PALAEONTOLOGICAL HERITAGE ASSESSMENT: DESKTOP STUDY

Proposed PV Solar Facility on a portion of the farm Rosendal 673 near Vryburg, Naledi Local Municipality, North-West Province

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EXECUTIVE SUMMARY

The company Sediba Power Plant (Pty) Ltd is proposing to construct a 75 MW photovoltaic solar facility on the farm Rosendal 673 located *c*. 2 km south of the town of Vryburg (Naledi Local Municipality), North-West Province. The southern part of the farm, where the proposed solar plant is to be constructed, is underlain by several formations of the Schmidtsdrif Subgroup (Ghaap Group, Transvaal Supergroup) of Late Archaean age (*c*. 2.64 billion years old). The oldest of these Precambrian rock units, the mixed fluvial and volcanic Vryburg Formation, is apparently unfossiliferous in this area. The carbonate-rich Boomplaas Formation is known to contain well-preserved stromatolite (microbial dome) assemblages in the Vryburg region but has a very small outcrop area on Rosendal 673 and is poorly exposed at surface. Marine mudrocks of the slightly younger Clearwater Formation might also contain minor stromatolitic carbonates but are also very poorly exposed. The central and northern portions of Rosendal 673 are underlain by Permo-carboniferous glacial rocks of the Dwyka Group as well as various Late Caenozoic superficial sediments such as pedogenic calcretes and surface gravels that are all of low palaeontological sensitivity. It is concluded that the overall impact of the proposed Sediba solar plant development on Rosendal 673 is of NEGATIVE LOW SIGNIFICANCE in palaeontological heritage terms and further studies or mitigation of fossil heritage resources for this alternative energy project are not warranted.

1. INTRODUCTION & BRIEF

The company Sediba Power Plant (Pty) Ltd is proposing to construct a 75 MW photovoltaic solar facility and associated infrastructure on a portion of Remaining Extent of the farm Rosendal 673 situated approximately 2 km south of the town of Vryburg (Naledi Local Municipality), North-West Province (NEAS Reference: DEA/EIA/0001359/2012. DEA Reference: 14/12/16/3/3/2/390). The study area is situated on flat lying terrain about one km east of the Droë Harts River and on the western side of the N18 tar road from Vryburg to Kimberley. The location of the study area is shown on the map Fig. 1 and a satellite image of the area is shown in Fig. 2.

The footprint of the proposed alternative energy project will be approximately 150 hectares (including supporting infrastructure). The main infrastructural components of the solar facility that are of relevance to the present fossil heritage study include:

- a photovoltaic (PV) panel array tilted at a fixed angle towards the north;

- building infrastructure including a new on-site control facility with a total footprint of 400 m^2 or less;
- electrical infrastructure including an on-site distribution substation (c. 90 m x 120 m) connected to the new Mookodi Substation *via* a 132 kV overhead line of up to 1 km length;
- new or upgraded gravels roads (4 m wide) forming an internal site road network;
- a laydown area (< 150 ha);
- fencing round the solar facility.

The proposed solar energy facility overlies potentially fossiliferous sediments of the Ghaap Group (Transvaal Supergroup) and / or Dwyka Group (Karoo Supergroup). Fossils preserved within the bedrock or superficial deposits may be disturbed, damaged or destroyed during the construction phase of the proposed project. The extent of the proposed development (over 5000 m^2) falls within the requirements for a Heritage Impact Assessment (HIA) as required by Section 38 (Heritage Resources Management) of the South African Heritage Resources Act (Act No. 25 of 1999). SAHRA has therefore requested a palaeontological heritage assessment of the proposed development (SAHRA Ref. no. 9/2/103/0002). According to their letter of 8 November 2012:

> A palaeontological assessment be compiled for the proposed project. This report must be submitted to SAHRA for comment before the project can proceed. If the palaeontologist deems the fossil resources of the area to be of low significance, or if the impact of the development is unlikely to be high, a letter of exemption from further palaeontological studies may be submitted to SAHRA.

This desktop palaeontological study has accordingly been commissioned on behalf of the client DPS79 Solar Energy (Pty) Ltd by Mr Bennie J. Scheepers (Project Manager, Subsolar Energy (Pty) Ltd. Cell: +27 79 822 2455. Tel: +27 54 461 0293. Fax: 086 527 1258. Email: scheepers@subsolar.co.za).

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

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

Minimum standards for the palaeontological component of heritage impact assessment reports are currently being developed by SAHRA. The latest version of the SAHRA guidelines is dated 2011.

