PALAEONTOLOGICAL ASSESSMENT: COMBINED FIELD ASSESSMENT AND DESKTOP STUDY

PROPOSED PROSPECTING FOR AND MINING OF FOSSILIFEROUS MARINE LIMESTONES OF EOCENE AGE NEAR BATHURST, BATHURST DISTRICT, EASTERN CAPE

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1. SUMMARY

Laman Group (Pty) Ltd are proposing to prospect for limestone on four land parcels situated within 15 km ENE of Bathurst near Port Alfred, Eastern Cape: Birbury Farm 206/5 and Farm 206/2 as well as White Bush Farm 101 and Limestone Hill Farm 102/1. If economically viable reserves are proven, it is then proposed to establish limestone mines in these areas. The limestone belongs to the Bathurst Formation (Algoa Group) of probable Palaeocene / Eocene age, around 50-55 million years old. Over the past century a range of shallow marine fossils have been recorded from the Bathurst Formation at Birbury and nearby localities in the Eastern Cape. These fossils include various shelly invertebrates (molluscs, brachiopods, echinoids *etc*), vertebrate remains (sharks' teeth, silicified bones), several groups of calcareous microfossils as well as trace fossils. The main Birbury fossil site (small quarry) has been proposed as a Reference Stratotype for the Bathurst Formation. Due to its high palaeontological and geological significance it has also been designated a Provincial Heritage Site (previously National Monument) and cannot be disturbed, damaged or mined without permission from SAHRA (South African Heritage Resources Agency).

Prospecting activities at all sites will mostly comprise the excavation of trial holes with a TLB/Excavator and drilling will only be undertaken if absolutely necessary to further prove reserves. Trial hole activities would include the removal of topsoil and overburden and the taking of a small surface sample of limestone from selected sites for analysis. Only small isolated areas will be directly impacted by the prospecting and significant impacts on local fossil heritage are not anticipated during this phase. No further specialist studies or specialist monitoring are recommended for this phase.

The proposed mining area represents a high proportion of the entire known, mapped outcrop area of the fossiliferous Bathurst Formation. This is the only known succession of marine sediments and fossils of Palaeocene / Eocene age in South Africa. There is a long history of fossil collection from Birbury and nearby sites, including ongoing unpermitted collection by amateur and commercial collectors (especially for shark teeth). As a result of the resulting shallow excavations, these sites are among the very few useful exposures of the Bathurst Formation outside Pato's Kop on the eastern side of the Great Fish River (previously mined) and Upper Need's Camp near East London (now unsafe).

It is likely that further outcrop areas of the Bathurst Formation, currently hidden beneath vegetation and soil, have yet to be discovered on the southern coastal plain of the Eastern Cape, although they are probably small. Our understanding of Bathurst palaeontology, sedimentology and stratigraphy has been severely limited by the paucity of fresh bedrock exposures. Most of the available data comes from artificial exposures such as road cuttings and quarries (*e.g.* Birbury, Pato's Kop). Further mining is likely to greatly improve this situation, *provided that appropriate mitigation measures are implemented*. The potential for constructive collaboration between mining, heritage management organisations and professional palaeontologists in this case is high.

Given the unusually high geological and fossil heritage significance of the limestone outcrops near Bathurst, as outlined above, it is essential that adequate specialist palaeontological monitoring and assessment should be carried out, should mining proceed here in future. It is therefore recommended that:

1. *Before* mining commences, a suitably qualified palaeontologist be contracted by the developer to draw up a palaeontological heritage management plan, including appropriate palaeontological monitoring, as part of a more comprehensive Environmental Management Plan. The fossil heritage management plan should be completed *before* mining operations commence.

2. Recommendations for palaeontological monitoring should include a realistic, collaborative fossil sampling and recording programme and protocol that will need to be drawn up by the contracted palaeontologist in conjunction with the developer, on the basis of field assessment and other relevant information. The collection and storage of bulk samples for later processing should be seriously considered.

3. In addition to palaeontological studies, detailed stratigraphic, sedimentological and palaeo-environmental data should also be recorded and incorporated into monitoring reports for SAHRA.

4. Mitigation measures should also involve the identification and protection from mining or other disturbance of representative reference sections / outcrop areas that adequately preserve and illustrate palaeontological and geological key features of the Bathurst Formation in the study area.

The palaeontologist(s) involved will be required to obtain a palaeontological collection permit from SAHRA and to arrange a suitable repository for any fossils collected (*e.g.* the Albany Museum, Grahamstown).

2. INTRODUCTION & BRIEF

The company Laman Group (Pty) Ltd wish to prospect for limestone on four land parcels situated within 15 km ENE of Bathurst near Port Alfred, Eastern Cape: Birbury Farm 206/5 and Farm 206/2 as well as White Bush Farm 101 and Limestone Hill Farm 102/1 (Figs. 1, 2 and 3). An initial desktop geological assessment of the area indicated that limestone is present at these sites, as is also indicated on the 1: 250 000 geology sheet 3326 Grahamstown (Fig. 6). Should sufficient reserves of limestone be identified to prove any of the three prospecting sites as an economically viable resource, then Laman propose establishing quarries at these sites, pending the current application for a Mining Permit from the Department of Mineral Resources. The mined limestone material will be used to supply a factory that will produce cement and cement blocks. The intention is to develop the factory in one of the towns in the area and thereby provide local employment.

Prospecting activities at all sites within the mining study area will mostly comprise the excavation of trial holes with a TLB/Excavator and drilling will only be undertaken if absolutely necessary to further prove reserves. Trial hole activities would include the removal of topsoil and overburden and the taking of a small surface sample of limestone from selected sites for analysis. Only small isolated areas will be directly impacted by the prospecting.

2.1. Fossils and the National Heritage Resources Act, 1999

Fossil heritage is generally protected in South Africa by the National Heritage Resources Act, 1999 (Act 25 of 1999). 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

The extent of the proposed mining development (over 5000 m^2) falls within the requirements for a Heritage Impact Assessment (HIA) as required by Section 38 (Heritage Resources Management) of the South African Heritage Resources Act (Act No. 25 of 1999). Minimum standards for the palaeontological component of heritage impact assessment reports are currently being developed by SAHRA. The latest version of the SAHRA guidelines is dated October 2011.

The present combined field-based and desktop palaeontological study was commissioned on behalf of the developer by Terreco Environmental cc, East London (Contact: Duncan Scott. Tel: 043 721 1502; Fax: 043 721 1535; Cell: 083 974 0553).This report provides an assessment of the observed or inferred palaeontological heritage within the study area, with recommendations for any specialist palaeontological mitigation where this is considered necessary. The report is based on a review of the relevant scientific literature, geological maps a previous palaeontological heritage assessments in the study region (Almond 2008) as well as on a three-day field scoping and museum collection study carried out on 18-20 April, 2012.

According to Section 35 of the National Heritage Resources Act, 1999:

(1) The protection of palaeontological sites and material is the responsibility of a provincial heritage resources authority.

(2) All palaeontological material is the property of the State. The responsible heritage authority must, on behalf of the State, at its discretion ensure that such objects are lodged with a museum or other public institution that has a collection policy acceptable to the heritage resources authority and may in so doing establish such terms and conditions as it sees fit for the conservation of such objects.

(3) Any person who discovers palaeontological objects or material 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 palaeontological site;
(b) destroy, damage, excavate, remove from its original position, collect or own any palaeontological material or object;
(c) trade in, sell for private gain, export or attempt to export from the Republic any category of palaeontological material or object; or
(d) bring onto or use at a palaeontological site any excavation equipment or any equipment which assist in the detection or recovery of palaeontological material or objects.

(5) When the responsible heritage resources authority has reasonable cause to believe that any activity or development which will destroy, damage or alter any 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 a 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 a 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.

(6) The responsible heritage resources authority may, after consultation with the owner of the land on which a palaeontological site is situated, serve a notice on the owner or any other controlling authority, to prevent activities within a specified distance from such site.

GPS LOCALITY DATA

GPS data for all localities specified by number in the text are provided in an appendix at the end of this report. All GPS readings were taken in the field using a hand-held Garmin GPSmap 60CSx instrument. The datum used is WGS 84.

