PALAEONTOLOGICAL SPECIALIST STUDY: DESKTOP ASSESSMENT

Expansion of River Bend Citrus Farm near Addo, Sundays River Valley Municipality, Eastern Cape

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1. SUMMARY

The study area on the River Bend Citrus Farm (Remainder of Farm 82 Wolve Kop, Portion 1 of Farm 77 Wellshaven and Portion 3 of Farm 77 Honeyvale) some 10 km north of Addo, Sundays River Valley Municipality, is largely underlain by non-marine, fluvial to estuarine sediments of Early Cretaceous age that are assigned to the Kirkwood Formation (Uitenhage Group). This succession has yielded important fossil biotas of Mesozoic land plants (ferns, cycads, conifers *etc*) and non-marine molluscs as well as sparse but numerous specimens of fossil bones, including large and small dinosaurs, from several localities along the northern margin of the Algoa Basin. There is also evidence for occasional marine incursions here in Early Cretaceous times from fossil marine molluscs.

However, the Kirkwood Formation bedrocks are mantled by alluvial sediments of the Coerney River in the southern part of the study area. Elsewhere they appear to lie beneath a thick (2m or more) superficial cover of soils, alluvium and colluvium of low palaeontological sensitivity. The proposed extension of the cultivated area on the River Bend Citrus Farm is therefore not considered significant in terms of palaeontological heritage conservation.

It is concluded that no further palaeontological heritage studies or specialist mitigation are required for this agricultural project, *pending* the discovery or exposure of any substantial fossil remains (*e.g.* vertebrate bones and teeth, large blocks of petrified wood, fossil plant-rich horizons, buried laminated shales) during the construction phase. The ECO responsible for these developments should be alerted to the possibility of important fossil remains being found either on the surface or exposed by fresh excavations during construction.

Should fossil remains be discovered during construction, these should be safeguarded (preferably *in situ*) and the ECO should alert the Eastern Cape Provincial Heritage Resources Authority (ECPHRA. Contact details: Mr Sello Mokhanya, 74 Alexander Road, King Williams Town 5600; Email: smokhanya@ecphra.org.zaso) so that appropriate mitigation (*e.g.* recording, sampling or collection) can be taken by a professional palaeontologist.

The specialist involved would require a collection permit from SAHRA (Contact details: Mrs Colette Scheermeyer, P.O. Box 4637, Cape Town 8000; Tel: 021 462 4502; Email: cscheermeyer@sahra.org.za). Fossil material must be curated in an approved repository (*e.g.* museum or university collection) and all fieldwork and reports should meet the minimum standards for palaeontological impact studies developed by SAHRA.

2. INTRODUCTION & BRIEF

The company San Miguel Fruits SA (Pty) Ltd is proposing to expand by 300 or more hectares the area under cultivation on the River Bend Citrus Farm situated near Addo, Sundays River Valley Municipality, Eastern Cape. Three properties that form part of the existing farm are involved, approximately 1058 hectares in combined extent : Remainder of Farm 82 Wolve Kop, Portion 1 of Farm 77 Wellshaven and Portion 3 of Farm 77 Honeyvale (Fig. 1). The study area, located on the western side of the R335 tar road between Addo and Suurberg, *c*. 10 km north of Addo and 22 km ESE of Kirkwood, lies on gently sloping ground either side of the Coerney River (a tributary of the Sundays River) at elevations of around 90 to 150m amsl and just south of the Suurberge Range. The Addo Elephant National Park lies just to the east (AENP in Fig. 1). The proposed agricultural expansion will include the following components:

- clearing of indigenous vegetation;
- landscaping and levelling the site for citrus orchards;
- installation of water reticulation and irrigation infrastructure;
- construction of a balancing dam;
- establishment of unpaved access roads;
- establishment of windbreaks.

The size and configuration of the area to be cleared will be determined in consultation with project specialists during the environmental impact assessment process. The company Public Process Consultants (Contact details: Sandy Wren, Public Process Consultants, PO Box 27688, Greenacres, 6057; Phone 041 - 374 8426; Fax 041 - 373 2002; Cell 082 4909 828; Email sandy@publicprocess.co.za) has been appointed by San Miguel Fruits SA (Pty) Ltd as the independent Environmental Assessment Practitioner (EAP) to undertake the Scoping and Environmental Impact Assessment for the project.

