N2 WILD COAST TOLL HIGHWAY PALAEONTOLOGICAL IMPACT ASSESSMENT REPORT

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In addition he has extensive experience in EIA work. This includes extensive consultancy and mitigation at Waterloo Farm near Grahamstown as well as numerous surveys including surveys for the Thyspunt Melkhout transmission lines, Eastern Cape Fibreco network, Albany Regional Water Scheme, Amathole District borrow pits, Chris Hani District borrowpits, Amanzi estates, Coega Chlor alkali Plant, Thornhill Housing project, Sarah Baartman Park, Kwanobuhle Extension, Nieu Betheda Water Plant works, Fort Brown Agrivillage, Waainek Windfarm, Wesley Windfarm, upgrade of R61 section 6, and National route 10 section 3

Palaeontological Papers in Peer-reviewed Journals include:

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Coates, M.I. and **Gess, R.W.** (2007). A new reconstruction of *Onychoselache traquairi*, comments on early chondrichthyan pectoral girdles, and hybodontiform phylogeny, *Palaeontology* **50**, **6**: 1421-1446.

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Declaration of Consultants independence

Dr R.W. Gess is an independent consultant to CCA Environmental (Pty) Ltd and has no business, financial, personal or other interest in the activity, application or appeal in respect of which he was appointed other than fair renumeration for work performed in connection with the activity, application or appeal. There are no circumstances whatsoever that compromise the objectivity of this specialist performing such work.

Executive summary

The proposed N2 Wild Coast Toll Highway extends over a total distance of approximately 560 km between the N2 Gonubie Interchange (near East London in the Eastern Cape) and the N2 Isipingo Interchange (south of Durban in KwaZulu-Natal).

The proposed route alignment would connect major economic centres, including East London, Butterworth, Mthatha, Lusikisiki, Port Edward, Port Shepstone and Durban, and would be approximately 75 km shorter than the existing N2 route between East London and Durban via Mount Frere, Kokstad and Harding. Approximately 80 % of the proposed route would utilise existing road sections.

A short preliminary desktop study for the project was completed by Dr Billy de Klerk, in April 2001.

In 2012 SAHRA requested a revised updated report complete with mitigatory recommendations.

CCA Environmental (Pty) contracted Rob Gess on 17th March 2011 to conduct a phase one Palaeontological Impact Assessment. The tight time constraints on this project only permitted a 5 day drive through examination of sensitive sections of the route with limited sampling, together with a basic desktop assessment.

The bedrock underlying this route is extremely diverse. It includes ancient basement comprising 1000 million year old granites and metamorpichic rocks of the Natal Metamorphic Suite; Ordivician to Devonian quartzites of the Natal Group and Msikaba Formation; Late Carboniferous to mid Triassic rocks of the Karoo Supergroup (including the Dwyka, Ecca and Beaufort Groups); dolerites associated with the Jurassic eruptions of the Stormsberg Group; Cretaceous marine sediments of the Mzamba Formation and Quaternary deposits of the Berea Formations.

Of these the rocks of the Devonian Msikaba Formation, sedimentary rocks of the Karroo Supergroup and Cretaceous rocks of the Mzamba Formation are all considered to be potentially palaeontologically sensitive.

Apparently least sensitive of these is the Msikaba Formation of southern Kwazulu-Natal and Pondoland, though this impression may result from the poor outcrop of rock in these areas and the possibility of fossiliferous shale layers being uncovered during roadworks cannot be excluded.

The palaeontology of the former Cis- and Transkei regions is extremely understudied for historic reasons and no palaeontological material had been recorded along the route prior to this study.

During the survey significant palaeontological material was located in existing roadcuttings along the route. These included the burrows and skulls of Triassic therapsids (members of the group ancestral to mammals) in mudstones of the Katberg Formation (Tarkastad Subgroup, Beaufort Group, Karoo Supergroup), both west of Mthatha and in the greater Mbashe River valley. Fossil skulls were also located in Balfour Formation (Adelaide Subgroup, Beaufort Group, Karoo Supergroup) mudstones underlying the

Katberg Formation in the Mbashe River valley and east of Mthatha.

Adelaide Subgroup (probably Balfour Formation) mudstones north of East London were also found to contain fossil vertebrate remains.

Plant fossil containing Ecca Group (Karoo Supergroup) mudstones are extensively exposed along the route approaching Tombo but these are apparently largely not to be impacted by the development.

It is not known whether or not fossiliferous Cretaceous Mzamba Formation strata that extend for 17 km north of the Mtamvuma River in southern Kwazulu-Natal will be impacted, as current outcrops are generally along the beach.

It was therefore recommended that:

1) A full phase two survey should be carried out on the sections between East London and Mooiplaas and the section through the Mbashe river valley prior to the commencement of road works, including identification and recovery of all significant paleontological material.

2) Phase two sampling is conducted at an important Ecca Group locality noted prior to commencement of road works.

3) Widening of the road through the Mbashe River valley is monitored by a qualified palaeontologist.

4) All new roadcuttings between East London and Hibberdene (in Kwazulu-Natal) are inspected after they have been cut but prior to trimming and rehabilitation to record and sample newly exposed palaeontological material. It is likely that this will need to be done at intervals through the project as the widening of different sections nears completion.

5) The ECO should monitor all excavations and instruct all personnel to be on the lookout for palaeontological material when working in areas identified to be of likely palaeontological sensitivity.

Contents:

List of Figures

bottom: weathered fossil bone exposed near base of above roadcutting.

Figure 18: *top*: Uppermost Ecca strata at point 2 (fig. 3), *middle left*: mudcracks superimposed on surface patterned by shallow water flowing over an algally bound surface, *middle right*: mud cracks superimposed on surface showing vertical invertebrate burrow and surface feeding traces, *bottom*: slender sphenophyte stem.

Figure 19: *top*: Thick section of Ecca Group lacustrine sediments exposed at point 4 (fig. 4) bottom: plant fragments observed at point 4 (fig. 3).

Figure 20: Black shale with silvery plant fragment fossils near the base of the Ecca Group alongside the Mngazi River (point 5, fig. 3).

Figure 21: Ecca Group strata exposed in roadcuttings north of the Mntafufu River.

Figure 22: Weathered Dwyka Group diamictite displaying coarse glacial pebbles set in a fine grained glacial mud matrix. Exposed in a roadcutting north of the Mntafufu River.

Figure 23: Landscape of deeply weathered Dwyka Group diamictites east of Lusikisiki.

Figure 24: Landscape of deeply weathered Msikaba Formation arenites 18 km east of Lusikisiki.

Background

The proposed N2 Wild Coast Toll Highway extends over a total distance of approximately 560 km between the N2 Gonubie Interchange (near East London in the Eastern Cape) and the N2 Isipingo Interchange (south of Durban in KwaZulu-Natal).

The key components of the proposed project include:
• Upgrading and widening of existing road sections (of the N2 and R61) included within the proposed project (approximately 470 km);
• New road construction within two “greenfields” sections (approximately 90 km);
• Construction of nine new bridges;
• Upgrading and/or construction of new road interchanges and intersections; and
• Construction of associated structures (such as toll plazas, pedestrian overpasses and animal underpasses).

The proposed route alignment would connect major economic centres, including East London, Butterworth, Mthatha, Lusikisiki, Port Edward, Port Shepstone and Durban, and would be approximately 75 km shorter than the existing N2 route between East London and Durban via Mount Frere, Kokstad and Harding. Approximately 80 % of the proposed route would utilise existing road sections, as follows:

• Existing N2 between the Gonubie Interchange and Mthatha;
• Existing R61 between Mthatha and Ndwalane;
• Existing R61 between Ntafufu River and Lusikisiki; and
• Existing R61 and N2 between the Mthamvuna River and the Isipingo Interchange.

New road construction is proposed between Ndwalane and Ntafufu, and between Lusikisiki and the Mthamvuna River (greenfields sections). Intersections (possible future interchanges) are proposed at all locations where the proposed toll highway would cross existing district and access roads. Within the new road sections, major bridge crossings are required at eight deeply incised gorges, namely the Mzimvubu, Msikaba, Kwadlambu, Mthentu, Mnyameni, Kulumbe, Mpahlane and Mzamba rivers.

A short preliminary desktop study for the project was completed by Dr Billy de Klerk, in April 2001.

In 2012 SAHRA requested a revised updated report complete with mitigatory recommendations.

CCA Environmental (Pty) contracted Rob Gess on 17th March 2011 to conduct a phase one Palaeontological Impact Assessment. The tight time constraints on this project only permitted a 5 day drive through examination of sensitive sections of the route with limited sampling, together with a basic desktop assessment.

In areas where there is not currently good outcrop of strata, such as in Pondoland, its likelihood of being palaeontologically sensitive is extrapolated from what is known elsewhere of those strata.

Areas where mitigations are needed and where monitoring may be required during earthmoving operations were identified.

