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PALAEONTOLOGICAL ASSESSMENT (DESKTOP) REQUESTED IN TERMS OF SECTION 38 OF THE NATIONAL HERITAGE RESOURCES ACT NO 25/1999 FOR A MINING RIGHT ON A PORTION OF PORTION 1 & PORTION OF PORTION 351 OF 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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EXECUTIVE SUMMARY

This desktop palaeontological impact assessment (PIA) has been conducted in support of an application by Kimcrush (Pty Ltd) for a Mining Right on a Portion of Portion 1 & Portion of Portion 351 of the Farm Vooruitzigt 81, Kimberley District, Northern Cape Province.

The proposed mining will be undertaken by open cast methods. The target mineral is dolerite which will be crushed at the site to obtain various grades of stone for civil works: ballast stone, crusher sand, crusher dust, paving gravel, building concrete stone, and other grades of concrete stone for roadworks and rail installation. As the foot print of the mine will be extended new service roads will be opened and other support infrastructure developed. These physical works may result in the disturbance or destruction of heritage resources if they exist. For this reason an HIA is necessary to prepare a heritage impact statement showing what is present or what is likely to occur at the site.

In this desk study, the underlying rock units in 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 by various scholars.

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 Allanridge Formation, named after a town in the Free State, is a subgroup of the **Ventersdorp Supergroup** that 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 volcanic Allanidge Formation forms the upper most unit of the Ventersdorp Supergroup and extruded over large areas, now covering the underlying rocks in the Northern Cape, North West and Free State Provinces. The formation crops out extensively in the vicinity of Vryburg, Mafikeng, Warrenton, Bloemhof, the West Rand, west of Kimberley and along the Orange River northwest and southwest

of Hopetown (van der Westhuizen et al. 2006). The Allanridge Formation of igneous lavas is considered to be **unfossilferous.**

The Dwyka Group is a late Carboniferous to Early Permian which forms the lowermost and oldest deposit in the Karoo Supergroup basin. The rocks in this group northwest of Kimberley exhibit glacial pavements - glacially-striated and eroded bedrocks – of Permo-Carboniferous age, (*c*. 300 Ma) that tend to overlie the Allanridge Formation in the same region. The Dwyka tillite is mostly consists of 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 post-dating the Dwyka Group is a subcomponent of the Karoo Supergroup, a sedimentary complex 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 molluscs, brachiopods, coprolites, palaeoniscoid fish & sharks. There are also traces fossils, various microfossils, petrified wood. The palaeontological rating according to Almond (2012) is **high.**

Most of the areas in the Kimberley municipal are underlain by the Karroo dolerite of the Drakensberg Group sill. These are intrusions 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.**

The western outskirts of Kimberley on the Farm Vooruitzigt 81, and Fieldsview north of the city are covered with large areas of unconsolidated, reddish-brown to grey aeolian (*i.e.* wind-blown) sands of the Quaternary Gordonia Formation (Kalahari Group). Immediately below the sands may be a calcretic layer or pedogenic limestones generally considered of the same geological period. They are considered of **<u>low sensitivity</u>** 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*.

Overall, the impact of the proposed development on fossil resources is expected to be minimal. However, it is still recommended that the Environmental Control Officer (Eco) puts in place a contingency plan to rescue chance finds and where possible preserve them *in situ*. A standard Fossil Finds Procedure (FFP) is attached 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 on behalf of Kimcrush (Pty) Ltd so as to support an application for a prospecting rights on a Portion of Portion 1 of the Farm Vooruitzigt 81, Kimberley District 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 proposed mining will be undertaken by open cast methods. The target mineral is dolerite which will be crushed at the site to obtain various grades of stone for civil works: balast stone, crusher sand, crusher dust, paving gravel, building concrete stone, and other grades of concrete stone for roadworks and rail installation. As the foot print of the mine will be extended, new service roads will be opened and other support infrastructure developed. These physical works may result in the disturbance or destruction of heritage resources where they exist. For this reason an HIA is to prepare a heritage impact statement which shows what is present and or what is likely to occur at the site.

