PALAEONTOLOGICAL HERITAGE ASSESSMENT: COMBINED DESKTOP & FIELD-BASED STUDY

PROPOSED NEW 132/11KV INTABAZWE SUBSTATION AND ASSOCIATED POWER LINE LINKING TO THE EXISTING HARRISMITH-SORATA 132KV LINE, HARRISMITH, FREE STATE

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EXECUTIVE SUMMARY

Eskom are proposing to construct to construct a new electrical substation and short (< 5 km) associated 132 kV powerline on the north-western outskirts of Harrismith in the eastern Free State. The study area is underlain at depth by fluvial sandstones and mudrocks of the Beaufort Group (Karoo Supergroup) assigned to the upper part of the Normandien Formation and the overlying Katberg Formation. These latest Permian / earliest Triassic continental sediments are known for their wealth of fossil gymnospermous wood and may also contain fossil vertebrates of the *Dicynodon* and *Lystrosaurus* Assemblage Zones (*e.g.* mammal-like reptiles, various subgroups of true reptiles). Several important vertebrate fossils have previously been recorded from the Katberg Formation in the vicinity of Harrismith (*e.g.* Kitching 1977). However, the Beaufort Group bedrocks within the present electrical infrastructure study area are very poorly-exposed, with the exception of a few sites along the Wilgerivier, the Rietspruit and other deeply-incised tributaries. No *in situ* fossil plants or vertebrates were recorded from the Beaufort Group during this field study, while occasional very fragmentary petrified wood and tooth remains occur within overlying downwasted surface gravels. The proposed new substation site and powerline route are largely underlain near-surface by thick sandy alluvial deposits of the Wilgerivier and its tributaries as well as by thinner colluvial gravels and soils on neighbouring hillslopes. The semi-consolidated younger alluvium contains dispersed subfossil remains such as isolated or loosely-associated bones of small and large mammals. The underlying, better-consolidated and often calcretised to ferricretised older alluvium in the Harrismith area contains rare Pleistocene mammalian remains together with sparse MSA and LSA stone artefacts (*cf* Almond 2015). Only a single high-crowned fossil tooth (probably equid) recorded well away from the powerline corridor was found during the present field study, however.

Given (1) the apparent scarcity of well-preserved fossil material within the Permo-Triassic Beaufort Group bedrocks and in the Pleistocene - Holocene alluvial cover, as well as (2) the small scale of the 132 kV pylon footprints and substation involved, it is concluded that the proposed electrical infrastructure project does not pose a significant threat to local fossil heritage resources (*i.e.* LOW palaeontological heritage impact significance). No specialist palaeontological mitigation or monitoring measures are recommended for this project, pending the discovery of significant new fossil finds during construction. The ECO responsible for the development should be alerted to the possibility of scientifically important fossil finds (especially mammalian bones and teeth) within the older calcretised alluvium.

In the case of any substantial fossil finds during construction (*e.g.* vertebrate teeth, bones, burrows, petrified wood, shells), these should be carefully safeguarded - preferably *in situ* - and reported by the ECO as soon as possible to SAHRA (Contact details: Dr Ragna Redelstorff. South African Heritage Resources Agency. 111 Harrington Street, Cape Town 8001. Tel: +27 (0)21 202 8651. E-mail: rredelstorff@sahra.org.za). This is so that appropriate mitigation (*i.e.* recording, sampling or collection) by a palaeontological specialist can be considered and implemented. Fossil bones and teeth observed within the calcretised (pale grey) alluvial deposits near the Wilgerivier or other tributary drainage lines should be reported to Dr James Brink of the National Museum, Bloemfontein (jbrink@nasmus.co.za; tel. +27 51 447 9609. Address: 36 Aliwal Street, Bloemfontein, RSA) for professional recording and sampling. These recommendations should be incorporated into the Environmental Management Programme (EMPr) for the development.

1. INTRODUCTION & BRIEF

Eskom Distribution, Free State is proposing to construct the following new electrical infrastructure on the north-western outskirts of Harrismith, Maluti A Phofung Local Municipality, Free State Province (Figs. 1 & 2):

1. A new 132/11 kV Substation (to be known as the Intabazwe Substation) with a footprint of 100 x 100 m to be constructed on the farm Dorpsgronden van Harrismith 131, adjacent to the township of Phomolong;

2. A new 132 kV powerline (with one loop in and loop out line) approximately 4.9 km in length that will link the proposed new Intabazwe substation with the existing Harrismith-Sorata 132 kV line. The loop-in/loop-out line will cross the western section of farm Dorpsgronden van Harrismith 131 and end on the farm Roomvlei 444. The powerlines will be supported by double circuit steel lattice structures with a servitude of 31 m. The size of the tower foundation footprint depends on the type

of structure to be used and ranges from 24 m^2 to 225 m_2. The span length between the tower structures will range between 23.62 m and 420.00 m.

Since the proposed substation and powerline footprints overlie potentially fossiliferous bedrocks of the Lower and Upper Beaufort Group (Karoo Supergroup) as well as Late Caenozoic alluvial deposits, a palaeontological heritage field-based assessment report has been requested by SAHRA (Interim Comment of 9 May 2017, Case ID: 10996). The present combined desktop and field-based palaeontological heritage study has accordingly been commissioned by Eskom Distribution-FSOU (Contact details: Ms Mahlatse Moeng. Environmental Officer, Land Development and Environment. Eskom Distribution-FSOU, Eskom Centre First Floor, Bloemfontein. Tel: 051 404 2287. Cell: 079 199 0679. Fax: 086 604 5709. E-mail: Mahlatse.Moeng@eskom.co.za). Fieldwork for the palaeontological heritage assessment was carried out over two days on 6 and 7 June 2017.

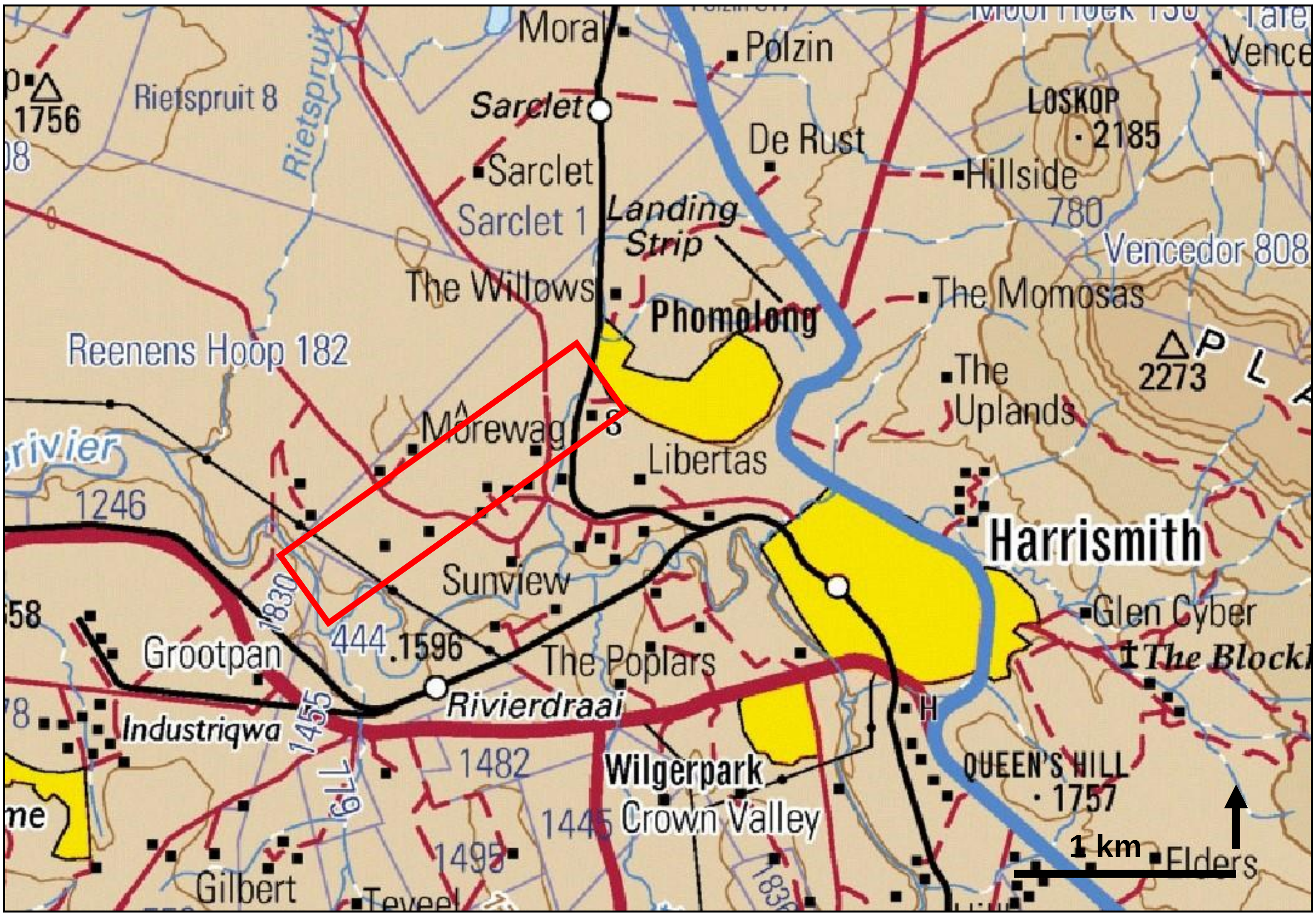


Figure 1. Extract from 1: 250 000 topographical sheet 2828 Phuthaditjhaba (Courtesy of the Chief Directorate: National Geo-spatial Information, Mowbray) showing the approximate location of the electrical infrastructure study area on the north-western outskirts of Harrismith, Free State, fromm Phomolong township south-westwards to the Wilgerivier (red rectangle).

