PALAEONTOLOGICAL IMPACT ASSESSMENT: DESKTOP STUDY

Proposed Suurplaat Wind Energy Facility near Sutherland, Western Cape & Northern Cape Provinces

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Picture on Cover Page: Reconstruction of a herd of rhino-sized dinocephalians from the Middle Permian Period (*c.* 265 million years ago). This important group of ancient Karoo vertebrates went extinct during the period when the rocks underlying the Suurplaat study area were being deposited. Numerous fossils of dinocephalians and other fascinating extinct vertebrates have been recorded within or close to this area. Mitigation of palaeontological heritage for the Suurplaat wind energy development should therefore yield significant scientific returns.

1. SUMMARY

Moyeng Energy (Pty) Ltd is proposing to establish the Suurplaat wind energy facility, which is spread over an area of 286km^2 straddling the Great Escarpment to the south-east of Sutherland. Up to 400 wind turbines will be installed in three phases. The study area is largely underlain by continental sediments of the Abrahamskraal and Teekloof Formations of the Lower Beaufort Group (Karoo Supergroup). These Mid to Late Permian sediments are renowned for their outstandingly rich fossil heritage of terrestrial vertebrates (most notably "mammal-like reptiles" or therapsids), as well as fish, amphibians, molluscs, trace fossils (*e.g.* trackways) and plants (*e.g.* petrified wood, leaves). The Abrahamskraal – Teekloof stratigraphic interval is of special palaeontological significance in that it immediately precedes a catastrophic mass extinction event at the end of the Mid Permian Period, some 260.4 million years ago and may record two earlier land-based extinctions. A benchmark study by Loock *et al.* (1994) identified the Suurplaat study area as a key area for research on the stratigraphy and palaeontology of the Abrahamskraal Formation and many fossil localities were identified in the region. A recent palaeontological impact study traversing the southern part of the Suurplaat study area by the author (Almond, 2010) also highlighted the density of fossil sites in this region of the Great Karoo. The palaeontological sensitivity of the Beaufort Group sediments within the study area is consequently very high. In contrast, Caenozoic surface sediments mantling the Beaufort bedrocks here (*e.g.* alluvium, fluvial gravels, colluvium) are generally of low palaeontological sensitivity, although sparse fossil remains such as mammalian bones and teeth, or freshwater molluscs, may also occur.

Construction work undertaken over Beaufort Group bedrock, in order to install the wind turbines and associated infrastructure (*e.g.* underground cables, access road network, substations, overhead power lines), is likely to expose, disturb, destroy or seal-in valuable fossil heritage. Although the direct impact will be local, these fossils are of importance to national as well as international research projects on the fossil biota of the ancient Karoo and the Permian mass extinction events. It is therefore recommended that:

1. Before any major construction commences a thorough palaeontological field survey of representative natural and artificial rock exposures within the study region as a whole, including all land parcels involved in this development, should be undertaken by a qualified palaeontologist. The main purpose of this survey is to identify specific areas or horizons ("hotspots") of high palaeontological sensitivity on the ground that may require further mitigation. An interim fossil heritage report for the Suurplaat study area should be submitted to HWC and SAHRA.
2. On the basis of the field survey should any significant finds of fossil material be predicted, a realistic, collaborative mitigation programme and protocol should be drawn up by the palaeontologist in conjunction with the developer, Heritage Western Cape and SAHRA. This

mitigation would normally involve the recording and judicious collection of fossil material within the development area as well as the recording of relevant geological data, before and during the construction phase of the development. A palaeontological collection permit from SAHRA will be required by the palaeontologist commissioned to carry out this work.
3. A short fossil training workshop, led by a suitably qualified palaeontologist, should be given to the ECOs before construction starts. The workshop should deal with the significance, recognition, safeguarding and conservation of fossil heritage relevant to this project.
4. A final technical report on fossil heritage resources within the Suurplaat development area should be submitted to HWC and SAHRA once mitigation and preliminary analysis of fossil material is completed.

2. INTRODUCTION & BRIEF

2.1. Outline of proposed development

Moyeng Energy (Pty) Ltd is proposing to establish a large wind farm, known as the Suurplaat Wind Energy Facility, across the Great Escarpment some 50-60km southeast of Sutherland. The proposed study area of approximately 286km^2 (See Figs. 1, 2a, 2b) extends for *c*. 35km in a north-south direction above and below the escarpment and incorporates the following land parcels with fall within the Northern Cape Province (Sutherland Magisterial District) and Western Cape Province (Laingsburg District):

- Portion 0 of Farm 30 (Klipfontein Extension)
- Portion 0 of Remaining Extent of Farm 31 (Klipfontein)
- Portions 0 and 1 of farm 7 (Modderfontein)
- Portions 2 and 3 of Farm 14 (Dwars Rivier)
- Portion 2 and Remaining Extent of Farm 9 (Boschmans Kloof)
- Remaining Extent of Farm 145 (Klippekraal)
- Portions 2 and 3 of Farm 2 (Wilgebosch Kloof)
- Portion 0 (Remaining Extent) of Farm 143 (Vinke Kuil)
- Portion 2 (Remaining Extent) of farm 144 (Vinke Kuil)
- Portion 0 of Farm 8 (Sterboom Hoek)
- Portion 1 of Farm 219
- Remaining Extent of farm 147 (Hartebeestefontein)

The following key components of the proposed wind energy facility have been listed in the BID prepared by Savannah Environmental (Pty) Ltd (See also map Figs. 2a, 2b):

- Up to 400 wind turbines, to be established in three phases (~95 turbines in Phase 1, ~109 in Phase 2, and ~196 in Phase 3)
- Foundations to support the turbine towers
- Underground cables between turbines
- One 400 kV substation, situated some 10km east of the wind farm (see Figs. 2a, 2b for alternative locations), and 13 x 132kV internal substations
- up to eight 132kV overhead power lines running from the wind farm eastwards to the new external substation (see Figs. 2a, 2b for alternative routes) and one 400kV

overhead power line between this external substation and an Eskom 400kV transmission line *c*. 3km to the south

- Internal access roads to each turbine
- A workshop/office

2.2. Potential implications of proposed development for fossil heritage

This large wind farm development may well compromise important palaeontological heritage embedded within potentially fossil-rich bedrocks of the Lower Beaufort Group (Karoo Supergroup) in the development area. Significant impacts on palaeontological heritage normally occur during the construction phase and not in the operational phase of the development. Excavations made during the course of installing the proposed wind farm turbines and associated developments (*e.g.* access roads, underground cables, substations, power lines) may expose, damage, disturb or permanently seal-in scientifically valuable fossil heritage that is currently buried beneath the land surface, mantled by dense vegetation, or lying exposed on the surface.

2.3. Relevant heritage legislation

The extent of the proposed wind farm development (over 5000 m^2) falls within the requirements for a Heritage Impact Assessment (HIA) as stipulated by Section 38 (Heritage Resources Management) of the South African Heritage Resources Act (Act No. 25 of 1999). The various categories of heritage resources recognised as part of the National Estate in Section 3 of the Heritage Resources Act include, among others:

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

Minimum standards for the palaeontological component of heritage impact assessment reports are currently being developed by SAHRA. The latest version of the SAHRA guidelines is dated May 2007.

A palaeontological impact assessment (PIA) as part of a comprehensive EIA for the Suurplaat wind farm project has been commissioned by Savannah Environmental (Pty) Ltd, Sunninghill, 2157. This report is a desktop study for inclusion in an EIA as well as an Environmental Management Plan for the Suurplaat wind farm project. Please note that the layouts of several components of the proposed development as outlined above (*e.g.* access road network, underground cables, internal substations) have not been finalised. These development components have therefore not been considered in detail during this preliminary palaeontological assessment.

2.4. Brief for this desktop study

The outline brief for the present desktop study is that it should include the following major components:

- an assessment of the likelihood of fossil material in the proposed area of development
- identification of aspects of the planned development that will have direct impact on paleontological deposits and materials
- recommendations for management of fossil heritage within the development area
- recommendations for mitigation of fossil heritage for the EMP (planning, construction and operation phases)

2.5. General approach used for palaeontological impact desktop studies

In preparing a palaeontological desktop study the potentially fossiliferous rock units (groups, formations *etc*) represented within the study area are determined from geological maps. The known fossil heritage within each rock unit is inventoried from the published scientific literature, previous palaeontological impact studies in the same region, and the author's field experience (Consultation with professional colleagues as well as examination of institutional fossil collections may play a role here or later, following field surveys, during the compilation of the final report). This data is then used to assess the palaeontological sensitivity of each rock unit to development (Provisional tabulations of palaeontological sensitivity of all formations in the Western, Eastern and Northern Cape have already been compiled by J. Almond and colleagues; *e.g.* Almond & Pether 2008). The likely impact of the proposed development on local fossil heritage is then determined on the basis of (1) the palaeontological sensitivity of the rock units concerned and (2) the nature of the development itself, most notably the extent of fresh bedrock excavation envisaged. When rock units of moderate to high palaeontological sensitivity are present within the development footprint, a field survey by a professional palaeontologist is usually warranted to identify fossil hotspots as a basis for further specialist mitigation (See Sections 7 and 8).

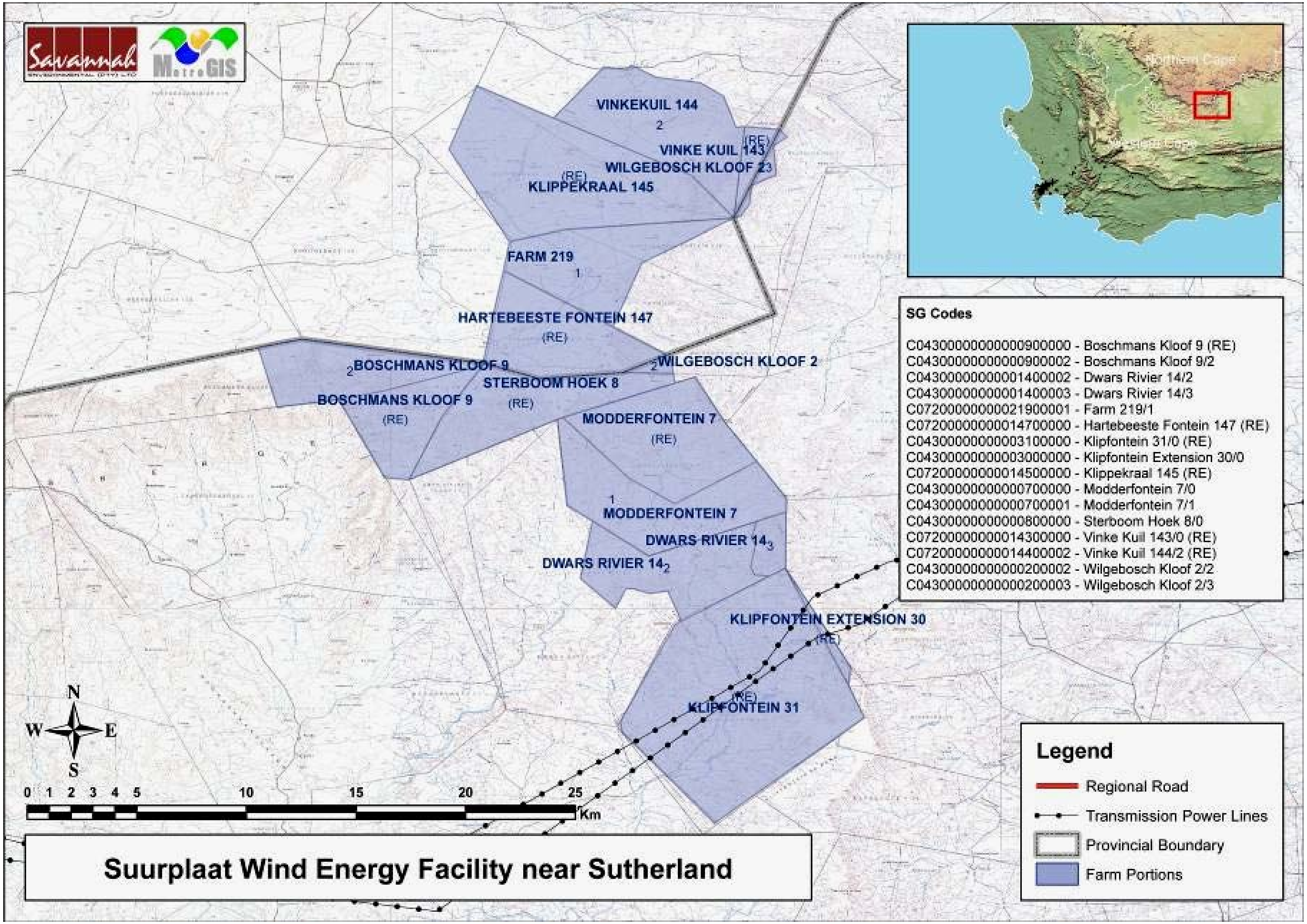
2.6. Assumptions made for this PIA desktop study

