Palaeontological impact assessment for Proposed establishment of the Middleberg Solar Park, Eastern Cape

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Background

African Clean Energy Developments (Pty) Ltd (ACED) is proposing the development of a commercial Photovoltaic (PV) Solar Energy Facility on a site located approximately 20 km north of Middelburg (Eastern Cape Province) and ~14 km south of Noupoort (Northern Cape Province). This site was previously investigated by ACED for the establishment of a wind energy facility, but has proven to be unfeasible for this technology due to the limited wind resource measured on the site. However, the site has proven to be potentially viable for the development of a PV solar energy facility. This project will be split into 2 development phases of 75MW each, to be known as Middleburg Solar Park 1 and Middleburg Solar Park 2. Each of these parks will to be operated by a Special Purpose Vehicle (SPV) to be established for the project and therefore separate Environmental Authorisations would be required for each park. However, a single EIA process is being undertaken as the sites are adjacent to one another.

The project is proposed of the following farm portions:

» Middleburg Solar Park 1 - Remainder of Farm 11 (Twee Fontein)
» Middleburg Solar Park 2 – Portion 4 of Farm 11 (Twee Fontein)

A broader area of approximately 1670 hectares is being considered within which the facility is to be constructed.

Geology and Palaeontology

The entire study area is underlain by strata of the uppermost Balfour Formation (Adelaide Subgroup, Beaufort Group, Karoo Supergroup). 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 and possibly uppermost Elandsberg Members. The Permotriassic boundary is situated within the Palingkloof Member. This was initiated by 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). Sandstones of the

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.

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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 also 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 earths 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 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.