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 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 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]

The breadth of palaeontological research has been expanding to also determine long-term physical changes in paleogeography and paleoclimatology and how they that affected the history of life 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 is located 2km from the western limits of Kimberley along the N8 highway from the city to Griekwastad. The highway forms the southern boundary of the property. While a small eastern portion of the property has been used as a quarry or borrow pit, a large portion to the west is undisturbed and exhibits the natural vegetation and soil characteristics of this part of the highveld. The terrain is flat, an open grassland with scattered acacia trees (dominated by *Acacia erioloba*).

[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)

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

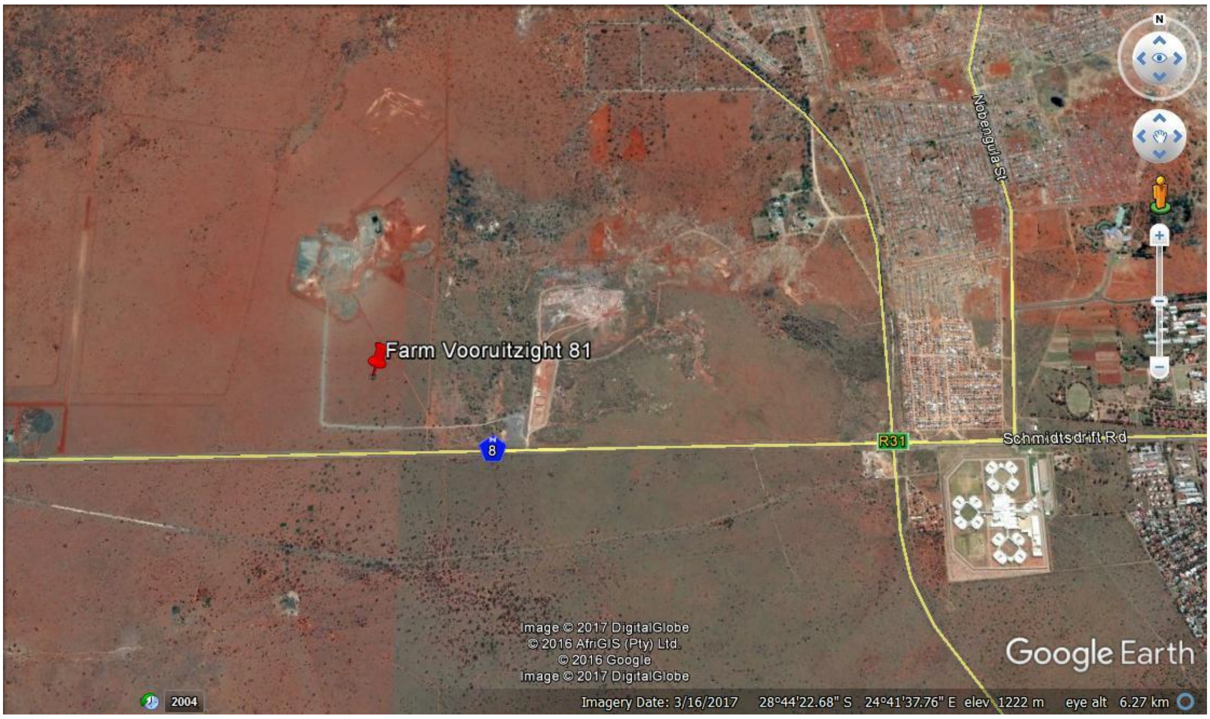

Fig 2. Google-Earth view of the location of Portion of Portion 1 and Portion 351 of Farm Vooruitzigt 81 (Kimcrush Pty Ltd), on the western outskirts of Kimberley.