In inferring the palaeontological sensitivity of rock units underlying a development from field and other data obtained outside the study area it is assumed that fossil heritage is fairly uniformly distributed throughout the outcrop area of a given formation. Experience shows that this assumption does not always hold. This is because the original depositional setting across a formation that may extend over hundreds of kilometres may vary significantly, with palaeoecological implications (*e.g,* from a shallow to deeper water environment), while fossils are often patchy in their occurrence. Furthermore, the levels of tectonic deformation (folding, cleavage development *etc*), as well as the intensity and nature of metamorphism and weathering experienced by a given formation may change markedly across its outcrop area. These factors may seriously compromise the preservation of fossil remains present within the original sedimentary rock so that the effective palaeontological sensitivity of a rock unit that is normally highly fossiliferous may be effectively very low in some areas.

Fig. 1 (Page 6). Location and extent of the proposed Suurplaat Wind Energy Facility southeast of Sutherland, Northern and Western Cape Provinces, showing land parcels involved (Image kindly supplied by Savannah Environmental (Pty) Ltd).

Fig. 2a. (Page 7). Satellite image of the Great Escarpment region southeast of Sutherland showing the extent of the proposed Suurplaat Wind Energy Facility, provisional wind turbine positions, as well as the position of the new external substation to the east and three alternative routes for the 132kV overhead power line connecting the two. Note also the short 400kV overhead power line connecting the new substation to a 400kV Eskom transmission line to the south (Image kindly supplied by Savannah Environmental (Pty) Ltd).

Fig. 2b. (Page 8). Same as previous figure showing alternative layout for the external substation and 132 overhead power line (Image kindly supplied by Savannah Environmental (Pty) Ltd).


VINKEKUIL 144
VINKE KUIL 143
WILGEBOSCH KLOOF 23
KLIPPEKRAAL 145
FARM 219
HARTEBEESTE FONTEIN 147
BOSCHMANS KLOOF 9
STERBOOM HOEK 8
WILGEBOSCH KLOOF 2
MODDERFONTEIN 7
DWARS RIVIER 14
KLIPFONTEIN EXTENSION 30
KLIPFONTEIN 31
Northern Cape
Western Cape
SG Codes
C04300000000000900000 - Boschmans Kloof 9 (RE)
C04300000000000900002 - Boschmans Kloof 9/2
C04300000000001400002 - Dwars Rivier 14/2
C04300000000001400003 - Dwars Rivier 14/3
C07200000000021900001 - Farm 219/1
C07200000000014700000 - Hartebeeste Fontein 147 (RE)
C04300000000003100000 - Klipfontein 31/0 (RE)
C04300000000003000000 - Klipfontein Extension 30/0
C07200000000014500000 - Klippekraal 145 (RE)
C04300000000000700000 - Modderfontein 7/0
C04300000000000700001 - Modderfontein 7/1
C04300000000000800000 - Sterboom Hoek 8/0
C07200000000014300000 - Vinke Kuil 143/0 (RE)
C07200000000014400002 - Vinke Kuil 144/2 (RE)
C04300000000000200002 - Wilgebosch Kloof 2/2
C04300000000000200003 - Wilgebosch Kloof 2/3
Legend
Regional Road
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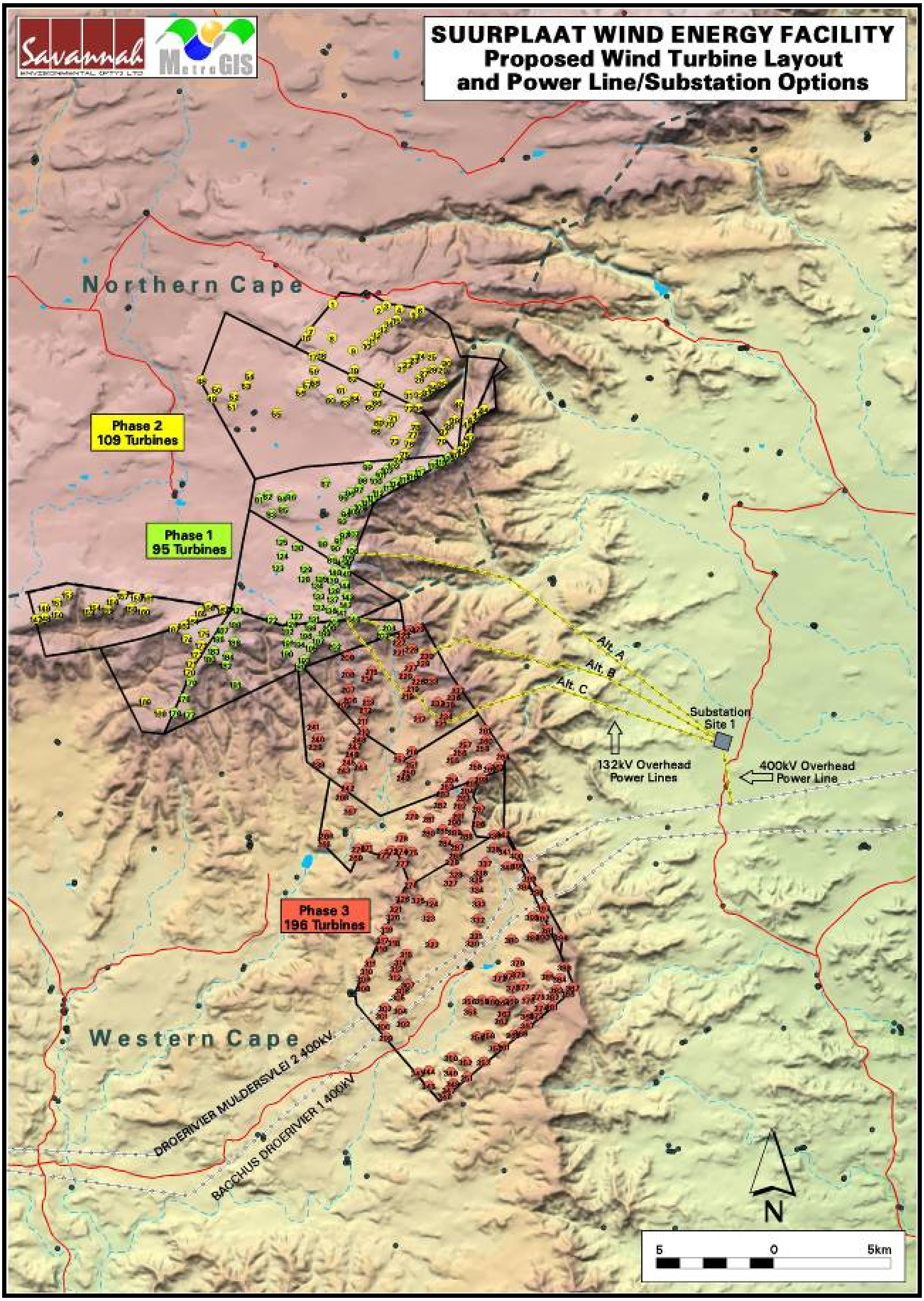
Suurplaat Wind Energy Facility near Sutherland


SUURPLAAT WIND ENERGY FACILITY
Proposed Wind Turbine Layout
and Power Line/Substation Options
Savannah
MetroGIS
Northern Cape
Phase 2
109 Turbines
Phase 1
95 Turbines
Phase 3
196 Turbines
Alt. A
Alt. B
Alt. C
Substation
Site 1
132kV Overhead
Power Lines
400kV Overhead
Power Line
Western Cape
DROERIVIER MULDERSVLEI 2 400kV
BACCHUS DROERIVIER 1 400kV
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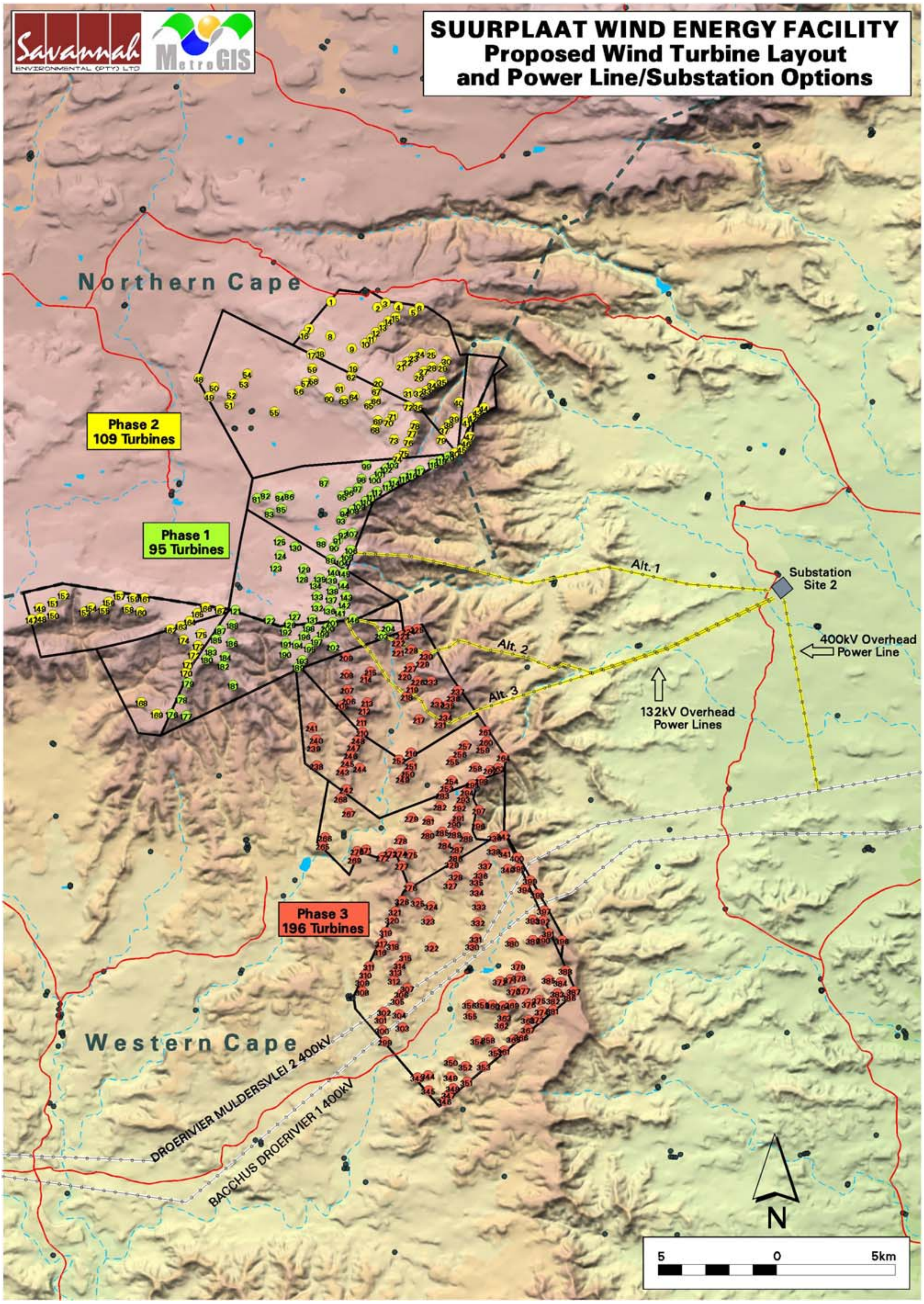
SUURPLAAT WIND ENERGY FACILITY
Proposed Wind Turbine Layout
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Savannah ENVIRONMENTAL (PTY) LTD
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Phase 2
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400kV Overhead
Power Line
132kV Overhead
Power Lines
DROERIVIER MULDERSVLEI 2 400kV
BACCHUS DROERIVIER 1 400kV
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3. GEOLOGICAL CONTEXT

