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

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PALAEONTOLOGICAL SPECIALIST ASSESSMENT (DESKTOP) REQUESTED IN TERMS OF SECTION 38 OF THE NATIONAL HERITAGE RESOURCES ACT NO 25/1999 FOR A PROSPECTING RIGHT ON A PORTION OF PORTION 1 OF THE FARM VOORUITZIGT 81, KIMBERLEY DISTRICT, NORTHERN CAPE PROVINCE

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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 the National Heritage Resources Act (No 25 of 1999).

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CONTENTS

EXECUTIVE SUMMARY

This desktop palaeontological impact assessment (PIA) has been conducted in support of an application by Mystical Pearl (Pty Ltd) Northern Cape Province for s prospecting right on a Portion of Portion 1 of the Farm Vooruitzigt 81, Kimberley District, in the Northern Cape Province.

The proposed activity entails excavating 50 test trenches. It is estimated that an average 3m depth of overburden (calcrete and soil) will be removed before accessing the gravel layer (average width 2 – 4m) which is host to the diamonds. The trenches will be 25m x 15m x 0.5 – 7m deep. A palaentological assessment is necessary as these superficial levels might contain fossils in view of the known palaeontological sensitivity of the area.

The rock units underlying the area of the proposed development have been identified from the 1: 250 000 geology map 2824 Kimberley (Council for Geosciences, Pretoria), scientific literature and previous palaeontological impact assessments that have been conducted in the broader area. The following is a summary of the findings:

The Allanridge Formation andesite lavas belong to the Ventersdorp Supergroup (VSG) which date back to the Precambrian 2600 MYA. The **Ventersdorp Supergroup** represents a major episode of igneous extrusion, what is termed a Large Igneous Province (LIP) from below the Kaapvaal Craton some 2.7 Ga (billion years) ago. The Allanridge Formation of igneous lavas are considered to be unfossilferous.

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. The Dwyka tillite is mostly 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 paleontological rating of the glacial tillites of the Dwyka Group are considered to be **medium to low**.

The Ecca group is a subcomponent of the Karoo Supergroup, a sedimentary complex post-dating Dwyka in which principally shales and sandstones were laid down in the sandy shorelines of swamplands during the Permian Period. The Ecca fossil marine deposition may contain marine invertebrates (esp. molluscs, brachiopods), coprolites, palaeoniscoid fish & sharks. There are also traces fossils, various microfossils, petrified wood. The palaeontological rating according to Almond (2012) is **high.**

The Karroo dolerite of the Drakensberg Group sill underlies most of the area in the Kimberley municipal area. It represents an intrusion of ingenious lavas between183.0 to 182.3 MYA. Dwyka shales lying immediately below the dolerite sheet have usually been metamorphosed to lydianite and homstone as a result of exposure to intense heat during the intrusion event, with a possibility of destroying fossil materials in the upper layers of these sediments. The Karoo dolerite (igneous lavas) are considered to be unfossilferous.

Large areas of unconsolidated, reddish-brown to grey aeolian (*i.e.* wind-blown) sands of the Quaternary Gordonia Formation (Kalahari Group) have been observed on the western outskirts of Kimberley and at the Farm Vooruitzigt 81 and Fieldsview north of the city. Immediately below the sands may be a calcretic layer or pedogenic limestones generally considered of the same geological period. They are considered of **low sensitivity** with the possibility of finding calcretised rhizoliths & termitaria, ostrich egg shells, land snail shells, rare mammalian and reptile (*e.g.* tortoise) bones, teeth freshwater units associated with diatoms, molluscs, stromatolites *etc*.

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

1. INTRODUCTION

This desktop palaeontological impact assessment (PIA) has been conducted in support of an application by Mystical Pearl (Pty) Ltd for a prospecting right on a Portion of Portion 1 of the Farm Vooruitzigt 81, Kimberley District, Northern Cape Province. The palaeontological assessment is in fulfilment of 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 prospecting entails excavating 50 test trenches. It is estimated that an average 3m of overburden (calcrete and soil) will be removed before accessing the gravel layer (average width 2 – 4m) which is host to the diamonds. The trenches will be 25m x 15m x 0.5 – 7m deep. A palaentological assessment is necessary as these superficial levels might contain fossils in view of the known palaeontological sensitivity of the area.

