Desktop Palaeontological Impact Assessment for Section 102 Application, to include bulk sampling into existing Prospecting Right, over Remaining Extent, Portion 1, Portion 2 and Portion 3 of the Farm Vlakfontein 433, Hay District, Northern Cape Province, South Africa.

Report prepared for: M & S Consulting

By

Pulafel 4D Consulting (Pty) Ltd

DECLARATION OF INDEPENDENCE

We declare that other from compensation for services rendered in accordance with applicable legislation, neither the professional consultants herein nor Pulafel4D Consulting have any financial or other fiduciary interest in the planned development project or the clients listed herein.

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Final Report	✓
Signed	

EXECUTIVE SUMMARY

A Desktop Palaeontological Impact Assessment (PIA) was carried out on behalf of M and S Consulting that had been appointed by Cipla Projects (Pty) Ltd to undertake an environmental Authorisation (EA) application in support of a Section 102 Amendment process for the extension of prospecting activities as part of an approved Prospecting Right and EA (NC 30/5/1/1/2/12276 PR) on Remaining Extent, Portion 1, Portion 2 and Portion 3 of the Farm Vlakfontein 433, near Beeshoek, in the Northern Cape Province. It is expected that the proposed prospecting activities could impact on early Proterozoic sedimentary strata which are not considered to be paleontologically sensitive. Given the scope of the proposed activities, the likelihood of palaeontological impact on early Proterozoic carbonate rocks is considered **LOW**, especially if prospecting by way of core drilling is considered. However, because of the thick sandy overburden in most of the portions of the farm (which are not considered to be palaeontologically significant in this case) it is recommended that in the event of impact on fresh carbonate rocks that may result from trenching and pitting, new exposures should require brief monitoring by a palaeontologist.

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INTRODUCTION

A Desktop Palaeontological Impact Assessment (PIA) was carried out on, the Farm Vlakfontein 433, Postmasburg, Northern Cape Province**,** where Cipla Projects (Pty) Ltd has applied for a prospecting right to more prospecting activities. The region's unique and non-renewable archaeological and palaeontological heritage sites are 'Generally' protected in terms of the National Heritage Resources Act (Act No 25 of 1999, section 35) and may not be disturbed at all without a permit from the relevant heritage resources authority.

A Palaeontological Impact Assessment was requested for the mining right application. To comply with the South African Heritage Resources Agency (SAHRA) in terms of Section 38(8) of the National Heritage Resources Act, 1999 (Act No. 25 of 1999) (NHRA), a desktop Palaeontological Impact Assessment (PIA) was completed for the proposed project and is reported herein.

Table 1: Specialist report requirements in terms of Appendix 6 of the EIA Regulations (amended 2017)

Legislative Framework

The primary legal trigger for identifying when heritage specialist involvement is required in the Environmental Impact Assessment process is the National Heritage Resources (NHR) Act (Act No 25 of 1999). The NHR Act requires that all heritage resources, that is, all places or objects of aesthetic, architectural, historical, scientific, social, spiritual, linguistic or technological value or significance are protected. Thus, any assessment should make provision for the protection of all these heritage components, including archaeology, shipwrecks, battlefields, graves, and structures over 60 years of age, living heritage and the collection of oral histories, historical settlements, landscapes, geological sites, palaeontological sites and objects.

The Act identifies what is defined as a heritage resource, the criteria for establishing its significance and lists specific activities for which a heritage specialist study may be required. In this regard, categories of development relevant to this study are listed in Section 34 (1), Section 35 (4), Section 36 (3) and Section 38 (1) of the NHR Act as follows:

34. (1) No person may alter or demolish any structure or part of a structure which is older than 60 years without a permit issued by the relevant provincial heritage resources authority.

35 (4) No person may, without a permit issued by the responsible heritage resources authority—

- 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;

36 36 (3) No person may, without a permit issued by SAHRA or a provincial heritage resources authority—

- (a) destroy, damage, alter, exhume or remove from its original position or otherwise disturb the grave of a victim of conflict, or any burial ground or part thereof which contains such graves;
- (b) destroy, damage, alter, exhume, remove from its original position or otherwise disturb any grave or burial ground older than 60 years which is situated outside a formal cemetery administered by a local authority; or
- (c) bring onto or use at a burial ground or grave referred to in paragraph *(a)* or *(b)* any excavation equipment, or any equipment which assists in the detection or recovery of metals.

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

- The construction of a road, wall, power line, pipeline, canal or other similar form of linear development or barrier exceeding 300m in length;
- The construction of a bridge or similar structure exceeding 50m in length; • Any development or other activity which will change the character of the site

a) exceeding 5000 m² in extent; or

b) involving three or more existing erven or subdivisions thereof; or

c) involving three or more subdivisions thereof which have been consolidated within the past five years;

- The rezoning of a site exceeding 10 000 m²; or
- Any other category of development provided for in regulations by the South African Heritage Resources Agency (SAHRA).

A range of contexts can be identified which typically have high or potential cultural significance and which would require some form of heritage specialist involvement (**Table 1**). This may include formally protected heritage sites or unprotected, but potentially significant sites or landscapes (**Table 2**). The involvement of the heritage specialist in such a process is usually necessary when a proposed development may affect a heritage resource, whether it is formally protected or unprotected, known, or unknown. In many cases, the nature and degree of heritage significance is largely unknown pending further investigation (e.g., capped sites, assemblages or subsurface fossil remains). On the other hand, it is also possible that a site may contain heritage resources (e.g., structures older than 60 years), with little or no conservation value.

