Palaeontological Heritage component of FibreCo Telecommunications, basic assessment for the proposed fibre optic data cable project: Route 2: Graaf Reinet to Bloemfontein

DEA REFERENCE: 12/12/20/2162

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Background

SRK Consulting Pty (Ltd) ("SRK") has been appointed by FibreCo Telecommunications ("FibreCo"), to undertake a BAR in terms of the National Environmental Management Act (NEMA), (Act No. 107 of 1998) as amended in 2010 for the construction and operation of an optic fibre data cable and associated infrastructure linking certain cities and towns in South Africa. The authorisation of the BA study will be managed by the Department of Environmental Affairs (DEA).

This BA (DEA reference 12/12/20/2141) deals with the section of the route linking Port Elizabeth and Colesberg. Separate BA's are being undertaken for other sections of the route in South Africa. The FibreCo data cable is anticipated to follow national/ provincial road servitudes. Exact details regarding road cutting and river crossings have not yet been finalized.

Rob Gess consulting was contracted on 17th March 2011 to conduct a phase one Palaeontological Impact Assessment for this and five other routes within two weeks. The tight time constraints on this project only permitted a drive through examination of sensitive routes with very limited sampling, together with a basic desktop assessment.

Geology

The study area is underlain by mudstones and sandstones, ranging stratigraphically from the mid Permian Middleton Formation (Adelaide Subgroup, Beaufort Group, Karoo Supergroup) to the late Triassic Molteno Formation (Stormsberg Group, Karoo Supergroup) (fig. 1).

The strata of the Karoo Supergroup were deposited within the Karoo sedimentary Basin, which resulted from shortening and thickening of the southern margin of Africa, with coeval folding and uplift of the Cape Supergroup strata along its southern margin. The Karoo Supergroup strata are between 310 and 182 million years old and span the Upper Carboniferous to Middle Jurassic Periods. During this interval the basin evolved from an inland sea, 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 sediments of the mid Beaufort Group Middleton and Balfour Formations were deposited at a time when the Karoo Sea was largely silted up and rivers arising in the Cape Fold Belt Mountains, to the south, meandered across extensive flood planes into an inland lake. Sands were deposited along the river channels whereas periodic flooding deposited muds on the flood planes. These in time came to form the interbedded sandstones and mudstones of the Beaufort Group.

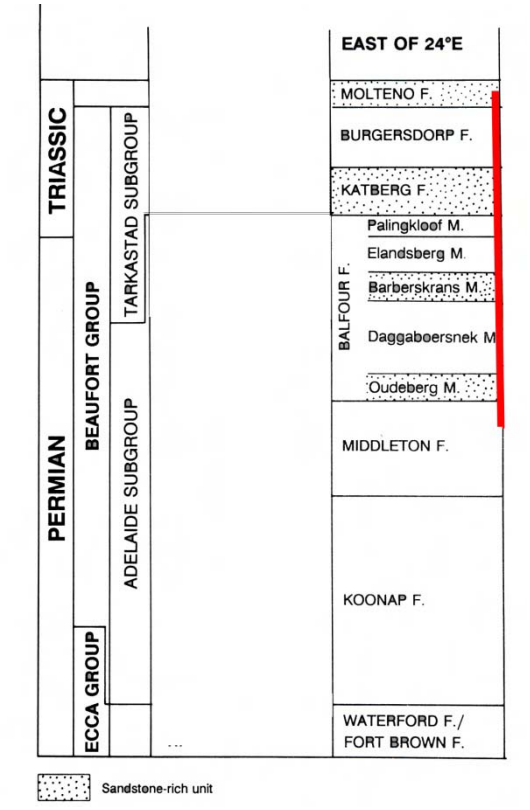
The beginning of the Triassic Period in South Africa was marked by a change in sedimentation, leading to the distinct sandstone dominated lithology of the Katberg Formation (Tarkastad

Subgroup). Extensive sandy deposits resulted from multi channelled braided river systems that replaced the meandering rivers of the 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.

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). These are overlain by thick sandstones that constitute the Molteno Formation (lowermost member of the Stormsberg Group). These sandstones were deposited by large braided river systems, following uplift of the subcontinent and the onset of a cycle of increasing aridification. Occasional coal seams in the Molteno Formation represent localised swamps.

During the formation of the volcanic Drakensberg Group, crack like fissues in the earths crust became filled with molten lava that later cooled to form dolerite dykes. Other magma was injected under pressure between horizontal sedimentary strata and cooled to form extensive horizontal sills of dolerite.