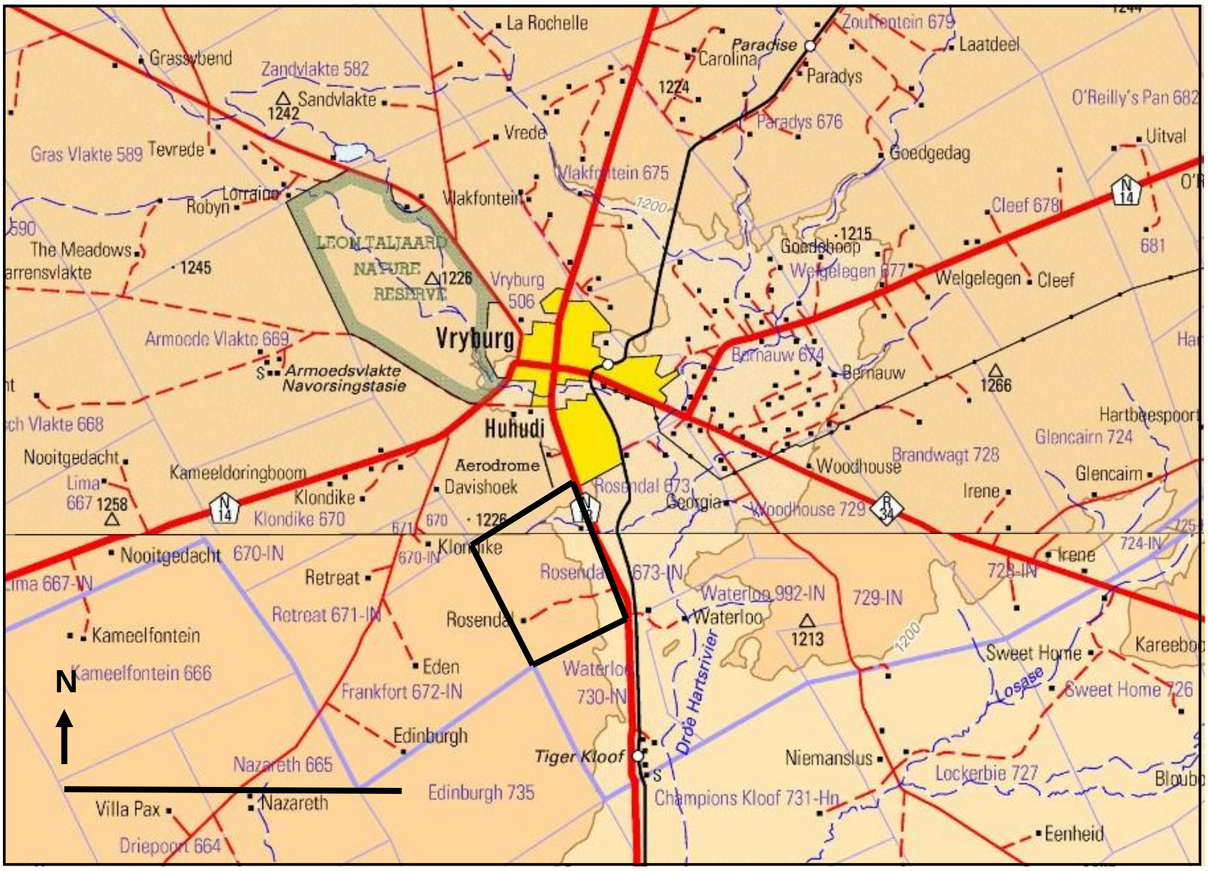

Fig. 1. Extracts from adjoining 1: 250 000 topographical maps 2624 Vryburg and 2724 Christiana (Courtesy of the Chief Directorate of Surveys & Mapping, Mowbray) showing approximate location of the study area on farm Rosendal 673 some 2 km south of Vryburg, North-West Province (black polygon). Scale bar is *c*. 10 km.

