Palaentological Impact Assesssment for Proposed construction of the Mahikeng Main Transmission Substation and a 400kV Pluto-Mahikeng powerline, North West Province

Pluto Mahikeng PIA

July 15, 2018

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1. Executive Summary

The proposed northern route (Route 2 marked in blue on the geological maps) runs for the most of its length over the dolomites extending over the length of North West Province between Mafikeng and Carletonville. This area is demarcated as having a High Palaeontological Sensitivity due to the probability of finding stromatolites this region. Even though no distinct outcrops of stromatolites were found during the field assessment, the chances of exposing stromatolites during construction are good and for this reason a Chance Find Procedure has been included in the Recommendations. Even though it is not essential to salvage every piece of stromatolite exposed because of its ubiquitous distribution in the dolomites of South Africa, it will be prudent not to destroy a major stromatolite find for scientific and heritage reasons.

In the case of the proposed southern route (Route2 marked in red on the geological maps), only the easternmost section between Carletonville and Welverdiend and a short section east of Mafikeng run over the dolomites of this region. The bulk of this route runs over rock strata demarcated as having medium, low to insignificant palaeontological sensitivity. The chances of finding fossils in this section are low and the procedure that should be followed in the case of the discovery of fossils in this section is covered in the Chance Find Procedure.

The proposed northern route (Route 2) will have a far greater impact on potential fossil sites in the region between Carletonville and Mafikeng than the southern route. Although the chances of finding an exceptional site that surpasses those already known to science are small, it remains important to alert the palaeontological community and SAHRA if a major fossil find is made and to prevent the destruction of those fossiliferous areas by moving the pylon further away.

2. Introduction

The palaeontological heritage of South Africa is unsurpassed and can only be described in superlatives. The South African palaeontological record gives us insight in *i.a.* the origin of life, dinosaurs and humans. Fossils are also used to identify rock strata and determine the geological context of the geological formations and the chronostratigraphy of Southern Africa.

Some of the oldest evidence of life on Earth came from the rocks at Barberton which contain fossilized bacteria. Stromatolites in the dolomitic regions in South Africa were formed by shallow marine mats of cyanobacteria. The cyanobacteria, which were some of the first photosynthesising organisms, provided most of the oxygen in our atmosphere.

The first evidence of tectonic plate movement was discovered after studying the distribution of Karoo-age fossils in South Africa and other continents and subcontinents such as India, Antarctica, South America and Australia. Fossils are also used to study evolutionary relationships, sedimentary processes and palaeoenvironments.

South Africa is probably best known palaeontologically for having more than half of all the hominin specimens in the world, the greatest variety of hominins in a country and the longest record of continuous hominin occupation in the world.

The Heritage Act of South Africa stipulates that fossils and fossil sites may not be altered or destroyed. The purpose of this document is to detail the probability of finding fossils in the study area which may be impacted by the proposed development.

3. Terms of reference for the report

According to the South African Heritage Resources Act (Act 25 of 1999) (Republic of South Africa, 1999), certain clauses are relevant to palaeontological aspects for a terrain suitability assessment.

- **Subsection 35(4)** No person may, without a permit issued by the responsible heritage resources authority-
- (a) destroy, damage, excavate, alter, deface or otherwise disturb any archaeological or palaeontological site or any meteorite;
- (b) destroy, damage, excavate, remove from its original position, collect or own any archaeological or palaeontological material or object or any meteorite;
- (c) trade in, sell for private gain, export or attempt to export from the republic any category of archaeological or palaeontological material or object, or any meteorite; or
- (d) bring onto or use at an archaeological or palaeontological site any excavation equipment or any equipment which assist with the detection or recovery of metals or archaeological material or objects, or use such equipment for the recovery of meteorites.
- **Subsection 35(5)** When the responsible heritage resources authority has reasonable cause to believe that any activity or development which will destroy, damage or alter any archaeological or palaeontological site is under way, and where no application for a permit has been submitted and no heritage resources management procedures in terms of section 38 has been followed, it may-
- (a) serve on the owner or occupier of the site or on the person undertaking such development an order for the development to cease immediately for such period as is specified in the order;
- (b) carry out an investigation for the purpose of obtaining information on whether or not an archaeological or palaeontological site exists and whether mitigation is necessary;
- (c) if mitigation is deemed by the heritage resources authority to be necessary, assist the person on whom the order has been served under paragraph (a) to apply for a permit as required in subsection (4); and
- (d) recover the costs of such investigation form the owner or occupier of the land on which it is believed an archaeological or palaeontological site is located or from the person proposing to undertake the development if no application for a permit is received within two weeks of the order being served.

South Africa's unique and non-renewable palaeontological heritage is protected in terms of the NHRA. According to this act, heritage resources may not be excavated, damaged, destroyed or otherwise impacted by any development without prior assessment and without a permit from the relevant heritage resources authority.

As areas are developed and landscapes are modified, heritage resources, including palaeontological resources, are threatened. As such, both the environmental and heritage legislation require that development activities must be preceded by an assessment of the impact undertaken by qualified professionals. Palaeontological Impact Assessments (PIAs) are specialist reports that form part of the wider heritage component of:

- Heritage Impact Assessments (HIAs) called for in terms of Section 38 of the National Heritage Resources Act, Act No. 25, 1999 by a heritage resources authority.
- Environmental Impact Assessment process as required in terms of other legislation listed in s. 38(8) of NHRA;
- Environmental Management Plans (EMPs) required by the Department of Mineral Resources.