In more geologically recent times the poor drainage of the low gradient plains of the northern Karoo has resulted in deposition of isolated calretised palaeosols associated with former brak pans.



Stratigraphy of Permotriassic sedimentary rocks in the Eastern Cape. Red line represents strata affected by the proposed development. F. = Formation, M. = Member
(modified after Rubidge *et al*. In *Biostratigraphy of the Beaufort Group* (1995), Council for Geoscience)

Palaeontology

The flood planes of the Beaufort Group 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 worlds 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 Middleton Formation includes the upper *Pristerognathus, Tropidostoma* and lower *Cistecephalus* Assemblage zones. These zones are characterised by a changing cast of captorhinind and eosuchian reptiles as well as therapsids of the Dicynodontia, Biarmosuchia, Gorgonopsia and Therocephalia. Small numbers of fish and Amphibia are also known. Most of the Balfour Formation corresponds to the *Dicynodon* Assemblage Zone. Characterised by the co-occurence of *Dicynodon* and *Theriognathus* this zone demonstrates the Beaufort Groups greatest diversity of vertebrate taxa, 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.

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 and the lower part of the Burgersdorp Formation.

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. As yet the Molteno Formation has not yielded vertebrate material.

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. Coaly and mudstone units within the Molteno Formation have

provided an incredible view of late Triassic gymnosperm diversity. On an ordinal level, this appears to have been far greater than modern gymnosperm diversity, extensive reduction in taxa have occurred during an extinction event towards the end of the Triassic.

The strata of the Karoo basin have also yielded fossil insects and insect leaf damage of a range of ages, millipedes, bivalves and behavioural traces of both vertebrates and invertebrates,

Dolerite, being an intrusive igneous rock contains no fossils.

Calcrete hardpans may contain the remains of mammal species differing from those of today, in addition, potentially, to the remains of early *Homo sapiens*. Though of little importance, rhizoliths formed by the calcretisation of plant roots are also common.

Site visit

a: Graaf Reinet to Middleberg

A drive through site inspection of the more sensitive portion of this route was conducted.
In general it was observed that, where the landscape is flat it is frequently deeply weathered and the road reserve has often been build up by a thick broad road bed. As a result, these stretches of the route may be considered to be of relatively low sensitivity.

Where the roadway passes between road cuts it will often be necessary to cut the cable route into the exposed rocky outcrops. Where these roadcuts expose potentially palaeontologically valuable strata a significant sensitivity can be identified.

North of Graaf Reinet the Middleton Formation has been planed off to a deeply weathered surface covered in alluvium (photo 1).

Photo 1: Alluvial plane north of Graaf Reinet (photo 1)

Only where the route passes through the Perrieshoogte is outcrop of the Middleberg Formation exposed in road cuttings (photo 2).

Photo 2: Middleton Formation, lithified channel sands and floodplane muds at Perrieshoogte

Balfour Formation sediments are first encountered in roadcuts at Amandelhoogte. These lower Balfour Formation rocks belong to the *Cistecephalus* Assemblage Zone, the type locality of which is situated about 15 km north east of the Amandelshoogde, along strike in the Gatsberg Pass.

Balfour Formation cuttings belonging to the *Dicynodont* Assemblage Zone are encountered in the Naudesberg Pass and in sparse outcrops near Quaggasfontein (photo 3). The most northerly roadcutting at Quaggasfontein exhibits abundant trace fossils (photo 4) and vegetation drag marks. The road gutter opposite the roadcutting exposes a fine palaeorippled surface.

Photo 3: Balfour Formation exposed at Quaggasfontein.

Photo 4: Trace fossils at Quaggasfontein

Fine exposures of red to purple mudstone belonging to the Katberg Formation are exposed in the cuttings of the Lootsberg Pass. This geosite is of extreme importance as it is the **holostratotype locality of the *Lystrosaurus* Assemblage Zone**.

Photo 5: Maroon mudstones exposed in cuttings in the Lootsberg Pass

Photo 6: Broken through vertebra observed in the Lootsberg Pass

One further outcrop is present between the Lootsberg and Middleberg. This comprises a small exposure of Balfour Formation strata (exposed due to a topographic high resultant from its close proximity to a dolerite intrusion) at Rooihoogte.

