Palaeontological impact assessment for Proposed construction of a photovoltaic solar power station near Collett Substation, Middleberg, Eastern Cape

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Background

AE-AMD Renewable Energy proposes to develop a 75 megawatt (MW) solar Photovoltaic (PV) power plant, as well as associated infrastructure such as roads and a power line, at a site adjacent to the Collett railway siding near Rosmead, in the vicinity of Middleburg in the Eastern Province. It is currently engaged in the process of securing the development rights, consents and authorisations.

The development of the proposed PV facility and associated infrastructure involves activities listed in terms of NEMA and requires that a full Environmental Impact Assessment must be conducted to obtain Environmental Authorisation, prior to the commencement of those activities.

The construction of the proposed PV facility will be the first phase of establishing the 75 MW facility that will generate electricity from solar radiation. The proposed facility will be comprised of:

- Arrays of photovoltaic panels for the generation of electricity;
- Dedicated inverters to convert the electricity from DC to AC;
- Underground cabling between the photovoltaic panels and dedicated inverters (buried 1m deep);
- An overhead 132 kV power line connecting into the Collett substation;
- External access road along Rosmead-Cradock railway line or across the farm Buffelspoort 336;
- Internal access roads and
- Administrative/security buildings.

Geology and Palaeontology

The study area is situated on a near horizontal plane underlain by strata of the uppermost Balfour Formation (Adelaide Subgroup, Beaufort Group, Karoo Supergroup). Large hills (such as) that distantly surround the study area are comprised of more resistant sandstone dominated strata of the Katberg Formation (Tarkastad Subgroup, Beaufort Group, Karoo Supergroup), often intruded by Jurassic dolerite. A dolerite dyke in the Balfour Formation is responsible for a range of low hills that demarcate the westerly boundary of the study area. A number of small hills near the access route approaching Rosmead are also comprised of dolerite.

Within the study area these rocks are patchily overlain by Quaternary calcrete deposits, which are in turn overlain by (generally thin) recent soils.

These are intruded by dolerite dykes and sills implaced during the Jurassic.

The strata of the **Karoo Supergroup** were deposited within the Karoo sedimentary Basin, which resulted from shortening and thickening of the southern margin of Africa, with coeval folding and uplift of the Cape Supergroup strata along its southern margin. The Karoo Supergroup strata are between 310 and 182 million years old and span the Upper Carboniferous to Middle Jurassic Periods. During this interval the basin evolved from an inland sea flooded by a melting ice cap, to a giant lake (the Ecca Lake) fed by seasonal meandering (and at times braided) rivers. This lake steadily shrank as it filled with sediment and the basin's rate of subsidence stabilised. The land became increasingly arid and was covered with wind blown sand towards the end of its cycle. Finally the subcontinent was inundated with basaltic lava that issued from widespread linear cracks within the crust, to form the capping basalts of the Drakensberg Group.

The uppermost Balfour Formation (Adelaide Subgroup, Beaufort Group, Karoo Supergroup) mudstones within the area comprise the Palingkloof Member. The Permotriassic boundary is situated within the Palingkloof Member, apparently at the top of the first purple mudstone. The Permotriassic boundary reflects a massive extinction event that decimated life. In the Karoo Basin it is reflected in the biotic changes separating the underlying *Dicynodon* from the overlying *Lystrosaurus* assemblage Zones.

The after effects of this extinction event led to a change in sedimentary patterns, possibly due to the extinction of the dominant *Glossopteris* flora. A change from meandering river systems to more high energy braided river systems is reflected in a change in lithology from the mudstone dominated upper Balfour Formation to the sandstone dominated lithology of the Katberg Formation (lower Tarkastad Subgroup, Beaufort Group, Karoo Supergroup).

The flood planes of the **Beaufort** Group (Karoo Supergroup) provide an internationally important record of life during the early diversification of land vertebrates. During its deposition giant amphibians coexisted with diapsid reptiles (the ancestors of dinosaurs, birds and most modern reptiles), anapsids (which probably include the ancestors of tortoises) and synapsids, the dominant group of the time which included the diverse therapsids (including the ancestors of mammals). Rocks of the Beaufort Group provide the world's most complete record of the important transition from early reptiles to mammals.

