(AHSA) Archaeological and Heritage Services Africa (Pty) Ltd

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PALAEONTOLOGICAL ASSESSMENT (DESKTOP) REQUESTED IN TERMS OF SECTION 38 OF THE NATIONAL HERITAGE RESOURCES ACT NO 25/1999 FOR MINING RIGHT ON VAALBOS ISLAND ON THE VAAL RIVER NEAR LONGLANDS, BARKLY WEST DISTRICT, NORTHERN CAPE PROVINCE

Prepared by

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DECLARATION OF INDEPENDENCE

AHSA is an independent consultancy: I hereby declare that I have no interest, be it business, financial, personal or other vested interest in the undertaking of the proposed activity, other than fair remuneration for work performed, in terms of the National Heritage Resources Act (No 25 of 1999).

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EXECUTIVE SUMMARY

This desktop palaeontological impact assessment (PIA) was conducted in support of an application by Emmanuel Diamonds Pty Ltd for a Mining Right on a portion of Vaalbos Island (State Land), Longlands, Barkly West District in the Northern Cape Province.

The applicant intends to mine alluvial diamonds in the superficial gravels (placers) on a portion of Vaalbos Island. These gems may be found on channels on the island. Excavations may extend to the river sides. Where there are fillings or potholes digging may reach the river bedrock. Such activities may result in the disturbance or destruction of fossils where they exist. The purpose of this palaeontological assessment is to prepare an impact statement which shows what is present and/or what is likely to occur on the island.

The underlying rock units in the area of the proposed development have been studied from the 1: 250 000 geology map - 2824 Kimberley -, scientific literature and previous palaeontological impact assessments that have been conducted in the broader area by various scholars.

The following is a summary of the findings:

The area which will be affected by the proposed mining is relatively small. From the available literature it is easy to provide basic geological profiles for large areas, but for a small area 5ha in extent it is difficult to be reasonably accurate without ground-truthing. At the small scale the 1:250 000 map which is based on aerial photographs does not provide high resolution. Under the circumstances an intensive search was made on the internet to dig out the "grey literature" in the form of unpublished university theses, impact studies and other reports (e.g. of commercial mining companies) some of which has been uploaded there. An MSc Thesis by Fabrice Gilbert (1990) entitled *The Alluvial Diamond Deposits of the Lower Vaal River between Barkly West and the Vaal-Harts confluence* (Rhodes University) proved to be the an invaluable source.

While the mining focuses on the fluvial gravels, the basal rocks forming the bedrock, below and on the sides of the river may also be affected. This assessment thus provides an inventory of all the rock units found in the locality and state their known palaeontological sensitivity.

The section of the Vaal River under study crosses a narrow band of the **Allanridge Formation** andesite lavas (Ventersdorp Supergroup) which forms the underlying bedrock. According to Matheys 1990 (20) the steep reaches of the Vaal Valley between Barkly West and Delportshoop are exhumed resistant units of the Ventersdorp (Allanridge Formation) lava. There is a strong possibility of exposures on or near the Vaalbos Island. However the Allanridge Formation of igneous lavas are considered to be **unfossilferous** (Almond 2012a: 2)

The **Dwyka Group** forms the lowermost and oldest deposit in the Karoo Supergroup basin. Northwest of Kimberley the rocks in this group exhibit glacial pavements - glacially-striated and eroded bedrocks of Permo-Carboniferous age (*c*. 300 MYA) that tend to overlie the Allanridge Formation outcrop in this area.

According to Matheys (1990: 20-21), this rock unit is generally absent from the channel. The Vaal valley was filled with comparatively soft Dwyka sediments, which were selectively removed during the Caenozoic exhumation. But 5km upstream at Gong Gong there are exposures of Dwyka tillite. These are typically preserved in the lower parts of the channels. Potholes are also developed within the tillite which are generally 0.3 to 0.8m deep (Matheys 1990: 27). According to Almond (2012:12) the paleontological rating of the glacial tillites of the Dwyka Group are considered to **medium to low**.

The **Prince Albert Formation** of the Permian Ecca Group is composed principally of shales and sandstones laid down in the sandy shorelines of swamplands during the Permian Period. As the Gondwana palaeo-continent moved north towards the equator the great ice sheets retreated and the Ecca Sea took its place. A period of active sedimentation set in creating the Ecca Group horizons. According to Matheys (1990: 27) the Prince Albert shales form the palaeo-channel bottom between Delportshoop (further downstream of Vaalbos Island) and the Vaal-Harts confluence.

Isolated patches of Prince Albert shales overlying the Dwyka tillite or the Ventersdorp andesite lavas occur between Longlands and Winter's Rush (includes the study area). The horizontally bedded shale is slightly undulated (Matheys 1990: 28).

The Ecca fossil marine deposits contain marine invertebrates such as molluscs andbrachiopods. They have also proved to contain coprolites, palaeoniscoid fish and sharks, traces fossils, various microfossils, and petrified wood. In addition, rare fossil insect wings have also been reported in the same formation. According to McLachlan and Anderson (1973) cited in Johnson *et al.* (2006) the Prince Alberton Formation of the Ecca Group revealed plant fossils near the base of the formation at Douglas. Visser (1994) discusses the presence of fossil sharks, sponge spicule, foraminifera, radiolarian and acritarchs in the Prince Alberton Formation. The Tierberg Formation is also fossilferously rich. Potgieter (1974) cited by Johnson *et al. (*2006) found fish scales and sponge spicules in some of the concretions. Clastic rhythmites occur at various levels in the sequences and value trace fossils (Neretites and Planolites) may occur (Johnson *et al.* 2006).Therefore the palaeontological rating is **high** (Almond 2012).