1.2. Scientific value of fossils

In terms of the National Heritage Resources Act, palaeontological resources are fossilised remains or traces of animals or plants which lived in geological times other than fossil fuels or fossiliferous rocks intended for industrial use. Scientists use fossils to reconstruct different types of plants and animals that no longer exist and put together a "tree of life" to describe the evolutionary relationships between organisms. In the geological provenance in which fossils are found there lies a “natural museum” 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 if 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.[1]

[1] 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)

The horizon of palaeontological research has been expanding to also determine long-term physical changes in global geography (paleogeography) and climate (paleoclimatology) that have affected the history of life, to show how ecosystems have responded to these changes and have changed the planetary environment in turn, and how these mutual responses have affected today's patterns of biodiversity.

Palaeontological studies help to identify key moments that led to current patterns of biodiversity, and understand humanity's role in the story of life. South Africa is replete with palaeontological and paleoanthropological heritage resources that can be used to piece together the extraordinary puzzle of evolution. Fossils provide irrefutable empirical data relevant to how and why biodiversity has changed in the past. This brings to the fore the subject of extinctions and how best human can deal with it.

2. LOCATION AND PHYSICAL SETTING

The study area is located on the western outskirts of the City of Kimberley. Kimberley is situated on a plain between the Orange and Vaal Rivers. The property is situated northwest of the intersection of the N8 and R31 highways. The N8 highway trends EW from Kimberley to Griekwastad while the R31 highway is skirting the city on its western side and leads NW to Barkly West.

Fig 1. Google-Earth map shows the location of Kimberley between the Vaal and Orange Rivers.

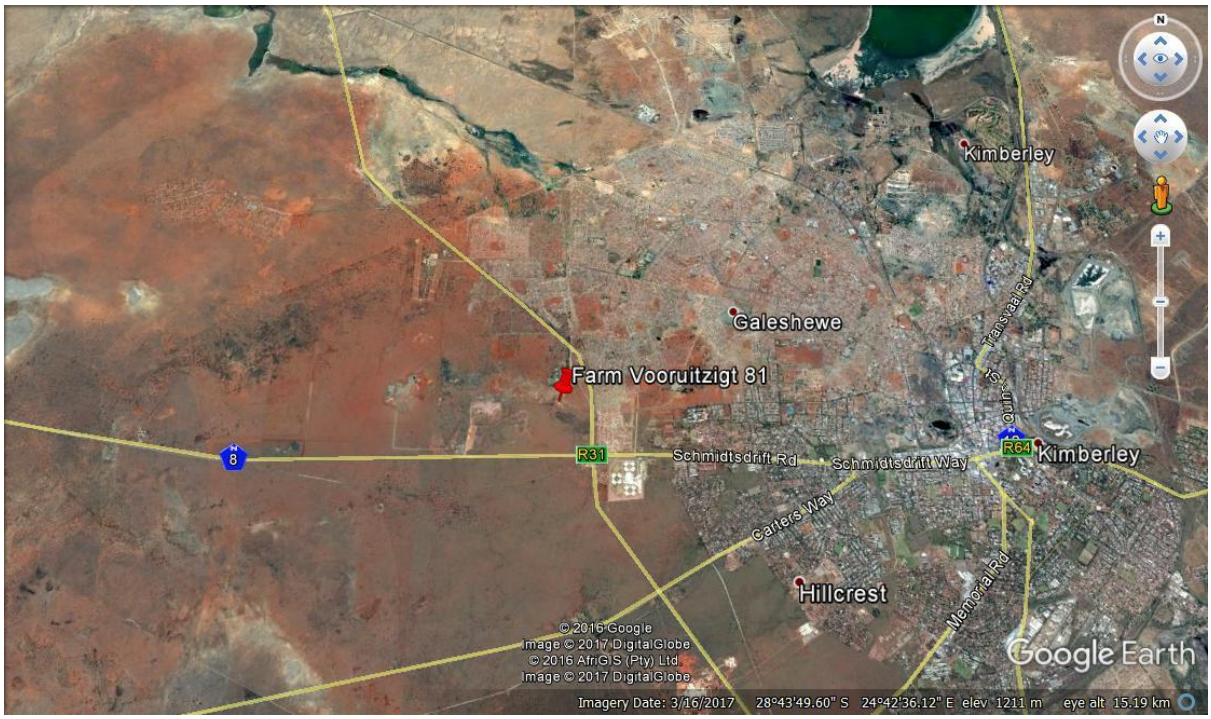

Fig 2. Google-Earth view of the location of Farm Vooruitzight 81 (Mystical Pearly Pty Ltd), on the western outskirts of Kimberley.

