area near Daniëlskuil is shown on the 1: 250 000 geology map 2822 Postmasburg (Council for Geoscience, Pretoria; Fig. 3 herein). A separate explanation for the Postmasburg geological map has not yet been published while a short account of the geology is printed on the map itself.

The geology of the study area in the Asbesberge is dominated by ancient Precambrian sediments of the **Asbestos Hills Subgroup** (also referred to in the older literature as the Asbesheuwels Subgroup). This succession forms the upper part of the Late Archaean to Early Proterozoic **Ghaap Group** of the Griqualand West Basin, Prieska Subbasin. Useful reviews of the stratigraphy and sedimentology of these Transvaal Supergroup rocks have been given by Moore *et al.* (2001) and Eriksson *et al.* (2006). The Ghaap Group represents some 200 Ma of chemical sedimentation - notably iron and manganese ores, cherts and carbonates - within the Griqualand West Basin that was situated towards the western edge of the Kaapvaal Craton (Fig. 4; see also fig. 4.19 in McCarthy & Rubidge 2005). The Asbestos Hills Subgroup consists predominantly of banded iron formations (BIF) overlying the stromatolite-rich carbonate succession of Campbell Rand Subgroup (Fig. 4). These BIF rocks consist of rhythmically bedded, thinly composition- and colour-banded cycles of fine-grained mudrock, chert and iron minerals (siderite, magnetite, haematite) that were deposited in an offshore, intermittently anoxic basin. BIF deposition characterizes the Late Archaean – Early Proterozoic interval (2600-2400 Ma) before the onset of well-oxygenated atmosphere and seas.

The proposed Welcome Wood PV power station overlies iron–rich rocks of the **Daniëlskuil Formation** (**Vad** in Fig. 3). This 200m-thick succession is interpreted as a current- or wave-reworked banded iron formation, as suggested by the abundance of BIF intraclasts and sedimentary structures (Beukes 1983, Klein & Beukes 1989, Beukes & Klein 1990). The base of the Danielskuil Formation has been radiometrically dated to 2.43-2.49Ga, *i.e.* Early Proterozoic (Trendall *et al.* 1990, Barton *et al.* 1994, Nelson *et al.* 1999).

Also mapped in the neighbourhood of the Welcome Wood study area are unconsolidated aeolian (*i.e.* wind-blown) sands of the Quaternary **Gordonia Formation** (**Kalahari Group**) (**Qs** in Fig. 3) whose thickness here is uncertain. 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.

