PALAEONTOLOGICAL IMPACT ASSESSMENT

NGQAMAKHWE RENEWABLE ENERGY PROJECT, AMATHOLE DISTRICT, EASTERN CAPE, RSA

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SUMMARY

Inno Wind (Pty) Ltd. are applying for authorisation to develop a renewable energy facility, at a site in the Ngqamakhwe area, south of Tsomo in the Amatole District (Mnquma Local Municipality), Eastern Cape. They plan to erect 15-18 wind turbines with a potential power output of 30 megawatts (MW) and a 10 ha photovoltaic power generation system with a generation capacity of 4MW. Maximum total output of the facility is estimated to be 45 MW.

The area to be developed is underlain by rocks of the Tarkastad Subgroup, i.e. the Katberg and Burgersdorp Formations, that have been heavily intruded by non-fossiliferous dolerite dykes and sills. Early to Middle Triassic rocks of the Karoo Supergroup in other parts of South Africa have been extensively studied for their rich and diverse vertebrate fauna and associated trace fossils. These sequences also record a critical time in Earth's history, following the greatest mass extinction event ever to have occurred. Although relatively few fossils have been documented from the Katberg and Burgersdorp Formations in the vicinity of the study area, and in fact from all of the eastern parts of the Eastern Cape, there is every indication that this is due to a lack of prior investigations, and the region has great palaeontological potential.

The Katberg and Burgersdorp Formations in this area is therefore considered to be of high palaeontological significance/sensitivity, although fossil densities are apparently very low and of sporadic occurrence. **Excavations during the construction of access roads and the photovoltaic arrays may intersect potentially fossiliferous sedimentary rocks, and these excavations must be carefully monitored. Any fossil occurrences must be reported to SAHRA and/or a qualified palaeontologist for further assessment and excavation. However, the proposed sites for wind turbines are mostly underlain by dolerite, and mitigation measures for the construction of these are not required.**

Although unlikely to occur because of the low density of fossils in the area, damage to or destruction of any fossil during construction would be a **highly negative, permanent impact**. Discovery of fossils during excavation, followed by effective mitigation in collaboration with a palaeontologist, would result in the curation of new and important fossil material – therefore the development **could potentially have a positive**, **beneficial impact** on South Africa's palaeontological heritage.

Impact significance rating table as per CES template (see PIA Appendix I for definitions)

SIGNIFICANCE RATING							
Rock Unit	**Temporal Scale**	**Spatial Scale**	**Degree of confidence**	**Impact severity**		**Overall Significance**	
				with mitigation	**without mitigation**	**with mitigation**	**without mitigation**
Burgersdorp Formation	permanent	international	unsure	beneficial	very severe	beneficial	high negative
Katberg Formation	permanent	international	unsure	beneficial	very severe	beneficial	high negative

NOTE: fossil occurrences are important but rare in this area

TABLE OF CONTENTS

LIST OF FIGURES

TABLES

INTRODUCTION

Inno Wind (Pty) Ltd. plan to develop a renewable energy facility near Ngqamakhwe, Amathole District, Mnquma Local Municipality, in the former Transkei, Eastern Cape, South Africa. The envisaged facility comprises 15 to 18 wind turbines with a potential power output of 30 megawatts (MW) and a 10 hectare photovoltaic power generation system with a generation capacity of 4MW. The total output of the facility is estimated to be a maximum of 45 MW.

Coastal & Environmental Services (CES) were appointed by InnoWind (Pty) Ltd in the capacity of Environmental Assessment Practitioner (EAP) to conduct an Environmental Impact Assessment (EIA). Umlando cc. was contracted by CES to perform the heritage impact component of the assessment, and the current study represents the palaeontological component (palaeontological impact assessment - PIA) of the heritage impact assessment (HIA). The purpose of this PIA is to identify exposed and potential palaeontological heritage on the site of the proposed development, to assess the impact the development may have on this resource, and to make recommendations as to how this impact might be mitigated.

Relevant Legislation

Protection of South Africa's environmental resources is regulated by the Department of Environmental Affairs (DEA), in part through the National Environmental Management Act ("NEMA" Act 107 of 1998). In accordance with the Act, developers must apply to the competent authority for approval of their plans, which is subject to assessment of the anticipated impacts these activities will have on the environment. Activities are categorised according to the 2010 *Government Listing Notices 1 (GN R544), 2 (GN R545) & 3 (GN R546)* issued by the DEA. In cases where impact is considered to be minimal (*Listing Notices 1 & 3*), the applicant is required to submit a basic assessment report with their application. When a greater degree of disturbance is expected *(Listing Notice 2)*, then a more rigorous, two-tiered assessment may be required, comprising a Scoping Report, followed by a full Environmental Impact Assessment (EIA).

Because the proposed development triggers a listed activity from GN R545, the Ngqamakhwe Wind Energy Project is subject to the requirement for both a Scoping Assessment and full EIA (see table below).

The Ngqamakhwe Wind Energy development is subject to assessment in terms of the following listed activities (extracted from the relevant BID document issued by CES, 2010):

Activity No (s)		**Required assessment**	**Listed activity**
GN R544	**10 (i)**	Basic Assessment	The construction of facilities or infrastructure for the transmission and distribution of electricity outside urban areas or industrial complexes with a capacity of more than 33 but less than 275 kilovolts.
GN R544	**23 (ii)**	Basic Assessment	The transformation of undeveloped, vacant or derelict land to residential, retail, commercial, recreational, industrial or institutional use, outside an urban area and where the total area to be transformed is bigger than 1 hectare but less than 20 hectares.
GN R545	**1**	EIA	The construction of facilities or infrastructure for the generation of electricity where the electricity output is 20 megawatts or more.
GN R546	**14 (a) i**	Basic assessment	The clearance of an area of 5 hectare or more of vegetation where 75% or more of the vegetative cover constitutes indigenous vegetation in all areas outside urban areas (in the Eastern Cape).

The primary piece of legislation protecting *national heritage* in South Africa, is the **South African Heritage Resources Act (Act No. 25) of 1999**. In accordance with Section 38 (Heritage Resources Management) of the act, developers must apply to the relevant authority (South African Heritage Resources Agency - SAHRA) for authorisation to proceed with their planned activities. This application must be accompanied by documentation detailing the expected impact this will have on national heritage in particular.

Categories of heritage resources recognised as part of the National Estate in Section 3 of the Heritage Resources Act, and which therefore fall under its protection, include:

- geological sites of scientific or cultural importance;
- objects recovered from the soil or waters of South Africa, including archaeological and palaeontological objects and material, meteorites and rare geological specimens;
- objects with the potential to yield information that will contribute to an understanding of South Africa’s natural or cultural heritage.

To address concerns relating to the protection of these particular heritage resources, a Heritage Impact Assessment (HIA) is a required component of the EIA, to assess any potential impacts to archaeological and palaeontological heritage within the development footprint. This report represents the palaeontological component of the HIA.

PROPOSED DEVELOPMENT

According to the BID issued by CES (2010), the proposed development is a renewable energy facility involving the construction of 15 wind turbines with a potential power output of thirty megawatts, and a 10 Ha photovoltaic photovoltaic power generation system with a generation capacity of 4MW. Infrastructure associated with the proposed wind farm would be as follows:

- concrete foundations to support the wind towers (20 m wide, 3m deep)
- > 4 meter wide internal access roads to each turbine
- underground cables (1 m deep, under access roads) connecting each turbine to the other and to the substation
- small building to house the control instrumentation and interconnection elements, as well as a storeroom for maintenance equipment.

The photovoltaic arrays comprise modules of 5.7 m^2 suported on a metal frame and anchored in the ground by a small concrete foot. Additional infrastructure includes:

- a group station (small cabin, 2.5 x 4 m) per ~1.5 ha
- a main station (small cabin, ~2.5 x 4 m)
- underground powerline connecting main station to the Ngqamakhwe Substation
- fencing
- small control cabin

Some access roads will require construction, connecting existing roads to building sites.

Location of proposed development

The proposed site for the Ngqamakhwe renewable energy facility is a north-east to south-west trending strip of rural communal land approximately 18 km long and 4 km wide (Figs 1-3), south of Tsomo and north-west of Butterworth. The site is approximately bisected by the R409, linking the R61 and the N2 in a roughly NW to SE direction. The demarcated area lies along the border between the Mnquma and the Intsika Yethu Local Municipalities, with the majority of the site falls under the jurisdiction of the Mnquma Local Municipality, in the Amathole District. The north-eastern tip falls under the jurisdiction of the Intsika Yethu Local Municipality of the Chris Hani District.