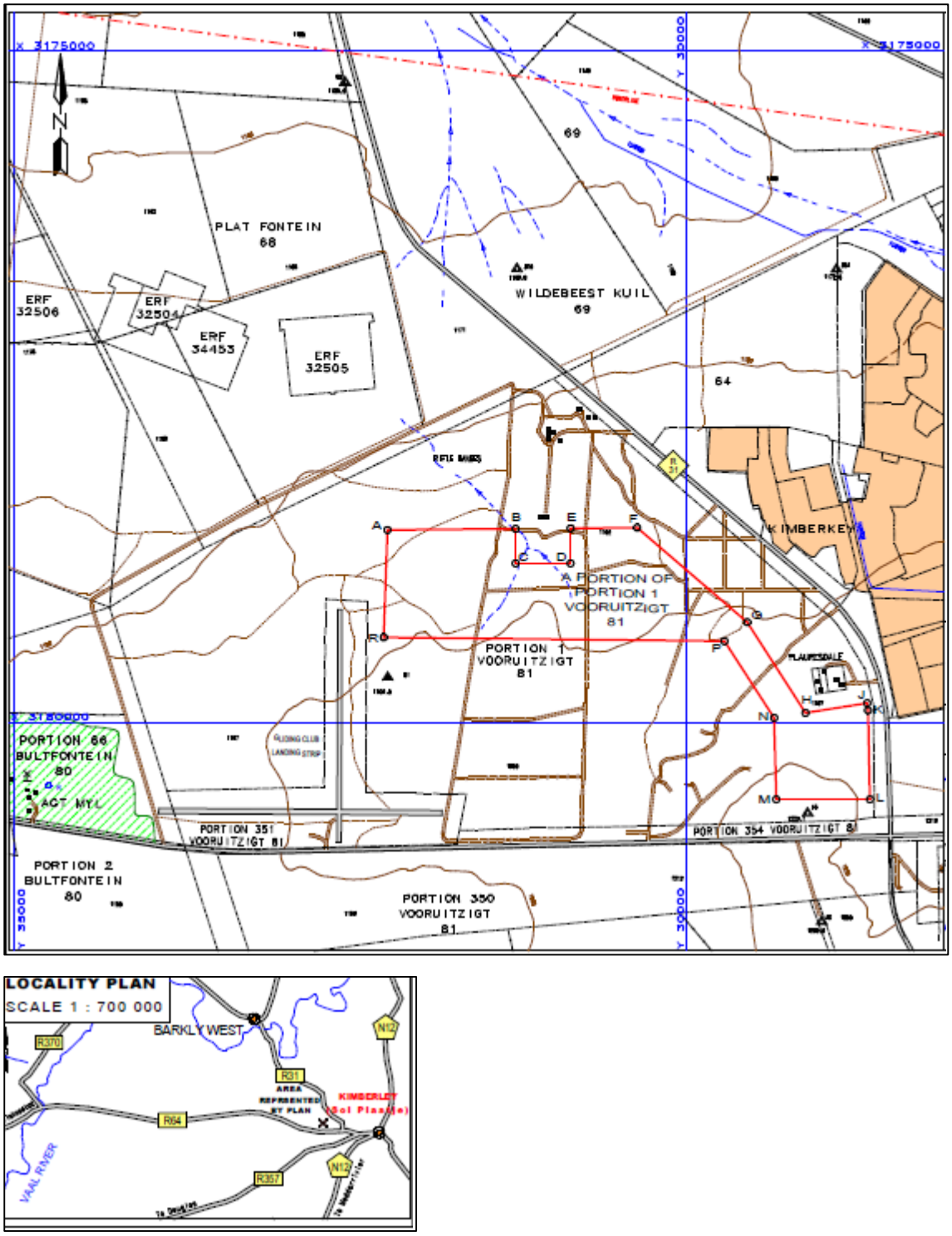

Fig 3. Layout map of the property (courtesy of Mystical Pearl (Pty) Ltd).