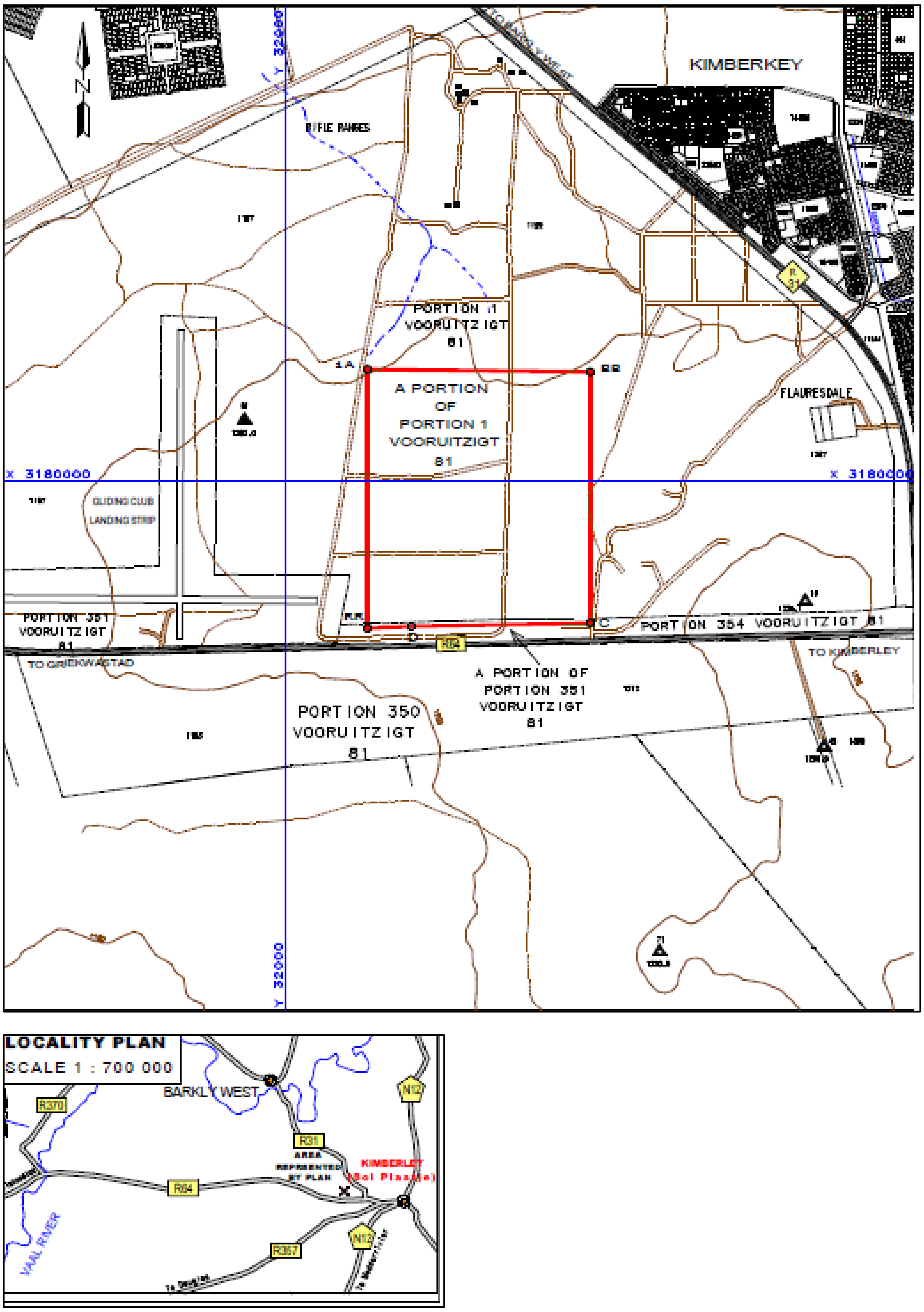

Fig 3. Layout map of the property (courtesy of Kimcrush (Pty) Ltd).

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

The National Heritage Resources Act (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 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

A significant 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

It was assumed in this PIA study 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. There are, 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 which may change markedly across its outcrop area. Thus 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 discussed in Section 4.1 the geology and palaentological sensitivity of the area has been informed by geological maps, scientific literature as well as previous impact assessments in the region. The Big Hole located in the centre of Kimberley, 5km east of the study area has provided significantly valuable profiles that have been considered as a useful reference.

5.1. Geology map of Kimberley (2824)

The geological map (Fig 5) shows that the area is overlain by Gordonia Formation (Kalahali Group) aeolian sands and below them a calcretic horizon (Qc) dating to the Plio-Pleistocene. Furthermore, it shows the presence of a dolerite sill (Jd) 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 (QS) dating to the Plio-Pleistocene and Calcretes (Qc) of the same age.

