Palaeontological specialist assessment: combined desktop and field-based study

PROPOSED NXUBA WIND FARM BETWEEN COOKHOUSE & BEDFORD, BLUE CRANE LOCAL MUNICIPALITY, EASTERN CAPE

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EXECUTIVE SUMMARY

It is proposed to construct a wind energy facility, to be known as the Nxuba Wind Farm, in the Blue Crane Route Local Municipality, Eastern Cape, and to be situated some 14 km to the ENE of Cookhouse and 12 km SW of Bedford

The Nxuba Wind Farm project area is almost entirely underlain by potentially fossiliferous fluvial sediments of the Karoo Supergroup of Late Permian age but bedrock exposure levels here are very limited indeed. The Lower Beaufort Group sediments (Balfour Formation of the Adelaide Subgroup) underlying the study area contain important fossils of terrestrial animals such as reptiles and therapsids ("mammal-like reptiles") as well as representatives of the Late Permian *Glossopteris* Flora of Gondwana. However, the present five-day field palaeontological field assessment, as well as a number of recent field studies carried out in the Cookhouse – Middleton – Bedford area and existing Karoo fossil databases, suggest that Late Permian vertebrate remains tend to be very sparse in this part of the Eastern Cape, even where bedrock exposure is good.

Sparse fossil material recorded from the Balfour Formation within the Nxuba Wind Farm project area during the present field study, all from Van Wyks Kraal 73, includes (1) three fossil vertebrate localities (one of which features the semi-articulated skeleton of a medium-sized therapsid); (2) rare fossil invertebrate and vertebrate burrows; (3) rare float specimens of well-preserved petrified wood and (4) dense concentrations of woody plant moulds within the base of a channel sandstone. Key fossil sites are indicated on a satellite image of the study area in Fig. 61 herein.

The great majority of infrastructure developments (*e.g.* wind turbines, access roads) for the proposed Nxuba Wind Farm are located in elevated plateau or ridge areas where exposure of Beaufort Group bedrocks is poor, due to soil and vegetation cover, and no fossil remains were recorded is these areas during the field assessment. Significant

impacts on thick, potentially fossiliferous Pleistocene alluvium in major stream valleys, such as that running between the Van Wyks Kraal and Roberts Kraal homestead, are not anticipated. The inferred impact significance of the proposed Nxuba Wind Farm project as far as palaeontological heritage is concerned is LOW (negative). Confidence levels for this assessment are moderate, given the limited bedrock exposure within most of the study area.

Unless significant new fossil finds are made during the construction phase of the development, further specialist palaeontological studies or mitigation of the project are not regarded as warranted here. Given the scarcity of fossil remains in the broader region, the cumulative impact on fossil heritage of the Nxuba Wind Farm in conjunction with several other wind energy projects in the Cookhouse - Middleton - Bedford region of the Eastern Cape is probably low.

The ECO for the project should be alerted to the potential for, and scientific significance of, new fossil finds during the construction phase of the development. They should familiarise themselves with the sort of fossils concerned through museum displays and accessible, well-illustrated literature.

Should important new fossil remains such as vertebrate bones and teeth, plant-rich fossil lenses or dense fossil burrow assemblages be exposed during construction, the responsible Environmental Control Officer should alert ECPHRA (*i.e.* The Eastern Cape Provincial Heritage Resources Authority. Contact details: Mr Sello Mokhanya, 74 Alexander Road, King Williams Town 5600; smokhanya@ecphra.org.za) as soon as possible so that appropriate action can be taken in good time by a professional palaeontologist at the developer's expense.

Palaeontological mitigation would normally involve the scientific recording and judicious sampling or collection of fossil material as well as of associated geological data (*e.g.* stratigraphy, sedimentology, taphonomy). The palaeontologist concerned with mitigation work will need a valid fossil collection permit from SAHRA (Contact details: Mrs Colette Scheermeyer, P.O. Box 4637, Cape Town 8000. Tel: 021 462 4502. Email: cscheermeyer@sahra.org.za) and any material collected would have to be curated in an approved depository (*e.g.* museum or university collection).

All palaeontological specialist work should conform to international best practice for palaeontological fieldwork and the study (*e.g.* data recording fossil collection and curation, final report) should adhere as far as possible to the minimum standards for Phase 2 palaeontological studies recently developed by SAHRA (2013). These recommendations should be incorporated into the EMP for the Nxuba Wind Farm project.

1. INTRODUCTION AND BRIEF

It is proposed to construct a wind energy facility, to be known as the Nxuba Wind Farm, in the Blue Crane Route Local Municipality, Eastern Cape, and to be situated some 14 km to the ENE of Cookhouse and 12 km SW of Bedford (Fig. 1). The following background information for this alternative energy project has been supplied by Savannah Environmental (Pty) Ltd:

> ACED Bedford Wind Farm (Pty) Ltd obtained an environmental authorisation in February 2012 from the National Department of Environmental Affairs (DEA Ref No. 12/12/20/1569/2) for the construction of a wind energy facility and associated infrastructure on a site near Cookhouse in the Eastern Cape Province (DEA Ref No. 12/12/20/1569/2). Great Fish River Wind Farm (Pty) Ltd also obtained an environmental authorisation in February 2012 from the National Department of Environmental Affairs (DEA Ref No. 12/12/20/2290) for the construction of a wind energy facility and associated infrastructure on a site near Cookhouse in the Eastern Cape Province (DEA Ref No. 12/12/20/2290). Based on technical aspects of the two above-mentioned projects, it has now been determined that the two projects will be more energy efficient when combined together. The combined projects will be developed by Nxuba Wind Farm (Pty) Ltd and will be referred to as Nxuba Wind Farm.

The following land parcels have been authorised for the siting of the proposed Nxuba Wind Farm (Figs. 1 & 61):

- Remaining Extent of the Farm Request 71;
- Portion 12 of the Farm Request 71;
- Portion 13 of the Farm Request 71;
- Portion 11 of the Farm Request 71;
- Remaining Extent of the Farm Van Wyks Kraal 73;
- Portion 1 of the Farm Van Wyks Kraal 73;
- Portion 4 of the Farm Van Wyks Kraal 73;
- Portion 2 of Van Wyks Kraal 73;
- Portion 3 of Van Wyks Kraal 73;
- Roberts Kraal 281.

These land parcels are included within the black polygon shown on satellite images of the region in Figures 1 and 61 (Please note that the triangular land parcel to the northwest marked 75 will not receive any infrastructure and has accordingly *not* been included within the scope of the present report).

The main infrastructural components of the proposed for the Nxuba Wind Farm include:

- Up to 60 wind turbines units (*c*. 100 m high steel tower nacelle; up to 100 m diameter rotor consisting of 3 x 50 m blades) with concrete foundations;
- Underground electrical distribution cabling between the turbines;
- A 132 kV on-site substation (132kV);
- A 132 kV power line from the new onsite substation to the existing Poseidon Substation on the south-western edge of the study area (Fig. 1);
- An access road to the site from the main road/s within the area;
- Internal access roads (approximately 3-5 m in width) to each wind turbine;
- Offices and a workshop building.

The Nxuba Wind Farm project area is underlain by potentially fossiliferous sediments of the Karoo Supergroup of Permian age as well as much younger (Pleistocene – Holocene) superficial deposits that may also contain scientifically important fossil remains. Fossil heritage preserved within these rocks is protected by law (National Heritage Resources Act of 1999). A brief desktop palaeontological study covering portions of the Nxuba Wind Farm study area as well adjacent wind farm project areas to the east of Cookhouse was completed by Almond (2009). This report recommended that:

1. *Before* any major construction commences a thorough field scoping survey of natural and artificial rock exposures within the study region as a whole should be undertaken by a qualified palaeontologist to identify specific areas or horizons of palaeontological sensitivity on the ground.
2. On the basis of the initial scoping, a realistic, collaborative monitoring programme and protocol should be drawn up by the palaeontologist in conjunction with the developer.
3. Monitoring of selected bedrock excavations by the palaeontologist should be carried out during the construction phase of the wind energy facility.

The review comment in response to this report by SAHRA as well as the AIA for the Cookhouse II project (South African Heritage Resources Agency, File No. 9/2/034/0002, dated 20 February 2012) was as follows:

> Considering that an environmental authorization has already been received for all energy facilities and considering the high grade of palaeontological significance of the entire area of the developments, a palaeontological impact assessment, inclusive of a site visit, should have already been commissioned.

> A palaeontological impact assessment inclusive of a site visit must be undertaken before any construction activities for any of the two wind energy facilities start. The report must be submitted to SAHRA for comments. Monitoring may be necessary for excavations in the Balfour Formation, however a site visit before any construction activities start will confirm this.

The present combined desktop and field-based assessment of the Nxuba Wind Farm study area has accordingly been commissioned as part of the broad-based Heritage and Environmental Impact Assessment that is being co-ordinated by Savannah Environmental (Pty) Ltd, Woodmead (Contact details: Ms Tebogo Mapinga. Savannah Environmental (Pty) Ltd. 1st Floor, Block 2, 5 Woodlands Drive Office Park, Woodlands Drive, Woodmead, 2191. Tel: +27 11 656 3237. Fax: +27 86 684 0547. Cell: +27 72 738 3836. Postal address: P.O. Box 148, Sunninghill, 2157).

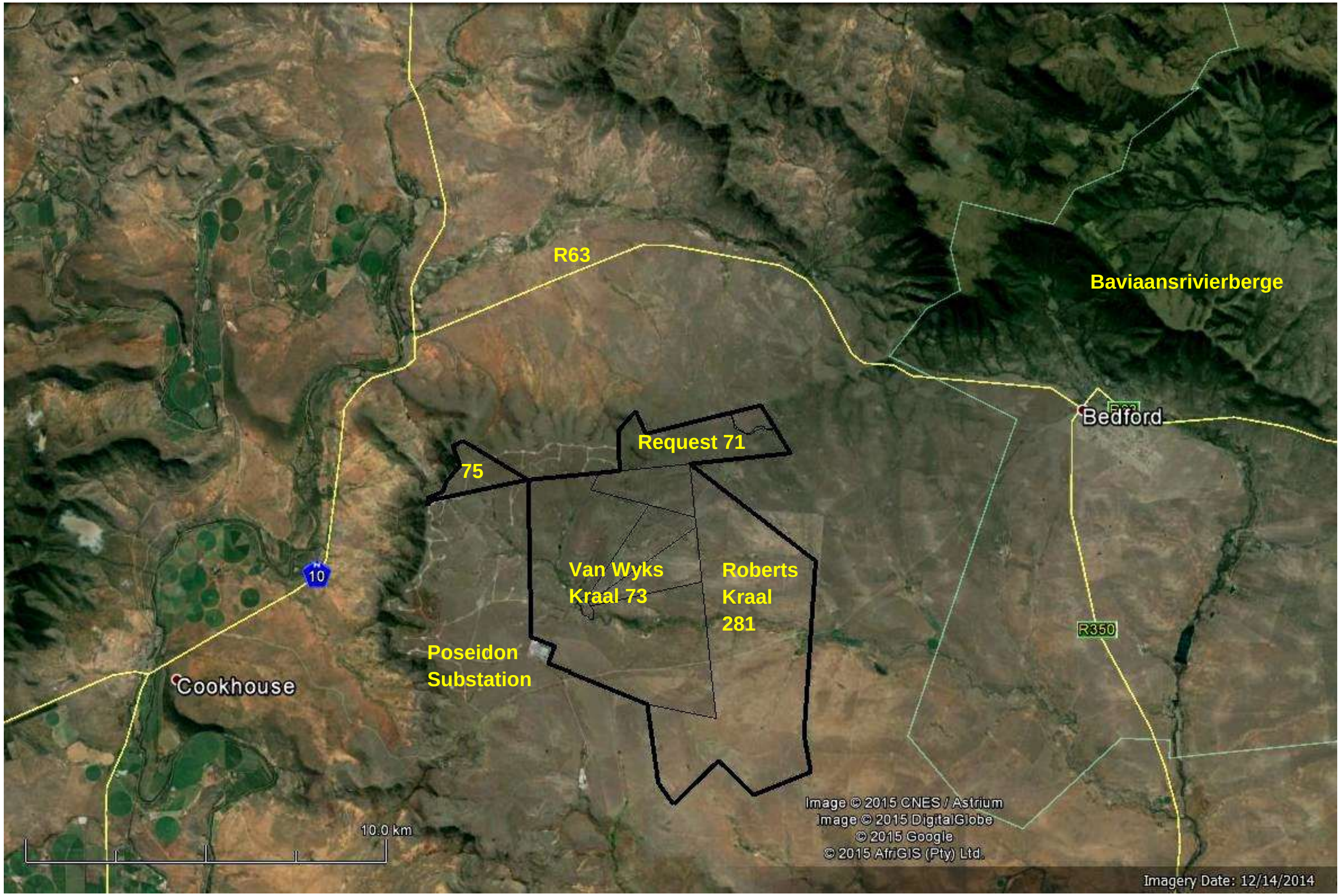

Figure 1. Google earth© satellite image of the Nxuba Wind Farm study area situated in hilly terrain to the south of the R63 between the towns of Cookhouse and Bedford, Eastern Cape (black polygon). Please note that the small land parcel labled 75 will not receive any infrastructure and does not form part of the present assessment.

1.2. Legislative context for palaeontological assessment studies

The Nxuba Wind Farm near Cookhouse is located in an area that is underlain by potentially fossil-rich sedimentary rocks of Late Palaeozoic and younger, Late Tertiary or Quaternary, age (Section 3). The construction phase of the proposed development will entail substantial excavations into the superficial sediment cover and locally into the underlying bedrock as well. These notably include excavations for turbine foundations, new internal access roads, underground cables, the new substation and associated building infrastructure. In addition, substantial areas of bedrock may be sealed-in or sterilized by infrastructure such as hard standing areas for each wind turbine, any lay down areas, as well as the new gravel road system. All these developments may adversely affect potential fossil heritage within the study area by destroying, disturbing or permanently sealing-in fossils at or beneath the surface of the ground that are then no longer available for scientific research or other public good. The decommissioning phase of the wind farm development is unlikely to involve further adverse impacts on local palaeontological heritage, however.

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 Plan 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).

1.3. Approach to the palaeontological heritage study

The approach to this palaeontological heritage study is briefly as follows. Fossil bearing rock units occurring within the broader study area are determined from geological maps and satellite images. Known fossil heritage in each rock unit is inventoried from scientific literature, previous assessments of the broader study region, and the author's field experience and palaeontological database. Based on this data as well as field examination of representative exposures of all major sedimentary rock units present, the impact significance of the proposed development is assessed with recommendations for any further studies or mitigation.

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 field assessment during the compilation of the final report). This data is then used to assess the palaeontological sensitivity of each rock unit to development (provisional tabulations of palaeontological sensitivity of all formations in the Western, Eastern and Northern Cape have already been compiled by J. Almond and colleagues; *e.g.* Almond *et al.* 2008). The likely impact of the proposed development on local fossil heritage is then determined on the basis of (1) the palaeontological sensitivity of the rock units concerned and (2) the nature and scale of the development itself, most significantly the extent of fresh bedrock excavation envisaged. When rock units of moderate to high palaeontological sensitivity are present within the development footprint, a Phase 1 field assessment study by a professional palaeontologist is usually warranted to identify any palaeontological hotspots and make specific recommendations for any mitigation required before or during the construction phase of the development.

On the basis of the desktop and Phase 1 field assessment 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. Phase 2 mitigation by a professional palaeontologist – normally involving the recording and sampling of fossil material and associated geological information (*e.g.* sedimentological data) may be required (a) in the pre-construction phase where important fossils are already exposed at or near the land surface and / or (b) 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, *i.e.* ECPHRA (The Eastern Cape Provincial Heritage Resources Authority. Contact details: Mr Sello Mokhanya, 74 Alexander Road, King Williams Town 5600; smokhanya@ecphra.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.

1.4. Assumptions & limitations

The accuracy and reliability of palaeontological specialist studies as components of heritage impact assessments are generally limited by the following constraints:

1. Inadequate database for fossil heritage for much of the RSA, given the large size of the country and the small number of professional palaeontologists carrying out fieldwork here. Most development study areas have never been surveyed by a palaeontologist.

2. Variable accuracy of geological maps which underpin these desktop studies. For large areas of terrain these maps are largely based on aerial photographs alone, without ground-truthing. The maps generally depict only significant ("mappable") bedrock units as well as major areas of superficial "drift" deposits (alluvium, colluvium) but for most regions give little or no idea of the level of bedrock outcrop, depth of superficial cover (soil *etc*), degree of bedrock weathering or levels of small-scale tectonic deformation, such as cleavage. All of these factors may have a major influence on the impact significance of a given development on fossil heritage and can only be reliably assessed in the field.

3. Inadequate sheet explanations for geological maps, with little or no attention paid to palaeontological issues in many cases, including poor locality information;

4. The extensive relevant palaeontological "grey literature" - in the form of unpublished university theses, impact studies and other reports (*e.g*. of commercial mining companies) - that is not readily available for desktop studies;

5. Absence of a comprehensive computerized database of fossil collections in major RSA institutions which can be consulted for impact studies. A Karoo fossil vertebrate database is now accessible for impact study work.

In the case of palaeontological desktop studies without supporting Phase 1 field assessments these limitations may variously lead to either:

(a) *underestimation* of the palaeontological significance of a given study area due to ignorance of significant recorded or unrecorded fossils preserved there, or

(b) *overestimation* of the palaeontological sensitivity of a study area, for example when originally rich fossil assemblages inferred from geological maps have in fact been destroyed by tectonism or weathering, or are buried beneath a thick mantle of unfossiliferous "drift" (soil, alluvium *etc*).