The **Gordonia Formation Aeolian** sands **are not found** on the Vaal River channel; but they are extensively deposited south of the river from just beyond its banks. But calcretes associated with ancient alluvial gravels might contain trace fossils such as rhizoliths, termite and other insect burrows, or even mammalian trackways. Mammalian bones, teeth and horn cores (also tortoise remains, and fish, amphibian or even crocodiles in wetter depositional settings such as pans) may be expected occasionally expected within both Kalahari Group sediments and calcretes, (Almond 2012b: 18)

The alluvial sedimentology of the Vaal River is associated with the deposition of diamonds which are the object of the mining. These gems are geologically traced to numerous diamondiferous kimberlite pipes spread across the southern African hinterland. They were released by weathering and erosion from their primary host formations (kimberlite pipes) and transported by ice sheets and the post-glacial major drainages which subsequently developed. Subsequently major tectonic uplift of the subcontinent affected the erosion behaviour of the palaeo-Vaal River. Several dispositional cycles have been identified:

(i) **Cretaceous aged Nooitgedacht-Droogeveldt Terraces** (Older Gravels c. 65 MYA) 80 – 120m above the modern Vaal River. *These deposits may be present in the vicinity of the study area.*

(ii) **Miocene-age Holpan and Klipdam Channel deposits** (23 MYA), c. 60m above the Vaal River. Younger terraces include the Pliocene-age Proksch Koppie and Wedburg Terraces, which occur at 30-45 and 20-30 meters respectively. *These deposits may occur on the banks and terraces in or near the study area.*

(iii) **Pliocene - Holocene deposits** (4m – 1.8 MYA): These youngest terraces include the current Vaal River channel and occur between 0-20 meters and are collectively referred to as the Rietputs Terrace. *These deposits may be present in the study area.*

(iv) **Rooikoppies deposits:** Through a process of progressive weathering, deflation and winnowing of the above deposits, 'secondary' deposits known as Rooikoppies developed over large areas of the landscape. Typically these deposits are found to be broadly associated with older terraces and buried channels, these readily accessible deflation deposits were extensively mined by the old timers and Diggers. *Deposits occur at Holpan upstream of Vaalbos Island (23km northeast of Barkly West); it is unlikely they occur in the study area*.

(v) **Lower Vaal alluvial deposits (towards confluence with the Harts River):** The extensive diamondiferous gravels of the Lower Vaal and Harts River valleys are associated with remnants of outwash deposits formed during the retreat of the ancient Ghaap (Kaap) Valley[1] glacial system and subsequent reworking and alluvial deposition by major rivers including the Vaal. These drainage events in large part utilized the structurally controlled south- west trending trough which is today flanked by the prominent Ghaap Plateau Escarpment. Locally, bedrock features including large boulders (glacial erratics) protruding from and released by the Dwyka diamictites of the floor

[1] Vaalbos Island might have fallen within the eastern limits of this old drainage system.

rocks, and fractures and potholes found on Ventersdorp bedrock played an important role in the concentration diamonds in the older alluvial deposits. These deposits may be present in the study area.

OLD CLASSIFICATION	**NEW CLASSIFICATION**	**AGE**	**Status**
Younger Gravels	Riverton Formation	<1.0MYA	Present
	Rietput Formation	Ca2-1MYA	Present
Older Gravels	Wedburg Terrace	Ca3-2.6MYA	May be in the vicinity
	Proksch Koppie Terrace	Ca4-3MYA	May be in the vicinity
	Holpan Terrace	?Miocene (23MYA)	May be in the vicinity
	Nooitgedacht-Droogeveldt Terraces	Cretaceous 65 MYA	May be present in the vicinity
Pre-Tertiary	Basement	Pre-Cainozoic	

Palaeontological sensitivity of the Vaal gravels

The relict “Older” Vaal River Gravels (also grouped in the Windsorton Formation) of possible Miocene-Pliocene age have been mapped along the Vaal River in the Windsorton-Longlands area. They have not yet yielded well-dated fossil biotas (Partridge et al., 2006). A “sparse, poorly provenanced vertebrate fauna from diamond diggings” is noted herein by De Wit et al. (2000). In contrast, a wide range of Pleistocene mammal remains (bones, teeth) as well as Acheulian stone tools are recorded from the “Younger” Vaal River Gravels or Rietputs Formation (Almond 2012b). These are assigned to the Mid-Pleistocene Cornelian Mammal Age and include various equids and artiodactyls as well as African elephant and hippopotamus (Almond 2010: 12). The “Younger Gravels” (Rietputs Formation) of the Vaal River system, at lower elevations, are associated with Acheulian stone tools and are therefore considered to be Early to Middle Pleistocene in age. (Almond 2010: 6).

Overall the impact of the proposed development on fossil resources is expected to be minimal. However it is recommended that the Environmental Control Officer (ECO) puts in place a contingency plan to rescue chance finds and where possible preserve them *in situ*. It is further advised that the recommendations made here should also be incorporated into the Environmental Management Plan (EMP) for the proposed mining operations. A standard Fossil Finds Procedure (FFP) is appended to this report to provide field guidance to the ECO.

1. INTRODUCTION

This desktop palaeontological impact assessment (PIA) was conducted on behalf of Emmanuel Diamonds (Pty) Ltd to support an application for a Mining Right on a portion apportion of Vaalbos Island on the Vaal River described as State Land, in Northern Cape Province. The palaeontological assessment fulfils the requirements for a Heritage Impact Assessment (HIA) as prescribed under Section 38 of the National African Heritage Resources Act (Act No. 25 of 1999).

1.1. Nature of development and expected impacts

The applicant intends to mine alluvial diamonds in the superficial gravels (placers) on a portion of Vaalbos Island. These may be found on channels and detritus on the island. Excavations may extend to the river sides. Where there are fillings or potholes digging may reach the river bedrock. Such activities may result in the disturbance or destruction of heritage resources where they exist. The purpose of a PIA is to prepare a heritage impact statement which shows what is present and or what is likely to occur at the site and the potential impact of the development.

1.2. Research value of the fossils

The National Heritage Resources Act (No 25 of 1999) defines palaeontological resources as fossilised remains or traces of animals or plants which lived in geological times other than fossil fuels or fossiliferous rocks intended for industrial use. Palaeontological fossils therefore have scientific research value whereby scientists identify and reconstruct different types of plants and animals that no longer exist and put together a "tree of life" to describe the evolutionary relationships between them and also with extant organisms. Thus in the geological provenance in which fossils are found there lies natural libraries or archives in which a few ancient organisms (plants and animals) have been preserved. Fossilization is a relatively rare process, yet it nevertheless provides a surprisingly important window into the past and has allowed scientists to put together a picture of the history of life on earth.

The fossil record is better understood when it is placed in a geologic timeframe. The oldest fossils are approximately 3.8 billion years old. But in this long timeline multicellular organisms with skeletons appeared only 580 million years ago.[2]

The breadth of palaeontological research has been expanding to also determine long-term physical changes in paleogeography and paleoclimatology and how they affected today's patterns of biodiversity. Palaeontologists help identify key moments that led to current patterns of biodiversity, and understand humanity's role in the story of life. Fossils provide irrefutable empirical scientific data relevant to how and why biodiversity has changed in the past. This brings to the fore the subject of extinctions and how best humans can deal with them.