Table 1: Relationship between different heritage contexts, heritage resources likely to occur within these contexts, and likely sources of heritage impacts in the central interior of South Africa.

Heritage Context	Heritage Resources	Impact
Palaeontology	Precambrian shallow marine and lacustrine stromatolites, organic-walled microfossils, Ghaap Plateau (Transvaal Supergroup) Palaeozoic and Mesozoic fossil remains, e.g. Karoo Supergroup Neogene regolith	Road cuttings Quarry excavation Bridge and pipeline construction (Quaternary alluvial deposits)
Archaeology Early Stone Age Middle Stone Age LSA - Herder Historical	Types of sites that could occur in the Free State include Localized Stone Age sites containing lithic artifacts, animal and human remains found near *inter alia* the following: River courses/springs Stone tool making sites. Cave sites and rock shelters Freshwater shell middens Ancient, kraals and stonewalled complexes Abandoned areas of past human settlement Burials over 100 years old Historical middens Structural remains Objects including industrial machinery and aircraft.	Subsurface excavations including ground. levelling, landscaping, foundation preparation, road building, bridge building, pipeline construction, construction of electrical infrastructure and alternative energy facilities, township development.

History	Historical townscapes, e.g., Kimberley Historical structures, i.e., older than 60 years Historical burial sites Places associated with social identity/displacement, e.g., Witsieshoek Cave, Oppermansgronde Historical mission settlements, e.g., Bethulie, Beersheba, Moffat Mission	Demolition or alteration work. New development.
Natural Landscapes	Formally proclaimed nature reserves Evidence of pre-colonial occupation Scenic resources, e.g., view corridors, viewing sites, Historical structures/settlements older than 60 years Geological sites of cultural significance.	Demolition or alteration work. New development.
Relic Landscape Context	Battle and military sites, e.g Magersfontein Precolonial settlement and burial sites Historical graves (marked or unmarked, known or unknown) Human remains (older than 100 years) Associated burial goods (older than 100 years) Burial architecture (older than 60 years)	Demolition or alteration work. New development.

Table 2. Examples of heritage resources located in the central interior of South Africa.

Historically, archaeologically and palaeontologically significant heritage sites & landscapes	**Examples**
Landscapes with unique geological or palaeontological history	Karoo Basin Beaufort Group sedimentary strata Glacial striations on Ventersdorp andesites Vredefort Dome World Heritage Site. Taung World Heritage Site

Landscapes characterised by certain geomorphological attributes where a range of archaeological and palaeontological sites could be located.	Vaal, Modder and Riet River valleys Pans, pandunes and natural springs of the Free State panveld. Ghaap Plateau
Relic landscapes with evidence of past, now discontinued human activities	Wonderwerk Cave Stone Age deposits Cave sites and rock shelters in the Maluti Drakensberg region (rock art) Southern Highveld pre-colonial settlement complexes. Dithakong settlement complexes Rock engravings on Ventersdorp andesites
Landscapes containing concentrations of historical structures.	Concentration camps & cemeteries from the South African War.
Historical towns, historically significant farmsteads, settlements & routes	Batho historical township area in Mangaung (Bloemfontein). Kimberley
Battlefield Sites, burial grounds and grave sites older than 60 years.	Sannaspos Magersfontein

Scope of work

This is a Desktop Heritage Impact Assessment, including Archaeological, Cultural heritage, and Desktop Palaeontological Assessment to determine the potential of impacts on heritage resources within the study area.

The following are the required to perform the assessment:

- A desk-top investigation of the area;
- Identify possible archaeological, cultural, historic and palaeontological sites within the proposed development area through analysis of known information;
- Evaluate the potential of impacts occurring due to construction and operation of the proposed development on archaeological, cultural, historical resources; built and palaeontological resources; and
- Recommend mitigation measures in terms of detailed studies to determine and ameliorate any negative impacts on areas of archaeological, cultural, historical, built and palaeontological importance.

The purpose of this study is to determine the possible occurrence of sites with cultural heritage significance within the study area. The study is based on archival, and document combined with terrain evaluation. No fieldwork was performed.

Methodology

Archaeological and Palaeonontological significance was evaluated through a desktop study and carried out because of existing field data, database information and published literature.

Terms of reference:

- Identify and map possible heritage sites and occurrences using available resources.
- Determine and assess the potential impacts of the proposed development on potential heritage resources;
- Recommend mitigation measures to minimize potential impacts associated with the proposed development.

The study area is rated according to field rating categories as prescribed by SAHRA (**Table 3**).

Table 3. Field rating categories as prescribed by SAHRA.

Field Rating	**Grade**	**Significance**	**Mitigation**
National Significance (NS)	Grade 1	-	Conservation; national site nomination
Provincial Significance (PS)	Grade 2	-	Conservation; provincial site nomination
Local Significance (LS)	Grade 3A	High significance	Conservation: mitigation not advised
Local Significance (LS)	Grade 3B	High significance	Mitigation (part of site should be retained)
Generally Protected A (GP.A)	-	High/medium significance	Mitigation before destruction
Generally Protected B (GP.B)	-	Medium significance	Recording before destruction
Generally Protected	-	Low significance	Destruction

C (GP.C)			

DESCRIPTION OF THE AFFECTED AREA

Locality data

1: 250 000 scale topographic map 2822 Postmasburg (Council for Geoscience, Pretoria) (**Fig.1**)