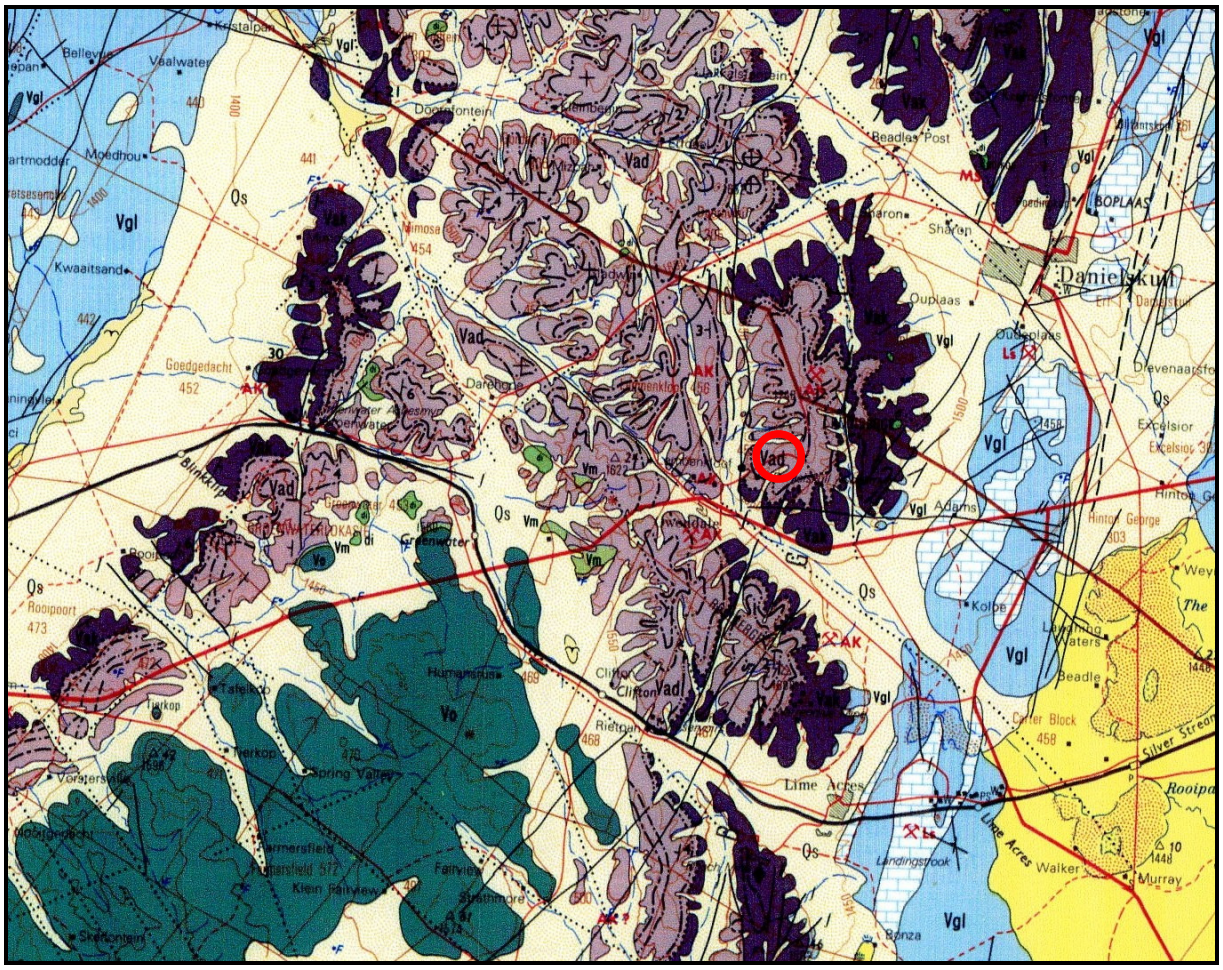

Fig. 3. Extract from 1: 250 000 geological map 2822 Postmasburg (Council for Geoscience, Pretoria) showing location of the proposed Welcome Wood photovoltaic power station (red circle) in the Asbesberge region to the southwest of Daniëlskuil. The rocks indicated in purple belong to the Asbestos Hills Subgroup of the Early Proterozoic Ghaap Group. Dark purple (Vak) = Kuruman Formation. Pale purple (Vad) = Daniëlskuil Formation. Pale yellow (Qs) = aeolian sand of Gordonia Formation (Kalahari Group)

