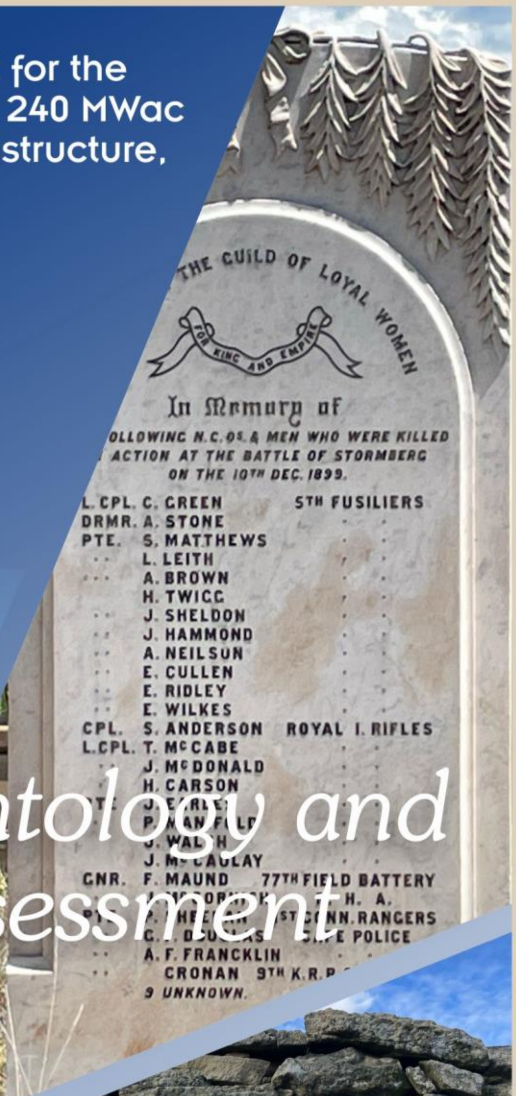
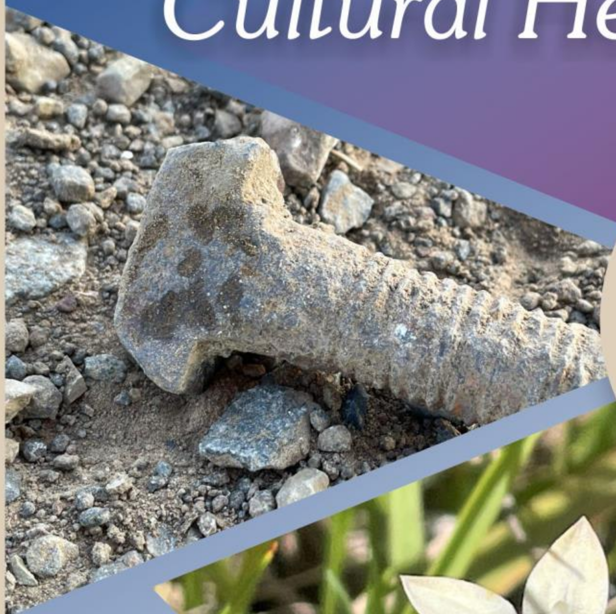
Scoping and Environmental Impact Assessment for the Proposed Construction and Operation of the up to 240 MWac Ingwe Wind Energy Facility 1 and associated infrastructure, near Molteno in the Eastern Cape

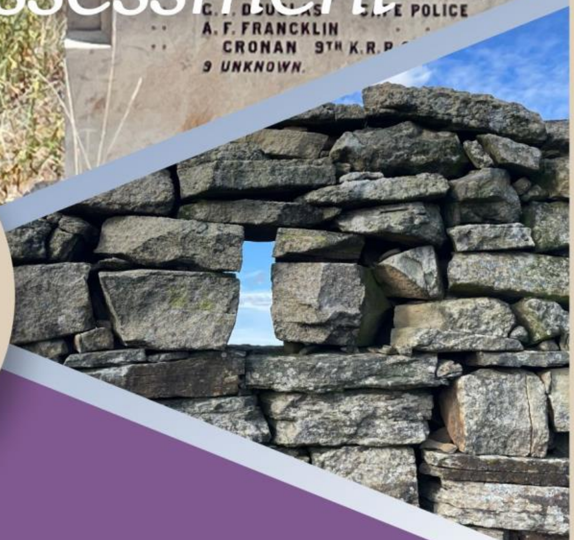
DRAFT ENVIRONMENTAL IMPACT ASSESSMENT REPORT

CHAPTER 7:

Archaeology, Palaeontology and Cultural Heritage Assessment







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PALAEONTOLOGICAL HERITAGE: COMBINED DESKTOP & FIELD-BASED ASSESSMENT

Proposed Ingwe Wind Energy Facility 1 and Wind Energy Facility 2 and their associated electrical infrastructure near Molteno, Chris Hani District Municipality, Eastern Cape Province

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EXECUTIVE SUMMARY

Ingwe Wind Energy Facility 1 (Pty) Ltd is proposing to develop the Ingwe Wind Energy Facility 1, and Ingwe Wind Energy Facility 2 (Pty) Ltd is proposing to develop the Ingwe Wind Energy Facility 2 and its associated Electrical Grid Infrastructure (EGI) (which is part of a greater cluster of Wind and Solar PV Energy Facilities to be developed under various project companies) near Molteno in the Eastern Cape Province. This palaeontological assessment report concerns the Ingwe Wind Energy Facility 1 and Ingwe Wind Energy Facility 2 renewable energy projects.

Ingwe Wind Energy Facility 1

The Ingwe WEF 1 project area is underlain by Late Triassic continental sediments of the sandstone-dominated Molteno Formation (Stormberg Group, Karoo Supergroup). These Karoo Supergroup bedrocks are extensively intruded and baked by Early Jurassic dolerite sills and dykes and mantled by Late Caenozoic superficial deposits (colluvium, alluvium, soils) as well as grassy vegetation. Good exposures of potentially fossiliferous mudrocks are accordingly very rare.

Important Late Triassic fossil plant sites as well as coal seams are known from the Molteno Formation near Molteno town which lies within the Molteno Coal Field (*cf* Anderson & Anderson 1985, Cairncross *et al.* 1995, Hancox & Götz 2014). However, no historical or new fossil sites or horizons of significant scientific or conservation value are known from the Ingwe WEF 1 project area itself. The few new fossil sites recorded mainly comprise small blocks of petrified wood and impressions of woody axes within channel sandstones and associated eluvial gravels. All recorded sites lie *outside* the proposed WEF footprint, while many or most of the sites are already protected within standard ecological buffer zones along drainage lines (Appendix 1). If threatened by the proposed developments, all the known sites could be mitigated in the Pre-construction Phase by professional palaeontological recording and collection. Since the WEF project area lies within the Molteno Coalfield, the potential remains for rare, largely unpredictable subsurface horizons or sites (carbonaceous mudrocks / coals) rich in well-preserved Triassic fossil plants of High to Very High Palaeosensitivity. These readily eroded fossiliferous units are generally not exposed at surface at present due to soil and vegetation cover and therefore cannot be identified in the Pre-construction Phase; they can only be detected and mitigated following initial site clearance and excavations during the Construction Phase.

Provisional palaeosensitivity mapping of the Ingwe WEF 1 project area by the DFFE Screening Tool suggests that this largely of Very High Palaeosensitivity, based on the underlying bedrocks of the Stormberg Group (Karoo Supergroup). However, desktop reviews as well as recent palaeontological field surveys indicate that, in practice, the WEF project area is of Low Palaeosensitivity overall, with the potential for rare, largely unpredictable subsurface horizons or sites rich in well-preserved Triassic fossil plants of High to Very High Palaeosensitivity (See Appendix 4). The provisional Very High Palaeosensitivity mapped within the majority of the Ingwe WEF 1 project area by the DFFE Screening Tool is accordingly *contested* in this report. No areas of High to Very High Palaeosensitivity or No-Go Areas have been identified here so far.

Given (1) the paucity of recorded fossil sites (none of which lies within the proposed project footprints) within the Ingwe WEF 1 project area and (2) the inferred Low Palaeosensitivity of the Ingwe cluster project area in general, the significance of anticipated impacts on local, legally protected fossil heritage is anticipated to be Low Negative without mitigation, falling to Very Low Negative following mitigation. The No-Go Option would probably have a Neutral impact significance.

Given the almost complete lack of relevant palaeontological field data for the handful of renewable energy facilities proposed / authorized within *c*. 30km of the Ingwe Renewable Energy Cluster, it is not possible to undertake a meaningful cumulative impact assessment for the Ingwe WEF projects at present. However, given the inferred low palaeosensitivity of the majority of the project areas concerned, it is probable that the cumulative impacts fall within acceptable limits.

The proposed WEF project is not fatally flawed. On palaeontological heritage grounds there are no objections to the Ingwe WEF 1 project receiving Environmental Authorisation and no preferences for a specific infrastructure layout among any options that may ever be under consideration. The recommendations made below for Construction Phase palaeontological monitoring and mitigation must be included within the EMPr for the Ingwe WEF 1 development.

- **Monitoring and mitigation recommendations for Ingwe WEF 1**

Since none of the known fossil sites within the Ingwe cluster project area fall within or close to (≤ 20 m) the proposed project footprints, no specific mitigation is recommended in their regard. All these sites could be mitigated in the pre-construction phase, should they be threatened by the proposed development. Given the potential for unrecorded plant fossil sites of High Palaeosensitivity hidden within the subsurface which cannot be identified and delineated in the Pre-construction Phase, the following recommendations are made:

1. Surveying of the authorized WEF project footprint by a qualified palaeontologist during the early Construction Phase (*following* initial site clearance and excavations) to identify any newly exposed, sensitive fossil sites or horizons (*e.g*. carbonaceous shales, coals) at or beneath the ground surface.

2. Recording and judicious sampling of new, scientifically valuable fossil remains within or close to (≤ 20 m) project footprint by a qualified palaeontologist.

This should be backed-up by consistent application of the Chance Fossil Finds Procedure throughout the Construction Phase (See Appendix 2).

Mitigation through micro-siting of WEF infrastructure (*e.g.* wind turbines, access roads, substations) would only be necessary in the case of the discovery of extensive new fossil sites of very high scientific / conservation value within the final, authorized project footprints; this eventuality cannot be entirely excluded but is considered unlikely. The qualified palaeontologist concerned with mitigation work would need a valid collection permit from the Eastern Cape Provincial Heritage Resources Agency, ECPHRA (Contact details: Mr Sello Mokhanya, 74 Alexander Road, King Williams Town 5600; smokhanya@ecphra.org.za). Fossil material collected must be curated, together with full collection data, in an approved depository (*e.g.* university of museum collection). 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 published by SAHRA (2013).

Ingwe Wind Energy Facility 2

The Ingwe WEF 2 project area is underlain by Early to Late Triassic continental sediments of the mudrock-dominated Burgersdorp Formation (Upper Beaufort Group) and the unconformably overlying sandstone-dominated Molteno Formation (Stormberg Group, Karoo Supergroup). These Karoo Supergroup bedrocks are extensively intruded and baked by Early Jurassic dolerite sills and dykes and mantled by Late Caenozoic superficial deposits (colluvium, alluvium, soils) as well as grassy vegetation. Good exposures of potentially fossiliferous mudrocks are accordingly very rare.

Important Late Triassic fossil plant sites as well as coal seams are known from the Molteno Formation near Molteno town which lies within the Molteno Coal Field (*cf* Anderson & Anderson 1985, Cairncross *et al.* 1995, Hancox & Götz 2014). However, no historical or new fossil sites or horizons of significant scientific or conservation value are known from the Ingwe WEF 2 project area itself. The few new fossil sites recorded mainly comprise very rare, highly weathered bone fragments and silicified wood from the Burgersdorp Formation as well as small blocks of petrified wood and impressions of woody axes within Molteno Formation channel sandstones and associated eluvial gravels. All recorded sites lie *outside* the proposed WEF footprint, while many or most of the sites are already protected within standard ecological buffer zones along drainage lines (Appendix 1). If threatened by the proposed developments, all the known sites could be mitigated in the Pre-construction Phase by professional palaeontological recording and collection. However, since the WEF project area lies within the Molteno Coalfield, the potential remains for rare, largely unpredictable subsurface horizons or sites (carbonaceous mudrocks / coals) rich in well-preserved Triassic fossil plants of High to Very High Palaeosensitivity. These readily eroded fossiliferous units are generally not exposed at surface at present due to soil and vegetation cover and therefore cannot be identified in the Pre-construction Phase; they can only be detected and mitigated following initial site clearance and excavations during the Construction Phase.

Provisional palaeosensitivity mapping of the Ingwe WEF 2 project area by the DFFE Screening Tool suggests that this largely of Very High Palaeosensitivity, based on the underlying bedrocks of the Beaufort Group and Stormberg Group (Karoo Supergroup). However, desktop reviews as well as recent palaeontological field surveys indicate that, in practice, the WEF project area is of Low Palaeosensitivity overall, with the potential for rare, largely unpredictable subsurface horizons or sites rich in well-preserved Triassic fossil plants of High to Very High Palaeosensitivity (Appendix 4). The provisional Very High Palaeosensitivity mapped within the majority of the Ingwe WEF 2 project area by the DFFE Screening Tool is accordingly *contested* in this report. No areas of High to Very High Palaeosensitivity or No-Go Areas have been identified here so far.

Given (1) the paucity of recorded fossil sites (none of which lies within the proposed project footprints) within the Ingwe WEF 2 project area and (2) the inferred Low Palaeosensitivity of the Ingwe cluster project area in general, the significance of anticipated impacts on local, legally protected fossil heritage is anticipated to be Low Negative without mitigation, falling to Very Low Negative following mitigation. The No-Go Option would probably have a Neutral impact significance.

Given the almost complete lack of relevant palaeontological field data for the handful of renewable energy facilities proposed / authorized within *c*. 30 km of the Ingwe Renewable Energy Cluster, it is not possible to undertake a meaningful cumulative impact assessment for the Ingwe WEF projects at present. However, given the inferred low palaeosensitivity of the majority of the project areas concerned, it is probable that the cumulative impacts fall within acceptable limits.

The proposed WEF project is not fatally flawed. On palaeontological heritage grounds there are no objections to the Ingwe WEF 2 project receiving Environmental Authorisation and no preferences for a specific infrastructure layout among any options that may ever be under consideration. The recommendations made below for Construction Phase palaeontological monitoring and mitigation must be included within the EMPr for the Ingwe WEF 2 development.

- **Monitoring and mitigation recommendations for Ingwe WEF 2**

Since none of the known fossil sites within the Ingwe cluster project area fall within or close to (≤ 20 m) the proposed project footprints, no specific mitigation is recommended in their regard. All these sites could be mitigated in the pre-construction phase, should they be threatened by the proposed development. Given the potential for unrecorded plant fossil sites of High Palaeosensitivity hidden within the subsurface which cannot be identified and delineated in the Pre-construction Phase, the following recommendations are made:

1. Surveying of the authorized WEF project footprint by a qualified palaeontologist during the early Construction Phase (*following* initial site clearance and excavations) to identify any newly exposed, sensitive fossil sites or horizons (*e.g*. carbonaceous shales, coals) at or beneath the ground surface.

2. Recording and judicious sampling of new, scientifically valuable fossil remains within or close to (≤ 20 m) project footprint by a qualified palaeontologist.

This should be backed-up by consistent application of the Chance Fossil Finds Procedure throughout the Construction Phase (See Appendix 2).

Mitigation through micro-siting of WEF infrastructure (*e.g.* wind turbines, access roads, substations) would only be necessary in the case of the discovery of extensive new fossil sites of very high scientific / conservation value within the final, authorized project footprints; this eventuality cannot be entirely excluded but is considered unlikely. The qualified palaeontologist concerned with mitigation work would need a valid collection permit from the Eastern Cape Provincial Heritage Resources Agency, ECPHRA (Contact details: Mr Sello Mokhanya, 74 Alexander Road, King Williams Town 5600; smokhanya@ecphra.org.za). Fossil material collected must be curated, together with full collection data, in an approved depository (*e.g.* university of museum collection). 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 published by SAHRA (2013).

1. INTRODUCTION & PROJECT OUTLINE

The proposed development forms part of the greater proposed Ingwe Wind and Solar PV Energy Facilities cluster and its associated Electrical Grid Infrastructure (EGI) on a site near the small town of Molteno in the Eastern Cape Province, noting that each project has a separate Applicant. The Ingwe WEF project area is situated within the Enoch Mgijima Local Municipality, which fall within the Chris Hani District Municipality respectively, in the Eastern Cape Province.

The two Ingwe WEFs (to be constructed on adjoining farm properties), as well as a further five solar PV energy facilities (called Ingwe SEFs 1-5) are concurrently being considered on the surrounding properties and are assessed by way of separate environmental impact assessment processes. The two wind energy projects forming part of the Ingwe cluster are listed in Table 1 and their project areas are mapped in Figure 1. It is proposed that the associated Electrical Grid Connection (EGI) would comprise a new loop-in loop-out connection into the existing Beta-Delphi 400kV line, and a new loop-in loop-out connection into the existing Dorper-Stormberg 132kV line, at the point where these existing lines cross the project site, and with both options including associated and supporting infrastructure for the respective projects. The EGI will be assessed separately.

The Ingwe project cluster study area falls outside of the Stormberg Renewable Energy Development Zone (REDZ) (GG 41445, GN R114 of 16 February 2018) (*cf* Fourie *et al.* 2015). The proposed Ingwe Wind and Solar PV project cluster will therefore be subject to full Scoping and EIA processes. Separate Scoping and EIA processes will be undertaken for each of the two wind and five solar PV facilities. In addition, one separate Scoping and EIA Report will be prepared for the 400 kV Beta-Delphi power line, and a separate BA process will be undertaken for the proposed 132 kV Beta-Delphi power line and associated infrastructure. The present palaeontological heritage report deals with the two Ingwe wind energy facilities (WEFs) alone.

The combined project area for the Ingwe cluster near Molteno overlies Middle to Late Triassic continental sedimentary bedrocks of the Burgersdorp and Molteno Formations (Karoo Supergroup) which are provisionally considered to be of Very High palaeosensitivity (SAHRIS palaeosensitivity map, DFFE screening tool maps; see Appendix 4).

The present combined desktop and field-based palaeontological heritage assessment for the two Ingwe WEF projects (*excluding* the grid connection) has been commissioned as part of the Site Sensitivity Verification and Environmental Assessment Processes on behalf of the proponent by the CSIR as the independent Environmental Assessment Practitioner for the cluster developments (CSIR Contact details: Ms Lizande Kellerman. Council for Scientific & Industrial Research, 11 Jan Celliers Street, Stellenbosch 7599, Western Cape. Tel: +27 21 888 2489. Fax: +27 86 556 3267. Cell: +27 83 799 0949. E-mail: lkellerman@csir.co.za). This report will contribute to the consolidated Heritage Impact Assessments for the WEF projects that are being compiled by Dr Jayson Orton of ASHA Consulting, Muizenberg (Contact details: Dr J. Orton. ASHA Consulting, 23 Dover Road Muizenberg, 7945. Tel: 021 788 1025. Cell: 083 272 3225. E-mail: jayson@asha-consulting.co.za) as well as to the Environmental Management Programmes (EMPrs) for the WEF developments. As part of the S&EIA process undertaken by CSIR for the proposed Ingwe Wind Energy Facility 1 and Wind Energy Facility 2, the present report will be included in the EIA Phase reports for these renewable energy developments which would be subject to the legislated Public Participation Process. Any comments received would be addressed through the process.

Table 1: List of component renewable energy projects within the proposed Ingwe Wind cluster near Molteno, Eastern Cape

Facility Name	Applicant	Reg no	Technology	Proposed permitted capacity	No of WTG's	Landowners
Ingwe Wind Energy Facility 1	Ingwe Wind Energy Facility 1 (Pty) Ltd	2022/566614/07	Wind + BESS	Up to 307,5MW	Up to 41	multiple
Ingwe Wind Energy Facility 2	Ingwe Wind Energy Facility 2 (Pty) Ltd	2022/566649/07	Wind + BESS	Up to 510MW	Up to 64	multiple

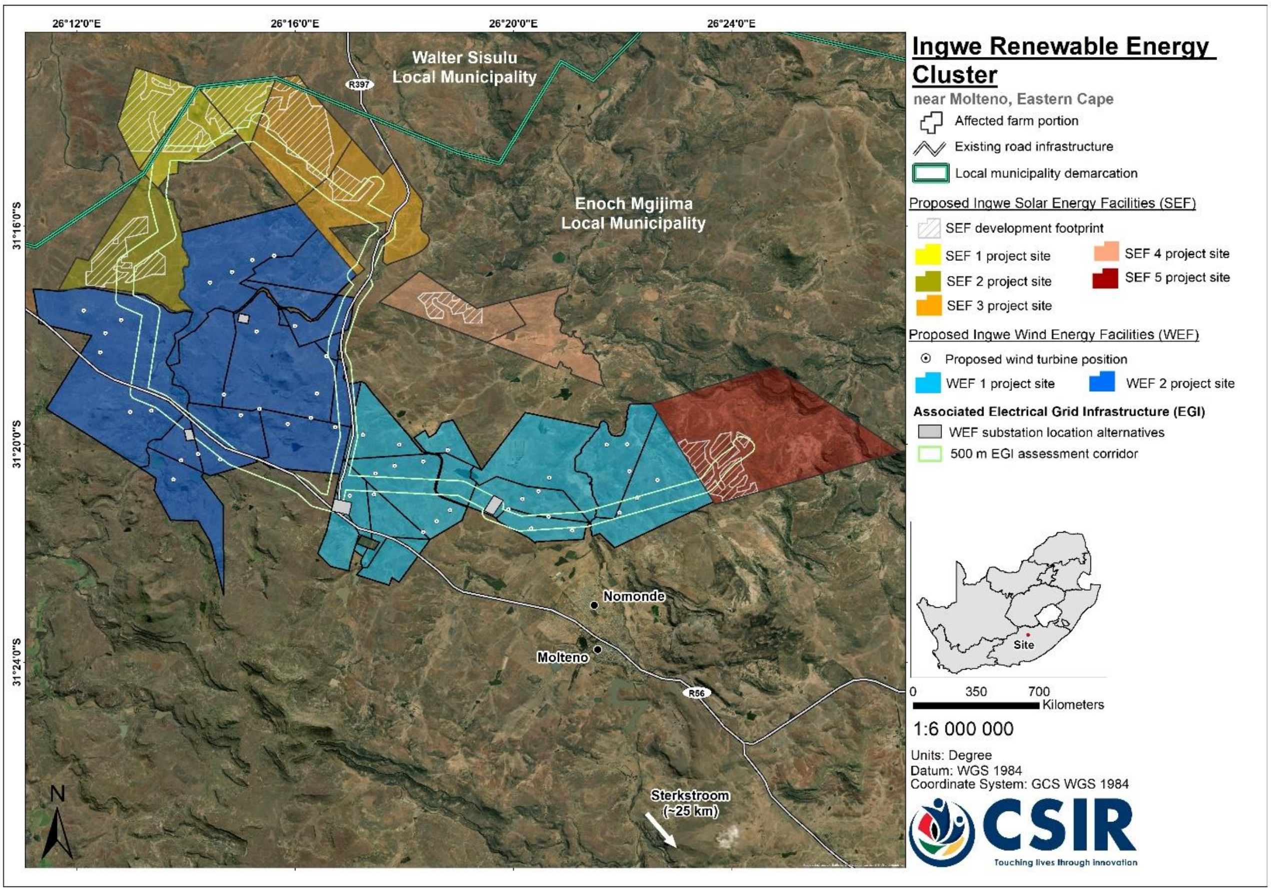


Figure 1: Satellite image showing the project areas for the proposed Ingwe Wind and Solar PV Energy Facilities cluster and associated Electrical Grid Infrastructure near Molteno in the Eastern Cape Province (Image provided by CSIR). The Ingwe WEF 1 and 2 project areas are shown in pale blue and dark blue.

