Palaeontological specialist assessment: desktop study

RESIDENTIAL DEVELOPMENT ON REMAINDER AND PORTION 3 OF FARM BESTWOOD RD 459 IN KATHU, GAMAGARA MUNICIPALITY, NORTHERN CAPE PROVINCE

John E. Almond PhD (Cantab.)

***Natura Viva* cc, PO Box 12410 Mill Street,**

Cape Town 8010, RSA

naturaviva@universe.co.za

January 2014

EXECUTIVE SUMMARY

A large township of *c*. 5500 residential units with associated industrial / commercial developments and associated infrastructure, known as the "*Bestwood residential development*", is currently under construction on Remainder and Portion 3 of Farm Bestwood RD 459 that is situated on the eastern side of the N14 near Kathu, Gamagara Municipality, Northern Cape. A desktop palaeontological heritage assessment for the project, requested as part of an HIA by SAHRA in 2008 and recent written request[1], has never been submitted on behalf of the developers (Kathu Property Developers *viz. "*KPD*"*) although construction, including substantial excavations, is now far advanced. This is of particular concern since the very important Pleistocene fossil mammal site at Kathu Pan, with a broadly similar geological context, is located only 7 km or so to the northwest. The present desktop palaeontological heritage assessment for the Bestwood residential development has been commissioned as part of the rectification process being managed by Jeffares & Green, the Independent Environmental Consultants for this project.

According to geological maps, the brief geotechnical report[2] and recently acquired on-site field data[3], the flat-lying Bestwood residential development study area is underlain by a considerable thickness of Plio-Pleistocene to Recent sediments of the Kalahari Group. The underlying Precambrian bedrocks – *viz*. dolomites, cherts and possibly iron formations of the Transvaal Supergroup – are too deeply buried to be directly affected by the housing development. The Kalahari Group succession east of Kathu mainly comprises well-developed calcretes or surface limestones (Mokolanen Formation) that may total 30m or more in thickness in the region, together with a thin (< 1m) surface veneer of aeolian sands (Gordonia Formation) and sparse near-surface gravels. In general the Kalahari Group calcretes and sands are of low palaeontological sensitivity, mainly featuring widely-occurring plant and animal trace fossils (*e.g.* invertebrate burrows, plant root casts). Recent field-based palaeontological heritage assessments in the Sishen – Hotazel region by the author (Almond 2013a, 2013b) have not recorded significant fossil material within these near-surface Kalahari successions. A very important fossil assemblage of Pleistocene to Holocene mammal remains - predominantly teeth with scarce bone material associated with Earlier, Middle and Later Stone Age artefacts, well-preserved peats and pollens - is recorded from unconsolidated doline (solution hollow) sediments at the well-known Kathu Pan site, located some 7 km northwest of the Bestwood study area. However, there are no indications of comparable fossiliferous, tool-bearing solution hollow infills exposed at present in the study area (Dr D. Morris, McGregor Museum, pers. comm., 2014). Such fossil-bearing sediments might conceivably be present but hidden beneath cover sands, however; if so, the most likely location for solution hollows would be within Erf 8434[4], in line with the Vlermuisleegte pans that extend to the northwest of the study area.

The overall impact significance of the Bestwood residential development is rated as LOW as far as palaeontological heritage is concerned. Likewise, cumulative impacts are likely to be of LOW significance, given the scarcity of macrofossils (especially vertebrate remains) within the sedimentary rock units concerned as well as the huge outcrop area of the Kalahari Group as a whole. This assessment applies to all relevant components of the project listed in the scope of work for this study, *viz*. Phase 1 and Phase 2 of the development, including the construction / management camp located on Erf 8434, the affected area where the proposed sewage pipeline traverses third party land (west of the development area as well as east of the development area), and includes the location of the wastewater treatment works (WWTW)[5]. The degree of confidence for this assessment is rated as

---

[1] 9 January 2014 letter. SAHRA Ref: 9/2/055/0002

[2] Undertaken by V&V Consulting Engineers: 2008

[3] Obtained in 2014

[4] Where the construction / management camp has been built

[5] Of which construction has ceased on 26 November 2013 as per the DWA directive

medium due to the uncertainty surrounding the presence or absence of potentially fossiliferous buried doline infill deposits within the study area.

Due to the inferred low impact significance of the Bestwood residential development as far as fossil heritage resources are concerned, no further specialist palaeontological studies or monitoring are recommended at this stage. The following mitigation measures to safeguard fossils exposed on site during the construction phase of the development are proposed:

- The Site Engineer and /or Environmental Control Officer (ECO) responsible for monitoring environmental compliance of the development must remain aware that all sedimentary deposits have the potential to contain fossils and he/she should thus monitor all substantial excavations into sedimentary bedrock for fossil remains. If any substantial fossil remains (*e.g.* vertebrate bones, teeth, horn cores) are found during construction, SAHRA should be notified immediately (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) so that appropriate mitigation (*i.e.* recording, sampling or collection) by a palaeontological specialist can be considered and implemented, at the developer's expense.

- A chance-find procedure should be implemented so that, in the event of fossils being uncovered, the Site Engineer and / or ECO will take the appropriate action, which includes:

    - Stopping work in the immediate vicinity and fencing off the area with tape to prevent further access;

    - Reporting the discovery to the provincial heritage agency and/or SAHRA;

    - Appointing a palaeontological specialist to inspect, record and (if warranted) sample or collect the fossil remains;

    - Implementing further mitigation measures proposed by the palaeontologist; and

    - Allowing work to resume only once clearance is given in writing by the relevant authorities.

- During maintenance and servicing of infrastructure, if excavation is required, it shall be limited to the disturbed footprint as far as practicable. Should bulk works exceed the currently proposed development footprint, as outlined in Fig. 3 of this report, SAHRA should be notified.

If the mitigation measures outlined above are adhered to, the residual impact significance of any construction phase impacts on local palaeontological resources is considered to be low. The mitigation measures proposed here must be incorporated into the Environmental Management Programme (EMP) for the Bestwood residential development project.

The palaeontologist concerned with mitigation work will need a valid collection permit from SAHRA. All work would have to conform to international best practice for palaeontological fieldwork and the study (*e.g.* data recording fossil collection and curation, final report) should adhere to the minimum standards for Phase 2 palaeontological studies recently published by SAHRA (2013).

1. INTRODUCTION, PROJECT OUTLINE AND BRIEF

A large township of *c*. 5500 residential units with associated industrial / commercial developments and associated infrastructure, known as the "*Bestwood residential development*", is currently under construction on the farm Bestwood 459 that is situated on the eastern side of the N14 near Kathu, Gamagara Municipality, Northern Cape (Fig. 1). The following project outline and report on construction progress to date (December 2013) is abstracted, with minor modifications, from the online submission to SAHRA by Ms Tamara Drake on behalf of Jeffares & Green, the Independent Environmental Consultants for this project:

1.1. Project description and need for the project

The Bestwood residential development is located on Remainder, and Portion 3 of Farm Bestwood 459 near the town of Kathu, Northern Cape. The development is divided into Phase 1 and Phase 2 and "*consists of a mixed use human settlement comprising of affordable housing, general residential, institutional and commercial opportunities, fulfilling the needs of the various mining expansion programmes for the region*"[6]. The Bestwood development, together with new extensions within / around the town of Kathu will create a new regional node for the Northern Cape with towns such as Olifantshoek, Postmasburg, Kuruman and Hotazel benefiting from this initiative. The phased development at Bestwood will be undertaken on a 200 ha portion of the farm Bestwood No. 459 RD which is situated adjacent to the N14 National road and opposite the entrance to Kathu from the N14.

The Housing Impact Fund of South Africa ("HIFSA") is a subsidiary of Old Mutual Investments which is involved in financing the development of approximately 3 300 residential units within the Bestwood development, all of which will be constructed on Erven 8440, 8439, and 8438 as part of Phase 1 [See annotated site layout in Fig. 3 of this report]**.** The remaining 2 200 houses and most of the industrial / commercial developments form part of Phase 2 of the construction phase. A temporary management / construction camp has also been built on Erf 8434 (north of the site). Construction of the Waste Water Treatment Works ("WWTW") to service the development has begun, but construction has ceased[7] as the required approval/s have not been obtained from the competent authority /ies. Discussions are being held in this regard with the relevant competent authorities to regularise / rectify a number of issues on site, which includes the WWTW and construction camp.

1.2. Construction progress and developments on site

Approximately 280 residential units have already been built on Erf 8440 as part of Phase 1 of the Bestwood development and are currently occupied [Green arrows in Fig. 3 of this report]. A further 50 residential units are awaiting transfer, and it is predicted that a total of 300 houses will be constructed by the end of February 2014. Earthworks and concomitant services have been laid in both Phase 1 and Phase 2, with more development (top structures) having been built in Phase 1. Construction of services that have already been undertaken / completed on the site since 12 December 2013 include:

- roads

---

[6] Bestwood Estate, Kathu, Northern Cape: *General Sales Project Information: October 2011*

[7] On 26 November 2013 as per the DWA directive

- internal sewers
- internal water reticulation
- internal gas reticulation, and
- external works (borehole and rising main to the Municipal reservoir and water tower, water supply line from the Municipal reservoir and water tower to the Bestwood development, sewer pump station and rising main to the oxidation pond and Bestwood WWTW).

The Bestwood residential development area is underlain by potentially fossiliferous sedimentary rocks of Late Caenozoic age (Sections 2 and 3). The construction phase of the development entails substantial excavations into the superficial sediment cover (*e.g.* for building foundations, roads, pipelines and other services). In addition, sizeable areas will be sealed-in or sterilized beneath the housing and associated commercial / industrial developments. All these developments may adversely affect potential fossil heritage at or beneath the surface of the ground within the study area by destroying, disturbing or permanently sealing-in fossils that are then no longer available for scientific research or other public good.

All palaeontological heritage resources in the Republic of South Africa are protected by the National Heritage Resources Act (Act 25 of 1999) (See Section 1.1 below). Heritage resource management in the Northern Cape is the responsibility of the South African Heritage Resources Agency or 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).

On 19 November 2008 SAHRA requested a palaeontological desktop study, or at least a letter of exemption from an accredited palaeontologist to indicate that this (a palaeontological desktop study) was not necessary, as part of a Heritage Impact Assessment (HIA) for the Bestwood residential project in terms of Section 38 of the National Heritage Resources Act. This request was re-iterated by SAHRA on 19 November 2008 and 2 October 2008 (SAHRA Ref. No. 9/2/055/0002). Construction of the housing development nevertheless commenced without a palaeontological heritage assessment having been submitted to SAHRA, in contravention of the conditions attached to the Environmental Authorisation for the development issued by the Department of Tourism, Environment and Conservation on 13 November 2008.

