PALAEONTOLOGICAL IMPACT ASSESSMENT: FIELD SCOPING STUDY

Proposed photovoltaic power station adjacent to Herbert Substation near Douglas, Northern Cape Province

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1. SUMMARY

The proposed 5 MW photovoltaic power plant site is situated on the Farm Atherton 82, 4.5 km north of the Vaal River and some 7 km northeast of Douglas, Northern Cape Province. The project involves the construction of a 25 ha photovoltaic array close to the existing Herbert Substation. An earlier desktop palaeontological impact assessment for the project has been completed by Almond (2010) who recommended a follow-up field scoping study.

The present scoping study shows that bedrock exposure in the study area around the Herbert electrical substation is insufficient to determine whether this is underlain by Dwyka or Ecca Group sediments. Apart from occasional stromatolitic limestone or dolomite erratics reworked from the 2.6-2.5 billion year old Ghaap Group, the varied Permocarboniferous sediments of the Mbizane Formation (Dwyka Group) near Douglas appear to be largely unfossiliferous but are of scientific interest for their rich variety of glacial-related features. These include extensive ice-scoured rock pavements, some of which feature numerous well-preserved rock engravings. The Early Permian Prince Albert Formation (Ecca Group) rocks in the region yield a sparse but palaeontologically interesting fauna of fossil fish, invertebrates, coprolites and petrified wood, mainly preserved within cannon-ball sized nodules. However, in the substation study area itself the Karoo Supergroup bedrocks are entirely blanketed with a thick (2 or more meters) layer of surface calcrete on top of which lies a thin veneer of Kalahari sands and down-wasted gravels. These superficial deposits are only sparsely fossiliferous, and no fossils were observed within them during the present scoping study.

It is concluded that the shallow excavations envisaged during construction of the proposed photovoltaic power station are unlikely to intersect fossil-bearing bedrock and no specialist palaeontological mitigation is recommended here. Should fossil remains be encountered during development, however, the responsible ECO should inform SAHRA at the earliest opportunity to consider possible mitigation measures.

2. INTRODUCTION & BRIEF

Alt e Technologies in partnership with AMDA energía are proposing to construct four new 5 MW 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 Herbert PV power station is to be located on the farm Atherton 82 situated on the northern side of the Vaal River some 7 km northeast of the town of Douglas (Fig. 1). The proposed construction site overlies potentially fossiliferous bedrock of the Palaeozoic Dwyka and/or Ecca Groups as well as Quaternary calcretes. A palaeontological impact assessment for the project is therefore necessary in accordance with the requirements of the National Heritage Resources Act, 1999.

A desktop palaeontological impact assessment for the proposed photovoltaic power station adjacent to the existing Herbert substation was commissioned from the author earlier in 2010 by Van Zyl Environmental Consultants cc, Upington (Almond 2010). This earlier study made the following recommendations regarding palaeontological heritage in the study area:

> Given the unusually high geological and palaeontological significance of the Prince Albert Formation (and to a lesser extent the Mbizane Formation) within a 10 km radius of the study site, it is recommended that a palaeontological field scoping study of the area is carried out by a professional palaeontologist before construction commences.
>
> The purposes of the scoping 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 scoping information, and finally (d) to make recommendations for any further palaeontological mitigation deemed necessary for this project.

The present palaeontological field scoping study was accordingly commissioned by Van Zyl Environmental Consultants cc, Upington. Fieldwork in the Douglas area was carried out by the author on 24-25th September 2010.

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.