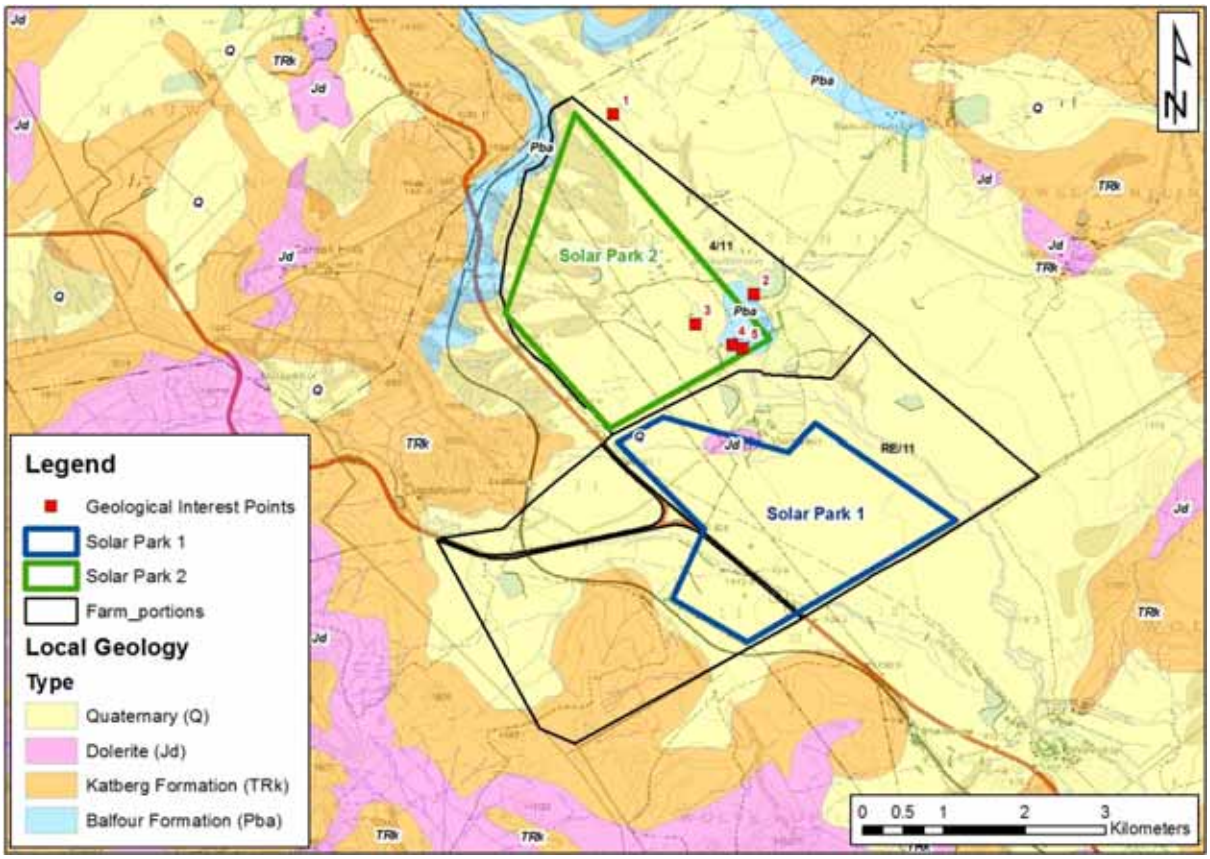

Figure 1: Map of the proposed development area overlain by geological survey data and annotated with points of interest illustratedd in the report.