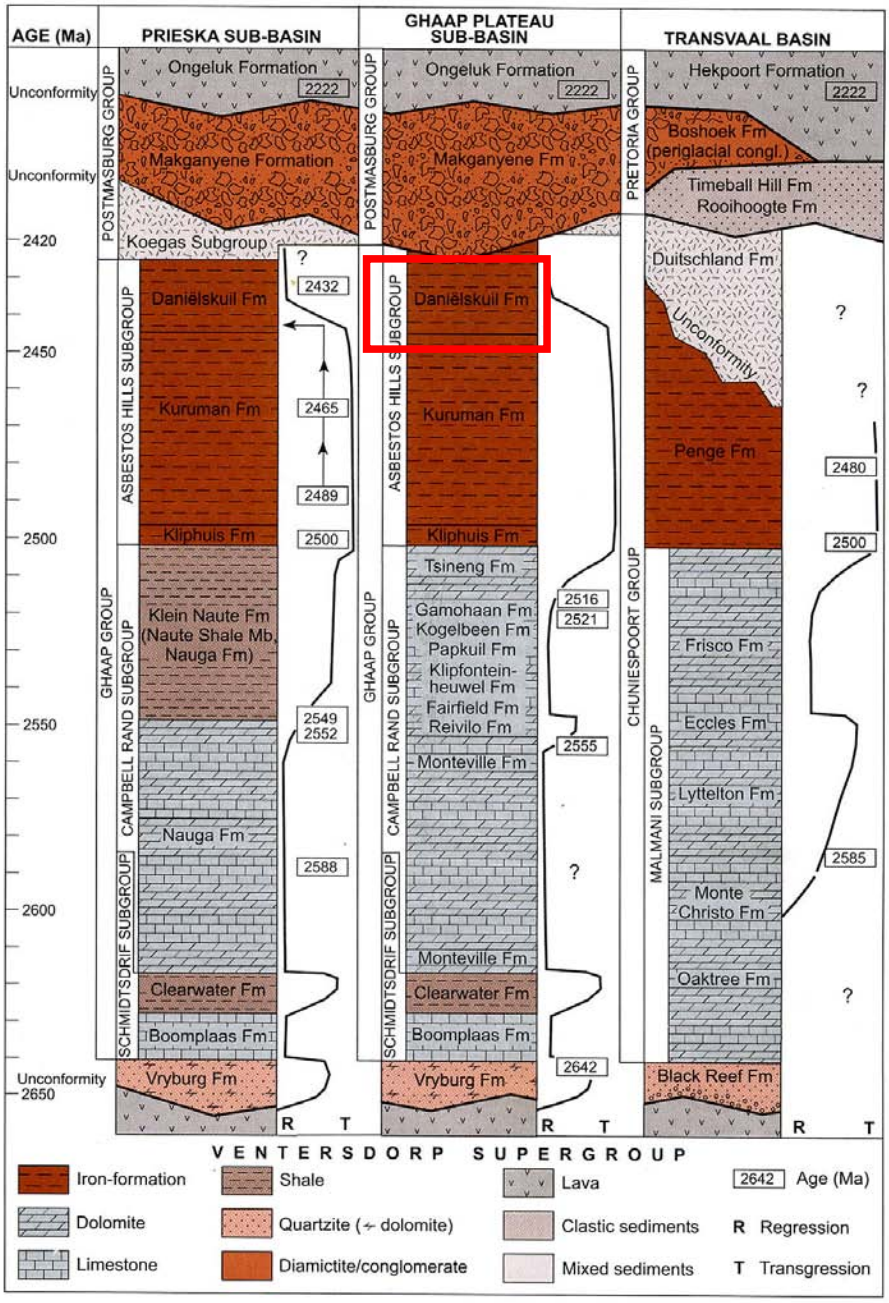

Fig. 4. Stratigraphy of the Late Archaean to Early Proterozoic Ghaap and Chuniespoort Groups (From Eriksson *et al.* 2006). The position of the Daniëlskuil Formation is indicated by the red rectangle.

4. PALAEONTOLOGICAL HERITAGE

The fossil heritage recorded within each of the main sedimentary rock successions occurring within the study region near Danielskuil is outlined here (See also Table 1).

4.2. Fossils within the Ghaap Group

The fossil record of the Precambrian sediments of the Northern Cape has been briefly reviewed by Almond & Pether (2008). The shallow shelf and intertidal sediments of the carbonate-dominated lower part of the Ghaap Group (*i.e.* Schmidtsdrif and Campbell Rand Subgroups) are famous for their rich fossil biota of *stromatolites* or microbially-generated, finely laminated mounds and branching structures. Some stromatolite occurrences on the Ghaap Plateau of the Northern Cape are spectacularly well-preserved (*e.g.* Boetsap locality figured by McCarthy & Rubidge 2005, Eriksson *et al.* 2006). Detailed studies of these 2.6-2.5Ga carbonate sediments and their stromatolitic biotas have been presented by Young (1932), Beukes (1980, 1983), Eriksson & Truswell (1974), Eriksson & Altermann (1998), Eriksson *et al.* (2006), Altermann and Herbig (1991), Altermann and Wotherspoon (1995). The last paper refers especially to Lime Acres just south of the study area (see Fig. 3). Some of the oldest known (2.6 Ga) fossil microbial asemblages with filaments and coccoids have been recorded from stromatolitic cherty limestones of the Lime Acres Member, Kogelbeen Formation at Lime Acres (Altermann & Schopf 1995). The Archaean stromatolite occurrences from the Ghaap Group have been reviewed by Schopf (2006, with full references therein). The Tsineng Formation just below the base of the Asbestos Hills succession has yielded both stromatolites (previously assigned to the Tsineng Member of the Gamohaan Formation) as well as filamentous microfossils named *Siphonophycus* (Klein *et al.*1987, Altermann & Schopf 1995).

