Palaeontological heritage assessment: desktop study

WRENCHVILLE PHASE 2 LOW COST HOUSING DEVELOPMENT ON THE REMAINDER OF ERF 1, KURUMAN, GA-SEGONYANA MUNICIPALITY, KURUMAN DISTRICT, NORTHERN CAPE

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EXECUTIVE SUMMARY

The proposed Phase 2 low cost housing development on the Remainder of Erf 1, Wrenchville, will comprise *c*. 200 housing units within an area of *c*. 10 ha. The site lies on the eastern outskirts of Kuruman, Ga-Segonyana Local Municipality in the Kuruman District of the Northern Cape.

The Precambrian (late Archaean) carbonate bedrocks of the Campbellrand Subgroup (Ghaap Group, Transvaal Supergroup) underlying the Wrenchville Phase 2 housing project area are generally poorly-exposed and karstified near-surface. Based on field photographs, they do not appear to contain well-developed stromatolitic horizons. The overlying semi-consolidated carbonate / chert / banded ironstone gravels, which locally mantle subsurface limestone pinnacle karst, are generally of low palaeontological sensitivity in this region, as indicated by recent wider-ranging palaeontological field studies (Almond 2018a-d, 2019). Consolidated, calcretised alluvial gravels and finer-grained sediments are recorded along the Kuruman River and its various tributaries but not within the present development footprint. The Kalahari aeolian sands in the region are likewise of low palaeontological sensitivity. The project footprint is comparatively small. It is concluded that proposed housing development is unlikely to have significant impacts on local palaeontological heritage resources.

It is therefore recommended that, pending the discovery of significant new fossils remains before or during construction, exemption from further specialist palaeontological studies and mitigation be granted for the Wrenchville Phase 2 housing development near Kuruman, Northern Cape.

Should any substantial fossil remains (*e.g.* mammalian bones and teeth) be encountered during construction, however, these should be safeguarded, preferably *in situ*, and reported by the ECO to SAHRA, *i.e.* The South African Heritage Resources Agency, as soon as possible (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). This so that appropriate action can be taken by a professional palaeontologist, at the developer's expense. Mitigation would normally involve the scientific recording and judicious sampling or collection of fossil material as well as associated geological data (*e.g.* stratigraphy, sedimentology, taphonomy) by a professional palaeontologist. A Chance Fossil Finds Procedure for the Kuruman study region is appended to this report.

1. OUTLINE OF THE PROPOSED DEVELOPMENT

It is proposed to construct Phase 2 of the Wrenchville low cost housing development on a site (Remainder of Erf 1) lying close to existing residential communities and adjacent to Phase 1 of the Wrenchville housing project and Wrenchville School. The site lies on the eastern outskirts of Kuruman, Ga-Segonyana Local Municipality in the Kuruman District of the Northern Cape (Figs. 1 & 2). The housing development will comprise approximately 200 residential units as well as internal streets and engineering services. The total extent of the property is about 10 ha.

The South African Heritage Resources Agency, SAHRA, has commented as follows in their Interim Comment of Friday, September 6, 2019 (Case ID: 14281):

> *The proposed development area is located within an area of moderate and very high sensitivity as per the SAHRIS PalaeoSensitivity map; therefore a desktop Palaeontological study must be completed as part of the EA process. The report must comply with the 2012 Minimum Standards: Palaeontological Component of Heritage Impact Assessments*

The present palaeontological heritage desktop study contributes to the Heritage Impact Assessment for the development project that is being compiled by ACRM, Rondebosch (Jonathan Kaplan. 5 Stuart Road, Rondebosch, 7700. Phone / Fax: 021 685 7589. Cell: 082 321 0172. E-mail: acrm@wcaccess.co.za).

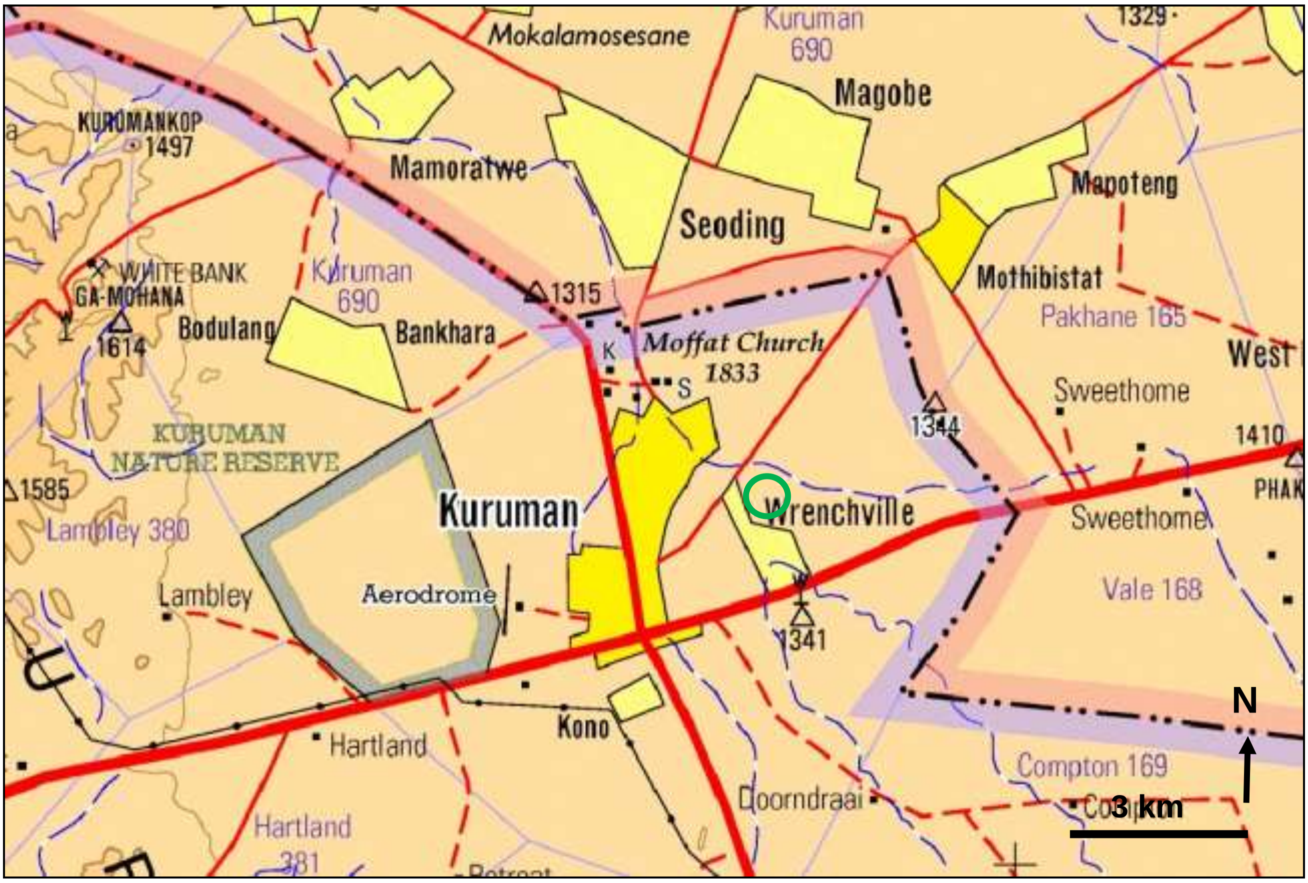

Figure 1: Extract from 1: 250 000 topographical map 2722 Kuruman (courtesy of the Chief Directorate: National Geo-spatial Information, Mowbray) showing the approximate location of the Wrenchville Phase 2 Low Cost Housing Development on the Remainder of Erf 1 Kuruman, Kuruman District, Northern Cape (green circle).