1.1. AFFECTED FARM PROPERTIES

The proposed **Ingwe WEF 1** project site covers approximately 4 974 ha and will be developed on the following farm properties:

Property Description	SG Code	Landowner
Remainder of the Farm Zwavel Krantz Number 39	C04900000000003900000	Glenmilner Communal Property Association
Remainder of Portion 2 of the Farm Zwavel Krantz Number 39	C04900000000003900002	Tyhilas Agricultural Primary Cooperative
The Farm No. 60	C04900000000006000000	Liebe Trust

The Farm No. 61	C04900000000006100000	Liebe Trust
The Farm No. 62	C04900000000006200000	Liebe Trust
Remainder of Portion 4 of the Farm Onverwagt No. 63	C04900000000006300004	Liebe Trust
Remainder of Portion 7 (Portion of Portion 4) of the Farm Onverwacht No. 63	C04900000000006300007	Izak Griebenouw
Remainder of Portion 30 (Sunnyside) of the Farm Onverwagt No. 63	C04900000000006300030	Francois Jacques Hugo Le Roux
Portion 32 (Sunnyside North) (Portion of Portion 30) of the Farm Onverwagt No. 63	C04900000000006300032	Francois Jacques Hugo Le Roux
Portion 33 (Portion of Portion 3) of the Farm Onverwagt No. 63	C04900000000006300033	Henrico Johannes Pretorius and Valda Anne Pretorius
Portion 34 (Portion of Portion 3) of the Farm Onverwagt No. 63	C04900000000006300034	Henrico Johannes Pretorius and Valda Anne Pretorius
Portion 37 (Sunny Side South) (a Portion of Portion 30) of the Farm Onverwagt No. 63	C04900000000006300037	Masizakhe Communal Property Association
Portion 23 of the Farm Onverwagt No. 63[1]	C04900000000006300023	Transnet SOC Ltd

The proposed **Ingwe WEF 2** project site covers approximately 7 346 ha and will be developed on the following farm properties:

Property Description	**SG Code**	**Landowner**
Remainder of the Farm Klip Fountain No. 40	C04900000000004000000	White Wools (Pty) Ltd
Portion 8 of the Farm Klip Fountain No. 40	C04900000000004000008	Johannes Hendrik Van Zyl
Remainder of Portion 14 (Welgegund) (a portion of portion 1) of the Farm Klip Fountain No. 40	C04900000000004000014	White Wools (Pty) Ltd
Portion 15 (Gegund) (a portion of portion 2) of the Farm Klip Fountain No. 40	C04900000000004000015	White Wools (Pty) Ltd
Portion 18 (Klip Kop) (portion of portion 13) of the Farm Klip Fountain No. 40	C04900000000004000018	Johannes Hendrik Van Zyl
Portion 21 (Veg Koppies) of the Farm Klip Fountain No. 40	C04900000000004000021	Johannes Hendrik Van Zyl
Portion 22 (Boomplaas) of the Farm Klip Fountain No. 40	C04900000000004000022	Johannes Hendrik Van Zyl
Portion 24 of the Farm Klip Fountain No. 40[1]	C04900000000004000024	Transnet SOC Ltd
Portion 25 of the Farm Klip Fountain No. 40	C04900000000004000025	White Wools (Pty) Ltd
Portion 26 (a portion of Portion 21 (Vegkoppies)) of the Farm Klip Fountain No. 40[1]	C04900000000004000026	Transnet SOC Ltd
Remainder of the Farm Bamboo No. 43	C04900000000004300000	White Wools (Pty) Ltd
Portion 1 of the Farm Bamboo No. 43	C04900000000004300001	Dries Pienaar Familie Trust
Remainder of Portion 6 (a portion of portion 5) of the Farm Oud Klip No. 44	C04900000000004400006	White Wools (Pty) Ltd
Portion 14 of the Farm Oud Klip No. 44	C04900000000004400014	Gerber Familie Trust
Remainder of Portion 29 of the Farm Oud Klip No. 44	C04900000000004400029	Dries Pienaar Familie Trust
Portion 8 of the Farm Modderfontein No. 58	C04900000000005800008	Gerber Familie Trust

[1] *These farm properties will be dealt with by means of wayleave applications.*

1.2. PROJECT INFRASTRUCTURE

The proposed Ingwe WEFs will typically consist of the below listed project components. It is important to note at the outset that the exact specifications of the proposed project components will be determined during the detailed engineering design phase (subsequent to the issuing of an EA, should such an authorisation be granted), but that the information provided in the table below is seen as the maximum proposed development footprint for the proposed WEF projects.

Infrastructure	Description
Number of turbines:	WEF 1: Up to 24 WEF 2: Up to 24
Turbine Capacity:	Up to 10 MW
Hub Height:	Up to 180 m
Rotor (Blade) Diameter:	Up to 190 m
Blade length:	Up to 95 m
WEF Project Size / Generation Capacity:	WEF 1: Up to 240 MWac WEF 2: Up to 240 MWac
Reinforced foundation and crane platform:	Up to 1 ha per turbine
On-site substation hub:	The proposed projects will each include an on-site substation hub incorporating the facility substation, switchyard, collector infrastructure, BESS, and associated O&M buildings. The substation hub will comprise an area of up to 22 ha. The substation-built infrastructure will have a maximum height of 10 m.
On-site Substation Hub Alternatives:	WEF 1: Two (2) WEF 2: Two (2)
Capacity of on-site substation:	33/132 kV
Construction compound and laydown areas:	WEF 1: Up to 10 ha Three (3) placement locations for the construction compound and laydown areas have been identified at each WEF and have been assessed during the EIA Phase WEF 2: Up to 23 ha Four (4) placement locations for the construction compound and laydown areas have been identified at each WEF and have been assessed during the EIA Phase.
Internal service road network:	WEF 1: Up to approximately 25 km WEF 2: Up to approximately 27 km
Internal service roads at each WEF:	Permanent service roads will be up to 10 m wide and may require side drains on one or both sides. All service roads will be gravel and may have underground cables running alongside them. During construction, an up to 12 m road corridor may be temporarily impacted upon which will be rehabilitated to a width of up to 10 m after construction has been completed. Temporary clearing of up to 50 m may be required in areas where cut and fill may be required as well for the construction of the bell mouth road junction, turning circles and temporary passing lanes on site. The network layouts are designed to provide efficient access to all elements of each facility and effective accommodation of the anticipated internal traffic. The specialists have assessed in detail all proposed internal service roads during the EIA

	Phase.
Concrete batching plant:	Up to 0.25 ha at each WEF
Operational and Maintenance (O&M) Building Complex:	To be located within the development footprint of the on-site substation hub at each WEF
Battery Energy Storage System (BESS):	The BESS will cover an area of approximately five (5) ha at each WEF. The BESS technology types that are being considered include: - Lithium ion, NiCd, NiMH-based Batteries - Redox Flow Batteries (VRFB, Zn-Fe, Zn-Br)
Site Access:	The proposed projects and associated infrastructure will be located approximately 1.5 km north and northwest of the town of Molteno in the Eastern Cape Province. Access to the proposed project sites will be facilitated via existing public roads off the R56 provincial asphalt trunk road connecting Molteno with Steynsburg and Sterkstroom, the R397 provincial gravel main road, as well as two district gravel roads herein referred to as “DR1” and “DR2”.
Site Access Points:	WEF 1: Up to 5 WEF 2: Up to 4
Proximity to grid connection:	It is proposed that the electrical grid connection component will likely comprise of a new loop-in loop-out (LILO) connection into the existing Beta-Delphi 400 kV overhead powerline, and a new LILO connection into the existing Dorper-Stormberg 132 kV overhead powerline, at the point where these existing powerlines cross the project site, to facilitate the connection of the proposed project to the national grid. Both options will include associated and supporting infrastructure for the respective projects among other associated and supporting infrastructure. In order to identify sensitivities and environmental features that need to be avoided, the specialists will assess an approximately 500 m wide corridor (250 m on either side of the overhead powerline routes) for the existing Beta-Delphi 400 kV overhead powerline and the proposed 132 kV overhead powerline. ***Note from the CSIR:*** *A separate Environmental Assessment Process will be undertaken once the grid connection and the 132 kV powerline routing for the proposed project has been confirmed, and hence does not form part of this S&EIA Process.*
Fencing:	For various reasons such as security, public protection and lawful requirements, the proposed built infrastructure on site will be secured via the installation of appropriate fencing. Existing livestock fencing on the affected farms portions may be upgraded in places where deemed insufficiently secure, whereas permanent fencing will be required around the O&M areas and on-site substation hubs. Access points will be managed and monitored by an appointed security service provider. The type and height of fencing to be installed will be confirmed during the detailed design phase prior to construction.

2. STUDY APPROACH & INFORMATION SOURCES

In preparing a palaeontological desktop study the potentially fossiliferous rock units (groups, formations, members *etc.*) represented within the study area are determined from geological maps and satellite images. The known fossil heritage within each rock unit is inventoried from the published scientific literature, previous palaeontological impact studies in the same region, and the author's field experience (consultation with professional colleagues as well as examination of institutional fossil collections may play a role here, or later following scoping during the compilation of the final report). This data is then used to assess the palaeontological sensitivity of each rock unit to development (provisional tabulations of palaeontological sensitivity of all formations in the Eastern Cape have already been compiled by J. Almond and colleagues (Almond *et al.* 2008) and are shown on the palaeosensitivity map on the SAHRIS (South African Heritage Resources Information System) website. The likely impact of the development on local fossil heritage is then determined on the basis of (1) the palaeontological sensitivity of the rock units concerned and (2) the nature and scale of the development itself, most notably the extent of fresh bedrock excavation and ground clearance envisaged. When rock units of moderate to high palaeontological sensitivity are present within the development footprint, a field assessment study by a professional palaeontologist is usually warranted.

The focus of palaeontological field assessment is *not* simply to survey the development footprint or even the development area as a whole (*e.g.* farms or other parcels of land concerned in the development). Rather, the palaeontologist seeks to assess or predict the diversity, density and distribution of fossils within and beneath the study area, as well as their heritage or scientific interest. This is primarily achieved through a careful field examination of one or more representative exposures of all the sedimentary rock units present (*N.B.* Metamorphic and igneous rocks rarely contain fossils). The best rock exposures are generally those that are easily accessible, extensive, fresh (*i.e.* unweathered) and include a large fraction of the stratigraphic unit concerned (*e.g.* formation). These exposures may be natural or artificial and include, for example, rocky outcrops in stream or river banks, cliffs, quarries, dams, dongas, open building excavations or road and railway cuttings. Consolidated as well as uncemented superficial deposits, such as alluvium, scree or wind-blown sands, may occasionally contain fossils and should also be included in the field study where they are well-represented in the study area. It is normal practice for impact palaeontologists to collect representative, well-localised (*e.g.* GPS and stratigraphic data) samples of fossil material during field assessment studies. In order to do so, a fossil collection permit from the Eastern Cape Provincial Heritage Resources Agency (ECPHRA) is required and all fossil material collected must be properly curated within an approved repository (usually a museum or university collection).

Note that while fossil localities recorded during field work within the study area itself are obviously highly relevant, most fossil heritage here is embedded within rocks beneath the land surface or obscured by surface deposits (soil, alluvium, *etc.*) and by vegetation cover. In many cases where levels of fresh (*i.e.* unweathered) bedrock exposure are low, the hidden fossil resources have to be *inferred* from palaeontological observations made from better exposures of the same formations elsewhere in the region but outside the immediate study area. Therefore, a palaeontologist might reasonably spend far *more* time examining road cuts and borrow pits close to, but outside, the study area / project footprint than within the study area / project footprint itself. Field data from localities even further afield (*e.g.* an adjacent province) may also be adduced to build up a realistic picture of the likely fossil heritage within the study area.

2.1. Information sources

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

1. A short project outline, maps and kmz files provided by the CSIR, Environmental and Management Services, Stellenbosch;
2. A review of the key relevant scientific literature, including published geological maps (1: 250 000 geology sheet 3126 Queenstown) and accompanying sheet explanation (Johnson 1984) as well as several desktop and field-based palaeontological assessment studies in the wider Molteno Formation outcrop area of the Eastern Cape by the author and others (See References, especially Fourie 2012, Almond 2010a, 2010b, 2018);
3. Examination of relevant topographical maps (*e.g.* 1: 250 000 sheet 3126 Queenstown, 1: 50 000 sheets 3126AA Kees se Berg, 3126AB Lower Adamson, 3126AC Henning & 3126AD Molteno) as well as Google Earth© satellite images;
4. An eight-day reconnaissance-level palaeontological site visit by the author to the combined Ingwe Wind and Solar PV Energy Facilities cluster project area during the period 17 to 24 May (2021) which focused on a representative sample of potentially-fossiliferous exposures of bedrock units (especially potentially fossiliferous mudrock exposures) as well as Late Caenozoic alluvial and eluvial deposits.
5. The author's previous field experience with the formations concerned and their palaeontological heritage (*e.g.* Almond *et al.* 2008).

2.2. Legislative context

This combined desktop and field-based palaeontological heritage report falls under Sections 35 and 38 (Heritage Resources Management) of the South African Heritage Resources Act (Act No. 25 of 1999), and it will also inform the EMPr for this project.

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

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

According to Section 35 of the National Heritage Resources Act, dealing with archaeology, palaeontology and meteorites:
(1) The protection of archaeological and palaeontological sites and material and meteorites is the responsibility of a provincial heritage resources authority.
(2) All archaeological objects, palaeontological material and meteorites are the property of the State.
(3) Any person who discovers archaeological or palaeontological objects or material or a meteorite in the course of development or agricultural activity must immediately report the find to the responsible heritage resources authority, or to the nearest local authority offices or museum, which must immediately notify such heritage resources authority.
(4) No person may, without a permit issued by the responsible heritage resources authority—
   (a) destroy, damage, excavate, alter, deface or otherwise disturb any archaeological or palaeontological site or any meteorite;

(b) destroy, damage, excavate, remove from its original position, collect or own any archaeological or palaeontological material or object or any meteorite;
(c) trade in, sell for private gain, export or attempt to export from the Republic any category of archaeological or palaeontological material or object, or any meteorite; or
(d) bring onto or use at an archaeological or palaeontological site any excavation equipment or any equipment which assist in the detection or recovery of metals or archaeological and palaeontological material or objects, or use such equipment for the recovery of meteorites.

(5) When the responsible heritage resources authority has reasonable cause to believe that any activity or development which will destroy, damage or alter any archaeological or palaeontological site is under way, and where no application for a permit has been submitted and no heritage resources management procedure in terms of section 38 has been followed, it may—

(a) serve on the owner or occupier of the site or on the person undertaking such development an order for the development to cease immediately for such period as is specified in the order;
(b) carry out an investigation for the purpose of obtaining information on whether or not an archaeological or palaeontological site exists and whether mitigation is necessary;
(c) if mitigation is deemed by the heritage resources authority to be necessary, assist the person on whom the order has been served under paragraph *(a)* to apply for a permit as required in subsection (4); and
(d) recover the costs of such investigation from the owner or occupier of the land on which it is believed an archaeological or palaeontological site is located or from the person proposing to undertake the development if no application for a permit is received within two weeks of the order being served.

Minimum standards for the palaeontological component of heritage impact assessment reports (PIAs) have been published by SAHRA (2013) and by Heritage Western Cape (2021).

2.3. Assumptions and 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 computerised database of fossil collections in major RSA institutions which can be consulted for impact studies.

In the case of palaeontological desktop studies without supporting Phase 1 field assessments these limitations may variously lead to either:

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

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

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

Fieldwork in the Molteno area undertaken during May 2022 was partially constrained by heavy rains, river flooding and locally by very muddy roads while visibility for palaeontological recording was limited by poor exposure of potentially fossiliferous mudrock facies due to colluvium, alluvium, soils and pervasive grassy vegetation. Some sectors of the combined Molteno cluster project area could therefore not be accessed in the time available. Confidence levels for the observations and conclusions reached in this report are therefore rated as Medium. Note however that the suggested mitigation measures would still adequately mitigate against any unacceptable adverse impacts. Most of the constraints experienced would apply throughout the year, so the season during which fieldwork took place did not have a substantial impact on the conclusions reached here.

3. GEOLOGICAL CONTEXT OF COMBINED INGWE CLUSTER PROJECT AREA

The combined project area for the proposed Ingwe Wind and Solar PV Energy Facilities cluster and its associated Electrical Grid Infrastructure straddling the R56 tar road and railway network to the west and north of Molteno (Figure 1) lies within dissected hilly to topographically subdued terrain of the Eastern Escarpment Hinterland geomorphic province (Partridge *et al.* 2010), situated to the northeast of the Bamboesberge Range. Prominent mountains surrounding the project area include Rooiberg (2018 m amsl,) in the SW, Grootberg (1994 m amsl.) in the west, another Rooiberg (1930 m amsl.) in the east and an unnamed ridge (2067 m amsl.) to the south. Several lower named *koppies* and ridges within the project area itself are built largely of, or capped by, dolerite (*e.g.* Rooikop 1811 m amsl., Vegkoppies 1722 m amsl.) or of pale Molteno Formation sandstones; the latter build numerous low ridges, *kranzes* and *koppies* with steep, rubble-strewn, stepped slopes in the region. Topographically more subdued terrain in the northwest is underlain by the mudrock-dominated Burgersdorp Formation. The project area is drained broadly towards the north, away from the Great Escarpment, by several small rivers and tributary streams such as the Stormbergspruit, Wonderhoekspruit and Wonderboomspruit whose incised valleys witness the existence of much larger drainage systems in the past. Apart from the ridges and *kranzes* of prominent-weathering dolerite and pale Molteno sandstones, bedrock exposure in the region – especially in lower-lying areas - is generally very poor due to extensive cover by colluvium, alluvium, soils and grassy vegetation (Aliwal North Dry Grassland vegetation type). Typical terrain within and on the margins of the project area is illustrated in Figures 8 to 16 below.

The geology of the Ingwe cluster project area is outlined on the 1: 250 000 geological map sheet 3126 Queenstown (Council for Geoscience, Pretoria) (Figure 2) for which a short explanation has been published by Johnson (1984). The study area is situated within the south-eastern sector of the Main Karoo Basin (Johnson *et al.* 2006). It is underlain by Triassic continental sediments of the mudrock-dominated **Burgersdorp Formation** (Upper Beaufort Group, Karoo Supergroup) in the northwest while the topographically varied terrain in the remainder of the area is built by the sandstone-dominated **Molteno Formation** (Stormberg Group, Karoo Supergroup) (See stratigraphic column in Figure 3). Outliers of younger Stormberg Subgroup units, including the Elliot and Clarens Formations, build the upper slopes of higher mountains on the margins of but *outside* the project area (*e.g.* upper slopes of Rooiberg to the northeast) (Figure 9).

The Upper Beaufort Group and Stormberg Group sediments in the Molteno region are extensively intruded and baked by sills and dykes referred to the **Karoo Dolerite Suite** of Early Jurassic age (*c*. 182 Ma; Duncan & Marsh 2006). These erode out as low ridges and *koppies* (*e.g.* Vegkoppies, Rooikop near Stormberg Station) and have thermally metamorphosed (baked) adjacent sedimentary country rocks to hornfels and metaquartzite. These tough lithologies form a major component of local colluvial gravels and have been widely exploited for the manufacture of stone artefacts. Mudrocks in the vicinity of dolerite intrusions are often pale and highly altered or weathered. The intrusive dolerites themselves are usually highly jointed and weathered with the formation of rounded corestones and crumbly saprolite (*sabunga*). Locally the dolerite contains sizeable enveloped rafts or xenoliths of metamorphosed sandstone, as well seen in the vicinity of Vegkoppies.

Various types of **superficial deposits** of Late Caenozoic (Miocene / Pliocene to Recent) age occur widely throughout the Molteno study region. They include pedocretes (*e.g*. calcretes, ferricretes), slope deposits (scree, hillwash *etc*), river alluvium, diverse soils and surface gravels as well as spring and pan sediments (*cf* Partridge *et al*. 2006). As a result of these deposits as well as pervasive grassy vegetation cover, surface exposure of fresh Karoo Supergroup rocks within the region – apart from the resistant weathering Molteno Formation channel sandstones - is usually poor, apart from occasional stream banks and beds, erosional gullies or *dongas* and steeper hill slopes as well as artificial exposures in road and railway cuttings, farm dams and borrow pits or quarries.

Upper hillslopes below sandstone *kranzes* are blanketed with large, downwasted blocks of karstified sandstone. Lower hill slopes are typically mantled with a thin to thick prism of semi-consolidated, often partially calcretised, sandy to gravelly colluvial or slope deposits (*e.g.* sandstone and dolerite scree, finer-grained hill wash) and soil. These widespread colluvial to alluvial prisms are generally assigned to the Pleistocene to Holocene **Masotcheni Formation** and typically show high levels of erosional gullying. Sandstone clasts, including karst rubble, are often ferruginised.

Thick accumulations of silty, sandy, gravelly and bouldery **alluvium** of Late Caenozoic age (< 5 Ma), including occasional elevated pediment gravels, are found in streams and river valleys. Older colluvial and alluvial deposits may be partially to extensively calcretised (*i.e.* cemented with soil limestone or calcrete) or ferricretised, especially in the neighbourhood of dolerite intrusions. Well-rounded cobbles and boulders derived from conglomeratic horizons within the Molteno Formation sandstones (*e.g.* basal Indwe Member Kolo Pebble Bed) locally dominate colluvial and alluvial gravels and have been extensively exploited for stone tools (*e.g.* ESA bifaces and crudely flaked artefacts, MSA blades in grey, patinated hornfels). Occasional flaked tools occur embedded within Pleistocene or younger alluvium and are frequently seen among bands of elevated "High Level Gravels" overlying bedrock or consolidated older alluvium along major drainage lines.

Polygonally jointed horizons of massive, gritty, orange-brown sandstone with fine dispersed gravels and incipient calcretisation which underlie unconsolidated younger alluvium are probably debrites of Pleistocene age.

Thin sheetwash and eluvial surface gravels – best seen in open, unvegetated patches in the *vlaktes* - are various dominated by dolerite, sandstone, metaquartzite, hornfels, reworked quartzite cobbles and boulders, as well as rare blocks of greenish-yellow chert which may be tuffutic (possibly exotic manuports, source unknown but possibly the Kolo Pebble Bed). Note that no *in situ* tuffs were recorded within the Molteno Formation bedrocks; if present, they would be of considerable interest for dating the Molteno succession.

Field photographs covering the terrain and representative exposures of the main rock units present within the combined Ingwe cluster project area are provided below in Figures 8 to 72 below, together with explanatory figure legends.

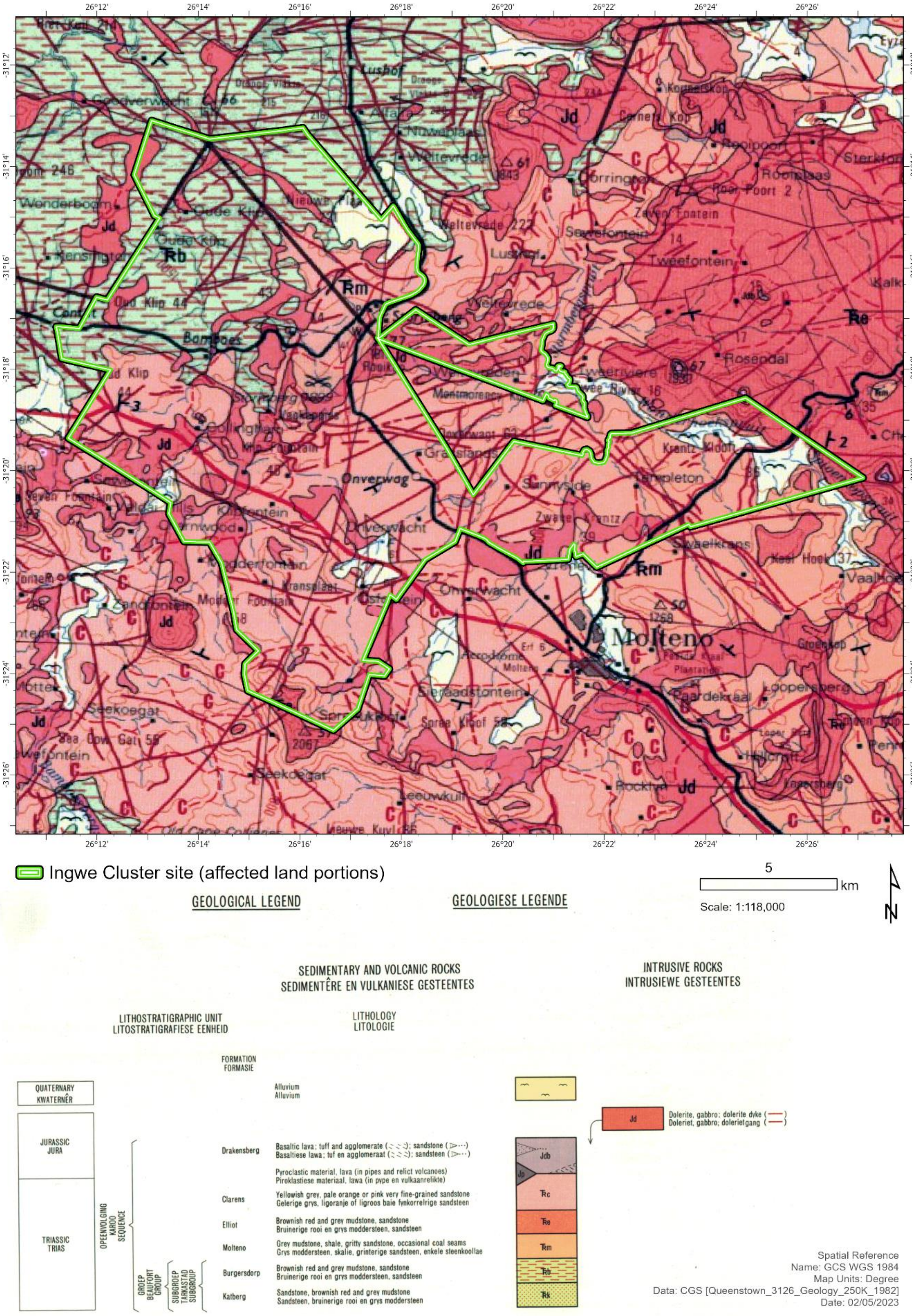


Figure 2: Extract from 1: 250 000 geological map 3126 Queenstown (Council for Geoscience, Pretoria) showing the location of the combined Ingwe cluster project area near Molteno, Eastern Cape (Image prepared by the CSIR).