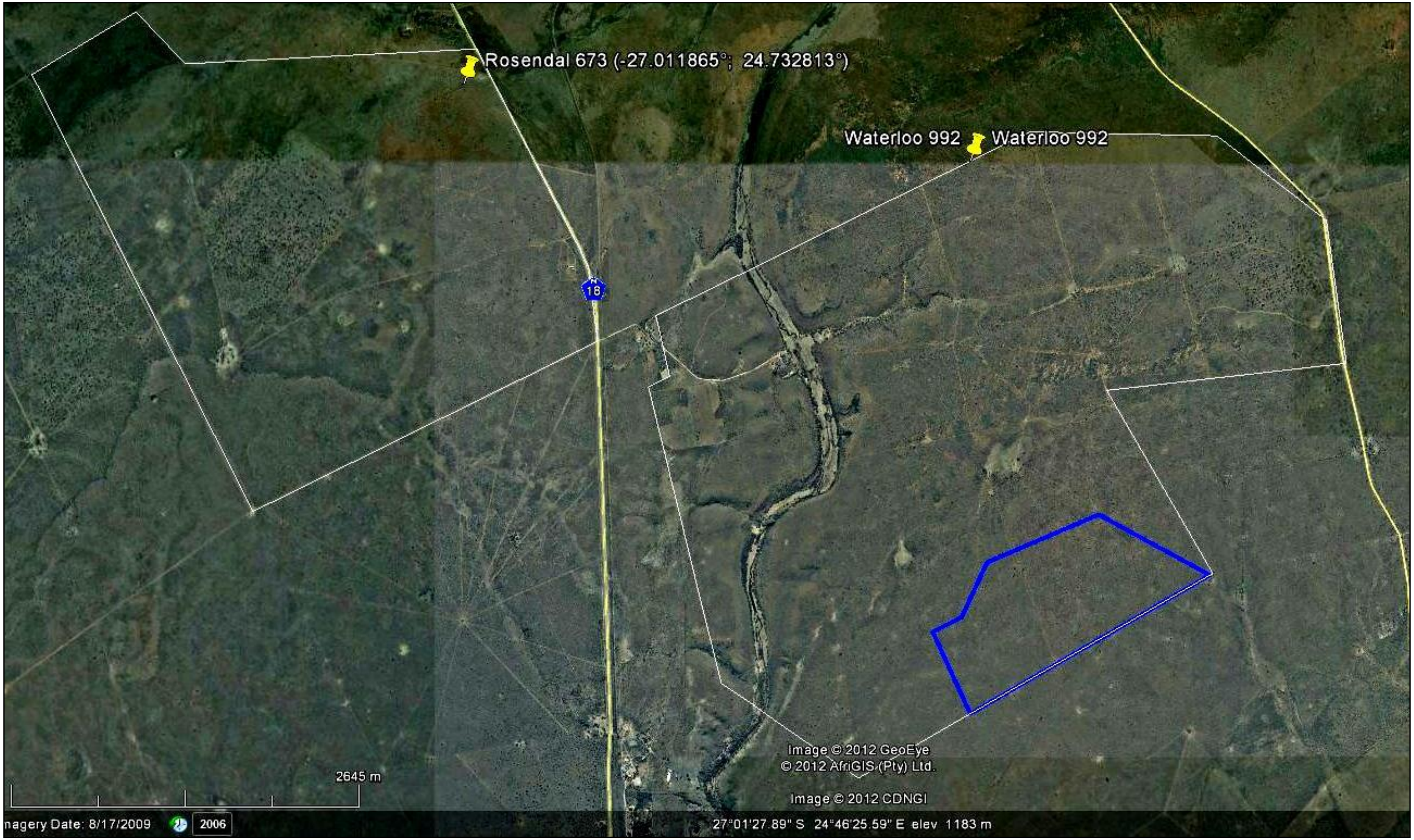

Fig. 2. Google earth© satellite image of the solar plant study area on farms Waterloo 992 and Rosendal 673 to the south of Vryburg, North-West Province (The solar project on Waterloo 992 is the subject of a separate palaeontological assessment).

1.1. General approach used for palaeontological assessment studies

In preparing a palaeontological desktop study the potentially fossiliferous rock units (groups, formations *etc*) represented within the study area are determined from geological maps. The known fossil heritage within each rock unit is inventoried from the published scientific literature, previous palaeontological impact studies in the same region, and the author's field experience (Consultation with professional colleagues as well as examination of institutional fossil collections may play a role here, or later during the compilation of the final report). This data is then used to assess the palaeontological sensitivity of each rock unit to development (Provisional tabulations of palaeontological sensitivity of all formations in the Western, Eastern and Northern Cape have already been compiled by J. Almond and colleagues; *e.g.* Almond & Pether 2008). The likely impact of the proposed development on local fossil heritage is then determined on the basis of (1) the palaeontological sensitivity of the rock units concerned and (2) the nature of the development itself, most notably the extent of fresh bedrock excavation envisaged.

When rock units of moderate to high palaeontological sensitivity are exposed within the development footprint, a Phase 1 field-based study by a professional palaeontologist is usually warranted. Most detrimental impacts on palaeontological heritage occur during the construction phase when fossils may be disturbed, destroyed or permanently sealed-in during excavations and subsequent construction activity. Where specialist palaeontological mitigation is recommended, this may take place before construction starts or, most effectively, during the construction phase while fresh, potentially fossiliferous bedrock is still exposed for study. Mitigation usually involves the judicious sampling, collection and recording of fossils as well as of relevant contextual data concerning the surrounding sedimentary matrix. The palaeontologist concerned would need to apply beforehand for a collection permit from SAHRA. It should be emphasised that, *provided* appropriate mitigation is carried out, many developments involving bedrock excavation actually have a *positive* impact on our understanding of local palaeontological heritage. Constructive collaboration between palaeontologists and developers should therefore be the expected norm

2. GEOLOGICAL & PALAEONTOLOGICAL BACKGROUND

The study area on farm Rosendal 673 near Vryburg consists of typical flat-lying terrain of the Ghaap Plateau region at *c*. 1200-1230 m amsl that is currently used for agricultural purposes (principally cattle farming). A new municipal landfill site and Eskom's new Mookodi substation are currently being constructed on the farm Rosendal to the north of the proposed solar plant development site on the southern portion of the farm. The climate is semi-arid and the dense vegetation cover of grassy thornveld is mapped as Ghaap Plateau Vaalbosveld. The area is traversed by several shallow water courses. The proposed solar plant development area in the part of the farm is especially flat (*c*. 1200m amsl) with at most small, low and scattered bedrock exposures.

