PALAEONTOLOGICAL HERITAGE OF THE EASTERN CAPE

John Almond
***Natura Viva* cc, CAPE TOWN**

Billy de Klerk
Albany Museum, GRAHAMSTOWN

Robert Gess
Bernard Price Institute (Palaeontology), Wits University, JOHANNESBURG

The Eastern Cape is the second largest province in South Africa, comprising some 14% of the area of the RSA. The population is about seven million. The province is renowned for its living biodiversity and it also boasts a rich fossil record stretching back some 560 million years. The majority of the provincial area is underlain by shallow marine, coastal and terrestrial sediments of Phanerozoic (*ie* post-Precambrian) age that are known to contain fossils of some sort, or are potentially fossiliferous (See accompanying simplified geological map and stratigraphic chart, both produced by the Council for Geoscience, Pretoria).

Among the palaeontological highlights of the Eastern Cape are:

- diverse, high-latitude lacustrine to lagoonal biotas from the Late Devonian – Early Carboniferous Witteberg Group (*c*. 360-345 Ma = million years ago). These include a variety of fish and vascular plants as well as rarer arthropods.
- fish, reptiles and therapsids ("mammal-like reptiles") from the Late Permian to Early Triassic Beaufort Group (*c*. 266-250 Ma)
- extraordinarily rich fossil floras from the Late Triassic Molteno Formation (*c*. 220 Ma)
- a range of Early Cretaceous dinosaurs and plant fossils from the Kirkwood Formation (*c*. 135 Ma)
- rich shelly marine faunas from the Early Cretaceous Sundays River Formation (*c*. 135 Ma)
- important coastal marine fossil biotas of the Algoa Group ranging from Eocene to Recent in age (50 to 0 Ma).

Important fossil collections from the Eastern Cape are housed at several South African Institutions, such as: Iziko: South African Museum (Cape Town), Albany Museum (Grahamstown), Port Elizabeth Museum (Port Elizabeth), Bernard Price Institute for Palaeontology, Wits.

(Johannesburg), the Transvaal Museum (Pretoria) and the Council for Geoscience (Pretoria and Bellville). Small fossil collections are probably also found in various smaller local museums.

The 1: 1 000 000 geological map of South Africa published by the Council for Geoscience (6 sheets) provides a useful medium-scale overview of the geology of the Northern Cape. The Eastern Cape Province has been mapped by the Geological Survey / Council for Geoscience at the scale of 1: 250 000. There are 15 sheets at this scale covering the entire province (see enclosed plan).

Table 1: Fossil heritage of the Eastern Cape included here subdivides the rock record of the region into nineteen major subunits with an outline of the age, depositional environment and fossil record of each subunit. A colour-coding scheme is used to rank the units in terms of their palaeontological significance. This scheme is *provisional*, however, and will need to be modified in the light of discussions with heritage managers and palaeontological colleagues.

In the final version of this report, tabulations of all significant rock units indicated on these maps, together with an outline of their palaeontological significance will be provided. On the basis of the published geological maps and this technical report heritage managers should then be able to quickly assess the potential significance of proposed developments and to take appropriate action.

SAHRA TECHNICAL REPORT (March 2009)

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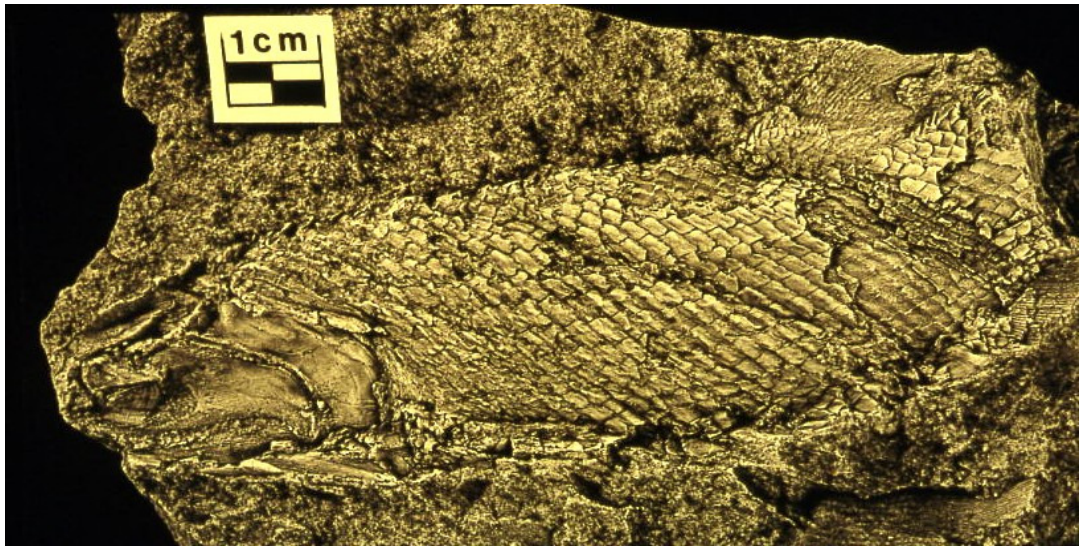


Primitive bony fish (palaeoniscoid) from the Early Carboniferous Waaipoort Formation (*c.* 345 million years old)

JOHN E. ALMOND
Natura Viva cc, CAPE TOWN 8010

BILLY DE KLERK
Albany Museum, GRAHAMSTOWN

ROBERT GESS
Bernard Price Institute (Palaeontology), Wits University, JOHANNESBURG

PALAEONTOLOGICAL SIGNIFICANCE OF ROCK UNITS

COLOUR OF ROCK UNIT	PALAEONTOLOGICAL SIGNIFICANCE / VULNERABILITY	RECOMMENDED ACTION
RED	very high	field scoping study recommended before excavation takes place
PURPLE	high	desk top study + scoping study may be necessary
GREEN	moderate	desk top study
BLUE	low	no action required (any fossil finds to be reported by developer)
BLACK	insignificant or zero	no action required

NB.1. **These significance / vulnerability ratings are *provisional***
NB.2. **Some rock units are largely unfossiliferous, but have thin subunits of high palaeontological significance (*eg* Table Mountain Group).**

TABLE 1: FOSSIL HERITAGE OF THE EASTERN CAPE (For use with 1: 1 000 000 geological maps)			
GEOLOGICAL UNIT	**ROCK TYPES & AGE**	**FOSSIL HERITAGE**	**COMMENTS**
19. CAVE DEPOSITS			[see archaeological literature]
18. NEOGENE-PLEISTOCENE DRIFT - ALLUVIUM *ETC*	alluvium, aeolian sands, lake sediments *etc* in the interior *eg* Kudu's Kloof Formation Late Miocene and younger (correlated with Alexandria Fm *etc*, Algoa Group)	pollens, freshwater molluscs, mammal bones and teeth *etc*	Hofmeyer Man, Karoo (36 000 BP)
17. KALKKOP IMPACT CRATER	calcrete, laminated limestone, shale, sandstone of crater lake Pleistocene 250 ± 50 ka	crater lake fauna – molluscs *etc*	Near Jansenville fossil fauna unpublished
16. GRAHAMSTOWN	silcretes and ferricretes	rare fossil plants	

FORMATION **(Tg)**	associated with deeply weathered saprolite Late Cretaceous (are also younger Tertiary silcretes)	reworked Beaufort Group silicified wood	
15. ALGOA GROUP (Ta) **+ MAPUTALAND GROUP (T-Qm)** **+ Schelm Hoek Fm (Qsc)**	estuarine, coastal, shallow marine silicalstic sediments, limestones, coquinites, aeolian sands Early / Middle Eocene - Holocene	rich marine / estuarine invertebrate fauna including diverse molluscs, plus corals, bryozoans, brachiopods, echinoids, crustaceans, microfossils, sharks' teeth, trace fossils (including human & other mammal tracks), land snails	
14. GRIQUALAND EAST KIMBERLITE PROVINCE	intrusive / volcanic kimberlites, Early-Late Jurassic 194-150 Ma, tuffs (Melkfontein) Cretaceous (63.4 Ma)	NO FOSSILS recorded – check for crater lake facies	

13. COASTAL – MARINE CRETACEOUS OUTLIERS **Igoda Formation** **Mzamba Formation (Kmz)** **Mbotyi Formation (Kmb)** **Mngazana Formation (Kmg)**		coastal and shallow marine siliciclastic sediments, with subordinate limestones (including bryozoan limestones, coquinites) Early – Late Cretaceous *c.* 135-70 Ma	shelly marine fossils, including corals, sea urchins, molluscs (bivalves, ammonites, gastropods), brachiopods, sharks teeth, ostracods, bryozoans, foraminifera, vascular plants (*eg* cycads, carbonised and bored wood), reptile bones (incl. chelonians) *etc*	These marine faunas are of considerable palaeobiogeographic significance
12. UITENHAGE GROUP	**Buffelskloof Formation (Kb)**	terrestrial / fluvial breccio-conglomerates Early Cretaceous	no fossils recorded	Algoa Basin of E. Cape is the key area for terrestrial and shallow marine biotas of the

UITENHAGE GROUP continued	**Sundays River Formation** **(Ks)**	shallow marine / estuarine siliciclastics Early Cretaceous	rich marine invertebrate fauna (molluscs, echinoderms *etc*), vertebrates (*eg* plesiosaurs), microfossils (foraminiferans, ostracods), trace fossils	Uitenhage Group in RSA
	Kirkwood Formation (J-K)	terrestrial (fluvial / lacustrine) siliciclastics Early Cretaceous	**variety of small to large dinosaurs (theropods, sauropods, ornithopods), other reptiles, Mesozoic mammals, important floras of petrified wood ("Wood Beds"), leaves (ferns, cycads, conifers), freshwater invertebrates (bivalves, crustaceans)** shelly marine biotas, microfossils (Colchester Shale Member)	
	Enon Formation (Je)	Late Jurassic	transported bone fragments, coalified wood	
11. SUURBERG GROUP **(Js)**		volcanics (breccias, tuffs, basalts) Mid to Late Jurassic *c* 162 ± 7 Ma	isolated bones, bone fragments (including dinosaurs), silicified wood, plants	
10. DRAKENSBERG GROUP **(Jdr, Jp)** **+** **KAROO DOLERITE SUITE (Jd)**		flood basalts with intercalated continental sediments, pyroclastics, diatremes, intrusive dolerites Early Jurassic	range of tetrapod trackways, vascular plants (arthrophytes, conifers, cycads *et al.*), charred tree trunks in intercalated sediments NO fossils in dolerites	Late Jurassic extinction event attributed to Karoo-Ferrar Large Igneous Province

		182 Ma		
9. STORMBERG GROUP **STORMBERG GROUP continued**	**9c. Clarens Formation (TRc)**	aeolian desert sandstones ("Cave Sandstone") Early Jurassic	dinosaurs, freshwater fish (palaeoniscoids *etc*), trace fossils of tetrapods and invertebrates	
	9b. Elliot Formation **(TRe)**	**alluvial sediments, playa lakes (Red Beds)** Late Triassic – Early Jurassic	important early dinosaur fauna (prosauropods, sauropods, ornithischians, tetrapod trackways *etc*), amphibians, turtles, crocodilians, advanced therapsids, primitive mammals	Key evidence for early dinosaur diversification on Gondwana, early mammal evolution
	9a. Molteno Formation **(TRm)**	alluvial sediments, thin coals ("Coal Measures") Late Triassic	very diverse vascular plant (*Dicroidium* Flora, especially rich in gymnosperms) and insect biota, dinosaur trackways, rare fish	Key Triassic continental biota
8. BEAUFORT GROUP	**8b. Tarkastad Subgroup: Katberg, Burgersdorp Fms (TRt)**	continental (fluvial, lacustrine) siliciclastic sediments, pedocretes (calcretes)	diverse terrestrial and freshwater tetrapods of *Tapinocephalus* to *Cynognathus* Biozones (amphibians, true reptiles, synapsids – especially therapsids), palaeoniscoid fish, freshwater bivalves, trace fossils (including tetrapod trackways), sparse vascular plants (*Glossopteris* Flora, including petrified wood)	Biozonation of Beaufort Group in some areas of E. Cape still requires resolution richest Permotriassic tetrapod fauna from Pangaea / Gondwana key evidence for evolution of mammalian characters among therapsids continental record of Late Permian Mass Extinction Events
	8a. Adelaide Subgroup: Koonap, Middleton, Balfour Fms **(Pa)**	Late Permian – Early Triassic *c.* 266 – 250 Ma		
7. ECCA GROUP **(Pr, Pf, Pwa, Pe)**		Early – Mid Permian non-marine / lacustrine sediments (basin plain, turbidite fan, delta	diverse non-marine trace fossil assemblages, *Glossopteris* flora, mesosaurid reptiles,	

		etc), minor tuffs (volcanic ashes)	palaeoniscoid fish, crustaceans	
6. DWYKA GROUP (C-Pd) **Elandsvlei Formation** **?Mbizane Formation**		Late Carboniferous – Early Permian	interglacial and post-glacial trace fossil assemblages possibility of body fossils (*eg* molluscs, fish, plants)	
5. WITTEBERG GROUP **including Msikaba Fm (Dm)**	**5d. Kommadagga Subgroup (Dl)**	glacial and shallow marine siliciclastics Early / Mid Carboniferous	sparse vascular plants, traces, palynomorphs	Msikaba Formation (**Dm**) correlated with Witteberg Group (lycopods) Thick sandstone units (eg most of Witpoort Fm.) are poorly fossiliferous whereas mudrocks are of high palaeontological significance. Important record of Late Devonian high palaeolatitude biodiversity and extinction events. Witpoort lagoonal biota lived close to Late Devonian South Pole. Most diverse shelly faunas known from Weltevrede Subgroup are from E. Cape.
	5c. Lake Mentz Subgroup **(Dl)**	lacustrine / lagoonal / coastal mudrocks, sandstones, minor conglomerates Early Carboniferous	non-marine fish fauna (palaeoniscoids, sharks, acanthodians), vascular plants (*eg* lycopods), freshwater bivalves, traces, organic-walled microfossils	
WITTEBERG GROUP continued	**5b. Witpoort Formation** **(Dw)**	shallow marine sandstones, quartzites with minor lagoonal mudrocks, glacial sediments Late Devonian	diverse lagoonal biota of fish (placoderms, sharks, bony fish, lampreys *etc*), arthropods (*eg* eurypterids), vascular plant flora, seaweeds, charophytes, traces	
	5a. Weltevrede Subgroup (Dw)	shallow marine sandstones, mudrocks Mid to Late Devonian	sparse shelly invertebrates (brachiopods, molluscs, rare trilobites), trace fossils	