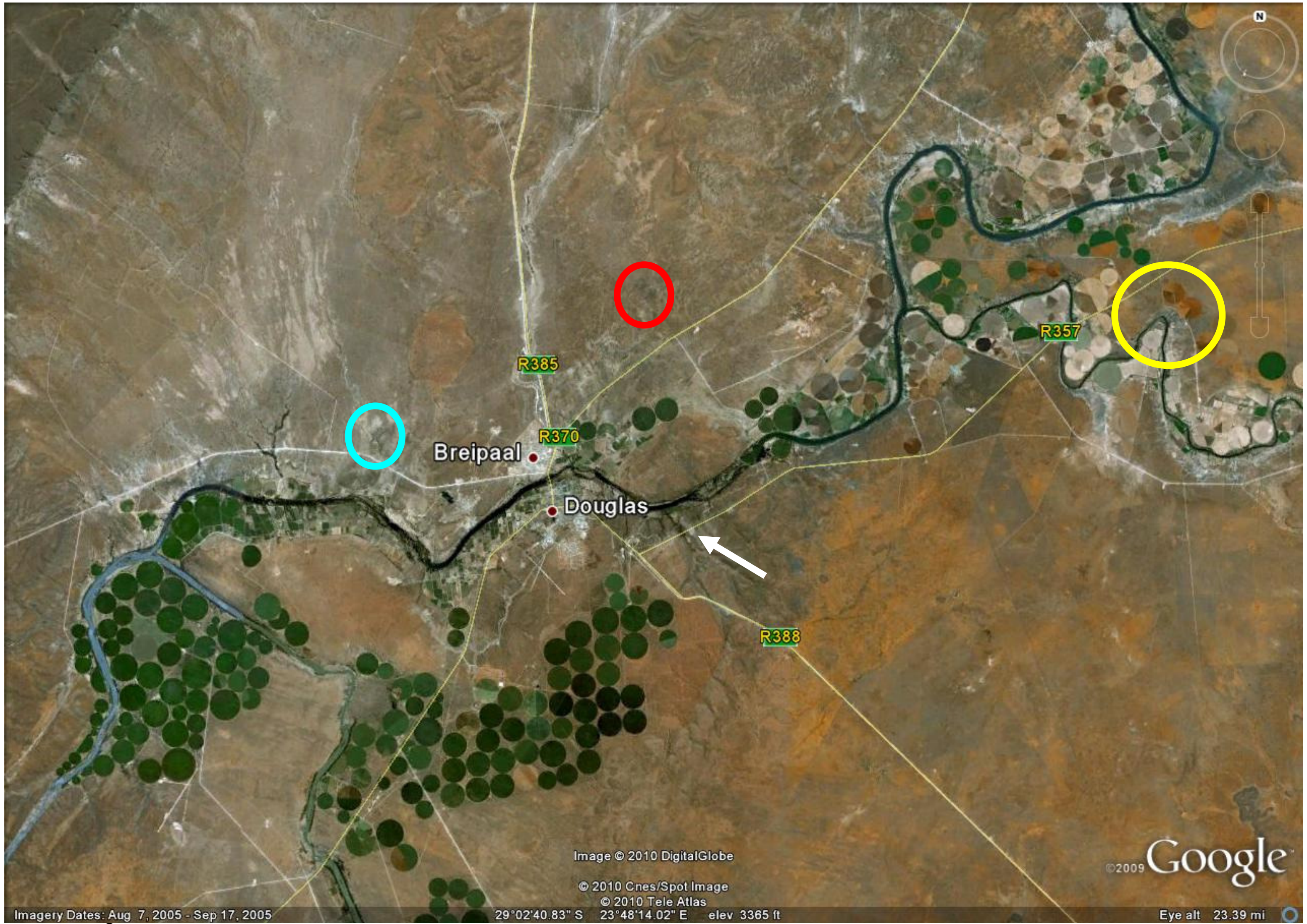

Fig. 1. ***Google Earth*®** **satellite image, showing the location (red circle) of the proposed photovoltaic power station at the Herbert Substation *c.* 7 km northeast of Douglas, Northern Cape Province. The Stratotype C section of the Mbizane Formation (Dwyka Group) on the Farm Blaauwboschdrift is indicated by the blue circle. A key fossil site within the Prince Albert Formation on the farm Blaauwkrantz along the Riet River is indicated by the yellow circle. The white arrow indicates a borrow pit south of the R357 where the contact between calcretised High Level Gravels and the Dwyka Group is well exposed.**

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 following scoping 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 and scale 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.