Jeffares & Green, Cape Town, have now been appointed as the Independent Environmental Consultants for the Bestwood residential development project to managethe rectification process for this project (Contact details: Ms Tamara Drake. Jeffares & Green (Pty) Ltd. 14 Central Square, Pinelands, Cape Town, 7405, South Africa. P.O. Box 38561, Pinelands, Cape Town, Western Cape, 7430, South Africa. Tel: +27 21 532 0940. Fax: +27 21 532 0950. Email: draket@jgi.co.za).

A palaeontological heritage desktop assessment for the Bestwood residential project - including Phases 1 and 2 of the development, the construction management camp located on Erf 8434, the proposed sewage pipeline to the west and east of the development and the waste water treatment works (See Fig. 3) - has accordingly been commissioned by Jeffares & Green. The brief for this study is as follows:

• Undertaking a desktop background / literature search in terms of potential fossil heritage resources within the project area / on all the land parcels concerned. The assessment would cover the project area which includes Phase 1 and Phase 2 of the development, including the construction / management camp located on erf 8434, as well as the affected area where the proposed sewage pipeline (pink dashed line) traverses third party land (west of the development area as well as east of the development area), as well as the location of the wastewater treatment works (WWTW) where construction has ceased until further notice (refer to the purple demarcated area in Fig. 3 herein).

This assessment / evaluation would factor in the disturbance to the area that has already been undertaken and that your work is in response to meeting SAHRA's requirements to 'rectify' the current situation.

• Where required/ applicable, comply with the relevant guidelines on conducting specialist studies / reporting for EIA / to meet SAHRA's requirements.

• Describe the nature and significance of paleontological material within the affected study area / land parcels.

• Assess all potential impacts in terms of J&G's standardised impact assessment criteria based on the current circumstances where construction has already begun and / or in some instances, been completed.

• Consider any cumulative impacts, negative or positive, based on the current circumstances where construction has already begun and / or in some instances, been completed.

• Where required/ relevant (based on the fact that construction has already begun and in some instances has been completed), the specialist report must contain all information that will meet and satisfy SAHRA's requirements as the decision-making authority.

• Based on the disturbance already undertaken on site, provide recommendations on the most effective way to document and (if required) remove and / or salvage any material of paleontological significance within the study area.

• If required, apply for and obtain the necessary permits and any other heritage approvals relating to paleontological aspects in terms of the National Heritage Resources Act1.

• Where possible, provide mitigation measures that could be implemented to remediate / reduce the potential impact to paleontological resources within the study area (if present and required) based on the fact that construction has already begun and in some instances has been completed.

• Make available own report to the archaeologist for alignment of reporting if required.

1.3. Legislative context for palaeontological assessment studies

The various categories of heritage resources recognised as part of the National Estate in Section 3 of the National Heritage Resources Act (Act 25 of 1999) 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 recently been published by SAHRA (2013).

1.4. Approach to the desktop palaeontological heritage study

The approach to this desktop 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 (Table 1). 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, 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 field assessment during the compilation of the final report). This data is then used to assess the palaeontological sensitivity of each rock unit to a 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 significantly the extent of fresh bedrock excavation envisaged. When rock units of moderate to high palaeontological sensitivity are present within the development footprint, a Phase 1 field assessment study by a professional palaeontologist is usually warranted to identify any palaeontological hotspots and make specific recommendations for any mitigation required before or during the construction phase of the development.

On the basis of the desktop and Phase 1 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. Phase 2 mitigation by a professional palaeontologist – normally involving 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 a palaeontological collection permit from the relevant heritage management authority (*e.g.* SAHRA for the Northern Cape). It should be emphasized that, *provided that appropriate mitigation is carried out*, the majority of developments involving bedrock excavation can make a *positive* contribution to our understanding of local palaeontological heritage.

1.5. 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. A Karoo fossil vertebrate database is now accessible for impact study work.

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 present case, site visits to the various loop and borrow pit study areas in some cases considerably modified our understanding of the rock units (and hence potential fossil heritage) represented there.

In the case of the study area near Kathu a major limitation for fossil heritage studies is the possible low level of surface exposure of potentially fossiliferous bedrocks such as any doline infills within the near-surface calcrete hardpans, as well as the paucity of previous specialist palaeontological studies in the Northern Cape region as a whole.

1.6. Information sources

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

1. A project outline, map (Fig. 3) and summary of construction completed to date provided by Jeffares & Green (dated 18 December 2013);

2. A review of the relevant scientific literature, including published geological maps and accompanying sheet explanations as well as several desktop and field-based palaeontological assessment studies in the broader Sishen / Kathu / Hotazel region of the Northern Cape by the author (*e.g.* Almond 2012, 2013a, 2013b);

3. Examination of relevant topographical maps and satellite images;

4. Geotechnical site investigation report undertaken by V&V Consulting Engineers, 2008;

5. The author’s previous field experience with the formations concerned and their palaeontological heritage (See also review of Northern Cape fossil heritage by Almond & Pether 2008).

6. Field data, including photographs, kindly supplied by Dr David Morris of the McGregor Museum, Kimberley (January 2014).

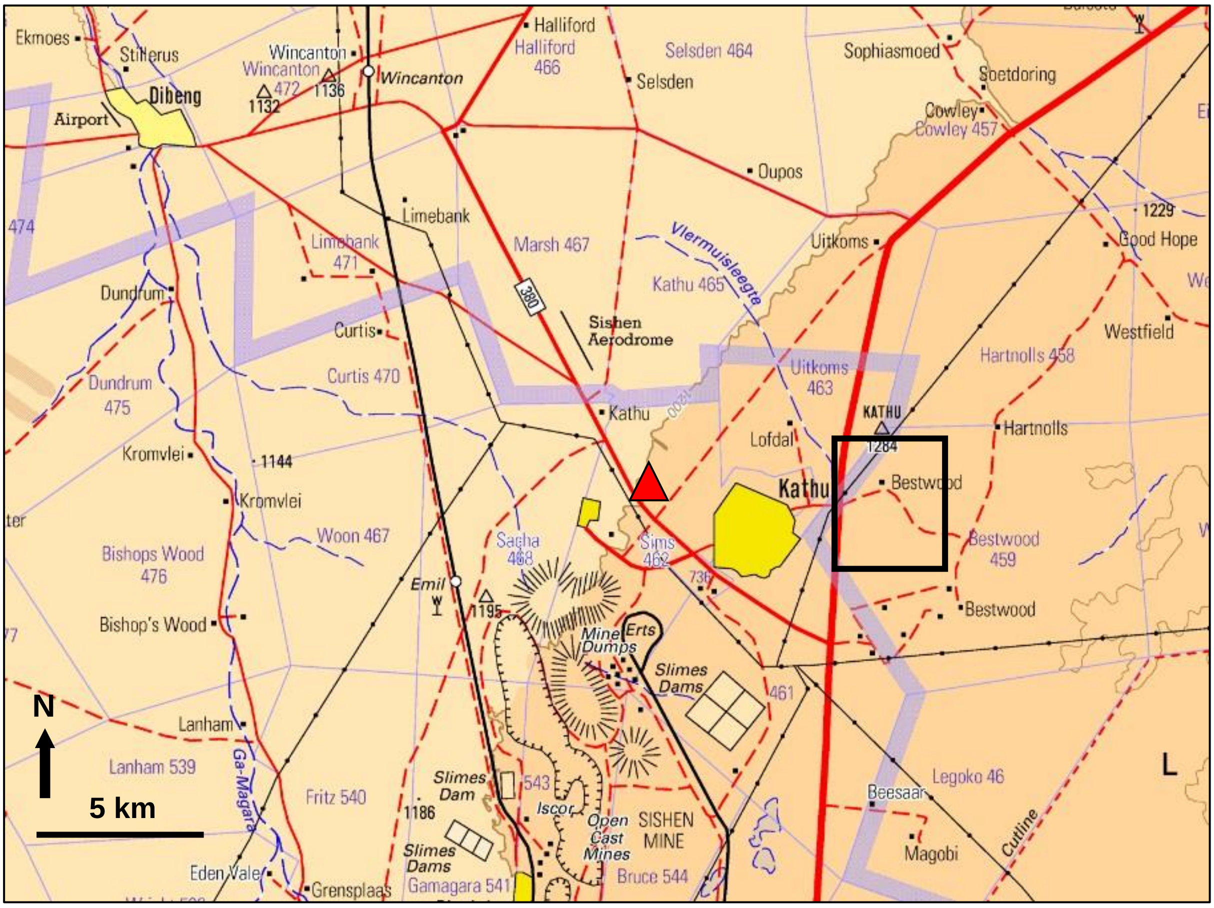

Fig. 1. Map showing the approximate location (black rectangle) of the study area for the Bestwood residential development on Remainder and Portion 3 of Farm Bestwood 459 on the eastern side of the N14, just to the east of the town of Kathu, Northern Cape (Extract from 1: 250 000 topographical map 2722 Kuruman, Courtesy of the Chief Directorate Surveys and Mapping, Mowbray). See Fig. 3 for a more accurate outline of the study area. The red triangle indicates the key Kathu Pan Pleistocene fossil site *c*. 5.5 km NW of Kathu.