4.BOKKEVELD GROUP	**4b. TRAKA SUBGROUP (Dk)**	shallow marine (deltaic / estuarine?) siliciclastics Mid Devonian	fish (sharks, acanthodians, placoderms, bony fish), bivalves, vascular plants, traces rare brachiopods	fossil record of these fosiliferous units in E. Cape poorly recorded **tectonic deformation limits fossil collection, especially within mudrock horizons**
	4a. CERES SUBGROUP (Dc)	shallow marine siliciclastics Early – Mid Devonian	diverse shelly invertebrate biota and trace fossils, rare fish remains & plants; microfossils	
3. TABLE MOUNTAIN GROUP **including** **NARDOUW SUBGROUP (Sn)** **and** **Peninsula, Pakhuis, Cederberg Fms (Ope)**		predominantly fluvial sandstones, with subordinate mudrocks, tillites Early – Late Ordovician (Ope), Silurian - Early Devonian (Sn)	acritarchs (Sardinia Bay Fm) shallow marine / estuarine trace fossils (Peninsula Formation, Nardouw Subgroup) Soom Biota of post-glacial marine invertebrates, jawless fish, microfossils *etc* (Cederberg Fm) Baviaanskloof Fm marine shelly faunule (brachiopods, molluscs, rare trilobites, bryozoans *etc*)	Sardinia Bay Formation (trace fossils, poorly-preserved acritarchs) =? Cambrian or Early Ordovician Soom biota (Cederberg Formation) not yet recorded in E. Cape, but expected
2. GAMTOOS GROUP (Nga) **+ "CANGO GROUP" (Nk) = undifferentiated Late Proterozoic**		deformed siliciclastic sediments, carbonates, shallow marine to alluvial Late Ediacaran	acritarchs (organic-walled microfossils) potential for stromatolites in carbonate rocks Vendobiontans in "Cango Group"	Gamtoos Gp is correlated with Cango Caves Group of W. Cape. Vendobiontans recentl;y discovered in Cango Caves Group of W. Cape
1. MARGATE SUITE Namaqua-Natal Metamorphic Province (Mmar, MD)		granite-gneisses Mid Proterozoic Mokolian 1.2 Ga	NO FOSSILS RECORDED	outcrops near coast SW of Port Edward

KEY & GLOSSARY:

Ma = millions of years old **Ga** = billions of years old
metasediments = metamorphosed sediments (*eg* quartzite = metamorphosed sandstone).
high grade metasediments = sedimentary rocks that have been strongly metamorphosed, and therefore not fossiliferous (*eg* schist, gneiss), as opposed to **low grade metasediments** that have only been slightly metamorphosed, and may therefore still contain fossils (*eg* quartzites, slates).
siliciclastics = sediments mainly composed of silicate minerals (*eg* quartz, feldspar, clays), as opposed to **carbonates** = sediments composed of carbonate minerals (*eg* limestone, dolomite, calcrete).
fluvial sediments = deposited by rivers (alluvium) **lacustrine sediments** = deposited in lakes **aeolian sediments** = deposited by wind
tillites = glacial sediments **pyroclastics** = fragmentary rocks extruded by volcano such as **tuffs** (= volcanic ashes)
pedocretes = secondarily cemented soils (*eg* lime-cemented calcretes, silica-cemented silcretes)
palynomorphs = organic-walled microfossils of plant, or plant-like origin (*eg* spores, pollens)
vendozoans (or vendobiontans) = problematic macroscopic fossils of Late Precambrian (mainly Ediacaran) age with a peculiar quilted or tubular substructure, controversial biological affinities
BIF = banded ironstone formations **laterite** = red, iron-rich soils formed from highly weathered bedrock

TABLE 2: FOSSIL HERITAGE OF THE EASTERN CAPE (For use with 1: 250 000 geological maps)			
GEOLOGICAL UNIT	**ROCK TYPES & AGE**	**FOSSIL HERITAGE**	**COMMENTS**
19. CAVE DEPOSITS			[see archaeological literature]
18. NEOGENE-PLEISTOCENE DRIFT - ALLUVIUM *ETC*	alluvium, aeolian sands, lake sediments *etc* in the interior *eg* Kudu's Kloof Formation Late Miocene and younger (correlated with Alexandria Fm *etc*, Algoa Group)	pollens, freshwater molluscs, mammal bones and teeth *etc*	Hofmeyer Man, Karoo (36 000 BP)
17. KALKKOP IMPACT CRATER	calcrete, laminated limestone, shale, sandstone of crater lake Pleistocene 250 ± 50 ka	crater lake fauna – molluscs *etc*	Near Jansenville fossil fauna unpublished
16. GRAHAMSTOWN FORMATION **(Tg)**	silcretes and ferricretes associated with deeply weathered saprolite Late Cretaceous (are also younger Tertiary silcretes)	rare fossil plants reworked Beaufort Group silicified wood	
15. ALGOA GROUP (Ta) **+ MAPUTALAND GROUP (T-Qm)** **+ Schelm Hoek Fm (Qsc)**	estuarine, coastal, shallow marine silicalstic sediments, limestones, coquinites, aeolian sands Early / Middle Eocene - Holocene	rich marine / estuarine invertebrate fauna including diverse molluscs, plus corals, bryozoans, brachiopods, echinoids, crustaceans, microfossils, sharks' teeth, trace fossils (including human & other mammal tracks), land snails	
14. GRIQUALAND EAST KIMBERLITE PROVINCE	intrusive / volcanic kimberlites, Early-Late Jurassic 194-150 Ma, tuffs (Melkfontein) Cretaceous (63.4 Ma)	NO FOSSILS recorded – check for crater lake facies	

13. COASTAL – MARINE CRETACEOUS OUTLIERS **Igoda Formation** **Mzamba Formation (Kmz)** **Mbotyi Formation (Kmb)** **Mngazana Formation (Kmg)**		coastal and shallow marine siliciclastic sediments, with subordinate limestones (including bryozoan limestones, coquinites) Early – Late Cretaceous *c.* 135-70 Ma	shelly marine fossils, including corals, sea urchins, molluscs (bivalves, ammonites, gastropods), brachiopods, sharks teeth, ostracods, bryozoans, foraminifera, vascular plants (*eg* cycads, carbonised and bored wood), reptile bones (incl. chelonians) *etc*	These marine faunas are of considerable palaeobiogeographic significance
12. UITENHAGE GROUP	**Buffelskloof Formation (Kb)**	terrestrial / fluvial breccio-conglomerates Early Cretaceous	no fossils recorded	Algoa Basin of E. Cape is the key area for terrestrial and shallow marine biotas of the Uitenhage Group in RSA
	Sundays River Formation **(Ks)**	shallow marine / estuarine siliciclastics Early Cretaceous	rich marine invertebrate fauna (molluscs, echinoderms *etc*), vertebrates (*eg* plesiosaurs), microfossils (foraminiferans, ostracods), trace fossils	
UITENHAGE GROUP continued	**Kirkwood Formation (J-K)**	terrestrial (fluvial / lacustrine) siliciclastics Early Cretaceous	**variety of small to large dinosaurs (theropods, sauropods, ornithopods), other reptiles, Mesozoic mammals, important floras of petrified wood ("Wood Beds"), leaves (ferns, cycads, conifers), freshwater invertebrates (bivalves, crustaceans)** shelly marine biotas, microfossils (Colchester Shale Member)	

	Enon Formation (Je)	Late Jurassic	transported bone fragments, coalified wood	
11. SUURBERG GROUP **(Js)**		volcanics (breccias, tuffs, basalts) Mid to Late Jurassic *c* 162 ± 7 Ma	isolated bones, bone fragments (including dinosaurs), silicified wood, plants	
10. DRAKENSBERG GROUP **(Jdr, Jp)** **+** **KAROO DOLERITE SUITE (Jd)**		flood basalts with intercalated continental sediments, pyroclastics, diatremes, intrusive dolerites Early Jurassic 182 Ma	range of tetrapod trackways, vascular plants (arthrophytes, conifers, cycads *et al.*), charred tree trunks in intercalated sediments NO fossils in dolerites	Late Jurassic extinction event attributed to Karoo-Ferrar Large Igneous Province
9. STORMBERG GROUP **STORMBERG GROUP continued**	**9c. Clarens Formation (TRc)**	aeolian desert sandstones ("Cave Sandstone") Early Jurassic	dinosaurs, freshwater fish (palaeoniscoids *etc*), trace fossils of tetrapods and invertebrates	
	9b. Elliot Formation **(TRe)**	**alluvial sediments, playa lakes (Red Beds)** Late Triassic – Early Jurassic	important early dinosaur fauna (prosauropods, sauropods, ornithischians, tetrapod trackways *etc*), amphibians, turtles, crocodilians, advanced therapsids, primitive mammals	Key evidence for early dinosaur diversification on Gondwana, early mammal evolution
	9a. Molteno Formation **(TRm)**	alluvial sediments, thin coals ("Coal Measures") Late Triassic	very diverse vascular plant (*Dicroidium* Flora, especially rich in gymnosperms) and insect biota, dinosaur trackways, rare fish	Key Triassic continental biota

8. BEAUFORT GROUP	**8b. Tarkastad Subgroup: Katberg, Burgersdorp Fms (TRt)** **8a. Adelaide Subgroup: Koonap, Middleton, Balfour Fms** **(Pa)**	continental (fluvial, lacustrine) siliciclastic sediments, pedocretes (calcretes) Late Permian – Early Triassic *c.* 266 – 250 Ma	diverse terrestrial and freshwater tetrapods of *Tapinocephalus* to *Cynognathus* Biozones (amphibians, true reptiles, synapsids – especially therapsids), palaeoniscoid fish, freshwater bivalves, trace fossils (including tetrapod trackways), sparse vascular plants (*Glossopteris* Flora, including petrified wood)	Biozonation of Beaufort Group in some areas of E. Cape still requires resolution richest Permotriassic tetrapod fauna from Pangaea / Gondwana key evidence for evolution of mammalian characters among therapsids continental record of Late Permian Mass Extinction Events
7. ECCA GROUP **(Pr, Pf, Pwa, Pe)**		Early – Mid Permian non-marine / lacustrine sediments (basin plain, turbidite fan, delta *etc*), minor tuffs (volcanic ashes)	diverse non-marine trace fossil assemblages, *Glossopteris* flora, mesosaurid reptiles, palaeoniscoid fish, crustaceans	
6. DWYKA GROUP (C-Pd) **Elandsvlei Formation** **?Mbizane Formation**		Late Carboniferous – Early Permian	interglacial and post-glacial trace fossil assemblages possibility of body fossils (*eg* molluscs, fish, plants)	
5. WITTEBERG GROUP **including Msikaba Fm (Dm)**	**5d. Kommadagga Subgroup (Dl)**	glacial and shallow marine siliciclastics Early / Mid Carboniferous	sparse vascular plants, traces, palynomorphs	Msikaba Formation (**Dm**) correlated with Witteberg Group (lycopods)

WITTEBERG GROUP continued	**5c. Lake Mentz Subgroup** **(Dl)**	lacustrine / lagoonal / coastal mudrocks, sandstones, minor conglomerates Early Carboniferous	non-marine fish fauna (palaeoniscoids, sharks, acanthodians), vascular plants (*eg* lycopods), freshwater bivalves, traces, organic-walled microfossils	
	5b. Witpoort Formation **(Dw)**	shallow marine sandstones, quartzites with minor lagoonal mudrocks, glacial sediments Late Devonian	diverse lagoonal biota of fish (placoderms, acanthodians, sharks, several subgroups of bony fish, lampreys *etc*), arthropods (*eg* eurypterids), rich vascular plant flora (lycopods, progymnosperms *etc*), seaweeds, charophytes, low diversity trace assemblages, including *Spirophyton*	Thick sandstone units (eg most of Witpoort Fm.) are poorly fossiliferous whereas mudrocks are of high palaeontological significance. **Important record of Late Devonian high palaeolatitude biodiversity and extinction events.** Witpoort lagoonal biota lived close to Late Devonian South Pole.
	5a. Weltevrede Subgroup (Dw)	shallow marine sandstones, mudrocks Mid to Late Devonian	sparse shelly invertebrates (brachiopods, molluscs, rare trilobites), low diversity trace fossils (notably *Spirophyton*)	Most diverse shelly faunas known from Weltevrede Subgroup are from E. Cape.