In accordance with the National Heritage Resources Act, 1999, a palaeontological heritage assessment is required as part of a Heritage Impact Assessment for this project since important fossil material (*e.g.* Cretaceous dinosaurs) has previously been recorded from the Kirkwood – Addo area of the Eastern Cape study area. The various categories of heritage resources recognised as part of the National Estate in Section 3 of the Heritage Resources Act include, among others:

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

In view of the very limited exposure of Creatceous bedrocks within the study area, a preliminary desktop assessment of the fossil heritage resources in the study region was commissioned by Public Process Consultants.

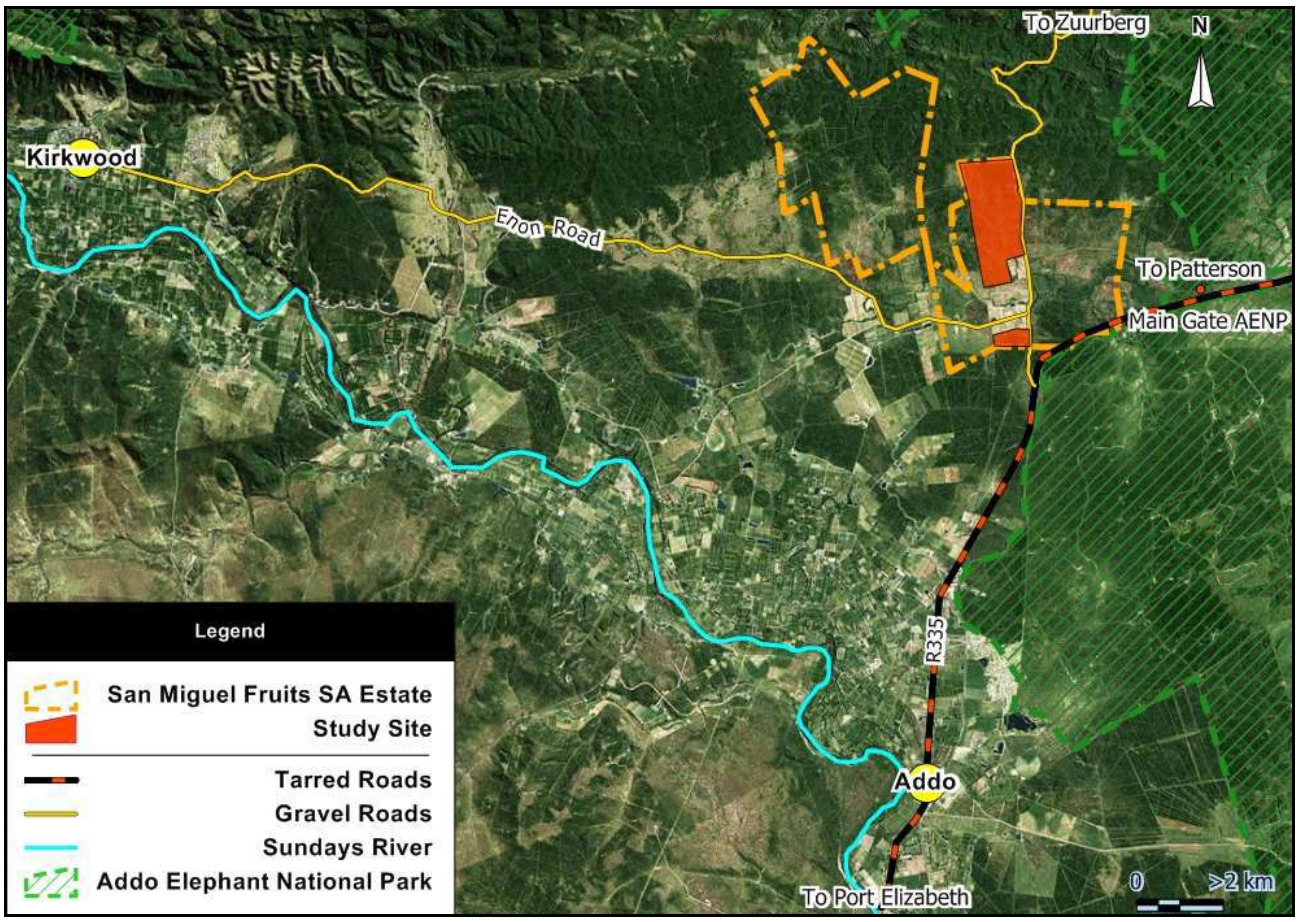

Fig. 1. Location of the study site (orange areas) on the River Bend Citrus Farm located *c*. 10 km north of Addo, Sundays River Valley Municipality, Eastern Cape (Image abstracted from Basic Information Document prepared by Public Process Consultants, Greenacres, February 2011).

2.1. Approach used for this specialist palaeontological study

This palaeontological report provides an assessment of the recorded or inferred palaeontological heritage within the study area near Addo, with recommendations for specialist palaeontological mitigation where this is considered necessary. The report is based on (1) a review of the relevant scientific literature, including previous palaeontological impact assessments for the Eastern Cape region (*e.g.* Almond 2010), and (2) published geological maps and accompanying sheet explanations.

In preparing a palaeontological desktop study the potentially fossiliferous rock units (groups, formations *etc*) represented within the study area are determined from geological maps. 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 Western, Eastern and Northern Cape have already been compiled by J. Almond and colleagues; *e.g.* Almond *et al.* 2008). The likely impact of the proposed development on local fossil heritage is then determined on the basis of (1) the palaeontological sensitivity of the rock units concerned and (2) the nature and scale of the development itself, most notably the extent of fresh bedrock excavation envisaged. When rock units of moderate to high palaeontological sensitivity are present within the

development footprint, a field-based assessment by a professional palaeontologist is usually warranted.

On the basis of the desktop and any recommended follow-up field assessment studies, the likely impact of the proposed development on local fossil heritage and any need for specialist mitigation are then determined. Adverse palaeontological impacts normally occur during the construction rather than the operational or decommissioning phase. Mitigation by a professional palaeontologist – normally involving the recording and sampling of fossil material and associated geological information (*e.g.