In Figure 2, rock units mapped within the wider study area include:

- TRb (greenish yellow with dashes) = Early to MidTriassic Burgersdorp Formation (Upper Beaufort Group / Tarkastad Subgroup)
- TRm (flesh pink) = Late Triassic Molteno Formation (Stormberg Group)
- TRe (red) = Late Triassic to Early Jurassic Elliot Formation (Stormberg Group)
- TRc (pink) = Jurassic Clarens Formation (Stormberg Group)
- Jd (bright pink) = Early Jurassic intrusions of the Karoo Dolerite Suite
- Pale yellow areas = Late Caenozoic alluvium (including Pleistocene Masotcheni Formation)

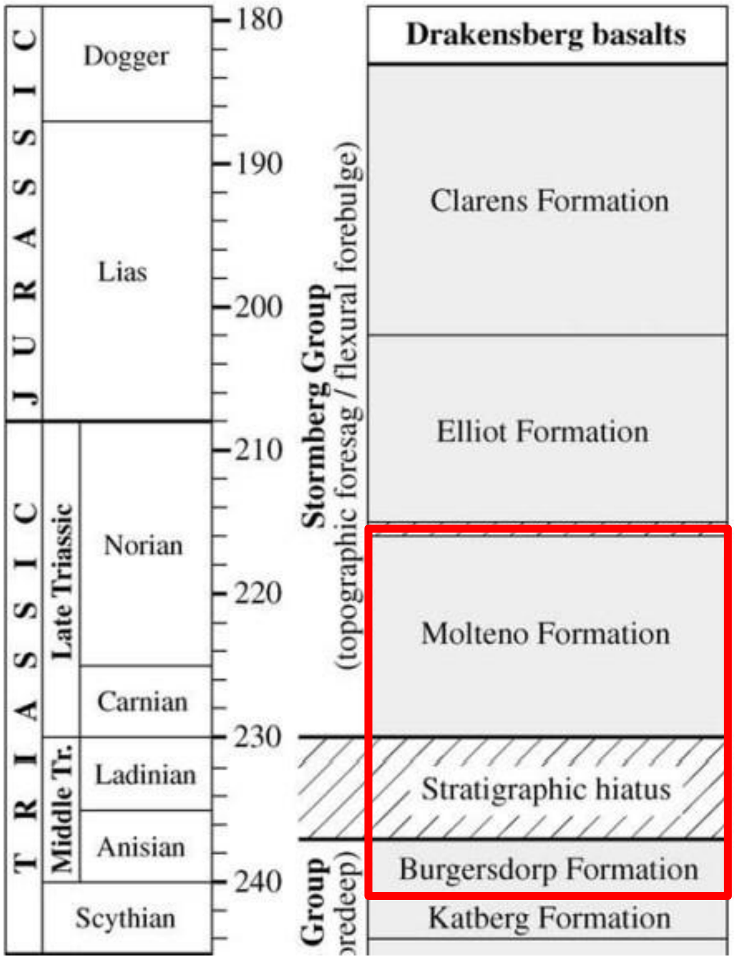


Figure 3: Stratigraphic column for the upper portion of the Karoo Supergroup showing the position of the Triassic continental sedimentary bedrocks represented within the Ingwe cluster project area (red rectangle). Note the substantial hiatus or time gap between the Burgersdorp and Molteno Formations. A smaller gap is now recognised at the base of the overlying Elliot Formation. Small outliers of Elliot and Clarens Formation are present on the margins of but *outside* the project area.

3.1. Burgersdorp Formation

The Burgersdorp Formation is the youngest subunit of the Permo-Triassic Beaufort Group (Karoo Supergroup, Tarkastad Subgroup) and is paraconformably overlain by the Molteno and Elliot Formations of the Stormberg Group. It is a mudrock-rich redbed succession of Early to Middle Triassic age with a total thickness of some 900-1000 m in its southern outcrop area near Queenstown (Johnson *et al.* 2006). Kitching (1995) quotes a thickness of 600 m in the type area for this formation between Queenstown and Lady Frere. Brief geological descriptions of the Burgersdorp Formation are given by Karpeta and Johnson (1979), Dingle *et al.* (1983), Johnson (1976, 1984), Hiller & Stavrakis (1984), Johnson & Hiller (1990), Kitching (1995) and Hancox (2000; see also extensive references therein).

The Burgersdorp rocks were laid down within the Main Karoo Basin by north-westwards flowing meandering rivers during a warm, arid to semi-arid climatic interval (Figure 4). They comprise isolated, lenticular, feldspathic channel sandstones, abundant crevasse splay sandstones, and typically greyish-red to dusky red overbank mudrocks, forming upwards-fining cycles of a few meters to tens of meters in thickness. Intraformational mudflake breccio-conglomerates are common at the base of the sandstone units. The mudrocks are generally massive (unbedded) but occasionally display sand-infilled mudcracks and clastic dykes. Well-laminated reddish mudrocks with pedocrete horizons are interpreted as playa lake deposits. Lacustrine palaeoenvironments predominated in the northern part of the Karoo Basin at this time and these lake deposits have recently received considerable palaeontological attention (*e.g.* Free State; Welman *et al.* 1991, Hancox *et al.* 2010 and references therein). A brief description of the Burgersdorp beds in the Queenstown sheet area is given by Johnson (1984).

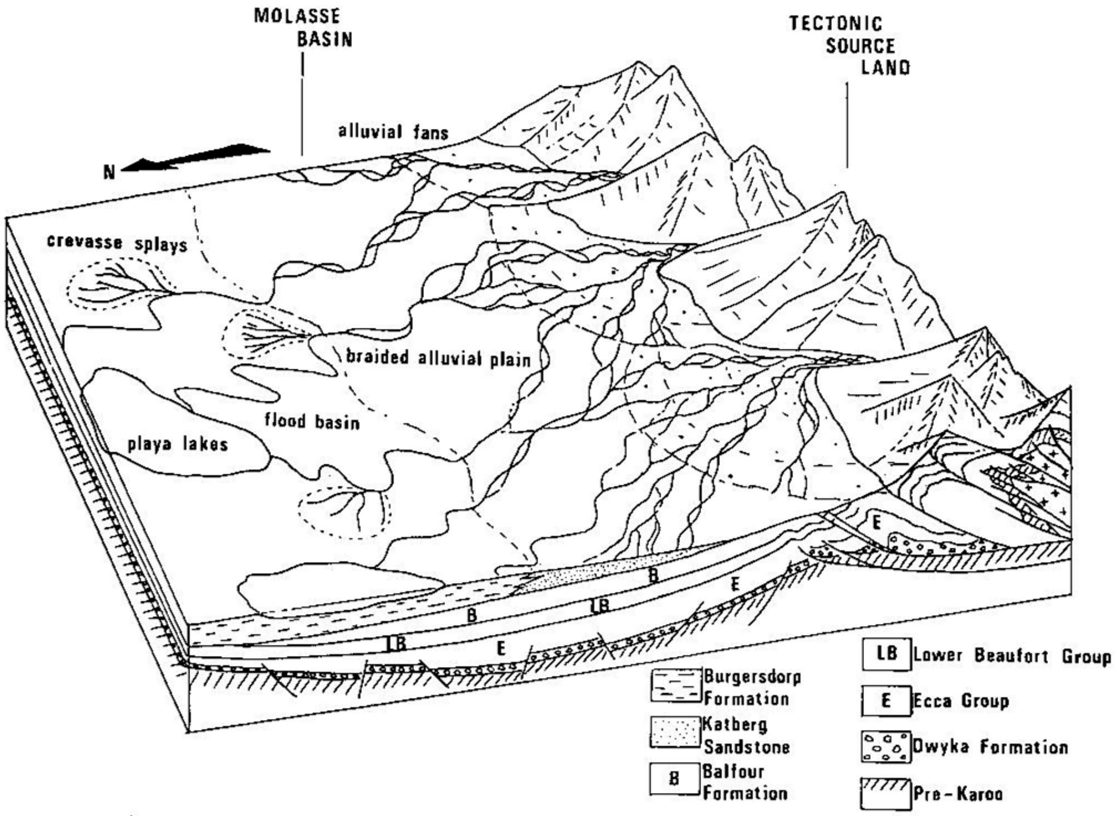


Figure 4: Reconstruction of the south-eastern Main Karoo Basin in Early Triassic times showing the deposition of the sandy Katberg Formation near the mountainous source area

in the south. The mudrock-dominated Burgersdorp Formation was deposited on the distal floodplain where numerous playa lakes are also found (From Hiller & Stavrakis 1984). Only the Burgersdorp Formation is represented within the Ingwe cluster project area.

The Burgersdorp Formation outcrop area within the Ingwe cluster project area is generally of low to very low relief, largely blanketed by alluvium, surface gravels and soils as well as pervasive grassy vegetation with very little bedrock exposure (Figures 16 to 21). Occasional low scarps and ridges built by subordinate, thin packages of fine- to medium-grained, well-sorted channel sandstones are weathered and locally display pale reduction spots and veins. Dusky purple-grey mudrocks are very rarely well-exposed and often deeply weathered near surface, while overlying eluvial sandstone blocks typically display secondary ferruginisation and a dark, blackish ferro-manganese patina. These features may be related to palaeoweathering along the regional basal-Molteno unconformity.

3.2. Molteno Formation

The Molteno Formation is a stratigraphically complex wedge of perennial braided alluvial sediments of estimated early Late Triassic (Carnian) age that crops out around the margins of the Stormberg Group outcrop area centred on the Drakensberg highlands. The sandstone-rich Molteno succession is more resistant-weathering than the underlying and overlying rocks (Burgersdorp and Elliot Formations respectively) and therefore tends to form a pronounced stepped topographic escarpment. At its thickest, in the south, the formation reaches 600-650 m and has been subdivided into a series of five members, but it tapers rapidly towards the north. According to Turner (1983) only the first three upward-fining members are represented near Molteno in the south-western sector of the Molteno Formation outcrop area (Figures 6 & 7). The basal Bamboesberg Member comprises several thin cycles and is best seen in the southern part of the Ingwe cluster project area as well as low escarpments and *kranzes* directly overlying the Burgersdorp Formation outcrop area further north. The thick Indwe Member (second cycle) has an erosional, conglomeratic base (the Kolo Pebble Bed) and is a major sandstone cliff-former, well seen, for example, at Kransplaat. The overlying third member comprises several thinner cycles with spaced basal sandstone packages, as well seen beneath the Elliot Formation red beds on the lower slopes of Rooiberg just NE of the Ingwe cluster project area (Figure 9) and the (unnamed) high *koppie* on the southern margins of the area (Figure 12).

Useful short geological accounts of the Molteno Formation are given by Dingle *et al.* (1983), Visser (1984), Smith *et al.* (1998), Hancox (2000) and Johnson *et al.* (2006), while a brief description of these rocks in the Queenstown 1: 250 000 geology sheet area is provided by Johnson (1984). A paper by Rust (1962) (not seen) covers the Molteno beds near Molteno. Key technical papers include those by Turner (*e.g.* 1975, 1983), Eriksson (1984), Christie (1981), Dingle *et al.* (1983), Cairncross *et al.* (1995), Anderson *et al.* (1998) and Hancox (1998). An excellent summary with fuller geological references are provided by Hancox (2000) while a recent study of the Beaufort – Stormberg Group contact (*i.e.* Burgersdorp – Molteno contact) has been presented by Hancox and Rubidge (2023).

The Molteno succession is made up of an alternation of laterally-persistent, erosive-based, medium- to coarse-grained, poorly-sorted, gritty and occasionally pebbly, arkosic (feldspathic) sandstones and subordinate khaki, olive-grey to occasionally reddish mudrocks (Figures 22 to 53). These rocks were deposited in braided alluvial channels, overbank floodplains and lakes on an extensive, northwards-flowing braided alluvial braidplain (Figure 5). The sandstones typically show a “glittering” appearance due to extensive development of secondary quartz overgrowths. Internal sedimentary structures include trough and planar cross-bedding, flat-lamination and soft-sediment deformation features including convolute and overturned cross-bedding associated with dewatering triggered by seismic and / or sudden flood events (best seen in the Ingwe Member). Numerous fining-upwards sequences of 5-50 m thickness, averaging 20-30 m, are commonly present within the Molteno succession (Johnson 1984). These sequences, which can be readily seen on aerial and satellite images, grade upwards from pebbly, coarse sandstones at the base through finer sandstones, siltstones and finally into carbonaceous, thinly-bedded to laminated claystones (Figures 6 & 7). These last may be highly fossiliferous (Section 4.2). Thin, lenticular coals – mined locally in the Molteno area (*e.g.* Old Cape Collieries; Hancox & Götz 2014) (Figure 76) - were formed in peaty swamp settings on the alluvial floodplain, but many so-called "coals" are effectively only carbonaceous mudstones and are generally poorly exposed (*e.g.* occasional road cuttings, stream gullies). Humid, warm climates with a pronounced seasonality are suggested by the rich plant and insect life preserved in these sediments, especially the finer-grained mudrocks, as well as by the sedimentology and fossil soils (Hancox 2000). However, given the high palaeolatitudinal and continental interior setting, some authors infer an alternation of warm, dry summers and cool, wet winters (*e.g.* Anderson *et al.* 1998, Johnson *et al.* 2006). The precise age of the Molteno Formation has not yet been firmly established, but an early Late Triassic (Carnian, 228-216.5 Ma) age is favoured for at least the lower part of the formation by most recent authors on the basis of the fossil plants (*Dicroidium* Flora) and palynomorphs (*Allisporites / Falcisporites* assemblages) as well as biostratigraphic correlation with Australian Triassic successions (Hancox 2000, Rubidge 2005).

Molteno sandstone packages in the project area are variously massive (possibly with cryptic bedding) or thick- to thin-bedded and tabular to lenticular in geometry with erosive bases incising underlying mudrock facies. Tabular and large scale trough foresets consistently indicate palaeocurrents towards the NNW and NW (*i.e.* little meandering). Mudrock intraclast breccio-conglomerate horizons are usually preserved as moulds. Cobble to occasional boulder-sized, very well-rounded clasts of pale grey quartzite occur within more conglomeratic horizons towards the base of several Molteno cycles, most notably the Kolo Pebble Bed at the base of the Indwe Member (see arrow in Figure 6). The extra-basinal provenance of these quartzites may be the Witteberg Group (or even older Table Mountain Group) of the eroding Cape Fold Belt to the south. Blocks of silicified wood associated with cobbly eluvial gravels, and possibly also rare clasts of yellowish-green tuffite, may have been downwasted from these coarser-grained horizons.

Packages of highly tabular, thin- to medium-bedded, brownish, fine, silty to medium-grained sandstones are locally seen in road cutting and valley sides, overlying dark grey mudrocks. They may be ascribed to crevasse-splays or sheet floods (Cairncross *et al.* 1995).

Secondary silicification of coarse, gritty Molteno sandstones – probably, at least in part, related to regional dolerite intrusion - is associated with the development of concentrations of pebble- to cobble-sized, prominent-weathering spheroidal concretions, some of which weather to doughnut-shapes. The Molteno sandstone packages – especially those of the Ingwe Member – show well-developed karstic weathering features (*e.g.* scabby surfaces, crocodile weathering, case hardening, chicken heads, shallow rock pools). In addition, many sandstone surfaces have been extensively etched and moulded by ongoing lichen weathering processes. Consequently well-preserved, extensive bedding plane surfaces are rare.

Mudrock facies of the Molteno Formation are only rarely exposed in the present study area. They vary in hue from khaki to grey-green, olive green or pale to dark grey, with very occasional purplish beds. The mudrocks vary from massive to thin-bedded or laminated and usually highly weathered near surface. True coals were not encountered during the site visit but occasional thin horizons of blackish, coalified, highly carbonaceous shales are seen; where interbedded with coarse sandstone facies they probably reflect peaty areas in abandoned river channels and elsewhere represent overbank swampy areas.

Prominent-weathering, tabular banks (*c*. 20-30 cm thick) of pale greenish-grey to pale olive green, fine-grained silty sandstone occur at intervals within the Molteno mudrock packages (*e.g.* R56 road cuttings N of Kransplaat and NW-facing hillslopes on Modderfontein 58 – mapped within the lower Molteno Formation / Bamboesberg Member). The banks are typically well-jointed, blocky weathering with fairly sharp bases overlying grey-green mudrocks and show possible bioturbation textures (*e.g.* equivocal forking root traces) and mudcrack-infills. Texturally they are massive, occasionally with fine angular cavities or vugs and dispersed pale mudflakes. These units appear to be secondarily silicified (*e.g.* conchoidal fracture, polygonal jointing) and may be paler and quite cherty towards the base. The most likely interpretation is that they represent secondarily silicified pedocrete (ancient soil) horizons but this requires confirmation. They are locally baked and intruded by dolerite dykes and overlain by Pleistocene Masotchini colluvial sediments. Cairncross *et al.* (1995 p458) refer to poorly developed beige and khaki palaeosols within floodplain deposits which are intensely rooted and bioturbated.

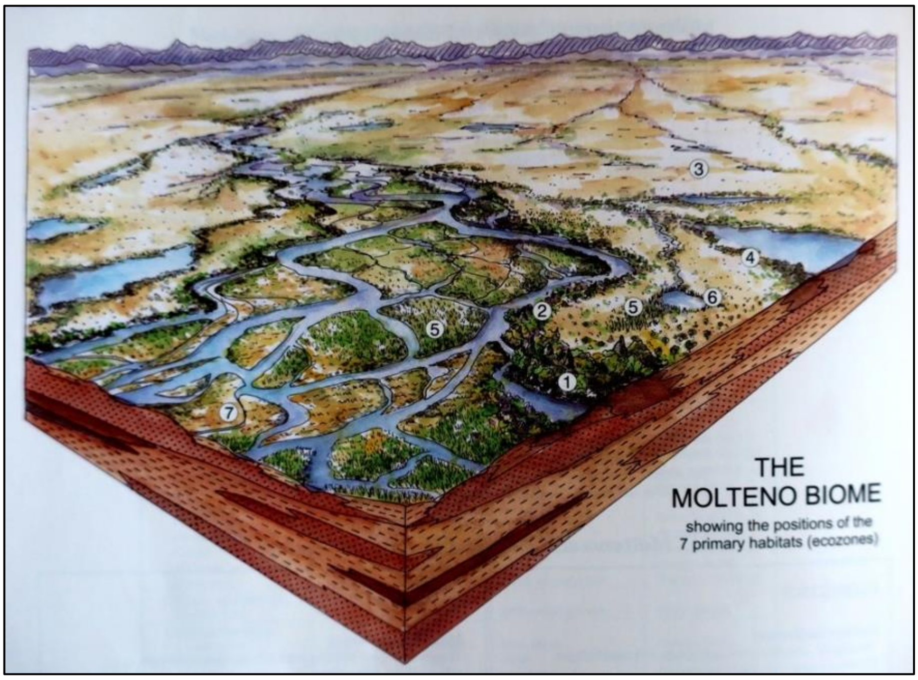


Figure 5: Artist's reconstruction of the depositional setting of the Late Triassic Molteno Formation – a well-vegetated sandy braidplain fed by major river systems from the emergent Cape Fold Belt mountains to the south (from Anderson (ed.) 2001. *Towards Gondwana Alive*).

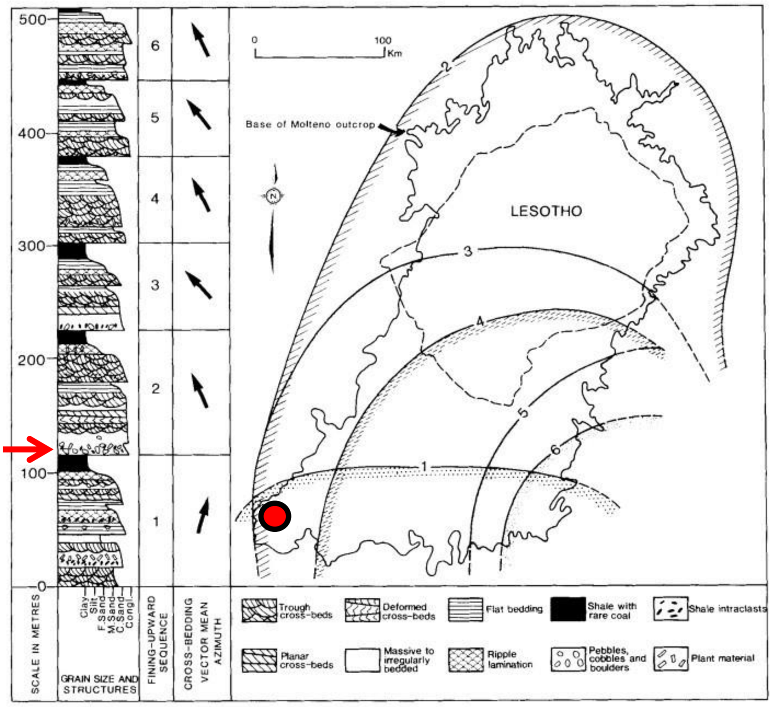


Figure 6: Schematic sedimentary section of the Molteno Formation (from Turner 1983). Upward-fining Cycles 1 (Bamboesberg Member), 2 (Indwe Member) and 3 are represented in the southwestern outcrop area near Molteno (red dot). Palaeocurrent transport directions deduced from cross-bedding are broadly towards the N to NNW. The important conglomeratic marker of the Kolo Pebble Bed at the base of the Indwe Member is arrowed.

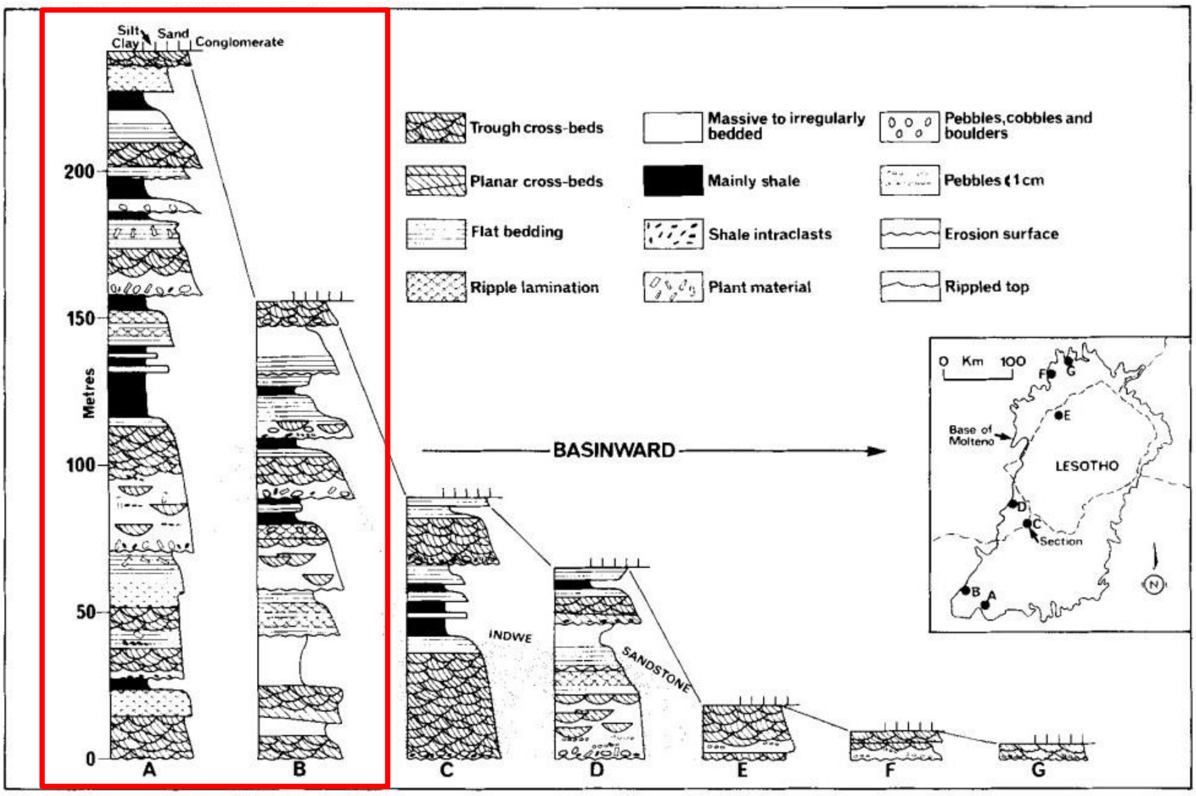


Figure 7: Representative sections through the Molteno Formation succession (Turner 1983). Measured sections A and B, *c*. 150-250 m thick, correspond most closely to the successions present in the present study area near Molteno, situated in the more proximal, south-western sector of the Molteno Formation outcrop area.

