Palaeontological Impact Assessment for the proposed Mining Rights application on Gloucester 674, Glosam Manganese, north of Postmasburg, Northern Cape Province

Site Visit (Phase 2) Report

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Expertise of Specialist

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Qualifications: PhD (Wits Univ, 1990); FRSSAf, ASSAf
Experience: 31 years research; 23 years PIA studies

Declaration of Independence

This report has been compiled by Professor Marion Bamford, of the University of the Witwatersrand, sub-contracted by, Archaeological and Heritage Services Africa (Pty) Ltd, Pretoria, South Africa. The views expressed in this report are entirely those of the author and no other interest was displayed during the decision making process for the Project.

Specialist: Prof Marion Bamford

Signature:

Executive Summary

A site visit (phase 2) Palaeontological Impact Assessment was requested (SAHRA Case ID: 16331) for the proposed Mining rights application on RE of Farm Gloucester 674, Glosam (north of Postmasburg), Northern Cape Province.

To comply with the South African Heritage Resources Agency (SAHRA) in terms of Section 38(8) of the National Heritage Resources Act, 1999 (Act No. 25 of 1999) (NHRA), a site visit Palaeontological Impact Assessment (PIA) was completed for the project by palaeontologists Marion Bamford and Alisoun House on 15 November 2021.

The proposed site lies on the non-fossiliferous Kuruman Formation, Gamogara Formation and the potentially fossiliferous limestones of the Ghaap Group and Kalahari sands. From the site visit NO FOSSILS were found. No limestone, no stromatolites and no palaeo-pan or palaeo-spring features were found so it is extremely unlikely that fossils occur on the property. Since the SAHRIS palaeosensitivity map indicates that the Ghaap Group stratum is potentially fossiliferous, a Fossil Chance Find Protocol should be added to the EMPr. Based on this information it is recommended that no further palaeontological site visit is required unless fossils are found by the geologist or other responsible person when excavations or drilling commences.

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1. Background

ASSMANG has sold a number of its ferro-manganese rich properties on the Maremane dome to other mining companies and Wepex Trading (Pty) Ltd owns the Remaining Extent of Gloucester No. 674, near Glosam. They propose to carry out open cast mining with yellow equipment for manganese and iron ore (Figures 1-2).

Wadala Mining and Consulting Pty Ltd has been appointed by Wepex Trading (Pty) Ltd to conduct an Environmental Authorisation Application in support of a Mining Right Application for Glosam Manganese Mine for proposed mining activities on Remaining Extent of Gloucester No. 674, near Glosam, Northern Cape Province (NC 30/5/1/2/2/10186 MR).

A draft Environmental Impact Assessment (EIA) has been submitted in terms of the National Environmental Management Act, 1998 (NEMA) and the NEMA EIA Regulations for activities that trigger the Mineral and Petroleum Resources Development Act, 2002 (MPRDA)(As amended). The proposed mining right application area covers 1 165.8 ha. The proposed activities and infrastructure include blasting, explosives magazine, sewage facilities, clean and dirty water system, fuel storage, open pit, generator, offices, parking, processing plant, access and haul roads, salvage yard, security, various stockpiles, stormwater dam, topsoil storage area, waste disposal site, rock dump, concurrent rehabilitation, workshop and wash bay, water distribution pipeline, water tanks, weigh bridge and control room.

SAHRA has requested a Palaeontological site visit (Case ID: 16331) for the mining rights application. The site visit and walk through was conducted by professional palaeontologists Marion Bamford and Alisoun House on 15th November 2021 and is reported herein.

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

	A specialist report prepared in terms of the Environmental Impact Regulations of 2017 must contain:	**Relevant section in report**
ai	Details of the specialists who prepared the report	Appendix B
aii	The expertise of that person to compile a specialist report including a curriculum vitae	Appendix B
b	A declaration that the person is independent in a form as may be specified by the competent authority	Page 1
c	An indication of the scope of, and the purpose for which, the report was prepared	Section 1
ci	An indication of the quality and age of the base data used for the specialist report: SAHRIS palaeosensitivity map accessed – date of this report	Yes
cii	A description of existing impacts on the site, cumulative impacts of the proposed development and levels of acceptable change	Section 5
d	The date and season of the site investigation and the relevance of the season to the outcome of the assessment	N/A

e	A description of the methodology adopted in preparing the report or carrying out the specialised process	Section 2
f	The specific identified sensitivity of the site related to the activity and its associated structures and infrastructure	Section 4
g	An identification of any areas to be avoided, including buffers	Section 7
h	A map superimposing the activity including the associated structures and infrastructure on the environmental sensitivities of the site including areas to be avoided, including buffers;	N/A
i	A description of any assumptions made and any uncertainties or gaps in knowledge;	Section 5
j	A description of the findings and potential implications of such findings on the impact of the proposed activity, including identified alternatives, on the environment	Section 4
k	Any mitigation measures for inclusion in the EMPr	Section 8, Appendix A
l	Any conditions for inclusion in the environmental authorisation	N/A
m	Any monitoring requirements for inclusion in the EMPr or environmental authorisation	Section 8, Appendix A
ni	A reasoned opinion as to whether the proposed activity or portions thereof should be authorised	Section 7
nii	If the opinion is that the proposed activity or portions thereof should be authorised, any avoidance, management and mitigation measures that should be included in the EMPr, and where applicable, the closure plan	N/A
o	A description of any consultation process that was undertaken during the course of carrying out the study	N/A
p	A summary and copies if any comments that were received during any consultation process	N/A
q	Any other information requested by the competent authority.	N/A

Figure 1: Google Earth map of the RE of Gloucester 674 Mining rights area relative to other landmarks.