* sedimentological data) – is usually most effective during the construction phase when fresh fossiliferous bedrock has been exposed by excavations, although pre-construction recording of surface-exposed material may sometimes be more appropriate. To carry out mitigation, the palaeontologist involved will need to apply for a palaeontological collection permit from the relevant heritage management authority (*i.e.* SAHRA, Cape Town). It should be emphasized that, *providing appropriate mitigation is carried out*, the majority of developments involving bedrock excavation can make a *positive* contribution to our understanding of local palaeontological heritage.

2.2. Assumptions & limitations

The accuracy and reliability of palaeontological specialist studies as components of heritage impact assessments are generally limited by the following constraints:

1. Inadequate database for fossil heritage for much of the RSA, given the large size of the country and the small number of professional palaeontologists carrying out fieldwork here. Most development study areas have never been surveyed by a palaeontologist.

2. Variable accuracy of geological maps which underpin these desktop studies. For large areas of terrain these maps are largely based on aerial photographs alone, without ground-truthing. The maps generally depict only significant ("mappable") bedrock units as well as major areas of superficial "drift" deposits (alluvium, colluvium) but for most regions give little or no idea of the level of bedrock outcrop, depth of superficial cover (soil *etc*), degree of bedrock weathering or levels of small-scale tectonic deformation, such as cleavage. All of these factors may have a major influence on the impact significance of a given development on fossil heritage and can only be reliably assessed in the field.

3. Inadequate sheet explanations for geological maps, with little or no attention paid to palaeontological issues in many cases, including poor locality information.

4. The extensive relevant palaeontological "grey literature" - in the form of unpublished university theses, impact studies and other reports (*e.g.* of commercial mining companies) - that is not readily available for desktop studies.

5. Absence of a comprehensive computerized database of fossil collections in major RSA institutions which can be consulted for impact studies. A Karoo fossil vertebrate database is now accessible for impact study work.

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

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

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

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

In the case of palaeontological field studies in the Addo study region, the main limitation is the high levels of bedrock cover by alluvial and colluvial soils such that exposure of Mesozoic rocks is minimal to non-existent (Paul Steyn, Public Process Consultants, pers. comm. 2012).