5.2. The geology of the Big Hole of Kimberley

The chrono-stratigraphic profile of the Big Hole in the centre of the city provides an important reference point and control for this desktop palaentological study (Fig 5). Caution is however always advised as there are unpredictable variations in the sedimentations and trending of the rock formations. But this 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:

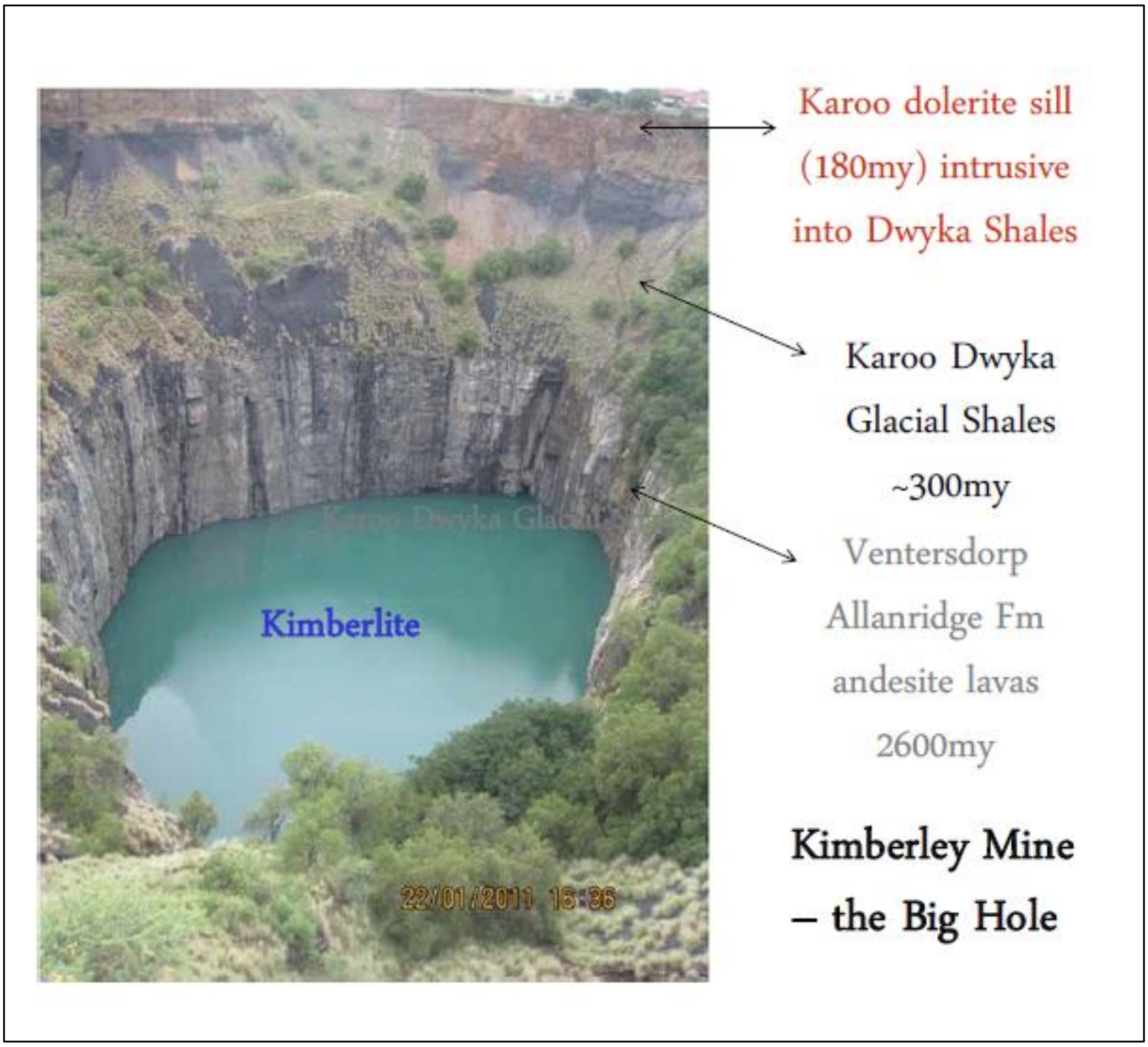

Fig 5. Chrono-stratigraphic sequence at the Big Hole Kimberly, located 3km south of the study area (courtesy of Jock Robey).[2]

[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. According to McCarthy and Rubidge (2005:109), the rise of the Ventersdorp Supergroup may be related to the collision of the Zimbabwe Craton with the Kaapvaal Craton. 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; Chikumbirike 2017).