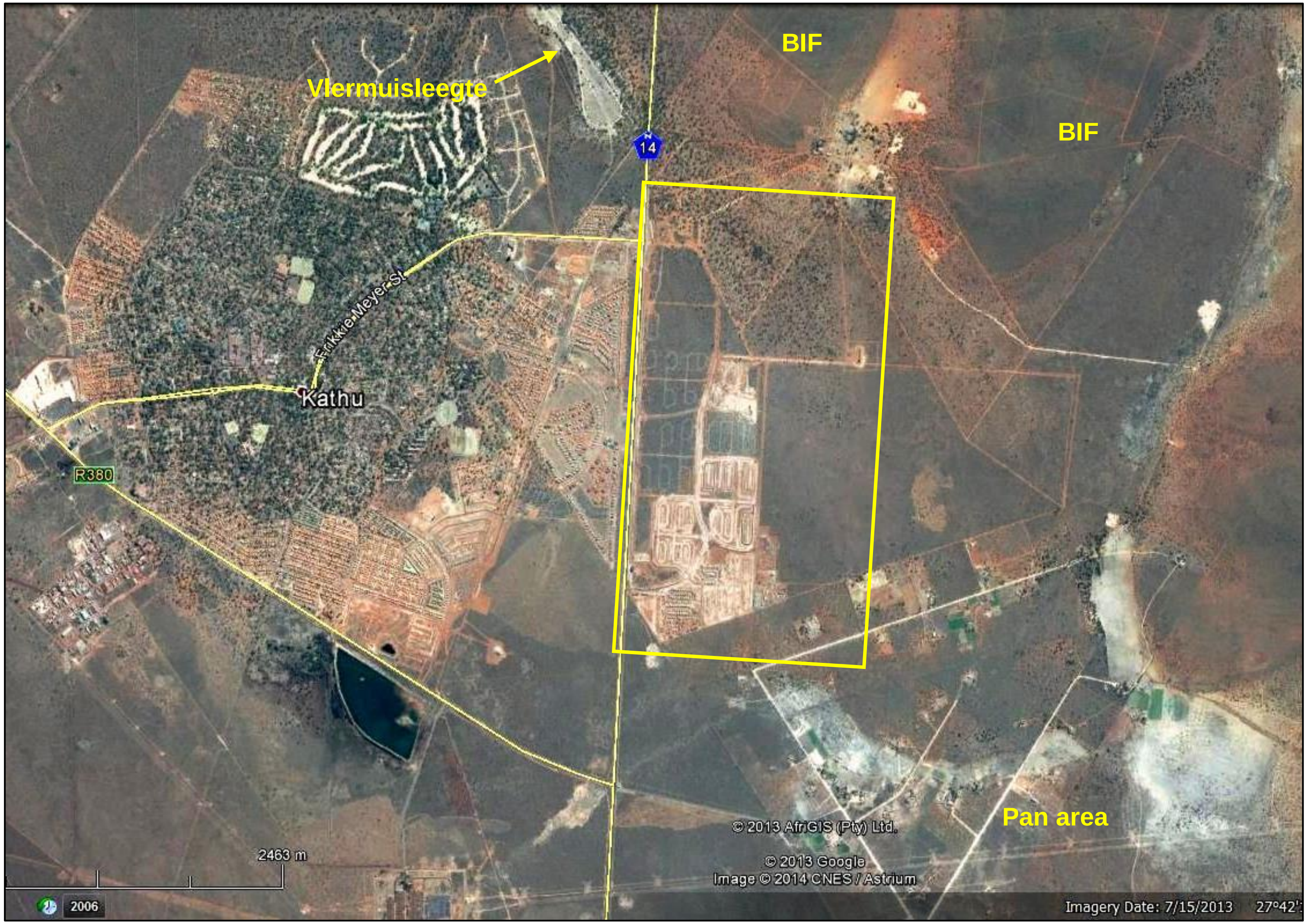

Fig. 2. Google earth© satellite image of the broader Bestwood residential development study area (yellow rectangle) on the eastern side of the N14 opposite the town of Kathu, Northern Cape. BIF = iron formation of the Asbestos Hills Subgroup.

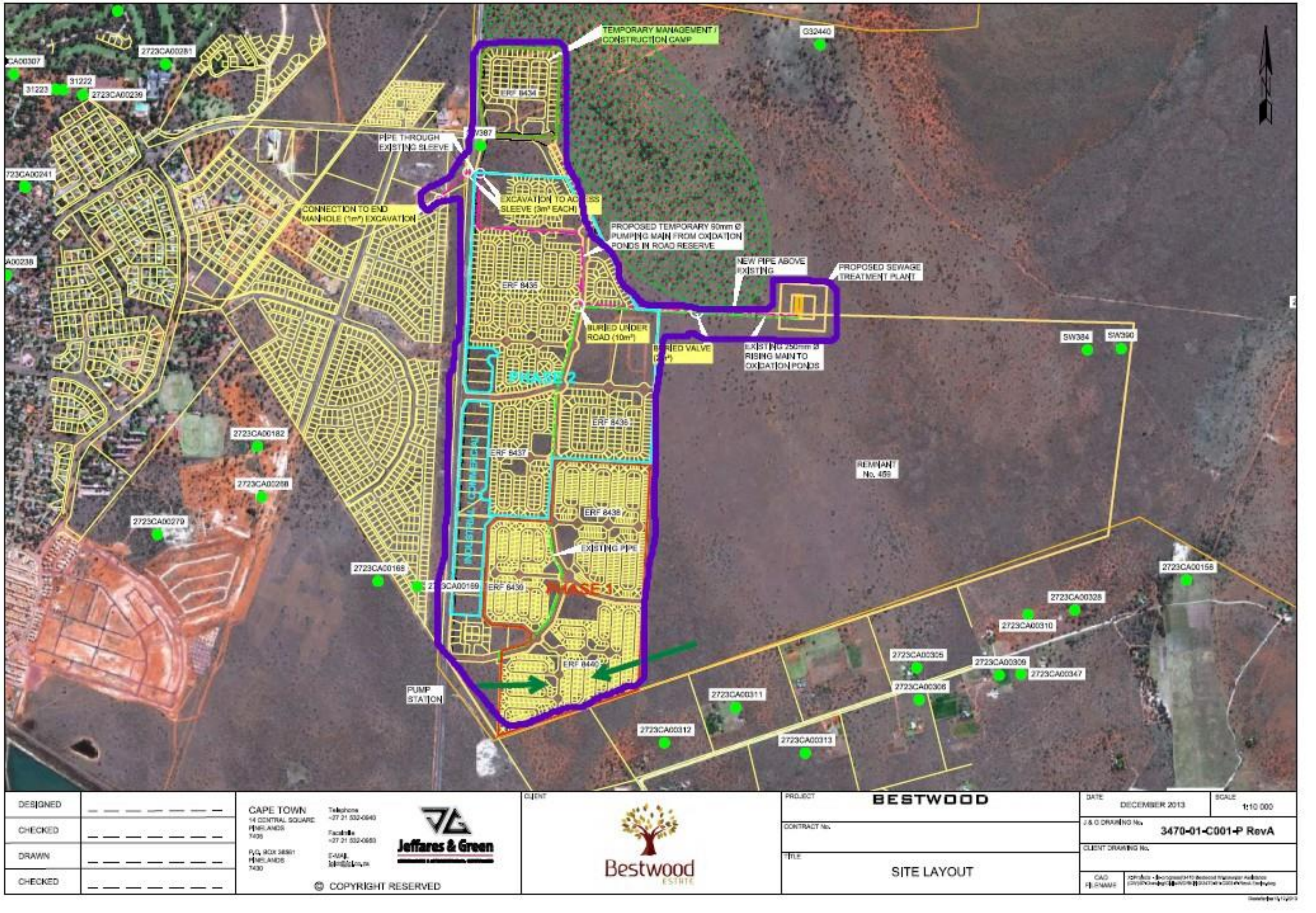
TEMPORARY MANAGEMENT / CONSTRUCTION CAMP
PIPE THROUGH EXISTING SLEEVE
EXCAVATION TO ACCESS SLEEVE (3m³ EACH)
CONNECTION TO END MANHOLE (1m³) EXCAVATION
PROPOSED TEMPORARY 90mm Ø PUMPING MAIN FROM OXIDATION PONDS IN ROAD RESERVE
NEW PIPE ABOVE EXISTING
PROPOSED SEWAGE TREATMENT PLANT
BURIED UNDER ROAD (10m³)
BURIED VALVE
EXISTING 250mm Ø RISING MAIN TO OXIDATION PONDS
PHASE 2
PHASE 1
EXISTING PIPE
PUMP STATION
REMNANT No. 459
ERF 8436
ERF 8437
ERF 8438
ERF 8439
ERF 8440
DESIGNED
CHECKED
DRAWN
CHECKED
CAPE TOWN
Jeffares & Green
© COPYRIGHT RESERVED
CLIENT
Bestwood ESTATE
PROJECT
BESTWOOD
CONTRACT No.
TITLE
SITE LAYOUT
DATE
DECEMBER 2013
SCALE
1:10 000
J & G DRAWING No.
3470-01-C001-P RevA
CLIENT DRAWING No.

Fig. 3 (Previous page). Outline of the present study area for the Bestwood residential development near Kathu (purple polygon). This outline includes Phase 1 and Phase 2 of the development, including the construction / management camp located on erf 8434, as well as the affected area where the proposed sewage pipeline (pink dashed line) traverses third party land (west of the development area as well as east of the development area), as well as the location of the wastewater treatment works (WWTW) where construction has ceased until further notice (Image kindly supplied by Jeffares & Green, Cape Town).

2. GEOLOGICAL OUTLINE OF THE STUDY AREA

The town of Kathu lies within a semi-arid, flat-lying region at 1200 – 1300m amsl situated between the Langberge mountain range in the west and the low-lying Kurumanheuwels in the east. This region is drained by the Ga-Mogara River which flows northwards into the Kuruman River to the north of Hotazel. The study area for the Bestwood housing development is situated on the eastern side of the N14 tar road between Postmasburg and Kuruman, opposite the turnoff to Kathu, Gamagara Municipality, Northern Cape (Figs. 1 to 3).

Study of satellite images (Fig. 2) shows that the terrain within the study area itself is generally very flat, situated at around 1230-1240m. Subdued gentle hill slopes of banded iron formation, outliers of the Kurumanheuwels, border the area on the northern and eastern sides (darker grey on satellite images). Judging from recent and historical satellite images available on Google earth, there are, and probably were, no major surface pans within the Bestwood study area itself. A complex of sizeable pans present within a 1-3 km radius to the SE and E of the area is related to a north-south trending ancient drainage course that runs just east of Remnant 459, outside the present study area. The intermittent drainage line of the Vlermuisleegte runs NW - SE to the north of Kathu town and west of the N14 and is marked by a series of elongate pans at its south-eastern termination, close to the N14. This drainage line might have previously extended further to the southeast, across the line of the N14, into the area of Erf 8434 (Temporary Management Construction Camp in Fig. 3). Associated fluvial, doline or pan deposits may therefore be buried at shallow depths beneath younger surface sands here. This is one of several palaeodrainage lines that belong to the broader Ga-Mogara drainage system whose subparallel, NW to SE trending orientation presumably reflects underlying structural control (*cf* Almond 2013a, 2013b).

The geology of the study region is shown on the 1: 250 000 geological sheet 2722 Kuruman (Council for Geoscience, Pretoria) (Fig. 6 herein). This map is now out of print and is not accompanied by a detailed sheet explanation (A brief explanation is printed on the map itself, however). Since this geological map was published, there have been considerable revisions to the stratigraphic subdivision and assignment of the several Precambrian rock units represented within the Kuruman sheet area. Where possible, the recent stratigraphic account for the Transvaal Supergroup given by Eriksson *et al.* (2006) is followed here, but correlations for all the subdivisions indicated on the older maps are not always clear.