4.BOKKEVELD GROUP	**4b. TRAKA SUBGROUP (Dk)** **Sandpoort (Ds)** **Adolphspoort (Da)** **Karies (Dk)**	Shallow marine (deltaic / estuarine?) siliciclastics Mid Devonian (Eifelian – Givetian)	Fish (sharks, acanthodians, placoderms, bony fish, recorded especially from Da), bivalves, vascular plants (psilophytes, lycopods), common but low diversity traces, including *Spirophyton*, and rare brachiopods	Sparse fossils in these units in E. Cape poorly recorded compared with W. Cape. **Tectonic deformation limits fossil collection, especially within mudrock-rich horizons, and distorts fossils.**
	4a. CERES SUBGROUP (Dc) **Boplaas (Db)** **Tra Tra (Dt)** **Hexrivier (Dh)** **Voorstehoek (Dv)** **Gamka (Dga)** **Gydo (Dg)**	Shallow marine siliciclastics (alternating sandstone- and mudrock-dominated formations) Early – Mid Devonian (Emsian – Eifelian)	Diverse shelly invertebrate biotas dominated by brachiopods, echinoderms, trilobites and molluscs (with several other minor groups), diverse trace fossils, rare fish remains (acanthodians, placoderms, sharks, bony fish) & primitive vascular plants (psilophytes, lycopods); microfossils	Rich fossil record of these units in E. Cape poorly recorded compared with W. Cape. **Tectonic deformation limits fossil collection, especially within mudrock-rich horizons** Rich fossil invertebrate biotas commoner in mudrock-dominated units (esp. Gydo and Voorstehoek Fms), with low diversity shelly coquinas in sandstones (Dga, Dh), while trace fossils are best preserved in heterolithic units (thin bedded sandstones and mudrocks)

9. TABLE MOUNTAIN GROUP	**NARDOUW SUBGROUP**	**3f. Baviaanskloof Fm (Sb, S-Db)** Early Devonian	Shallow marine "dirty" sandstones and subordinate mudrocks	Low diversity, brachiopod-dominated shelly marine faunas (also bivalves, trilobites, tentaculitids, bryozoans, gastropods, crinoids, trace fossils). Possible primitive vascular plants.	Correlated with Rietvlei Fm in western Cape Basin Early Devonian age well-established on fossil evidence.
		3e. Skurweberg Fm (Ss, Sk) Silurian	Braided fluvial pebbly sandstones with thin subordinate mudrocks, especially in shallow marine-/estuarine- influenced parts of succession, especially towards east	Sparse marine / estuarine /?fluvial trace fossil assemblages (trilobite burrows, *Skolithos* "pipe rock", horizontal burrows) within more mudrock-rich part of succession (W. Cape)	Previously also known as the Kouga Fm (Sk)
		3d. Goudini Fm (Sg, St) Early Silurian			Previously also known as the Tchando Fm (St)
	3c. Cederberg Fm (Ow) Late Ordovician		Post-glacial mudrocks (**Soom Member**) grading up into shallow marine sandstones (**Disa Member**)	**Soom Member** with moderately diverse marine biota of various microfossils, "algae", soft-bodied and shelly invertebrates (eurypterids, trilobites, nautiloids, brachiopods *etc*), primitive jawless fish, some showing exceptional soft tissue preservation. **Disa Member** with low-diversity shelly invertebrate dominated by brachiopods, also rare molluscs, trilobites, shallow marine trace fossil assemblages	Cederberg Fm biota not recorded yet in E. Cape. Potentially fossiliferous mudrocks in E. Cape often affected by intense cleavage and shearing, compromising both preservation and collection of fossil material. **This unit often obscured by Cape age deformation and poor exposure of mudrocks in mountainous terrain. Its development in the E. Cape is not well understood.**

	3c. Pakhuis Fm (Ow) Late Ordovician	Sandy and muddy glacial diamictites (tillites) associated with subglacial defomation of underlying Peninsula Fm sandstones.	V. rare interglacial / post-glacial trace fossils (W. Cape)	This unit often poorly developed in E. Cape or obscured by Cape age deformation. Global mass extinctions correlated with two short end-Ordovician glaciations on Gondwana
	3b. Peninsula Fm (Op) Early – Late Ordovician	Fluvial sandstones, quartzites, subordinate mudrocks within thin marine / estuarine intercalations	Sparse shallow marine / coastal /estuarine to freshwater trace fossils, including eurypterid trackways, trilobite burrows	Traces mainly recorded from mudrock-rich, more marine-influenced parts of succession in W. Cape but also expected in E. Cape.
	3a. Sardinia Bay Formation ?Early Ordovician or Cambrian	Deformed metasediments – conglomerates, sandstones, phyllites – of possible tidal shelf setting	Low diversity of acritarchs, questionable shallow marine trace fossils (*Cruziana, Skolithos etc*)	Stratigraphic boundaries of this unit uncertain. Correlated by different workers with Graafwater Fm or pre-Cape (Klipheuwel Group?) of W. Cape Trace fossils v. controversial.
2. GAMTOOS GROUP **Van Staadens Fm (Nv)** **Kaan Fm (Nka)** **Kleinrivier Fm (Nk)** **Lime Bank Fm (Nl)** **+ Undifferentiated Late Proterozoic (N)**		highly deformed siliciclastic sediments, carbonates deposited in shallow marine, turbidite fan to alluvial settings Late Ediacaran	Acritarchs (organic-walled microfossils) in all formations Potential for stromatolites in carbonate rocks (Lime Bank, Kaan Fms) and vendobiontans in siliciclastic sediments (Kleinrivier, Van Staadens Fms)	Gamtoos Gp is correlated with Cango Caves Group of W. Cape. *NB* Vendobiontans recently (2008) discovered in Cango Caves Group (Groenefontein Fm.) of W. Cape
1. MARGATE SUITE / TERRANE **Namaqua-Natal Metamorphic Province (N**)**		granite-gneisses Mid Proterozoic / Namibian 1.2 Ga	NO FOSSILS RECORDED	Outcrops near coast SW of Port Edward

APPENDIX 1: GLOSSARY OF SOME COMMON TECHNICAL TERMS

For unfamiliar groups of fossils, geological terms (*eg* periods of geological time), consultation of a standard geology textbook or dictionary is recommended (See References).

acritarch – miscellaneous assemblage of probably unrelated organic-walled microfossils of uncertain affinity, mainly marine, of Precambrian to Recent age

aeolian sediments (aeolianites) = sediments deposited by wind (*eg* dune sands)

archaeology = the scientific study of the behaviour, history, culture, evolution and environment of ancient humans (Genus *Homo*) and their close relatives, mainly based on their artefacts and sites where they were active. The archaeological record stretches back some 2.5 *million* years in time. Compare palaeontology below.

BIF = banded ironstone formations - sedimentary rock composed of alternating bands of iron ore and chert

biomat = thin sediment layer bound together by mucilaginous microbes (*eg* cyanobacteria)

biostratigraphy = the correlation of rocks of similar age using fossils

biozone (or **assemblage zone**) = stratigraphic unit defined on basis of occurrence of one or more biostratigraphically significant **zone fossils** (*eg* vertebrate assemablge zones of the Great Karoo Basin)

calcrete = lime-cemented pedocrete

carbonates = sediments composed of carbonate minerals (*eg* limestone, dolomite, calcrete)

chert = very fine-grained / cryptocrystalline or amorphous (non-crystalline) siliceous sedimentary rock (*eg* flint)

clastic sediment – sediment composed of aggregate of transported rock fragments & mineral grains (*eg* conglomerate, sandstone, limestone breccia, tillite)

coprolite = fossil faeces (*eg* hyaena dung)

cyanobacteria – important subgroup of photosynthetic bacteria, previously known as blue-green algae

diamictite – very poorly sorted clastic sediment composed of large rock fragments embedded in a fine-grained matrix. Typical examples are glacial tillites and scree deposits

diatomite = fine-grained siliceous sediment composed largely of the tiny shells of diatoms, a group of unicellular algae (= diatomaceous earth)

duricrust = pedocrete (qv)

evaporites = sediments precipitated as result of evaporation of highly saturated solutions, such as brines (*eg* rock salt / halite, gypsum)

eurypterid = extinct group of aquatic predatory arthropods closely related to scorpions and king crabs (= water scorpion)

fluvial sediments = deposited by rivers (alluvium)
foraminiferan (foram) = important marine group of planktic or bottom-dwelling amoeboid protozoans, usually with a shell of calcium carbonate

fossiliferous = fossil bearing

Ga = billions of years old

gastrolith = stomach stone (*eg* of dinosaur, bird)

ichnofossils = trace fossils (qv). An assemblage of trace fossils is an ichnoassemblage

igneous rock = rock formed by cooling or crystallisation of a rock melt or magma (*eg* basalt, dolerite, granite)

intrusion = igneous body formed by the underground crystallisation of magma that has been forced into the surrounding "country" rocks (*eg* granite pluton, dolerite dyke or sill)

lacustrine sediments = deposited in lakes

laterite = red, iron-rich soils formed from highly weathered bedrock

lignite = incompletely coalified plant material with a woody structure, intermediate in grade between peat and bituminous coal; often Tertiary in age

Ma = millions of years old

macrofossils = substantial-sized fossils that can be seen with the naked eye (macroscopic)

member = subdivision of a sedimentary rock formation characterised by distinctive lithology (rock type), palaeontology and / or other features (*eg* Soom Member of Cederberg Formation)

metasediments = metamorphosed sediments (*eg* quartzite = metamorphosed sandstone). **High grade metasediments** = sedimentary rocks that have been strongly metamorphosed, and therefore not fossiliferous (*eg* schist, gneiss), as opposed to **low grade metasediments** that have only been slightly metamorphosed, and may therefore still contain fossils (*eg* quartzites, slates)

metavolcanics = metamorphosed volcanic rocks

metazoan = multicellular animal (*cf* unicellular protozoans)

microfossils = microscopically small fossils (*eg* pollen, spores, acritarchs, foraminiferans)

microvertebrates = disarticulated skeletal remains of large- or small-bodied vertebrates, such as isolated bones, scales and teeth

oncolites, oolites = rounded structures formed in carbonate settings through accretion or precipitation of concentric layers round a central core, under the influence of currents

palaeontology = the scientific study of ancient ("prehistoric") life, from bacteria and biomolecules to bananas and bigwigs. This field mainly concerns organisms other than humans, but also includes the scientific study of fossil humans and their primate relatives (palaeoanthropology) as well as the study of animal and plant remains at archaeological sites (archaeozoology, archaeobotany). There is therefore considerable overlap and cross-fertilisation with the field of archaeology (qv) which has a specifically human emphasis. The palaeontological record stretches back some 3.5 billion years in time.

palynomorphs = organic-walled microfossils of plant, or plant-like origin (*eg* spores, pollens)

pedocretes = secondarily cemented soils (*eg* lime-cemented **calcretes**, silica-cemented **silcretes**, ferruginous cemented **ferricretes**)

pseudofossil = fossil-like structure found in rocks that does not have a biological origin (*eg* fern-like mineral dendrites)

regression = retreat of the coastline due to sea-level fall

rhizolith (**rhizomorph**) – fossilised root cast in ancient soil horizon

shelly fossils = macroscopic invertebrates with mineralised shells (*eg* molluscs, trilobites)

silcrete = silica-cemented pedocrete

siliciclastics = sediments mainly composed of silicate minerals (*eg* quartz, feldspar, clays), as opposed to **carbonates** (see above)

soft-bodied = unmineralised (*eg* tissues other than bones, teeth, shells)

stromatolite = finely-laminated horizontal, dome-shaped or columnar structures formed by rhythmic growth and sediment trapping by bottom-dwelling microbes (*eg* cyanobacteria); usually preserved in carbonates, freshwater or (mostly) marine

submarine fan = conical-tapering subaqueous deposit usually formed in deep sea or lake by succession of turbidites (qv)

termitarium = termite nest (fossil examples usually calcretised)

tetrapod = four-legged, air-breathing vertebrate, including amphibians, reptiles, birds and mammals and their extinct relatives, but not fish

therapsids (“mammal-like reptiles”) = major subgroup of tetrapods that dominated terrestrial ecosystems during the later Permian and earlier Triassic Periods and eventually gave rise to the mammals

thrombolites = stromatolite-like microbial mounds with a distinctive “clotted” rather than laminar texture inside

tillites = glacial sediments

trace fossils / **ichnofossils** = fossilised animal behaviour in the form of burrows, borings, trackways, coprolites, tools and the like

transgression = invasion of coastal area by the sea as refult of sea level rise (*cf* regression)

tufa = calcareous (or siliceous) rock formed by precipitation from springs, seeping water in cave systems (*eg* flow-stone)

tuffs = volcanic ashes

turbidite = bed of sediment deposited by a submarine avalanche or turbidity flow

vascular plants = terrestrial plants with well-developed vascular transport tissues (xylem, phloem) such as ferns, gymnosperms, angiosperms (but not mosses, algae)

vendozoans / **vendobiontans** = problematic macroscopic fossils of late Precambrian (mainly Ediacaran) age with a peculiar quilted or tubular substructure, controversial biological affinities

volcanic rocks = igneous rocks formed by the eruption of molten magma / lava at the Earth's surface (*eg* basalt, rhyolite)

zone fossil = fossil taxon (usually a species) used to define a particular time interval within one or more sedimentary successions (*eg* ammonite species for marine Cretaceous rocks, or therapsid species for terrestrial Permian rocks)

APPENDIX 2: 1:250 000 SCALE GEOLOGY SHEETS & SHEET EXPLANATIONS, EASTERN CAPE

The 1: 1 000 000 geological map of the RSA (in 4 sheets) published by the Council for Geoscience, Pretoria (previously the Geological Survey) provides a very useful overview of the geographical distribution of fossiliferous and other rock units within South Africa. Table 1 is designed to be used in conjunction with this map.