2. LOCATION AND PHYSICAL SETTING

The property forms a northern portion of an Island on the Vaal River 20km northwest of Barkly West and 8.5km upstream of its confluence with the Harts River (Lat: 28°27'32.70"S, Long: 24°20'18.50"E). Longlands is Village situated on the northern banks of the Vaal River 2.3km east of the study area. The key geomorphological feature is the Vaal River itself. This perennial river meanders across the semi-arid southern plains from its sources on the western foot of the Drakensberg Mountains following a course west some 1 120km to its confluence with the Orange River, which continues another 1 350km to the Atlantic Ocean (Figs 1-3).

[2] http://sciencing.com/importance-fossils-2470.html (Consulted 25 April 2016); https://www.msnucleus.org/membership/html/k-6/rc/pastlife/6/rcpl6_1a.html (Consulted 25 April 2016)

Fig 1. Google-Earth map shows the location of Vaalbos Island on the Vaal River.

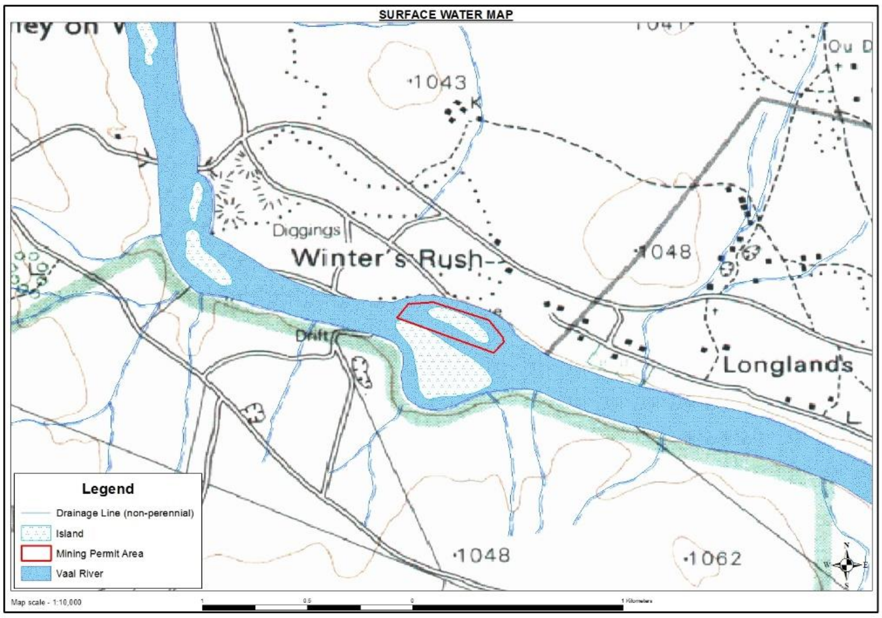

Fig 2. Map of the area shows high water level.

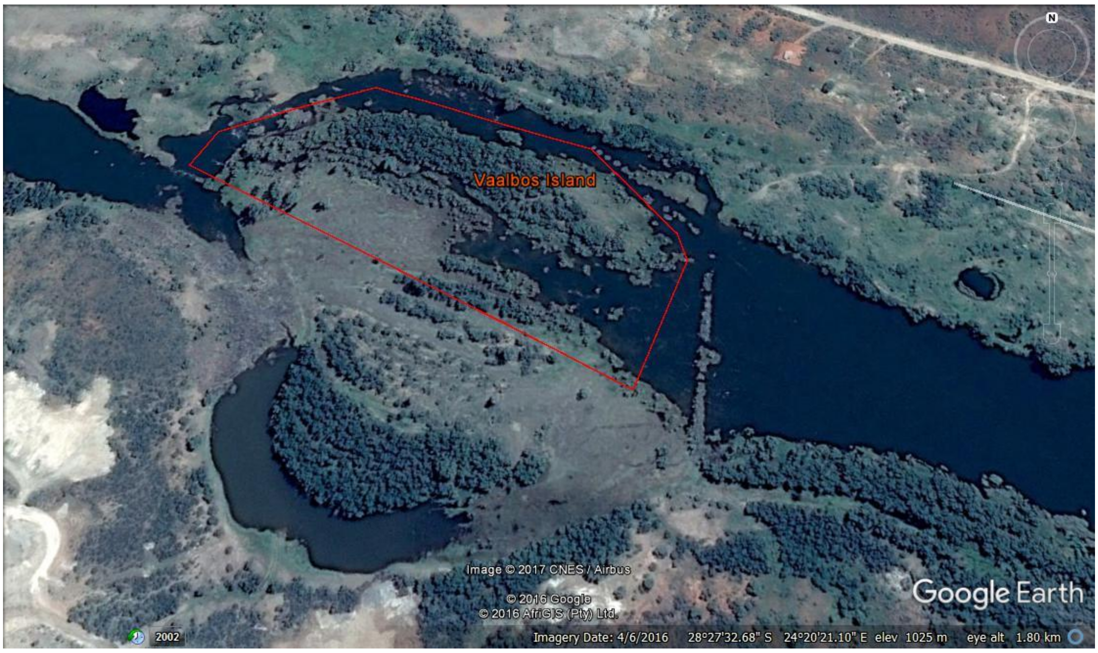

Fig 3. Close-up Google-Earth view of Vaalbos Island shows the boundaries of the surveyed area.

3. RELEVANT LEGISLATION

Various categories of heritage resources are recognised as part of the National Estate in Section 3 of the National Heritage Resources Act (25/1999) (NHRA) including:

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

The National Heritage Resources Act (No 25/1999) (NHRA) treats fossils as a palaeontological heritage and are regarded as part of the National Estate (section 32.1(a)). Sections 35 and 38 of the same Act form the legal context in which Heritage Impact Assessments are prescribed. Sections 35 and 38 guided fieldwork and preparation of this report as a statutory reference. The PIA has been conducted at the same time with a Heritage Impact Assessment (HIA) to locate sites of heritage significance and assess potential adverse impacts of the proposed mining.

