PALAEONTOLOGICAL HERITAGE BASIC ASSESSMENT: DESKTOP STUDY

Proposed rehabilitation of Section 10 of the N11 trunk road between Middelburg and Loskop Dam, Middelburg Magisterial District, Mpumalanga Province

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March 2014

EXECUTIVE SUMMARY

SANRAL is proposing to undertake the rehabilitation of Section 10 of the N11 trunk road between Middelburg (KM 3,4) and the Loskop dam (KM 53,4), Mpumalanga Province (DEA Ref No. 12/12/20/2612). The section to be upgraded is approximately 50 km in length. The proposed road works will include the following activities: widening of the existing road, adding overtaking lanes where required, upgrading existing culverts, and possible upgrading of bridges.

The N11 (Section 10) study area between Middelburg and the Loskop Dam is largely underlain by ancient Precambrian (Proterozoic) bedrocks, mostly ranging in age between 1.7 and 2 billion years. The oldest of these bedrocks include igneous rocks (lavas, granitoid intrusions) of the Rooiberg Group and Bushveld Complex that crop out on the northern side of the Selons River Valley, to the N and NE of the Loskop Dam, and are completely unfossiliferous. Minor sedimentary horizons within the Rooiberg Group are metamorphosed fluvial deposits that are unlikely to contain fossils.

Most of the southern and central portions of the N11 (Section 10) traverse immature, continental (fluvial / lacustrine) “red beds” of the Proterozoic Wilge River Formation (Waterberg Group). Broadly comparable red bed successions in the Waterberg Group of Limpopo have yielded important early fossils of lacustrine microbial mats but these have not been recorded in the Middelburg Basin. The Waterberg sediments and the post-Waterberg diabase dykes and sills intruding them are therefore rated as of low palaeontological sensitivity.

The N11 crosses small erosional outliers of the Permo-Carboniferous Dwyka Group (Karoo Supergroup) close to and north of Middelburg. These glacially-related sediments are generally of low palaeontological sensitivity and to the author’s knowledge have not yielded fossil remains in this region so far.

Late Caenozoic superficial deposits (colluvium, alluvium, soils, surface gravels *etc*) are not mapped on the relevant 1: 250 000 geology sheet 2528 Pretoria. However, substantial, potentially-fossiliferous alluvial deposits are likely to be present on floor and margins of the Selon’s and Olifants River Valleys. This includes the west-east section of the N11 (Section 10) that runs up to six kilometres east of the Loskop Dam as well as the short road section running north from the dam. There is a small possibility that excavations into alluvium during road rehabilitation along this section of the road might exposure scientifically valuable fossil remains. The palaeontological sensitivity of these geologically youthful deposits is generally low, however.

The overall impact significance of the proposed N11 (Section 10) road rehabilitation is considered to be LOW. Pending the discovery of substantial new fossil remains during construction, no further specialist palaeontological studies or mitigation for this project are considered necessary.

- The ECO responsible for the development should be aware of the possibility of important fossils being present or unearthed on site and should monitor all substantial excavations into fresh (*i.e.* unweathered) sedimentary bedrock for fossil remains;

- In the case of any significant fossil finds (*e.g.* vertebrate teeth, bones, burrows, petrified wood, calcretised termitaria) during construction, these should be safeguarded - preferably *in situ* - and reported by the ECO as soon as possible to the relevant heritage management authority (South African Heritage Resources Agency. Contact details: SAHRA, 111 Harrington Street, Cape Town. PO Box 4637, Cape Town 8000, South Africa. Phone: +27 (0)21 462 4502. Fax: +27 (0)21 462 4509. Web: www.sahra.org.za) so that any appropriate mitigation by a palaeontological specialist can be considered and implemented, at the developer's expense;

- These recommendations should be incorporated into the EMP for the N11 road rehabilitation project.

The palaeontologist concerned with mitigation work will need a valid collection permit from SAHRA. All work would have to conform to international best practice for palaeontological fieldwork and the study (*e.g.* data recording fossil collection and curation, final report) should adhere to the minimum standards for Phase 2 palaeontological studies recently published by SAHRA (2013).