Since most areas of the RSA have not been studied palaeontologically, a palaeontological desktop study usually entails *inferring* the presence of buried fossil heritage within the study area from relevant fossil data collected from similar or the same rock units elsewhere, sometimes at localities far away. Where substantial exposures of bedrocks or potentially fossiliferous superficial sediments are present in the study area, the reliability of a palaeontological impact assessment may be significantly enhanced through field assessment by a professional palaeontologist. In the present case, site visits to the various loop and borrow pit study areas in some cases considerably modified our understanding of the rock units (and hence potential fossil heritage) represented there.

In the case of the present study area in the Cookhouse - Bedford region of the Eastern Cape exposure of potentially fossiliferous bedrocks is mainly limited to stream and river banks, erosion gullies and steep hill slopes, as well as artificial excavations such as road and railway cuttings and borrow pits, due to extensive cover by superficial sediments and vegetation. Comparatively few academic palaeontological studies have been carried out in the region so any new data from impact studies here are of scientific interest.

1.5. Information sources

The information used in this desktop study was based on the following:

1. A brief project outline kindly supplied by Savannah Environmental (Pty) Ltd;

2. A short desktop palaeontological assessment report for a broader study area to the east of Cookhouse by the author (Almond 2009);

3. A review of the relevant scientific literature, including published geological maps and accompanying sheet explanations (*e.g.* Hill 1993) as well as several previous fossil heritage assessments in the Cookhouse – Middleton – Bedford area (*e.g.* Almond 2009, De Klerk 2010, Almond 2011, Durand 2012, Almond 2013a, 2013b, 2013c, 2014);

4. The author's previous field experience with the formations concerned and their palaeontological heritage (*cf* Almond *et al.* 2008);

5. A short five-day field assessment of the study area during the period 7 to 11 July, 2015. Fieldwork mainly focussed on the limited number of natural or artificial exposures

of potentially fossiliferous Beaufort Group bedrocks within the study area as well as on thick deposits of Pleistocene alluvium in stream valleys (See GPS locality data provided in the Appendix). Few of the informative rock exposures were situated in the upland plateau and hilltop sites where the wind turbines and most of the access roads will be situated since the bedrocks here are usually mantled by soil and vegetation.

2. GEOLOGICAL OUTLINE OF THE STUDY AREA

The Nxuba Wind Farm study area is situated at elevations between c. 780 and 1020 m amsl on an extensive plateau that lies on the eastern side of the Great Fish River between the small towns of Cookhouse and Bedford, Eastern Cape (Figs. 1 & 61). The area lies south of the main R63 tar road and old railway line between Cookhouse and Bedford while it is transected towards the south by the dust road between these two towns that runs up the Patryshoogte escarpment. Most of the proposed wind farm infrastructure will be developed in rolling hilly terrain, some 3 km or more east of the low, west- to south-facing Patryshoogte Escarpment, both north and south of this dust road. The study area is dissected by several small intermittent-flowing streams (Figs. 6), most of which converge close to the Van Wyks Kraal homestead. The main drainage then runs eastwards within a narrow but fairly deeply-incised valley, eventually joining the eNyara River to the south of Bedford, itself a west bank tributary of the Koonap River further to the east. The termitarium-studded grassy uplands to the south of the Cookhouse – Bedford dust road, known as the Patryshoogte, lie at elevations of *c*. 780 – 830 m amsl and are fairly featureless (Fig. 3). A gentle escarpment separates the northern margin of the hilly study area on the Patryshoogte plateau from lower-lying terrain running along the foot of the Baviaansrivierberge uplands that stretch eastwards past Bedford.

The study area lies in the south-eastern portion of the Main Karoo Basin, underlain by bedrocks of the Lower Beaufort Group (Karoo Supergroup) (Fig. 3). However, exposure of the sedimentary bedrocks in this region is generally very poor, and mainly restricted to stream beds, erosion gullies (*dongas*) and occasional patches on hill slopes, together with a few road and railway cuttings, dams and quarries or borrow pits (Figs. 4 to 9). Elsewhere the bedrocks are generally mantled with thick superficial deposits (soils, colluvium, alluvium) and grassy vegetation on the higher-lying plateau (Bedford Dry Grassland), with more woody Fish River Thicket vegetation on the escarpment slopes, especially along stream valleys. A thin, impersistent veneer of downwasted or colluvial, angular sandstone gravels cover large areas of Lower Beaufort Group outcrop area, including many of the hillcrest areas where vegetation is sparse and where many of the wind turbines will be sited.

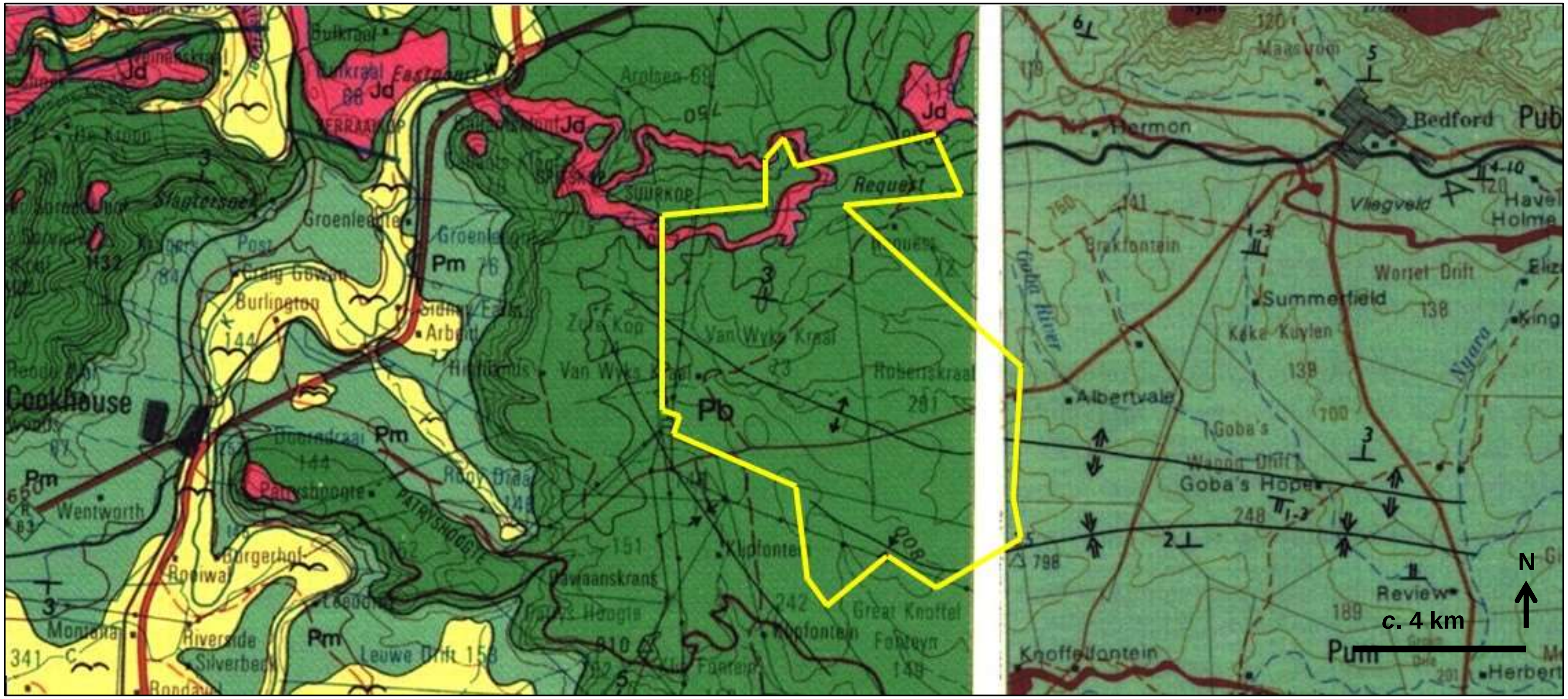

Figure 2. Extract from the adjoining 1: 250 000 scale geological maps 3224 Graaff-Reinet on the left and 3226 King William's Town on the right (Council for Geoscience, Pretoria) showing the location of the Nxuba Wind Farm study area *c.* 14 ENE of Cookhouse, Eastern Cape (yellow polygon). The main rock units represented within the wind energy project area include: (1) the Late Permian to Earliest Triassic Balfour Formation (Pb, dark green) (LOWER BEAUFORT GROUP / ADELAIDE SUBGROUP); (2) the Early Jurassic KAROO DOLERITE SUITE (Jd, pink); various types of LATE CAENOZOIC SUPERFICIAL DEPOSITS such as alluvium (pale yellow with "flying bird" symbol), colluvium, soils and pedocretes. Most of these superficial sediments are probably of Pleistocene to Recent age and are not mapped at 1: 250 000 scale.

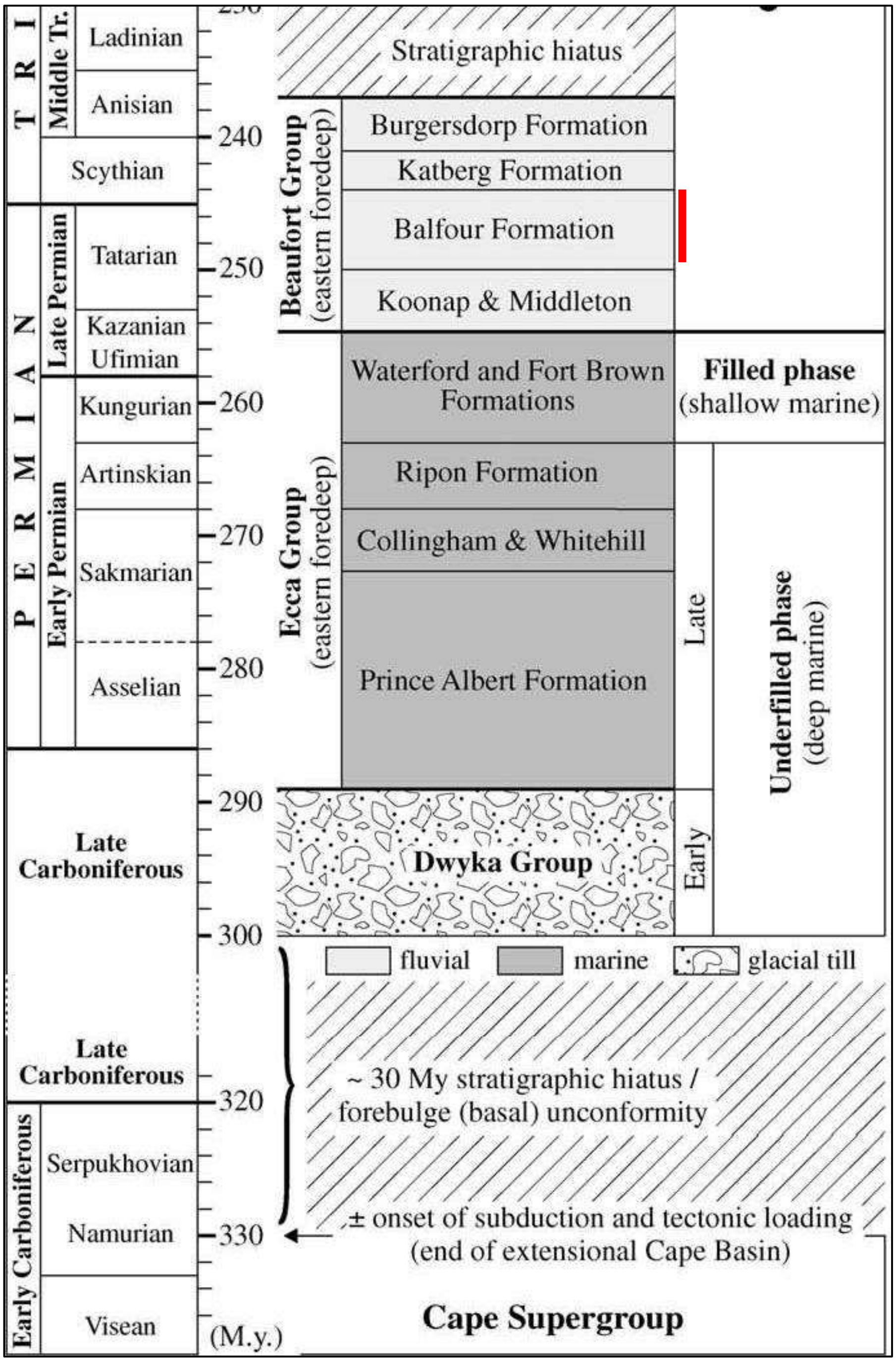

Figure 3. Stratigraphic subdivision of the Carboniferous and Permian portions of the Karoo Supergroup in the Main Karoo Basin (From Catuneanu *et al.* 2005). The Late Permian Balfour Formation at the top of the Lower Beaufort Group (= Adelaide Subgroup) succession that underlies the Nxuba Wind Farm project area is emphasized by the thick red bar.

As shown on the relevant 1: 250 000 geological maps, adjoining sheets 3224 Graaff-Reinet and 3226 King William's Town published by the Council for Geoscience (Fig. 2), the study area is almost entirely underlain by Late Permian continental sediments of the **Lower Beaufort Group** (Adelaide Subgroup, Karoo Supergroup). In particular the Karoo sediments belong to the **Balfour Formation** (**Pb**) at the top of the Adelaide Subgroup succession (Hill 1993, Cole *et al*. 2004, Johnson *et al*., 2006) (Fig. 3). Structural dips of the Beaufort Group sediments in the study region are generally shallow (3 to 5°), with small-scale NE-SW or ENE-WSW fold axes mapped to the south and east of Cookhouse, so that in general low levels of tectonic deformation and cleavage development are expected. However, steeply-dipping Beaufort Group beds are encountered locally in several stream, railway cutting and donga exposures, perhaps related to local dolerite intrusion and / or faulting (Fig. 28). Fault zones are suggested by concentrations of quartz veins, bedrock brecciation and oblique surfaces showing well-developed quartz mineral lineation (*e.g.* railway cuttings on Request 71, Loc. 386).

Lower Beaufort Group sedimentation patterns in the Cookhouse region may reflect wetter, more humid conditions on the floodplain compared to those obtaining in the western portion of the Main Karoo Basin (Almond 2013c, 2014). This is suggested by the comparative paucity of well-developed palaeosols marked by calcrete nodules (*cf* Catuneanu & Bowker 2001) as well as the rarity of prominent mudcracked horizons, of basal channel breccio-conglomerates with reworked mudflakes and calcrete glaebules, and of gypsum pseudomorphs. Local soft sediment deformation of channel sandstones (*e.g.* loading, ball-and-pillow formation) and pyrite pseudomorphs within calcrete nodules and sandstones suggest swampy conditions and high water tables. This is supported by abundant evidence for ponds and playa lakes on the floodplain (small scale wave-ripples, algal matted surfaces, invertebrate trace fossils and other evidence for emergence discussed above). Plant life, as usual in the Lower Beaufort Group, is poorly represented, and then mainly by water-loving reedy plants such as the sphenophyte ferns (horsetails) and petrified woods. Intermittent anoxia and reducing conditions within near-surface sediments (reflected by pyrite formation) may nevertheless have favoured the preservation of plant remains over bones and teeth (*cf* Tordiffe *et al.* 1985, Oghenekome 2012). The rarity of terrestrial vertebrate remains may also be a reflection of more challenging palaeoenvironmental conditions in this region as well as the lack of profound drought events to concentrate skeletal remains at the land surface (*cf* Smith 1993b). Note that, due to the oblique NW-SE orientation of the Main Karoo Basin in Late Permian times, the Lower Beaufort beds in the Eastern Cape were deposited at higher, cooler palaeolatitudes to those of the Western and Northern Cape.

On the north-western margins of the Nxuba study area, east of Suurkop, the Lower Beaufort Group sedimentary bedrocks are extensively intruded and baked by major intrusive sills of the **Karoo Dolerite Suite** (**Jd**) of Early Jurassic age (*c*. 183 Ma; Duncan & Marsh 2006) (Figs. 2 & 29). These dolerite intrusions are generally poorly exposed here and because they are of little interest in palaeontological terms they will not be considered in any detail here.

Gently rolling, grassy upland areas within the Nxuba Wind Farm study area that are mainly targeted for wind turbine emplacements and related infrastructure generally show very little bedrock exposure (Figs. 4 to 9). This applies most notably to almost the entire area lying south of the Patryshoogte – Bedford dust road as well as the higher ridges within the portion of the study area to the north of the road. Occasional projecting beds (Loc.418) or exposed patches of buff Balfour sandstone bedding planes, often well-jointed and associated with angular gravels (Loc. 390, 417), are seen here. The main bedrock exposures occur along the stream valleys and favour the more resistent-weathering sandstone facies over the potentially more fossiliferous mudrocks. Shallow farm dams usually do not penetrate down to bedrock due to the thick alluvial / colluvial cover, especially along drainage lines. All potentially fossiliferous bedrock exposures encountered during the present field assessment are located in the more dissected terrain to the north of the Patryshoogte – Bedford dust road (See Fig. 61).

Figure 4. View towards Poseidon Substation and the existing wind farm to the west of the Nxuba Wind Farm project area showing low relief, grassy terrain with abundant domical termitaria that characterises much of the Patryshoogte Plateau to the east of Cookhouse.