Section 38 of the NHRA states the nature and scale of development which triggers a HIA:

38. (1) Subject to the provisions of subsections (7), (8) and (9), any person who intends to undertake a development categorised as—

(a) the construction of a road, wall, powerline, pipeline, canal or other similar form of linear development or barrier exceeding 300m in length;
(b) the construction of a bridge or similar structure exceeding 50 m in length;
(c) any development or other activity which will change the character of a site— exceeding 5 000 m^2 in extent; or
(ii) involving three or more existing erven or subdivisions thereof; or
(iii) involving three or more erven or divisions thereof which have been consolidated within the past five years; or
(*iv) the costs of which will exceed a sum set in terms of regulations by*
SAHRA or a provincial heritage resources authority;
(d) the re-zoning of a site exceeding 10 000 m^2 in extent; or
(e) any other category of development provided for in the regulations by SAHRA or a provincial heritage resources authority, must at the very earliest stages of initiating such a development, notify the responsible heritage resources authority and furnish it with details regarding the location, nature and extent of the proposed development.

Section 35 (4) of the NHRA prohibits the destruction of archaeological, palaeontological and meteorite sites:
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.

It is important to highlight other pieces of legislation apply as well as this PIA is part of an Environmental Impact Assessment (EIA) required in terms of the National

Environmental Management Act (No 107 of 1998) and Minerals and Petroleum Resources Development Act (Act 28 of 2002 as amended).

4. APPROACHES AND METHODOLOGY

4.1. Overview

A significantly large amount of relevant literature was consulted. The reviewed literature includes books, scientific reports and reports of previous PIAs which have been done in the broader area. Geological maps of the study area were used to determine potentially rich fossiliferous rock units (groups, formations etc.) represented within the study area. The fossil heritage within each rock unit was further analysed and inventoried from the published scientific literature, previous palaeontological impact studies in the same region, and the author's own field experience. 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.

4.2. Assumptions and limitations

The area which will be affected by the proposed mining is relatively small. From the available literature it is easy to provide basic geological profiles for large areas, but for a small area 5ha in extent, it is difficult to be reasonably accurate without ground-truthing. At the small scale the 1:250 000 map which is based on aerial photographs would be helpful. Under the circumstances an intensive search was made on the internet to dig out the "grey literature" in the form of unpublished university theses, impact studies and other reports (e.g. of commercial mining companies) some of which has been uploaded there. An MSc Thesis by Fabrice Gilbert (1990) entitled *The Alluvial Diamond Deposits of the Lower Vaal River between Barkly West and the Vaal-Harts confluence* (Rhodes University) proved to be the "holy grail".

5. GEOLOGY CONTEXT OF THE ORIGIN OF ALLUVIAL DIAMONDS

5.1. Geology map of Kimberley (2824)

The geological map (Fig 4) shows this section of the Vaal River breaching a narrow band of the Allanridge Formataion (Ra) (Ventersdorp Group of igneous lavas). This might possibly suggest these Archean rocks are not far below the bedrock or that exposures of the rocks are found in this section of the Vaal River. Diamondiferous alluvial gravels flank the river on both sides, which represent the depositional and erosional sequence of the Vaal River over a long period of time (they will be described in detail in Section 7). The extensive Gordonia Formation (Kalahali Group) aeolian sands are shown in the vicinity of the Island south of the Vaal River but need not concern us in this study.