The overlying deep water BIF facies of the Asbestos Hills Subgroup have not yielded stromatolites which are restricted to the shallow water photic zone since they are constructed primarily by photosynthetic microbes. However, there are several reports of microfossils from cherty sediments within the Kuruman Formation, just below the Danielskuil Formation, according to MacRae (1999) and Tankard *et al.* (1982 – see refs. therein by Fockema 1967, Cloud & Licari 1968, La Berge 1973. *N.B.* the stratigraphic position of these older records may require confirmation). It is likely that cherts within the Daniëlskuil Formation also contain scientifically interesting Early Proterozoic microfossil assemblages.

4.2. Fossils within the Kalahari Group

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 underlying lime-rich bedrocks 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. 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) may be expected occasionally expected within Kalahari Group sediments and calcretes, notably those associated with ancient alluvial gravels .

5. CONCLUSIONS & RECOMMENDATIONS

The inferred palaeontological sensitivity of each of the main fossil-bearing rock units represented within, or close to, the study area near Danielskluil is summarized in Table 1 below (See also Almond & Pether 2008).

The proposed Welcome Wood PV power station site is underlain by iron-rich basinal sediments of the Daniëlskuil Formation of the Ghaap Group. These rocks are extremely ancient - some 2.4 billion years old – and are unlikely to contain substantial fossil remains. Cherty layers (fine grained siliceous rocks) may contain microfossil assemblages but these have not yet been recorded in the scientific literature. Aeolian (wind-blown) sands of the Gordonia Formation (Kalahari Group) in the study region are poorly fossilferous.

Given the generally low palaeontological sensitivity of sedimentary rocks in the study area, the small footprint of the development and the shallow excavations envisaged, no further palaeontological mitigation is recommended for this development. Should substantial fossil remains be exposed during construction, however, the ECO should safeguard these, preferably *in situ*, and alert SAHRA as soon as possible so that appropriate action (*e.g.* recording, sampling or collection) can be taken by a professional palaeontologist.

6. ACKNOWLEDGEMENTS

Ms I.B. Van Zyl of Van Zyl Environmental Consultants cc, Upington, is thanked for commissioning this study and for kindly providing all the necessary background information.

TABLE 1: FOSSIL HERITAGE IN THE DANIELSKUIL AREA				
GEOLOGICAL UNIT	**ROCK TYPES & AGE**	**FOSSIL HERITAGE**	**PALAEONT-OLOGICAL SENSITIVITY**	**RECOMMENDED MITIGATION**
Gordonia Formation **KALAHARI GROUP** ***plus*** **SURFACE CALCRETE**	**mainly aeolian sands *plus* minor fluvial gravels, freshwater pan deposits, calcretes** **PLEISTOCENE to RECENT**	**calcretised rhizoliths & termitaria, ostrich egg shells, land snail shells, rare mammalian and reptile (*e.g.* tortoise) bones, teeth** **freshwater units associated with diatoms, molluscs, stromatolites *etc***	**LOW**	**none recommended** **any substantial fossil finds to be reported by ECO to SAHRA**
Asbestos Hills Subgroup **GHAAP GROUP**	**BIF (banded iron formations) with cherty bands** **EARLY PROTEROZOIC (*c.* 2.5-2.4 Ga)**	**important early microfossil biotas**	**LOW**	**none recommended**
Campbell Rand Subgroup **GHAAP GROUP**	**shallow marine to intertidal limestones / dolomites** **LATE ARCHAEAN (*c.* 2.6-2.5 Ga)**	**rich stromatolite assemblages (stratiform, domical, columnar), important early microfossil biotas**	**MODERATE TO HIGH**	**field scoping of development footprint**

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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 projects, 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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