Figure 2: Google Earth© satellite image of the Phase 2 low cost housing project study area on the eastern outskirts of Wrenchville township (red polygon) (Image abstracted from the AIA report by Kaplan, 2019).

1.1. Legislative context for palaeontological assessment studies

The present palaeontological heritage report falls under Sections 35 and 38 (Heritage Resources Management) of the South African Heritage Resources Act (Act No. 25 of 1999), and it will also inform the Environmental Management Programme for this project.

The proposed agricultural development is located in an area that is underlain by Precambrian basement rocks as well as Late Caenozoic superficial sediments (Sections 2 and 3). The construction phase will entail surface ground clearance as well as limited shallow excavations into the superficial sediment cover, and probably also into the older bedrocks. These developments may adversely affect known or potential fossil heritage at or beneath the surface of the ground within the study area by damaging, destroying, disturbing or sealing-in fossils that are then no longer available for scientific research or other public good.

The various categories of heritage resources recognised as part of the National Estate in Section 3 of the National Heritage Resources Act include, among others:

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

According to Section 35 of the National Heritage Resources Act, dealing with archaeology, palaeontology and meteorites:

(1) The protection of archaeological and palaeontological sites and material and meteorites is the responsibility of a provincial heritage resources authority.

(2) All archaeological objects, palaeontological material and meteorites are the property of the State.

(3) Any person who discovers archaeological or palaeontological objects or material or a meteorite in the course of development or agricultural activity must immediately report the find to the responsible heritage resources authority, or to the nearest local authority offices or museum, which must immediately notify such heritage resources authority.

(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 in the detection or recovery of metals or archaeological and palaeontological material or objects, or use such equipment for the recovery of meteorites.

(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 procedure 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 from 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.

Minimum standards for the palaeontological component of heritage impact assessment reports (PIAs) have been published by SAHRA (2013).

1.2. Approach used for this specialist palaeontological study

This palaeontological report provides an assessment of the recorded or inferred palaeontological heritage within the study region near Kuruman, with recommendations for specialist palaeontological mitigation where this is considered necessary. The report is based on:

(1) a review of the relevant scientific literature, published geological maps as well as satellite images;
(2) background information, field photographs, maps and an Archaeological Impact Assessment report for this project supplied by ACRM, Rondebosch;
(4) the author's palaeontological database and field experience of the rock units concerned, including previous palaeontological heritage studies in the broader region (*cf* Almond & Pether 2008, Almond 2018a-d, Almond 2019).

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, and the author's field experience (Consultation with professional colleagues as well as examination of institutional fossil collections may play a role here, or later following scoping during the compilation of the final report). This data is then used to assess the palaeontological sensitivity of each rock unit to development (Provisional tabulations of palaeontological sensitivity of all formations in the Western, Eastern and Northern Cape have already been compiled by J. Almond and colleagues; *e.g.* Almond & Pether 2008). 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 and scale 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-based assessment by a professional palaeontologist is usually warranted.

On the basis of the desktop and any recommended follow-up field assessment studies, the likely impact of the proposed development on local fossil heritage and any need for specialist mitigation are then determined. Adverse palaeontological impacts normally occur during the construction rather than the operational or decommissioning phase. Mitigation by a professional palaeontologist – normally involving the recording and sampling of fossil material and associated geological information (*e.g.* sedimentological data) – is usually most effective during the construction phase when fresh fossiliferous bedrock has been exposed by excavations, although pre-construction recording of surface-exposed material may sometimes be more appropriate. To carry out mitigation, the palaeontologist involved will need to apply for a palaeontological collection permit from the relevant heritage management agency (*i.e.* 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*, the majority of developments involving bedrock excavation can make a *positive* contribution to our understanding of local palaeontological heritage.

1.3. 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 of 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.

In the case of palaeontological desktop studies without supporting Phase 1 field assessments 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.

In the case of palaeontological studies in the Kuruman study region, the main limitations are the absence of detailed sedimentological and palaeontological field data and the paucity of previous palaeontological impact studies in the southern Kalahari region as a whole. Recent field-based PIA reports by Almond (2018a-d, 2019) are highly relevant to the present study. Potentially-fossiliferous carbonate bedrocks are rarely well-exposed in this region. An extensive series of field photographs depicting local exposures of bedrock and superficial sediments was kindly provided by Mr J. Kaplan of ACRM. Confidence levels for the present desktop study are therefore rated as MODERATE.

2. GEOLOGICAL BACKGROUND

The Wrenchville Phase 2 housing project study area near Kuruman comprises highly disturbed, fairly flat-lying terrain between 1320 and 1340 m amsl on the southern margins of the Kalahari region of the Northern Cape (Figs. 2 & 6). On the basis of satellite images as well as field photographs the area comprises arid Kalahari thornveld with low shrubs and grasses as well as scattered thorn trees, especially along water courses and bedrock fractures. The area lies to the north of the N14 tar road from Kuruman to Vryburg and is situated between two normally dry tributaries of the Kuruman River. Pale hues visible in satellite images along major drainage lines are associated with calcretised alluvial deposits while orange-brown hues reflect Kalahari aeolian sands as well as ferruginised surface gravels (Almond 2018d, 2019). Away from the shallowly incised drainage lines levels of natural bedrock exposure are generally low, but several useful cuttings through the overlying superficial deposits are visible in the walls of artificial excavations (*e.g.* gravel pits).

The geology of the housing project area is shown on the 1: 250 000 geology map 2722 Kuruman (Council for Geoscience, Pretoria; Fig. 1) for which a detailed field explanation has not yet been published. The grey-weathering carbonate bedrocks here are assigned to the Precambrian (Late Archaean to Early Proterozoic) **Transvaal Supergroup** (Griqualand West Basin) on the western margins of the ancient Kaapvaal Craton (McCarthy & Rubidge 2005, Eriksson *et al.* 2006). They lie within the Ghaap Plateau Sub basin of the Transvaal succession, situated to the NE of the Griquatown Fault Zone. The **Campbell Rand Subgroup** (Vgd in Fig. 3) of the Ghaap Group - previously included within the "Ghaapplato Formation" in older literature – represented here is a very thick (1.6 - 2.5 km) carbonate platform succession of dolostones, dolomitic limestones and cherts with minor tuffs and siliciclastic rocks. It was deposited on the shallow submerged shelf of the Kaapvaal Craton roughly 2.6 to 2.5 Ga (billion years ago) (See the readable general account by McCarthy & Rubidge, pp. 112-118 and Fig. 4.10 therein). A range of shallow water facies, often forming depositional cycles reflecting sea level changes, are represented here, including stromatolitic limestones and dolostones, oolites, oncolites, laminated calcilutites, cherts and marls, with subordinate siliclastics (shales, siltstones) and minor tuffs (Beukes 1980, Beukes 1986, Sumner 2002, Eriksson *et al.* 2006, Sumner & Beukes 2006).