Figure 5. Typical upland ridge terrain in the north-western sector of the Nxuba Wind Farm project area showing gentle, grassy slopes and lack of bedrock exposure (Request 71, close to Loc. 389).

Figure 6. View of south-western portion of Van Wyks Kraal 73 showing gentle grassy ridges mantled by thin colluvial gravels (foreground) with wooded stream valleys where most potentially-fossiliferous bedrock and alluvial deposits are exposed.

Figure 7. Typical low-relief, grassy terrain of the Patryshoogte Plateau to the south of the dust road to Bedford, showing very limited bedding plane exposures of Balfour Formation sandstone (Roberts Kraal 281, Loc. 417).

Figure 8. Ridge-like exposure of thick-bedded Balfour Formation channel sandstones on Van Wyks Kraal 73, just south of the dust road to Bedford (Loc. 418).

Figure 9. Upland bedding plane exposure of well-jointed Balfour Formation channel sandstones, Van Wyks Kraal 73 (Loc. 390).

3.1. Balfour Formation

The fluvial Balfour Formation comprises recessive weathering, grey to greenish-grey overbank mudrocks with subordinate resistant-weathering, grey, fine-grained channel sandstones deposited by large meandering river systems in the Late Permian to Earliest Triassic Period (Hill 1993). The formation reaches a maximum thickness of over 2000 m in the Fort Beaufort area but is only 650 m near Graaff-Reinet (Johnson 1976, Visser & Dukas 1979). Thin wave-rippled sandstones were laid down in transient playa lakes on the flood plain. Reddish mudrocks are comparatively rare, but increase in abundance towards the top of the Adelaide Subgroup succession near the upper contact with the Katberg Formation.

The base of the Balfour succession is defined by a sandstone-rich zone, some 50-100 m thick, known as the **Oudeberg Member**. The Oudeberg Member sandstones and interbedded mudrocks crop out along the edge of the Patryshoogte escarpment to the east of Cookhouse and probably underlie the greater part of the Nxuba study area on the Patryshoogte plateau. Thick, cross-cutting channel sandstone bodies are well-exposed in vertical section in the walls of the steeply incised valley to the east of Van Wyks Kraal homestead (Fig. 11). It is likely that at least the lowermost portion of the overlying mudrock-dominated **Daggaboersnek Member** underlies some of the interior and more northern portions of the study area, away from the escarpment edge (*e.g.* railway cuttings on Request 71; Fig. 25; khaki mudrocks on the upper hillslopes on Robertskraal 281), but this is difficult to confirm given the low levels of bedrock exposure here. Dark grey mudrocks with thin, tabular sandstones and wave ripples (formed in shallow lakes) within this member are well-exposed at higher elevations in Daggaboersnek itself along the main road between Cookhouse and Cradock (Hill 1993). The recessive-weathering Daggaboersnek Member underlies the extensive lowlands running to the north of the Nxuba Wind Farm study area along the foot of the Baviaansrivierberge; the latter uplands are constructed of resistant-weathering Barberskrans Member sandstones (see map Fig. 10).

Key recent reviews of the Balfour Formation fluvial succession have been given by Visser and Dukas (1979), Catuneanu and Elango (2001), Katemaunzanga (2009) and Oghenekome (2012). Catuneanu and Elango (2001) identified six upward-fining depositional sequences within the Balfour succession that are separated by subaerial unconformities and lasted on average about 0.7 Ma (million years). The sequences were generated by tectonic processes within the Cape Fold Belt. Fluvial deposition by sandy braided rivers in the early part of each sequence was followed by more mixed channel sandstones and overbank mudrocks laid down by meandering rivers higher in the sequence. Sedimentological data, such as the rarity of palaeosols (fossil soils, desiccation cracks, red beds), suggest that palaeoclimates during this period were predominantly temperate to humid and water tables were generally high.

The stratigraphy and sedimentology of the five stratigraphic members recognised within the Balfour Formation in the Eastern Cape are discussed by Oghenekome (2012) and mapped for the Bedford – Adelaide area just to the east of the Nxuba Wind Farm (Fig. 10). This mapping would suggest that a major portion of the present study area is underlain by the mudrock-dominated Daggaboersnek Member. The underlying thick sandstone-dominated package of the Oudeberg Member at the base of the Balfour Formation succession would then be only represented in the southernmost portions of the study area (This is Sequence 'A' of Catuneanu and Elango (2001), described as *c*. 400 m thick and composed of braided fluvial sandstones towards the base passing up to sand-bed and fine-grained meandering river deposits towards the top). Older fossil biozonation maps (based, admittedly, on very little fossil data for this particular region) by Keyser & Smith 1977-78 appear to support this interpretation (Fig. 44). However, the latest biostratigraphic map for the Main Karoo Basin assigns the bulk of the present field area to the *Cistecephalus* Assemblage Zone (Fig. 45) that is associated with the Oudeberg Member. This latter interpretation is supported by the thick channel sandstone bodies well-exposed to the east of Van Wyks Kraal homestead (Fig. 11) as well as extensive sandstone subcrop implied by the stripey appearance of hillslopes to the north in satellite images (Fig. 61). Further fieldwork, including recording of biostratigraphically-significant fossil data, that is needed to resolve this ambiguity is beyond the scope of the present reconnaissance-level study.

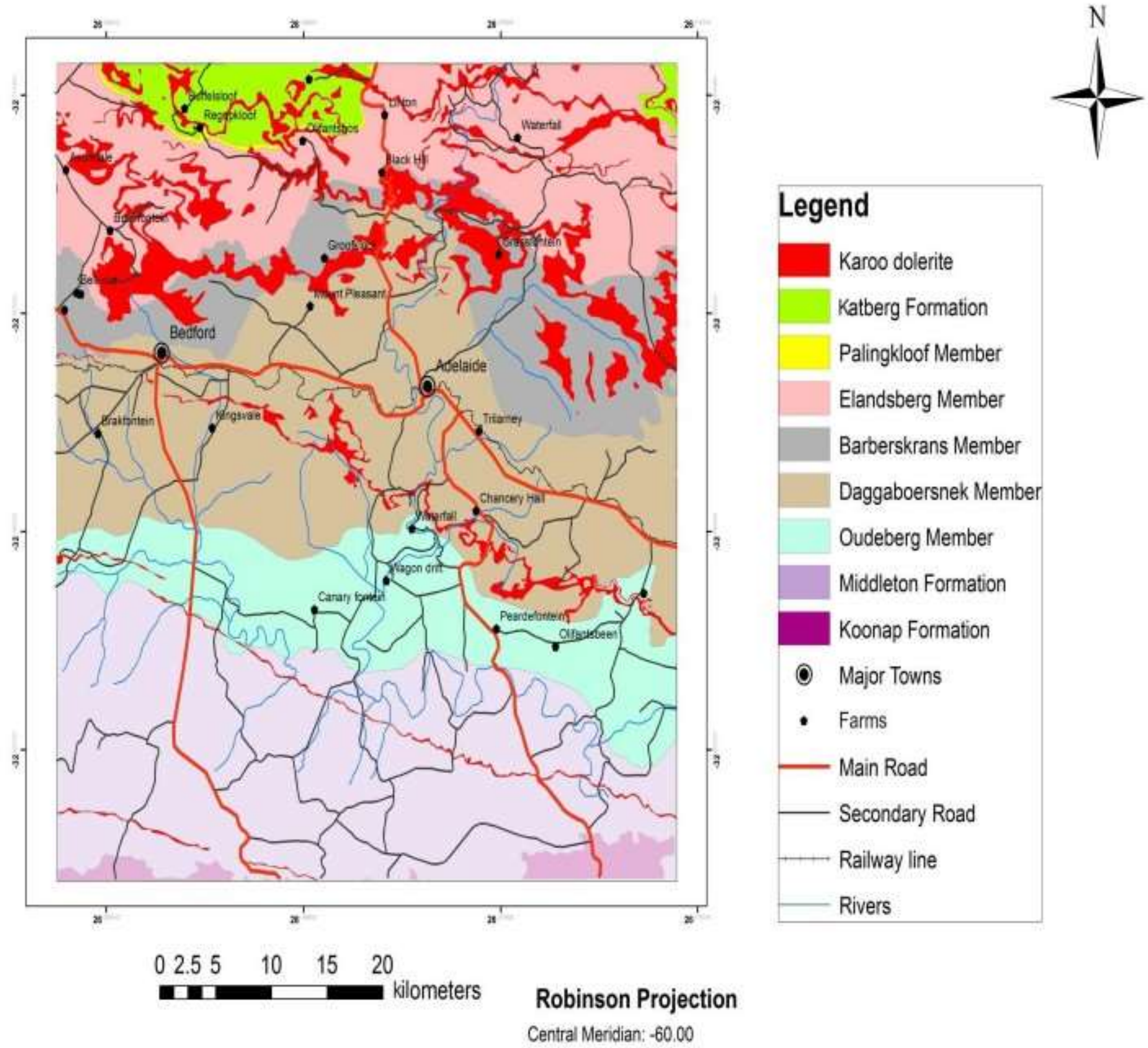

Figure 10. Detailed mapping of the various members of the Balfour Formation in the Bedford – Adelaide area, just to the east of the Nxuba Wind Farm (Oghenekome 2012). According to this map, most of the study area is underlain by the mudrock-rich Daggaboersnek Member. The latest fossil assemblage zone map (Fig. 45) suggests that the study area is mainly underlain by the sandstone-dominated Oudeberg Member, however, characterised by fossils of the *Cistecephalus* Assemblage Zone.

Good stream bank exposures of a thick package of thin- to medium-bedded Balfour Fm grey-green and purple-brown mudrocks, together with an underlying package of horizontally-laminated tabular sandstones, are seen close to a farm dam at Loc. 400 on Van Wyks Kraal 73 (Figs. 17 & 22). Subordinate thin crevasse splay sandstones are associated with deep (20-30 cm), downward-tapering sandy mudcrack infills suggesting prolonged desiccation of the distal floodplain.

Further good exposures of Balfour Formation (Oudeberg Member) channel sandstones can be seen in the river bed close to the homestead on Van Wyks Kraal 73 (Loc. 403, Fig. 14) as well as in a stream bed north of Poseidon Substation (Loc. 419). Sedimentary features include tabular flaggy sandstones whose bedding planes show primary current lineation, large-scale megaripples and trough cross-bedding (variable palaoecurrent azimuths to N and W), mudrock intraclasts, current-rippled bedding surfaces, internal ripple cross-lamination, and local patches of cobble-sized ferruginous carbonate nodules. The medium to coarse-grained, medium- to thick-bedded sandstones are often distinctly speckled. A heterolithic package of interbedded tabular sandstones with current-rippled tops and mudrocks overlies the main channel sandstone at Loc. 419 (Fig. 19). Extensive hillslope exposure of the overlying thick mudrock grey-green to purple-brown package extending to the western boundary of the study area features very abundant pale grey-weathering pedogenic calcrete nodules, many of which show a distinctive septarian cracking pattern (Figs. 23 & 24). Internally the nodules have veins of dark sparry calcite, and very rarely fossil bone (Fig. 49). Thin-bedded sandstones just beneath the mudrock-dominated interval show successive bedding planes covered with small-scale wave ripples (Fig. 18). These beds and associated thin-bedded mudrocks probably represent playa lake deposits. Another good section through the Balfour Formation mudrocks with several pedocrete palaeosol horizons is seen along strike in a stream valley some 0.5 km to the northeast (Loc. 420; Figs. 20 & 21). Cycles (*c*. 2m thick) of interbedded prominent-weathering siltstone and more crumbly claystone are seen here as well as thin channel sandstone packages and thin-bedded possible lacustrine / distal floodplain facies. The uppermost beds exposed here are crumbly-weathering purple-brown mudrocks with thin crevasse-splay sandstones and pedocrete nodule horizons.

Vertical sections through major, cross-cutting channel sandstone packages of the Oudeberg Member building the Patryshoogte plateau are well seen along the steep sides of the river valley to the east of Van Wyks Kraal 73 homestead (Loc. 404; Figs. 11 & 12). Some of the sandstone units are ten or more meters thick and display spectacular horizontal lamination or thin-bedding below and massive facies higher up. The base of the main channel sandstone is erosive and characterised here by a moderately thin basal breccia with reworked mudrock intraclasts and palaeocalcrete nodules associated with locally abundant fossil woody material (Figs. 13 & 56). Interbedded tabular grey-green mudrock and sandstone facies underlie and are incised by the major channel sandstones. Similar heterolithic facies with well-developed pedocrete horizons (some with unusually large, ferruginous-brown calcrete nodules) are displayed beneath thick alluvial cover deposits further to the east along the same valley at Loc. 409 as well as at Locs. 419 and

420 near the western boundary of Van Wyks Kraal 73. On Roberts Kraal 281 sandstone pointbar sandstones display low-angle cross-bedding and well-developed fine-scale ripple cross-lamination (Loc. 433, Fig. 15).

At Loc. 427 near the western boundary of Van Wyks Kraal 73 a north-sloping, fine-grained sandstone unit exposed on the south side of a stream shows a peculiar hummocky upper surface (Fig. 16). This may be due to differential cementation and weathering, perhaps a consequence of secondary mineralisation during regional dolerite intrusion. Sandstone loading and pillow formation is another possibility to consider here.

The best vertical sections through the Balfour Formation in the study area are seen along extensive, deep railway cuttings along the Cookhouse – Bedford line on Request 71 (Locs. 386-389; Figs. 25 to 28). This section may belong to the mudrock-rich Daggaboersnek Member of the Balfour succession (cf. map fig 10). The bedrocks are dominated by grey-green and purple-brown silty mudrocks with packages of medium-bedded, tabular to lenticular, fine- to medium-grained sandstones. The sharp, flat to erosive-based single storey sandstones are often flaggy towards the base, massive internally and fine upwards into wackes with ill-defined, gradational tops. Well-developed basal channel breccias are not seen here. The mudrocks are variously massive and hackly-weathering to medium-bedded or thin-bedded. Packages of thin-bedded mudrocks with occasional thin sandstones contain dispersed small (pebble- to cobble-sized) pale grey to rusty-brown, rounded pedocrete nodules showing a dark grey, fine-grained internal texture (Fig. 27). There are also occasional well-developed, laterally-persistent horizons of larger, cobble-sized calcrete nodules with a distinctive mottled coloration and porcellanous (possibly baked) texture (Fig. 25). A several meter-thick package of interbedded, thin- to medium-bedded tabular sandstones with internal horizontal laminations and thin mudrock partings is exposed towards the northern end of the railway cutting. The bedrocks in the railway cutting are gently dipping towards the south and also show evidence of minor tectonism in the form of small scale folds and faults, including low angle normal and thrust fault planes associated with disrupted bedding and brecciation.

A thick package of khaki mudrocks with thin-bedded and heterolithic units as well as thin mottled sandstone intervals and sparse, rusty-brown pedocrete nodules is exposed around a farm dam on Roberts Kraal 281 (Loc. 430). These beds lie at an elevation of c 700 m amsl and might belong to the Daggaboersnek Member but finely-striped hillslopes along strike to the west indicate the presence of numerous sandstones at this stratigraphic level.

Figure 11. Cross-cutting large-scale channel sandstones of the Oudeberg Member exposed along the southern side of the incised river valley to the east of Van Wyks Kraal homestead (Loc. 404).

Figure 12. Close-up of thick, horizontally-laminated sandstone towards the base of the lowermost major channel body seen in the previous figure (Loc. 404).

Figure 13. Channel lag (*c*. 20 cm thick) composed of reworked calcrete nodules at the base of horizontally-laminated channel infill sandstones and overlying incised overbank mudrocks, Balfour Formation (Loc. 404). No reworked vertebrate fossils were recorded within the lag deposits here.

Figure 14. Large-scale trough cross-bedding in Balfour Formation channel sandstones exposed in the riverbed just east of the Van Wyks Kraal homestead (Loc. 402).

Figure 15. Laterally-prograding, cross-bedded and ripple cross-laminated point bar sandstone exposed on a stream bank, Roberts Kraal 281 (Loc. 433). (Hammer = 30 cm).

Figure 16. Curious hummocky weathering of a fine-grained sandstone unit, reflecting differential cementation or perhaps loading (Van Wyks Kraal 73, Loc. 427) (Hammer = 30 cm).

Figure 17. Interbedded single-storey sandstone beds and hackly-weathering mudrocks underlying a thick mudrock package in stream bed (dam overflow), Van Wyks Kraal 73 (Loc. 400). (Hammer = 30 cm).

Figure 18. Package of thin-bedded sandstones showing small-scale wave ripples on successive upper bedding planes, Van Wyks Kraal 73 (Loc. 419). (Hammer = 30 cm).

Figure 19. Interbedded current-rippled sandstones and recessive-weathering mudrocks lying beneath the main mudrock package at Loc. 419, Van Wyks Kraal 73 (Hammer = 30 cm).

Figure 20. Interbedded tabular units of prominent-weathering siltstone and recessive-weathering claystone, hillslope exposure on Van Wyks Kraal 73 (Loc. 421).

Figure 21. Typical palaoesol horizon within Balfour Formation overbank mudrocks showing dense array of pale calcrete nodules, Van Wyks Kraal 73 (Loc. 421) (Hammer = 30 cm).

Figure 22. Package of thin-bedded, grey-green overbank mudrocks with thin crevasse-splay sandstones towards the base. Note sandstone-infilled desiccation cracks at the level of the hammer (= 30 cm) (Loc. 400, Van Wyks Kraal 73).