The geology of the Sutherland region is outlined on the 1: 250 000 geology sheet 3220 Sutherland (Theron 1983, Cole & Vorster 1999) (Fig. 3). The study area is almost entirely underlain by Middle Permian continental sediments of the **Lower Beaufort Group** (Adelaide Subgroup, Karoo Supergroup). Two successive formations within the Lower Beaufort Group are represented within the study area: the Mid Permian **Abrahamskraal Formation** (**Pa**) and the conformably overlying Mid to Late Permian **Teekloof Formation** (**Pt**) (Rubidge 1995 and Fig. 4 herein). The latter is represented here only by a sandstone-rich lowermost interval known as the **Poortjie Member** (Fig. 5). As discussed in the palaeontological section below (Section 4), these two rock units are characterized by significantly different fossil biotas separated by a major Mid Permian extinction event.

As is clear from the generally low to very low stratigraphic dips indicated on the geological map (2-35°), the Lower Beaufort Group rocks within the study area are only slightly to moderately deformed, with numerous small-scale, east-west trending fold axes and minor faults. The Poortjie Member contains a high proportion of resistant-weathering sandstones. As can be clearly seen on satellite images, it forms the steep upper slopes and plateau of the Klipfontein se Berg at the southern end of the study area as well as steep cliffs, stepped slopes and plateau areas along the margin of the Great Escarpment in the northern part of the study area (Besemgoedberg, Platberg and Roggeveldberge). The greater part of the Escarpment slopes and foothills are carved into less resistant, mudrock-dominated sediments and subordinate sandstones of the underlying Abrahamskraal Formation. These areas have been extensively dissected by numerous post-Gondwana drainage systems originating along the Great Escarpment.

In the Great Escarpment region in the north the Lower Beaufort Group sediments have been intruded and thermally metamorphosed (baked) by substantial dolerite sills of the **Karoo Dolerite Suite** of Early Jurassic age (*c*. 182 Ma = million years ago; Duncan & Marsh 2006). These igneous rocks were intruded during an interval of crustal uplift and stretching that preceded the break-up of the supercontinent Gondwana. They are entirely unfossiliferous and will therefore not be treated further here.

The elevated north-south ridge along which the proposed Suurplaat wind farm is to be constructed forms an upland barrier or watershed between the lower-lying Moordenaarskaroo region in the west, drained by the Buffels River, and the even lower-lying subregion of the Great Karoo around Merweville known as the Die Koup (or Gouph) in the east which is drained by the Gamka River and its tributaries. Large areas of the Beaufort Group outcrop area, both along the escarpment and below it, are mantled by various **superficial deposits** or “drift” of poorly constrained Late Caenozoic age. They are largely Late Tertiary to Recent, *i.e.* 20 Ma or less, and comprise rocky colluvium (slope deposits such as scree), bouldery to silty alluvium (stream and river deposits), sheet wash and pedocretes (cemented soils) such as calcretes.

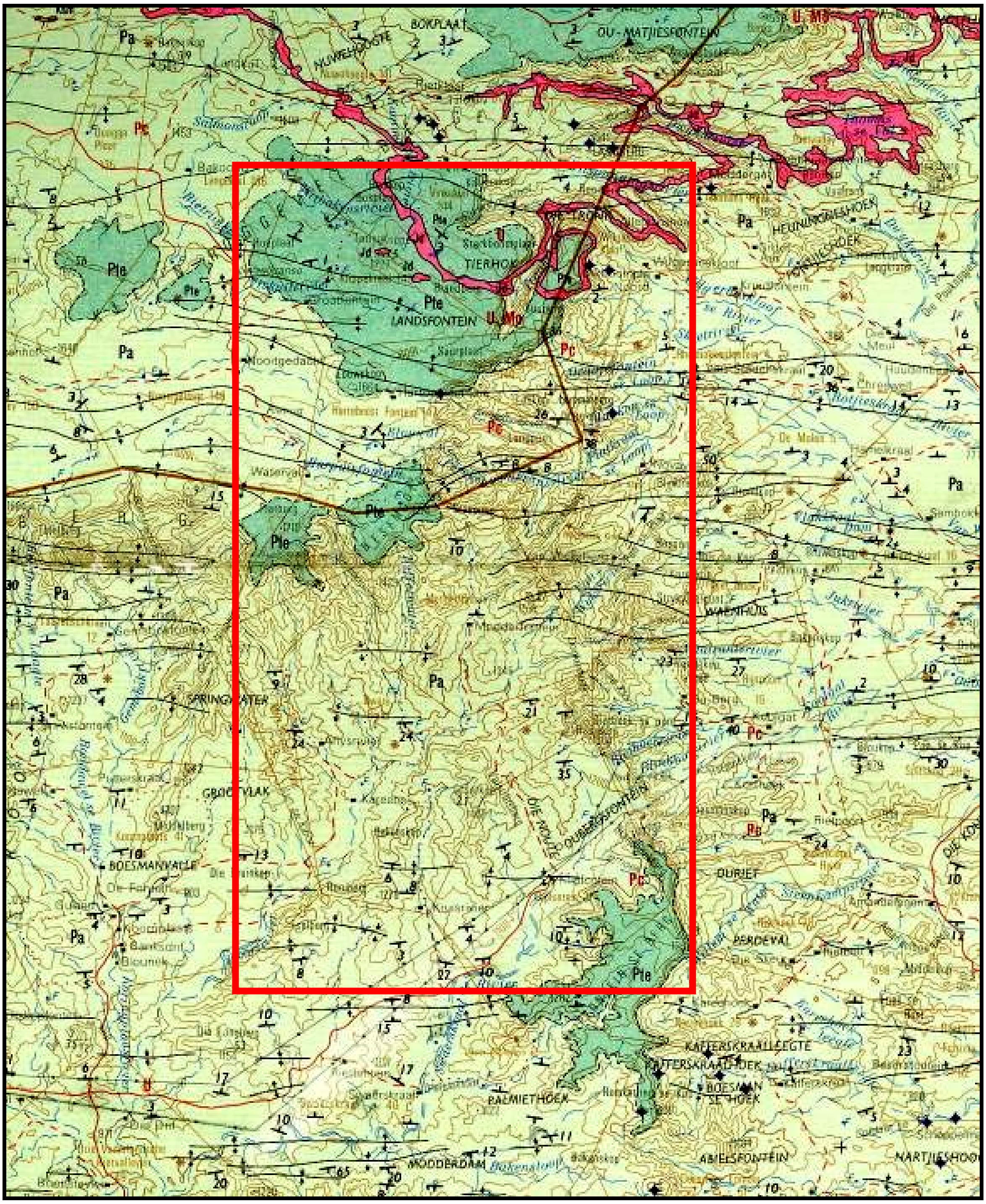

Fig. 3. Extract from 1: 250 000 geology sheet 3220 Sutherland showing the geology of the study region southeast of Sutherland, straddling the Great Escarpment between the Moordenaarskaroo and Koup regions. The red rectangle broadly encloses the Suurplaat wind farm study region.

Pa (pale green) = Mid Permian Abrahamskraal Formation (Adelaide Subgroup, Lower Beaufort Group). Pt (dark green) = Mid to Late Teekloof Formation (Adelaide Subgroup, Lower Beaufort Group). Jd (pink) = Early Jurassic Karoo Dolerite Suite. Caenozoic alluvium is not mapped separately here. Note numerous W-E trending minor fold axes within the Lower Beaufort Group outcrop.

Diamond symbols indicate fossil localities recorded within the *Tapinocephalus* Assemblage Zone. Triangles towards the top edge of the map indicate fossils within the succeeding *Pristerognathus* Assemblage Zone (See also Fig. 6).