Geology

The bedrock underlying this route is extremely diverse. It includes ancient basement comprising 1000 million year old granites and metamorpichic rocks of the Natal Metamorphic Suite; Ordivician to Devonian quartzites of the Natal Group and Msikaba Formation; Late Carboniferous to mid Triassic rocks of the Karoo Supergroup (including the Dwyka, Ecca and Beaufort Groups); dolerites associated with the Jurassic eruptions of the Stormsberg Group; Cretaceous marine sediments of the Mzamba Formation and Quaternary deposits of the Berea Formations. The geological history is discussed below chronologically from oldest to youngest.

Natal Metamorphic Suite gneises and schists were transformed by compression during the assembly of the Supercontinent Rodinia from the continents Nena, Ur and Atlantica. They, together with other rocks of the Namaqualand Natal Metamorphic belt, originated as sediments deposited in the seaway between Ur and Nena. Closure of this Sea and compression of its floor during the prolonged collision of Ur and Nena resulted in the formation of enormous mountains the roots of which were intruded with granite forming magmas due to melting of subducted crust. Metamorphic rocks of this complex encountered along the route **between Port Edward and Isipingo** include the Mapumulo, Leasure Bay, Mkomazi, Munster, Turtle Bay, Mucklebraes, and Sezela Formations which are variously intruded by the Margate Granite, and Mzumbe Granitoid (Figure 1).

Quartzites of the **Natal Group** were formed following early rifting of the supercontinent Gondwana during the Ordivician. As a rift valley began to form, rivers diverted into it and deposited the coarse sands which produced the Natal Group. These rocks were once believed to all be the eastern equivalent of the Peninsular Formation of the Ordivician Table Mountain Group (Cape Supergroup), although this is now only thought to be true of those (or some of those) sediments of this group north of Hibberdene. Rocks of this age have a patchy outcrop **between Hibberdene and Isipingo** (Figure 1). Recent work (Marshall and Von Brunn, 1999) excludes sediments south of Hibberdene, including those in Pondoland and southern Natal (southwards from Hibberdene) from the Natal Group, placing them in the **Msikaba Formation**, which they interpret as being of shallow marine late Devonian age – roughly equivalent to the Witteberg Group (Cape Supergroup). The presence of large lycopod stems in a quarry at Port St Johns (Anderson and Anderson, 1985) are consistent with this interpretation. The route extensively traverses the Msikaba Formation **between Lusikisiki and Hibberdene** (Figures 1, 2).

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. Lowermost Karoo strata of the Dwyka and lower Ecca Groups were affected by folding in the vicinity of the Cape Fold Belt. Deposition was shifted from the northern edge of the Agulhas Sea to the increasingly freshwater, inland Karoo Basin. 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 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 **Dwyka Group** (particularly here in the south of the basin) consists almost exclusively of diamictite known as the Dwyka tillite. This is a distinctive rock type which, when freshly exposed, consists of a hard fine-grained blueish-black matrix in which abundant roughly shaped clasts are embedded. These vary greatly in both lithology and size. During the formation of the Dwyka, beginning in the Late Carboniferous, southern Africa had drifted over the south pole, whilst simultaneously, the world was experiencing a cold episode. Glaciers flowing into the flooded Karoo basin broke up, melted and discharged a mixture of finely ground rock flour and rough chunks of rock. These formed the matrix and clasts of the Dwyka tillite. The Dwyka Group outcrops from **north of the Mtafufu River to about half way between Lusikisiki and Port Shepstone** (Figure 2).

Early in the Permian period the ice sheets retreated and sediment carried into the Ecca Lake by rivers draining the recently upthrust Cape Mountains formed the deposits of the **Ecca Group** (Karoo Supergroup). These rivers formed deltas where they flowed into the Ecca Lake. Proximally the deltas tended to be sandy. Mud accumulating on the more distal front of the deltas periodically slumped and cascaded down into deep water, spreading out and depositing large layered fan shaped turbidite deposits. Outcrop of these sediments is found along the route from about **25 kilometers east of Mthatha till near Lusikisiki** (Figures 2,3).

As the Ecca Lake silted up a subaerial (exposed) shoreline began to develop, initially in the south east of the basin. The lake steadily shrank towards the centre of the basin, leaving behind flat silty plains across which long rivers meandered from the Cape Mountains towards the much reduced lake. Sands were deposited along the river channels whereas periodic flooding deposited muds on the broad flood plains. These in time came to form the interbedded sandstones and mudstones of the Koonap, Middleton and Balfour formations of the Adelaide Subgroup, (**Beaufort Group,** Karoo Supergroup) and the Katberg and Burgersdorp Formations of the Tarkastad Subgroup (**Beaufort Group,** Karoo Supergroup), within the Eastern Cape. Of these only the Balfour and Katberg Formations are represented along the route. Balfour Formation sediments underly the route between **1 kilometre west of Mthatha to 25 kilometres east of Mthatha** (Figure 3) and from **East London to midway between Butterworth/Gcuwa and Dutywa** with the exeption of 6 kilometres starting 17 kilometres north of east London (Figure 4).

In the Free State and Kwazulu Natal the sequence differs from that in the Eastern Cape due to far longer persistence of the Ecca Lake than in the Eastern Cape. The **Volksrust Formation** (**Ecca Group**, Karoo Supergroup), a lacustrine shaly unit initially co-eval with the Fort Brown Formation continued to accumulate throughout deposition of the lower two thirds of the Adelaide Subgroup, Beaufort Group, (including the Koonap and Middleton formations which are locally not expressed). The **Volksrust Formation** is directly overlain by the Normandien Formation, which is the local equivalent of the Balfour Formation (Adelaide Subgroup).

The beginning of the Triassic Period in South Africa was marked by a change in sedimentation, leading to the distinct sandstone dominated lithology of the **Katberg Formation** (lower **Tarkastad Subgroup**, Karoo Supergroup). Extensive sandy deposits resulted from multi channelled braided river systems that replaced the meandering rivers of the underlying Adelaide Subgroup. This change may have resulted from increased erosion of the landscape due to widespread extinction of plant groups during the end-Permian mass extinction. The Katberg Formation underlies the route for **6 kilometres starting 17 kilometres north east of East London** and from **midway between Butterworth/Gcuwa and Dutywa to 1 kilometer west of Mthatha** (Figure 4).

A return to a meandering river system, possibly as a result of a recovery of vegetation cover is reflected in the mudstone dominated strata of the Burgersdorp Formation (Tarkastad Subgroup).

The eruption of Drakensberg Group (Karoo Supergroup) lavas during the Jurassic led to implacement of **dolerite** dykes and sills as intrusions within mudstones of the Ecca and Beaufort Groups (Karoo Supergroup). These outcrop patchily between **East London and Lusikisiki** (Figures 1-3).

For historical reasons the Transkei region has not been extensively surveyed from a palaeontological point of view and remained until recently a data vacuum. Work by Bordy (Bordy 2010) revealed vertebrate palaeontological potential near Tsomo in the former Transkei. Subsequent borrow pit surveys conducted by this author have revealed plant fossils throughout the former Transkei. Although no fossils had previously been recorded along this route, abundant vertebrate skeletal elements and trace fossils were revealed during the site survey, considerably adding to the sparse knowledge of vertebrate fossils from this understudied region

During the final breakup of Gondwana during the Cretaceous a number of small coastal basins were created by stretching and tearing of the crust. These include a small basin in southern Natal in which the **Mzamba Formation** was deposited in a shallow marine setting between about 85 and 70 million years ago. Lower beds consist of pebbly conglomerates which are overlain by alternating shelly limestone and sand calcareous claystone. The Mzamba Formation occurs for **17 kilometres north of the Mtamvuma River** (Figure 1, Km).

Quaternary cover along the Kwazulu-Natal coast is dominated by reddish decalcified sands of the **Berea Formation** accumulated as dune deposits of Pleistocene age. These contain stone tools on the basis of which they have been dated to the last two million years. Quaternary cover occurs **sporadically between Port Edward and Isipingo**.