The Bestwood study area lies close to the axis of a major, elongate NNW-SSE trending domal structure in the underlying Precambrian bedrocks that is known as the Maremane Anticline. The bedrocks here belong to the Late Archaean to Early Proterozoic **Transvaal Supergroup** and were deposited within the Ghaap Plateau Subbasin of the Griqualand West Basin (Eriksson *et al.* 2006). Useful reviews of the stratigraphy and sedimentology of these Transvaal Supergroup rocks have been given by Moore *et al.* (2001), Eriksson and Altermann (1998) as well as Eriksson *et al.* (2006). The **Ghaap Group** represents some 200 million years of chemical sedimentation - notably iron and manganese ores, cherts and carbonates - within the Griqualand West Basin that was situated towards the western edge of the Kaapvaal Craton (*c.* 2.6 – 2.4 Ga, Fig. 7; see also fig. 4.19 in McCarthy & Rubidge 2005). Carbonate sediments underlying the Bestwood development study area are assigned to the Campbell Rand Subgroup. Banded iron formations of the overlying Asbestos Hills Subgroup build the low hills just to the north and east but lie outside the study area itself and are not treated further here. Note that borehole data from the region show subsurface dolomite overlain by banded iron formation (D. Morris, pers. comm., January 2013).

The **Campbell Rand Subgroup** (previously included within the Ghaapplato Formation) is a very thick (1.6 - 2.5 km) carbonate platform succession of dolomites, dolomitic limestones and cherts with minor tuffs that was deposited on the shallow submerged shelf of the Kaapvaal Craton roughly 2.6 to 2.5 Ga (billion years ago; see 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 dolomites, oolites, oncolites, laminated calcilutites, cherts and marls, with subordinate siliclastics (shales, siltstones) and minor tuffs (Eriksson *et al.* 2006).

Campbell Rand carbonates do not crop out at surface within the study area where they are probably blanketed by thick superficial sediments. Note that since the 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, Eriksson *et al.* 2006 and Fig. 7 herein). It is unclear exactly which of these newer units are represented at depth beneath the present study area. However, this resolution is not critical for the current report since these older bedrocks are unlikely to be significantly impacted by the present development project. Since the northernmost portion of the study area (Erf 8434) lies close to the contact with the Asbestos Hills Subgroup, it is probably underlain by the **Tsineng Formation**, comprising laminated carbonates and cherts (Eriksson *et al.* 2006), with older Campbell Rand formations present further south beneath the area. A siliceous / cherty breccia or manganese marker that lies at the top of the Campbell Rand succession may be a downwasted palaeoweathering product of secondarily mineralised Campbell Rand carbonates and cherts. An unidentified NNE-SSW trending linear feature indicated on the geological map by a dotted line on the north-eastern side of the study area might be a dolerite dyke.

The Campbell Rand carbonates in the Kathu region are entirely mantled by Late Caenozoic calcretes and aeolian sands of the **Kalahari Group** (**Tl** for Tertiary Limestone in Fig. 6). The pedogenic limestones reflect seasonally arid climates in the region over the last five or so million years and are briefly described by Truter *et al.* (1938) and in more detail by Haddon (2005). The surface limestones may reach thicknesses of over 20 m, but are often much thinner, and are locally conglomeratic with clasts of reworked calcrete as well as exotic pebbles. The limestones may be secondarily silicified and incorporate blocks of the underlying Precambrian carbonate rocks. The older, Pliocene - Pleistocene calcretes in the broader Kalahari region, including sandy limestones and calcretised conglomerates, have been assigned to the **Mokalanen Formation** of the **Kalahari Group**. They are possibly related in large part to a globally arid time period between 2.8 and 2.6 million years ago, *i.e.* late Pliocene (Partridge *et al.* 2006).

Large areas of unconsolidated, reddish-brown aeolian (*i.e.* wind-blown) sands of the Quaternary **Gordonia Formation** (Kalahari Group; **Qs** in Fig. 6) are mapped in the Sishen - Kathu region where their thickness is variable. The geology of the Late Cretaceous to Recent Kalahari Group is reviewed by Thomas (1981), Dingle *et al.* (1983), Thomas & Shaw 1991, Haddon (2000 & 2005) and Partridge *et al.* (2006). The Gordonia dune sands are considered to range in age from the Late Pliocene / Early Pleistocene to Recent, dated in part from enclosed Middle to Later Stone Age stone tools (Dingle *et al*., 1983, p. 291). Note that the recent extension of the Pliocene - Pleistocene boundary from 1.8 Ma back to 2.588 Ma would place the Gordonia Formation almost entirely within the Pleistocene Epoch.

Haddon (2005) reports a total thickness of *about* 80 m of Kalahari Group sediments overlying the Precambrian bedrocks in the Sishen Iron Ore Mine, located some seven kilometres southwest of the Bestwood study area. The lower-lying beds, which may be as old as Late Cretaceous (Partridge et al. 2006, p. 590) are assigned to the **Wessels Formation** (basal debris flow gravels associated with local faults) and **Budin Formation** (lacustrine calcareous clays with sparse suspended pebbles associated with palaeodrainage systems). The uppermost 15 m of the Kalahari succession here comprises well-indurated calcretised siltstones, pebbly horizons and clays with the development of solution hollows along joint surfaces within 10 m of the surface. Close to the surface calcretised silcretes showing *in situ* brecciation are also recognised. It is also noted that there is considerable, rapid horizontal variation in the Kalahari Group rocks, so it is unlikely that the succession underlying the Bestwood study area is identical.

Fig. 4. Recent deep trenching within the Bestwood development area showing the thick development of calcrete hardpan in the subsurface (Image kindly provided by Dr D. Morris, McGregor Museum, Kimberley. January 2014).

A recent field study associated with the manganese ore railway line (Sishen New Loop), some 17 km SW of the present study area, records a thick (> several meters) pale pinkish, karstified calcrete hardpan at surface that is partially mantled with a thin layer of downwasted surfaced gravels (*e.g.* calcrete rubble) and orange-brown Kalahari sands (Almond 2013a). Various calcrete facies are exposed in local stormwater trenches, including gravelly, pelleted, brecciated, silicified and honeycomb types. Several blocks contain well-defined, tubular to irregular solution pipes lined with pale brown calcareous silt. Consolidated, poorly-sorted calcrete gravel breccia and reddish-brown sands partially infill some of these solution hollows, but no associated fossil bones or teeth were observed within them (Fig. 5).

At Kathu Pan, located some 5.5 km NW of Kathu town (27º 39’ 50” S, 23º 0’ 30” E), an important succession of stratified, unconsolidated, fossiliferous Quaternary to Holocene sediments up to 12 m thick infilling a series of solution hollows (sinkholes / dolines) within a thick calcrete hardpan has been studied in some detail (*e.g.* Butzer 1984, Klein 1988, Beaumont 1990, Partridge & Scott 2000, Beaumont 2004, and refs. therein). Porat *et al.* (2010) provide important recent data on the sedimentology and dating of the site. The Kathu Pan site is indicated by a red triangle in Figure 1 herein. Boreholes within the pan area record a Kalahari Group succession here that is over 70 m thick, including 30 m of basal gravels, clays and sands (Wessels, Budin and possibly also Eden Formations) overlain by over 40 m of calcrete (Mokalanen Formation) and unconsolidated superficial sediments (*e.g.* Gordonia Formation aeolian sands). The various doline infill successions investigated at Kathu Pan comprise a variety of Mid to Late Pleistocene and Holocene sands, gravels, calcareous silty sands and several peat horizons. Several spring eyes can be identified. Apart from the sterile basal layers overlying the karstified calcrete surface, the sediments are associated with a series of stone artefact assemblages ranging from Early Acheulean through Fauresmith and Middle Stone Age to Later Stone Age.

Fig. 5. Excavated block of surface calcrete showing large, subvertical, silt-lined solution hollow, Sishen New Loop, c. 18 km SW of the Bestwood study area (Hammer = *c*. 30 cm). Such karstic weathering hollows might have served as traps for vertebrates (*e.g.* small mammals and reptiles, reworked bones and teeth) as well as land snails in the Pleistocene Epoch (Image from Almond 2013).

The brief geotechnical report[8] for the Bestwood development states that the entire project area is blanketed by unconsolidated, light red, fine to medium grained aeolian sands. These are 20 to 80 cm thick and can be assigned to the Quaternary Gordonia Formation of the Kalahari Group. They are underlain by fine- to medium-grained limestone (calcrete) which extends to 1m or more below surface (the maximum depth of the test pits concerned). No surface gravels or pan sediments are reported above or below the aeolian sands in the study area. According to recent independent field observations from the Bestwood development area, the superficial sands here are up to one meter deep, often much less, and locally contain sparse gravels of (flaked) banded ironstone at the base (D. Morris, pers. comm., January 2014). On-site excavations up to 11 m deep extend down into the underlying calcrete without encountering bedrock (Fig. 4). Apparently, up to 30 m of calcrete have been recorded in bore holes in the vicinity, underlain by banded ironstone and dolomite below that. Critically, there are no indications of sinkhole or other karstic solution infills in the study area (*ibid*.) such as have been recorded at Kathu Pan only some 7 km to the northwest.