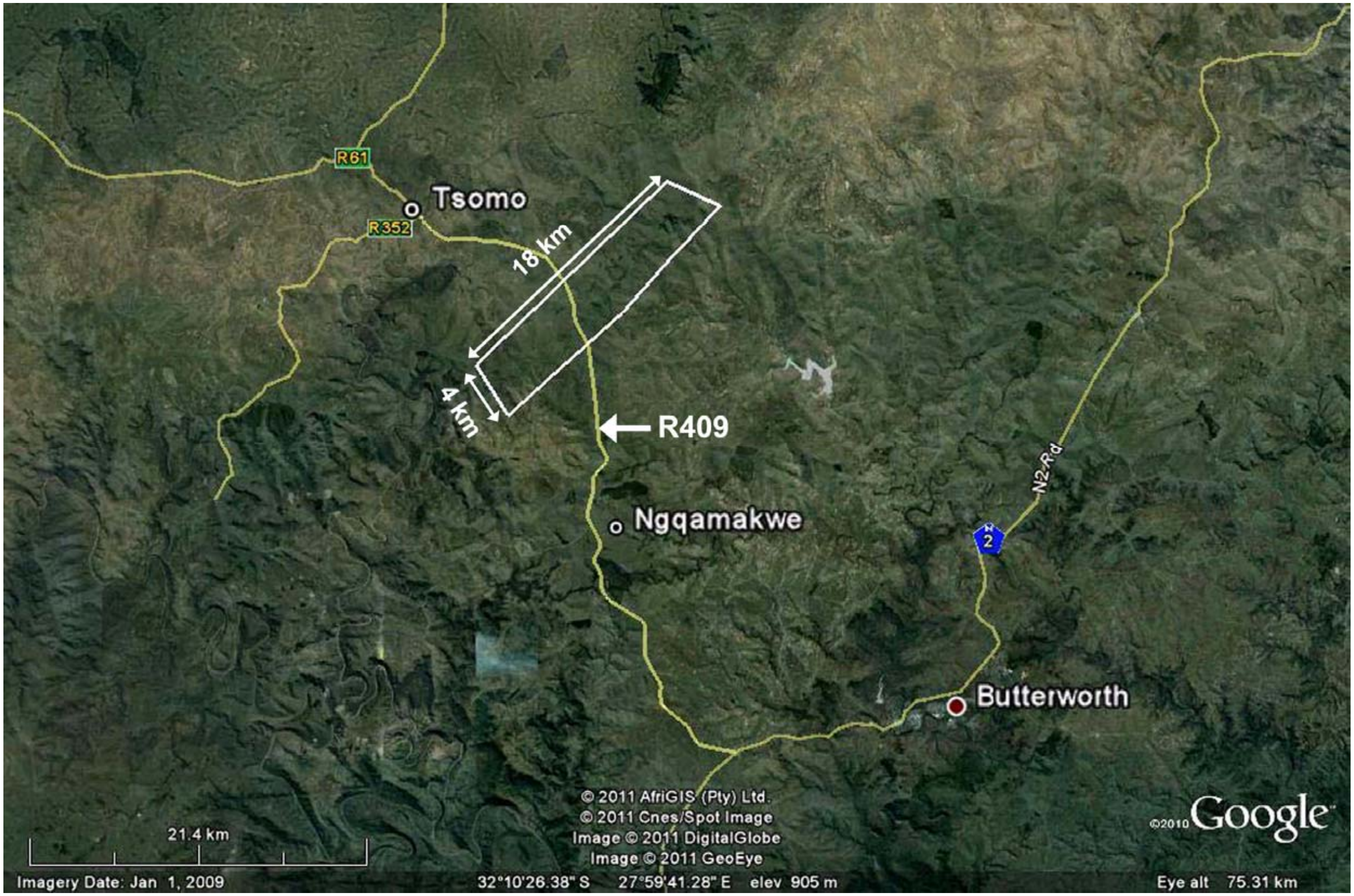

FIG. 1 General location and extent of the proposed Ngqamakhwe Renewable Energy Project (white outline).

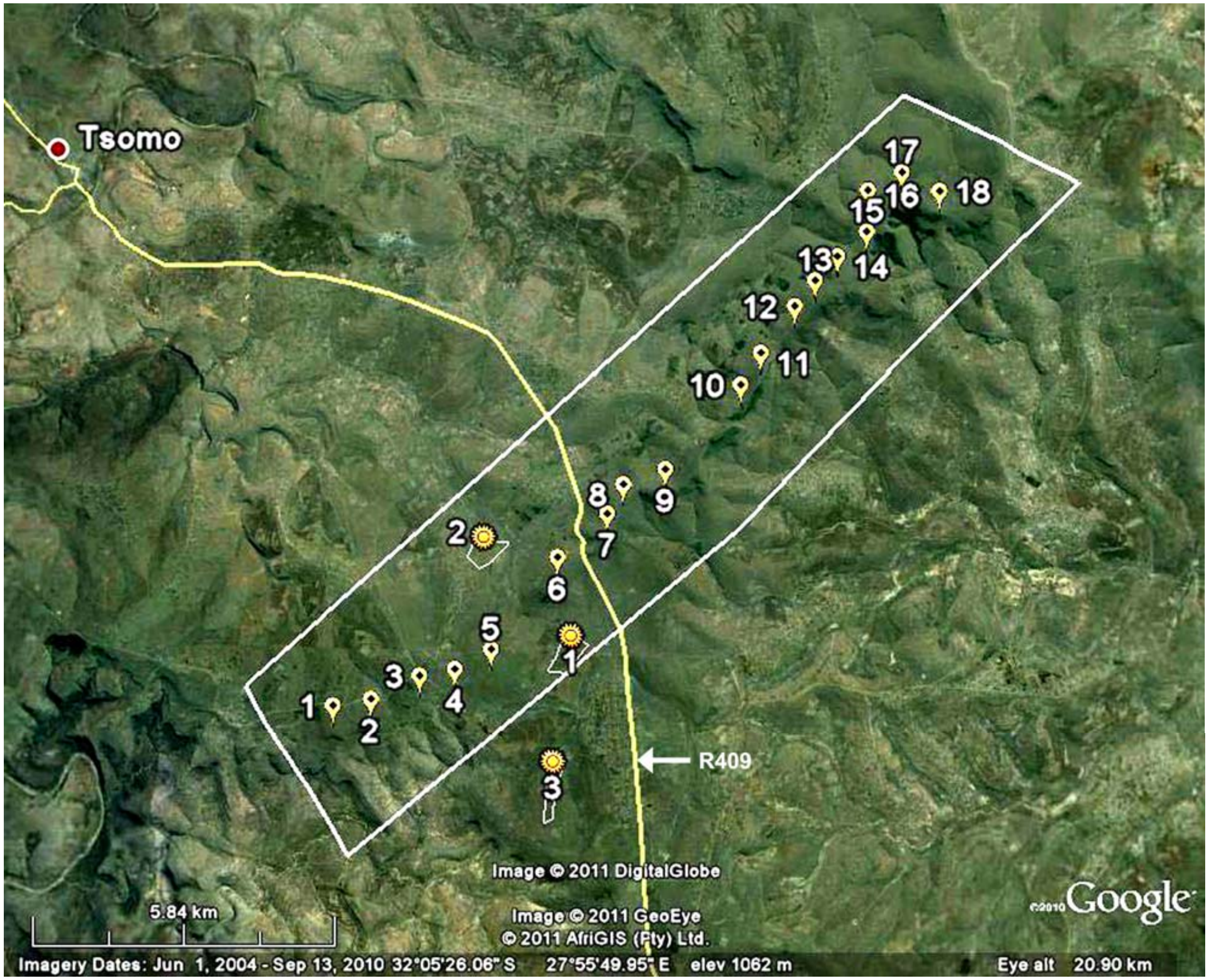

FIG. 2. Proposed locations of wind turbines and photovoltaic arrays (yellow balloons – turbines; sun icons – photovoltaic panels).

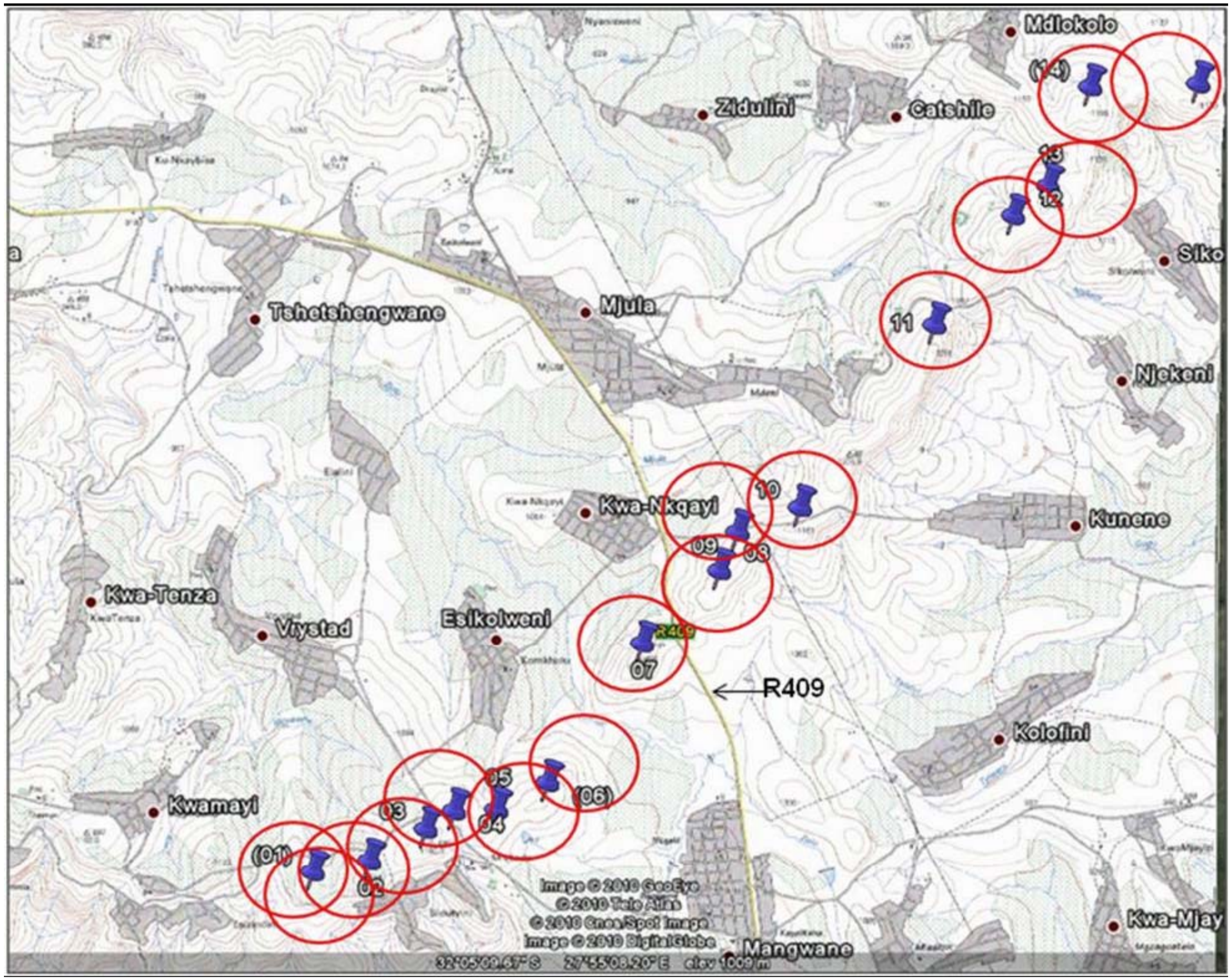

FIG. 3. A 1:50 000 topographic map illustrating a conceptual layout of 15 wind turbines at the proposed site of the Ngqamakhwe wind farm (extracted from BID compiled by CES, 2010).