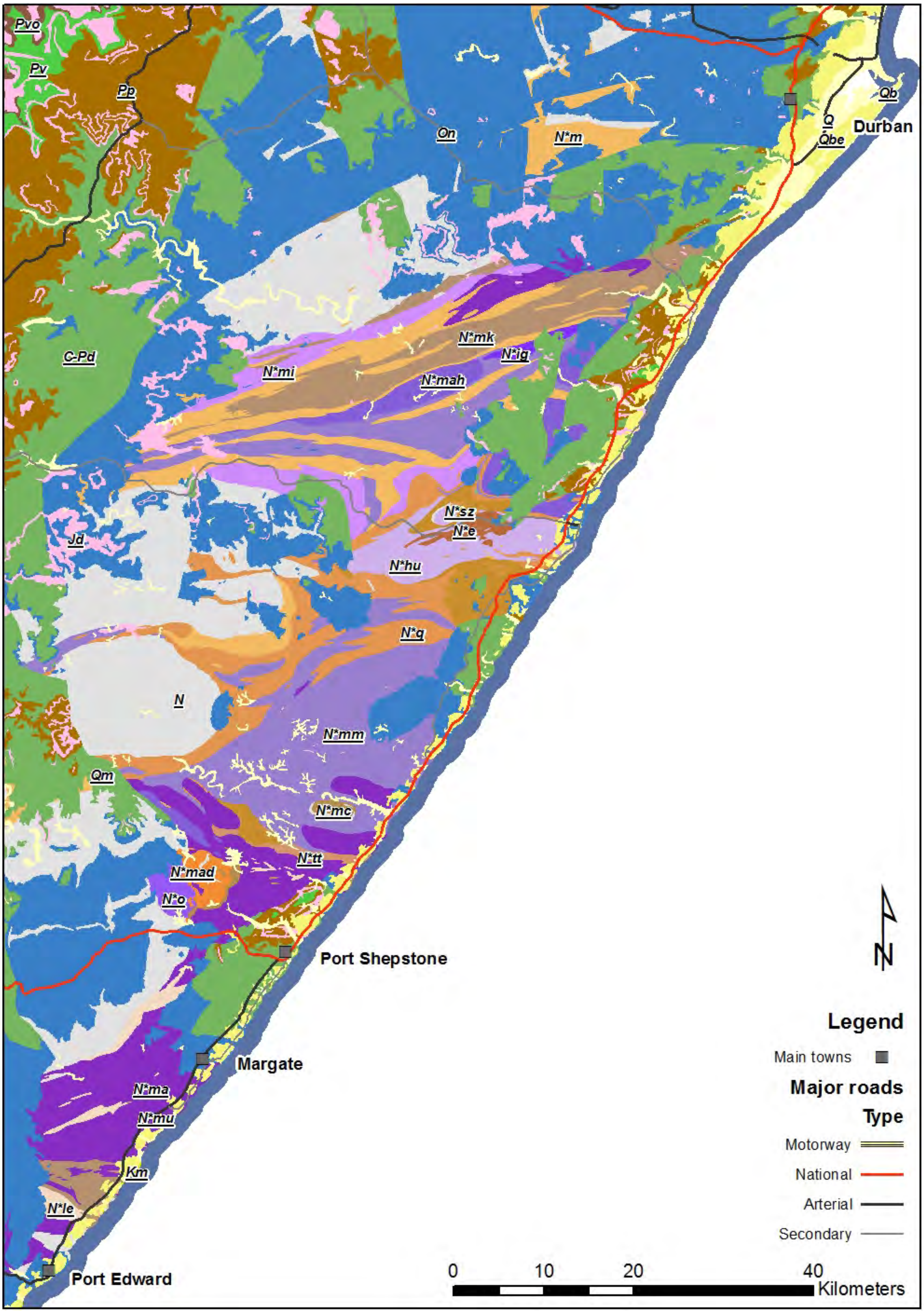


Figure 1: Section of route between Port Edward and Isipingo showing geology (for key see figure 5).

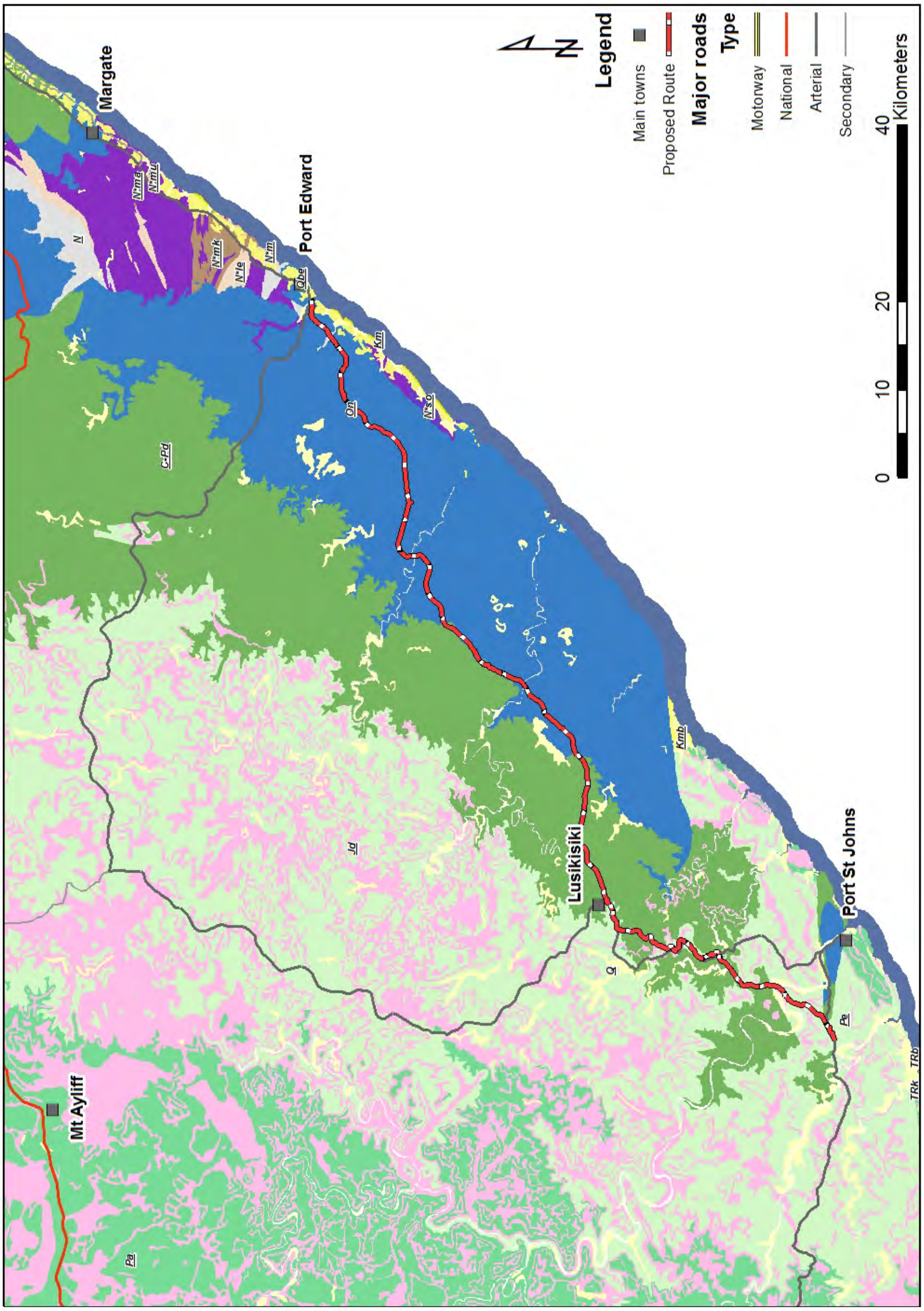


Figure 2: Section of route between Tombo and Port Edward showing geology (for key see figure 5).