[8] Undertaken by V&V Consulting Engineers: 2008

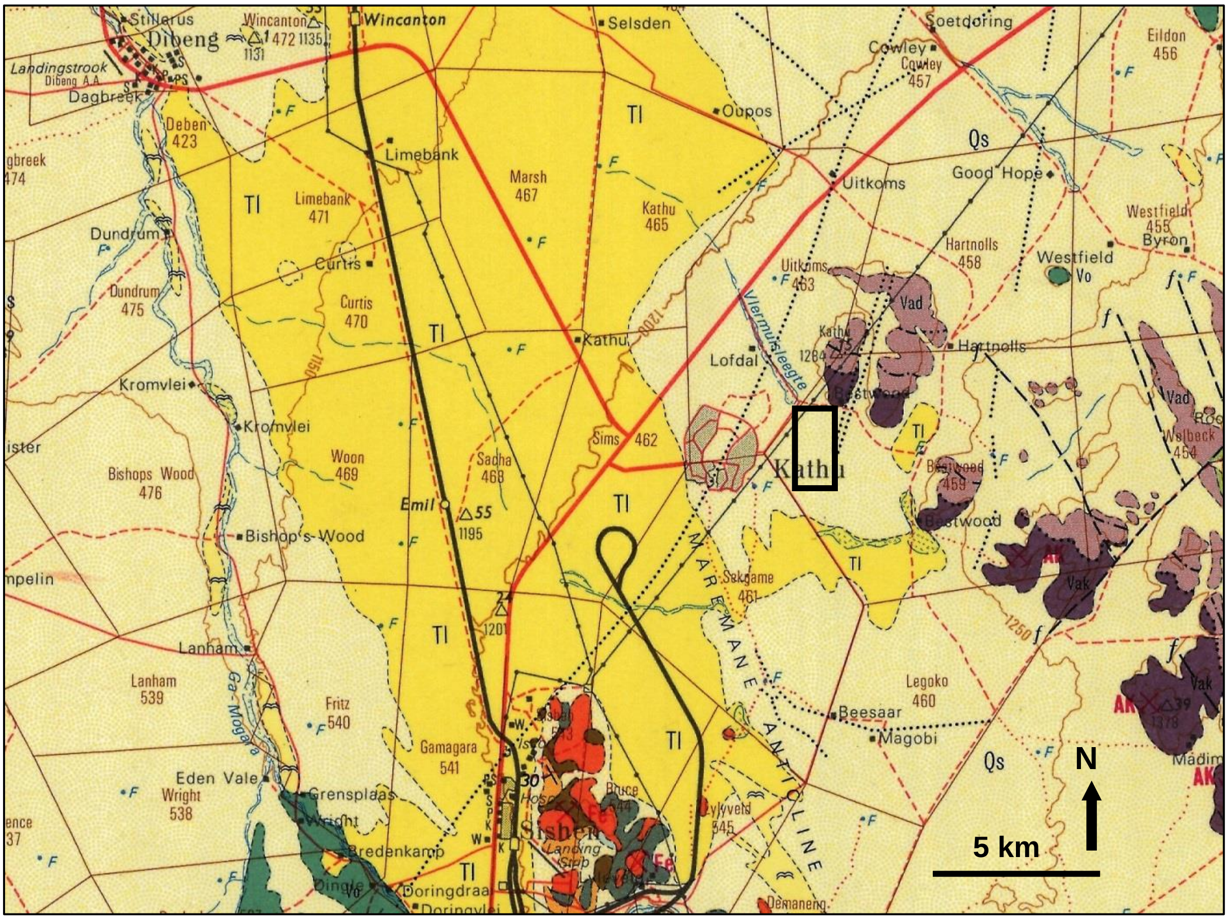

Fig. 6. Extract from 1: 250 000 geological map 2722 Kuruman (Council for Geoscience, Pretoria) showing the *approximate* location of the Bestwood housing project study area to the east of Kathu and northeast of the Sishen Mine (black polygon). Note that the road network shown here is out of date.

Geological units represented within the broader study region on sheet 2722 Kuruman include the following (*N.B.* many of these units are only represented subsurface within the study area itself):

CAENOZOIC SUPERFICIAL DEPOSITS (Quaternary to Recent)
Tl (dark yellow) – calcretes ("surface limestone") of the Kalahari Group
Qs (pale yellow) – aeolian sands of the Gordinia Formation, Kalahari Group
Blue stippled areas = pans

TRANSVAAL SUPERGROUP (Late Archaean to Palaeoproterozoic)

Vak (grey) – banded iron formation of the Kuruman Formation (Asbestos Hills Subgroup, Ghaap Group)
Vad (lilac) – banded iron formation of the Daniëlskuil Formation (Asbestos Hills Subgroup, Ghaap Group)

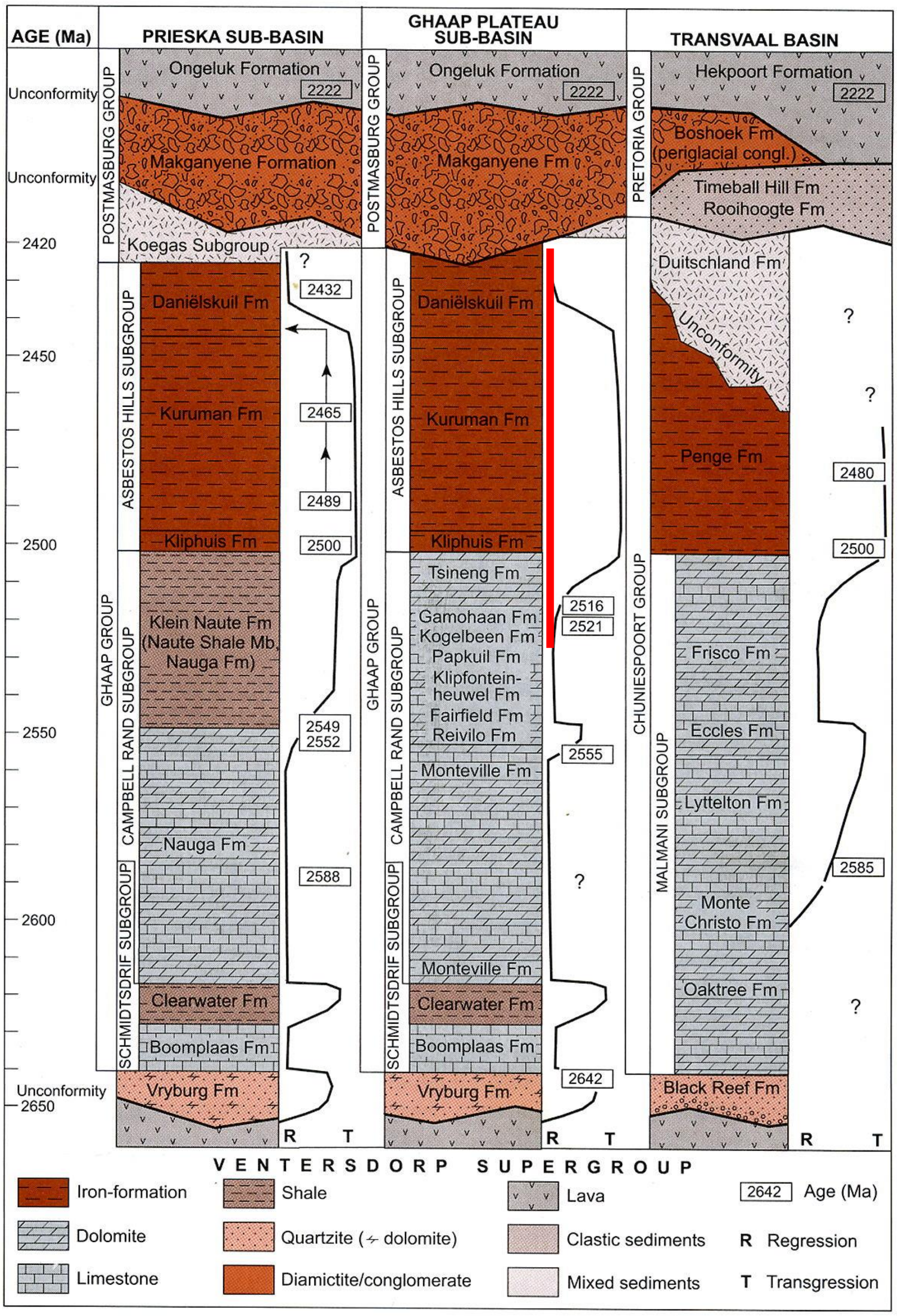

Fig. 7. Stratigraphy of the Late Archaean to Early Proterozoic Transvaal Supergroup (Ghaap Group and Postmasburg Groups) in the Kuruman Area, Ghaap Plateau Subbasin – see central column here (From Eriksson *et al.* 2006). The vertical red line indicates the rock units that are represented in the broader study region near Kathu, although they are mainly encountered in the subsurface here.

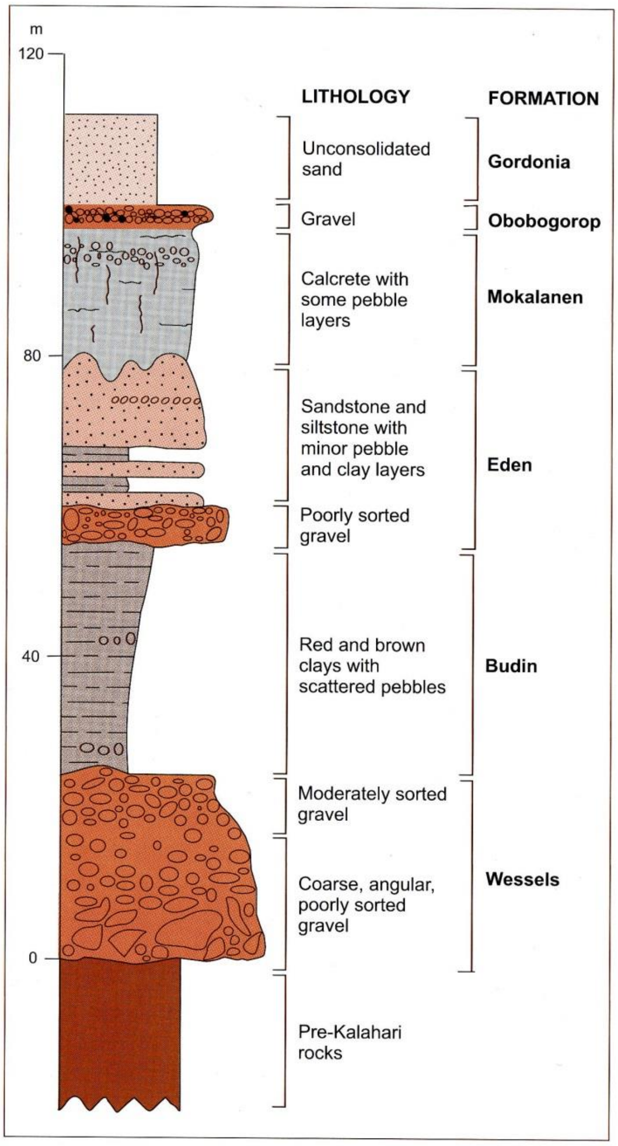

Fig. 8. Generalised stratigraphy of the Late Cretaceous to Recent Kalahari Group (From Partridge *et al.* 2006). Most or all of these rock units are represented within the Kathu – Sishen study region but only Plio-Pleistocene subsurface calcretes (Mokalanen Formation) and overlying Pleistocene to Recent aeolian sands of the Gordonia Formation are definitely recorded in the Bestwood project area.

3. POTENTIAL PALAEONTOLOGICAL HERITAGE WITHIN THE STUDY AREA

Fossil biotas recorded from each of the main rock units mapped at surface within the study region are briefly reviewed in Table 1 (Based largely on Almond & Pether 2008 and references therein), where an indication of the palaeontological sensitivity of each rock unit is also given. Pervasive calcretisation and chemical weathering of many near-surface bedrocks in the Northern Cape has often compromised their original fossil heritage in many areas.