AIMS AND METHODS

This report represents the palaeontological component of a Phase 1 HIA, as per the latest version of the SAHRA guidelines (May 2007, revised 2009). The aims of the PIA are to assess the exposed and potential palaeontological heritage of the area targeted for development by:

1) identifying exposed and subsurface rock formations that are considered to be palaeontologically significant;
2) assessing the level of palaeontological significance of these formations;
3) conducting fieldwork to assess the immediate risk to exposed fossils, and to document and sample these localities;
3) commenting on the impact of the development on these exposed and/or potential fossil resources;
4) making recommendations as to how the developer should conserve or mitigate damage to these resources.

Using appropriate geological (1:250 000) maps in conjunction with Google Earth, a basic assessment of the topography and geology of the area was made. A review of the literature on the geological formations exposed at surface within the development site, and the fossils that have been associated with these geological strata in the former Transkei and elsewhere in South Africa, was undertaken. Specimen catalogues at the Albany Museum were consulted for additional information in this regard, as were previous PIA reports available on the internet. Dr Emese Bordy (Geology Department, Rhodes University), who is currently involved in detailed geological and palaeontological investigations in the region, provided valuable input.

A field investigation of the site was conducted on 26 February 2011, by a team of three (R. Prevec, C.C. Labandeira and J. Hepple), each experienced in looking for fossils. The aims of the fieldwork were to document any exposed fossil material, and to assess the palaeontological potential of the region in terms of the type and extent of rock outcrop in the area. The short time available to us for exploration meant that we could not investigate every erosion gully or small exposure in the area. Our approach was to explore the areas that appeared to offer the best opportunities for fossil recovery, in terms of broader extent of exposure.

GEOLOGICAL AND PALAEONTOLOGICAL CONTEXT

Regional and local geology

As indicated by the 1:250 000 geological map of the King William's Town region (3226; 1974; Fig. 5), the underlying rocks in the area fall within the palaeontologically highly significant **Beaufort Group,** of the Karoo Supergroup, in the south-eastern reaches of the main Karoo Basin.

The entire area was heavily intruded by **dolerite dykes and sills** during Jurassic times (scattered pink areas in Fig. 5; Jd). Because of the igneous nature of these rocks, they have no palaeontological potential, and are not considered further here.

The Beaufort Group, underlain conformably by the predominantly deep-water mudrocks of the Ecca Group, is characterized as a fluvial succession comprising upward-fining sequences of mudrock and sandstones, the latter mostly representing channel fills (see Hancox & Rubidge, 2001 for overview). The Beaufort Group (see Fig. 4) is divided into two subgroups, viz. the Upper Permian, Adelaide Subgroup (pale blue-green, Pub in Fig. 5) and the overlying Lower to Mid-Triassic, Tarkastad Subgroup (yellow-green, Trlk; light green, Trlb in Fig. 5).

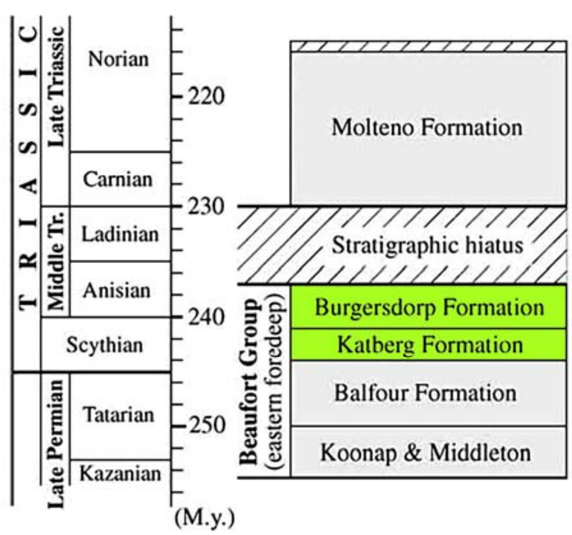

FIG. 4. Major lithostratigraphic subdivisions (Upper Permian to lower Upper Triassic) of the Karoo Supergroup, Main Karoo Basin of South Africa (adapted from Cataneanu *et al.*, 2005).

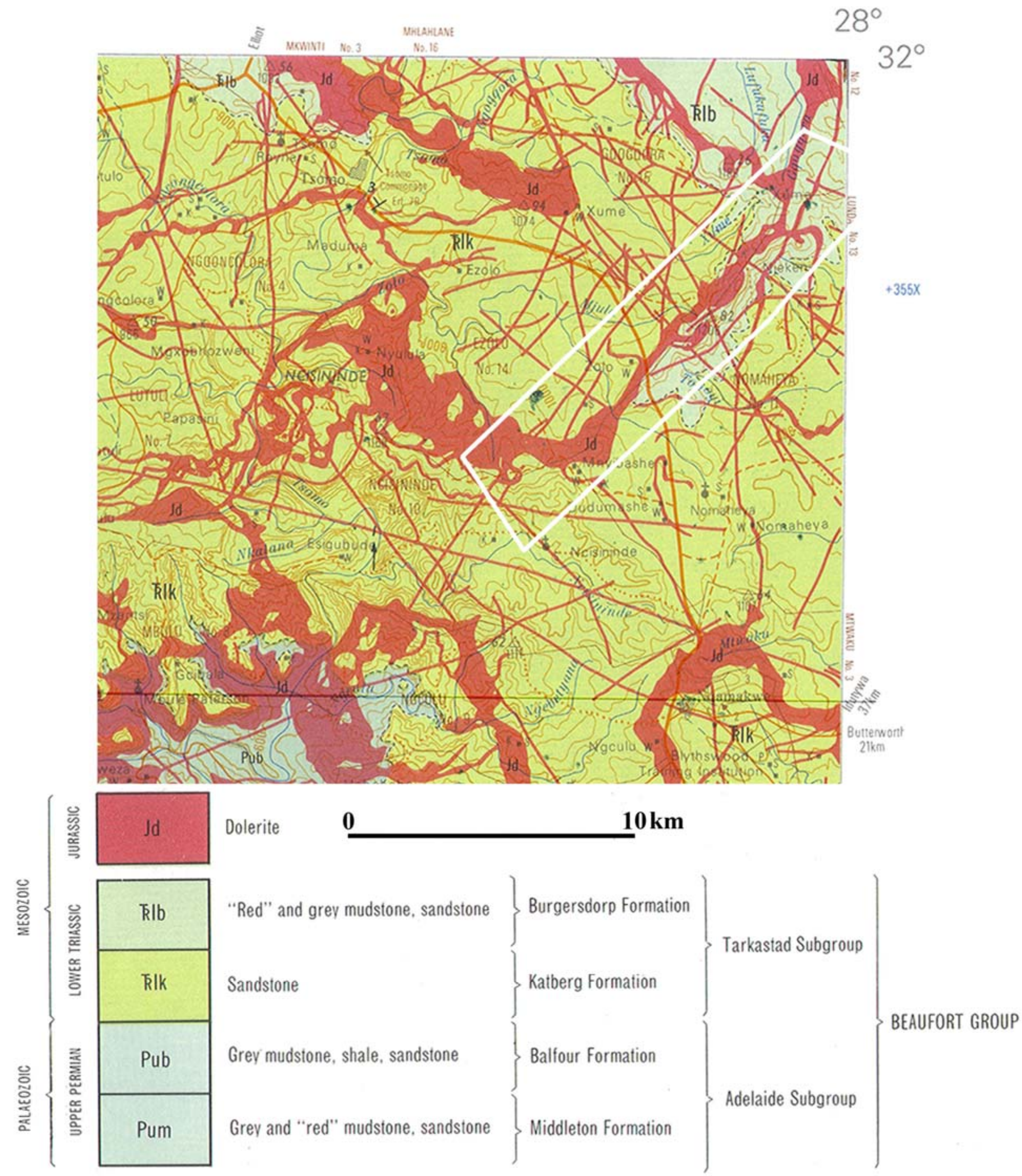

FIG. 5. Regional geology, as mapped in the vicinity of the proposed Ngqamakhwe Wind Energy Project (site outlined in white).

(Extract from the 1:250 000 geological map, 3226 King William's Town; compiled by M.R. Johnson, 1974; Council for Geoscience, Pretoria)

The area targeted for development is underlain by rocks of the **Tarkastad Subgroup** (Fig. 5, outline). The Tarkastad Subgroup, which only crops out to the east of 24°E in the main Karoo Basin, consists of two clearly distinguishable formations: the lower predominantly arenaceous (sandy) Katberg Formation (Trlk), and the overlying, predominantly argillaceous (shaly) Burgersdorp Formation (Trlb) (Karpeta & Johnson, 1979; S.A.C.S., 1980), as indicated in the 1:250 000 geological map of the region (Fig. 5). The study area is underlain by rocks of the **Katberg Formation** to the south-west of the bisecting R409, and by rocks of the **Burgersdorp Formation** to the north-east. Most of the highland areas are capped with dolerite (pink, Jd).

The **Katberg Formation** comprises thick (up to 30 m) horizons of yellowish-grey to light greenish-grey sandstones and bluish-grey and reddish-grey mudstones. The sandstones characteristically comprise repeating, mutually truncating, trough cross-bedded channel-fill sand lenses, and mud-pebble conglomerates are often present at the base. Well-rounded pebbles are found in the sandstones. The sandstones are by far the dominant element, with mudstones tending to be thin (2-10m) and of limited lateral extent (Karpeta & Johnson, 1979; Hiller & Stavrakis, 1984, Groenewald, 1996). The formation reaches a maximum thickness of about 1000 m near East London, progressively thinning to the north (Hiller & Stavrakis, 1984; Neveling, 2004). The upper boundary of the Katberg Formation conformably grades into the Burgersdorp Formation. This transition zone is about 100 m thick, and lies within the uppermost *Lystrosaurus* Assemblage Zone (Neveling, 2004).