Between Rooihoogte and Middleberg the landscape has been reduced to a flat weathered and alluvially covered plane without few topographic features and negligable sedimentary outcrop. This is the 'African Surface', planed off during a time of relative sea level stability extending from the Cretaceous into the early Tertiary.

b: Middleberg to Aliwal North

The evenly planed land surface continues east of Middleberg and no outcrop is found in the road reserve until approximately 10km south east of Steynsburg where the road climbs through low hills of Katberg Formation strata stabilised by cappings of dolerite. These hills, with occasional outcrops belonging to the Katberg Group, continue for approximately 10km beyond Steynsburg.

Thereafter the route is underlain by strata of the stratigraphically overlying Burgersdorp Formation, which is composed of a greater proportion of mudstone than the Katberg Formation and has offered less resistance to the effects of erosion. Nonetheless a large number of outcrops occur within the road reserve between this point and Burgersdorp, most commonly where Burgersdorp Formation rocks underly resistant dolerite, which has protected them from erosion.

Along the route, north east of Burgersdorp no significant outcrops are encountered before the route intercepts strata of the Molteno Formation approximately 20 km west of Aliwal North.

Photo 7: Molteno Formation sandstones approximately 20 km west of Aliwal North

Between the Molteno Formation outcrops and Aliwal North the landscape drops, cutting back down into the Burgersdorp Formation. Approximately 7 km from Aliwal North purplish mudstones capped by buff sandstones of the Burgersdorp Formation are exposed in a road cutting. These sandstones contain rip up clasts of mudstone and abundant woody plant fragments ranging from a few centimetres long to the remains of a small tree trunk.

Photo 8: Burgersdorp Formation mudstones and sandstones west of Aliwal North.

Photo 9: Plant trunk embedded in Burgerdorp Formation sandstone west of Aliwal North.

c: Aliwal North to Bloemfontein

The extremely flat topography associated with the ancient African Surface persists from Aliwal North to Bloemfontein. Nonetheless there are a number of road cutting along the route, exposing mudstones and sandstones belonging to the Burgersdorp, Katberg and Balfour formations. These outcrops have most frequently been protected from erosion by immediate proximity to resistant dolerite dykes, or by cappings comprising dolerite sills.

Due to time constraints, systematic mapping of these outcrops was not possible at this stage.

Conclusions and Recommendations

As noted above recent alluvium deposited on planar surfaces along the route are of extremely low, though not zero, palaeontological sensitivity.

There are, however, a large number of roadcuttings along this route consisting of strata of potentially very high palaeontological importance.

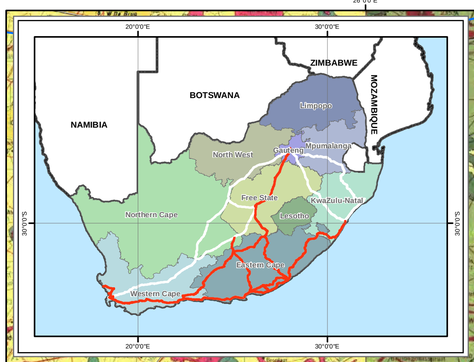
It is therefore recommended that:

1. Excavations into roadcuttings identified during the survey in sensitive Karoo Supergroup sedimentary strata (see map) between Graaf Reinet and Aliwal North are monitored on site by a qualified palaeontologist, who should collect and log important palaeontological material identifiable prior to cutting, aswell as material freshly disturbed during cutting.

2. Disturbance of Palaeontological material in Karoo Supergroup road cuttings between Aliwal North and Bloemfontein, or in more recent alluvial deposits between roadcuttings along the entire route, should be immediately reported to a palaeontologist.

			EAST OF 24°E
TRIASSIC			MOLTENO F.
			BURGERSDORP F.
PERMIAN	BEAUFORT GROUP	TARKASTAD SUBGROUP	KATBERG F.
		ADELAIDE SUBGROUP	BALFOUR F.: Palingkloof M. / Elandsberg M. / Barberskrans M. / Daggaboersnek M. / Oudeberg M.
			MIDDLETON F.
	ECCA GROUP		KOONAP F.
			WATERFORD F./ FORT BROWN F.