Most of / The entire Eastern Cape Province has been mapped at 1: 50 000 scale on at least reconnaissance level by the Council for Geoscience, Pretoria, on the basis of fieldwork and remote sensing (*eg* satellite and aerial photographs).

The province is covered by 15 maps at 1: 250 000 scale, as shown on **Table A2.1** and plan in **Figure A2.1**. The majority / All of these geological maps have now been compiled and published by the Council for Geoscience. Table 2 of this report is designed to be used in conjunction with the 1: 250 000 geological maps. Some of the geological maps are currently out of print, but colour prints can be obtained through the offices of the Council for Geoscience. Each map is accompanied by a separate sheet explanation, with the exception of the King William's Town sheet (*NB* Some of these explanations are only available in Afrikaans). Full references to the sheet explanations are given in the literature list at the back of this report.

The level of attention paid to palaeontology varies markedly between sheet explanations, depending on the interests and priorities of the compilers and the stratigraphic units present in the area mapped (**Table A2.1**). For the most part, fossils are only mentioned briefly, or largely neglected, in sheet explanations for Eastern Cape geology maps, even where extensive fossiliferous units are present (A notable exception is the Middelburg sheet explanation which has extensive palaeontological input). Therefore these publications usually do not constitute as useful a resource on local palaeontological heritage as might be expected.

Paradoxically, some of the sheet explanations for Geological Survey maps published prior to the current 1: 250 000 series provide a richer palaeontological resource than the latter. Good examples are explanations by Haughton (1928) for the area between Grahamstown and Port Elizabeth, Haughton *et al*. (1937) for the coastal belt near the Gamtoos Valley, Engelbrecht *et al*. (1962) for the area between Port Elizabeth and Alexandria (which contains extensive tabulations of fossils), and Mountain (1962) for the Port Alfred area. In general, the older Survey geologists were experienced in fossil collection and more attuned to the value of palaeontological data for biostratigraphic correlation and (perhaps to a lesser extent) palaeoenvironmental analysis.

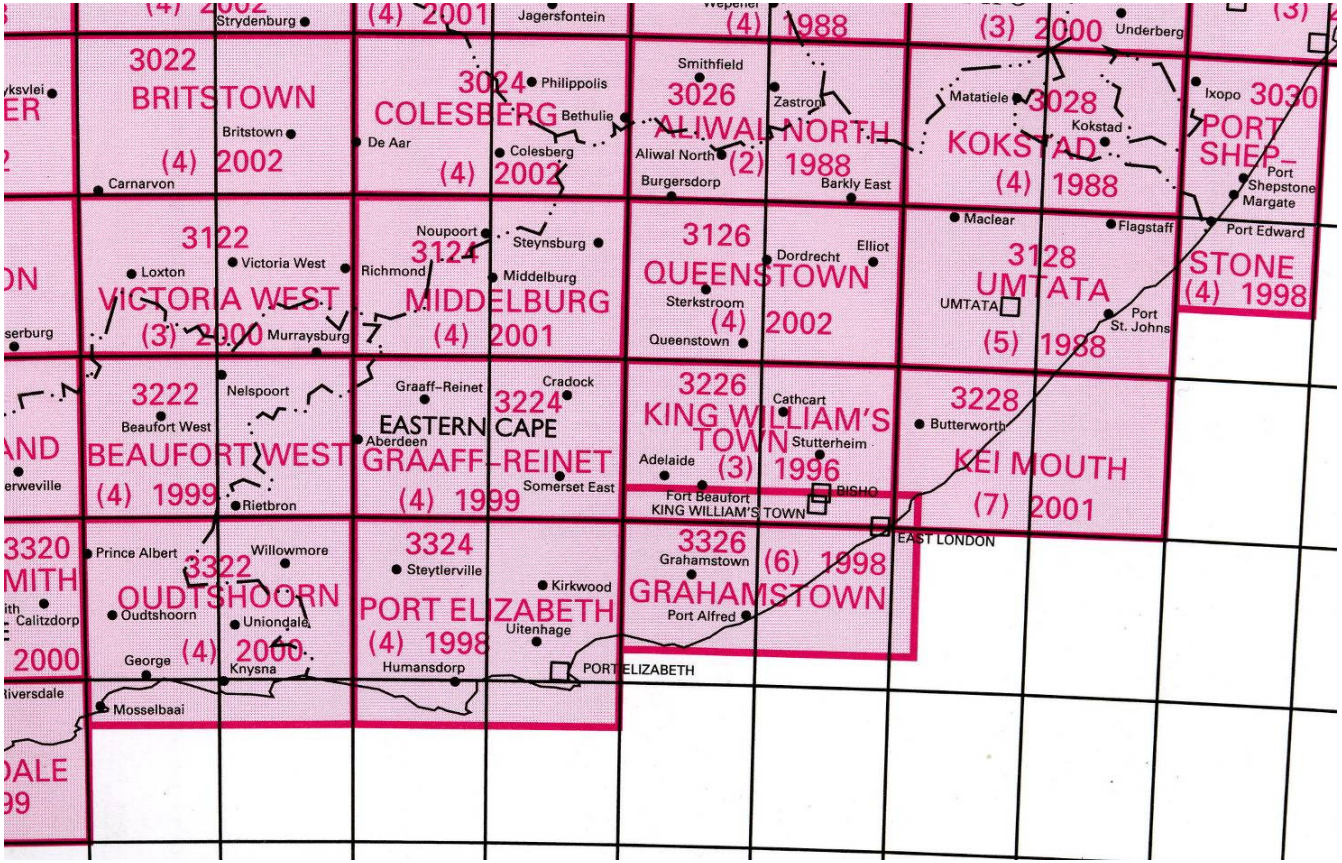
TO ADD:

local maps at 1: 50 000 scale eg Le Roux (2000) PE area
full list of older maps and sheet explanations

1: 250 000 SCALE GEOLOGICAL MAPS, EASTERN CAPE			
Sheet Name & Number	**Mapping status**	**Sheet Explanation**	**Palaeontology coverage**
2928 DRAKENSBERG			
3024 COLESBERG	Published 1997	Le Roux (1993)	poor
3026 ALIWAL-NORTH	Published 1983	Bruce *et al*. (1983)	modest
3028 KOKSTAD	Published 2002	De Decker (1981)	poor
3030 PORT SHEPSTONE	Published 1988	Thomas (1988)	poor (lot of basement rocks)
3124 MIDDELBURG	Published 1996	Cole et al. (2004)	extensive
3126 QUEENSTOWN	Published 1982	Johnson (1984)	modest
3128 UMTATA	Published 1979	Karpeta & Johnson (1979)	poor
3222 BEAUFORT WEST	Published 1979	Johnson & Keyser (1979)	moderate
3224 GRAAFF-REINET	Published 1993	Hill (1993)	moderate
3226 KING WILLIAM'S TOWN	Published 1976	Sheet explanation printed on map	poor
3228 KEI MOUTH	Published 1979	Johnson & Caston (1979)	poor
3322 OUDTSHOORN	Published 1979	Toerien (1979)	poor
3324 PORT ELIZABETH	Published 1991	Toerien & Hill (1989)	modest
3326 GRAHAMSTOWN	Published 1995	Johnson & Le Roux (1994)	moderate

Table. A2.1. Summary of 1: 250 000 geological maps and sheet explanations covering the Eastern Cape Province.

FIG. A2.1. PLAN OF 1: 250 000 GEOLOGICAL SHEETS COVERING THE EASTERN CAPE PROVINCE



APPENDIX 3: KEY REFERENCES

This list includes key references, especially more recent review papers and books, directly concerning or relevant to fossil heritage within the stratigraphic units covered by this report. The tables in the report were compiled from a more extensive list of technical papers, as well as a considerable body of unpublished data.

1. GENERAL PALAEONTOLOGICAL & GEOLOGICAL REFERENCES

ALLABY, A. & ALLABY, M. 1991. The concise Oxford dictionary of earth sciences. 41pp. Oxford University Press, Oxford.

ANDERSON, J.M. (ed.) 2001. Towards Gondwana Alive. Promoting biodiversity and stemming the Sixth Extinction. 140 pp. Gondwana Alive Society.

ANDERSON, J.M. & ANDERSON, H.M. 1985. Palaeoflora of southern Africa. Prodromus of South African megafloras, Devonian to Lower Cretaceous, 423 pp, 226 pls. Botanical Research Institute, Pretoria & Balkema, Rotterdam.

CAIRNCROSS, B. 2004. Field guide to rocks and minerals of southern Africa. 292 pp.
Struik Publishers, Cape Town.

CLUVER, M.A. 1978. Fossil reptiles of the South African Karoo. 54 pp. South African Museum, Cape Town.

DU TOIT, A. 1954. The geology of South Africa. xii + 611pp, 41 pls. Oliver & Boyd, Edinburgh.

FORTEY, R. 1997. Life – an unauthorised biography. A natural history of the first 4, 000, 000 years of life on Earth. 399 pp. Flamingo / Harper Collins, London.

GOULD, S.J. (ed.) 1993. The book of life. 256 pp. Ebury Hutchinson, London.

JOHNSON, M.R. 1976. Stratigraphy and sedimentology of the Cape and Karoo sequences in the Eastern Cape Province. Unpublished PhD thesis, Rhodes University, Grahamstown, xiv + 335 pp, 1pl.

JOHNSON, M.R., ANHAEUSSER, C.R. & THOMAS, R.J. 2006. The geology of South Africa. 691 pp. Geological Society of South Africa, Johannesburg and Council for Geoscience, Pretoria.

MACRAE, C. 1999**.** Life etched in stone. Fossils of South Africa. 305 pp. The Geological Society of South Africa, Johannesburg.

McCARTHY, T. & RUBIDGE, B. 2005. The story of Earth and Life. A southern African perspective on a 4.6-billion-year journey. 334 pp. Struik Publishers, Cape Town.

PLUMSTEAD, E.P. 1969. three thousand million years of plant life in Africa. Transactions of the Geological Society of South Africa 72 (Annexure), 72 pp, 25 pls.

ROGERS, A.W. 1937. The pioneers in South African geology and their work. Transactions of the Geological Society of South Africa, Transactions of the Geological Society of South Africa 39 (Annexure), 138 pp.

SCHNEIDER, G. & MARAIS, C. 2004. Passage through time – the fossils of Namibia. 159 pp. Gamsberg MacMillan, Windhoek.

TANKARD, A.J., JACKSON, M.P.A., ERIKSSON, K.A., HOBDAY, D.K., HUNTER, D.R. & MINTER, W.E.L. 1982. Crustal evolution of southern Africa – 3.8 billion years of Earth history, xv + 523 pp., pls. Springer Verlag, New York.

VILJOEN, M.J. & REIMOLD, W.U. (eds) 1999. An introduction to South Africa's geological and mining heritage. 193 pp. Mintek, Randburg.

WHITTEN, D.G.A. & BROOKS, J.R.V. 1972**.** The Penguin dictionary of geology. 416 pp. Penguin Books, London.

WHITTOW, J.B. Dictionary of physical geography. 2nd. Ed. 590 pp. Penguin Books, London.

2. GEOLOGICAL MAP SHEET EXPLANATIONS (EASTERN CAPE)

BRUCE, R.W., KRUGER, G.P. & JOHNSON, M.R. 1983. Die geologie van die gebied Aliwal-Noord. Explanation to 1: 250 000 geology Sheet 3026 Aliwal-Noord, 7 pp. Council for Geoscience, Pretoria.