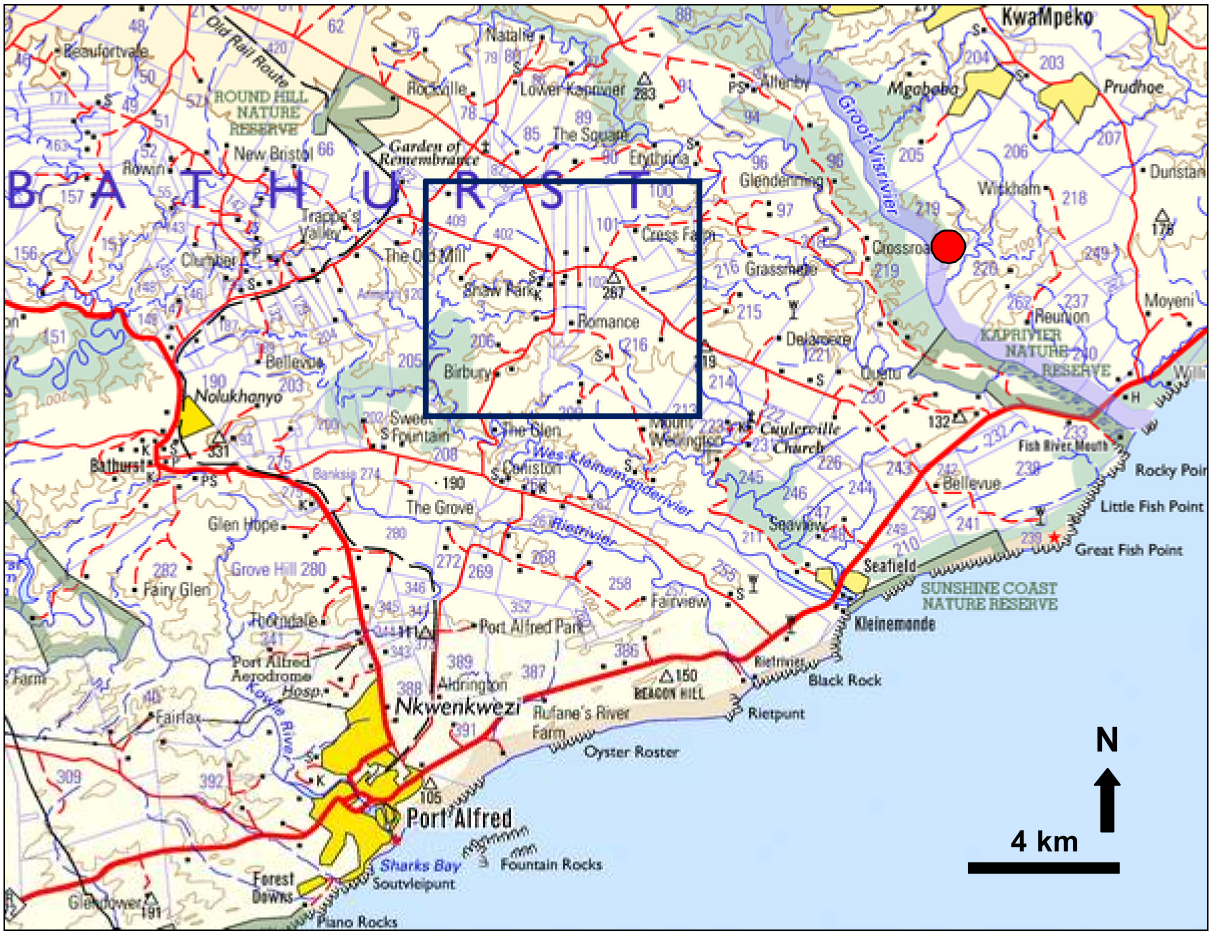


Fig. 1. Extract from 1: 250 000 topographical sheet 3326 Grahamstown (Courtesy of the Chief Directorate: National Geo-spatial Information, Mowbray) showing the approximate location (black rectangle) of broader study region for limestone mining project to the north-east of Bathurst, Eastern Cape. See Figs. 2 and 3 for detailed maps of study areas. The stratotype section for the Bathurst Formation at Pato's Kop 219 on eastern side of the Great Fish River, Peddie District, is indicated on this figure by a red dot.

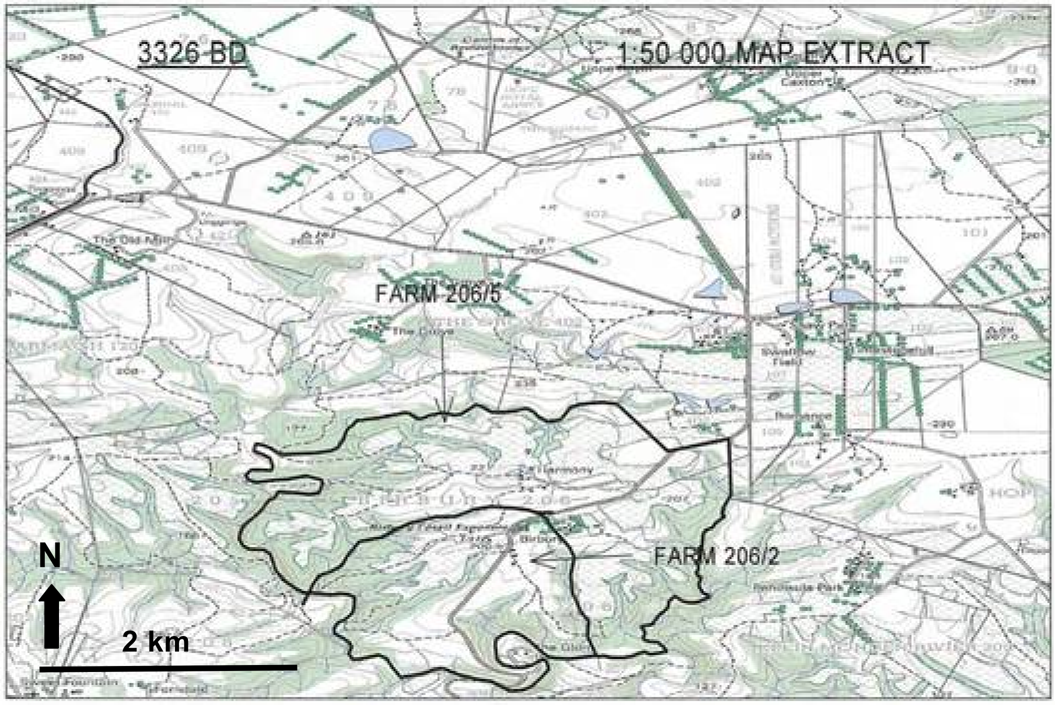


Fig. 2. Extract from 1: 50 000 topographical map 3326BD showing location of study areas on Farms 206/5 and 206/2 Birbury (Image kindly provided by Terreco Environmental cc).