The Beaufort Group is subdivided into a series of biostratigraphic units on the basis of its faunal content.

The *Dicynodon* Assemblage Zone extends into the lower Palingkloof Member. Characterised by the co-occurence of two therapsids, *Dicynodon* and *Theriognathus*, this zone demonstrates the Beaufort Groups greatest diversity of vertebrate taxa, including numerous genera and species of dicynodont, biarmosuchian, gorgonopsian and therocephalian and cynodont therapsid Synapsida, together with diverse captorhinid Reptilia and less well represented eosuchian Reptilia, Amphibia and Pisces. Trace fossils of invertebrates and vertebrates as well as *Glossopteris* flora plants have also been described. The lower Palingkloof Member provides important evidence regarding the fauna and flora, immediately preceding the Permotriassic extinction event which decimated the vertebrate fauna and extinguished the diverse glossopterid plants.

The *Lystrosaurus* Assemblage Zone contains a limited fauna surviving immediately after the Permotriassic extinction event. It is dominated by a single genus of dicynodont, *Lystrosaurus*, which together with the captorhinid reptile, *Procolophon*, characterise this zone. Therocephalian and cynodontian Therapsida were moderately abundant. Small numbers of Captorhinid Reptilia survived the biotic turnover. An unprecedented diversity of giant amphibians characterises this interval and fish have been recorded. Fossil millipedes, a range of plants and diverse trace fossils have also been recorded.

During the formation of the volcanic **Drakensberg Group (Stormsberg Group, Karoo Supergroup)**, during the Jurassic, crack like fissures in the earth's crust became filled with molten lava that later cooled to form dolerite dykes. Other magma was injected under pressure between horizontal sedimentary strata and cooled to form extensive horizontal sills of dolerite. Dolerite, being an intrusive igneous rock, contains no fossils.

Much of the area is covered in a thick deposit of unconsolidated and calcretised Quaternary alluvium. Although this is unlikely to contain significant fossils an important early modern human skull has been collected from an erosion gully near Hofmeyer, a little to the east of the study area.