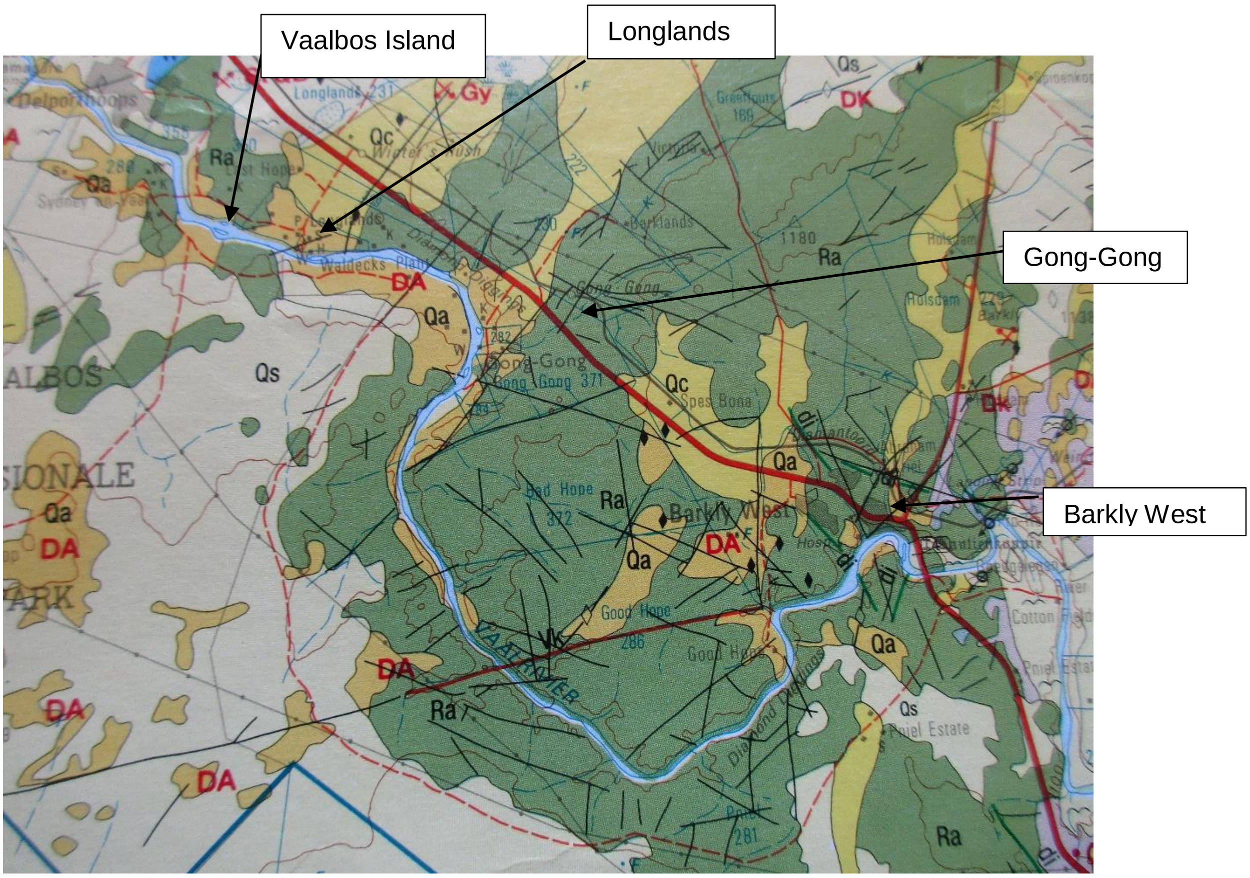

Fig 4. Extract from the 1:250 000 geology map 2824 (Kimberley) shows the section of the Vaal River at Vaalbos Island breaching a narrow band of Allanridge Formation rocks and diomondiferous alluvial gravels (Qa) flanking the river. Extensive Gordonia Formation aeolian sands (QS) occur to the south of the river but not on the Island. Plio-Pleistocene Calcretes (Qc) also occur near the northern bank of the river.

6. GEOLOGICAL PROFILE AND PALAEONTOLOGICAL SENSITIVITY

While the mining focuses on the fluvial gravels, the basal rocks forming the bedrock, below and on the sides of the river may also be affected. It was therefore found necessary in this study to inventory all the rock units found in the locality and to state their known palaeontological sensitivity.

6.1. The Ventersdorp Allanridge Formation andesite lavas (at the bottom) (2600 MYA)

As mentioned earlier the Ventersdorp Supergroup is represented by the Allanridge Formation andesite lavas which date back to the Precambrian 2600 MYA (Fig 5). Ventersdorp was an igneous mega-eruption termed a Large Igneous Province (LIP) from below the Kaapvaal Craton 2.7 Ga (billion years) ago. It can reach a thickness of 1000m in this area (Matheys 1990: 11). On top of the succession of several eruptions or welling up during the Ventersdorp event lies greyish-green amydaloidal and porphyritic lavas - mainly basaltic andesites of the Allanridge Formation. This is a horizon of lava that goes up to 14m thick with vesicular tops, pipe like structures due to lava degassing, and pillow structures formed during subaqueous eruptions (Bosch 1993 cited by Almond 2012). Gas vesicles within the amygdaloidal lavas are infilled with a range of secondary minerals including reddish chalcedony, quartz, calcite, chlorite and epidote (Almond 2012: 18). They can go to a depth of 1000m (Methys 1990: 10).

Status: *According to Matheys 1990 (20): The steep reaches of the Vaal Valley between Barkly West and Delportshoop, are exhumed resistant units of the Ventersdorp (Allanridge Formation lava) lava. There is a strong possibility of exposures on or near the Vaalbos Island*

Palaeontological sensitivity

The Allanridge Formation of igneous lavas are considered to be **unfossilferous** (Almond 2012 p2)

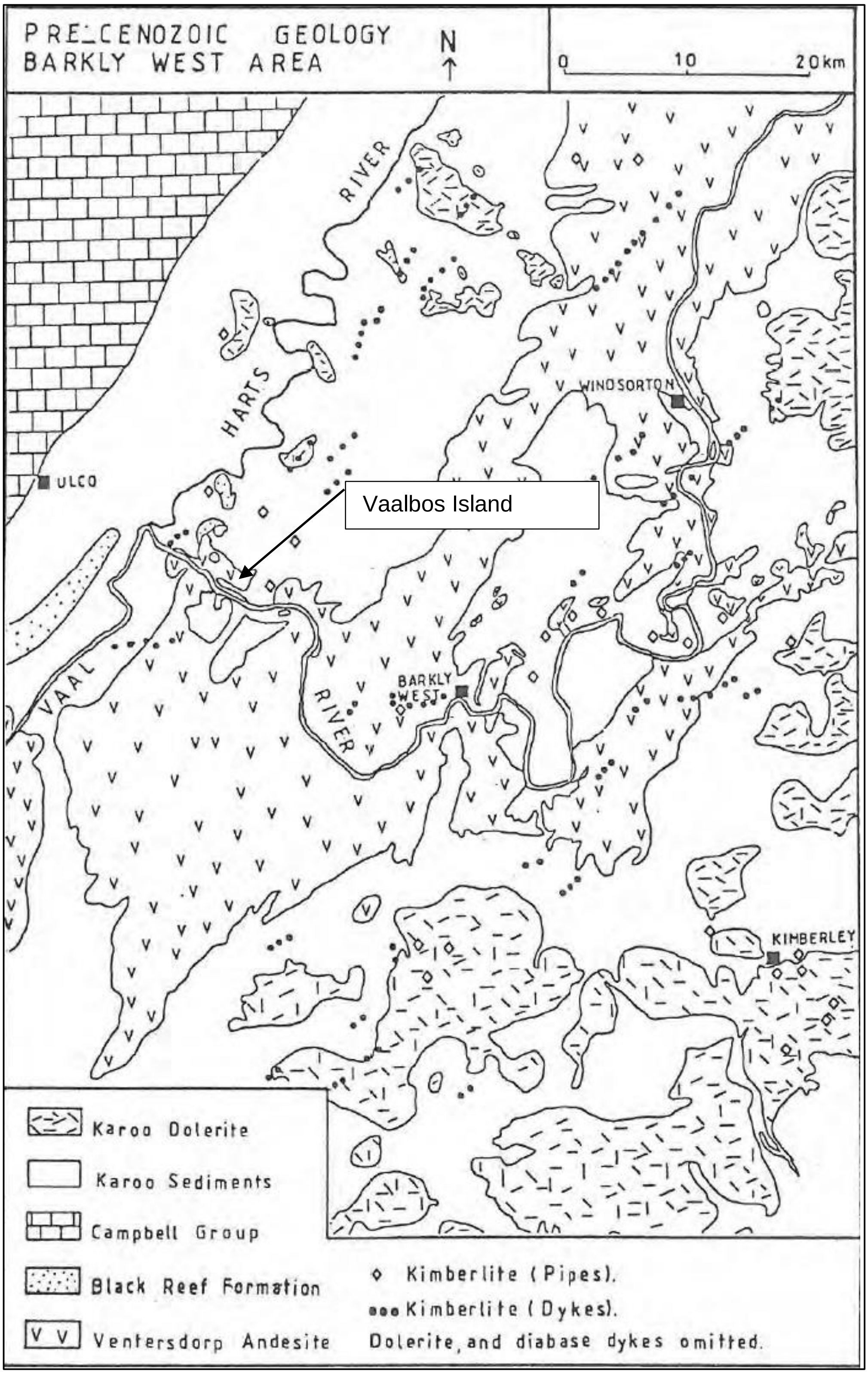

Fig 5. The extent of the basal Allanridge Formation, which is exposed in many areas (Adapted from Methys 1990: 10).