Figure 23. Extensive hillslope exposure of overbank mudrocks on Van Wyks Kraal 73, *c*. 1 km north of Poseidon Substation (Loc. 419). The surface gravels here are rich in downwasted calcrete nodules.

Figure 24. Close-up of pedogenic calcrete nodules showing distinctive septarian cracking pattern from the locality illustrated in the previous figure (scale in cm). These nodules are occasionally but rarely fossiliferous (*cf* Fig. 49).

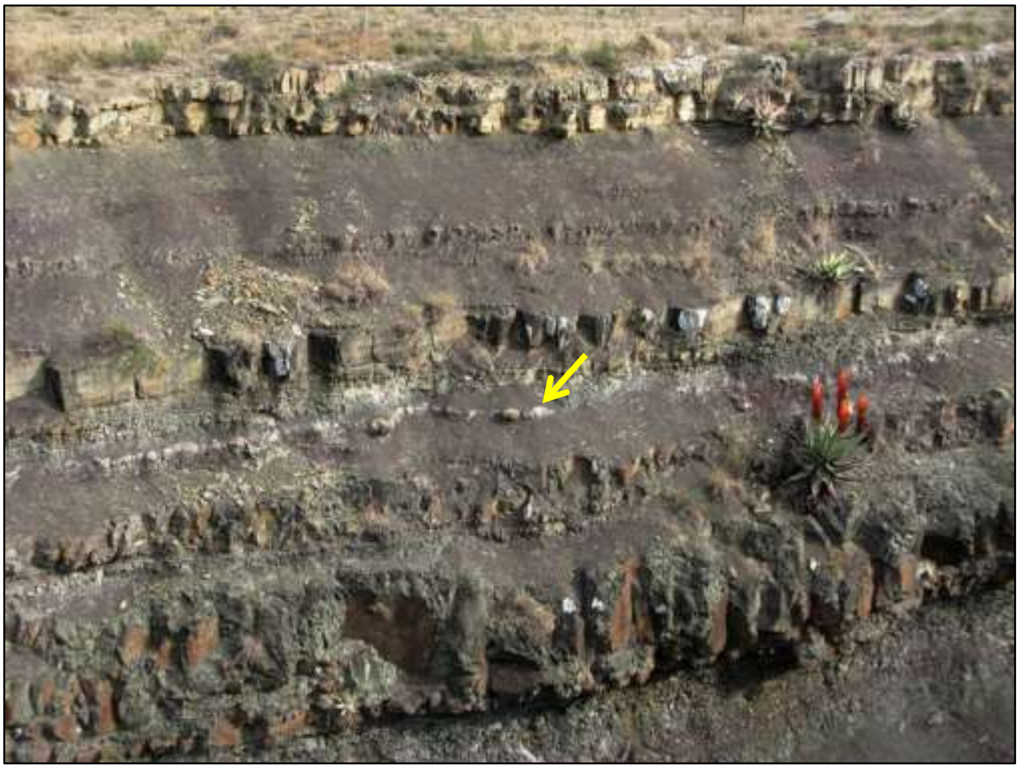

Figure 25. Extensive railway cutting exposure of Balfour Formation mudrocks and thin channel sandstones on Request 71 (Loc. 386). The mudrock-rich succession here may belong to the Daggaboersnek Member. Note laterally-persistent pedocrete nodule horizon (arrowed).

Figure 26. Close-up of thin-bedded overbank mudrocks within the lower part of the succession illustrated above showing dispersed small calcrete nodules (Hammer = 30 cm).

Figure 27. Detail of dark grey calcrete nodules from the overbank mudrocks seen above (Scale in cm and mm). The nodules are apparently unfossiliferous.

Figure 28. Thin- to medium-bedded channel sandstones with intercalated mudrock horizons overlying the main mudrock package seen in Figures 25 & 26 above, northern end of railway cutting on Request 71 (Loc. 386).

3.2. Karoo Dolerite Suite

The dolerite intrusions mapped in the north-western portion of the Nxuba study area (Fig 2) are not well-exposed at surface. Low exposures of Karoo dolerite bedrock and boulder-sized corestones as well as downwasted doleritic surface gravels are seen at higher elevations on Request 71, for example (Loc. 384, Fig. 19) and around Suurkop (1016 m amsl). Baking and secondary mineralisation of the Balfour Formation country rocks is suggested by ferruginised calcrete nodules and the local development of quartzite and hornfels.

Figure 29. Low lichen-covered outcrops of Karoo dolerite exposed on upland hillslopes on Request 71 (Loc. 384) (Hammer = 30 cm).

3.3. Caenozoic superficial deposits

Surface exposure of fresh Beaufort Group rocks within the development footprint is generally very poor, as also evident from satellite images, apart from stream beds, *dongas* (erosion gullies) and steeper hill slopes. The hill slopes are typically mantled with a thin to thick layer of **colluvium** or slope deposits (*e.g.* sandstone scree and downwasted gravels, sheetwash sands and gravels) as well as soil.

Most of the larger stream valleys in areas of moderate to high relief are partially infilled with thick deposits of massive to well-bedded silty, sandy to gravelly older alluvium that has been consolidated by calcrete and subsequently exposed during episodes of donga erosion (*e.g.* Locs. 392, 393, 398, 407, 409, 410, 414, 432, 435, 436 *etc*; Figs. 30 to 38). On Roberts Kraal 281 these alluvial deposits have been exploited for brick-making (Loc. 429). The older alluvium is probably of Pleistocene age (*cf* Almond 2014). The best examples of thick older alluvium seen during the present field study are situated on the southern side of the main stream valley on Van Wyks Kraal 73 (Loc. 409; Figs. 30 & 31). Here a considerable thickness of well-bedded, orange-hued, well-consolidated alluvium dips gently northwards towards the valley axis. The basal unit is several meters thick, with abundant dispersed angular gravel clasts (probably a major flood or debris flow deposit), and appears to infill an erosional channel feature incised into the horizontally-bedded Balfour Formation bedrocks. More densely-calcretised alluvial siltstone to fine sandstone horizons weather out prominently as benches and presumably represent successive flood events. The upper beds have a more intense orange-brown hue and are capped by downwasted surface gravels (including numerous flaked artefacts) and younger brownish alluvium and soils.

A lower horizon of coarse, rubbly, poorly-sorted basal gravels (usually sandstone-dominated) is overlain by several to many (10 or more) meters of extensively calcretised, well-consolidated older alluvium of pale creamy-brown to orange-brown hues. Pale creamy calcrete glaebules, larger nodules and veins may be abundant at some horizons and weather out at surface. Discrete calcrete hardpans are occasionally developed (Loc. 432) and some horizons show a pervasive burrowed texture. There may be thin gravel lenticles within the succession as well as dispersed gravels and flaked stone artefacts, some attributable to the MSA (*e.g.* hornfels and fine sandstone / quartzite blades). Poorly-sorted basal gravels between Beaufort Group bedrocks and calcretised orange-brown older alluvial deposits are seen on Roberts Kraal 281 (Loc. 435).

Dense arrays of pale creamy calcrete nodules occur within sandy to gravelly soils overlying Beaufort Group bedrocks on Request 71 (Loc. 386). The calcretised soils contain embedded stone artefacts of hornfels and sandstone, including large MSA blades, suggesting a Pleistocene or younger age (Fig. 34). Veins of calcrete often extend for up to a few meters into into the underlying Beaufort Group bedrocks. Older soils and alluvium may be various calcretised and ferricretised.

The younger alluvial sediments (possibly Holocene) tend to be pale brown and unconsolidated, in contrast to the older alluvial deposits (Figs. 37 & 38). They vary from a few dm to several meters in thickness and contain dispersed gravels, gravel lenticles and occasional unmineralised subfossil vertebrae remains (Figs. 59 & 60). Coarse blocky alluvial gravels occur in upland streams while larger lowland streams may have banks of better-rounded cobbles and pebbles, predominantly of sandstone.

Coarse, rubbly pediment gravels (High Level Gravels) some 5 m above present drainage level are seen to the south of a stream bed at Loc. 427 on Van Wyks Kraal (Fig. 35). The gravels are rubbly, poorly-sorted and consist largely of angular to subrounded sandstone clasts. Numerous examples of crudely flaked sandstone artefacts occur here (as well as occasional hornfels tools), some of which a bifacially flaked hand axes of Acheulian age (*i.e.* Earlier Stone Age) as well as rarer MSA blades (Fig. 36). Poorly-sorted, semi-consolidated coarse gravels apparently overlying older calcretised alluvium on Roberts Kraal 281 (Loc. 433) also contain crudely-flaked sandstone artefacts of possible ESA affinity.

Pale brown debris flow deposits (diamictites / debrites) consisting of poorly-sorted, angular blocks of sandstone floating within a pale brown, semi-consolidated muddy sand matrix are encountered on the banks of some upland stream valleys, overlying older alluvium (*e.g.* Locs. 395-396; Fig. 43).

Thick deposits of mixed colluvial and alluvial origin mantle many of the upland slopes within the study area, especially within the stream valleys. Good erosion gulley sections through several meters of weakly-consolidated, bedded sandy and gravelly colluvium overlying Balfour Formation bedrocks are seen, for example, at Loc. 421 on Van Wyks Kraal 73 (Fig. 39). Thin, sparse to concentrated and rubbly, downwasted, angular to subrounded colluvial gravels of sandstone, quartzite, minor hornfels and dolerite underlie sandy to gravelly soils in many upland areas, especially where sandstone bedrocks are present (Loc. 391; Figs. 40 to 42). The clasts often show a shiny darker brown surface patina. Occasionally well-rounded clasts hint at the possibility of reworked High Level Gravels locally (some possibly brought in from elsewhere for construction purposes).

Figure 30. Thick succession of well-consolidated and prominently–bedded orange-brown older alluvium overlying Balfour Formation bedrocks on Van Wyks Kraal 73 (Loc. 409). The beds of alluvium here dip gently northwards towards the valley axis.

Figure 31. Close-up of thick older alluvial deposits seen in the previous figure showing massive basal beds with dispersed gravels erosively overlying Balfour Formation bedrocks.

Figure 32. Heavily-calcretised, sparsely gravelly older alluvium overlying Balfour Formation bedrocks, stream valley on Van Wyks Kraal 73 (Loc. 394).

Figure 33. Stream valley alluvial infill, Van Wyks Kraal 73, with basal gravels, pale older calcretised alluvium capped by darker brown younger alluvium and soils (Loc. 392).

Figure 34. Calcretised and ferruginised alluvial cover overlying Balfour Formation bedrocks and containing embedded MSA artefacts (arrowed), Request 71 (Scale = 15 cm) (Loc. 386).

Figure 35. Thin mantle of rubbly, unconsolidated High Level Gravels (background) capping Balfour Formation bedrocks *c.* 5 m above modern stream level, Van Wyks Kraal 73 (Loc. 427).

Figure 36. Crudely-flaked sandstone clasts found among the High Level Gravels illustrated in the previous figure (Scale in cm). Some of the bifacially-flaked artefacts are probably referable to the Early Stone Age, suggesting a Pleistocene or younger age for the source gravels.

Figure 37. Thick unconsolidated, brown silty to sandy alluvium exposed in steep stream banks on Roberts Kraal 281 (Loc. 436).

Figure 38. Deep *donga* exposures of thick, sparsely-gravelly silty to sandy alluvial and colluvial deposits on lower river valley slopes, Van Wyks Kraal 73 (Loc. 414).

Figure 39. Thick mantle of silty, sandy and sparsely gravelly colluvial to alluvial deposits mantling Balfour Formation bedrocks on gentler hillslopes, Van Wyks Kraal (Loc. 421).

Figure 40. Poorly-sorted sandstone colluvial gravels overlying Balfour Formation bedrocks on Van Wyks Kraal 73 (close to Loc. 413).

Figure 41. Thin veneer of pebbly to cobbly, sandstone-dominated, downwasted colluvial gravels overlying Balfour Formation mudrocks, roadside exposure on Van Wyks Kraal 73 (Loc. 391) (Hammer = 30 cm).

Figure 42. Angular downwasted sandstone gravels associated with low sandstone bedrock exposure around margins of a farm dam, Roberts Kraal 281 (Loc. 415).

Figure 43. Sandy debris flow diamictite with dispersed sandstone blocks, stream banks on Van Wyks Kraal 73 (Loc. 395).

4. PALAEONTOLOGICAL HERITAGE WITHIN THE STUDY REGION

4.1. Balfour Formation

The overall palaeontological sensitivity of the Beaufort Group sediments is high (Almond *et al*. 2008). These continental sediments have yielded one of the richest fossil records of land-dwelling plants and animals of Permo-Triassic age anywhere in the world. A chronological series of mappable fossil biozones or assemblage zones (AZ), defined mainly on their characteristic tetrapod faunas, has been established for the Main Karoo Basin of South Africa (Rubidge 1995). Maps showing the distribution of the Beaufort assemblage zones within the Main Karoo Basin have been provided by Keyser and Smith (1977-1978) (Fig. 44) and Rubidge (1995), and for the Graaff-Reinet sheet area they are available in Hill (1993). According to the latest biozonation map produced by Van der Walt *et al.* (2010) the Nxuba study area to the east of Cookhouse lies largely or entirely within the *Cistecephalus* Assemblage Zone (Fig. 45). However, as discussed previously (Section 3.1), it is possible that younger *Dicynodon* Assemblage Zone fossils within Daggaboersnek Member beds occur within the northern portion of the study area.

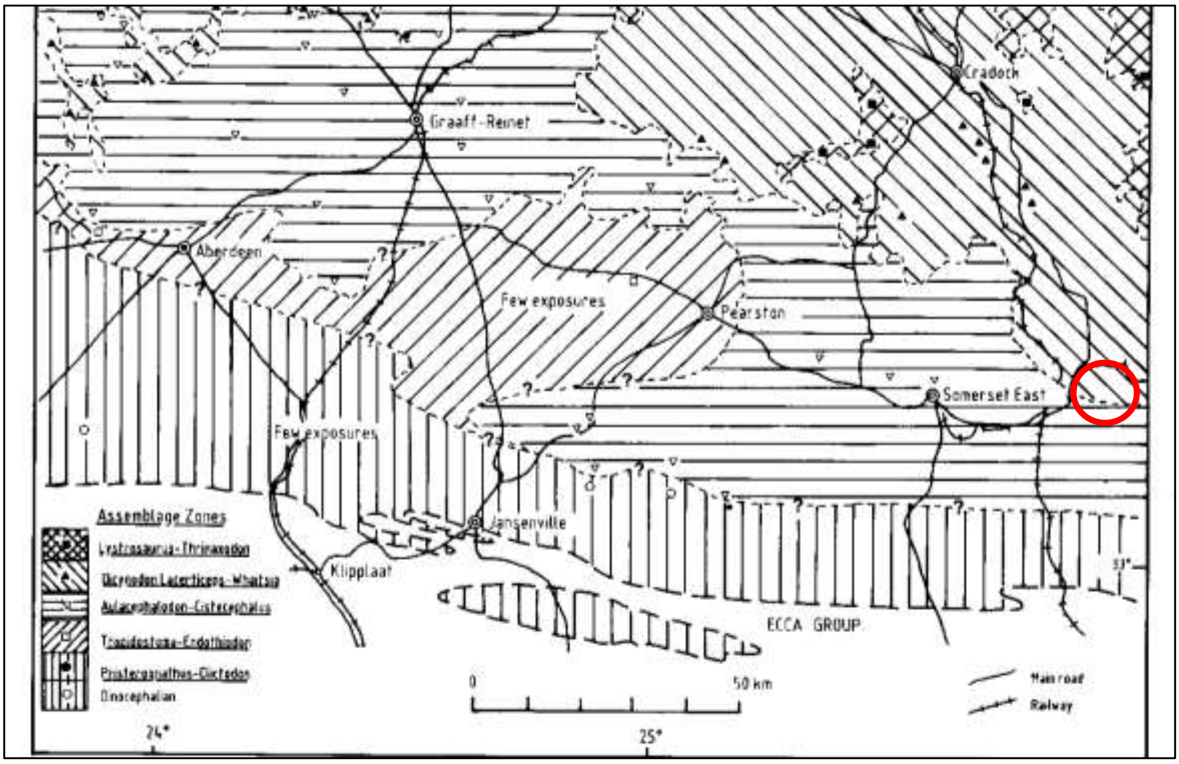

Figure 44. Distribution of Beaufort Group fossil assemblage zones in the Graaff-Reinet sheet area (After Keyser & Smith 1977-78). According to this map the Nxuba Wind Farm study area to the east of Cookhouse, indicated by the red circle, spans the boundary between the *Cistecephalus* Assemblage Zone (previously known as the *Aulacephalodon – Cistecephalus* Zone) and the overlying *Dicynodon* Assemblage Zone (Compare following figure). Note the paucity of fossil vertebrate records from this particular area of the Main Karoo Basin.

Fossil vertebrate remains appear to be surprisingly rare in the Lower Beaufort Group outcrop area near Cookhouse compared to similar-aged deposits further west within the Great Karoo (Almond 2010, 2013c). The important compendium of Karoo fossil faunas by Kitching (1977) lists numerous finds from the *Cistecephalus* Assemblage Zone near Pearston, some 75 km to the WNW of the study area. A few therapsid genera - the dicynodonts *Emydops* and *Cistecephalus plus* the therocephalian *Ictidosuchoides* – are reported from Bruintjieshoogte, between Pearston and Somerset East, although fossils are recorded as rare even here, despite the excellent level of exposure. Sparse dicynodonts are also mentioned from Bedford, *c*. 30 km to the ENE of Cookhouse. Fossils of the long-ranging, small, communal burrowing dicynodont *Diictodon* are recorded from Slaghtersnek to the south of Cookhouse (precise location not provided, Kitching 1977, p. 66).