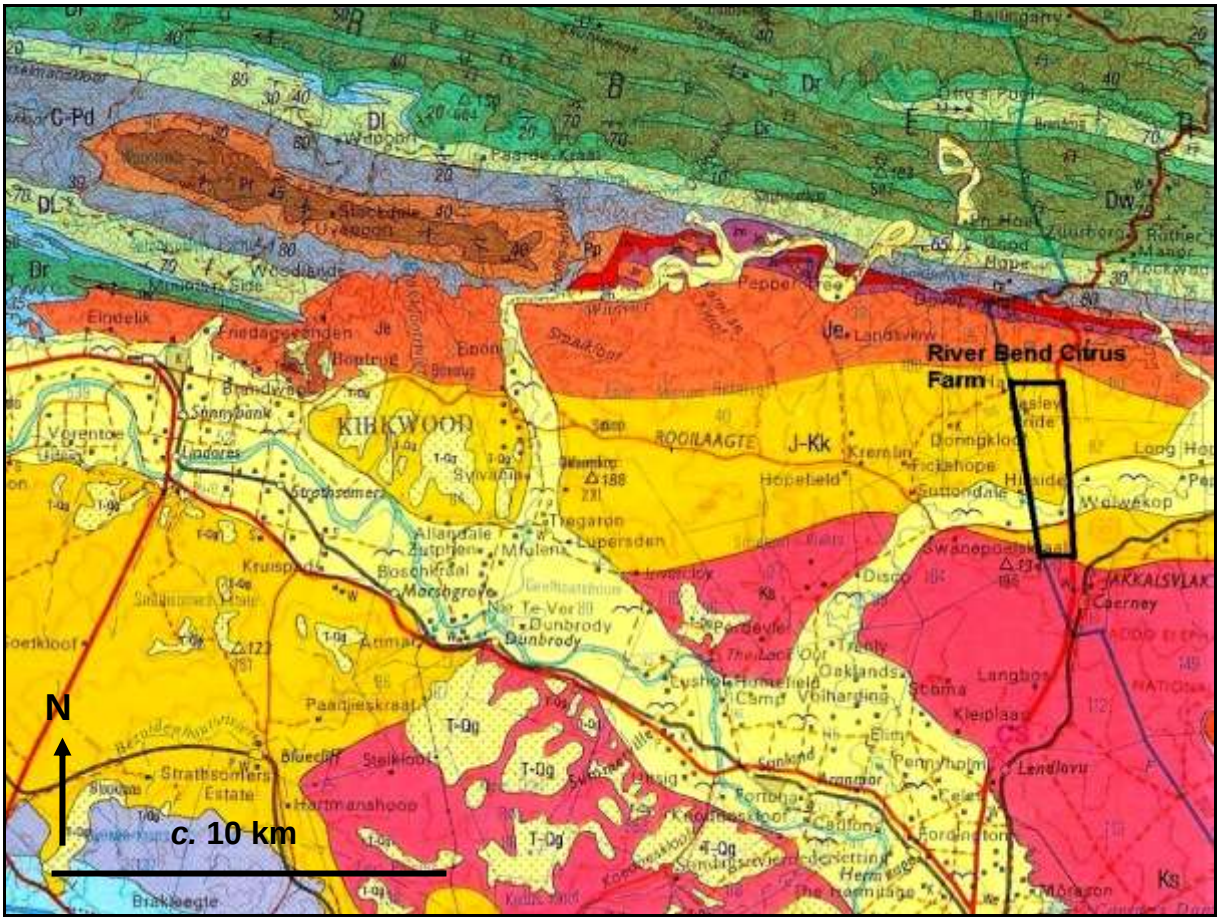

Fig. 2. Extract from 1: 250 000 geological map 3324 Port Elizabeth (Council for Geoscience, Pretoria). The study area on River Bend Citrus Farm some 10 km north of Addo, Eastern Cape (black polygon), lies towards the northern edge of the Mesozoic Algoa Basin. It is entirely underlain by Early Cretaceous sediments of the Kirkwood Formation (J-Kk, yellow) that along the Coerney River are mantled with Late Caenozoic alluvium (pale yellow with 'flying bird" symbol).