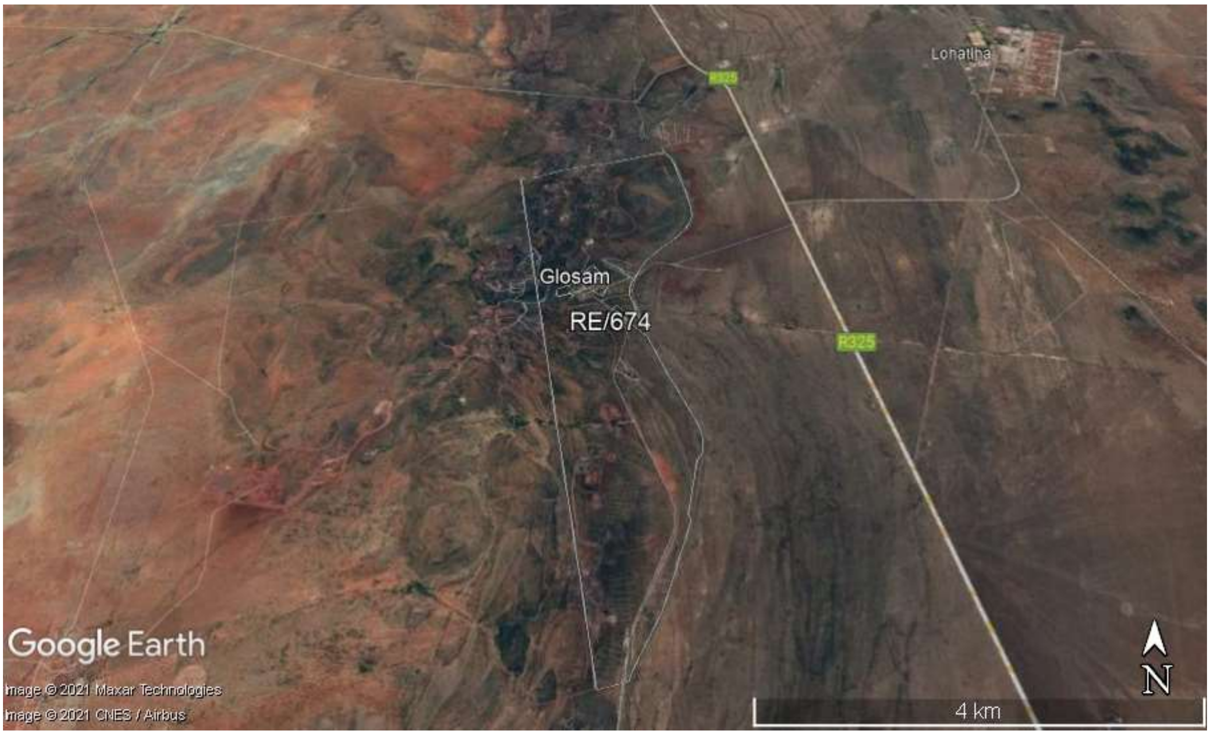

Figure 2: Google Earth map showing the boundary of the Wepex Gloucester 674 mining rights “Glosam Manganese” area shown within the white polygon. Note extensive existing mining impact in the north and along the west and central portions.

2. Methods and Terms of Reference

The Terms of Reference (ToR) for this study were to undertake a PIA and provide feasible management measures to comply with the requirements of SAHRA.
The methods employed to address the ToR included:

1. Consultation of geological maps, literature, palaeontological databases, published and unpublished records to determine the likelihood of fossils occurring in the affected areas. Sources included records housed at the Evolutionary Studies Institute at the University of the Witwatersrand and SAHRA databases;
2. Where necessary, site visits by a qualified palaeontologist to locate any fossils and assess their importance (as reported herein, and collect or rescue fossils if required);
3. Where appropriate, collection of unique or rare fossils with the necessary permits for storage and curation at an appropriate facility (*as indicated in section 4 below)*; and
4. Determination of fossils' representivity or scientific importance to decide if the fossils can be destroyed or a just a representative sample collected and housed in a recognised repository.

3. Geology and Palaeontology

i. Project location and geological context

The mine area lies in the central part of the large Maremane Dome that is in the western side of the Griqualand West Basin. This basin is one of three large, ancient basins that contain sediments of the Transvaal Supergroup. Underlain by the Venterdorp Supergroup and overlain by the Olifantshoek Supergroup, the Transvaal Supergroup rocks preserve one of world's earliest carbonate platform successions (Beukes, 1987; Eriksson et al., 2006; Zeh et al., 2020). In some areas there are well preserved stromatolites that are evidence of the photosynthetic activity of blue green bacteria and green algae. These microbes formed colonies in warm, shallow seas.

The Late Archaean to early Proterozoic Transvaal Supergroup is preserved in three structural basins on the Kaapvaal Craton (Eriksson et al., 2006). In South Africa are the Transvaal and Griqualand West Basins, and the Kanye Basin is in southern Botswana. The Griqualand West Basin is divided into the Ghaap Plateau sub-basin and the Prieska sub-basin. Sediments in the lower parts of the basins are very similar but they differ somewhat higher up the sequences. Several tectonic events have greatly deformed the south western portion of the Griqualand West Basin between the two sub-basins

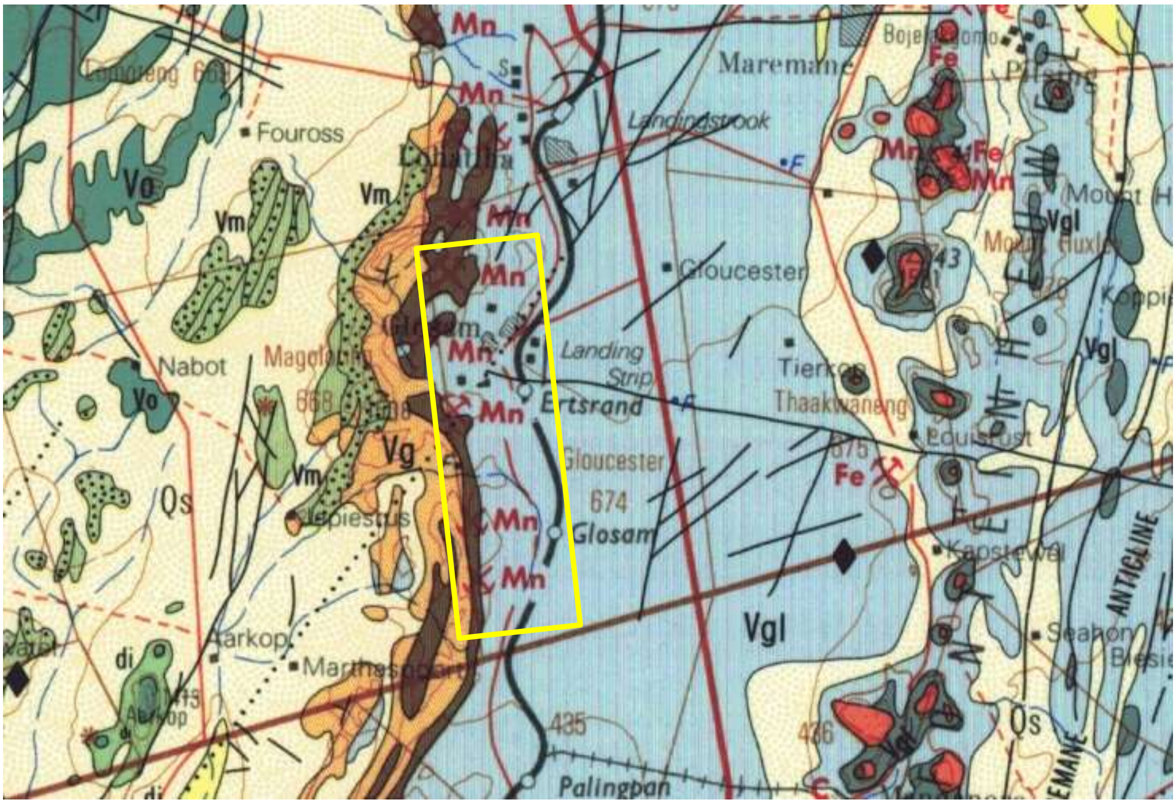

Figure 3: Geological map of the area around the farm Gloucester 674. The location of the proposed project is indicated within the yellow outline. Abbreviations of the rock types are explained in Table 2. Map enlarged from the Geological Survey 1: 250 000 map 2722 Kuruman.