Figure 8: Fairly flat, grassy terrain on Krantz Kloof 36 in the south-eastern sector of the Ingwe cluster project area, looking towards Rooiberg in the northwest, with typical stepped topography of the Molteno Formation outcrop area in the middle ground.

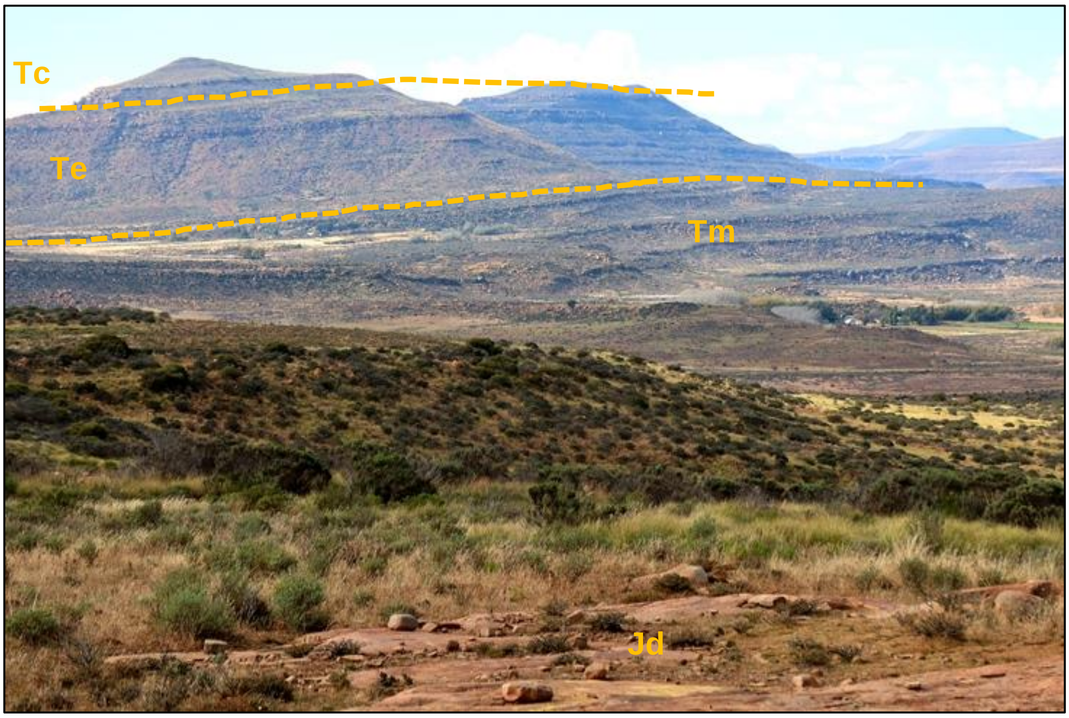


Figure 9: Stormberg Group stratigraphy on the SW flanks of Rooiberg, NNE of Molteno and just *outside* the Ingwe cluster project area, viewed from the northwest (Farm Weltevrede 27/222) with a major dolerite intrusion in the foreground (Tm – Molteno Fm; Te – Elliot Fm; Tc – Clarens Fm; Jd – Karoo dolerite).

Figure 10: Wide valley incised into the sandstone-dominated cycles of Molteno Member by a tributary of the Stormbergspruit, Farm Zwavel Krantz RE/39 (WEF 1).

Figure 11: Flattish, grassy terrain with domical termitaria within the Molteno Formation outcrop area on Zwavel Krantz RE/39 (WEF 1).

Figure 12: Unnamed ridge-like *koppie* on the south-western margin of the Ingwe cluster project area, viewed across low-relief terrain from Farm Modderfontein 2/58 (WEF 2) to the NE, with doleritic eluvial rubble in the foreground. The ridge is built of Molteno and Elliot Formation beds.

Figure 13: Low-relief grassy terrain in the Molteno Formation outcrop area on Farm Oud Klip 29/44 (WEF 2).

Figure 14: Typical sandstone-capped scarp of Molteno Formation sandstones in the south-western sector of Ingwe cluster project area – here at Kransplaat on Farm Modderfontein 2/58 (WEF 2), viewed from the west.

Figure 15: Low, dolerite capped hills of the historically important Vegkoppies on Farm Klip Fountain 40 (WEF 2), viewed from the east. The dolerite overlies baked sandstones of the Molteno Formation.

Figure 16: Typical flat-lying, grassy terrain seen in the Burgersdorp Formation outcrop area, here on Farm Bamboo RE/43 (WEF 2).

Figure 17: Typical blackish, ferromanganese patinated gravels seen close to the Burgersdorp / Molteno contact, Farm Bamboo RE/43 (WEF 2). These gravels may be related to the major regional unconformity along the basal Stormberg Group contact.

Figure 18: Rare exposure of purple-brown channel sandstones of the Burgersdorp Formation on Farm Oud Klip 16/44 (WEF 2), here showing pale reduction spots and possible rounded concretions (*cf* Figure 80).

Figure 19: Gullied hillslope exposure of purple-brown and khaki Burgersdorp Formation overbank mudrocks on Farm Oud Klip 16/44 (WEF 2), close to the contact with the overlying pale Molteno Formation sandstones.

Figure 20: Collapsed blocks of pale yellowish sandstone of the basal Bamboesberg Member downwasted onto mudrocks of the underlying Burgersdorp Formation, Farm Bamboo RE/43 (WEF 2).

Figure 21: Sharp basal contact of a thinly bedded, tabular lower Molteno Formation channel sandstone (Bamboesberg Member) with khaki weathered mudrocks, probably of the Burgersdorp Formation, Farm Oud Klip 16/44 (WEF 2) (hammer = 30 cm).

Figure 22: Thin sandstone cycles of the Bamboesberg Member (Lower Molteno Formation) on Farm Stockdale 282, NE of Stormberg Station and just outside the present project area.

Figure 23: Limited exposure of weathered greyish and khaki overbank mudrocks of the Molteno Formation on Farm Onverwagt 32/63 (WEF 1). Most fine-grained bedrocks in the project area are covered by colluvial and alluvial deposits.

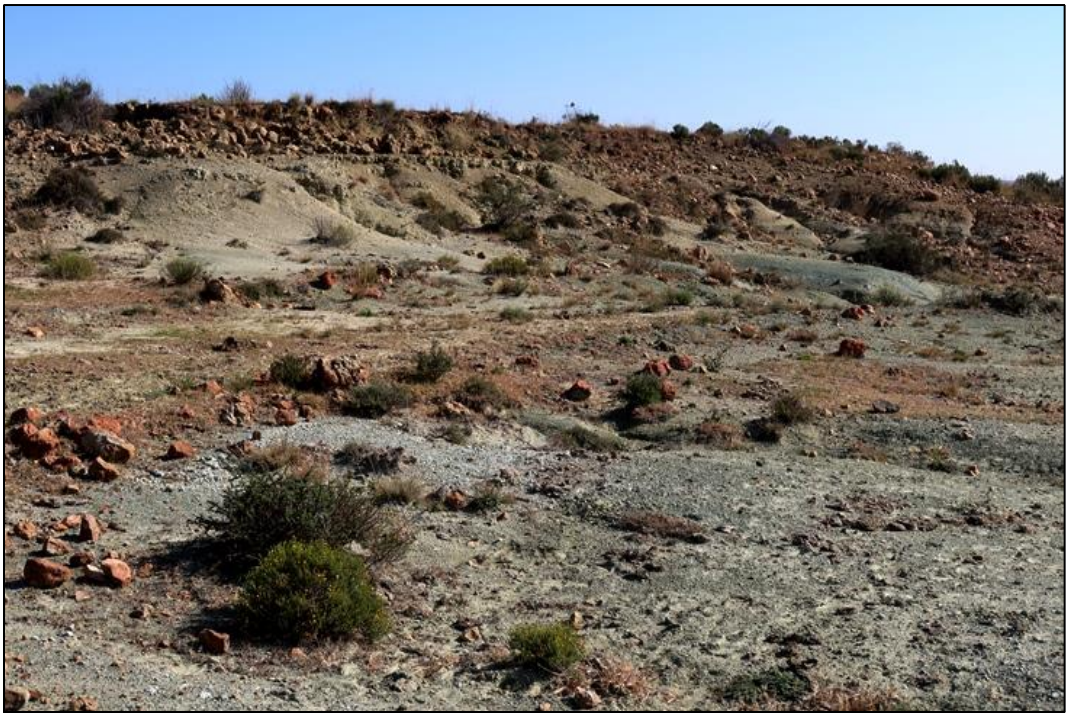


Figure 24: Gullied lowland exposure of greyish and khaki weathered mudrocks of the Molteno Formation on Farm Krantz Kloof 36 (WEF 2), capped here by a thin silicified pedocrete horizon showing rubbly weathering.

Figure 25: Thin Bamboesberg Member sandstone packages overlain by the cliff-forming Indwe Member sandstone on Modderfontein 2/58 (WEF 2).

Figure 26: Bamboesberg Member stepped hillslopes on Modderfontein 2/58 (WEF 2) showing limited exposure of a pale khaki mudrock package.

Figure 27: Detail of weathered Bamboesberg Member weathered mudrocks illustrated above, here showing a series of resistant-weathering, yellowish to grey-green silicified and bioturbated pedocrete horizons (hammer = 30cm).

Figure 28: Well-jointed, silicified, pale pedocrete horizon of the Molteno Formation mantled by gravelly colluvial deposits on Farm Spreeuwkloof 1/59 (WEF 1).

Figure 29: Heterolithic package within the lower Molteno Formation on Farm Modderfontein 58/2 (WEF 2) showing thinly interbedded, tabular sandstones and khaki mudrocks. Hammer = 30 cm.

Figure 30: Road cutting along the R56 showing multi-hued, weathered mudrocks of the Molteno Formation (including are reddish facies) with occasional prominent-weathering pedocrete horizons, Farm 62 (WEF 1).

Figure 31: R36 road cutting showing pale Molteno Formation channel sandstone overlain by cross-bedded sandstone unit and a package of brownish, tabular, thin-bedded sandstones (*c*. 2 km west of Molteno outskirts and south of Onverwacht homestead). Hammer = 30 cm.

Figure 32: Extension of road cutting illustrated above with a thin, dark grey mudrock interval between the lower, cross-bedded channel sandstone and darker, thinly bedded, tabular facies above.

Figure 33: Weathered, greyish, thin-bedded to laminated carbonaceous mudrocks of the Molteno Formation on Farm Onverwagt 32/63 (WEF 1). Hammer = 30 cm. See Figure 23 above for context.

Figure 34: Downwasted blocks of coalified laminated mudrock eroding out from thin, dark, carbonaceous mudrock horizon of the Molteno Formation on Farm 32/63 (WEF 1) (Loc. 061) (hammer = 30 cm). This potentially fossiliferous unit is not well-exposed *in situ*.

Figure 35: Kranz of pale brown, highly tabular, thin-bedded sandstones – possibly deposited by crevasse splays or sheet floods - overlying dark carbonaceous mudrocks on Farm 32/63 (WEF 1). Hammer = 30 cm.

Figure 36: Cliff-forming, amalgamated channel sandstone packages of the Indwe Member (middle Molteno Formation) seen at Kransplaat on Farm Klip Fountain 7/40 (WEF 2), viewed from the north.

Figure 37: Tabular, thick, horizontally-bedded channel sandstones of the Molteno Formation on Farm Weltevrede 16/222 (SEF 4) showing clear evidence of karst (solution) weathering.

Figure 38: Deeply incised erosional base of a thick-bedded Molteno Formation channel sandstone package overlying khaki, thin- to medium-bedded mudrocks, road cutting on Farm Weltevrede 16/222 (SEF 4).

Figure 39: Large scale trough crossbeds within Molteno Formation channel sandstones exposed in a riverbed on Zwavel Krantz 2/39 (WEF 1). Palaeocurrents were consistently to the NNW / NW.

Figure 40: Low angle cross-bedding within Molteno Formation channel sandstone body on Farm Onverwagt 63/30 (WEF 1). Hammer = 30cm.

Figure 41: Convolute deformed bedding within Molteno Formation channel sandstones (probably Indwe Member), perhaps generated by seismic- or flood-triggered dewatering, Farm Klipfontein 283 (SEF 1). Hammer = 30 cm.

Figure 42: Sharp erosional contact between a Molteno Formation channel sandstone and underlying olive-green overbank mudrocks, road cutting south of Stormberg Station, Farm 23/40 (WEF 2). The contact is marked by a thin, lenticular lag of well-rounded quartzite cobbles (arrow).

Figure 43: Surface gravels dominated by quartzite cobbles (some flaked) weathered out from the nearby Molteno sandstone escarpment (possibly the Kolo Pebble Bed or an older conglomeratic unit), Farm Oud Klip 44/16. Hammer = 30 cm.

Figure 44: Detail of well-rounded, extra-basinal cobbles of pale greyish or brownish quartzite (Witteberg or Table Mountain Group) weathered out from the Molteno Formation channel sandstones on Farm Weltevrede 16/222 (SEF 4). Scale = 15 cm.

Figure 45: Flaked block of pale yellowish-green, speckled tuffite among surface gravels overlying the Molteno Formation on Farm 29/44 (WEF 2) (scale in cm). This clast may have weathered out from basal channel conglomerates of the Molteno succession. No *in situ* tuffite horizons were observed within the project area (If present, they would be of great interest for radiometric dating).

Figure 46: Rugged, karstified Molteno Formation channel sandstones along the edge of a north-facing scarp, Farm Klipfontein 283 (SEF 3).

Figure 47: Polygonally-etched bedding plane (karstic crocodile weathering) on Molteno channel sandstone on Farm Onverwagt 3/63. Hammer = 30 cm. The paucity of good bedding planes in the Molteno Formation outcrop area has probably compromised the preservation of tetrapod trackways.

Figure 48: Extensively karstified and lichen-weathered slabs of Molteno Formaion channel sandstone on Farm Onverwagt 3/63.

Figure 49: Good example of well-developed, on-going lichen etch-weathering on karstified channel sandstone of the Molteno Formation, Farm Klipfontein 283 (SEF 1). Hammer = 30 cm.

Figure 50: Karstified and ferruginised blocks of Molteno Formation channel sandstone within colluvial breccias on Farm Zwavel Krantz RE/39 (WEF 1).

Figure 51: Boxwork of prominent-weathering, silicified, joint-controlled ridges within Molteno Formation sandstones in the southern footslopes of the Vegkoppies on Farm Klip Fountain 21/40 (WEF 2). This phenomenon is probably related to nearby dolerite intrusion.

Figure 52: Cannonball- sized concretions of silicified sandstone within the lower Molteno Formation on Modderfontein 2/58 (WEF 2) whose formation is probably due to nearby dolerite intrusion. Hammer = 30 cm.

Figure 53: Doughnut-shaped siliceous concretions weathering-out of a Molteno Formatio sandstone block on Modderfontein 2/58 (WEF 2). Scale = 15 cm.

Figure 54: Cut face through a weathered dolerite sill showing intensive jointing and corestone formation, small quarry on Farm 37/63 (WEF 1) near Molteno.

Figure 55: Columnar jointing within an inclined dolerite dyke picked-out and exaggerated by karstic solution weathering, Farm Bamboo RE/43 (WEF 2).

Figure 56: Thin, inclined dolerite dyke cutting weathered Molteno Formation mudrocks and pedocrete horizons, Farm Spreeuwkloof 1/59 (WEF 1). Hammer – 30 cm.

Figure 57: Substantial inclined dolerite intrusion cutting through baked Molteno Formation sandstone and mudrock facies exposed in a small quarry near Eldorado homestead *c.* 1.4 km NE of the outskirts of Molteno, outside and just south of the present project area.

Figure 58: Substantial xenolith of pale metaquartzite comprising a raft of baked Molteno sandstone enclosed by corestone-weathered intrusive dolerite, Farm Klip Fountain 21/40 (WEF 2). Hammer = 30 cm.

Figure 59: Rubbly sandstone eluvial gravels overlain by darker, well-bedded, finer-grained colluvial and sheetwash sediments on Farm Nieuwe Plaats RE/221 (SEF 1).

Figure 60: Thick, semi-consolidated, gravelly to sandy colluvial to alluvial deposits of the Masotcheni Formation exposed by extensive gullying along the foot of the basal Molteno escarpment.

Figure 61: Gravelly colluvium dominated by brownish quartzite overlying gullied, pale, calcretised Masotcheni Formation deposits mantling the footslopes of low Molteno sandstone hills on Farm Krantz Kloof 36 (SEF 5).

Figure 62: Pale greyish, calcretised, fine-grained older alluvium of possible Pleistocene age exposed along a tributary of the Stormbergspruit on Farm RE/39 Zwavel Krantz (WEF 1).

Figure 63: Intensely gullied, semi-consolidated colluvial to alluvial sediments of the Masotcheni Formation exposed along a valley floor on Farm Krantz Kloof 36 (SEF 5).

Figure 64: Detail of the thick, brownish, sandy to silty alluvium with coarse basal gravels in the area illustrated above.

Figure 65: Occasional flaked artefacts (arrow) embedded within the alluvial deposits seen above indicate a Pleistocene or younger age.

Figure 66: Polygonally-cracked horizon of semi-consolidated, orange-brown hued gritty sandstone of possible debrite origin and Pleistocene age underlying younger alluvial and colluvial deposits on Farm Weltevrede 222 (SEF 4). Hammer = 30 cm.

Figure 67: Coarse fluvial gravels overlying benches of calcretised alluvium and sandstone bedrock and elevated several meters above modern stream levels, Farm Krantz Kloof 36 (SEF 5). These oligomict gravels contain occasional ESA crudely flaked artefacts, including Acheulean bifaces (inset).

Figure 68: Orange-brown sandy alluvial soils overlying the Burgersdorp Formation outcrop area on Farm Klipfontein 283 (SEF 3) showing incipient calcretisation. Hammer = 30 cm.

Figure 69: Mantle of polygonally-jointed, brownish, sandy alluvial soils overlying Burgersdorp Formation bedrocks in low relief terrain on Farm Oud Klip 16/44 (WEF 2).

Figure 70: Open patches in grassy terrain on Zwavel Krantz 39 (WEF 1) exposing sandy soils and a sparse veneer of surface gravels.

Figure 71: Close-up of surface gravels illustrated above showing predominance of brownish ferriginous sandstone, yellowish-brown patinated hornfels (often flaked) and occasional well-rounded quartzite pebbles of extra-basinal provenance. Scale is 15 cm long.

Figure 72: Dense carpet of angular surface gravels of pale metaquartzite derived from baked Molteno sandstones in the region, Farm Krantz Kloof 36 (SEF 5).

4. PALAEONTOLOGICAL HERITAGE CONTEXT OF THE INGWE CLUSTER PROJECT AREA

Fossil assemblages known elsewhere from the Burgersdorp and Molteno Formations are briefly outlined here. New fossil sites from the combined Ingwe cluster project area are briefly described and illustrated (Section 4.3, Figures 78 to 94) with GPS locality details provided in Appendix 1 where the sites are also plotted on satellite images of the WEF project areas.

4.1. Burgersdorp Formation fossil biotas

The Burgersdorp Formation is characterized by a diverse continental fossil biota of Early to Middle Triassic (Olenekian to Anisian) age, some 249 to 237 million years old (Kitching 1995, Hancox 2000, Rubidge 2005, Neveling *et al.* 2005, Smith *et al.* 2012, Hancox *et al.* 2020). Karoo fossil biotas of this age are of special interest in that they document the recovery of life on land following the catastrophic end-Permian mass extinction event. The Burgersdorp fauna is dominated by a wide variety of tetrapod taxa, notably a range of temnospondyl amphibians, archosaur and other reptiles as well as a range of therapsids ("mammal-like reptiles") *plus* various fish groups, vascular plants and trace fossils of both vertebrate and invertebrate origin. This distinctive biota is referred to the ***Cynognathus* Assemblage Zone** (= *Kannemeyeria* – *Diademodon* Assemblage Zone of earlier authors; see Keyser & Smith 1977-78, Kitching 1995) which has been recently reviewed and subdivided by Hancox *et al.* (2020). Comparable Triassic faunas have been described from various parts of the ancient supercontinent Pangaea, including Russia, China, India, Argentina, Australia and Antarctica.

Useful accounts of the palaeontological heritage of the Burgersdorp Formation – which has recently being recognised as yielding one of the richest Early-Mid Triassic biotas worldwide – are given by Kitching (1977, 1995), Keyser and Smith (1977-78), MacRae (1999), Hancox (2000; see also many references therein), Cole *et al.* (2004), Rubidge (2005), Smith *et al.* (2012), Hancox *et al.* (2020), Wolvaardt (2021) and Wolvaardt *et al.* (2023). The Burgersdorp biotas include a rich freshwater vertebrate fauna, with a range of fish groups (*e.g.* sharks, lungfish, coelacanths, ray-finned bony fish such as palaeoniscoids) as well as large capitosaurid and trematosuchid amphibians; the latter are of considerable important for long-range biostratigraphic correlation. The interesting reptile fauna includes lizard-like sphenodontids, beaked rhynchosaurs, and various primitive archosaurs (distant relatives of the dinosaurs) such as the crocodile-like erythrosuchids, some of which reached body lengths of 5m (Figure 73), as well as the more gracile *Euparkeria*. The therapsid fauna contains large herbivorous dicynodonts like *Kannemeyeria* (Figure 74), which may have lived in herds, *plus* several small to medium-sized carnivorous or herbivorous therocephalians (*e.g. Bauria*) and advanced cynodonts. The most famous cynodont here is probably the powerful-jawed genus *Cynognathus*, but remains of the omnivorous *Diademodon* are much commoner. Tetrapods are also represented by several fossil trackways while large *Cruziana*–like burrow systems with coarsely scratched ventral walls are attributed to burrowing vertebrates (*cf* Shone 1978, Bordy *et al.* 2019). Locally abundant vertebrate burrows have been attributed to small procolophonid reptiles (Groenewald *et al.* 2001). Important new studies on lacustrine biotas in the northern Burgersdorp outcrop area have yielded rich microvertebrate faunas as well as vertebrate coprolites; sites such as Driefontein in the Free State are now among the best-documented non-marine occurrences of Early Triassic age anywhere in the world (Bender & Hancox 2003, 2004, Hancox *et al.* 2010, Ortiz *et al.* 2010 and refs. therein).

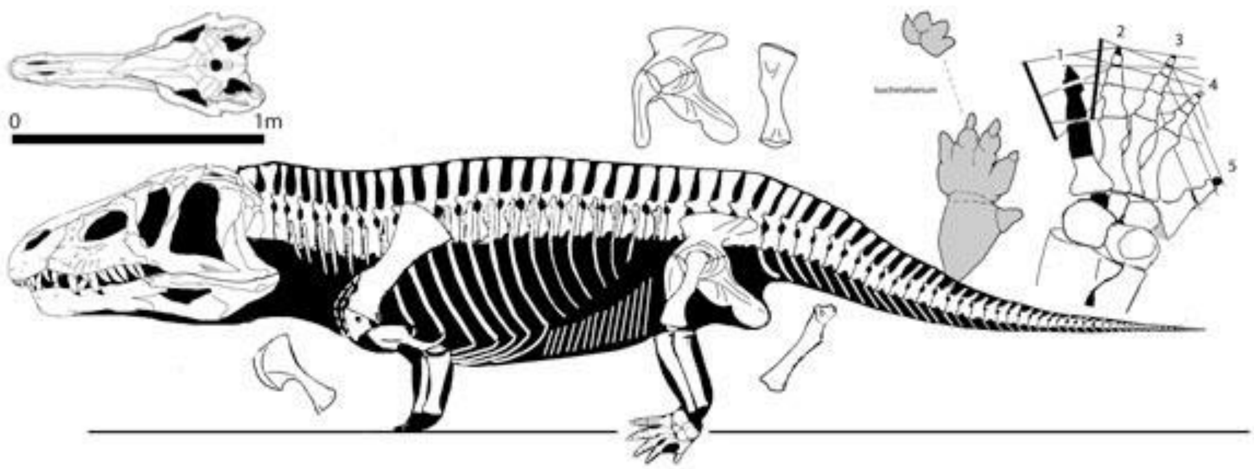


Figure 73: Reconstruction of a large-bodied erythrosuchid reptile, an early member of the archosaur group which included the top predators of Middle Triassic times, before the first dinosaurs, when the Burgersdorp Formation was deposited.