6.2. Karoo Dwyka glacial sediments (300 MYA)

The Dwyka Group forms the lowermost and oldest deposit in the Karoo Supergroup basin. Northwest of Kimberley the rocks in this group exhibit glacial pavements - glacially-striated and eroded bedrocks – of Permo-Carboniferous age, (*c*. 300 Ma) that tend to overlie the Allanridge Formation outcrop area in the same region. According to Winter (1976), cited in van der Weshuizen et al. (2006), the Allanridge Formation has a conformable relationship with the underlying Bothaville Formation in the deeper parts of the basin. However, van der Weshuizen et al. (2006) states that Keyser (1998) found a prominent unconformable relationship towards the northwestern margin of the Ventersdorp depository. The Dwyka tillite consists of a very fine-grained, blue-grey rock comprised of clay / mud matrix with inclusions (or clasts) of many other fragments picked up by glaciers during their travels.

The Dwyka event was a long-term deposition of glacio-ogenic till, subglacial till, glacio-lacustrine till and terrestrial moraine. This sedimentation demonstrates the action of advancing and retreating ice-sheets on the borders of the Karoo Basin (Cadle *et al.* 1990).The geology of the Dwyka Group shows lithological differences which led to the recognition of a northern and southern facies. A general profile can be presented here along the north-western margin of the Main Karoo Basin. Massive tillites at the base of the Dwyka succession were deposited by dry-based ice sheets in deeper basement valleys. Later climatic amelioration led to melting, marine transgression and the retreat of ice sheets onto the continental highlands in the north. The valleys were then occupied by marine inlets within which drifting glaciers deposited dropstones onto the muddy sea bed ("boulder shales"). The upper Dwyka beds (Mbizane Formation) are typically heterolithic, with shales, siltstones and fine-grained sandstones of deltaic and / or turbiditic origin. These upper successions are typically upwards-coarsening and show extensive soft-sediment deformation (loading and slumping). Varved (rhythmically laminated) mudrocks with gritty to fine gravely dropstones indicate the onset of highly seasonal climates, with warmer intervals leading occasionally even to limestone precipitation. Across the entire northern margin of the Main Karoo Basin the Mbizane Formation that is approximately 190m thick is recognized .Here it may form the whole or only the *upper* part of the Dwyka succession. It is extremely heterolithic (Almond 2012, p6).

Status: *According to Matheys (1990: 20-21), this rock unit is generally absent from the channel. The Vaal valley was filled with comparatively soft Dwyka sediments, which were selectively removed during Caenozoic exhumation. But 5km upstream at Gong Gong there are exposures of Dwyka tillite. These are typically preserved in the lower parts of the channels. Potholes are also developed within the tillite which are generally 0.3 to 0.8m deep (Matheys 1990: 27).*

Palaeontological sensitivity

The paleontological rating of the glacial tillites of the Dwyka Group are considered to **medium to low** (Almond 2012a:12).

6.3. The Ecca Group c270 MYA

The Permian Ecca Group is a component of the Karoo Supergroup post-dating Dwyka and represents a total of 16 formations. These formations reflect lateral facies changes that characterize this succession where the individual formations can be grouped into three geographical areas namely southern, western plus north-western and north western) for descriptive purposes. The Ecca Group comprises the Tierberg Formation, Waterford Formation, Whitehill Formation, and Prince Albert Formation. The Ecca Group is made up principally of shales and sandstones laid down in the sandy shorelines of swamplands during the Permian Period. According to Johnson et al (2006), as the Gondwana moved north towards the equator the great ice sheets retreated and the Ecca Sea took its place. A period of active sedimentation set in creating the Ecca Group comprising marine shales, submarine fan sandstones and shales and shelf shales. Variations are to be expected in the composition of depth of the Ecca sediments.

Status: *According to Matheys (1990: 27), the Prince Albert Shale (Ecca Group) forms the palaeo-channel bottom between Delportshoop (further downstream of Vaalbos Island) and the Vaal-Harts confluence. Isolated patches of Prince Albert shale overlying the Dwyka tillite or the Ventersdorp andesite occur between Longlands and Winter's Rush (covers the study area). The horizontally bedded shale is slightly undulated (Matheys 1990: 28).*

Palaeontological sensitivity

The Ecca fossil marine deposits have been shown to contain marine invertebrates such as molluscs and brachiopods. They have also proved to contain coprolites, palaeoniscoid fish & sharks, traces fossils, various microfossils, and petrified wood. Mesosaurus have also been recorded in the Whitehill Formation. In addition to that rare fossil insect wings have also been reported in the same formation. According to McLachlan and Anderson (1973) cited in Johnson *et al.* (2006) the Prince Alberton Formation of the Ecca Group revealed plant fossils near the base of the formation at Douglas. Visser (1994) discusses the presence of fossil sharks, sponge spicule, foraminifera, radiolarian and acritarchs in the Prince Alberton Formation. The Tierberg Formation is also fossilferously rich. Potgieter (1974) cited by Johnson *et al.(* 2006) found fish scales and sponge spicules in some of the concretions. Clastic rhythmites occur at various levels in the sequences and value trace fossils (Neretites and Planolites) occur here in the Tierberg (Johnson *et al.* 2006).Therefore the palaeontological rating is **high** (Almond 2012).

