PALAEONTOLOGICAL IMPACT ASSESSMENT: DESKTOP STUDY

PROPOSED BEZALEL ECO-ESTATE DEVELOPMENT ON PORTIONS 135 AND 136 OF THE FARM TOWNLANDS OF MARTHINUS WESSELSTROOM 121 HT NEAR WAKKERSTROOM, MPUMALANGA

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November 2013

1. SUMMARY

Nulani Investments Pty Ltd is proposing to construct a residential development, known as the Bezalel Eco-estate, on portions 135 and 136 of the farm Townlands of Marthinus Wesselstroom 121HT, situated *c*. 6.5 km northwest of the small town of Wakkerstroom, Mpumalanga.

The lower-lying, southern portion of the Bezalel Eco-estate study area is underlain by offshore mudrocks of the Middle to Late Permian Volksrust Formation (Ecca Group) that are extensively intruded by dolerite sills. The fossil record of the dark Volksrust mudrocks is generally poor, with locally abundant organic-walled microfossils and trace fossils (*e.g.* invertebrate burrows) *plus* rare records of both marine and freshwater bivalve molluscs. Richer plant and insect biotas may occur in nearshore, deltaic sediments high up within the succession, but the stratigraphic position of these fossiliferous beds is poorly-defined. Steeper escarpment slopes featuring prominent-weathering sandstones in the study area are assigned to the Normandien Formation (Lower Beaufort Group) of Latest Permian age. This fluvio-deltaic succession of interbedded mudrocks and sandstones (previously referred to the Estcourt Formation) is well-known in Kwazulu-Natal for its diverse, well-preserved fossil floras - predominantly ferns and glossopterid pteridosperms, with minor coniferophytes. These are sometimes associated with important insect faunas. The Normandien fossil assemblages are generally found within recessive-weathering laminated mudrock horizons that are not at all well-exposed in the study area and that may well have been baked by the dolerite sill that caps the higher ground in the study area.

Infrastructure constructed in the low-lying, southwestern portions of the Belazel study area is unlikely to have significant impacts on local fossil heritage resources since this region is underlain by poorly-fossiliferous, baked Volksrust mudrocks and unfossiliferous dolerite. The higher-lying, steeper slopes built of sandstone-rich Normandien (Escourt) Formation rocks are more palaeontologically sensitive, but again baking by dolerite may have compromised fossil heritage here. Any substantial excavations (*e.g.* for building foundations) into the Normandien bedrocks should be monitored for fossils (*e.g.* plant-rich mudrock horizons) by a professional palaeontologist during the construction phase. The highest ground along the north-eastern and eastern edge of the study area overlies unfossiliferous dolerite.

Should any substantial fossil remains (*e.g.* vertebrate bones and teeth, petrified wood, plant fossil assemblages) be encountered during excavation, these should be reported to SAHRA for possible mitigation by a professional palaeontologist at the developers expense (SAHRA contact details: Ms. Colette Scheermeyer, South African Heritage Resources Agency, 111 Harrington Street. P.O. Box 4637, Cape Town 8000. Tel: 021 462 4502. Email: cscheermeyer@sahra.org.za. Fax: +27 (0)21 462 4509. Web:www.sahra.org.za).

2. INTRODUCTION & BRIEF

The company Nulani Investments Pty Ltd is proposing to develop a residential eco-estate (Bezalel Eco-estate) on portions 135 (a portion of portion 1) and 136 (a portion of portion 1) of the farm Townlands of Marthinus Wesselstroom 121HT, situated some 6.5 km northwest of the small town of Wakkerstroom, Mpumalanga (Figs. 1 to 3). The residential component of the estate, comprising 59 residential erven and a hotel, will be situated on a portion of Portion 136 while a manager's residence with workshop, estate services and stables will be accommodated on Portion 135.

The development footprint will be no more than 19 ha and include:

- 59 residential erven and related infrastructure;
- A hotel erf including conference venue and convenience shops as well as 25 accommodation rooms; and
- an erf for the management of the estate with a manager's residence, estate office, guard house, workshop, services, animal accommodation and stables.

The study area near Wakkerstroom is underlain by potentially fossiliferous sediments of Palaeozoic age (Ecca and Beaufort Groups, Karoo Supergroup) that may be disturbed or excavated during the construction phase of development. A palaeontological heritage assessment for the project was requested by SAHRA in accordance with the requirements of the National Heritage Resources Act, 1999 (SAHRA Ref: 16/5/1 Bezalel Eco-Estate, dated August 19, 2013). The present desktop report was therefore commissioned on behalf of the developer by KZK Urban Planning Studio (Contact details: Sieghard Knöcklein. KZK Urban Planning Studio, 282 Joubert Street, WAKKERSTROOM 2480. Tel: +27(81) 797 6211; Fax: +27 (86) 766 6795; E-mail: info.bezalelecoestate@gmail.com).