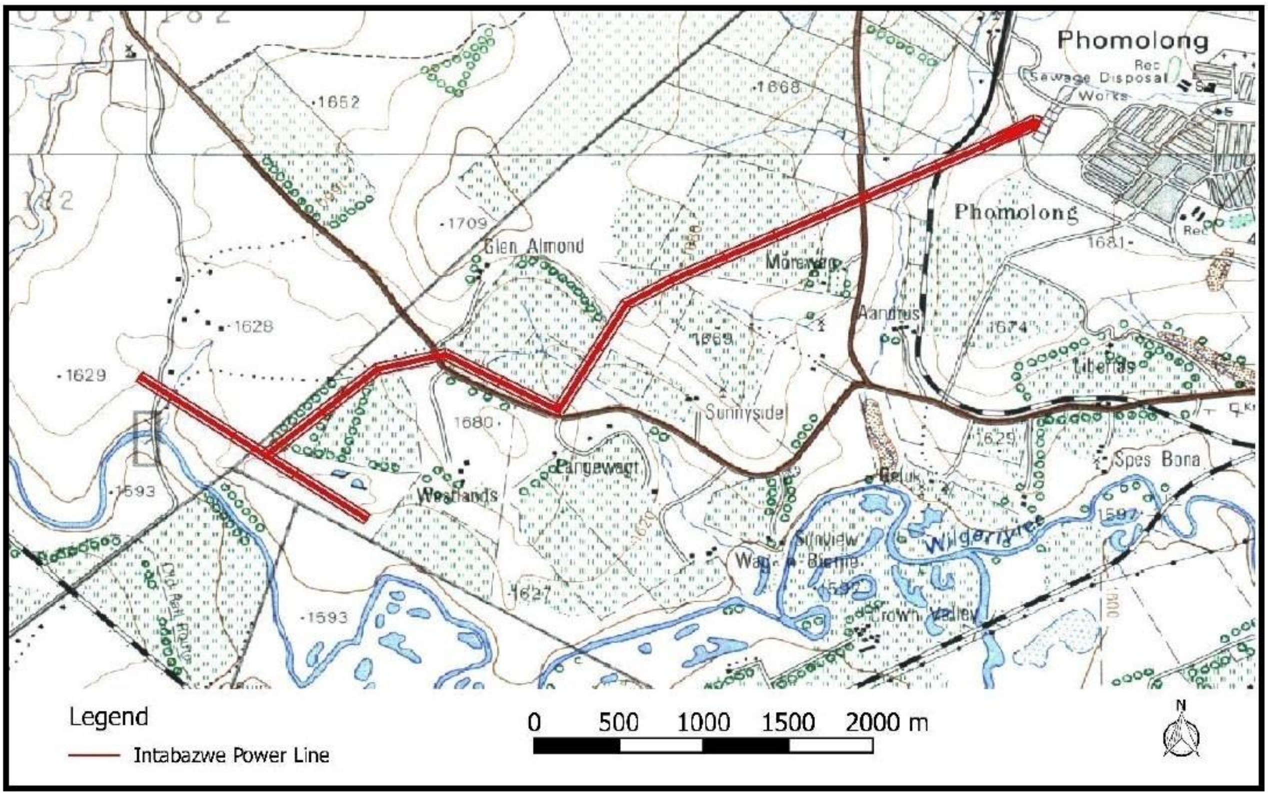


Figure 2. Extract from adjoining 1: 250 000 topographical sheets 2829 AA and 2829AC (now outdated) showing in red the corridor for the proposed new 132 kV transmission line crossing Farm Dorpsgronden van Harrismith 131 and ending in the west on the Farm Roomvlei 444 (Image abstracted from the HIA by Van Schalkwyk 2017). Please refer to satellite images in Figs. 3 & 4 for a more accurate depiction of the proposed 132 kV powerlines as well as the proposed Intabazwe Substation location. Note extensive agricultural lands along the powerline route.

2. LEGISLATIVE CONTEXT FOR PALAEONTOLOGICAL ASSESSMENT STUDIES

The present combined desktop and field-based palaeontological heritage report falls under Sections 35 and 38 (Heritage Resources Management) of the South African Heritage Resources Act (Act No. 25 of 1999), and it will also inform the Environmental Management Programme for this project.

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

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

According to Section 35 of the National Heritage Resources Act, dealing with archaeology, palaeontology and meteorites:

(1) The protection of archaeological and palaeontological sites and material and meteorites is the responsibility of a provincial heritage resources authority.

(2) All archaeological objects, palaeontological material and meteorites are the property of the State.

(3) Any person who discovers archaeological or palaeontological objects or material or a meteorite in the course of development or agricultural activity must immediately report the find to the responsible heritage resources authority, or to the nearest local authority offices or museum, which must immediately notify such heritage resources authority.

(4) No person may, without a permit issued by the responsible heritage resources authority—

(a) destroy, damage, excavate, alter, deface or otherwise disturb any archaeological or palaeontological site or any meteorite;

(b) destroy, damage, excavate, remove from its original position, collect or own any archaeological or palaeontological material or object or any meteorite;

(c) trade in, sell for private gain, export or attempt to export from the Republic any category of archaeological or palaeontological material or object, or any meteorite; or

(d) bring onto or use at an archaeological or palaeontological site any excavation equipment or any equipment which assist in the detection or recovery of metals or archaeological and palaeontological material or objects, or use such equipment for the recovery of meteorites.

(5) When the responsible heritage resources authority has reasonable cause to believe that any activity or development which will destroy, damage or alter any archaeological or palaeontological site is under way, and where no application for a permit has been submitted and no heritage resources management procedure in terms of section 38 has been followed, it may—

(a) serve on the owner or occupier of the site or on the person undertaking such development an order for the development to cease immediately for such period as is specified in the order;

(b) carry out an investigation for the purpose of obtaining information on whether or not an archaeological or palaeontological site exists and whether mitigation is necessary;

(c) if mitigation is deemed by the heritage resources authority to be necessary, assist the person on whom the order has been served under paragraph *(a)* to apply for a permit as required in subsection (4); and

(d) recover the costs of such investigation from the owner or occupier of the land on which it is believed an archaeological or palaeontological site is located or from the person proposing to

undertake the development if no application for a permit is received within two weeks of the order being served.

Minimum standards for the palaeontological component of heritage impact assessment reports (PIAs) have recently been published by SAHRA (2013).

3. GENERAL APPROACH USED FOR THIS PALAEONTOLOGICAL IMPACT STUDY

This PIA report provides an assessment of the observed or inferred palaeontological heritage within the broader study area, with recommendations for specialist palaeontological mitigation where this is considered necessary. The report is based on (1) a review of the relevant scientific literature, including previous palaeontological impact assessments in the area (*e.g.* Rubidge 2008, Groenewald 2011b, Almond 2015), (2) published geological maps and accompanying sheet explanations (*e.g.* Johnson & Verster 1994), (3) a two-day field study in the area near Harrismith (6-7 June, 2017). GPS locality data for numbered sites mentioned in the text as well as numbered fossil localities shown on satellite images (Figs. 3 & 4) are provided in the Appendix.

In preparing a palaeontological desktop study the potentially fossiliferous rock units (groups, formations *etc*) represented within the study area are determined from geological maps and satellite images. The known fossil heritage within each rock unit is inventoried from the published scientific literature, previous palaeontological impact studies in the same region, and the author's field experience (Consultation with professional colleagues as well as examination of institutional fossil collections may play a role here, or later following scoping during the compilation of the final report). This data is then used to assess the palaeontological sensitivity of each rock unit to development (The SAHRIS palaeosensitivity maps are also consulted on the SAHRA website). 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 assessment study by a professional palaeontologist is usually warranted.

The focus of palaeontological field assessment 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, 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 wind-blown sands, may occasionally contain fossils and should also be included in the field 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 field assessment studies. In order to do so, a fossil collection permit from SAHRA is required and 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 field 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 field 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 and taphonomic 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, SAHRA (Contact details: Dr Ragna Redelstorff. South African Heritage Resources Agency. 111 Harrington Street, Cape Town 8001. Tel: +27 (0)21 202 8651. E-mail: rredelstorff@sahra.org.za). 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. In the case of developments in the Free State the relevant Provincial Heritage Resources Agency is Heritage Free State and is an automatic stakeholder (*i.e.* no registration as such required) while SAHRA is the final decision making body as *per* Section 38 of the National Heritage Resources Act, 1999.

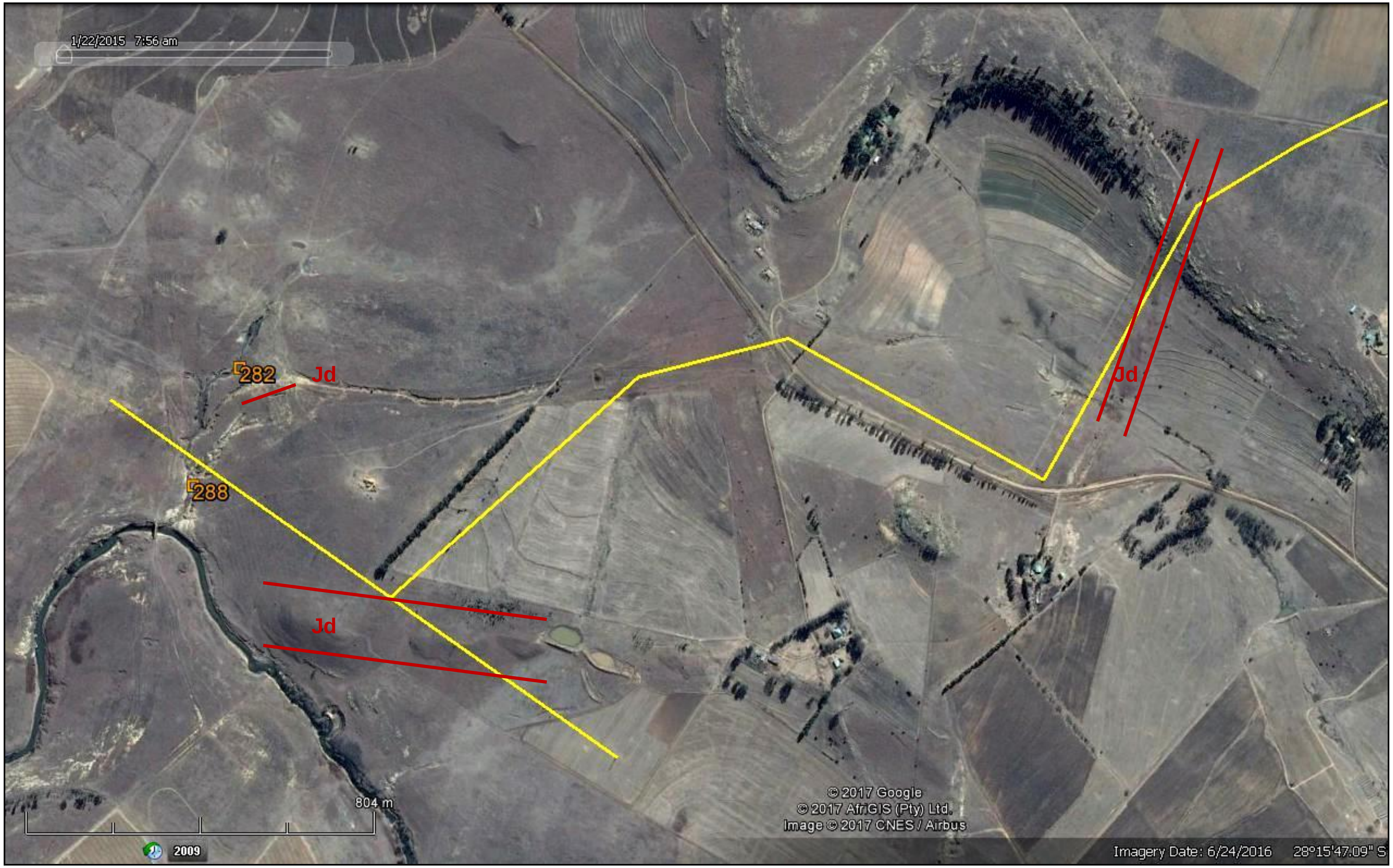


Figure 3. Google earth© satellite image of the western portion of the proposed electrical infrastructure development (132 kV powerline – yellow line) near Harrismith. Numbered fossil localities are listed in the Appendix with gps data. None of these are considered to be of conservation significance. Selected dolerite intrusions encountered during fieldwork (Jd) are indicated in red.

