Palaeontological Desktop Assessment of 5 new Solar Photovoltaic facilities to be established over nine farms near Dealesville, Free State Province.

Report prepared for

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31 January 2016

Executive Summary

The CSIR has been contracted by Twenty Nine Solar (Pty) Ltd to conduct Environmental Impact Assessments (EIA) for five new Solar Photovoltaic (PV) projects near Dealesville in the Free State province. Twenty Nine Solar (Pty) Ltd is proposing five (5) 100 MW solar photovoltaic (PV) facilities and associated electrical infrastructure over 9 farms close to Dealesville, in the Free State Province. The affected areas lie within the outcrop belt of the Middle Permian Tierberg Formation (Ecca Group). The Tierberg Formation is fairly to poorly fossilliferous and of moderate palaeontological sensitivity. Fossil assemblages from this unit mainly comprise trace fossil assemblages, fragmentary fish remains and plant remains that include petrified wood and leaves. Dolerite, in the form of dykes and sills, is common throughout the study area and are not palaeontologically significant. Quaternary alluvial deposits along major water courses, as well as spring and pan dune deposits are of high palaeontological sensitivity, whereas sediments along ephemeral water courses or residual drift and sheet wash deposits are of low palaeontological significance. The probability of fossils occurring within the Tierfontein Formation strata being impacted by activities during the construction phase of the project is considered **unlikely to very unlikely** depending on the PV facility. Outcrops are to a large extent covered (and protected) by superficial overburden. However, it is recommended that a palaeontologist be requested to examine the pre-construction geo-technical report in order to determine the likelihood of impacts and the need for any monitoring of trench excavations into exposed Ecca bedrockwhile fresh and potentially fossiliferous strata is still exposed for study and recording. In this way palaeontological heritage will benefit from the impact without hampering the construction phase as this may lead to the recovery of previously unexposed fossil material. The likelihood of direct negative impact on palaeontological heritage in superficial Quaternary sediments (calcretes, residual soils, and sheet wash deposits) is regarded as **extremely unlikely**. The likelihood of finding palaeontological heritage in Quaternary alluvial deposits along major water courses, as well as within localized spring and pan dune deposits in the study area is high, and the probability of direct negative impact will be **very likely** if such areas are included within the development footprints. Quaternary vertebrate fossil localities are generally regarded as a scarce palaeontological resource. It is therefore recommended that localized spring and pan dune deposits are strictly avoided where possible. A site visit is advised prior to the construction phase of the projects in order to pinpoint localized spring and pan dune deposits that may be located within the development footprints.

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Introduction

The CSIR has been contracted by Twenty Nine Solar (Pty) Ltd to conduct Environmental Impact Assessments (EIA) for five new Solar Photovoltaic (PV) projects near Dealesville in the Free State province. Twenty Nine Solar (Pty) Ltd is proposing five (5) 100 MW solar photovoltaic (PV) facilities and associated electrical infrastructure over nine farms close to Dealesville, in the Free State Province. The farms which are being considered for this development are:

Farm name	Farm no.	Area (ha)
Brakfontein	2/ 636	183.66
Brakfontein	3/ 636	183.6
Carlton	RE 74	427.97
Cornelia	RE 1550	85.26
Doornhoek	RE 37	416.84
Modderpan	RE 750	428.05
Mooihoek	RE 1551	342.81
Palmietfontein	RE 140	810.75
Sterkfontein	4/639	237.24

The projects are located between 5 and 12 km west-northwest of Dealesville, in the Tokologo Local Municipality in the Free State Province (**Fig. 1**).

The solar field will consist of:

- Solar arrays (panels) and building infrastructure, covering a total surface area of approx. 250 - 350 ha each.
- On-site buildings. Including operational control centre, offices, warehouse/workshop for spare parts and maintenance equipment, ablution and welfare facilities. The buildings will likely be of single storey design, with the largest building (the warehouse/workshop) unlikely to exceed 5 m in height and a maximum footprint of 400m^2.
- Inverter units and 22 kV underground electrical cables.
- Security enclosures

The electricity transmission corridor will consist of:

- 275/132 kV Main Transmission Station (MTS) occupying 300 m x 200 m and 25 m high;
- 35 m high 132 kV lines from collector substations to MTS; and
- 35 m high 275 kV line (MTS to Loop-in-Loop-out (LILO) on existing 275 kV line).

The extent of the proposed development (over 5000 m2) falls within the requirements for a Heritage Impact Assessment (HIA) as required by Section 38 (Heritage Resources Management) of the South African National Heritage Resources Act (Act No. 25 of 1999). As

a prerequisite for new development in terms of the National Heritage Resources Act, the present report has been commissioned by the CSIR as part of the EIA for the proposed construction of the solar PV energy facilities. The task involved an assessment of possible impact by the proposed development on potential fossil heritage, an assessment of their significance and recommendations for mitigation where relevant.

Methodology

The assessment provided within this report is based upon a review of relevant palaeontological and geological literature, database information and field reports. The geology represented within the study area was determined from published literature and relevant geological maps. The impact assessment ratings were provided by CSIR for consistency between specialists.

Assumptions and Limitations

The assessment provided within this report is based upon a desktop study without the benefit of a site visit. As such, the presentation of geological units present within the study area is derived from 1:250 000 geological maps that may vary in their accuracy. A major limitation is the lack of knowledge of the depth of quaternary sand cover above the Ecca bedrock. Because exposed shale was not seen by the archaeologist (Orton, pers. comm. 2016), it is assumed that impacts are unlikely. It is also assumed, for the sake of prudence, that fossil remains are always uniformly distributed in fossil-bearing rock units, although in reality their distribution may vary significantly.