Since the current 1: 250 000 geological maps were produced, the Campbell Rand succession has been subdivided into a series of formations, some of which were previously included within the older Schmidtsdrift Formation or Subgroup (Beukes 1980, 1986, Altermann and Wotherspoon 1995, Eriksson *et al.* 2006) (Figs. 4 & 5). The carbonate bedrocks in the present study area are probably referable to the late Archaean **Kogelbeen Formation**. This comprises a *c*. 450 m thick, varied succession of dolomite, limestone and chert, with important horizons of stromatolites and microbial laminites; secondary chert replacement is common, especially within stromatolitic horizons. Small exposures of Kogelbeen Formation bedrocks on the western outskirts of Kuruman have been briefly described and illustrated by Almond (2018d, 2019).

Field photos of the Wrenchville housing project area provided by J. Kaplan of ACRM indicate that bedrock exposure levels here are very low overall. There are occasional low, karstified exposures of grey-brown, massive to bedded carbonates with irregular horizons and lenses of secondary silicification and ferruginisation (Fig. 4). These are best seen on the NW-facing slopes of the shallow stream valley to the NE of the project area. Isolated, reworked blocks of thin-bedded carbonate show flat to undulose lamination but no well-developed domical or columnar stromatolites are visible here (Fig. 8). Karstified pinnacles of carbonate bedrock draped by rubbly carbonate gravels are seen to the northwest of the site (close to Buitekant Street) (Fig. 9).

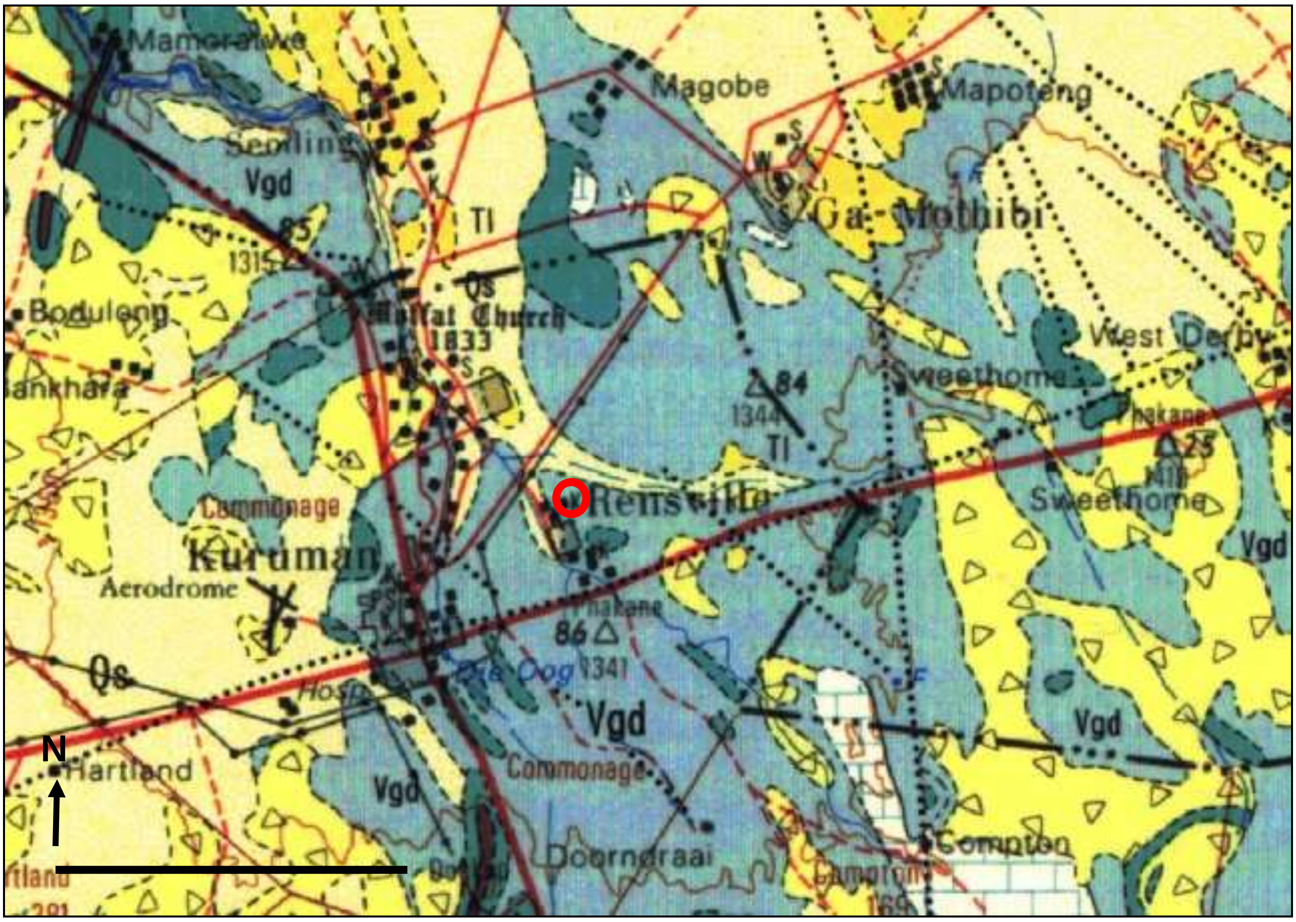

Figure 3: Extract from 1: 250 000 geology sheet 2722 Kuruman (Council for Geoscience, Pretoria) showing the approximate location of the study area for the proposed Wrenchville Phase 2 low cost housing project near Kuruman (red circle). The main rock units mapped in this region include:

GHAAP GROUP

Campbell Rand Subgroup: "Ghaap Plateau" dolomites, limestones and secondary cherts (Vgd, pale blue), ***plus*** **overlying chert breccias (Vgd, dark blue)**

LATE CAENOZOIC SUPERFICIAL SEDIMENTS

Surface rubble (middle yellow with triangle ornament)
Calcrete (Tl, dark yellow) – largely calcretised alluvial deposits
Gordonia Formation aeolian sands (Qs, pale yellow)