1. INTRODUCTION & BRIEF

SANRAL is proposing to undertake the rehabilitation of Section 10 of the N11 trunk road between Middelburg (KM 3,4) and the Loskop dam (KM 53,4), Middelburg Magisterial District, Mpumalanga Province (DEA Ref No. 12/12/20/2612). The proposed section to be upgraded is approximately 50 km in length. The proposed road works will include the following activities (See Figs. 1a and 1b below):

- Widening of the existing road;
- Adding overtaking lanes where required (*e.g.* the Kranspoort Pass);
- Upgrading existing culverts;
- Possible upgrading of the bridges.

In response to a Heritage Assessment (HIA) Report submitted by van Schalkwyk (2012) SAHRA issued an Interim Comment dated Thursday May 16, 2013 requesting a palaeontological assessment for the project (their ref: 9/2/242/0004).

The study area for the proposed road developments overlies potentially fossiliferous sediments of Precambrian, Palaeozoic and younger age (Sections 3 & 4, Fig. 2). The construction phase of the project, notably in sections where the existing road will be widened, will entail fresh excavations into the superficial sediment cover (soils, alluvium *etc*) and probably also into the underlying bedrock. These activities may adversely affect fossil heritage at or near the surface 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.

The extent of the proposed development (over 5000 m^2) falls within the requirements for a Heritage Impact Assessment (HIA) as required by Section 38 (Heritage Resources Management) of the South African Heritage Resources Act (Act No. 25 of 1999). A desktop palaeontological heritage assessment for the proposed road project has accordingly been commissioned by LIDWALA Consulting Engineers (Contact details: Marinus Boon, Lidwala Consulting Engineers, P.O. Box 32497, Waverley, Pretoria, 0135.Tel: 0861 LIDWALA / 0861 543 9252. Cell: 074 76 123 27. Fax: 086 557 3141).