1: 250 000 scale geological map 2822 Postmasburg (Council for Geoscience, Pretoria) **(Fig. 2)**

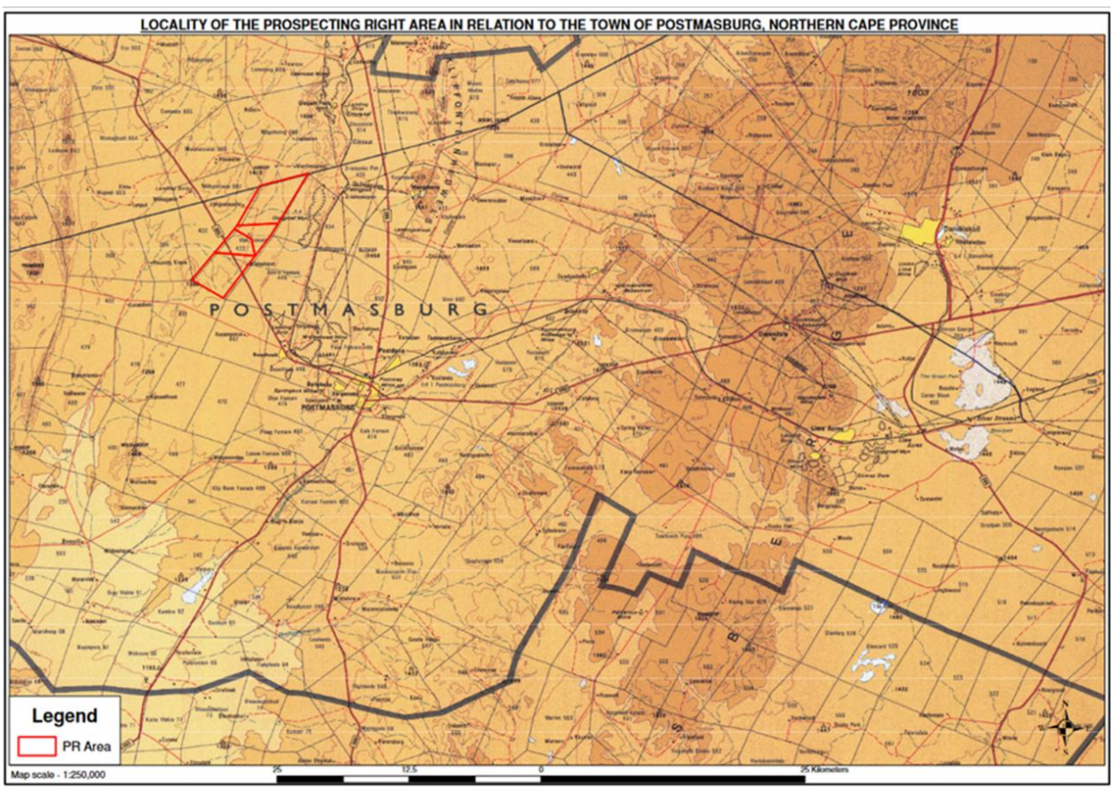

Fig. 1. Extract from 1: 250 000 topographical map 2822 Postmasburg showing the approximate location of the mining rights study area on Farm Vlakfontein 433 located c. 20 km northwest of Postmasburg, Northern Cape.

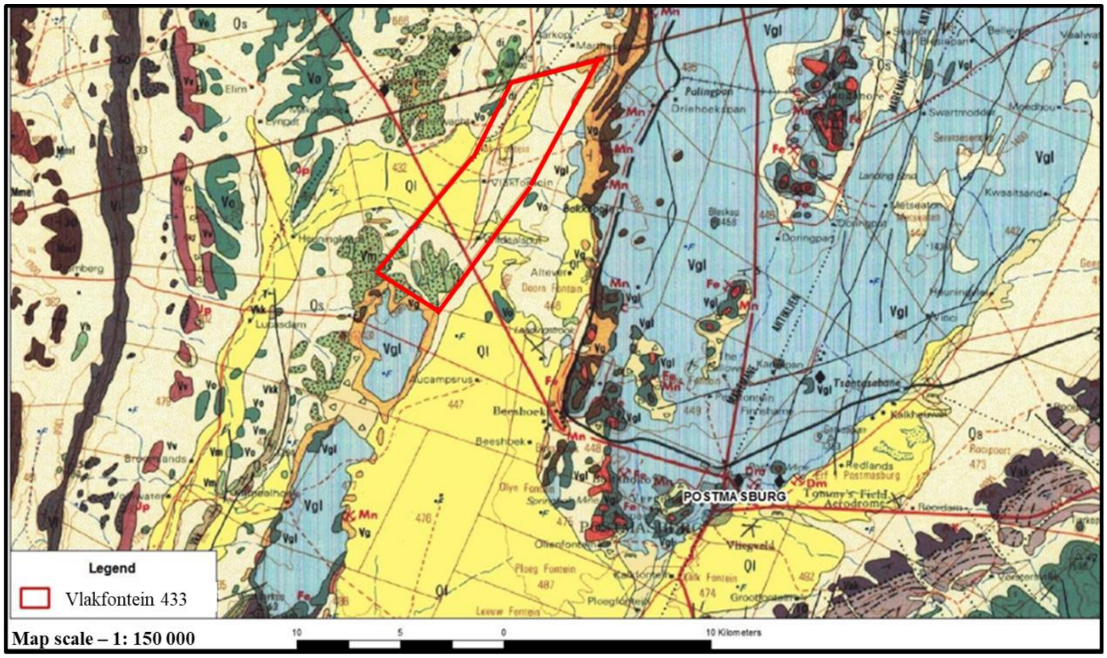

Fig. 2. Detail of the 1: 250 000 geological map shown above to show the main rock units mapped on the farm Vlakfontein 433 and surrounding farms around Postmasburg. Main rock units: Vg (orange) = Gamagara Formation; Vm (green with stipple) = Makganyene Formation; Ql (dark yellow) = Kalahari Group calcrete, limestone and alluvium; Qs (pale yellow) = red Kalahari Group aeolian sands (Gordonia Formation)