The upper boundary of the Katberg Formation grades conformably into the **Burgersdorp Formation**. This transition zone is about 100 m thick, and lies within the uppermost *Lystrosaurus* Assemblage Zone (Neveling, 2004). The lower boundary of the Burgersdorp Formation is arbitrarily defined as the horizon where sandstone:mudstone ratio drops to less than 1:1 (Johnson, 1984). The Burgersdorp Formation therefore constitutes the relatively mudstone-rich upper part of the Tarkastad Subgroup, comprising alternating layers of fine-grained, greenish-grey sandstone and grayish-red mudstone. Sandstone and mudstone sequences generally form upward fining cycles ranging in thickness from a few metres, to tens of metres, the average being around 10 to 20 m (Johnson, 1984). The Burgersdorp Formation is in the region of 600 m thick in the Queenstown area. Lateral extent of most sandstones is in the region of a few hundred meters to a few kilometers before pinching out (Johnson, 1984). The lower boundaries are generally sharp, and rest on scoured surfaces displaying variable degrees of relief. Upper boundaries are always gradational. Average sandstone can be characterized as being moderately sorted, fine grained and lithic (Johnson, 1984).

Sandstone generally makes up 20 to 30 per cent of the formation, and is most abundant towards the base and the top. The Burgersdorp Formation was deposited in a fluvial environment, the sandstones representing channel deposits, and the mudstones overbank floodplain deposits. The high mudstone:sandstone ratio suggests meandering rather than braided stream deposits.

The Beaufort Group as a whole contains few mappable lithological markers and these are diachronous, so biostratigraphic criteria are used to refine further subdivision of the group. The biozones employed are based on the vertebrate fossil remains that are so abundant in these rocks. In South Africa there has been a long tradition of vertebrate faunal studies and their biostratigraphic utilization in the Beaufort Group (Broom, 1906; Keyser & Smith 1977-78; Rubidge, 1995; Hancox & Rubidge, 2001; Cataneaunu *et al.*, 2005).

Palaeontological Heritage

The Beaufort Group is internationally recognised as a succession of great palaeontological value. These rocks provide a continuous and abundant record of terrestrial vertebrate life over a time-span ranging from the Middle Permian to the Middle Triassic, documenting important evolutionary events such as the transition from reptiles to mammals (e.g. Hancox & Rubidge, 2001; McCarthy and Rubidge, 2005), and reflecting the major biotic turmoil associated with the most dramatic extinction event in Earth's history – the Permian/Triassic extinction. This latter event occurred some 251 million years ago, and is marked in the fossil record by a massive turnover of plant and animal species (eg. Erwin 1994; Looy et al.. 2001; Smith & Ward, 2001; McCarthy & Rubidge, 2005; Smith & Botha, 2005).

Aside from the fascinating zoological and evolutionary implications of the Beaufort Group fossils, the profuse and continuous fossil record has provided an opportunity for palaeontologists to develop an effective biostratigraphic framework for a geological succession that has few geological features hinting at its subdivision (SACS, 1980; Rubidge, 1995; Hancox & Rubidge, 2001; Rubidge, 2005; see fig. 6). The Assemblage Zones (AZ) that have been recognised as a result of this work can be followed across much of South Africa. The Katberg Formation falls entirely within the *Lystrosaurus* AZ. The base of the Burgersdorp Formation falls within the *Lystrosaurus* AZ, and the upper two thirds falls within the *Cynognathus* AZ.

Katberg Formation Fossils

An extensive amount of research has been conducted on the animal life found in the Katberg Formation. Groenewald & Kitching (1995) provided a comprehensive list of fossil vertebrate taxa that have been found in the *Lystrosaurus* AZ, which has subsequently been updated by Hancox & Rubidge (2001), Rubidge (2005) and Botha & Smith (2006). Included in these faunas are amphibians, captorhinids, eosuchids, dicynodonts, therocephalians and cynodonts. Vertebrate fossils are found predominantly in the mudrock sequences between channel sandstones, and skeletal and skull fragments may be locally abundant in channel lag conglomerates. Articulated skeletons of the vertebrate taxa *Lystrosaurus, Thrinaxodon, Galesaurus* and the small amphibian *Lydekkerina* are commonly found preserved in well-defined, blue-grey or red-brown calcareous nodules (Groenewald & Kitching, 1995).

In addition to vertebrate fossil taxa, numerous trace fossils have been recorded from the Katberg Formation, both of invertebrate (Gastaldo & Rolerson, 2008) and vertebrate origin (Bordy et al., 2010a&b), as well as limited fossil insect remains (Groenewald & Kitching, 1995). Although only fragmentary fossil plants are known from the Katberg Formation (e.g. Gastaldo et al. 2005), the potential exists to find highly significant plant fossil localities within this rock unit.

Burgersdorp Formation fossils

The Burgersdorp Formation is well-known for its tetrapod faunas, which are are dominated in terms of diversity and abundance by therapsids (so-called 'mammal-like reptiles'). Temnospondyls (amphibians) are also abundant. Other animal fossils include a variety of **fish** (Kitching, 1995; Bender & Hancox, 2004), trace fossils and freshwater molluscs (*Unio karrooensis*, Kitching, 1995).

In the Queenstown area in particular (~90 km west of the proposed Ngqamakhwe development), the therapsids *Lystrosaurus* and *Thrinaxodon* are common in the lower parts of the Burgersdorp Formation (*Lystrosaurus* AZ), and within the Cynognathus AZ the therapsid herbivores *Kannemeyeria*, *Diademedon* and *Bauria cynops* have been found, as well as the carnivorous *Cynognathus* and the large crocodile-like amphibian *Erythrosuchus* (Johnson, 1984). Typically, vertebrate fossils of the *Cynognathus* AZ are not abundant, and occur mainly as dispersed and isolated specimens in mudrocks and are commonly associated with calcareous concretions. They may also be found in fine to medium-grained sandstone lenses, and fragmentary specimens may be locally concentrated in bone-beds in mudrock or at the base of lenticular sandstones (Kitching, 1963, 1995).

Important **plant fossils** are known from the Burgersdorp Formation, recording the first established flora following the Permian-Triassic mass extinction. Collections of this material are lodged at Iziko Museum in Cape Town, and at the Bernard Price Institute, University of the Witwatersrand. The floras that have been documented are of low diversity and the fossils are in most cases sparse and widely scattered on the bedding planes of yellow, buff to light olive-grey, fine to medium feldspathic, cross-bedded sandstones (Brown, 1859-1920 (unpub. diaries); Du Toit, 1927; Anderson & Anderson, 1983, 1985, 1989; Gastaldo *et al.*, 2005).

Thirteen genera have been recorded including the lycopsid *Gregicaulis*, sphenopsid *Calamites*, ferns *Asterotheca* and *Cladophlebis*, peltasperms *Lepidopteris*, corystosperm *Dicroidium*, conifer *Sewardistrobus* as well as the ginkgophytes *Ginkgoites* and *Sphenobaiera*, and cycads *Pseudoctenis* and *Nilssoniopteris*. The latter two represent the earliest occurring cycads on record in Gondwana (Anderson & Anderson, 1985; Grauvogel-Stamm & Ash, 2005). Leaves are generally preserved as impressions, stems as casts and moulds. Fossilised wood is rare, but has been found in the past (*Agathoxylon, Podocarpoxylon*; Bamford, 2004).

Historically, the two most productive localities (in terms of floral diversity and size of collections) are in the Aliwal North and Lady Frere districts (Anderson & Anderson, 1985; Gastaldo *et al*., 2005). Localities closest to the Ngqamakhwe site are at Lady Frere and Glen Grey, less than 80 km away, to the north-west.

Karpeta & Johnson (1979) stated that fossils are uncommon in the Tarkstad Subgroup in the Mthatha region. In fact, palaeontological investigation of the Eastern Cape, particularly in the area formerly known as the Transkei, has lagged behind that of the north-eastern and southern parts of the Main Karoo Basin. Historically, this has been for a number of reasons, including the perceived political instability of the region, physical remoteness of the region from main centers and what were previously hazardous and poorly maintained access roads. The dense vegetation and relative scarcity of outcrop (due to higher rates of chemical and physical weathering and gentler topography) in the region have also deterred palaeontologists - comparable time spent in the southern and western parts of the basin, which are more arid with sparser vegetation and better outcrop, promises much higher fossil returns.

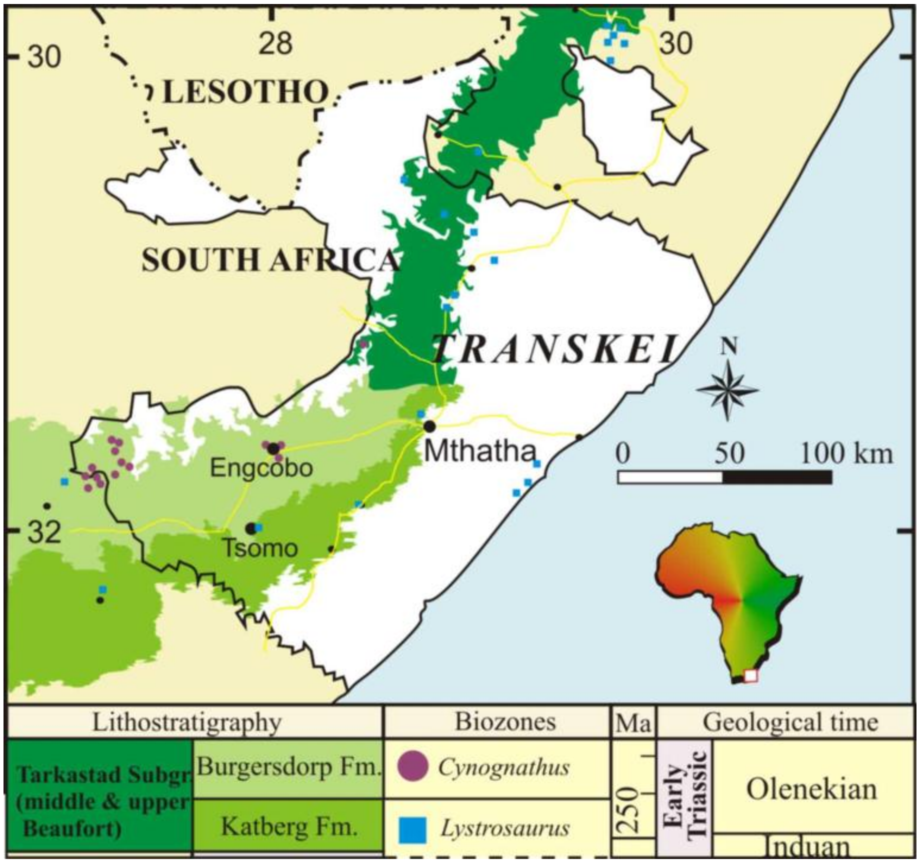

FIG. 6. Recorded occurrences in the eastern parts of the Eastern Cape of index fossils *Lystrosaurus* and *Cynognathus* (used in the subdivision of the Tarkastad Subgroup)

[Graphic created by Bordy (2010a) and reproduced here with permission; data generated from literature and museum catalogues].