The focus of palaeontological scoping work is *not* simply to survey the development footprint or even the development area as a whole (*e.g.* farms or other parcels of land concerned in the development). Rather, the palaeontologist seeks to assess or predict the diversity, density and distribution of fossils within and beneath the study area, as well as their heritage or scientific interest. This is primarily achieved through a careful field examination of one or more representative exposures of all the sedimentary rock units present (*N.B.* metamorphic and igneous rocks rarely contain fossils). The best rock exposures are generally those that are easily accessible, extensive and fresh (*i.e.* unweathered) and include a large fraction of the stratigraphic unit concerned (*e.g.* formation). These exposures may be natural or artificial and include, for example, rocky outcrops in stream or river banks, cliffs, quarries, dams, dongas, open building excavations or road and railway cuttings. Uncemented superficial deposits, such as alluvium, scree or windblown sands, may occasionally contain fossils and should also be included in the scoping study where they are well-represented in the study area. It is normal practice for impact palaeontologists to collect representative, well-localized (*e.g.* GPS and stratigraphic data) samples of fossil material during scoping studies. All fossil material collected must be properly curated within an approved repository (usually a museum or university collection).

Note that while fossil localities recorded during scoping work within the study area itself are obviously highly relevant, most fossil heritage here is embedded within rocks beneath the land surface or obscured by surface deposits (soil, alluvium etc.) and by vegetation cover. In many cases where levels of fresh (*i.e.* unweathered) bedrock exposure are low, the hidden fossil resources have to be *inferred* from palaeontological observations made from better exposures of the same formations elsewhere in the region but outside the immediate study area. Therefore a palaeontologist might reasonably spend far *more* time examining road cuts and borrow pits close to, but outside, the study area than within the study area itself. Field data from localities even further afield (*e.g.* an adjacent province) may also be adduced to build up a realistic picture of the likely fossil heritage within the study area.

On the basis of the desktop and scoping 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. Mitigation by a professional palaeontologist – normally involving the recording and sampling of fossil material and associated geological information (*e.g.* sedimentological data) – is usually most effective 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 (*e.g.* Heritage Western Cape for the Western Cape). 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.

This PIA scoping report provides an assessment of the observed or inferred palaeontological heritage within the study area near Douglas, with recommendations for specialist palaeontological mitigation where this is considered necessary. The report is based on (1) a review of the relevant scientific literature (See previous desktop study for this project, Almond 2010), (2) published geological maps and accompanying sheet explanations, (3) a two-day field scoping study (24th to 25th September 2010) as well as (4) the author's extensive field experience with the formations concerned and their palaeontological heritage.

3. GEOLOGICAL BACKGROUND

The geology of the study region near Douglas is shown on the 1:250 000 geology map 2922 Prieska (Council for Geoscience, Pretoria; Fig. 2 herein) and has already been outlined by Almond (2010).