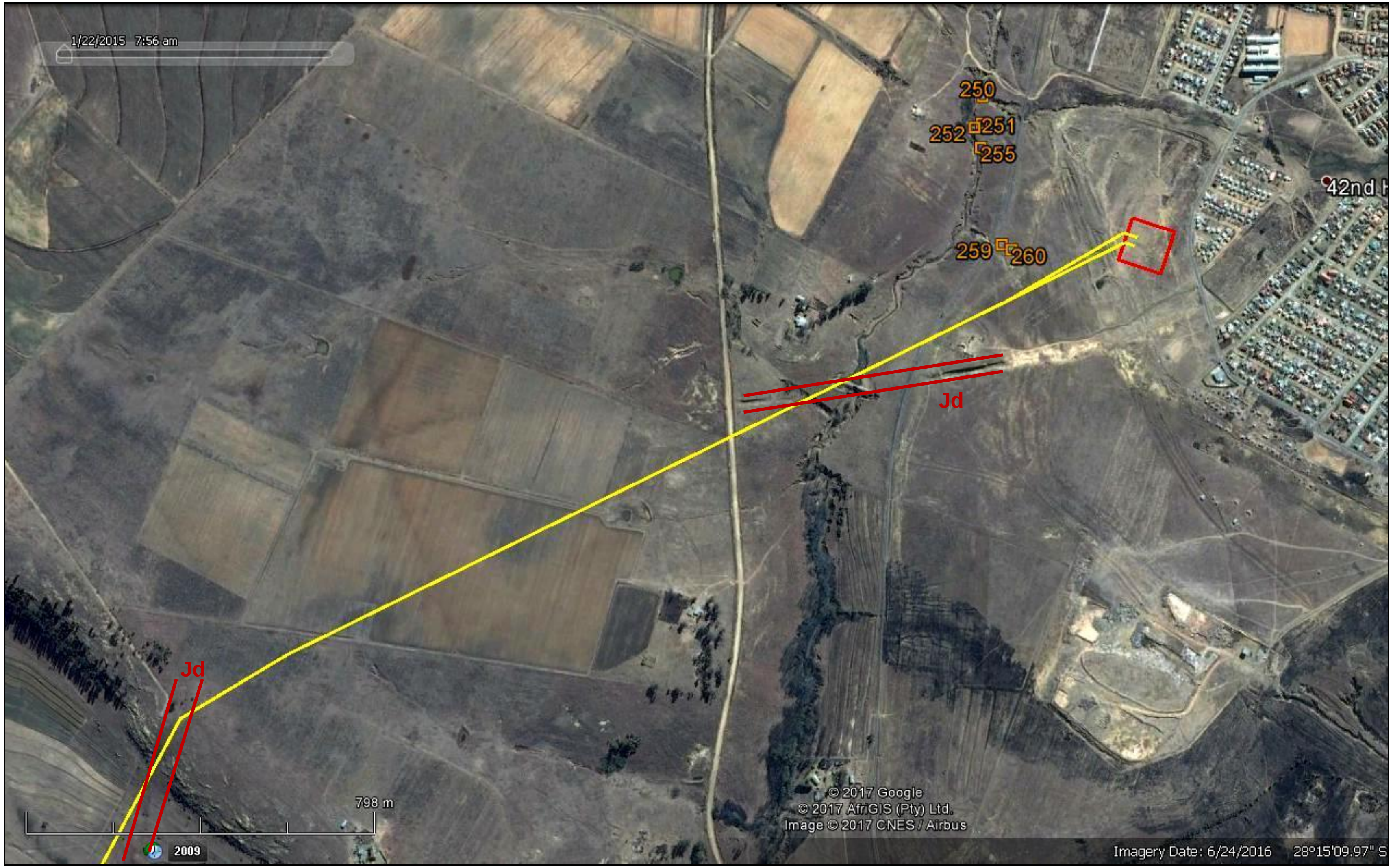


Figure 4. Google earth© satellite image of the eastern portion of the proposed electrical infrastructure development (132 kV powerline – yellow lines; Intabazwe Substation site – red square) near Harrismith. Numbered fossil localities are listed in the Appendix with gps data. With the exception of an isolated fossil tooth found well away from the powerline route (Loc. 250), none of these occurrences are considered to be of conservation significance. Selected dolerite intrusions encountered during fieldwork (Jd) are indicated in red.

4. GEOLOGICAL BACKGROUND

The study area near the small town of Harrismith is situated in gently hilly, grassland terrain in the foothills of the Drakensberg Escarpment (here represented by the Maluti Mountains) of the eastern Free State. Prominent *koppies* in the Harrismith area include Platberg (*c*. 2400 m amsl) and Loskop (2185 m amsl) to the northeast of town and Baker's Kop (2026 m amsl) to the southwest. The present substation and powerline study area extends from the margins of Phomolong township south-westwards to the meandering course of the Wilgerivier and its much smaller north-bank tributary the Rietspruit (Figs. 1 to 4). It also crosses an unnamed small south-flowing tributary stream to the west of the railway line. The Wilgerivier and its tributaries generally have steep banks that are incised to a depth of several meters into alluvial floodplain deposits as well as into underlying weathered sedimentary bedrocks of the Beaufort Group (Figs. 10 to 24). Away from the river the terrain is fairly flat to gently-sloping and grassy with occasional shallow streams, dams, erosion *dongas* and domical termitaria (Figs. 7 to 9). No bedrock exposures are available in the uneven, flattish terrain on the outskirts of Phomolong township where the new Intabazwe Substation is to be constructed (Fig. 6). Considerable stretches of the powerline corridor traverse established agricultural lands (maize, sunflower) and – with the exception of occasional sandstone *kranzes* - on the whole levels of bedrock exposure away from the larger watercourses and erosion gullies (*dongas*) are very low.

The geology of the Harrismith area is outlined on 1: 250 000 sheet 2828 Harrismith / Phuthaditjhaba (Council for Geoscience, Pretoria) (Fig. 5) and in the accompanying brief sheet explanation by Johnson and Verster (1994). The Palaeozoic sedimentary bedrocks beneath the study area are assigned on the published geological map to the **Lower Beaufort Group** (**Adelaide Subgroup**, pale green **Pa** on geological map) as well as the overlying **Katberg Formation** (**Tarkastad Subgroup / Upper Beaufort Group**, dark green **TRt** on geological map) of the Karoo Supergroup (Johnson *et al.* 2006). In practice, the contact between these two successions in the area northwest of Harrismith is not straightforward due to probable intertonguing of sandstone and mudrock packages and more detailed mapping is required here.

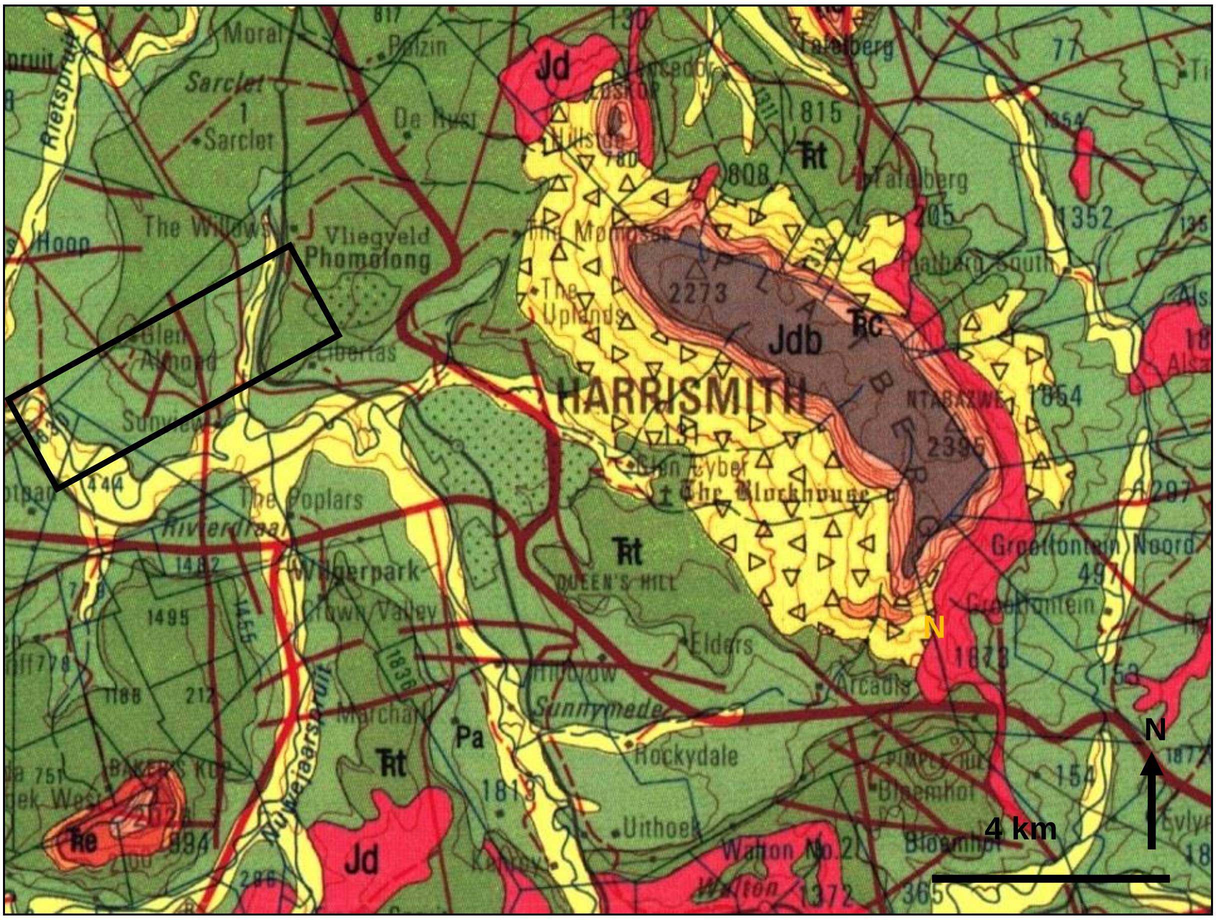


Figure 5. Extract from 1: 250 000 geology sheet 2828 Harrismith showing the geology of the Harrismith area, eastern Free State (Council for Geoscience, Pretoria). The present study area on the north-western outskirts of town lies within the black rectangle. Note that the mapping of the contact between the Katberg and underlying Adelaide Subgroup rocks here may require revision. The main rock units represented within and close to the study area are:

1. KAROO SUPERGROUP (BEAUFORT GROUP)

- **Normandien Formation (Pa, pale green) – Adelaide Subgroup (Lower Beaufort Group)**
- **Katberg Formation (TRt, dark green) – Tarkastad Subgroup (Upper Beaufort Group)**

2. KAROO DOLERITE SUITE

- **Dolerite sills and dykes (J-d, pink)**

3. LATE CAENOZOIC SUPERFICIAL SEDIMENTS

- **Stream and river alluvium (pale yellow)**

N.B. **Other superficial deposit such as surface gravels, scree and soils are not mapped at this scale.**

Figure 6. View towards NE across the Intabazwe Substation study area on the outskirts of Phomolong township near Harrismith. Note fairly flat, uneven grassy terrain with no bedrock exposure.

Figure 7. View north-eastwards towards Phomolong township and Platberg on the skyline with grassy, gently hilly terrain traversed by the eastern portion of the powerline corridor in the foreground. Note minimal bedrock exposure here.

Figure 8. View to the southwest down the Katberg sandstone escarpment between Sunnyside and Glen Almond farmsteads. The powerline corridor runs to the right of the raised, reddish-brown ridge in the middle ground that marks a dolerite dyke.

Figure 9. View to the northwest along the existing Harrismith-Sorata 132 kV line near Westlands farmstead. The raised terrain here mantled in reddish-brown rock rubble is underlain by a dolerite intrusion.

Figure 10. View south-eastwards towards the existing Harrismith-Sorata 132 kV line showing the steep banks of alluvium along the Rietspruit in the foreground.