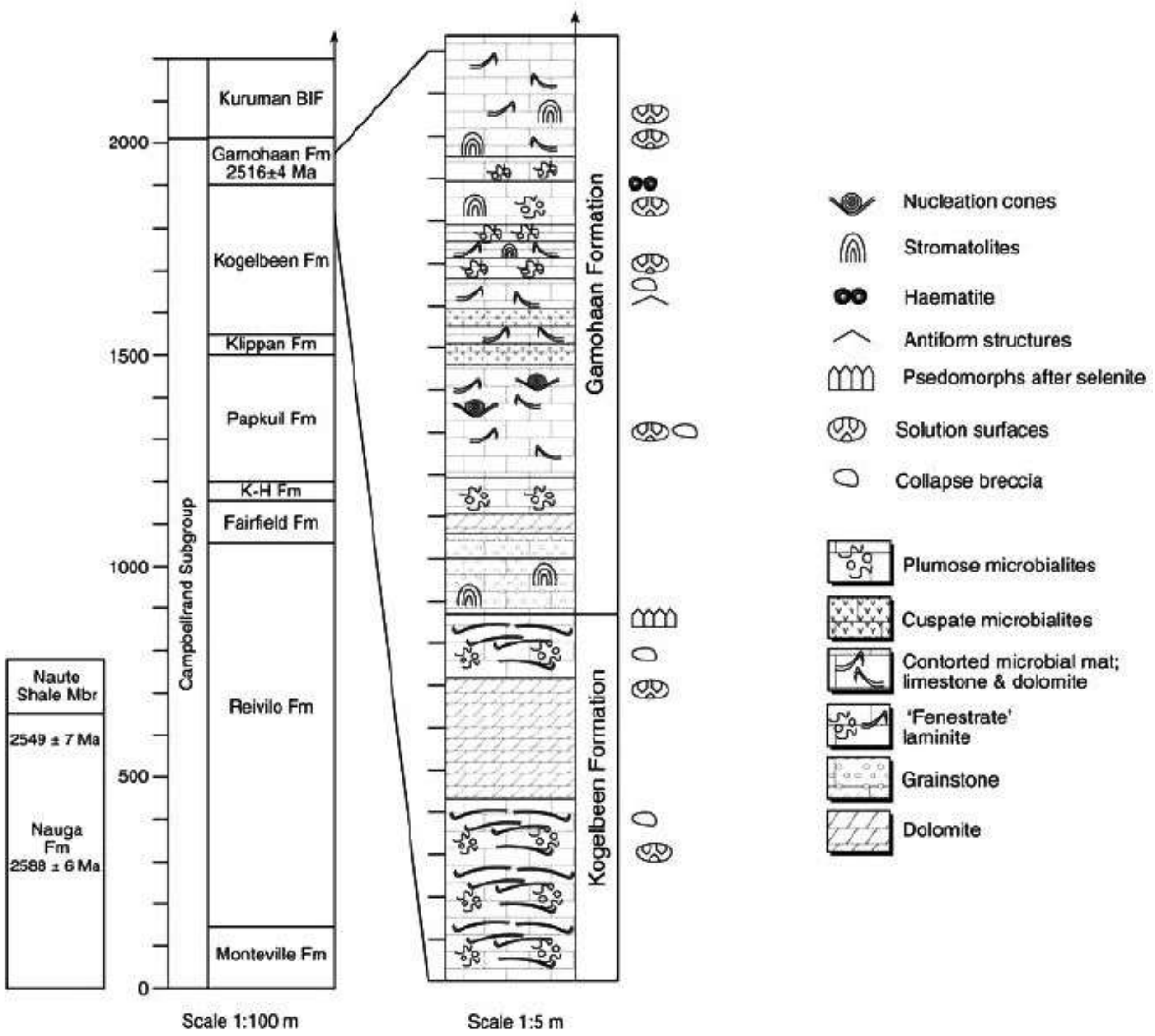

Figure 4: Stratigraphy and sedimentology of the Campbell Rand carbonate succession at Kurumankop near Kuruman – a key locality for diverse Precambrian stromatolites and other biosedimentary structures (From Gandin & Wright 2007). The present study area is probably underlain by stromatolitic carbonates of the Kogelbeen Formation.

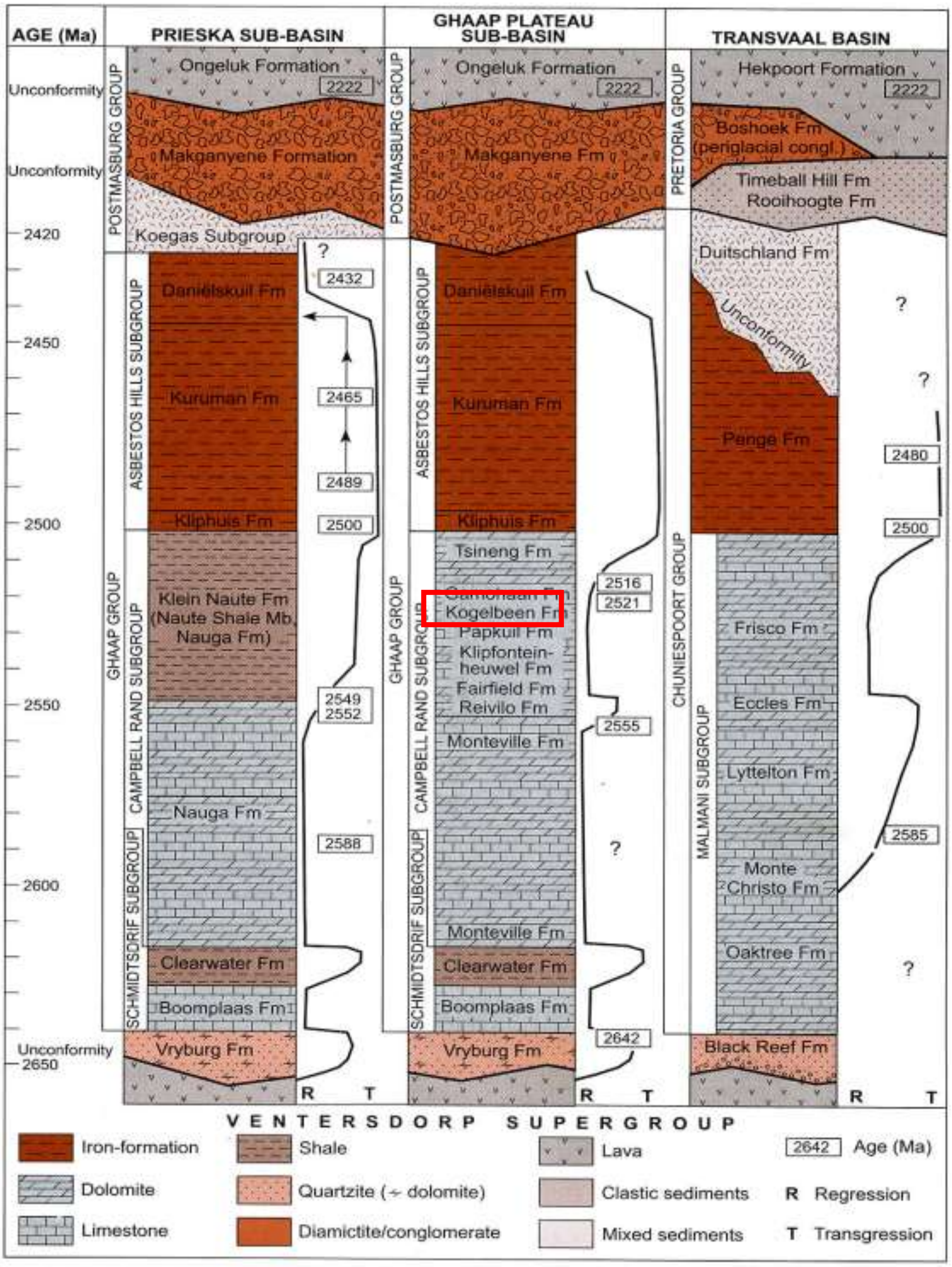

Figure 5: Stratigraphy of the Transvaal Supergroup of the Ghaap Plateau Sub-basin (central column) showing Precambrian bedrock units represented in the Kuruman housing project area (red rectangle) (Modified from Eriksson *et al.* 2006). Figures in boxes indicate radiometric ages in millions of years (Ma).