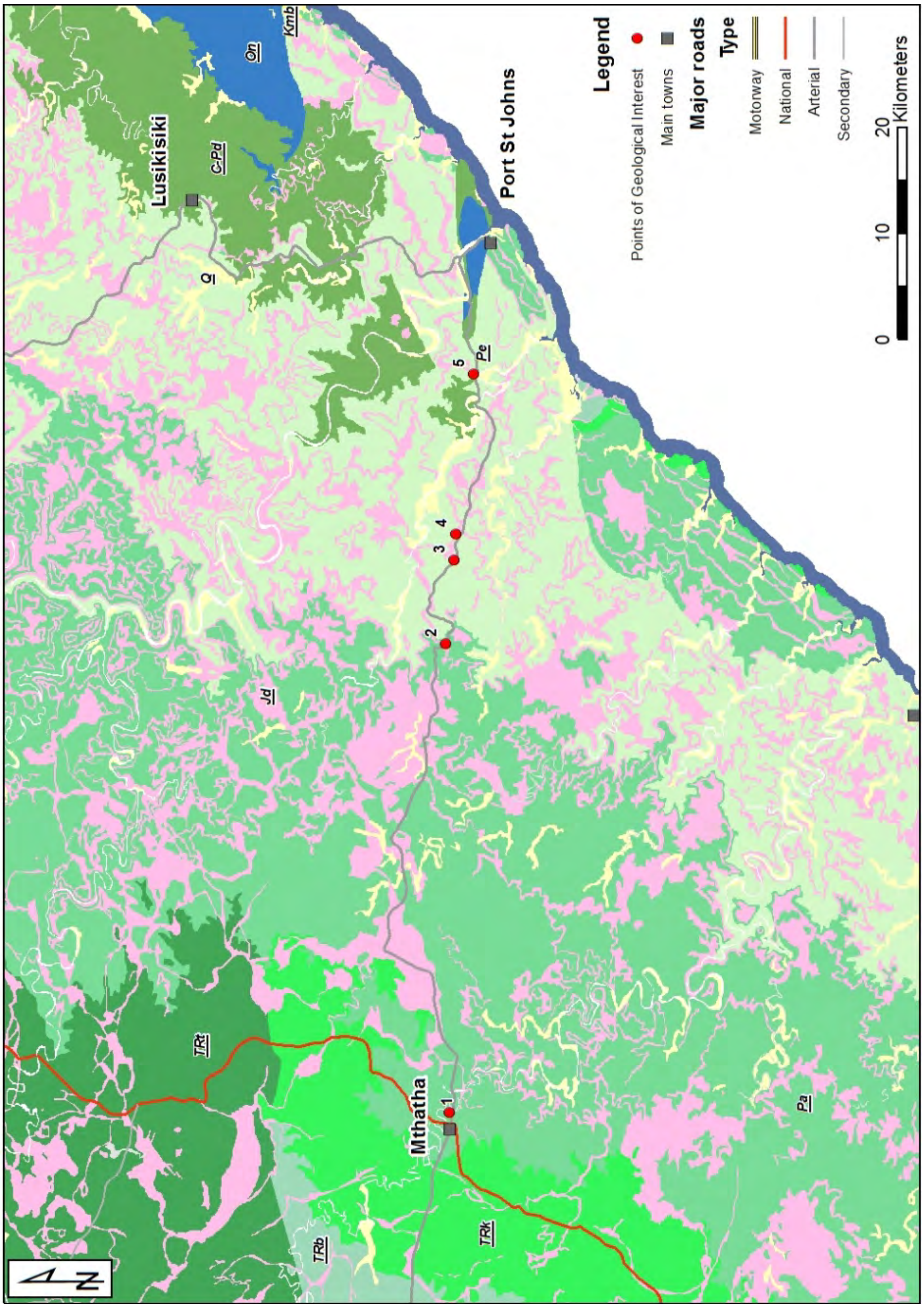


Figure 3: Section of route between Mthatha and Tombo showing geology (for key see figure 5).

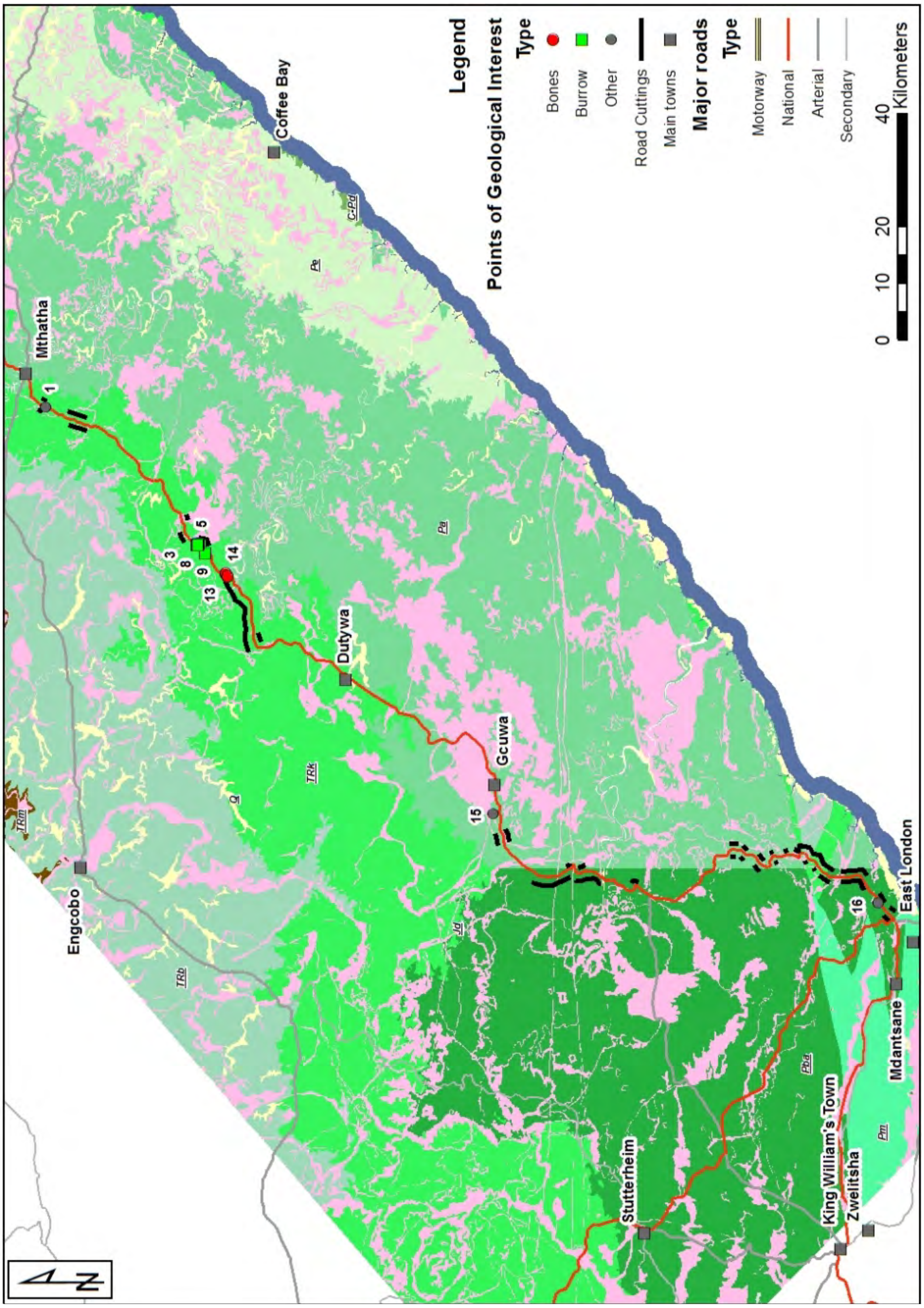
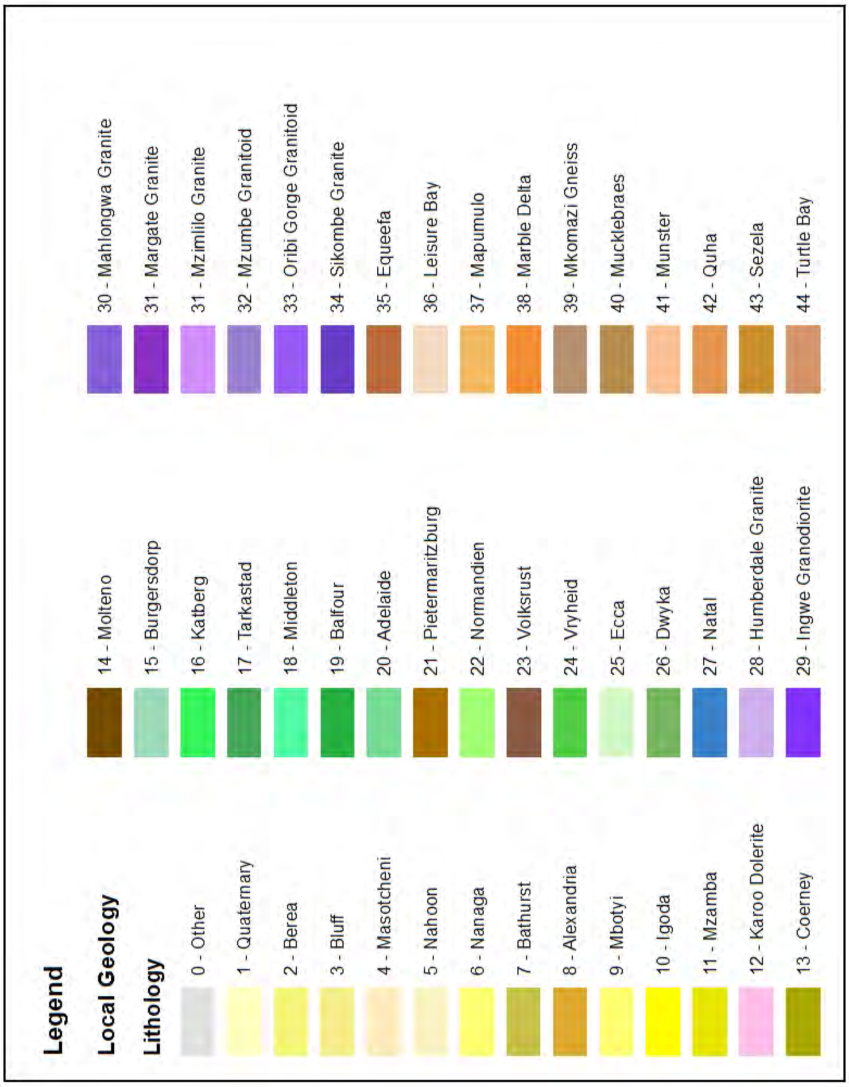


Figure 4: Section of route between East London and Mthatha showing geology (for key see figure 5).