4.1. Lower Beaufort Group

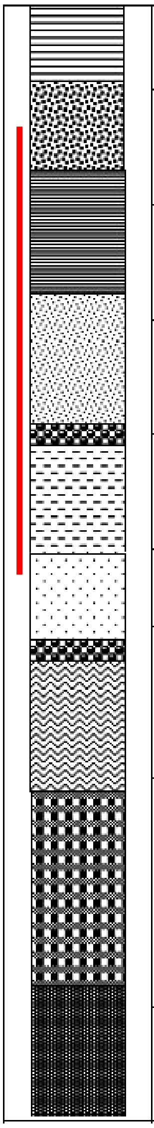
The Middle Permian to earliest Triassic fluvial mudrocks and sandstones of the Lower Beaufort Group in the Harrismith area are currently assigned to the **Normandien Formation**. This unit is intercalated stratigraphically between offshore marine to estuarine / brackish mudrocks of the Volksrust Formation (Ecca Group) and Early Triassic fluvial red beds of the Tarkastad Subgroup (Upper Beaufort Group) and represents the entire Adelaide Subgroup succession in the region. Deltaic facies of the previously recognised Estcourt Formation of the eastern Free State and western Kwazulu-Natal are incorporated by recent authors into the base of the Normandien Formation (Frankfort Member). Key accounts of the Normandien succession are given by Groenewald (1984, 1989) as well as Johnson and Verster (1994), with useful summaries given by Johnson (1994), Johnson *et al.* (2006) and Groenewald (2012).

The Normandien Formation comprises some 100-320 m of deltaic to fluvial and lacustrine mudrocks (grey, grey-green, red) and impure, prominent-weathering sandstones that crop out in the northern Free State and western Kwazulu-Natal. The lower contact with the underlying Volksrust shales is conformable, while the sharp upper contact with the Katberg Formation represents an erosional hiatus. Table 1 below, taken from Groenewald (2012), shows the stratigraphic subdivision of the Normandien Formation into several members of contrasting lithology, sedimentology and palaeontological content. Given that much of the powerline study area traverses the Katberg Formation outcrop area, the underlying Lower Beaufort Group bedrocks mapped in lower-lying terrain are inferred to lie high up within the Normandien succession. The Harrismith Member at the top of the Normandien Formation is characterised by brightly-hued reddish / pink and green mudrocks that were only occasionally encountered in the easternmost sector of the study area (*e.g.* Fig. 13). Yellowish-green silty mudrocks and thin, medium-grained sandstones seen further to the west *may* belong to the Schoondraai Member and underlying mudrock package, but this is uncertain. The thick package of medium to coarse, trough cross-bedded sandstones cropping out along the Wilgerivier in the west might then be referred to the Rooinek Member. However, the possibility remains that these sandstone packages represent a tongues of Katberg Formation sandstone facies intercalated with the mudrock-dominated Adelaide Subgroup succession. These alternative interpretations can only be tested by detailed mapping that lies beyond the scope of the present palaeontological assessment.

The Normandien succession in northern part of the Harrismith 1: 250 000 sheet area, mainly comprising khaki to grey-green mudrocks and fine- to coarse-grained sandstones, was previously assigned to the upper part of his “Van Reenen Formation” by Terblanche (1984), as outlined by Johnson and Verster (1994). The sandstones are yellowish-grey, feldspathic and locally conglomeratic at the base. Common sedimentary structures include large-scale trough cross beds and small-scale ripple cross-lamination, erosional channel bases with mudflake breccias, horizontal lamination and primary current lineation. Palaeocurrents are mainly from a northerly or north-easterly source area. Coarse, poorly-sorted conglomerates of angular to subrounded quartz, granite as well as reworked mudrock intraclasts are recorded locally. Thin (few cm) coal horizons occur at the base of coarse-grained channel sandstones or within dark grey carbonaceous shaly facies in the eastern outcrop area.

Exposures of Beaufort Group bedrocks within or close to the study area to the northwest of Harrismith are limited to occasional outcrops of channel sandstones and mudrocks on the banks of the Wilgerivier and Rietspruit, an unnamed tributary stream close to the railway line as well as a few sandstone cliffs or *kranzes* and erosion gullies (*dongas*); elsewhere the bedrocks are buried beneath several meters of alluvium (Figs. 6 to 10).

The Normandien sandstones are medium- to coarse-grained and gritty, poorly-sorted and -cemented, speckled, feldspathic, and greyish to yellow-brown in hue. Sedimentary structures within the channel sandstones include tabular and trough cross-bedding, current ripple cross-lamination towards the tops of beds, thin mudflake lag conglomerates and casts of flute marks at their erosional bases. Flaggy facies show well-developed current lineation. There are local developments of oblate, dark brown ferruginous carbonate concretions and the sandstone themselves may be ferruginised, perhaps as a result of nearby dolerite intrusion. Khaki-to grey-green hued, weathered Normandien overbank mudrocks were best seen in the various branches of the Rietspruit drainage system (Figs. 19, 21). Here thin upward-fining packages of grey-green siltstones with intercalated thin-bedded, flaggy sandstones show local development of ball-and-pillow structures and small-scale cut-and-fill channels. The overbank mudrocks contain horizons rich in irregular-shaped, rusty-brown ferruginous carbonate concretions. Some of these show cone-in-cone structures indicating a late-diagenetic origin (Fig. 20). They are not secondarily altered (ferruginised) calcrete nodules, although occasional sphaeroidal palaeocalcrete nodules were observed (*e.g.* Loc. 249).



Burgersdorp/Driekoppen Formation. Red mudstone and thin yellow-brown sandstone. Cynognathus Assemblage Zone vertebrate fossils and trace fossils.
Katberg/Verkykerskop Formation. Coarse-grained sandstone with manganese enriched conglomerates – Braided River Fluvial deposit. No record of fossil finds to date.
Harrismith Member – Normandien Formation. Brightly coloured siltstone – highly dissipating and expansive. Concretions with numerous fossils of Lystrosaurus Assemblage Zone material and vertebrate burrows
Schoondraai Member – Normandien Formation. Fine to medium-grained sandstone with prominent conglomerate of granitic pebbles at the base. Large scale petrified tree fossils of Glossopteris and very thin coal beds.
Green and grey mudstone and siltstone with prominent concretions of Calcium and Gypsum. Fossils of plants and coal beds in upper layers and very productive vertebrate fossil layers of the Dicynodon Assemblage Zone.
Rooinek Member – Normandien Formation. Coarse-grained fluvial feldspathic sandstone with basal conglomerates, fossil trees of Glossopteris and coal beds.
Green and grey mudstone and siltstone with thin coal beds. Fluvial crevasse splay deposits with micro cross-bedding in silt deposits. Trace fossils abundant on sandstone bedding planes. (Fossil remains of Rhachiocephalus recorded towards the west where weathering is not as severe as along the escarpment).
Frankfort Member – Normandien Formation - Dark grey shale and siltstone, interbedded with lenses of deltaic very coarse-grained feldspathic sandstone deposits of up to 20 m thick. Lenses of sandstone discontinuous over 500 m. Plant fossils of Glossopteris abundant. Prominent but discontinuous coal beds and abundant trace fossils on bedding planes of sandstones, siltstones and mudstones. No vertebrate remains recorded to date.
Volksrust Formation – Ecca Group. Dark grey shale – deep water sedimentary deposits with very little recorded evidence of vertebrate life. Trace fossils recorded in the upper part of the formation.

Figure 11. Stratigraphic subdivision of the Beaufort Group in the eastern Free State showing the various subunits recognised within the Normandien Formation (Adelaide Subgroup) (From Groenewald 2012). The red bar indicates the *possible* stratigraphic range of Beaufort Group bedrocks in the Harrismith powerline study area (*N.B.* This is uncertain pending detailed mapping).

4.2. Katberg Formation

The Katberg Formation forms the regionally extensive, sandstone-rich lower portion of the Tarkastad Subgroup (Upper Beaufort Group) that can be traced throughout large areas of the Main Karoo Basin. Useful geological descriptions of the Katberg Formation are given by Johnson (1976), Hancox (2000), Johnson *et al.* (2006), Smith *et al.* (2002) and for the Harrismith sheet area in particular by Johnson and Verster (1994). The more detailed sedimentological accounts by Stavrakis (1980), Hiller and Stavrakis (1980, 1984), Haycock *et al.* (1994), Groenewald (1996) and Neveling (1998) are also relevant to the present study area. In the Harrismith 1: 250 000 sheet area the lowermost portion of the Tarkastad Subgroup – correlated with the Verkykerskop Formation to the north and the Katberg Formation to the south - comprises three to five sandstone packages that are up to 10 m thick and intercalated with subordinate mudrocks (Johnson & Verster 1994). Pending detailed mapping, it is uncertain to what extent the sandstone packages encountered in the present study area to the northwest of Harrismith might all belong to the Early Triassic Tarkastad Subgroup and be correlated with the Katberg Formation to the south.

In general, the predominant Katberg Formation sediments are (a) prominent-weathering, pale buff to greyish, tabular or ribbon-shaped sandstones up to 60 m thick that are interbedded with (b) recessive-weathering, reddish or occasionally green-grey mudrocks. Up to four discrete sandstone packages can be identified within the succession. Katberg channel sandstones are typically rich in feldspar and lithic grains (*i.e*. lithofeldspathic). They build laterally extensive, multistorey units with an erosional base that is often marked by intraformational conglomerates up to one meter thick consisting of mudrock pebbles, reworked calcrete nodules and occasional rolled fragments of bone. While the basal Katberg succession is often marked by a major cliff-forming sandstone unit, in some areas there is a transitional relationship with the underlying Adelaide Subgroup that is marked by an upward-thickening series of sandstone sheets. Internally the moderately well-sorted sandstones are variously massive, horizontally-laminated or cross-bedded and heavy mineral laminae occur frequently. Sphaeroidal carbonate concretions up to 10 cm across are common. The predominantly reddish Katberg mudrocks are typically massive with horizons of pedocrete nodules (calcretes), and mudcracks. Mudrock exposure within the study area is very limited due to extensive mantling of these recessive-weathering rocks by superficial sediments. Sandstone deposition was mainly due to intermittently flooding, low-sinuosity braided river systems flowing northwards from the rising Cape Fold Belt mountains in the south into the subsiding Main Karoo Basin (Fig. 12). Mudrocks were largely laid down by suspension settling within overbank areas following episodic inundation events, while other fine-grained sediments are associated with lakes and temporary playas in lower-lying areas on the arid floodplain, especially in the northern Katberg outcrop area and its lateral correlatives in the Burgersdorp Formation. Palaeoclimates inferred for the Early Triassic Period in the Main Karoo Basin were arid with highly seasonal rainfall and extensive periods of drought. This is suggested by the abundant oxidised (“rusty red”) mudrocks, desiccation cracks, and palaeosols associated with well-developed calcretes. Arid settings are also supported by taphonomic and behavioural evidence such as pervasive carbonate encrustation of fossil bones, mummification of postcrania, bone-bed death assemblages associated with water holes and the frequency of burrowing habits among tetrapods, including large dicynodonts like *Lystrosaurus* (Groenewald 1991, Smith & Botha 2005, Viglietti 2010).