In the Kuruman region the Precambrian bedrocks are mostly covered by various, mostly unconsolidated **superficial deposits** of Late Caenozoic age (Almond 2018d, 2019). These younger deposits include thick mantles of colluvial to alluvial gravels, downwasted cherty surface rubble, orange-hued aeolian (wind-blown) Kalahari sands, as well as sandy to gravelly alluvial sediments (often calcretised) along stream and river valley floors.

Downwasting of secondary chert from within the carbonate succession in Precambrian times led to the development of a distinctive, highly-resistant, blocky-weathering siliceous breccia that caps the carbonate bedrocks in many areas (darker blue areas on geological map, Fig. 5). This silcrete-like breccia contains angular clasts of laminated silicified carbonate and chert but no BIF, indicating that it formed during a major erosive episode preceding transgression and deposition of the Asbestos Hills deep marine succession. Good examples of these ancient Precambrian breccias are seen on the eastern and southern outskirts of Kuruman (Almond 2018d, 2019). In low-lying areas of the Ghaap Plateau around Kuruman the upper surface of the carbonate bedrocks has been extensively karstified in Caenozoic times, with widespread steep-sided solution hollows - often infilled with ferruginised surface gravels of chert and BIF - together with the development of an underground drainage network (*cf* the Eye of Kuruman, cave systems with stalactites on Kurumankop) (Almond 2019). Other consolidated to unconsolidated superficial deposits of Late Caenozoic age in the broader Kuruman study region include locally thick mantles of BIF colluvial gravels, calcrete pedocretes, orange-hued aeolian (wind-blown) Kalahari sands, as well as sandy to gravelly alluvial sediments (often calcretised) along stream and river valley floors.

During a recent PIA field study Almond (2019) recorded a wide variety of superficial sediments within a radius of one kilometre of the Wrenchville housing study site (See waypoints indicated on Fig. 6). These include:

(a) Thick (*c*. 10 m) poorly-sorted, coarse, calcretised alluvial deposits related to Kuruman River drainage system (Loc. 237 in Fig. 6);
(b) Thick calcretised alluvium as well as downwasted and alluvially-reworked calcrete rubble overlying Campbell Rand massive grey carbonate bedrocks (Loc. 238 in Fig. 6);
(c) Thick grey-brown, calcretised sandy alluvium overlain by unconsolidated BIF gravels in a dry, wide, shallow tributary valley of Kuruman River (Loc. 239 in Fig. 6);
(d) Several m-thick. orange-brown gravels (platy BIF, some subrounded pebbles and cobbles of chert, carbonate, quartzite, calcrete) infilling solution hollows within karstified surface of underlying Campbell Rand carbonate bedrock in a borrow pit excavated into BIF gravels on SE side of N14 just N of Wrenchville (Loc. 240 in Fig. 6).

Field photos of the Wrenchville housing project area show locally thick, semi-consolidated, rubbly gravels draping the karstified bedrocks, in some cases infilling deep, steep-sided hollows between karst pinnacles (Fig. 9). Thick, loose rubbly gravels are exposed in the cut face of a gravel borrow pit near the school (Fig. 10). The gravel clasts are angular and are probably composed of mainly resistant secondary chert with subordinate carbonate and BIF. Well-developed, consolidated older alluvial deposits were not noted within the housing project footprint but calcretised alluvium may be present at depth along the stream valley to the northeast (*cf* Almond 2019). For the most part the superficial deposits are highly disturbed by small excavations, dumping, tracks *etc*.

Figure 6: Google Earth© satellite image of the context for the Phase 2 low cost housing project study area on the eastern outskirts of Wrenchville township (*cf* Fig. 2). Numbered waypoints in the vicinity refer to field observations of Almond (2019) (See text). Blue ellipse = area with patchy carbonate bedrock exposures. Red ellipse = area with ongoing gravel mining.

Figure 7: Low kartsified exposures of brownish-grey Campbell Rand carbonate bedrocks mantled by orange-hued sands on NW-facing stream valley slopes within the housing project area (J. Kaplan).

Figure 8: Large displaced block of Campbell Rand carbonate showing thin, horizontal to slightly undulose bedding (J. Kaplan). Obvious stromatolitic horizons are not visible here.

Figure 9: Karst pinnacle of carbonate bedrock draped by consolidated rubbly gravels, to NW of the housing project area (J. Kaplan).

Figure 10: Thick, unconsolidated rubbly gravels exposed in the cut face of a borrow pit near the school, housing project study area (J. Kaplan).

Figure 11: Thick, highly-calcretised, coarse, oligomict, matrix-supported alluvial gravels associated with a tributary of the Kuruman River, road cutting near Wrenchville (From Almond 2019, Loc. 237) (Hammer = 30 cm).

3. PALAEONTOLOGICAL HERITAGE

The shallow shelf and intertidal sediments of the carbonate-dominated lower part of the **Ghaap Group** (*i.e.* **Schmidtsdrif** and **Campbell Rand Subgroups**) are well known for their rich fossil biota of *stromatolites* or microbially-generated, finely-laminated sheets, mounds, domes, columns and branching structures. Some stromatolite occurrences on the Ghaap Plateau of the Northern Cape are spectacularly well-preserved (*e.g.* Boetsap locality northeast of Daniëlskuil figured by McCarthy & Rubidge 2005, Eriksson *et al.* 2006). Detailed studies of these 2.6-2.5 Ga carbonate sediments and their stromatolitic biotas have been presented by Young (1932 and several subsequent papers), Beukes (1980, 1983), Eriksson & Truswell (1974), Eriksson & Altermann (1998), Eriksson *et al* (2006), Altermann and Herbig (1991), Altermann and Wotherspoon (1995), and Sumner (2002). The oldest, Archaean stromatolite occurrences from the Ghaap Group have been reviewed by Schopf (2006, with full references therein).

Horizons of microbial mats as well as domal and columnar stromatolites on various scales are reported from the **Kogelbeen Formation**. Some of the oldest known (2.6 Ga) fossil microbial assemblages with filaments and coccoids have been recorded from stromatolitic cherty limestones of the Lime Acres Member (Kogelbeen Formation) at Lime Acres near Kuruman (Altermann & Schopf 1995, Altermann & Wotherspoon 1995). Recent illustrated of stromatolitic carbonates from the Kuruman region of the Northern Cape have been given by Almond (2018a-d, 2019) (Fig. 12).

Most of the **Late Caenozoic superficial sediments** within the Kuruman region are of low palaeontological sensitivity, preserving few, if any, scientifically-valuable fossil remains (Almond 2018a-d, 2019). Calcretes associated with the Campbell Rand carbonates on the Ghaap Plateau to the east of the Kurumanberge might contain trace fossils such as rhizoliths, termite and other insect burrows, or even mammalian trackways. Reworked blocks of calcretised fine-grained alluvium encountered in the bed of the Kuruman River contain subfossil, stromatolite-like laminations generated by fresh- or brackish-water microbial communities (Almond 2019).