COLE, D.I., NEVELING, J., HATTINGH, J., CHEVALLIER, L.P., REDDERING, J.S.V. & BENDER, P.A. 2004. The geology of the Middelburg area. Explanation to 1: 250 000 geology Sheet 3124 Middelburg, 44 pp. Council for Geoscience, Pretoria.

DE DECKER, R.H. 1981. Geology of the Kokstad area. Explanation to 1: 250 000 geology Sheet 3028 Kokstad, 22 pp. Council for Geoscience, Pretoria.

DU TOIT, A.L. & ROGERS, A.W. 1917. The geology of part of the Transkei. An explanation of Sheet 27 (Cape) (MacLear-Umtata), 28 pp. Geological Survey / Council for Geoscience, Pretoria.

ENGELBRECHT, L.N.J., COERTZE, F.J. & SNYMAN, A.A. 1962. Die geologie van die gebied tussen Port Elizabeth en Alexandria, Kaapprovinsie. Explanation to geology sheet 3325 D Port Elizabeth, 3326 C Alexandria and 3425 B, 54pp., 8 pls. Geological Survey of South Africa / Council for Geosciences, Pretoria.

HAUGHTON, S.H. 1928. The geology of the country between Grahamstown and Port Elizabeth. An explanation of Cape Sheet No. 9 (Port Elizabeth), 45 pp. Geological Survey / Council for Geoscience, Pretoria.

HAUGHTON, S.H. 1935. The geology of portion of the country east of Steytlerville, Cape Province. An explanation of Sheet No. 150 (Sundays River), 35 pp. Geological Survey / Council for Geoscience, Pretoria.

HAUGHTON, S.H., FROMMURZE, H.F. & VISSER, D.J.L. 1937. The geology of portion of the coastal belt near the Gamtoos Valley, Cape Province. An explanation of Sheets Nos. 151 North and 151 South (Gamtoos River), 55 pp. Geological Survey / Council for Geoscience, Pretoria.

HILL, R.S. 1993. The geology of the Graaff-Reinet area. Explanation to 1: 250 000 geology Sheet 3224 Graaff-Reinet, 31 pp. Council for Geoscience, Pretoria.

JOHNSON, M.R. 1984. The geology of the Queenstown area. Explanation to 1: 250 000 geology Sheet 3126 Queenstown, 21 pp. Council for Geoscience, Pretoria.

JOHNSON, M.R. & KEYSER, A.W. 1979. The geology of the Beaufort West area. Explanation to 1: 250 000 geology Sheet 3222 Beaufort West, 14 pp. Council for Geoscience, Pretoria.

JOHNSON, M.R. & CASTON, D.L. 1979. The geology of the Kei Mouth area. Explanation to 1: 250 000 geology Sheet 3228 Kei Mouth, 7 pp. Council for Geoscience, Pretoria.

JOHNSON, M.R. & LE ROUX, F.G. 1994. The geology of the Grahamstown area. Explanation to 1: 250 000 geology Sheet 3326 Grahamstown, 40 pp. Council for Geoscience, Pretoria.

KARPETA, W.P. & JOHNSON, M.R. 1979. The geology of the Umtata area. Explanation to 1: 250 000 geology Sheet 3128 Umtata, 16 pp. Council for Geoscience, Pretoria.

LE ROUX, F.G. 1993. Die geologie van die gebied Colesberg. Explanation to 1: 250 000 geology Sheet 3024 Colesberg, 14 pp. Council for Geoscience, Pretoria.

LE ROUX, F.G. 2000. The geology of the Port Elizabeth – Uitenhage area. Explanation of 1: 50 000 geology Sheets 3325 DC and DD, 3425 BA Port Elizabeth, 3325 CD and 3425 AB Uitenhage, 3325 CB Uitenhage Noord and 3325 DA Addo, 55pp. Council for Geoscience, Pretoria.

MOUNTAIN, E.D. 1946. The geology of an area east of Grahamstown. An explanation of Sheet No. 136 (Grahamstown), 56 pp. Geological Survey / Council for Geoscience, Pretoria.

MOUNTAIN, E.D. 1962. The geology of the country around Port Alfred, Cape Province. An explanation of Sheets 3326D (Port Alfred) and 3327C, 28 pp. Geological Survey / Council for Geoscience, Pretoria.

MOUNTAIN, E.D. 1974. The geology of the area around East London, Cape Province. An explanation of sheet map 3227D (East London), 3228 (Kei Mouth). Geological Survey / Council for Geoscience, Pretoria.

THOMAS, R.J. 1988. The geology of the Port Shepstone area. Explanation to 1: 250 000 geology Sheet 3030 Port Shepstone, 136 pp. Council for Geoscience, Pretoria.

TOERIEN, D.K. 1979. The geology of the Oudtshoorn area. Explanation to 1: 250 000 geology Sheet 3322 Oudtshoorn, 13 pp. Council for Geoscience, Pretoria.

TOERIEN, D.K. & HILL, R.S. 1989. The geology of the Port Elizabeth area. Explanation to 1: 250 000 geology Sheet 3324 Port Elizabeth, 35 pp. Council for Geoscience, Pretoria.

MARGATE SUITE / TERRANE

CORNELL, D.H. et al. 2006. The Namqua-Natal Province. In: Johnson, M.R., Anhaeusser, C.R. & Thomas, R.J. (Eds.) The geology of South Africa, pp. 325-379. Geological Society of South Africa, Marshalltown.

THOMAS, R.J. 1988. The geology of the Port Shepstone area. Explanation to 1: 250 000 geology Sheet 3030 Port Shepstone, 136 pp. Council for Geoscience, Pretoria.

GAMTOOS GROUP

GAUCHER, C. & GERMS, G.J.B. 2006. Recent advances in South African Neoproterozoic-Early Palaeozoic biostratigraphy: correlation of the Cango Caves and Gamtoos Groups and acritarchs of the Sardinia Bay Formation, Saldania Belt. South African Journal of Geology 109, 193-214.

GRESSE, P.G., VON VEH, M.W. & FRIMMEL, H.E. 2006. Namibian (Neoproterozoic) to Early Cambrian successions. In: Johnson, M.R., Anhaeusser, C.R. & Thomas, R.J. (Eds.) The geology of South Africa, pp. 395-420. Geological Society of South Africa, Marshalltown.

HILL, R.S. & NOLTE, C.C. 1989. Gamtoos Group. In: Johnson, M.R. (Ed.) Catalogue of South African lithostratigraphic units 1, 2 pp. SACS, Council for Geoscience, Pretoria.

NOLTE, C.C. 1990. Structure and tectonostratigraphy of the Gamtoos Belt between Tweewaters and Classen Point, Eastern Cape Province, RSA. Unpublished MSc thesis, University of Port Elizabeth, 237 pp.

SHONE, R.W., NOLTE, C.C. & BOOTH, P.W.K. 1990. Pre-Cape rocks of the Gamtoos area - a complex tectonostratigraphic package preserved as a horst block. South African Journal of Geology 93, 616-621.

THAMM, A.G. & JOHNSON, M.R. 2006. The Cape Supergroup. In: Johnson, M.R., Anhaeusser, C.R. & Thomas, R.J. (Eds.) The geology of South Africa, pp. 443-459. Geological Society of South Africa, Marshalltown.

TABLE MOUNTAIN GROUP

General

ALMOND, J.E. 1998a. Early Palaeozoic trace fossils from southern Africa. Tercera Reunión Argentina de Icnologia, Mar del Plata, 1998, Abstracts p. 4.

ALMOND, J.E. 1998b. Trace fossils from the Cape Supergroup (Early Ordovician – Early Carboniferous) of South Africa. Journal of African Earth Sciences 27 (1A): 4-5.

ALMOND, J.E. 2008. Palaeozoic fossil record of the Clanwilliam sheet area (1: 250 000 geological sheet 3218). Unpublished report for the Council for Gesocience, Pretoria, 49 pp,

ANDERSON, A.M. 1975. The “trilobite” trackways in the Table Mountain Group (Ordovician) of South Africa. Palaeontologia africana 18: 35-45.

BRADDY, S.J. & ALMOND, J.E. 1999. Eurypterid trackways from the Table Mountain Group (Ordovician) of South Africa. Journal of African Earth Sciences 29: 165-177.

BROQUET, C.A.M. 1990. Trace fossils and ichno-sedimentary facies from the Lower Palaeozoic Peninsula Formation, Cape Peninsula, South Africa. Abstracts, Geocongress ’90, Cape Town, pp 64-67. Geological Society of South Africa.

BROQUET, C.A.M. 1992. The sedimentary record of the Cape Supergroup: a review. In: De Wit, M.J. & Ransome, I.G. (Eds.) Inversion tectonics of the Cape Fold Belt, Karoo and Cretaceous Basins of Southern Africa, pp. 159-183. Balkema, Rotterdam.

DE BEER, C.H. 2002. The stratigraphy, lithology and structure of the Table Mountain Group. In: Pietersen, K. & Parsons, R. (Eds.) A synthesis of the hydrogeology of the Table Mountain Group – formation of a research strategy. Water Research Commission Report No. TT 158/01, pp. 9-18.

HILLER, N. 1992. The Ordovician System in South Africa: a review. In Webby, B.D. & Laurie, J.R. (Eds.) Global perspectives on Ordovician geology, pp 473-485. Balkema, Rotterdam.

JOHNSON, M.R. 1976. Stratigraphy and sedimentology of the Cape and Karoo sequences in the Eastern Cape Province. Unpublished PhD thesis, Rhodes University, Grahamstown, xiv + 335 pp, 1pl.

JOHNSON, M.R., THERON, J.N. & RUST, I.C. 1999. Table Mountain Group. South African Committee for Stratigraphy, Catalogue of South African Lithostratigraphic Units 6: 43-45. Council for Geoscience, Pretoria.

PLUMSTEAD, E.P. 1967. A general review of the Devonian fossil plants found in the Cape System of South Africa. Palaeontologia africana 10: 1-83, 25 pls.

RUST, I.C. 1967a. On the sedimentation of the Table Mountain Group in the Western Cape province. Unpublished PhD thesis, University of Stellenbosch, South Africa, 110 pp.

RUST, I.C. 1973. The evolution of the Paleozoic Cape Basin, southern margin of Africa. In: Nairn, A.E.M. & Stehli, F.G. (Eds.) The ocean basins and margins, Volume 1: The South Atlantic, pp. 247-275. Plenum Press, London.

RUST, I.C. 1981. Lower Palaeozoic rocks of Southern Africa. In: Holland, C.H. (Ed.) Lower Palaeozoic rocks of the world. Volume 3: Lower Palaeozoic of the Middle East, Eastern and Southern Africa, and Antarctica, pp. 165-187. John Wiley & Sons Ltd, New York.

TANKARD, A.J., JACKSON, M.P.A., ERIKSSON, K.A., HOBDAY, D.K., HUNTER, D.R. & MINTER, W.E.L. 1982. Crustal evolution of southern Africa – 3.8 billion years of Earth history, xv + 523 pp., pls. Springer Verlag, New York.

THAMM, A.G. & JOHNSON, M.R. 2006. The Cape Supergroup. In: Johnson, M.R., Anhaeusser, C.R. & Thomas, R.J. (Eds.) The geology of South Africa, pp. 443-459. Geological Society of South Africa, Marshalltown.

Sardinia Bay Formation

GAUCHER, C. & GERMS, G.J.B. 2006. Recent advances in South African Neoproterozoic-Early Palaeozoic biostratigraphy: correlation of the Cango Caves and Gamtoos Groups and acritarchs of the Sardinia Bay Formation, Saldania Belt. South African Journal of Geology 109, 193-214.

LE ROUX, F.G. 2000. The geology of the Port Elizabeth – Uitenhage area. Explanation of 1: 50 000 geology Sheets 3325 DC and DD, 3425 BA Port Elizabeth, 3325 CD and 3425 AB Uitenhage, 3325 CB Uitenhage Noord and 3325 DA Addo, 55pp. Council for Geoscience, Pretoria.

RUBIDGE, B.S., DE KLERK, W.K. & ALMOND, J.E. 2008. Southern Karoo margins, Swartberg and Little Karoo. Biennial Conference of the Palaeontological Society of South Africa, Matjiesfontein, September 2008, Post-conference field excursion guide, 35 pp.

SHONE, R.W. 1983. The geology of the Sardinia Bay Formation. Unpublished PhD thesis University of Port Elizabeth, South Africa, 405 pp.

SHONE, R.W. 1987. A resedimented conglomerate and shallow-water turbidite from the Sardinia Bay Formation, lower Table Mountain Group. South African Journal of Geology 90, 86-93.

SHONE, R.W. 1991. Trace fossils of the ?Early Ordovician Sardinia Bay Formation, Table Mountain Group. Annals of the South African Museum 101, 9-25.

SHONE, R.W. 1994. Sardinia Bay Formation. Excursion Guide, 8th Biennial Conference of the Palaeontological Society of South Africa, Grahamstown 1994, 10 pp.

SHONE, R.W. & BOOTH, P.W.K. 2005 The Cape Basin, South Africa: a review. Journal of African Earth Sciences 43, 196-210.