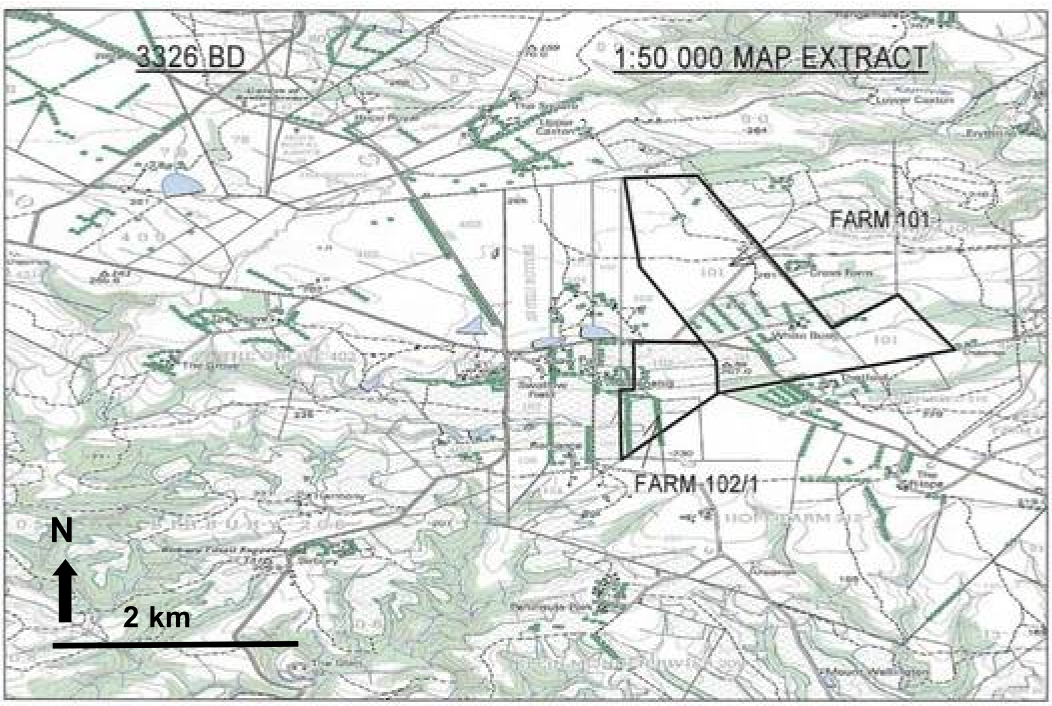


Fig. 3. Extract from 1: 50 000 topographical map 3326BD showing location of study areas on Farms 101 White Bush and 102/1 Limestone Hill to the east of Birbury (Image kindly provided by Terreco Environmental cc).

3. GEOLOGICAL BACKGROUND

The geology of the study area northeast of Bathurst is shown on 1: 250 000 geology sheet 3326 Grahamstown (Council for Geoscience, Pretoria, Johnson & Le Roux 1994) (Fig. 6). The small outcrop areas of limestone targeted by the present mining proposal are assigned to the **Bathurst Formation**. This formation is the lowermost, shallow marine subunit of the **Algoa Group** and is reliably dated on palaeontological grounds as Paleogene or Early Tertiary (Paleocene / Eocene) in age (Fig. 5).

The Caenozoic Algoa Group succession comprises five formations of aeolian, coastal and shallow marine sediments that range in age from the Paleocene / Eocene, roughly 55-50 million years ago, through to the Recent (Fig. 5). The Algoa Group rocks unconformably or paraconformably overlie much older sediments of the Palaeozoic Cape Supergroup and the Mesozoic Uitenhage Group. Predominant sediment types include calcareous sandstones (both marine and aeolian), sandy and shelly clastic limestones, conglomerates and coquinite (*i.e.* gritty to gravelly "shell hash"). Due to their high content of finely comminuted (ground-up) shell material of marine origin, many of these units are very lime-rich. Since deposition, they have frequently been modified to form well-consolidated calcareous rocks that are informally known as "coastal limestones". These include tough, white surface calcretes (pedogenic limestones) that have been formed through the solution and reprecipitation of carbonate minerals by groundwaters and that are typical of semi-arid climates. The complex overlapping distribution of the various Algoa Group formations reflects the pattern of continental uplift and global changes in sea levels during the late Caenozoic Era. Useful summaries of Algoa Group geology have been given by Le Roux (1990a), Maud & Botha (2000) and Roberts *et al.* (2006).

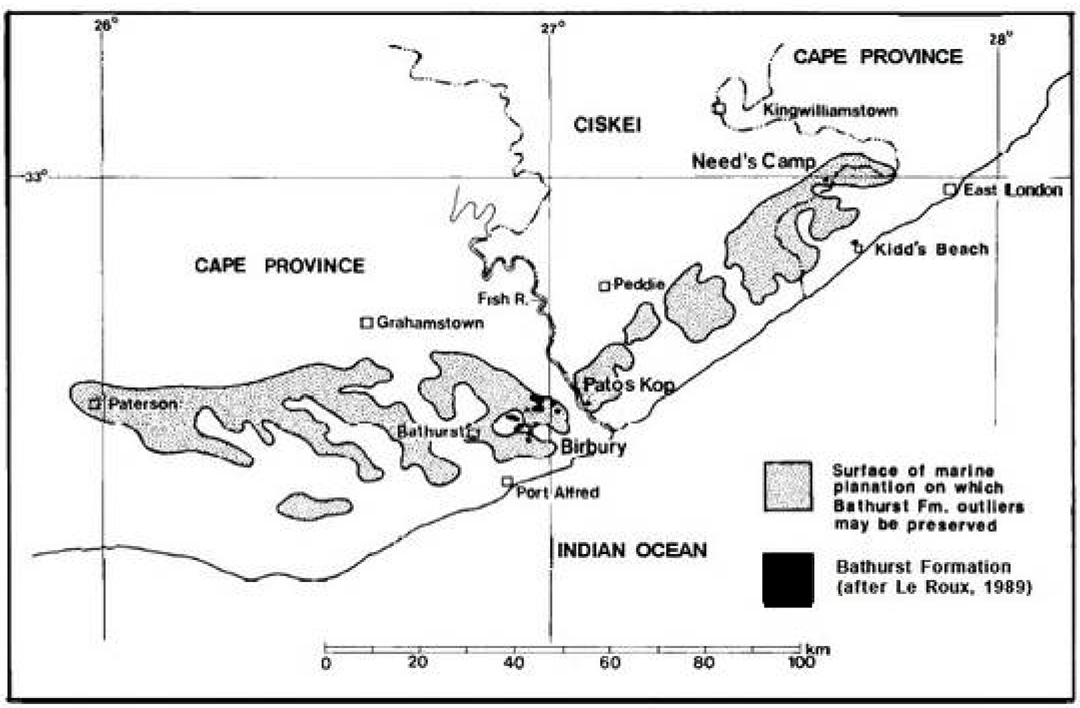


Fig. 4. Distribution of the various small outcrop areas (black dots) of the Bathurst Formation on an elevated wave-cut coastal platform, Eastern Cape (Modified from Maud & Partridge 1990). Note several outcrops in the Birbury area northeast of Bathurst.