Cadastral details of the proposed site

Property details:

1 Vlakfontein 433 0 28°11'27.37S 22°57'45.2E Farm

2 Vlak fontein 433 3 28°11'20.99S 22°58'19.34E Farm Portion

3 Vlak fontein 433 1 28°13'19.61S 22°56'29.76E Farm Portion

4 Vlak fontein 433 0 28°9'42.22S 22°59'3.28E Farm Portion

5 Vlak fontein 433 2 28°11'56.21S 22°57'15.38E Farm Portion

Palaeosensitivity rating

As per the Palaeosensitivity report created for Cipla Projects (Pty) Ltd for the farm Vlakfontein 433 (EIA Reference number: NC 30/5/1/1/2/12276 PR), there is a high Palaeosensitivity rating on this farm.

Geology

In the Griqualand West Basin, the Ghaap Group of the Transvaal Supergroup, is divided into four subgroups, from the oldest, Schmidtsdrift, Campbell Rand, Asbestos Hills and Koegas-Subgroups (Eriksson et al., 2006). The Koegas Subgroup is overlain by the Postmasburg Group and the latter is divided into the lower Makganyene Formation and the Ongeluk Formation. There are three formations in the Asbestos Hills Subgroup, from the base, the Kliphuis, Kuruman and Danielskuil Formations, with all three composed of iron-formation. The Asbestos Hills Subgroup is dated at about 2500 Ma.

The Koegas Subgroup overlies the Griquatown Iron Formation, which has youngest zircon U–Pb ages of ~ 2490– 2440 Ma (Beukes, 1978, 1983; Pickard, 2003; Beukes and Gutzmer, 2008). Zircons from a tuffaceous bed near the top of the Koegas Subgroup gave an age of 2415 ± 6 Ma (Fig. 2; Gutzmer and Beukes, 1998). Outcrop, core and chronostratigraphic data suggest a regional unconformity between the Koegas Subgroup and the overlying Postmasburg Group (glacial Makganyene Formation and volcanic Ongeluk Formation) (Beukes, 1978, 1983). Zircon ages of 2250–2220 Ma for the Ongeluk Formation (Cornell et al., 1996; Deposition of continental siliciclastics in the Koegas Subgroup ended a period of about 150 Ma, during which some 2–3 km of chemical sediments were deposited on the Kaapvaal craton (Ghaap Group, Beukes, 1984, 1987). Furthermore, the Koegas Subgroup was deposited around the time, or some time before the first postulated Paleoproterozoic glacial period (Evans et al., 1997), and the rise of oxygen during the Great Oxidation Event (Bekker et al., 2004).