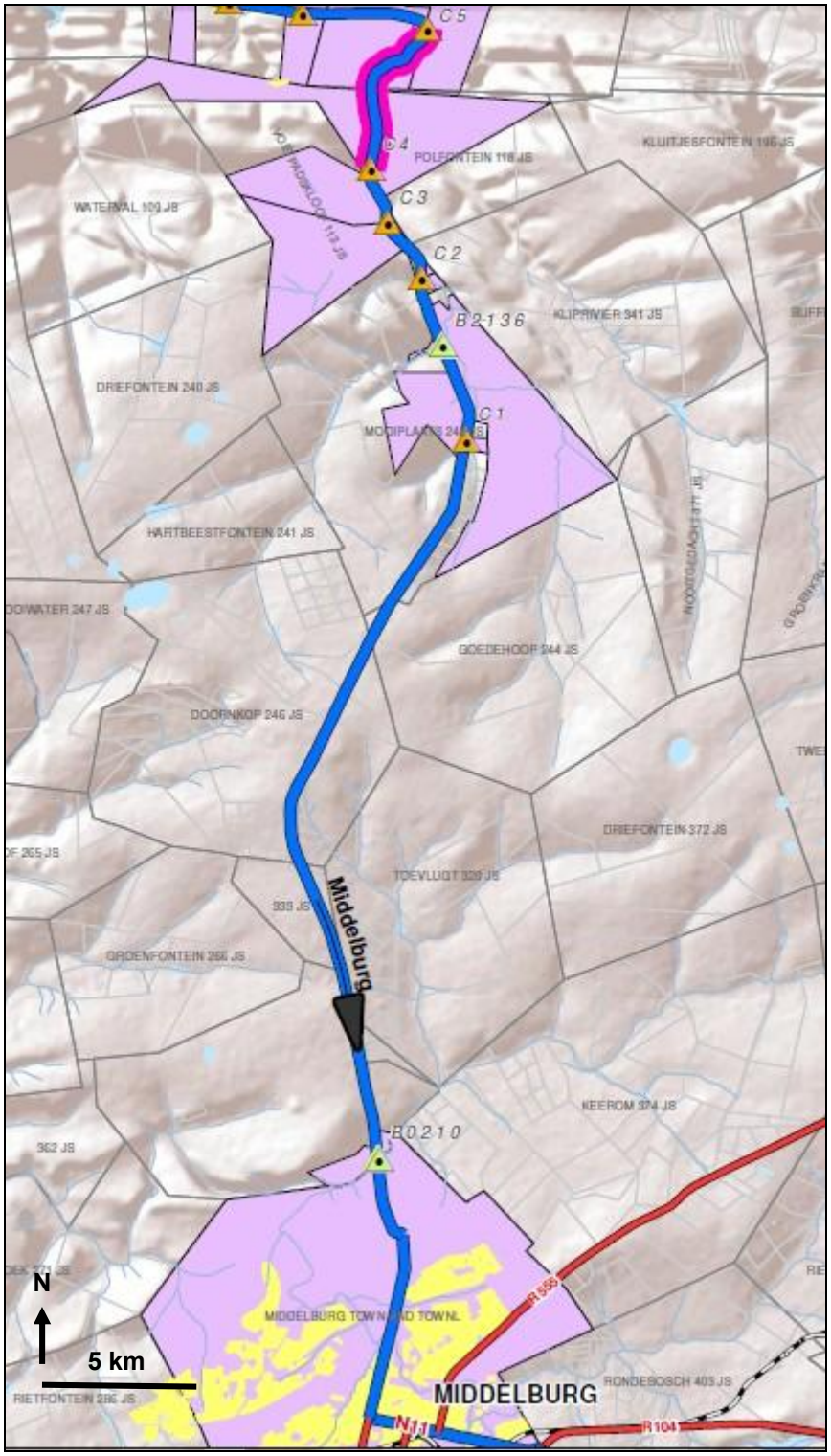

Fig. 1a. Location of the proposed rehabilitation work along Section 10 of the N11 trunk road between Middelburg (KM 3,4) and the Loskop dam (KM 53,4), Mpumalanga Province, southern portion of study area near Middelburg (Modified from image produced by Lidwala Consulting Engineers). See key on following page.