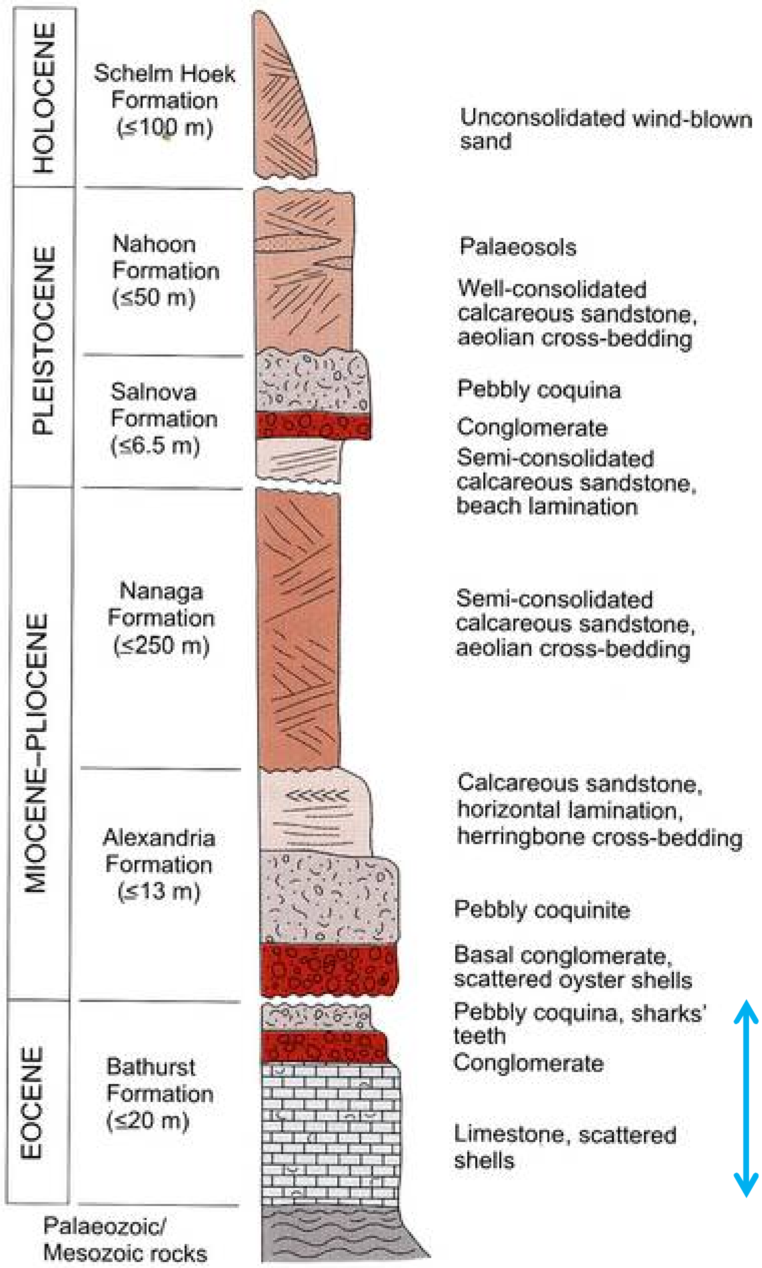


Fig. 5. Schematic stratigraphic column for the Algoa Group along the southeastern Cape coast (Roberts *et al*., 2006), emphasizing the Paleogene / Early Tertiary Bathurst Formation (blue arrow). In the Bathurst area these rocks overlie a wave-cut platform incised into the Witteberg Group.

The Bathurst Formation outcrop area comprises a series of small to very small, thin (usually < 10m) erosional relicts in the Eastern Cape coastal belt between East London and Port Elizabeth (Fig. 4). Until recently these were included within the Alexandria Formation (*cf* Mountain 1946). This latter unit is now re-defined as including comparable shallow marine deposits of later, Miocene – Pliocene age (Fig. 5). It has a much larger outcrop area than the Bathurst Formation *sensu stricto*, including patches of fossiliferous limestones at and north of Bathurst village; no Bathurst Formation rocks are now recognised at Bathurst itself (See map Fig. 6). A list of outcrops of the Bathurst Formation, together with a tabulation of criteria to differentiate between the Bathurst and Alexandria Formations, is given by Johnson and Le Roux (1994) (Fig. 7).

The so-called "Bathurst Limestone" of Schwarz (1908, after Atherstone 1850) was originally considered to be Late Cretaceous in age. More recent palaeontological (and notably micropalaeontological) work has led to the separation of the pre-Miocene occurrences as the Bathurst Formation within the lowermost Algoa Group (*e.g.* Maud *et al*., 1987, Le Roux 1989, 1990a, 1990b, 1993, Maud & Botha 2000, Roberts *et al*., 2006), with a stratotype section designated at Pato's Kop in the Peddie District, Eastern Cape (Maud & Partridge 1990, Almond 2008). The section lies on the eastern side of the Great Fish River in the former Ciskei, some 9km inland and NW of the river mouth and 23km ENE of the village of Bathurst (27° 04' 40" E, 33° 26' 40" S). The outcrop is indicated (Tb) on the 1: 250 000 geology sheet 3326 Grahamstown (See also geology sheet explanations for this area by Mountain 1946, Johnson & Le Roux 1994). The limestone deposit here comprises a small (*c*. 40 ha), isolated outcrop capping the hill Pato's Kop on the Farm Pato's Kop 219 at an elevation of 140m asl (Maud *et al*., 1987). Note that there are at least two other limestone outcrops named Pato's Kop in the Bathurst area in addition to the main occurrence just east of the Great Fish River (Mountain 1946, p. 33).

An informative account of the geology of the Bathurst Formation at the Pato's Kop stratotype locality together with a discussion of its age, micropalaeontology and its considerable significance in the context of the geomorphological evolution of the Eastern Cape coastal plain is given by Maud *et al*. (1987). The marine limestone averages 9-10m thick, with a maximum of about 20m. The outcrop is covered by calcrete and soil, but due to previous mining for limestone here exposure of the limestone succession is unusually good. It largely consists of weakly bedded, brownish yellow, sparsely shelly limestone, with gritty layers, calcareous clay and local limestone nodules at the base. A one metre-thick pebbly coquina (*i.e.* shell-rich bed or lenticle) overlies the marine limestones at Pato's Kop (Maud & Botha 2000). The Tertiary sediments overlie a marine-cut platform incised into steeply dipping beds of the Ripon Formation (Ecca Group) that is equated by these authors with the multiphase (pre-Mid Miocene) African Surface of Partridge & Maud (1987).

The Bathurst Formation limestone outcrops in the present study area around Birbury and Limestone Hill / Spanish Reeds overlie a gently south-sloping coastal platform ("African Surface") that is incised here into siliciclastic, frequently quartzitic, shallow marine sedimentary rocks of the Witteberg Group (Cape Supergroup). Around Birbury these Witteberg Group rocks are assigned to the heterolithic **Weltevrede Formation** (**Dw**) of Middle Devonian age (Figs. 9-10), while in the Limestone Hill / Spanish Reeds area to the east they belong to the Late Devonian **Witpoort Formation** (**Dwi**) (Fig. 11). The smooth-sloping coastal platform is clearly visible in satellite images (Fig. 8). Following Mid to Late Tertiary epeirogenic uplift, the platform has been elevated to around 175 to 250 m amsl in this region and has also been extensively dissected by a network of small rivers including the Kaprivier and Kleinemonderivier. Good sections through the coastal platform showing the underlying steeply-dipping Witteberg quartzites can be seen in steep river banks 2 km south of Birbury (Figs. 9-10).