Sandstone-rich unit



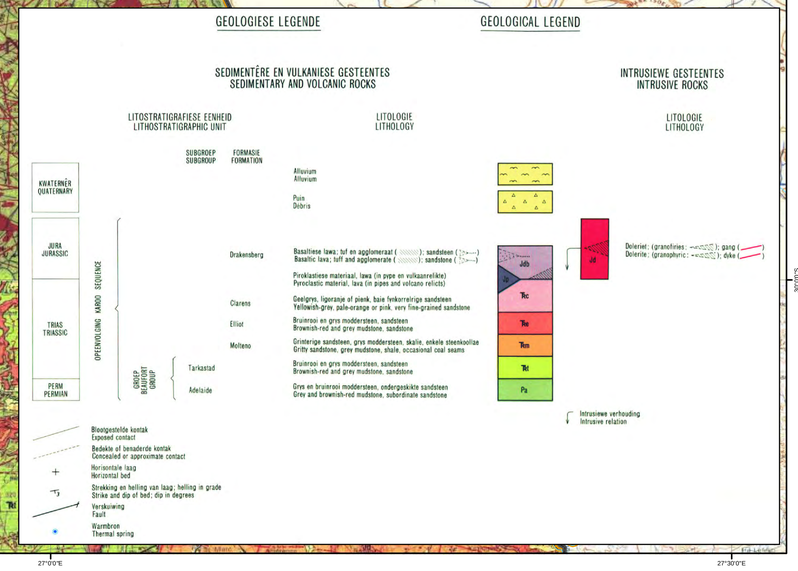
GEOLOGIESE LEGENDE

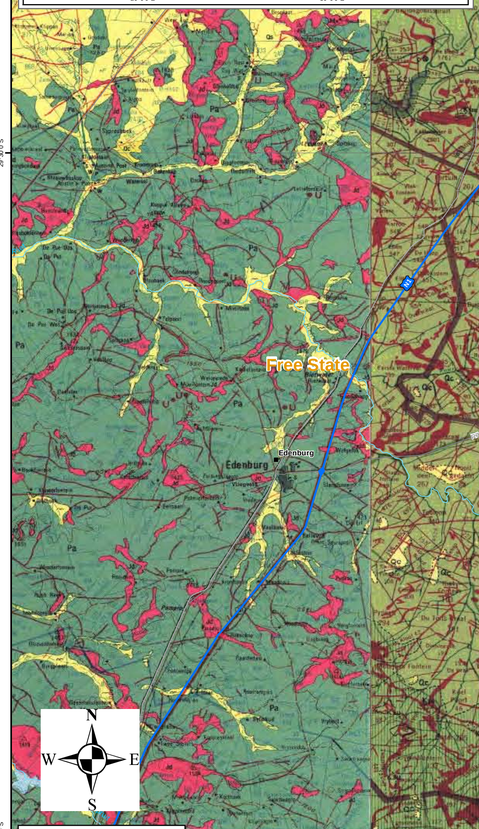
Qc	Surface-limestone Oppervlakkalksteen		Recent
Kb	Kimberlite dyke Kimberlietgang		Cretaceous?
	Diatreme Diatrema		Post-Karroo
	Volcanic neck Vulkaniese pyp		
	Dolerite, overprinted on geological formations Doleriet, oorgedruk op geologiese formasies		
K4d	Basaltic lava Basaltiese lawa	Drakensberg Formation	Stormberg Group / KAROO SUPERGROUP
K4c	Massive sandstone, thin shale Massiewe sandsteen, dun skalie	Clarens Formation	
K4r	Purple shale and mudstone; thin sandstone Pers skalie en moddersteen; dun sandsteen	Elliot Formation	
K4m	Feldspathic sandstone and grit, green shale Veldspatiese sand- en grintsteen, groen skalie	Molteno Formation	
K3u	Purple and green shale, thick sandstone beds Pers en groen skalie, dik sandsteenlae	Upper Stage	Beaufort Group / KAROO SUPERGROUP
K3m	Sandstone, shale and mudstone Sandsteen, skalie en moddersteen	Middle Stage	
K3l	Sandstone, shale and mudstone Sandsteen, skalie en moddersteen	Lower Stage	
K2u	Mudstone, shale Moddersteen, skalie	Upper Stage	Ecca Group / KAROO SUPERGROUP