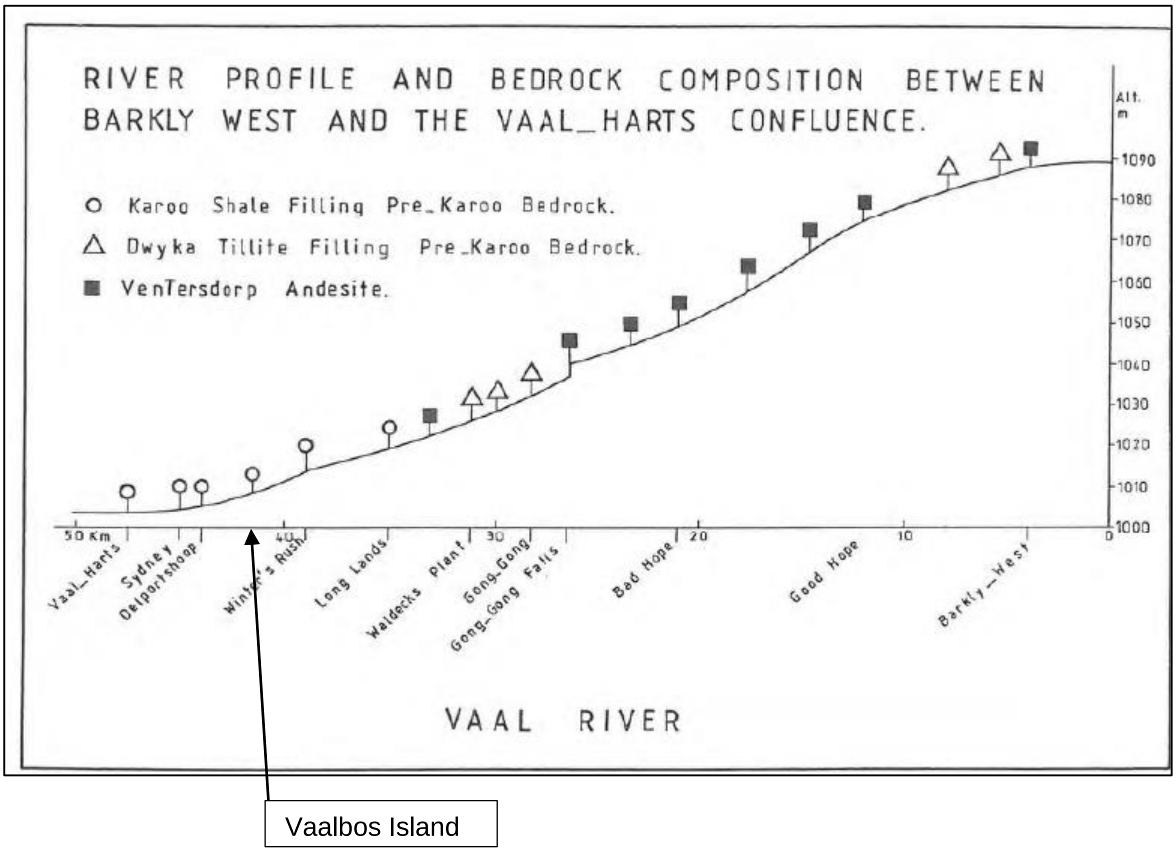

Fig 7. Profile of the Vaal River and bedrock composition (Adapted from Matheys 1990: 26).

6.4. Gordonia Formation of the Kalahari Group (40 MYA)

The Gordonia Formation Aeolian sands usually with a calcretic horizon immediately below dates to the late Caenozoic (probably Plio-Pleistocene) (Almond 2012a:10) are extensively deposited south of the Vaal River from just beyond its banks. They are not present on the Island as they wash away easily. But calcretes associated with ancient alluvial gravels might contain trace fossils such as rhizoliths, termite and other insect burrows, or even mammalian trackways. Mammalian bones, teeth and horn cores (also tortoise remains, and fish, amphibian or even crocodiles in wetter depositional settings such as pans) may be expected occasionally expected within both Kalahari Group sediments and calcretes, (Almond 2012b: 18)

7. SEDIMENTOLOGY OF THE VAAL RIVER GRAVELS

For the past 140 years a section of the lower Vaal River from Windsorton through Barkly West to Gong Gong and Longlands has been steeped in legends of fabulous diamonds to be mined from the gravels on the river bed and its margins. It is necessary to establish the geological context of these alluvial diamonds.

The alluvial diamonds of the Vaal (and Orange) Rivers can be geologically traced to numerous diamondiferous kimberlite pipes spread across the southern African hinterland. They were released by weathering and erosion from their primary host formations (kimberlite pipes) and transported by ice sheets and the post-glacial major drainages which subsequently developed. In this sequence two prolonged periods of exposure and erosion have been identified:

(i) first between the Archaean eruption of the Ventersdorp lavas (~2700Ma) and initial Karoo sedimentation at about (Dwyka) 300MYA;

(ii) second between the end of the major Karoo event at 150 Ma and the Palaeo- Orange and Vaal River sedimentation from late Cretaceous to about 5 MYA.

The two erosion events also prepared the landscape across which the palaeo-Vaal (and Orange) Rivers and their tributaries were to chart their courses. The Permian glacial event which initiated the Karoo sedimentation (Dwyka) shaped the post-Ventersdorp surface which helped to facilitate the transportation of the diamonds. On a micro-scale the palaeo-Vaal River channels (and its tributaries) would have irregular bedrock surfaces which provided trap sites in which diamondiferous gravels

were subsequently deposited (fluvial placers) [3] Later major tectonic uplift of the subcontinent affected the erosion behaviour of the Palaeo-Vaal River. Firstly and significantly the Vaal River which was flowing in the direction of Schimdtdrift (more southerly direction) shifted west leaving behind a plain of fluvial gravels. The river was captured by an encroachment tributary of the Harts River eroding head-ward east probably as a result of the tectonic event aforementioned.
Studies of the Lower Vaal, Harts Rivers and the alluvial deposits have also shown that there were five broad phases of prominent alluvial deposit development (in some kind of reverse stratigraphy) in these areas reflected by several deposit types (Norton et al 2007).

(vi) **Cretaceous aged Nooitgedacht-Droogeveldt Terraces (c. 65 MYA)**
These are considered to be the oldest alluvial deposits and they occur between 80 – 120m above the modern Vaal River southwest of Barkly West. These deposits probably conform in age to the initial period of late-Cretacous uplift which triggered a period of accelerated river incision and simultaneous lowering and peneplanation of the land surfaces, accompanied by the supply of downwash with diamonds

Status: These deposits may be present in the vicinity of the study area.

(vii) **Miocene-age Holpan and Klipdam Channel deposits (23 MYA)**
These deposits occur at ca 60 meters above the Vaal River (Older Gravels). Younger terraces include the Pliocene-age Proksch Koppie and Wedburg Terraces, which occur at 30-45 and 20-30 meters respectively.

Status: These deposits may occur on the banks and terraces in or near the study area.