Mammalian bones, teeth and horn cores (also tortoise remains, and fish, amphibian or even crocodiles in wetter depositional settings) may be expected occasionally expected within Kalahari Group sediments and calcretes, notably those associated with ancient alluvial sands and gravels. Unconsolidated surface gravels and colluvium are for the most entirely unfossiliferous. However, sporadic reworked cherty carbonate blocks within ferruginous colluvial gravels do contain small silicified stromatolitic domes; stromatolitic horizons were preferentially silicified during diagenesis, and are therefore preferentially represented within surface gravels that concentrate resistant-weathering rock rubble. Occurrences of calc-tufa, flowstone and fissure-infill breccias in the karstified Campbell Rand outcrop area – as recorded, for example, along the eastern edge of the Kurumanberge and Kurumankop – might possibly be associated with micromammal remains as well as the bones and teeth of larger mammals (including hominins), reptiles and birds, plant fossils *etc*, as well-seen, for example, in karstified Precambrian carbonate successions in Namibia.

Based on field photos (*e.g.* Figs. 7 to 9 herein), well-developed stromatolitic horizons do not appear to be represented within the small areas of carbonate bedrocks exposed in the Wrenchville housing project area. No mammalian bones, teeth or other fossil remains have been recorded from the overlying superficial sands and gravels, which show high levels of disturbance and have been assessed as of low palaeontological sensitivity in recent surveys of the Kuruman area (Almond 2018a-d, 2019).

Figure 12. Vertical section through well-preserved columnar stromatolites with rounded to squared-off internal lamination (upward accretion towards the left) exposed in a float block near Moffat Substation, western outskirts of Kuruman (Scale in cm and mm) (From Almond 2019).

4. CONCLUSIONS & RECOMMENDATIONS

The Precambrian (late Archaean) carbonate bedrocks of the Campbellrand Subgroup (Ghaap Group, Transvaal Supergroup) underlying the Wrenchville Phase 2 housing project area are generally poorly-exposed and karstified near-surface. Based on field photographs, they do not appear to contain well-developed stromatolitic horizons. The overlying semi-consolidated carbonate / chert / banded ironstone gravels, which locally mantle subsurface limestone pinnacle karst, are generally of low palaeontological sensitivity in this region, as indicated by recent wider-ranging palaeontological field studies (Almond 2018a-d, 2019). Consolidated, calcretised alluvial gravels and finer-grained sediments are recorded along the Kuruman River and its various tributaries but not within the present development footprint. The Kalahari aeolian sands in the region are likewise of low palaeontological sensitivity. The project footprint is comparatively small. It is concluded that proposed housing development is unlikely to have significant impacts on local palaeontological heritage resources.

It is therefore recommended that, pending the discovery of significant new fossils remains before or during construction, exemption from further specialist palaeontological studies and mitigation be granted for the Wrenchville Phase 2 housing development near Kuruman, Northern Cape.

Should any substantial fossil remains (*e.g.* mammalian bones and teeth) be encountered during construction, however, these should be safeguarded, preferably *in situ*, and reported by the ECO to SAHRA, *i.e.* The South African Heritage Resources Agency, as soon as possible (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). This so that appropriate action can be taken by a professional palaeontologist, at the developer’s expense. Mitigation would normally involve the scientific recording and judicious sampling or collection of fossil material as well as associated geological data (*e.g.* stratigraphy, sedimentology, taphonomy) by a professional palaeontologist. A Chance Fossil Finds Procedure for the Kuruman study region is appended to this report.

5. KEY REFERENCES

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.

ALMOND, J.E. 2013a. 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. Part 1: Hotazel to Kimberley, Northern Cape. Palaeontological specialist assessment: combined desktop and field-based study, 85 pp. Natura Viva cc, Cape Town.

ALMOND, J.E. 2013b. Proposed construction of a 132 kV power line and switchyard associated with the Redstone Solar Thermal Energy Plant near Postmasburg, Northern Cape Province. Palaeontological heritage assessment: desktop study, 25 pp. Natura Viva cc, Cape Town.

ALMOND, J.E. 2014a. Proposed construction of a 132 kV power line and switchyard associated with the Redstone Solar Thermal Energy Plant near Postmasburg, Northern Cape Province. Palaeontological heritage basic assessment: combined desktop & field-based study, 46 pp.

ALMOND, J.2. 2014b. Residential development on Remainder and Portion 3 of Farm Bestwood RD 459 in Kathu, Gamagara Municipality, Northern Cape Province. Palaeontological specialist assessment: desktop study, 33 pp. Natura Viva cc, Cape Town.

ALMOND, J.E. 2015a. Proposed AEP Legoko Solar PV Energy Facility on Farm 460 Legoka near Kathu, Gamagara Municipality, Northern Cape. Palaeontological specialist assessment: desktop study, 26 pp. Natura Viva cc, Cape Town.

ALMOND, J.E. 2015b. Proposed AEP Magobe Solar PV Energy Facility on Farm 460 Legoka near Kathu, Gamagara Municipality, Northern Cape. Palaeontological specialist assessment: desktop study, 26 pp. Natura Viva cc, Cape Town.

ALMOND, J.E. 2018a. Proposed 75 MW Gaetsewe Solar PV Energy Facility and associated infrastructure on the farm 460 Legoko Portion 1 and 2, and Farm 461 Sekgame near Kathu, Gamagara Local Municipality, Northern Cape.Palaeontological specialist assessment: desktop study, 29 pp. Natura Viva cc, Cape Town.

ALMOND, J.E. 2018b. Kuruman Wind Energy Facility Phase 1 near Kuruman, Kuruman District, Northern Cape. Palaeontological heritage: input for combined desktop and field-based EIA Assessment, 43 pp. Natura Viva cc, Cape Town.

ALMOND, J.E. 2018c. Kuruman Wind Energy Facility Phase 2 near Kuruman, Kuruman District, Northern Cape. Palaeontological heritage: input for combined desktop and field-based EIA Assessment, 34 pp. Natura Viva cc, Cape Town.

ALMOND, J.E. 2018d. Kuruman Wind Energy Facility grid connection, Kathu & Kuruman, Northern Cape. Palaeontological heritage: input for combined desktop and field-based Basic Assessment, 29 pp. Natura Viva cc, Cape Town.

ALMOND, J.E. 2019. Proposed upgrading of the 66 kV network to a 132 kV network between Hotazel, Kuruman and Kathu, Northern Cape. Palaeontological heritage: combined desktop and field-based assessment, 72 pp. Natura Viva cc, Cape Town.

ALMOND, J.E. & PETHER, J. 2008. Palaeontological heritage of the Northern Cape. Interim SAHRA technical report, 124 pp. Natura Viva cc., Cape Town.

ALTERMANN, J. & HERBIG 1991. Tidal flats deposits of the Lower Proterozoic Campbell Group along the southwestern margin of the Kaapvaal Craton, Northern Cape province, South Africa. Journal of African Earth Science 13: 415-435.

ALTERMANN, W. & SCHOPF, J.W. 1995. Microfossils from the Neoarchaean Campbell Group, Griqualand West Sequence of the Transvaal Supergroup, and their paleoenvironmental and evolutionary implications. Precambrian Research 75, 65-90.

ALTERMANN, W. & WOTHERSPOON, J. McD. 1995. The carbonates of the Transvaal and Griqualand West sequences of the Kaapvaal craton, with special reference to the Limje Acres limestone deposit. Mineralium Deposita 30, 124-134.