3. GEOLOGICAL BACKGROUND

The geology of the Addo study area is shown on 1: 250 000 geological map 3324 Port Elizabeth (Council for Geoscience, Pretoria; Toerien & Hill 1989) (Fig. 2). The area lies towards the northern edge of the large Algoa Basin that is infilled with a 3.5 km thick sucession of alluvial fan, fluvial and estuarine to marine shelf sediments of Late Jurassic to Early Cretaceous age (*c*. 150-125 Ma) that are referred to the **Uitenhage Group** (McLachlan & Anderson 1976, Shone 2006). The River Bend study area is entirely underlain at depth by non-marine sediments of the **Kirkwood Formation** (**J-Kk**, yellow in map Fig. 2) that overlies the Enon Formation (Je, orange) to the north and is in turn overlain by the Sundays River Formation (Ks, pink) to the south. The Kirkwood Formation comprises readily-weathered, silty overbank mudrocks and subordinate channel sandstones and pebbly conglomerates of fluvial origin and Early Cretaceous (Berriasian / Valanginian). Key geological accounts of the Kirkwood Formation include those by Rigassi & Dixon (1972), McLachlan & McMillan (1976), Tankard *et al.* (1982), Dingle *et al.,* (1983) and Shone (1976, 2006). Early geologists called these rocks the "Variegated Marls" referring to the distinctive reddish-brown, pinkish and greenish-grey colour spectrum shown by the sediments (*NB* "marl" is a misnomer, technically referring only to calcareous, clay-rich mudrocks). Another older name for the same succession was the "Wood Beds", referring to the abundant petrified wood recorded in the Algoa Basin and elsewhere (see fossil record below). Volcanic tuffs (ashes) and reworked tuffs constitute an important component of the Kirkwood succession in parts of its outcrop area (*e.g.* Herbertsdale – Hartenbos Basin; Viljoen & Malan 1993).

At the time that the Uitenhage sediments were being deposited, some 140 million years ago, Africa and South America – previously united within the West Gondwana supercontinent - were starting to pull apart. Uplift, faulting and erosion of the youthful southern African continent led to the rapid deposition of huge amounts of alluvium by systems of meandering rivers and estuaries fringing a new Mediterranean-sized seaway that was opening up in the southern Cape area. Well-preserved calcrete-rich palaeosols (fossil soils) within the Kirkwood alluvium suggest that prevailing climates were semi-arid, warm to hot, with a low seasonal rainfall of 100-500mm / year. This pattern is supported by the abundance of leathery- and small-leaved plants in the fossil flora, while well-developed seasonal growth rings are preserved in at least some fossil woods.

In the southern part of the River Bend study area the Kirkwood bedrocks are overlain by thick **Late Caenozoic alluvial deposits** of the Coerney River (pale yellow area with "flying bird" symbol in Fig. 2). According to field observations and test pits dug within the study area, Kirkwood sandstones and mudrocks are not exposed at surface and were not encountered within 2 to 2.5 m of the ground surface in trial pits (Paul Steyn, Public Process Consultants, pers. comm., 2012). Field images of test pits kindly provided by Public Process Consultants show buff, brown to orange-brown hued fine-grained superficial sediments, with sparse gravel clasts towards the surface. It should be noted that *in situ* weathered Kirkwood mudrocks would probably resemble unconsolidated soils or alluvium but may sometimes be recognised by their variegated hues (grey-green, brick red *etc*), polymict pebbles (often showing a very high surface polish), and fossil content.

4. PALAEONTOLOGICAL HERITAGE

The Kirkwood Formation is the most palaeontologically productive unit in southern Africa that yields terrestrial biotas of Early Cretaceous age. Its overall palaeontological sensitivity is rated as high (Almond *et al.* 2008). Fossils include vascular plants (including concentrations of petrified logs, lignite beds, charcoal), tetrapod vertebrates (notably dinosaurs) and freshwater invertebrates, among others (Du Toit 1954, McLachlan & McMillan 1976, Almond 2010 and further references listed below). Recent palaeontological research has yielded a number of new dinosaur taxa, for the most part from the Algoa Basin to the northeast of Port Elizabeth, but also from the Oudtshoorn Basin of the Little Karoo (De Klerk 2008).