Lithstrat	Label	Chronological Order
QUATERNARY	Q	1
BEREA	Qbe	2
BLUFF	Qb	3
MASOTCHENI	Qm	4
NAHOON	Qn	5
NANAGA	C^n	6
BATHURST	Tb	7
ALEXANDRIA	Ta	8
MBOTYI	Kmb	9
IGODA	Ki	10
MZAMBA	Km	11
KAROO DOLERITE	Jd	12
COERNEY	Jco	13
MOLTENO	TRm	14
BURGERSDORP	TRb	15
KATBERG	TRk	16
TARKASTAD	TRt	17
MIDDLETON	Pm	18
BALFOUR	Pba	19
ADELAIDE	Pa	20
PIETERMARITZBURG	Pp	21
NORMANDIEN	Pn	22
VOLKSRUST	Pvo	23
VRYHEID	Pv	24
ECCA	Pe	25
DWYKA	C-Pd	26
NATAL	On	27
HUMBERDALE GRANITE	N*hu	28
INGWE GRANODIORITE	N*ig	29
MAHLONGWA GRANITE	N*mah	30
MARGATE GRANITE	N*ma	31
MZIMLILO GRANITE	N*mi	31
MZUMBE GRANITOID	N*mm	32
ORIBI GORGE GRANITOID	N*o	33
SIKOMBE GRANITE	N*so	34
EQUEEFA	N*e	35
LEISURE BAY	N*le	36
MAPUMULO	N*m	37
MARBLE DELTA	N*mad	38
MKOMAZI GNEISS	N*mk	39
MUCKLEBRAES	N*mc	40
MUNSTER	N*mu	41
QUHA	N*q	42
SEZELA	N*sz	43
TURTLE BAY	N*tt	44
Other	N	

Figure 5: Geological key for figures 1-5.

Palaeontology

The Precambrian **Natal Metamorphic Suite** rocks have never yielded any palaeontological material and are unlikely to ever do so, due to their genesis before the advent of hard tissue bearing metazoans and also their high state of alteration. Granites intruded into them, being of magmatic origin, contain no fossils.

The **Natal Group** is not known to be fossiliferous north of Hibberdene. Rocks of the **Msikaba** Formation have not yielded abundant fossils, though this may result from the deeply weathered nature of the landscape. Abundant lycopod stems seemingly belonging to a single taxon have been recorded from Port St Johns (Anderson and Anderson, 1985). Some rare invertebrate and trace fossils have also been reported from southern Natal (Lock, 1973; Hobday and Mathews, 1974; Kingsley, 1975).

Within the study area fossils are not known from the **Dwyka Group (Karoo Supergroup)**.

Probably due to the lack of good outcrop in the Eastern Cape, body fossils have as yet not been found in rocks of the lowermost **Ecca Group, (Karoo Supergroup),** though invertebrate trace fossils are known. In other parts of the country the Whitehill Formation (lowermost Ecca) has, however, yielded some exquisite fossils. These include Africa’s earliest known reptile, the aquatic *Mesosaurus*, early crustaceans, and scarce but beautifully preserved ray-finned fish. Within the Eastern Cape plant fossils have been recovered from higher in the Ecca sequence including *Glossopteris*, an early genus of seed plant, that may ultimately have included the ancestors of flowering plants. Actinoptergian fish body fossils and traces are also known.

The flood planes of the **Beaufort Group (Karoo Supergroup)** provide an internationally important record of life during the early diversification of land vertebrates. 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

Therapsid diversity, along with that of most plant and animals was decimated during the end-Permian extinction event, a serious contender for the most severe extinction event to affect life on Earth. Ongoing research on the effects of this extinction event is facilitated by the detailed record, afforded by Beaufort Group strata, of life immediately before and after the event, as well as the gradual recovery of life afterwards.

The Beaufort Group is subdivided into a series of biostratigraphic units on the basis of its faunal content. The lowermost zones not represented in this area.

Though including the upper *Cistephalus* Assemblage Zone and lowermost *Lystrosaurus* Assemblage Zones, the **Balfour Formation** (**Adelaide Subgroup, Beaufort Group, Karoo Supergroup)** corresponds to the *Dicynodon* Assemblage Zone. Characterised by the co-occurence of *Dicynodon* and *Theriognathus* this zone demonstrates the Beaufort Groups greatest diversity of vertebrates, including numerous taxa of dicynodont, biarmosuchian, gorgonopsian and therocephalian and cynodont therapsid Synapsida, together with diverse captorhinid Reptilia and less well represented eosuchian Reptilia, Amphibia and Pisces. *Glossopteris* flora plants and trace fossils are also described.

A marked faunal change occurs between the *Dicynodon* and *Lystrosaurus* Assemblage Zones approaching the top of the Balfour Formation, corresponding with the major extinction event associated with the Permo-triassic boundary. The *Lystrosaurus* Assemblage Zone spans the uppermost (Palingkloof) member of the Balfour Formation, the **Katberg Formation (Tarkastad Subgroup, Beaufort Group, Karoo Supergroup)** and the lower part of the Burgersdorp Formation **(Tarkastad Subgroup**, **Beaufort Group, Karoo Supergroup).**

The *Lystrosaurus* Assemblage Zone is dominated by a single genus of dicynodont, *Lystrosaurus*, which together with the captorhinid reptile, *Procolophon*, characterise this zone. Biarmosuchian and gorgonopsian Therapsida do not survive into the *Lystrosaurus* Assemblage Zone, though therocephalian and cynodontian Therapsida exhibit moderate abundance. Captorhinid Reptilia are reduced, however an unprecedented diversity of giant amphibians characterises this interval.

The effects of the end Permian extinction event are also evident in the extensive and important record of fossil plants present in the rocks of the Karoo. Whereas faunas of Permian age are dominated by a wide range of early seed plants, the Glossopteridales (which probably include the ancestors of modern gymnosperms and ultimately angiosperms), this group appears to have gone entirely extinct during the end-Permian extinction. The rocks of the Karoo provide an unrivalled sequential record of these changes and the diversification of other groups of plants in the aftermath of the extinction. The strata of the Karoo basin have also yielded fossil insects and insect leaf damage of a range of ages.

For historical reasons the Transkei region has not been extensively surveyed from a palaeontological point of view and remained until recently a data vacuum. Work by Bordy (Bordy 2010) revealed vertebrate palaeontological potential near Tsomo in the former Transkei. Subsequent borrow pit surveys conducted by this author have revealed plant fossils throughout the former Transkei. Although no fossils had previously been recorded along this route, abundant vertebrate skeletal elements and trace fossils were revealed during the site survey, considerably adding to the sparse knowledge of vertebrate fossils from this understudied region

Dolerite, being an intrusive igneous rock, contains no fossils.

The Cretaceous **Mzamba Formation** deposits are fossiliferous. The lower, conglomerate layer contains fossil wood (Klinger, 1986) and rarely dinosaur bones (Albany Museum collection). Marine invertebrate fossils are not uncommon in the overlying strata.