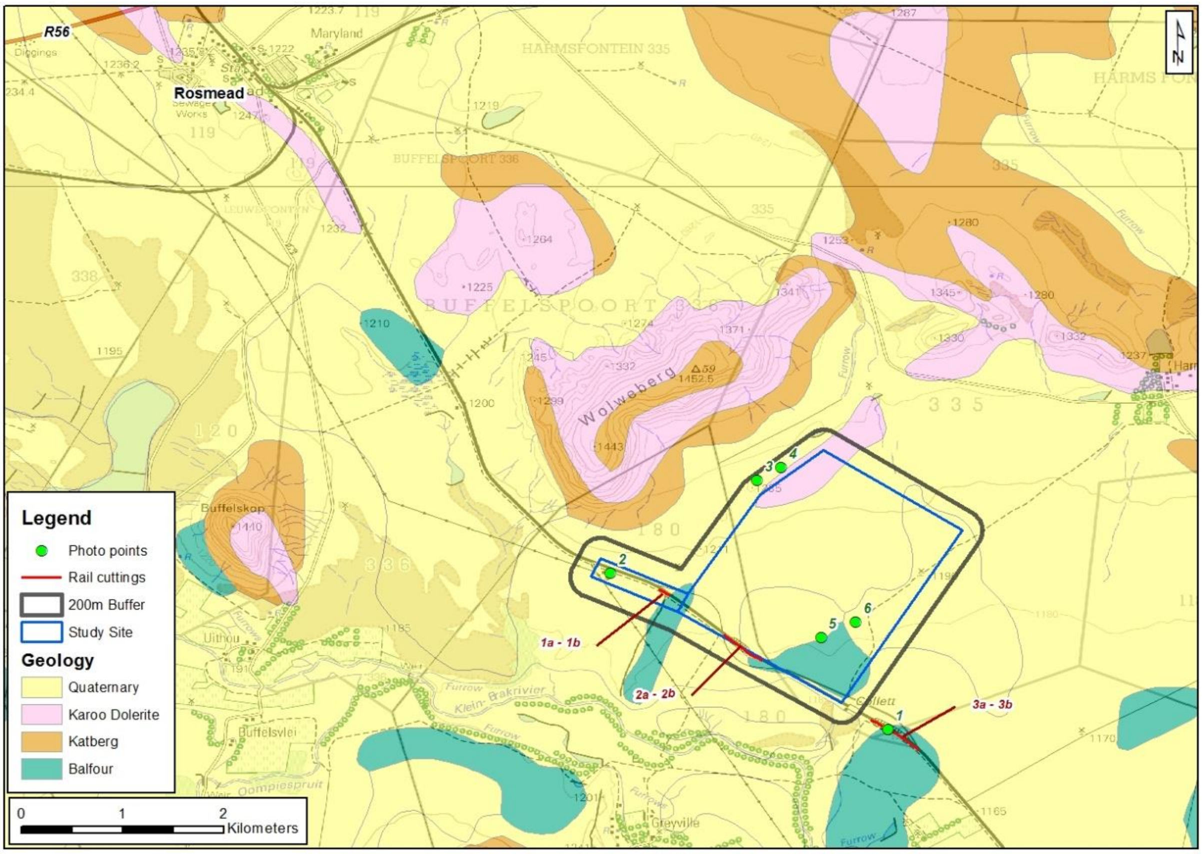

Figure 1: Map of the proposed development area overlain by geological survey data and annotated with points of interest illustratedd in the report.