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. 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 is described as 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 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. 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).

Palaentological sensitivity

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

6.3. The Ecca Group c270 MYA

Johnson et al. (2006) indicate that the Permian Ecca Group is made up of 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 a component of the Karoo Supergroup post-dating Dwyka in which principally shales and sandstones were 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. There is an absence of the Ecca horizon at the Big Hole, however, it cannot be ruled out that there might be localities of this Karoo subgroup in the locality.

Palaeontological sensitivity

The Ecca fossil marine deposits have been shown to contain marine invertebrates such as molluscs andbrachiopods. 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).

6.4. The Karoo dolerite intrusion (Drakensberg Group)

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

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 7 - 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).

The western outskirts of Kimberley on the farm Vooruitzigt 81 and Fieldsview north of the city (Fig 6) contain large areas of unconsolidated, reddish-brown to grey aeolian (*i.e.* wind-blown) sands of the Quaternary Gordonia Formation (Kalahari Group). The Gordonia sands in the Kimberley area with approximate thicknesses of up to 8m are made up of up to 85% quartz associated with minor feldspar, mica and a range of heavy minerals. The Gordonia dune sands date to the Pleistocene.

According to Almond the fossil sensitivity of the **Kalahari Group** is considered generally sparse and of low diversity (Partridge et al. 2006). 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 generally do not preserve fossils, mummification of soft tissues may be possible here and in addition 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. Terrestrial fossil remains that might be anticipate 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). These occur on an occasional basis. 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 and these are other groups of fossils that are found here. 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 6. Loamy sandy top soil which exemplify the Gordonia Formation (field photo: E. Matenga 2017).

Fig 7. Occasional exposures of the calcrete which underlies the Gordonia sand (field photo by E. Matenga)

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).