ALTERMANN, W. & NELSON, D. R. 1998. Sedimentation rates, basin analysis and regional correlations of three Neoarchean and Palaeoproterozoic sub-basins of the Kaapvaal craton as inferred from precise U–Pb zircon ages from volcaniclastic sediments. Sedimentary Geology 120, 225–256.

ANDERSEN, D.T., SUMNER, D.Y., HAWES, I., WEBSTER-BRWON, J. & MCKAY, C.P. 2011. Discovery of large conical stromatolites in Lake Untersee, Antarctica. Geobiology 9, 280-293.

BERTRAND-SARFATI, J. 1977. Columnar stromatolites from the Early Proterozoic Schmidtsdrift Formation, Northern Cape Province, South Africa – Part 1: systematic and diagnostic features. Palaeontologia Africana 20, 1-26.

BEUKES, N.J. 1980. Stratigraphie en litofasies van die Campbellrand-Subgroep van die Proterofitiese Ghaap-Group, Noord-Kaapland. Transactions of the Geological Society of South Africa 83, 141-170.

BEUKES, N.J. 1986. The Transvaal Sequence in Griqualand West. In: Anhaeusser, C.R. & Maske, S. (Eds.) Mineral deposits of Southern Africa, Volume 1, pp. 819-828. Geological Society of South Africa.

CAIRNCROSS, B. & BEUKES, N.J. 2013. The Kalahari Manganese Field. The adventure continues…384 pp. Struik Nature, Cape Town.

DINGLE, R.V., SIESSER, W.G. & NEWTON, A.R. 1983. Mesozoic and Tertiary geology of southern Africa. viii + 375 pp. Balkema, Rotterdam.

DU TOIT, A. 1954. The geology of South Africa. xii + 611pp, 41 pls. Oliver & Boyd, Edinburgh.

ERIKSSON, P.G. & TRUSWELL, J.F. 1974. Tidal flat associations from a Lower Proterozoic carbonate sequence in South Africa. Sedimentology 21: 293-309.

ERIKSSON, P.G. & ALTERMANN, W. 1998. An overview of the geology of the Transvaal Supergroup dolomites (South Africa). Environmental Geology 36, 179-188.

ERIKSSON, P.G., ALTERMANN, W. & HARTZER, F.J. 2006. The Transvaal Supergroup and its precursors. In: Johnson, M.R., Anhaeusser, C.R. & Thomas, R.J. (Eds.) The geology of South Africa, pp. 237-260. Geological Society of South Africa, Marshalltown.

FOURIE, H. 2018a. Proposed upgrading of the 66 kV network to a 132 kV network in the Hotazel, Kuruman and Kathu area, Ga-Segonyana -, Joe Morolong - and Gamagara Local Municipalities, John Taolo Gaetsewe District Municipality, Northern Cape Province. Palaeontological Impact Assessment: Phase 1: Field Study, 23 pp.

FOURIE, H. 2018b. Proposed upgrading of the 66 kV network to a 132 kV network in the Hotazel, Kuruman and Kathu area, Ga-Segonyana -, Joe Morolong - and Gamagara Local Municipalities, John Taolo Gaetsewe District Municipality, Northern Cape Province. Palaeontological Impact Assessment: Addendum Case ID 11967, 15 pp.

GANDIN, A., WRIGHT, D. T. & MELEZHIK, V. 2005. Vanished evaporites and carbonate formation in the Neoarchaean Kogelbeen and Gamohaan formations of the Campbellrand Subgroup, South Africa. Journal of African Earth Sciences 41, 1–23.

GANDIN, A. & WRIGHT, D.T. 2007. Evidence of vanished evaporites in Neoarchaean carbonates of South Africa. In: Schreiber, B.C., Lugli, S. & Babel, M. (Eds.) Evaporites through space and time. Geological Society (London) Special Publications 285, 285-308.

HADDON, I.G. 2000. Kalahari Group sediments. In: Partridge, T.C. & Maud, R.R. (Eds.) The Cenozoic of southern Africa, pp. 173-181. Oxford University Press, Oxford.

HAUGHTON, S.H. 1969. Geological history of southern Africa, 535 pp, Johannesburg. The Geological Society of South Africa.

KLEIN, C., BEUKES, N.J. & SCHOPF, J.W. 1987. Filamentous microfossils in the early Proterozoic Transvaal Supergroup: their morphology, significance, and palaeoenvironmental setting. Precambrian Research 36, 81-94.

KLEIN, C. & BEUKES, N.J. 1989. Geochemistry and sedimentology of a facies transition from limestone to iron formation deposition in the early Proterozoic Transvaal Supergroup, South Africa. Economic Geology 84, 1733-1774.

MACRAE , C. 1999. Life etched in stone. Fossils of South Africa. 305 pp. The Geological Society of South Africa, Johannesburg.

MCCARTHY, T. & RUBIDGE, B. 2005. The story of Earth and life: a southern African perspective on a 4.6-billion-year journey. 334pp. Struik, Cape Town.

MOORE, J.M., TSIKOS, H. & POLTEAU, S. 2001. Deconstructing the Transvaal Supergroup, South Africa: implications for Palaeoproterozoic palaeoclimate models. African Earth Sciences 33, 437-444.

MOORE, J.M., POLTEAU, S., ARMSTRONG, R.A., CORFU, F. & TSIKOS, H. 2012. The age and correlation of the Postmasburg Group, southern Africa: constraints from detrital zircons. Journal of African Earth Sciences 64, 9-19.

PARTRIDGE, T.C., BOTHA, G.A. & HADDON, I.G. 2006. Cenozoic deposits of the interior. In: Johnson, M.R., Anhaeusser, C.R. & Thomas, R.J. (Eds.) The geology of South Africa, pp. 585-604. Geological Society of South Africa, Marshalltown.

PARTRIDGE, T.C., DOLLAR, E.S.J., MOOLMAN, J. & DOLLAR, L.H. 2010. The geomorphic provinces of South Africa, Lesotho and Swaziland: a physiographic subdivision for earth and environmental scientists. Transactions of the Royal Society of South Africa 65, 1-47.

RIDING, R. 2008. Abiogenic, microbial and hybrid authigenic carbonate crusts: components of Precambrian stromatolites. Geologia Croatica 61, 73–103.

RIDING, R. 2011. The nature of stromatolites: 3,500 million years of history and a century of research. In: J. Reitner, N-V. Quéric and G. Arp. (Eds) Advances in Stromatolite Geobiology, Springer, Heidelberg, Lecture Notes in Earth Sciences 131, 29-74.

SAHRA 2013. Minimum standards: palaeontological component of heritage impact assessment reports, 15 pp. South African Heritage Resources Agency, Cape Town.

SCHOPF, J.W. 2006. Fossil evidence of Archaean life. Philosophical Transactions of the Royal Society of London B 361, 869-885.

SUMNER, D. Y. 1997. Late Archean calcite–microbe interactions: two morphologically distinct microbial communities that affected calcite nucleation differently. Palaios 12, 302–318.

SUMNER, D. Y. 2000. Microbial vs environmental influences on the morphology of Late Archean fenestrate microbialites. In: RIDING, R. E. & AWRAMIK, S. M. (eds) Microbial Sediments, 307–314. Springer, Berlin.