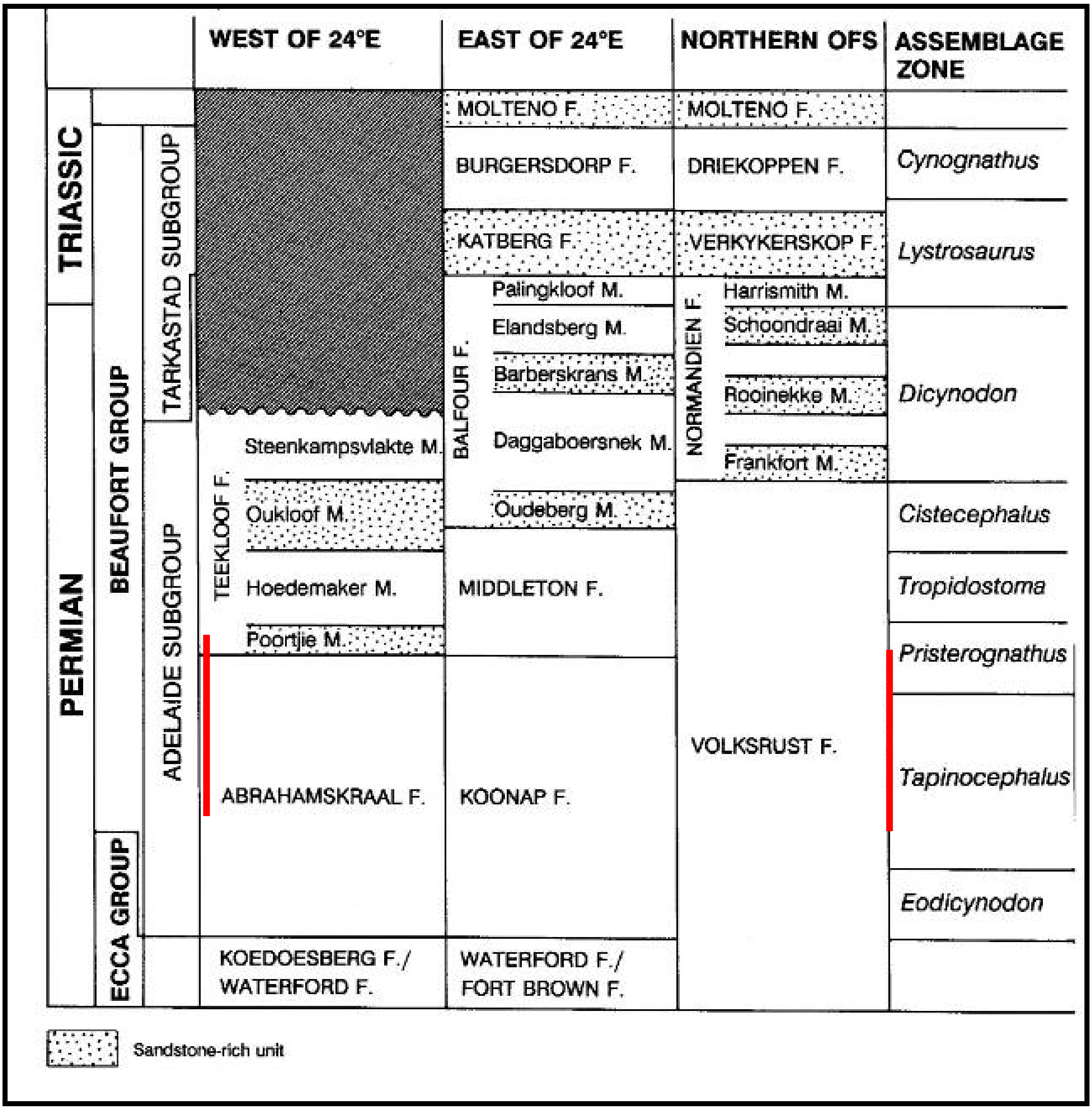

Fig. 4. Stratigraphy and biostratigraphic zonation of the Beaufort Group of the Main Karoo Basin (From Rubidge (Ed.) 1995). The vertical red lines indicate the Lower Beaufort rock units and fossil assemblage zones that are represented in the study area.

3.1. Lower Beaufort Group (Adelaide Subgroup)

A useful recent overview of the internationally famous Beaufort Group succession has been given by Johnson *et al.* (2006). Geological and palaeoenvironmental analyses of the Lower Beaufort Group sediments in the western Great Karoo region have been conducted by a number of workers. Key references within an extensive scientific literature include various papers by Roger Smith (*e.g.* Smith 1979, 1980, 1986, 1987a, 1987b, 1988, 1989, 1990, 1993a, 1993b) and Stear (1978, 1980), as well as several informative field guides (*e.g.* Cole *et al.* 1990, Cole & Smith 2008) and two geological sheet explanations for the Sutherland area (Theron 1983, Cole & Vorster 1999). In brief, the thick Beaufort Group successions of clastic sediments were laid down by a series of large, meandering rivers within a subsiding basin over a period of some ten or more million years, largely within the Mid to Late Permian Period (*c.* 266-251 Ma). Sinuous sandstone bodies of lenticular cross-section represent ancient channel infills, while thin (<1.5m), laterally-extensive sandstone beds were deposited by crevasse splays during occasional overbank floods. The bulk of the Beaufort sediments are greyish-green to reddish-brown or purplish mudrocks ("mudstones" = fine-grained claystones and slightly coarser siltstones) that were deposited over the floodplains during major floods. Thin-bedded, fine-grained playa lake deposits also accumulated locally where water ponded-up in floodplain depressions and are associated with distinctive fossil assemblages (*e.g.* fish, amphibians, coprolites or fossil droppings, arthropod, vertebrate and other trace fossils).

Frequent development of fine-grained pedogenic (soil) limestone or calcrete as nodules and more continuous banks indicates that semi-arid, highly seasonal climates prevailed in the Late Permian Karoo. This is also indicated by the common occurrence of sand-infilled mudcracks and silicified gypsum "desert roses" (Smith 1980, 1990, 1993a, 1993b). Highly continental climates can be expected from the palaeogeographic setting of the Karoo Basin at the time – embedded deep within the interior of the Supercontinent Pangaea and in the rainshadow of the developing Gondwanide Mountain Belt. Fluctuating water tables and redox processes in the alluvial plain soil and subsoil are indicated by interbedded mudrock horizons of contrasting colours. Reddish-brown to purplish mudrocks probably developed during drier, more oxidising conditions associated with lowered water tables, while greenish-grey mudrocks reflect reducing conditions in waterlogged soils during periods of raised water tables. However, diagenetic (post-burial) processes also greatly influence predominant mudrock colour (Smith 1990).

3.1.1. Abrahamskraal Formation

The Abrahamskraal Formation (Pa in map Fig. 3) is a very thick (*c.* 2.5km) succession of fluvial deposits laid down in the Main Karoo Basin by meandering rivers on an extensive, low-relief floodplain during the Mid Permian Period, some 266-260 million years ago (Rossouw & De Villiers 1952, Johnson & Keyser 1979, Turner 1981, Theron 1983, Smith 1979, 1980, 1990, 1993a, 1993b, Smith & Keyser 1995a, Loock *et al*., 1994, McCarthy & Rubidge 2005, Johnson *et al*., 2006). These sediments include (a) lenticular to sheet-like channel sandstones, often associated with thin, impersistent intraformational breccio-conglomerates (larger clasts mainly of reworked mudflakes, calcrete nodules, *plus* sparse rolled bones, teeth, petrified wood), (b) well-bedded to laminated, grey-green to purple-brown floodplain mudrocks with common pedocrete horizons (calcrete nodules formed in ancient soils), (c) thin, sheet-like crevassesplay sandstones, as well as more (d) localized playa lake deposits (*e.g.* wave-rippled sandstones, laminated mudrocks, limestones, evaporites). A number of greenish to reddish weathering, silica-rich "chert" horizons are also found. Many of these appear to be secondarily silicified mudrocks or limestones but at least some contain reworked volcanic ash (tuffs). A wide range of sedimentological and palaeontological observations point to deposition under seasonally arid climates. These include, for example, the abundance of calcretes and evaporites (silicified gypsum pseudomorphs or "desert roses"), reddened mudrocks, sun-cracked muds, "flashy" river systems, sun-baked fossil bones, well-developed seasonal growth rings in fossil wood, rarity of fauna, and little evidence for substantial bioturbation or vegetation cover (*e.g.* root casts) on floodplains away from the river banks.

There have been a number of attempts, only partially successful, to subdivide the very thick Abrahamskraal Formation succession in both lithostratigraphic and biostratigraphic terms. Among the most recent these was the study by Loock *et al.* (1994) in the Moordenaarskaroo area north of Laingsburg. This study is highly relevant to the proposed Suurplaat wind farm project because the authors established the northern portion of their geological traverse along the NW-SE topographic high joining Klipfontein se Berg with the Escarpment that runs through the present study area (Fig. 5). Detailed geological mapping here led to the identification of six lithologically-defined members within the Abrahamskraal Formation (Figs. 6-7). Intensive fossil collection within the middle part of the succession suggested that a significant faunal turnover event may have occurred at or towards the top of the sandstone-rich Koornplaats Member as defined by these authors, with the replacement of a more archaic, dinocephalian-dominated fauna (with primitive therapsids like the biarmosuchians) by a more advanced, dicynodont-dominated one at this level. This is the "faunal reversal" previously noted by Boonstra (1969) as well as Rossouw and De Villiers (1953). Other fossil groups such as therocephalians and pareiasaurs do not seem to have been equally affected. Problems have arisen in trying to correlate the lithologically-defined members recognized within the Abrahamskraal Formation by different authors across the whole outcrop area, with evidence for complex lateral interdigitation of the sandstone-dominated packages (D. Cole, pers. com., 2009). A research project is currently underway to subdivide the Abrahamskraal Formation on a biostratigraphic basis, emphasizing the range zones of various genera of small dicynodonts such as *Eodicynodon, Robertia* and *Diictodon* (Day & Rubidge 2010, Jirah & Rubidge 2010). Following the work of Loock *et al.* (1994) the topographic high between the Moordenaarskaroo and the Koup remains a key research area for the Abrahamskraal Formation in both lithostratigraphic and biostratigraphic terms (See also recent palaeontological impact study by Almond 2010).

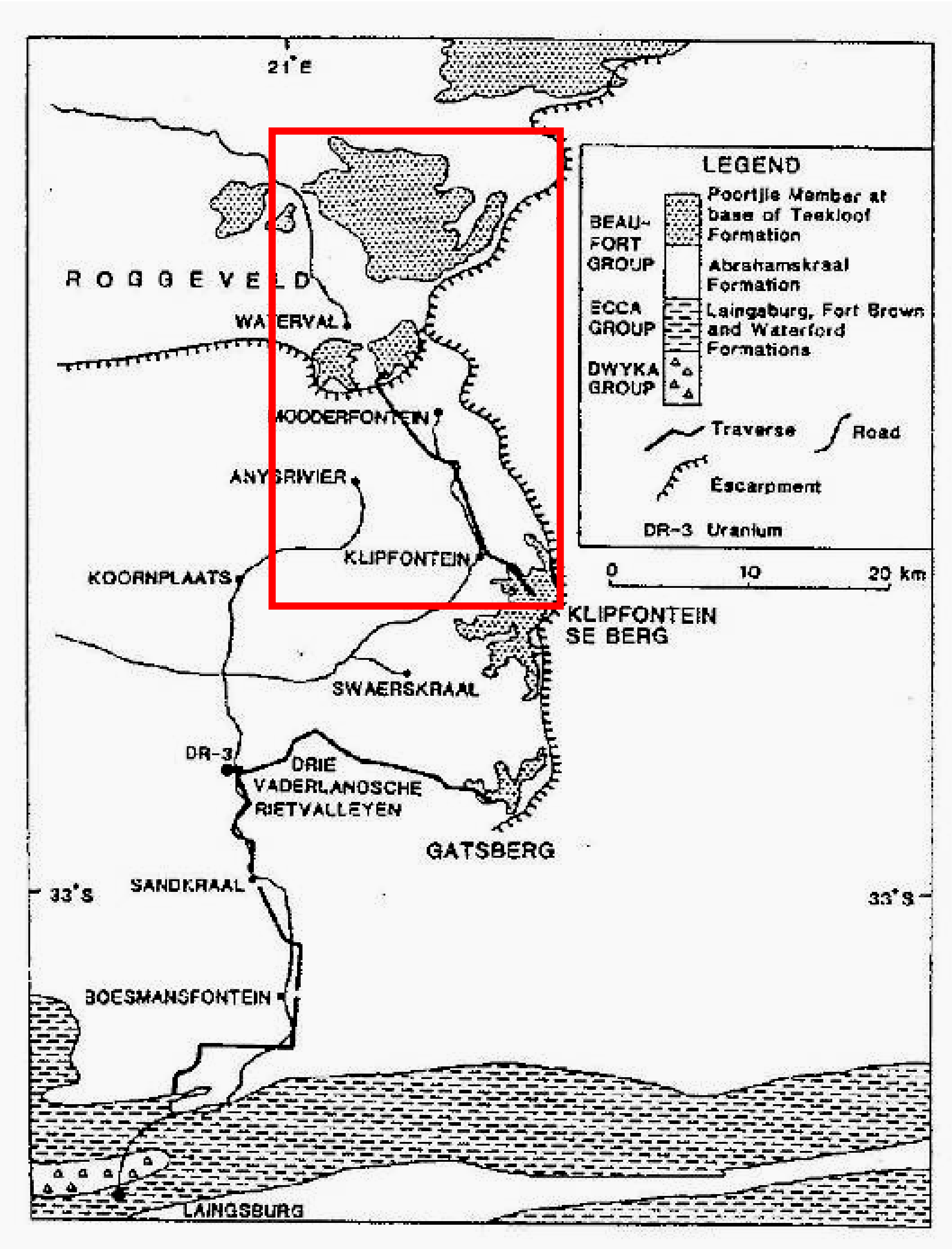

Fig. 5. Outline geological map of the Moordenaars Karoo – Great Escarpment area north of Laingsburg showing outcrop area of the Abrahamskraal Formation and basal Teekloof Formation (Poortjie Member), from Loock *et al.* (1994). Note that the key stratigraphic and palaeontological traverse (solid black line) selected by these authors, from Klipfontein se Berg NNW *via* Modderfontein to Waterval, runs through the Suurplaat wind farm study area (red rectangle).