Recently Bordy *et al.* (2010a) found several vertebrate fossil localities and a trace fossil locality in the region, including very well-preserved specimens of the vertebrate taxa *Lystrosaurus* and *Thrinaxodon*. Clearly, the **palaeontological significance** of these poorly explored areas should not be underestimated (see Fig. 6), and is here rated as **high** (Table 1), although concentrations of fossils appear to be low in the region.

FIELD EXAMINATION OF DEVELOPMENT SITE

The proposed Ngqamakhwe renewable energy project, involves the construction of wind turbines along a rolling highland area roughly corresponding to the linear exposure of a large dolerite intrusion, oriented in a north-east to south-west direction. The site is approximately bisected by the R409. The north-eastern half is dominated by dolerite exposures, with few outcrops of the Burgersdorp Formation. In the south-western half, outcrops are of dolerite or Katberg Formation (Fig. 5).

The highland areas are well vegetated with heavily grazed grassland with minimal forested areas on the steeper escarpments or in the larger gullies. Rock exposures are not abundant. Most of the highland area targeted for construction of the wind turbines, is capped with dolerite.

NE of the R409

(See Figs 7-9).

The far north-eastern reaches of the site are well-vegetated, with very little exposure. The highlands are all capped with dolerite, and the rivers and erosion gullies expose soils rather than bedrock. It was not possible to gain a good sense of the abundance and diversity of fossils in the area, because of the lack of rock exposure. An exception was a mudrock quarry exposing Burgersdorp Formation rocks along the R409 (Figs 9 c-e). A few, poorly preserved trace fossils were found in a coarse siltstone layer.

SW of the R409

(See Figs 10-12).

The most promising exposures, as seen on Google Earth (Fig. 12d), were those on the steep slopes of spurs in the far south-western corner of the site. Overgrazing and steep slope gradients, have resulted in apparently extensive exposures of the more resistant sandstone layers of the Katberg Formation. However, in reality these exposures represented thin, repeated outcrops of very coarse sandstone, with almost all finer intervening matrix badly weathered and vegetated with grasses. The highland areas are capped with dolerite.

Exploration of the valleys yielded no fossils, although the limited exposure of bedrock severely hindered our ability to assess the palaeontological potential of the area.

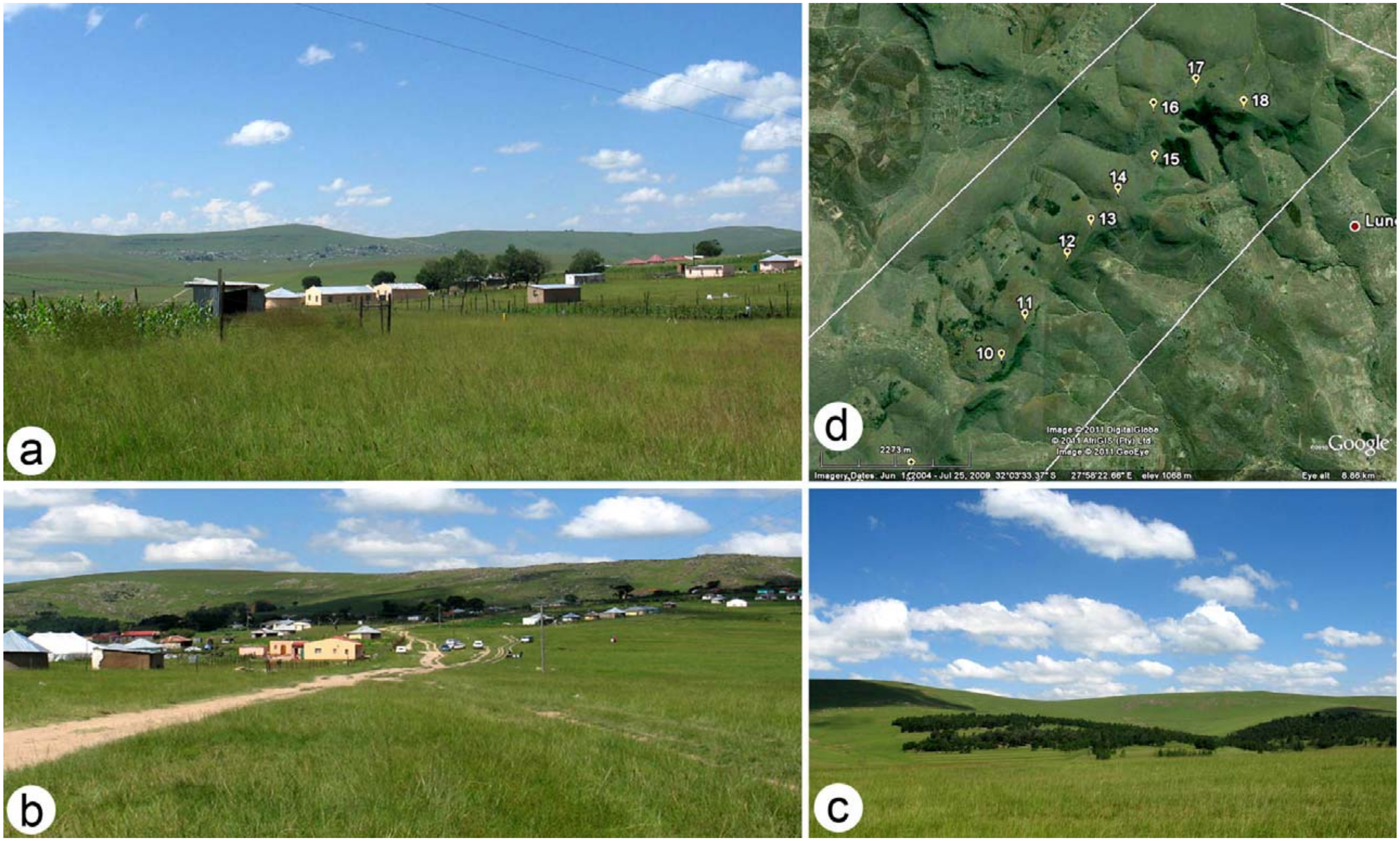

FIG. 7. North-eastern reaches of the site of the proposed Ngqamakhwe Renewable Energy Facility: rolling grasslands and doleritic highlands; very little rock exposure, with gullies and streams in the area only exposing soils.

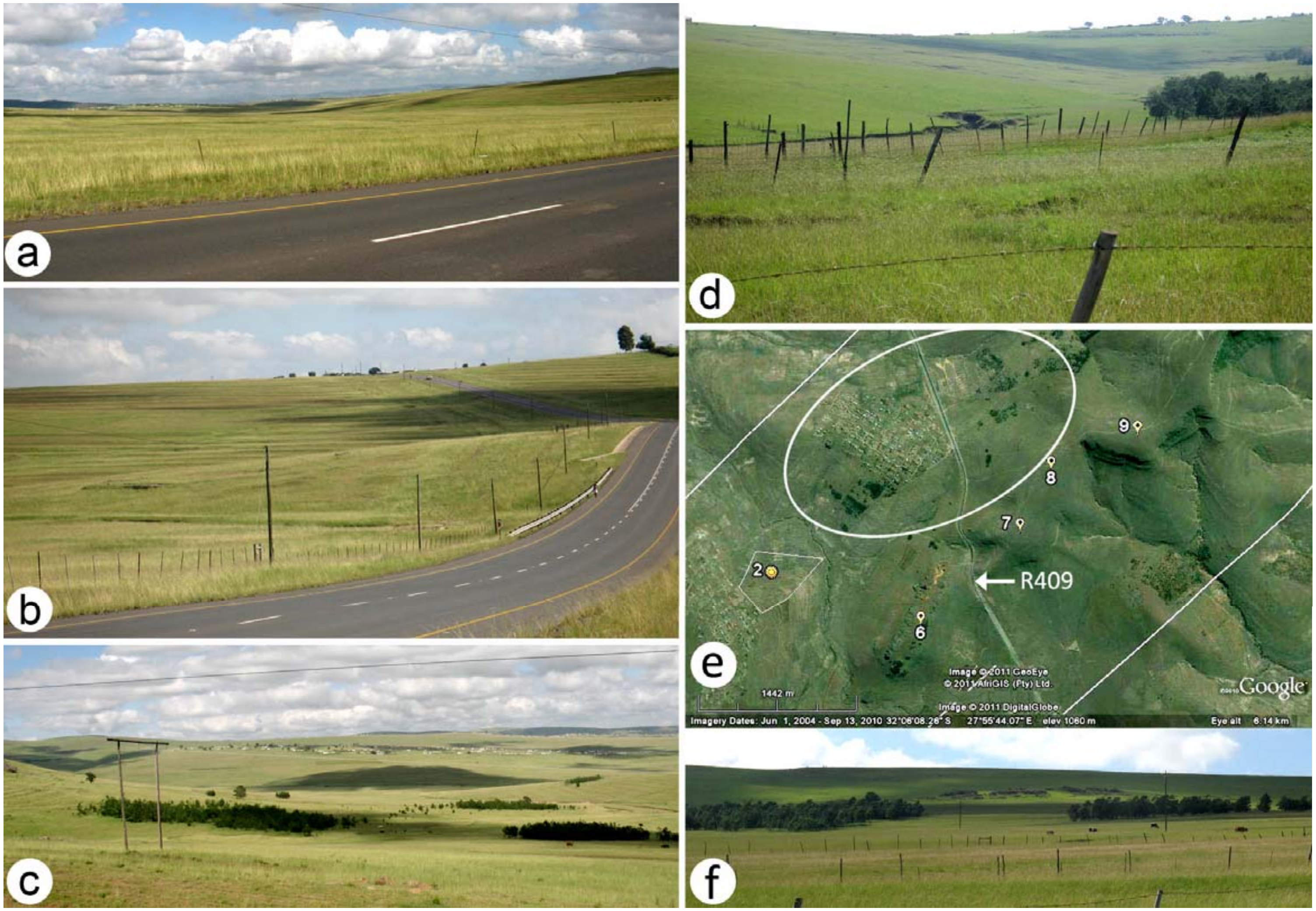

FIG. 8. Along the R409: the northern stretch – grasslands, little relief, few erosion gullies exposing soil horizons only.