Locality data

Relevant 1:50 000 topographic maps: 2825DA Elandsfontein and 2825DB Dealesville.

Relevant geological map: 2824 Kimberley

The five proposed PV facilities are primarily located on farm land near Dealesville and close to the eastern margin of the Free State pan veld (**Fig. 2**). The western Free State is extensively covered by shallow and usually waterless depressions underlain by a shale substrate. These pans are frequently archaeologically as well as palaeontologically significant.

Local Geology

The geology of the area has been described by Bosch (1993). The area in question is underlain by sediments of widely different geological ages (**Fig. 3**, portion of 1: 250 000 scale geological map 2824 Kimberley, Council for Geoscience, Pretoria, 1991). From oldest to youngest, the geology in and around the affected area is made up of Permian Ecca shales (Tierberg Formation., *Pt*), Jurassic dolerite intrusions (*Jd*, Karoo Dolerite Suite), well-developed

Quaternary calcretes (**Fig. 4**), surface limestones, calcified pandunes (*Qc*) and aeolian sands (*Qs*) (Kalahari Group). The wind-blown sands represent the latest geological phase and are made up of the characteristically red-brown Kalahari sands (Hutton sands).

Fossil Heritage

Karoo Supergroup

The affected areas lie within the outcrop belt of the Tierberg Formation (Ecca Group). Deposition of the Tierberg shales took place under reducing conditions in an inland sea, through suspension settling of fine mud and silt, during the Middle Permian. Fossils from the Tierberg Formation are generally poorly represented. They largely occur as sparsely distributed and generally not diverse assemblages of trace fossils (Anderson 1976; De Beer et al. 2002; Viljoen 2005; Johnson *et al.* 2006). These ichnoassemblages include arthropod trackways and associated resting impressions, fish swimming trails, horizontal epichnial furrows often attributed to gastropods, as well as a variety of different kinds of small burrows. Plant remains, including fossilized wood becomes more abundant in the upper layers of the formation (Ryan 1967; Wickens 1996). Impressions of *Gondwanidium validum* and pieces of *Dadoxylon* have been discovered between Douglas and Belmont, south of Kimberley (McLaren 1976). Sponge spicules, fish scales and disarticulated microvertebrate remains from calcareous concretions have also been recorded (Zawada 1992, Bosch 1993).

Karoo Dolerites

Dolerite, in the form of dykes and sills, is common throughout the study area. Regarded as feeders of Drakensberg lavas, dolerites are not palaeontologically significant and can be excluded from further consideration in the present evaluation.

Cenozoic Superficial Deposits

Quaternary-age surface deposits in the region can be highly fossiliferous in places, especially those that are directly related to fluvial environments along major river courses. Fossil assemblages (including an assortment of mammalian bones and teeth, coprolites, freshwater molluscs and plant microfossils), individual specimens and fossilized hyena burrows have been found preserved in Late Pleistocene alluvial sediments of the nearby Modder River (Broom 1909 a, b; Cooke 1955; Churchill *et al.* 2000; Rossouw 2006). Intrusive features such as fossilized hyena lairs or fossilized bone accumulations are sometimes located outside the present river valleys along calcified pan dunes and localized spring deposits (Scott & Brink 1991). Fossilized bone accumulations as well as fosilliferous sediments (local peat deposits) also occur within calcified pan dunes frequently found in the region (Horowitz *et al*. 1978;

Scott and Klein 1981; Butzer 1984). When these types of pans were formed, the prevailing winds blew unconsolidated material (aeolian sands) into newly formed lunettes on the lee side of the deflation hollows which occasionally provided a locus for hyena activities (burrows) and prehistoric human habitation in the past. Spring and associated pan dune deposits, such as at Baden Baden north of Dealesville, Florisbad northwest of Bloemfontein, and Liebenbergspan (Voigts Post) and Deelpan between Bloemfontein and Petrusburg, may contain Pleistocene vertebrate fossils and plant microfossils (Brink 1987, 1988; Scott & Rossouw 2005) (**Fig**. 5 **& 6**). The archaeologically and palaeontologically significant spring mound at Baden Baden is situated next to Annaspan about 10 km north of Dealesville, where research conducted by the National Museum is currently in progress (van Aardt *et al.* 2015)

Impact Statement

Potential impacts for each site are summarized in **Table 1.**

Palaeontological Significance

The palaeontological sensitivity of the area is considered moderate to high according to the SA National Fossil Sensitivity Map (SAHRIS). The Middle Permian shales and siltstones of the Tierberg Formation (Ecca Group) are fairly to poorly fosilliferous and of moderate palaeontological sensitivity. Fossil assemblages from this unit mainly comprise trace fossil assemblages, fragmentary fish remains and plant remains that include petrified wood and leaves. Quaternary alluvial deposits along major water courses, as well as spring and pan dune deposits are of high palaeontological sensitivity, whereas sediments along ephemeral water courses or residual drift and sheet wash deposits are of low palaeontological significance.