THERON, J.N. 1993. The Ordovician System in South Africa. Correlation chart and explanatory notes. In: Williams, S.H. (Ed.) The Ordovician System in Greenland and South Africa. International Union of Geological Sciences Publication No. 29, pp1-5, chart.

TOERIEN, D.K. & HILL, R.S. 1989. The geology of the Port Elizabeth area. Explanation to 1: 250 000 geology Sheet 3324 Port Elizabeth, 35 pp. Council for Geoscience, Pretoria.

Cederberg Formation

ALDRIDGE, R.J., THERON, J.N. & GABBOTT, S.E. 1994a. The Soom Shale: a unique Ordovician fossil horizon in South Africa. Geology Today 10: 218-221.

ALDRIDGE, R.J., GABBOTT, S.E. & THERON, J.N. 2001. The Soom Shale. In: Briggs, D.E.G. & Crowther, P.R. (Eds.) Palaeobiology II, pp. 340-342. Blackwell Science Ltd, Oxford.

COCKS, L.R.M., BRUNTON, C.H.C., ROWELL, A.J. & RUST, I.C. 1970. The first Lower Palaeozoic fauna proved from South Africa. Quarterly Journal of the Geological Society, London 125: 583-603, pls. 39-41.

COCKS, L.R.M. & FORTEY, R.A. 1986. New evidence on the South African Lower Palaeozoic: age and fossils revisited. Geological Magazine 123: 437-444.

Nardouw Subgroup

BOUCOT, A.J., CASTER, K.E., IVES, D. & TALENT, J.A. 1963. Relationships of a new Lower Devonian terebratuloid (Brachiopoda) from Antarctica. Bulletin of American Paleontology 46, No. 207: 81-123, pls. 16-41.

HILL, R.S. 1987. Lithostratigraphy of the Baviaanskloof Formation (Table Mountain Group), including the Kareedouw Sandstone Member. South African Committee for Stratigraphy, Lithostratigraphic Series No. 12, 6 pp. Council for Geoscience, Pretoria.

MALAN, J.A. & THERON, J.N. 1989. Nardouw Subgroup. Catalogue of South African lithostratigraphic units, 2 pp. Council for Geoscience, Pretoria.

MALAN, J.A., THERON, J.N. & HILL, R.S. 1989. Lithostratigraphy of the Goudini Formation (Table Mountain Group). South African Committee for Stratigraphy, Lithostratigraphic Series No. 2, 5pp. Council for Geoscience, Pretoria.

THERON, J.N., MALAN, J.A. & HILL, R.S. 1989. Lithostratigraphy of the Skurweberg Formation (Table Mountain Group). South African Committee for Stratigraphy, Lithostratigraphic Series No. 3, 6pp.

BOKKEVELD GROUP

ALMOND, J.E. 1997. Fish fossils from the Devonian Bokkeveld Group of South Africa. Stratigraphy. African Anthropology, Archaeology, Geology and Palaeontology 1(2): 15-28.

ALMOND, J.E. 1998b. Trace fossils from the Cape Supergroup (Early Ordovician – Early Carboniferous) of South Africa. Journal of African Earth Sciences 27 (1A): 4-5.

ANDERSON, J.M. & ANDERSON, H.M. 1985. Palaeoflora of southern Africa. Prodromus of South African megafloras, Devonian to Lower Cretaceous, 423 pp, 226 pls. Botanical Research Institute, Pretoria & Balkema, Rotterdam.

ANDERSON, M.E., ALMOND, J.E., EVANS, F.J. & LONG, J.A. 1999a. Devonian (Emsian-Eifelian) fish from the Lower Bokkeveld Group (Ceres Subgroup), South Africa. Journal of African Earth Sciences 29: 179-194.

ANDERSON, M.E., LONG, J.A., EVANS, F.J., ALMOND, J.E., THERON, J.N. & BENDER, P.A. 1999b. Biogeographic affinities of Middle and Late Devonian fishes of South Africa. Records of the Western Australian Museum, Supplement No. 57: 157-168.

BASSON, W.A., THERON, J.N. & HILL, R.S. 1995. Lithostratigraphy of the Boplaas Formation (Bokkeveld Group). South African Committee for Stratigraphy, Lithostratigraphic Series No.31, 10 pp.

BECKER, G., BLESS, M.J.M. & THERON, J.N. 1994. Malvinokaffric ostracods from South Africa (Southern Cape; Bokkeveld Group, Devonian). Courier Forschungsinstitut Senckenberg 169: 239-259, 4 pls.

BOUCOT, A.J. 1999. Southern African Phanerozoic marine invertebrates: biogeography, palaeoecology, climatology and comments on adjacent regions. Journal of African Earth Sciences 28: 129-143.

BROQUET, C.A.M. 1992. The sedimentary record of the Cape Supergroup: a review. In: De Wit, M.J. & Ransome, I.G. (Eds.) Inversion tectonics of the Cape Fold Belt, Karoo and Cretaceous Basins of Southern Africa, pp. 159-183. Balkema, Rotterdam.

CHALONER, W.G., FOREY, P.L., GARDINER, B.G., HILL, A.J. & YOUNG, V.T. 1980. Devonian fish and plants from the Bokkeveld Series of South Africa. Annals of the South African Museum 81, 127-157.

COOPER, M.R. 1982. A revision of the Devonian (Emsian – Eifelian) Trilobita from the Bokkeveld Group of South Africa. Annals of the South African Museum 89: 1-174.

COOPER, M.R. 1986. Facies shifts, sea-level changes and event stratigraphy in the Devonian of South Africa. South African Journal of Science 82: 255-258.

HILLER, N. 1980. Lower Devonian fossils in the Kaba Valley. The Eastern Cape Naturalist 24 (3), 25-27.

HILLER, N. 1990. Devonian hyoliths in South Africa, and their palaeoenvironmental significance. Palaeontologia africana 27, 5-8.

HILLER, N. 1995. Devonian chonetacean brachiopods from South Africa. Annals of the South African Museum 104: 159-180.

HILLER, N. & THERON, J.N. 1988. Benthic communities in the South African Devonian. In: McMillan, N.J., Embry, A.F., & Glass, D.J. (Eds.) Devonian of the World, Volume III: Paleontology, Paleoecology and Biostratigraphy. Canadian Society of Petroleum Geologists, Memoir No. 14, pp 229-242.

JELL, P.A. & THERON, J.N. 1999. Early Devonian echinoderms from South Africa. Memoirs of the Queensland Museum 43: 115-199.

JOHNSON, M.R. 1976. Stratigraphy and sedimentology of the Cape and Karoo sequences in the Eastern Cape Province. Unpublished PhD thesis, Rhodes University, Grahamstown, xiv + 335 pp, 1pl.

OOSTHUIZEN, R.D.F. 1984. Preliminary catalogue and report on the biostratigraphy and palaeogeographic distribution of the Bokkeveld Fauna. Transactions of the Geological Society of South Africa 87: 125-140.

PLUMSTEAD, E.P. 1967. A general review of the Devonian fossil plants found in the Cape System of South Africa. Palaeontologia africana 10: 1-83, 25 pls.

PLUMSTEAD, E.P. 1969. Three thousand million years of plant life in Africa. Transactions of the Geoogical Society of South Africa, Annexure to Volume 27, 72 pp, 25 pls.

PLUMSTEAD, E.P. 1977. A new phytostratigraphical Devonian zone in southern Africa which includes the first record of *Zosterophyllum*. Transactions of the Geological Society of South Africa 80: 267-277.

REED, F.R.C. 1904. Mollusca from the Bokkeveld Beds. Annals of the South African Museum 4, 239-272, pls. 30-32.

REED, F.R.C. 1906. New fossils from the Bokkeveld Beds, South Africa. Geological Magasine (Decade 5) 3, 301-310, pls. 16-17.

REED, F.R.C. 1907. Fauna of the Bokkeveld Beds. Geological Magasine 4, 166-171, 222-232.

REED, F.R.C. 1908. New fossils from the Bokkeveld Beds. Annals of the South African Museum 4, 381-406, pls. 47-48.

REED, F.R.C. 1925a. Revision of the fauna of the Bokkeveld Beds. Annals of the South African Museum 22: 27-225, pls. 4-11.

REED, F.R.C. 1925b. Some new lamellibranches from the Bokkeveld Beds. Records of the Albany Museum 3, 257-260, pls. 9-10.

RUTA, M. 1997. First record of a paranacystid mitrate from the Bokkeveld Group of South Africa. Palaeontologia africana 34: 15-25.

RUTA, M. & THERON, J.N. 1997. Two Devonian mitrates from South Africa. Palaeontology 40: 201-243, 8 pls.

SCHWARZ, E.H.L. 1906. South Africa Palaeozoic fossils. Records of the Albany Museum 1, 347-404, pls. 6-10.

SHONE, R.W. & BOOTH, P.W.K. 2005 The Cape Basin, South Africa: a review. Journal of African Earth Sciences 43, 196-210.

TANKARD, A.J. & BARWIS, J.H. 1982. Wave-dominated deltaic sedimentation in the Devonian Bokkeveld Basin of South Africa. Journal of Sedimentary Petrology 52, 0959-0974.

THAMM, A.G. & JOHNSON, M.R. 2006. The Cape Supergroup. In: Johnson, M.R., Anhaeusser, C.R. & Thomas, R.J. (Eds.) The geology of South Africa, pp. 443-459. Geological Society of South Africa, Marshalltown.

THERON, J.N. 1972. The stratigraphy and sedimentation of the Bokkeveld Group. Unpublished DSc thesis, University of Stellenbosch, 175pp, 17pls.

THERON, J.N. 1999. Lithostratigraphy of the Gydo Formation (Bokkeveld Group). South African Committee for Stratigraphy, Lithostratigraphic Series No. 33, 11 + 1 page erratum.

THERON, J.N. 2003. Lithostratigraphy of the Voorstehoek Formation (Bokkeveld Group). South African Committee for Stratigraphy Lithostratigraphic Series No. 38, 11 pp.

THERON, J.N. & LOOCK, J.C. 1988. Devonian deltas of the Cape Supergroup, South Africa. In: McMillan, N.J., Embry, A.F. & Glass, D.J. (Eds.) Devonian of the World, Volume I: Regional syntheses. Canadian Society of Petroleum Geologists, Memoir No. 14, pp 729-740.

THERON, J.N. & JOHNSON, M.R. 1991. Bokkeveld Group (including the Ceres, Bidouw and Traka Subgroups). Catalogue of South African Lithostratigraphic Units 3: 3-5. Council for Geoscience. Pretoria.

THERON, J.N., BASSON, W.A. & HILL, R.S. 1995. Lithostratigraphy of the Gamka Formation (Bokkeveld Group). South African Committee for Stratigraphy, Lithostratigraphic Series No. 29, 13 pp. Council for Geoscience. Pretoria.

THERON, J.N., HILL, R.S. & BASSON, W.A. 1995. Lithostratigraphy of the Hex River Formation (Bokkeveld Group). South African Committee for Stratigraphy, Lithostratigraphic Series No. 30, 9 pp. Council for Geoscience. Pretoria.

WITTEBERG GROUP

ALGEO,T.J.,SCHECKLER, E. and MAYNARD, J.B. (2001). Effects of the Middle to Late Devonian spread of vascular land plants on weathering regimes, marine biotas and global climate. In: Gensel, P.G. and Edwards, D. (Eds.) Plants Invade the Land: Evolutionary and Environmental Perspectives, 213-236. Columbia University Press, New York.

ALMOND, J.E. 1998b. Trace fossils from the Cape Supergroup (Early Ordovician – Early Carboniferous) of South Africa. Journal of African Earth Sciences 27 (1A): 4-5.

ALMOND, J., MARSHALL, J. & EVANS, F. 2002. Latest Devonian and earliest Carboniferous glacial events in South Africa. Abstracts, 16th International Sedimentological Congress, RAU, Johannesburg, pp 11-12.

ANDERSON, J.M. & ANDERSON, H.M. 1985. Palaeoflora of southern Africa. Prodromus of South African megafloras, Devonian to Lower Cretaceous, 423 pp, 226 pls. Botanical Research Institute, Pretoria & Balkema, Rotterdam.

ANDERSON, H.M., HILLER, N. & GESS, R.W. 1995. *Archaeopteris* (Progymnospermopsida) from the Devonian of southern Africa. Botanical Journal of the Linnean Society 117: 305-320.

ANDERSON, M.E., HILLER, N. & GESS, R.W. 1994. The first *Bothriolepis*-associated Devonian fish fauna from Africa. South African Journal of Science 90: 397-403.

ANDERSON, M.E., LONG, J.A., GESS, R.W. & HILLER, N. 1999. An unusual new fossil shark (Pisces: Chondrichthyes) from the Late Devonian of South Africa. Records of the Western Australian Museum, Supplement No. 57: 151-156.

ANDERSON, M.E., LONG, J.A., EVANS, F.J., ALMOND, J.E., THERON, J.N. & BENDER, P.A. 1999b. Biogeographic affinities of Middle and Late Devonian fishes of South Africa. Records of the Western Australian Museum, Supplement No. 57: 157-168.