Heritage Impact Assessments (HIA) are intended to ensure that all heritage resources are protected, and where it is not possible to preserve them in *situ*, appropriate mitigation measures are applied. An HIA is a comprehensive study that comprises a palaeontological, archaeological, built environment, living heritage, etc specialist studies. Palaeontologists must acknowledge this and ensure that they collaborate with other heritage practitioners. Where palaeontologists are engaged for the entire HIA, they must refer heritage components for which they do not have expertise on to appropriate specialists. Where they are engaged specifically for the palaeontology, they must draw the attention of environmental consultants and developers to the need for assessment of other aspects of heritage. In this sense, Palaeontological Impact Assessments that are part of Heritage Impact Assessments are similar to specialist reports that form part of the EIA reports.

The standards and procedures discussed here are therefore meant to guide the conduct of PIAs and specialists undertaking such studies must adhere to them. The process of assessment for the palaeontological (PIA) specialist components of heritage impact assessments, involves:

Scoping stage in line with regulation 28 of the National Environmental Management Act (No. 107 of 1998) Regulations on Environmental Impact Assessment. This involves an **initial assessment** where the specialist evaluates the scope of the project (based, for example, on NID/BIDs) and advises on the form and extent of the assessment process. At this stage the palaeontologist may also decide to compile a **Letter of Recommendation for Exemption from further Palaeontological Studies**. This letter will state that there is little or no likelihood that any significant fossil resources will be impacted by the development. This letter should present a reasoned case for exemption, supported by consultation of the relevant geological maps and key literature.

A **Palaeontological Desktop Study** – the palaeontologist will investigate available resources (geological maps, scientific literature, previous impact assessment reports, institutional fossil collections, satellite images or aerial photos, etc) to inform an assessment of fossil heritage and/or exposure of potentially fossiliferous rocks within the study area. A Desktop studies will conclude whether a further field assessment is warranted or not. Where further studies are required, the desktop study would normally be an integral part of a field assessment of relevant palaeontological resources.

A **Phase 1 Palaeontological Impact Assessment** is generally warranted where rock units of high palaeontological sensitivity are concerned, levels of bedrock exposure within the study area are adequate; large-scale projects with high potential heritage impact are planned; and where the distribution and nature of fossil remains in the proposed project area is unknown. In the recommendations of Phase 1, the specialist will inform whether further monitoring and mitigation are necessary. The Phase 1 should identify the rock units and significant fossil heritage resources present, or by inference likely to be present, within the study area, assess the palaeontological significance of these rock units, fossil sites or other fossil heritage, comment on the impact of the development on palaeontological heritage resources and make recommendations for their mitigation or conservation, or for any further specialist studies that are required in order to adequately assess the nature, distribution and conservation value of palaeontological resources within the study area.

A **Phase 2 Palaeontological Mitigation** involves planning the protection of significant fossil sites, rock units or other palaeontological resources and/or the recording and sampling of fossil heritage that might be lost during development, together with pertinent geological data. The mitigation may take place before and / or during the construction phase of development. The specialist will require a Phase 2 mitigation permit from the relevant Heritage Resources Authority before Phase 2 may be implemented.

A **‘Phase 3’ Palaeontological Site Conservation and Management Plan** may be required in cases where the site is so important that development will not be allowed, or where development is to co-exist with the resource. Developers may be required to enhance the value of the sites retained on their properties with appropriate interpretive material or displays as a way of promoting access of such resources to the public.

The assessment reports will be assessed by the relevant heritage resources authority, and depending on which piece of legislation triggered the study, a response will be given in the form of a Review Comment or Record of Decision (RoD). In the case of PIAs that are part of EIAs or EMPs, the heritage resources authority will issue a comment or a record of decision that may be forwarded to the consultant or developer, relevant government department or heritage practitioner and where feasible to all three.

4. Details of study area and the type of assessment:

The site was visited and the relevant literature and geological maps for the region in which the development is proposed to take place, have been studied for a Palaeontological Impact Assessment. This region is mostly used for farming but there are areas where natural bush and grassland occur. There are diamond, manganese and dolomite mines in this region. The undulating landscape is typical of that of a karstic region.

Figure 1: Google Earth photo indicating the areas where development is proposed (beige and red 2 km wide corridors).