Table 2: Explanation of symbols for the geological map and approximate ages (Eriksson et al., 2006; Partridge et al., 2006; Zeh et al., 2020). SG = Supergroup; Fm = Formation; Ma = million years; grey shading = formations impacted by the project.

Symbol	Group/Formation	Lithology	Approximate Age
Qs	Quaternary	Alluvium, sand, calcrete	Neogene, ca 2.5 Ma to present
Tl	Tertiary surface limestone	Surface limestones	Last 65 Ma
Vg	Gamagara Fm, Olifantshoek SG	Quartzite, conglomerate, flagstone, shale, basaltic lava	Ca 2200 Ma
Vo	Ongeluk Fm, Postmasburg Group, Transvaal SG	Lava, volcanic rocks	Ca 2222 Ma
Vm	Makganyene Fm, Postmasburg Group, Transvaal SG	Diamictites, banded jasper, siltstone, mudstone	Ca 2256 Ma
Vak	Kuruman Fm, Asbestos Hills Subgroup, Ghaap Group, Transvaal SG	Banded iron formation	Ca 2460 – 2440 Ma
Vgl	Ghaap Group, Transvaal SG	Dolomite, limestones, chert	2600 – 2400 Ma

The Transvaal Supergroup rocks in the Griqualand West Basin can be correlated with the rocks in the Transvaal Basin, closely according to Beukes and colleagues, or not so closely according to Moore and colleagues. Nonetheless, these rocks represent on a very large scale, a sequence of sediments filling the basins under conditions of lacustrine, fluvial, volcanic and glacial cycles in a tectonically active region. The predominantly carbonaceous sediments are evidence of the increase in the atmosphere of oxygen produced by algal colony photosynthesis, the so-called Great Oxygen Event (ca 2.40 – 2.32 Ga) and precursor to an environment where diverse life forms could evolve. The Neoarchean-Paleoproterozoic Transvaal Supergroup in South Africa contains the well-preserved stromatolitic Campbellrand - Malmani carbonate platform (Griqualand West Basin – Transvaal Basin respectively), which were deposited in shallow seawater shortly before the Great Oxidation Event (GOE).

Gloucester 674 (Figure 3) falls in the Postmasburg karst-hosted type of manganese deposits whereas the BIF-hosted Kalahari Manganese Field (KMF) is in the Hotazel area and has by far the largest of such deposits holding some 4,200 Mt of manganese metal that represents about 77% of the world's known land-based resource (Beukes et al., 2016). The ferruginous ore bodies of the Western Belt are less irregular and laterally more continuous and extensive than those of the Eastern Belt due to their apparent original deposition as surficial sediment in small lakes or depressions on the ancient pre-Gamagara karstic land surface (ibid). This is one reason why these deposits have been mined for a longer period (up to the early 1980s), at a relatively large scale, in mines such as Glosam, Lohatlha and Bishop in the centre of the Maremane dome (ibid).

To the east are dolomites, limestones and cherts of the Ghaap Group, according to the geological map (Figure 3) but these were only encountered east of parallel to the road, during the survey. Overlying much of the area are the aeolian sands and alluvium of the Quaternary Kalahari Group.

ii. Palaeontological context

The palaeontological sensitivity of the area under consideration is presented in Figure 4. Most of the area is indicated as moderately sensitive (green) and this applies to the Gamogara Formation shales and quartzites and the Kalahari sands. The former has been interpreted as a synsedimentary feature of the Maremane Anticline with localised erosion and redeposition (Moen, 2006). No fossils have been recorded from this lithology.

The Kalahari sands have been transported by wind or water and so would not preserve fossils but they might have entrained more robust fossils such as bone fragments or silicified wood fragments. These fragments, however, would be out of context and so of minimal scientific interest.

Very highly sensitive rocks are indicated along the eastern margin and this applies to the Ghaap Group, but no formations have been distinguished. This group is divided into the lower Campbell Rand Subgroup dolomites, limestones and cherts and upper Asbestos Hills Subgroup iron formation. Only the Campbell Rand dolomites and limestones can preserve trace fossils such as stromatolites that are layers of mineral sediments deposited by the photosynthetic activity of green and blue-green algal colonies. The algal cells, however, are very rarely preserved. A variety of types and forms of stromatolites have been described by Beukes (1987). Banded iron and haematite in the Asbestos Hills Subgroup were formed by the seasonal oxidation of iron but these are not a trace fossils. The SAHRIS mapping appears to have taken the conservative approach and indicated all of the Ghaap Group as potentially fossiliferous.

The Ongeluk Formation outcrops in the western part of the Farm Gloucester but this portion is not part of the current project. These rocks are of volcanic origin and do not preserve fossils.

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

Figure 4: SAHRIS palaeosensitivity map for the site for the proposed Glosam-Gloucester 674 MR application shown within the yellow outline. Background colours indicate the following degrees of sensitivity: red = very highly sensitive; orange/yellow = high; green = moderate; blue = low; grey = insignificant/zero.

Iii Site visit observations

The palaeontological site visit and survey was carried on the 15th of November, 2021, focussing on the very highly sensitive areas (Figure 4) along the eastern part of the property, from north to south (Table 3). The area was walked in the north around the points (1-7) and in the southern cluster (8-9) but only a few GPS points were taken.

Note the areas that have been or are being mined were not surveyed because they are in the non-fossiliferous Kuruman Formation that contains the ferro-manganese that is the target of the mining operation.