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

In terms of the heritage Act fossils are treated as a category of heritage – palaeontological heritage - and are regarded as part of the National Estate (section 32.1(a)). Sections 35 and 38 of the National Heritage Resources Act form the legal context in which Heritage Impact Assessments are prescribed. As statutory reference they guided fieldwork and preparation of this report. The PIA has been conducted in tandem with a Heritage Impact Assessment (HIA) to locate sites of heritage significance and assess potential adverse or positive 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 suffice to mention that other pieces of legislation apply as well as this palaeontological impact assessment (PIA) is part of an Environmental Impact Assessment (EIA) required in terms of the National Environmental Management Act (Act 107 of 1998) and Mineral and Petroleum Resources Development Act (Act 28 of 2002 as amended).

4. APPROACHES AND METHODOLOGY

4.1. Overview

Relevant literature which include books, scientific reports and reports of previous PIAs which have been done in the broader area. Potentially fossiliferous rock units (groups, formations etc.) represented within the study area were determined from geological maps. The 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 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.

It was revealed from the scoping heritage survey that a western portion of the property has been excavated to varying depths and as a result to an extent disturbed.

4.2. Assumptions and limitations

Assumptions were made that palaeontological sensitivity of rock units underlying the study area and from field and other data obtained outside the study area is fairly uniformly distributed. However factors such as variations in the deposition setting across a formation, tectonic deformation as well as the intensity and nature of metamorphism and weathering experienced by a given formation may change markedly across its outcrop area. On the basis of reading other surveys in the broader area one may fail to predict variations present within a sedimentary rock unit so that there might be highly fossiliferous localities where the rating has been determined to be low, or low sensitivity localities where the rating has been determined to be high.

5. GEOLOGY AND PALAEONTOLOGICAL PROFILE OF THE STUDY AREA

As mentioned in Section 4.1 an impression of the geology and palaeontological sensitivity of the area has been determined from geological maps, scientific literature as well as previous impact assessments in the region. Significantly profiles from the Big Hole in the centre of Kimberley, 5km east of the study area have been considered as useful reference.

5.1. Geology map of Kimberley (2824)

The geological map shows that the area is underlain by Gordonia Formation (Kalahali Group) aeolian sands and below them a calcretic horizon (Qc) dating to the Plio-Pleistocene (Fig 5). It also shows the presence of dolerite sill above the Dwyka horizon.

Fig 4. Extract from the 1:250 000 geology map 2824 (Kimberley) which shows the development area as have intrusive dolerites (Jd) of the Jurassic age and Gordonia Formation (Kalahali Group) aeolian sands and calcretes (QS) dating to the Plio-Pleistocene.

5.2. The geology of the Big Hole of Kimberley

The chrono-stratigraphic profile of the Big Hole in the centre of the city may provide an important reference point and control for this desktop palaeontological study (Fig 5). Caution is however always advised as there are unpredictable variations in the sedimentations and trending of the rock formations. But the succession of rock units is quite informative as a basic guidebook for purposes of this desk survey. This is considering that the Vooruitzigt 81 lies only 5km west of the Big Hole. The succession is summarised as follows:

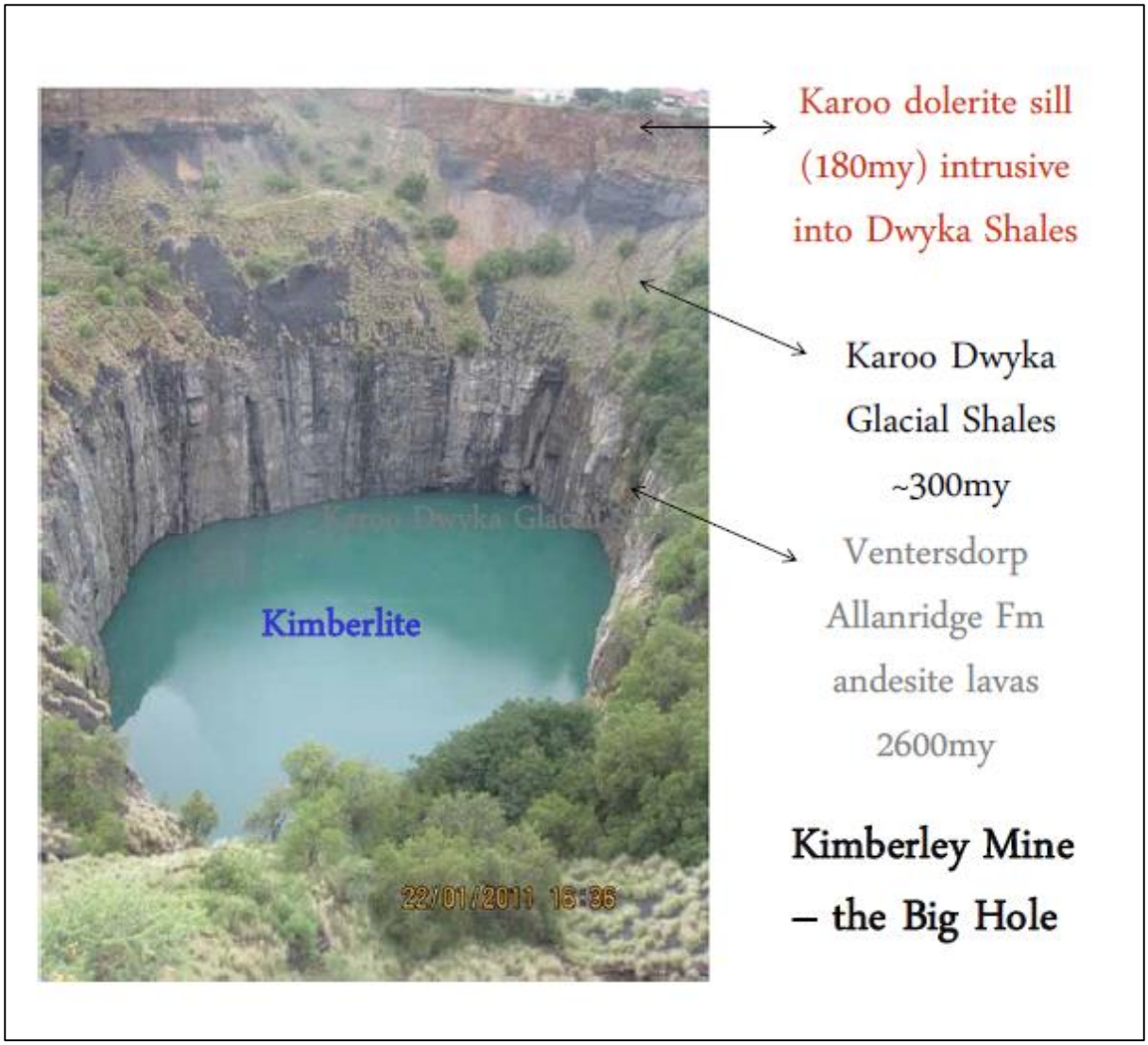

Fig 5. Chrono-stratigraphic sequence at the Big Hole Kimberly, located 3km south of the study area (courtesy of Jock Robey).[2]

[2] http://azef.co.za/.cm4all/iproc.php/2013/Presentations/4.1_Arid%20Zone%20Conference%20talk%20-%20J%20Robey.pdf?cdp=a.

The age of the rock units are summarised as follows (Jock Robey. Ibid):

MYA	ROCK UNITS
90my	Kimberlite pipes
~180	Karoo dolerite sills
~300	Basal Karoo glacial sediments – Dwyka Group
~2600	Allanridge Formation andesite lavas and quartzite of the Ventersdorp Supergroup (VSG)
~3200	Basement granitoids, amphibolites and schists

6. CHRONOLOGICAL DEVELOPMENT OF ROCK UNITS IN KIMBERLEY AND SURROUNDINGS AND THEIR PALAEONTOLOGICAL SENSITIVITY

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

The Allanridge Formation andesite lavas belong to the Ventersdorp Supergroup (VSG) which date back to the Precambrian 2600 MYA. The **Ventersdorp Supergroup** represents a major episode of igneous extrusion, what is termed a Large Igneous Province (LIP) from below the Kaapvaal Craton some 2.7 Ga (billion years) ago. 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 p18).

Palaeontological sensitivity

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

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. The Dwyka tillite is mostly 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 along the north-western margin of the Main Karoo Basin and a general profile can be presented here. 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 the 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. The Mbizane Formation, up to 190m thick, is recognized across the entire northern margin of the Main Karoo Basin where it may variously form the whole or only the *upper* part of the Dwyka succession. It is characterized by its extremely heterolithic nature (Almond 2012, p6).

Palaentological sensitivity

The paleontological rating of the glacial tillites of the Dwyka Group are considered to **medium to low** (Almond 2012, p22).