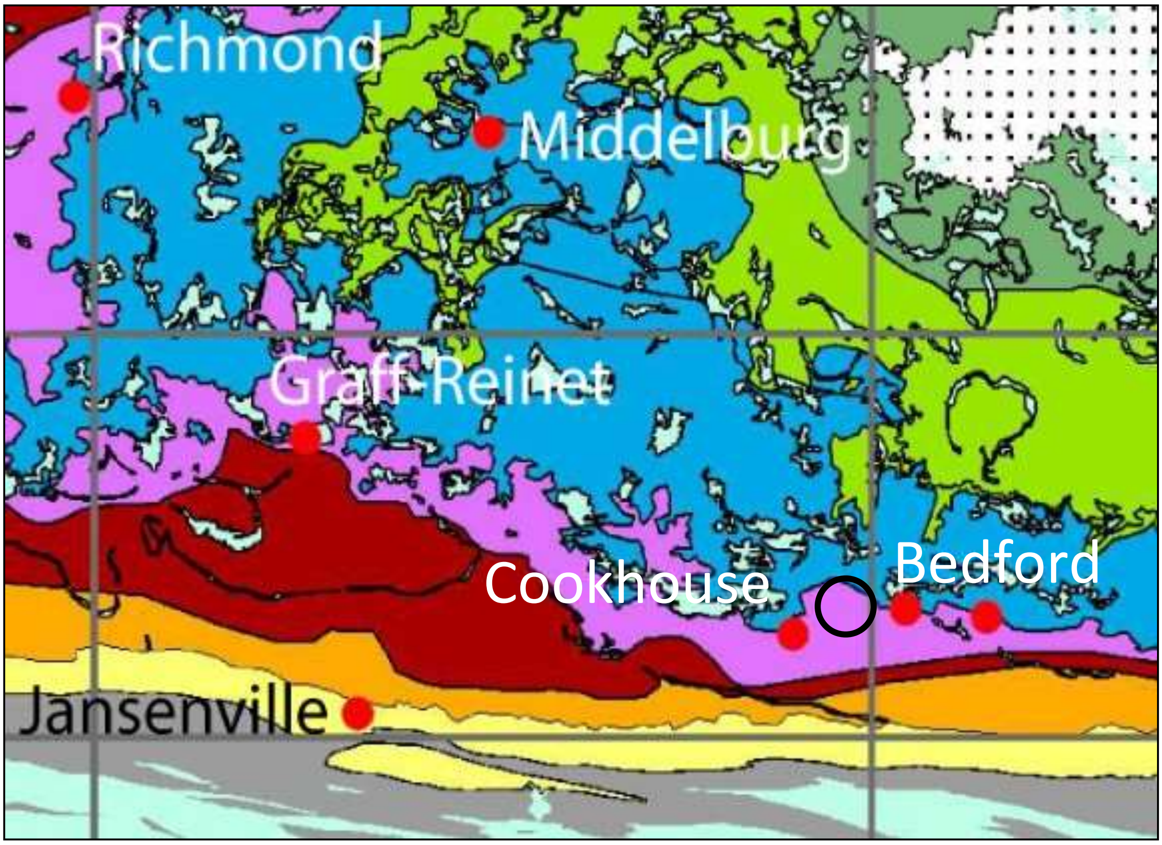

Figure 45. Extract from the most recent fossil assemblage zone map for the Main Karoo Basin showing the main biozones represented in the Nxuba Wind Farm study area between Cookhouse and Bedford (black circle), *viz*. the *Cistecephalus* Assemblage Zone (lilac) within the sandstone-dominated Oudeberg Member to the south and possibly also the *Dicynodon* Assemblage Zone (blue) within the mudrock-rich Daggaboersnek Member to the north (Map modified from Van der Walt *et al.* 2010).

Apart from a few isolated postcranial bone fragments, no vertebrate remains were found within the Lower Beaufort Group sediments during recent palaeontological field studies for wind farm projects near Cookhouse and Bedford by De Klerk (2010) and Durand (2012). A limited number of well-preserved dicynodont skulls (probably *Oudenodon, Diictodon*) as well as scattered postcranial therapsid remains, sphenophytes (horsetail ferns), locally abundant silicified wood (some showing insect borings), and low diversity assemblages of horizontal burrows (including *Scoyenia* arthropod scratch burrows) were recorded from the Middleton Formation in the Cookhouse – Middleton area during recent palaeontological field studies by the author (Almond 2010b, 2011, 2013c). A couple of poorly-preserved therapsid tracks are also recorded from this succession near Middleton (Prof. Bruce Rubidge, pers. comm., and Almond 2011, 2013c). The recent discovery of a specimen of the rare, turtle-like parareptile *Eunotosaurus* in the same area supports the assignation of the lower Middleton Formation succession to the *Pristerognathus* Assemblage Zone, correlated with the Poortjie Member of the Teekloof Formation of the western Main Karoo Basin (Day *et al*. 2013). The recent palaeontological assessment of the Nojoli Wind Farm study area just to the south of the Nxuba project area yielded almost no fossil vertebrate remains (Almond 2014). Locally abundant well-preserved silicified wood within alluvial and colluvial deposits overlying the Lower Beaufort Group bedrocks here was inferred to have weathered out of the Oudeberg Member channel sandstones. However, it was never observed *in situ*.

The reason for the comparative scarcity of vertebrate fossil material within the Beaufort beds near Cookhouse is unknown. It might be related to the area's southern, high palaeolatitudinal position within the N-S orientated Main Karoo Basin. The comparative scarcity of richly calcretized pedogenic horizons, gypsum pseudomorphs, desiccation cracks and maroon mudrocks may suggest colder, wetter climates here. The paucity of coarse clastic material, the rarity of deeply erosive channel bases within the river systems, the soft-sediment deformation seen at some channel sandstone bases, and the high proportion of ferruginous and pyritic calcrete nodules possibly suggest distal, swampy environments that may have been less conducive to terrestrial wildlife. Reducing conditions within the basinal mudrocks, as indicated by the common occurrence of pyrite within sandstones and secondary nodules, would have favoured the preservation of plant material, such as wood, over vertebrate bones and teeth. This is all highly speculative, however!

The *Cistecephalus* Assemblage Zone ((= upper *Cistecephalus* Biozone or *Aulacephalodon-Cistecephalus* Assemblage Zone of earlier authors; see table 2.2 in Hill 1993) to which the Oudeberg Member of the Balfour Formation is assigned (Rubidge 1995) belongs to the Wuchiapingian Stage of the Late Permian Period, with an approximate age range of 260-254 million years (Rubidge 1995, 2005).

The following major categories of fossils might be expected within *Cistecephalus* AZ sediments in the study area (Keyser & Smith 1979, Anderson & Anderson 1985, Hill 1993, Smith & Keyser *in* Rubidge 1995, MacRae 1999, Cole *et al*., 2004, Almond *et al*. 2008, Smith *et al.* 2012):

- isolated petrified bones as well as rare articulated skeletons of **terrestrial vertebrates** such as true **reptiles** (notably large herbivorous pareiasaurs, small insectivorous owenettids) and **therapsids** or "mammal-like reptiles" (*e.g.* diverse herbivorous dicynodonts, flesh-eating gorgonopsians, and insectivorous therocephalians) (Fig. 46)
- aquatic vertebrates such as large **temnospondyl amphibians** (*Rhinesuchus*, usually disarticulated), and **palaeoniscoid bony fish** (*Atherstonia*, *Namaichthys*, often represented by scattered scales rather than intact fish)
- freshwater **bivalves** (*Palaeomutela*)
- **trace fossils** such as worm, arthropod and tetrapod burrows and trackways, coprolites (fossil droppings)
- **vascular plant remains** including leaves, twigs, roots and petrified woods ("*Dadoxylon*") of the *Glossopteris* Flora (usually sparse, fragmentary), especially glossopterid trees and arthrophytes (horsetails).

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 (Rubidge 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.

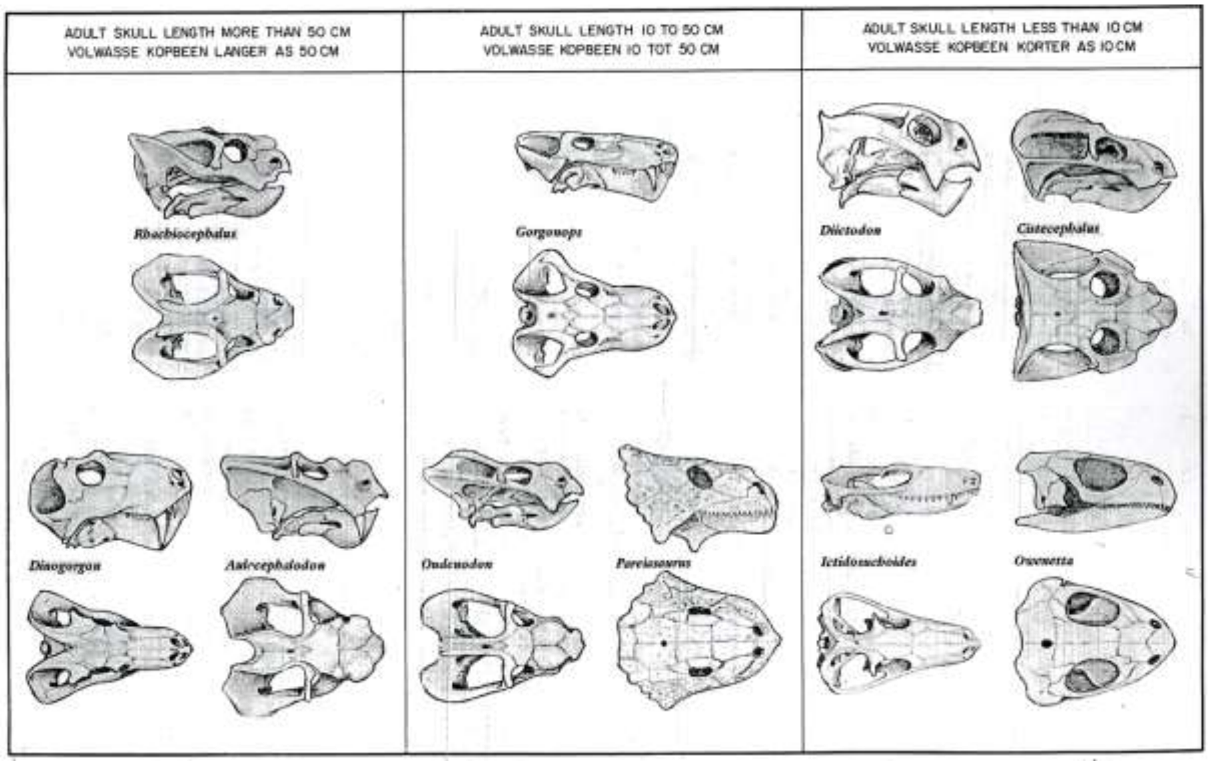

Figure 46. Skulls of characteristic fossil vertebrates from the *Cistecephalus* Assemblage Zone (From Keyser & Smith 1977-1978). *Pareiasaurus* a large herbivore, and *Owenetta*, a small insectivore, are true reptiles. The remainder are therapsids or "mammal-like reptiles". Of these, *Gorgonops* and *Dinogorgon* are large flesh-eating gorgonopsians, *Ictidosuchoides* is an insectivorous therocephalian, while the remainder are small – to large-bodied herbivorous dicynodonts.

The biostratigraphic placement of the Daggaboersnek Member of the Balfour Formation, whose occurrence within the Nxuba Wind Farm study area has not yet been unequivocally established, is less clear. Le Roux and Keyser (1988) report *Cistecephalus* AZ fossils from this member in the Victoria West sheet area, whereas the Daggaboersnek Member on the Middelburg sheet area is assigned to the ***Dicynodon* Assemblage Zone** and this certainly applies to the greater part of the Balfour Formation (Rubidge 1995, Cole *et al*., 2004 p. 21). This younger 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).

Good accounts, with detailed faunal lists, of the rich Late Permian fossil biotas of the *Dicynodon* Assemblage Zone have been given by Kitching (*in* Rubidge 1995) and by Cole *et al*. (2004). See also the reviews by Cluver (1978), MacRae (1999), McCarthy & Rubidge (2005), Almond *et al*. (2008) and Smith *et al.* (2012). In general, the following broad categories of fossils might be expected within the Balfour Formation in the Cookhouse - Bedford area:

- isolated petrified bones as well as articulated skeletons of terrestrial vertebrates such as true **reptiles** (notably large herbivorous pareiasaurs, small lizard-like millerettids and younginids) and **therapsids** (diverse dicynodonts such as *Dicynodon* and the much smaller *Diictodon*, carnivorous gorgonopsians, therocephalians such as *Theriognathus* (= *Whaitsia*), primitive cynodonts like *Procynosuchus*, and biarmosuchians) (See Fig. 47 herein).
- aquatic vertebrates such as large, crocodile-like temnospondyl **amphibians** like *Rhinesuchus* (usually disarticulated), and palaeoniscoid **bony fish** (*Atherstonia*, *Namaichthys*)
- freshwater **bivalves** (*Palaeomutela*)
- **trace fossils** such as worm, arthropod and tetrapod burrows and trackways, coprolites (fossil droppings)
- **vascular plant remains** including leaves, twigs, roots and petrified woods ("*Dadoxylon*") of the *Glossopteris* Flora (usually sparse, fragmentary), especially glossopterids and arthrophytes (horsetails)

The abundance and variety of fossils within the *Dicynodon* Assemblage Zone decreases towards the top of the succession (Cole *et al*., 2004). From a palaeontological viewpoint, these diverse *Dicynodon* AZ 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).

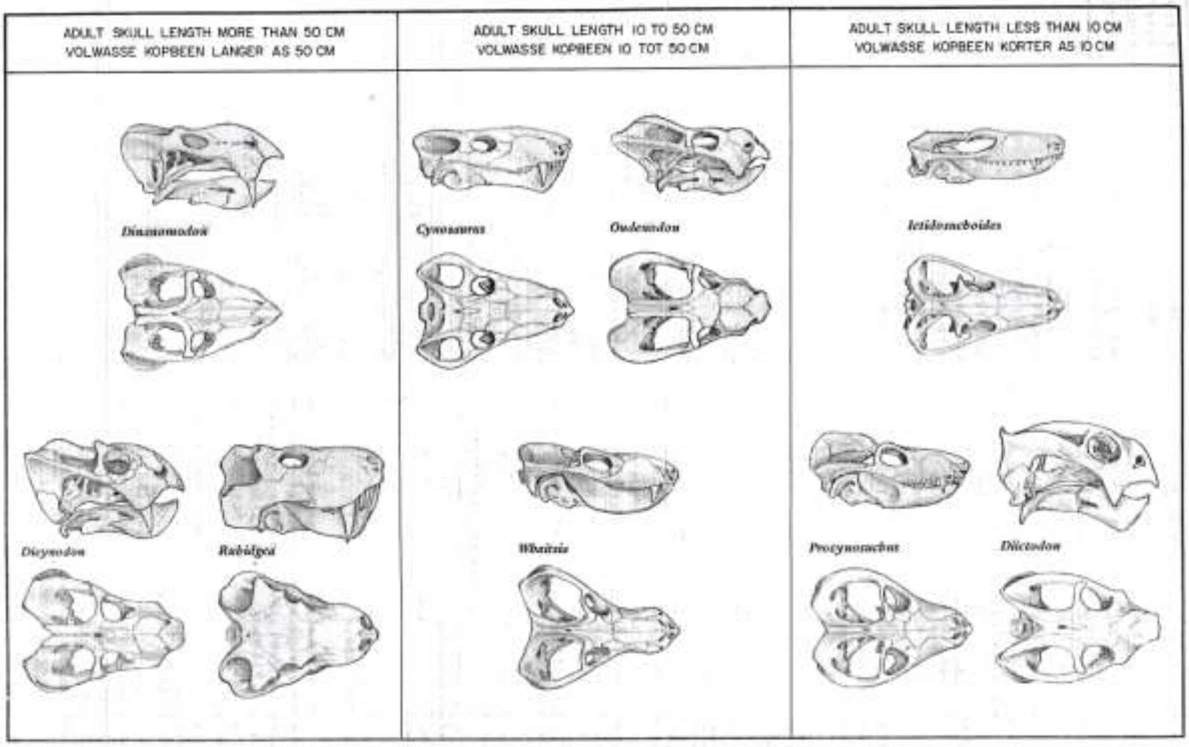

Figure 47. Skulls of characteristic fossil vertebrates – all therapsids - from the *Dicynodon* Assemblage Zone (From Keyser & Smith 1977-1978). Among the dominant therapsids ("mammal-like reptiles"), *Rubidgea* and *Cynosaurus* are carnivorous gorgonopsians, *Whaitsia* (now *Theriognathus*) is a predatory therocephalian while *Ictidosuchoides* is a small insectivorous member of the same group, *Procynosuchus* is a primitive cynodont, and the remainder are large- to small-bodied dicynodont herbivores.