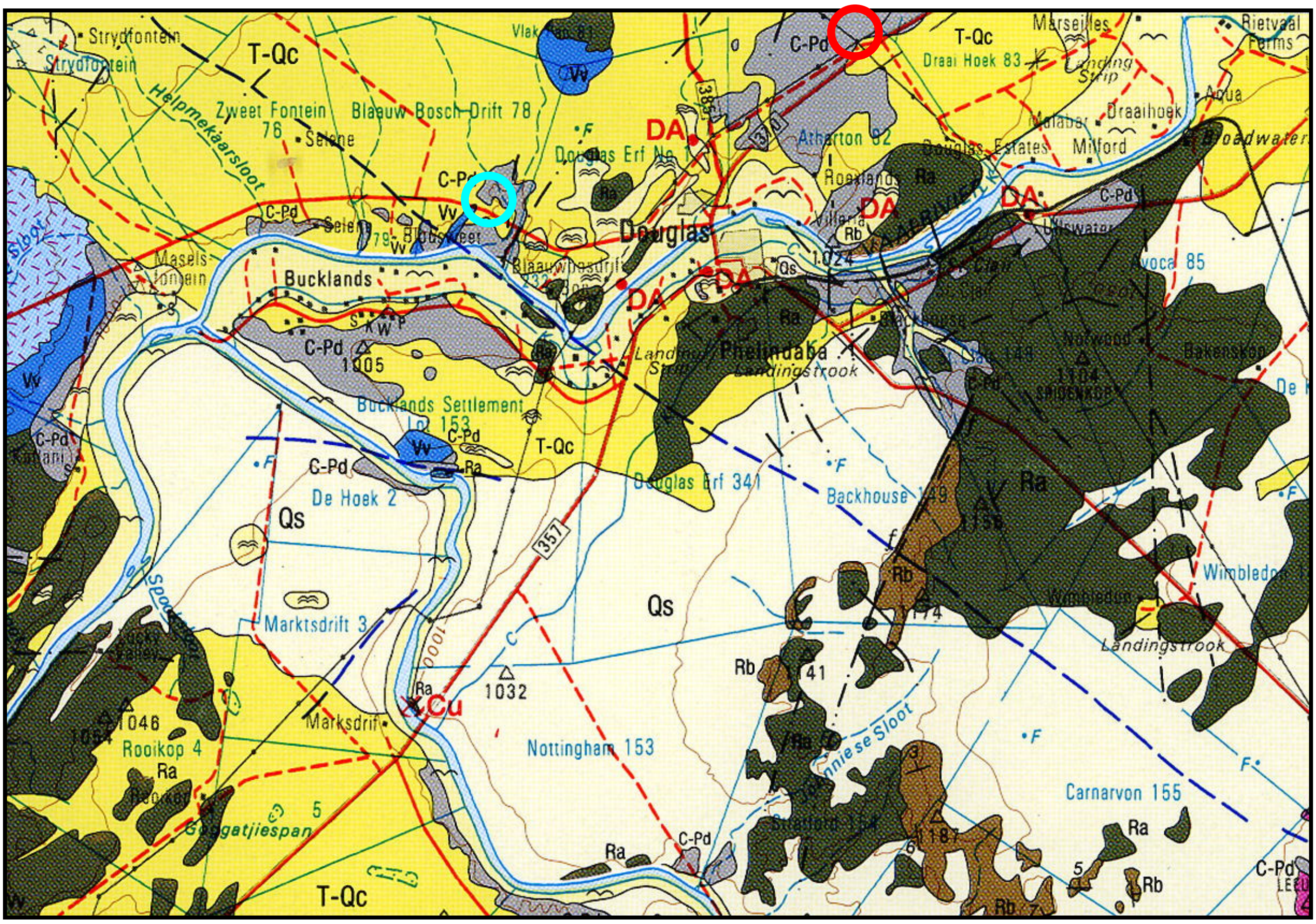

Fig. 2. Extract from 1:250 000 geological map 2922 Prieska (Council for Geoscience, Pretoria) showing location of proposed Herbert photovoltaic power station north of the Vaal River (red circle at top edge of map). The pale blue circle to the southwest indicates the Stratotype C section of the Mbizane Formation (Dwyka Group) designated by Von Brunn & Visser (1999). This section is capped by mudrocks of Prince Albert Formation which are not separately indicated on the map.

Dark Blue (Vv) = Vryburg Formation (just beneath the Ghaap Group) Dark Grey (Ra) = Allanridge Formation (Ventersdorp Supergroup) Grey (C-Pd) = Dwyka Group Yellow (T-Qc) = Neogene calcrete Pale yellow (Qs) = Quaternary to Recent sands and sandy soil of the Gordonia Formation (Kalahari Group). DA marks ancient High Level Gravels associated with alluvial diamond occurrences close to the Orange and Vaal Rivers.

4. PALAEONTOLOGICAL HERITAGE

The fossil heritage recorded within each of the main sedimentary rock successions occurring within the study region near Douglas has been outlined by Almond (2010).

5. SUMMARY OF OBSERVATIONS FROM FIELD SCOPING STUDY

The main purpose of the present field scoping study was (a) to assess the palaeontological sensitivity of the Dwyka and Ecca Group sediments in the Douglas area as well as (b) to determine whether fossiliferous beds are exposed in the study area itself, adjacent to the existing Herbert electrical substation (See outline brief in Section 2 above).