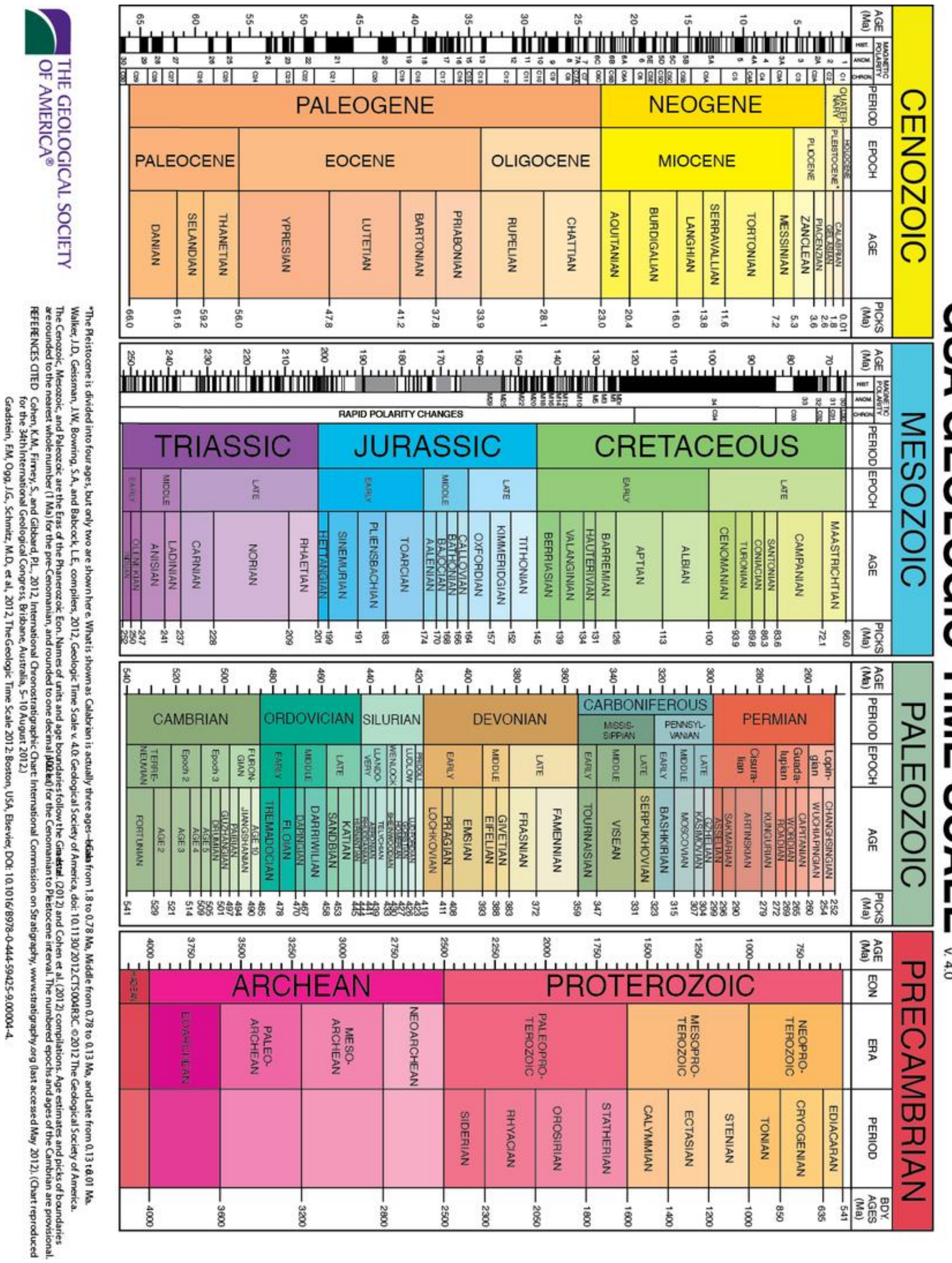

Figure 3: Geological Time scale (Adapted from Walker et al 2012)

Koegas iron formations and carbonates tend to be enriched in Mn, predating major Mn deposits of the Hotazel Formation in the Griquanland West structural basin (Cairncross et al., 1997).

Whether Mn in the Koegas Subgroup is derived from reduced or oxidized sources is an important proxy for atmospheric O2 levels, but this is as yet unresolved.

Koegas iron formations are compositionally and genetically similar to the thick iron formations preceding it (Beukes, 1983; Moore et al., 2001). At the same time, some of its detrital units are stained red by iron (Fe), which may pre-empt extensive red beds deposited later. Depositional processes for iron formations are still controversial (Beukes and Klein, 1992; Trendall, 2002). The close association of iron formation and siliciclastic rocks in the Koegas Subgroup thus allows insights into the interaction between chemical depositional environments and physical processes linked to continental input.

Stratigraphic correlations between the Transvaal and Griqualand West sub-basins (Beukes et al., 2002; Dorland, 2004) further indicate that the Postmasburg Group is much younger than the Koegas Subgroup. In an alternative view, Polteau et al. (2006) follow the age estimate of ~2.4 Ga for the Koegas but refute the hiatus below the Postmasburg Group. Instead, the Makganyene Formation conformably overlies the Koegas Subgroup, and sedimentary environments as well as depositional ages should be very similar (diamictite lenses in the Koegas, similar geochemistry of iron formations). The base of the Makganyene Formation is unconformable and erosive in the studied sections. Striated pavements have been observed below the Makganyene Formation (Coetzee et al., 2006). Currently available ages and correlations favor a distinct hiatus between the Koegas Subgroup and the Makganyene Formation (Schroder et al., 2011).

The Makganyene Formation is a Siderian (2.45–2.22 Ga) diamictite-dominated succession, with both outcrop and subcrop in the Griqualand West Basin of the Transvaal Group of South Africa. We provide new outcrop and core descriptions from this succession, supplemented by microscopic analyses, to present an updated depositional model for a classic Palaeoproterozoic diamictite. Although internal correlation of core and outcrop successions is not possible, a recurring pattern is observed where diamictites are organised into coarsening-upward motifs at the tens of metres scale. With additional finds of striated clasts, and evidence for dropstones both at the core scale and at the microscopic scale, earlier interpretations of glacial control on sedimentation can be substantiated, with modification of glacial diamictites by mass flow processes also recognised. Overall, given the characteristic progradational stratigraphic architecture, we propose a new model for the Makganyene Formation which is considered to represent deposition of a grounding zone wedge at an ancient, oscillating ice margin (Heron et al., 2022).

Debate has surrounded the bounding relationships between diamictites and underlying strata. The Postmasburg Group (with the Makganyene Formation at the base) was considered to rest unconformably upon the Ghaap Group (Beukes, 1983; Beukes and Smit, 1987). The Ghaap Group consists of dolomitic carbonates that are capped by banded iron formations of the Asbestos Hills Subgroup and mixed marine clastic and chemical sedimentary rocks of the Koegas Subgroup (Lantink et al., 2018 and refs therein). Based on mapping, Polteau et al. (2006) argued that the unconformity between the Ghaap and Postmasburg groups was only locally developed at basin margins and conformable contacts were more typical. Schröder et al. (2011) emphasised the complexities in correlating between the Griqualand West and Transvaal basins. This was specifically owing to the issue of the Griqualand West basin having a considerably more condensed section than the Transvaal Basin, and hence the requirement to interpret several "converging unconformities" between the two basins recording Palaeoproterozoic rifting (Schroeder et al., 2016). In terms of geotectonic setting, Bekker et al. (2020) interpreted that the Koegas Subgroup sat within the foredeep of a foreland basin system, with the orogen to the SW and the backbulge/craton interior to the NE. An important stratigraphic observation in this regard is that the Makganyene Formation locally interfingers with and is covered by Ongeluk Formation flood basalts (Lantink et al., 2018), raising questions about the depositional context of the diamictites and whether they are really of glaciogenic origin. Schröder et al. (2011) provided a detailed stratigraphic and sedimentological analysis of formations of the Ghaap Group, the succession lying immediately underneath the Makganyene.