The geology of the study area south of Vryburg is shown on the adjoining 1: 250 000 geology maps 2624 Vryburg and 2724 Christiana (Council for Geoscience, Pretoria; Fig. 3 herein). An explanation for the Christiana geological map has been published by Schutte (1994) and for the adjoining Vryburg sheet 2624 by Keyser & Du Plessis (1993). The greater part of farm Rosendal 673 is underlain by Permocarbonifeorus glacial sediments of the **Dwyka Group** (Karoo Supergroup, **C-Pd**). In the Vryburg region this succession mainly consists of glacial tillite (boulder mudstone) and interglacial shale. Exposures levels are typically very poor, since the mudrock matrix weathers very readily, and consequently the Dwyka outcrop area represented at surface only by scattered erratic boulders (Keyser & Du Plessis 1993). Glacial striations of Dwyka age incised into older resistant quartzitic rocks of the Vryburg Formation on the farm indicate southerly ice transport directions (circular symbol with arrow on geological map) (Schutte 1994). Northern outcrops of the Dwyka Group may contain low diversity non-marine trace fossil assemblages (predominantly fish and arthropod traces, *Rhizocorallium*) within interglacial mudrocks as well as scattered vascular plant remains (*e.g. Glossopteris* leaves, petrified wood) but the likelihood of significant fossil heritage in the Vryburg area is considered to be low.

A narrow strip of the Dwyka outcrop area towards the northern edge of the farm is overlain by Late Caenozoic **calcretes** (= pedogenic limestones, **T-Qc**). These geologically recent surface deposits contain stone age artefacts on Rosendal 673 (Schutte 1994) and may contain other fossil remains such as termite burrows or vertebrate bones and teeth. However, since direct impacts on these beds are highly unlikely, they will not be considered further here.

In the southern and eastern portions of Rosendal 673 much older sedimentary rocks of the **Schmidtsdrif Subgroup** crop out where the Dwyka cover rocks have been removed by erosion. These ancient Precambrian rocks are almost flat-lying, with a gentle dip towards the south. This is the basal subdivision of the Late Archaean to Early Proterozoic **Ghaap Group** (**Transvaal Supergroup**) in the Griqualand West Basin, Ghaap Plateau Subbasin (Fig. 4). Useful reviews of the stratigraphy and sedimentology of these Transvaal Supergroup rocks have been given by Moore *et al.* (2001), Eriksson and Altermann (1998) as well as Eriksson *et al.* (1993, 1995, 2006). The Ghaap Group represents some 200 Ma of chemical sedimentation - notably iron and manganese ores, cherts and carbonates with subordinate silicastic rocks - within the Griqualand West Basin that was situated towards the western edge of the Kaapvaal Craton (See fig. 4.19 in McCarthy & Rubidge 2005).

The area close to the N18 tar road is underlain by siliclastic fluvial and shallow marine / lagoonal sediments as well as volcanic rocks of the **Vryburg Formation** (**Vv**). The Vryburg Formation is approximately 140 m thick in this area and unconformably overlies lavas of the Venterdorp Supergroup (Allanridge Formation). The holostratotype of the formation lies near Dry Harts Siding some 35 km to the south. An important reference section (Stratotype G), including good examples of the two major volcanic packages known as the Rosendal and Waterloo Members, is located on Waterloo Farm to the east of the N18 (Smit *et al.* 1991). These last authors give a useful summary of the geology and sedimentology of the Vryburg succession, together with a detailed stratigraphic column for Waterloo Farm largely based on exposures along or close to the Droë Harts River. The lower portion of the Vryburg succession here comprises a basal conglomerate followed by a 20 m-thick, prominent-weathering package of cross-bedded feldspathic quartzites known as the Kobaga beds. This is overlain by *c*. 20 m of andesitic or basaltic lavas (the **Rosendal Member**) and pyroclastic sediments and then another 20 m package of varied siliciclastic rocks including conglomerates, quartzites, grits, flaggy sandstones (often ripple marked) and shales. These last are often pitch black and calcitic. The overlying **Waterloo Member** consists of c. 20-50 m of amydaloidal and non-amydaloidal basaltic / andesitic lavas and is overlain by 14 m of interbedded pyroclastic sediments and thin lenticular limestones. These last beds form the top of the Vryburg Formation and are followed by the carbonate-dominated facies of the Boomplaas Formation (see below).