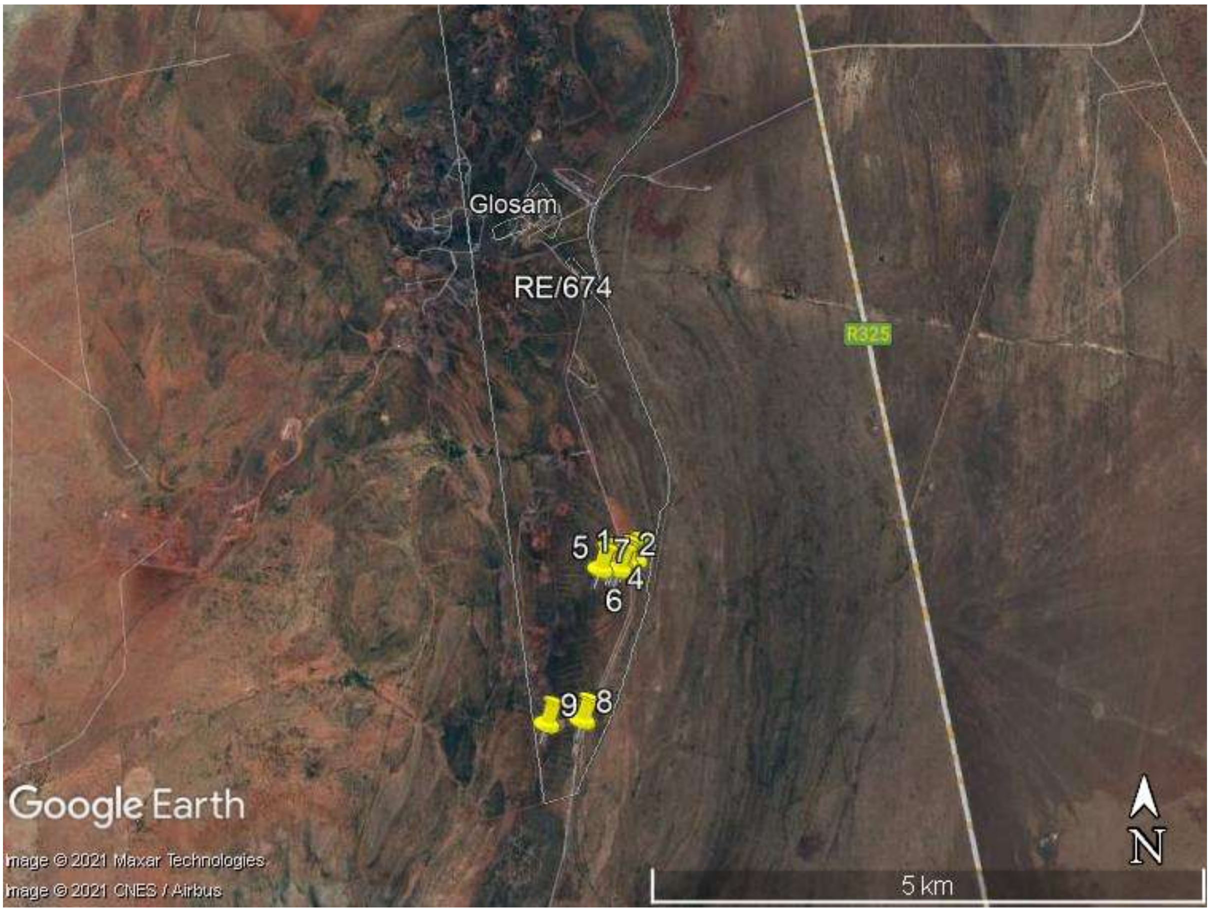

Figure 5: Google Earth map with GPS points and sites as indicated. Refer to Table 3 for site observations and related photographs (Figures 8-12). Stop 1 is the base of the test strip, moving uphill (westwards from Ghaap Plateau rocks to Kuruman Fm rocks). Strips are 5m wide and traverse from the valley to the ridge top (next property). Test trenches are at random positions within the test strip and are less than 1m wide and up to 2m deep.

Figure 6: Google Earth map with the first cluster of points along the east-west transect shown in detail.

Figure 7: Google Earth map showing the southern cluster of points in detail. The lighter horizontal bands are the old transects where woody vegetation was cleared previously.

Table 3: Site visit observations for Glosam Manganese mine on 15th November 2021.

GPS coordinates	Observations	Figure
Stop 1: test strip 28° 6' 46" S 23° 2' 48" E	Central part of mine. A – view eastwards from bottom of hill to the railway line, i.e. the valley on rocks of the Ghaap Group. No rocky outcrops, no stromatolites and no mining will take place her. B - D, first test strip done by previous owners looking for ore presence and depth. Soils and thick vegetation cover the surface but the shallow trenches show the profile below ground. Scree of dark-red to black pebbles (redder = more iron content; blacker = more manganese content). No fossils even though this is in the mapped Ghaap Plateau stratum.	8A-D; 9A-D
Stop 2: ripple marks 28° 6' 47" S 23° 2' 45" E	Moving uphill. Rafted piece of red to brown shale with ripple marks signifying the ancient shoreline	10A
Stop 3: moving upslope 28° 6' 48" S 23° 2' 43" E	Test trench indicates increasing depth of ferro-manganese ore. No dolomite and no stromatolites	10B-D
Stop 4: 28° 6' 48" S 23° 2' 41" E	Test trench indicates increasing depth of ferro-manganese ore. Red-brown shales. No dolomite and no stromatolites	11A
Stop 5: 28° 6' 48" S 23° 2' 40" E	Test trench indicates increasing depth of ferro-manganese ore. No dolomite and no stromatolites	11B
Stop 6: *Acacia mellifera* 28° 6' 49" S 23° 2' 38" E	Test trench indicates increasing depth of ferro-manganese ore. Fragmented pieces of stromatolitic dolomite but no real stromatolites present.	11C
Stop 7: manganese pit, top of slope 28° 6' 49" S 23° 2' 36" E	Existing mining area with pure ferro-manganese and no other rock types.	11D
Stop 8: old quarry, erosion profile, shales 28° 7' 34" S 23° 2' 30" E	Southern part of RE Gloucester property and an old quarry that had been excavated many years ago. Profile of the rocks with mostly shales at the base and an erosion surface that had been down-cut by the overlying coarser material. Few boulders, some made of dolomite but no stromatolites seen. Floor of quarry has vertically oriented shales and must be close to a fault or shear zone. No ferro-manganese so the area will not be mined.	
Stop 9: last stop, diggings 28° 7' 35" S 23° 2' 18" E	Actively mined ferro-manganese ore along the ridge that forms the margin of the property. No shales, dolomite or stromatolites.	

Figure 8: Central part of mine. A – view eastwards across the valley that will not be mined. B - Site 1 – base of hill looking westwards along transect to top of hill. Woody vegetation was cleared by previous operators. C – one of the many shallow trenches dug along the transects. Note pebbly texture and coarse sandy soils. D – ferro-manganese pebbles.

Figure 9: Walking from site 1 to 2: A – Reddish shales exposed from an excavation. B – ferro-manganese pebbles. C – lighter-red shales. D – one isolated block of dolomite (40 cm long) but no stromatolites associated with it.

Figure 10: Site 2. A – isolated block with ripple marks. B – stop 3 pebbles and small boulders. C – view down transect and D – close up of ferro-manganese pebbles.