BOUCOT, A.J. 1999. Southern African Phanerozoic marine invertebrates: biogeography, palaeoecology, climatology and comments on adjacent regions. Journal of African Earth Sciences 28: 129-143.

BOUCOT, A.J., BRUNTON, C.H.C. & THERON, J.N. 1983. Implications for the age of South African Devonian rocks in which *Tropidoleptus* (Brachiopoda) has been found. Geological Magazine 120: 51-58.

BROQUET, C.A.M. 1992. The sedimentary record of the Cape Supergroup: a review. In: De Wit, M.J. & Ransome, I.G. (Eds.) Inversion tectonics of the Cape Fold Belt, Karoo and Cretaceous Basins of Southern Africa, pp. 159-183. Balkema, Rotterdam.

CLACK, J.A., (2002). Gaining ground: the origin and evolution of tetrapods, **pp. Indiana University Press.

COTTER, E. 2000. Depositional setting and cyclical development of the lower part of the Witteberg Group (Mid- to Upper Devonian), Cape Supergroup, Western Cape, South Africa. South African Journal of Geology 103: 1-14.

EVANS, F.J. 1997. Palaeobiology of Early Carboniferous fishes and contemporary lacustrine biota of the Waaipoort Formation (Witteberg Group), South Africa. Unpublished MSc thesis, University of Stellenbosch, xii + 213 pp, 85 pls.

EVANS, F.J. 1998. Taphonomy of some Upper Palaeozoic actinopterygian fish from southern Africa. Journal of African Earth Sciences 27(1A): 69-70.

EVANS, F.J. 1999. Palaeobiology of Early Carboniferous lacustrine biota of the Waaipoort Formation (Witteberg Group), South Africa. Palaeontologia africana 35: 1-6.

EVANS, F.J. 2005. Taxonomy, palaeoecology and palaeobiogeography of some Palaeozoic fish of southern Gondwana. Unpublished PhD thesis, University of Stellenbosch, 629 pp.

GARDINER, B.G. 1969. New palaeoniscoid fish from the Witteberg series of South Africa. Zoological Journal of the Linnean Society, London 48: 423-452.

GARDINER, B.G. 1973. New Palaeozoic fish remains from southern Africa. Palaeontologia africana 15: 33-35.

GESS, R.W. 1995a. Unlocking Grahamstown's past – an Upper Devonian estuary. The Eastern Cape Naturalist 39, 20-25.

GESS, R.W. 1995b. Taking the lid off a geological plant press. The Phoenix 8, 18-22.

GESS, R.W. 2001. A new species of *Diplacanthus* from the Late Devonian (Famennian) of South Africa. Annales de Paléontologie 87: 49-60.

GESS, R.W. 2002. The palaeoecology of a coastal lagoon of the Witpoort Formation (Upper Devonian, Famennian) in the Eastern Cape province, South Africa. Unpublished MSc thesis, University of Fort Hare, 66 pp.

GESS, R. 2008. The vertebrate fauna of the Late Devonian, Famennian, Witpoort Formation, Waterloo Farm locality, near Grahamstown. Programme and abstracts, Biennial Conference of the Palaeontological Society of South Africa, Matjiesfontein September 2008, 101-105.

GESS, R.W. & HILLER, N. 1995a. A preliminary catalogue of fossil algal, plant, arthropod, and fish remains from a Late Devonian black shale near Grahamstown, South Africa. Annals of the Cape Provincial Museums (Natural History) 19: 225-304.

GESS, R.W. & HILLER, N. 1985b. Late Devonian charophytes from the Witteberg Group, South Africa. Review of palaeobotany and palynology 89, 417-149.

GESS, R.W., COATES, M.I. & RUBIDGE, B.S. 2006. A lamprey from the Devonian Period of South Africa. Nature 443: 981-984.

HILLER, N. 1990b. Benthic communities and sedimentary facies in the lower Witteberg Group (Devonian, South Africa). Annals of the South African Museum 99: 215-230.

HILLER, N. & TAYLOR, F.F. 1992. Late Devonian shoreline changes: an analysis of Witteberg Group stratigraphy in the Grahamstown area. South African Journal of Geology 95: 203-212.

HILLER, N. & GESS, R.W. 1996. Marine algal remains from the Upper Devonian of South Africa. Review of palaeobotany and palynology 91, 143-149.

JOHNSON, M.R. 1976. Stratigraphy and sedimentology of the Cape and Karoo sequences in the Eastern Cape Province. Unpublished PhD thesis, Rhodes University, Grahamstown, xiv + 335 pp, 1pl.

JOHNSON, M.R., THERON, J.N. & LOOCK, J.C. 2006. Witteberg Group. South African Committee for Stratigraphy, Catalogue of South African Lithostratigraphic Units 9: 47-49.

JUBB, R.A. 1965. A new palaeoniscoid fish from the Witteberg Series (Lower Carboniferous) of South Africa. Annals of the South African Museum 48: 267-272, pl. 6.

JUBB, R.A. & GARDINER, B.G. 1975. A preliminary catalogue of identifiable fossil fish material from southern Africa. Annals of the South African Museum 67: 381-440.

LONG, J.A., ANDERSON, M.E., GESS, R. & HILLER, N. 1997. New placoderm fishes from the Late Devonian of South Africa. Journal of Vertebrate Paleontology 17: 253-268.

OELOFSEN, B.W. 1981a. The fossil record of the Class Chondrichthyes in southern Africa. Palaeontologia africana 24: 11-13.

PLUMSTEAD, E.P. 1967. A general review of the Devonian fossil plants found in the Cape System of South Africa. Palaeontologia africana 10: 1-83, 25 pls.

PLUMSTEAD, E.P. 1969. Three thousand million years of plant life in Africa. Transactions of the Geoogical Society of South Africa, Annexure to Volume 27, 72 pp, 25 pls.

RAYNER, R.J. 1988. Early land plants from South Africa. Botanical Journal of the Linnean Society 97, 229-237.

RENNIE, J.V.L. 1934. Note on an *Estheria* from the Witteberg Series. South African Journal of Science 31, 233-235.

SHONE, R.W. & BOOTH, P.W.K. 2005 The Cape Basin, South Africa: a review. Journal of African Earth Sciences 43, 196-210.

TAYLOR, F.F. & HILLER, N. 1993. A new Devonian fossil plant locality in the eastern Cape Province, South Africa. South African Journal of Science 89, 565-568.

THAMM, A.G. & JOHNSON, M.R. 2006. The Cape Supergroup. In: Johnson, M.R., Anhaeusser, C.R. & Thomas, R.J. (Eds.) The geology of South Africa, pp. 443-459. Geological Society of South Africa, Marshalltown.

THERON, J.N. 1994. The Devonian –Carboniferous boundary in South Africa. Annales de la Societé géologique de Belgique 116: 291-3000.

THERON, J.N. & LOOCK, J.C. 1988. Devonian deltas of the Cape Supergroup, South Africa. In: McMillan, N.J., Embry, A.F. & Glass, D.J. (Eds.) Devonian of the World, Volume I: Regional syntheses. Canadian Society of Petroleum Geologists, Memoir No. 14, pp 729-740.

WATERSTON, C.D., OELOFSEN, B.W. & OOSTHUIZEN, R.D.F. 1985. *Cyrtoctenus wittebergensis* sp. nov. (Chelicerata: Eurypterida), a large sweep-feeder from the Carboniferous of South Africa. Transactions of the Royal Society of Edinburgh 76: 339-358.

KAROO

JOHNSON, M.R. 1966. The stratigraphy of the Cape and Karoo Systems in the Eastern Cape province. Unpublished MSc Thesis, Rhodes University, Grahamstown, ** pp.

JOHNSON, M.R. 1976. Stratigraphy and sedimentology of the Cape and Karoo sequences in the Eastern Cape Province. Unpublished PhD thesis, Rhodes University, Grahamstown, xiv + 335 pp, 1pl.

UITENHAGE GROUP

Enon Formation

HAUGHTON, S.H., FROMMURZE, H.F. & VISSER, D.J.L. 1937. The geology of portion of the coastal belt near the Gamtoos Valley, Cape Province. An explanation of Sheets Nos. 151 North and 151 South (Gamtoos River), 55 pp. Geological Survey / Council for Geoscience, Pretoria.

Kirkwood Formation

ANDERSON, J.M. & ANDERSON, H.M. 1985. Palaeoflora of southern Africa. Prodromus of South African megafloras, Devonian to Lower Cretaceous, 423 pp, 226 pls. Botanical Research Institute, Pretoria & Balkema, Rotterdam.

BAMFORD, M.K. 1986. Aspects of the palaeoflora of the Kirkwood and Sundays River Formations, Algoa Basin, South Africa. Unpublished M.Sc. Thesis, Univ. Witwatersrand, 160pp.

BROOM, R. 1904. On the occurrence of an opisthocoelian dinosaur (*Algoasaurus bauri*) in the Cretaceous beds of South Africa. Geological Magazine 5:445-447.

BROWN, J.T. and GOW, C.E. 1976. Plant fossils as indicators of the rate of deposition of the Kirkwood Formation in the Algoa basin. South African Journal of Science 72(9), 278-279.

DE KLERK, W.J. 2008. A review of the occurrence of disarticulated Early Cretaceous sauropod dinosaur fossils from the Kirkwood Formation of the Oudtshoorn and Algoa Basins. Programme and abstracts, Biennial Conference of the Palaeontological Society of South Africa, Matjiesfontein September 2008, 90-91.

DE KLERK, W. J., FORSTER, C.A., ROSS, C. F., SAMPSON, C. D. & CHINSAMY, A. 1997. New maniraptoran and iguanodontian dinosaurs from the Early Cretaceous Kirkwood Formation, South Africa. Journal of Vertebrate Paleontology 17, Supplement: p42A.

DE KLERK, W. J., FORSTER, C. A., ROSS, C. F., SAMPSON, S. D. & CHINSAMY, A. 1998. A review of recent dinosaur and other vertebrate discoveries in the Early Cretaceous Kirkwood Formation in the Algoa Basin, Eastern Cape, South Africa. Journal of African Earth Sciences 27:p55.

DE KLERK, W.J., 2000 South Africa's first dinosaur revisited - history of the discovery of the stegosaur *Paranthodon africanus* (Broom). Annals of the Eastern Cape Museums 1, 54-60.

DE KLERK, W.J., RAATH, M.A. & HILLER, N. 1992. The first South African dinosaur: a palaeontological site of historical significance. Abstracts of the Seventh Biennial Conference of the Palaeontological Society of South Africa, University of Witwatersrand, Johannesburg, **p.

DE KLERK, FORSTER, C.A., SAMPSON, S.D., CHINSAMY, A. and ROSS, C.F. 2000. A new coelurosaurian dinosaur from the Early Cretaceous of South Africa. Journal of Vertebrate Paleontology, 20(2), 324-332.

DINGLE, R.V., SIESSER, W.G. & NEWTON, A.R. 1983. Mesozoic and Tertiary geology of southern Africa. viii + 375 pp. Balkema, Rotterdam.

DU TOIT, A.L. 1954. The geology of South Africa (3rd edition). 611 pp, 41 pls, geological map insert.

FORSTER, C.A., FROST, S. & ROSS, C.F. 1995. New dinosaur material and paleoenvironment of the Early Cretaceous Kirkwood Formation, Algoa Basin, South Africa. Journal of Vertebrate Paleontology 15, Supplement, p28A.

FORSTER, C.A. & DE KLERK, W.J. 2008. Preliminary report on a new basal iguanodontian dinosaur from the Early Cretaceous Kirkwood Formation, South Africa. Programme and abstracts, Biennial conference of the Palaeontological Society of South Africa, Matjiesfontein September 2008, p98.

GALTON, P.M. and COOMBS, W.P. 1981. *Paranthodon africanus* (Broom): A stegosaurian dinosaur from the lower Cretaceous of South Africa. Geobios 14,299-309.

GOMEZ, B. BAMFORD, M. MARTINEZ-DELCLOS, X. 2002. Lower Cretaceous plant cuticles and amber (Kirkwood Formation, South Africa). C.R. Palevol 1. 83 – 87.

HOFFMAN, A.C. 1966. A gigantic plesiosaur from the South African Cretaceous. South African Journal of Science 62, 138-140.

McLACHLAN, I.R. & McMILLAN, I.K. 1976. Review and stratigraphic significance of southern Cape Mesozoic palaeontology. Transactions of the Geological Society of South Africa. 79: 197-212.

RICH, T.H.V. and RICH, P.V. 1977. Search for Gondwana Late Mesozoic Mammals and Birds. National Geographic Society Research Reports, 1977 Projects: 643 -649 June 95 Algoa Basin Kirkwood Formation South Africa ** pp.

RICH, T.H., MOLNAR, R.E., and RICH, P.V. 1983. Fossil vertebrates from the Late Jurassic or Early Cretaceous Kirkwood Formation, Algoa Basin, South Africa. Transactions of the Geological Society of South Africa 86:281-291.

ROSS, C.F., SUES, H-D. & DE KLERK, W.J. 1999. Lepidosaurian remains from the lower Cretaceous Kirkwood Formation of South Africa. Journal of Vertebrate Paleontology, 19(1), 21-27.