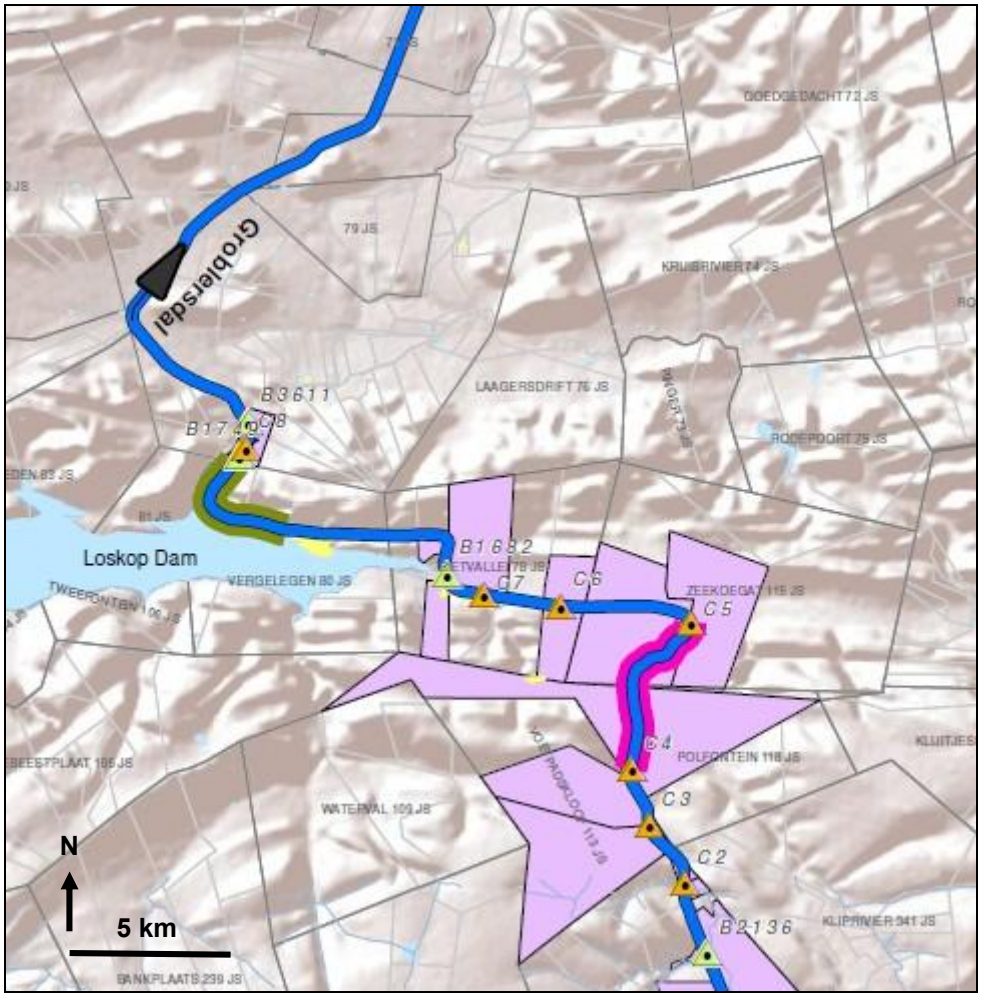

Fig. 1b. Location of the proposed rehabilitation work along Section 10 of the N11 trunk road between Middelburg (KM 3,4) and the Loskop dam (KM 53,4), Mpumalanga Province, northern portion of study area near Loskop Dam (Modified from image produced by Lidwala Consulting Engineers). See key below.

1.1. 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 short project outline abstracted from the Heritage Impact Assessment for the project by Van Schalkwyk (2012) as well as maps kindly provided by Lidwala Consulting Engineers;

2. A review of the relevant scientific literature, including published geological maps, satellite images and previous palaeontological heritage reports (*e.g.* Durand 2013);

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.

2.1. 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 development projects in the Middelburg region the major limitation for fossil heritage assessments is the paucity of previous specialist palaeontological field studies in this region. The relevant geological explanation for 1: 250 000 sheet 2528 Pretoria has not been published and the short explanation printed on the map itself includes almost no palaeontological data.

3. GEOLOGICAL BACKGROUND

3.1. Location and brief description of study area

The N11 (Section 10) study area is situated between the town of Middelburg, some 125 km east of Pretoria, and the Loskop Dam on the Olifants River, *c*. 30 km south of Groblersdal, Mpumalanga. The southern and central sectors of Section 10 traverse the Mpumalanga Highveld region at elevations of *c*. 1440 and 1600 m amsl. The terrain here is hilly, undulating and incised by several shallow drainage courses. The northern sector descends down into the valley of the Selons River which enters the Loskop Dam at an elevation of around 1000 m amsl. Here the terrain is characterised by prominent, west-east trending ridges and valleys away from the gently-sloping valley floor. Beyond the Loskop Dam a short section of road along the eastern side of the Olifants River descends northwards towards Groblersdal.

3.2. Geology of the study area

The geology of the study area between Middelburg and Groblersdal is shown on the 1: 250 000 geology map 2528 Pretoria (Council for Geoscience, Pretoria; Fig. 2 herein). A comprehensive sheet explanation for this map has not yet been published but there is a very short geological summary printed on the back of the map itself.

The oldest rocks in the study area, cropping out to the northeast and north of the Loskop Dam, are two billion-year old volcanics of the Proterozoic **Rooiberg Group** that form part of the Bushveld Magmatic Province (Buchanan 2006). These rocks are mapped as the **Damwal Formation** (**Vdr**, orange in Fig. 2) and the overlying **Selons River Formation** (**Vs**, pink in Fig. 2). Since they largely comprise unfossiliferous acidic lavas they will not be treated further here. Thin, laterally-persistent sedimentary interbeds (sandstone, mudrock, chert) are recorded between the lavas in the Loskop Dam Nature Reserve but these sediments are metamorphosed. They still preserve small-scale sedimentary features, however, such as cross-bedding, ripple marks and mudcracks (Eriksson *et al.* 1994, Buchanan 2006). According to the 1: 250 000 Pretoria sheet explanation a prominent-weathering, laterally-persistent horizon is used as a marker bed for the contact between the Damwal and Selons River Formations. Porphyritic granites of the **Rashoop Granophyre Suite** (**Mr**, yellow with stipple in Fig. 2), a component of the **Bushveld Complex**, intrude the Rooiberg Group volcanics and overlying Loskop Formation sediments in the Loskop Dam area (See Cawthorne *et al.* 2006).