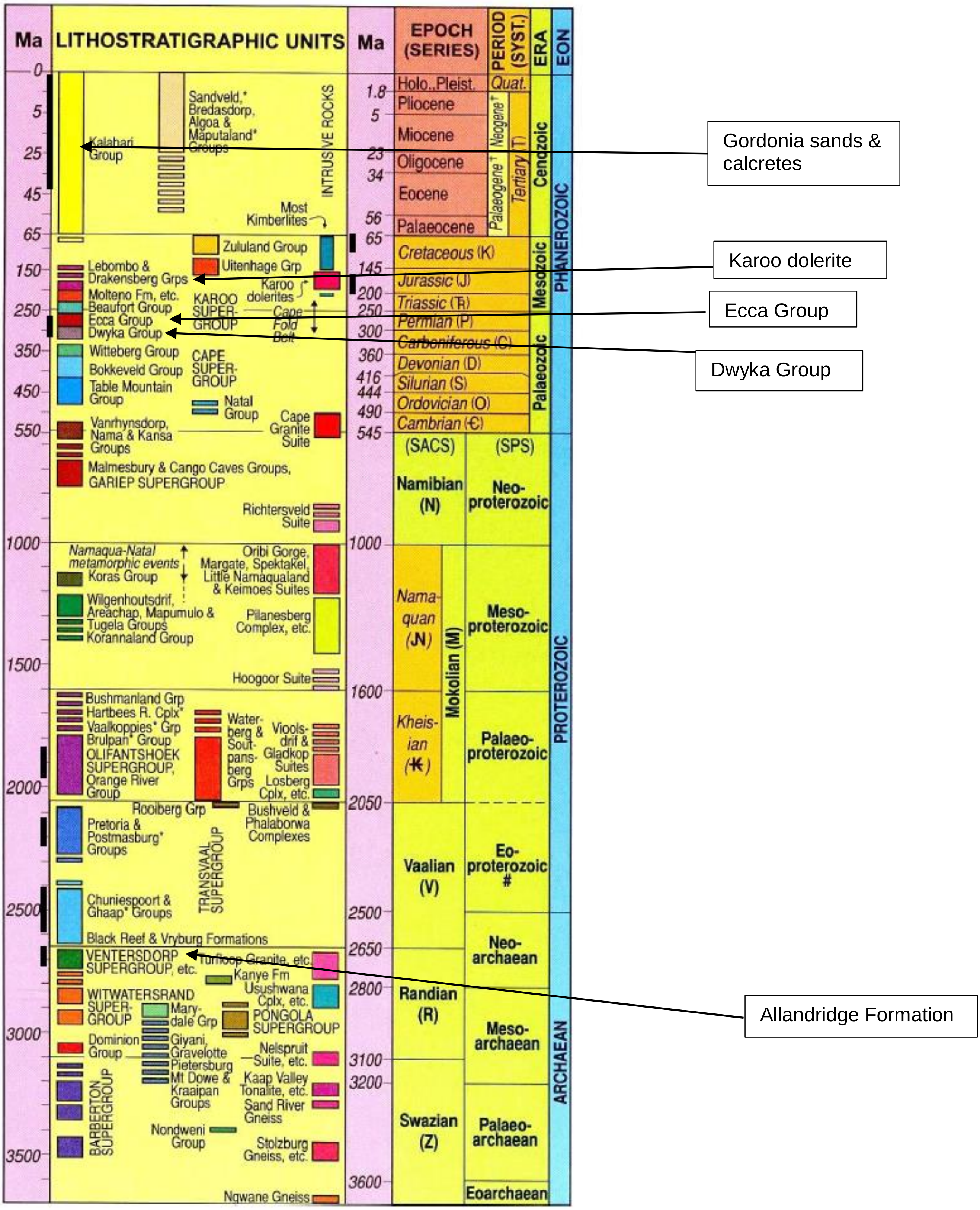

Fig 8. Chronological sequence of the rock units (adapted from Almond 2012, p11)

7. CONCLUSIONS AND RECOMMENDATIONS

Besides the fact that the impact of the proposed development on fossil resources is expected to be minimal, 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.

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.

9. SELECTED BIBLIOGRAPHY

1. BEAUMONT, P.B., SMITH, A.B. & VOGEL, J.C. 1995. Before the Einiqua: the archaeology of the frontier zone. In Smith, A.B. (Ed.). Einiqualand: Studies of the Orange River Frontier. Cape Town: UCT Press.
2. DEACON, J. 1992. Archaeology for Planners, Developers and Local Authorities. Cape Town: National Monuments Council.
3. HUMPHREYS, A.J.B. 1986. Searching for the past. Cape Town: David Philip.
4. PISTORIUS, J.C.C. 1994. Eskom Archaeological Site Identification Guide. Johannesburg: Eskom.