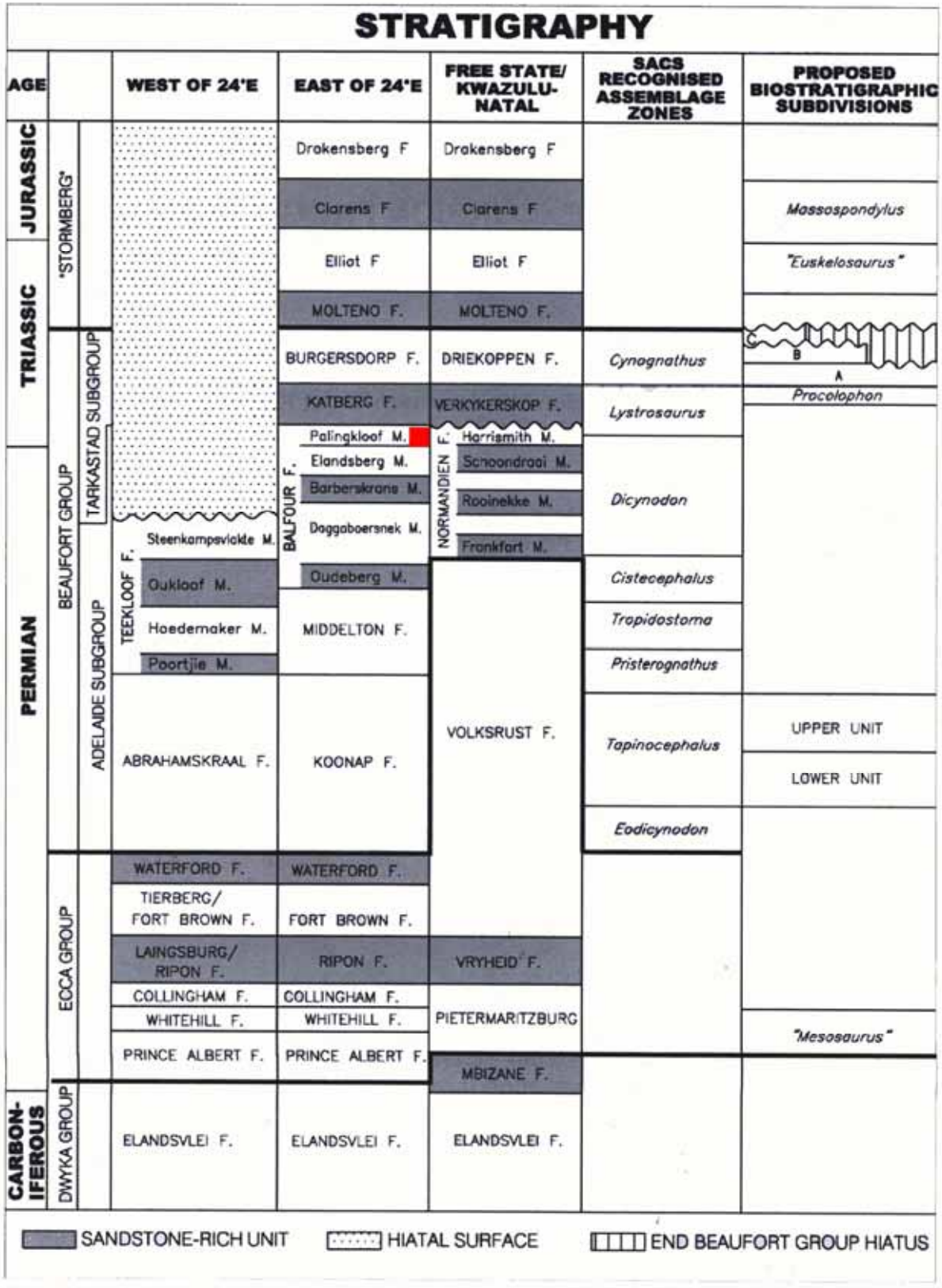

Figure 2: Karoo stratigraphy and biostratigraphy (after Smith *et al*., 2012). Red line indicates stratigraphic interval impacted by proposed development.

Site Visit

The study site was extensively surveyed on foot and by vehicle over two days in February 2012. The south east portions of both proposed solar parks are covered in a thick level plane of Quaternary alluvium, currently used for cultivating prickly pears (figs 3,4). A river bed, to the east of the highway, in the south of Solar Park 1 cuts into a deep layer of alluvium without encountering Balfour Formation mudstone (fig. 5).

Figure 3: Alluvial plain seen looking east over solar park one site.

Figure 4: Looking west over solar park two site.

Figure 5: Deep alluvium exposed in a river bed in the southern corner of solar park one site.

Balfour Formation mudstones are however exposed:

- around the edges of the dolerite capping the raised ground in the north west of the solar park one site (see fig 1),
- in the bottom of erosion gulleys cutting through the alluvium in the northern and eastern portions of the solar park two site (figs 6-8),
- in the form of a small hill in the east of the solar park two site between the two dams (see outcrop shown in blue in fig. 1)

Figure 6: Balfour Formation mudstones exposed at point 1 (fig.1)

Figure 7: Eroded and gullied alluvium in the north of the Solar Park 2 site

Figure 8: Balfour Formation strata exposed in a gulley floor in the northern part of the Solar Park 2 site.

A number of significant fossils were found in the south eastern corner of the Solar Park 1 site. These included an almost complete therapsid skeleton found in a roadway at point 5 (fig.1),

(figs 9, 10). As this specimen was significant and very vulnerable it was removed to the Albany Museum.

Figure 9: Mudstone exposed in bed of farm road at point 5 (fig. 1)

Figure 10: Therapsid skeleton exposed in the road bed at point 5 (fig.1), skull at left.

Figure 11: Vertebrate remains observed in the south east of the Solar Park 2 site. *Top*: large bones embedded in the roadway at point 5(fig.1), *bottom left*: piece of vertebrate maxilla with two tooth sockets (indicating that it is not from a dicynodont which has only one per side) at point 3 (fig.1), *bottom right*: vertebrate tooth at point 4 (fig.1).

At point 4 is situated a small gravel quarry in which abundant plant stems and invertebrate trace fossils are preserved.