Nature of Impacts

It is expected that infrastructure development will involve installation of multiple photovoltaic panels and associated underground cables and wiring, as well as access roads that will extend over a relatively large surface area. The desktop assessment indicates that the proposed developments will primarily impact on superficial Quaternary sediments (*Qs, Qc*) and intrusive dolerite bedrock (*Jd*), which has no palaeontological potential, as well as potentially fossil-bearing rock units of the Tierberg Formation (Ecca Group, *Pt*). Potential direct negative impacts of the proposed project on the palaeontological heritage of the area may occur when excavations into more recent Quaternary pan dune and spring deposits and underlying Tierberg Formation strata are required during the construction phase of the project. This may lead to:

- irreversible damage or destruction of fossils during the construction phase;

- removing fossil material out of context which would either significantly reduce or entirely destroy their scientific significance;
- loss of access by scientists to conduct palaeontological studies after the proposed infrastructure is in place (operational phase).

Extent of Impact

Possible extent of impact of the proposed projects will be **locally restricted (site specific)** to palaeontologically significant superficial Quaternary sediments (*Qs, Qc*) and intrusive dolerite bedrock (*Jd*), which has no palaeontological potential, as well as potentially fossil-bearing rock units of the Tierberg Formation (Ecca Group, *Pt*).

Duration of Impact

The proposed developments are considered long term with the possible consequence that any damage or destruction to potential palaeontological material within the affected area will be **permanent** and **irreversible**.

Probability of Impact

Even though the affected areas are underlain by Paleozoic rocks known for their sparse palaeontological record, it is probable that considering the scale of the area in question, fossils may occur within the Tierfontein Formation strata (*Pt*) underlying the affected areas. However, fossils are generally not evenly distributed in their occurrence in sedimentary strata, so the probability of finding Ecca Group fossil exposures on the landscape is fairly low. As such, the probability of fossils occurring within the Tierfontein Formation strata being impacted by activities during the construction phase of the project is considered **unlikely to very unlikely**.

Construction occurring on intrusive dolerite bedrock (*Jd*), will not result in any palaeontological impact. The likelihood of direct negative impact on palaeontological heritage in dolerite is regarded as **extremely unlikely**.

The likelihood of direct negative impact on palaeontological heritage in superficial Quaternary sediments (calcretes, residual soils, and sheet wash deposits, *Qc*, *Qs*) is regarded as **extremely unlikely**.

The likelihood of finding palaeontological heritage in Quaternary alluvial deposits along major water courses, as well as within localized spring and pan dune deposits (*Qs, Qc*) in the study area is high, and the probability of direct negative impact will be **very likely** if such areas are included within the development footprints.

Cumulative Impacts

There are currently a number of renewable energy project applications within a 100 km radius of the proposed development. These projects have received Environmental Authorization or are in the process of receiving Environmental Authorization and have either proceeded into the construction phase, or are expected to be constructed in the near future. If all these projects proceed, then the Twenty Nine Solar development will be established on a landscape where renewable energy facilities are a common feature. There will be no significant cumulative impacts on the palaeontology of the area provided that the recommended mitigation measures are reached for this project.

Recommendations

Mitigation

Moderate to high palaeontologically sensitive sedimentary strata usually requires a field assessment by a professional palaeontologist, since most detrimental impacts on palaeontological heritage usually occur during the construction phase when fossils may be disturbed or destroyed during excavations and subsequent construction activities.

- Palaeontological impact on Tierberg Formation strata is difficult to assess because outcrops are to a large extent covered (and protected) by superficial overburden. Because of the overburden (which makes impacts unlikely) and the lack of detailed knowledge of the on-site subsurface geology, no formal mitigation has been suggested yet. However, it is recommended that prior to commencement of development, a geo-technical report should be examined by a palaeontologist to determine whether there might be any further mitigation requirements relating to the Ecca bedrock. In the case of widespread trench excavations into unweathered Ecca bedrock, exposures may require brief monitoring while fresh and potentially fossiliferous strata are still exposed for study and recording. In this way palaeontological heritage will benefit from the impact without hampering the construction phase as this may lead to the recovery of previously unexposed fossil material.
- The likelihood of palaeontological impact resulting from excavations and ground moving activities into localized pan dune deposits to the east of the Edison and Marconi footprints, to the south of the Maxwell Option B footprint and along the inner loop of the Electricity Infrastructure Corridor footprint during the construction phase of the solar facilities and their associated infrastructure is considered high without on-site inspection by a specialist.

- Quaternary vertebrate fossil localities are generally regarded as a scarce palaeontological resource. It is therefore recommended that localized spring and pan dune deposits are strictly avoided if possible.
- A site visit is advised prior to the construction phase of the projects in order to pinpoint localized spring and pan dune deposits that may be located within the development footprints.

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Tables & Figures

Table 1. Summary of potential direct impacts at the proposed PV sites including alternative options.