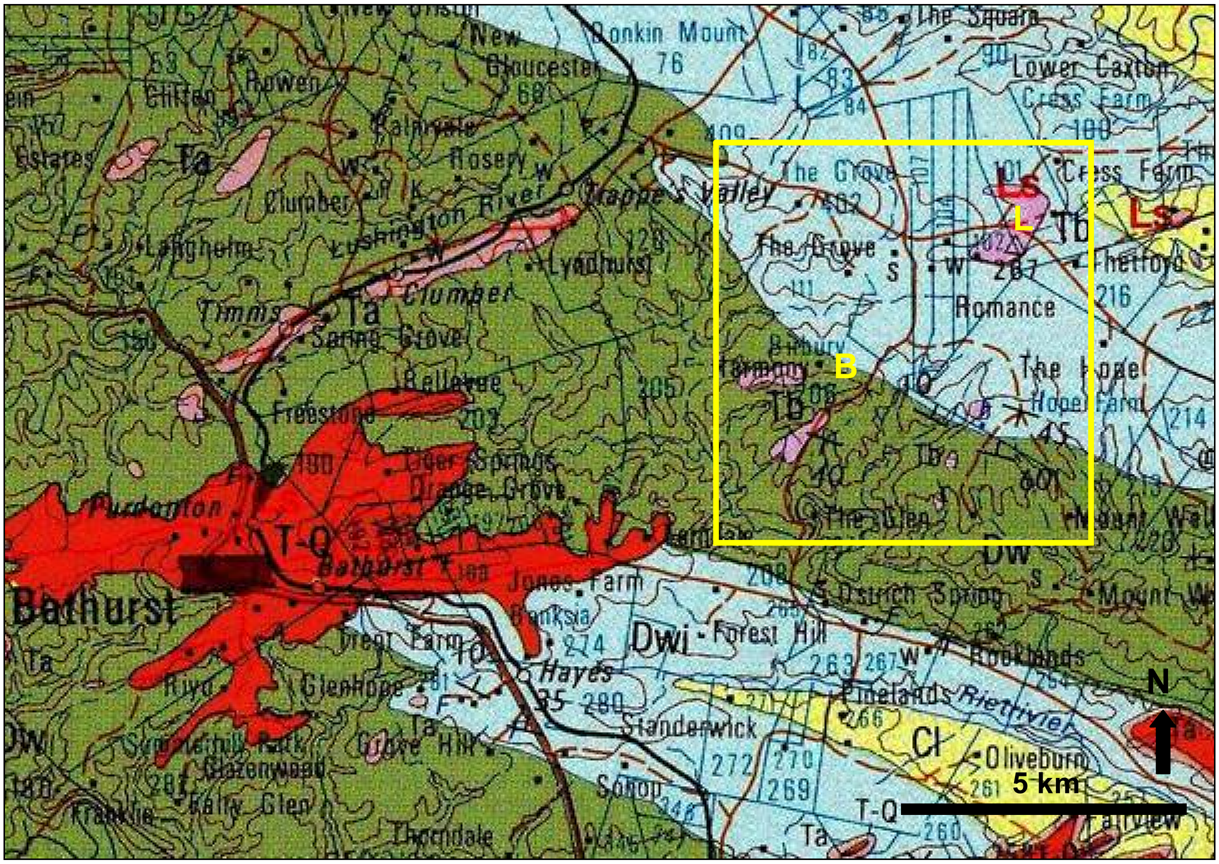


Fig. 6. Extract from 1: 250 000 geological sheet 3326 Grahamstown (Council for Geoscience, Pretoria) showing geology of the study area (yellow rectangle) northeast of Bathurst, Eastern Cape. The small relict patches of Bathurst Formation limestone at Birbury (B) and Limestone Hill / White Bush (L) concerned in the proposed mining project are indicated in pale pink (Tb). Larger areas of younger, Miocene-Pliocene, coastal limestones of the Alexandria Formation (Ta, dark pink) are present at and to the north of Bathurst but are not the target of the present mining proposal. These coastal limestone successions of the Algoa Group overlie an extensive elevated, wave-cut platform incised into much older bedrocks of the Witteberg Group – the Weltevrede Formation (Dw, dark green) and the Witpoort Formation (Dwi, pale blue).

In general, the levels of exposure of the Bathurst Formation are very low indeed, due to extensive cover by soils, vegetation and crops (*e.g.* pineapple plantations). Numerous boulders and blocks of fossiliferous Bathurst limestone and sandstone are scattered across overlying fields and have sometimes been collected and dumped at the field edge by farmers (Fig. 17). Only a few, small, natural bedrock exposures were noted within the Bathurst study area during fieldwork, mainly surface exposures on the crest of Limestone Hill and karstic weathered, calcretised limestones outcrops *c*. 1 km to the northeast (Farm 102, Fig. 18). Artificial exposures include occasional road cuttings (Fig. 16), a low but fairly extensive embankment alongside the dust road at Birbury farmstead (Figs. 12-13), now largely obscured by vegetation, and a small quarry site, also largely overgrown, located some 100m southwest from the same road (Figs. 14-15). Due to its valuable palaeontological heritage, this quarry was proclaimed a National Monument in 1956 (*cf* Maud & Partridge 1990. The Upper Needs Camp site is similarly protected). Under the National Heritage Resources Act, 1999 (Act 25 of 1999) the site is now recognised as a Provincial Heritage Site and may in future be gazetted as a National Heritage Site, pending adequate motivation. The site used to be fenced and was regularly monitored and rehabilitated by the authorities in the past, but the fencing has since fallen into disrepair and the site is becoming overgrown. Due to formal and informal collection over many decades, these two sites near Birbury farmstead have probably yielded the majority of Bathurst Formation fossils in institutional collections and private hands.

Unfortunately, the whereabouts of much of this older fossil material is unclear, and apparently uncontrolled private collection - especially for shark teeth, some of which are apparently sold as curios or jewellery locally – continues apace. The site is also used for school educational purposes (Mr P. Elliot, Dr R. Gess, pers. comm., 2012).

	BATHURST FORMATION	ALEXANDRIA FORMATION	SALNOVA FORMATION
1.	Hard crystalline limestone generally abundant	Hard crystalline limestone scarce	Hard crystalline limestone absent
2.	Silcrete clasts present in some conglomerates	Silcrete clasts absent	Silcrete clasts absent
3.	Generally well consolidated	Consolidated	Consolidated to partially consolidated
4.	Occurs at altitudes above 30 m above M.S.L.	Occurs at altitudes above 30 m above M.S.L.	Occurs at altitudes below 30 m above M.S.L.
5.	Palaeogene in age (micro-fossils)	Neogene in age (macrofossils)	Pleistocene in age (^{14}C dating)
6.	Characterised by species such as *Aturia* sp., *Terabratulina* sp., *Panopea gurgitis*, *Entolium corneum*, *Pecten bathurstensis*, *Aequipecten* sp., as well as an unidentified echinoïd	Characterised by species such as *Glycymeris borgesi*, *Cardium edgari*, *Notocallista schwarzi*, *Pirenella stowi*, *Cypraea zietsmani*, *Tivela baini*, *Melapium patersonae*, *Calyptraea kilburni* and *Ostrea redhousiensis* (all extinct)	Characterised by species of the so-called "Swartkops fauna" such as *Cerithium scabridum rufonodulosum*, *Cantharidus suarezensis fultoni* and *Monilea obscura ponsonoyi*, also extinct species such as *Duplicaria otiosa*, *Pupa daviesi* and *Gastrana fibrosa*
7.	Silicified bone fragments present (Lock 1973, p. 2)	Silicified bone fragments absent	Silicified bone fragments absent
8.	Sharks' teeth (various species) abundant	Sharks' teeth scarce	Sharks' teeth absent
9.	Biogenic structures (trace fossils) scarce	Biogenic structures abundant	Biogenic structures abundant

Fig. 7. Tabulation of coastal limestone successions within the Algoa Group emphasizing their distinguishing features (From Johnson & Le Roux 1994).

The key roadside and quarry exposures near Birbury mainly comprise portions of the upper part of the Bathurst Formation succession with a *c*. 60cm to 1m thick, well-cemented small pebble conglomerate, generally overlain by weathered, vuggy and secondarily calcretised material. The matrix- to clast-supported pebbly conglomerate contains well-sorted, well-rounded, variously elongate, flattened to subspherical clasts of greenish sandstone, siltstone, vein quartz and cherty material (possibly silcrete) and sparse fossil remains (*e.g.* shell fragments, shark teeth) set in a paler, coarse, sandy, calcareous matrix (Figs. 13, 19). The pellet-like clasts are up to 2-3 cm in diameter and are arranged chaotically or form a crude layered fabric. According to Dr Robert Gess (pers. comm., 2012) the conglomerate is underlain at Birbury by a thinly-developed marine mudrock facies containing well-preserved fossil shells (*e.g.* terebratulid brachiopods).

A range of other Bathurst Formation lithologies are mainly encountered as float blocks in fields and hedgerows rather than as bedrock exposures (Figs. 19-20). They include more resistant, often highly indurated blocks of calcareous sandstone, sparsely pebbly sandy limestones, finely-comminuted, pebbly shell hash or *coquinite*, as well as foraminiferal limestone reminiscent of the famous Eocene "Nummulitic Limestones" of North Africa (See Section 4). Calcareous sandstones are commonly speckled with dark green to black grains of the authigenic marine mineral *glauconite* (a clay mineral or mica). This mineral is typically found in continental shelf settings where sedimentation rates are low while oxygen levels are high and organic matter is present (*e.g.* inshore areas experiencing frequent reworking of sandy sediment by waves and currents). Glauconite-rich sandstones are informally termned "greensands" (*e.g.* Cretaceous of Europe). Glauconitic internal casts of microfossils such as ostracods are also reported (Mountain 1946).

Some surface limestone exposures show extensive secondary calcretisation (various massive, pseudolaminated to vuggy or brecciated facies) as well as karstic weathering with the development of dolines or sink holes (Livestock losses due to collapse into hidden sinkholes and underground drainage conduits have been reported in the Birbury area; Mr P. Elliot, pers. comm., 2012). Soils overlying Bathurst limestone vary from dark brown to reddish-brown, iron-enriched *terra rossa* type. Large domical termitaria in the Bathurst limestone outcrop area are pale buff in colour, reflecting the underlying bedrock. They may prove to be a useful indicator of subsurface outcrop during field surveys.