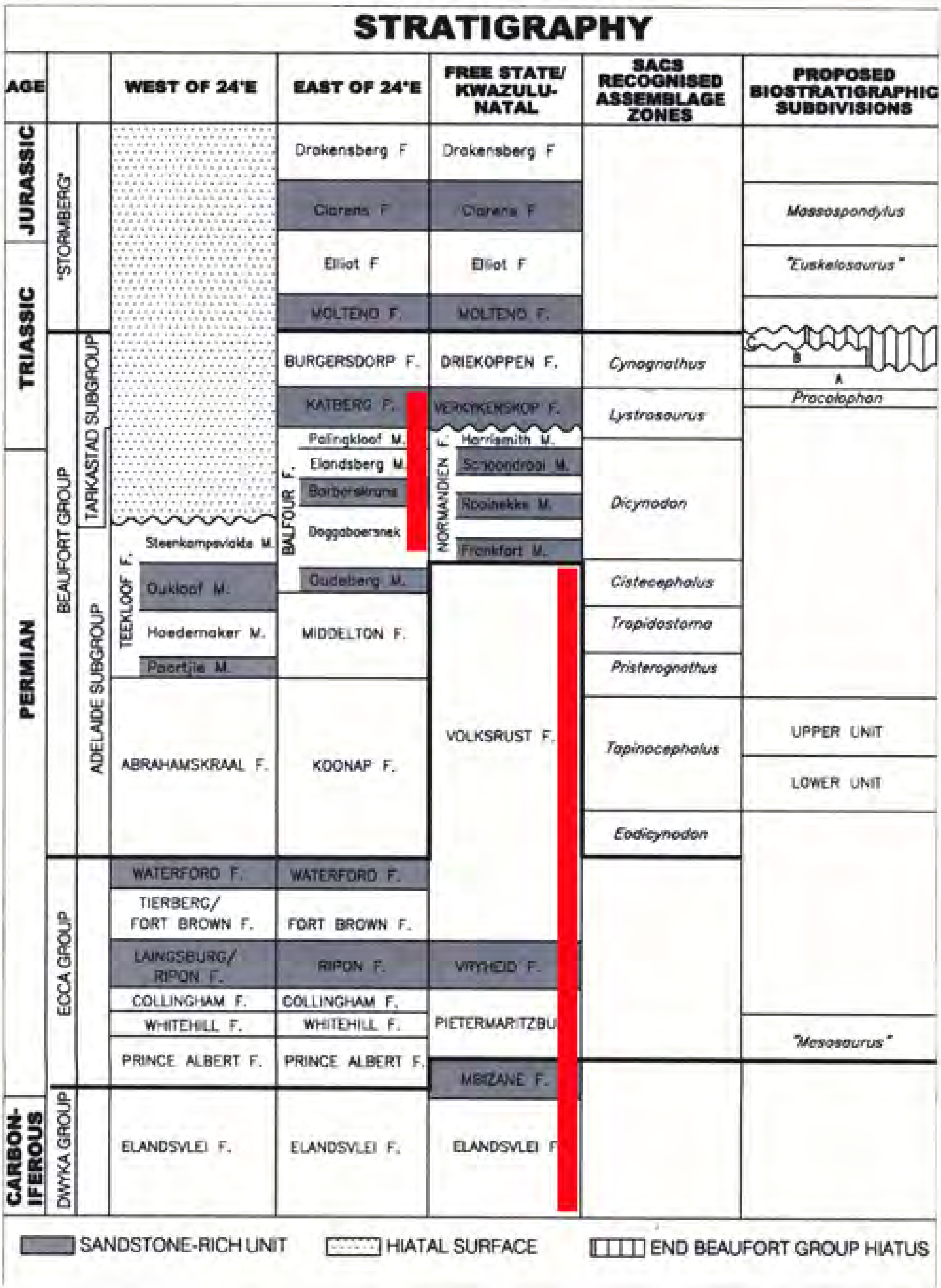


Figure 6: Karoo stratigraphy and biostratigraphy (after Smith *et al*., 2012). Red lines indicate approximate stratigraphic intervals impacted by proposed development.

Site Visit Findings

After a preliminary desktop investigation a drive through survey of the more sensitive portion of the route (from East London to north of Lusikisiki) was conducted in order to assess the actual outcrop of palaeontologically sensitive strata along the tollroad route. Due to time limitations foot surveys were only conducted on a representative sample of the extensive existent outcrops. As a general rule, palaeontologically sensitive outcrop was found to occur where the highway, and therefore the route, cuts through the valleys of large rivers set back from the coast. The largest concentrations of palaeontologically sensitive strata were found to occur in Beaufort Group sediments between East London and Mthatha (fig. 4). Areas of particular importance include Adelaide Subgroup strata believed to belong to the Balfour Formation that extend from East London for about 40 kilometers as the road cuts its way up in to the interior (fig. 7). Examination of select outcrops revealed the presence of fossilised bone (fig. 8).

Figure 7: Fossil bearing mudstones of the Adelaide Subgroup (probably Balfour Formation) north of East London (see fig 4. Point 16).

Figure 8: Fossil bone in mudstones of the Adelaide Subgroup (probably Balfour Formation) north of East London (see fig 4. Point 16).

Extensive outcrops of the Balfour Formation (Adelaide Subgroup) also occur in a long series of roadcuttings lining the Kei River pass (fig. 9). In the centre of this sequence sediments display soft sediment deformation features characteristic of deposition in standing water (Fig. 10). To the north of the Kei cuttings outcrops display the character of fluvial deposits (fig. 11).

Figure 9: Balfour Formation sediments exposed in cutting in the Kei River Pass.

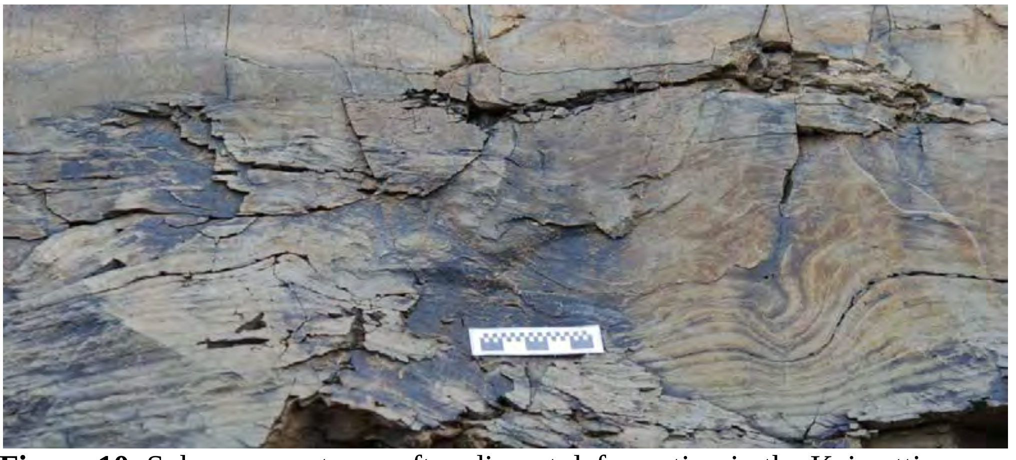


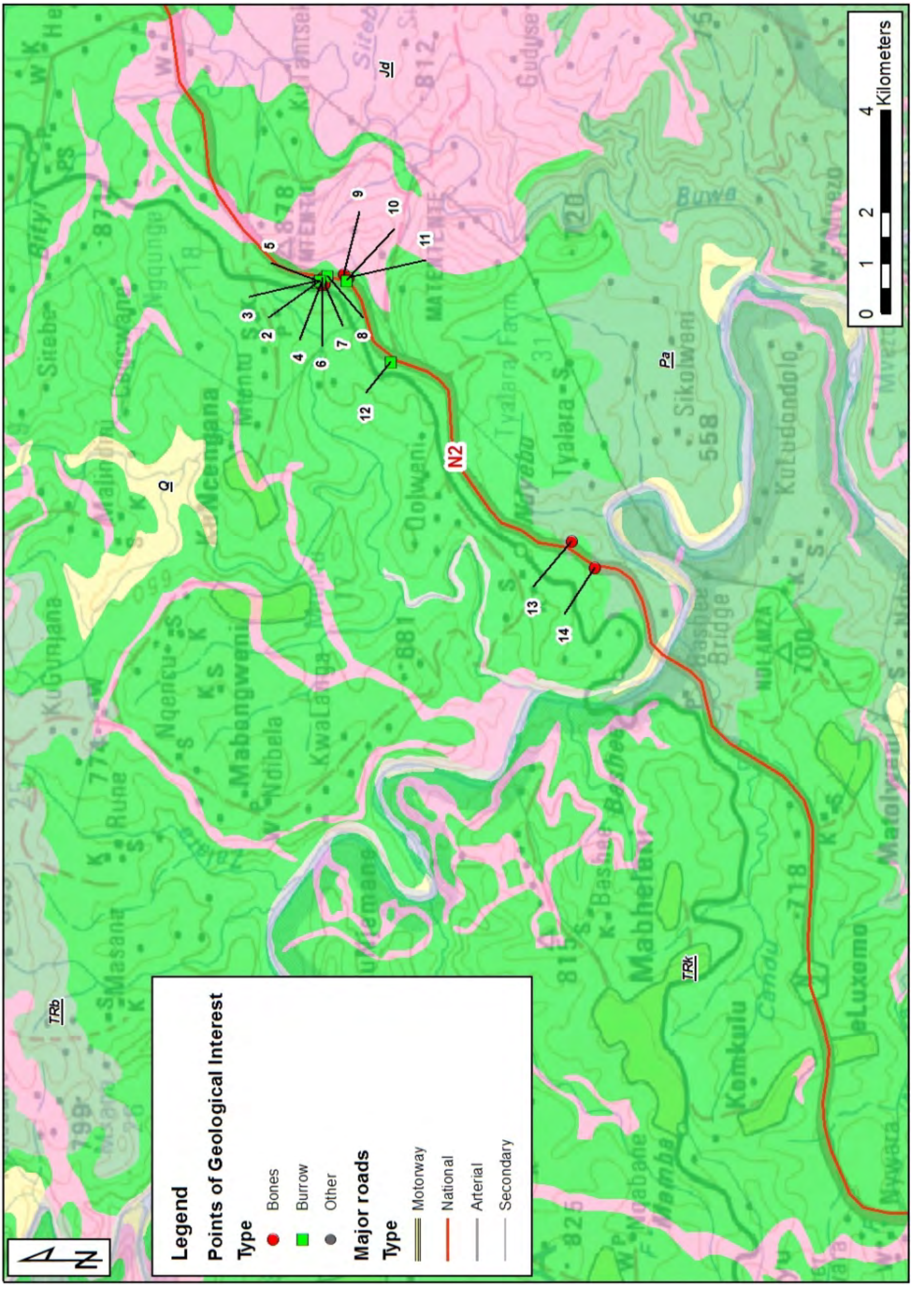
Figure 10: Sub-aqueous type soft-sediment deformation in the Kei cuttings.

Figure 11: Fluvial type Balfour Formation sediments north of the Kei cuttings (fig. 4. Pt. 15).