The brief for the study, as specified by SAHRA, is as follows:

> A Palaeontological study must be undertaken to assess whether or not the development will impact upon significant palaeontological resources. Alternatively, a letter of exemption from a Palaeontologist is required to indicate that this is unnecessary. If the area is deemed sensitive or if significant heritage is identified, a full Palaeontological Report may be required.

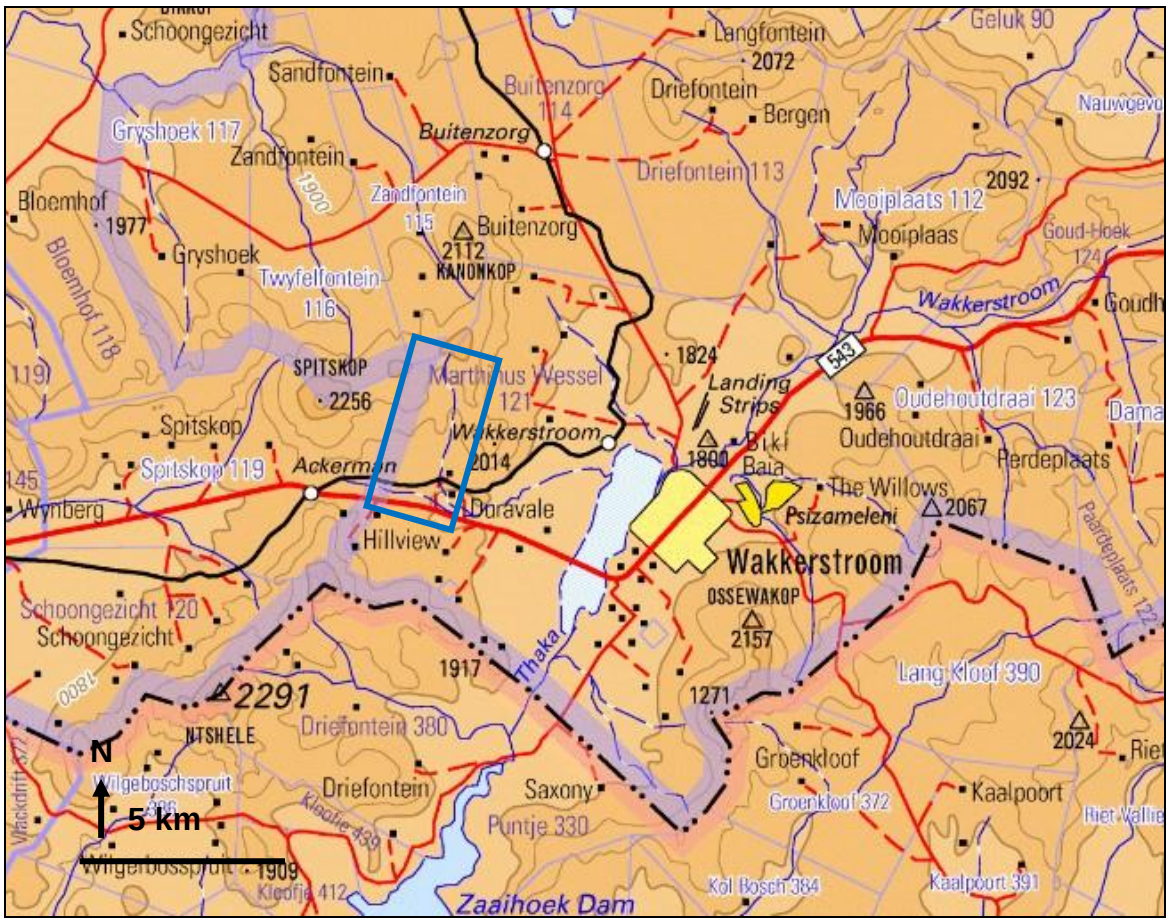

Fig. 1. Approximate location (blue rectangle) of the proposed Bezalel Eco-Estate study area some 6.5 km northwest of Wakkerstroom, Mpumalanga (Map abstracted from topographical sheet 2720 Vryheid, Courtesy of the Chief Directorate, National Geo-spatial Information, Mowbray).