Aspect	Nature of impact	Status (negative or positive)	Spatial Extent	Duration	Consequence	Probability	Reversibility of Impact	Irreplaceability	Potential mitigation measures	Significance of impact / risk = consequence x probability		Ranking of Impact	Confidence level
										Without mitigation	With mitigation		
Construction Phase													
Edison PV	Impact of excavations into intrusive dolerite bedrock, superficial deposits (sheet wash, residual soils) pan dune and spring deposits	Negative, low to moderate likelihood of destruction of *in situ* fossils in pan dune deposits	Site	Long term	Substantial	Unikely (pan dune deposits)	Non-reversible	High	- Phase 1 PIA prior to the construction phase in order to pinpoint pan dune deposits that may be located within the development footprints. - Palaeontologist to inspect geotechnical report to evaluate impacts to Ecca Formation.	Moderate	Very low	2	High
Watt PV	Impact of excavations into intrusive dolerite bedrock, superficial deposits (calcretes, sheet wash, residual soils)	Neutral, no destruction of *in situ* fossils likely	Site	Long term	Moderate	Very unlikely	Non-reversible	High	Palaeontologist to inspect geotechnical report to evaluate impacts to Ecca Formation	Low	Very low	3	High
Marconi PV	Impact of excavations into TierbergFormation strata, superficial deposits (calcretes, sheet wash, residual soils) pan dune and spring deposits	Negative, low to moderate likelihood of destruction of *in situ* fossils in pan dune deposits	Site	Long term	Substantial	Unlikely (pan dune deposits)	Non-reversible	High	- Phase 1 PIA prior to the construction phase in order to pinpoint pan dune deposits that may be located within the development footprints. - Palaeontologist to inspect geotechnical report to evaluate impacts to Ecca Formation	Moderate	Very low	2	High
Faraday Option A	Impact of excavations into intrusive dolerite bedrock, superficial deposits (sheet wash, residual soils)	Neutral, no destruction of *in situ* fossils likely	Site	Long term	Moderate	Very unlikely	Non-reversible	High	- Palaeontologist to inspect geotechnical report to evaluate impacts to Ecca Formation	Low	Very low	3	High

Faraday Option B	Impact of excavations into TierbergFormation strata, intrusive dolerite bedrock, superficial deposits (sheet wash, residual soils)	Neutral, no destruction of *in situ* fossils likely	Site	Long term	Moderate	Very unlikely	Non-reversible	High	- Palaeontologist to inspect geotechnical report to evaluate impacts to Ecca Formation	Low	Very low	2	High
Maxwell Option A	Impact of excavations into intrusive dolerite bedrock, superficial deposits (sheet wash, residual soils)	Neutral, no destruction of *in situ* fossils likely	Site	Long term	Moderate	Very unlikely	Non-reversible	High	- Palaeontologist to inspect geotechnical report to evaluate impacts to Ecca Formation	Low	Very low	2	High
Maxwell Option B	Impact of excavations into intrusive dolerite bedrock, superficial deposits (sheet wash, residual soils) pan dune and spring deposits	Negative, low to moderate likelihood of destruction of *in situ* fossils in pan dune deposits	Site	Long term	Substantial	Unlikely (pan dune deposits)	Non-reversible	High	- Phase 1 PIA prior to the construction phase in order to pinpoint pan dune deposits that may be located within the development footprints. - Palaeontologist to inspect geotechnical report to evaluate impacts to Ecca Formation	Moderate	Very low	2	High
Electricity Infrastructure Corridor	Impact of excavations into pan dune and spring deposits	Negative, likely destruction of *in situ* fossils in pan dune deposits	Site	Long term	Substantial	Very likely (pan dune deposits)	Non-reversible	High	- Phase 1 PIA prior to the construction phase in order to pinpoint pan dune deposits that may be located within the development footprints. - Palaeontologist to inspect geotechnical report to evaluate impacts to Ecca Formation	Moderate	Very low	1	High
Operational Phase													
Edison PV	Impact of everyday operational activities on dolerite bedrock, superficial deposits (sheet wash, residual soils) pan dune and spring deposits	Neutral, no destruction of *in situ* fossils likely	Site	Long term	Slight	Extremely unlikely	Non-reversible	High	- No mitigation required following construction phase mitigation	Very low	Very low	4	High
Watt PV	Impact of everyday operational activities on dolerite bedrock, superficial deposits (calcretes, sheet wash, residual soils)	Neutral, no destruction of *in situ* fossils likely	Site	Long term	Slight	Extremely unlikely	Non-reversible	High	- No mitigation required following construction phase mitigation	Very low	Very low	4	High

Marconi PV	Impact of everyday operational activities on Tierberg Formation strata, superficial deposits (calcretes, sheet wash, residual soils) pan dune and spring deposits	Neutral, no destruction of *in situ* fossils likely	Site	Long term	Slight	Extremely unlikely	Non-reversible	High	- No mitigation required following construction phase mitigation	Very low	Very low	4	High
Faraday PV Option A	Impact of everyday operational activities on dolerite bedrock, superficial deposits (sheet wash, residual soils)	Neutral, no destruction of *in situ* fossils likely	Site	Long term	Slight	Extremely unlikely	Non-reversible	High	- No mitigation required following construction phase mitigation	Very low	Very low	4	High
Faraday PV Option B	Impact of everyday operational activities on Tierberg Formation strata, intrusive dolerite bedrock, superficial deposits (sheet wash, residual soils)	Neutral, no destruction of *in situ* fossils likely	Site	Long term	Slight	Extremely unlikely	Non-reversible	High	- No mitigation required following construction phase mitigation	Very low	Very low	4	High
Maxwell PV Option A	Impact of everyday operational activities on dolerite bedrock, superficial deposits (sheet wash, residual soils)	Neutral, no destruction of *in situ* fossils likely	Site	Long term	Slight	Extremely unlikely	Non-reversible	High	- No mitigation required following construction phase mitigation	Very low	Very low	4	High
Maxwell PV Option B	Impact of everyday operational activities on dolerite bedrock, superficial deposits (sheet wash, residual soils) pan dune and spring deposits	Neutral, no destruction of *in situ* fossils likely	Site	Long term	Slight	Extremely unlikely	Non-reversible	High	- No mitigation required following construction phase mitigation	Very low	Very low	4	High
Electricity Infrastructure Corridor	Impact of excavations into pan dune and spring deposits	Neutral, no destruction of *in situ* fossils likely	Site	Long term	Slight	Extremely unlikely	Non-reversible	High	- No mitigation required following construction phase mitigation	Very low	Very low	4	High