Minor carbonate interbeds within the upper Vryburg Formation in its southern, more distal outcrop area (*e.g.* near Douglas) contain microbial stromatolites, and these are also recorded from the holostratotype section some 40 km south of Vryburg (Smit *et al.* 1991). The stromatolitic carbonates within the Vryburg succession interfinger with and pass up into siliclastic sediments and are interpreted as intertidal in setting (Altermann & Wotherspoon 1995). To the author's knowledge, a detailed description of the Vryburg stromatolite occurrences has not yet been published. Useful reviews of Archaean stromatolites and associated organic-walled microfossils from southern Africa and elsewhere are provided by Altermann (2001), Buick (2001), Brasier *et al.* (2006) and Schopf (2006). Bertrand-Sarfarti and Eriksson (1977) describe columnar stromatolites from the Schmidtsdrift Subgroup of the Northern Cape.

The southern margin of farm Rosendal 673 is underlain by shallow marine carbonates (predominantly dolomites) and subordinate siliclastic sediments of the **Boomplaas Formation** (**Vb**). This mixed carbonate and siliciclastic succession is 100 – 185 m in thickness and is transitional between the predominantly continental Vryburg beds and the fully marine Campbell Rand platform carbonates of the Kaapvaal Craton. The Boomplaas beds are dominated by grey dolomites (weathering reddish-brown) with subordinate interbeds of limestone (weathering blue-grey), quartzite, flaggy sandstone and shale. Packages of oolitic and stromatolitic dolomite alternate with intervals of carbonaceous mudrocks (possibly lagoonal) containing interbeds of calcareous sandstone and mudclast breccias. Nearshore oolitic and stromatolitic facies with cherty layers and inclusions (probably secondary replacement of carbonate) predominate in the northern outcrop area of the Boomplaas Formation, as at Vryburg, while offshore mudrock facies are found towards the south.

In a small area of Rosendal 673, towards the southwestern corner of the farm, the Boomplaas beds are overlain by the grey- to khaki-hued mudrocks and interbedded dolomites, flagstones, tuffites and BIF-like cherts of the **Clearwater Formation** (**Vc**, = Lokamonna Formation), the uppermost subunit of the Schmidtsdrif Subgroup. The finer mudrocks are pitch black and locally pyritic and calcitic while the carbonates may show crinkly stromatolitic textures.

A detailed, comprehensive account of the Neoarchaean stromatolites from the Boomplaas Formation of the Schmidtsdrif Subgroup has not been published, to the author's knowledge. Brief mention of large stromatolites from 50 cm up to 2 m across within the Boplaas Formation in the Vryburg area is made by Keyser and Du Plessis (1993). Preferential north-south elongation seen in some examples may reflect dominant onshore-offshore, wave-generated currents scouring sediment from between the domes. Wright and Altermann (2000) discuss slumping and contortion of partially decomposed, pyrite-rich stromatolitic laminae as well as preservation of organic-walled filamentous cyanobacterial microfossils within stromatolites of the Boomplaas Formation. A shallow subtidal setting for large stromatolitic domes in the Transvaal Supergroup is inferred by Truswell and Eriksson (1973), with oolites generated in higher energy inshore settings, although they may subsequently have been reworked into deeper waters offshore (See also Eriksson & Altermann 1998).

The Vryburg Formation is treated as the basal unit of the Schmidtsdrif Subgroup by several recent authors (*e.g.* Altermann & Wotherspoon 1995, Sumner & Beukes 2006) but was previously placed below the base of the Ghaap Group succession (See stratigraphic column in Fig. 4). The Vryburg siliciclastics and overlying carbonate-rich Boomplaas Formation of the Griqualand West Basin have classically been correlated with the Black Reef Formation and overlying basal Malmani dolomites of the Transvaal Basin (*e.g.* Eriksson *et al.* 1995, 2006). However, recent sequence stratigraphic studies of the Transvaal Supergroup have demonstrated that the Vryburg / Boomplaas / Clearwater sequence is in fact older than the Black Reef Formation (Sumner & Beukes 2006). Lavas from the Vryburg Formation have been radiometrically dated to 2.64 Ga (billion years old), *i.e.* Late Archaean in age (Eriksson *et al.* 2006), and the overlying Boomplaas stromatolitic carbonates are likewise assigned a Neoarchaean age (Fig. 4).