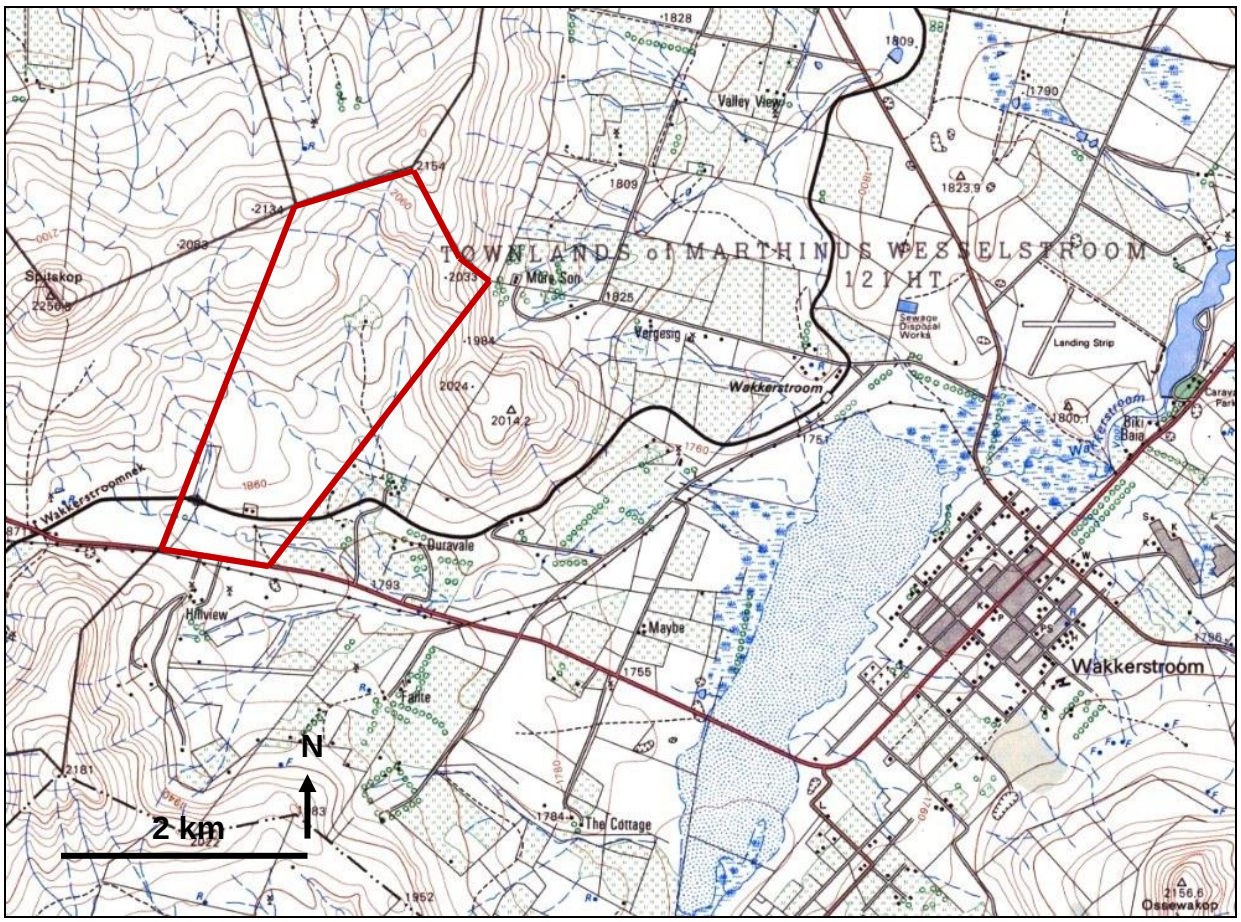

Fig. 2. Extract from 1: 50 000 topographical sheet 2730AC Wakkerstroom (courtesy of the Chief Directorate, National Geo-spatial Information, Mowbray) showing the outline of the Bezalel Eco-estate study area on portions 135 and 136 of the farm Townlands Of Marthinus Wesselstroom 121 HT, northwest of Wakkerstroom (red polygon).