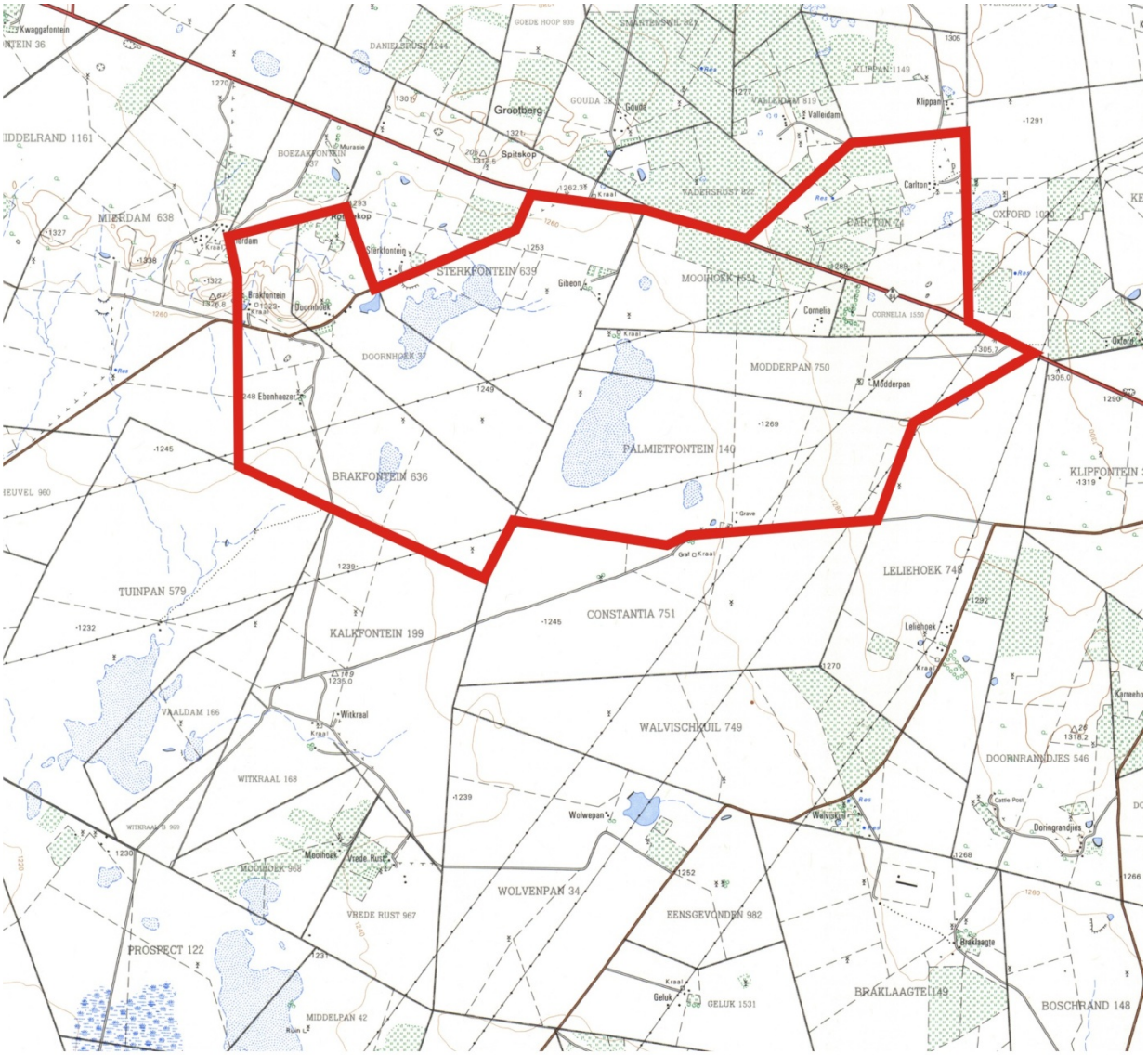


Figure 1. Portions of 1:50 000 scale topograpical maps 2825DA Elandsfontein showing the proposed locality of the five new PV facilities.