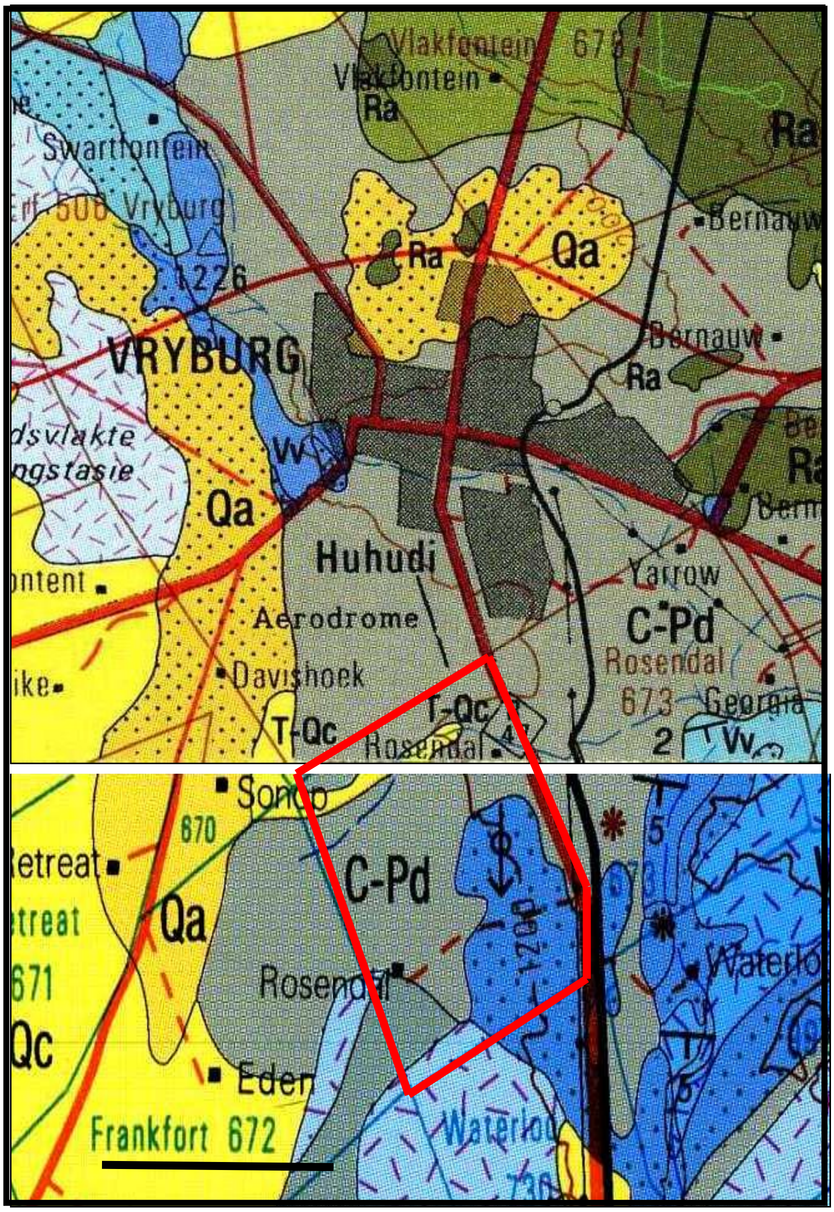

Fig. 3. Extracts from the adjoining 1: 250 000 geological maps 2624 Vryburg and 2724 Christiana (Council for Geoscience, Pretoria) showing the outline of the study area on the farm Rosendal 673 approximately 2 km south of Vryburg (red polygon). Scale bar = *c*. 5 km. The main geological units represented mapped within the broader study region include:

GHAAP GROUP (SCHMIDTSDRIF SUBGROUP): VRYBURG FORMATION (Vv, dark blue with stipple) – late Archaean fluvial and shallow marine quartzites, mudrocks, conglomerates with two intervals of andesitic volcanics; BOOMPLAAS FORMATION (Vb, pale blue with dashes) – late Archaean dolomites (locally stromatolitic or oolitic) interbedded with siliciclastics (quartzite, shale, flagstone); CLEARWATER FORMATION (Vc, dark grey) – late Archaean mudrocks with interbedded dolomites, flagstones, tuffites, cherts.

KAROO SUPERGROUP: DWYKA GROUP (C-Pd, middle grey) – Permocarboniferous glacial sediments (tillites, interglacial mudrocks)

SUPERFICIAL SEDIMENTS: Late Caenozoic calcretes (yellow)