The bedrock geology underlying Section 10 of the N11 is dominated by Early Proterozoic (1.7 – 2.0 Ga = billion years old) continental “red bed” sediments of the **Waterberg Group** that are assigned to the Middelburg Basin situated to the east of Pretoria (Barker *et al.* 2006). The basal **Loskop Formation** (**Vls**, grey in Fig. 2), once regarded as the uppermost Transvaal Supergroup succession but now interpreted as a probable Proto-Waterberg unit (Barker *et al.*, 2006), crops out around Middelburg as well along the Selons River Valley east of the Loskop Dam, the type area for the succession. It comprises up to 1000 m of predominantly fine-grained, thin-bedded clastic sedimentary rocks with a prominent-weathering basal conglomerate and subordinate sandstones and basic to acidic lavas (Martini 1998, Barker *et al.* 2006). The lower contact with lavas of the Rooiberg Group (Bushveld Complex), as seen in the Loskop Dam area, is locally gradational but regionally unconformable whereas the upper contact with the Waterberg Group *sensu stricto* (Wilge River Formation) is characterised by a major angular unconformity. The Loskop rocks are interpreted as a molasse-type depositional unit, with associated lava extrusion and minor igneous intrusives, that was deposited contemporaneously with the Bushveld Complex plume event.

Coarse-grained continental red beds of the **Wilge River Formation** (Waterberg Group) underlie most of the Highveld terrain between Middelburg and the Selons River Valley (**Mw**, orange in Fig. 2). This succession of up to 2500 m thickness is dominated by immature, coarse-grained, lenticular-bedded, red to reddish-brown sandstones showing tabular cross-bedding and soft-sediment deformation features (Vos & Eriksson 1977, Eriksson & Vos, 1979, Van der Neut *et al.* 1991, Barker *et al,* 2006). Fining-upward sequences feature minor conglomerates towards the base and thin mudrocks towards the top. Clasts in the conglomerates are mainly derived from quartzitic intervals within the Transvaal Supergroup as well as lavas and cherts from the Rooiberg Group. The depositional settings most recently suggested for the Wilge River Formation include alluvial fans and fan deltas with occasional wave reworking along the margins of lakes (Van der Neut *et al.* 1991). Minor volcanic subunits within the Wilge River Formation include pyroclastic beds and andesitic lavas. Most of the Wilge River succession shows shallow dips, but more steeply-dipping beds associated with faulting and folding of Proterozoic age (*c*. 2.1 – 1 Ga) are encountered along the north-eastern basin margin (*e.g.* southern side of Selons River Valley).

Several major **post-Waterberg intrusions** into the Wilge River succession are traversed by the N11 to the north of Middelburg (**di**, yellowish-green in Fig. 2). These include dykes and sills of microgabbro of poorly-defined age ("diabase"; Barker *et al.* 2006).

Small patches of **Karoo Supergroup** sediments along the northern edge of the Main Karoo Basin unconformably overlie the Proterozoic sedimentary and igneous rocks of the Mpumalanga Highveld region around and to the north of Middelburg. These include erosional relicts of the **Dwyka Group** (**Pd**, yellow in Fig. 2) and the overlying **Ecca Group** (**Pe**, grey in Fig. 2), only the first of which are traversed by the N11 (Section 10). According to the brief sheet explanation, the Dwyka rocks – notably glacial tillites - in the 1: 250 000 2528 Pretoria sheet area are mainly confined to lows in the pre-Karoo topography but no further site-specific data is available.

The Proterozoic to Palaeozoic bedrocks in the N11 study area are frequently mantled by a range of **Late Caenozoic superficial deposits**. These include colluvium, alluvium (*e.g.* along the floor of the Selons River Valley), surface gravels and various soils. However, no details of these superficial deposits are provided in the Pretoria sheet explanation. It is possible that elevated ancient "High Level Gravels" of alluvial origin and Late Tertiary / Quaternary age are associated with the Selons and Olifants Rivers.