RUBIDGE, B.S., DE KLERK, W.J. & ALMOND, J.E. 2008. Southern Karoo Margins, Swartberg and Little Karoo. Palaeontological Society of South Africa, 15th Biennial Meeting, Matjiesfontein. Post-conference excursion guide, 35 pp.

SCHWARZ, E.H.L. 1913. The Bushmans River Cretaceous rocks. Transactions of the Geological Society of South Africa 16:41-43.

SCOTT, L. 1971. Lower Cretaceous pollen and spores from the Algoa Basin (South Africa). Unpublished MSc Thesis, University of the Orange Free State, Bloemfontein, 1-80.

SCOTT, L. 1976. Palynology of Lower Cretaceous deposits from the Algoa Basin (Republic of South Africa). Pollen et Spores 18(4), 563-609.

SCOTT, L. 1976. Palynology of the Lower Cretaceous deposits (the Uitenhage Series) from the Algoa Basin. Palaeoecology of Africa 7, 42-44.

SEWARD, A.C. 1903. Fossil floras of Cape Colony. Annals of the South African Museum 4, 1-122.

VON HEUNE, F. 1932. Die fossile Reptil-Ordnung Saurischia, ihre Entwicklung und Geschichte. Monogr. Geol. Pal., (1)4(1-2), I-viii + 1-361.

Sundays River Formation

ANDREWS, C.W. 1910. Description of a new plesiosaur (*Plesiosaurus capensis* sp. nov.) from the Uitenhage beds of Cape Colony. Annals of the South African Museum 7, 309-323, pl. 18, 4 textfigs.

ATHERSTONE, W.G. 1857. Geology of Uitenhage. The Eastern Province Monthly Magazine, Grahamstown 1(10):518-532 and continued in 1(11):580-595. [alternatively 1, 642-651, and 2, 1-8. From Rigassi & Dixon 1972].

BAMFORD, M.K. 1986. Aspects of the palaeoflora of the Kirkwood and Sundays River Formations, Algoa Basin, South Africa. Unpublished M.Sc. Thesis, Univ. Witwatersrand, 160pp.

BEER, E.M. 1972. Note. Annals of the Geological Survey of South Africa 9, 25.

BOUCOT, A.J. 1999. Southern African Phanerozoic marine invertebrates: biogeography, palaeoecology, climatology and comments on adjacent regions. Journal of African Earth Sciences 28: 129-143.

BRENNER, P. & OERTLI, H.J. 1976. Lower Cretaceous ostracodes (Valanginian to Hauterivian) from the Sundays River Formation, Algoa Basin, South Africa. Centre Rech. Pau-S.N.P.A. Bull. 10, 471-533.

COOPER, M.R. 1973. A review of the Lower Cretaceous (Upper Valanginian) Cephalopoda from the Uitenhage Formation of South Africa. Unpublished MSc thesis, University of Natal, Durban, 221 pp.

COOPER, M.R. 1979. A new species of *Myophorella* (Bivalvia, Trigoniidae) from the Sunday's River Formation, South Africa. Annals of the South African Museum 78 (3), 21-27.

COOPER, M.R. 1981. Revision of the Late Valanginian Cephalopoda from the Sundays River Formation of South Africa, with special reference to the Genus *Olcostephanus*. Annals of the South African Museum 83: 147-366, 206 figs.
[useful historical review]

COOPER, M.R. 1983. The ammonite genus *Umgazaniceras* in the Sundays River Formation. Transactions of the Geological Society of South Africa 86(1):63-64.

COOPER, M.R. 1991. Lower Cretaceous Trigonioida (Mollusca, Bivalvia) from the Algoa Basin, with a revised classification of the order. Annals of the South African Museum 100(1):1-52.

DINGLE, R.V. 1969. Marine Neocomian Ostracoda from South Africa. Transactions of the Royal Society of South Africa 38, 139-164, pl. 9, 14 text figs., 1 table.

DINGLE, R.V. 1973. Mesozoic paleogeography of the southern Cape, South Africa. Palaeogeography, Palaeoclimatology, Palaeoecology 13, 203-213, 6 text figs.

DINGLE, R.V., SIESSER, W.G. & NEWTON, A.R. 1983. Mesozoic and Tertiary geology of southern Africa. viii + 375 pp. Balkema, Rotterdam.

DU TOIT, A. 1954. The geology of South Africa. xii + 611pp, 41 pls. Oliver & Boyd, Edinburgh.

ENGELBRECHT, L.N.J., COERTZE, F.J. & SNYMAN, A.A. 1962. Die geologie van die gebied tussen Port Elizabeth en Alexandria, Kaapprovinsie. Explanation to geology sheet 3325 D Port Elizabeth, 3326 C Alexandria and 3425 B, 54pp., 8 pls. Geological Survey of South Africa / Council for Geosciences, Pretoria.
[Table 1 – fossils from Sundays River Fm]

HAUGHTON, S.H. 1928. The geology of the country between Grahamstown and Port Elizabeth. Explanation to Cape Sheet 9 Port Elizabeth, 45 pp, 4 figs. Geological Survey of South Africa.

HAUGHTON, S.H. 1935. The geology of a portion of the country east of Steytlerville, Cape Province. Explanation to geology Sheet 150 Sundays River, 35 pp., 3 figs. Geological Survey of South Africa.

HAUGHTON, S.H. 1969. Geological history of southern Africa, 535 pp. Geological Society of South Africa, Johannesburg.

HAUSMANN, J.F.L. 1837. Beiträge zur Kunde der geognostischen Constitution von Süd-Afrika. Gottingische gelehrte Anzeigen 1837, 1449-1462.

HILL, R.S. 1975. The geology of the northern Algoa Basin, Port Elizabeth. Annals of the University of Stellenbosch Series A1.1, 105-191.

HOLUB, E. & NEUMAYR, M. 1882. Ueber einige Fossilien aus der Uitenhage-Formation in Süd-Afrika. Denkschriften der Akademie der Wissenschaften Wien, Math.-nat. Klasse 44, 12. [267 in Cooper 1991]

JOHNSON, M.R. & LE ROUX, F.G. 1994. The geology of the Grahamstown area. Explanation to 1: 250 000 geology Sheet 3326 Grahamstown, 40 pp. Council for Geoscience. Pretoria.

JOUBERT, P. & JOHNSON, M.R. 1998. Abridged lexicon of South African stratigraphy. South African Committee for Stratigraphy, 160 pp. Council for Geoscience, Pretoria.

KITCHIN, F.L. 1907. Notes on the invertebrate fauna of the Uitenhage series in Cape Colony. Geological Magazine, London 54, 289-295.

KITCHIN, F.L. 1908. The invertebrate fauna and palaeontological relationships of the Uitenhage Series. Annals of the South African Museum 7(2):21-250, pls. 2-11.

KLINGER, H.C. & KENNEDY, W.J. 1979. Cretaceous faunas from southern Africa: Lower Cretaceous ammonites, including a new Bochianitid genus from Umgazana, Transkei. Annals of the South African Museum 78: 11-19.

KRAUSS, F. 1850. Ueber einige Petrefacten aus der unteren Keide des Kaplandes. Nova Acta Acadamiae Caesareae Leopoldino Carolinae germanicae naturae curiousum 22 (2), 439-464.

MACRAE, C. 1999. Life etched in stone. Fossils of South Africa. 305pp. The Geological Society of South Africa, Johannesburg.

McCARTHY & RUBIDGE The story of Earth and Life. Cg. 9. The modern world takes shape.

McLACHLAN, I.R. & McMILLAN, I.K. 1976. Review and stratigraphic significance of southern Cape Mesozoic palaeontology. Transactions of the Geological Society of South Africa. 79: 197-212.

McLACHLAN, I.R. & McMILLAN, I.K. 1979. Microfaunal biostratigraphy, chronostratigraphy and history of Mesozoic and Cenozoic deposits on the coastal margin of South Africa. In: Anderson, A.M. & Van Biljon, W.J. (Eds.) Some sedimentary basins and associated ore deposits of South Africa. Special Publication of the Geological Society of South Africa 6, 161-181.

McMILLAN, I. K., 2003. The Foraminifera of the Late Valanginian to Hauterivian (Early Cretaceous) Sundays River Formation of the Algoa Basin, Eastern Cape Province, South Africa. Annals of the South Africa Museum 106:1-274, 84 figs, 4 tables.

NEWTON, R.B. 1896. On the occurrence of *Alectryonia ungulata* in S.E. Africa, with a notice of previous researches on the Cretaceous conchology of southern Africa. J. Conch., London 8, 136-151, 1 text fig.

PORTLOCK, ?. 1852. Note on fossils collected by R. Rubidge at Sundays River, exhibited by Lieut-Col. Portlock at the Ipswich meeting of the British Association, 1851. Rep. Br. Assoc. Advancement of Science 1852, 68.

PRINGLE, J.A. 1961. A new species of *Trigonia* from the Sundays River Beds of the Uitenhage Series, Cape Province. Annals of the Natal Museum 15, 89-92, 1 pl.

RENNIE, J.V.L. 1934. Two new species of *Pleurotomaria* from the Lower Cretaceous Uitenhage Series. South African Journal of Science 31:233-235, pls. 5,6.
[See other possible pp:
Pleurotomaria TYPE AM.4101, 4102, 3737 (p.230), 4165 (p.234), 225-226.]

RIGASSI, D.A. & DIXON, G.E. 1972. Cretaceous of the Cape Province, Republic of South Africa. Proceedings, Conference on African geology, Ibadan Dec. 1970, pp. 513-527.

ROGERS, A.W. 1906. Geological survey of parts of the divisions of Uitenhage and Alexandria, with appendix on Occurrence of the wood beds on Loerie and Gamtoos Rivers. Annual Report of the Geological Commission of the Cape of Good Hope for 1905, 11-46, 1 map, 6 text figures.

ROGERS, A.W. & SCHWARZ, E.H.L. 1901. Report on the survey of parts of the Uitenhage and Port Elizabeth divisions. Annual Report of the Geological Commission of the Cape of Good Hope for 1901, 1-18.

SCHWARZ, E.H.L. 1913. The Bushmans River Cretaceous rocks. Transactions of the Geological Society of South Africa 16:41-43.

SCOTT, L. 1971. Lower Cretaceous pollen and spores from the Algoa basin (South Africa). Unpublished MSc thesis, University of the Orange Free State, 80 pp, 5 pls.

SHARPE, D. 1856. Description of fossils from the secondary rocks of Sundays River and Zwartkops River, South Africa, collected by Dr. Atherstone and A. G. Bain, Esq. Transactions of the Geological Society, London (2nd Series) 7(4):193-203.

SHONE, R.W. 1976. The sedimentology of the Mesozoic Algoa Basin. Unpublished MSc thesis, University of Port Elizabeth, 48 pp.

SHONE, R.W. 1978. A case of lateral gradation between the Kirkwood and Sundays River Formations, Algoa Basin. Transactions of the Geological Society of South Africa 81: 319-326.

SHONE, R.W. 2006. Onshore post-Karoo Mesozoic deposits. In: Johnson, M.R., Anhaeusser, C.R. & Thomas, R.J. (Eds.) The geology of South Africa, pp. 541-552. Geological Society of South Africa, Marshalltown.

SMITTER, Y.H. 1957. The species relationships and stratigraphic distribution of southern African Upper Cretaceous Epistomina. Palaeontologia africana 5:83-85.

SPATH, L. F. 1930. On the Cephalopoda of the Uitenhage beds. Annals of the South African Museum 28(2):131-157, pls. 13-15, 1 text fig.

TANKARD, A.J., JACKSON, M.P.A., ERIKSSON, K.A., HOBDAY, D.K., HUNTER, D.R. & MINTER, W.E.L. 1982. Crustal evolution of southern Africa – 3.8 billion years of Earth history, xv + 523 pp., pls. Springer Verlag, New York.
[Ch. 12. Fragmentation and Mesozoic paleogeography]

TATE, R. 1867. On some secondary fossils from South Africa. Quarterly Journal of the Geological Society of London 23, 139-174, pls. 5-9.

TOERIEN, D.K. & HILL, R.S. 1989. The geology of the Port Elizabeth area. Explanation to 1: 250 000 geology Sheet 3324 Port Elizabeth, 35 pp. Council for Geoscience. Pretoria.

TRUSWELL, J.F. 1977. The geological evolution of South Africa, 218 pp. Purnell & Sons, Cape Town.

WINTER, H. DE LA R. 1973. Geology of the Algoa Basin, South Africa. In: Blant, G. (Ed.) Sedimentary basins of the African coast. Part, 2 South and East Coast, pp. 17-48. Association of African Geological Surveys, Paris.

WINTER, H. DE LA R. 1979. Application of basic principles of stratigraphy to the Jurassic-Cretaceous interval in southern Africa. Geological Sociiety of South Africa, Special Publication No. 6, 183-196.

WYLEY, A. 1859. Notes of a journey in two directions across the Colony made in the years 1857-8, with a view to determine the character and order of the various geological formations. Appendix to Parliamentary Report G54, ** pp. Cape Town.