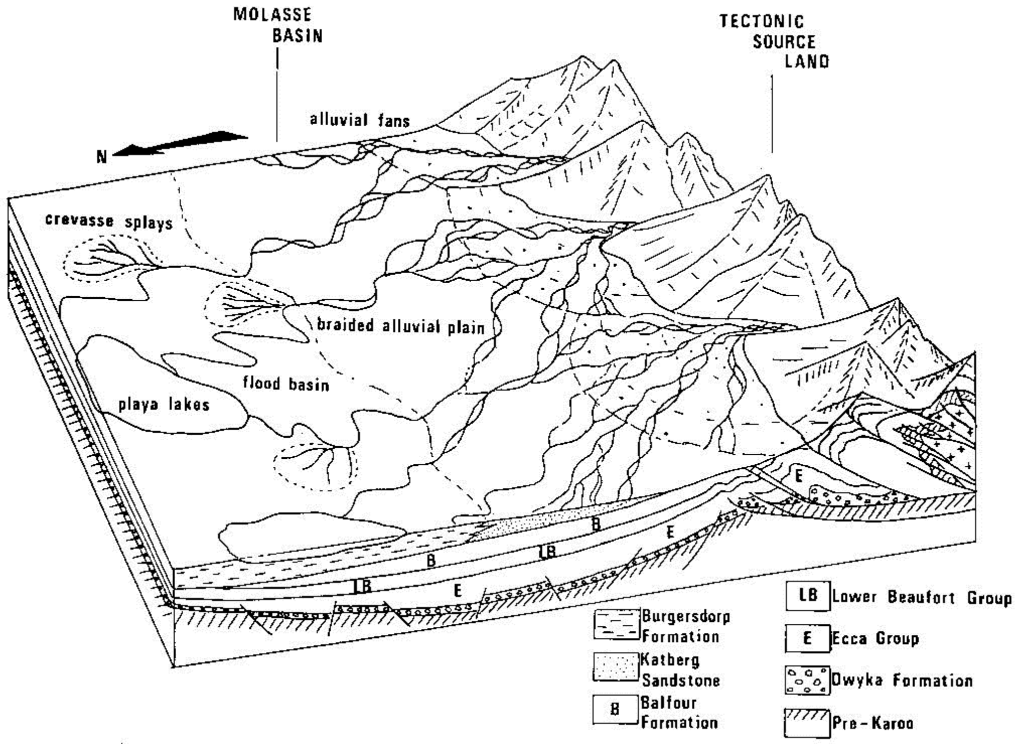


Figure 12. Reconstruction of the south-eastern part of the Main Karoo Basin in Early Triassic times showing the deposition of the sandy Katberg Formation near the mountainous source area in the south (From Hiller & Stavrakis 1984).

As discussed earlier, the major packages of yellowish-brown, medium- to coarse-grained channel sandstones encountered at various points along the powerline route corridor (Figs. 14 to 18) - including along all the larger watercourses as well as the SW-facing kranz between Sunnyside and Glen Almond farmsteads – might all belong to the Katberg Formation which in the Harrismith region comprises several intercalated sandstone and mudrock tongues. Prominent features of these sandstones include tabular to lenticular geometry, well-developed, large-scale, low angle trough cross-sets or occasionally tabular cross-bedding with broadly northerly-directed palaeocurrents, and thin mudflake breccio-conglomerates. Well-developed basal breccias were not seen. Karstic (solution-weathering) features such as honeycomb-weathering is apparent on some of the better-exposed sandstone kranzes (Fig. 15). Another interesting feature observed on Beaufort Group weathered sandstone surfaces are shallow subcircular etched depressions generated by epilithic lichens that have been well-studied in the Golden Gate National Park (Grab *et al*. 2011) (Fig. 16).

Figure 13. Weathered grey-green and brick-red overbank mudrocks of the Beaufort Group with thin cross-bedded, yellow-brown sandstones exposed on eroded hillslopes to the west of the Intabazwe Substation site (Loc. 259) (Hammer = 30 cm).

Figure 14. Deep linear channel excavated or eroded along a dolerite dyke with a thick package of erosive-based, fractured Katberg sandstones exposed in its walls (Loc. 264).

Figure 15. Karstic honeycomb solution weathering of Katberg sandstones along the SW-facing escarpment edge near Glen Almond homestead (Loc. 267).

Figure 16. Rounded, shallow depressions etched by epilithic lichens into weathered Katberg sandstones, escarpment near Glen Almond homestead (Loc. 267) (Scale in cm).

Figure 17. Bedding plane exposure of Katberg sandstones showing large scale, low-angle trough cross-bedding with palaeocurrents towards the N, NNE (Hammer = 30 cm) (Loc. 274).

Figure 18. Thick package of cross-bedded fluvial sandstones exposed in the banks of the Wilgerivier just west of the Old Toll Bridge. These sandstones may belong to the Katberg Formation or perhaps form part of the underlying Normandien Formation.

Figure 19. Hillslope exposure of grey-green expansive-weathering mudrocks and thin sandstone interbeds along the west bank of the Rietspruit (Loc. 283) (Hammer = 30 cm).

Figure 20. Large ferruginous carbonate concretion within Beaufort Group overbank mudrocks (*c*. 30 cm across in this view) (Loc. 283). These concretions show cone-in-cone structures and are therefore late diagenetic in origin and not ferruginised pedogenic calcretes.

Figure 21. Thin, upward-fining sequences within a thick package of grey-green siltstones and thin sandstone interbeds exposed along a branch of the Rietspruit drainage system (Loc. 291). These overbank mudrocks may belong to the Normandien Formation.

4.3. Karoo Dolerite Suite

The Karoo Supergroup succession near Harrismith is intruded by dolerites of the **Karoo Dolerite Suite** (Jd) (*e.g.* the prominent columnar-jointed sill capping Platberg – mistakenly mapped on the 1: 250 000 sheet as Drakensberg Group lavas). The Karoo dolerites form part of a suite of basic igneous bodies (dykes, sills) that were intruded into sediments of the Main Karoo Basin in the Early Jurassic Period, about 183 million years ago (Duncan & Marsh 2006, Cole *et al.* 2004). They form part of the Karoo Igneous Province of Southern Africa that developed in response to crustal doming and stretching preceding the break-up of Gondwana. Close to the margins of the intrusions the country mudrocks have been thermally metamorphosed or baked to form tough, splintery hornfels.

Several linear dolerite dykes are mapped to the northwest of Harrismith, including within the present study area, but a number of additional unmapped dykes and sills were encountered during fieldwork (See red lines in Figs. 3 & 4). The intrusions are variously expressed at surface as deep linear trenches (*e.g.* Fig. 14), steeply-dipping dykes with baked margins of country rock (*e.g.* Fig. 22), gentle-sloped topographic ridges mantled rusty brown doleritic rubble (*e.g.* Figs. 8 & 9), or sill-like sheets with well-developed columnar joining (*e.g.* Fig. 23).

Figure 22. Steeply-dipping, well-jointed dolerite dyke and baked sandstone country rocks exposed in the bed of an unnamed stream to the NE of Morewag farmstead (Loc. 265a). This is an extension of the same WSW-ENE dyke that runs along the gulley shown in Figure 14.

Figure 23. Columnar-jointed dolerite intrusion (sill or major dyke) exposed along the eastern banks of the Wilgerivier, overlain by thermally metamorphosed Beaufort Group sandstones (Hammer = 30 cm) (Loc. 272).

4.4. Late Caenozoic superficial deposits

Various types of **superficial deposits** of Late Caenozoic (Miocene / Pliocene to Recent) age occur widely throughout the Karoo study region (*e.g.* Holmes & Marker 1995, Cole *et al.* 2004, Partridge *et al.* 2006). They include pedocretes (*e.g*. calcretes, ferricretes), colluvial slope deposits, down-wasted surface gravels, river alluvium, wind-blown sands as well as spring and pan sediments. This mantle of superficial deposits – especially alluvium of the Wilgerivier, Rietspruit and other drainage lines - obscures the Palaeozoic and Mesozoic bedrock geology in most parts of the study area (These are not well shown on the geological map, Fig. 5). Furthermore, deep chemical weathering in the Late Cretaceous to Tertiary interval has converted some of the near-surface bedrocks to *in situ* weathered saprolite. Useful geological overviews of talus deposits, alluvium and calcrete occurrences in a semi-arid Karoo region are given by Cole *et al.* (2004).

The great majority of the study area is mantled with Late Caenozoic fine-grained alluvial deposits of the Wilgerivier and its tributaries that reach thicknesses of several meters (≥ 6 m locally) and are largely covered with modern soils, grassy vegetation with sporadic pale buff domical termitaria. Much of the featureless, flat-lying substation area is underlain by thick alluvial deposits and soils (Fig. 6) that are exposed in nearby stream banks and areas of gulley erosion (Figs. 24 to 30). Excellent vertical sections through older, semi-consolidated sandy alluvium – often featuring dispersed calcrete and ferricrete glaebules – with occasional poorly-sorted sandstone gravel horizons are seen along the Wilgerivier, Rietspruit and other drainage lines. The alluvium varies from massive to well-bedded; in the latter case bedding may dip towards the drainage line. Well-developed coarse basal gravels were not observed, however (*cf* Almond 2015). Thinner alluvial soils with fine-grained basal or downwasted surface gravels are well exposed in areas of *donga* erosion. In addition to ferricrete and calcrete glaebules, the surface gravels contain sparse to locally common agates, ferruginous sandstone and dolerite clasts, small (microlithic) stone artefacts of cherty material and grey hornfels as well as rare reworked fragments of petrified wood and teeth that have weathered out of the underlying Beaufort Group bedrocks (Figs. 27 & 34). Coarse alluvial deposits were rarely encountered in the study area; an exception is a relict bar of rubbly sandstone and dolerite, cobbly to bouldery conglomerates at an intersection to two branches of the Rietspruit drainage system (Fig. 30).

Figure 24. Streambed exposure of yellow-brown Katberg sandstones mantled by thick, well-bedded sandy alluvium, unnamed stream to NW of the Intabazwe Substation study site (Loc. 249).

Figure 25. Good stream bank section through well-bedded sandy alluvial succession capped by darker brown soils (Hammer = 30 cm) (Loc. 250). A high-crowned fossil mammalian tooth is embedded in the semi-consolidated older alluvium here (arrow) (See also Figure 35).

Figure 26. Horizon of coarse, poorly-sorted alluvial gravels of subangular sandstone clasts within well-bedded Late Caenozoic alluvial succession (Loc. 251) (Hammer = 30 cm).

Figure 27. Hillslope erosion gulley north of Morewag farmstead showing pale brown sandy soils overlying older orange-brown, sandy alluvial to colluvial deposits with pale, flattish calcrete concretions and abundant rusty-brown ferricrete glaebules (Loc. 266) (Hammer = 30 cm).

Figure 28. Thick semi-consolidated sandy alluvium with densely-spaced, small spherical calcrete glaebules overlain by much darker modern sandy soils, eastern banks of the Rietspruit (Loc. 282) (Hammer = 30 cm).

Figure 29. Thick, tabular layers of sandy alluvium exposed along the steep western banks of the Wilgerivier *c*. 650 m SE of the Old Toll Bridge (Loc. 275).

Figure 30. Lens or bar of coarse alluvial gravels of cobbles and boulders of sandstone and dolerite exposed on the banks of the Rietspruit (Loc. 285) (Hammer = 30 cm).

5. PALAEONTOLOGICAL HERITAGE

Palaeontological heritage reported elsewhere within the main rock units represented in the transmission line study area near Harrismith is outlined here, with a brief account of new fossil finds made during the present field assessment. GPS locality data for numbered fossil sites is provided in the Appendix and these are indicated on satellite images in Figures 3 and 4. Note that it has not been clearly established to what extent the study area overlies Normandien Formation as well as Katberg Formation bedrocks (See discussion in previous section of the report).