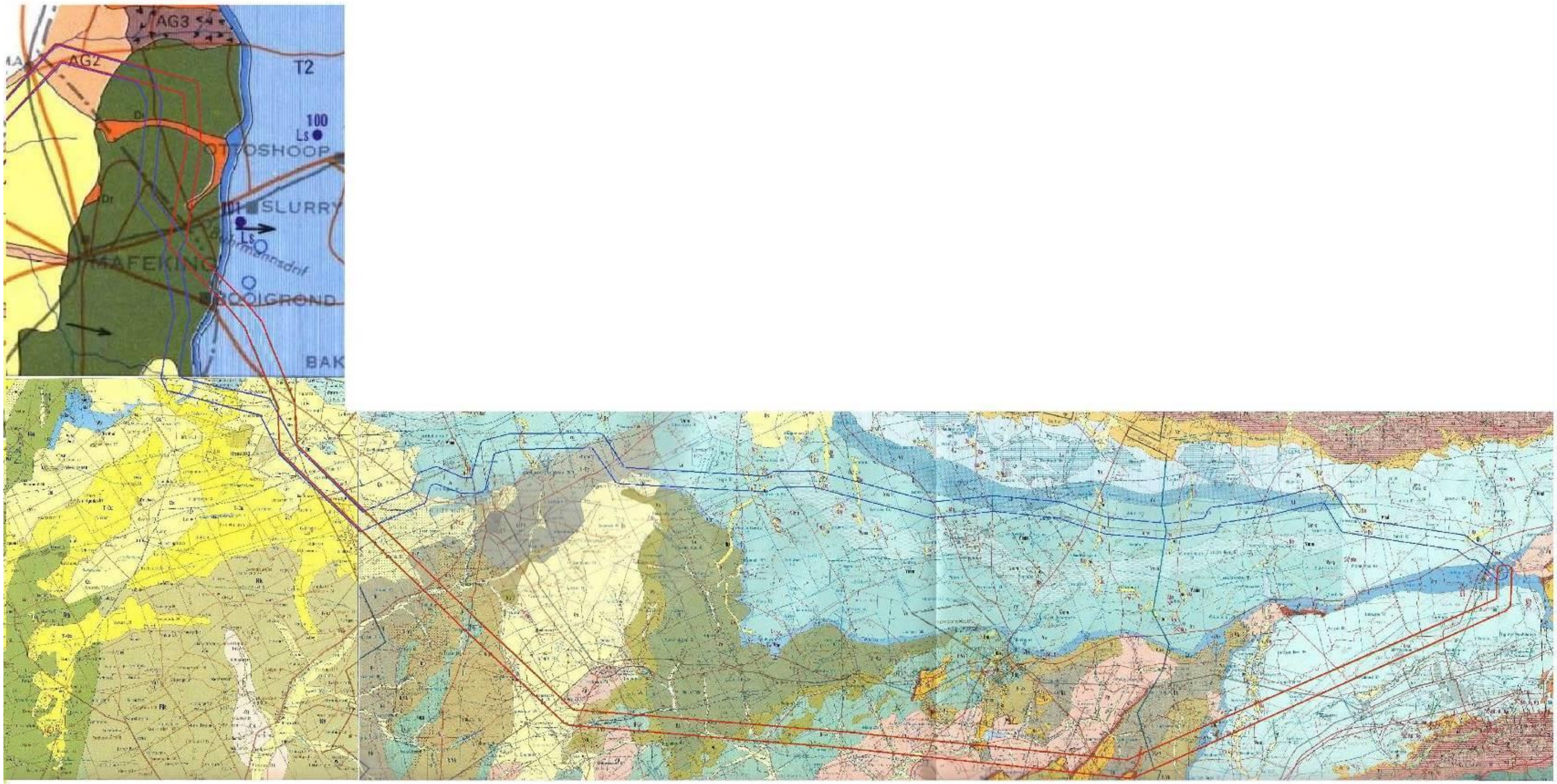

Figure 2: Geological Map of the study area and surroundings (adapted from the 2626 West Rand (1996), 2624 Vryburg (2002) 1:250 000 Geology Maps and the 1:1 000 000 Geology Map of South Africa (1970) (Council for Geoscience)
The study areas are indicated by the blue and red outlines]

5. Geological setting of the study area

GEOLOGICAL LEGEND OF THE STUDY AREA

<table>
<tr><th colspan="2"></th><th>Lithology</th><th colspan="2">Formation</th><th>Group</th><th>Super-group</th><th>Age</th></tr>
<tr><td colspan="2">Qs</td><td>Soil cover</td><td colspan="2"></td><td></td><td></td><td rowspan="3">Quaternary Tertiary</td></tr>
<tr><td colspan="2">Qg</td><td>Gravel, diamondiferous in places</td><td colspan="2"></td><td></td><td></td></tr>
<tr><td colspan="2">Qc</td><td>Calcrete</td><td colspan="2"></td><td></td><td></td></tr>
<tr><td colspan="2">C-Pd</td><td>Diamictite, shale</td><td colspan="2"></td><td>Dwyka</td><td>Karoo</td><td>Carbonife-rous</td></tr>
<tr><td colspan="2">Vh</td><td>Andesite, agglomerate, tuff</td><td colspan="2">Hekpoort</td><td>Pretoria</td><td rowspan="8">Transvaal</td><td rowspan="9">Vaalian</td></tr>
<tr><td>Ve</td><td rowspan="6">Vmd (dolomite & chert), T2</td><td>Chert-rich dolomite, chert</td><td>Eccles</td><td rowspan="6">Malmani Subroup</td><td rowspan="7">Chuniespoort</td></tr>
<tr><td>Vl</td><td>Dark, chert-poor dolomite</td><td>Lyttleton</td></tr>
<tr><td>Vmm</td><td>Chert-rich dolomite</td><td rowspan="3">Monte Christo</td></tr>
<tr><td>Vmm</td><td>Interbedded banded chert</td></tr>
<tr><td>Vmm</td><td>Interbedded oolitic chert</td></tr>
<tr><td></td><td>Dark chert-poor dolomite</td><td>Oaktree</td></tr>
<tr><td colspan="2">Vbr</td><td>Quartzite, conglomerate and shale</td><td colspan="2">Black Reef</td></tr>
<tr><td colspan="2">Va</td><td>Basaltic amygdaloidal lava</td><td colspan="2">Allanridge</td><td></td><td rowspan="4">Ventersdorp</td></tr>
<tr><td colspan="2">R-Vr</td><td>Amygdaloidal lava, agglomerate, tuff</td><td colspan="2">Rietgat</td><td rowspan="2">Platberg</td><td rowspan="5">Randian</td></tr>
<tr><td colspan="2">R-Vk</td><td>Breccia, conglomerate, greywacke, shale, limestone and tuff</td><td colspan="2">Kameeldoorns</td></tr>
<tr><td colspan="2">Rk</td><td>Basaltic lava, conglomerate, tuff</td><td colspan="2"></td><td>Kliprivier-berg</td></tr>
<tr><td colspan="2">Rh</td><td>Ferruginous shale, quartzite, banded ironstone, hornfels</td><td colspan="2">Hospital Hill Subgroup</td><td rowspan="2">West Rand</td><td rowspan="2">Witwatersrand</td></tr>
<tr><td colspan="2">Ro</td><td>Quartzite, shale</td><td colspan="2">Orange Grove of the Hospital Hill Subgroup</td></tr>
</table>