Fig. 8. Google earth© satellite image of the Birbury – Limestone Hill region northeast of Bathurst showing the gently sloping wave-cut coastal platform dissected by numerous small river courses with heavily vegetated banks. The location of the main Birbury fossil site in the Bathurst Formation is arrowed.

Fig. 9. View southwards across the gently sloping coastal platform to the south of Birbury.

Fig. 10. Close-up of previous view showing steeply south-dipping Witteberg quartzites (Weltevrede Formation) underlying the coastal platform here.

Fig. 11. Steeply south-dipping, prominent-weathering quartzites of the Witpoort Formation (Witteberg Group) cropping out on the margins of a relict Bathurst Formation capping, Farm 102 (Loc. 482) (Hammer = 27 cm). In this area small pockets of ferruginised breccia overlie the Witteberg bedrocks.

Fig. 12. North-facing roadside exposure of the upper Bathurst Formation at Birbury (Loc. 475). The pebbly conglomerates here have been extensively exploited for fossil shark teeth by amateur palaeontologists, and the rock face has been cut back into the hillslope.

Fig. 13. Close-up view of the small pebble conglomerate facies towards the top of the Bathurst Formation at the Birbury roadcutting site (Loc. 475) (Hammer = 27 cm).

Fig. 14. The main north-facing quarry exposure of the Bathurst Formation at Birbury, previously designated as a National Monument and now a Provincial Heritage Site (Loc. 477).

Fig. 15. Close-up of north-facing quarry rock face at Birbury illustrated in previous figure showing *c*. 1.5 m of massive to crudely bedded, creamy, slightly ferruginised limestone, pebbly in part. The Bathurst Formation bedrocks are highly weathered and secondarily calcretized above and overlain by dark brown soils (Hammer = 27 cm) (Loc. 477).

Fig. 16. Relatively extensive oblique road cutting through superficially calcretised, localy feruginised Bathurst Formation to the west of Harmony farmstead, Farm Birbury 206/5 (Loc. 484) (Hammer = 27 cm). The succession here includes pebbly conglomate layers or lenticles.

Fig. 17. Blocks of fossiliferous Bathurst limestone and calcareous sandstone cleared from fields, Farm Birbury 206/2 (Loc. 479) (Hammer = 27 cm).

Fig. 18. Karstic surface weathering, with sinkhole, in Bathurst Formation limestones, Farm 102 (Loc. 481). Surface calcretes in this area feature possible hollow root casts (probably post-Eocene in age). Other sinkholes in the area are hidden by small trees.

Fig. 19. Contrasting lithologies from the Bathurst Formation – small pebble conglomerate (LHS) and sandy limestone (RHS). The former rock type is the main source of reworked fossil shark teeth. The specimen on the right contains sparse shark teeth and fragmentary bryozoan remains (arrow). Scale in cm and mm.

Fig. 20. Close up of float block of Bathurst shelly limestone or coquinite showing mass of small shell fragments (shell hash) and small pebbles. The largest pebble here is *c*. 1 cm across.

4. PALAEONTOLOGY OF THE BATHURST FORMATION

A range of micro- and macroscopic fossil remains have been recorded since at least the early twentieth century from the Bathurst Formation at the type area at Pato's Kop, at Birbury and Spanish Reeds northeast of Bathurst, and from various other locailites in the Eastern Cape (*e.g.* Haughton 1925, Mountain 1946 and earlier references therein, Maud *et al*., 1987, Siesser & Miles 1983, Le Roux 1993, Johnson & Le Roux 1994).

Note that the extensive fossil faunal lists given for Tertiary Algoa Group limestones near Bathurst village by Mountain (1946) refer to units now included within the Miocene / Pliocene Alexandria Formation as well as the older Bathurst Formation (Material from the Birbury east of the Kowie River, for example, refers to the latter unit; Le Roux 1989, 1990b). Early collections from these fossiliferous limestones (*e.g.* some of those in the Albany Museum) were often not accurately localised, adding to the ongoing biostratigraphic confusion (*cf* faunal lists in Mountain 1946, p. 36). A useful recent review of Paleogene marine macrofossils of the southeastern Cape Coast has been given by Le Roux (1993, Table 2). This was mainly based on palaeontological collections in the Albany Museum, Grahamstown as well as earlier faunal lists provided by Ruddock (1973) and Lock (1973).

Recorded Paleogene fossil groups from the Bathurst Formation include:

- articulate brachiopods (*e.g. Terebratulina* sp.)
- nautiloid cephalopods (*Aturia* sp., a widespread Eocene genus)
- bivalves (*e.g.* the giant clam *Panopea* or "geoduck" as well as various pectinoids, oysters *etc*)
- gastropods (*e.g. Lyria*)
- echinoids (unidentified, fragmentary remains, but probably including various types of sand dollars)
- bryozoans ("Polyzoa")
- solitary corals
- silicified bone fragments (rare)
- abundant sharks teeth belong to several genera and species (*e.g. Odontaspis, Lamna*; *cf* taxa listed in Mountain 1946, p. 36)
- sparse trace fossils (*e.g.* borings within shells, bivalve borings)
- calcareous microfossils (foraminiferans including discoidal nummulitoids such as *Discocylina* spp., coccoliths, ostracods). Some of these are preserved as glauconitic internal moulds.

The Bathurst limestone at the type section on Pato's Kop is described by Maud *et al*. (1987) as only "slightly shelly", but with a rich microfossil fauna (20 taxa of algae, ibid., Table 1). A pebbly, shelly coquina with sharks teeth occurs at the top of the succession (Maud & Botha 2000, Roberts *et al*. 2006, fig. 6). This is stratigraphically equivalent to the conglomeratic horizon with shark teeth recorded at Birbury near Bathurst. As noted earlier, the pebbly conglomerates at Birbury are apparently underlain by a thinly-developed marine mudrock facies containing well-preserved fossil shells (*e.g.* terebratulid brachiopods; R. Gess, pers. comm., 2012). During the present field study a range of shelly fossils, including locally common terebratuloid brachiopods, solitary corals, bryozoans, various pectinoid bivalves, as well as occasional shark teeth were observed in float blocks of pebbly limestone, sandy limestone and calcareous sandstone in the Birbury area (Figs. 25-26). Several float blocks of buff to brownish limestone packed with large (2-3 mm wide) discoidal foraminiferans with a lenticular cross-section – probably the genus *Discocyclina* - were also recorded (Figs. 22-23; *cf* Mountain 1946). Most limestone exposures examined were superficially weathered and / or calcretised and did not yield fossil remains, however. Clearly fossils are best observed and collected from fresh rock exposures, and these are very scarce in the study region. In this respect, it is expected that any future mining here, if accompanied by appropriate mitigation, should provide an excellent opportunity to obtain a more comprehensive picture of the stratigraphy, sedimentology and palaeontology of the Bathurst Formation.

On the basis of microfossil data a probable middle Early Eocene to earliest Middle Eocene age for the Bathurst Formation was determined by Maud *et al*. (1987), *i.e*. approximately 50 million years ago. Siesser and Dingle (1981), in contrast, prefer an earlier, Late Paleocene age, *c*. 55 Ma, which may be supported by refined global sea level curves illustrated by Pickford (1998) (Fig. 21). In either case, the Bathurst Formation is of particular interest in that surface exposures of such an early Tertiary (Paleogene) age have not been identified anywhere else along the South African coastline, although the richly fossiliferous Salamanga Formation of Mozambique is probably of similar Eocene age (Roberts *et al*. 2006). Somewhat younger, late Middle to Late Eocene, fossiliferous marine deposits are known from Buntfeldschuh and Langental in southern Namibia (Pickford 1998).