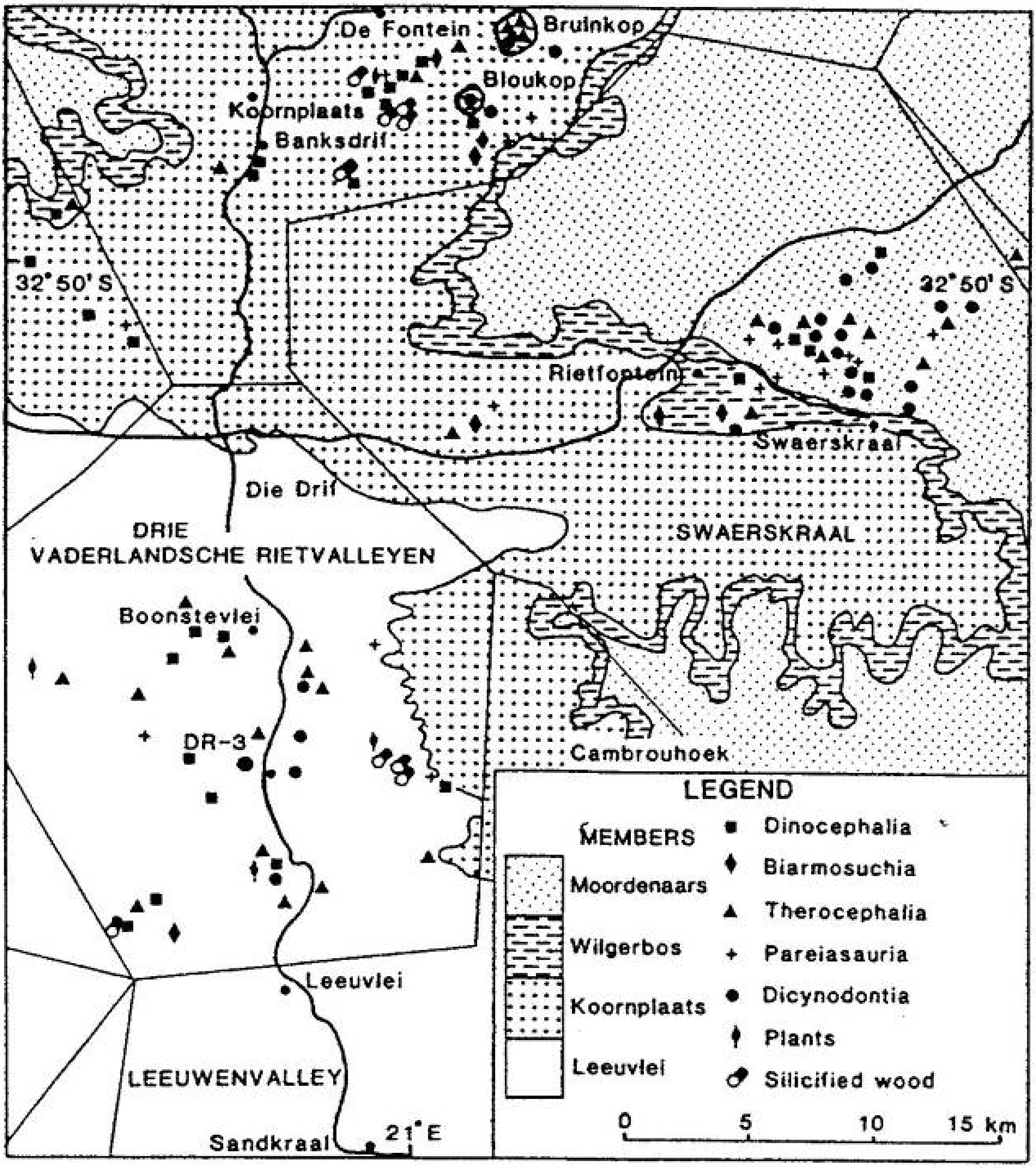

Fig. 6. Geological map of the Lower Beaufort rocks in the Moordenaarskaroo region north of Laingsburg showing outcrops of various stratigraphic members within the Abrahamskraal Formation as well as fossil localities (Loock *et al*. 1994). Note dense concentration of fossil localities east of the farm Rietfontein which lies directly in the path of a proposed new Eskom transmission line (Almond 2010). The Suurplaat wind farm study area lies just northeast of this map and is underlain by several of the same fossiliferous stratigraphic units that have been mapped in the Rietfontein area shown here.

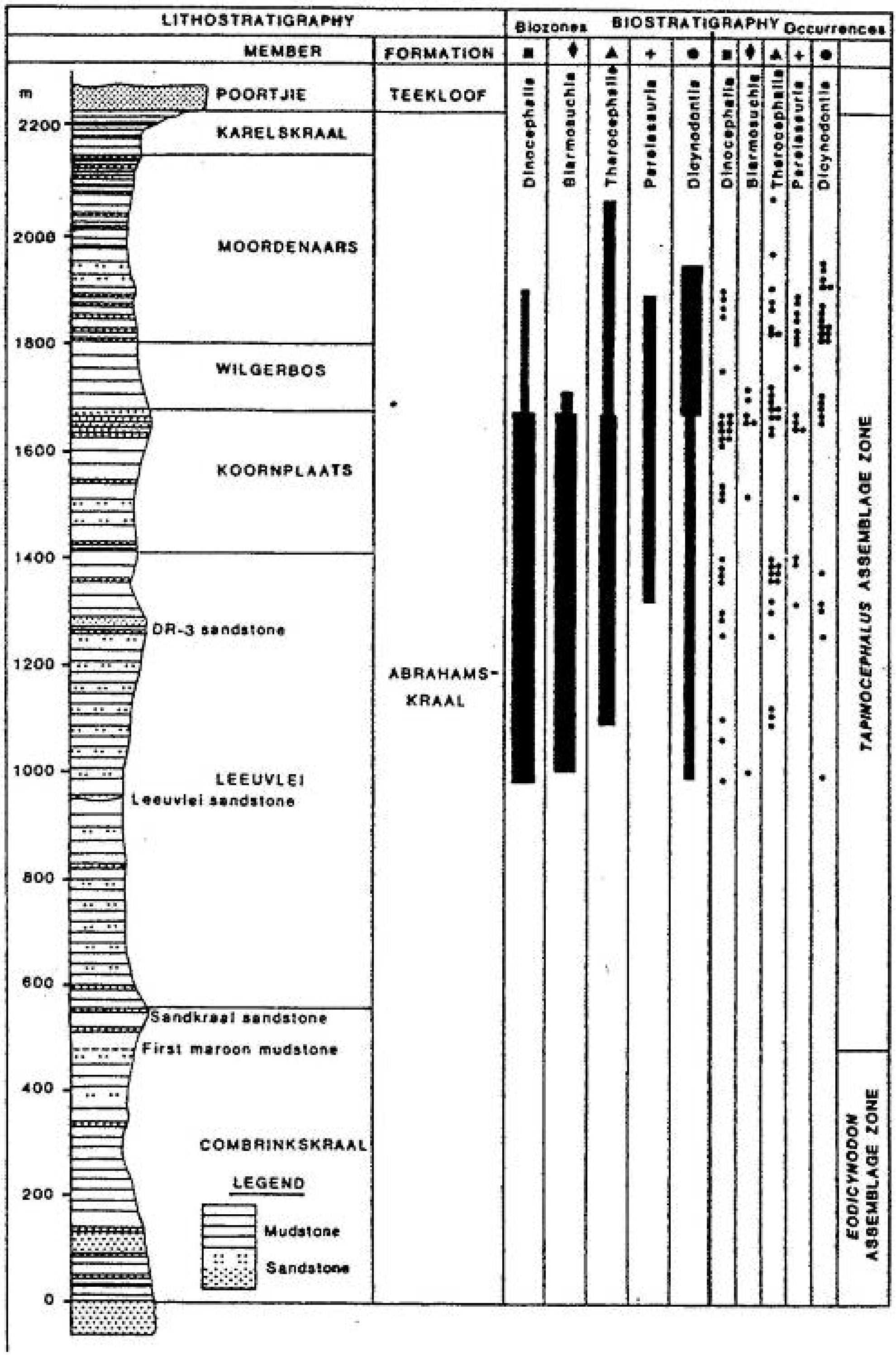

Fig. 7. Chart showing subdivision of the Abrahamskraal Formation in the Moordenaarskaroo area with stratigraphic distribution of major fossil groups. Note the inferred faunal turnover episode at the top of the Koornplaats Member (Loock *et al*. 1994).

3.1.2. Teekloof Formation

Compared with the underlying Abrahamskraal rocks the Teekloof Formation (Pt in map Fig. 3) has a generally higher proportion of sandstones and reddish mudrocks are more abundant here. Multi-storied sandstones are common in the basal arenaceous **Poortjie Member**. These are clearly seen in aerial photos and satellite images and the Poortjie appears to be the only member of the Teekloof Formation represented in the study area (This needs field confirmation, however). Thin, impersistent lenses of pinkish “cherts” that are probably altered volcanic ashes (Johnson & Keyser 1979, Theron 1983, Smith & Keyser 1995b, Rubidge 2010). Several economically interesting uranium ore deposits occur within the Poortjie Member in association with brown-weathering, ferruginous channel sandstones (“koffieklip”) and transported plant material. Interesting accounts of the sedimentology and palaeontology of the Poortjie Member are given by Stear (1978) as well as by Cole and Smith (2008). The Poortjie Member has a thickness of some 200m while the entire Teekloof succession is *c*. 1000m thick (Cole *et al.* 1990, Cole & Voster 1999). Recent, unpublished radiometric dating of zircons from tuff layers within the Poortjie Member gives an age of 261.3 Ma (Rubidge *et al.* 2010 and pers. comm. 2010), placing this stratigraphic unit within the Gaudalupian Epoch (late Middle Permian). Previously the Poortjie Member was considered to be earliest Late Permian or Lopingian in age (*cf* Smith & Keyser 1995, Rubidge 2005).