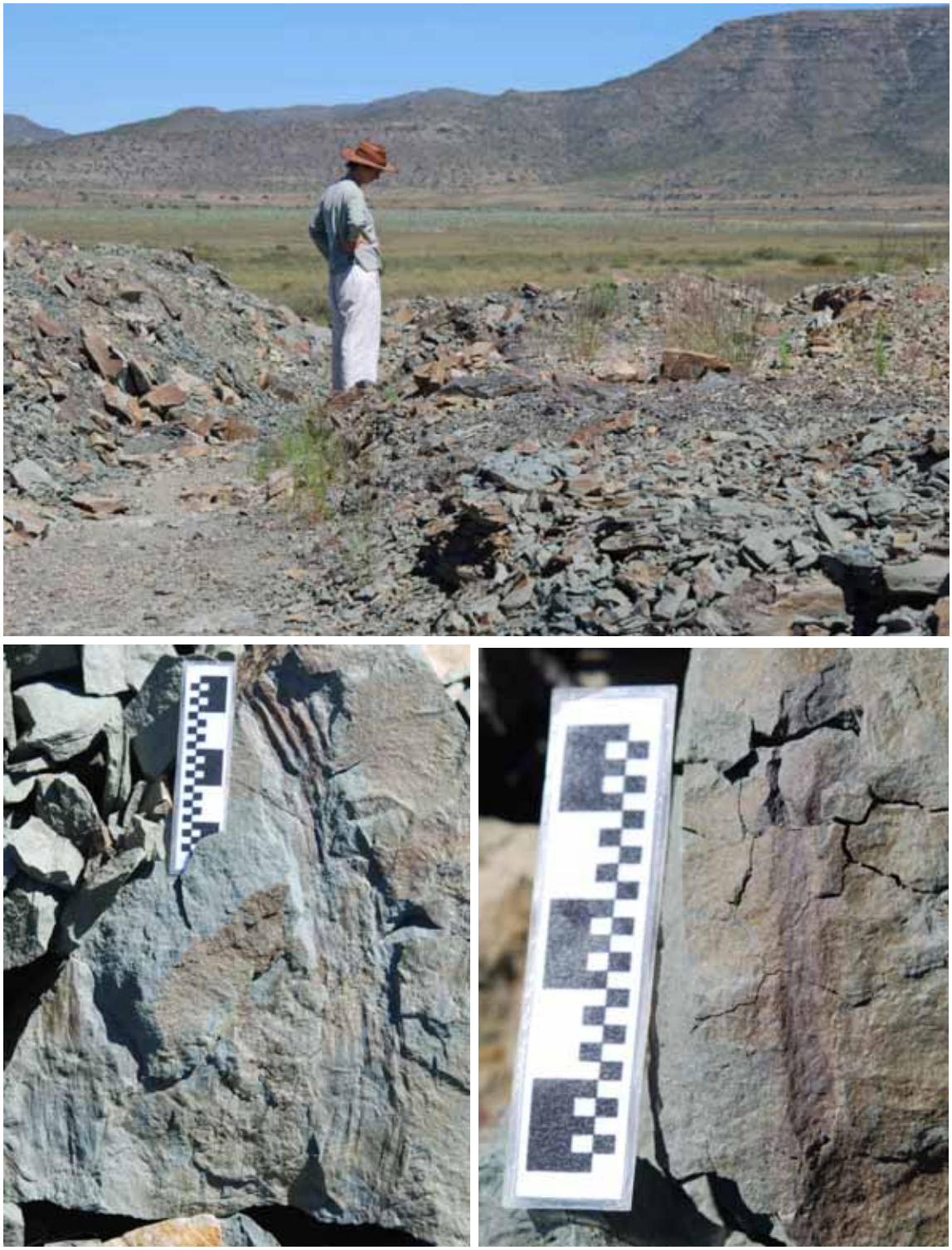

Figure 12: Small quarry at point 4 (figure 1). *Top*: view of quarry in Balfour Formation strata with Katberg Formation sandstone stra forming the hills behind, *bottom left*: sphenophyte stems, *bottom right*: lycopod stem.

Conclusions and Recommendations

It is clear that the alluvial cover in the northern and eastern areas of Solar Park 2 and the northern central part of Solar Park 1 is very thin or absent, exposing uppermost Balfour Formation mudstones. These are fossiliferous, containing significant vertebrate fossil remains of a high quality as well as plant fossil remains. These are made all the more important by their proximity in age to the faunal and floral turnover of the end Permian extinction event.

It is highly likely that construction of new roads and infrastructure within these areas will result in exposure of important palaeontological resources.

It is therefore **recommended that the environmental management plan should require that new exposures of mudstone resulting from the construction phase should be inspected by a palaeontologist**.

Any fossil material noticed during construction activities should be reported to SAHRA and a palaeontologist.

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