Despite the presence of well-developed pedogenic calcrete horizons at several Balfour Formation bedrock exposures examined within the study area, fossilised tetrapod bones and teeth were only rarely encountered during the field study. At Loc. 419 on Van Wyks Kraal 73 most of the very abundant septarian calcrete concretions were barren of fossils, with the exception of one example containing well-preserved bone in association with very dark sparry calcite (Fig. 49). It is likely that more fossils are in fact present here, but they are very difficult to recognise within the extensively veined nodules.

An isolated large tusk (11 cm long, 2 cm across the base) of a dicynodont therapsid occurs embedded within hackly-grey mudrocks of the Balfour Formation (probably Daggaboersnek Member) on Request 71 (Loc. 387; Fig. 50). According to Cluver and King (1983, p. 239) many of the large-tusked dicynodont genera described in the earlier literature may actually be forms of *Dicynodon*.

A large calcrete nodule containing a fragmentary limb bone and a set of subparallel ribs of a small tetrapod was recorded as float overlying purple-brown Balfour Formation mudrocks at Loc. 394 (Fig. 48).

The most significant fossil vertebrate find during the present field study is the semi-articulated skeleton of an unidentified, medium-sized tetrapod (probable therapsid) preserved within a pedogenic calcrete lens at Loc. 421 on Van Wyks Lraal 73, about one kilometer north of Poseidon Substation (Figs. 51 & 52). The bones are preserved in two separate clumps about a meter apart, and may or may not belong to the same individual. Only post-cranial elements were identified in the field (*e.g.* articulated vertebrae, limb bones, ribs), some showing evidence of sun-cracking, and it is unclear at this stage whether or not the skull is present. Given the general scarcity of tetrapod fossil records in the Cookhouse - Bedford region, this specimen is of research interest and should be formally collected.

Rare invertebrate traces within Balfour Formation channel sandstones include sparse walled cylindrical burrows observed on large scale foresets near the homestead on Van Wyks Kraal 73 (Loc. 403; Fig. 54). The only vertebrate traces recorded were a few isolated sand casts (*c*. 20 cm in diameter) of sizeable, subhorizontal cylindrical tetrapod burrows within a Balfour Formation mudrock package on Van Wyks Kraal 73 (Loc. 401; Fig. 53).

Sicilified fossil wood was nowhere observed *in situ* in the Balfour Formation of the Nxuba Wind Farm study area (as in the Nojoli Wind Farm study area; *cf* Almond 2014). A small number of yellowish-orange petrified wood specimens showing well-developed seasonal growth banding as well as good xylem tissue preservation were recorded as float overlying Balfour streamside and hillslope exposures, however (Locs. 412, 413; Fig. 57). Locally abundant sandstone moulds of compressed, transported woody material up to a meter or more in length was seen towards the erosive base of a major channel sandstone of the Oudeberg Member (just above or within the basal channel breccio-conglomerates) on Van Wyks Kraal 73 (Loc. 405; Figs. 55 & 56). The moulds are coated in ferruginous minerals and show impressions of fibrous woody fabric and knots. They are locally associated with mudrock intraclasts. This new data supports earlier speculations that at least some of the abundant petrified wood material encountered probably comes from the Oudeberg Member of the Balfour Formation (Almond 2014).

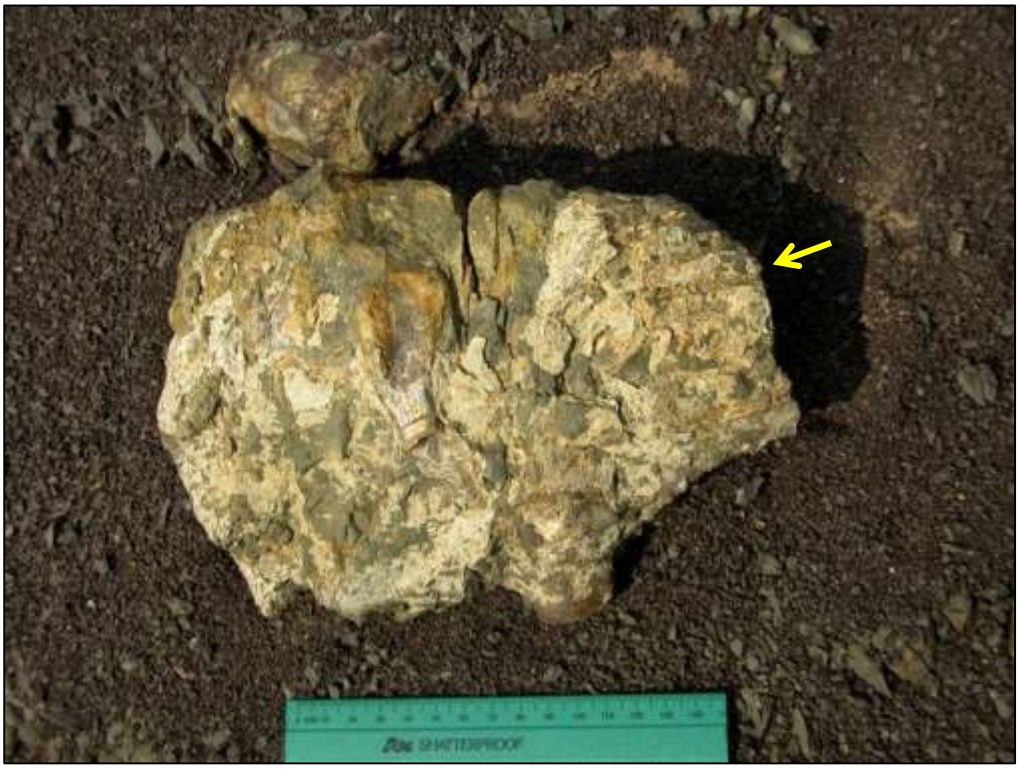

Figure 48. Large calcrete nodule containing a disarticulated limb bone *plus* several parallel ribs (RHS, arrowed) of a small tetrapod (probably therapsid), stream bed exposure of Balfour Group mudrocks on Van Wyks Kraal 73 (Loc 394) (Scale in cm and mm).

Figure 49. Calcrete septarian nodule containing well-preserved bone fragment associated with dark sparry calcite, Van Wyks Kraal 73 (Loc. 419). Nodule is 7.5 cm across.

Figure 50. Isolated canine of a large-tusked dicynodont (possibly *Dicynodon*) embedded in hackly-weathering overbank mudrocks, Request 71 (Loc. 387). (Scale in cm and mm). The tusk appears to show a wear facet towards the tip.

Figure 51. Semi-articulated postcranial remains of a medium-sized tetrapod (probably therapsid) embedded within a lens of pedogenic calcrete, Van Wyks Kraal 73 (Loc. 421) (Hammer = 30 cm).

Figure 52. Concentration of fossil bones within a calcrete lens situated *c*. 1 m away from the specimen illustrated above and possibly belonging to the same individual (Scale in cm).

Figure 53. Probable sand-infilled cylindrical vertebrate burrow within Balfour Formation overbank mudrocks (Scale = 15 cm) (Loc. 401, Van Wyks Kraal 73).

Figure 54. Small cylindrical invertebrate burrow preserved on large channel sandstone foresets, Balfour Formation (Loc. 403, Van Wyks Kraal 73) (Scale in cm and mm).

Figure 55. Ferruginised mould of woody stem with knot embedded within channel sandstone float block, Van Wyks Kraal 73 (Loc. 405) (Scale in cm). See following figure for provenance.

Figure 56. Basal contact of the major channel sandstone (Oudeberg Member) seen in Figure 55 showing a thin basal breccia of reworked mudrock intraclasts and calcrete nodules overlain by pale buff sandstones with abundant moulds of woody plant material (arrowed) (Scale = 15 cm), (Loc. 405 on Van Wyks Kraal 73).

Figure 57. Small float block of well-preserved silicified wood weathered out from the Balfour Formation (Loc. 412, Van Wyks Kraal 73). Note clear seasonal growth lines (Scale in cm).

4.2. Karoo Dolerite Suite

The very minor dolerite outcrops within the study area (*e.g.* Loc. 384) (Fig. 29) are in themselves of no palaeontological significance since these are high temperature igneous rocks emplaced at depth within the Earth's crust. However, as a consequence of their proximity to subsurface dolerite intrusions, the Beaufort Group sediments appear locally to have been thermally metamorphosed or "baked" (*i.e*. recrystallised, impregnated with secondary minerals). Embedded fossil material of phosphatic composition, such as bones and teeth, is frequently altered by baking – bones may become blackened, for example - and can be very difficult to extract from the hard matrix by mechanical preparation (Smith & Keyser, p. 23 *in* Rubidge 1995). Thermal metamorphism by dolerite intrusions therefore tends to reduce the palaeontological heritage potential of Beaufort Group sediments.

4.3. Late Caenozoic superficial deposits

Various types of superficial deposits ("drift") of geologically young, Late Caenozoic (Miocene / Pliocene to Recent) age occur throughout the Great Karoo region. They include pedocretes (*e.g.* calcretes), colluvial slope deposits (sandstone and dolerite scree *etc*), river alluvium, as well as spring and pan sediments (*e.g.* Partridge *et al*. 2006). These Karoo drift deposits have been comparatively neglected in palaeontological terms for the most part. However, older (Quaternary) alluvial sediments, such as seen along larger stream valleys on Klipfonteyn 150, may occasionally contain important fossil biotas, notably the bones, teeth and horn cores of mammals (*e.g.* Skead 1980, Klein 1984, MacRae 1999, Partridge & Scott 2000, Brink & Rossouw 2000, Churchill *et al.* 2000, Rossouw 2006). 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, *rhizoliths* or plant root casts), and plant remains such as peats or palynomorphs (pollens) in organic-rich alluvial horizons.

Within the heavily calcretised older alluvium seen in the Nxuba Wind Farm study area elongate, subcylindrical to branching casts of invertebrate burrows or plant roots (i.e. rhizoliths) may occasionally be seen (*e.g*. Loc. 393; Fig. 58). Small pieces of ferruginised and silicified wood reworked from the Balfour Formation bedrocks occur locally at or near-surface (Loc. 407; Fig. 59) (*cf* Nojoli Wind Farm study area to the south; Almond 2014). Some well-consolidated beds of older alluvium display highly bioturbated textures, probably attributable to burrowing invertebrates such as insects (Loc. 432).

Pale, unmineralised (light, porous) and often sun-cracked bones of mammals occur within the unconsolidated younger alluvium and are regarded as subfossil or even Recent in origin (*e.g.* Locs. 392, 407, 410; Fig. 59) A good example if the skull with articulated mandible of an unidentified large mammal shown in Fig. 60. They are usually disarticulated and often show evidence of sun-cracking.

Figure 58. Elongate, subcylindrical calcretised casts of roots (rhizoliths) or invertebrate borrows, older alluvial deposits on Van Wyks Kraal (Loc. 393) (Scale in cm and mm).

Figure 59. Small fragments of reworked, ferruginised petrified wood as well as unmineralised disarticulated subfossil bone on surface of older alluvium, Van Wyks Kraal 73 (Loc. 407) (Scale in cm and mm).

Figure 60. Unmineralised subfossil skull of a large mammal embedded in silty younger alluvial deposits, Van Wyks Kraal 73 (Loc. 412) (Scale in cm).

5. CONCLUSIONS AND RECOMMENDATIONS

The Nxuba Wind Farm project area is almost entirely underlain by potentially fossiliferous fluvial sediments of the Karoo Supergroup of Late Permian age but bedrock exposure levels here are very limited indeed. The Lower Beaufort Group sediments (Balfour Formation of the Adelaide Subgroup) underlying the study area contain important fossils of terrestrial animals such as reptiles and therapsids ("mammal-like reptiles") as well as representatives of the Late Permian *Glossopteris* Flora of Gondwana. However, the present five-day field palaeontological field assessment, as well as a number of recent field studies carried out in the Cookhouse – Middleton – Bedford area and existing Karoo fossil databases, suggest that Late Permian vertebrate remains tend to be very sparse in this part of the Eastern Cape, even where bedrock exposure is good.

Sparse fossil material recorded from the Balfour Formation within the Nxuba Wind Farm project area during the present field study, all from Van Wyks Kraal 73, includes (1) three fossil vertebrate localities (one of which features the semi-articulated skeleton of a medium-sized therapsid); (2) rare fossil invertebrate and vertebrate burrows; (3) rare float specimens of well-preserved petrified wood and (4) dense concentrations of woody plant moulds within the base of a channel sandstone. Key fossil sites are indicated on a satellite image of the study area in Fig. 61 herein.

The great majority of infrastructure developments (*e.g.* wind turbines, access roads) for the proposed Nxuba Wind Farm are located in elevated plateau or ridge areas where exposure of Beaufort Group bedrocks is poor, due to soil and vegetation cover, and no fossil remains were recorded is these areas during the field assessment. Significant impacts on thick, potentially fossiliferous Pleistocene alluvium in major stream valleys, such as that running between the Van Wyks Kraal and Roberts Kraal homestead, are not anticipated. The inferred impact significance of the proposed Nxuba Wind Farm project as far as palaeontological heritage is concerned is LOW (negative). Confidence levels for this assessment are moderate, given the limited bedrock exposure within most of the study area.

Unless significant new fossil finds are made during the construction phase of the development, further specialist palaeontological studies or mitigation of the project are not regarded as warranted here. Given the scarcity of fossil remains in the broader region, the cumulative impact on fossil heritage of the Nxuba Wind Farm in conjunction with several other wind energy projects in the Cookhouse - Middleton - Bedford region of the Eastern Cape is probably low.

The ECO for the project should be alerted to the potential for, and scientific significance of, new fossil finds during the construction phase of the development. They should familiarise themselves with the sort of fossils concerned through museum displays and accessible, well-illustrated literature.

Should important new fossil remains such as vertebrate bones and teeth, plant-rich fossil lenses or dense fossil burrow assemblages be exposed during construction, the responsible Environmental Control Officer should alert ECPHRA (*i.e.* The Eastern Cape Provincial Heritage Resources Authority. Contact details: Mr Sello Mokhanya, 74 Alexander Road, King Williams Town 5600; smokhanya@ecphra.org.za) as soon as possible so that appropriate action can be taken in good time by a professional palaeontologist at the developer's expense.

Palaeontological mitigation would normally involve the scientific recording and judicious sampling or collection of fossil material as well as of associated geological data (*e.g.* stratigraphy, sedimentology, taphonomy). The palaeontologist concerned with mitigation work will need a valid fossil collection permit from SAHRA (Contact details: Mrs Colette Scheermeyer, P.O. Box 4637, Cape Town 8000. Tel: 021 462 4502. Email: cscheermeyer@sahra.org.za) and any material collected would have to be curated in an approved depository (*e.g.* museum or university collection).

All palaeontological specialist work should conform to international best practice for palaeontological fieldwork and the study (*e.g.* data recording fossil collection and curation, final report) should adhere as far as possible to the minimum standards for Phase 2 palaeontological studies recently developed by SAHRA (2013). These recommendations should be incorporated into the EMP for the Nxuba Wind Farm project.

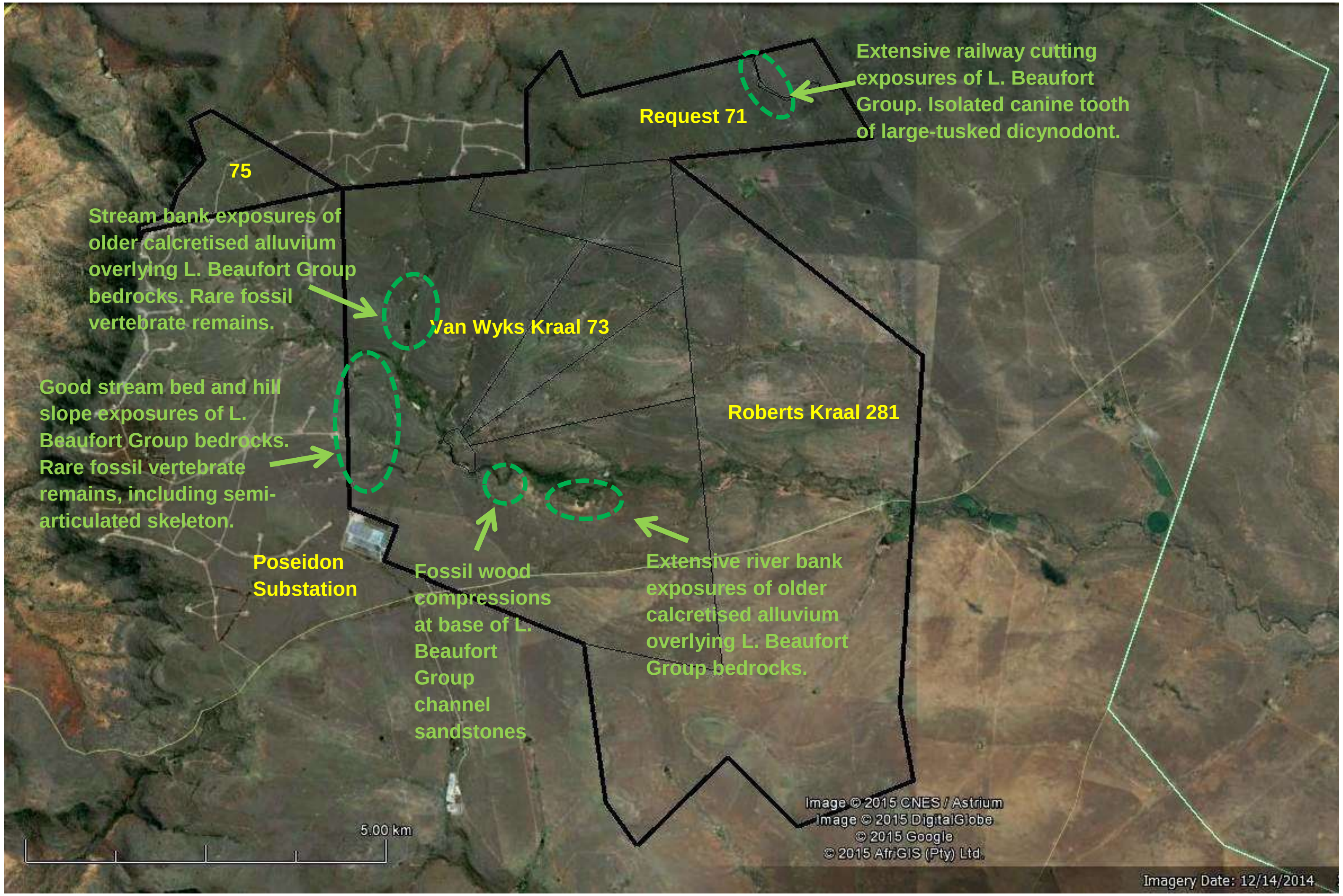

Fig. 61. Google earth© satellite image of the Nxuba Wind Farm study area situated in hilly terrain between the towns of Cookhouse and Bedford, Eastern Cape (black polygon). Areas of palaeontological interest are highlighted (see text).