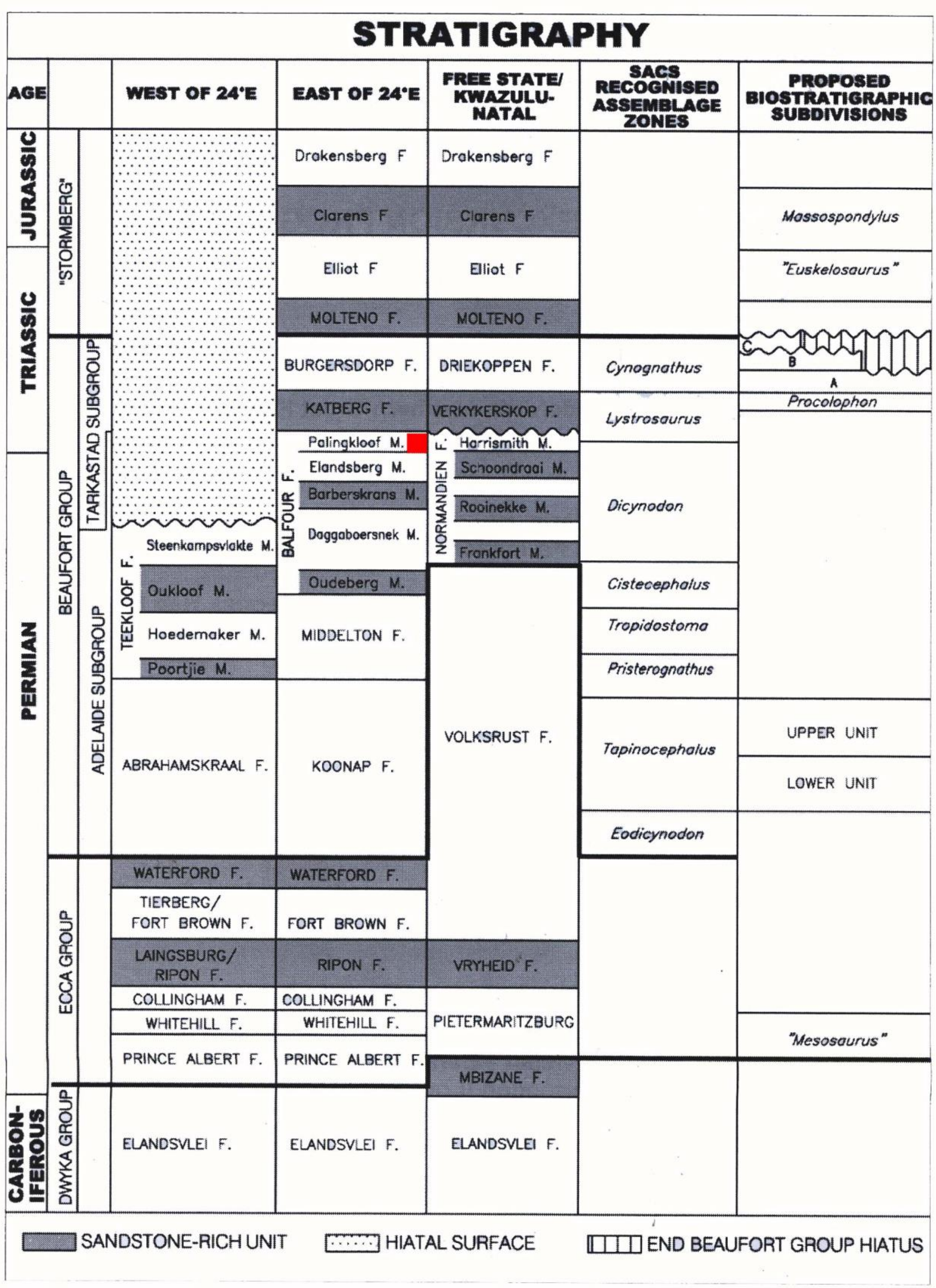

Figure 2: Karoo stratigraphy and biostratigraphy (after Smith *et al.*, 2012). Red line indicates stratigraphic interval impacted by proposed development.

Site Visit

The study site was extensively surveyed on foot and by vehicle over three days from late November to early December 2012.

The main study area is bounded along its north-west margin by a dolerite dyke, which is displayed in a chain of distinctive low hills (Figure 3). Towards the south west it becomes too narrow to reflect on the report map. To the south-east the study area consists of a near horizontal plain, broken by a low step approximately half way across its south westerly margin. Soil cover is very thin over most of the plain, though it largely veils the underlying geology. Surveys on foot revealed a number of small outcrops on the plain, however the best windows into the underlying geology were provided by three railway route cuttings, rail cut 1 (fig. 1, 1a-1b) and rail cut 2 (fig. 1, 2a-2b) situated along the south western boundary of the study area, and rail cut 3 (fig. 1, 3a-3b) situated marginally to the west of the study area.

Figure 3: Row of low dolerite hills outlining a dolerite dyke along the north western boundary of the study area (picture taken from point 3, fig. 1)

Figure 4: View south east from the dolerite hills across the plain of the study area.

Figure 5: View diagonally across the study area towards Collett siding from point 4.

The dolerite dyke may be seen in cross section where the railway cutting is incised through one of the dolerite topped hills (Fig.1, 1a-1b). It is apparent that towards the north east the hills are backed by a wedge of greenish mudstones and thin interbedded sandstones of the Balfour Formation (Fig 6) which has been shielded from erosion by the adjacent resistant dolerite. Where the hills have not been cut through outcrops of Balfour Formation sediments are very sparse as they are largely concealed beneath a scree of dolerite boulders that cascades down from the hill crest. In the saddle between the two hills to the south east of railcut 1 lydianite (a black hornfels caused by baking of mudstones adjacent to a dolerite dyke) is exposed. This has been worked during the Late Stoneage as a source of materials for tool manufacture.

Figure 6: Railcutting 1 (looking south west) showing the contact between the dolerite dyke (at left) and greenish mudstones and thin interbedded sandstones of the Balfour Formation (at right).

Roadcutting 2 intersects a slight bulge in the landscape, comprised of a thick layer of purplish mudstone (Figure 7), seen in the south east overlying greenish mudstone and thin interbedded sandstone (Figure 8). At intervals throughout the roadcutting, generally originating in more greenish interbeds, extensive plant roots may be observed (Figure 9, 10), often radiating from a common origination.