Bathurst fossil groups such as nautiloids, corals and nummulitoid foraminiferans suggest a warm water, shallow marine setting. It is of interest that the Early Eocene period was the warmest "greenhouse" climatic interval since the end of the Cretaceous (Prothero 2006 and refs. therein), preceding the establishment of major ice caps on the Antarctic continent by Early Oligocene times. Latitudinal temperature gradients were low, with warm waters extending to temperate latitudes such as the southern African coast. Extremely diverse marine shelly and fish biotas of Early to Middle Eocene age are known from numerous localities in North Africa, North America, Europe and elsewhere. The proliferation of large discoidal benthic foraminiferans is well seen in the nummulitic limestones of Egypt and the Paris Basin, for example. Nautiloid cephalopods experienced a final burst of diversification, with the "tropical" genus *Aturia* recorded from a wide range of latitudes in both hemispheres from Paleocene to Miocene times (*e.g.* Stenzel 1935, Sastry & Mathur 1967, Cockbain 1968, Dzik & Gazdzicki 2001). A high proportion of the warm water – adapted marine biotas was wiped out during a major end – Middle Eocene extinction event at 37-38 Ma that was triggered by dramatic global cooling (Prothero 2006).

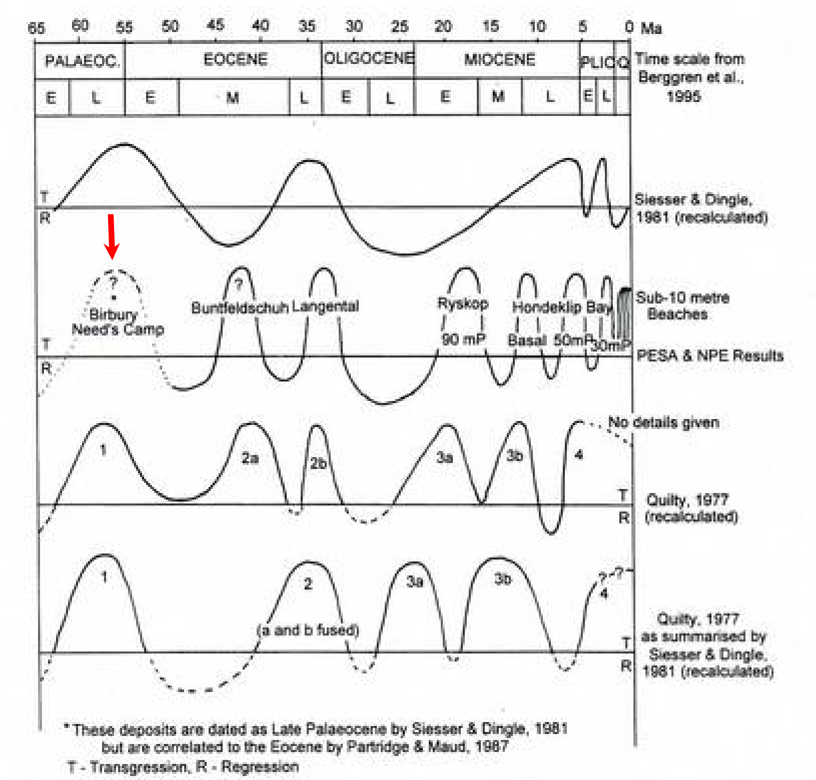


Fig. 21. Comparative global sea-level curves for the Caenozoic based on data from Southern Africa (top 2 curves) and Australia (bottom 2 curves). A suggested correlation of the Bathurst Formation (Birbury, Need's Camp, Pato's Kop *etc*) with the major transgression event or sea level rise (red arrow) in the Late Paleocene / Early Eocene is suggested here (From Pickford 1998).

Fig. 22. Bedding surface view of foraminiferal limestone from the Bathurst Formation showing numerous discoidal tests of large nummulitoid forams, possibly the typical Eocene genus *Discocyclina*. The tests are *c*. 2-3 mm across. The green colour seen here is due to superficial algal growth. See following illustration for a cleaner surface.

Fig. 23. Vertical section through Bathurst foraminiferal limestone showing lenticular cross-sections through preferentially orientated tests of nummulitoid forams (*c*. 2-3 mm across) as well as a small brachiopod or bivalve shell (Loc. 478).

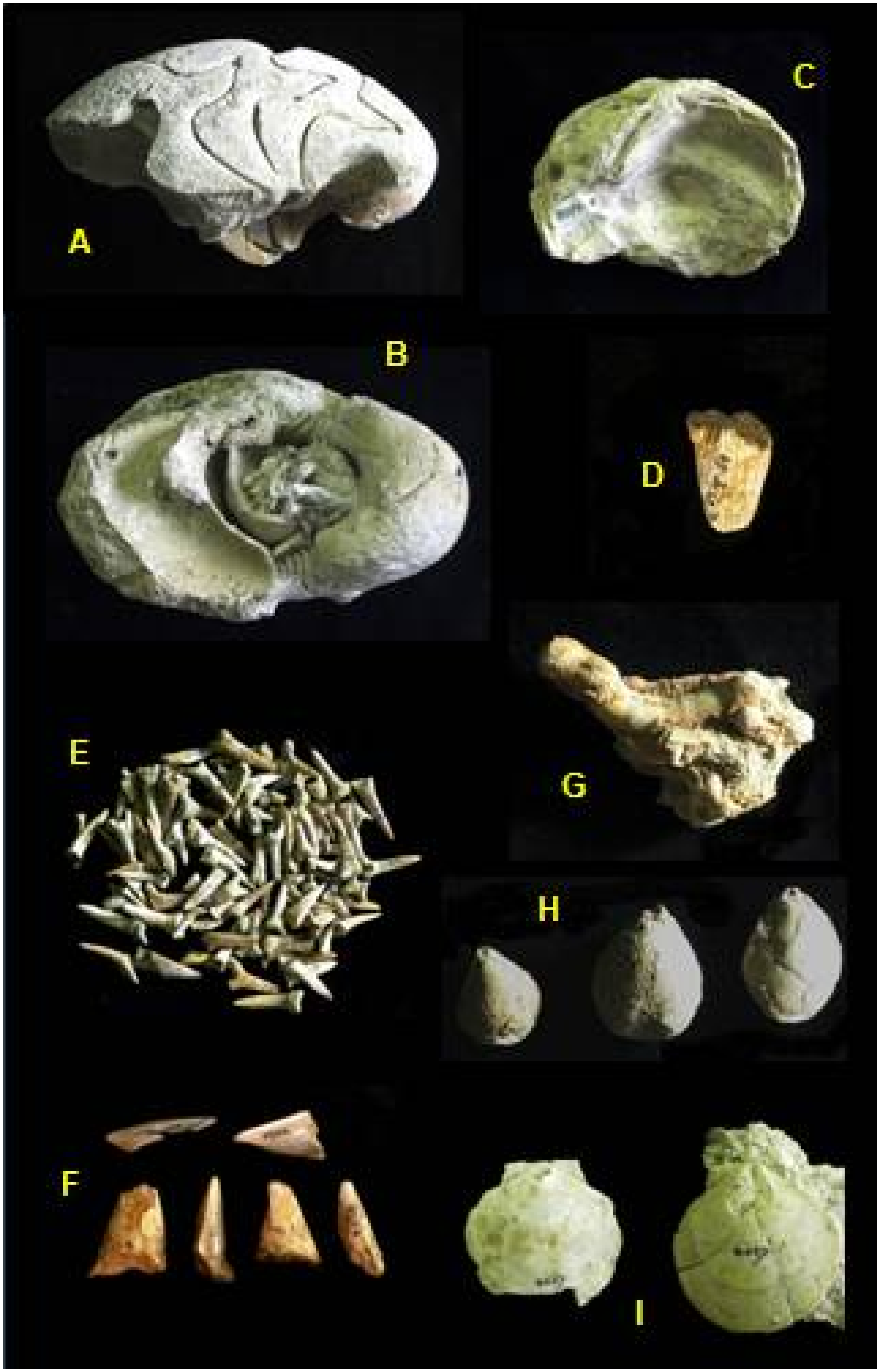
Fig. 24. Close up of well-sorted, fine-grained shell hash or coquinite from the Bathurst Formation. Shelly fragements here are a few mm across at most.

Fig. 25. Float block of Bathurst limestone from Farm 206/2 (Loc. 479) showing moulds of two small solitary corals (arrowed). Corals are approximately 1 cm across.