5.1. Dwyka Group (Mbizane Formation)

Good stream valley exposures of the Permocarboniferous Dwyka Group overlying Late Archaean sedimentary rocks of the Transvaal Supergroup were examined in the stratotype area of the Mbizane Formation on the farm Blaauwboschdrift, situated on the northern banks of the Vaal River *c*. 6 km northwest of Douglas (Von Brunn & Visser 1999; blue circle in Fig. 1) as well as in a large borrow pit 3.5 km ESE of Douglas on the southern side of the R357 Kimberley-Douglas road (white arrow on Fig. 1). The lithologically varied Mbizane beds were deposited in a shallow sea overlapping the margins of the Kalahari Craton within valleys and inlets incised into much older, Archaean to Proterozoic bedrocks.

Thin-bedded, heterolithic to flaggy Dwyka successions with sparse cobble to boulder-sized dropstones are seen at Locs. 602 and 614 (Figs. 13 & 14). The heterolithic facies comprises thin greyish-green fine sandstones interbedded with shales and thin diamictite lenticles or layers. Some of the latter can be described as “dropstone laminites” where the bedding surfaces are sprinkled with fine to coarse-grained, often angular gravel clasts that have melted out of the base of floating ice sheets. Elsewhere similar dropstone laminites are often associated with fine arthropod trackways (*e.g. Umfolozia*), but no traces were observed in the Douglas area. Locally folded bedding suggests soft-sediment deformation by downslope slumping. Larger dropstones are often facetted and striated, and show characteristic draping of overlying beds/laminae as well as – syn- or postdepositional – compactional deformation of underlying laminae. Small (dm-scale), rounded stromatolitic structures occur in some of the dark grey limestone erratics of the Precambrian Ghaap Group (Fig. 5). Several meters of cyclically bedded, fining-up rhythmites are seen in a stream cutting on the southern portion of Blaauwboschdrift (Fig. 6). These might represent periglacial varvites. Bedding plane exposure here is limited and no trace or other fossils were observed here. Large, meter-scale diagenetic concretions of brown ferruginous carbonate are associated with these beds.

Low cliffs of well-consolidated, massive greyish-green diamictite (“boulder mudstone”) are well-exposed in streambed sections on Blaauwboschdrift (Fig. 3). Many of the larger inclusions show faceting and striation. They represent a wide range of rock types, including Ghaap Group limestones, jaspilitic cherts, banded iron formation, granites and distinctive amygaloidal lavas that probably belong to the 2.7 Ga Ventersdorp Supergroup. Some boulder-sized rock lumps are well-consolidated intraclasts of pebbly diamictite, perhaps originally held together by permafrost.

Clast- to matrix-supported pebbly to bouldery lenticles and beds within the Dwyka succession are usually well-consolidated, slightly ferruginous and prominent-weathering. They can occasionally be seen to infill erosive-based channels and may be interbedded with brown-weathering calcareous sandstones (Figs. 3 & 4). They may represent distributary channel conglomerates on the surface of proximal (nearshore) turbidite fans, and/or debris flow diamictites.

The basal contact of the Dwyka on the underlying, well-jointed Precambrian basement rocks is well exposed in several areas on Blaauwboschdrift and locally shows vertical relief of several meters.

The basement here comprises tough, well-sorted, brownish-grey fine sandstones or greywackes (possibly turbidites) of the 2.6Ga **Vryburg Formation** (Vv in Fig. 2). This fluvial to marine succession underlies the Ghaap Group and overlies the Ventersdorp Supergroup in the Griqualand West Basin (Eriksson *et al.* 2006). Away from the glacial pavements the exposed upper surface of the Vryburg rocks is locally reddened. Sedimentary structures include well-developed interference ripples, linear-crested current ripples, fluted small-scale slump scars, and abundant evidence for dewatering in the form of stromatolite-like convolute lamination, suggesting rapid deposition of water-rich sediments. Extensive glacially striated pavements on Blaauwboschdrift are incised into the flat to gently sloping surfaces of Vryburg basement rocks (Fig. 7). The pavements are directly overlain by massive Dwyka "boulder mudstones" and they are sometimes associated with rock engravings of geometric shapes and a variety of animals. The striations are orientated NE-SW at 60-65°. Well-developed series of arcuate *chatter marks* are often present on these surfaces. These marks are orientated transversely to the striations and indicate the sense of ice movement – in the direction of the "horns" of the crescentic marks. It is possible that in some cases the striated surfaces may have been scraped into a thin veneer of sandy material abraded from the bedrock by moving ice and emplaced as lodgement till before being overridden and grooved by later ice movement.