Zg	Undifferentiated granite and gneiss				Swazian

The largest part of the study area is underlain by the Malmani Subgroup dolomites. This subgroup is subdivided into five formations based on the chert content, stromatolite structure, intercalated shales, erosion surfaces and colour of the dolomite (see Legend, Fig.2) (Eriksson *et al*., 2009). The Malmani Subgroup which follows on the Black Reef Formation is in places up to 2000 m thick and forms a substantial part of the geology of the North West Province. The proposed northern corridor runs for most of its length along the dolomitic region between Carletonville and Mafikeng.

The Oaktree Formation which forms the oldest unit of the Malmani Subgroup consists of 10-200 m of carbonaceous shales, stromatolitic dolomites and quartzites.

The following Monte Christo Formation is a 300-500 m thick sedimentary unit which consists of erosive breccia and stromatolitic and oolitic platformal dolomites. The Lyttelton Formation which follows the Monte Christo Formation consists of a 100-200 m thick sequence of shales, quartzites and stromatolitic dolomites. This formation is covered by the up to 600m chert-rich Eccles Formation which also contains a series of erosion breccias which seperates it from the upper up to 400 m thick unit of the Malmani Subgroup – the Frisco Formation - which is characterised by its stromatolitic dolomites which becomes shale-rich towards the top of this unit (Eriksson *et al*., 2009).

The proposed southern corridor runs along a variety of older geological units of the Witwatersrand and Transvaal Supergroup. In places it also traverses Tertiary calcrete and unconsolidated Quaternary sediments (see Fig. 2).

6. Palaeontological potential of study area

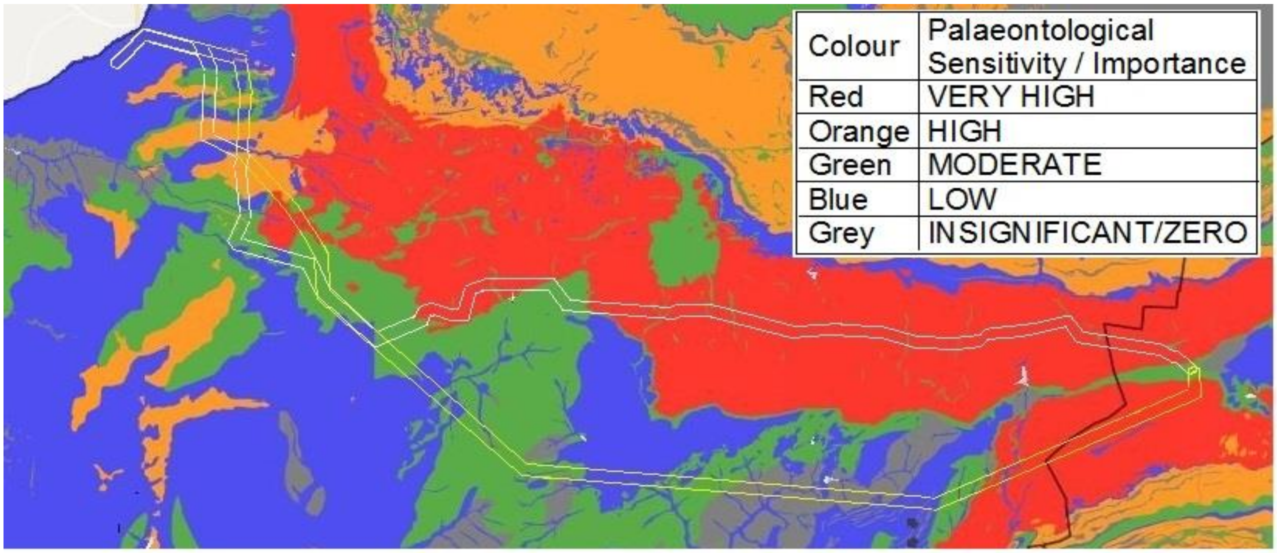

Figure 3: Palaeontological sensitivity of the region (SAHRA, 2018)