5.1. Fossil heritage within the Normandien Formation

The upper part of the Lower Beaufort Group (Adelaide Subgroup) succession in the Harrismith area, including the Normandien Formation, is characterised by Late Permian fossil biotas of the ***Dicynodon* Assemblage Zone** (Rubidge 1995, Van der Walt *et al.* 2010). This biozone has been assigned to the Changhsingian Stage (= Late Tartarian) right at the end of the Permian Period, with an approximate age range of 253.8-251.4 million years (Rubidge 1995, 2005; *N.B.* Smith *et al.* 2012 refer the biozone to the Wuchiapingian and Changhsingian Stages). Good accounts, with detailed faunal lists, of the fossil biotas of the *Dicynodon* Assemblage Zone have been given by

Kitching (*in* Rubidge 1995), Cole *et al*. (2004) and Smith *et al.* (2012). See also the reviews by Cluver (1978), MacRae (1999), McCarthy & Rubidge (2005) as well as recent papers on Permo-Triassic boundary tetrapod faunas of the Main Karoo Basin by Smith and Botha (2005), Botha and Smith (2006, 2007) as well as Viglietti *et al.* (2015). In general, the following broad categories of fossils might be expected within the Lower Beaufort Group rocks:

- isolated petrified bones as well as articulated skeletons of terrestrial vertebrates such as true **reptiles** (notably large pareiasaurs, small millerettids) and **therapsids** (diverse dicynodonts such as *Aulacephalodon*, *Oudenodon*, *Dicynodon* and the much smaller *Diictodon*, gorgonopsians, therocephalians such as *Theriognathus*, primitive cynodonts like *Procynosuchus*, and biarmosuchians) (Fig. 31);
- aquatic vertebrates such as large temnospondyl **amphibians** like *Rhinesuchus* (usually disarticulated), and palaeoniscoid **bony fish** (*Atherstonia*, *Namaichthys*);
- freshwater **bivalves;**
- **trace fossils** such as worm, arthropod and tetrapod burrows and trackways, coprolites;
- **vascular plant remains** including leaves, twigs, roots and petrified woods ("*Dadoxylon*") of the *Glossopteris* Flora (usually sparse, fragmentary), especially glossopterids and arthrophytes (horsetails).

From a palaeontological viewpoint, these diverse *Dicynodon* Assemblage Zone biotas are of extraordinary interest in that they provide some of the best available evidence for the last flowering of ecologically-complex terrestrial ecosystems immediately preceding the catastrophic end-Permian mass extinction (*e.g.* Smith & Ward, 2001, Rubidge 2005, Retallack *et al*., 2006, Smith & Botha 2005, Botha & Smith 2006, 2007). The faunal turnover at the Permian – Triassic boundary, which has been identified within the Palingkloof Member of the Balfour Formation and probably correlated with the Schoondraai Member of the Normandien Formation, is discussed in some detail by Smith and Botha (2005), Botha and Smith (2007) as well as more recently by Smith *et al.* (2012) (See also Groenewald 2012 and references therein).

As far as the biostratigraphically important tetrapod remains are concerned, the best fossil material is generally found within overbank mudrocks, whereas fossils preserved within channel sandstones tend to be fragmentary and water-worn (Kitching 1995, Smith 1993). Many fossils are found in association with ancient soils (palaeosol horizons) that can usually be recognised by bedding-parallel concentrations of calcrete nodules. The abundance and variety of fossils within the *Dicynodon* Assemblage Zone decreases towards the top of the succession (Cole *et al*., 2004).

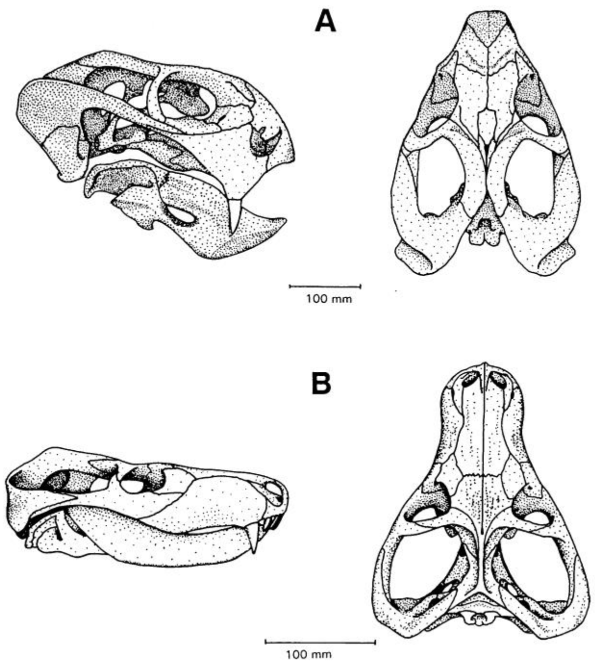


Figure 31. Skulls of key therapsids ("mammal-like reptiles") from the Late Permian *Dicynodon* Assemblage Zone: the dicynodont *Dicynodon* and the therocephalian *Theriognathus* (From Kitching *in* Rubidge 1995).

The fossil record of the Normandien Formation has been reviewed by Groenewald (2012 and earlier works listed in the References below) as well as Johnson and Verster (1994). The diverse fossil plant and insect biotas associated with the previously-recognised Estcourt Formation are now assigned to the basal Normandien Formation (Frankfort Member; see Table 1) that lies outside the present study area. Tetrapod fossil records from the Harrismith region itself are detailed by Kitching (1977) and include important temnospondyl amphibians. The forms mentioned belong to beds at the top of the Normandien succession that are assigned to the Early Triassic *Lystrosaurus* Assemblage Zone (Table 1). The underlying part of the Normandien succession (Latest Permian Schoondraai Member) is associated with abundant petrified wood ("*Dadoxylon*"), including large logs of gymnosperms (See Johnson & Verster 1994, their fig. 1; *cf* also Thomas *et al.* 1983). These well-preserved fossil woods have been assigned to the genera *Araucarioxylon* and *Australoxylon*, based in part on material collected from the Harrismith area (Bamford 1999). The abundant reworked silicified wood clasts illustrated by Almond (2015) from Late Caenozoic alluvial gravels near Harrismith are probably derived from the underlying Normandien Formation bedrocks.

No *in situ* fossil vertebrate remains were recorded in the Normandien Formation bedrocks during this study, although this may be attributed in part to the very low levels of bedrock exposure here. The sparse, small petrified wood and tooth fragments recorded from surface gravels in the area may have been reworked from this succession, however (Section 5.3).

5.2. Fossil heritage within the Katberg Formation

The Katberg Formation is known to host a low-diversity but palaeontologically important terrestrial fossil biota of Early Triassic (Scythian / Induan - Early Olenekian) age, *i.e.* around 250 million years old (Groenewald & Kitching 1995, Rubidge 2005). The biota is dominated by a small range of therapsids ("mammal-like reptiles"), amphibians and other tetrapods, with rare vascular plants and trace fossils, and has been assigned to the ***Lystrosaurus*** **Assemblage Zone** (**LAZ**). This impoverished fossil assemblage characterizes Early Triassic successions of the upper part of the Palingkloof Member (Adelaide Subgroup) as well as the Katberg Formation and - according to some earlier authors – the lowermost Burgersdorp Formations of the Tarkstad Subgroup. Recent research has emphasized the rapidity of faunal turnover during the transition between the sand-dominated Katberg Formation (*Lystrosaurus* Assemblage Zone) and the overlying mudrock-dominated Burgersdorp Formation (*Cynognathus* Assemblage Zone) (Neveling *et al.* 2005). In the proximal (southern) part of the basin the abrupt faunal turnover occurs within the uppermost sandstones of the Katberg Formation and the lowermost sandstones of the Burgersdorp Formation (*ibid*., p.83 and Neveling 2004). This work shows that the *Cynognathus* Assemblage Zone correlates with the entire Burgersdorp Formation; previous authors had proposed that the lowermost Burgersdorp beds belonged to the *Lystrosaurus* Assemblage Zone (*e.g.* Keyser & Smith 1977-78, Johnson & Hiller 1990, Kitching 1995). It should also be noted that the dicynodont *Lystrosaurus* has now been recorded from the uppermost beds of the Latest Permian *Dicynodon* Assemblage Zone but only becomes super-abundant in Early Triassic times (*e.g.* Smith & Botha 2005, Botha & Smith 2007 and refs. therein).

Useful illustrated accounts of LAZ fossils are given by Kitching (1977), Keyser and Smith (1977-1978), Groenewald and Kitching (1995), MacRae (1999), Hancox (2000), Smith *et al.* (2002), Cole *et al*. (2004), Rubidge (2005 *plus* refs therein), Damiani *et al.* (2003a), and Smith *et al.* (2012), among others. These fossil biotas are of special palaeontological significance in that they document the recovery phase of terrestrial ecosystems following the catastrophic end-Permian Mass Extinction of 251.4 million years ago (*e.g.* Smith & Botha 2005, Botha & Smith 2007 and refs. therein). They also provide interesting insights into the adaptations and taphonomy of terrestrial animals and plants during a particularly stressful, arid phase of Earth history in the Early Triassic.

Key tetrapods in the *Lystrosaurus* Assemblage Zone biota are various species of the medium-sized, shovel-snouted dicynodont *Lystrosaurus* (by far the commonest fossil form in this biozone. contributing up to 95% of fossils found), the small captorhinid parareptile *Procolophon*, the crocodile-like early archosaur *Proterosuchus*, and a wide range of small to large armour-plated "labyrinthodont" amphibians such as *Lydekkerina* (Fig. 32). Botha and Smith (2007) have charted the ranges of several discrete *Lystrosaurus* species either side of the Permo-Triassic boundary. Also present in the LAZ are several genera of small-bodied true reptiles (*e.g.* owenettids), therocephalians, and early cynodonts (*e.g. Galesaurus, Thrinaxodon*). Animal burrows are attributable to various aquatic and land-living invertebrates, including arthropods (*e.g. Scoyenia* scratch burrows), as well as several subgroups of fossorial tetrapods such as cynodonts, procolophonids and even *Lystrosaurus* itself (*e.g.* Groenewald 1991, Damiani *et al.* 2003b, Abdala *et al.* 2006, Modesto & Brink 2010, Bordy *et al.* 2009, 2011). Vascular plant fossils are generally rare and include petrified wood ("*Dadoxylon*") as well as leaves of glossopterid progymnosperms and arthrophyte ferns (*Schizoneura*, *Phyllotheca*). An important, albeit poorly-preserved, basal Katberg palaeoflora has recently been documented from the Noupoort area (Carlton Heights) by Gastaldo *et al.* (2005). Plant taxa here include sphenopsid axes, dispersed fern pinnules and possible peltasperm (seed fern) reproductive structures. Pebbles of reworked silicified wood of possible post-Devonian age occur within the Katberg sandstones in the proximal outcrop area near East London (Hiller & Stavrakis 1980, Almond unpublished obs.). Between typical fossil assemblages of the *Lystrosaurus* and *Cynognathus* Assemblage Zones lies a possible *Procolophon* Acme Zone characterized by abundant material of procolophonids and of the amphibian *Kestrosaurus* but lacking both *Lystrosaurus* and *Cynognathus* (Hancox 2000 and refs. therein).

Most Katberg vertebrate fossils are found in the mudrock facies rather than channel sandstones. Articulated skeletons enclosed by calcareous pedogenic nodules are locally common, while intact procolophonids, dicynodonts and cynodonts have been recorded from burrow infills (Groenewald and Kitching 1995). Fragmentary rolled bone and teeth (*e.g.* dicynodont tusks) are found in the intraformational conglomerates at the base of some the channel sandstones

Palaeontological data for the Katberg Formation in the 1: 250 000 geology sheet 2828 area is unfortunately not provided by Johnson and Verster (1994). However, there are extensive Katberg fossil records for Harrismith Commonage listed in Kitching (1977, p. 93; see also p. 89), including localities along the base of the Platberg, along the Wilgerivier and the slopes of Queen's Hill. A wide range of fossi vertebrate taxa have been collected here, including reptiles (procolophonids, prolacertids, proterosuchids), small-bodied dicynodonts, lystrosaurids, therocephalians and cynodonts.