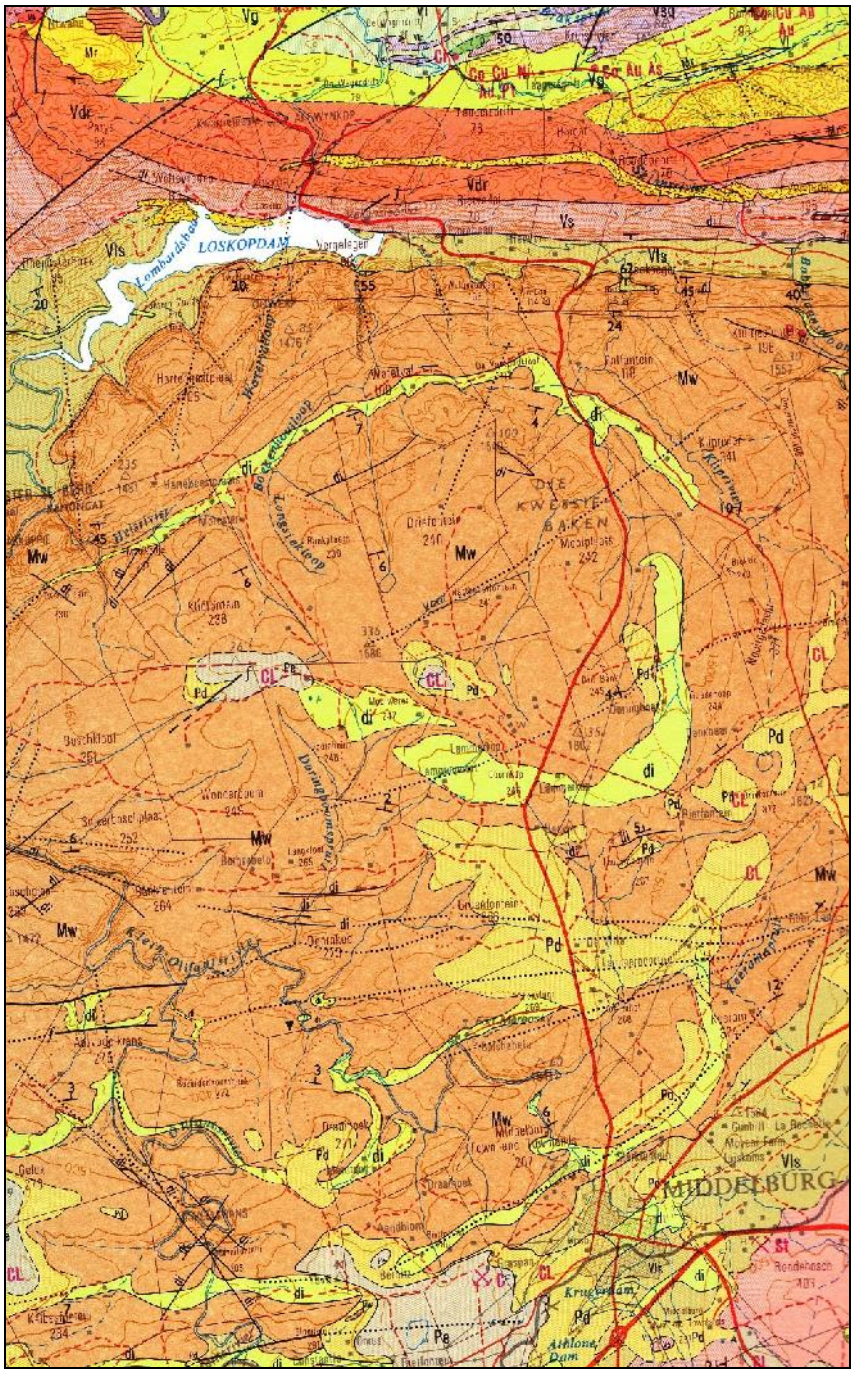

Fig. 2. Extract from 1: 250 000 geology map 2528 Pretoria (Council for Geoscience, Pretoria) showing the N11 study area between Middelburg and the Loskop Dam, Mpumulanga. The main geological units represented in the study area include:
Pe (grey) = Ecca Group (Karoo Supergroup)
Pd (middle yellow) = Dwyka Group (Karoo Supergroup)
Di (greenish-yellow) = diabase (post-Waterberg microgabbroic intrusions)
Mw (pale orange) = Wilgerivier Formation (Waterberg Group)
Vls (pale brown) = Loskop Formation
Mr (yellow stippled) = Rashoop Granophyre Suite (Bushveld Complex)
Vs (pink) = Selonsrivier Formation (Rooiberg Group)
Vdr (dark orange) = Damwal Formation (Rooiberg Group)
***N.B.* Late Caenozoic superficial sediments such as colluvium, alluvium (*e.g.* along the Selons River Valley) are not mapped on this sheet.**

4. PALAEONTOLOGICAL HERITAGE

A brief review of the known fossil record and palaeontological sensitivity of the various major rock units represented in the N11 (Section 10) study area is given here.