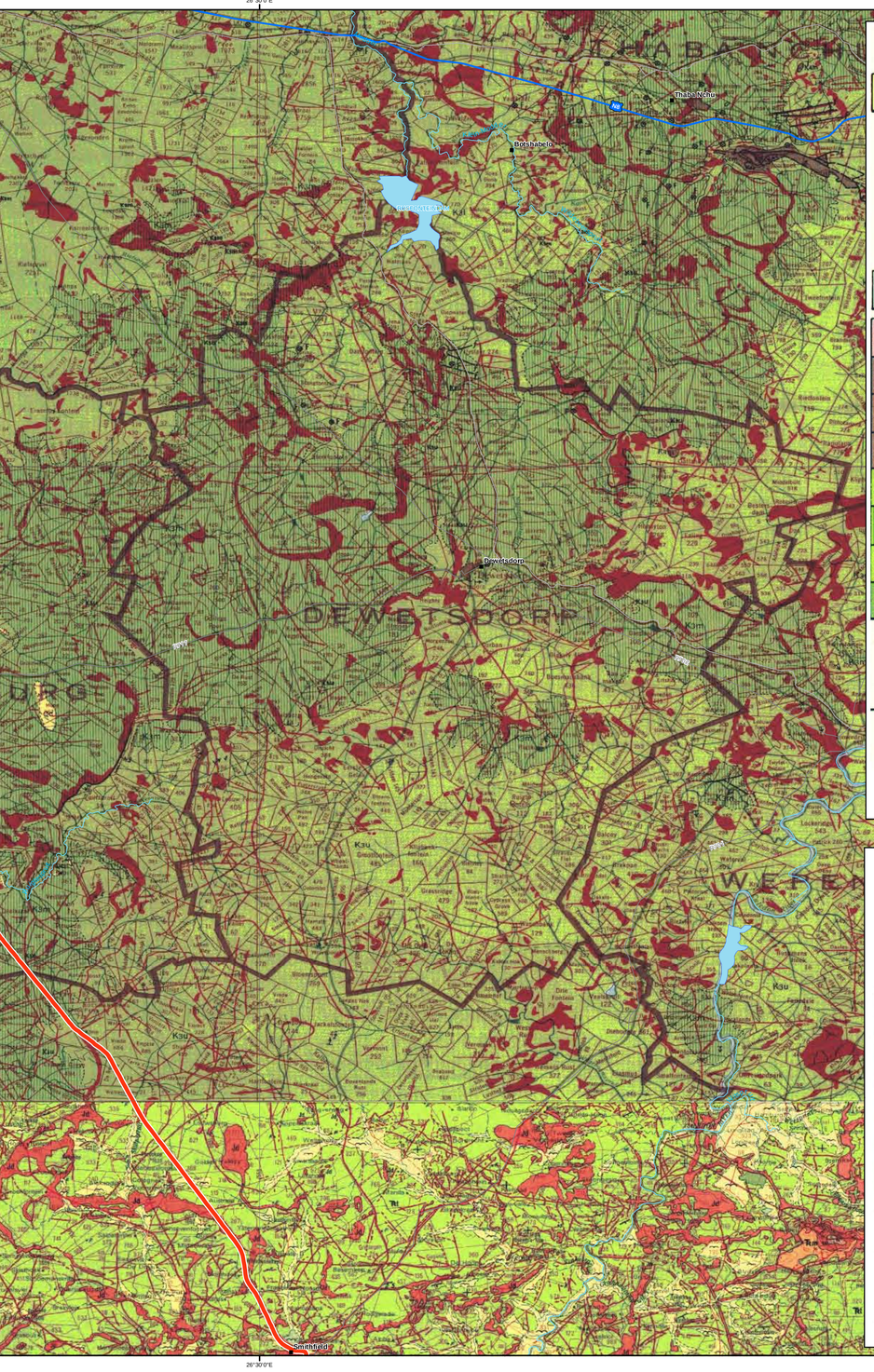
Strike and dip of strata
Strekking en helling van lae

Fault with downthrow indicated
Verskuiwing met valkant aangetoon

F Fossil locality (see list below)
Fossielvindplek (kyk lys hieronder)







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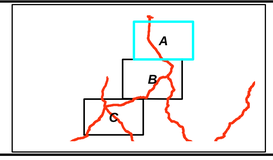

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TITLE:
FIBRE OPTIC DATA PROJECT, SOUTH AFRICA
ROUTE 2 - BLOEMFONTEIN TO GRAAF REINET GEOLOGY