Contemporary invertebrate faunas are still very poorly known. Freshwater unionid molluscs are rare, while the chitinous exoskeletons of the once-abundant terrestrial arthropods do not preserve well in the highly oxidising arid-climate sediments found here; arthropod trace fossils are known but so far no fossil insects. Likewise fossil plants of the characteristic Triassic *Dicroidium* Flora are poorly represented. They include lycophytes (club mosses), ferns (including horsetails), "seed ferns" (*e.g. Dicroidium*) and several gymnospermous groups (conifers, ginkgos, cycads *etc*) (Anderson & Anderson, 1985, Bamford 2004, Hancox *et al*. 2020). A small range of silicified gymnospermous fossil woods are also present including *Agathoxylon, Podocarpoxylon* and *Mesembrioxylon* (Bamford 1999, 2004, 2016).

According to Kitching (1963, 1995) isolated, dispersed fossil bones, as well as some well-articulated skeletons, are associated with "thin localised lenses of silty sandstone" within the Burgersdorp Formation. Pedogenic, brown-weathering calcrete concretions occasionally contain complete fossil skeletons, while transported "rolled" bone is associated with intraformational conglomeratic facies at the base of channel sandstones. Fossil diversity decreases upwards through the succession. Complete tetrapod specimens are commoner lower down and amphibian remains higher up (Kitching 1995).

The biostratigraphy of the Early–Middle Triassic sediments of the Karoo Supergroup (Tarkastad Subgroup) has been the focus of considerable palaeontological research in recent years, and the subdivision of the *Cynognathus* Assemblage Zone into three subunits has been proposed by several authors (See Hancox *et al.*, 1995, Hancox 2000, Neveling *et al.,* 2005, Rubidge 2005, Abdala *et al.* 2005, Hancox *et al.* 2020, Wolvaardt *et al.* 2023 and refs therein). Recent research has also emphasized the rapidity of faunal turnover during the transition between the sand-dominated Katberg Formation (*Lystrosaurus* Assemblage Zone) and the overlying mudrock-dominated Burgersdorp Formation (Neveling *et al.,* 2005). In the proximal (southern) part of the basin the abrupt faunal turnover occurs in the uppermost sandstones of the Katberg Formation and the lowermost sandstones of the Burgersdorp Formation (*ibid*., p.83 and Neveling 2004). This recent work shows that the *Cynognathus* Assemblage Zone correlates with the entire Burgersdorp Formation; previous authors had proposed that the lowermost Burgersdorp beds belonged to the *Lystrosaurus* Assemblage Zone (*e.g.* Keyser & Smith 1977-78, Johnson & Hiller 1990, Kitching 1995).

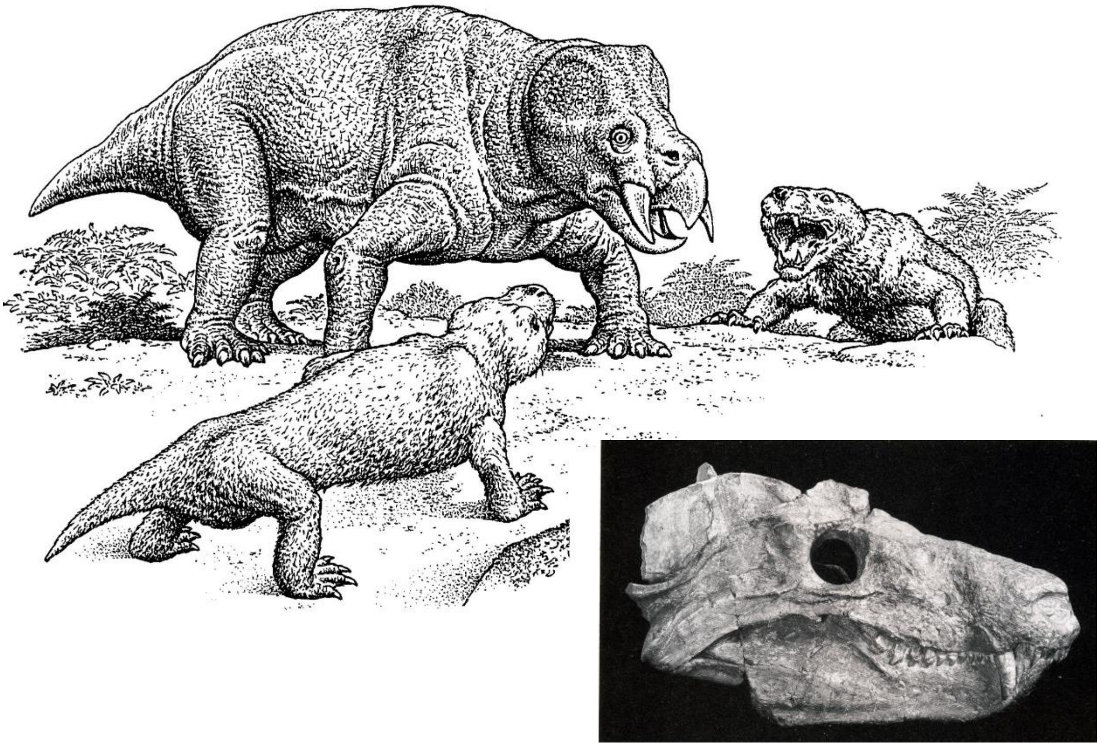


Figure 74: Reconstruction of typical therapsids of the Early Triassic *Cynognathus* Assemblage Zone - the large tusked herbivorous dicynodont *Kannemeyeria* and the predatory, bear-sized cynodont *Cynognathus*. The inset shows the heavily-built skull of *Cynognathus* (*c*. 30 cm long) in lateral view.

4.2. Molteno Formation biotas

In terms of plant and insect fossils - but *not* vertebrates or traces - the early Late Triassic (Carnian) **Molteno Formation** is one of the most productive rock units within the Main Karoo Basin. Indeed, it has produced the richest known floras of Triassic age anywhere in the world and its palaeontological sensitivity towards development is correspondingly high (*cf* Almond *et al.* 2008). Excellent reviews of the Molteno fossil biota have been provided by Ander son & Anderson (1985), Cairncross *et al.* (1995), Anderson *et al.* (1998), Anderson and Anderson *in* MacRae (1999), Hancox (2000) and Anderson (2001). These key accounts include references to the extensive technical literature on the Molteno flora and fauna stretching back to pioneering work by Wyley (1856) and Stow (1871) on coals and petrified forests as well as by Alex du Toit in the early 1900s on fossil plant remains (See Hancox 2000 for early references). Several key systematic and synthetic papers on the Molteno palaeoflora published by John and Heidi Anderson are listed in the references to this report.

The fossil biota recorded so far from the Molteno Formation (Figure 77) may briefly summarised as follows:

- A very rich **megaflora** of fossil foliage, fruits, seeds and stems, mostly preserved as carbonaceous compressions within carbonaceous mudrocks. The flora contains over sixty genera and is strongly dominated by “pteridophytes” (over 50 species of spore-bearing ferns, including horsetails) and a rich variety of gymnosperms (27 genera, 114 species, including ginkgophytes, cycads, conifers and “seed ferns”). The four dominant plant genera are the characteristic Triassic "seed fern" *Dicroidium* (Peltaspermales), the maidenhair tree relative *Sphenobaiera* (Ginkgoales), the conifer *Heidiphyllum* (Voltziales) and the horsetail fern *Equisetum* (Equisetales). Over 200 plant species have been identified, including sixteen orders of gymnosperms alone. Minor groups include bryophytes such as mosses, liverworts and club-mosses.

- **Silicified woods**, including petrified tree trunks, now assigned to a range of gymnospermous genera (*e.g. Agathoxylon, Podocarpoxylon, Rhexoxylon*; Bamford 1999, 2004, 2016). Some of the petrified wood blocks recorded within the Molteno Formation may represent reworked material from channel sandstones and basal conglomerates which also include extra-basinal quartzite clasts as well as moulds of substantial woody axes, so their provenance and age is ambiguous. Hancox & Götz (2014) report that within the Bamboesberg Member (lower Molteno Formation) "well preserved fossil plant remains, including silicified tree trunks, are frequently concentrated on bedding plains, as well as randomly interspersed within the siltstones and mudstones".

- Poorly-studied **palynomorph assemblages** dominated by pteridophyte spores and gymnosperm pollens assigned to the Triassic *Allisporites / Falcisporites* assemblage (Hancox 2000 and refs. therein).

- Rare **fossil fish** belonging to four genera, representing the only vertebrate body fossils from the formation (Anderson *et al.* 1998).

- Relatively abundant and diverse **fossil insects** associated with compression floras in fine-grained mudrocks. These important insect assemblages comprise several thousand specimens of about 350 species, mainly preserved as disarticulated wings but with some intact or partially intact bodies. They are dominated by cockroaches, beetles, bugs and dragonflies and include eighteen different insect orders. The only other terrestrial arthropods recorded so far are extremely rare spiders (Selden *et al.* 1999, Selden 2009).

- Rare shelly invertebrates including three genera of **conchostracans** (freshwater clam shrimps) and two genera of **bivalves**.

- Occasional **trace fossils** including dinosaur trackways (among the earliest indirect evidence for early dinosaurs in southern Africa; Raath *et al.* 1990, Raath 1996), invertebrate burrows of the *Scolicia* Group, perhaps generated by gastropods (Turner 1978), *Skolithos* vertical burrows, arthropod traces and a few unnamed forms (Hancox 2000).

The absence of fossilised bone and coprolites of vertebrates is notable and, at least in the former case, is attributed to the diagenetic dissolution of bone under humic, poorly-oxygenated and acid conditions that rather favour the preservation of plant remains (Anderson *et al.* 1998). The Molteno fossil flora is of considerable palaeontological interest in documenting the explosive radiation of Mesozoic, gymnosperm-dominated floras in the later part of the Triassic Period, while the associated rich insect fauna shows great promise in documenting early plant – insect interactions during this critical period in Earth history (See numerous references by J. & H Anderson listed below). Over one hundred Molteno plant fossil assemblages from some seventy localities have been recorded so far (Anderson & Anderson 1985, Anderson 2001), with the richest assemblages yielding over seventy species. Insects are recorded from over forty localities. Figure 76 gives an approximate idea of the distribution of recorded fossil-rich localities within the outcrop area of the Molteno Formation. Plant fossil sites from the south-western outcrop area of the Molteno Formation near Molteno town recorded in Anderson & Anderson (1985, pp. 40-43) include Bamboeshoek, Aasvoëlberg, Boesmanshoek Pass, Cyphergat and Molteno.

The town of Molteno and the Ingwe cluster project area lie within the Molteno Coal Field of the Eastern Cape Province (Hancock & Götz 2014) (Figure 75). Coal seams are scarce, with only two laterally persistent units of economic interest, and are located in the uppermost portions of up to five upward-fining cycles within the Bamboesberg Member (lower Molteno Formation). According to Hancock & Götz (2014):

> The coal seams of the Bamboesberg Member are typically horizontally zonated, with bands of dull (inertinite/fusinite) and bright (vitrinite) coal alternating with carbonaceous siltstone and mudstone. The Indwe Seam varies in lithology and thickness over short distances and is a composite seam consisting of alternating coal and shale, of which the coal percentage varies between 30 and 65%. It attains a maximum thickness of 4.5 m at the town of Indwe (Christie, 1981). Christie (1986) notes that it is not a laterally continuous seam, but rather a number of coals formed in discrete settings at the same stratigraphic horizon.

Disused mines near Molteno marked on topographic maps include several sites around Syfergat to the SE of town, Zandfontein located between Grootberg and Rooiberg shortly SW of the project area and the Old Cape Collieries further south (1:50 000 topographical sheets 3126AC and 3126AD). There are no coal mines mapped within the Ingwe cluster project area itself.

4.3. Late Caenozoic superficial sediment fossil biotas

Late Caenozoic superficial deposits of the Karoo region are poorly studied in palaeontological terms but may contain local concentrations of fossil vertebrate, invertebrate and plant remains as well as trace fossils (*e.g.* mammalian bones, teeth, horncores, freshwater or terrestrial molluscs, coalified wood, palynomorphs, calcretised root casts and termitaria) (*cf* Skead 1980, Klein 1984, MacRae 1999, Brink *et al.* 1999, Brink & Rossouw 2000, Churchill *et al.* 2000, Partridge & Scott 2000). The potential for scientifically important human remains is shown by the discovery of the famous Hofmeyr Man skull recovered from Late Pleistocene alluvial deposits of the Eastern Cape (Grine *et al*. 2007). Key fossiliferous facies are mostly associated with extant or defunct drainage lines and include older consolidated alluvium and terrace gravels, lake, pan and *vlei* deposits (Partridge *et al.,* 2006). The Pleistocene to Holocene Masotcheni Formation, for example, is often characterised by concentrations of petrified fossil wood reworked from the Karoo Supergroup bedrocks as well as Early to Middle Stone Age stone artefacts. In Quaternary deposits, fossil remains may be associated with human artefacts such as stone tools and are also of archaeological interest (*e.g.* Smith 1999 and refs. therein).

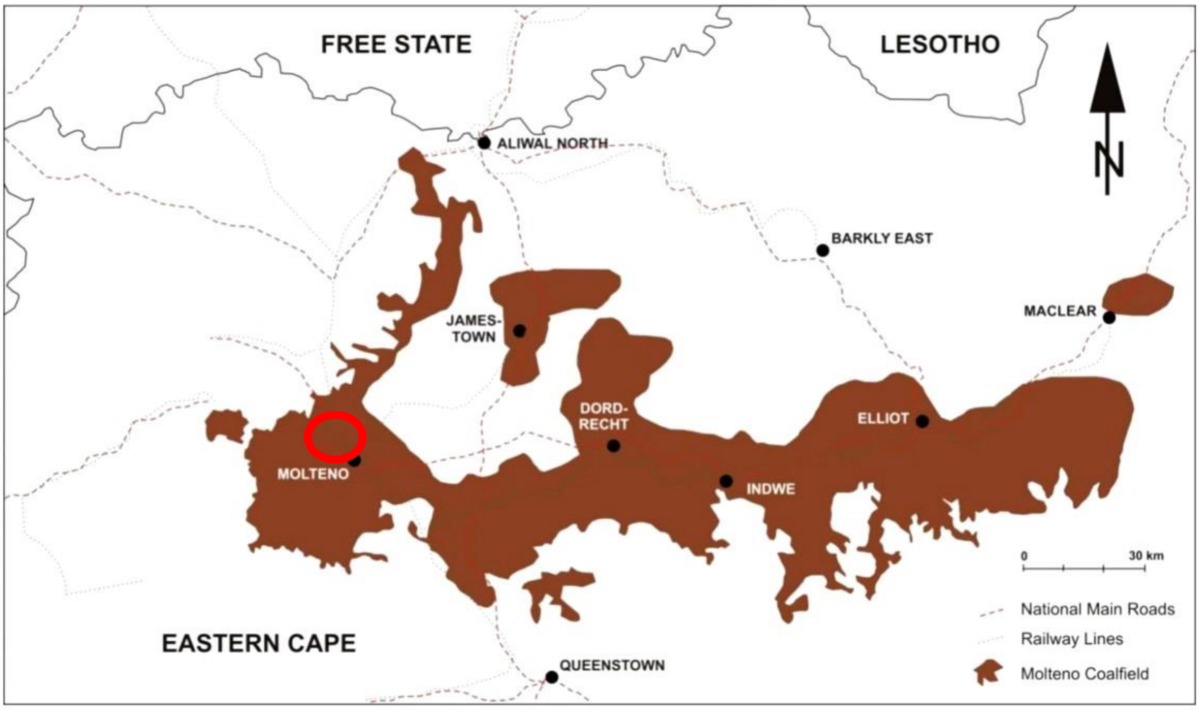
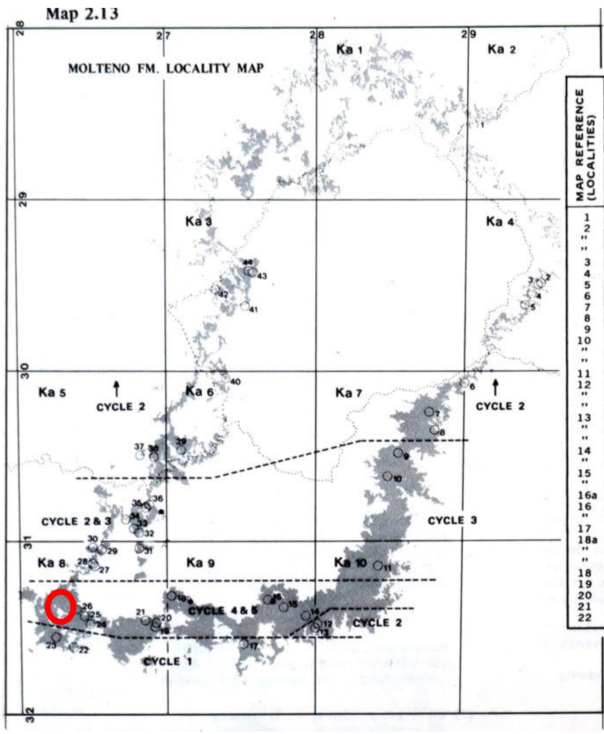


Figure 75: Map showing the extent of the Molteno Coal Field in the Eastern Cape Province (from Hancock & Götz 2014). Productive coals are associated with lower part of the Molteno Formation succession (Bamboesberg Member) but additional thin coals occur stratigraphically higher up. The approximate location of the Ingwe renewable energy cluster is indicated by a red circle.



Tab. 2.8 MOLTENO FM., MEGAPLANT LOCALITIES & ASSEMBLAGES

MAP REFERENCE (LOCALITIES)	SUPERLOC. (10 km)	LOCALITY (1 km) SUBLOC. (100 m) SUPERSITE (10 m)	ASSEMBLAGE	SUPERLOCALITY	MAP REFERENCE (LOCALITIES)	SUPERLOC. (10 km)	LOCALITY (1 km) SUBLOC. (100 m) SUPERSITE (10 m)	ASSEMBLAGE	SUPERLOCALITY
1	Lit	111	Dic/Hei	Little Switzerland	23	Aas	111	Hei elo	Aasvoëlberg
2	Hla	211	Dic 3spp	Hlatimbe Valley	24	Boe	111	Lep sto	Boesmanshoek Pass
"	"	212	Dic 3spp	" "	"	"	"	Neo car	" "
"	"	213	Dic elo	" "	"	"	"	Dic/Hei	" "
3	"	111	Neo car	" "	"	"	112	Dic cor	" "
4	Umk	111	Dic 2spp	Umkomaas Valley	25	Cyp	111	Dic cra	Cyphergat
5	San	111	Dic cra	Sani Pass	"	"	"	Hei elo	"
6	Mng	111	Dic 2spp	Mngeni Valley	26	Mol	111	Bai spA	Molteno
7	Qac	111	Hei/Dic	Qachasnek	27	Kle	111	Neo car	Klein Hoek
8	Mat	111	Dic dub	Matatiele	"	"	"	Hei elo	"
9	Ken	111	Dic cra	Kenegapoort	"	"	"	Hei/Dic	"
10	Tin	111	Sch spA	Tina Bridge	28	"	211	Bai spA	"
"	"	121	Bai 2spp	" "	29	Kul	111	Bai spA	Kullfontein
"	"	131	Hei/Ast	" "	30	Kom	111	Bai/Dic	Kommandantskop
11	Wal	111	Dic odo	Waldeck	"	"	"	Ast/Gin	"
12	Kon	222	Dic odo	Konings Kroon (K.Kr.)	31	Tel	111	Hei elo	Telemaghus Spruit
"	"	211,221	Ast 2spp	" " "	32	Vin	211	Neo car	Vineyard
"	"	" "	Hei elo	" " "	33	"	111	Dic odo	"
13	"	111	Dic odo	" " (Rooipoort)	34	Ela	111	Dic odo	Elandspruit
"	"	"	Neo car	" " "	"	"	112	Neo car	"
"	"	"	Hei elo	" " "	"	"	"	Hei/Neo	"
14	Kan	111	Hei elo	Kannaskop	"	"	"	Dic/Hei	"
"	"	"	Ast spA	"	35	Kra	211	Neo car	Kraai River (Plaatkop)
15	Nav	111	Neo car	Navar	36	"	111	Dic odo	" (Kraai R.)
"	"	"	Dic odo	"	36a	"	311	Dic odo	" (Glenburn)
16a	Cal	211	Hei elo	Cala Road	37	Nuw	211	Hei elo	Nuwejaarspruit
16	"	111	Neo car	"	"	"	"	Neo car	"
"	"	"	Dic/Hei	"	"	"	"	Dic 2spp	"
17	Ask	111	Neo car	Askeaton	38	"	111	♂ cone E	"
18a	Gre	121	Hei elo	Greenvale	"	"	"	Dic zub	"
"	"	111	Bai spA	"	39	Win	111	Hei elo	Winnaarspruit
"	"	"	Neo car	"	40	Qua	111	Dic odo	Qualasi Hill
18	Dor	111	Hei elo	Dordrecht	41	Mor	111	Dic zub	Morija
19	Bir	211	Bai 2spp	Birds River	"	"	"	Dic odo	"
20	"	311	Hei/Bai	" "	42	Mak	111	Dic odo	Makoaneng
21	"	111	Bai 2spp	" "	43	Maz	111	Dic cra	Mazenod (Luka)
22	Bam	111	Dic dub	Bamboeshoek	44	"	211	Hei/Dic	" (Lechesa)

Notes (a) 36 superlocalities, 47 localities, 56 supersites, 74 assemblages (see also Tab. 2).
(b) Includes collections to Dec. 1982.
(c) Localities 16a, 18a & 36a (discovered in 1982) are indicated by full dots.
(d) Bai (*Baiera*) should read Sph (*Sphenobaiera*).
(e) Full explanatory notes on location ranks and assemblage codes in And. & And. '83a

Figure 76: Outline map showing the stippled outcrop area of the Late Triassic Molteno Formation with important fossil plant localities reported by Anderson and Anderson (1985). The red circle outlines the approximate location of the Molteno study area in the southwest, close to but outside Localities 22 to 26.

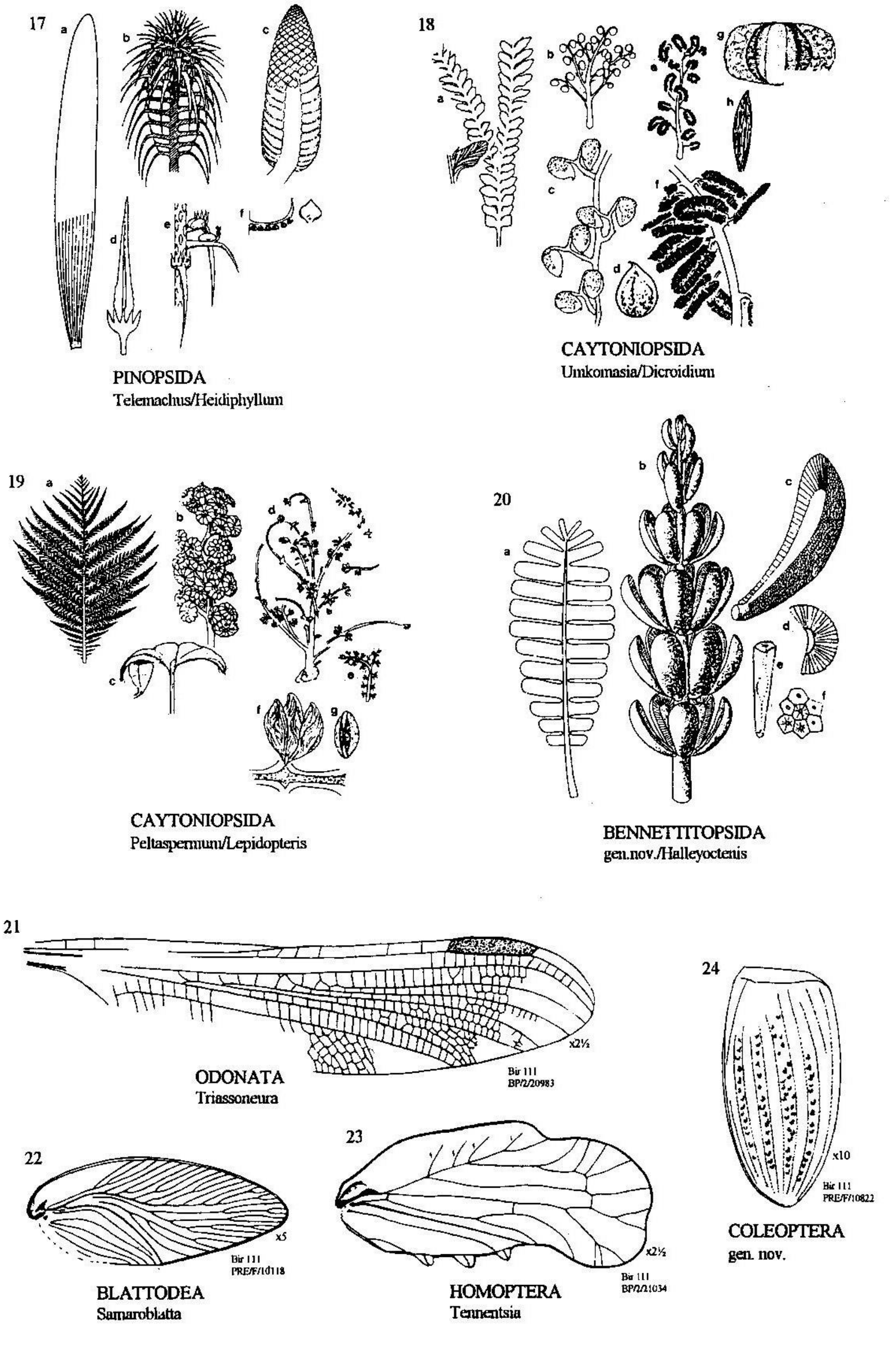


Figure 77: Selection of Late Triassic plants (leaves and reproductive organs of gymnosperms) and insect remains (dragonflies, cockroaches, bugs and beetles) from the Molteno Formation of South Africa (From Anderson & Anderson 1997).