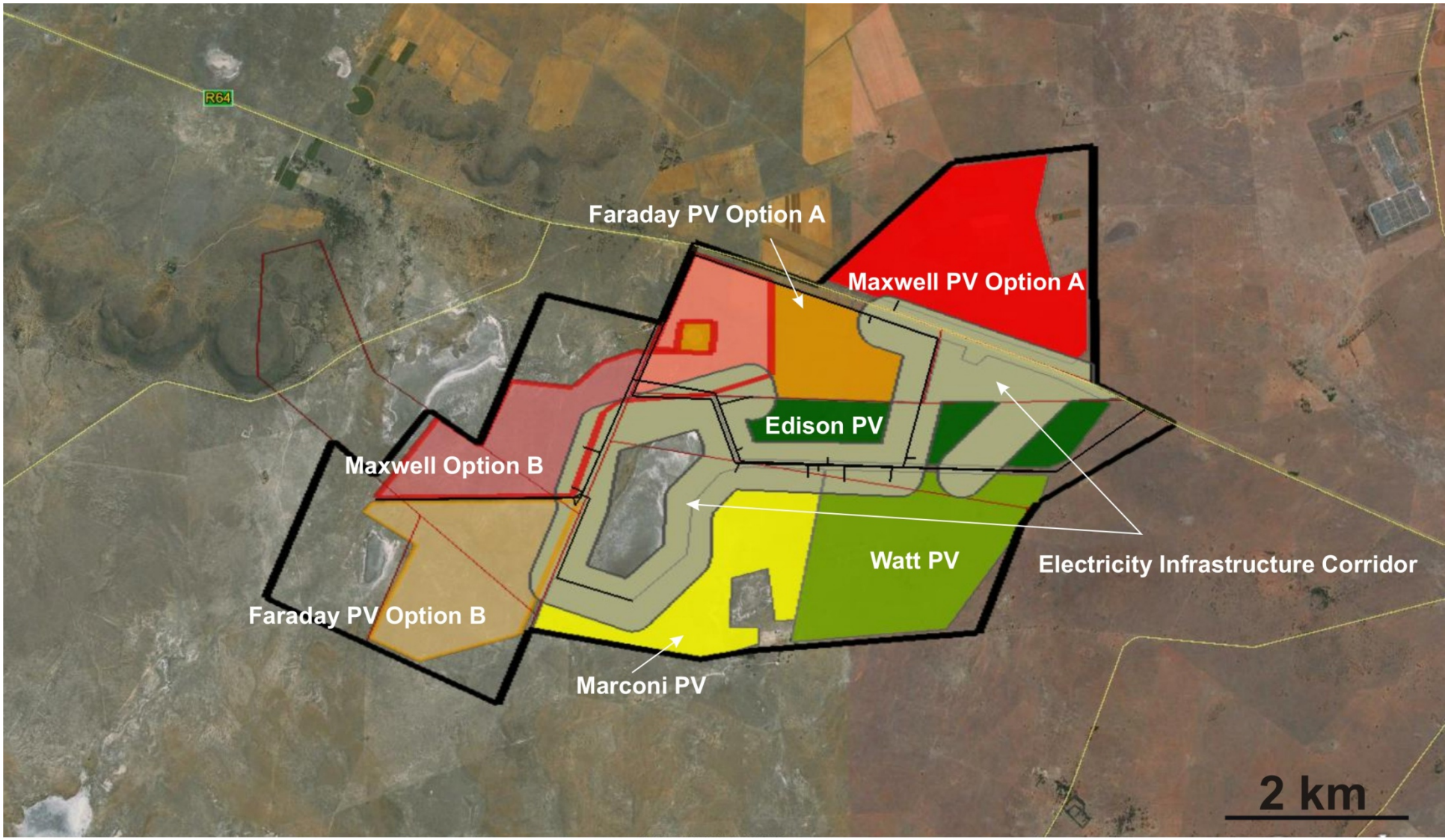
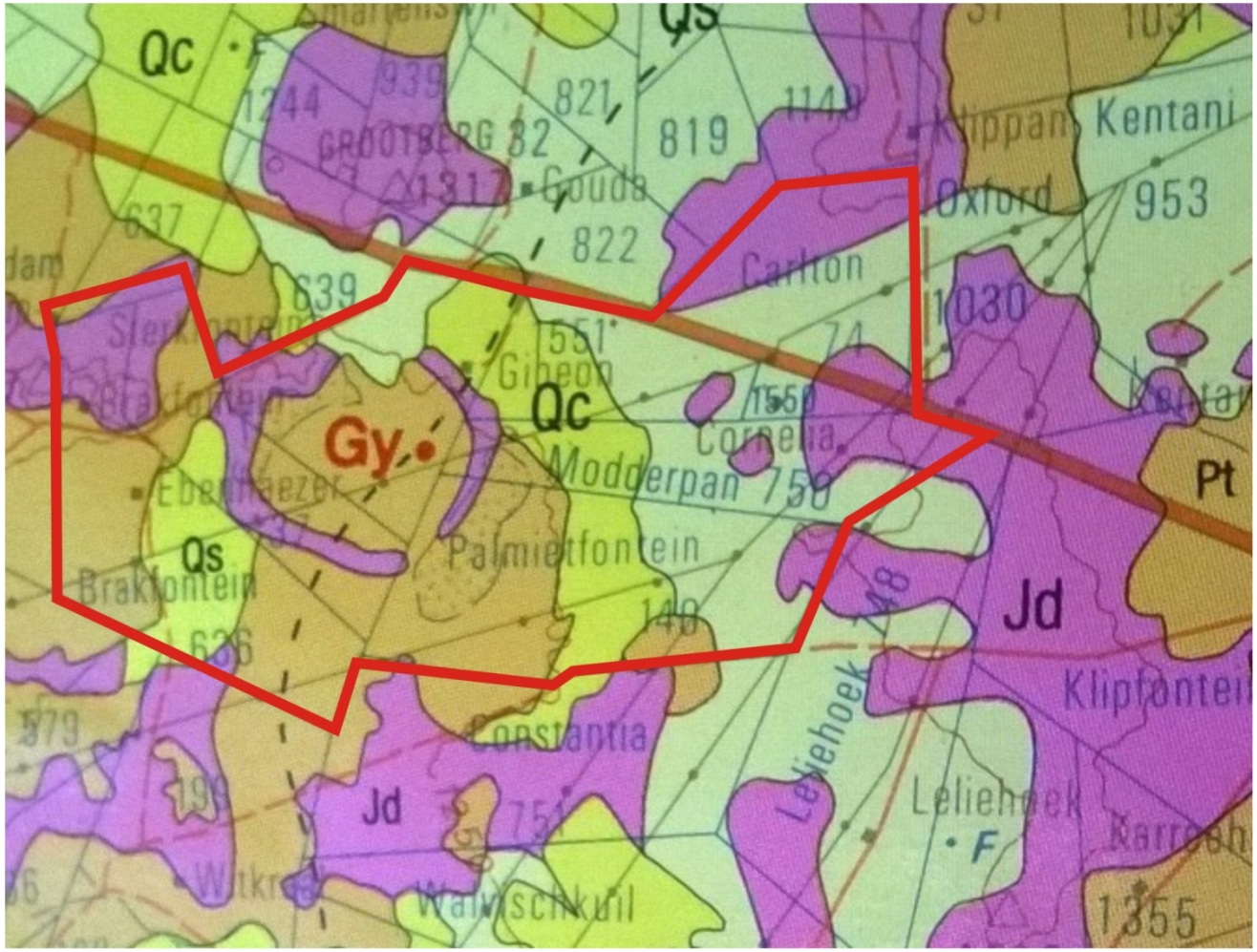