Extensive and extremely important cuttings occur throughout the lengthy descent to and ascent from the Mbashe River (fig. 12). These generally expose strata of the Katberg Formation (Tarkastad Subgroup, Beaufort Group) (figs. 12, 13 & 14), though the stratigraphically lowermost horizons expose strata of the underlying Balfour Formation (fig. 13, 15). A walk through survey was conducted of the representative series of cuttings (and their back drains) north-east of the Mbashe Bridge. Important fossil bones, including skulls, were found within both formations. Vertebrate burrows were found to be abundant in the upper part of the Katberg Formation. These finds are extremely significant as fossil skulls have only previously been recorded from 8 localities in the former Ciskei and Transkei regions and fossil burrows have previously only been recorded from 2 localities in the same area. The collection of identifiable fossil skulls from a wide range of localities is necessary for completing an accurate biostratigraphic picture of the Karoo Basin, which has been accurately mapped in most of the rest of its outcrop area.

Figure 12: Katberg Formation exposed in cuttings and backdrains to the east of the Mbashe.

Figure 13 ***(overleaf)***: Map showing extent of area characterised by abundant significant road cuttings descending to and ascending from the Mbashe River. Points indicate the positions of fossil bones and vertebrate burrows encountered during a walkthrough survey of the roadcuttings east of the Mbashe Bridge. For geological key see figure 5.


Legend
Points of Geological Interest
Type
Bones
Burrow
Other
Major roads
Type
Motorway
National
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Secondary
N2
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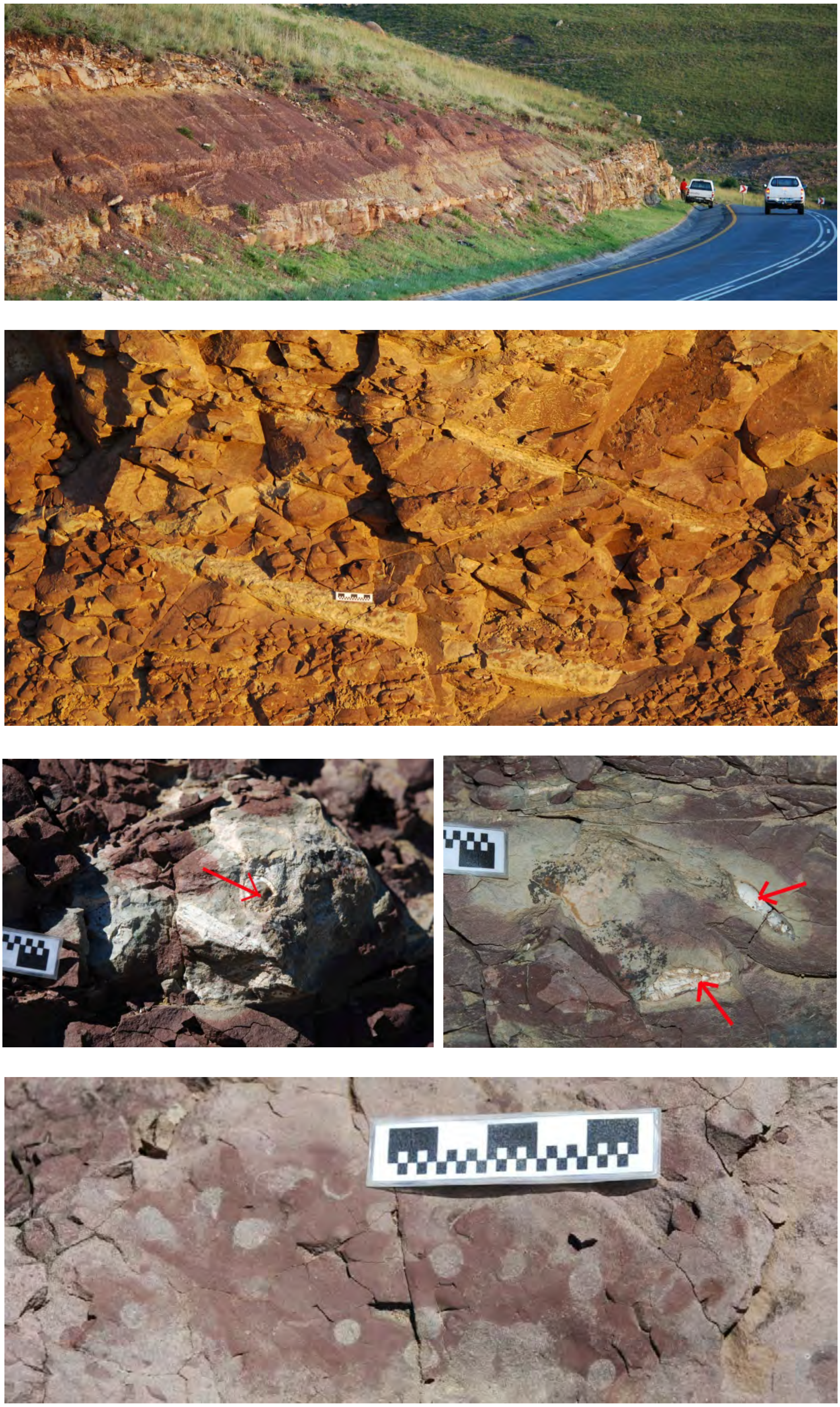

Figure 14: Katberg Formation outcrops east of the Mbashe River. *top*, mudstones, *upper middle*, small therapsid burrows (fig. 10 pt. 2), *lower middle* 2 partial *Lystrosaurus* skulls (fig. 10 pts. 2,3) red arrows indicate canine tusks, *bottom*, invertebrate burrows (fig. 10, pt. 10). Scale bar = 4 cm.

Figure 15: Uppermost Balfour Formation towards the bottom of the Mbashe River pass. *top*: Outcrop at fig. 10 pt 14. *bottom*: fossil bone outcropping at fig. 10 pt 14.

A series of roadcuttings to the west of Mthatha also expose mudstones of the Katberg Formation. That closest to Mthatha was sampled for paleontological material (fig. 16). It was found to contain fossil bone including a probable *Lystrosaurus skull*, as well as a small therapsid burrow (fig. 4 pt 1, fig. 15)

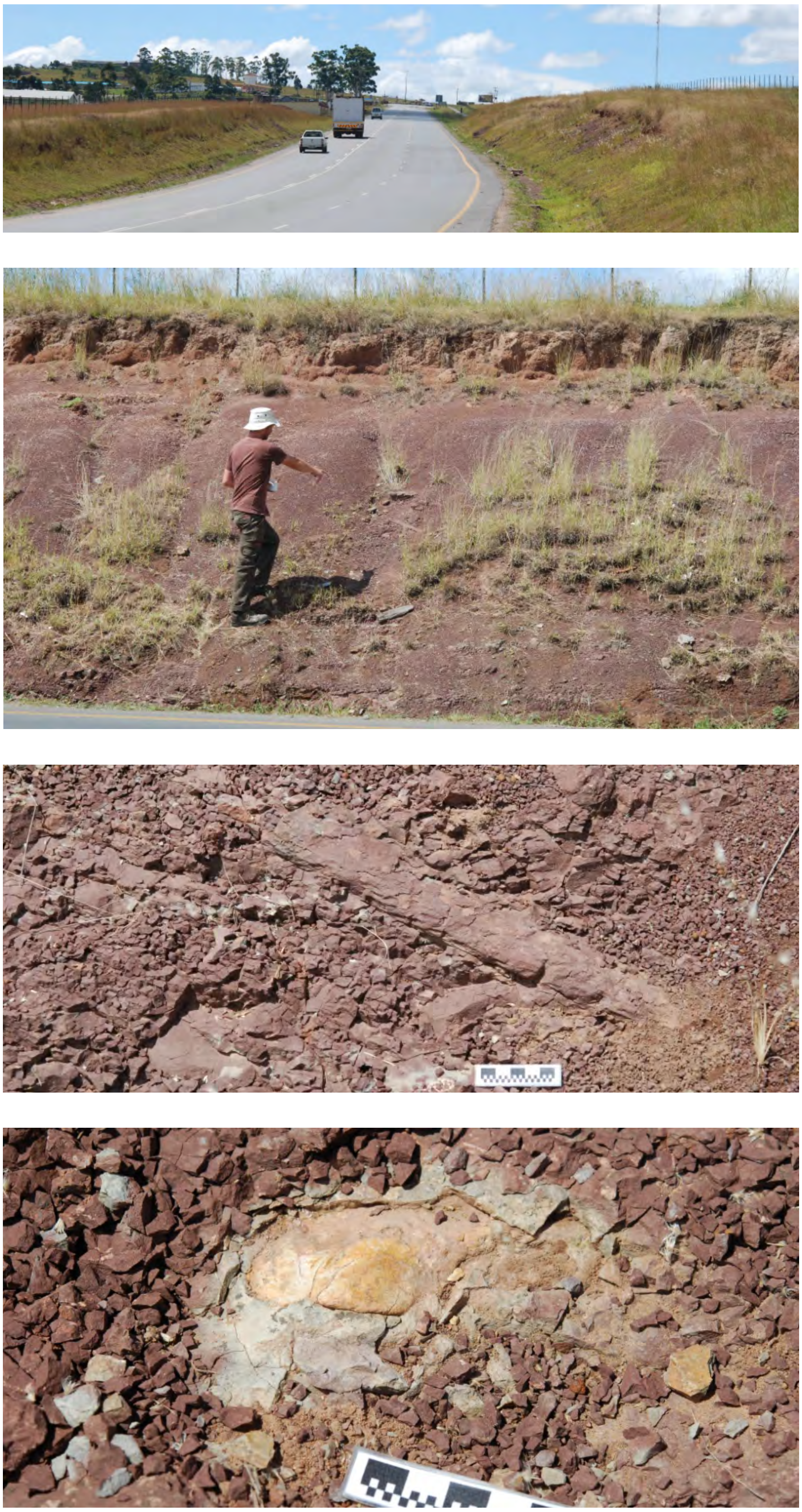

Figure 16: Katberg Formation in a roadcutting immediately west of Mthatha. *top*: view eastwards*; upper middle*: field assistant pointing out position of fossil burrow; *lower middle*: small therapsid burrow with clear impressions of scratch marks; *bottom*: roof of complete probable *Lystrosaurus* skull.