5.2. Prince Albert Formation

Postglacial basinal mudrocks of the Prince Albert Formation (basal Ecca Group) were examined at the classic fossil locality of Blaawkranz on the northern banks of the Rietrivier, *c*. 20 km ENE of Douglas (yellow circle in Fig. 1. The Ecca beds are capped by surface calcretes and a thin veneer of reddish Kalahari sands. The stratigraphy and fossil faunas in this area have been described in detail by McLachlan and Anderson (1973; see also Almond 2010).

The soft-weathering, grey-green mudrocks of the Prince Albert Formation are exposed here on the inside of a northern bend in the Rietrivier (Locs. 611 & 612). The succession also features thin, prominent-weathering pinkish-brown limestones and horizons of irregularly shaped, rounded to elongate concretions of probable phosphatic carbonate composition (Fig. 8). There are also horizons of pale creamy-buff, oblate spheroidal concretions up to 20 cm in diameter. These often, but not always, contain fossils in the form of wood fragments, irregular coprolites containing comminuted fish remains (scales, teeth, dermal bones) as well as spiral shark coprolites. The original fossil bone or shell material has usually been replaced by powdery limonite or kaolinite (Figs. 9 & 10). The matrix of the concretions contains small (*c*. 1 mm diameter) rounded hollows or "spherulites" that have been interpreted by some authors as radiolarian protozoans, but this remains contentious. Silicified wood fragments are also found embedded in the mudrock matrix and generally show well-developed seasonal growth rings. Some have been rounded during transport (Fig. 11).

A monotonous succession of well-laminated, greyish-green mudrocks of the Prince Albert Formation was also examined for fossils, without success, at Loc. 613 to the east. This is a low roadcut close to the east bank of the Vaal River on the road to Schmidtsdrift from the R357 Douglas-Kimberley main tar road. The mudrocks here are hackly weathering and intruded by dolerite dykes (Fig. 12).

5.3. Superficial deposits

A thickness of up to three meters (sometimes more) of **surface calcrete** (pedogenic limestone) of Quaternary or younger age blankets large areas of the Dwyka Group outcrop in the Douglas area (Figs. 13 & 14). Ground waters in this region, which lies less than 15 km southwest of the edge of the dolomite/limestone-capped Ghaap Plateau, are rich in dissolved carbonate which promotes pedogenic calcrete development. The surface calcretes incorporate variable amounts of coarse rock debris, including platy sandstone and mudrock clasts from the underlying bedded Dwyka, downwasted cobbly and bouldery erratics from the tillites, as well as subangular to well-rounded, polymict alluvial gravels – Tertiary "**High Level Gravels**" – of the Vaal drainage system (Fig. 15). Locally the Tertiary gravels infill erosional channels incised into the Dwyka succession (Fig. 13). No fossils were observed in these coarse-grained deposits during the scoping study.

Thick, well-bedded **silty alluvium** is seen at Loc. 607 on the northern banks of the Vaal River at Blaauwboschdrift. Calcretized rhizoliths (root casts), some branched, are abundant in the older alluvial horizons. Vertebrate remains among the river gravels themselves include numerous mammalian teeth (*e.g.* of hippos), water-worn bones as well as horn cores (Figs.16 to 18). Archaeological remains here include vertical sections through stone-lined hearths, numerous MSA and LSA stone artefacts, ostrich egg shell fragments as well as chunks of crude pottery. Calcretized matts of reedy plant material (Fig. 19) have also been collected on the western portion of the farm (Hecules Smith, pers. comm., 2010).

Thin (2 m or less) patches of orange-hued Kalahari sands (**Gordonia Formation**) overlie the surface calcretes in the Douglas area. Vertical sections are seen in roadcuts, for example along the road from the R357 to Schmidtsdrift. No fossils were observed in these aeolian sands which locally support large conical to domical termitaria (*cf* Fig. 20).