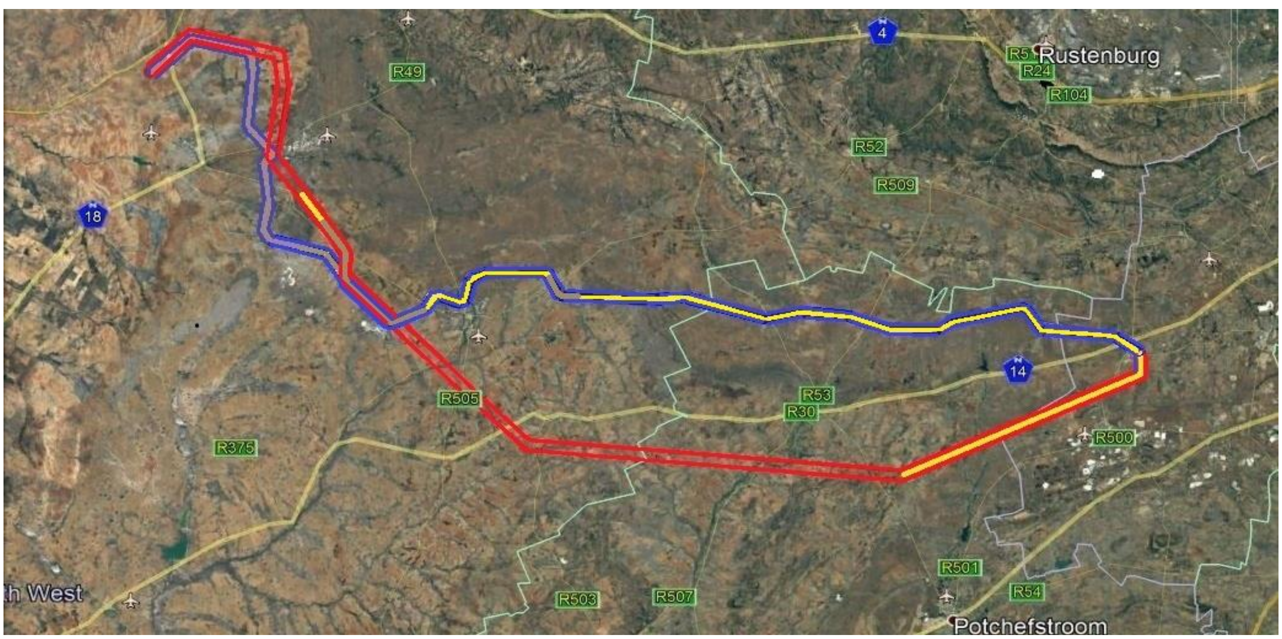

Figure 4: Palaeontologically highly sensitive sections in the study area marked in yellow

During the field assessment particular attention was given to the areas demarcated as having a high palaeontological sensitivity. These areas are underlain by dolomite and chert. Sections that are demarcated as having a medium palaeontological sensitivity were also visited. These areas are underlain mostly by non-fossiliferous shales, conglomerate, lavas and tuff and potentially fossiliferous Carboniferous-aged diamictite and shale and Quaternary aged calcrete, gravel, sand and soil and Carboniferous-aged diamictite and shale. No distinct fossils were discovered during the field assessment.

7. Site visit

Northern route (blue outline)

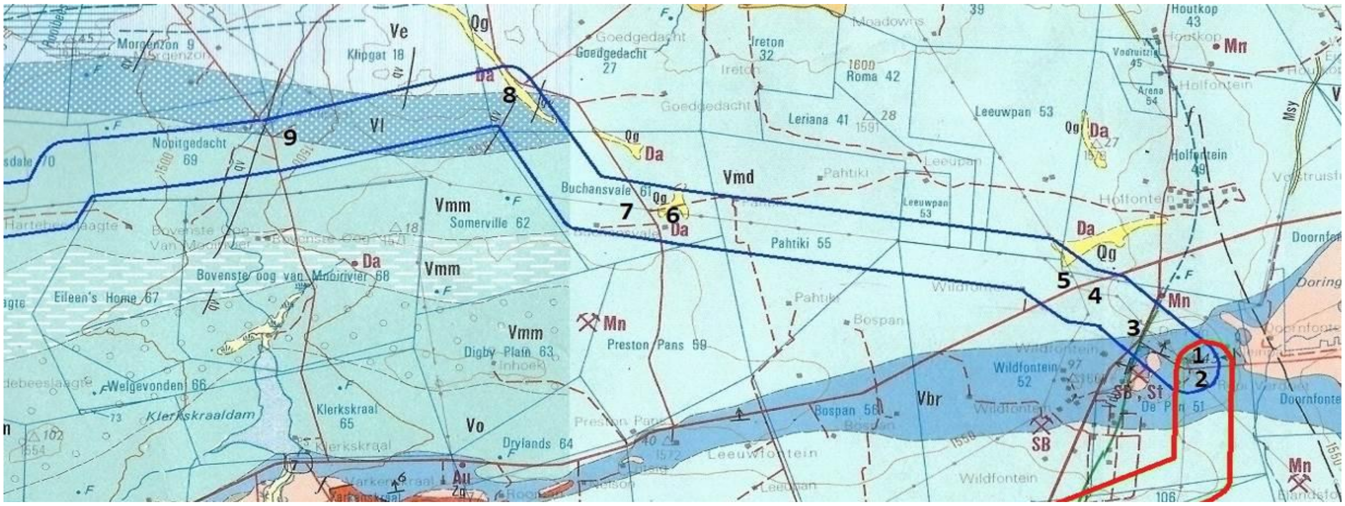

Figure 5: Detail of the eastern section of the northern route in the Carleton area indicating sites visited