SUMNER, D. Y. 2001. Decimeter-thick encrustations of calcite and aragonite on the sea floor and implications for Neoarchean and Neoproterozoic ocean chemistry. In: ALTERMANN, W. & CORCORAN, P. L. (Eds) Precambrian Sedimentary Environments. A Modern Approach to Ancient Depositional Systems. International Association of Sedimentologists, Special Publications 33, 107–120.

SUMNER, D.Y. 2002. Neoarchaean carbonates – clues to early life and early ocean chemistry. Excursion A6, 1-6 July 2002, 24 pp. 16th International Sedimentological Congress, International Association of Sedimentologists. Rand Afrikaans University, Johannesburg.

SUMNER, D. Y. & GROTZINGER, J. P. 1996. Herringbone calcite. Petrography and environmental significance. Journal of Sedimentary Research 66, 419–429.

SUMNER, D.Y. & BOWRING, S.A. 1996. U-Pb geochronologic constraints on deposition of the Campbellrand Subgroup, Transvaal Supergroup, South Africa. Precambrian Research 78, 25–35.

SUMNER, D. Y. & GROTZINGER, J. P. 2000. Late Archean Aragonite Precipitation: Petrography, Facies Associations, and Environmental Significance in Carbonate Sedimentation and Diagenesis in the Evolving Precambrian World.SEPM Special Publications 67, 123–144.

SUMNER, D.Y. & GROTZINGER, J. P. 2004. Implications for Neoarchean ocean chemistry from primary carbonate mineralogy of the Campbellrand-Malmani Platform, South Africa. Sedimentology 51, 1273–1299.

SUMNER, D.Y. & BEUKES, N.J. 2006. Sequence stratigraphic development of the Neoarchaean Transvaal carbonate platform, Kaapvaal Craton, South Africa. South African Journal of Geology 109, 11-22.

TANKARD, A.J., JACKSON, M.P.A., ERIKSSON, K.A., HOBDAY, D.K., HUNTER, D.R. & MINTER, W.E.L. 1982. Crustal evolution of southern Africa – 3.8 billion years of earth history, xv + 523pp. Springer Verlag, New York.

THOMAS, M.J. 1981. The geology of the Kalahari in the Northern Cape Province (Areas 2620 and 2720). Unpublished MSc thesis, University of the Orange Free State, Bloemfontein, 138 pp.

THOMAS, D.S.G. & SHAW, P.A. 1991. The Kalahari environment, 284 pp. Cambridge University Press.

YOUNG, R.B. 1932. The occurrence of stromatolitic or algal limestones in the Campbell Rand Series, Griqualand West. Transactions of the Geological Society of South Africa 53: 29-36.

6. ACKNOWLEDGEMENTS

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7. QUALIFICATIONS & EXPERIENCE OF THE AUTHOR

Dr John Almond has an Honours Degree in Natural Sciences (Zoology) as well as a PhD in Palaeontology from the University of Cambridge, UK. He has been awarded post-doctoral research fellowships at Cambridge University and in Germany, and has carried out palaeontological research in Europe, North America, the Middle East as well as North and South Africa. For eight years he was a scientific officer (palaeontologist) for the Geological Survey / Council for Geoscience in the RSA. His current palaeontological research focuses on fossil record of the Precambrian - Cambrian boundary and the Cape Supergroup of South Africa. He has recently written palaeontological reviews for several 1: 250 000 geological maps published by the Council for Geoscience and has contributed educational material on fossils and evolution for new school textbooks in the RSA.

Since 2002 Dr Almond has also carried out palaeontological impact assessments for developments and conservation areas in the Western, Eastern and Northern Cape, Limpopo, Northwest, Mpumalanga, KwaZulu-Natal and the Free State under the aegis of his Cape Town-based company

Natura Viva cc. He has previously served as a long-standing member of the Archaeology, Palaeontology and Meteorites Committee for Heritage Western Cape (HWC) and an advisor on palaeontological conservation and management issues for the Palaeontological Society of South Africa (PSSA), HWC and SAHRA. He is currently compiling technical reports on the provincial palaeontological heritage of Western, Northern and Eastern Cape for SAHRA and HWC. Dr Almond is an accredited member of PSSA and APHP (Association of Professional Heritage Practitioners – Western Cape).

Declaration of Independence

I, John E. Almond, declare that I am an independent consultant and have no business, financial, personal or other interest in the proposed development project, application or appeal in respect of which I was appointed other than fair remuneration for work performed in connection with the activity, application or appeal. There are no circumstances that compromise the objectivity of my performing such work.

Dr John E. Almond,
Palaeontologist, *Natura Viva* cc

APPENDIX 1: CHANCE FOSSIL FINDS PROCEDURE: WRENCHVILLE PHASE 2 HOUSING PROJECT NEAR KURUMAN		
Province & region:	KURUMAN DISTRICT, NORTHERN CAPE	
Responsible Heritage Management Authority	South African Heritage Resources Agency. 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	
Rock unit(s)	Campbell Rand Subgroup, Caenozoic alluvium, surface gravels, calcretes, breccias & calctufa, aeolian sands	
Potential fossils	Stromatolites in carbonate rocks. Mammalian and other vertebrate bones, teeth, horn cores, trace fossils in older alluvium, calc tufa, breccias & calcretes.	
ECO protocol	1. Once alerted to fossil occurrence(s): alert site foreman, stop work in area immediately (*N.B.* safety first!), safeguard site with security tape / fence / sand bags if necessary.	
	2. Record key data while fossil remains are still *in situ:* Accurate geographic location – describe and mark on site map / 1: 50 000 map / satellite image / aerial photo Context – describe position of fossils within stratigraphy (rock layering), depth below surface Photograph fossil(s) *in situ* with scale, from different angles, including images showing context (*e.g.* rock layering)	
	3. If feasible to leave fossils *in situ*: Alert Heritage Management Authority and project palaeontologist (if any) who will advise on any necessary mitigation Ensure fossil site remains safeguarded until clearance is given by the Heritage Management Authority for work to resume.	3. If *not* feasible to leave fossils *in situ* (emergency procedure only): *Carefully* remove fossils, as far as possible still enclosed within the original sedimentary matrix (*e.g.* entire block of fossiliferous rock) Photograph fossils against a plain, level background, with scale Carefully wrap fossils in several layers of newspaper / tissue paper / plastic bags Safeguard fossils together with locality and collection data (including collector and date) in a box in a safe place for examination by a palaeontologist Alert Heritage Management Authority and project palaeontologist (if any) who will advise on any necessary mitigation
	4. If required by Heritage Management Authority, ensure that a suitably-qualified specialist palaeontologist is appointed as soon as possible by the developer.	
	5. Implement any further mitigation measures proposed by the palaeontologist and Heritage Management Authority	
Specialist palaeontologist	Record, describe and judiciously sample fossil remains together with relevant contextual data (stratigraphy / sedimentology / taphonomy). Ensure that fossils are curated in an approved repository (e.g. museum / university / Council for Geoscience collection) together with full collection data. Submit Palaeontological Mitigation report to Heritage Resources Authority. Adhere to best international practice for palaeontological fieldwork and Heritage Management Authority minimum standards.	