Figure 11: A - Site 4, ferro-manganese pebbles. B – stop 5 with mostly coarse sands and soil. C – stop 6 with the only example of stromatolitic dolomite, i.e. some possible layering but no stromatolite forms. D – Stop 7 pile of previously excavated rocks – no stromatolites.

Figure 12: A – Stop 8 in old abandoned quarry showing profile of eroded and contorted rocks. B – C - pavement of quarry with vertically displaced shales. D – stop 9 southern end of area where active mining is taking place in the Kuruman Formation. No fossils.

4. Impact assessment

An assessment of the potential impacts to possible palaeontological resources considers the criteria encapsulated in **Error! Reference source not found.**A-D. The criteria for the description and assessment of environmental impacts were drawn from the EIA Guidelines (DEAT, Environmental Impact Assessment Guidelines., 1998) and as amended from time to time (DEAT, Impact Significance, Integrated Environmental Management, Information series 5, 2002).

Table 4A: Impact Assessment Criteria

EXTENT	
Classification of the physical and spatial scale of the impact	
Footprint	The impacted area extends only as far as the activity, such as footprint occurring within the total site area.
Site	The impact could affect the whole, or a significant portion of the site.
Regional	The impact could affect the area including the neighbouring farms, the transport routes and the adjoining towns.
National	The impact could have an effect that expands throughout the country (South Africa).
International	Where the impact has international ramifications that extend beyond the boundaries of South Africa.
DURATION	
The lifetime of the impact that is measured in relation to the lifetime of the proposed development.	
Short term	The impact will either disappear with mitigation or will be mitigated through a natural process in a period shorter than that of the construction phase.
Short to Medium term	The impact will be relevant through to the end of a construction phase (1.5 years).
Medium term	The impact will last up to the end of the development phases, where after it will be entirely negated.
Long term	The impact will continue or last for the entire operational lifetime i.e. exceed 30 years of the development, but will be mitigated by direct human action or by natural processes thereafter.
Permanent	This is the only class of impact, which will be non-transitory. Mitigation either by man or natural process will not occur in such a way or in such a time span that the impact can be considered transient.
INTENSITY	
The intensity of the impact is considered by examining whether the impact is destructive or benign, whether it destroys the impacted environment, alters its functioning, or slightly alters the environment itself. The intensity is rated as	
Low	The impact alters the affected environment in such a way that the natural processes or functions are not affected.
Medium	The affected environment is altered, but functions and processes continue, albeit in a modified way.
High	Function or process of the affected environment is disturbed to the extent where it temporarily or permanently ceases.
PROBABILITY	
This describes the likelihood of the impacts actually occurring. The impact may occur for any length of time during the life cycle of the activity, and not at any given time. The classes are rated as follows:	
Improbable	The possibility of the impact occurring is none, due either to the circumstances, design or experience. The chance of this impact occurring is zero (0 %).
Possible	The possibility of the impact occurring is very low, due either to the circumstances, design or experience. The chances of this impact occurring is defined as 25 %.
Likely	There is a possibility that the impact will occur to the extent that provisions must therefore be made. The chances of this impact occurring is defined as 50 %.
Highly Likely	It is most likely that the impacts will occur at some stage of the development. Plans must be drawn up before carrying out the activity. The chances of this impact occurring is defined as 75 %.
Definite	The impact will take place regardless of any prevention plans, and only mitigation actions or contingency plans to contain the effect can be relied on. The chance of this impact occurring is defined as 100 %.

Table 4B: Significance-Without Mitigation

NO SIGNIFICANCE	The impact is not substantial and does not require any mitigation action.
LOW	The impact is of little importance, but may require limited mitigation.
MEDIUM	The impact is of importance and is therefore considered to have a negative impact. Mitigation is required to reduce the negative impacts to acceptable levels.

HIGH	The impact is of major importance. Failure to mitigate, with the objective of reducing the impact to acceptable levels, could render the entire development option or entire project proposal unacceptable. Mitigation is therefore essential.

Table 4C: Significance- With Mitigation

NO SIGNIFICANCE	The impact will be mitigated to the point where it is regarded as insubstantial.
LOW	The impact will be mitigated to the point where it is of limited importance.
LOW TO MEDIUM	The impact is of importance, however, through the implementation of the correct mitigation measures such potential impacts can be reduced to acceptable levels.
MEDIUM	Notwithstanding the successful implementation of the mitigation measures, to reduce the negative impacts to acceptable levels, the negative impact will remain of significance. However, taken within the overall context of the project, the persistent impact does not constitute a fatal flaw.
MEDIUM TO HIGH	The impact is of major importance but through the implementation of the correct mitigation measures, the negative impacts will be reduced to acceptable levels.
HIGH	The impact is of major importance. Mitigation of the impact is not possible on a cost-effective basis. The impact is regarded as high importance and taken within the overall context of the project, is regarded as a fatal flaw. An impact regarded as high significance, after mitigation could render the entire development option or entire project proposal unacceptable.

Table 4D: Description of assessment parameters with its respective weighting. The pink indicates the results for the palaeontology only

EXTENT		**DURATION**		**INTENSITY**		**PROBABILITY**		**WEIGHTING FACTOR (WF)**		**SIGNIFICANCE RATING (SR)**	
Footprint	1	Short term	1	Low	1	Probable	1	Low	1	Low	0-19
Site	2	Short to Medium	2			Possible	2	Low to Medium	2	Low to Medium	20-39
Regional	3	Medium term	3	Medium	3	Likely	3	Medium	3	Medium	40-59
National	4	Long term	4			Highly Likely	4	Medium to High	4	Medium to High	60-79
International	5	Permanent	5	High	5	Definite	5	High	5	High	80-100

MITIGATION EFFICIENCY (ME)		**SIGNIFICANCE FOLLOWING MITIGATION (SFM)**	
High	0.2	Low	0 - 19
Medium to High	0.4	Low to Medium	20 - 39
Medium	0.6	Medium	40 - 59
Low to Medium	0.8	Medium to High	60 - 79
Low	1.0	High	80 - 100

Identifying the Potential Impacts Without Mitigation Measures (WOM)

Following the assignment of the necessary weights to the respective aspects, criteria are summed and multiplied by their assigned weightings, resulting in a value for each impact (prior to the implementation of mitigation measures).

Equation 1:

Significance Rating (WOM) = (Extent + Intensity + Duration + Probability) x Weighting Factor

= (1 + 1 + 5 + 2) x 3

= 27

Identifying the Potential Impacts With Mitigation Measures (WM)

In order to gain a comprehensive understanding of the overall significance of the impact, after implementation of the mitigation measures, it was necessary to re-evaluate the impact.

Mitigation Efficiency (ME)

The most effective means of deriving a quantitative value of mitigated impacts is to assign each significance rating value (WOM) a mitigation efficiency (ME) rating (refer to **Error! Reference source not found.**). The allocation of such a rating is a measure of the efficiency and effectiveness, as identified through professional experience and empirical evidence of how effectively the proposed mitigation measures will manage the impact.