Figure 2. Aerial view of areas marked for the five proposed PV facilities (Google Earth).



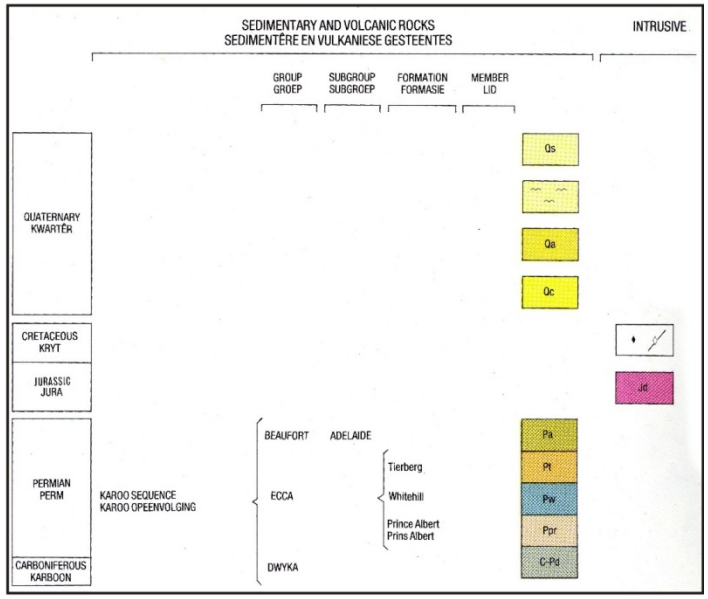


Figure 3. Portion of 1 : 250 000 scale geological map 2824 Kimberley of the study area. From oldest to youngest, the geology in and around the affected area is made up of Permian Ecca shales (Tierfontein Formation, *Pt*), Jurassic dolerite intrusions (*Jd*, Karoo Dolerite Suite), Quaternary calcretes, surface limestones, calcified pandunes (*Qc*) and aeolian sands (*Qs*) (Kalahari Group).

Figure 4. Well-developed calcrete deposits at the Edison PV footprint on the farm Palmietfontein 140 (photo J. Orton).