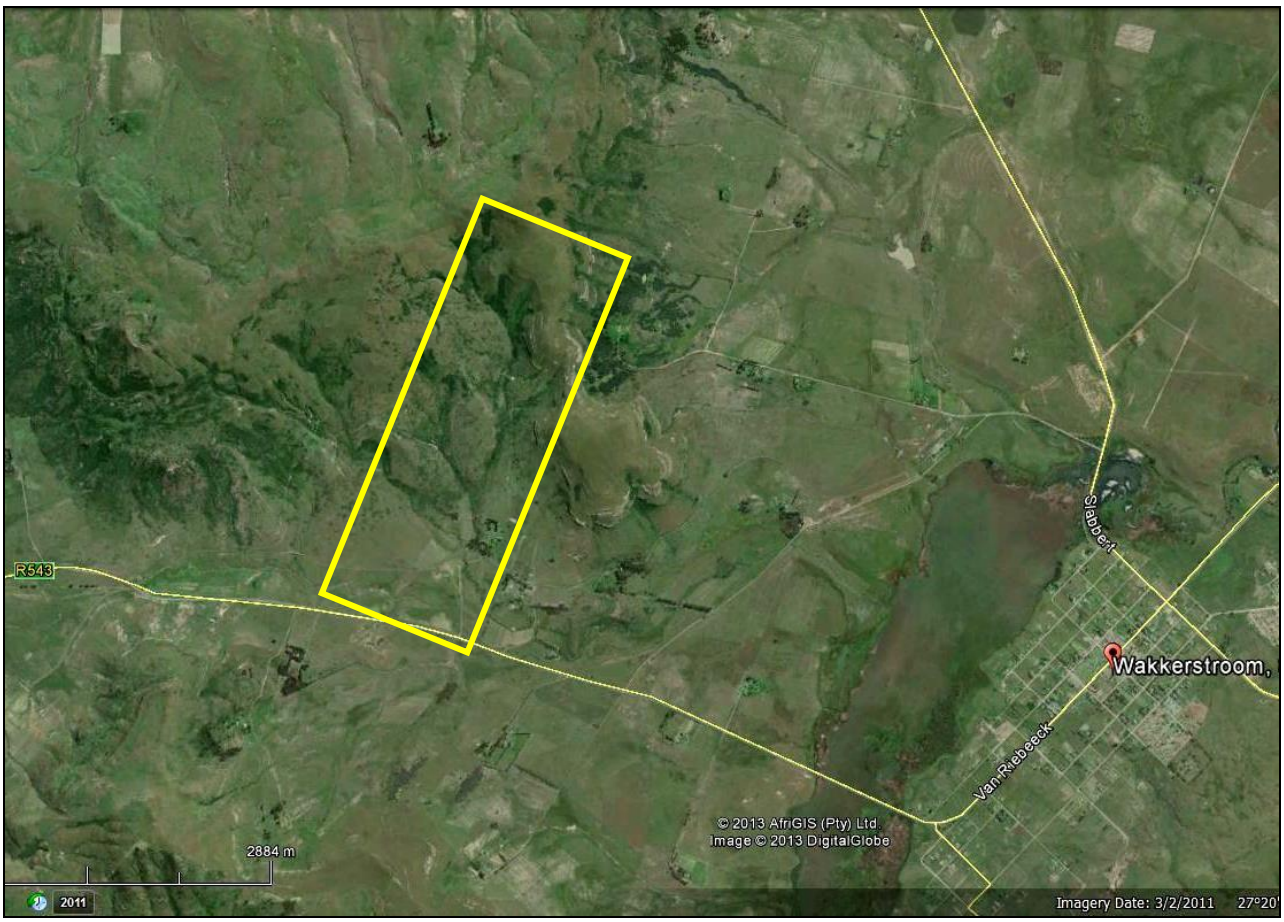

Fig. 3. Google earth© satellite image of the region to the northwest of Wakkerstroom, Mpumalanga showing the dissected mountainous terrain in the Bezalel Eco-estate study area (approximately indicated by the yellow rectangle). Gently-sloping to hilly terrain in the lowlands, away from the mountains, is underlain by mudrocks of the Volksrust Formation. Prominent-weathering pale sandstones of the Normandien Formation (= Escourt Formation) are seen in the escarpment. Faint reddish-brown hues on the plateau above the sandstones as well as beneath them reflect intrusive sills of the Karoo Dolerite Suite.

1.2. Legislative context of this palaeontological study

The various categories of heritage resources recognised as part of the National Estate in Section 3 of the National Heritage Resources Act (1999) 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 have been developed by SAHRA (2013).

2. APPROACH TO THE PALAEONTOLOGICAL HERITAGE ASSESSMENT

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

1. A project outline and maps provided by KZK Urban Planning Studio;

2. A review of the relevant scientific literature, including published geological maps, and satellite images;

3. The author's database on the formations concerned and their palaeontological heritage.

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. The potential 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.* SAHRA for the Northern Cape (Contact details: Mrs Colette Scheermeyer, P.O. Box 4637, Cape Town 8000. Tel: 021 462 4502. Email: cscheermeyer@sahra.org.za). It should be emphasized that, *providing appropriate mitigation is carried out*, the majority of developments involving bedrock excavation can make a *positive* contribution to our understanding of local palaeontological heritage.

3. 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 case of the Belazel Eco-estate project the major limitation for fossil heritage assessments is the paucity of previous specialist palaeontological studies on Palaeozoic rocks in this region of Mpumalanga as well as the very low levels of bedrock exposure. The relevant geological sheet explanation (Lindström 1987) contains very little relevant palaeontological data.