Figure 6: Site 1

Figure 7: Site 2

Figure 8: Site 3

Figure 9: Site 4

Figure 10: Site 5

Figure 11: Site 6

Figure 12: Site 7

Figure 13: Site 8

Figure 14: Site 9

Figure 15: Detail of the central section of the northern route in the Ventersdorp area indicating sites visited

Figure 16: Site 10

Figure 17: Quartzite and dolomite at Site 10

Figure 18: Site 11

Figure 19: Site 12

Figure 20: Site 13

Figure 21: Site 14

Figure 22: Site 15

Figure 23: Site 16

Figure 24: Site 17

Figure 25: Dolomite and chert at Site 17

Figure 26: Site 18

Figure 27: Site 19

Figure 28: Site 20

Figure 29: Detail of the western section of the northern route in the Lichtenburg area indicating sites visited

Figure 30: Site 21

Figure 31: Site 22

Figure 32: Chert at Site 22

Figure 33: Site 23

Figure 34: Site 24

Figure 35: Site 25

Southern route (red outline)

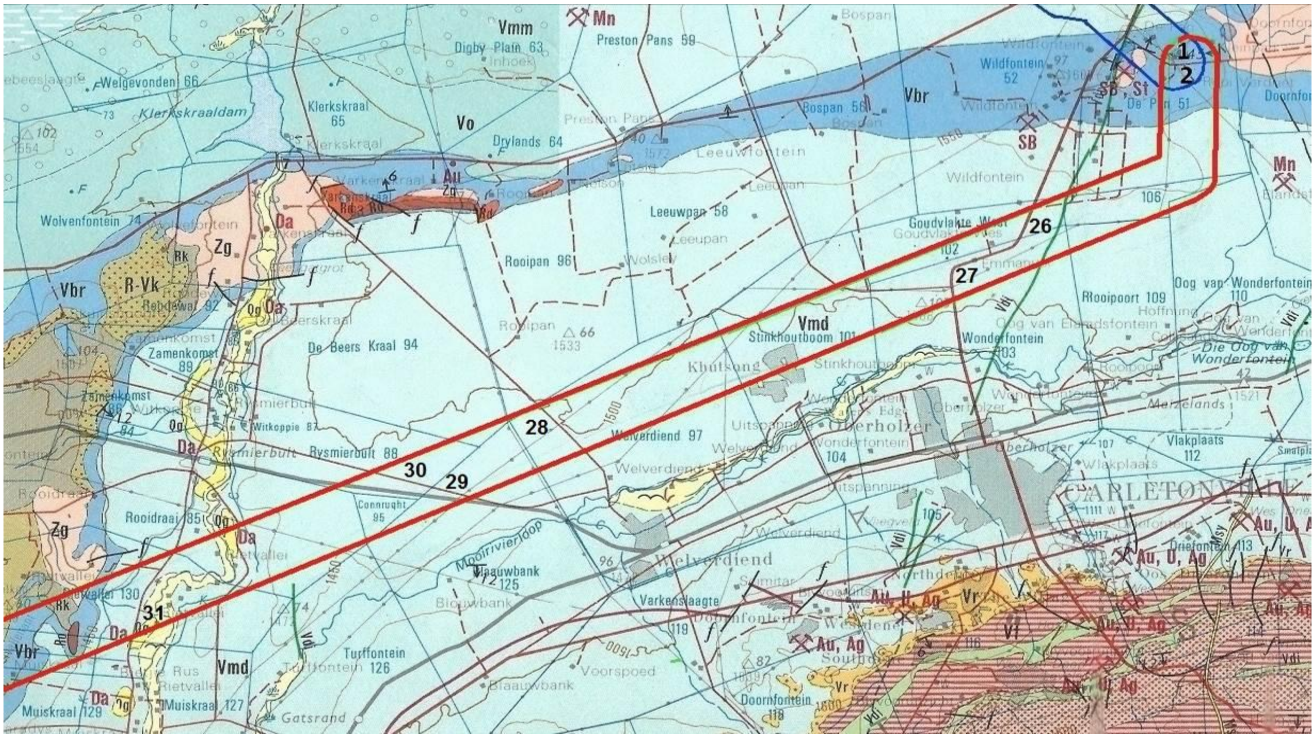

Figure 36: Detail of the eastern section of the southern route in the Carletonville area indicating sites visited (the northern and southern routes overlap at Sites 1 & 2)

Figure 37: Site 1

Figure 38: Site 2

Figure 39: Site 26

Figure 40: Site 27

Figure 41: Site 28

Figure 42: Site 29

Figure 43: Dolomite interbedded with layers of chert at Site 29

Figure 44: Site 30

Figure 45: Site 31

Figure 46: Dolomite at Site 31

Figure 47: Detail of the western section of the southern route in the Mahikeng area indicating sites visited

Figure 48: Site 32

Figure 49: Site 33

Figure 50: Site 34

8. Discussion

The main land use that occurs in the study area is farming (cattle and agriculture), while game farming in areas with natural bush and grassland and mining are the other two main land use activities in the region. The areas which are proposed for development extend over farms that are well-maintained and where little or no outcrops of the underlying rock formations occur. For the most part crops (see Figs. 9, 11, 20, 30), grass and bush covered the study area (see Figs. 7, 12, 23, 24, 34, 35, 39, 41, 48, 49, 50). The red soil of the study area seems to be deep in places where furrows had been dug without exposing the bedrock (see Figs. 8, 10, 13, 33). There were places where the soils were not that thick however and rocks eroded out of the ground (see Figs. 16, 17, 21, 22, 26, 27, 28, 29, 31, 42, 43, 45, 46) while it was a common sight in this region to find piles of rocks in quarries (see Fig. 18) or on the side of maize fields where they were dumped after being ploughed out from the ground (see Figs. 19, 25).