6.3. The Ecca Group c270 MYA

The Permian Ecca Group comprises a total of 16 formations that 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. Ecca comprises the Tierberg Formation, Waterford Formation, Whitehill Formation, and Prince Albert Formation. A component of the Karoo Supergroup, the Ecca group is a sedimentary complex post-dating Dwyka in which principally shales and sandstones were laid down in the sandy shorelines of swamplands during the Permian Period. As the primitive continent Gondwana moved north towards the equator the great ice sheets retreated and the Ecca Sea took its place. A period of active sedimentation set it 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. An Ecca horizon is absent at the Big Hole although it cannot be ruled out that there might be localities of this Karoo subgroup in the locality.

Palaeontological sensitivity

The Ecca fossil marine deposition may contain Marine invertebrates (esp. molluscs, brachiopods), coprolites, palaeoniscoid fish & sharks. There are also traces fossils, various microfossils, petrified wood. Mesosaurus have also been recorded in the Whitehill Formation. Rare fossil insect wings have also been reported in the same formation. According to McLachlan and Anderson (1973) in Johnson *et al.* (2006) the Prince Alberton Formation of the Ecca Group revealed plant fossils near the base of the formation at Douglas. According to Visser (1994), fossil sharks, sponge spicule, foraminifera, radiolarian and acritarchs have been found in the Prince Alberton Formation. The Tierberg Formation is also fossiferously 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).The palaeontological rating according to Almond is **high.**

Fig 6. Sedimentary profile of the area shows upper horizon of the red-brown loamy sand Gordonia Formation (field photo: E. Matenga 2017).

Fig. 7. Another view of the upper stratigraphic profile with the loamy sand overburden (field photo: E. Matenga 2017).

6.4. The Karoo dolerite intrusion (Drakensberg Group)

The Karroo dolerite sill sometimes referred to as Kimberley Sheet is evident on the summits of ridges and koppies in the vicinity of Kimberley. Most of the Kimberley municipal area is underlain by this Sheet, which is flat-lying and very regular in its mode of occurrence. The shales lying immediately below the dolerite have usually been metamorphosed to lydianite and homstone as a result of the heat and pressure during the intrusion event. The intense heat has had a tendency to destroy fossil material in the upper layers of the Dwyka sediments. The intrusion event happened between183.0 to 182.3 MYA as part of the Drakensberg Group (Coetzee 2016, p1).

Palaeontological sensitivity

The Karoo dolerite (igneous lavas) (Drakensberg Group) are considered to be unfossilferous.

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

The Gordonia Formation Aeolian sands (and the calcretic layer or pedogenic limestones which lie below it - Fig 8) probably date to the late Caenozoic (probably Plio-Pleistocene) (Almond 2012, p10). The Gordonia sands and calcretes generally fall within late superficial sediments chronologically assigned to the Kalahari Group (Almond 2012, p10).

Large areas of unconsolidated, reddish-brown to grey aeolian (*i.e.* wind-blown) sands of the Quaternary Gordonia Formation (Kalahari Group) have been seen on the western outskirts of Kimberley and at Vooruitzigt 81 and Fieldsview north of the city (Fig 8). The Gordonia sands in the Kimberley area may reach thicknesses of up to 8m and consist of up to 85% quartz associated with minor feldspar, mica and a range of heavy minerals. The Gordonia dune sands are considered to date to the Pleistocene. According to Almond the fossil sensitivity of the **Kalahari Group** is considered generally sparse and of low diversity. The **Gordonia Formation** dune sands were mainly active during cold, drier intervals of the Pleistocene epoch that were inimical to most forms of life, apart from hardy, desert-adapted species. Porous dune sands are not generally conducive to fossil preservation. However, mummification of soft tissues may play a role here and migrating lime-rich groundwaters derived from the underlying bedrocks (including, for example, dolerite) may lead to the rapid calcretisation of organic structures such as burrows and root

casts. Occasional terrestrial fossil remains that might be expected within this unit include calcretized rhizoliths (root casts) and termitaria (*e.g. Hodotermes*, the harvester termite), ostrich egg shells (*Struthio*) and shells of land snails (*e.g. Trigonephrus*) (Almond 2008, Almond & Pether 2009). Other fossil groups such as freshwater bivalves and gastropods (*e.g. Corbula, Unio*) and snails, ostracods (seed shrimps), charophytes (stonewort algae), diatoms (microscopic algae within siliceous shells) and stromatolites (laminated microbial limestones) are associated with local watercourses and pans. These Kalahari fossils (or subfossils) can be expected to occur sporadically but widely, and the overall palaeontological sensitivity of the Gordonia Formation is therefore considered to be low.

Fig 8. Loamy sandy top soil which exemplify the Gordonia Formation (field photo: E. Matenga 2017).