Vlakfontein 433 study area lies on the western side of a major N-S trending anticline within the Early Proterozoic bedrocks of the Ghaap Group (Transvaal Supergroup) known as the Maremane Dome. A major unconformity at the base of the Palaeoproterozoic Elim Group (basal Keis Supergroup), dated at approximately 2.2 Ga, truncates the gently folded Ghaap Group succession on the western side of the Maremane Dome - viz. Campbell Rand carbonates, Asbesheuwels BIF and Koegas quartzites and iron formation. This regional unconformity is associated with the major development of iron and manganese ores that are extensively exploited in the Sishen – Postmasburg region of Griqualand West. The metallic ores are associated with (1) the palaeokarst-related Manganore Formation overlying Campbell Rand Subgroup carbonates of the Maremane Dome as well as the Gamagara Formation at the base of the Elim Group (Van Niekerk 2006, Da Silva 2011, Cairncross & Beukes 2013, Smith & Beukes 2016).

The Gamagara Formation unconformably overlies Late Archaean to Early Proterozoic Campbell Rand dolomites where basal haematite pebble conglomerates (Doornfontein Member) are followed firstly by thin shales and quartzites. These beds are overlain by several thick, upward-coarsening shale to quartzite packages of the Lucknow Formation. The Elim beds are tectonically overlain by wedges of older Palaeoproterozoic sediments assigned to the Koegas Subgroup and the unconformably overlying Postmasburg Group. These upper Transvaal Supergroup successions have been displaced eastwards onto the western flank of the Maremane Dome along multiple thrust planes constituting the Blackridge Thrust (Moen 2006, Mienie 2017). The Koegas Subgroup is represented here by several thin, upward-shoaling marine packages within which offshore ferruginous muds pass up into pale shoreface quartzites.

Information sources for this study

The information used in this desktop palaeontological heritage study was based on the following:

1. A review of the relevant scientific literature, including published geological maps and accompanying sheet explanations, as well as previous palaeontological assessment reports for the broader Postmasburg region

2. The authors' database on the geological formations concerned and their palaeontological heritage.

Cipla Projects (Pty) Ltd prospecting activities to be conducted include drilling of 60 boreholes, 12 trenches (70 m x 20 m), blasting, storage of diesel, mobile offices and ablution facilities, processing plant, roads, salvage yard, wash bay, waste rock dumps, weighbridge and control room, and workshop within an application area of 3 661.5088 ha.

Assumptions & limitations

The accuracy and reliability of palaeontological specialist studies as components of heritage impact assessments are generally limited by the following constraints:

1. Inadequate database for fossil heritage for much of the RSA, given the large size of the country and the small number of professional palaeontologists carrying out fieldwork here. Most development study areas have never been surveyed by a palaeontologist.

2. Variable accuracy of geological maps which underpin these desktop studies. For large areas of terrain these maps are largely based on aerial photographs alone, without ground truthing. The maps generally depict only significant ("mappable") bedrock units as well as major areas of superficial "drift" deposits (alluvium, colluvium) but for most regions give little or no idea of the level of bedrock outcrop, depth of superficial cover (soil *etc.*), degree of bedrock weathering or levels of small-scale tectonic deformation, such as cleavage. All these factors may have a major influence on the impact significance of a given development on fossil heritage and can only be reliably assessed in the field.

3. Inadequate sheet explanations for geological maps, with little or no attention paid to palaeontological issues in many cases, including poor locality information.

4. The extensive relevant palaeontological "grey literature" - in the form of unpublished university theses, impact studies and other reports (*e.g.*, of commercial mining companies) - that is not readily available for desktop studies.

5. Absence of a comprehensive computerized database of fossil collections in major RSA institutions which can be consulted for impact studies. A Karoo fossil vertebrate database is now. accessible for impact study work.

In the case of palaeontological desktop studies, these limitations may variously lead to either:

(a) *underestimation* of the palaeontological significance of a given study area due to ignorance of significant recorded or unrecorded fossils preserved there, or

(b) *overestimation* of the palaeontological sensitivity of a study area, for example when originally rich fossil assemblages inferred from geological maps have in fact been destroyed by tectonism or weathering or are buried beneath a thick mantle of unfossiliferous "drift" (soil, alluvium *etc.*).

Since most areas of the RSA have not been studied palaeontologically, a palaeontological desktop study usually entails *inferring* the presence of buried fossil heritage within the study area from relevant fossil data collected from similar or the same rock units elsewhere, sometimes at localities far away. Where substantial exposures of bedrocks or potentially fossiliferous superficial sediments are present in the study area, the reliability of a palaeontological impact assessment may be significantly enhanced through field assessment by a professional palaeontologist.

To the authors' knowledge (*cf* SAHRIS website), there have been very few field-based specialist palaeontological field studies in this part of the Southern Kalahari region. Bedrock exposure levels in some parts of on the Farm Vlakfontein 433 are low due to pervasive cover by Late Caenozoic superficial deposits (*e.g.,* Kalahari Group sands, calcretes as well as colluvium, alluvium and downwasted surface gravels). Confidence levels for the palaeontological assessment on the Farm Vlakfontein 433 are therefore only **MODERATE**.