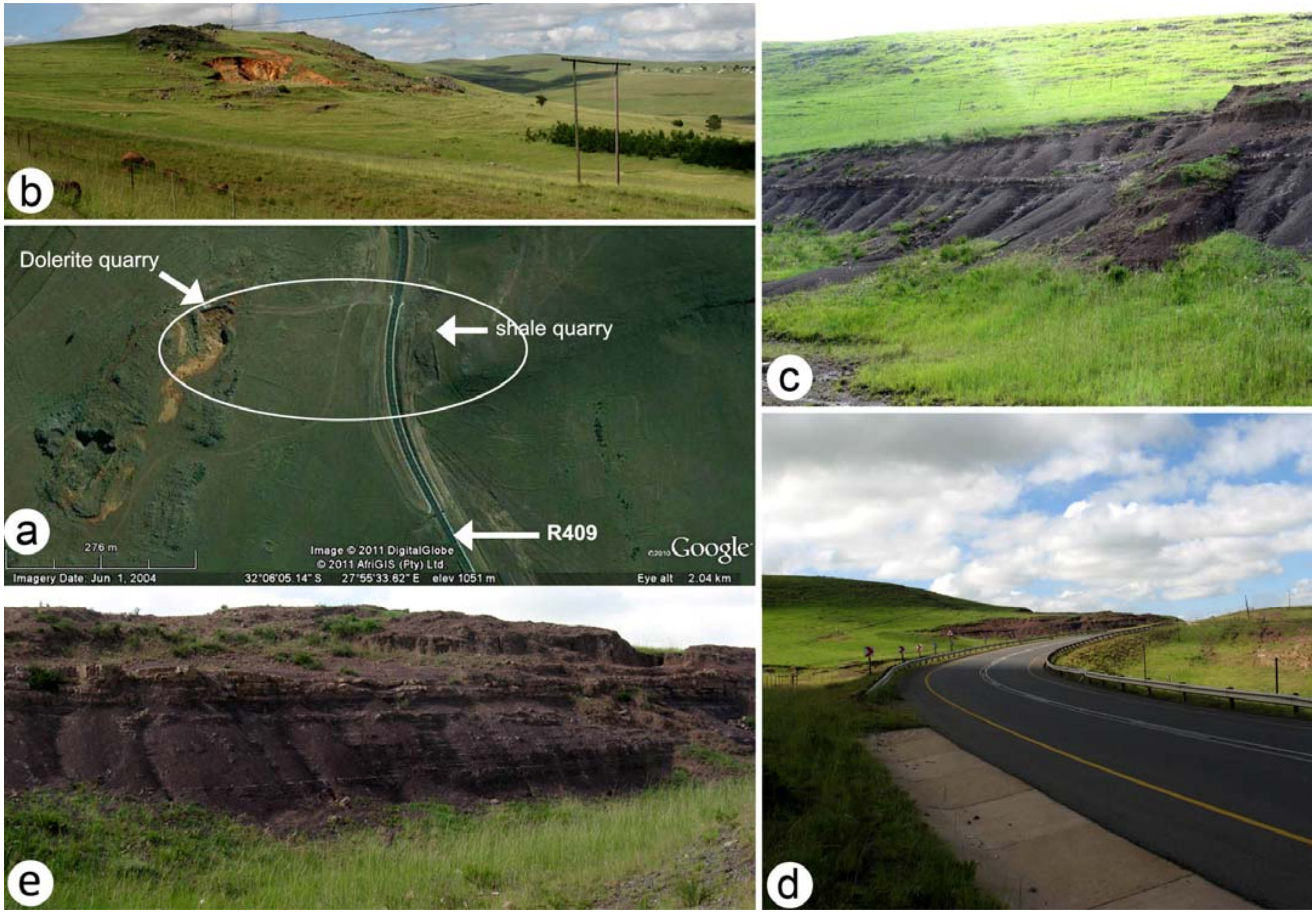

FIG. 9. Along the R409, midsection: the best exposures of the potentially fossiliferous red mudrocks of the Burgersdorp Formation can be seen in a road quarry on the R409; no fossils found here, apart from some poorly preserved (weathered) trace fossils. (a) Dolerite quarry on opposite side of the road to the Burgersdorp Formation shale quarry figured in (c)-(e).

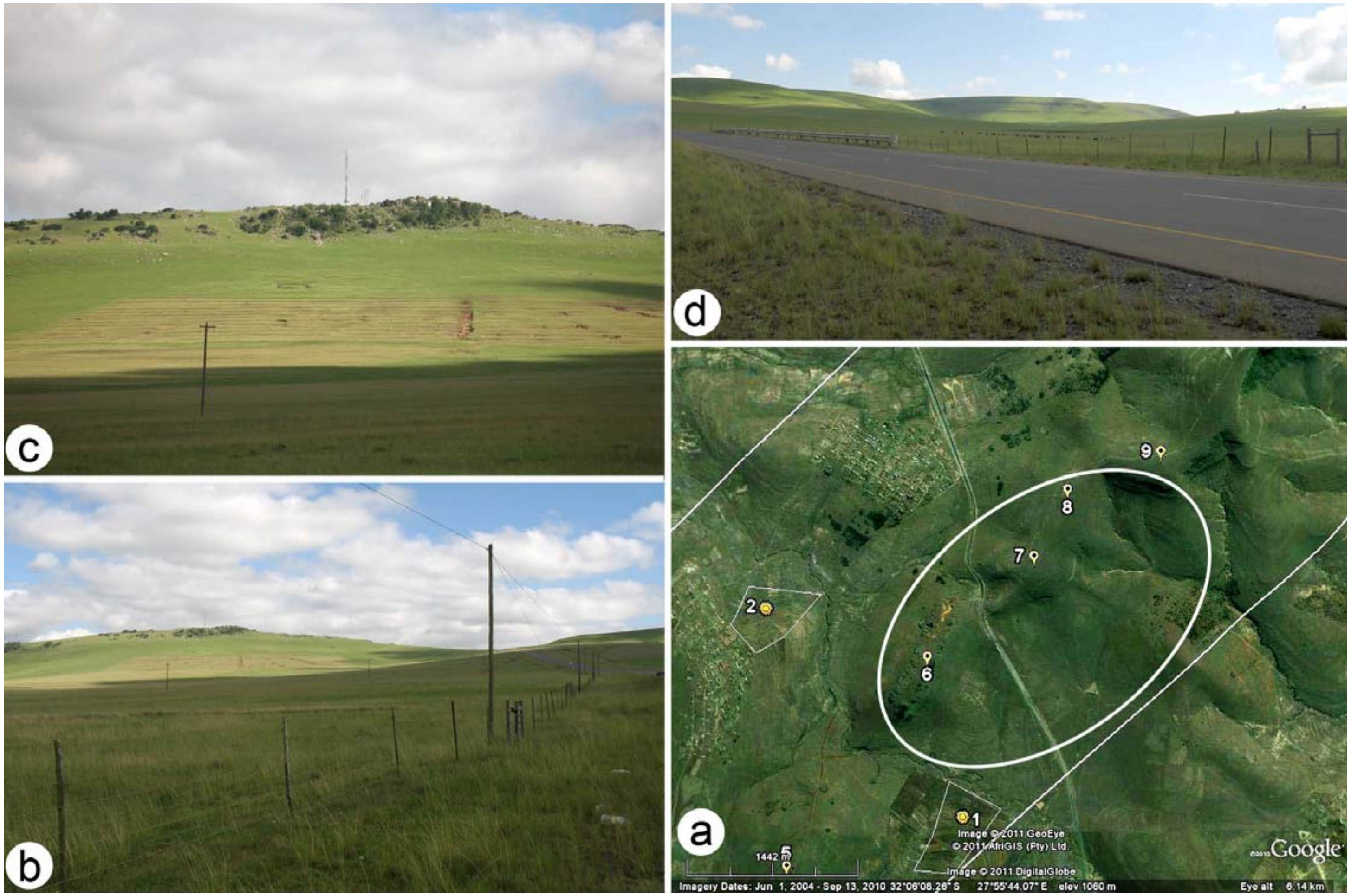

FIG. 10. Southern section of the R409: very little exposure, apart from dolerite caps in highland areas (c, b); erosion gullies shallow, only exposing soil horizons.