4.4. Results of palaeontological site visit

Due in part to generally low levels of bedrock exposure (especially potentially fossiliferous mudrocks), and perhaps also to the influence of nearly dolerite intrusions, only a small number (less than 20) fossil sites were recorded from the Ingwe cluster project area during the recent palaeontological site visit (See Appendix 1 with tabulated fossil site data and satellite maps of fossil site distribution). Most of the recorded fossil remains are *ex situ*, poorly preserved and represent widely-occurring taxa; they are of very limited scientific or conservation value and are accordingly assigned a low Provisional Field Rating. Several fossil sites are associated with bedrock and alluvial exposures along major drainage courses that are protected within standard ecological buffer zones. As noted previously, as far as is known no coal mines or historical plant / insect fossil sites area mapped within the project area (cf Anderson & Anderson 1985, Cairncross *et al.* 1995).

The only fossil remains recorded from the **Burgersdorp Formation** outcrop area within the Ingwe cluster project area comprise a single, fragmentary, robust bone of a large tetrapod as well as a few small blocks of finely-banded silicified wood (Figures 78 & 79). This material occurs among ferruginised surface gravels close to the unconformable Burgersdorp / Molteno contact. It may have been downwasted from the underlying Burgersdorp beds during the major hiatus preceding deposition of the Molteno Formation, or have eroded out from the basal Molteno channel sandstones nearby. Its stratigraphic provenance is therefore unclear and, given the poor preservation of the skeletal material, the scientific and conservation significance of the site is low.

No well-exposed, potentially fossiliferous packages of coalified **Molteno Formation** mudrocks were encountered within the during the Ingwe cluster project area palaeontological site visit. Black to dark grey laminated mudrocks are seen in road cuttings along the R56 (Figure 32) and weathering out in a stream gulley on Farm 32/63 (Figure 34) but no plant or other fossils were recorded here. Poorly-preserved moulds of substantial woody axes, frequently ferruginised, occur commonly in basal channel breccio-conglomerates of the Molteno Formation (Bamboesberg, Indwe Members and elsewhere). These coarser beds are also the probable source of most or all of the *ex situ* silicified wood blocks recorded within surface gravels overlying the Molteno Formation and adjoining margins of the Burgersdorp Formation outcrop area, as suggested by the frequent association with reworked, well-rounded quartzite cobbles (*cf* Kolo Pebble Bed, basal Indwe Member) (Figure 84). The petrified wood is usually very dark to almost black with a pale surface patina and obscure to well-developed seasonal growth rings. As noted previously, the common association with extra-basinal quartzite clasts means that the original stratigraphic provenance of these fossil woods is ambiguous. Bamford (2004) notes that in most Molteno Formation woods studied by her details of the xylem anatomy have been obscured due to thermal metamorphosis.

No fossil vertebrate skeletal remains (bones, teeth *etc*) have been recorded from the Molteno beds in the present study area and, as noted previously, they are generally absent in this stratigraphic unit, apart from very rare fish. No tetrapod burrows or trackways or invertebrate trace fossils were recorded here either. This may be in part due to the generally poor preservation of bedding plane surfaces which have been obscured by widespread karstic (solution) weathering as well as lichen weathering. An isolated, small, subrounded block of whitish to slightly pink, suncracked bone recorded by Dr Jayson Orton (ASHA) below the south-eastern flank of Vegkoppies (Loc127) probably comes from the Elliot Formation (Figure 93). It occurs in association with a surface scatter of LSA artefacts and is probably a manuport collected and transported to the site by curious-minded Stone Age people.

Possible but very *equivocal* trace fossil assemblages as well as equally ambiguous plant root moulds are associated with prominent-weathering beds provisionally interpreted here as secondarily silicified pedocrete / palaeosol horizons (Figures 91 & 92). Poorly-defined traces occur both within as well as on upper and lower bedding planes of these units (Figure 90) which are best developed within khaki mudrock packages of the Bamboesberg Member.

The only fossil remains recorded from the Late Caenozoic superficial deposits within the Ingwe cluster project area comprise locally abundant, subcylindrical calcrete bodies (≤ 1cm wide) within consolidated older alluvial deposits of probable Pleistocene age (Figure 94). They are interpreted as probable plant root or reedy stem casts.

Figure 78: Chunk of large tetrapod bone (*c*. 10 cm across) among surface float, partially encrusted with a dark ferro-manganese mineral coating, ferruginised surface gravels overlying the upper Burgersdorp Formation, Farm Bamboo 43 (WEF 2) (Loc. 138).

Figure 79: Small blocks of seasonally banded silicified wood associated with fossil bone (also shown in previous illustration), upper Burgersdorp Formation, Farm Bamboo 43 (WEF 2) (Loc. 138).

Figure 80: Pale cylindrical or sphaeroidal inclusion within purple-brown channel sandstones of the Burgersdorp Formation, Farm 16/44 (WEF 2) (Loc. 147) (scale in cm). This structure may be concretionary in nature or, less likely, a lungfish burrow cast. See Figure 18 for context.

Figure 81: Mould of woody plant stem (*c*. 8 cm wide) on ferruginised bedding plane of Molteno Formation coarse-grained channel sandstone, Farm 2/39 (WEF 1) (Loc. 072).

Figure 82: Float block of ferruginised, karstified, coarse Molteno Formation sandy channel basal breccia with angular moulds of mudrock intraclasts as well as sparse moulds of woody plant axes, Farm RE/39 (WEF 1) (Loc. 057). Scale = 15 cm.

Figure 83: Crumbly brown, thin-bedded Molteno Formation sandstones with sparse, shiny moulds of woody plant axes (*c*. 6 cm wide), patinated by blackish-brown iron / manganese minerals, Farm Weltevrede 222 (SEF 4) (Loc. 090).

Figure 84: Pale quartzite cobbles - probably weathered-out from the Kolo Pebble Bed, basal Ingwe Member of the Molteno Formation - as well as small, angular blocks of dark grey to black silicified wood, surface gravels on Farm Klip Fountain 21/40 (WEF 2) (Loc. 131). Scale = 15 cm.

Figure 85: Crudely flaked pale quartzite cobbles (ESA) associated with medium-sized (*c*. 10 cm diam.) block of finely-banded, pale-patinated silicified wood – probably downwasted from lower Molteno Fm (Bamboesberg Member or Kolo Pebble Bed), Farm 16/44 Oud Klip (WEF 2) (Loc. 153). Scale = 15 cm.

Figure 86: Float block of dark, silicified wood (c. 8 cm across) overlying Bamboesberg Member beneath base of Indwe sandstone package (possibly downwasted from basal Indwe Member), Farm 2/58 Modderfontein (WEF 2) (Loc. 173).

Figure 87: Small block of finely-banded, pale to dark silicified wood associated with flaked quartzite cobbles among ferruginised eluvial gravels overlying the upper Burgersdorp Formation at the base of Molteno Formation escarpment, Farm 16/44 Oud Klip (WEF 2) (Loc. 151). Scale in cm and mm.

Figure 88: Small block (*c*. 4 cm long) of very dark silicified wood with fine seasonal growth lines recorded among surface gravels overlying the Molteno Formation on Farm Weltevrede 222 (SEF 4) (Loc. 090).

Figure 89: Float block of Bamboesberg Member coarse channel sandstone with pale yellowish, silicified wood fragments, Farm 2/58 Modderfontein (WEF 2) (Loc. 172). Scale in cm.

Figure 90: Possible bioturbated textures and mud crack infills on soles of inferred silicified pedocrete horizon, Bamboesberg Member of Molteno Formation, Farm 2/58 Modderfontein (WEF 2) (Loc. 170). Scale in cm and mm.

Figure 91: Equivocal branching plant root moulds within inferred silicified pedocrete horizon, Bamboesberg Member of Molteno Formation, Farm 2/58 Modderfontein (WEF 2) (Loc. 170). Scale in cm and mm. Block is c. 13 cm across.

Figure 92: Equivocal plant root moulds or woody axis within inferred silicified pedocrete horizon, Bamboesberg Member of Molteno Formation, Farm 2/58 Modderfontein (WEF 2) (Loc. 170). Scale in cm.

Figure 93: Small block of whitish to pinkish, sun-cracked bone recorded by Dr J. Orton at a LSA site near Vegkoppies, Farm Klip Fountain 11/40 (Loc. 127). This is probably a manuport collected by Stone Age people from the Elliot Formation and not derived from the Molteno Formation bedrocks beneath the site.

Figure 94: Thick calcretised and locally ferruginised, fine-grained older alluvium with abundant weathering-out subcylindrical, calcrete casts of plant roots (rhizoliths) and / or reedy plant stems (*c*. 1 cm wide or less), Farm RE/39 Zwavel Krantz (WEF 1) (Loc. 058). Scale in cm.

7. HIGH LEVEL IMPACT ASSESSMENT

Existing impacts on local palaeontological heritage resources within the combined Ingwe WEF project area include (1) background low-level loss of fossils exposed at the ground surface due to agricultural activities and small-scale mining (*e.g.* vehicle activity, irrigation infrastructure, small-scale agriculture, stock farming, excavation of borrow pits) as well as (2) on-going natural weathering and erosion processes that both destroy fossil material as well as expose and prepare-out previously-buried fossils. Loss of fossils though illegal collection is unlikely to be a major factor at present.

Potential future impacts on local, legally-protected palaeontological heritage resources resulting from the proposed WEF projects are assessed at a high level in this section of the PIA report. This assessment applies only to the Construction Phase of the projects as no significant further impacts are anticipated during operational and decommissioning phases. Note that the Impacts identified during the Construction Phase in Table 2 apply equally to both Ingwe WEF 1 and Ingwe WEF 2 projects under consideration (Table 2).

7.1. Potential Impacts during the Construction Phase

The construction phase of the proposed WEFs will entail limited surface clearance as well as excavations into the superficial sediment cover and underlying, potentially fossiliferous bedrock (*e.g.* for widened or new access roads, wind turbine foundations, laydown areas, BESS, O&M buildings, pylon footings, substations). Construction of the WEFs and associated infrastructure may adversely affect potential fossil heritage within the development footprints by damaging, destroying, disturbing or permanently sealing-in legally-protected fossil heritage preserved at or beneath the surface of the ground that are then no longer available for scientific research or other public good.

Potential impacts during the Construction Phase of each of the proposed Ingwe WEFs on local fossil heritage resources, before and after mitigation, are assessed below and summarized in Table 2, applying the Environmental Impact Assessment (EIA) Methodology developed by the CSIR. The planning, operational and de-commissioning phases of the renewable energy projects are unlikely to involve further adverse impacts on local palaeontological heritage and are therefore not separately assessed in this report.

Given (1) the very similar geological context - and hence anticipated palaeontological heritage resources – within the combined Ingwe cluster project area, (2) the paucity of fossil sites recorded here as well as (3) the potential for effective mitigation of all recorded fossil sites in the Pre-Construction Phase, this impact assessment *applies equally to both WEFs under consideration*. *Furthermore, there is therefore no preference on palaeontological heritage groups for any particular infrastructure layout among those that would ever be under consideration*.

The destruction, damage or disturbance out of context of legally-protected, scientifically-important fossils preserved at the ground surface or below ground that may occur during construction of the WEFs and associated infrastructure entail *direct negative* impacts to palaeontological heritage resources that are confined to the development footprint (*site specific*). These impacts can often be mitigated but cannot be fully rectified (*i.e.* they are *non-reversible / permanent*). All the sedimentary formations represented within the study area contain fossils of *some* sort, so impacts at some level on fossil heritage are *definite*. However, this analysis focuses primarily on fossil heritage *of significant scientific or conservation value*, in which case the probability of impacts is rated somewhat lower as *unlikely*. Very few fossil sites have been recorded within the WEF project areas so far, while all of the fossils identified are of widespread occurrence elsewhere within the large outcrop areas of the formations concerned. However *some* unique, well-preserved, scientifically-important fossils are known to occur in the Molteno region of the Great Karoo (*cf* Molteno Coal Field). The severity or consequence of potential losses of irreplaceable fossil resources of substantial scientific / conservation value without mitigation are conservatively rated as *moderate*, applying the precautionary principle. Without mitigation, a LOW NEGATIVE impact significance is accordingly inferred for each Ingwe WEF project.

Potential negative impacts can be substantially reduced through implementation of the proposed palaeontological mitigation measures outlined in Section 8.1 below. After mitigation, the residual impact significance of the proposed WEF projects falls to VERY LOW NEGATIVE.

Due to the necessarily reconnaissance level of the field surveys of the extensive combined WEF study area, as well as the generally low levels of bedrock exposure, confidence levels for this palaeontological heritage assessment are only moderate (*medium*), although the suggested mitigation measures would still adequately mitigate against any unacceptable adverse impacts.

In the case of the **No-Go Option** (*i.e.* no WEF development), the possible loss of local heritage resources through construction of the proposed WEFs (negative impact) would be avoided while potential improvements in palaeontological understanding through professional mitigation - *i.e.* recording and collection of palaeontological material and data (positive impacts) - would be lost. The slow background destruction of fossils exposed at the surface through natural weathering and erosion would continue, but at the same time new fossils are revealed for scientific study. On balance, it is concluded that in both WEF cases the No-Go alternative would probably have a *neutral* impact on palaeontological heritage

7.1. Cumulative impacts

A small number of renewable energy projects, including the five proposed Ingwe Solar PV Facilities, have been proposed / authorized within a radius of some 30 km of the Ingwe WEFs; these are mapped and listed in Figure 95 below. The five Ingwe SEFs adjoining the two Ingwe WEFs are anticipated to have a Low to Very Low impact significance on palaeontological heritage (J. Almond, work in progress).

A short field-based study of the Dorper Wind Energy Facility project area to the south and southeast of Molteno was presented by Fourie (2012). The field study focused mainly on proposed turbine positions and no fossils were recorded, in part due to the paucity of bedrock exposure at the limited number of sites visited. The authorised Dorper WEF project was subsequently split into five phases named the Dorper Wind Energy Facility, Loperberg Wind Energy Facility, Malabar Wind Energy Facility, Spinning Head Wind Energy Facility and the Spreeukloof Wind Energy Facility. Heritage Screener amendment reports submitted by CTS in 2021 for the authorised Malabar, Loperberg and Spreeukloof WEFs relied on the original data of Fourie (2012).

A palaeontological heritage desktop report (Millstead 2013) was submitted for the proposed Stormberg Wind Energy Facility near Sterkstroom, some 25 km east of Molteno, but was apparently not followed-up with the recommended field-based study. The study area is largely underlain by the Molteno and Elliot Formations with smaller outcrop areas of Clarens Formation and Karoo dolerite.

Given the almost complete lack of relevant palaeontological field data for the handful of renewable energy facilities proposed / authorized within *c*. 30 km of the Ingwe Renewable Energy Cluster, it is not possible to undertake a meaningful cumulative impact assessment

for the Ingwe WEF projects at present. However, given the inferred low palaeosensitivity of the majority of the project areas concerned, it is probable that the cumulative impacts fall within acceptable limits.

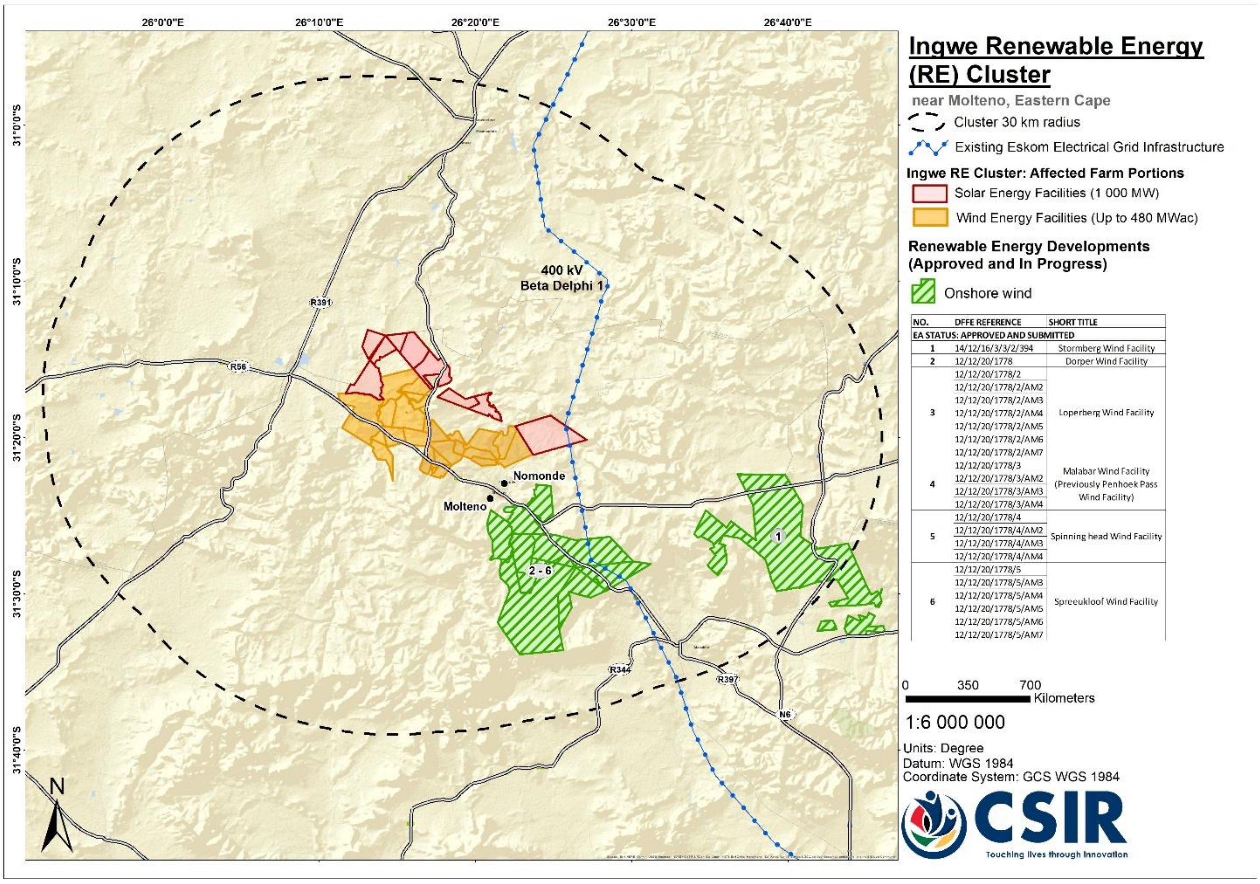


Figure 95: Map showing the proposed / authorized renewable energy projects within an envelope of approximately 30 km radius of the Ingwe Renewable Energy Cluster near Molteno (dotted shape). Adequate palaeontological field data for the Stormberg WEF and the Dorper WEF cluster is not available, so a meaningful cumulative impact assessment for these projects is not yet possible.

Table 2: Palaeontological heritage impact assessment summary table for the Construction Phase of the Ingwe WEF 1 and WEF 2 near Molteno, Eastern Cape

<table>
<tr><th>Impact</th><th colspan="2">Impact Criteria</th><th>Significance and Ranking (Pre-Mitigation)</th><th>Potential mitigation measures</th><th>Significance and Ranking (Post-Mitigation)</th><th>Confidence Level</th></tr>
<tr><td colspan="7">CONSTRUCTION PHASE</td></tr>
<tr><td rowspan="7">Disturbance, damage or destruction of fossils preserved at or beneath ground surface within WEF development footprint due to excavations and surface clearance</td><td>Status</td><td>Negative</td><td rowspan="7">Low impact (4)</td><td rowspan="7">1. Survey by qualified palaeontologist of authorized WEF project footprint during early Construction Phase (following initial site clearance and excavations) to identify any newly exposed, sensitive fossil sites or horizons (e.g. carbonaceous shales, coals) at or beneath the ground surface.
2. Recording and judicious sampling of new, scientifically valuable fossil remains within or close to (≤ 20 m) project footprint by qualified palaeontologist.
3. Monitoring for fossil remains on an on-going basis by ECO / ESO during the construction phase.
4. Application of Chance Fossil Finds Procedure throughout Construction Phase.</td><td rowspan="7">Very low impact (5)</td><td rowspan="7">Medium</td></tr>
<tr><td>Spatial Extent</td><td>Site specific</td></tr>
<tr><td>Duration</td><td>Permanent</td></tr>
<tr><td>Consequence</td><td>Moderate</td></tr>
<tr><td>Probability</td><td>Unlikely</td></tr>
<tr><td>Reversibility</td><td>Non-reversible</td></tr>
<tr><td>Irreplaceability</td><td>Low</td></tr>
</table>

- *N.B.* Refers to legally-protected fossil heritage of significant scientific and / or conservation value
- No significant further impacts anticipated during operational and decommissioning phases.

8. CONCLUSIONS & RECOMMENDATIONS

The combined Ingwe cluster project area is underlain by Triassic continental sediments of the mudrock-dominated **Burgersdorp Formation** (Upper Beaufort Group, Karoo Supergroup) in the northwest while the topographically varied terrain in the remainder of the area is built by the sandstone-dominated **Molteno Formation** (Stormberg Group, Karoo Supergroup). These Karoo Supergroup bedrocks are extensively intruded and baked by Early Jurassic dolerite sills and dykes and mantled by Late Caenozoic superficial deposits (colluvium, alluvium, soils) as well as grassy vegetation, Good exposures of potentially fossiliferous mudrocks are accordingly very rare.

Several important Late Triassic fossil plant sites as well as coal seams are known from fine-grained facies of the Molteno Formation in the wider Molteno region which lies within the extensive Molteno Coal Field (*cf* Anderson & Anderson 1985, Cairncross *et al.* 1995, Hancox & Götz 2014). However, no historical or new fossil sites or horizons of significant scientific or conservation value have been recorded from the combined Ingwe cluster WEF project area itself (see Provisional Field Rating in Appendix 1). The few new fossil sites all lie outside the proposed WEF footprints, while many or most of the sites are already protected within standard ecological buffer zones along drainage lines. If threatened by the proposed developments, all the known sites could be mitigated in the Pre-construction Phase by professional palaeontological recording and collection. However, since the WEF project areas lie within the Molteno Coalfield, the potential remains for rare, largely unpredictable subsurface horizons or sites (carbonaceous mudrocks / coals) rich in well-preserved Triassic fossil plants of High to Very High Palaeosensitivity. These fossiliferous units are generally not exposed at surface at present due to soil and vegetation cover and therefore cannot be identified in the Pre-construction Phase; they can only be detected and mitigated following initial site clearance and excavations during the Construction Phase.

Provisional palaeosensitivity mapping of the combined Ingwe WEF 1 and WEF 2 project areas by the DFFE Screening Tool suggests that these are largely of Very High Palaeosensitivity, based on the underlying bedrocks of the Beaufort Group and Stormberg Group (Karoo Supergroup). However, desktop reviews as well as recent palaeontological field surveys indicate that, in practice, the WEF project areas are of Low Palaeosensitivity overall, with the potential for rare, largely unpredictable subsurface horizons or sites rich in well-preserved Triassic fossil plants of High to Very High Palaeosensitivity (See Appendix 4). This analysis is largely based on the following observations:

- Very few fossil sites have been recorded in the project areas and these are all of widely occurring forms of limited scientific interest, mostly poorly-preserved and from channel sandstone facies (*viz.* moulds of woody plant axes, small blocks of – possibly reworked – petrified wood, equivocal invertebrate trace fossils, calcretised plant roots / stems);
- Most of the outcrop area of potentially fossiliferous mudrocks within the Burgersdorp and Molteno Formations are mantled by superficial sediments (colluvium, alluvium, surface gravels) of Low Palaeosensitivity;
- Due to intensive karstic (solution) weathering as well as on-going lichen weathering, well-preserved sandstone bedding planes are rare;

- No High or Very High Sensitivity fossil sites – such as plant-rich horizons of laminated carbonaceous mudrocks or coal beds, well-preserved vertebrate skeletal material or trackways - have been recorded within the WEF project areas.

The provisional Very High Palaeosensitivity mapped within the majority of the Ingwe WEF project areas by the DFFE Screening Tool is accordingly *contested* in this report. No areas of High to Very High Palaeosensitivity or No-Go Areas have been identified here so far. However, since the WEF project areas lie within the Molteno Coalfield, the potential remains for rare, largely unpredictable subsurface horizons or sites rich in well-preserved Triassic fossil plants of High to Very High Palaeosensitivity.