3.3. Superficial deposits

Various types of superficial deposits (“drift”) of Late Caenozoic (Miocene / Pliocene to Recent) age occur widely throughout the Karoo region, including the study area (Theron 1983). They include pedocretes (*e.g.*calcretes or soil limestones), colluvial slope deposits (sandstone scree, downwasted gravels *etc*), sheet wash, river channel alluvium and terrace gravels, as well as spring and pan sediments (Theron 1983, Cole *et al.* 2004, Partridge *et al*. 2006). Tracts of alluvium overlying the Beaufort Group bedrock are not indicated separately in the study area on the Sutherland sheet, presumably because they are too narrow.

4. PALAEONTOLOGICAL HERITAGE

A brief outline of the known and expected fossil heritage within the main geological units represented in the study area is given here.

4.1. Fossil biotas of the Lower Beaufort Group (Adelaide Subgroup)

The overall palaeontological sensitivity of the Beaufort Group sediments is high to very high (Almond & Pether 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 (MacRae 1999, Rubidge 2005, McCarthy & Rubidge 2005). Bones and teeth of Late Permian tetrapods have been collected in the western Great Karoo region since at least the 1820s and this area remains a major focus of palaeontological research in South Africa.

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, 2005). Maps showing the distribution of the Beaufort assemblage zones within the Main Karoo Basin have been provided by Keyser and Smith (1979, Fig. 8 herein) and Rubidge (1995, 2005); a new updated version is currently in press. Two successive assemblage zones are represented within the study area, *viz*. the Middle Permian *Tapinocephalus* AZ and the Middle to Late Permian *Pristerognathus* AZ (Theron 1983, Rubidge 1995; Figs. 4 & 8).

Selected fossil sites recorded within the *Tapinocephalus* and *Pristerognathus* Assemblage Zones in the Sutherland area are indicated on outline maps by Kitching (1977) as well as Keyser and Smith (1977-78). Several fossil sites also shown on the 1: 250 000 geological sheet 3220 Sutherland published by the Council for Geoscience, Pretoria (Fig. 3 herein). In addition Kitching (1977) provides palaeofaunal lists for specific localities within the Great Karoo region.

4.1.1. Abrahamskraal Formation

The fossil biota of the greater part of the Abrahamskraal Formation is assigned to the ***Tapinocephalus* Assemblage Zone** of Mid Permian age on the basis of key vertebrate fossils, notably large dinocephalian therapsids *plus* smaller carnivorous therocephalians. The main categories of fossils expected within the *Tapinocephalus* fossil biozone (Keyser & Smith 1977-78, Anderson & Anderson 1985, Smith & Keyser 1995a, MacRae 1999, Rubidge 2005, Almond 2010) include:

- isolated petrified bones as well as rare articulated skeletons of tetrapods (*i.e.* air-breathing terrestrial vertebrates) such as true **reptiles** (notably large herbivorous pareiasaurs like *Bradysaurus* (Fig. 9), small insectivorous millerettids), rare pelycosaurs, and diverse **therapsids** or "mammal-like reptiles" (*e.g.* numerous genera of large-bodied dinocephalians (Figs. 9-10), herbivorous dicynodonts, flesh-eating biarmosuchians, gorgonopsians and therocephalians)

- 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) and plant root casts.
- **vascular plant remains** (usually sparse and fragmentary), including leaves, twigs, roots and petrified woods ("*Dadoxylon*") of the *Glossopteris* Flora, especially glossopterid trees and arthrophytes (horsetails).

In general, tetrapod fossil assemblages in this zone are dominated by a wide range of dinocephalian genera and small therocephalians *plus* pareiasaurs. while relatively few dicynodonts can be expected (Day & Rubidge 2010 Jirah & Rubidge 2010 and refs. therein). Vertebrate fossils in this zone are generally much rarer than seen in younger assemblage zones of the Lower Beaufort Group, with almost no fossils to be found in the lowermost beds.

Despite their comparative rarity, there has been a long history of productive fossil collection from the *Tapinocephalus* Assemblage Zone in the western and central Great Karoo area, as summarised by Rossouw and De Villiers (1952) and Boonstra (1969). Numerous fossil sites recorded in the region are marked on the published 1: 250 000 Sutherland geology sheet 3220, Beaufort West sheet 3222, and on the map in Keyser and Smith (1977-78; Fig. 8). Vertebrate fossils found in the Sutherland sheet area are also listed by Kitching (1977) as well as Theron (1983). They include forms such as the pareiasaur *Bradysaurus*, tapinocephalid and titanosuchid dinocephalians *plus* rarer dicynodonts, gorgonopsians and therocephalians (*e.g.* pristerognathids, *Lycosuchus*) as well as land plant remains (*e.g.* stems and leaves on Hartebeest Fontein 147). Numerous fossil sites were recorded along the eastern edge of the Moordenaarskaroo in the key biostratigraphic study of the Abrahamskraal Formation by Loock *et al.* (1994), as shown in Figures 5 to 7 above. Note that the map in Fig. 6 depicts an area just to the southwest of the present Suurplaat study area. A recent palaeontological scoping study was carried out by the author within the Abrahamskraal Formation of the Moordenaarskaroo, along the proposed new Gamma-Omega 765kV transmission line that passes through the farm Klipfontein at the southern end of the Suurplaat study area. This fieldwork yielded locally abundant dinocephalian and other therapsid skeletal remains, large, cylindrical vertical burrows or plant stem casts, *Scoyenia* Ichnofacies trace fossil assemblages and sphenophytes (horsetail ferns) associated with probable playa lake deposits, as well as locally abundant petrified wood (Almond, 2010).

Fossils in the *Tapinocephalus* Assemblage Zone occur in association with both mudrocks and sandstones, most notably in thin intraformational conglomerates (*beenbreksie*) at the base of channel sandstones (Rossouw & De Villiers 1952, Turner 1981, Smith & Keyser 1995a, Almond 2010).

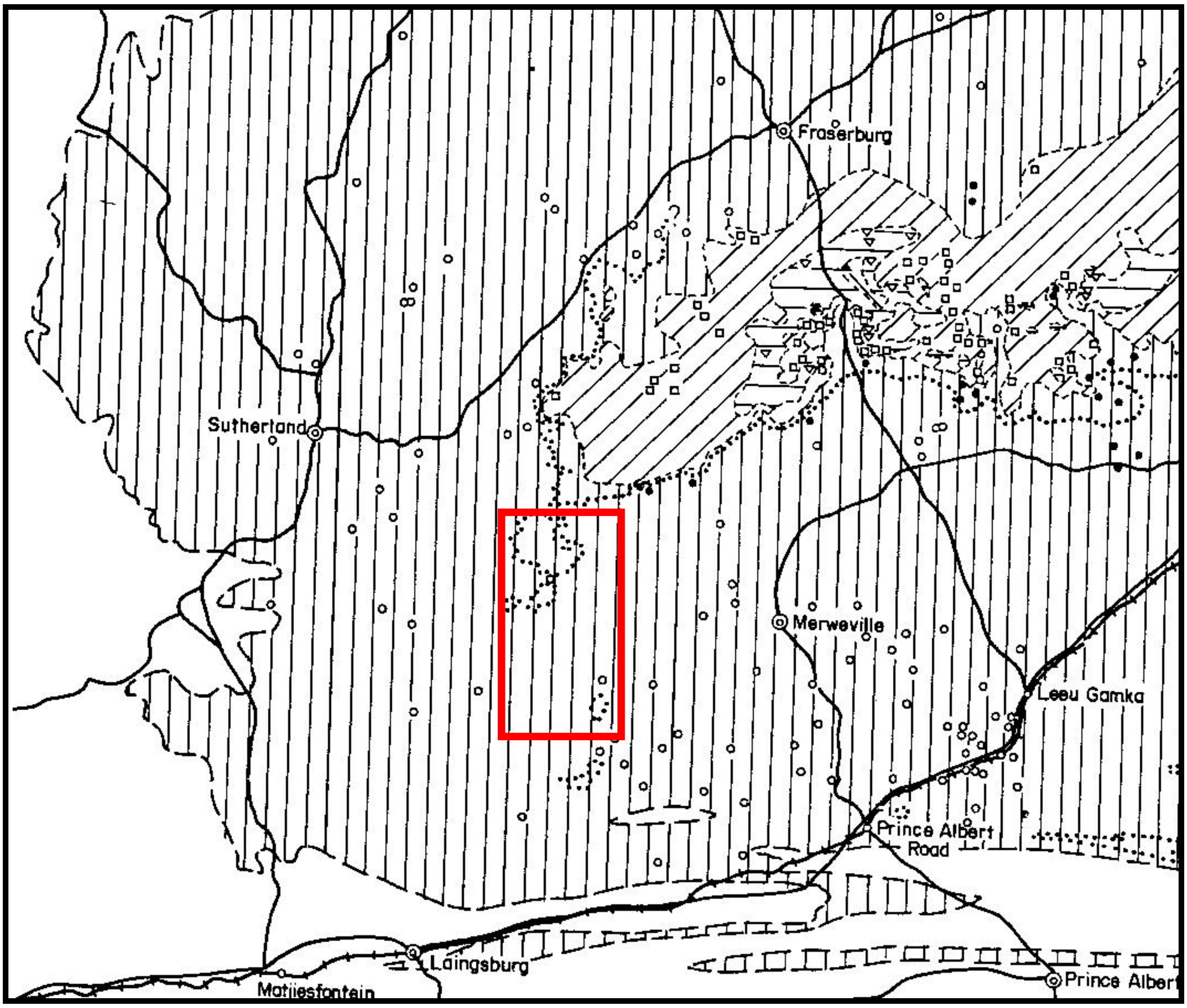

Fig. 8. Vertebrate fossil localities within the Lower Beaufort Group in the study region southeast of Sutherland (red rectangle). In this particular wide-ranging field study of the 1970s *Tapinocephalus* Assemblage Zone specimens were found in the southern and northern sectors of the Suurplaat study area (small open circles). *Pristerognathus* Assemblage Zone fossils (black spots) are associated with outcrops of the lowermost Teekloof Formation (Poortjie Member, shown by the dotted line) to the northeast of the Suurplaat study area (Map abstracted from Keyser & Smith 1977-78). Note that the high fossil density in this region is highlighted in the later detailed study by Loock *et al.* (1994) – see Fig. 6 above.