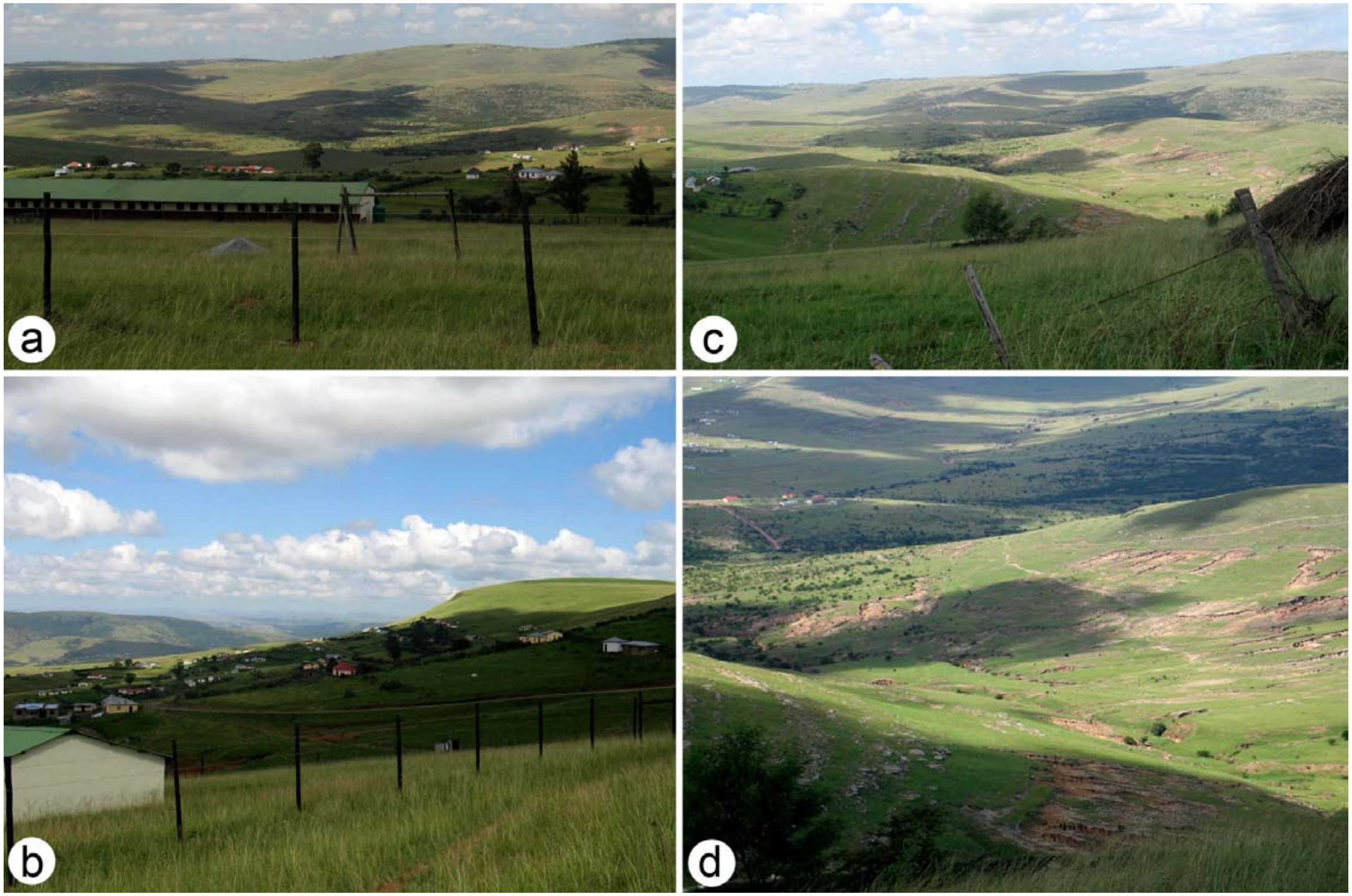

FIG. 11. South-western reaches of the site of the proposed Ngqamakhwe Renewable Energy Facility: greater relief in the topography of this area, with doleritic highlands giving way to steep, eroded valleys, with abundant gullies on the grassy slopes. Exposures limited to bases of deeper gullies and thin, repeated layers of weathered sandstone exposed on slopes.

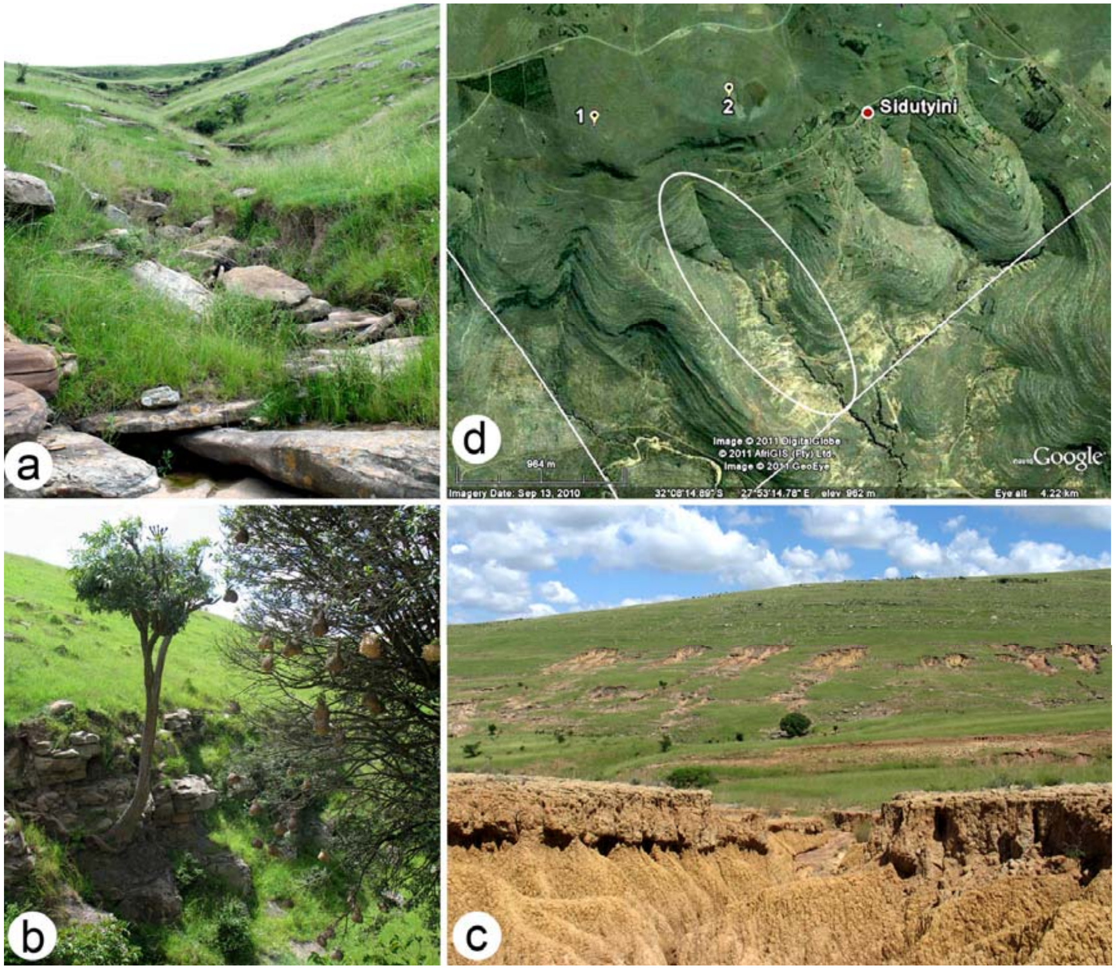

FIG. 12. South-western reaches of the site - examples of exposures found within one of the steep valleys in the region: grassy slopes with regularly repeated exposures of weathered sandstone; deep erosion gullies, mostly into the soil layers, with little exposure of bedrock.

PREDICTED IMPACT OF PROPOSED DEVELOPMENT

The proposed development, involving the installation of wind turbines, photovoltaic arrays and infrastructure including roads and buildings, has the potential to impact on fossil heritage, as construction will inevitably require excavation of bedrock (Tables 1, 2). However, depending on the effectiveness of the management plan set in place, this could have a positive impact palaeontologically. The region is highly weathered, and rock exposures are few and of poor quality, making exploration for fossils labour intensive and low yield. If excavations of fresh bedrock are monitored adequately during the course of the proposed development, then any fossil discovery made in the process could be seen as facilitating a significant scientific advancement.

Field investigations of the development site indicate that much of the highland area is probably underlain by dolerite, a rock type resistant to erosion and therefore commonly responsible for the creation of elevated areas in the topography of the region. This rock type is devoid of fossil potential, and therefore any excavations into dolerite do not require monitoring or mitigation in terms of palaeontological heritage. This means that construction of the wind turbine complex is highly unlikely to have any palaeontological impact.

However, the construction of the photovoltaic arrays and infrastructure such as roads at lower elevations, may result in the exposure of potentially fossiliferous rock layers of the Burgersdorp and Katberg Formations. Considering the apparent scarcity of fossils in the region, it is unlikely that the developers will encounter fossils.

RECOMMENDATIONS/ MITIGATION

Construction of the wind turbines at the Ngqamakwe development is restricted to highland areas, all apparently with dolerite caps. No mitigation is recommended for the construction of the turbines themselves, although excavations for access roads and photovoltaic arrays lower down the slopes and in the flatter regions, are likely to intersect potentially fossiliferous bedrock, and will require monitoring.

If fossil material is exposed by the developers, it must be reported immediately to the on-site Environmental Control Officer (ECO), and to SAHRA, so that an appropriate palaeontological expert can be consulted to further assess, record and professionally excavate or sample the material.

If feasible, the exposed fossil material should be photographed (with a scale), covered over with loose sediment (or otherwise protected from the elements), and the site carefully recorded (GPS reading/ 1:50 000 map/aerial photograph).

It should also be noted that it is not just the actual bone/plant material/shell etc. itself that is of interest and importance to a palaeontologist. Increasingly, scientists appreciate the value of information evident in the immediate vicinity of fossils that is not necessarily inherent to the fossil itself, such as the geology of the host rock stratum, the orientation of individual fossil organs, organism associations, preservational aspects etc. These types of information can provide important clues about past environments, and can help to place fossils within their original context. This information can be lost through indiscriminate sampling by untrained personnel.

CONCLUSIONS

Relatively few fossils have been documented from the Burgersdorp and Katberg Formations in the region incorporating the study area. This can be attributed partly to a lack of prior investigations in the eastern parts of the Eastern Cape, and also to the apparently patchy distribution of relatively rare fossils. The rarity of fossil occurrences should not detract from, but rather enhance their value, and any discoveries made during excavation activities should be regarded as a highly significant contribution to our understanding of the life history and geology of South Africa – **provided that adequate monitoring and reporting procedures are adopted during excavation.**.

The site earmarked for the Ngqamakhwe development has accordingly been assigned a **palaeontological sensitivity rating of high** (Tables 1 and 2), although this only applies to excavations into sedimentary rock in the footprint. Given the high proportion of dolerite present, particularly in the highland areas targeted for wind turbine construction, developers need only monitor excavations for access roads and possibly the photovoltaic arrays.