Palaeontological context

The palaeontological sensitivity of the area under consideration is presented in Figure 3

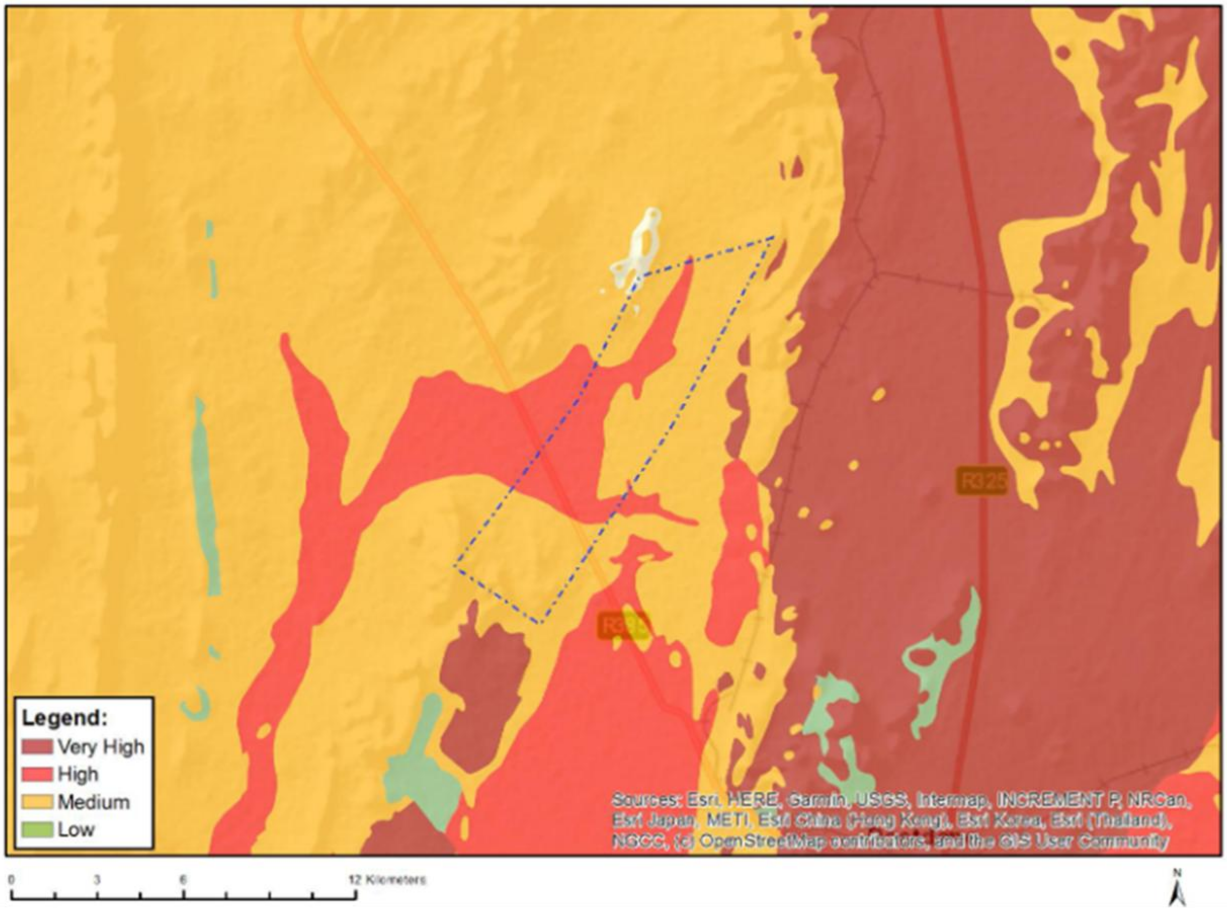

Fig. 3. Palaeosensitivity report created for Cipla Projects (Pty) Ltd for the farm Vlakfontein 433 (EIA Reference number: NC 30/5/1/1/2/12276 PR), showing a high Palaeo-sensitivity rating on this farm.

In the case of the Vlakfontein 433 application in support of a Section 102 Amendment process for the extension of prospecting activities as part of an approved Prospecting Right and EA (NC 30/5/1/1/2/12276 PR) on Remaining Extent, Portion 1, Portion 2 and Portion 3 of the Farm Vlakfontein 433, near Beeshoek, Northern Cape Province, the main potentially fossiliferous rock units present include:

- possible stromatolitic carbonate horizons or lenses within the Koegas Subgroup and
- Makganyene Formation (Postmasburg Group), both subunits of the Transvaal Supergroup and of Early Proterozoic age;
- Kalahari Group sands, calcretes.

The approach to this palaeontological heritage study is briefly as follows. Fossil bearing rock units occurring within the broader study area are determined from geological maps and satellite images.

Known fossil heritage in each rock unit is inventoried from scientific literature, previous assessments of the broader study region, and the author's field experience and palaeontological database. Based on this data as well as field examination of representative exposures of all major sedimentary rock units present, the impact significance of the proposed development is assessed with recommendations for any further studies or mitigation.

In preparing a palaeontological desktop study the potentially fossiliferous rock units (groups, formations etc.) represented within the study area are determined from geological maps and satellite images. The known fossil heritage within each rock unit is inventoried from the published scientific literature, previous palaeontological impact studies in the same region. Consultation with professional colleagues as well as examination of institutional fossil collections may play a role here during the compilation of the final report. This data is then used to assess the palaeontological sensitivity of each rock unit to development.