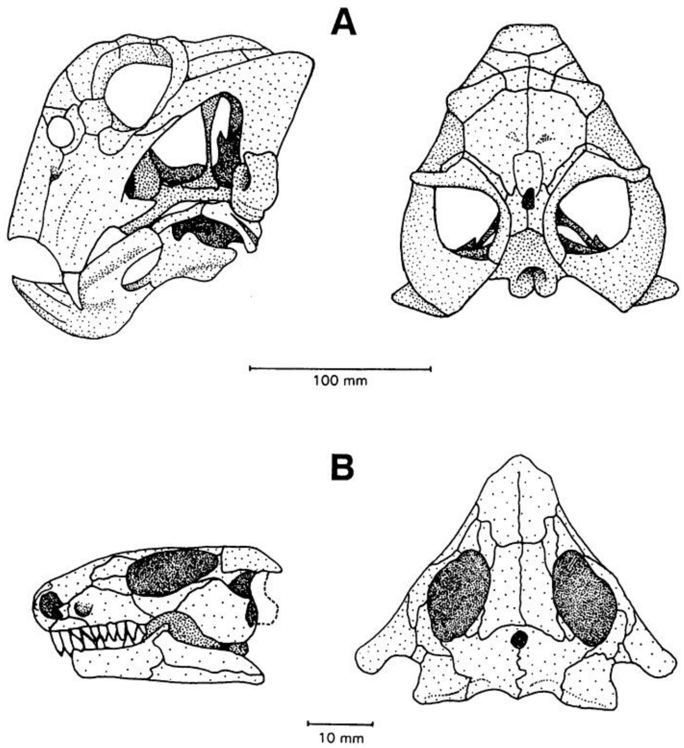


Figure 32. Skulls of two key tetrapod genera from the Early Triassic *Lystrosaurus* Assemblage Zone of the Main Karoo Basin: the pig-sized dicynodont *Lystrosaurus* (A) and the small primitive reptile *Procolophon* (B) (From Groenewald and Kitching, 1995).

No *in situ* fossil remains were collected from the Permo-Triassic Beaufort Group sediments exposed in the present electrical infrastructure study area to the northwest of Harrismith during the field assessment. Fragments of tusk and petrified wood recorded in basal gravels of the overlying alluvial deposits have probably been reworked from the Beaufort Group bedrocks but their exact provenance is unclear and the material is very scrappy (Figs. 33 and 34); these fossil remains are therefore of low conservation significance.

5.3. Fossil heritage within the Late Caenozoic superficial deposits

The central Karoo "drift deposits" have been comparatively neglected in palaeontological terms. However, they may occasionally contain important fossil biotas, notably the bones, teeth and horn cores of mammals as well as remains of reptiles like tortoises. Good examples are the Pleistocene mammal faunas at Florisbad, Cornelia and Erfkroon in the Free State and elsewhere (Wells & Cooke 1942, Cooke 1974, Skead 1980, Klein 1984, Brink, J.S. 1987, Bousman *et al.* 1988, Bender & Brink 1992, Brink *et al*. 1995, MacRae 1999, Meadows & Watkeys 1999, Churchill *et al*. 2000 Partridge & Scott 2000). Other late Caenozoic fossil biotas from these superficial deposits include non-marine molluscs (bivalves, gastropods), ostrich egg shells, trace fossils (*e.g.* calcretised termitaria, coprolites), and plant remains such as peats or palynomorphs (pollens, spores) in organic-rich alluvial horizons (Scott 2000) and siliceous diatoms in pan sediments. In Quaternary deposits, fossil remains may be associated with human artefacts such as stone tools and are also of archaeological interest (*e.g.* Smith 1999 and refs. therein). Stone artefacts of Pleistocene and younger age may additionally prove useful in constraining the age of superficial deposits such as gravelly alluvium within which they are occasionally embedded.

The thick sandy to silty alluvial deposits of the Wilgerivier, Rietspruit and other water courses (*e.g.* that near the railway line) contain isolated or occasional clumps of disarticulated, decalcified bones and teeth of small and large mammals, snail shells and small microlithic stone tools (LSA *e.g.* of chert) (Figs. 36 & 37; see also Almond 2015). The upper zones are highly bioturbated by soil invertebrates and plant roots. In some cases it is unclear whether the bones are truly embedded in the older alluvium or have been washed down from above. The high-crowned rectangular tooth embedded within alluvial deposits that is shown here in Figs. 25 and 35 resembles the Pleistocene equid tooth recorded from calcretised alluvial deposits near Harrismith by Almond (2015, Fig. 27 therein). The site lies well outside the proposed development footprint (See Loc. 250 in Fig. 4) and does not require mitigation. Any further, identifiable fossil remains discovered in Pleistocene alluvial deposits in the development footprint itself would be of scientific interest and should be reported to the National Museum, Bloemfontein for possible professional mitigation (Dr J. Brink. jbrink@nasmus.co.za).

Semi-consolidated ferricretised and / or calcretised alluvial deposits exposed on hillslopes by *donga* erosion in the eastern, central and western portions of the powerline study area usually feature fine gravels eroding out of the lower part of profile, include calcrete, ferricrete, reworked petrified wood, occasional small bone and tooth fragments, agates and cherty LSA microliths (*e.g.* Figs. 33 & 34). Some of the silicified wood clasts are fairly angular, suggesting that long-distance transport is not involved. The silicified wood and permineralised tooth fragments have been reworked from the Beaufort Group bedrocks but their exact provenance is unclear. The recorded sites are not considered to be of conservation significance.

Figure 33. Isolated fragment of permineralised tooth (12 mm diameter, 21 mm long) – possibly a canine tusk – found in the Rietspruit area within Late Caenozoic alluvial gravels but probably reworked from the Beaufort Group bedrocks (Loc. 290).

Figure 34. Surface gravels overlying a *donga* exposure of Beaufort Group bedrocks *c*. 400 m SW of the substation footprint, including detached articular head of a Recent or subfossil long bone (top left), three fragments of reworked petrified wood (centre and right) as well as a banded agate (bottom left) (Scale in mm) (Loc. 259).

Figure 35. High-crowned, rectangular mammalian tooth (probably equid) of probable Pleistocene age embedded within sandy alluvium exposed in a stream bank *c*. 430 m NW of the proposed powerline (Loc. 250; see also Fig. 25). Tooth is *c*. 4 cm long.

Figure 36. Exposed termination of a large mammal long bone (arrowed) apparently embedded within semi-consolidated alluvial sediments on the banks of the Rietspruit (Loc. 288). The bone is suncracked and not mineralised.

Figure 37. Disarticulated subfossil limb bones of a small mammal embedded in partially ferricretised older alluvial deposits, together with a cherty flake (Scale in cm and mm) (Loc. 255).

6. SUMMARY & RECOMMENDATIONS

The electrical infrastructure study area near Harrismith is underlain at depth by fluvial sandstones and mudrocks of the Beaufort Group (Karoo Supergroup) assigned to the upper part of the Normandien Formation and the overlying Katberg Formation. These latest Permian / earliest Triassic continental sediments are known for their wealth of fossil gymnospermous wood and may also contain fossil vertebrates of the *Dicynodon* and *Lystrosaurus* Assemblage Zones (*e.g.* mammal-like reptiles, various subgroups of true reptiles). Several important vertebrate fossils have previously been recorded from the Katberg Formation in the vicinity of Harrismith (*e.g.* Kitching 1977). However, the Beaufort Group bedrocks within the present electrical infrastructure study area are very poorly-exposed, with the exception of a few sites along the Wilgerivier, the Rietspruit and other deeply-incised tributaries. No *in situ* fossil plants or vertebrates were recorded from the Beaufort Group during this field study, while occasional very fragmentary petrified wood and tooth remains occur within overlying downwasted surface gravels. The proposed new substation site and powerline route are largely underlain near-surface by thick sandy alluvial deposits of the Wilgerivier and its tributaries as well as by thinner colluvial gravels and soils on neighbouring hillslopes. The semi-consolidated younger alluvium contains dispersed subfossil remains such as isolated or loosely-associated bones of small and large mammals. The underlying, better-consolidated and often calcretised to ferricretised older alluvium in the Harrismith area contains rare Pleistocene mammalian remains together with sparse MSA and LSA stone artefacts (*cf* Almond 2015). Only a single high-crowned fossil tooth (probably equid) recorded well away from the powerline corridor was found during the present field study, however.

Given (1) the apparent scarcity of well-preserved fossil material within the Permo-Triassic Beaufort Group bedrocks and in the Pleistocene - Holocene alluvial cover, as well as (2) the small scale of the 132 kV pylon footprints and substation involved, it is concluded that the proposed electrical infrastructure project does not pose a significant threat to local fossil heritage resources (*i.e.* LOW palaeontological heritage impact significance). No specialist palaeontological mitigation or monitoring measures are recommended for this project, pending the discovery of significant new fossil finds during construction. The ECO responsible for the development should be alerted to the possibility of scientifically important fossil finds (especially mammalian bones and teeth) within the older calcretised alluvium.

In the case of any substantial fossil finds during construction (*e.g.* vertebrate teeth, bones, burrows, petrified wood, shells), these should be carefully safeguarded - preferably *in situ* - and reported by the ECO as soon as possible to SAHRA (Contact details: Dr Ragna Redelstorff. South African Heritage Resources Agency. 111 Harrington Street, Cape Town 8001. Tel: +27 (0)21 202 8651. E-mail: rredelstorff@sahra.org.za). This is so that appropriate mitigation (*i.e.* recording, sampling or collection) by a palaeontological specialist can be considered and implemented. Fossil bones and teeth observed within the calcretised (pale grey) alluvial deposits near the Wilgerivier or other tributary drainage lines should be reported to Dr James Brink of the National Museum, Bloemfontein (jbrink@nasmus.co.za; tel. +27 51 447 9609. Address: 36 Aliwal Street, Bloemfontein, RSA) for professional recording and sampling. These recommendations should be incorporated into the Environmental Management Programme (EMPr) for the development.

7. ACKNOWLEDGEMENTS

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9. 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, Limpopo, Mpumalanga, Northwest Province and the Free State under the aegis of his Cape Town-based company *Natura Viva* cc. He has previously served as 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 APHP (Association of Professional Heritage Practitioners – Western Cape).

Declaration of Independence

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

John E. Almond

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APPENDIX: GPS LOCALITY DATA FOR NUMBERED SITES MENTIONED IN TEXT

All GPS readings were taken in the field using a hand-held Garmin GPSmap 62sc instrument. The datum used is WGS 84. Only those localities mentioned by number in the text are listed here. Fossil localities are indicated on satellite images in Figures 3 and 4 of the report.