Thus, the lower the assigned value the greater the effectiveness of the proposed mitigation measures and subsequently, the lower the impacts with mitigation.

Equation 2:

Significance Rating (WM) = Significance Rating (WOM) x Mitigation Efficiency

or WM = WOM x ME

= 27 x 0.2

= 5.4

Significance Following Mitigation (SFM)

The significance of the impact after the mitigation measures are taken into consideration. The efficiency of the mitigation measure determines the significance of the impact. The level of impact is therefore seen in its entirety with all considerations taken into account.

SFM = 0 – 19 (green) = LOW

Mitigation = removal of any fossils found once drilling or excavations have commenced.

Based on the nature of the project, surface activities may impact upon the fossil heritage if preserved in the development footprint. The geological structures suggest that the rocks are either of the wrong kind to contain fossils in the case of the Kuruman and Gamagara Formations, or no trace fossils were found in this site, as in the case of the Ghaap Group. Furthermore, the material to be targeted is not in the limestones of the Ghaap Group. Since there is an extremely small chance that trace fossils from the nearby Ghaap Group limestones may be disturbed a Fossil Chance Find Protocol has been added to this report. Taking account of the defined criteria, and the impact assessment in Tables 4A-D, the potential impact to fossil heritage resources is extremely low.

5. Assumptions and uncertainties

Based on the geology of the area and the palaeontological record as we know it, it can be assumed that the formation and layout of the banded iron, dolomites, sandstones, shales and sands are typical for the country and do not contain fossil plant, insect, invertebrate and vertebrate material. Only the limestones might preserve trace fossils. There were no palaeo-pan or palaeo-spring features in the site, therefore, the overlying sands and soils of the Quaternary period would not preserve fossils.

6. Recommendation

Based on the site visit survey and observations and the lack of any previously recorded fossils from the area, it is extremely unlikely that any fossils would be preserved in the Ghaap Group limestones or soils and loose sands of the Quaternary. There is a very small chance that fossils may occur in the limestones (however these will not be mined) so a Fossil Chance Find Protocol should be added to the EMPr. If fossils are found once mining has commenced then they should be rescued and a palaeontologist called to assess and collect a representative sample.

7. References

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Smith, A.B.J., Beukes, N.J., 2016. Palaeoproterozoic banded iron formation hosted high-grade hematite iron ore deposits of the Transvaal Supergroup, South Africa. Episodes 39(2), 269-284.

Walker, S.J.H., Lukich, V., Chazan, M., 2014. Kathu Townlands: A High Density Earlier Stone Age Locality in the Interior of South Africa. PLoS ONE 9(7): e103436. doi:10.1371/journal.pone.0103436

8. Chance Find Protocol

Monitoring Programme for Palaeontology – to commence once the excavations / drilling / mining activities begin.

1. The following procedure is only required if fossils are seen on the surface and when excavations/mining commence.
2. When excavations begin the rocks and must be given a cursory inspection by the environmental officer or designated person. Any fossiliferous material (stromatolites, plants, insects, bone) should be put aside in a suitably protected place. This way the mining activities will not be interrupted.
3. Photographs of similar fossil plants must be provided to the developer to assist in recognizing the fossil plants in the shales and mudstones (for example see Figure 13, 14). This information will be built into the EMP's training and awareness plan and procedures.
4. Photographs of the putative fossils can be sent to the palaeontologist for a preliminary assessment.
5. If there is any possible fossil material found by the developer/environmental officer/miners then the qualified palaeontologist sub-contracted for this project, should visit the site to inspect the selected material and check the dumps where feasible.
6. Fossil plants or vertebrates that are considered to be of good quality or scientific interest by the palaeontologist must be removed, catalogued and housed in a suitable institution where they can be made available for further study. Before the fossils are removed from the site a SAHRA permit must be obtained. Annual reports must be submitted to SAHRA as required by the relevant permits.
7. If no good fossil material is recovered then no site inspections by the palaeontologist will not be necessary. A final report by the palaeontologist must be sent to SAHRA once the project has been completed and only if there are fossils.
8. If no fossils are found and the excavations have finished then no further monitoring is required.

Appendix A – Examples of fossils that could be found

Figure 13: Stromatolites from the Malmani Subgroup as seen from the surface

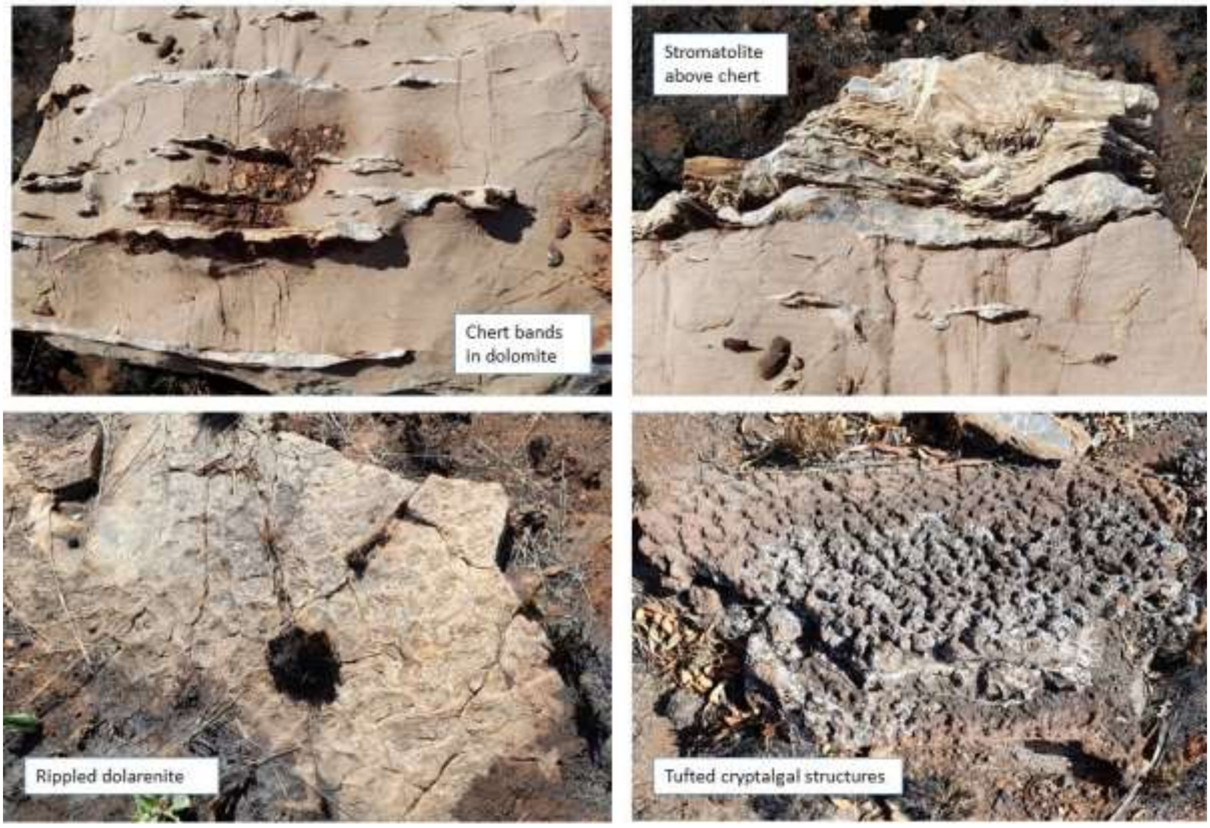

Figure 14: Various types of stromatolites (Malmani subgroup).