3. GEOLOGICAL BACKGROUND

The Bezalel Eco-estate project area lies within a west-east trending mountainous upland area to the northwest of Wakkerstroom, ranging in elevation from 1820 m amsl (above mean sea level) in the southwest, adjacent to the R543 road and railway to Volksrust, up to 2150 m amsl along the ridge in the northeast (Figs. 2 & 3).

The geology of the Wakkerstroom region is outlined on the 1: 250 000 geological sheet 2730 Vryheid (Council for Geoscience, Pretoria; Lindström 1987) (Fig. 4). According to this map, the study area is underlain by Permian-aged sediments of the Ecca and Lower Beaufort Groups (Karoo Supergroup). These include Middle to Late Permian basinal mudroks of the **Volksrust Formation** (Pvo, buff, in Fig. 4; Ecca Group) that are recessive weathering and build the gently sloping lowland areas. The Volksrust mudrocks are overlain by the more varied, sandstone-rich succession of the **Normandien Formation** (Pe, darker buff in Fig. 4; Adelaide Subgroup / Lower Beaufort Group) that are more resistant-weathering and build the more rugged uplands. Prominent bands of pale Normandien sandstone are visible on satellite images of the steep escarpment in the north-eastern portion of the study area (Fig. 3). The Normandien Formation in this region was previously known as the Escourt Formation and is Late Permian in age (Prevec *et al.* 2009 and refs. therein). Satellite images show that levels of exposure of Karoo Supergroup bedrocks, especially of the potentially fossiliferous mudrock facies, is very low within the study area.

The Karoo Supergroup succession in the Wakkerstroom area is extensively intruded by Early Jurassic dolerites of the **Karoo Dolerite Suite** (Jd, pink in Fig. 4) (Duncan & Marsh 2006). The dolerites take the form of subhorizontal to gently sloping, sheet-like bodies or sills and intrude both the Ecca and Lower Beaufort rocks here. The dolerite bedrock is often reflected by faint rusty-brown hues on satellite images (Fig. 3). As shown on the geological map, a dolerite sill intrudes the Volksrust mudrocks in the lower-lying southern part of the study area and another sill overlies the Normandien sandstone scarp where it builds flat-lying upland areas on the eastern and northern edges of the area. During intrusion of the hot dolerite magma in Early Jurassic times the adjacent country rocks will have been thermally metamorphosed (baked), with clay-rich mudrocks becoming dark, flinty hornfels while sandstones were concerted to tough, pale-hued quartzites.

A range of much younger (mainly Late Caenozoic) superficial sediments blanket much of the outcrop area of the Karoo Supergoup bedrocks. They will include colluvial slope deposits (*e.g.* sandstone and dolerite scree, sheetwash), alluvium associated with several streams that dissect the escarpment area, as well as various soils. Since these younger sediments are not mapped at 1: 250 000 scale, and are generally of low to very low palaeontological sensitivity, they will not be considered further here.