The likely impact of the proposed development on local fossil heritage is then determined based on:

(1) the palaeontological sensitivity of the rock units concerned and

(2) the nature and scale of the development itself, most significantly the extent of fresh bedrock excavation envisaged.

When rock units of moderate to high palaeontological sensitivity are present within the development footprint, a professional palaeontologist is usually warranted to identify any palaeontological hotspots and make specific recommendations for any monitoring or mitigation required before or during the construction phase of the development.

Based on the desktop, the likely impact of the proposed development on local fossil heritage and any need for specialist mitigation are determined. Adverse palaeontological impacts normally occur during the construction rather than the operational or decommissioning phase. The recording and sampling of fossil material and associated geological information (e.g., sedimentological data) may be required:

(a) in the pre-construction phase where important fossils are already exposed at or near the land surface and / or

(b) during the construction phase when fresh fossiliferous bedrock has been exposed by excavations.

To carry out mitigation, the palaeontologist involved will need to apply for palaeontological collection permits from the relevant heritage management authorities, i.e., the South African Heritage Resources Agency, SAHRA (Contact details: SAHRA, 111 Harrington Street, Cape Town. PO Box 4637, Cape Town 8000, South Africa. Phone: +27 (0)21 462 4502. Fax: +27 (0)21 462 4509. Web: www.sahra.org.za). It should be emphasized that, providing appropriate mitigation is carried out, most developments involving bedrock excavation can make a positive contribution to our understanding of local palaeontological heritage.

The palaeontological sensitivity of the area under consideration is presented in Figure 3. Most of the area is indicated as moderately sensitive (Yellow) and this applies to the Gamogara Formation shales and quartzites and the Kalahari sands. The former has been interpreted as a synsedimentary feature of the Maremane Anticline with localised erosion and redeposition (Moen, 2006). No fossils have been recorded from this lithology.

Kalahari Group sands of Quaternary age are windblown and weathered so they do not preserve fossils. Only such features as palaeo-pans or palaeo-springs might entrap bones or robust plant material in the Later Tertiary and Quaternary settings (Goudie & Wells, 1995; Holmes et al., 2017; Walker et al., 2014).

Impact assessment

There will be no impact for the operational and closure (decommissioning) phases. No monitoring is required if there are no fossils or if the fossils have been rescued already. The status of the impact during the planning phase and before mitigation (removal of fossils) will be negative; it becomes positive if fossils are absent or have been removed.

- The extent of the impact is low because only fossils in the expansion area or along the prospecting routes on Vlakfontein 433 Farm could be affected.
- The duration of the impact would be permanent if fossils are not removed but is low if they are removed.
- The probability of any fossils occurring in the expansion footprint that is already highly disturbed from prior mining activities, or along the route, is very low because there are no palaeo-pans or palaeo-springs visible on the satellite imagery.
- The intensity of the impact is only local.
- Significance of the impact is **LOW to MEDIUM**.

Assumptions and uncertainties

Based on the geology of the area and the palaeontological record as we know it, it can be assumed that the formation and layout of the aeolian sands, sandstones and calcrete are typical for the country and do not contain fossil plant, insect, invertebrate and vertebrate material. No palaeo-pans or palaeo-springs that could entrap fossil, are visible in the satellite imagery, therefore, it is extremely unlikely that they occur in the prospecting area.

Recommendation

Based on experience and the lack of any previously recorded fossils from the area, it is extremely unlikely that any fossils in the loose sands or calcretes of the Quaternary Kalahari Sands. There is a very small chance that fossils may occur in palaeo-pans BUT no such feature is visible. Therefore, a Fossil Chance Find Protocol should be added to the EMPr: if fossils are found once the surveyor and/or the environmental officer walks the route and expansion areas, they should be photographed, position recorded, removed, and stored. Photographs sent to the palaeontologist will enable him/her to assess the scientific importance of the fossils and act accordingly.

Chance Find Protocol

Programme for Palaeontology – to commence once the expansion area and routes are surveyed by the surveyor or environmental officer. Planning/pre-construction phase

1. The following procedure is only required if fossils are seen on the surface when surveyed and any palaeo-pan or palaeo-spring feature is recognised, or if stromatolites are seen.

2. If any fossiliferous material (plants, insects, bones, or stromatolites) is seen it should be

put aside in a suitably protected place. This way the construction activities will not be interrupted.

3. Photographs of similar fossil plants must be provided to the developer to assist in recognizing the fossil plants in the shales and mudstones (for example see Figure 7-9). This information will be built into the EMP's training and awareness plan and procedures.

4. Photographs of the putative fossils can be sent to the palaeontologist for a preliminary assessment.

5. If there is any scientifically important fossil material as assessed from the submitted photographs, then the qualified palaeontologist sub-contracted for this project, should visit the site to inspect the site and excavate (having obtained a SAHRA permit).

6. Stromatolites, fossil plants or vertebrates that are considered to be of good quality or scientific interest by the palaeontologist must be removed, catalogued and housed in a suitable institution where they can be made available for further study.

7. Annual reports must be submitted to SAHRA as required by the relevant permits.

8. If no good fossil material is recovered then the site inspection by the palaeontologist will

not be necessary.

9. If no fossils are found during the survey, then no further palaeontological impact assessment is required.

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