The Early Proterozoic **Rooiberg Group** succession is generally of low palaeontological sensitivity since it consists largely of unfossiliferous lavas. Fossil remains are unlikely to be preserved in the minor thin sedimentary units within the succession because of their fluvial depositional setting and subsequent metamorphism (*e.g.* baking of sandstones to quartzites), although the latter has not completely obliterated small-scale sedimentary structures within the metasedimentary rocks (Buchanan 2006).

No fossils are recorded from the Proterozoic (*c*. 2 Ga) **Bushveld Complex** (including the **Rashoop Granophyre Suite**) since these rocks are entirely igneous. The same applies to **post-Waterberg diabase intrusions** in the study area.

The Early Proterozoic **Waterberg and Soutpansberg Group** "red bed" successions are of considerable palaeobiological and palaeoenvironmental significance in that they provide key evidence for the development of an oxygenated atmosphere on Earth after *c*. 2 billion years ago. Some of the earliest known (1.8 Ga) terrestrial cyanobacterial mats have been recorded from playa lake deposits of the Makgabeng Formation within the Waterberg Group outcrop area on the Makgabeng Plateau, west of Soutpansberg, Limpopo Province (Eriksson *et al.* 2000, Eriksson *et al.* 2008). Comparable microbial mats have not yet been recorded from the Waterberg Group of the Middelburg Basin and the palaeontological sensitivity of the Wilge River Formation represented here is accordingly rated as low.

The fossil record of the **Dwyka Group** in the Main Karoo Basin is generally poor, as expected for a glacial sedimentary succession (McLachlan & Anderson 1973, Anderson & McLachlan 1976, Visser 1989, Visser *et al*., 1990, MacRae 1999, Visser 2003, Almond 2008a, 2008b, Almond & Pether 2008a, 2008b). Sparse, low diversity trace fossil biotas from the Elandsvlei Formation mainly consist of delicate arthropod trackways (probably crustacean) and fish swimming trails associated with recessive-weathering dropstone laminites (Anderson 1974, 1975, 1976, 1981). Sporadic vascular plant remains (drifted wood and leaves of the *Glossopteris* Flora) are recorded (Anderson & Anderson 1985, Bamford 2000, 2004), and are also known from Dwyka-equivalent coal seams in the Springbok Flats Basin of Limpopo (Johnson *et al.* 2006). Palynomorphs (organic-walled microfossils) are be present within at least some finer-grained mudrock facies of the Dwyka Group. Glacial diamictites (tillites or "boulder mudstones") are normally unfossiliferous but do occasionally contain fragmentary transported plant material as well as palynomorphs in the fine-grained matrix (Plumstead 1969). There are biogeographically interesting records of limestone glacial erratics from tillites along the southern margins of the Great Karoo that contain Cambrian eodiscid trilobites as well as archaeocyathid sponges. Such derived fossils provide important data for reconstructing the movement of Gondwana ice sheets (Cooper & Oosthuizen 1974, Stone & Thompson 2005). To the author's knowledge, there are no fossil records from the various small Dwyka Group outliers overlying the Proterozoic bedrocks of the Middelburg Basin. The palaeontological sensitivity of these Permo-Carboniferous glacially-related rocks is therefore rated as low (*cf* Durand 2013).

The fossil record of most **Late Caenozoic superficial sediments** or "drift" deposits in the subcontinental interior have been comparatively neglected in palaeontological terms. The palaeontological sensitivity of these geologically youthful deposits is generally low. However, they may occasionally contain important fossil biotas, notably the bones, teeth and horn cores of mammals as well as remains of reptiles like tortoises. Good examples are the Pleistocene mammal faunas from alluvial and pan sediments in the Free State and elsewhere (Wells & Cooke 1942, Cooke 1974, Skead 1980, Klein 1984, Brink, J.S. 1987, Bousman *et al.* 1988, Bender & Brink 1992, Brink *et al*. 1995, MacRae 1999, Meadows & Watkeys 1999, Churchill *et al*. 2000, Partridge & Scott 2000, Brink & Rossouw 2000, Rossouw 2006). Other late Caenozoic fossil biotas from these superficial deposits

include non-marine molluscs (bivalves, gastropods), ostrich egg shells, tortoise remains, trace fossils (*e.g.* calcretised termitaria, coprolites, invertebrate burrows), and plant material such as peats or palynomorphs (pollens) in organic-rich alluvial horizons (Scott 2000) and diatoms in pan sediments. In Quaternary deposits, fossil remains may be associated with human artefacts such as stone tools and are also of archaeological interest.