The proposed northern route (marked in blue on the geological maps) runs for the most of its length over the dolomites extending over the length of North West Province between Mafikeng and Carletonville. This area is demarcated as having a High Palaeontological Sensitivity due to the probability of finding stromatolites this region. No distinct or remarkable fossil finds were made on this field trip. Only one rock sample was found (see Fig. 43) that had the thin parallel undulating cherty layers which one associates with stromatolites (see Fig. 51). This however does not imply that stromatolites would not be discovered once construction commences and it is highly probable that they will be discovered in this region.

Figure 51: Stromatolites at Sterkfontein Caves

From an evolutionary, environmental, ecological and geological perspective stromatolites are very important. Stromatolites were formed approximately 2.2 Ga ago when mats of cyanobacteria covered the sea floor up to a certain depth which allowed them to photosynthesize. The slimy surface caused fine grained mud and precipitates to adhere to them after which cyanobacterial strands consisting of chains of bacterial cells would continue to extend by means through the sediment in order to get enough light to photosynthesize. Very thin layers of sediments were set down during this process. In time these sedimentary layers were petrified and turned into columns of rock. Some of these columns which are stacked closely together are as thin as pencils, while others are formed mushroom-like scallops (see Fig. 52) and others formed bigger domes (see Fig. 53) and even megadomes which are meters across.