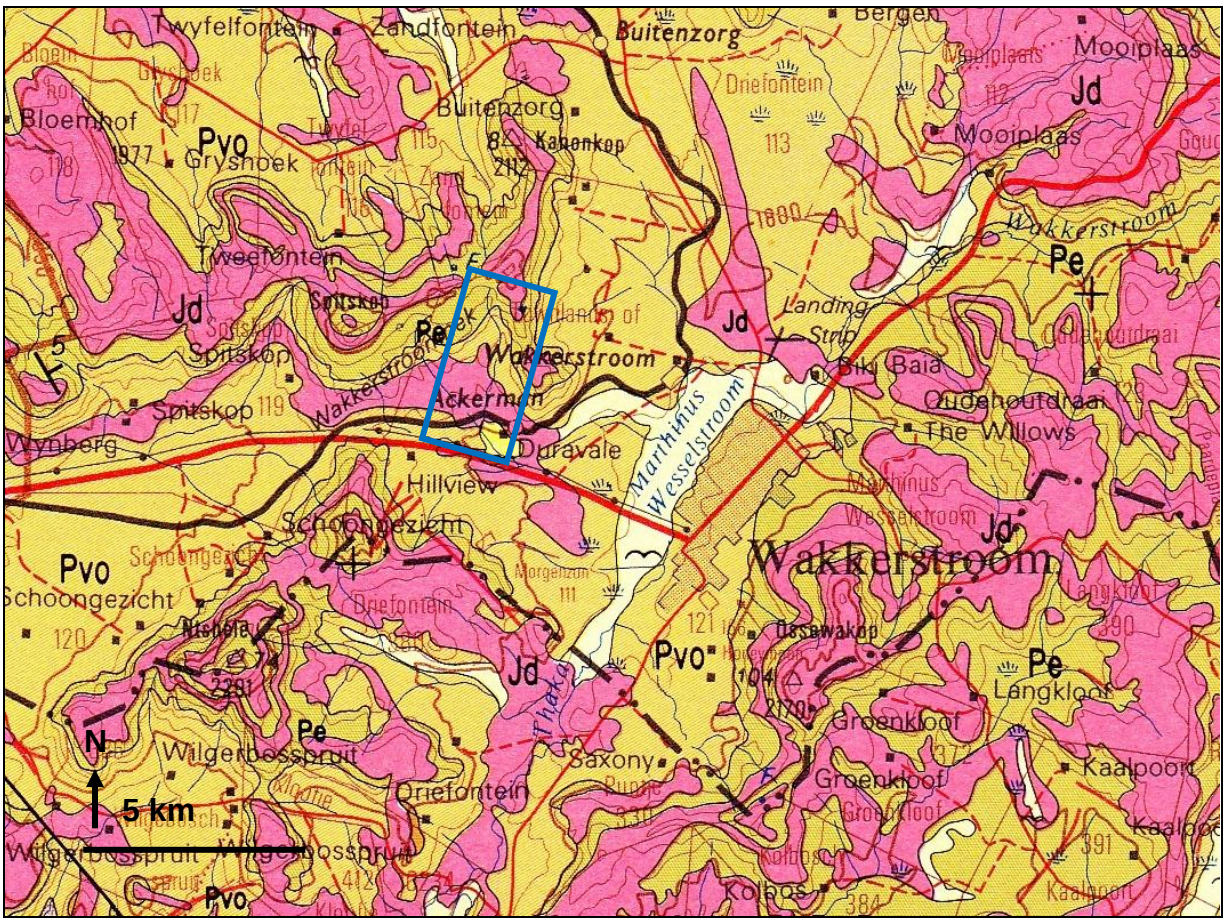

Fig. 4. Extract from 1: 250 000 geology sheet 2730 Vryheid (Council for Geoscience, Pretoria) showing the approximate location of the Bezalel Eco-estate study area to the northwest of Wakkerstroom, Mpumalanga (blue rectangle). The main bedrock units represented in the study area include (1) the mudrock-dominated Volksrust Formation (Ecca Group; Pvo, paler buff) of Middle to Late Permian age, (2) the Normandien Formation (= Escourt Formation, Adelaide Subgroup, Beaufort Group; Pe, darker buff) of Late Permian age and (3) intrusive dolerites of the Karoo Dolerite Suite (Jd, pink) of Early Jurassic age.

3.1. Volksrust Formation (Ecca Group)

The Volksrust Formation ("Upper Ecca Shales" of early authors) mainly comprises dark, offshore basinal mudrocks that were deposited in an epicontinental sea setting within the northern and north-eastern portions of the Main Karoo Basin. They conformably overlie the fluvio-deltaic sandstones of the Vryheid Formation and are overlain in turn by continental rocks of the Beaufort Group (Tavener-Smith *et al.* 1988, Johnson 1994, Mutingh 1997, Johnson 2009, Johnson *et al.* 2006). The contact between these adjacent rock units is interfingering. The Volksrust mudrocks are predominantly dark blue-grey to black, finely-laminated shales but siltstones and minor thin sandstones occur towards the base and top of the succession; these coarser facies often show higher levels of bioturbation. Diagenetic concretions or beds of phosphate, carbonate and siderite may occur. In the western portion of the Vryheid sheet area, close to its type area, the Volksrust Formation is *c*. 130 m thick, but up to 400 m of mudrocks are recorded in north-eastern KZN. The Volksrust Formation in the north-eastern and eastern parts of the Main Karoo Basin is probably equivalent to the lower part of the Lower Beaufort Group (Adelaide Subgroup) succession further west and is inferred to be Middle to Late Permian (Capitanian – Wuchiapingian) in age (Bordy & Prevec 2008).

3.2. Normandien Formation (Lower Beaufort Group)

The Normandien Formation is the equivalent of the upper Adelaide Subgroup (Lower Beaufort Group) in large parts of the north-eastern Main Karoo Basin. It now includes continental facies beds that were previously assigned to the Estcourt Formation in western KZN and southern Mpumalanga. In its type area the formation is 100 to 320 m thick and comprises greyish to reddish mudrocks with prominent-weathering sandstone interbeds (Groenewald 1984, 1989, Johnson 1994). In the more southern "Escourt Formation" outcrop area the sandstones are coarser and occasionally pebbly with rare thin (1-10 cm) coal seams at the top of upward-fining cycles (Johnson 1994, Lindström 1987). The lower contact with basinal mudrocks of the Volksrust Formation is conformable, while the upper boundary with the Tarkastad Subgroup (Upper Beaufort Group) is an erosional unconformity.