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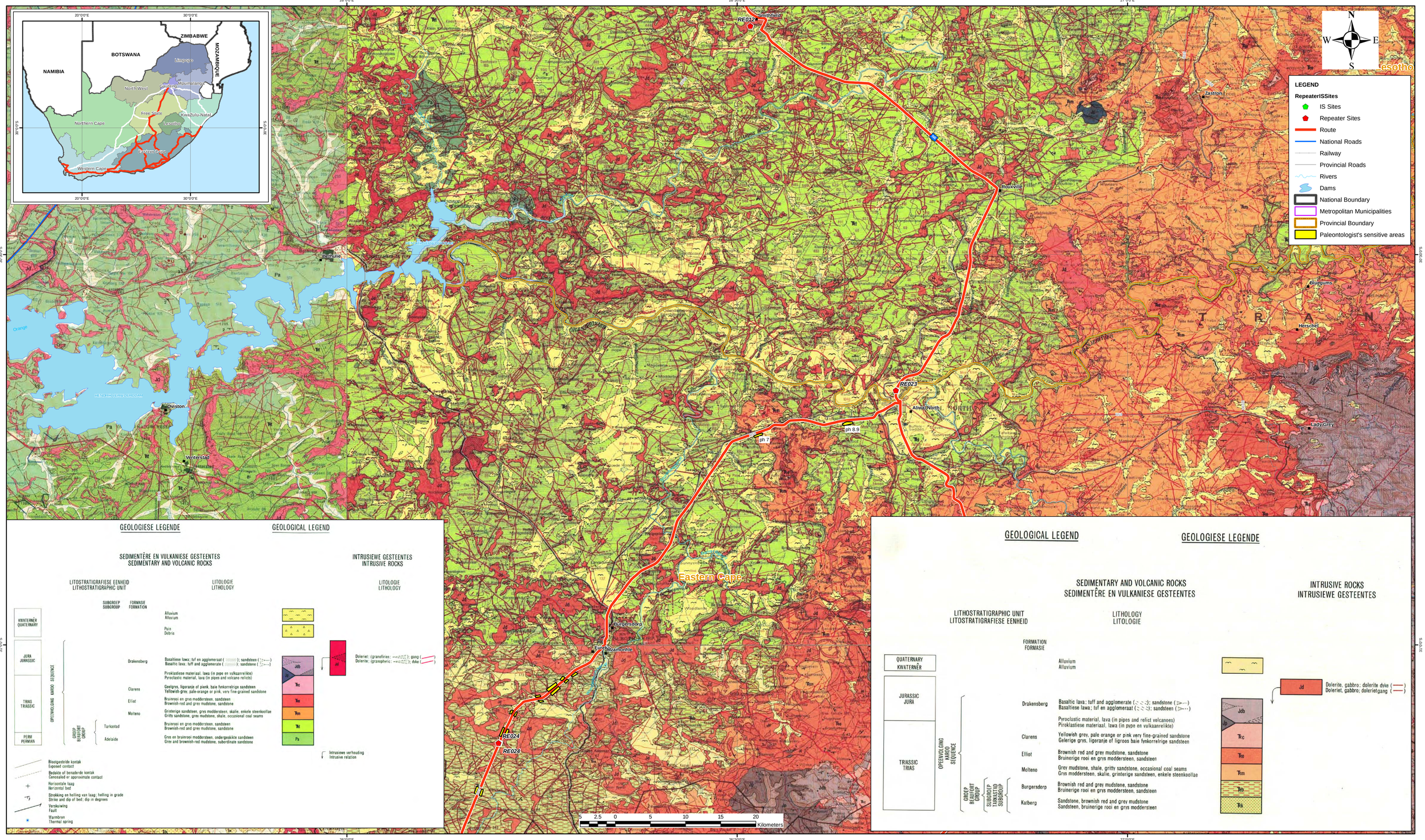

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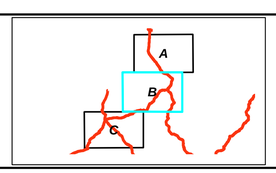

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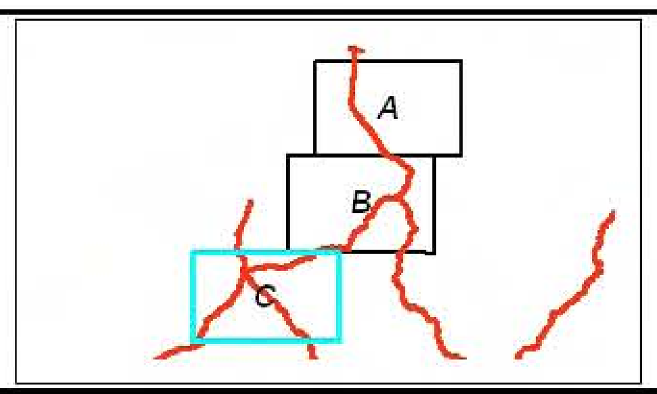

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