6. ACKNOWLEDGEMENTS

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7. REFERENCES

ALMOND, J.E. 2009. Proposed wind energy facility near Cookhouse, Western District Municipality, Eastern Cape Province. Unpublished impact report prepared for Savannah Environmental (Pty) Ltd by Natura Viva cc, Cape Town, 12pp.

ALMOND, J.E. 2010a. Eskom Gamma-Omega 765kV transmission line: Phase 2 palaeontological impact assessment. Sector 1, Tanqua Karoo to Omega Substation (Western and Northern Cape Provinces), 95 pp + appendix. Natura Viva cc, Cape Town.

ALMOND, J.E. 2010b. Palaeontological impact assessment: Cookhouse wind energy project, Blue Crane Route Local Municipality, Eastern Cape Province of South Africa. Unpublished impact report prepared for Coastal & Environmental Services, Grahamstown by Natura Viva cc, Cape Town, 45 pp.

ALMOND, J.E. 2011. Proposed Middleton Wind Energy Project, Blue Crane Route Local Municipality. Palaeontological Impact Assessment, 48 pp. Natura Viva cc, Cape Town.

ALMOND, J.E. 2013a. Proposed Spitskop Wind Energy Facility, Somerset East and Albany Magisterial Districts, Eastern Cape Province. Palaeontological specialist study: combined desktop & field-based assessment, 81 pp. Natura Viva cc, Cape Town.

ALMOND, J.E. 2013b. Proposed 16 Mtpa expansion of Transnet's existing manganese ore export railway line & associated infrastructure between Hotazel and the Port of Ngqura, Northern & Eastern Cape. Part 2: De Aar to the Coega IDZ, Northern and Eastern Cape. Palaeontological specialist assessment: combined desktop and field-based study, 76 pp. Natura Viva cc, Cape Town.

ALMOND, J.E. 2013c. Palaeontological impact assessment – Middleton Wind Energy Facility, Eastern Cape Province, 69 pp. Natura Viva cc, Cape Town.

ALMOND, J.E. 2014. Proposed Nojoli Wind Farm near Cookhouse, Blue Crane Municipality, Eastern Cape. Palaeontological specialist assessment: combined desktop and field-based study, 69 PP. Natura Viva cc, Cape Town.

ALMOND, J.E., DE KLERK, W.J. & GESS, R. 2008. Palaeontological heritage of the Eastern Cape. Draft report for SAHRA, 20 pp. *Natura Viva* cc, Cape Town.

ANDERSON, A.M. 1974. Arthropod trackways and other trace fossils from the Early Permian lower Karoo Beds of South Africa. Unpublished PhD thesis, University of Witwatersrand, Johannesburg, 172 pp.

ANDERSON, A.M. 1975. Turbidites and arthropod trackways in the Dwyka glacial deposits (Early Permian) of southern Africa. Transactions of the Geological Society of South Africa 78: 265-273.

ANDERSON, A.M. 1976. Fish trails from the Early Permian of South Africa. Palaeontology 19: 397-409, pl. 54.

ANDERSON, A.M. 1981. The *Umfolozia* arthropod trackways in the Permian Dwyka and Ecca Groups of South Africa. Journal of Paleontology 55: 84-108, pls. 1-4.

ANDERSON, J.M. & ANDERSON, H.M. 1985. Palaeoflora of southern Africa. Prodromus of South African megafloras, Devonian to Lower Cretaceous, 423 pp. Botanical Research Institute, Pretoria & Balkema, Rotterdam.

BAMFORD, M. 1999. Permo-Triassic fossil woods from the South African Karoo Basin. Palaeontologia africana 35, 25-40.

BAMFORD, M.K. 2004. Diversity of woody vegetation of Gondwanan southern Africa. Gondwana Research 7, 153-164.

BENDER, P.A. 2004. Late Permian actinopterygian (palaeoniscid) fishes from the Beaufort Group, South Africa: biostratigraphic and biogeographic implications. Bulletin 135, 84pp. Council for Geoscience, Pretoria.

BENDER, P.A., RUBIDGE, B.S., GARDINER, B.S., LOOCK. J.C. & BREMNER, A.T. 1991. The stratigraphic range of the palaeoniscoid fish Namaichthys digitata in rocks of the Karoo sequence and its palaeoenvironmental significance. South African Journal of Science 87: 468-469.

BENTON, M.J. 2003. When life nearly died. The greatest mass extinction of all time, 336 pp. Thames & Hudson Ltd., London.

BLIGNAULT, J.J.G., ROSSOUW, P.J., DE VILLIERS, J. & RUSSELL, H.D. 1948. The geology of the Schoorsteenberg area, Cape Province, 40 pp. Geological Survey of South Africa / Council for Geoscience, Pretoria.

BOTHA, J. & ANGIELCZYK, K.D. 2007. An integrative approach to distinguishing the Late Permian dicynodont species *Oudenodon bainii* and *Tropidistoma microtrema* (Therapsida: Anomodontia). Palaeontology 50, 1175-1209.

BRINK, J.S. & ROSSOUW, L. 2000. New trial excavations at the Cornelia-Uitzoek type locality. Navorsinge van die Nasionale Museum Bloemfontein 16, 141-156.

BUATOIS, L. & MANGANO, M.G. 1991. Trace fossils from a Carboniferous turbiditic lake: implications for the recognition of additional nonmarine ichnofacies. Ichnos 2: 237-258.

BUATOIS, L. & MANGANO, M.G. 1995. The paleoenvironmental and paleoecological significance of the lacustrine *Mermia* ichnofacies: an archetypal subaqueous nonmarine trace fossil assemblage. Ichnos 4: 151-161.

BUATOIS, L. & MANGANO, M.G. 2004. Animal-substrate interactions in freshwater environments: applications of ichnology in facies and sequence stratigraphic analysis of fluvio-lacustrine successions. In: McIlroy, D. (Ed.) The application of ichnology to palaeoenvironmental and stratigraphic analysis. Geological Society, London, Special Publications 228, pp 311-333.

BUATOIS, L.A. & MÁNGANO, M.G. 2007. Invertebrate ichnology of continental freshwater environments. In: Miller, W. III (Ed.) Trace fossils: concepts, problems, prospects, pp. 285-323. Elsevier, Amsterdam.

CATUNEANU, O., WOPFNER, H., ERIKSSON, P.G., CAIRNCROSS, B., RUBIDGE, B.S., SMITH, R.M.H. & HANCOX, P.J. 2005. The Karoo basins of south-central Africa. Journal of African Earth Sciences 43, 211-253.

CATUNEANU, O. & BOWKER, D. 2001. Sequence stratigraphy of the Koonap and Middleton fluvial formations in the Karoo foredeep, South Africa. African Earth Sciences 33, 579-595.

CATUNEANU, O. AND ELANGO, H.N. 2001. Tectonic control on fluvial styles: the Balfour Formation of the Karoo Basin, South Africa. Sedimentary Geology 140, 291-313.

CHURCHER, C.S. 1986. The extinct Cape Zebra. Sagittarius 1(4), 4-5.

CHURCHER, C.S. 2006. Distribution and history of the Cape zebra (*Equus capensis*) in the Quarternary of Africa. Transactions of the Royal Society of South Africa 61, 89-95.

CHURCHILL, S.E. *et al.* 2000. Erfkroon: a new Florisian fossil locality from fluvial contexts in the western Free State, South Africa. South African Journal of Science 96: 161-163.

CICHAN, M. A. AND TAYLOR, T.N. 1982. Wood-borings in *Premnoxylon*: Plant-animal interactions in the Carboniferous. Palaeogeography, Palaeoclimatology, Palaeoecology 39, 123–127.

CLUVER, M.A. 1978. Fossil reptiles of the South African Karoo, 54pp. South African Museum, Cape Town.

CLUVER, M.A. & KING, G.M. 1983. A reassessment of the relationships of Permian Dicynodontia (Reptilia, Therapsida) and a new classification of dicynodonts. Annals of the South African Museum 91, 195-273.

COLE, D.I., NEVELING, J., HATTINGH, J., CHEVALLIER, L.P., REDDERING, J.S.V. & BENDER, P.A. 2004. The geology of the Middelburg area. Explanation to 1: 250 000 geology Sheet 3124 Middelburg, 44 pp. Council for Geoscience, Pretoria.

COOPER, M.R. & KENSLEY, B. 1984. Endemic South American Permian bivalve molluscs from the Ecca of South Africa. Journal of Paleontology 58: 1360-1363.

DAY, M., RUBIDGE, B., ALMOND, J. & JIRAH, S. 2013. Biostratigraphic correlation in the Karoo: the case of the Middle Permian parareptile *Eunotosaurus*. South African Journal of Science 109, 1-4.

DE KLERK, W.J. 2010. Palaeontological heritage impact assessment of a proposed wind energy facility to be situated on a site south-east of Cookhouse and south of Bedford in the Eastern Cape Province. The Amakhala Emoyeni Wind Energy Facility, 15 pp. Albany Museum Earth Sciences, Grahamstown.

DE WIT, M.C.J., MARSHALL, T.R. & PARTRIDGE, T.C. 2000. Fluvial deposits and drainage evolution. In: Partridge, T.C. & Maud, R.R. (eds.) The Cenozoic of Southern Africa, pp.55-72. Oxford University Press, Oxford.

DUNCAN & MARSH 2006. The Karoo Igneous Province. In: Johnson, M.R., Anhaeusser, C.R. & Thomas, R.J. (Eds.) The geology of South Africa, pp. 501-520. Geological Society of South Africa, Marshalltown.

DURAND, J.F. 2012. Palaeontological survey of proposed wind energy facility at Cookhouse, Eastern Cape Province, 16 pp.

GOTH, K. AND WILDE, V. 1992. Fraβpuren in permischen Hölzern aus der Wetterau. Senckenbergiana Lethaea 72, 1–6.

HAUGHTON, S.H. 1928. The geology of the country between Grahamstown and Port Elizabeth. An explanation of Cape Sheet No. 9 (Port Elizabeth), 45 pp. Geological Survey / Council for Geoscience, Pretoria.

HILL, R.S. 1993. The geology of the Graaff-Reinet area. Explanation to 1: 250 000 geology Sheet 3224 Graaff-Reinet, 31 pp. Council for Geoscience, Pretoria.

JACOBSEN, L., LOOCK, J.C., VAN DER WESTHUIZEN, W.A., HUFFMAN, T.N. & DREYER, J.J.B. 2003. The occurrence of vitrified dung from the Kamdeboo district, southern Karoo, and Den Straat, Limpopo Valley, South Africa: research in action. South African Journal of Science 99, 26-28.

JOHNSON, M.R. 1976. Stratigraphy and sedimentology of the Cape and Karoo sequences in the Eastern Cape province. Unpublished PhD thesis, Rhodes University, Grahamstown, 336 pp.

JOHNSON, M.R. 1989. Britskraal Member. Catalogue of South African Lithostratigraphic Units 1, 2 pp.

JOHNSON, M.R. (Ed.) 1994. Lexicon of South African stratigraphy. Part 1: Phanerozoic units, 56 pp. South African Committee for Stratigraphy, Council for Geoscience, Pretoria.

JOHNSON, M.R. & KINGSLEY, C.S. 1993. Lithostratigraphy of the Ripon Formation (Ecca Group), including the Pluto's Vale, Wonderfontein and Trumpeters Members. South African Committee for Stratigraphy, Lithostratigraphic Series No. 26, 8 pp.

JOHNSON, M.R., VAN VUUREN, C.J., VISSER, J.N.J., COLE, D.I., DE V. WICKENS, H., CHRISTIE, A.D.M., ROBERTS, D.L. & BRANDL, G. 2006. Sedimentary rocks of the Karoo Supergroup. In: Johnson, M.R., Anhaeusser, C.R. & Thomas, R.J. (Eds.) The geology of South Africa, pp. 461-499. Geological Society of South Africa, Marshalltown.

KAISER, T.M. & FRANZ-ODENDAAL, T.A. 2004. A mixed-feeding *Equus* species from the Middle Pleistocene of South Africa. Quaternary Research 62, 316-323.

KATEMAUNZANGA, D. 2009. Lithostratigraphy, sedimentology and provenance of the Balfour Formation (Beaufort Group) in the Fort Beaufort-Alice, Eastern Cape Province, South Africa. Unpublished M.Sc. Thesis, University of Fort Hare, 1-140.

KEYSER, A.W. & SMITH, R.M.H. 1977-78. Vertebrate biozonation of the Beaufort Group with special reference to the western Karoo Basin. Annals of the Geological Survey of South Africa 12, 1-35.

KINGSLEY, C.S. 1977. Stratigraphy and sedimentology of the Ecca Group in the Eastern Cape Province, South Africa. Unpublished PhD thesis, University of Port Elizabeth, 286 pp.

KINGSLEY, C.S. 1981. A composite submarine fan – delta – fluvial model for the Ecca and Lower Beaufort Groups of Permian age in the Eastern Cape Province, South Africa. Transactions of the Geological Society of South Africa 84, 27-40.

KITCHING, J.W. 1977. The distribution of the Karroo vertebrate fauna, with special reference to certain genera and the bearing of this distribution on the zoning of the Beaufort beds. Memoirs of the Bernard Price Institute for Palaeontological Research, University of the Witwatersrand, No. 1, 133 pp (incl. 15 pls).

KLEIN, R. 1980. Environmental and ecological implications of large mammals from Upper Pleistocene and Hoocene sites in southern Africa. Annals of the South African Museum 81, 223-283.

KLEIN, R.G. 1984. The large mammals of southern Africa: Late Pliocene to Recent. In: Klein, R.G. (Ed.) Southern African prehistory and paleoenvironments, pp 107-146. Balkema, Rotterdam.

LOCK, B.E. & JOHNSON, M.R. 1976. A crystal tuff from the Ecca Group near Lake Mentz, eastern Cape Province. Transactions of the Geological Society of South Africa 77, 373-374.

LUCAS, D.G. 2009. Global Middle Permian reptile mass extinction: the dinocephalian extinction event. Geological Society of America Abstracts with Programs 41, No. 7, p. 360

MACRAE, C. 1999. Life etched in stone. Fossils of South Africa. 305pp. The Geological Society of South Africa, Johannesburg.

MCCARTHY, T. & RUBIDGE, B. 2005. The story of Earth and life: a southern African perspective on a 4.6-billion-year journey. 334pp. Struik, Cape Town.

MODESTO, S.P., RUBIDGE, B.S., DE KLERK, W.J. & WELMAN, J. 2001. A dinocephalian therapsid fauna on the Ecca-Beaufort contact in Eastern Cape Province, South Africa. South African Journal of Science 97, 161-163.

MOUNTAIN, E.D. 1946. The geology of an area east of Grahamstown. An explanation of Sheet No. 136 (Grahamstown), 56 pp. Geological Survey / Council for Geoscience, Pretoria.

NETTERBERG, F. 1969a. Ages of calcretes in southern Africa. South African Archaeological Bulletin 24, 88-92.

NETTERBERG, F. 1969b. Interpretation of some basic calcrete types. South African Archaeological Bulletin 24, 117-122.

NETTERBERG, F. 1978. Dating and correlation of calcretes and other pedocretes. Transactions of the Geological Society of South Africa 81, 379-391.

NETTERBERG, F. 1980. Geology of South African calcretes: 1. Terminology, description, macrofeatures, and classification. Transactions of the Geological Society of South Africa 83, 255-283.

NETTERBERG, F. 1985. Pedocretes in Engineering geology of southern Africa 4: Post-Gondwana deposits (Ed. Brink, A.B.A.), 286-307.

NICOLAS, M.V. 2007. Tetrapod diversity through the Permo-Triassic Beaufort Group (Karoo Supergroup) of South Africa. Unpublished PhD thesis, University of Witwatersrand, Johannesburg.

NICOLAS, M. & RUBIDGE, B.S. 2010. Changes in Permo-Triassic terrestrial tetrapod ecological representation in the Beaufort Group (Karoo Supergroup) of South Africa. Lethaia 43, 45-59.

OGHENEKOME, M.E. 2012. Sedimentary environments and provenance of the Balfour Formation (Beaufort Group) in the area between Bedford and Adelaide, Eastern Cape Province, South Africa. Unpublished MSc thesis, University of Fort Hare, 132 pp.