Superficial deposits are not indicated within the present study area on the available 1: 250 000 geological map (Fig. 2) but it likely that substantial, potentially-fossiliferous alluvial deposits are present along the floor and margins of the Selons River and Olifants River Valleys. This includes the west-east section of the N11 that runs up to six kilometres east of the Loskop Dam as well as the short road section running north from the dam. There is a small possibility that excavations into alluvium during road rehabilitation along this section of the road might exposure scientifically valuable fossil remains.

5. CONCLUSIONS & RECOMMENDATIONS

The N11 (Section 10) study area between Middelburg and the Loskop Dam is largely underlain by ancient Precambrian (Proterozoic) bedrocks, mostly ranging in age between 1.7 and 2 billion years. The oldest of these bedrocks include igneous rocks (lavas, granitoid intrusions) of the Rooiberg Group and Bushveld Complex that crop out on the northern side of the Selons River Valley, to the N and NE of the Loskop Dam, and are completely unfossiliferous. Minor sedimentary horizons within the Rooiberg Group are metamorphosed fluvial deposits that are unlikely to contain fossils.

Most of the southern and central portions of the N11 (Section 10) traverse immature, continental (fluvial / lacustrine) “red beds” of the Proterozoic Wilge River Formation (Waterberg Group). Broadly comparable red bed successions in the Waterberg Group of Limpopo have yielded important early fossils of lacustrine microbial mats but these have not been recorded in the Middelburg Basin. The Waterberg sediments and the post-Waterberg diabase dykes and sills intruding them are therefore rated as of low palaeontological sensitivity.

The N11 crosses small erosional outliers of the Permo-Carboniferous Dwyka Group (Karoo Supergroup) close to and north of Middelburg. These glacially-related sediments are generally of low palaeontological sensitivity and to the author’s knowledge have not yielded fossil remains in this region so far.

Late Caenozoic superficial deposits (colluvium, alluvium, soils, surface gravels *etc*) are not mapped on the relevant 1: 250 000 geology sheet 2528 Pretoria. However, substantial, potentially-fossiliferous alluvial deposits are likely to be present on floor and margins of the Selon’s and Olifants River Valleys. This includes the west-east section of the N11 (Section 10) that runs up to six kilometres east of the Loskop Dam as well as the short road section running north from the dam. There is a small possibility that excavations into alluvium during road rehabilitation along this section of the road might exposure scientifically valuable fossil remains. The palaeontological sensitivity of these geologically youthful deposits is generally low, however.

The overall impact significance of the proposed N11 (Section 10) road rehabilitation is considered to be LOW. Pending the discovery of substantial new fossil remains during construction, no further specialist palaeontological studies or mitigation for this project are considered necessary.

- The ECO responsible for the development should be aware of the possibility of important fossils being present or unearthed on site and should monitor all substantial excavations into fresh (*i.e.* unweathered) sedimentary bedrock for fossil remains;

- In the case of any significant fossil finds (*e.g.* vertebrate teeth, bones, burrows, petrified wood, calcretised termitaria) during construction, these should be safeguarded - preferably *in situ* - and reported by the ECO as soon as possible to the relevant heritage management authority (South African Heritage Resources Agency. Contact details: SAHRA, 111 Harrington Street, Cape Town. PO Box 4637, Cape Town 8000, South Africa. Phone: +27 (0)21 462 4502. Fax: +27 (0)21 462 4509. Web: www.sahra.org.za) so that any appropriate mitigation by a palaeontological specialist can be considered and implemented, at the developer's expense;

- These recommendations should be incorporated into the EMP for the N11 road rehabilitation project.

The palaeontologist concerned with mitigation work will need a valid collection permit from SAHRA. All work would have to conform to international best practice for palaeontological fieldwork and the study (*e.g.* data recording fossil collection and curation, final report) should adhere to the minimum standards for Phase 2 palaeontological studies recently published by SAHRA (2013).

7. ACKNOWLEDGEMENTS

Mr Marinus Boon of LIDWALA Consulting Engineers, Pretoria, is thanked for commissioning this study and for kindly providing the necessary background information.

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9. QUALIFICATIONS & EXPERIENCE OF THE AUTHOR

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

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

Declaration of Independence

I, John E. Almond, declare that I am an independent consultant and have no business, financial, personal or other interest in the proposed development 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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