The palaeobotanically famous "Variegated Marls" and "Wood Beds" of the Kirkwood Formation in the Eastern Cape have yielded a diverse fossil flora. Woody vegetation was dominated by gymnosperms including conifers such as *Araucaria* and *Podocarpus*, extinct cycad-like bennettitaleans like *Zamites*, as well as true cycads. In addition there are charophytes (stoneworts, an advanced group of freshwater algae), bryophytes (liverworts) and pteridophytes such as ferns (Tate 1867, Seward 1903, Du Toit 1954, McLachlan & McMillan 1976, 1979, Anderson & Anderson 1985, Bamford 1986, MacRae 1999). Angiosperms (flowering plants), which first radiated during this period, are not represented, however. Plant microfossils include pollens, spores and cuticular fragments, while amber and charcoal are locally common. So far no inclusions such as fossil insects have been recorded within the amber, which represents the oldest Cretaceous material recorded from Gondwana.

Cretaceous dinosaurs have been collected from the Kirkwood Formation of the Algoa Basin since the mid nineteenth century and a number of exciting new finds have been made recently. Most of the Kirkwood dinosaur fossils found so far are highly fragmentary, however. The earliest discoveries, in 1845, were of the stegosaur *Paranthodon* from Bushman's River Valley and represent some of the first dinosaur finds made anywhere in the world (De Klerk 1995, 2000). The gigantic remains – mainly isolated vertebrae, leg bones and teeth - of several different titanosaurid and diplodocid sauropods are known from the Algoa and Oudtshoorn Basins (Rich *et al*., 1983, De Klerk 2008). These include the poorly-known *Algoasaurus* from Dispatch near Port Elizabeth (a possible camarasaurid), most of whose bones were made into bricks before they could be rescued (Broom 1904), and huge bones from the Calitzdorp area that were originally described as a giant plesiosaurus (Hoffman 1966). Disarticulated remains of numerous juveniles (hatchlings) of a primitive iguanodontian were discovered recently near Kirkwood (Forster & De Klerk 2008 and paper in press). The most completely preserved Kirkwood dinosaur is the small coelurosaur therapod *Nquebasaurus* (De Klerk *et al*., 2000); recent studies suggest this form may in fact be more closely related to the bird-like dinosaurs or alvarezsaurids (B. De Klerk, pers. comm., 2010). At least one other theropod, a basal tetanuran, is known from fragmentary remains in the Kirkwood Formation (Rich *et al*., 1983, Mateer 1987, Forster *et al*., 2009). Other vertebrate fossil groups from the Kirkwood Formation include frogs, crocodiles, turtles, sphenodontid and other lizards, mammals and freshwater fish such as garfish (De Klerk *et al*., 1998, Rich *et al*., 1983, Ross *et al*., 1999).

Non-marine invertebrate fossils in the Kirkwood Formation are represented by freshwater or estuarine molluscs (*e.g.* unionid bivalves), rare insects such as beetles, and several groups of small crustaceans including ostracods (seed shrimps), conchostracans (clam shrimps) and notostracans (tadpole shrimps) (McLachlan & McMillan 1976, Dingle *et al.* 1983, MacRae 1999, Rich *et al*. 1983, Ross *et al*. 1999, Mostovski & Muller 2010). Trace fossils include borings into petrified tree trunks that are variously attributed to bivalves (*Gastrochaena*) and insects (possibly beetles).

Historical records of fossils from the Kirkwood Formation in the Addo region are ably reviewed by McLachlan and Anderson (1976; see Fig. 3 herein), several culled from the earlier geological sheet explanation for the region between Grahamstown and Port Elizabeth by Haughton (1928). Key Kirkwood fossil sites some 10km or more to the west of the present River Bend study area at Geelhout Boom (Dunbrodie), Blue Cliff Station and the junction of the Wit and Sundays Rivers

have yielded a range of fossil plants (ferns, cycads, conifers, woods *etc*) and vertebrate bones, including those of large dinosaurs (McLachlan & Anderson 1976, p. 204 and their Fig. 4). The plant-rich horizons here are often associated with estuarine oyster beds or non-marine unionid bivalves and gastropods (*Unio, Psammobia*), but fully marine molluscan faunas are also recorded near Dunbrodie. A marshy, marginal estuarine setting with occasional marine incursions has been postulated as a plausible depositional setting for the Early Cretaceous deposits in this area. Important new dinosaur finds have been made along the northern margin of the Algoa Basin further to the west in the Kirkwood area (See references given above).