Appendix B – Details of specialist

Curriculum vitae (short) - Marion Bamford PhD
July 2021

I) Personal details

Surname	:	**Bamford**
First names	:	**Marion Kathleen**
Present employment	:	Professor; Director of the Evolutionary Studies Institute. Member Management Committee of the NRF/DST Centre of Excellence Palaeosciences, University of the Witwatersrand, Johannesburg, South Africa-
Telephone	:	+27 11 717 6690
Fax	:	+27 11 717 6694
Cell	:	082 555 6937
E-mail	:	marion.bamford@wits.ac.za ; marionbamford12@gmail.com

ii) Academic qualifications

Tertiary Education: All at the University of the Witwatersrand:
1980-1982: BSc, majors in Botany and Microbiology. Graduated April 1983.
1983: BSc Honours, Botany and Palaeobotany. Graduated April 1984.
1984-1986: MSc in Palaeobotany. Graduated with Distinction, November 1986.
1986-1989: PhD in Palaeobotany. Graduated in June 1990.

iii) Professional qualifications

Wood Anatomy Training (overseas as nothing was available in South Africa):
1994 - Service d'Anatomie des Bois, Musée Royal de l'Afrique Centrale, Tervuren, Belgium, by Roger Dechamps
1997 - Université Pierre et Marie Curie, Paris, France, by Dr Jean-Claude Koeniguer
1997 - Université Claude Bernard, Lyon, France by Prof Georges Barale, Dr Jean-Pierre Gros, and Dr Marc Philippe

iv) Membership of professional bodies/associations

Palaeontological Society of Southern Africa
Royal Society of Southern Africa - Fellow: 2006 onwards
Academy of Sciences of South Africa - Member: Oct 2014 onwards
International Association of Wood Anatomists - First enrolled: January 1991
International Organization of Palaeobotany – 1993+
Botanical Society of South Africa
South African Committee on Stratigraphy – Biostratigraphy - 1997 - 2016
SASQUA (South African Society for Quaternary Research) – 1997+
PAGES - 2008 –onwards: South African representative

ROCEEH / WAVE – 2008+
INQUA – PALCOMM – 2011+onwards

vii) Supervision of Higher Degrees

All at Wits University

Degree	Graduated/completed	Current
Honours	9	2
Masters	11	5
PhD	11	5
Postdoctoral fellows	11	4

viii) Undergraduate teaching
Geology II – Palaeobotany GEOL2008 – average 65 students per year
Biology III – Palaeobotany APES3029 – average 25 students per year
Honours – Evolution of Terrestrial Ecosystems; African Plio-Pleistocene Palaeoecology; Micropalaeontology – average 2-8 students per year.

ix) Editing and reviewing
Editor: Palaeontologia africana: 2003 to 2013; 2014 – Assistant editor
Guest Editor: Quaternary International: 2005 volume
Member of Board of Review: Review of Palaeobotany and Palynology: 2010 –
Cretaceous Research: 2014 –

Review of manuscripts for ISI-listed journals: 25 local and international journals

x) Palaeontological Impact Assessments

Selected – list not complete:

- Thukela Biosphere Conservancy 1996; 2002 for DWAF
- Vioolsdrift 2007 for Xibula Exploration
- Rietfontein 2009 for Zitholele Consulting
- Bloeddrift-Baken 2010 for TransHex
- New Kleinfontein Gold Mine 2012 for Prime Resources (Pty) Ltd.
- Thabazimbi Iron Cave 2012 for Professional Grave Solutions (Pty) Ltd
- Delmas 2013 for Jones and Wagener
- Klipfontein 2013 for Jones and Wagener
- Platinum mine 2013 for Lonmin
- Syferfontein 2014 for Digby Wells
- Canyon Springs 2014 for Prime Resources
- Kimberley Eskom 2014 for Landscape Dynamics
- Yzermyne 2014 for Digby Wells
- Matimba 2015 for Royal HaskoningDV
- Commissiekraal 2015 for SLR
- Harmony PV 2015 for Savannah Environmental
- Glencore-Tweefontein 2015 for Digby Wells

- Umkomazi 2015 for JLB Consulting
- Ixia coal 2016 for Digby Wells
- Lambda Eskom for Digby Wells
- Alexander Scoping for SLR
- Perseus-Kronos-Aries Eskom 2016 for NGT
- Mala Mala 2017 for Henwood
- Modimolle 2017 for Green Vision
- Klipoortjie and Finaalspan 2017 for Delta BEC
- Ledjadja borrow pits 2018 for Digby Wells
- Lungile poultry farm 2018 for CTS
- Olienhout Dam 2018 for JP Celliers
- Isondlo and Kwasobabili 2018 for GCS
- Kanakies Gypsum 2018 for Cabanga
- Nababeep Copper mine 2018
- Glencore-Mbali pipeline 2018 for Digby Wells
- Remhoogte PR 2019 for A&HAS
- Bospoort Agriculture 2019 for Kudzala
- Overlooked Quarry 2019 for Cabanga
- Richards Bay Powerline 2019 for NGT
- Eilandia dam 2019 for ACO
- Eastlands Residential 2019 for HCAC
- Fairview MR 2019 for Cabanga
- Graspan project 2019 for HCAC
- Lieliefontein N&D 2019 for Enviropro
  Skeerpoort Farm Mast 2020 for HCAC
  Vulindlela Eco village 2020 for 1World
  KwaZamakhule Township 2020 for Kudzala
  Sunset Copper 2020 for Digby Wells

xi) Research Output

Publications by M K Bamford up to July 2021 peer-reviewed journals or scholarly books: over 160 articles published; 5 submitted/in press; 8 book chapters.
Scopus h index = 29; Google scholar h index = 36;
Conferences: numerous presentations at local and international conferences.

xii) NRF Rating

NRF Rating: B-2 (2016-2020)
NRF Rating: B-3 (2010-2015)
NRF Rating: B-3 (2005-2009)
NRF Rating: C-2 (1999-2004)

CV of Alisoun Valentine House

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KEY SKILLS AND ATTRIBUTES

- The stamina and ability to work effectively under pressure.
- Highly developed social and interpersonal skills.
- Good communication skills, both oral and written.
- The ability to be creative and innovative and to find workable strategies to achieve stated aims.
- Excellent organisational skills.
- The ability to analyse situations, behaviour and thinking and respond with patience and understanding.
- Research and scientific writing.