The fossil record of the **Kalahari Group** is generally sparse and low in diversity. The **Gordonia Formation** dune sands were mainly active during cold, drier intervals of the Pleistocene Epoch that were inimical to most forms of life, apart from hardy, desert-adapted species. Porous dune sands are not generally conducive to fossil preservation. However, mummification of soft tissues may play a role here and migrating lime-rich groundwaters derived from the underlying bedrocks (including, for example, dolerite) may lead to the rapid calcretisation of organic structures such as burrows and root casts. Occasional terrestrial fossil remains that might be expected within this unit include calcretized rhizoliths (root casts) and termitaria (*e.g. Hodotermes*, the harvester termite), ostrich egg shells (*Struthio*) and shells of land snails (*e.g. Trigonephrus*) (Almond 2008, Almond & Pether 2008). Other fossil groups such as freshwater bivalves and gastropods (*e.g. Corbula, Unio*) and snails, ostracods (seed shrimps), charophytes (stonewort algae), diatoms (microscopic algae within siliceous shells) and stromatolites (laminated microbial limestones) are associated with local watercourses and pans. Microfossils such as diatoms may be blown by wind into nearby dune sands (Du Toit 1954, Dingle *et al*., 1983). These Kalahari fossils (or subfossils) can be expected to occur sporadically but widely, and the overall palaeontological sensitivity of the Gordonia Formation is therefore considered to be low. Underlying calcretes of the **Mokolanen Formation** might also contain trace fossils such as rhizoliths, termite and other insect burrows, or even mammalian trackways. Mammalian bones, teeth and horn cores (also tortoise remains, and fish, amphibian or even crocodiles in wetter depositional settings such as pans) may be expected occasionally expected within Kalahari Group sediments and calcretes, notably those associated with ancient, Plio-Pleistocene alluvial gravels, pans and solution cavity infills.

Important, taxonomically diverse Middle to Late Pleistocene mammalian macrofaunas have been recorded from multiple doline infill sediments at **Kathu Pan**, *c*. 5.5. km NW of Kathu town. The fauna mainly consists of delicate, fragmentary tooth material (caps or shells or dental enamel) but also include some bones with at least one almost intact ungulate skeleton (Fig. 9). Most teeth and associated artefacts are covered with a distinctive shiny silicate patina. The fossils are assigned to the Cornelian Mammal Age (c. 1.6 Ma to 500 ka) and Florisian Mammal Age (c. 200 to 12 ka) that are associated with Acheulean and MSA stone artefact assemblages respectively (Klein 1984, 1988, Beaumont *et al.* 1984, Beaumont 1990, Beaumont 2004, Porat *et al.* 2010 and refs. therein; see also MacRae 1999). Interesting Cornelian mammal taxa found here include the extinct *Elephas recki* and *Hippopotamus gorgops* as well as various equids, white rhino and hartebeest / wildebeest-sized alcephalines. The dominance of grazers over browsers or mixed feeders among the Middle Pleistocene mammalian fauna suggests that the vegetation was grassy savannah at the time. Higher up in the succession the remains of typical Florisian forms such as *Pelorovis antiquus* the Giant Buffalo*, Megalotragus priscus* the Giant Hartebeest and *Equus capensis* the giant Cape Horse also occur (Fig. 10). Many of the tooth fragments as well as the associated MSA stone artefacts in this younger horizon are abraded, suggesting fluvial reworking of material into the doline together with the gravelly sand matrix. Additional fossil material of biostratigraphic and palaeoecological interest from the Kathu Pan doline infills include fossil pollens from well-developed peat horizons (Scott 2000), bird fossils, ostrich egg shell fragments and terrestrial gastropods. The mammalian remains may belong to animals attracted to permanent waterholes (*e.g.* spring eyes), especially during drier phases of the Pleistocene Epoch. The close association of large mammal fossils with abundant stone tools as well as occasional evidence for butchering suggests that human hunters or scavengers may also have played a role as concentration agents.

It is noted that potentially fossiliferous doline infill sediments similar to those at Kathu Pan are not apparent near-surface within the Bestwood development area (D. Morris, pers. comm. January 2014). However, the possibility that they are present but hidden beneath superficial sediments (*e.g.* aeolian sands) cannot be excluded. If so, they are most likely to occur along the NW-SE trending Vlermuisleegte drainage line that might extend into Erf 8434 at the northern end of the study area (Temporary Management Construction Camp).

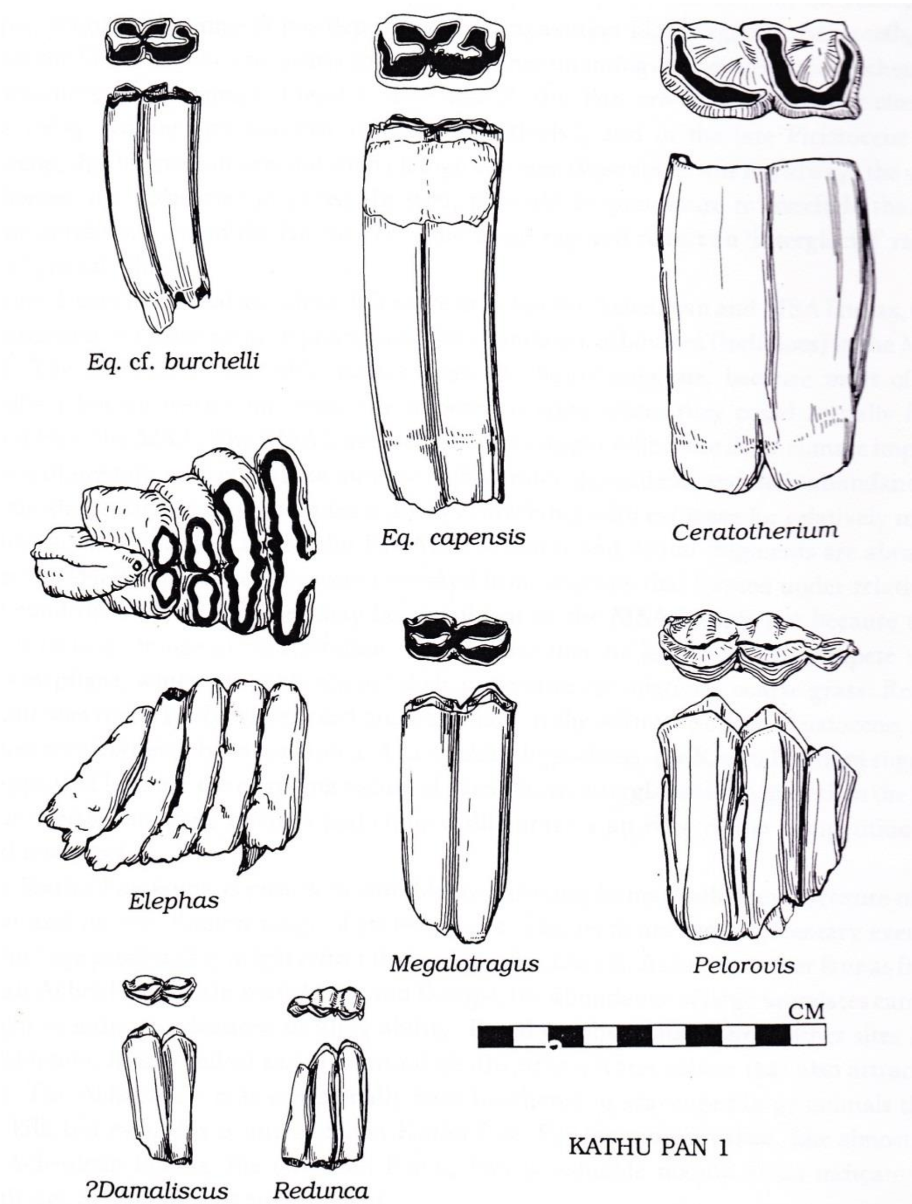

Fig. 9. Selection of Pleistocene large mammal teeth collected from solution cavity infills (dolines) at Kathu Pan, Northern Cape (From Klein 1988).

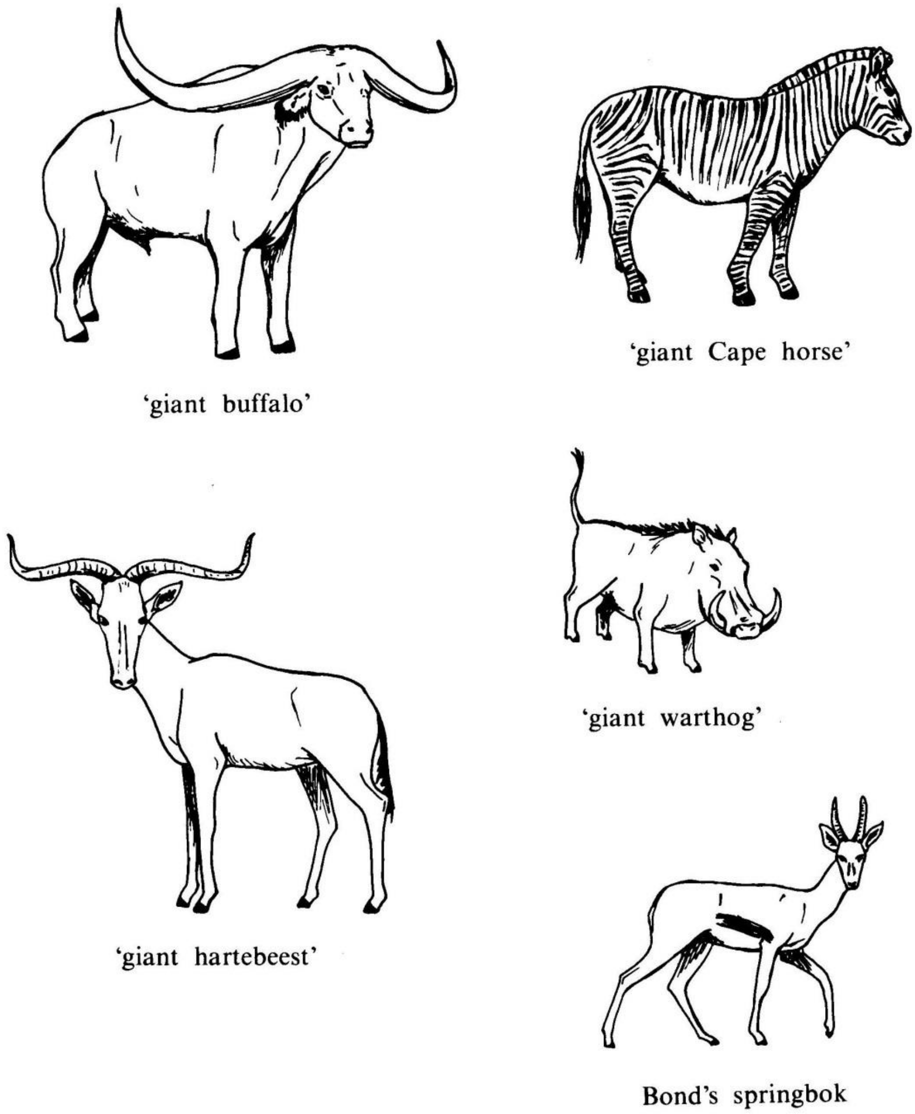

Fig. 10. Selection of extinct Pleistocene mammals of the Florisian Mammal Age, most of which are represented at Kathu Pan (From Klein 1984).