The "Escourt Formation" beds in the Vryheid sheet area (Pe), which are some 90 m thick, have been briefly described by Turner (1977) and Lindström (1987). Broadly upwards-fining successions are attributed to deposition by meandering rivers. Freshwater settings are implied by mudrock units containing conchostracan crustaceans. A detailed study of Normandien Formation meandering fluvial sediments and associated fossil biotas near Escourt, KZN, has been published by Prevec *et al.* (2009). A Late Permian (Changhsingian) age for the Normandien Formation is inferred by these last authors on the basis of the sparse fossil vertebrates (*e.g.* the dicynodont *Oudenodon*) supported by glossopterid floras, palynomorphs and insect faunas. Equivalent Late Permian coal-bearing beds in the Lebombo Basin to the east are referred to the separate Emakwezini Formation and have recently been described by Bordy and Prevec (2008). Selover and Gastaldo (2005) provide sedimentological evidence for turbidite fan sedimentation within the Late Permian "Ectcourt Formation" near Escourt, KZN.

4. PALAEONTOLOGICAL HERITAGE

The fossil record of the main rock units represented within the Bezalel Eco-estate study area is briefly outlined here, based on the published scientific literature. The Early Jurassic dolerite intrusions are not in themselves fossiliferous and their intrusion may well have compromised fossils preserved within the adjacent sediments of the Karoo Supergroup.

4.1. Fossil heritage within the Volksrust Formation

The fossil record of the Volksrust Formation ("Upper Ecca Shales") remains very poorly known. In general basinal mudrocks of the eastern Main Karoo Basin might be expected to contain representatives of some or all of the following fossil groups:

- acritarchs (organic-walled microfossils, some related to dinoflagellate algae);
- megadesmid bivalves (marine) and / or freshwater molluscs;
- rare temnospondyl amphibian remains;
- vertebrate microfossils (*e.g.* fish teeth, spines, scales) within diagenetic nodules;
- wind-blown insect remains;
- petrified woods ("*Dadoxylon*") or other drifted terrigenous plant material;
- low-diversity trace fossils assemblages of the *Cruziana, Scoyenia* and – especially - *Mermia* ichnofacies.

Organic-walled microfossils, including acanthomorph acritarchs and tasmanitids, have been described from borehole cores through the Volksrust Formation in the Free State and elsewhere (Hart 1969). So-called anellotubulate microfossils from Ecca borehole cores in the northern Main Karoo Basin (McLachlan 1973) have since been recognised as preparation artefacts.

Invertebrate fossil records are very sparse from this succession. Non-marine molluscs (*Carbonicola*) are noted from a carbonaceous oil-shale (torbanite) in the Wakkerstroom area by Anderson and Anderson (1985, p. 24). A large marine megadesmid bivalve has been recorded from hetreolithic, storm-influenced prodeltaic sediments of the upper Volksrust Formation near Newcastle by Cairncross *et al.* (2005) where it is associated with a range of *Cruziana* ichnofacies traces. Offshore basinal mudrocks contain *Mermia* ichnofacies trace assemblages which the *Scoyenia* ichnofacies is associated with marginal marine settings. Trace fossils, mainly associated with coarser, silty and sandy facies of the Volksrust Formation, are also recorded by Tavener-Smith *et al.* (1988). Small beetle wing cases are reported from plant fossil-rich beds in the Volkrust Formation of KZN (Lidgetton, Balgowan) by Ponomarenko and Mostovski (2005). These continental biotas have been variously assigned to the Estcourt (= Normandien) and Volksrust Formations, however, due to uncertainty concerning the Ecca / Beaufort boundary in this area (*See* discussion in Van Dijk 1981); they are referred to the Volksrust Formation by Van Dijk (1998). Upper Ecca deltaic facies coals assigned to the Volksrust Formation in Anderson and Anderson (1985, pp. 24-25), from sites like Cedara in KZN, contain rich fern palaeofloras (including sphenophytes) but only rare glossopterid remains.