WORK HISTORY

Postdoc Fellow – Evolutionary Studies Institute
January 2019 – December 2020
January 2018 – December 2018
January 2017 – December 2017
Analysis of archaeological charcoal from an Middle Stone Age and Early Iron Age sites
Host: Professor Marion Bamford

Sessional position – School of Animal, Plant and Environmental Sciences
March 2016 – November 2016
Academic support for postgraduate students

Short term internship – University of the Witwatersrand
August – November 2015

Assistant to Editor for 'Flora of the Witwatersrand' – University of the Witwatersrand
September 2008 – February 2010
Assisted with editing and preparing the Flora for publication

Tutor at the College of Science – University of the Witwatersrand
Academic years 2000 – 2003
Responsibilities included teaching general biology to first and second year students in the College of Science; as well as marking essays and assignments.

P.A. to Director/Manager of Cowling Davies (Small Advertising/Design Studio)
April 1992 – December 1992
Responsibilities included reception work; office administration; preparation of quotations; booking media advertisements and general assistance.

Herbarium Technician - University of the Witwatersrand
October 1991 – March 1992
Responsibilities included identification, pressing and mounting of plant specimens; capturing and maintaining data in the Herbarium computer system; maintaining the collection; filing; acting as librarian for the reference book collection and assisting students with research.

EDUCATION

Doctor of Philosophy (PhD) University of the Witwatersrand (2015)
Title: Systematic Applications of Pollen Grain Morphology and Development in the Acanthaceae
Supervisor: Professor Kevin Balkwill

Master of Science (MSc) University of the Witwatersrand (1991)
Title: A developmental study of *Nephroselmis viridis* (Inouye, Suda et Pienaar) Prasinophyceae
Supervisor: Professor Richard Pienaar
Degree awarded with Distinction.

Bachelor of Science with Honours (B.Sc. Hon.) University of the Witwatersrand (1987)
Awarded the Florence D. Hancock prize for a Dissertation in Phycology (1988)

Higher Diploma in Education (Postgraduate) for Secondary Education University of the Witwatersrand (1985)
Teaching subjects: Biology and Science

Bachelor of Science (B.Sc.) University of Witwatersrand (1984)
Major: Botany
Sub-majors: Microbiology and Zoology

Matriculation Certificate Hyde Park High School (1979)
Subjects passed: English, Afrikaans, Biology, Mathematics, Geography, Home Economics

PUBLICATIONS

Young A.V. and Pienaar R.N. 1989. The ultra structure of a new species of *Nephroselmis* (Prasinophyceae). Proceedings of the Electron Microscopy Society of Southern Africa. 19: 113–114.

House A. and Balkwill K. 2013. FIB-SEM: An Additional Technique for Investigating Internal Structure of Pollen Walls. Microscopy & Microanalysis 19: 1535–1541.

House A. and Balkwill K. 2014. FIB-SEM: A new technique for investigating pollen walls. Microscopy: advances in scientific research and education (A. Méndez-Vilas, Ed.) 1: 54–58. © FORMATEX.

House A. and Balkwill K. 2016. Labyrinths, columns and cavities: new internal features of pollen grain walls in the Acanthaceae detected by FIB-SEM. Journal of Plant Research 129: 225–240.

House A. and Balkwill K. 2017. FIB-SEM enhances the potential taxonomic significance of internal pollen wall structure at the generic level. Flora-Morphology, Distribution, Functional Ecology of Plants 236–237C: 44–57.

House A. 2017. FIB-SEM: a new method for examining pollen grain walls and palaeontological specimens in 3D. Proceedings of the 21st diennial conference of the South African Society of Quaternary Research. Palaeontologia Africana, 52:21–22. ISSN 2410-4418.

House A. and Balkwill K. 2019. Development and expansion of the pollen wall in *Barleria obtusa* Nees (Acanthaceae). South African Journal of Botany 125: 188–195.

House, A., Bamford, M.K., 2019. Investigating the utilisation of woody plant species at an Early Iron Age site in KwaZulu-Natal, South Africa, by means of identifying archaeological charcoal. Archaeological and Anthropological Sciences 11, 6737-6750. https://doi.org/10.1007/s12520-019-00939-9

House, A., Bamford, M.K., Chikumbirike, J., (2021). Charcoal from Holocene deposits at Wonderwerk Cave, South Africa: A source of palaeoclimate information. Special issue on WW, in Quaternary International https://doi.org/10.1016/j.quaint.2020.10.039

Esteban, I., Bamford, M.K., Miller, C.S., Neumann, F.H., Schefuß, E., House, A., Pargeter, J., Cawthra, H., C., Fisher, E.C., 2021. Palaeoenvironments of hunter-gatherers from MIS 3 to the Holocene 1 in coastal Pondoland (South Africa): a biochemical and palaeobotanical approach. Quaternary Research.

McCullum DA, House AV, Balkwill K (Eds).The Flora of the Witwatersrand. (Vol. 2). Dicotyledons – Piperaceae to Ebenaceae. NiSC. IN PRESS, (Publishing date-December 2019).

McCullum DA, House AV, Balkwill K (Eds).The Flora of the Witwatersrand. (Vol. 3). Dicotyledons – Oleaceae to Compositae. NiSC IN PRESS, (Publishing date-December 2019).

House A. and Bamford M.K. (in prep). Furnaces, hearths, rituals and construction: investigating the utilisation of woody plant species at an Early Iron Age site by means of identifying archaeological charcoal.

PALAEONTOLOGICAL IMPACT FIELD EXPERIENCE

May 2018 – SARAO Williston and Carnarvon for Digby Wells
August 2019 – Idlanga Coal MR, Rietvlei, Vryheid area – Digby Wells
September 2019 – Schmidtsdrift PR for Thaya Environmental Specialist
September 2019 – Estcourt Pvt Hospital for EnviroPro
September 2019 – Vulindlela BWS for KSEMS
November 2019 – Derseley outfall sewer for Digby Wells
June-Nov 2020 – Frankfort-Windfield 88kV line for Eskom and 1World.
October 2020 – McCarthy – Salene iron and manganese – Prescali
August 2021 – Smithfield-Rouxville-Zastron 22kV line – Theroserv.