5. SOHNGE, P.G. VISSER, D.J.L. AND VAN RIET LOWE, C. 1937. The geology and archaeology of the Vaal River Basin. Pretoria: Government Printer.
6. SMITH, A.B. (Ed.). 1995. Einiq
7. ALMOND, J.E. 2008. Fossil record of the Loeriesfontein sheet area (1: 250 000 geological sheet 3018). Unpublished report for the Council for Geoscience. Pretoria, 32 pp. Natura Viva cc, Cape Town.
8. ALMOND, J.E. & PETHER, J. 2008. Palaeontological heritage of the Northern Cape. Interim SAHRA technical report, 124 pp. Natura Viva cc., Cape Town.
9. CORNELL, D.H., THOMAS, R.J., MOEN, H.F.G., REID, D.L., MOORE, J.M. & GIBSON, R.L. 2006. The Namaqua-Natal Province. In: Johnson, M.R., Anhaeusser, C.R. & Thomas, R.J. (Eds.) The geology of South Africa, pp. 461-499. Geological Society of South Africa, Marshalltown.
10. DE BEER, C.H., GRESSE, P.G., THERON, J.N. & ALMOND, J.E. 2002. The geology of the Calvinia area. Explanation to 1: 250 000 geology Sheet 3118 Calvinia. 92 pp. Council for Geoscience, Pretoria.
11. GRESSE, P.G., VON VEH, M.W. & FRIMMEL, H.E. 2006. Namibian (Neoproterozoic) to Early Cambrian successions. In: Johnson, M.R., Anhaeusser, C.R. & Thomas, R.J. (Eds.). The geology of South Africa, pp. 395-420. Geological Society of South Africa, Marshalltown.
12. HAUGHTON, S.H. 1932. The fossil Equidae of South Africa. Annalsof the South African Museum 28, 407-427.
13. ALMOND, J.E. 2008. Fossil record of the Loeriesfontein sheet area (1: 250 000 geological sheet 3018). Unpublished report for the Council for Geoscience. Pretoria, 32 pp. Natura Viva cc, Cape Town.
14. ALMOND, J.E. & PETHER, J. 2008. Palaeontological heritage of the Northern Cape. Interim SAHRA technical report, 124 pp. Natura Viva cc., Cape Town.
15. ALMOND, J. E. 2012. Proposed 16 MTPA expansion of Transnet's existing manganese ore export railway line & associated infrastructure between Hotazel and the port of Ngqura, Northern & Eastern Cape (September 2012).
16. ALMOND, J. E. 2011. Palaeontological Impact Assessment: Desktop study: Proposed Solar Cape Photovoltaic Electricity Generation Facility near Kenhardt, Northern Cape Province (January 2011)
17. CORNELL, D.H., THOMAS, R.J., MOEN, H.F.G., REID, D.L., MOORE, J.M. & GIBSON, R.L. 2006. The Namaqua-Natal Province. In: Johnson, M.R.,

Anhaeusser, C.R. & Thomas, R.J. (Eds.).The geology of South Africa, pp. 461-499. Geological Society of South Africa, Marshalltown.

18. DE BEER, C.H., GRESSE, P.G., THERON, J.N. & ALMOND, J.E. 2002. The geology of the Calvinia area. Explanation to 1: 250 000 geology Sheet 3118 Calvinia. 92 pp. Council for Geoscience, Pretoria.
19. GRESSE, P.G., VON VEH, M.W. & FRIMMEL, H.E. 2006. Namibian (Neoproterozoic) to Early Cambrian successions. In: Johnson, M.R., Anhaeusser, C.R. & Thomas, R.J. (Eds.). The geology of South Africa, pp. 395-420. Geological Society of South Africa, Marshalltown.
20. HAUGHTON, S.H. 1932. The fossil Equidae of South Africa. Annals of the South African Museum 28, 407-427.
21. CRADLE, A. B., B CAIRNCROSS, A. D. M. CHRISTE & D. L. ROBERTS. The Permo-Triassic Coal-Bearing Deposits of the Karoo Basin, Southern Africa. Economic Geology Research Unit. University of Witwatersrand. Information Circular No 218,
22. JOHNSON, M.R., VAN VUUREN, C.J., VISSER, J.N., COLE, D.I., DE V WICKENS, H., SHRISTIE, A.D.M., ROBERTS, D.L AND BRANDLE, G. 2006. Sedimentary rocks of the Karoo Supergoup. In Johnson, M.R., Anhaeusser, C.R. and Thomas, R.J (editors): The Geology of South Africa, pge 461- 499. Council of Geoscience, Pretoria
23. BOSCH, P.J.A. 1993. Die geologie van die gebied Kimberley. Explanation to 1: 250 000 geology Sheet 2824 Kimberley, 60 pp. Council for Geoscience, Pretoria.
24. COETZEE, A. 2016. The geometry of Karoo dolerite dykes and saucers in the Highveld Coalfield: constraints on emplacement processes of mafic magmas in the shallow crust. Master of Science Dissertation, University of Stellenbosch.

Websites

Jock Robey: Geology of Kimberley Area. Found at: http://azef.co.za/.cm4all/iproc.php/2013/Presentations/4.1_Arid%20Zone%20Conference%20talk%20-%20J%20Robey.pdf?cdp=a.