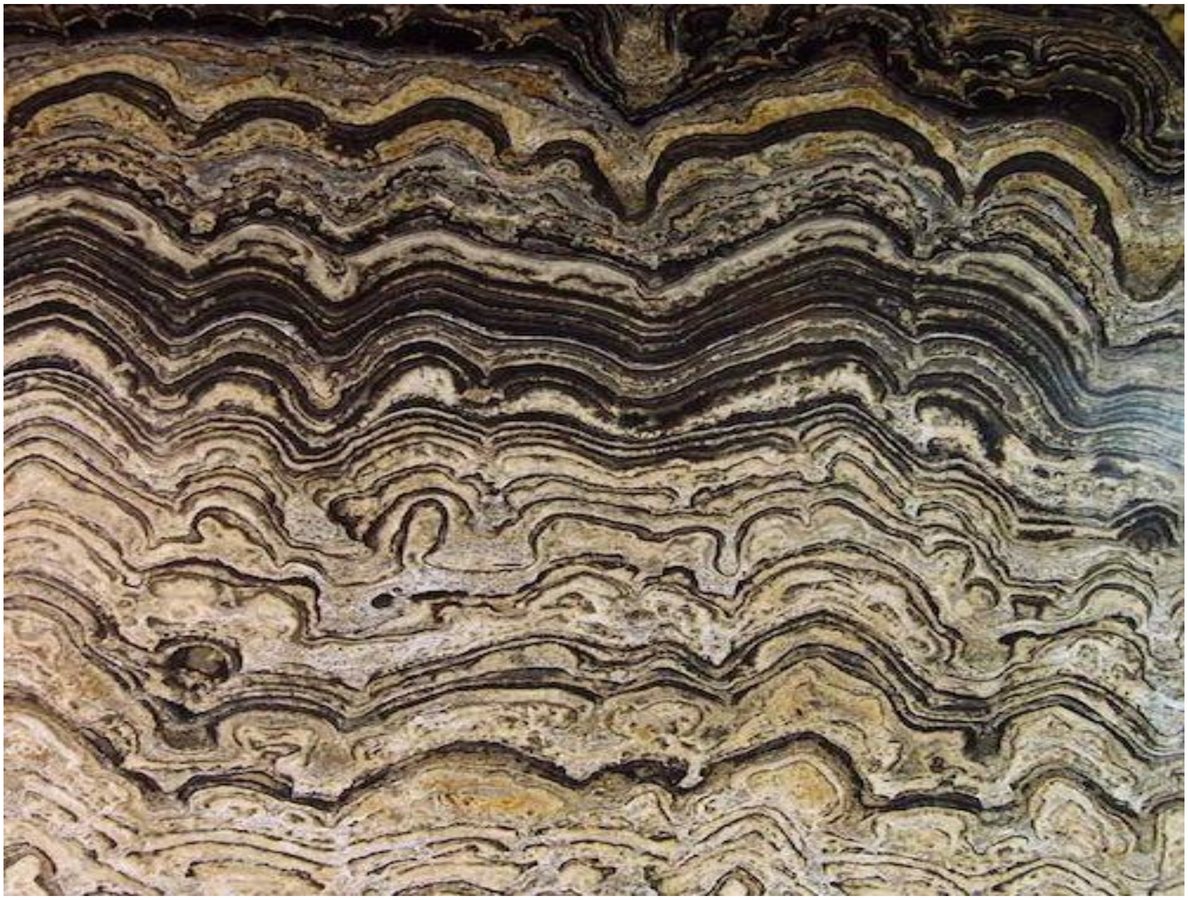

Figure 52: Polished vertical section through stromatolites

(https://www.google.co.za/imgres?imgurl=http%3A%2F%2Fwww.therockgallery.co.uk%2Fekmps%2Fshops%2Ftherockgallery%2Fimages%2Fstromatolite-large-polished-slice-100-million-years-old-andes-mountains-bolivia-%5B4%5D-1997-p.jpg&imgrefurl=http%3A%2F%2Fwww.therockgallery.co.uk%2Fstromatolite-large-polished-slice----100-million-years-old-----andes-mountains-bolivia-1997p. asp&docid=2vFkg_vqTH0I5M&tbnid=FQcixxQGdtBUFM%3A&vet=10ahUKEwinl8rfwqjcAhUGsKQKHf8wBy0QMwgsKAYwBg..i&w=500&h=500&bih=918&biw=1280&q=stromatolites&ved=0ahUKEwinl8rfwqjcAhUGsKQKHf8wBy0QMwgsKAYwBg&iact=mrc&uact=8)

These bacteria were amongst the first photosynthesizing organisms and it is thought that the chloroplast found in plants has evolved from a cyanobacterial ancestor. Cyanobacteria released oxygen as a by-product of photosynthesis in such quantities that it irrevocably changed the atmosphere from a reducing to an oxidizing atmosphere which had a devastating effect to the majority of bacteria which were and still are anoxic. On the other hand, higher organisms such as fungi, plants and animals would not have been able to exist without the oxygen in the atmosphere and would therefore not have evolved if it were not for cyanobacteria.

Figure 53: Domal structures of stromatolites seen from above

(from: https://www.google.co.za/imgres?imgurl=http%3A%2F%2Fwww.kidsdiscover.com%2Fwp-content%2Fuploads%2F2015%2F04%2FBacteria_2.jpg&imgrefurl=http%3A%2F%2Fwww.kidsdiscover.com%2Fspotlight%2Fbacteria%2F%3Fmc_cid%3D97b6810d71%26mc_eid%3Df31cca173c&docid=jpZALMrhmI6d1M&tbnid=6zCWRFeJArwpQM%3A&vet=10ahUKEwioiMq6z6jcAhWisqQKHTkzCSoQMwhCKAMwAw..i&w=1000&h=683&bih=344&biw=553&q=Bacteria_2%20stromatolites&ved=0ahUKEwioiMq6z6jcAhWisqQKHTkzCSoQMwhCKAMwAw&iact=mrc&uact=8)

9. Conclusion and recommendations:

Although stromatolites are considered to be fossils, there are hundreds of square kilometres of stromatolites in South Africa and it is not considered to be so scarce that every stromatolite has to be preserved. In the event of the discovery of an exceptional stromatolite formation it is advised that it should on principle not be destroyed if an alternative position for the placing of a specific pylon can be found.

Although the proposed northern corridor has got a much higher probability to impact on fossils than the proposed southern corridor, it is not considered to be a reason why the development should not continue along the northern corridor if all the other environmental and heritage considerations should favour it. Fossils are of no use to science if they remain undiscovered and the development will create an opportunity to discover new fossils and fossil sites just like road works led to the discovery of new fish and amphibian fossil species in the Eastern Cape and the limestone mining in Gauteng and North West Provinces was directly responsible for the discovery of our world famous hominin sites.

There is a low likelihood that the Quaternary alluvium and aeolian sand and Tertiary calcrete may contain fossils. Elsewhere rare fossils of ostrich egg shells, mollusc shells, isolated bones, root casts, burrows and termitaria were found in Quaternary deposits (Almond & Pether 2008) and the possibility of finding similar fossils in the area cannot be excluded.

In the unlikely event of fossils being discovered in the sands, soils, calcrete or dolomite formations in the study area, the CEO should follow the instructions below. Although disturbed fossils should be collected and stored safely until it can be inspected by a palaeontologist, no attempt should be made to remove such accidentally discovered fossils from the rock by an unqualified person.

10. Mitigation Measures

PROCEDURE FOR CHANCE PALAEONTOLOGICAL FINDS

Extracted and adapted from the National Heritage Resources Act, 1999 Regulations Reg No. 6820, GN: 548.

The following procedure must be considered in the event that previously unknown fossils or fossil sites are exposed or found during the life of the project:

1. Surface excavations should continuously be monitored by the ECO and any fossil material be unearthed the excavation must be halted.

2. If fossiliferous material has been disturbed during the excavation process it should be put aside to prevent it from being destroyed.

3. The ECO then has to take a GPS reading of the site and take digital pictures of the fossil material and the site from which it came.

4. The ECO then should contact a palaeontologist and supply the palaeontologist with the information (locality and pictures) so that the palaeontologist can assess the importance of the find and make recommendations.

5. If the palaeontologist is convinced that this is a major find an inspection of the site must be scheduled as soon as possible in order to minimise delays to the development.

From the photographs and/or the site visit the palaeontologist will make one of the following recommendations:

a. The material is of no value so development can proceed, or:

b. Fossil material is of some interest and a representative sample should be collected and put aside for further study and to be incorporated into a recognised fossil repository after a permit was obtained from SAHRA for the removal of the fossils, after which the development may proceed, or:

c. The fossils are scientifically important and the palaeontologist must obtain a SAHRA permit to excavate the fossils and take them to a recognised fossil repository, after which the development may proceed.

7. If any fossils are found then a schedule of monitoring will be set up between the developer and palaeontologist in case of further discoveries.

11. References:

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