It is unclear what factors have contributed to the formation of this low ridge which extends onto the plain and drops off fairly steeply to the south east. Along this low scarp sandy horizons are patchily exposed (Fig. 11). The top of the low ridge is densely scattered with lydianite flaking indicating Late Stoneage tool manufacture over a consider length of time (Fig. 12). Lack of evidence for a dolerite dyke, prerequisite for the formation of lydianite suggests that much of the stone may have been carried from the back of the dolerite hills for working. The good vantage point for hunting provided by this ridge may suggest a reason.

To the north east of this ridge, purplish shales are occasionally exposed in washouts and along animal tracks, indicating that the soil is very thin (Fig. 13). Further outcrops of this horizon occur along a former rail embankment that curves around the rise to the south of the current cutting.

Figure7: Thick layer of purplish Balfour Formation mudstone exposed in railcutting 2.

Figure 8: Greenish Balfour Formation mudstone underlying the purplish mudstone in the south east of railcut 2.

Figure 9: Fossil root exposed in railcut 2.

Figure 10: Detail of root exposed in railcut 2, showing surface texture.

Figure 11: Sandy Balfour Formation sediments exposed at point 5, Fig.1.

Figure 12: Dense scatters of lydianite, flaked during the Late Stoneage, along the ridge north east of roadcutting 2.

Figure 13: Balfour Formation purplish mudstone exposed in a washout at point 6, indicating the presence of very thin covering soils.

Roadcutting 3 lies slightly outside the study area but sheds light on the underlying strata in the east of the study area. It is composed of greenish mudstones and sandstones (Fig. 14) that stratigraphically underlie the purplish mudstone seen in railcut 2. A layer of flood generated mud chip conglomerate lenses containing numerous small bone fragments is interbedded within these strata (Fig. 15). Fossilised plant fragments also occur (Fig. 16).

Figure 14: Balfour Formation greenish mudstone and sandstone exposed in railcutting 3.

Figure 15: Bone fragments in mud chip conglomerate lenses in railcutting 3.

Figure 16: Plant fragments at point 1 in railcutting 3.

Immediately to the south of the Collett substation (Fig.1 point 2) a thick bed of Quaternary calcrete (Fig.17) has been excavated for aggregate for levelling the substation area. Balfour formation sandstone forms the bottom of the excavation, about 2 metres below the current ground surface. Near the surface the calcrete exhibits abundant invertebrate burrow traces (Fig. 18).

Figure 17: Thick bed of Quaternary calcrete exposed in an excavation immediately south of Collett Substation.

Figure 18: Invertebrate trace fossils in Quaternary calcrete in excavation immediately south of Collett Substation

The buffer zone around the proposed access route from Rosmead to Collett, along the rail route, does not exhibit much outcrop. A hill situated about half way along this route, to the north, is composed entirely of dolerite, as are a range of hills immediately to the south of this route, adjacent to Rosmead (Fig. 19).

Figure 19: Dolerite hills adjacent to the access route just outside Rosmead.

Conclusions and Recommendations

The proposed development is largely situated on purplish and greenish mudstones of the Balfour Formation, which are generally obscured by a thin veneer of Quaternary cover. Although no fossils of significance were discovered during the survey this most likely resulted from the scarcity of good outcrop. This is supported both by the nature of the strata exposed as well as by the abundance of fossil therapsid skulls from the district catalogued into the Rubidge and BPI collections. A number of fossils in the Rubidge collection have, for example, been collected from the farm Vogelstruisfontein near Rosmead, whearas both the Rubidge and BPI collections have numerous holdings from Tafelberg Siding south of the study area.

It seems likely that excavation of the metre deep electrical cable trenches will often intercept potentially fossiliferous mudstones of the upper Balfour Formation (Beaufort Group, Karoo Supergroup).

It is recommended that:

1) the EMO should be instructed to be on the lookout for fossil bones during all excavations on the site. Should fossil bones be uncovered SAHRA and/or a Palaeontologist should be notified.
2) A palaeontologist should visit the site at least once, at a point where a large proportion of the cable trenches are open, in order to carry out a palaeontological assessment. The developer should advise the palaeontologist regarding the best timing for this visit.

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