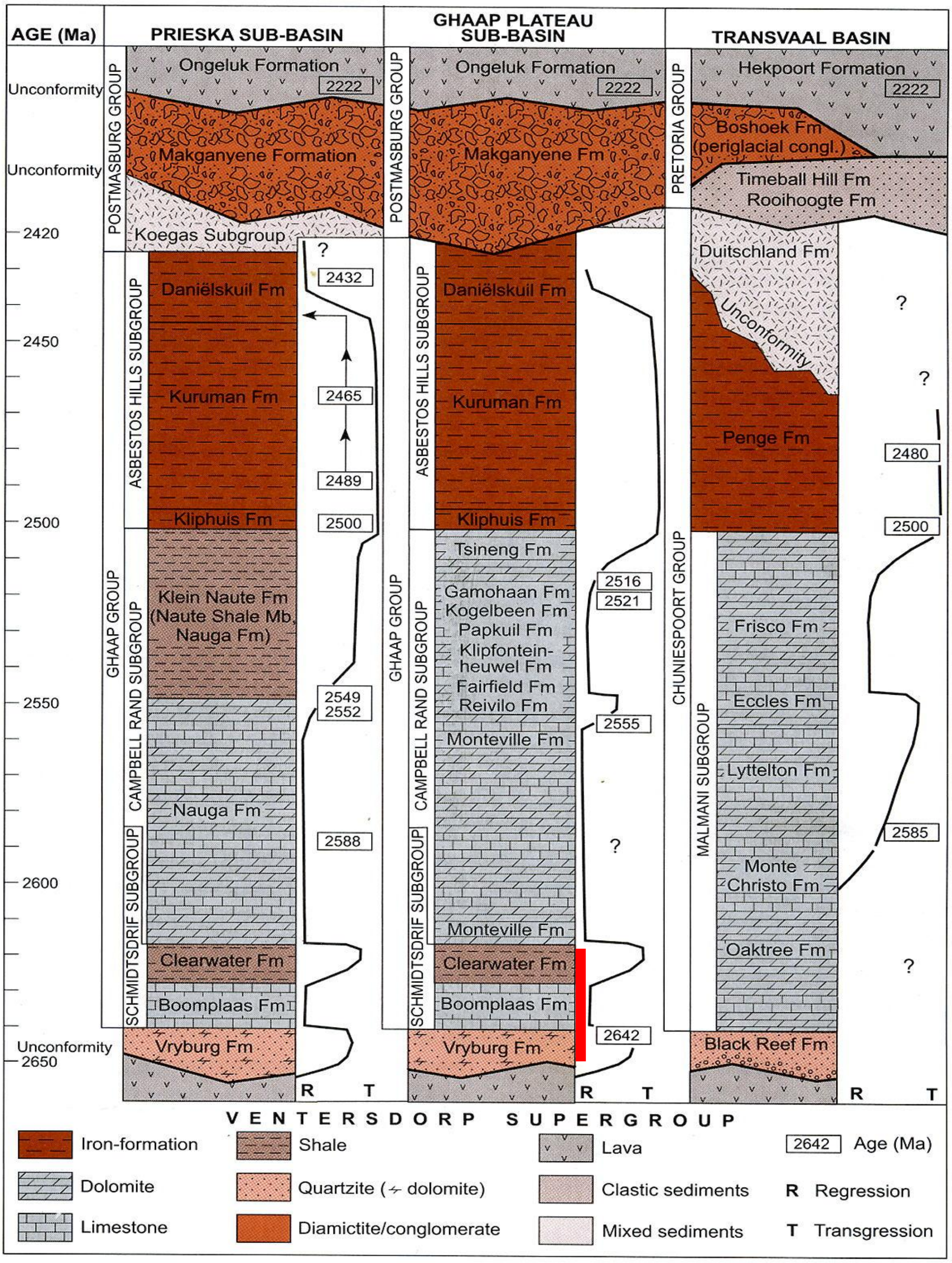

Fig. 4. Stratigraphy of the Transvaal Supergroup of the Ghaap Plateau Basin (central column) showing rock units represented in the study area (red line) (From Eriksson *et al.* 2006). Note that the Vryburg Formation is incorporated within the base of the Schmidtsdrif Subgroup by some recent authors and is no longer correlated with the Black Reef Formation of the Transvaal Basin as shown here (*e.g.* Altermann & Wotherspoon 1995, Sumner & Beukes 2006).

3. SIGNIFICANCE OF IMPACTS ON PALAEONTOLOGICAL HERITAGE

A brief assessment of the impact significance of the proposed photovoltaic solar facility development on local fossil heritage resources on Farm Rosendal 673 is presented here.

- **Nature of the impact**

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

- **Geographical extent and duration of the impact**

Significant impacts on fossil heritage are limited to the development site and to the construction phase when site clearance and excavations into fresh, potentially fossiliferous bedrock may take place. No further significant impacts are anticipated during the operational or decommissioning phases of the solar facility. Impacts on fossil heritage are generally permanent.

- **Probability of the impact occurring**

Given the very small area of potentially fossiliferous outcrop and the low levels of bedrock exposure in the southern portion of the farm, the probability of significant impacts on fossil heriage is considered to be low (unlikely).

- **Intensity / magnitude of impact**

The intensity of the impact on fossil heritage is rated as low.

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

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

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

Since little is known about the stratigraphic and geographical distribution of Late Archaean stromatolites within the Schmidtsdrift Subgroup, including the Boomplaas and Clearwater Formations, it is not yet possible to accurately assess the uniqueness of any stromatolite assemblages present on Farm Rosendal 673. It is very likely that better preserved examples are present within the more extensive outcrop area of the Boomplaas Formation on Waterloo Farm to the east of the N18. At most a marginal loss of the fossil resource is therefore anticipated for the current project.