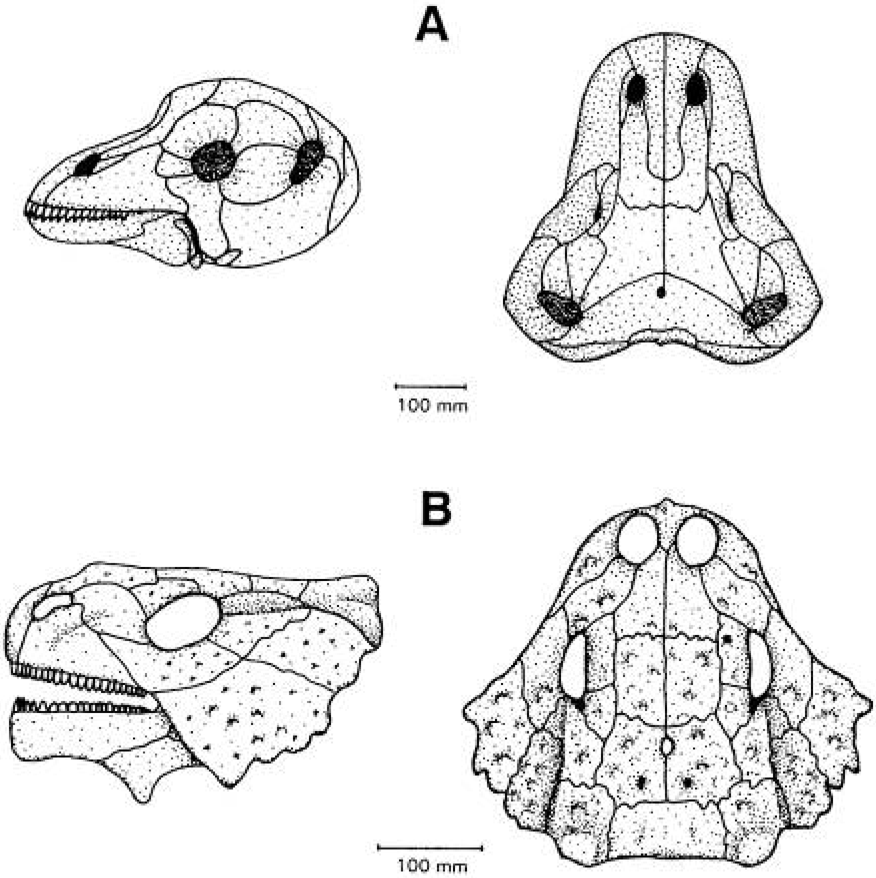

Fig. 9. Skulls of two key tetrapods of the *Tapinocephalus* Assemblage Zone: A – the dinocephalian therapsid *Tapinocephalus*; B – the pareiasaur *Bradysaurus* (From Smith & Keyser 1995b).

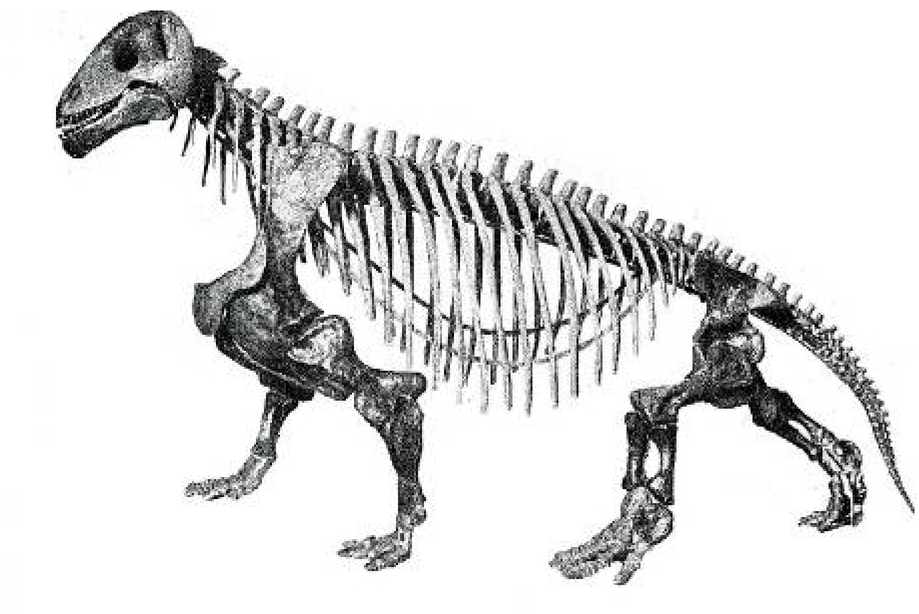

Fig. 10. Skeleton of the tapinocephalid (thick-skulled) dinocephalian *Moschops*, a rhino-sized herbivorous therapsid that reached lengths of 2.5 to 3m and may have lived in small herds.

4.1.2. Lowermost Teekloof Formation (Poortjie Member)

The arenaceous Poortjie Member as well as the uppermost beds of the underlying Abrahamskraal Formation are characterised palaeontologically by fossils of the *Pristerognathus* Assemblage Zone (Smith & Keyser 1995b). This important terrestrial biota is dominated by various therapsids ("mammal-like reptiles") such as the moderate-sized therocephalian carnivore *Pristerognathus* as well as several gorgonopsian predators / scavengers and herbivorous dicynodonts. The most common genus by far is the small burrowing dicynodont *Diictodon* (Keyser and Smith 1977-78, Smith & Keyser 1995b, MacRae 1999, Cole *et al*., 2004, Rubidge 2005; Fig.11 herein). There are also large, rhino-sized herbivorous reptiles (*Bradysaurus* spp.), crocodile-like temnospondyl amphibians (*Rhinesuchus*), palaeoniscoid fish, vascular plant fossils of the *Glossopteris* Flora (fossil wood, leaves *etc*) and various trace fossils, including invertebrate burrows and tetrapod trackways.

The fossil biota of the *Pristerognathus* Assemblage Zone is of special palaeontological interest because, at least until recently, it was thought to represent an impoverished post-extinction recovery fauna following the catastrophic End-Guadalupian (= end Mid Permian) mass extinction event of 260.4 million years ago (Rubidge 2005, Retallack *et al.,* 2006). The new radiometric date of 261.3 Ma obtained for the basal *Pristerognathus* Zone by Rubidge *et al.* (2010) is significant in that its shows that these low-diversity continental fossil assemblages actually *preceded* the global end-Mid Permian mass extinction event which is best established on the basis of marine invertebrate faunas (Erwin 2006, Retallack *et al.* 2006, Lucas 2009). This raises the possibility that two or more earlier extinction events in the continental realm are represented within the upper Abrahamskraal – Poortjie stratigraphic interval – *i.e.* (1) the faunal turnover at the top of the Koornplaats Member of the Abrahamskraal Formation (Fuig. 7) and (2) the sudden impoverishment of Karoo tetraods at the base of the *Pristerognathus* Zone, also within the upper Abrahamskraal Formation.

Most fossils in the *Pristerognathus* Assemblage Zone are found in the softer-weathering mudrock facies (floodplain sediments) that are usually only exposed on steeper hill slopes and in stream gullies. Fossils here are often associated with pedogenic limestone nodules or calcretes (Smith 1993a, Smith & Keyser 1995b). The mudrocks lie between the more resistant-weathering channel sandstones, which in the Poortjie Member display a distinctive "golden yellow" tint. Fossil skeletal remains also occur in the lenticular channel sandstones, especially in intraformational lag conglomerates towards the base, but are usually very fragmentary and water-worn ("rolled bone").

4.2. Fossil biotas within superficial deposits

The Karoo "drift" deposits have been comparatively neglected in palaeontological terms for the most part. However, they 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). Other late Caenozoic fossil biotas from these superficial deposits include non-marine molluscs (bivalves, gastropods, rhizoliths), ostrich egg shells, trace fossils (*e.g.* calcretised termitaria, coprolites), and plant remains such as peats or palynomorphs (pollens) in organic-rich alluvial horizons.

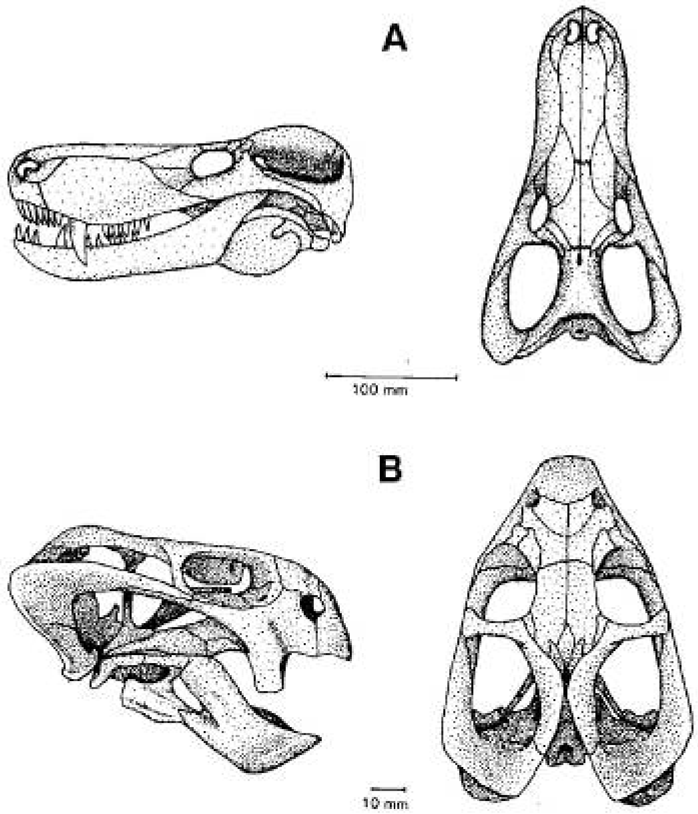

Fig. 11. Skulls of typical therapsids from the *Pristerognathus* Assemblage Zone: A - the dog-sized carnivorous therocephalian *Pristerognathus*; B - the small herbivorous dicynodont *Diictodon* (From Smith & Keyser 1995b).

6. ASSESSMENT OF IMPACT OF PROPOSED DEVELOPMENT ON PALAEONTOLOGICAL HERITAGE

The proposed Suurplaat Wind Energy Project near Sutherland is located in an area that is largely underlain by potentially fossil-rich sedimentary rocks of Permian Beaufort Group (Karoo Supergroup). These sediments are renowned for their rich fossil heritage of terrestrial vertebrates (most notably "mammal-like reptiles" or therapsids), as well as fish, amphibians, molluscs, trace fossils (*e.g.* trackways, burrows) and plants (*e.g.* petrified wood, leaves). The Abrahamskraal Formation to Teekloof Formation stratigraphic interval represented in the study area is of special palaeontological significance in that it immediately precedes the disastrous End-Guadalupian Mass Extinction Event some 260.4 million years ago and may record preceding extinction events among continental biotas. The palaeontological sensitivity of these Beaufort Group rocks is therefore considered to be very high. Caenozoic superficial sediments in the study area (*e.g.* alluvium, colluvium) are generally of low palaeontological sensitivity, but local concentrations of scientifically valuable fossils (*e.g*. mammalian bones, teeth) may also occur here.

The construction phase of the development will entail numerous, substantial excavations into any superficial sediment cover as well as the underlying bedrock. These notably include excavations for the *c*. 400 turbine foundations (typically 2.5m deep), buried cables between turbines (typically 1m deep), several substations, power line pylons, and an extensive network of new gravel access roads. Additional areas of bedrock may be sealed-in or sterilised by infrastructure such as standing areas for each wind turbine, a lay down area (this may well be temporary, however) as well as the new gravel road system. All these developments may adversely affect local fossil heritage within the study area by destroying, disturbing or permanently sealing-in fossils that are then no longer available for scientific research or other public good. Although the direct impact will be local, these fossils are of importance to national as well as international research projects on the fossil biota of the ancient Karoo Basin and the Permian mass extinction events. Consequently, the impact from disturbance and/or destruction of valuable – and internationally recognised - fossil heritage of the Beaufort Group bedrock is of heritage significance, at both local and regional levels.