Neogene to Recent colluvial, alluvial and lag gravel, sand and clay deposits may also contain fossil remains of various types. In coarser sediments like conglomerates these tend to be robust, highly disarticulated and abraded (*e.g*. rolled bones, teeth of vertebrates) but well-preserved skeletal remains of plants (*e.g.* wood, roots) and invertebrate animals (*e.g.* freshwater molluscs and crustaceans) as well as various trace fossils may be found within fine-grained alluvium. Embedded human artefacts such as stone tools that can be assigned to a specific interval of the archaeological time scale (*e.g.* Middle Stone Age) can be of value for constraining the age of Pleistocene to Recent drift deposits like alluvial terraces. Ancient to modern alluvial and colluvial "High Level Gravels" tend to be coarse and to have suffered extensive reworking (*e.g.* winnowing and erosional downwasting), so they are generally unlikely to contain useful fossils. Fine-grained carbonaceous muds associated with *vlei* areas may contain peats, palynomorphs (pollens, spores) and other microfossils as well as the bones and teeth of mammals and other fauna that died in the area.

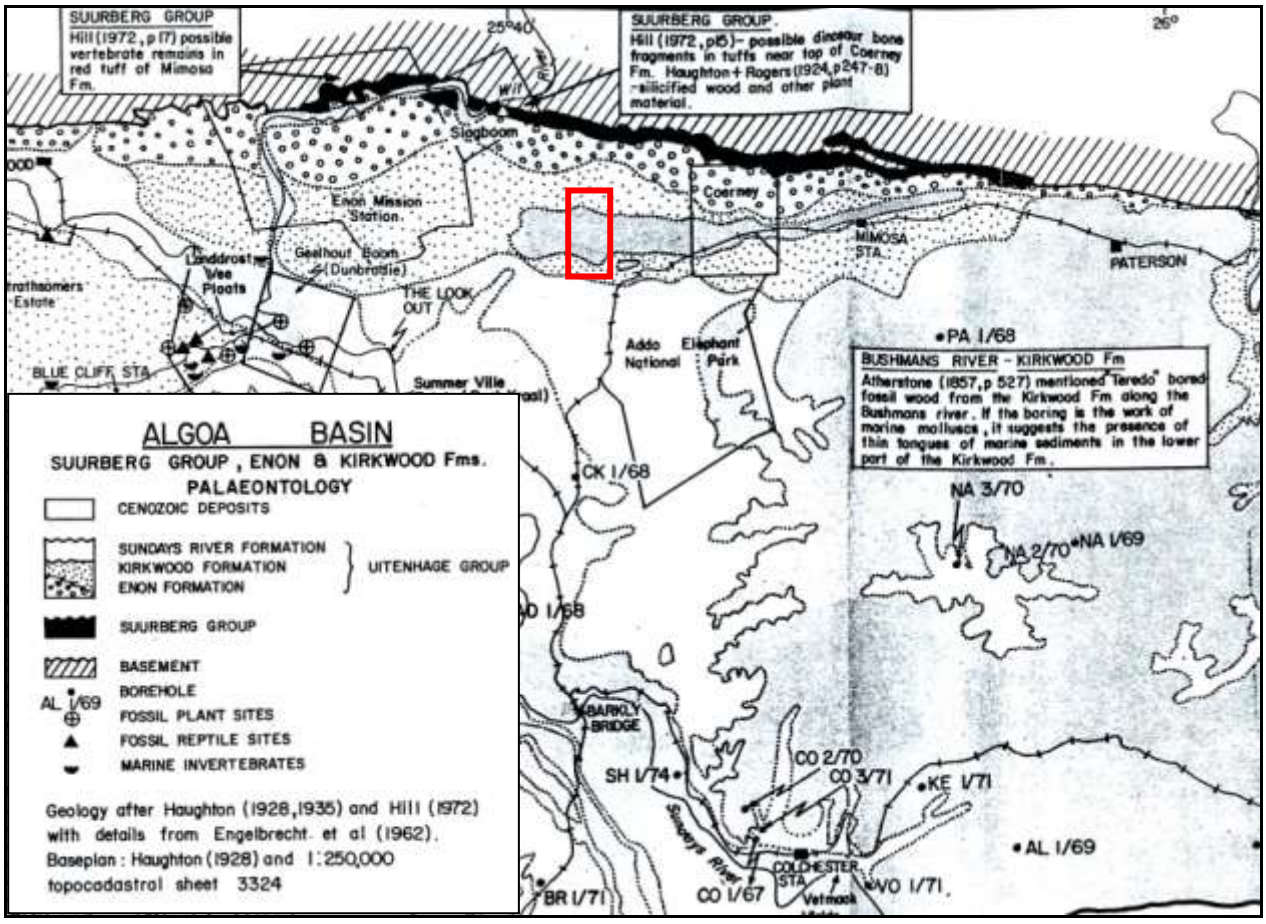

Fig. 3. Fossil localities in the Algoa Basin near Addo, with the present study area indicated by a red rectangle. The stippled areas are underlain by the Kirkwood Formation. Non-marine as well as marine invertebrates, fossil plants and vertebrate remains within the Kirkwood succession are indicated by the symbols shown in the key (Figure modified from McLachlan & Anderson 1976, their Fig. 4).

5. CONCLUSIONS & RECOMMENDATIONS

The study area on the River Bend Citrus Farm near Addo is largely underlain by non-marine fluvial to estuarine sediments of Early Cretaceous age assigned to the Kirkwood Formation (Uitenhage Group). This succession has yielded important fossil biotas of Mesozoic land plants (ferns, cycads, conifers *etc*) and non-marine molluscs as well as sparse but numerous specimens of fossil bones, including large and small dinosaurs, from several localities along the northern margin of the Algoa Basin. There is also evidence for occasional marine incursions here in Early Cretaceous times from fossil marine molluscs.