If any fossils are exposed during construction, the Environmental Control Officer must be notified so that the material can be appropriately protected, and the discovery reported to a local palaeontologist for removal.

Table 1: Regional palaeontological significance of geological units present on site

GEOLOGICAL UNIT				ROCK TYPE AND AGE	FOSSIL HERITAGE	VERTEBRATE BIOZONE	PALAEON-TOLOGICAL SENSITIVIY	RECOMMENDED MITIGATION
DRAKENSBERG GROUP				dolerite dykes and sills (igneous intrusives)	none	none	**NIL**	none
KAROO SUPERGROUP	BEAUFORT GROUP	Tarkastad Subgroup	Burgersdorp Formation	predominantly argillaceous MIDDLE TRIASSIC (Olenekian to Anisian)	vertebrate fossils including a variety of therapsids, amphibians, fish, trace fossils and freshwater molluscs; plant fossils of an early *Dicroidium* flora	*Cynognathus* AZ	**High sensitivity**	regular monitoring of any excavations into bedrock; in the event of fossils being encountered, excavation should cease until a palaeontologist can assess, extract and document the find
			Katberg Formation	medium to coarse-grained sandstone dominated EARLY TRIASSIC (Induan, Scythian Stage)	vertebrate fossils including amphibians, captorhinids, eosuchids, dicynodonts, therocephalians and cynodonts and trace fossils	*Lystrosaurus* AZ	**High sensitivity**	regular monitoring of any excavations into bedrock; in the event of fossils being encountered, excavation should cease until a palaeontologist can assess, extract and document the find

Table 2: Significance rating table as per CES template (see PIA Appendix I for definitions)

SIGNIFICANCE RATING							
Rock Unit	**Temporal Scale** (duration of impact)	**Spatial Scale** (area in which impact will have an effect)	**Degree of confidence** (confidence with which one has predicted the significance of an impact)	**Impact severity** (severity of negative impacts, or how beneficial positive impacts would be)		**Overall Significance** (The combination of all the other criteria as an overall significance)	
				with mitigation	**without mitigation**	**with mitigation**	**without mitigation**
Katberg Formation	permanent	international	unsure (fossils very rare, limited exposure of potentially fossiliferous rocks)	beneficial	very severe	beneficial	high negative

Explanation: There is a **small possibility** that fossils could be encountered during excavation of non-doleritic bedrock within the development footprint. These fossils however, should they be encountered, would be of **international significance**. If effective mitigation measures were in place at the time of exposure, and they were successfully excavated for study, this would represent a **beneficial** impact. Alternatively, if fossil specimens were destroyed in the absence of adequate monitoring during construction activities, this would represent a **permanent, very severe, highly negative** impact on South Africa's palaeontological heritage.

The possibility of encountering fossils in the region is low in any small, localized site. Within the Katberg and Burgersdorp Formations in this region, there is no way of assessing the likelihood of encountering fossils during excavation. As evidenced in other areas with exposures of these rocks, fossils may be apparently absent or very scarce over large areas, or it is possible to encounter locally dense accumulations.

To summarize, fossils within the Ngqamakhwe site could be characterized as **rare, but highly significant**, and any damage to, or loss of, these fossils due to inadequate mitigation would be a **highly negative palaeontological impact.** However, exposure and subsequent reporting of fossils (that would otherwise have remained undiscovered) to a qualified palaeontologist for excavation, could be seen as a **beneficial palaeontological impact**.

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QUALIFICATIONS & EXPERIENCE OF THE AUTHOR

Dr Rose Prevec has PhDs in Palaeontology and Plant Pathology from the University of the Witwatersrand (2005) and University of KwaZulu-Natal (1998) respectively. She specialises in research on South African Permian macrofossil floras, with an interest in taxonomy, biostratigraphy, and palaeoecological aspects such insect-plant interactions. She has held three postdoctoral fellowships, at Wits and Rhodes University, and is currently a Research Associate at the Albany Museum in Grahamstown. Dr Prevec has more than 10 years of experience in locating, collecting and curating fossils, including exploration field trips in search of new localities in the southern, eastern and north-eastern parts of the country. Her publication record includes multiple articles in internationally recognized journals. Dr Prevec is accredited by the Palaeontological Society of Southern Africa (society member for 13 years, and a member of the Executive Committee for 4 years).

Declaration of Independence

I, Rosemary Prevec, declare that I am an independent specialist consultant and have no financial, personal or other interest in the proposed development, nor the developers or any of their subsidiaries, apart from fair remuneration for work performed in the delivery of palaeontological heritage assessment services. There are no circumstances that compromise the objectivity of my performing such work.

Dr Rosemary Prevec
Palaeontologist

PIA APPENDIX I: EXPLANATION OF RISK AND SIGNIFICANCE RATINGS
(Compiled by CES)

Table A1: Criteria used to rate the significance of an impact

Significance Rating Table	
Temporal Scale (The duration of the impact)	
Short term	Less than 5 years (Many construction phase impacts are of a short duration).
Medium term	Between 5 and 20 years.
Long term	Between 20 and 40 years (From a human perspective almost permanent).
Permanent	Over 40 years or resulting in a permanent and lasting change that will always be there.
Spatial Scale (The area in which any impact will have an affect)	
Individual	Impacts affect an individual.
Localised	Impacts affect a small area of a few hectares in extent. Often only a portion of the project area.
Project Level	Impacts affect the entire project area.
Surrounding Areas	Impacts that affect the area surrounding the development
Municipal	Impacts affect either the Local Municipality, or any towns within them.
Regional	Impacts affect the wider district municipality or the province as a whole.
National	Impacts affect the entire country.
International/Global	Impacts affect other countries or have a global influence.
Degree of Confidence or Certainty (The confidence with which one has predicted the significance of an impact)	
Definite	More than 90% sure of a particular fact. Should have substantial supportive data.
Probable	Over 70% sure of a particular fact, or of the likelihood of that impact occurring.
Possible	Only over 40% sure of a particular fact, or of the likelihood of an impact occurring.
Unsure	Less than 40% sure of a particular fact, or of the likelihood of an impact occurring.

Table A2: The severity rating scale

Impact severity (The severity of negative impacts, or how beneficial positive impacts would be on a particular affected system or affected party)	
Very severe	**Very beneficial**
An irreversible and permanent change to the affected system(s) or parties which cannot be mitigated. For example the permanent loss of land.	A permanent and very substantial benefit to the affected system(s) or parties, with no real alternative to achieving this benefit. For example the vast improvement of sewage effluent quality.
Severe	**Beneficial**
Long term impacts on the affected system(s) or parties that could be mitigated. However, this mitigation would be difficult, expensive or time consuming, or some combination of these. For example, the clearing of forest vegetation.	A long term impact and substantial benefit to the affected system(s) or parties. Alternative ways of achieving this benefit would be difficult, expensive or time consuming, or some combination of these. For example an increase in the local economy.
Moderately severe	**Moderately beneficial**
Medium to long term impacts on the affected system(s) or parties, which could be mitigated. For example constructing the sewage treatment facility where there was vegetation with a low conservation value.	A medium to long term impact of real benefit to the affected system(s) or parties. Other ways of optimising the beneficial effects are equally difficult, expensive and time consuming (or some combination of these), as achieving them in this way. For example a 'slight' improvement in sewage effluent quality.
Slight	**Slightly beneficial**
Medium or short term impacts on the affected system(s) or parties. Mitigation is very easy, cheap, less time consuming or not necessary. For example a temporary fluctuation in the water table due to water abstraction.	A short to medium term impact and negligible benefit to the affected system(s) or parties. Other ways of optimising the beneficial effects are easier, cheaper and quicker, or some combination of these.
No effect	**Don't know/Can't know**
The system(s) or parties are not affected by the proposed development.	In certain cases it may not be possible to determine the severity of an impact.

Table A3: The rating of overall significance

Overall Significance (The combination of all the above criteria as an overall significance)	
VERY HIGH NEGATIVE	**VERY BENEFICIAL**
These impacts would be considered by society as constituting a major and usually permanent change to the (natural and/or social) environment, and usually result in **severe** or **very severe** effects, or **beneficial** or **very beneficial** effects. **Example:** The loss of a species would be viewed by informed society as being of VERY HIGH significance. **Example:** The establishment of a large amount of infrastructure in a rural area, which previously had very few services, would be regarded by the affected parties as resulting in benefits with VERY HIGH significance.	
HIGH NEGATIVE	**BENEFICIAL**
These impacts will usually result in long term effects on the social and/or natural environment. Impacts rated as HIGH will need to be considered by society as constituting an important and usually long term change to the (natural and/or social) environment. Society would probably view these impacts in a serious light. **Example:** The loss of a diverse vegetation type, which is fairly common elsewhere, would have a significance rating of HIGH over the long term, as the area could be rehabilitated. **Example:** The change to soil conditions will impact the natural system, and the impact on affected parties (such as people growing crops in the soil) would be HIGH.	
MODERATE NEGATIVE	**SOME BENEFITS**
These impacts will usually result in medium to long term effects on the social and/or natural environment. Impacts rated as MODERATE will need to be considered by society as constituting a fairly important and usually medium term change to the (natural and/or social) environment. These impacts are real but not substantial. **Example:** The loss of a sparse, open vegetation type of low diversity may be regarded as MODERATELY significant.	
LOW NEGATIVE	**FEW BENEFITS**
These impacts will usually result in medium to short term effects on the social and/or natural environment. Impacts rated as LOW will need to be considered by the public and/or the specialist as constituting a fairly unimportant and usually short term change to the (natural and/or social) environment. These impacts are not substantial and are likely to have little real effect. **Example:** The temporary change in the water table of a wetland habitat, as these systems is adapted to fluctuating water levels. **Example:** The increased earning potential of people employed as a result of a development would only result in benefits of LOW significance to people who live some distance away.	
NO SIGNIFICANCE	
There are no primary or secondary effects at all that are important to scientists or the public. **Example:** A change to the geology of a particular formation may be regarded as severe from a geological perspective, but is of NO significance in the overall context.	
DON'T KNOW	
In certain cases it may not be possible to determine the significance of an impact. For example, the primary or secondary impacts on the social or natural environment given the available information. **Example:** The effect of a particular development on people's psychological perspective of the environment.	