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

Mitigation of possible damage and destruction of fossil stromatolites within the proposed development area would involve the surveying, recording, description and judicious sampling of well-preserved fossil occurrences within the development footprint by a professional palaeontologist. This work should take place after initial vegetation clearance has taken place but *before* the ground is leveled for construction. However, given the low impact significance of the project concerned, no specific mitigation measures are recommended here.

- **Cumulative impacts**

According to the Draft Environmental Impact Report for this solar plant development (Environamics 2012) two other solar plants have been proposed in the vicinity. These are:

- A 19.5 MW solar plant on a northern portion of the farm Waterloo 992 (NEAS Reference: DEA/EIA/0001105/2012 & DEA Reference: 14/12/16/3/3/1/506) and

- A 75MW solar plant on a southern portion of the farm Waterloo 992 (NEAS Ref: DEA/EIA/0001090/2012; DEA Ref: 14/12/16/3/3/2/308).

Impacts on fossil stromatolite assemblages within the Boomplaas Formation are likely in these two cases. The cumulative effect of the three proposed solar plant developments is considered to be low, however, given the large outcrop area of this formation elsewhere.

The overall impact of the proposed Sediba solar plant development on Rosendal 673 is rated as of **NEGATIVE LOW SIGNIFICANCE** in palaeontological heritage terms.

4. CONCLUSIONS & RECOMMENDATIONS

The company Sediba Power Plant (Pty) Ltd is proposing to construct a 75 MW photovoltaic solar facility on the farm Rosendal 673 located *c*. 2 km south of the town of Vryburg (Naledi Local Municipality), North-West Province. The southern part of the farm, where the proposed solar plant is to be constructed, is underlain by several formations of the Schmidtsdrif Subgroup (Ghaap Group, Transvaal Supergroup) of Late Archaean age (*c*. 2.64 billion years old). The oldest of these Precambrian rock units, the mixed fluvial and volcanic Vryburg Formation, is apparently unfossiliferous in this area. The carbonate-rich Boomplaas Formation is known to contain well-preserved stromatolite (microbial dome) assemblages in the Vryburg region but has a very small outcrop area on Rosendal 673 and is poorly exposed at surface. Marine mudrocks of the slightly younger Clearwater Formation might also contain minor stromatolitic carbonates but are also very poorly exposed. The central and northern portions of Rosendal 673 are underlain by Permo-carboniferous glacial rocks of the Dwyka Group as well as various Late Caenozoic superficial sediments such as pedogenic calcretes and surface gravels that are all of low palaeontological sensitivity. It is concluded that the overall impact of the proposed Sediba solar plant development on Rosendal 673 is of NEGATIVE LOW SIGNIFICANCE in palaeontological heritage terms and further studies or mitigation of fossil heritage resources for this alternative energy project are not warranted.

5. ACKNOWLEDGEMENTS

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7. QUALIFICATIONS & EXPERIENCE OF THE AUTHOR

Dr John Almond has an Honours Degree in Natural Sciences (Zoology) as well as a PhD in Palaeontology from the University of Cambridge, UK. He has been awarded post-doctoral research fellowships at Cambridge University and in Germany, and has carried out palaeontological research in Europe, North America, the Middle East as well as North and South Africa. For eight years he was a scientific officer (palaeontologist) for the Geological Survey / Council for Geoscience in the RSA. His current palaeontological research focuses on fossil record of the Precambrian - Cambrian boundary and the Cape Supergroup of South Africa. He has recently written palaeontological reviews for several 1: 250 000 geological maps published by the Council for Geoscience and has contributed educational material on fossils and evolution for new school textbooks in the RSA.

Since 2002 Dr Almond has also carried out palaeontological impact assessments for developments and conservation areas in the Western, Eastern and Northern Cape under the aegis of his Cape Town-based company *Natura Viva* cc. He is a long-standing member of the Archaeology, Palaeontology and Meteorites Committee for Heritage Western Cape (HWC) and an advisor on palaeontological conservation and management issues for the Palaeontological Society of South Africa (PSSA), HWC and SAHRA. He is currently compiling technical reports on the provincial palaeontological heritage of Western, Northern and Eastern Cape for SAHRA and HWC. Dr Almond is an accredited member of PSSA and APHAP (Association of Professional Heritage Assessment Practitioners – Western Cape).

Declaration of Independence

I, John E. Almond, declare that I am an independent consultant and have no business, financial, personal or other interest in the proposed development project, application or appeal in respect of which I was appointed other than fair remuneration for work performed in connection with the activity, application or appeal. There are no circumstances that compromise the objectivity of my performing such work.

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