4.2. Fossils within the Normandien Formation

Late Permian (Lopingian / Changhsingian) fluvio-deltaic sediments of the Normandien Formation (including the previously recognised Estcourt Formation) in the eastern and north-eastern portion of the Main Karoo Basin are well-known for their rich fossil plant assemblages of the *Glossopteris* Flora, some of which are unusually well preserved. Key accounts of these palaeofloras include those by Lacey (1974, 1978), Lacey *et al.* (1985), Anderson and Anderson (1985 – Estcourt Formation, pp. 32-35), Van Dijk (2000 and earlier papers) and Claassen (2008). The excellent recent study by Prevec *et al.* (2009) has a strong palaeoecological emphasis, highlighting plant-insect interactions on the basis of diverse trace fossil data. Plant groups recorded from the Normandien succession include possible mosses, sphenophytes, other ferns, possible lycopods, a range of glossopterids represented by remains of leaves, axes, fertile structures and seeds, as well as several coniferophytes. Petrified wood has been assigned to the genus *Agathoxylon*. Microfossils include a limited range of palynomorphs. Most of the plant fossil remains are associated with finely-laminated shale intervals within the Normandien succession; these are interpreted as in-channel slack-water deposits in the case studied by Prevec *et al.* (2009). Comparable fossil floras are also recorded from the (in part) co-eval Emakwezeni Formation of the Lebombo Basin (Bordy & Prevec 2008).

Fossil insect assemblages as well as insect-caused trace fossils (*e.g.* traces of herbivory) are well-represented at some localities (Van Dijk *et al.* 2000, Prevec *et al.* 2009 and refs. therein). Conchostracans (clam shrimps) are represented within freshwater mudrocks (Lindström 1987). Vertebrate remains recorded from the Normandien succession include the dicynodont therapsids *Oudenodon* and *Dicynodon*, supporting correlation with the latest Permian *Dicynodon* Assemblage Zone (Rubidge *et al.* 1995, Claassen 2008, Prevec *et al.* 2009).

Palaeontological data for the type area of the Normandien Formation is given in the seminal accounts by Groenewald (1984, 1989; not seen).

5. SUMMARY & RECOMMENDATIONS

The lower-lying portions of the study area for the Bezalel Eco-estate near Wakkerstroom, Mpumalanga, are underlain by offshore mudrocks of the Middle to Late Permian Volksrust Formation (Ecca Group) that are extensively intruded by dolerite sills. The fossil record of the dark-hued Volksrust mudrocks is generally poor, with locally abundant organic-walled microfossils and trace fossils (*e.g.* invertebrate burrows) *plus* rare records of both marine and freshwater bivalve molluscs. Richer plant and insect biotas may occur in nearshore, deltaic sediments high up

within the succession, but the stratigraphic position of these fossiliferous beds is poorly-defined. Steeper escarpment slopes featuring prominent-weathering sandstones in the study area are assigned to the Normandien Formation (Lower Beaufort Group) of Latest Permian age. This fluvio-deltaic succession of interbedded mudrocks and sandstones (previously referred to the Estcourt Formation) is well-known in Kwazulu-Natal for its diverse, well-preserved fossil floras - predominantly ferns and glossopterid pteridosperms, with minor coniferophytes. These plant-rich beds are sometimes associated with important insect faunas. The Normandien fossil assemblages are generally found within recessive-weathering laminated mudrock horizons that are not at all well-exposed in the study area and that may well have been baked by the dolerite sill that caps the higher ground in the study area.

Infrastructure constructed in the low-lying, southwestern portions of the Belazel study area is unlikely to have significant impacts on local fossil heritage resources since this region is underlain by poorly-fossiliferous, baked Volksrust mudrocks and unfossiliferous dolerite. The higher-lying, steeper slopes built of sandstone-rich Normandien (Escourt) Formation rocks are more palaeontologically sensitive, but again baking by dolerite may have compromised fossil heritage here. Any substantial excavations (*e.g.* for building foundations) into the Normandien bedrocks should be monitored for fossils (*e.g.* plant-rich mudrock horizons) by a professional palaeontologist during the construction phase. The highest ground along the north-eastern and eastern edge of the study area overlies unfossiliferous dolerite.

Should any substantial fossil remains (*e.g.* vertebrate bones and teeth, petrified wood, plant fossil assemblages) be encountered during excavation, these should be reported to SAHRA for possible mitigation by a professional palaeontologist at the developers expense (SAHRA contact details: Ms. Colette Scheermeyer, South African Heritage Resources Agency, 111 Harrington Street. P.O. Box 4637, Cape Town 8000. Tel: 021 462 4502. Email: cscheermeyer@sahra.org.za. Fax: +27 (0)21 462 4509. Web:www.sahra.org.za).

6. ACKNOWLEDGEMENTS

Herr Sieghard Knöcklein of KZK Urban Planning Studio, Wakkerstroom is thanked for commissioning this study and for kindly providing the necessary background information. I am very grateful to Dr Rose Prevec (Albany Museum, Grahamstown) for supplying literature on the Normandien Formation of KZN.

7. REFERENCES

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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

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Declaration of Independence

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

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