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It is concluded that no further palaeontological heritage studies or specialist mitigation are required for this agricultural project, *pending* the discovery or exposure of any substantial fossil remains (*e.g.* vertebrate bones and teeth, large blocks of petrified wood, fossil plant-rich horizons, buried laminated shales) during the construction phase. The ECO responsible for these developments should be alerted to the possibility of important fossil remains being found either on the surface or exposed by fresh excavations during construction.

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6. ACKNOWLEDGEMENTS

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8. QUALIFICATIONS & EXPERIENCE OF THE AUTHOR

Dr John Almond has an Honours Degree in Natural Sciences (Zoology) as well as a PhD in Palaeontology from the University of Cambridge, UK. He has been awarded post-doctoral research fellowships at Cambridge University and in Germany, and has carried out palaeontological research in Europe, North America, the Middle East as well as North and South Africa. For eight years he was a scientific officer (palaeontologist) for the Geological Survey / Council for Geoscience in the RSA. His current palaeontological research focuses on fossil record of the Precambrian - Cambrian boundary and the Cape Supergroup of South Africa. He has recently written palaeontological reviews for several 1: 250 000 geological maps published by the Council for Geoscience and has contributed educational material on fossils and evolution for new school textbooks in the RSA.

Since 2002 Dr Almond has also carried out palaeontological impact assessments for developments and conservation areas in the Western, Eastern and Northern Cape under the aegis of his Cape Town-based company *Natura Viva* cc. He is a long-standing member of the Archaeology, Palaeontology and Meteorites Committee for Heritage Western Cape (HWC) and an advisor on palaeontological conservation and management issues for the Palaeontological Society of South Africa (PSSA), HWC and SAHRA. He is currently compiling technical reports on the provincial palaeontological heritage of Western, Northern and Eastern Cape for SAHRA and HWC. Dr Almond is an accredited member of PSSA and APHP (Association of Professional Heritage Practitioners – Western Cape).

Declaration of Independence

I, John E. Almond, declare that I am an independent consultant and have no business, financial, personal or other interest in the proposed alternative energy projects, 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.

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