Given (1) the paucity of recorded fossil sites (none of which lies within the proposed project footprints) within the WEF project areas and (2) the inferred Low Palaeosensitivity of the Ingwe cluster project area in general, the significance of anticipated impacts on local, legally protected fossil heritage is anticipated to be Low Negative without mitigation, falling to Very Low Negative following mitigation. The No-Go Option would probably have a Neutral impact significance.

Given the almost complete lack of relevant palaeontological field data for the handful of renewable energy facilities proposed / authorized within *c*. 30km of the Ingwe Renewable Energy Cluster, it is not possible to undertake a meaningful cumulative impact assessment for the Ingwe WEF projects at present. However, given the inferred low palaeosensitivity of the majority of the project areas concerned, it is probable that the cumulative impacts fall within acceptable limits.

The proposed WEF projects are not fatally flawed. On palaeontological heritage grounds there are no objections to the Ingwe WEF 1 and 2 projects receiving Environmental Authorisation and no preferences for a specific infrastructure layout. The recommendations made below for Construction Phase palaeontological monitoring and mitigation must be included within the EMPrs for the two Ingwe WEF projects.

8.1. Monitoring and mitigation recommendations regarding palaeontological heritage

Since none of the known fossil sites within the Ingwe cluster project area fall within or close to (≤ 20 m) the proposed project footprints, no specific mitigation is recommended in their regard. All these sites could be mitigated in the pre-construction phase, should they be threatened by the proposed development.

Given the potential for unrecorded plant fossil sites of High Palaeosensitivity hidden within the subsurface which cannot be identified and delineated in the Pre-construction Phase, the following recommendations are made:

1. Surveying of the authorized WEF project footprints by a qualified palaeontologist during the early Construction Phase (*following* initial site clearance and excavations) to identify any newly exposed, sensitive fossil sites or horizons (*e.g*. carbonaceous shales, coals) at or beneath the ground surface.

2. Recording and judicious sampling of new, scientifically valuable fossil remains within or close to (≤ 20 m) project footprint by a qualified palaeontologist.

This should be backed-up by consistent application of the Chance Fossil Finds Procedure throughout the Construction Phase (See Appendix 2).

Mitigation through micro-siting of WEF infrastructure (*e.g.* wind turbines, access roads, substations) would only be necessary in the case of the discovery of extensive new fossil sites of very high scientific / conservation value within the final, authorized project footprints; this eventuality cannot be entirely excluded but is considered unlikely.

The qualified palaeontologist concerned with mitigation work would need a valid collection permit from the Eastern Cape Provincial Heritage Resources Agency, ECPHRA (Contact details: Mr Sello Mokhanya, 74 Alexander Road, King Williams Town 5600; smokhanya@ecphra.org.za). Fossil material collected must be curated, together with full collection data, in an approved depository (*e.g.* university of museum collection). 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 published by SAHRA (2013).

9. ACKNOWLEDGEMENTS

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11. 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, Mpumalanga, Free State, Limpopo, Northwest and Kwazulu-Natal under the aegis of his Cape Town-based company *Natura Viva* cc. He has been 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 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
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APPENDIX 1: GPS LOCALITY DATA – INGWE CLUSTER NEAR MOLTENO, EASTERN CAPE (May 2022)

GPS readings were taken in the field using a hand-held Garmin GPSmap 64s instrument. The datum used is WGS 84. . *Note that locality data for South African fossil sites in not for public release due to conservation concerns.*

Recorded fossil sites are tabulated below, together with GPS data, brief description, Proposed Field Rating and any recommended mitigation. They are mapped in the context of the Ingwe cluster project areas and proposed layouts of the Ingwe WEF 1 and WEF 2 on satellite images in Figures A1.1 to A1.3 below. The fossil sites tabulated and mapped here obviously do not (and cannot) represent *all* fossil sites at surface within the combined Ingwe Cluster project area but, at most, a representative sample of these. Therefore the absence of recorded fossil sites in a particular area does *not* mean that fossils are not present here at surface or in the subsurface. For this reason, a Chance Fossil Finds Protocol is appended to this report.

Loc.	GPS data	Comments
057	-31.331072° 26.369264°	Farm RE/39 Zwavel Kranz Molteno Formation – float blocks of ferruginised, karstified, coarse sandy channel breccia of Molteno Formation within Masotcheni Fm colluvial rubble with angular moulds of mudrock intraclasts as well as sparse **moulds of woody plant axes**. Proposed Field Rating IIIC. Protected by ecological buffer along drainage lines. No mitigation recommended.
058	-31.331000° 26.370908°	Farm RE/39 Zwavel Kranz Thick calcretised and locally ferruginised, fine-grained older alluvium with abundant weathering-out subcylindrical, calcrete casts of plant roots (rhizoliths) and / or reedy plant stems (*c*. 1 cm wide or less). Proposed Field Rating IIIC. Protected by ecological buffer along drainage lines. No mitigation recommended.
072	-31.350322° 26.380684°	Farm 2/39 Zwavel Kranz Molteno Formation – coarse, gritty, large scale trough cross-bedded channel sandstones exposed in bed and banks of stream 1.45 km to SSE of Templeton Farmstead with sparse **moulds of woody plant axes** (c. 8 cm wide). Proposed Field Rating IIIC. Protected by ecological buffer along drainage lines. No mitigation recommended.
073	-31.350851° 26.380464°	Farm 2/39 Zwavel Kranz Molteno Formation, as above. Cluster of circular hollows (*c*. 10 cm wide), some surrounded by raised, doughnut-shaped rings and / or inflected cross-lamination. Possibly **moulds of woody stems or pseudofossils**. Proposed Field Rating IIIC. Protected by ecological buffer along drainage lines. No mitigation recommended.
076	-31.352884° 26.380319°	Farm 2/39 Zwavel Kranz Molteno Formation – float block of gritty channel sandstone in stream bed with **mould of woody plant stem**.

		Proposed Field Rating IIIC. Protected by ecological buffer along drainage lines. No mitigation recommended.
090	-31.302081° 26.333775°	Farm Weltevrede 222 Molteno Fm – probably within base of (basal breccio-conglomerates), or just below Indwe Member or higher Molteno Member, crumbly brown, thin-bedded sandstones with sparse, shiny dark brown **moulds of wood plant** axes (up to *c*. 6 cm wide), patinated by iron / manganese minerals, as well as weathered-out **small blocks of very dark silicified wood** with fine seasonal growth lines. Proposed Field Rating IIIC. Protected by ecological buffer along drainage lines. No mitigation recommended.
127	-31.314954° 26.271547°	Farm Klip Fountain 21/40 Alluvial gravels along small stream on SE margin of Vegkoppies, LSA artefacts with single **small block of suncracked (and possibly rolled) bone**, pale grey to pinkish. Possibly a manuport or reworked from Elliot or Burgersdorp Fm (latter crops out shortly to the NW). Proposed Field Rating IIIC. Protected by ecological buffer along drainage lines. No mitigation recommended.
131	-31.317434° 26.259026°	Farm Klip Fountain 21/40 Probable Molteno Formation. Eluvial / fluvial surface gravels adjacent to farm track *c*. 450m SSE of Vegkoppies farmstead with well-rounded pale quartzite cobbles (probably from Kolo Pebble Bed, Indwe Member or older pebbly unit within Bamboesberg Member) as well as **small, angular blocks of dark grey to black silicified wood**. Proposed Field Rating IIIC. Protected by ecological buffer along drainage lines. No mitigation recommended.
138	-31.277655° 26.241151°	Farm Bamboo 43 Thin channel sandstone of Burgersdorp Formation underlain by weathered, purple-grey overbank mudrocks. Surface gravels (dominantly sandstone) ferruginised, often with metallic blackish ferro-manganese patina. **Chunk of large tetrapod bone** among surface float, partially encrusted with ferro-manganese mineral coating, as well as **small blocks of dark brown, finely-banded petrified wood**. Proposed Field Rating IIIC. No mitigation recommended.
151	-31.256008° 26.257085°	Farm 16/44 Oud Klip Ferruginised eluvial gravels overlying Burgesdorp Fm at base of Molteno Fm escarpment. Pale quartzite cobbles (some crudely flaked, probably ESA) with occasional **small to medium-sized blocks of finely-banded, pale silicified wood** – possibly downwasted from lower Molteno Fm (or Kolo Pebble Bed) rather than from Burgersdorp Fm. Proposed Field Rating IIIC. No mitigation recommended.
153	-31.256373° 26.257423°	Farm 16/44 Oud Klip Ferruginised eluvial gravels overlying Burgesdorp Fm at base of Molteno Fm escarpment. Pale quartzite cobbles (some crudely flaked, probably ESA) with

		occasional **small to medium-sized (10 cm diam.) blocks of finely-banded, pale silicified wood** – possibly downwasted from lower Molteno Fm (or Kolo Pebble Bed) rather than from Burgersdorp Fm. Proposed Field Rating IIIC. No mitigation recommended.
164	- 31.327043° 26.210058°	Farm 29/44 Oud Klip Eluvial surface gravels overlying trough cross-bedded Molteno Fm sandstones with sparse **small blocks of very dark silicified wood** (growth banding cryptic). Proposed Field Rating IIIC. No mitigation recommended.
170	- 31.353086° 26.254977°	Farm 2/58 Modderfontein Bamboesberg Member hillslope exposures with thin sandstone packages and weathered grey-green overbank mudrocks. Latter contain several thin (c. 30 cm) horizons of prominent-weathering, silicified, grey-green to greenish-yellow beds, massive with fairly sharp bases – possibly modified (secondarily silicified?) pedocretes. Beds paler, more cherty towards base. **Possible bioturbated textures** on soles - **equivocal, mud-lined root moulds** (and / or mud cracks). Proposed Field Rating IIIC. No mitigation recommended.
171	- 31.353571° 26.255476°	Farm 2/58 Modderfontein Bamboesberg Member, **surface block of silicified wood** at foot of sandstone package. Proposed Field Rating IIIC. No mitigation recommended.
172	- 31.353700° 26.255511°	Farm 2/58 Modderfontein Bamboesberg Member, float block of coarse sandstone with **pale yellowish, silicified wood fragments**. Proposed Field Rating IIIC. No mitigation recommended.
173	- 31.353789° 26.255521°	Farm 2/58 Modderfontein Bamboesberg Member, **surface block of dark, silicified wood** (c. 8 cm across) beneath base of Indwe sandstone package – possibly downwasted from basal Indwe Member. Proposed Field Rating IIIC. No mitigation recommended.

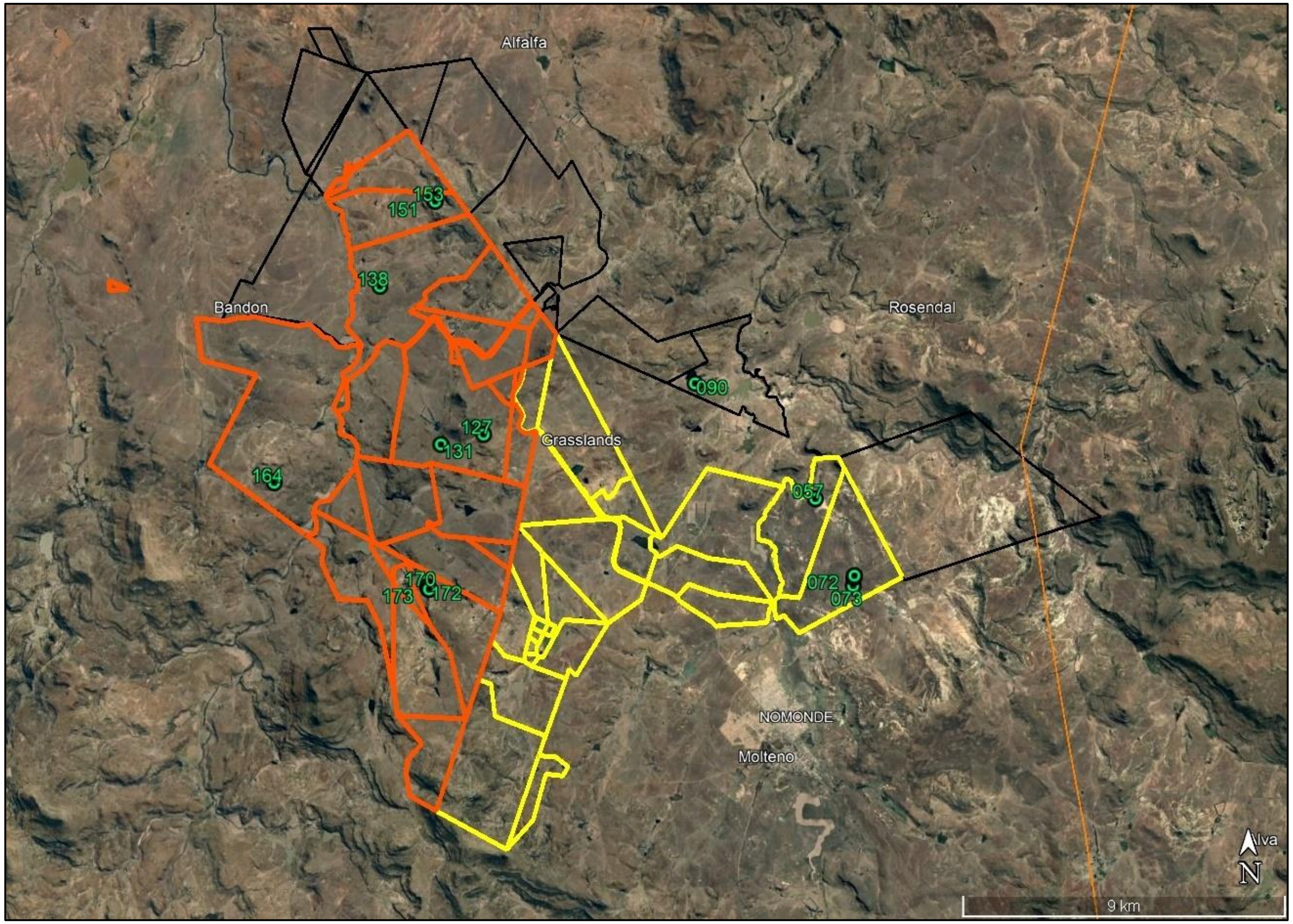

Figure A1.1: Google Earth© satellite image showing the limited number of new fossil sites (numbered green circles, detailed in the table above) recorded during the recent site visit within the combined Ingwe Renewable Energy Cluster project area near Molteno, Eastern Cape. Yellow = Ingwe WEF 1 project area. Orange = Ingwe WEF 2 project area.

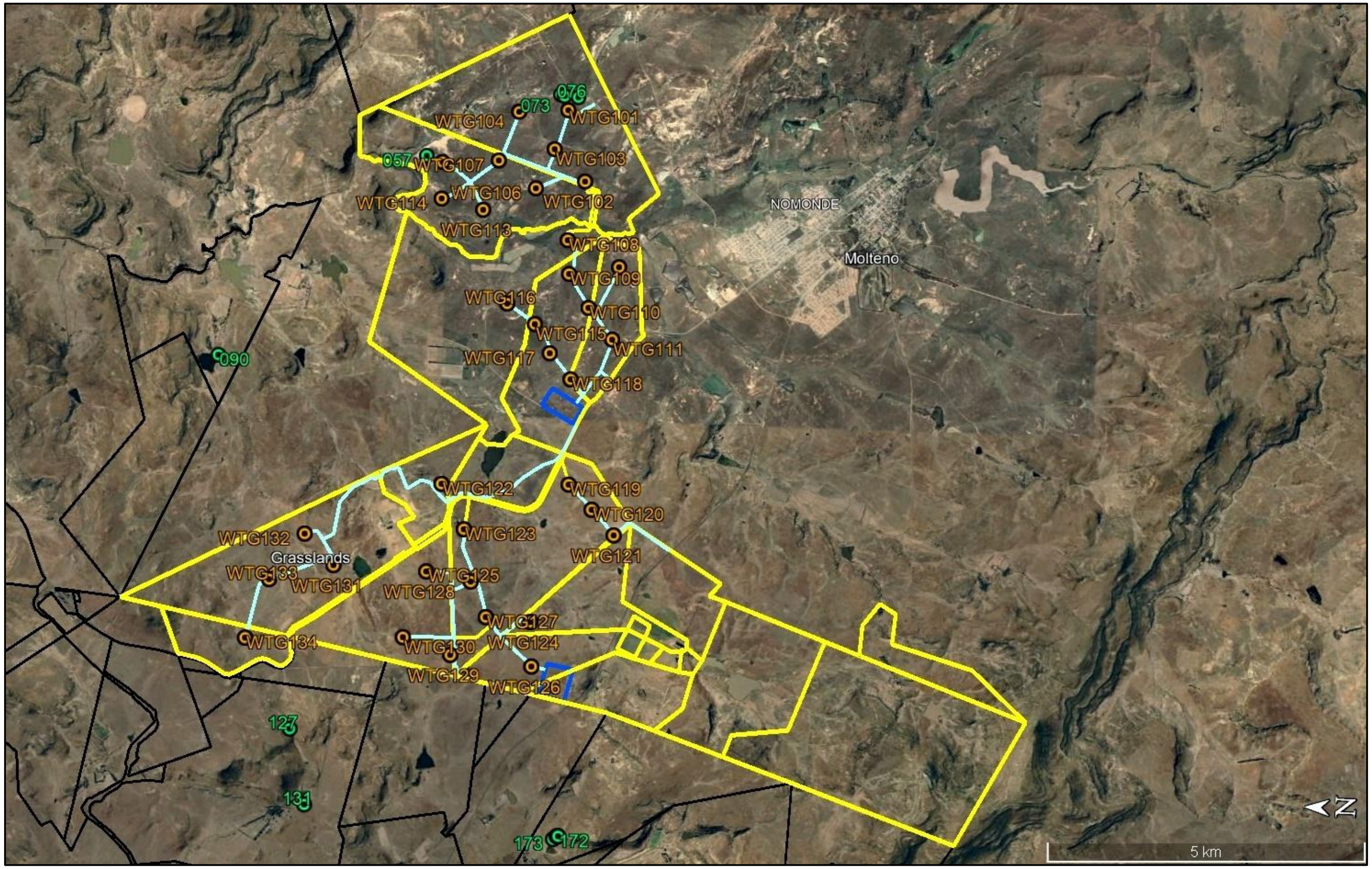

Figure A1.2: Google Earth© satellite image showing new fossil sites (numbered green circles) recorded within the Ingwe WEF 1 project area near Molteno in relation to the proposed layout (wind turbines – orange; internal access roads – pale blue; substation site options – dark blue). Land parcels concerned are outlined in yellow. None of the fossil sites lies within or close to (≤ 20m) of the proposed layout and no mitigation is recommended in regard to them. *N.B.* North is towards the LHS of the image.

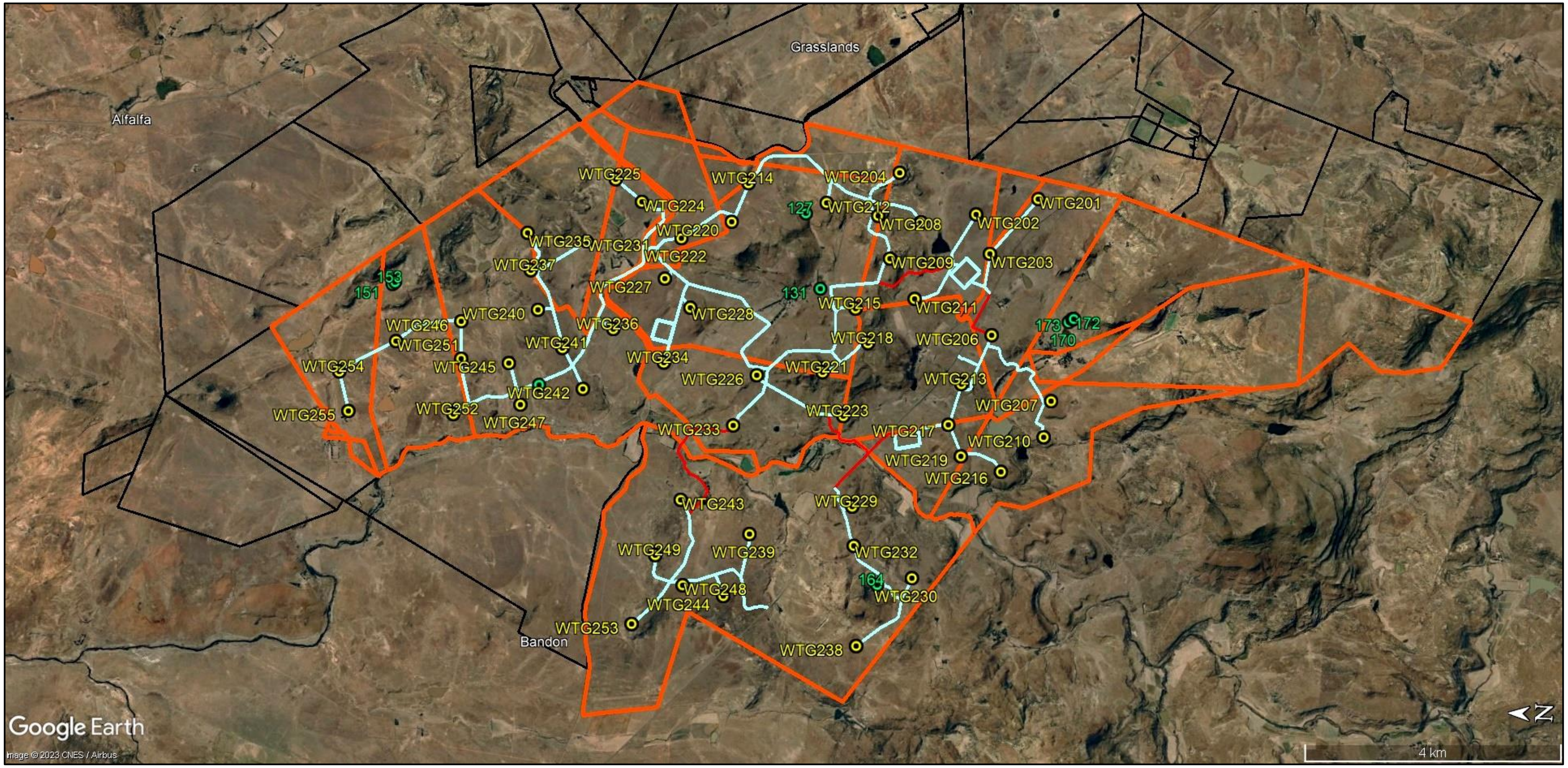

Figure A1.3: Google Earth© satellite image showing new fossil sites (numbered green circles) recorded within the Ingwe WEF 2 project area near Molteno in relation to the proposed layout (wind turbines – yello; internal access roads – pale blue; substation site options – pale blue). Land parcels concerned are outlined in orange. None of the fossil sites lies within or close to (≤ 20m) of the proposed layout and no mitigation is recommended in regard to them. *N.B.* North is towards the LHS of the image.