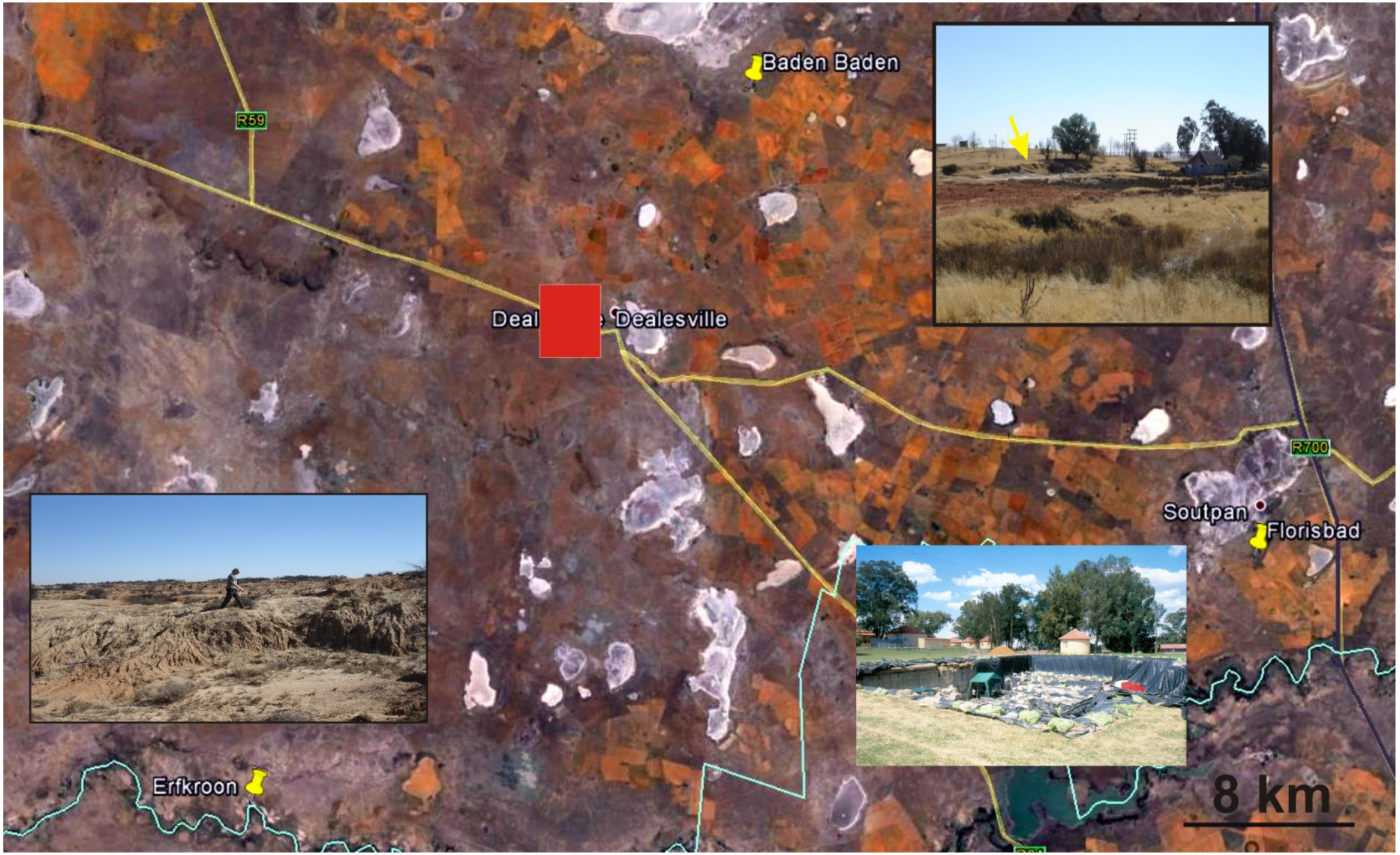


Figure 5. Position of the archaeologically and palaeontologically rich pan and spring deposits and alluvial deposits at Baden Baden, Florisbad and Erfkroon respectively, in relation to the position of the proposed new development (red rectangle).

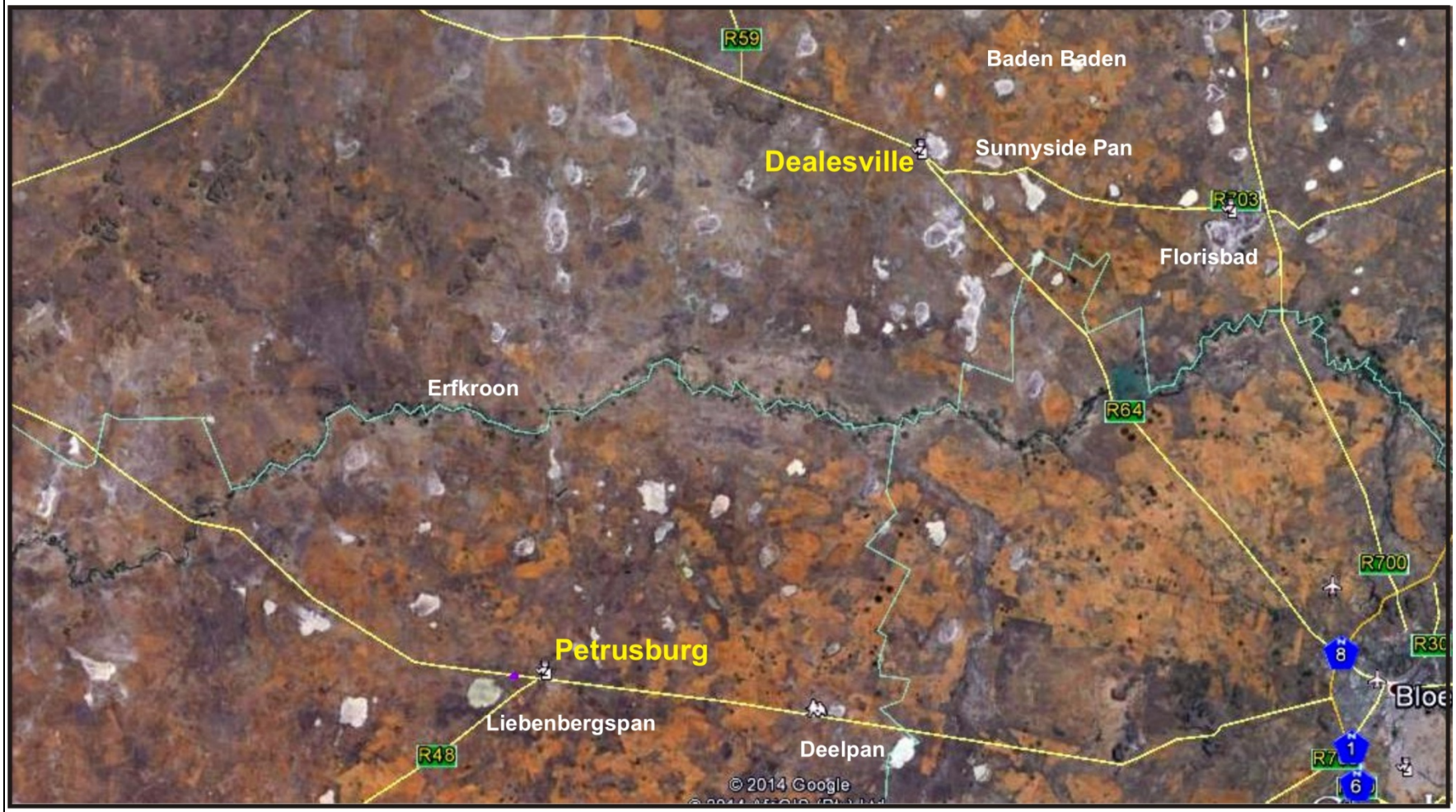


Figure 6. Important fossil localities in the region between Dealesville, Petrusburg and Bloemfontein.