(viii) **Pliocene - Holocene deposits (5m -18 MYA)**
These youngest terraces include the current Vaal River channel and occur between 0-20 meters and are collectively referred to as the Rietputs Terrace.

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[3] Norton, G., J. Bristow, & H. Van Wyk. 2007. Alluvial deposits and diamonds of the lower Vaal and middle Orange Rivers, Northern Cape Province RSA. *The Southern African Institute of Mining and Metallurgy.*

Status: These deposits may be present in the study area.

(ix) **Rooikoppies deposits**

Through a process of progressive weathering, deflation and winnowing of the above deposits, 'secondary' deposits known as Rooikoppies developed over large areas of the landscape. Typically these deposits are found to be broadly associated with older terraces and buried channels, these readily accessible deflation deposits were extensively mined by the old timers and Diggers. In many cases the presence of Rooikoppie deposits was useful in respect of highlighting the presence of older buried deposits. Owing to their remobilized state the Rooikoppie gravels cannot be constrained to a specific age. These primary fluvial gravels are deflated from their original thicknesses and have been reworked by eluvial and colluvial processes to form the Rooikoppie gravels. They exhibit a reddish colour, which has resulted from iron staining of the entire package during oxidation.[4]

In the some areas dry periods lead to the precipitation of an extensive hard calcrete horizon which effectively defines the "interface" between the surface Rooikoppies and lower primary gravel deposits in many areas, The calcrete prevented old time diggers from mining below the Rooikoppies and consequently large areas of primary gravel are being mined in areas such as the Middle Orange River by drilling, blasting and stripping the hard 1 to 2 meter calcrete layer and mining and processing the underlying preserved primary gravels.

Status: *Deposits occur at Holpan upstream of Vaalbos Island (23km northeast of Barkly West); it is unlikely they occur in the study area*.

(x) **Lower Vaal alluvial deposits (towards confluence with the Harts River)**

The extensive diamondiferous gravels of the Lower Vaal and Harts River valleys are associated with remnants of outwash deposits formed during the retreat of the ancient Ghaap (Kaap) Valley[5] glacial system and subsequent reworking and alluvial

[4] Ndwammbi, N. (Undated). A study of the variation in the Rooikoppie gravels in the Lower Vaal area. Rockwell Diamonds.

[5] Vaalbos Island might have fallen within the eastern limits of this old drainage system.

deposition by major rivers. These rivers included the proto-Vaal, - Orange, - Harts, and -Riet Rivers and their modem antecedents.

These drainage events in large part utilized the structurally controlled south- west trending trough which is today flanked by the prominent Ghaap Plateau Escarpment. The glacial system is identified as a prominent ice lobe emanation from the central Dwyka (Carboniferous) ice sheet of central Gondwana which utilized the structurally controlled trough flanking the Ghaap Escarpment. Subsequently this trough has also been utilized and resurrected by the erosive action of the Lower Vaal and Harts Rivers. Locally, bedrock features including large boulders (glacial erratics) protruding from and released by the Dwyka diamictites of the floor rocks, and fractures and potholes found on Ventersdorp bedrock played an important role in the concentration diamonds in the older alluvial deposits.

Status: These deposits may be present in the study area.

OLD CLASSIFICATION	**NEW CLASSIFICATION**	**AGE**	**Status**
Younger Gravels	Riverton Formation	<1.0MYA	Present
	Rietput Formation	Ca2-1MYA	Present
Older Gravels	Wedburg Terrace	Ca3-2.6MYA	May be in the vicinity
	Proksch Koppie Terrace	Ca4-3MYA	May be in the vicinity
	Holpan Terrace	?Miocene	May be in the vicinity
Pre-Tertiary	Basement	Pre-Cainozoic	

Fig 7: New classification of the Vaal Gravels Sequence Adapted from Brink … 5).

8. PALAEONTOLOGICAL ASSESSMENT

The relict "Older" Vaal River Gravels (sometimes placed in the Windsorton Formation) of possible Miocene-Pliocene age have been mapped along the Vaal River in the Windsorton-Longlands area. They not yet yielded well-dated fossil biotas (Partridge *et al.,* 2006). A "sparse, poorly provenanced vertebrate fauna from diamond diggings" is noted herein by De Wit *et al.* (2000) who favour a Pliocene age (4.5-3.5 Ma). In contrast, a wide range of Pleistocene mammal remains (bones, teeth) as well as Acheulian stone tools are recorded from the "Younger" Vaal River Gravels or Rietputs Formation (Cooke 1949, Wells 1964, Partridge & Brink 1967, Almond 2012b). These are assigned to the Mid-Pleistocene Cornelian Mammal Age and include various equids and artiodactyls as well as African elephant and hippopotamus (Almond 2010: 12).

In the Windsorton area heavily calcretized "Older Gravels" have been grouped into the Windsorton Formation and are suspected to be Miocene-Pliocene in age (Partridge & Brink 1967, De Wit *et a*l., 2000, Partridge *et al.* 2006). The "Younger Gravels" (Rietputs Formation) of the Vaal River system, at lower elevations, are associated with Acheulian stone tools and are therefore considered to be Early to Middle Pleistocene in age. (Almond 2010: 6).

9. CONCLUSIONS AND RECOMMENDATIONS

The impact of the proposed development on fossil resources is expected to be medium to low. It is recommended that the Environmental Control Officer (ECO) puts in place a contingency plan to rescue chance finds and where possible preserve them *in situ*. It is further advised that the recommendations made here are incorporated into the Environmental Management Plan (EMP) for the proposed mining operations. A standard Fossil Finds Procedure (FFP) is appended to this report to provide field guidance to the ECO.

10. DETAILS OF SPECIALIST

Specialist Details- Specialised in Palaeobotany which is a branch of Palaeontology dealing with the recovery and identification of plant remains from geological contexts, and their place in the reconstruction of past environments and the history of life. Palaeobotany includes the study of terrestrial plant fossils as well as the study of marine autotrophs, such as algae. A closely related field to palaeobotany is palynology, the study of fossil and extant spores and pollen. My PhD thesis focussed on the palaeoecology and anthracology of Great Zimbabwe. Paleoecology uses data from fossils and subfossils to reconstruct the ecosystems of the past. It includes the study of fossil organisms in terms of their life cycle, their living interactions, their natural environment, their manner of death, and their burial.

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