Adelaide Subgroup sandstones and mudstones, which stratigraphically underlie the Katberg Formation, are encountered along the route east of Mthatha. Although these extend for twenty five kilometres it is only within the first ten kilometres from Mthatha that the outcrop is sufficiently fresh to permit the hope that fossils may be recovered. Beyond this the mudstones have been reduced to a pinkish clay by deep weathering resultant of the moister more coastal climate.

Although road cuttings along this section were extensively surveyed paleontological material was only found in that immediately east of Mthatha (fig.3 pt 1, fig. 17). Very weathered remains probably representing a skull were noted here (fig. 17)

Figure 17: *top*: Sandstone and mudstone exposed in a roadcutting east of Mthatha (fig.3 pt 1) *bottom*: weathered fossil bone exposed near base of above roadcutting.

Between about 25 km from Umtata and Tombo the route cuts a section through almost the entire thickness of the Ecca Group, which locally persisted far later in time than in the west.
The uppermost strata of the Ecca are exposed at point 2 (fig. 3). Here evidence for the drying up of the Ecca Lake exists in the form of mudcracks, shallow water invertebrate trace fossils, algal mat impressions and mats of sphenophyte stems (up to 4 cm in diameter) (fig. 18). This is a significant locality in terms of its proximity to the Ecca lake shoreline.

Figure 18: *top*: Uppermost Ecca strata at point 2 (fig. 3), *middle left*: mudcracks superimposed on surface patterned by shallow water flowing over an algally bound surface, *middle right*: mud cracks superimposed on surface showing vertical invertebrate burrow and surface feeding traces, *bottom*: slender sphenophyte stem.

From point 2 (fig. 3) to Tombo, as the road descends steeply towards the coast, there are abundant roadcuttings exposing thick strata of fine grained Ecca Group lacustrine sediments. Due to the nature of these sediments and their long exposure they have unfortunately become extremely crumbly, making the search for fossils very difficult. Nonetheless at various points where strata were examined (eg. Points 3 and 4, fig. 3) plant fragments were identified (see fig 19). These are of low significance but indicate the potential for finding important plant fossils.

Figure 19: *top*: Thick section of Ecca Group lacustrine sediments exposed at point 4 (fig. 4) *bottom*: plant fragments observed at point 4 (fig. 3).

Shale layers low in the Ecca Group sequence are preserved where the road skirts the Mngazi river (point 5, fig. 3; fig. 20). Here the shales are different from those higher in the sequence, being almost black with silvery plant fragment impressions resembling those found in older Witteberg Group (Cape Supergroup) strata.

Figure 20: Black shale with silvery plant fragment fossils near the base of the Ecca Group alongside the Mngazi River (point 5, fig. 3).

Approximately 10 kilometres before Port St Johns the proposed route diverges from the current road route, cutting northwards across Ecca Group and Dwyka Group strata.

The route survey was continued where the route coincides with the R61 to Lusikisik, for about 8 kilometers, north of the Mntafufu River. Here both Ecca and Dwyka strata are exposed (figs 21-22).

Figure 21: Ecca Group strata exposed in roadcuttings north of the Mntafufu River.

Figure 22: Weathered Dwyka Group diamictite displaying coarse glacial pebbles set in a fine grained glacial mud matrix. Exposed in a roadcutting north of the Mntafufu River.

The R61 and the proposed route coincide again immediately west of Lusikisiki for about 5 kilometers. Although it is underlain by Ecca Group sediments at this point, these are virtually reduced to clay at this point through deep weathering.

East of Lusikisiki the road coincides for about 20 kilometres with the current road from Lusikisiki to Mkambati. Along this section it first crosses the Dwyka Group and then the older Msikaba Formation. This section is characterised by an extreme paucity of outcrop as the landscape has been reduced to a rolling deeply weathered profile (figs 23,24).

Figure 23: Landscape of deeply weathered Dwyka Group diamictites east of Lusikisiki.

Figure 24: Landscape of deeply weathered Msikaba Formation arenites 18 km east of Lusikisiki.

Within the time limits it was not possible to survey the route beyond the area of road accessibility. Due to the deeply weathered and undulating nature of the landscape it is however extremely unlikely that useful outcrop is currently afforded between this point and Port Edward, with the exception of where the route crosses major river canyons, including those of the Msikaba, KwaDlambu, Mtentu, Mnyameni and Mzamba rivers. Throughout this section of the route it is almost exclusively underlain by rock of the Msikaba Formation (the one exception being a small outcrop of Natal Metamorphic Suite rocks on the east bank of the Mzamba River). These are considered to have a low likelihood of producing fossils, though the excavation of new outcrops could change this.

The route from the Mtamvuma River (Port Edward) to Isipingo (Durban) (fig. 1) was not surveyed as it was assumed to be of low paleontological sensitivity. This is for two reasons. Firstly, it mainly lies along a deeply weathered subtropical coastline with low topography. Secondly most of the route is underlain by rocks with little or no paleontological potential. These include ancient granites and metamorphic gneisses and schists of the Natal Metamorphic Suite, coarse Devonian and Ordivician sandstones of the Msikaba and Natal Group, and Tertiary Aeolian sands of the Berea Formation.

The one exception is the highly fossiliferous Cretaceous Mzamba Formation that extends for 17 km north of the Mtamvuma River. As outcrop of this formation is chiefly along the beach, roadworks are unlikely to impinge upon it. Should they however intercept this formation important fossils may be disturbed.

Conclusion and Recommendations

Impacts may be divided into two categories. Firstly, impacts on existing outcrops which it has been possible to assess, and secondly impacts on material which has not yet been exposed.

Prior to this survey, due to an extreme paucity of research in this area, no significant fossils had been noted along this route and de Klerk (2001) noted that “any opportunity to recover any fossils from the Beaufort Group sediments would greatly increase the understanding of the evolution of the Karoo Basin and its age.”

During this survey abundant vertebrate skeletal remains and burrow casts were discovered during a survey of a representative selection of outcrops, particularly those between East London and Mthatha. As identifiable skulls have previously only been recorded from 8 localities in the former Cis and Transkei regions these are significant additions to South Africa’s biostratigraphic record. Vertebrate burrows have previously only been reported from 2 localities in this region.

Important localities were also identified marking the top and bottom of the Ecca Formation sequence between Mthatha and Tombo (see fig. 3 points 2 and 5).

Communications with SANRAL, post submission of a draft PIA indicate that upgrading of roadworks between East London and Umtata are nearing completion. Only those stretches between East London and Mooiplaas, between Magalakanqua and Komkulu and through the Mbashe River valley remain to be upgraded. For this reason mitigation prior to and during roadworks will only therefore be possible for limited remaining stretches.

It is therefore recommended that:

6) A full phase two survey should be carried out on the sections between East London and Mooiplaas and the section through the Mbashe river valley prior to the commencement of road works, including identification and recovery of all significant paleontological material.

7) Phase two sampling is conducted at the Ecca Group locality noted as fig. 3 point 5, prior to commencement of road works. (The other important Ecca Group locality noted will apparently be unaffected).

8) Widening of the road through the Mbashe River valley is monitored by a qualified palaeontologist.

It is furthermore recommended that:

9) All new roadcuttings between East London and Hibberdene (in Kwazulu-Natal) are inspected after they have been cut but prior to trimming and rehabilitation to record and sample newly exposed palaeontological material. It is likely that this will need to be done at intervals through the project as the widening of different sections nears completion.

10) The ECO should monitor all excavations and instruct all personnel to be on the lookout for palaeontological material when working in areas identified to be of likely palaeontological sensitivity. These include all areas where Ecca and Beaufort Group strata are freshly exposed (see figs 2, 3, 4); any shales that may become exposed in the Msikaba Formation (see fig. 2) and the potential outcrop area of the Mzamba Formation that extends for 17 km north of the Mtamvuma River Any suspected palaeontological material should immediately be reported to the palaeontologist for assessment.

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