Low diversity trace fossil assemblages attributable to invertebrates and plants are commonly associated with Kalahari Group calcrete horizons and are likely to be represented within the Bestwood development study area as well. Trace fossil assemblages recorded from calcretised upper Kalahari Group sediments in borrow pits near Witloop, *c.* 45 km NNW of the Bestwood study area, are probably attributable to infaunal invertebrates (*e.g.* insects such as termites), plant root moulds (rhizoliths) as well as the densely-packed stems of reedy vegetation associated with damp, vlei-like areas in the almost-abandoned course of the Witloopleegte in Late Pleistocene or Holocene times (Almond 2013a) (Fig. 11). Similar trace fossil assemblages are probably of widespread occurrence within the Kalahari Group (*cf* Nash & McLaren 2003).

Well-developed Kalahari calcrete hardpans exposed in quarries near Mamathwane, some 35 km NNW of the present study area near Kathu, display a well-developed vuggy, bioturbated texture. Good calcrete burrow casts and rhizoliths (plant root casts) are seen within the main hardpan (Almond 2013b). Burrow casts are *c*. 1 cm wide and even in width, reaching lengths of over 50 cm

(Fig. 12). Subparallel, thin vertical structures are probable plant stem or root casts, probably related to reedy vegetation in vlei areas associated with palaeo-watercourses.

Networks of karstic solution hollows, such as observed within calcrete hardpans in the Sishen area (Fig. 5), *c*. 18 km SW of the Bestwood study area, might have served as traps for vertebrates (*e.g.* small mammals and reptiles, reworked bones and teeth) as well as land snails in the Pleistocene Epoch (Almond 2013a). However, vertebrate or other fossil remains have not been recorded hitherto from such settings in the Kalahari region.

Table 1: Fossil heritage of rock units represented in the Kathu study region (From Almond & Pether 2008)

GEOLOGICAL UNIT	ROCK TYPES & AGE	FOSSIL HERITAGE	PALAEONT-OLOGICAL SENSITIVITY	RECOMMENDED MITIGATION
OTHER LATE CAENOZOIC TERRESTRIAL DEPOSITS OF THE INTERIOR **(Most too small to be indicated on 1: 250 000 geological maps)**	**Fluvial, pan, lake and terrestrial sediments, including diatomite (diatom deposits), pedocretes, spring tufa / travertine, cave deposits, peats, colluvium, soils, surface gravels including downwasted rubble** **MOSTLY QUATERNARY TO HOLOCENE** **(Possible peak formation 2.6-2.5 Ma)**	**Bones and teeth of wide range of mammals (*e.g.* mastodont proboscideans, rhinos, bovids, horses, micromammals), reptiles (crocodiles, tortoises), ostrich egg shells, fish, freshwater and terrestrial molluscs (unionid bivalves, gastropods), crabs, trace fossils (*e.g.* termitaria, horizontal invertebrate burrows, stone artefacts), petrified wood, leaves, rhizoliths, diatom floras, peats and palynomorphs.** **calcareous tufas at edge of Ghaap Escarpment might be highly fossiliferous (*cf* Taung in NW Province – abundant Makapanian Mammal Age vertebrate remains, including australopithecines)**	**LOW** **Scattered records, many poorly studied and of uncertain age**	**Any substantial fossil finds to be reported by ECO to SAHRA**
Gordonia Formation (Qs) **KALAHARI GROUP** ***plus*** **SURFACE CALCRETES (Tl / Qc)**	**Mainly aeolian sands *plus* minor fluvial gravels, freshwater pan deposits, calcretes** **PLEISTOCENE to RECENT**	**Calcretised rhizoliths & termitaria, ostrich egg shells, land snail shells, rare mammalian and reptile (*e.g.* tortoise) bones, teeth (e.g. doline infills)** **freshwater units associated with diatoms, molluscs, stromatolites *etc.***	**LOW**	**Any substantial fossil finds to be reported by ECO to SAHRA**

Fig. 11. Substantial hollow, branching invertebrate burrow systems with a discrete lining preserved within the near-surface calcrete hardpan near Witloop (Scale in cm and mm) (From Almond 2013a).

Fig. 12. Calcrete hardpan with bioturbated upper and lower zones, showing elongate, steeply-inclined invertebrate burrow casts *c*. 1 cm across, Mamathwane (Hammer = c. 30 cm) (From Almond 2013b).

4. PALAEONTOLOGICAL HERITAGE IMPACT ASSESSMENT

During construction of the Bestwood residential development the disturbance, damage or destruction of fossil remains preserved at or beneath the ground surface within the project footprint are negative impacts that may potentially compromise legally – protected fossil heritage here. Activities undertaken predominantly during the preparation and construction phases of the project will have the greatest potential to disturb or damage palaeontological resources on site. These activities include:

- Site and vegetation clearance;
- Levelling, compacting and grading activities;
- Trenching and excavations for infrastructure and pipelines; and
- The laying of foundations for buildings and structures.

At an operational phase, maintenance and servicing activities may result in forms of excavation, but will be limited to previously disturbed footprints.

The extent to which construction and operational activities are likely to interfere with such fossil resources is expected to be minimal owing to the generally sparse distribution of fossils within the Gordonia Formation aeolian sands and underlying thick Mokolanen Formation calcretes that mantle the site. Mammalian bones, teeth and horn cores (also tortoise remains, and fish, amphibian or even crocodiles in wetter depositional settings such as pans) may be expected occasionally within Kalahari Group calcretes, notably those associated with ancient, Plio-Pleistocene alluvial gravels and solution hollow infills. However, significant impacts on such rare fossil resources are unlikely here, with the possible exception of the Vlermuisleegte drainage line.

Potential impacts in fossil heritage resources within the Bestwood residential study area are assessed in Table 2 below. This assessment applies to all relevant components of the project listed in the scope of work for this study, *viz*. Phase 1 and Phase 2 of the development, including the construction / management camp located on Erf 8434, as well as the affected area where the proposed sewage pipeline (pink dashed line in Fig. 3) traverses third party land (west of the development area as well as east of the development area), as well as the location of the WWTW where construction has ceased until further notice (purple demarcated area in Fig. 3 herein).

It is concluded that the overall impact significance of the proposed development is LOW as far as palaeontological heritage is concerned. Likewise, cumulative impacts are likely to be of LOW significance, given the scarcity of important fossils (mainly vertebrate remains) within the sedimentary rock units concerned as well as the huge outcrop area of the Kalahari Group as a whole.

The degree of confidence for this assessment is rated as **medium** due to the uncertainty surrounding the presence or absence of buried, potentially fossiliferous doline infill deposits within the study area.

Table 2: Impact assessment for the Bestwood residential development: Disturbance, Damage or Destruction of Palaeontological Heritage Resources

CRITERIA	RATING	COMMENTS
Extent of impact	LOW	Limited to development footprint (which is albeit large)
Duration of impact	PERMANENT	
Intensity of impact	LOW	Significant fossil resources within the rocks underlying the development footprint are generally rare while the fossils usually found (*e.g.* trace fossils) are of widespread occurrence within the Kalahari Group outcrop area. There is currently no evidence for potentially fossiliferous solution cavity infill sediments within calcretes beneath the study area. If these are indeed present subsurface, the impact intensity would be locally HIGH.
Probability of impact	HIGH	Trace fossils (invertebrate burrows, plant root casts *etc.*) are likely to occur within the development footprint, **although these are not considered to be of high palaeontological significance**.
Degree of reversibility	LOW	Damage, destruction of fossil material and loss of contextual geological data is irreversible.
Irreplaceability of resource	LOW	This applies to the commoner Kalahari Group fossils (*e.g.* trace fossils) but NOT vertebrate remains.
Cumulative impacts	LOW	Cumulative impacts cannot be accurately assessed in the absence of data on other developments in the broader study region (*e.g.* numerous mining projects). However, given the large outcrop area of the Kalahari Group sediments, cumulative impacts are provisionally assessed here as LOW.
Significance rating	**LOW**	This rating applies pending the exposure of any significant fossil vertebrate remains (*e.g.* bones, teeth, horn cores) during the remainder of the construction phase of the development.

4.1. Recommended mitigation measures during the construction phase

Due to the inferred low impact significance of the Bestwood residential development as far as fossil heritage resources are concerned, no further specialist palaeontological studies or monitoring are recommended at this stage.

By analogy with the well-known nearby fossil site at Kathu Pan, fossil vertebrate remains (bones, teeth) that may be exposed and disturbed during the construction phase are likely to be associated with Early to Middle Stone Age stone artefacts embedded in unconsolidated sedimentary infills of solution cavities within the subsurface calcrete hardpan. Any archaeological monitoring for stone tools within the study area would probably reveal whether or not significant fossil material is also present.

The following generic palaeontological monitoring and mitigation measures should be implemented during the remaining part of the construction phase of the Bestwood residential development:

- The Site Engineer and /or Environmental Control Officer (ECO) responsible for monitoring environmental compliance of the development must remain aware that all sedimentary deposits have the potential to contain fossils and he/she should thus monitor all substantial excavations into sedimentary bedrock for fossil remains. If any substantial fossil remains (*e.g.* vertebrate bones, teeth, horn cores) are found during construction SAHRA should be notified immediately (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) so that appropriate mitigation (*i.e.* recording, sampling or collection) by a palaeontological specialist can be considered and implemented, at the developer's expense.

- A chance-find procedure should be implemented so that, in the event of fossils being uncovered, the ECO and /or Site Engineer will take the appropriate action, which includes:
  - Stopping work in the immediate vicinity and fencing off the area with tape to prevent further access;
  - Reporting the discovery to the provincial heritage agency and/or SAHRA;
  - Appointing a palaeontological specialist to inspect, record and (if warranted) sample or collect the fossil remains;
  - Implementing further mitigation measures proposed by the palaeontologist; and
  - Allowing work to resume only once clearance is given in writing by the relevant authorities.
- During maintenance and servicing of infrastructure, if excavation is required, it shall be limited to the disturbed footprint as far as practicable. Should bulk works exceed the currently proposed development footprint, as outlined in Fig. 3 of this report, SAHRA should be notified.