A summary of the estimated magnitude and significance of the proposed wind farm development on local fossil heritage is given in Table 1 below (System designed by Savannah Environmental (Pty) Ltd). It is inferred here that the establishment of the Suurplaat Wind Energy Facility near Sutherland is of medium significance in terms of palaeontological heritage and therefore specialist mitigation is called for here.

Note that on the basis of this regional-scale desktop analysis, the two locations of the external substation and the various alternative routes for the associated 132kV overhead power lines between the wind energy facility and the new external substation (Figs. 2a, 2b) are comparable in terms of their potential (negative) impact on local fossil heritage. Consequently none of the alternative substation locations or power line routes is considered preferable to the others on palaeontological heritage grounds alone.

It should also be noted that the palaeontological field scoping and mitigation measures such as fossil collection and recording before or during the construction phase will almost certainly make a *positive* contribution to the scientific understanding of extinct Permian biotas of the western Great Karoo and their palaeoenvironments. The operational and decommissioning phases of the proposed wind energy facility will not involve further significant adverse or other impacts on palaeontological heritage.

TABLE 1. Summary of significance of the proposed Suurplaat Wind Energy Facility on local palaeontological heritage (with and without mitigation).

Nature: Destruction, disturbance or sealing-in of scientifically important fossil heritage, either at the ground surface or embedded in bedrock, during excavations or other construction work (construction phase of development)		
	Without mitigation	**With mitigation**
Extent	Local (3)	**Regional (4)**
Duration	Permanent (5)	**Permanent (5)**
Magnitude	Moderate (5)	**Moderate (5)**
Probability	Highly probable (4)	**Highly probable (4)**
Significance	**52 (Medium)**	**56 (Medium)**
Status	Negative	**Positive**
Reversibility	Irreversible	**Irreversible**
Irreplaceable loss of resources?	Yes	**Yes**
Can impacts be mitigated?	Yes	
Mitigation: 1. Palaeontological field survey of broader development area (*i.e.* all land parcels), leading to interim fossil heritage report; 2. Short workshop to train ECOs in recognition, recording and safeguarding of relevant fossil heritage; 3. Recording and judicious sampling of representative as well as any exceptional fossil material from the development footprint; 3. Curation of fossil specimens at an approved repository (*e.g.* museum); 4. Final technical report on palaeontological heritage within study area.		
Cumulative impacts: None (all impacts at construction phase)		
Residual impacts: Sealing-in of fossil heritage by development		

7. RECOMMENDATIONS

Given (a) the generally high palaeontological sensitivity of the Beaufort Group bedrocks, and (b) the established record of fossil sites within or close to the Suurplaat wind farm study area, the following recommendations regarding fossil heritage management are made for this project.

1. Before any major construction commences, a thorough **palaeontological field survey** of natural and already existing, artificial bedrock exposures (*e.g.* dams, roadcuts) within the study region as a whole (*i.e.* all land parcels concerned in the development) should be undertaken by a qualified palaeontologist. The main purpose of such a field study is to identify specific areas, zones or horizons of high palaeontological sensitivity on the ground (palaeontological "hotspots") that may warrant further specialist mitigation. Experience with comparable Karoo projects suggests that this survey work would probably preclude the need for specialist mitigation over the greater part of the proposed development footprint, while highlighting a few areas that may require further mitigation. Mitigation is thereby confined to a realistic but effective minimum. Such surveys represent key measures for saving time and costs to the developer at a later stage in the development, as well as for identifying important fossil heritage resources within a proposed development area.

The palaeontological field survey envisaged (which should be standard for this sort of project in the Karoo) involves only studying a representative sample of natural and artificial exposures of rocks within the development area or close by. This in fact would involve far less work and time than visiting the footprints of all the separate components of the proposed development (all turbines, roads etc). Furthermore, it is likely that before construction the bedrock at many of the individual development sites will be mantled in soil / vegetation / scree etc and so won't be helpful for predicting buried fossil heritage. Therefore our practice is to visit one to several sites for each geological unit (e.g. formation) where bedrock is already well exposed and use the data from these to predict what fossil heritage may be present over the rest of the development area. It's a sampling procedure that saves a lot of time. Unlike the archaeologists, we are not obliged to traverse the whole area in search of fossils.

2. On the basis of the initial palaeontological field survey, a realistic, collaborative **mitigation programme** and protocol should be drawn up by the palaeontologist in conjunction with the developer, Heritage Western Cape and SAHRA so that any important fossil heritage on site may be conserved both time- and cost-effectively. This mitigation would normally involve (a) the safeguarding, recording and judicious collection of stratigraphically and geographically well-localised fossil material within the development area, as well as (b) the recording of relevant geological data (*e.g.* sedimentological observations), before or during the construction phase of the development. The palaeontologist involved in mitigation work will be required to obtain a palaeontological collection permit from SAHRA and to arrange a suitable respository for any fossils collected (*e.g.* Iziko: South African Museum, Cape Town).

Note that within identified sites, zones or areas of inferred high palaeontological sensitivity, repositioning of infrastructure should not be necessary except in exceptional cases (*e.g*. high density of important fossil material). However, selective monitoring during development of a representative fraction of substantial bedrock excavations by a specialist palaeontologist may be required. A final technical report on fossil heritage within the broader development area should be submitted to HWC and SAHRA once mitigation and any preliminary analysis of the fossil material has been completed.

3. A short **fossil training workshop for ECOs**, led by a suitably qualified palaeontologist, on the significance, recognition, safeguarding and conservation of fossil heritage relevant to this project is also recommended for large scale development projects of this nature. Should substantial fossil remains (notably articulated vertebrate skeletons or skulls) be exposed at any time during construction, these should be recorded (*e.g.* photographed, with GPS location) and safeguarded by the responsible ECO, preferably *in situ*. Heritage Western Cape, SAHRA and / or a qualified palaeontologist should be alerted as soon as possible so that any appropriate mitigation measures can be considered.

7.1. General remarks on palaeontological field scoping studies and surveys

The focus of palaeontological scoping or survey work is *not* simply to survey the development footprint or even the development area as a whole (*e.g.* farms or other parcels of land concerned in the development). Rather, the palaeontologist seeks to assess or predict the diversity, density and distribution of fossils within and beneath the study area, as well as their heritage or scientific interest. This compliments a preceding desktop study and is primarily achieved through a careful field examination of one or more representative exposures of all the sedimentary rock units present for fossils already exposed at the ground surface (*N.B.* Metamorphic and igneous rocks rarely contain fossils). The best rock exposures are generally those that are easily accessible, extensive, fresh (*i.e.* unweathered) and include a large fraction of the stratigraphic unit concerned (*e.g.* formation). These exposures may be natural or artificial and include, for example, rocky outcrops in stream or river banks, cliffs, quarries, dams, dongas, open building excavations or road and railway cuttings. Uncemented superficial deposits, such as alluvium, scree or wind-blown sands, may occasionally contain fossils and should also be included in the scoping study / survey where they are well-represented in the study area. It is normal practice for impact palaeontologists to collect representative, well-localized (*e.g.* GPS and stratigraphic data) samples of fossil material during scoping / survey studies. All fossil material collected must be properly curated within an approved repository (usually a museum or university collection).

Note that while palaeontological localities recorded from exposed fossil material during scoping or survey work within the study area itself are obviously highly relevant, most fossil heritage here is embedded within rocks beneath the land surface or obscured by surface deposits (soil, alluvium *etc*) and by vegetation cover. In many cases where levels of fresh (*i.e.* unweathered) bedrock exposure are low, the hidden fossil resources have to be *inferred* from palaeontological observations made from better exposures of the same formations elsewhere in the region but outside the immediate study area. Therefore a palaeontologist might reasonably spend far *more* time examining road cuts and borrow pits close to, but outside, the study area than within the study area itself. Field data from localities even further afield (*e.g.* an adjacent province) may also be adduced to build up a realistic picture of the likely fossil heritage within the study area.

On the basis of the desktop and field scoping or survey 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 of a development project. Mitigation by a professional palaeontologist – normally involving the recording and sampling of fossil material and associated geological information (*e.g.* sedimentological data) – is usually most effective during the construction phase when fresh fossiliferous bedrock has been exposed by excavations. To carry out mitigation, the palaeontologist involved will need to apply for a palaeontological collection permit from SAHRA. It should be emphasised that, *provided that appropriate mitigation is carried out*, the majority of developments involving bedrock excavation can make a *positive* contribution to our understanding of local palaeontological heritage.

8. RECOMMENDATIONS FOR THE ENVIRONMENTAL MANAGEMENT PLAN

The following measures for inclusion in the Environmental Management Plan for the proposed Suurplaat Wind Energy Facility development near Sutherland are outlined below, according to the scheme developed by Savannah Environmental (Pty) Ltd. These measures will need to be elaborated and more precisely constrained in the light of the preliminary palaeontological field survey of the broader development area (*i.e.* all land parcels involved in development). Note that the operational and decommissioning phases of the development are unlikely to have significant impacts on palaeontological heritage and no further recommendations are made in this regard.

OBJECTIVE: Recording distribution of fossil heritage and relevant geological data within broader Suurplaat development footprint, identification of palaeontological hotspots requiring mitigation, safeguarding and sampling of important fossil material

Project component/s	Construction of wind turbine emplacements, buried cables, access roads, transmission pylons, substations
Potential Impact	Disturbance, destruction or sealing-in of scientifically valuable fossil material embedded within bedrock or weathered out at ground surface
Activity/risk source	Extensive bedrock excavations and surface disturbance (*e.g.* road construction)
Mitigation: Target/Objective	Recording, sampling and curation of important fossil heritage within Suurplaat development area, both before and during construction, to be achieved before completion of construction phase.

Mitigation: Action/control	Responsibility	Timeframe
1. Palaeontological field survey of broader development area (*i.e.* all land parcels), leading to interim fossil heritage report	Professional palaeontologist	Before construction starts
2. Short workshop to train ECOs in recognition, recording and safeguarding of relevant fossil heritage	Professional palaeontologist	Following palaeontological field survey, before development commences
3. Recording and judicious sampling of representative as well as any exceptional fossil material from the development footprint	Professional palaeontologist assisted by ECOs	Before and during construction phase
3. Curation of fossil specimens at an approved repository (*e.g.* museum)	Professional palaeontologist	Following mitigation
4. Final technical report on palaeontological heritage within study area	Professional palaeontologist	Following mitigation and preliminary analysis of fossil finds

Performance Indicator	Identification of palaeontological hotspots within broader development footprint. Training of ECOs Cumulative acquisition of geographically and stratigraphically well-localised fossil records and samples from successive subsections of the development area. Submission of interim and final technical reports to HWC , SAHRA
Monitoring	Monitoring of compliance by professional palaeontologist in collaboration with ECOs Realistic frequency, scale and protocol of monitoring to be determined by professional palaeontologist in conjunction with Heritage Western Cape, SAHRA and developer Assessment of interim and final reports by Heritage Western Cape & SAHRA

9. ACKNOWLEDGEMENTS

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11. QUALIFICATIONS & EXPERIENCE OF THE AUTHOR

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

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

Declaration of Independence

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

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