PARTRIDGE, T.C., BOTHA, G.A. & HADDON, I.G. 2006. Cenozoic deposits of the interior. In: Johnson, M.R., Anhaeusser, C.R. & Thomas, R.J. (Eds.) The geology of South Africa, pp. 585-604. Geological Society of South Africa, Marshalltown.

PARTRIDGE, T.C. & SCOTT, L. 2000. Lakes and pans. In: Partridge, T.C. & Maud, R.R. (Eds.) The Cenozoic of southern Africa, pp.145-161. Oxford University Press, Oxford.

PETER, B. 2001. Vitrified dung in archaeological contexts: an experimental study on the process of its formation in the Mosu and Bobirwa areas. Pula: Botswana Journal of African Studies 15, 125-143.

RETALLACK, G.J., METZGER, C.A., GREAVER, T., HOPE JAHREN, A., SMITH, R.M.H. & SHELDON, N.D. 2006. Middle-Late Permian mass extinctions on land. GSA Buletin 118, 1398-1411.

ROSSOUW, L. 2006. Florisian mammal fossils from erosional gullies along the Modder River at Mitasrust Farm, Central Free State, South Africa. Navorsinge van die Nasionale Museum Bloemfontein 22, 145-162.

RUBIDGE, B.S. (Ed.) 1995. Biostratigraphy of the Beaufort Group (Karoo Supergroup). 46pp. South African Committee for Stratigraphy, Biostratigraphic Series No. 1. Council for Geoscience, Pretoria.

RUBIDGE, B.S. 2005. Re-uniting lost continents – fossil reptiles from the ancient Karoo and their wanderlust. South African Journal of Geology 108: 135-172.

RUBIDGE, B.S. & OELOFSEN, B.W. 1981. Reptilian fauna from Ecca rocks near Prince Albert, South Africa. South African Journal of Science 77, 425-426.

RUBIDGE, B.S., HANCOX, P.J. & CATUNEANU, O. 2000. Sequence analysis of the Ecca-Beaufort contact in the southern Karoo of South Africa. South African Journal of Geology 103, 81-96.

RUBIDGE, B., DE KLERK, B. & ALMOND, J. 2008. Southern Karoo margins, Swartberg and Little Karoo. Palaeontological Society of South Africa, 15th biennial meeting, Matjiesfontein, Post-conference field excursion guide, 35 pp. Natura Viva cc, Cape Town.

RUBIDGE, B.S., ERWIN, D.H., RAMEZANI, J., BOWRING, S.A. & DE KLERK, W.J. 2010. The first radiometric dates for the Beaufort Group, Karoo Supergroup of South Africa. Proceedings of the 16th conference of the Palaeontological Society of Southern Africa, Howick, August 5-8, 2010, pp. 82-83.

RUBIDGE, B.S., ERWIN, D.H., RAMEZANI, J., BOWRING, S.A. & DE KLERK, W.J. 2013. High-precision temporal calibration of Late Permian vertebrate biostratigraphy: U-Pb zircon constraints from the Karoo Supergroup, South Africa. Geology published online 4 January 2013. doi: 10.1130/G33622.1.

SAHRA 2013. Minimum standards: palaeontological component of heritage impact assessment reports, 15 pp. South African Heritage Resources Agency, Cape Town.

SKEAD, C.J. 1980. Historical mammal incidence in the Cape Province. Volume 1: The Western and Northern Cape. 903pp. Department of Nature and Environmental Conservation, Cape Town.

SMITH, R.M.H. 1993a. Sedimentology and ichnology of floodplain paleosurfaces in the Beaufort Group (Late Permian), Karoo Sequence, South Africa. Palaios 8, 339-357.

SMITH, R.M.H. 1993b. Vertebrate taphonomy of Late Permian floodplain deposits in the southwestern Karoo Basin of South Africa. Palaios 8: 45-67.

SMITH, R.M.H. & KEYSER, A.W. 1995a. Biostratigraphy of the *Tapinocephalus* Assemblage Zone. Pp. 8-12 *in* Rubidge, B.S. (ed.) Biostratigraphy of the Beaufort Group (Karoo Supergroup). South African Committee for Stratigraphy, Biostratigraphic Series No. 1. Council for Geoscience, Pretoria.

SMITH, R.M.H. & KEYSER, A.W. 1995b. Biostratigraphy of the *Pristerognathus* Assemblage Zone. Pp. 13-17 *in* Rubidge, B.S. (ed.) *Biostratigraphy of the Beaufort Group (Karoo Supergroup).* South African Committee for Stratigraphy, Biostratigraphic Series No. 1. Council for Geoscience, Pretoria.

SMITH, R.M.H. & KEYSER, A.W. 1995c. Biostratigraphy of the *Tropidostoma* Assemblage Zone. Pp. 18-22 *in* Rubidge, B.S. (ed.) Biostratigraphy of the Beaufort Group (Karoo Supergroup). South African Committee for Stratigraphy, Biostratigraphic Series No. 1. Council for Geoscience, Pretoria.

SMITH, R.M.H. & ALMOND, J.E. 1998. Late Permian continental trace assemblages from the Lower Beaufort Group (Karoo Supergroup), South Africa. Abstracts, Tercera Reunión Argentina de Icnologia, Mar del Plata, 1998, p. 29.

SMITH, R.H.M. & WARD, P.D. 2001. Pattern of vertebrate extinction across an event bed at the Permian-Triassic boundary in the Karoo Basin of South Africa. Geology 29, 1147-1150.

SMITH, R., RUBIDGE, B. & VAN DER WALT, M. 2012. Therapsid biodiversity patterns and paleoenvironments of the Karoo Basin, South Africa. Chapter 2 pp. 30-62 in Chinsamy-Turan, A. (Ed.) Forerunners of mammals. Radiation, histology, biology. xv + 330 pp. Indiana University Press, Bloomington & Indianapolis.

STEAR, W.M. 1978. Sedimentary structures related to fluctuating hydrodynamic conditions in flood plain deposits of the Beaufort Group near Beaufort West, Cape. Transactions of the Geological Society of South Africa 81, 393-399.

THERON, J.N. 1983. Die geologie van die gebied Sutherland. Explanation of 1: 250 000 geological Sheet 3220, 29 pp. Council for Geoscience, Pretoria.

TOERIEN, D.K. & HILL, R.S. 1989. The geology of the Port Elizabeth area. Explanation to 1: 250 000 geology Sheet 3324 Port Elizabeth, 35 pp. Council for Geoscience. Pretoria.

TORDIFFE, E.A.W. 1978. Aspects of the hydrogeochemistry of the Karoo sequence in the Great Fish River basin, Eastern Cape Province. Unpublished Ph.D. Thesis, University of the Orange Free State, Bloemfontein, 307 pp.

TORDIFFE, E.A.W., BOTHA, B.J.V. AND LOOCK, J.C. 1985. The relationship between the geology and the groundwater quality of the Great Fish River catchment north of Kommadagga. Water South Africa 11, 99-106.

VAN DER WALT, M., DAY, M., RUBIDGE, B., COOPER, A.K. & NETTERBERG, I. 2010. A new GIS-based biozone map of the Beaufort Group (Karoo Supergroup), South Africa. Palaeontologia Africana 45, 1-5.

VILJOEN, J.H.A. 1989. Die geologie van die gebied Williston. Explanation to geology sheet 3120 Williston, 30 pp. Council for Geoscience, Pretoria.

VISSER, J.N.J. AND DUKAS, B.A. 1979. Upward-fining fluviatile megacycles in the Beaufort Group, north of Graaff-Reinet, Cape Province. Transactions of the Geological Society of South Africa 82, 149-154.

WALKER, F. & POLDEVAART, A. 1949. Karroo dolerites of the Union of South Africa. Bulletin of the Geological Society of America 60, 591-706.

WICKENS, H. DE V. 1984. Die stratigraphie en sedimentologie van die Group Ecca wes van Sutherland. Unpublished MSc thesis, University of Port Elizabeth, viii + 86 pp.

WICKENS, H. DE V. 1996. Die stratigraphie en sedimentologie van die Ecca Groep wes van Sutherland. Council for Geosciences, Pretoria Bulletin 107, 49pp.

8. QUALIFICATIONS & EXPERIENCE OF THE AUTHOR

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

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

Dr John E. Almond
Palaeontologist, *Natura Viva* cc

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.

LOC. NO.	GPS POSITION	COMMENTS
384	32 41 12.4 S 25 58 17.1 E	Request 71. Low dolerite bedrock exposures, corestones, colluvial and downwasted gravels of dolerite and Beaufort sandstone on crest of hill.
386	32 41 10.7 S 25 58 51.6 E	Request 71. Extensive railway cutting into sandstone and mudrock packages of the Balfour Formation (possibly Daggaboersnek Mb) overlain by calcretised & ferricretised older alluvial soils with embedded MSA artefacts.
387	32 41 11.3 S 25 58 51.8 E	Request 71. Isolated large dicynodont tusk (possibly *Dicynodon*), railway cutting exposure of Balfour Fm (Daggaboersnek Mb).
388	32 41 26.7 S 25 58 11.3 E	Request 71. Small farm dam excavated into thick alluvial soils.
389	32 41 56.8 S 25 56 52.7 E	Request 71. Viewpoint from crest of hill. Sparse downwasted surface gravels and possible alluvial cobbles of sandstone, quartzite, hornfels, dolerite.
390	32 42 26.6 S 25 56 34.2 E	Van Wyks Kraal 73. Upland surface exposure of well-jointed Beaufort Group channel sandstone.
391	32 43 09.5 S 25 56 06.3 E	Van Wyks Kraal 73. Sandstone colluvial gravels at surface and base of soil profile.
392	32 43 20.5 S 25 56 16.0 E	Van Wyks Kraal 73. Donga exposure of calcretised older alluvium overlain by younger alluvium (with embedded sun-cracked bone) and soil.
393	32 43 24.1 S 25 56 17.9 E	Van Wyks Kraal 73. Donga exposure of calcretised older alluvium overlying Lower Beaufort Group bedrock. Possible calcretised rhizoliths.
394	32 43 27.6 S 25 56 19.1 E	Van Wyks Kraal 73. Bone breccia and articulated small ribs (or gastralia) of probable small therapsid with large palaeocalcrete nodule.
395	32 43 20.3 S 25 56 18.9 E	Van Wyks Kraal 73. Debris flow diamictite of younger brown soil and sparse sandstone blocks overlying older calcretised alluvium, stream bank exposure.
396	32 43 19.5 S 25 56 18.7 E	Van Wyks Kraal 73. Debris flow diamictite with large, angular sandstone blocks, stream bank exposure.
397	32 43 18.4 S 25 56 19.3 E	Stream bank and bed exposure of sandstone package within Balfour Formation.

398	32 42 48.3 S 25 55 52.1 E	Van Wyks Kraal 73. Stream bank and donga exposure of calcretised older alluvium with large calcrete nodules, surface concentrations of quartzite artefacts, younger soils with gravels at base.
399	32 42 51.0 S 25 55 45.4 E	Van Wyks Kraal 73. Small exposure of Balfour Fm mudrocks and palaeosol calcrete nodules.
400	32 43 02.9 S 25 55 51.3 E	Van Wyks Kraal 73. Good exposure of Balfour Fm mudrock and sandstones packages near farm dam. Sandstone-infilled mudcracks.
401	32 43 02.8 S 25 55 51.1 E	Van Wyks Kraal 73. Sandstone-infilled large vertebrate burrow at locality above.
402	32 43 53.1 S 25 56 12.1 E	Van Wyks Kraal 73. Good exposures of Balfour Fm channel sandstones in river bed just east of homestead.
403	32 43 55.0 S 25 56 11.9 E	Van Wyks Kraal 73. Sparse cylindrical invertebrate burrows on Balfour Fm. large-scale channel sandstone foresets.
404	32 44 10.7 S 25 56 39.8 E	Van Wyks Kraal 73. Major channel sandstone within Balfour Fm.
405	32 44 11.1 S 25 56 40.2 E	Van Wyks Kraal 73. Abundant transported fossil woody material (compressions / moulds) in base of channel sandstone.
407	32 44 11.5 S 25 56 48.1 E	Van Wyks Kraal 73. Small donga exposure of older calcretised alluvium. Sparse reworked small fragments of ferruginised silicified wood & subfossil bone material.
409	32 44 21.2 S 25 57 17.2 E	Van Wyks Kraal 73. Extensive exposure of very thick, calcretised older alluvium erosively overlying Balfour Fm bedrocks.
410	32 43 56.3 S 25 57 23.7 E	Van Wyks Kraal 73. Small streamside exposure of older calcretised alluvium overlying dipping Balfour Fm. bedrocks.
411	32 43 56.3 S 25 57 23.7 E	Van Wyks Kraal 73. Small streambank exposure of Balfour Fm sandstones and mudrocks.
412	32 43 56.4 S 25 57 23.5 E	Van Wyks Kraal 73. Unmineralised skull of unidentified large mammal embedded in unconsolidated younger alluvium, stream bank exposure. Float specimen of silicified fossil wood on nearby Balfour Fm hillslope exposure.
413	32 44 00.7 S 25 57 27.6 E	Van Wyks Kraal 73. Gentle hillslope exposure of Balfour Fm mudrocks. Float specimen of silicified fossil wood.
414	32 44 17.14 S 25 56 50.61 E	Van Wyks Kraal 73. Extensive donga exposures of younger unconsolidated alluvium and colluvium on valley slopes, overlying Balfour Fm bedrocks.
415	32 44 34.6 S 25 59 56.5 E	Robertskraal 281. Lower Balfour Fm sandstone exposure, alluvium and downwasted gravels around large farm dam.

416	32 44 55.4 S 25 59 50.5 E	Robertskraal 281. Stream bed exposure of Balfour Fm channel sandstones mantled by unconsolidated alluvium, downwasted surface gravels.
417	32 45 53.2 S 25 57 29.0 E	Robertskraal 281. Small, flat hillslope exposure of flaggy-bedded Balfour Fm sandstones, downwasted sandstone gravels.
418	32 44 02.6 S 25 57 08.4 E	Van Wyks Kraal 73 (south). Hillslope exposure of thick-bedded, massive Balfour Fm channel sandstones showing corestone weathering.
419	32 44 08.0 S 25 55 23.5 E	Van Wyks Kraal 73, near Poseidon Substation. Extensive streambed and hillslope exposure of Balfour Fm flaggy and cross-bedded channel sandstones, heterolithic packages and overbank mudrocks (with v. abundant palaeocalcrete nodules). Small-scale wave-rippled sandstone tops. Rare fossil bone within nodules.
420	32 43 54.0 S 25 55 33.3 E	Van Wyks Kraal 73. Good stream gulley and hillslope exposures of Balfour Fm mudrocks with calcrete nodules.
421	32 43 53.5 S 25 55 31.8 E	Van Wyks Kraal 73. Good gullied hillslope exposure of Balfour Fm mudrocks with pedocrete horizons. Streambank exposure of heterolithic package. Moderate-sized semi-articulated vertebrate skeleton embedded within palaeocalcrete. Sandy to gravelly colluvial and alluvial deposits.
423	32 43 53.2 S 25 55 28.7 E	Van Wyks Kraal 73. Small hillslope exposure of purple-brown Balfour Fm mudrocks. Hillslope colluvium.
427	32 43 17.0 S 25 55 23.09 E	Van Wyks Kraal 73. Extensive stream bed and bank exposure of calcretised, hackly weathering Balfour Group mudrocks and sandstone blobs capped by coarse pediment gravels with common ESA artefacts of sandstone. Thick sandy to gravelly unconsolidated alluvium.
429	32 44 16.43 S 25 59 51.79 E	Roberts Kraal 281. Brick kilns exploiting local alluvial deposits.
430	32 43 58.9 S 25 59 53.9 E	Roberts Kraal 281. Exposure of thick khaki mudrock package of Balfour Fm around margins of farm dam. Minor heterolithic packages and thin sandstones.
431	32 43 07.9 S 25 59 14.1 E	Roberts Kraal 281. Large farm dam excavated into reddish-brown alluvial to colluvial soils.
432	32 43 11.5 S 25 58 33.5 E	Roberts Kraal 281. Well-consolidated, calcretised older alluvium exposures in dongas and river banks, *banke* of bioturbated sandstone,
433	32 44 09.8 S 25 58 36.1 E	Roberts Kraal 281. Flaked sandstone artefacts (probably ESA) embedded within lenses of coarse alluvial gravels. Ripple

		cross-laminated prograding point-bar sandstones of Balfour Fm exposed in stream banks.
435	32 44 07.4 S 25 58 38.4 E	Roberts Kraal 281. Poorly-sorted basal gravels beneath well-consolidated, orange-brown older alluvium, stream bank exposure.
436	32 44 14.8 S 25 59 06.8 E	Roberts Kraal 281. Donga and stream bank exposures of thick, older consolidated orange-brown alluvium and unconsolidated brownish younger alluvium. Calcrete hardpans.
438	32 42 43.1 S 25 57 10.0 E	Van Wyks Kraal 73. Small hillside stream exposure of Balfour Fm mudrocks and sandstones.
440	32 42 07.9 S 25 57 17.7 E	Van Wyks Kraal 73. Small dam exposure of Balfour Fm mudrocks, downwasted surface gravels.
441	32 42 54.7 S 25 56 25.2 E	Van Wyks Kraal 73. Large borrow pit exposure of dark grey Balfour Fm mudrocks with pedocrete nodule horizons, near farmstead.