Palaeontological Sensitivity

Low sensitivity with the possibility of finding calcretised rhizoliths & termitaria, ostrich egg shells, land snail shells, rare mammalian and reptile (*e.g.* tortoise) bones, teeth freshwater units associated with diatoms, molluscs, stromatolites *etc* (Almond 2012, p 22).

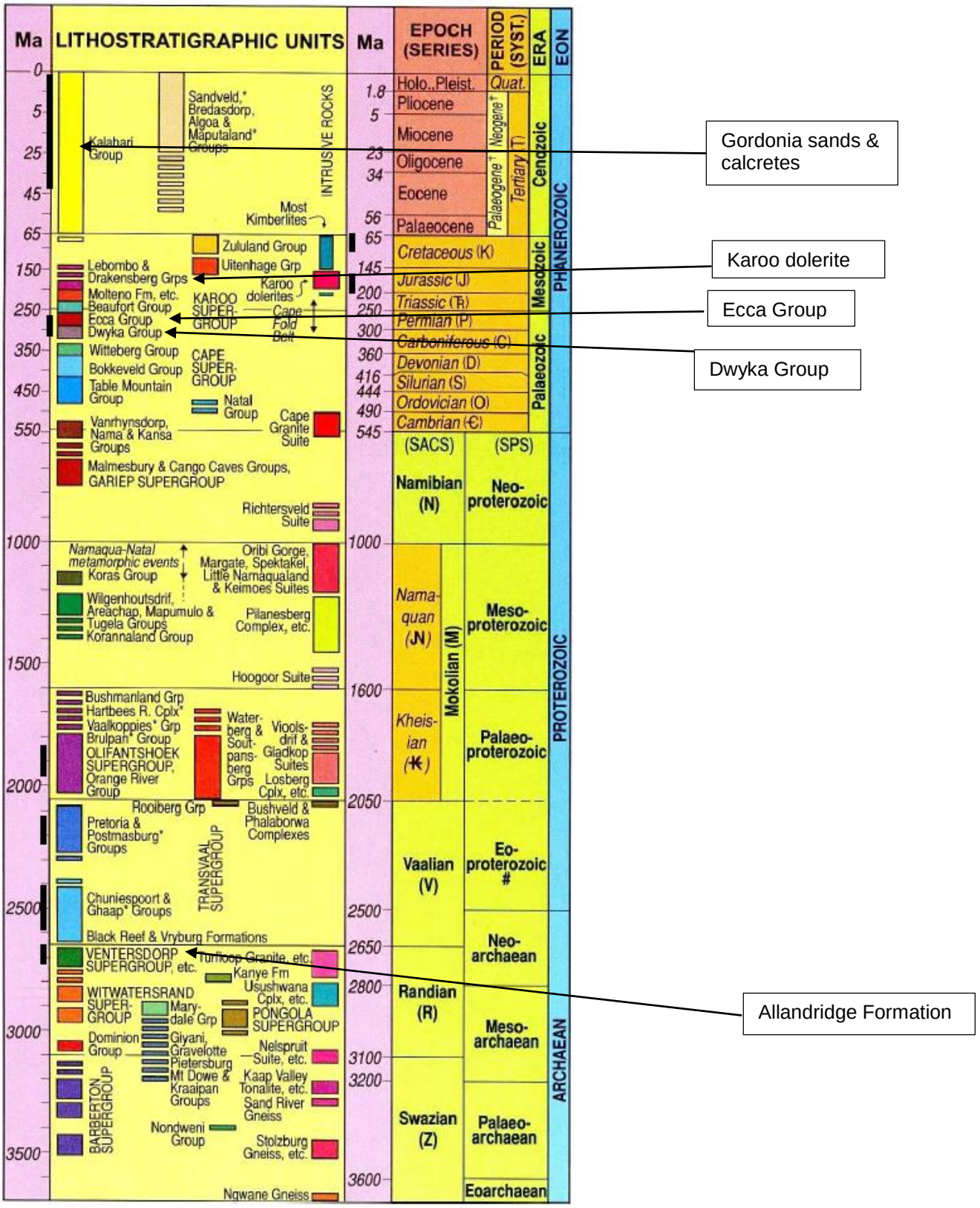

Fig 9. Chronological sequence of the rock units (adapted from Almond 2012, p11)

7. CONCLUSIONS AND RECOMMENDATIONS

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

8. 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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