LOC.	GPS DATA	COMMENTS
249	28 14 45.5 S 29 05 17.3 E	Package of yellow-brown Beaufort Group sandstones or wackes, thin-to medium-bedded, occasionally low-angle cross-bedded or flaggy, erosive-based. Nearby donga exposures show ripple-laminated bed tops, river palaeocurrents towards NE. Limited exposures of grey-green to reddish-brown overbank mudrocks. Beaufort Group bedrocks overlain by thick (2.5-4 m), massive to tabular-bedded, orange-brown (below) to yellowish sandy to silty alluvial deposits with sparse angular sandstone gravel clasts, extensive exposures on banks and bed of small stream. Darker brown soils at top of succession. No basal gravels at contact between bedrocks and alluvium seen. Small (< 1cm) sphaeroidal ferricrete glaebules and reworked palaeocalcrete nodules (few cm diameter with dark grey interiors, reworked from L. Beaufort Group) weathering out towards top of older alluvial succession.
250	28 14 45.1 S 29 05 15.2 E	Good vertical sections through well-bedded older and younger alluvial deposits in stream banks, bedding dipping gently towards the west. Older brownish sandy alluvium with lenticular horizons of angular, poorly-sorted sandstone gravels, dispersed ferricrete and calcrete glaebules, concretions. Fragile isolated, high-crowned fossil tooth (perhaps equid) embedded within older semi-consolidated alluvium (probably Pleistocene age). Sharp contact between older semi-consolidated sandy and silty alluvium and darker brown modern soils with rootlets.
251	28 14 47.1 S 29 05 15.1 E	Extensive lenticular horizon (c. 40 cm thick) of poorly-sorted, rubbly alluvial gravels of sandstone and ferricrete glaebules within well-bedded older alluvial deposits. Regularly-developed stratiform horizons of ferricrete glaebules within alluvial succession.
252	28 14 47.4 S 29 05 14.5 E	Fragment of thin subfossil small mammal bone (possibly hollow rib) weathering out of alluvium.
253	28 14 47.1 S 29 05 15.1 E	Occasional fragments of subfossil small mammalian bones, some possibly Recent and washed down from above, as well as reworked agates.
255	28 14 48.9 S 29 05 15.0 E	Local concentration of disarticulated subfossil small mammal bones (limb long bones) weathering out of older ferricretised alluvium. Small cherty flakes weathering out of alluvium (LSA microlith) – seen embedded in situ elsewhere.
257	28 14 51.9 S 29 05 14.5 E	Good vertical sections through well-bedded alluvial deposits (up to 4 m thick) and overlying soils along riverbanks. Sharply overlie cross-bedded, yellowish-brown Beaufort Group channel sandstones (no interface gravels seen).
258	28 14 53.5 S 29 05 14.1 E	Good vertical sections through well-bedded, silty to sandy alluvial deposits (up to 4 m thick) and overlying soils along riverbanks. Incipient calcretisation of older alluvium.
259	28 14 56.1 S 29 05 16.7 E	Shallow erosion gulley (donga) exposures of yellow-brown Beaufort Group sandstones and weathered yellowish-brown to brick red overbank mudrocks overlain by Late Caenozoic alluvium. Downwasted surface gravels include resistant-weathering reworked cherty agates, occasional small cherty and hornfels artefacts, ferricrete glaebules, sparse small pieces of rounded, transported petrified wood, subfossil bones. Surface gravels locally with ferro-manganese patina.
260	28 14 56.5 S 29 05 17.5 E	Ferricretised and calcretised older alluvium overlying Beaufort Group bedrocks (thin channel stones, multi-hued overbank silstones), downwasted gravels with cherty microlithic artefacts, agates, rare reworked fragments of petrified wood. Beaufort Group mudrocks with pale grey, irregular calcrete concretions of uncertain age (Permian *versus* Pleistocene).
261	28 14 57.4 S 29 05 23.8 E	Artificial earth embankments in vicinity of proposed new substation (possible site of old sewage works). Substation footprint area comprises fairly flat, disturbed grassy veld with downwasted sandstone, dolerite and ferricrete surface gravels, dumped building waste, sandy soils, no bedrock exposure.
262	28 15 03.7 S 29 05 24.4 E	Extensive linear donga exposures of sandy alluvial soils overlying yellow-brown Beaufort Group sandstones. Modern mammal bones at surface.
263	28 15 04.5 S 29 05 22.6 E	Donga exposures of weathered Beaufort Group bedrocks - lenticular, trough cross-bedded, yellowish channel sandstones, partially ferruginised, interbedded with khaki overbank mudrocks. Bedrocks mantled by thin, orange-brown sandy soils, ferricrete gravels.

264	28 15 04.8 S 29 05 15.8 E	Deep, steep-sided erosion gulley excavated along a long WSW-ENE, steeply-dipping Karoo dolerite dyke and exposing vertical section through a thick, grey-green to yellowish, lenticular-bedded, erosive-based Katberg Fm channel sandstone package showing erosive lower contact with greyer overbank mudrocks. Near-surface sandstones highly weathered, fractured (Dolerite dyke perhaps related to major fracture zone) .
265	28 15 06.4 S 29 05 06.0 E	Orange-brown soils, dolerite corestones close to line of dolerite dyke (Same dyke as at Loc. 264).
265a	28 15 06.9 S 29 05 03.8 E	Steeply-dipping, well-jointed dolerite dyke (< 10 m) intruding thin-bedded yellowish-brown Katberg sandstones exposed in river, sharp contacts showing baked margin of country rocks (quartzitic sandstones with spheroidal siliceous nodules). V. thick (> 6m) alluvium along river banks to the south.
266	28 15 03.3 S 29 04 51.5 E	Set of shallow dongas into pale sandy alluvial soils and fine gravels on hillslopes. Gravels composed of ferricrete glaebules, irregular flattish calcrete concretions, sparse sandstone clasts, rare stone artefacts (hornfels, cherty agates).
267	28 15 31.2 S 29 04 06.0 E	SW-facing scarp of yellow-brown, thin- to thick-bedded, laminated to massive Katberg Fm sandstone package with thin, impersistent mudflake and calcrete intraclast breccias. Feldspathic sandstones showing signs of karstic solution weathering (honeycomb weathering, solution hollows, wide polygonal cracks etc) as well as rounded lichen solution hollows.
268	28 15 43.9 S 29 03 57.3 E	Exposure of pale brown, sandy alluvial soils and fine gravels along margins of shallow farm dams and dongas. Calcrete glaebules within older alluvium.
269	28 16 03.0 S 29 03 57.3 E	Exposures of thick orange-brown to pale brown sandy soils around margins of two farm dams (dam walls mainly constructed of dolerite blocks; occasional sandstone blocks with mudflake lag conglomerates with moulds of well-rounded platy mudclasts)
272	28 16 15.3 S 29 03 00.0 E	Dolerite sill showing well-developed columnar jointing and baked sandstone country rocks with patchy mudflake conglomerates exposed in eastern banks of Wilgerivier. Western banks expose thick sandy alluvium.
274	28 16 13.8 S 29 02 59.9 E	Extensive bedding plane exposures of gritty, medium- to coarse-grained grey sandstone package (probably Katberg Fm) showing large scale tabular to trough cross-bedding, pitted weathering, dispersed small rounded silicified “concretions”. Palaeocurrents predominantly towards the N, NNE.
275	28 16 10.0 S 29 02 54.6 E	Views of good exposures of tabular, cross-bedded pale yellowish-brown Katberg Sandstone and overlying pale brown, semi-consolidated sandy alluvium on western banks of Wilgerivier (as viewed from the east). Semi-abandoned meander of Wilgerivier (incipient oxbow lake) with alluvial sandbank.
276	28 16 06.8 S 29 02 56.4 E	Package of trough cross-bedded yellow-brown sandstone (Katberg Fm) showing honeycomb karstic solution weathering.
277	28 16 06.8 S 29 02 56.4 E	Package of trough cross-bedded yellow-brown sandstone (Katberg Fm) showing honeycomb karstic solution weathering. Downwasted gravels of sandstone and small dolerite corestones, sparse agates.
278	28 16 05.9 S 29 02 51.0 E	Views towards west of steep western banks of Wilgerivier showing good vertical sections through thick, tabular-bedded, semi-consolidated pale brown sandy alluvium of the Wilgerivier.
279	28 16 02.5 S 29 03 04.1 E	W-E trending dolerite ridge intersecting existing powerline route. Downwasted rusty-brown doleritic rubble, including subrounded corestones, at surface.
280	28 15 42.4 S 29 02 51.6 E	Extensive W-E trending donga exposures of sandy alluvial soils with ferricrete glaebules and large domical termitaria overlying weathered khaki overbank siltstones and thin flaggy sandstones of the Beaufort Group. Downwasted fine gravels of resistant-weathering agates, dolerite and sandstone clasts, occasional quartz crystals, cherty microilithic artefacts.
282	28 15 41.8 S 29 02 47.0 E	Good streambank sections through sandy and gravelly alluvium overlying weathered Beaufort Group bedrocks (thin-bedded grey-green overbank siltstones with ferruginised palaeocalcrete nodules) along the eastern side of the deeply-incised Rietspruit. Orange-brown, semi-consolidated older alluvium with ferricrete glaebules and lenses of poorly-sorted, erosive-based basal gravels composed of imbricated flaggy sandstone clasts, with sparse agates, microlithic stone tools and small reworked fragments of petrified wood. Rounded calcrete concretions in upper part of older alluvial succession. Older alluvium sharply overlain by younger grey alluvial deposits, dark grey soils.
283	28 15 39.6 S 29 02 47.3 E	Rietspruit streambank exposures of grey-green Beaufort Group overbank mudrocks with horizons of irregular to spheroidal, rusty-brown concretions (some with cone-in-cone structure, so probably late diagenetic rather than ferruginised palaeocalcretes), thin laminated sandstone interbeds. Weathering style suggests presence of expansive clays (cf Harrismith Member of Normandien Fm). Surface gravels with cherty microlithic artefacts, agates.

285	28 15 49.5 S 29 02 42.3 E	Coarse, bouldery gravel bar within upper part of alluvial succession along Rietspruit, partially exposed near intersection of branches of Rietspruit drainage system. Uncemented boulders mainly of well-rounded dolerite corestones plus some sandstone blocks. Occasional MSA artefacts (*e.g.* hornfels point) among boulders. Alluvium rests on yellowish-brown, glistening Beaufort Group sandstones.
286	28 15 50.2 S 29 02 42.5 E	Well-exposed package of coarse, glistening Beaufort Group sandstones, lenticular and cross-bedded.
287	28 15 53.3 S 29 02 41.7 E	Good exposures of large-scale cross-bedded pale yellowish-brown sandstones in lower reaches of Rietspruit close to junction with Wilgerivier and old toll bridge. Palaeocurrent directions variable, NW to NE.
288	28 15 50.7 S 29 02 42.8 E	Large mammal longbone with sun-cracked surface apparently embedded in upper part of alluvial succession along Rietspruit (*N.B.* Bone may have downwasted from above).
289	28 15 49.3 S 29 02 44.1 E	Extensive linear exposures of thick package of grey-green, flat-lying, thin-bedded overbank siltstones of Lower Beaufort Group along eastern branch of Rietspruit drainage system. Bedding planes flat to ripple cross-laminated. Thin flaggy sandstone interbeds. Occasional horizons of rusty-brown ferruginous concretions (perhaps secondarily ferruginised calcrete or late stage diagenetic nodules), ball-and-pillow slump structures, small erosive-based channels.
290	28 15 48.1 S 29 02 44.9 E	Finely-gravelly basal alluvium overlying Lower Beaufort Group mudrocks. Gravels include numerous agates, occasional , small cherty microlithic tools, reworked fragment of a small permineralised tusk or tooth.
291	28 15 46.0 S 29 02 46.8 E	Lower Beaufort Group mudrocks structured into succession of thin (few dm) upward-fining packages. Horizons with oblate spheroidal to irregular ferruginous carbonate nodules which erode-out to dominate surface gravels, together with dolerite and sandstone pebbly clasts.
293	28 15 43.1 S 29 02 51.6 E	Relict patch of rubbly, poorly-sorted High Level Gravels, probably related to W-E donga system here. Clasts up to boulder-sized, mainly subrounded dolerite and sandstone.