If the mitigation measures outlined above are adhered to, the residual impact significance of any construction and operational phase impacts on local palaeontological resources is considered to be LOW.

5. CONCLUSIONS AND RECOMMENDATIONS

According to geological maps, the geotechnical report[9] and recently acquired on-site field data the flat-lying Bestwood residential development study area is underlain by a considerable thickness of Plio-Pleistocene to Recent sediments of the Kalahari Group. The underlying Precambrian bedrocks – *viz*. dolomites, cherts and possibly iron formations of the Transvaal Supergroup – are too deeply buried to be directly affected by the Bestwood development. The Kalahari Group succession east of Kathu mainly comprises well-developed calcretes or surface limestones (Mokolanen Formation) that may total 30 m or more in thickness in the region, together with a thin (< 1m) surface veneer of aeolian sands (Gordonia Formation) and sparse near-surface gravels. In general the Kalahari Group calcretes and sands are of low palaeontological sensitivity, mainly featuring widely-occurring plant and animal trace fossils (*e.g.* invertebrate burrows, plant root casts). Recent palaeontological heritage assessments in the Sishen – Hotazel region by the author (Almond 2013a, 2013b) have not recorded significant fossil material within these near-surface Kalahari successions. A very important fossil assemblage of Pleistocene to Holocene mammal remains - predominantly teeth with scarce bone material associated with Earlier, Middle and Later Stone Age artefacts, well-preserved peats and pollens - is recorded from unconsolidated doline (solution hollow) sediments at the well-known Kathu Pan site, located some 7 km northwest of the Bestwood study area. However, there are no indications of comparable fossiliferous, tool-bearing solution hollow infills exposed at present in the study area (Dr D. Morris, McGregor Museum, pers. comm., 2014). Such fossil-bearing sediments might conceivably be present but hidden beneath cover sands, however; if so, the most likely location for

[9] Undertaken by V&V Consulting Engineers: 2008

solution hollows would be within Erf 8434[10], in line with the Vlermuisleegte pans that extend to the northwest of the study area.

The overall impact significance of the proposed Bestwood residential development is rated as LOW as far as palaeontological heritage is concerned. Likewise, cumulative impacts are likely to be of LOW significance, given the scarcity of important fossils (especially vertebrate remains) within the sedimentary rock units concerned as well as the huge outcrop area of the Kalahari Group as a whole. This assessment applies to all relevant components of the project listed in the scope of work for this study, *viz*. Phase 1 and Phase 2 of the development, including the construction / management camp located on Erf 8434, the affected area where the proposed sewage pipeline traverses third party land (west of the development area as well as east of the development area), as well as the location of the wastewater treatment works (WWTW). The degree of confidence for this assessment is rated as medium due to the uncertainty surrounding the presence or absence of potentially fossiliferous buried doline infill deposits within the study area.

Due to the inferred low impact significance of the Bestwood residential development, as far as fossil heritage resources are concerned, no further specialist palaeontological studies or monitoring are recommended at this stage.

The following mitigation measures to safeguard fossils exposed on site during the construction phase of the development are proposed:

- The ECO and / or the Site Engineer responsible for the development must remain aware that all sedimentary deposits have the potential to contain fossils and he / she should thus monitor all substantial excavations into sedimentary bedrock for fossil remains. If any substantial fossil remains (*e.g.* vertebrate bones, teeth, horn cores) are found during construction SAHRA should be notified immediately (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) so that appropriate mitigation (*i.e.* recording, sampling or collection) by a palaeontological specialist can be considered and implemented, at the developer’s expense.

- A chance-find procedure should be implemented so that, in the event of fossils being uncovered, the ECO / Site Engineer will take the appropriate action, which includes:

    - Stopping work in the immediate vicinity and fencing off the area with tape to prevent further access;

    - Reporting the discovery to the provincial heritage agency and/or SAHRA;

    - Appointing a palaeontological specialist to inspect, record and (if warranted) sample or collect the fossil remains;

    - Implementing further mitigation measures proposed by the palaeontologist; and

    - Allowing work to resume only once clearance is given in writing by the relevant authorities.

- During maintenance and servicing of infrastructure, if excavation is required, it shall be limited to the disturbed footprint as far as practicable. Should bulk works exceed the currently proposed development footprint, as outlined in Fig. 3 of this report, SAHRA should be notified. If the mitigation measures outlined above are adhered to, the residual impact significance of any construction phase impacts on local palaeontological resources is considered to be low.

[10] Where the construction / management camp has been built

The mitigation measures proposed here must be incorporated into the Environmental Management Programme (EMP) for the Bestwood residential development project.

The palaeontologist concerned with mitigation work will need a valid collection permit from SAHRA. All work would have to conform to international best practice for palaeontological fieldwork and the study (*e.g.* data recording fossil collection and curation, final report) should adhere to the minimum standards for Phase 2 palaeontological studies recently published by SAHRA (2013).

6. ACKNOWLEDGEMENTS

Ms Tamara Drake of Jeffares & Green (Pty) Ltd, Cape Town, is thanked for commissioning this study, for providing the relevant background information, and for helpful discussions about this project. I also owe special thanks to Dr David Morris of the McGregor Museum, Kimberley, for sharing critical geological field data and photographs from the project area at very short notice.

7. 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. 2010. Prospecting application for iron ore and manganese between Sishen and Postmasburg, Northern Cape Province: farms Jenkins 562, Marokwa 672, Thaakwaneng 675, Driehoekspan 435, Doringpan 445 and Macarthy 559: desktop palaeontological assessment, 20 pp. Natura Viva cc, Cape Town.

ALMOND, J.E. 2012a. Proposed westerly extension of Sishen Iron Ore Mine near Kathu, Kalagadi District Municipality, Northern Cape. Palaeontological specialist study" desktop study, 18 pp. Natura Viva cc, Cape Town.

ALMOND, J.E. 2012b. 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 assessment: desktop study, 28 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 new railway compilation yard at Mamathwane near Hotazel, John Taolo Gaetsewe District Municipality, Northern Cape. Palaeontological specialist assessment: combined desktop and field-based study, 29 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.

BEAUMONT, P.B. 1990. Kathu Pan. In: Beaumont, P.B. & Morris, D. (Eds.) Guide to archaeological sites in the Northern Cape, pp. 75-100 *plus* table 1, figs 1-19. McGregor Museum, Kimberley.

BEAUMONT, P.B. 2004. Kathu Pan and Kathu Townlands / Uitkoms. In: Archaeology in the Northern Cape: some key sites, pp. 50-53 plus 4 pages of figs. McGregor Museum, Kimberley.

BEAUMONT, P.B., VAN ZINDEREN BAKKER, E.M. & VOGEL, J.C. 1984. Environmental changes since 32, 000 BP at Kathu Pan, Northern Cape. In: Vogel, J.C. (Ed.) Late Cenozoic palaeoclimates of the southern hemisphere, pp. 329-338. Balkema, Rotterdam.

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.

BOSCH, P.J.A. 1993. Die geologie van die gebied Kimberley. Explanation to 1: 250 000 geology Sheet 2824 Kimberley, 60 pp. Council for Geoscience, Pretoria.

BUTZER, K.W. 1984. Archaeology and Quaternary environment in the interior of southern Africa. In: Klein, R.G. (Ed.) Southern African prehistory and paleoenvironments, pp 1-64. Balkema, Rotterdam.

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. & 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.

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.

HADDON, I.G. 2005. The sub-Kalahari geology and tectonic evolution of the Kalahari Basin, Southern Africa. Unpublished PhD thesis, University of Johannesburg, 343 pp.

HENDEY, Q.B. 1984. Southern African late Tertiary vertebrates. In: Klein, R.G. (Ed.) Southern African prehistory and paleoenvironments, pp 81-106. Balkema, Rotterdam.

KLEIN, R.G. 1984. The large mammals of southern Africa: Late Pliocene to Recent. In: Klein, R.G. (Ed.) Southern African prehistory and paleoenvironments, pp 107-146. Balkema, Rotterdam.

KLEIN, R.G. 1988. The archaeological significance of animal bones from Acheulean sites in southern Africa. The African Archaeological Review 6, 3-25.

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.

NASH, D.J. & SHAW, P.A. 1998. Silica and carbonate relationships in silcrete-calcrete intergrade duricrusts from the Kalahari of Botswana and Namibia. Journal of African Earth Sciences 27, 11-25.

NASH, D.J. & MCLAREN, S.J. 2003. Kalahari valley calcretes: their nature, origins, and environmental significance. Quaternary International III, 3-22.

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.

PORAT, N., CHAZAN, M., GRÜN, R., AUBERT, M., EISENMANN, V. & HORWITZ, L.K. 2010. New radiometric ages for the Fauresmith industry from Kathu Pan, southern Africa: implications for Earlier to Middle Stone Age transition. Journal of Archaeological Science 37, 269-283.

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

SCOTT, L. 2000. Pollen. In: Partridge, T.C. & Maud, R.R. (Eds.) The Cenozoic of southern Africa, pp.339-35. Oxford University Press, Oxford.

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, R.J., THOMAS, M.A. & MALHERBE, S.J. 1988. The geology of the Nossob and Twee Rivieren areas. Explanation for 1: 250 000 geology sheets 2520-2620. 17pp. Council for Geoscience, Pretoria.

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

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.

TRUTER, F.C., WASSERSTEIN, B., BOTHA, P.R., VISSER, D.L.J., BOARDMAN, L.G. & PAVER, G.L. 1938. The geology and mineral deposits of the Olifants Hoek area, Cape Province. Explanation of 1: 125 000 geology sheet 173 Olifants Hoek, 144 pp. Council for Geoscience, Pretoria.

VISSER, D.L.J. 1958. The geology and mineral deposits of the Griquatown area, Cape Province. Explanation to 1: 125 000 geology sheet 175 Griquatown, 72 pp. Council for Geoscience, Pretoria.

VISSER, D.J.L. *et al.* 1989. The geology of the Republics of South Africa, Transkei, Bophuthatswana, Venda and Ciskei and the Kingdoms of Lesotho and Swaziland. Explanation of the 1: 1 000 000 geological map, fourth edition, 491 pp. Council for Geoscience, Pretoria.

8. 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 under the aegis of his Cape Town-based company *Natura Viva* cc. He is 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