<table>
<tr><th colspan="3">APPENDIX 2: CHANCE FOSSIL FINDS PROCEDURE –INGWE WIND ENERGY FACILITIES 1 & 2</th></tr>
<tr><td>Province & region:</td><td colspan="2">EASTERN CAPE, Joe Gqabi District Municipality and Chris Hani District Municipality</td></tr>
<tr><td>Responsible Heritage Resources Agency</td><td colspan="2">ECPHRA (Contact details: Mr Sello Mokhanya, 74 Alexander Road, King Williams Town 5600; smokhanya@ecphra.org.za)</td></tr>
<tr><td>Rock unit(s)</td><td colspan="2">Burgersdorp Formation (Early to Middle Triassic, Tarkastad Subgroup, Beaufort Group)
Molteno Formation (Late Triassic, Stormberg Group)
Masotcheni Formation (Pleistocene – Holocene)</td></tr>
<tr><td>Potential fossils</td><td colspan="2">Tetrapod bones, teeth, burrows, invertebrate trace fossils, petrified wood and plant fossils within Upper Beaufort Group.
Plant-rich horizons (especially within dark carbonaceous mudrocks, thin coals) with associated insects, rare dinosaur trackways, fish fossils in Molteno Formation.
Fossil teeth, bones and horn cores of mammals in Pleistocene colluvial and alluvial deposits.</td></tr>
<tr><td rowspan="5">ECO protocol</td><td colspan="2">1. Once alerted to fossil occurrence(s): alert site foreman, stop work in area immediately (N.B. safety first!), safeguard site with security tape / fence / sand bags if necessary.</td></tr>
<tr><td colspan="2">2. Record key data while fossil remains are still in situ:
Accurate geographic location – describe and mark on site map / 1: 50 000 map / satellite image / aerial photo
Context – describe position of fossils within stratigraphy (rock layering), depth below surface
Photograph fossil(s) in situ with scale, from different angles, including images showing context (e.g. rock layering)</td></tr>
<tr><td>3. If feasible to leave fossils in situ:
Alert Heritage Resources Agency and project palaeontologist (if any) who will advise on any necessary mitigation
Ensure fossil site remains safeguarded until clearance is given by the Heritage Resources Agency for work to resume</td><td>3. If not feasible to leave fossils in situ (emergency procedure only):

Carefully remove fossils, as far as possible still enclosed within the original sedimentary matrix (e.g. entire block of fossiliferous rock)
Photograph fossils against a plain, level background, with scale
Carefully wrap fossils in several layers of newspaper / tissue paper / plastic bags
Safeguard fossils together with locality and collection data (including collector and date) in a box in a safe place for examination by a palaeontologist
Alert Heritage Resources Agency and project palaeontologist (if any) who will advise on any necessary mitigation</td></tr>
<tr><td colspan="2">4. If required by Heritage Resources Agency, ensure that a suitably-qualified specialist palaeontologist is appointed as soon as possible by the developer.</td></tr>
<tr><td colspan="2">5. Implement any further mitigation measures proposed by the palaeontologist and Heritage Resources Agency.</td></tr>
<tr><td>Specialist palaeontologist</td><td colspan="2">Record, describe and judiciously sample fossil remains together with relevant contextual data (stratigraphy / sedimentology / taphonomy). Ensure that fossils are curated in an approved repository (e.g. museum / university / Council for Geoscience collection) together with full collection data. Submit Palaeontological Mitigation report to Heritage Resources Agency. Adhere to best international practice for palaeontological fieldwork and Heritage Resources Agency minimum standards.</td></tr>
</table>

APPENDIX 3: COMPLIANCE WITH THE APPENDIX 6 OF THE 2014 EIA REGULATIONS (AS AMENDED)

Requirements of Appendix 6 (Specialist Reports) of Government Notice R326 (Environmental Impact Assessment (EIA) Regulations of 2014, as amended)	***Section where this has been addressed in the Specialist Report***
1. (1) A specialist report prepared in terms of these Regulations must contain - *a) details of -* *i. the specialist who prepared the report; and* *ii. the expertise of that specialist to compile a specialist report including a curriculum vitae;*	**Section 11**
b) a declaration that the specialist is independent in a form as may be specified by the competent authority;	**Section 11 &** **Appendix 5**
c) an indication of the scope of, and the purpose for which, the report was prepared;	**Section 1**
(cA) an indication of the quality and age of base data used for the specialist report;	**Section 2.1.**
(cB) a description of existing impacts on the site, cumulative impacts of the proposed development and levels of acceptable change;	**Section 7**
d) the duration, date and season of the site investigation and the relevance of the season to the outcome of the assessment;	**Section 2.1.**
e) a description of the methodology adopted in preparing the report or carrying out the specialised process inclusive of equipment and modelling used;	**Section 2**
f) details of an assessment of the specific identified sensitivity of the site related to the proposed activity or activities and its associated structures and infrastructure, inclusive of a site plan identifying site alternatives;	**Sections 3, 4** **Appendices 1, 4**
g) an identification of any areas to be avoided, including buffers;	**Section 8** **Appendix 1**
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;	**Appendix 1**
i) a description of any assumptions made and any uncertainties or gaps in knowledge;	**Section 2.3.**
j) a description of the findings and potential implications of such findings on the impact of the proposed activity or activities;	**Sections 3,4, 8** **Appendix 1**
k) any mitigation measures for inclusion in the EMPr;	**Section 8**
l) any conditions for inclusion in the environmental authorisation;	**Section 8**
m) any monitoring requirements for inclusion in the EMPr or environmental authorisation;	**Section 8**
n) a reasoned opinion- *i. whether the proposed activity, activities or portions thereof should be authorised;* *(iA) regarding the acceptability of the proposed activity or activities; and* *ii. if the opinion is that the proposed activity, activities 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;*	**Section 8**
o) a description of any consultation process that was undertaken during	**Section 9**

the course of preparing the specialist report;	
p) a summary and copies of any comments received during any consultation process and where applicable all responses thereto; and	**n/a**
q) any other information requested by the competent authority.	**n/a**
(2) Where a government notice by the Minister provides for any protocol or minimum information requirement to be applied to a specialist report, the requirements as indicated in such notice will apply.	**Part A of the Assessment Protocols published in GN 320 on 20 March 2020 are applicable (i.e. Site sensitivity verification requirements where a specialist assessment is required but no specific assessment protocol has been prescribed).**

APPENDIX 4: SITE SENSITIVITY VERIFICATION REPORT: INGWE WIND ENERGY FACILITY 1 AND FACILITY 2 NEAR MOLTENO, EASTERN CAPE PROVINCE

1. Sensitivities identified by the National Web-Based Environmental Screening Tool

The combined Ingwe cluster project area near Molteno in the Eastern Cape falls within the south-eastern portion of the Main Karoo Basin of the RSA. The outcrop areas of the Beaufort and Stormberg Group bedrocks represented here are provisionally designated as being of Very High Sensitivity in palaeontological heritage terms on the basis of its rich fossil record of continental (fluvial / lacustrine / terrestrial) vertebrates of Triassic age. A provisional Very High Palaeosensitivity rating is assigned to the majority of the Ingwe WEF1 and Ingwe WEF2 project areas by the DFFE Screening Tool due to the occurrence here of the Burgersdorp and Molteno Formations (Figures A4.1 and A4.2). Small areas of thick alluvium along major drainage lines is assigned a Medium Palaeosensitivity while dolerite intrusions (unfossiliferous igneous rocks) are rated as of Zero Palaeosensitivity.

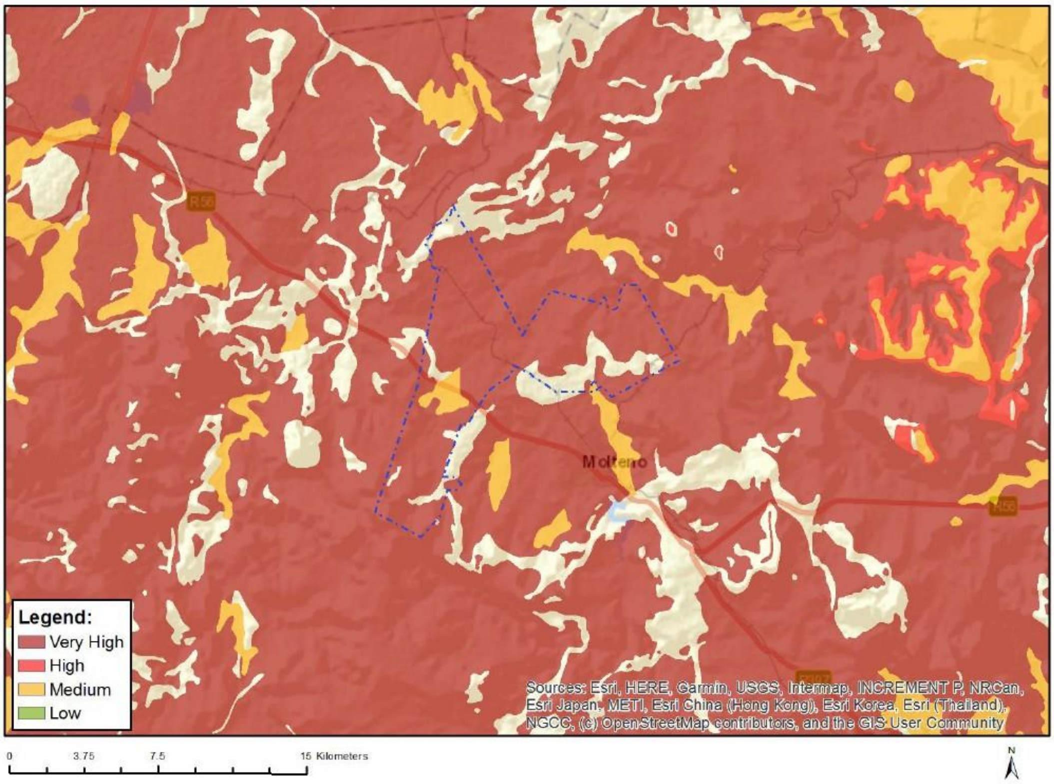

Figure A4.1: Provisional palaeosensitivity map of the Ingwe Wind Energy Facility 1 project area near Molteno, Eastern Cape (blue dashed polygon) generated by the DFFE Screening Tool (CSIR, March 2023). Most of the WEF project area is designated Very High Palaeosensitivity due to underlying sedimentary bedrocks of the Molteno Formation with subordinate small areas of Late Caenozoic alluvium (Medium Sensitivity) and Karoo dolerite (Zero Sensitivity). This provisional sensitivity mapping is *contested* in this PIA report.

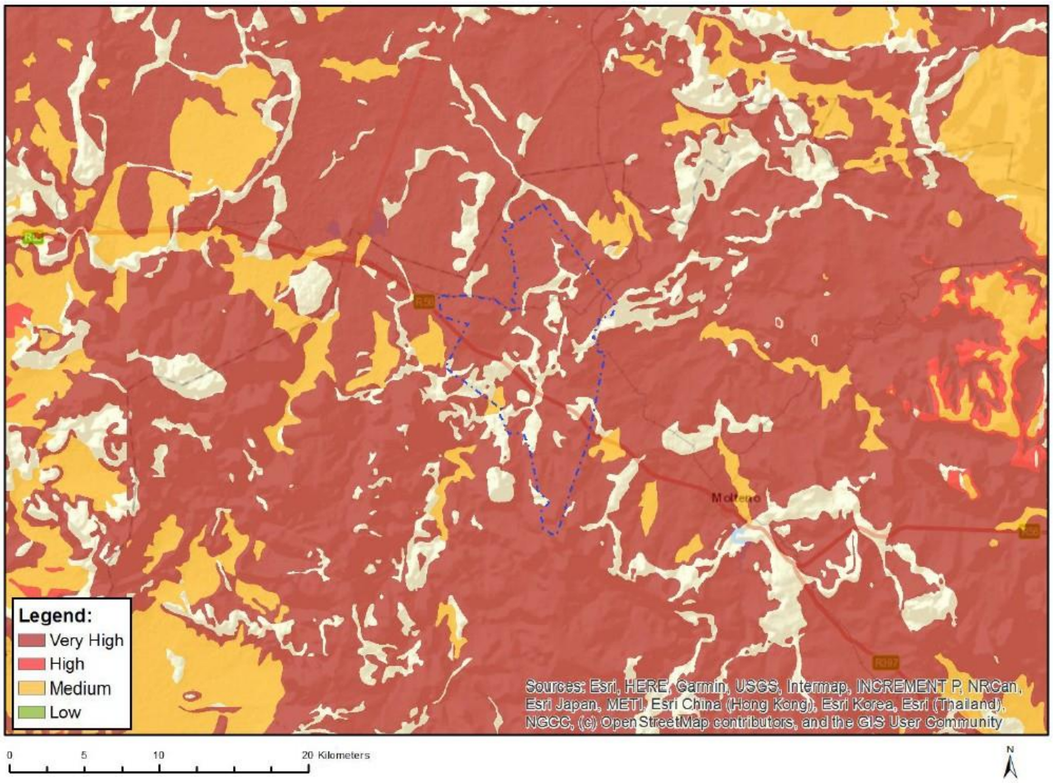

Figure A4.2: Provisional palaeosensitivity map of the Ingwe Wind Energy Facility 2 project area near Molteno, Eastern Cape (blue dashed polygon) generated by the DFFE Screening Tool (CSIR, March 2023). Most of the WEF project area is designated Very High Palaeosensitivity due to underlying sedimentary bedrocks of the Burgersdorp and Molteno Formations with subordinate small areas of Late Caenozoic alluvium (Medium Sensitivity) and Karoo dolerite (Zero Sensitivity). This provisional sensitivity mapping is *contested* in this PIA report.

7.2. Specialist Palaeosensitivity Analysis and Site Sensitivity Verification (SSV)

The present SSV report regarding palaeontological heritage within the combined Ingwe WEF 1 and WEF 2 project area is based on the following:

1. A short project outline, maps and kmz files provided by the CSIR, Environmental and Management Services, Stellenbosch;
2. A review of the key relevant scientific literature, including published geological maps (1: 250 000 geology sheet 3126 Queenstown) and accompanying sheet explanation (Johnson 1984) as well as several desktop and field-based palaeontological assessment studies in the wider Molteno Formation outcrop area of the Eastern Cape by the author and others (See References, especially Fourie 2012, Almond 2010a, 2010b, 2018);
3. Examination of relevant topographical maps (*e.g.* 1: 250 000 sheet 3126 Queenstown, 1: 50 000 sheets 3126AA Kees se Berg, 3126AB Lower Adamson, 3126AC Henning & 3126AD Molteno) as well as Google Earth© satellite images;
4. A seven-day reconnaissance-level palaeontological site visit by the author to the combined Ingwe Wind and Solar PV Energy Facilities cluster project area during the period 17 to 24 May (2021) which focused on a representative sample of potentially-fossiliferous

exposures of bedrock units (especially potentially fossiliferous mudrock exposures) as well as Late Caenozoic alluvial and eluvial deposits.
5. The author's previous field experience with the formations concerned and their palaeontological heritage (*e.g.* Almond *et al.* 2008).

Based on the information sources listed above, **it is concluded that the Ingwe WEF 1 and WEF2 project areas are in practice of *LOW palaeosensitivity overall, but with the potential for occasional plant fossil sites of High to Very High Palaeosensitivity*:**

- Very few fossil sites have been recorded in the project areas and these are all of widely occurring forms of limited scientific interest, mostly poorly-preserved and from channel sandstone facies (*viz.* moulds of woody plant axes, small blocks of – possibly reworked – petrified wood, equivocal invertebrate trace fossils, calcretised plant roots / stems);
- Most of the outcrop area of potentially fossiliferous mudrocks within the Burgersdorp and Molteno Formations are mantled by superficial sediments (colluvium, alluvium, surface gravels) of Low Palaeosensitivity;
- Due to intensive karstic (solution) weathering as well as on-going lichen weathering, well-preserved sandstone bedding planes are rare;
- No High or Very High Sensitivity fossil sites - such as plant-rich horizons of laminated carbonaceous mudrocks or coal beds, well-preserved vertebrate skeletal material or trackways - have been recorded within the project areas;
- However, since the WEF project areas lie within the Molteno Coalfield, the potential remains for rare, largely unpredictable subsurface horizons or sites rich in well-preserved Triassic fossil plants of High to Very High Palaeosensitivity.

The provisional palaeosensitivity mapping by the DFFE Screening Tool is accordingly *contested* in this report. No areas of High to Very High Palaeosensitivity or No-Go Areas have been identified within the WEF project areas. Most – indeed probably all – known fossil sites could be mitigated in the pre-construction phase, should they be threatened by the proposed development.

7.3. Sensitivity Analysis Summary Statement

Provisional palaeosensitivity mapping of the combined Ingwe WEF 1 and WEF 2 project areas by the DFFE Screening Tool suggests that these are largely of Very High Palaeosensitivity, based on the underlying bedrocks of the Beaufort Group and Stormberg Group (Karoo Supergroup). However, desktop reviews as well as recent palaeontological field surveys indicate that, in practice, the WEF project areas are of Low Palaeosensitivity overall, with the potential for rare, largely unpredictable subsurface horizons or sites rich in well-preserved Triassic fossil plants of High to Very High Palaeosensitivity.

APPENDIX 4: SPECIALIST PALAEONTOLOGIST CURRICULUM VITAE - JOHN E. ALMOND Ph.D. (Cantab)

***Natura Viva* cc, 76 Breda Park, Breda Street, Oranjezicht, CAPE TOWN 8001, RSA**
Tel: (021) 462 3622 e-mail: naturaviva@universe.co.za

- **Honours Degree in Natural Sciences (Zoology)**, University of Cambridge, UK (1980).

- **PhD in Earth Sciences (Palaeontology)**, University of Cambridge, UK (1986).

- **Post-doctoral Research Fellowships** at University of Cambridge, UK and Tübingen University, Germany (Humboldt Research Fellow).

- **Visiting Scientist** at various research institutions in Europe, North America, South Africa and fieldwork experience in all these areas, as well as in North Africa.

- **Scientific Officer, Council for Geoscience, RSA** (1990-1998) – palaeontological research and fieldwork – especially in western RSA and Namibia.

- **Managing Member, *Natura Viva* cc** – a Cape Town-based company specialising in broad-based natural history education, tourism and research – especially in the Arid West of Southern Africa (2000 onwards). *Natura Viva* cc produces **technical reports** on palaeontology, geology, botany and other aspects of natural history for public and private nature reserves.

- **Current palaeontological research** focuses on fossil record of the Precambrian / Cambrian boundary (especially trace fossils), and the Cape Supergroup of South Africa.

- **Registered Field Guide** for **South Africa** and **Namibia**

- **Member of the A-team, Botanical Society of SA** (Kirstenbosch Branch) – involved in teaching and training leaders for botanical excursions. Invited leader of annual Botanical Society excursions (Kirstenbosch Branch) to Little Karoo, Cederberg, Namaqualand and other areas since 2005.

- **Professional training of Western and Eastern Cape Field Guides** (FGASA Level 1 & 2, in conjunction with *The Gloriosa Nature Company*) and of Tourist Guides in various aspects of natural history.

- Involved in **extra-mural teaching in natural history** since the early 1980s. Extensive experience in **public lecturing**, running **intensive courses** and leading **field excursions for professional academics as well as enthusiastic amateurs** (*e.g.,* Geological Society / Archaeological Society / Friends of the SA Museum / Cape Natural History Club / Mineral Club / Botanical Society of South Africa / SA Museum Summer & Winter School Programmes / UCT Summer School)

- **Development of palaeontological teaching materials** (textbooks, teachers guides, palaeontological displays) and **teacher training** for the new school science curriculum (GET, FET).

- Former long-standing member of **Archaeology, Palaeontology and Meteorites Committee for Heritage Western Cape (HWC)**. Advisor on palaeontological conservation and management issues for the Palaeontological Society of South Africa (PSSA), HWC and SAHRA (including APM Permit Committee at HWC). Compilation of **technical reports on provincial palaeontological heritage of Western, Northern and Eastern Cape** for SAHRA and HWC. Accredited member of PSSA and APHP (Association of Professional Heritage Practitioners, Western Cape).

- **Palaeontological impact assessments for developments in the Western Cape, Eastern Cape, Northern Cape, Free State, Northwest Province, Mpumulanga, Gauteng, KwaZulu-Natal.**

- Several hundred **palaeontological heritage desktop studies and field assessments** completed over the past few years. Examples of recent larger projects include:

  (1) Numerous major alternative energy projects (wind / solar) in the Beaufort West, Sutherland, Tanqua Karoo, Kuruman, Prieska, De Aar, Loeriesfontein, Bedford / Cookhouse / Middleton / Somerset East, Kouga, Coega, East London and Uitenhage areas (N. Cape, E. Cape)

  (2) Palaeontological heritage survey of the Coega IDZ (E. Cape)

  (3) Surveys of borrow pits in the Western Cape

  (4) Palaeontological heritage assessments for the Transnet 16 mtpa railway development, Hotazel to Coega IDZ (N. Cape, E. Cape)

  (5) Eskom transmission line developments such as Gamma-Omega and Gamma Perseus projects (N. Cape, W. Cape, Free State)

  (6) Mining exploration studies on the Great Karoo, Northern Cape

  (7) Strategic Environmental Assessment Specialist Report – Heritage (palaeontological component) National Wind and Solar PV, Shale Gas in the Karoo, Square Kilometre Array (Karoo), Aquaculture.

- **Reviews of fossil heritage** related to new 1: 250 000 geological maps published by the Council for Geoscience (Geological Survey of SA) – *e.g.,* Clanwilliam, Loeriesfontein, Alexander Bay sheets.

APPENDIX 5: SPECIALIST DECLARATIONS

Annexure 1

Curriculum Vitae

JOHN E. ALMOND Ph.D. (Cantab)

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  Tel: (021) 462 3622 e-mail: naturaviva@universe.co.za

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- Several hundred **palaeontological heritage desktop studies and field assessments** completed over the past two decades. Examples of recent larger projects include:

  (1) Numerous major alternative energy projects (wind / solar) in the Beaufort West, Sutherland, Loxton, Victoria West, Three Sisters, Murraysburg, Tanqua Karoo, Kuruman, Prieska, De Aar, Loeriesfontein, Bedford / Cookhouse / Middleton / Somerset East, Kouga, Coega, East London and Uitenhage areas

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environmental affairs

Department:
Environmental Affairs
REPUBLIC OF SOUTH AFRICA

DETAILS OF THE SPECIALIST, DECLARATION OF INTEREST AND UNDERTAKING UNDER OATH

	(For official use only)
File Reference Number:	
NEAS Reference Number:	DEA/EIA/
Date Received:	

Application for authorisation in terms of the National Environmental Management Act, Act No. 107 of 1998, as amended and the Environmental Impact Assessment (EIA) Regulations, 2014, as amended (the Regulations)

PROJECT TITLE

Scoping and Environmental Impact Assessment for the proposed construction and operation of the up to 240 MWac Ingwe Wind Energy Facility (WEF) 1 and the up to 240 MWac Ingwe WEF 2, near Molteno in the Eastern Cape Province.

Kindly note the following:

1. This form must always be used for applications that must be subjected to Basic Assessment or Scoping & Environmental Impact Reporting where this Department is the Competent Authority.
2. This form is current as of 01 September 2018. It is the responsibility of the Applicant / Environmental Assessment Practitioner (EAP) to ascertain whether subsequent versions of the form have been published or produced by the Competent Authority. The latest available Departmental templates are available at https://www.environment.gov.za/documents/forms.
3. A copy of this form containing original signatures must be appended to all Draft and Final Reports submitted to the department for consideration.
4. All documentation delivered to the physical address contained in this form must be delivered during the official Departmental Officer Hours which is visible on the Departmental gate.
5. All EIA related documents (includes application forms, reports or any EIA related submissions) that are faxed; emailed; delivered to Security or placed in the Departmental Tender Box will not be accepted, only hardcopy submissions are accepted.

Departmental Details

Postal address:
Department of Environmental Affairs
Attention: Chief Director: Integrated Environmental Authorisations
Private Bag X447
Pretoria
0001

Physical address:
Department of Environmental Affairs
Attention: Chief Director: Integrated Environmental Authorisations
Environment House
473 Steve Biko Road
Arcadia

Queries must be directed to the Directorate: Coordination, Strategic Planning and Support at:
Email: EIAAdmin@environment.gov.za

1. SPECIALIST INFORMATION

Specialist Company Name:	Natura Viva cc			
B-BBEE	Contribution level (indicate 1 to 8 or non-compliant)	n/a	Percentage Procurement recognition	n/a
Specialist name:	Dr J.E. Almond			
Specialist Qualifications:	Ph.D			
Professional affiliation/registration:	Cantab			
Physical address:	76 Breda Park, Breda Street, Oranjezicht, Cape Town 8001			
Postal address:	76 Breda Park, Breda Street, Oranjezicht, Cape Town 8001			
Postal code:	8001	Cell:		
Telephone:	021 462 3622	Fax:		
E-mail:	naturaviva@universe.co.za			

2. DECLARATION BY THE SPECIALIST

I, John. E. Almond, declare that –

- I act as the independent specialist in this application;
- I will perform the work relating to the application in an objective manner, even if this results in views and findings that are not favourable to the applicant;
- I declare that there are no circumstances that may compromise my objectivity in performing such work;
- I have expertise in conducting the specialist report relevant to this application, including knowledge of the Act, Regulations and any guidelines that have relevance to the proposed activity;
- I will comply with the Act, Regulations and all other applicable legislation;
- I have no, and will not engage in, conflicting interests in the undertaking of the activity;
- I undertake to disclose to the applicant and the competent authority all material information in my possession that reasonably has or may have the potential of influencing - any decision to be taken with respect to the application by the competent authority; and - the objectivity of any report, plan or document to be prepared by myself for submission to the competent authority;
- all the particulars furnished by me in this form are true and correct; and
- I realise that a false declaration is an offence in terms of regulation 48 and is punishable in terms of section 24F of the Act.

John E Almond

Signature of the Specialist

NATURA VIVA CC

Name of Company:

19 April 2023

Date

3. UNDERTAKING UNDER OATH/ AFFIRMATION

I, John. E. Almond, swear under oath / affirm that all the information submitted or to be submitted for the purposes of this application is true and correct.

John E Almond

Signature of the Specialist

Name of company: **NATURA VIVA CC**

Date: **19 April 2023**

Signature of the Commissioner of Oaths:

SOUTH AFRICAN POLICE SERVICE
STATION COMMANDER
CAPE TOWN
19 APR 2023
CAPE TOWN
STATION COMMANDER
SOUTH AFRICAN POLICE SERVICE

Date: 2023-04-19

Designation: Constable

[1] Curriculum Vitae (CV) attached

Official stamp (below).