Fig. 26. Terebratuloid brachiopod (probably *Terebratulina*) from shelly sandy limestone, Farm 206/2 (Loc. 476). The shell is *18* mm long. Some of the dark green material in the matrix here is the mineral glauconite.

Fig. 27 (Following page). Representative fossil specimens from the Bathurst Formation (mainly from the Birbury area) in the collections of the Albany Museum, Grahamstown.

A,B. **Internal moulds of phragmocone of large nautiloid *Aturia*, a typical Eocene cephalopod.**
C. **Thick-shelled valve of an oyster.**
D. **Internal mould of a small solitary coral.**
E,F. **Teeth of various sharks, most of which are collected from the pebbly conglomerate facies.**
G. **Tubiculous fossil, possibly the boring bivalve *Teredo.***
H. **Small, biconvex terebratulid brachiopods (*Terebratulina*).**
I. **Pectinoid bivalves.**


A
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5. PALAEONTOLOGICAL HERITAGE SIGNIFICANCE

The shallow marine successions within the Caenozoic Algoa Group - *i.e.* the Bathurst, Alexandria and Salnova Formations - are often richly fossiliferous and their overall palaeontological sensitivity is rated as **very high** (Almond *et al*., 2008). However, in some areas their fossil content may be compromised near-surface by secondary calcretization and weathering (*cf* Almond 2010 for the Alexandria Formation near Port Elizabeth).

The Bathurst Formation outcrops in the study area northeast of Bathurst are of particular geological, palaeontological and heritage conservation significance because:

- they represent a large fraction of the very small total outcrop area / volume of these Early Tertiary marine sediments that have been mapped in South Africa;
- they form part of the Type Area for the Bathurst Formation, while the Birbury site has been proposed as a Reference Stratotype for this succession (Maud & Partridge 1990);
- the Paleocene / Eocene age of the marine sediments and fossils occurring here belongs to a time interval that is otherwise very poorly represented in the RSA fossil record on land due to widespread later uplift, regression and erosion along the continental margin (Roberts *et al*., 2006);
- these outcrops play a significant role in the geomorphological interpretation (landscape evolution) of the Eastern Cape coastal region as well as the palaeontological dating and palaeoenvironmental analysis of the Bathurst Formation;
- comparatively good exposures of the Bathurst Formation succession are present at Birbury due to excavations made by previous fossil collectors here;
- there is a long history of fossil collection from the Bathurst Limestone exposures at Birbury and nearby Spanish Farm. These sites are therefore of palaeontological-historical as well as of scientific interest, as reflected in the designation of one of the Birbury localities as a Provincial Heritage Site.

It should also be noted that:

- Part of the Birbury fossil area (Portion 3, being part of Portion 2) is specially protected as a Provincial Heritage Site and cannot be mined or otherwise damaged or disturbed pending consultation with SAHRA (South African Heritage Resources Agency);
- Illegal collection of fossils (especially shark teeth) by amateurs, in part for commercial purposes, has been taking place here for many years;
- It is quite likely that further (albeit small) outcrop areas of the Bathurst Formation, currently hidden beneath vegetation and soil, have yet to be discovered on the southern coastal plain of the Eastern Cape (Maud & Partridge 1990);
- Our understanding of Bathurst palaeontology, sedimentology and stratigraphy has been severely limited by the paucity of fresh bedrock exposures. Most of the available data comes from artificial exposures such as road cuttings and quarries (*e.g.* Birbury, Pato's Kop). Further mining is likely to greatly improve this situation, *provided that appropriate mitigation measures are implemented*.

The potential for constructive collaboration between mining, heritage management organisations and professional palaeontologists in this case is therefore high.

Only small isolated areas will be directly impacted during the proposed prospecting activities within the broader mining area and significant impacts on local fossil heritage are not anticipated during this phase.

6. RECOMMENDED PALAEONTOLOGICAL MITIGATION MEASURES

The proposed prospecting activities are on a small scale and will not have a significant impact on local fossil heritage resources. No further specialist studies or specialist monitoring are recommended for this phase. However, given the unusually high geological and palaeontological heritage significance of the Bathurst Formation outcrops near Bathurst, as outlined above, it is essential that adequate specialist palaeontological monitoring and assessment should be carried out should mining proceed here in future.

It is therefore recommended that:

1. *Before* mining commences, a suitably qualified palaeontologist be contracted by the developer to draw up a palaeontological heritage management plan, including appropriate palaeontological monitoring, as part of a more comprehensive Environmental Management Plan. The fossil heritage management plan should be completed *before* mining operations commence.

2. Recommendations for palaeontological monitoring should include a realistic, collaborative fossil sampling and recording programme and protocol that will need to be drawn up by the contracted palaeontologist in conjunction with the developer, on the basis of field assessment and other relevant information. The collection and storage of bulk samples for later processing should be seriously considered (as carried by for the Waterloo bypass fossil site near Grahamstown, for example; Dr R. Gess, pers. comm.).

3. In addition to palaeontological studies, detailed stratigraphic, sedimentological and palaeo-environmental data should also be recorded and incorporated into monitoring reports for SAHRA.

4. Mitigation measures should also involve the identification and protection from mining or other disturbance of representative reference sections / outcrop areas that adequately preserve and illustrate palaeontological and geological key features of the Bathurst Formation in the study area.

The palaeontologist(s) involved will be required to obtain a palaeontological collection permit from SAHRA and to arrange a suitable repository for any fossils collected (*e.g.* the Albany Museum, Grahamstown).

It is recommended that the developer consults the following locally-based palaeontologists:

Dr Robert Gess, Research Associate at the Albany Museum, Grahamstown (Contact details: Box 40, Bathurst 6166. email: robg@imaginet.co.za. tel: 046-625 0009. cell: 082-759 5848)

Dr Billy de Klerk (Curator: Earth Science, Albany Museum, Somerset Street, Grahamstown 6139. email: b.deklerk@ru.ac.za. tel: 0845826072. cell: 084-582 6072).

7. ACKNOWLEDGEMENTS

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APPENDIX: GPS LOCALITY DATA FOR SITES LISTED IN TEXT

All GPS readings were taken in the field using a hand-held Garmin GPSmap 60CSx instrument. The datum used is WGS 84.

LOCALITY NUMBER	GPS READING	COMMENTS
474	S33 28 43.4 E26 55 53.3 193 m	Bathurst Fm, roadcutting near Birbury farmstead (main amateur fossil collecting locality), Birbury Farm 206/2
475	S33 28 43.2 E26 55 54.0 192 m	Ditto, eastern extension, Birbury Farm 206/2
476	S33 28 45.5 E26 55 49.5 201 m	Bathurst Fm, eastern, more overgrown section of Birbury quarry area (Provincial Heritage Site), Birbury Farm 206/2
477	S33 28 45.6 E26 55 48.5 196 m	Western, better exposed section of Birbury quarry area (Provincial Heritage Site) Birbury Farm 206/2,
478	S33 28 49.3 E26 55 37.2 187 m	Float blocks of fossiliferous Bathurst limestone in fields, Birbury Farm 206/2
479	S33 28 49.0 E26 55 37.9 185 m	Fossiliferous Bathurst Fm float blocks, including boulders cleared to edge of field, Birbury Farm 206/2
480	S33 26 58.2 E26 58 20.8 247 m	Bathurst limestone road outcrop, Farm White Bush
481	S33 26 51.1 E26 57 56.7 256 m	Karstic weathering in calcretised Bathurst limestone, Farm White Hill
482	S33 26 43.5 E26 57 49.9 250 m	Steeply dipping Witteberg quartzites, Farm 102
483	S33 28 26.9 E26 55 26.7 175 m	Road exposure of Bathurst Formation, Birbury Farm 206/5
484	S33 28 30.6 E26 55 19.3 204 m	Road exposure of Bathurst Formation, Birbury Farm 206/5
485	S33 28 33.1 E26 55 14.3 192 m	Kaolinitized bedrock in erosion gully, Birbury Farm 205/5

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, Limpopo, Free State and Gauteng 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 mining 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.

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***Natura Viva* cc**