5.4. Herbert Substation study area

No bedrock outcrop was found in the area surrounding the Herbert substation on the farm Atherton 82. This area is underlain by a layer of surface calcretes with a thickness of 2 m or more, which are exposed in a small borrow pit close to the gate onto the R370 approach road from Douglas (Fig. 21, Loc. 608). The vertical section exposed here shows massive to nodular calcrete which is denser and false-bedded towards the top. No fossils were seen within the calcretes here. The calcretes are blanketed with down-wasted calcrete rubble and a thin veneer of orangey to grey-brown Kalahari sands, termitaria and thorn veld (Fig. 20).

Veneers of pebbly to fine gravels are also found in the study area (Fig. 22, Loc. 609). They include subangular gravels down-wasted from the weathered Dwyka bedrock in the neighbourhood as well as a component of alluvial gravels of the Vaal drainage system. The gravels are compositionally varied, including clasts of dark volcanic rocks (probably Ventersdorp Supergroup), cherts, Ghaap Group limestones, BIF and reworked calcrete. Many of the cherty clasts are flaked (MSA, LSA). Gravel carpets have been exposed or concentrated in some areas by wind deflation.

Road cuttings along the R370 between the Herbert substation and Douglas show a section through poorly-consolidated silty alluvium that is underlain by older calcretes as well as capped by younger calcretes, including vertical columnar structures (possibly megarhizoliths). These silty sediments are probably flood deposits of the Vaal system. Coarser "High Level Gravels" of the same system are mapped in this area but closer to Douglas (*cf.* Fig. 15).

6. CONCLUSIONS & RECOMMENDATIONS

Bedrock exposure in the study area around the Herbert electrical substation near Douglas is insufficient to determine whether this is underlain by Dwyka or Ecca Group sediments. Apart from occasional stromatolitic limestone or dolomite erratics reworked from the 2.6-2.5Ga Ghaap Group, the varied Permocarboniferous sediments of the Mbizane Formation (Dwyka Group) near Douglas appear to be largely unfossiliferous but are of scientific interest for their rich variety of glacial-related features. These include extensive ice-scoured rock pavements, some of which feature numerous well-preserved rock engravings. The Early Permian Prince Albert (Ecca Group) rocks in the region yield a sparse but palaeontologically interesting fauna of fossil fish, invertebrates, coprolites and petrified wood, mainly preserved within cannon-ball sized nodules. However, in the substation study area the Karoo Supergroup bedrocks are entirely blanketed with a thick (2 or more meters) layer of surface calcrete on top of which lies a veneer of Kalahari sands and down-wasted gravels. These superficial deposits are only sparsely fossiliferous, and no fossils were observed within them in the study area during the present scoping study.

It is concluded that the shallow excavations envisaged during construction of the proposed photovoltaic power station are unlikely to intersect fossil-bearing bedrock and no specialist palaeontological mitigation is recommended here. Should fossil remains be encountered during development, however, the responsible ECO should inform SAHRA at the earliest opportunity to consider possible mitigation measures.

7. ACKNOWLEDGEMENTS

Ms I.B. Van Zyl of Van Zyl Environmental Consultants cc, Upington, is thanked for commissioning this scoping study and for kindly providing all the necessary background information. Ms Madelon Tusenius provided able assistance and logistical back-up in the field. I am grateful to Mr Hercules Smith and his family at the farm Blaauwboschdrift for their hospitality during our visit and for showing us sites of palaeontological and archaeological significance on their land. The Cilliers Family at Blaauwkrantz kindly gave us permission to look for fossils on their farm.

8. REFERENCES

Please refer to the desktop study by Almond (2010) for a full set of geological and palaeontological references relevant to this impact study.

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Fig. 3. Massive grey, pebbly diamictites overlain by lenticular-bedded, ferruginised sandstones and coarse channel conglomerates, Mbizane Formation, Blaauwboschdrift.

Fig. 4. Detail of upper portion of section in previous figure showing erosive based channel and varied matrix- and clast-supported conglomeratic infill overlying massive grey tillites (Section shown is *c.* 2 m thick).

Fig. 5. Erratic of reworked Ghaap Group dolomite from the Mbizane Formation, Blaauwboschdrift (Loc. 602) showing small stromatolitic structures. Larger stromatolite on the left is *c.* 10 cm in exposed length.

Fig. 6. Streambank exposure of cyclically-deposited rhythmites in the Mbizane Formation, Blaauwboschdrift (Hammer = 27 cm).

Fig. 7. Uneven, striated glacial pavement incised into the Precambrian Vryburg Formation and overlain by massive diamictites of the Mbizane Formation, Blaauwboschdrift (Loc. 605)

Fig. 8. Basinal mudrocks of the Prince Albert Formation, Blaauwkrantz, showing thin pinkish-brown limestone horizon and pale spheroidal nodules (Hammer = 27 cm) (Loc. 612).

Fig. 9. Freshly broken spheroidal nodule from the Prince Albert Formation, Blaauwkrantz (Loc. 611) showing coprolite of disarticulated fish remains inside (Scale = 16 cm).

Fig. 10. Fossiliferous nodule from the Prince Albert Formation, Blaauwkrantz, containing a large fish plate. The original bone has been replaced by white kaolinite and rusty-brown limonite (Scale = 16 cm).

Fig. 11. Well-rounded, transported fragment of silicified wood showing clearly-developed seasonal growth rings, Prince Albert Formation, Blaauwkrantz (Scale in cm.).

Fig. 12. Road cutting through laminated mudrocks of the Prince Albert Formation east of the Vaal River (Hammer = 27 cm) (Loc. 613).

Fig. 13. Calcretised channel-infill gravels incised into convolute-bedded Mbizane Formation with dropstones (Hammer = 27 cm) (Loc. 602).

Fig. 14. Thin-bedded Mbizane Formation with boulder-sized dropstones overlain by calcretised Late Tertiary High Level Gravels (Loc. 614) (Hammer = 27 cm).

Fig. 15. Detail of the coarse, angular to well-rounded, Tertiary High Level Gravels above in a borrow pit south of the Vaal River (Hammer = 27 cm) (Loc. 614). Note abundance of grey Ghaap Group limestone clasts.

Fig. 16. Mammalian teeth and bone fragments eroding out of Vaal River silty alluvium and gravel deposits, Blaauwboschdrift (Scale in cm) (Loc. 607).

Fig. 17. Mammalian horn core from the Vaal River alluvium, Blaauwboschdrift (Loc. 607).

Fig. 18. Calcretised rhizoliths embedded in older silty alluvium of Vaal River, Blaauwboschdrift (Loc. 607) (Scale = 16 cm).

Fig. 19. Calcretised matt of reedy vegetation, Blaauwboschdrift (Scale = 16 cm).

Fig. 20. Orange-red Kalahari sands, termitaria and thornveld in the vicinity of the Herbert electricity substation, farm Atherton 82.

Fig. 21. Thick, nodular calcrete overlain by well-consolidated calcrete *hardebank* in a borrow pit just SE of the Herbert substation (Hammer = 27 cm) (Loc. 608).

Fig. 22. Polymict wind-deflated surface gravels north of the Herbert substation (Scale = 16 cm) (Loc. 609). Many of the cherty gravel clasts are flaked (*e.g.* pale quartzite in RHS middle).

9. GPS LOCALITY DATA FOR SITES LISTED IN TEXT

All GPS readings were taken in the field using a hand-held Garmin GPSmap 60CSx instrument. The datum used is WGS 84.

Only those localities mentioned in the text are listed here.

LOCALITY NUMBER	SOUTH	EAST
602	29° 02' 12.2"	23° 42' 31.6"
605	29° 02' 21.3"	23° 42' 43.0"
607	29° 03' 15.5"	23° 42' 01.3"
608	29° 00' 28.9"	23° 48' 31.2"
609	29° 00' 18.1"	23° 48' 01.9"
611	28° 59' 55.1"	23° 58' 30.6"
612	28° 59' 55.4"	23° 58' 30.8"
613	28° 56' 43.1"	23° 59' 37.2"
614	29° 03' 51.5"	23° 49' 04.5"

10. 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 records 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 Douglas 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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